CLIMATE CHANGE CENTRAL

REDUCTION AND REMOVAL OF AGRICULTURAL GREENHOUSE GAS EMISSIONS IN ALBERTA

SOIL MEASURING, MONITORING AND VERIFICATION LAND USE DATABASE AND BENCHMARK FIELD PLAN

Discussion Paper C3 – 01(b)

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1. Introduction

1.1 International, National and Provincial Context – Carbon Sequestration and Emission Reductions.

Parties to the Kyoto Protocol, except for the United States, have recently agreed on many of the rules for implementation of the protocol, including the rules for the inclusion of forestry and agricultural carbon sinks in the Kyoto protocol.

Should Canada ratify the Kyoto Protocol, the country will be committed to reducing its emissions by about 200 million tonnes of carbon dioxide equivalents per year in the first commitment period from 2008-2012.

Canada will be allowed to include in their inventory some 22 million tonnes CO2e per year of sequestered carbon from changes in agricultural and rangeland management in the first commitment period from 2008-2012. Canadian agriculture has the potential to deliver as little as 12 million tonnes and as much as 40 million tonnes CO2e per year. The immediate opportunities for Canadian farmers include greater adoption of conservation cropping methods (reduced tillage, reduced summerfallow, conversion of marginal cropland to perennial vegetation etc.), increasing grassland productivity, and improving the feeding efficiency and manure management methods for livestock.

Within Alberta, estimates (using only the immediate opportunities noted above) point to a potential to sequester 5 to 15 million tonnes CO2e per year on cropland from 2008 to 2012. Additional emission reductions of 2 to 4 million tonnes CO2e are possible from the livestock sector in Alberta from improved feed efficiency and manure management initiatives.

1.2 Measuring and Verifying Agricultural Emission Reductions and Removals.

There are a number of challenges if Alberta and Canada are to realize the potential emission removals and reductions from the agricultural sector. Two of the most significant challenges are:

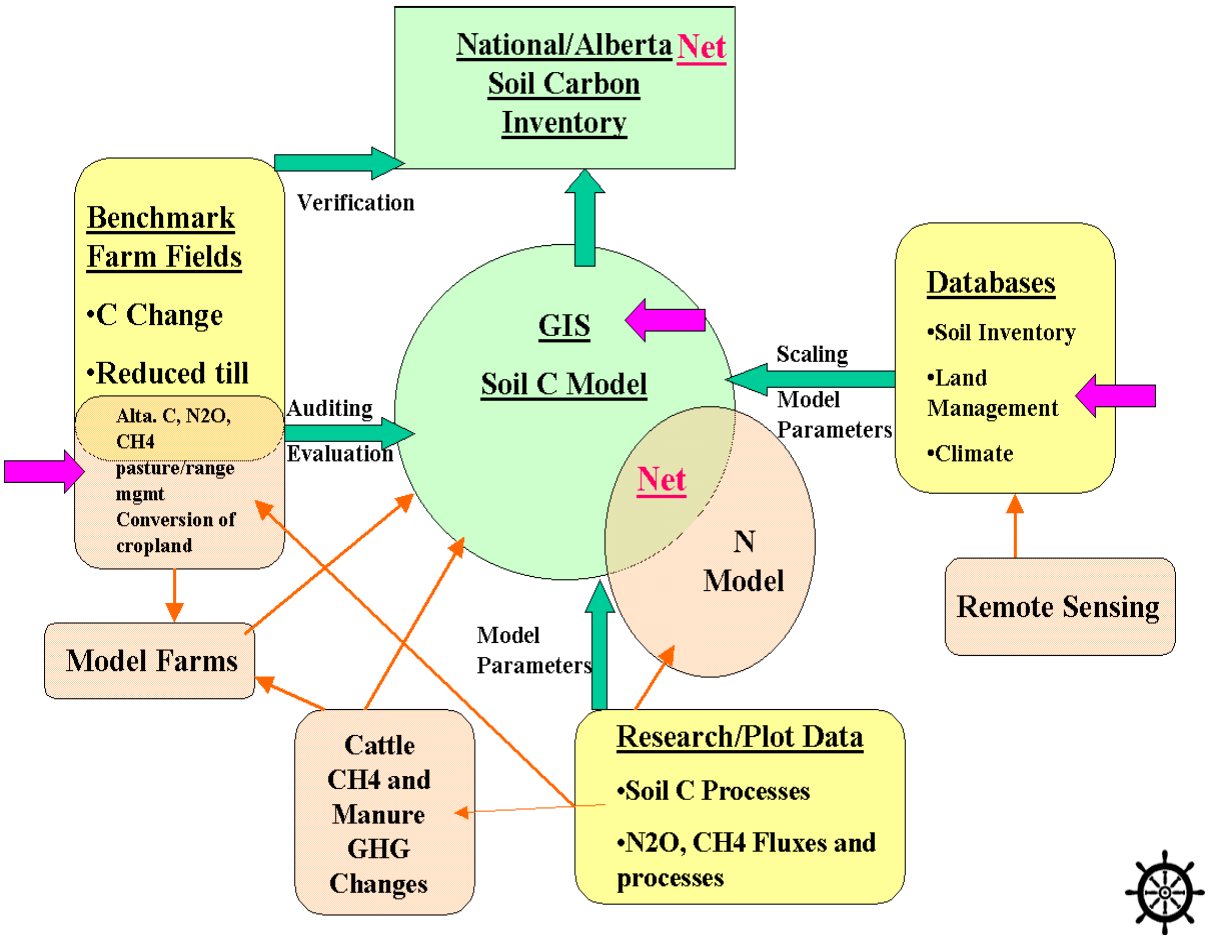
1. to develop and implement a scientifically-based method of measuring and verifying agricultural emission reductions and removals, and,
2. to encourage agricultural producers to adopt changes in farm management which not only reduce and remove emissions but also improve their financial position.

