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| **Integrative Projects** |
| **The environmental footprint of canola and canola-based products. Theme 5: Canola Integrated Crop Management and Sustainability.****Project Lead** Vern BaronThere are two components: 1. Life cycle assessment of 'on farm' canola production as affected by management change led by Dr. Reynald Lemke. 2. Determination of an 'on farm' carbon footprint for canola in a high yield and input region, Lacombe, AB led by Dr. Vern Baron. Advisors and collaborators are Drs. B. McConkey, K.N. Harker, and J. ODonovan. The LCA will be completed in 2012-13 and reviewed in 2013-14 and a manuscript will be drafted. The carbon footprint study is carried out at field scale in 20 ha fields at Lacombe, AB. with field equipment. Greenhouse gas emissions, carbon sequestration or loss are determined annually and net emission calculated annually. The carbon footprint is represented using canola and barley seed as a functional unit or greenhouse gas in C02 equivalent per kg seed produced (kg C02e kg seed1). A functional unit representing biological energy (e.g. lipid, carbohydrate and protein) will also be determined for comparison. The gross margins, costs and profit or losses will be determined annually. Data will be summarized annually and data from all years will be summarized and a final report written in 2016-17. |
| **The development of Fourier-transformation infrared spectroscopy (FTIR) as a tool to assess and identify soil quality under best management practices (BMP’s).**  **Project Lead** Xueming YangIn order to quantify and characterize the stabilities of SOM, currently, various techniques have been used to first fragment soil sample into fractions with distinct chemical and physical characteristics corresponding to different stabilizing mechanisms and soil functions. Then wet-chemistry or dry combustion methods are used to determine the carbon (C) and nitrogen (N) contents of the different SOM fractions. To obtain those fractions, treatments like dispersion (with chemicals), hydrolysis (oxidation), purification and derivation are often applied to soil samples and these processes are very time-consuming, can produce toxic wastes and may alter the compounds under investigation. These processes also require sophisticated laboratory facilities and skilled laboratory technicians. For routine analysis and study of organic C and N, faster, non-destructive, inexpensive methods are required which do not generate hazardous wastes. Fourier Transform (FT) mid- and near-infrared (MIR and NIR) spectroscopy shows promise in serving as a tool for this purpose as solid materials or aqueous extracts can be analyzed without chemical pre-treatments. However, there is lack of information regarding the application of infrared spectroscopy techniques to Canadian soils and soil fractions. Very recently we developed fast and non-destructive techniques to quantify and qualify key SOM components, amino sugars and particulate organic matter (POM) in bulk soils; however, these methods have only been tested on one soil type and need to be expanded to cover more soils from various climatic regions across Canada. We propose to use FTIR spectroscopy to quantify soil amino sugars and C and N in POM fractions for various types of soils from multiple field study sites across Canada’s agricultural regions. The predictive accuracy of the POM-C and -N contents and soil amino sugars in bulk soil determined using the FT-IR technique will be validated with the results identified using wet-chemistry and dry combustion methods. FTIR measures of amino sugar and the POM-C and -N contents will be evaluated as the indicators of soil quality for various soil management practices using AAFC long-term field trials in British Columbia, Alberta, Ontario and Quebec. This research will provide new methods to both quantify and qualify POM-C and -N and amino sugars using rapid non-destructive, inexpensive, and environmentally-friendly techniques. These methods enable Canadians to effectively monitor and manage agricultural soil for sustainable food production and environmental health. |
| **Sustainability metrics**  **Project Lead** Brian McConkeyThere is need for information on the sustainability of agriculture for evaluating and setting policy, to meet Canada’s national and international reporting commitments on sustainability, to document sustainability for the sector to retain market access, and to support potential growth of new markets for the sector for environmentally friendly agricultural products and/or for environmental goods and services. Providing measures of sustainability is an AAFC obligation to GoC and provinces under GF2. The project fulfills AAFC commitments to provide information required for reporting to the GoC on the Federal Sustainable Development Strategy, to the Organization for Economic Co-operation and Development (OECD), and to the United Nations Framework Convention on Climate Change. This project addresses objectives and focus areas within the STB Agroecosystem Productivity and Health Strategy. The project builds on and adds increased value to past AAFC accomplishments under the National Agri-Environmental Health Analysis and Reporting System (NAHARP) and National Carbon and Greenhouse-gas Accounting and Verification System (NCGAVS). The project supports improvements to accuracy and applicability of a suite of priority measures in areas of soil quality, water quality and quantity, air quality, and biodiversity that are commonly required by various national and international schemes for assessing the environmental sustainability of agriculture. To fully capture scientific synergies and efficiencies, the project works closely (shares personnel and complementary work plans) with a number of related but more topic-focused projects. Thus, the project has a strategic position within the STB to build on past and current science to produce and disseminate needed information on measures of sustainability for policy and sector uses. The first phase of the project up to fiscal year 2015-16 will demonstrate these enhancements for the priority suite of measures. The second phase to end of fiscal year 2017-18 will fully implement these enhancements and expand the range of indicators.  |
| **​Managing carbon to promote soil productivity, health, and biodiversity in Canadian farmlands**  **Project Lead** Edward GregorichMaintaining and improving soil health is becoming increasingly important because of growing demands on land for food, feed, and fuel, as well as stronger emphasis on other ecosystem services such as preserving biodiversity, filtering air and water, and reducing net greenhouse gas emissions. Climate change and other global stresses will exert additional pressure. The organic matter content of soil is closely related to soil health because it maintains soil structure, provides plant nutrients, and fuels microbial activity. To enhance the health of soils, therefore, we need to understand how it is influenced by changing management, climate, and other stresses. Soils are the most biologically active and diverse mediums on the planet, largely because of the energy and nutrients furnished by decaying organic matter. Understanding the factors that govern organic matter decay, and the microbial communities which mediate the process, will identify ways of fostering biodiversity, an objective increasingly recognized as critical. To do this we will use innovative, robust techniques in stable isotope analysis and probing to trace the flows of C and energy in agroecosystems across a broad range of climate and management conditions. In addition to quantifying these dynamics, we will examine how soil biota influence C transformations, providing a basic understanding that can be applied to climate change adaptation.  Our work will elucidate soil functions important for crop production (e.g. crop residue decomposition, soil C retention, nutrient cycling and soil biodiversity), and show ways in which improved management can thereby improve soil health for different soil types and climatic regions. The proposed research will advance and build upon a GF 2 project that established, in 2007, an international network at 14 locations (10 agricultural sites in Canada, one in the Arctic, and 3 international) already underway for more than 8 years. We are aware of no other ongoing project like it and researchers from other countries have expressed interest in collaborating in experiments already underway, and in establishing complementary experiments. The project proposed here will continue the previously-established research sites, incorporate other existing long-term soil experiments (notably the AAFC Soil Quality Benchmark sites established at sites across Canada ~25 years ago), and conduct new field and laboratory experiments, exploiting emerging microbiological and isotopic techniques, to improve our understanding of how organic matter, and hence, soil health responds to potential changes in management and climate. From this understanding will emerge new ways of preserving and augmenting organic matter and enhancing soil biodiversity for improved soil and ecosystem function. Some specific outcomes and benefits include:1) Improved knowledge about soil C dynamics resulting in better assessment of soil health and revealing ways of enhancing crop yields/quality, reducing nutrient loss to the environment, and improving profitability.2) Improved knowledge of SOM dynamics, storage and stability across the land and within the soil profile; better knowledge of the vulnerability of the SOM to perturbations will reveal soils most at risk from changes in management or climate.3) Improved sustainability of crop production systems, with reduced potential for nutrient loss affecting air and water quality, leading to economic and societal benefits.4) Improved models for exploring net ecosystem benefits of proposed mitigation practices and optimum management practices.5) A demonstration of how leading-edge biological methods can be melded into existing soil  |