This proposal focuses on the first challenge which provides the groundwork for addressing the second challenge.

Canadian research over the past six years has led to the development of an overall concept to address the first challenge. The overall concept is summarized in Figure 1.

The concept was developed to provide a more cost-effective way of verifying net agricultural soil carbon changes than actually measuring carbon dioxide, methane and nitrous oxide changes throughout every farm field.

Figure 1. Concept for Measuring, Monitoring and Verifying National and Provincial Net Soil Carbon Inventories.



The overall concept to determine the national and provincial inventory of agricultural soil carbon, net of all three major greenhouse gases (carbon dioxide, methane and nitrous oxide), includes many components from research: measuring changes in gases arising from livestock and crop field management changes; modeling the net greenhouse gas emissions from Canadian farms; enhancing and finding ways to use databases on soil distribution, climate and land-use change; and using the databases and measurements with models and scaling methods to derive the national and provincial inventory.

Clearly the scope of this concept requires the partnership and cooperation of federal, provincial and university scientists to address the components of the concept in an integrated manner, which avoids duplication and is useful input to other components of the overall concept.

Since 1996, Alberta Agriculture, Food and Rural Development, together with Agriculture and Agri-Food Canada (AAFC) and GEMCo, has been part of a prairie- wide initiative to measure and verify soil carbon changes which occur when farmers adopt soil conservation practices. The initiative, the Prairie Soil Carbon Balance Project (PSCB) concluded in 2000, with interim results of regional carbon sequestration rates determined from short term measurements from 137 farm field benchmark sites in Saskatchewan, and results from long term research plots in Alberta, Saskatchewan and Manitoba.

Several gaps or needs were identified during the synthesis of the results of the PSCB work including:

1. The need for ongoing measurement in three-year increments, of farm field benchmark sites in Saskatchewan, to allow confident extrapolation to other farms of a similar nature, even though regional extrapolation was satisfactory during the PSCB project.
2. The need for measurement monitoring and verification of net soil carbon changes on additional farm field benchmark sites on cropland in Alberta, particularly in the Peace River district and other areas where the agricultural soils are not well covered by the Saskatchewan benchmarks.
3. The need for measurement monitoring and verification of net soil carbon changes on additional benchmark sites on Alberta rangelands and pastures to determine the net carbon changes associated with methods of improving range and pasture productivity or condition.
4. The need to measure the potential changes in emissions of nitrous oxide and methane that may occur when farmers change to conservation tillage methods. The net emissions of all three greenhouse gases will be counted in the national inventory.
5. The need to measure and verify emission changes on mixed farms and livestock enterprises where significant emission reductions of methane and nitrous oxide are possible, and the need for this information to be included in the calculation of changes to net emissions from the farm.