| **Goods and Services and Climate Change Adaptation of Agroecosystems in Canada**  **Project Lead** David LapenEcological goods and services (EGS) for agroecosystems can be impacted negatively by excessive deforestation, elimination of riparian zones, and unnecessary dredging of water courses. Non-point source pollution is the dominant form of water pollution in agricultural watersheds. Yet it is difficult to determine the nature and location of such pollution. Thus intelligent BMP intervention is challenging. Thirdly, hydrological models retrospectively identify scenarios/conditions that are problematic from a water quantity/quality perspective. Yet, those approaches cannot be used to proactively reduce deleterious effects of floods, soil erosion, losses of nutrients, etc.. Fourthly, land drainage is rampant. There are many BMPs that can reduce agricultural drainage pollution, but most of these BMPs are not working as efficiently as they could. We address these problems via: i) Documenting at watershed scales, EGS benefits (eg., carbon sequestration, soil-water biodiversity, improved water/air/soil quality) resulting from conservation of natural terrestrial habitat in agroecosystems; ii) Use remote sensing technologies and novel chemical/biological source tracking markers to evaluate pollution hotspots in watersheds. Identification of key locations in water courses where water pollution is chronic or acute will help target BMP intervention intelligently. This will also reduce uncertainty in determining the dominant forms (eg., nutrients, bacteria, emerging contaminants) and sources (eg., agriculture, urban, etc.) of water pollution in mixed-use watersheds; iii) Develop a new real-time integrated watershed-scale surface-groundwater hydrological modeling platform that runs in real time and uses real-time model inputs to inform on-the-ground large and small water flow control systems (all for proactive management). Real time prediction of mass fluxes and exchange can be relayed to water managers and producers so that they can modify or regulate water flow control before a crisis happens; and, v) Treatment of pollution in agricultural drainage (eg., N and P and bacteria) via treatment bed substrates using ‘smart’ drainage systems (automated and linked to predictive analytics in Smart Watershed study) will be required in addition to other on-field BMPs to meet water quality targets associated with downstream receptors. Document via reactive transport modeling and field-plot observations, how smart water flow control and treatment systems, cover crops, and conservation tillage practices, can more optimally reduce surface and subsurface pollutant loadings from fields. Firstly, we will demonstrate experimentally using a paired-watershed approach, critical EGS and crop productivity benefits associated with maintaining a mosaicked agroecosystem. Science-based studies like this are necessary for on-the-ground change. Secondly, remote sensing-based technologies and new algorithms predictive of the nature and sources of water pollution (via novel use of chemical/biological source tracking markers), will be a new nexus for precision BMP implementation by watershed stewards. Thirdly, we anticipate that operationalized real-time modeling as noted above could save billions of dollars in crop and infrastructure insurance pay outs in flood-prone river basins; notwithstanding billions of dollars in soil, nutrients, and natural habitat conserved by proactive and interactive on-the-ground risk management. Fourthly, new ‘smart’ agricultural drainage control and treatment systems coupled with tillage/cover crop BMPs will be critical for meeting water quality targets: without nested and/or smart BMPs for field cropping systems, we doubt such targets will be efficient |
| **​Improving the yield-scaled greenhouse gas intensity of grain crop production on the Canadian prairies**  **Project Lead** Reynald LemkeThe human population’s food requirement is projected to double from present levels by 2050. Concurrently, there is an urgent need to limit greenhouse gas emissions to the atmosphere in an effort to avoid dangerous climate change. In Canada, agricultural activities are responsible for approximately 10% of overall anthropogenic greenhouse gas emissions. Consequently it is critically to find and deploy cropping practices that will not only improve yields but also minimize greenhouse gas (GHG) emissions. Previous research has identified a number of crop production practices that can minimize nitrous oxide emissions and/or maintain or improve soil organic carbon status (reduce net CO2 emissions). Management strategies that can increase or at least maintain SOC status include reduced tillage intensity, judicious use of fertilizers and continuous cropping - most particularly with a diversified crop mix. Strategies that reduce N2O emissions from annual grain production on the Canadian prairies include avoidance of fall applied fertilizer N, reduced tillage intensity, and including N-fixing crops into cereal or cereal-oilseed based rotations. Similarly, recent research has identified a number of crop management choices that can improve yield. For canola in particular, these options include shallow and early seeding, narrow row spacing, increased seeding rates, diverse crop sequences, and higher than soil test recommended fertilizer-N rates. The impact of these management strategies on net GHG emissions has not been assessed, nor has the potential synergy of stacking several strategies together been explored. Moreover, no measurement-based studies have documented their performance on an intensity (yield-scaled GHG) basis.We hypothesize that “layering” together a suite of carefully selected individual practices will synergistically improve the yield-scaled GHG intensity of cropping system on the Canadian prairies. Specifically, there are two objectives for the proposed project. First, to assess the yield-scaled GHG mitigation effectiveness of a bundled suite of crop production practices. Second, to quantify the GHG intensity reductions from improved grain production practices on the Canadian prairies.The study design will pair “mitigation” treatments against “standard practice” treatments. Two field studies will be initiated in Saskatchewan, one at Melfort (Black soil zone), and the other at Swift Current (Brown soil zone). All plots will be maintained under no-till management. The reference system will consist of a spring wheat [Triticum aestivum L.] - canola [Brassica napus L.] cropping sequence with target yields, row spacings, seeding rates and dates that are based on general agronomic practices for the respective region. One mitigation treatment will be a wheat-canola sequence with seeding dates and depths that will be as early as possible and as shallow as conditions allow, and utilize narrower row spacing and seeding rates that are markedly higher (target plant densities based on recent research). A second mitigation treatment will include the same management choices for wheat and canola as in the first mitigation treatment, but also introduce an N-fixing crop (Swift Current = lentil [Lens culinaris Medik L.]; Melfort = soybean [Glycine max L.]) into the cropping sequence. All appropriate agronomic and soil and plant analysis measurements will be collected, field operations will be carefully documented, and an intense GHG flux measurement campaign will be undertaken.  |
| **New digital approaches of soil and agricultural land use data development and integration: Canadian land productivity modelling case**  **Project Lead** Xiaoyuan GengDescription of the work: With a constantly increasing global demand for food and fibre, intensification of agricultural production can be expected to increase over the near future. In order to improve productivity, reduce environmental impact and assist producers in managing risk while remaining financially competitive, new, up-to-date and reliable national soil and land use data are essential. In addition, new spatially precise applications that integrate soil, land use, climate and land productivity data are needed to provide the basis for production estimates, sustainability indicators, assessments of greenhouse gas sources and sinks, food tracking and market development initiatives. This study will focus on research and development in the generation of detailed digital soil maps, high-accuracy land use and land use change databases and Earth Observation (EO)-based indices of crop and land productivity. Over the past decade, many digital soil mapping (DSM) techniques have been proposed and tested, including research work at AAFC but have not been applied over wide geographic areas of Canada. In this project, further application of DSM techniques will be undertaken to produce raster-based information at the spatial resolution of 50-250m at both regional and national scales. To enable this work, we will engage with a network of university and provincial colleagues to assemble as much point-based soil information as possible within a national point soil database. New soil frameworks will also be integrated with land use, crop inventory, productivity and residue mapping activities. Similarly, land use mapping using EO has received a great deal of attention over the past decade, but classification accuracies are generally still in the 80-90% range. Land use change, a driver for GHG emissions and loss of agriculturally productive land has never been adequately addressed in Canada. This study will build on existing research in land use and land use change and will, to the extent possible, integrate digital soil as ancillary data to develop accurate, high-resolution land use products for selected agricultural areas of Canada. Assessing crop productivity through the use of EO-based indices such as FAPAR (Fraction of Absorbed Photosynthetically Active Radiation), NDVI (Normalized Difference Vegetation Index) and EVI (Enhanced Vegetation Index) has been the subject of considerable research, but primarily on a plot or field basis. Work on