Climate Change Central's team working on the scope and development of this proposal identified additional gaps which include the need for a method of tracking agricultural land use changes over large areas on an annual or biannual basis (land use database and registry), and the need for methods of scaling information on greenhouse gas emission changes measured on small areas in farm fields to provide regional, provincial and national estimates. The uncertainty of estimates of land use change and scaling need to be addressed and documented also.

The following proposal addresses the first four gaps from the PSCB Project. The fifth gap, the need to measure and verify emission changes on mixed farms and livestock enterprises, is addressed in a separate Climate Change Central proposal. Some of the livestock measurement sites will be integrated with those from this proposal to insure that combined data are used to efficiently calculate net emission reductions and removals.

The proposal also addresses the need for a method of documenting and tracking land use changes. A variety of sources of information on land use change is available and need to be evaluated to determine if they provide sufficient accurate information to meet the needs of the overall concept in a cost effective manner. The most appropriate alternative then needs to be implemented in concert with field site measurement and modeling initiatives within the overall concept.

Methodology for scaling field measurements will be led by Agriculture and Agri-Food Canada (AAFC) in the development of a National Soil Carbon and Greenhouse Gas Inventory (NCGAVS). Climate Change Central's proposed project will be undertaken in collaboration with AAFC and will rely on AAFC to provide the necessary scaling techniques. The results of the Climate Change Central work will provide input to the NCGAVS process both from the benchmark measurement sites and from the land use database and registry work, as shown in Figure 1.

1.3 National Model, Ongoing Plans.

Agriculture and Agri-Food Canada (AAFC) has developed a proposal to continue monitoring the Saskatchewan benchmark sites and extend them on pasture and rangeland in that province. Additionally, they plan to develop the scaling up techniques to provide regional and national estimates of changes in soil carbon over time. They also propose to develop an accounting system for "model farms" across Canada to estimate greenhouse gas emissions and net reductions and removals achieved by farms which change their management methods. Information generated in this project will be important input to the AAFC initiatives.

University and AAFC researchers also have ongoing work on refining soil carbon and nitrogen models within the overall concept described in Figure 1. Input from the work proposed herein will help to evaluate and audit the output predictions from such models.

2. Purpose and Objectives.

The overall purpose of the work proposed in this plan is to gather sufficient information to allow the determination of how large the agricultural emission reduction and removal opportunity is in Alberta, and to fill in the major measuring monitoring and verification gaps so that the opportunity can be realized.

The objectives of the project are to:

- Develop and implement the use of a database, which tracks the amount and types of changes in Alberta farming methods related to emission reductions and removals.

- Measure, monitor and verify net soil carbon changes associated with changes to conservation tillage from conventional tillage methods, by supporting the existing Saskatchewan benchmark sites and on additional farm field benchmark sites on cropland in Alberta, particularly in the Peace River district and Chinook Belt where the agricultural soils are not well covered by the Saskatchewan benchmarks. This objective includes the measurement of the potential changes in emissions of nitrous oxide and methane that may occur when farmers change to conservation tillage methods, which store additional carbon on the soil.

- Measure, monitor and verify net soil carbon changes on benchmark sites on Alberta rangelands and pastures to determine the carbon changes associated with methods of improving range and pasture productivity or condition.

3. Approach to Land Use Database and Field Plan Development.

Climate Change Central is a public-private partnership to stimulate and encourage appropriate action to reduce greenhouse gas emissions in Alberta.

This plan is being developed within the context of a Climate Change Central initiative on the removal and reduction of agricultural greenhouse gases in Alberta. The initiative includes:

- development of measuring monitoring and verification of net emission reductions resulting from changes in land management practices, and
- development of an agriculture-based emission reduction trading protocol between buyers and sellers.