assessing the productivity of soil or landscape units using long-term, multi-seasonal images has shown some promise and will be further researched in this project. Coupled with the soil/climate-based LSRS (Land Suitability Rating System) and yield forecasting, methods of assessing and monitoring variability in crop productivity at the soil pixel level will be developed. Anticipated outcomes: Raster-based soil data: this data can be considered as one of the fundamental data sets for productivity modeling as well as for a wide range of other agri-environmental and sustainability projects. Improved and updated land use and land use change data: these LU products will improve the accuracy and validation of Canada’s international reports, assist in developing GHG adaptation and mitigation strategies, identify the magnitude and location of threats to production and identify the potential for new markets such as crop residue. Regional EO-based productivity indices: these indices will improve our understanding of changes in productivity and assist in anticipating production changes due to outside influences. Productivity framework: this initiative will identify which regions of Canada will have improved or degraded produc |
| **Measuring and assessing Canadian rangeland and other agricultural best management practices with the enhanced whole-farm model Holos**  **Project Lead** Roland KroebelSustainability of agriculture has re-emerged into prominence at round table discussions between producers, industry, consumers, and environmental groups, especially with respect to the cattle industry. Beef cattle are a critical component of Western Canadian agricultural production, and will likely remain so into the foreseeable future because of the unique capacity of ruminants to utilize grass and other forages to furnish high-value human food, while also preserving or enhancing other ecosystem services of the vast areas of lands used for grazing and forage production. Our focus, therefore, is to identify and advance sustainable management practices for agricultural land use (and grasslands specifically). In this systems-based project, we consider jointly measurements of productivity (plant, animal) and environmental impacts (e.g., greenhouse gases, carbon change) on pastures and grasslands in Saskatchewan and Alberta. The understanding derived from this synthesizing effort, will be used to augment Agriculture and Agri-Food (AAFC)’s farm-level model Holos, which allows users to explore ways of managing farms to maintain productivity while reducing overall environmental impact. Specifically, the measurement will exploit existing AAFC long-term studies, including:- 15 year native pasture reseeding and grazing treatment experiment (Swift Current) - 7 year native and tame pasture reseeding and grazing treatment experiment (Swift Current) - 22 year tame pasture under forage and grazing disturbance experiment (Lacombe)- various long-term field experiments from Lethbridge, Scott, and Swift Current. These measurements, as well as others drawn from ongoing research studies, will be used to expand and augment the Holos model. Specific modifications will include: an economic submodel, a feed database, new enteric methane calculations, new ammonia volatilization algorithms, and a further refinement of farm scenarios used as default inputs. In addition to this, work will commence on a new model version with a dynamic carbon model, and the development of a water and nitrogen budget, as well as a submodel to consider effects of trees in agricultural landscapes. These additions to the already existing farm-level greenhouse gas emission estimates will allow a more comprehensive assessment of recommended farm management practices. Example of outputs intended include:- assessing stocking density effects on the carbon footprint of beef cattle raised on rangeland - assessing the environmental impact of forage/feed production on converted cropland relative to an old grass baseline in a parkland environment - assessing the environmental impact of tame vs. native pasture management (e.g., grazing and haying) after conversion from cropland in a semi-arid environment- increased understanding of soil C changes as affected by pasture mixtures and management on converted cropland - a comparison of alfalfa-silage vs. recommended (enteric methane reducing) corn-silage in dairy production systems - an assessment of appropriate Canadian evapotranspiration estimates and the update of crop transpiration curves for Canadian conditions- re-assessment of Canadian crop biomass partitioning for a better understanding of carbon inputs- investigating the long-term crop rotation effects on farm-level carbon stock changes. This research, therefore, continues our established aim of melding emerging scientific findings into a comprehensive, interactive framework which is then used to explore, identify, and communicate to producers land use systems that maintain agricultural output while also enhancing the long-term integrity of our lands. |