The development of the land use database and benchmark site field plan to measure monitor and verify emission removals has been done by a team (MMV team) led by

Climate Change Central, and comprised of scientists from Alberta Agriculture, Food and Rural Development, University of Alberta, Agriculture and Agri-Food Canada, and farmers and private industry. (See Appendix A for a list of team members).

During the course of the MMV team's work, the team hosted two workshops to solicit the opinion and input of other scientists with experience in monitoring agricultural soil carbon sinks and related areas. Participants in the workshop addressed several key questions including:

1. What are the gaps in Alberta soil carbon benchmark information?
    a. Farm greenhouse gas (GHG) accounting template
    b. Existing Benchmark and research sites and databases
    c. Ongoing research
    d. Current best management practices
    e. Modeling and scale up of information
2. Should CO_2 and N_2O measurements be integrated at common field sites, and if so, how?
3. What are the priority areas the team should focus on for emission removals, based on changes in land management methods, the potential for carbon sequestration and the potential for adoption?
4. What initiatives are being undertaken by others and what can Alberta best contribute?

The results of these deliberations have been incorporated into the following proposal.

4. Scope.

Based on the gaps and priorities set by the MMV team (see Appendix B for details), the scope of this project includes:

- support for continued carbon sequestration and nitrous oxide emission measurements on existing benchmark sites in Saskatchewan,
- establishment of new benchmark sites, where most needed in Alberta, to measure, monitor and verify changes in soil carbon in farm fields in Alberta where changes in farm practices have taken place, and which sequester more carbon than a previous practice, and
- development and implementation of a method of tracking changes in farming practices that affect greenhouse gas emissions.

4.1 Support for Existing Benchmark Sites.

The existing benchmark farm fields in Saskatchewan provide the opportunity to gather longer term data on carbon changes associated with reduced tillage and reduced frequency of summerfallow within the major soil zones common to Alberta, Saskatchewan and Manitoba. AAFC will continue to lead this initiative, with proposed financial support from the proposed Alberta initiative. With this support the MMV team would encourage AAFC to institute the measurement of nitrous oxide fluxes, and plant available nitrogen in soil, water and added fertilizer on a subset of 20 per cent of the sites. This initiative will provide vital data for input to the AAFC model farm initiative and possibly to other models used for developing provincial and national estimates of carbon changes net of nitrous oxide and methane emission changes.

4.2 Establishment of New Benchmark Sites.

The MMV team identified the priority need for an additional 10 farm field benchmark sites in the Peace River Area and 10 sites in the Chinook Belt to complement the carbon change measurements from the Saskatchewan Benchmark sites. These new sites in Alberta will measure carbon changes associated with recent changes to reduced tillage and/or reduced summerfallow frequency in the same manner as the Saskatchewan sites. Nitrous oxide fluxes, and plant-available nitrogen in soil, water and added fertilizer, will be measured on a subset of two to three sites in the Peace River and two to three in the Chinook Belt. These measurements will be taken at selected times through the year, particularly during snowmelt and high rainfall events, as well as some dry periods in between.

Another 20 new sites will be established on pasture and range sites across Alberta, focusing on the short grass range in SE Alberta, the fescue pastures of the foothills, and pastureland in central Alberta. The measurement methods for these sites will follow those used previously in Saskatchewan and Alberta within the PSCB project. The pasture and range sites will be established at locations where a change in pasture management is taking place as of the start of this project. The changes in pasture management may include some form of rotational grazing or fertilizer use to improve pasture condition from initially “poor” to “good” condition. In addition to changes in soil carbon, methane emissions and nitrous oxide emissions from soil will be measured at a subset of four to six of these sites to provide preliminary data on net changes in soil carbon. The methodology for these measurements will be the same as described above for cropland.

The final design of the field plan will rely on existing research knowledge and experience with similar programs in other jurisdictions. The team has concluded that to be useful either in the context of possible emission reduction and removal trading, or for input to the provincial and national greenhouse gas emission inventories, it will be imperative to address the net removals and emissions associated with changes in farm management which sequester additional carbon. This means that not only will changes in soil carbon need to be verified, but also any associated changes in methane and nitrous oxide.

It was clearly pointed out at the workshops that the methods of measuring nitrous oxide emissions from soils need to be improved and the research needed to achieve this is either under way or planned for the near future. Given that our understanding of nitrous oxide emissions from agricultural soils is less well developed than that for carbon dioxide, the team was advised to start with a simple benchmark system that is flexible enough to build on in the future when additional knowledge becomes available.

Consequently, it will be important for the team involved in executing the field plan to maintain ongoing communication with those researchers developing new knowledge on both methane and nitrous oxide measurements and their importance to the net emissions and removals from agricultural soils. From time to time the measurement methods should be reviewed in light of emerging research information so that the most credible net emission and removal measurements can be achieved. Any new methods of measuring these gases must first be carefully calibrated with the current methods before being adopted into the project.

In Alberta there are a number of long-term research plots where data on changes in soil carbon and nitrogen related to changes in farm practice have been gathered (or soil samples from the plots have been collected and stored and from which data could be gathered). These plots have been in existence from five to over 75 years and can provide vital support data for the proposed benchmark measuring, monitoring and verification system. They can provide answers to questions such as:

1. how long can we expect a change in farm practice to continue to sequester carbon, and,
2. what ongoing rates of sequestration can we expect in different agro-climatic zones, and with changes in different types of farm management practices?

It will be important that the design of the benchmark measuring, monitoring and verification system includes a component of parallel measurements in time on long-term plots which are monitoring similar changes in farm management practice, so that the long- term trends from research plots can be directly related to the farm field benchmark sites.

One of the key conclusions of the PSCB project was that measurement of soil carbon changes, from changes in farm practices, must continue longer than three to four years to provide sufficient certainty in the prediction of carbon changes at the farm level. While the short-term measurements provided reasonable estimates of carbon changes at a regional level with groups of 10 to 20 benchmark fields, it was anticipated that an

additional four to six years of measurements might be needed to indicate the trends at the local level.

4.3 Development and Implementation of a Land Use Change Database.

The MMV Team identified the development and implementation of a method of tracking changes in agricultural land management as a priority area.

There are a variety of existing sources of information on agricultural land management, which are updated periodically and thus can be projected over time. These sources include Census Canada, Crop Insurance, Municipal Assessment, Canada Wheat Board, Woodlot Associations, Remote Sensing Initiatives and Market Survey Information. These sources need to be objectively evaluated to determine if they provide the necessary information in their current form, or can be adapted to be combined with land resource information (CANSIS/AGRISID databases) in a scaling up approach from soil polygon to eco-district to eco-region to province.

Based on the findings of the evaluation of data sources and methods of using the data, the development of the database will include testing the most appropriate alternative over a pilot area, evaluating the pilot and implementing the database province wide.

5. Work Plan.

5.1 Support for Existing Saskatchewan Benchmark Sites.

The major activity needed to support existing benchmark sites is to establish a partnership with AAFC, who will be leading this initiative, and Saskatchewan Agriculture and Food. The MMV project will establish and maintain a liaison with the working team in Saskatchewan to standardize measurement methods, and share information and results as they arise from both Saskatchewan and Alberta.

5.2 New Benchmark Sites.

Selection and Layout

Benchmarks sites will be established in commercial farm fields and pastures that will be converted to the new management practice from the old practice at the time of first sampling, or in fields where the new and old practices are being undertaken side by side in the same soil type. If the entire field is going to be converted to the new practice, the cooperator may be asked to leave a strip of one to three hectares in the old practice for comparison purposes. No other management changes will be requested.

Ten sites will be selected in cropped fields in the Peace River Area. An additional 10 sites will be selected in cropped fields in the Chinook Belt and 20 sites will be selected on pastures and rangeland in the Foothills, Southeast and Central Alberta.

The team will solicit help from the local applied Research Associations (ARAs) or Reduced Tillage Linkage staff (RTLs) to find appropriate farm cooperators, and later to collect farm management and crop yield information on an ongoing basis. The ARAs and RTLs will be asked to develop a list of potential cooperators in their area from which the benchmark sites will be selected. The list of potential cooperators should have 10 to 20 per cent more potential cooperators than will be needed, in the event that some farm fields are deemed not suitable.

In each field or pasture several benchmark locations will be selected. Benchmark locations will be carefully selected to avoid any anomalies of soil, landscape or mechanical effects associated with field edges and entrances.

Benchmark sites selected for comparing reduced/no till with conventional tillage may double as sites for examining reduced summerfallow frequency.

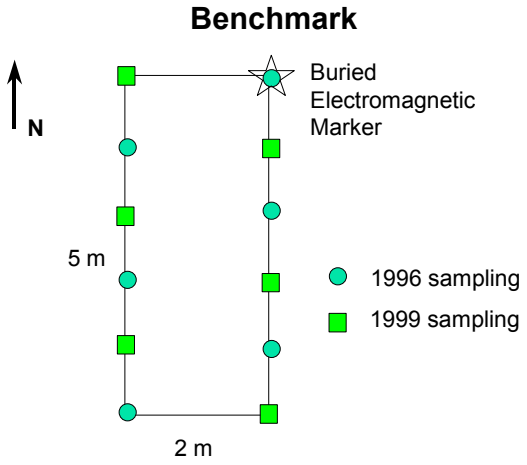
Benchmark sites chosen for comparing rotational/managed grazing and/or fertilization compared to no-management and no-fertilizer should be selected after discussion with the Climate Change Central Livestock team to integrate the benchmark sites if possible, with the pastures examined in the Livestock MMV project.

Each benchmark location will cover 10 square meters of uniform soil in a relatively level part of the field. Each location will be measured and mapped relative to an electronic marker in one corner. Sampling will be undertaken at the time of set up and a sampling layout within the site will allow re-sampling every third year (i.e. 2002, 2005, 2008). The soil at each benchmark site will also be described, classified and linked to the soil landscapes of Canada polygons so that the data may be used in other national projects related to the national inventory of greenhouse gas emissions and removals.

At about 20 per cent of the benchmark sites, measurements of nitrous oxide fluxes will periodically be taken in addition to soil carbon measurements, using sampling equipment similar to that used at the Lethbridge Research Centre. The researcher responsible will detail the final selection of specific sites, measurement timing and duration.

There are a number of farm fields in Alberta which have been set up with soil quality monitoring sites in the past. If any of these meet the above criteria, it may be most cost effective to include them in this work plan and add any necessary measurements to meet the needs of this project.

Example Benchmark Site Layout (after McConkey, PSCB Lessons Learned. 2001)



New Site Farm Management Data Needs

It will be important to record the type of farm management that has occurred in each of the fields with benchmark sites. In addition, crop yields will be measured and recorded for each benchmark site. Basic management data will include: crop type, rotation, tillage operations (number and timing), amount and type of nutrients added (fertilizer, manure, compost, etc.), timing of application of nutrients, annual fuel use for field operations, seeding and harvest dates, yields, spraying (type of pesticide and dates), residue management, cattle grazing (animals per ha. and length of time) and estimates of pasture condition and productivity. The management differences between the new and old

practice will be highlighted. Local ARA or RTL staff will be approached to assist in compiling this information on an annual basis.

Methane and Nitrous Oxide Sampling

Methods of methane and nitrous oxide emission measurement from soil are currently under development, but have been done at a research level for a number of years. It is desirable to try to integrate methane, nitrous oxide and carbon measurements at the same benchmark sites. The challenge is to measure changes in carbon over a three-year time increment, while measuring changes in nitrous oxide emissions, which can occur in minutes, or hours after a rainfall event or during snow melt. Methane may be emitted or stored in soils and the incremental changes may be small. For completeness, methane fluxes should be measured along with nitrous oxide. Scientists with the appropriate expertise and experience with such measurements will conduct this work.

It is recommended that methane and nitrous oxide emission measurements be taken at selected benchmark sites (as noted in the scope above), during selected major moisture events (rain or snowmelt), and during one or two other drier times of the growing season. At the same measurement times, soil samples will be measured for plant-available nitrogen and compared with fertilizer nitrogen application records for the field.

The method used to measure nitrous oxide and methane fluxes will follow that used in Alberta by Janzen et al. (personal communication, 2002). The method is a modification of that described by Hutchinson and Mosier. 1981. Soil Sci. Soc. Amer. J. 45:311-316.
The basic methodology includes the following steps:
1. Place a cylindrical chamber of known volume on the soil surface.
2. Extract fixed volumes of air from the chamber at time=0 and several times thereafter (e.g., 0, 10, 20, 30, and 60 minutes).
3. Analyze nitrous oxide and methane in the air samples using a gas chromatograph.
4. Calculate nitrous oxide emission rates from the increases in nitrous oxide concentration over time (or the methane oxidation rate from the decreases in methane over time).
As the measurement methodology becomes more refined and more efficient in the future, additional measurements may be added during the course of the project.

Soil Sampling and Analysis for Carbon Change

Soil sampling and analysis for carbon change measurement needs to be precise and repeatable. A protocol developed by Henry Janzen and Ben Ellert in 1995, and used in the PSCB project, will be followed in this project. This will also allow results from Saskatchewan and Alberta to be directly compared and combined for evaluation. The protocol itself is outlined in Ellert [et al] 2001.[1]

[1] Ellert, B.H., Janzen, H.H. and McConkey, B. 2001. "Measuring and Comparing Soil Carbon Storage". Chap. 10 in Assessment Methods For Soil Carbon. Ed. Lal, R. Kimble, J.M., Follett, R.F., and Stewart, B.A., Lewis Publishers, New York.

In addition to the protocol, specific sampling of surface residue will be conducted at the same time as other sampling. It has been suggested in the PSCB project that this component of carbon is usually ignored and is often difficult to measure. Nevertheless, estimates suggest that there are significant differences in carbon from the surface residue in reduced/no-till fields compared to conventionally-tilled fields and thus the residue should not be ignored during sampling and measurement of soil carbon.

Linkage to Long Term Plots

As noted earlier, it is vital that the data and trends from long-term plots in Alberta be linked to the proposed benchmark site data to allow early assessment of trends in the rates and longevity of carbon sequestration in Alberta. There are long-term plots in each of the areas of priority for benchmark sites in Alberta.

It is proposed that resources be made available in this project to collect incremental data on soil carbon and nitrogen changes in the long term plots, which examine the same changes in farm management practices that are being examined in this project. Researchers responsible for each of the long-term plots will implement, as closely as possible, the same sampling protocol as for the benchmark sites and collect the same management data set and crop yields. In addition, historic data will be evaluated and summarized for input to the analysis of the results of the entire project.

Evaluating and Summarizing Data

A number of individuals will be involved in and responsible for setting up, sampling, taking measurements, gathering management information, evaluating and summarizing the data. In addition, data will be available from the Saskatchewan benchmark sites and from Alberta's long-term plots. The team will be coordinated so that overall integrated summaries can be produced, which answer a number of key questions, including:

- What changes in soil carbon have occurred? In what time frame and under what changes in management?
- What is the average annual change in soil carbon in a region or soil zone, resulting from a given change in land management?
- What is the best estimate of the net change in carbon dioxide equivalents when nitrous oxide and methane are accounted for, in relation to specific changes in land management?

5.3 Development and Implementation of a Land-Use Change Database.

Characterization of land management practices has been identified as a crucial component in the modeling of greenhouse gas sinks and emissions. The purpose of the Land Use Management database will be to monitor the change in land use management practices within specific regions in Alberta. The changes in management practices that will be monitored include:

- no-tillage or reduced tillage versus conventional tillage,
- mechanical Summerfallow versus continuous cropping,
- rotational/managed grazing/pasture fertilization versus seasonal unfertilized pasture use, and
- change from annual cropping to perennial cover (grasses, shrubs and/or trees).

The benefit of gathering more detailed land use information is to improve the greenhouse gas sink and emission estimates as derived from the various greenhouse gas prediction models. Information provided from the database will be used to extrapolate to farms outside the grid to regional and provincial scales. Other added benefits include identification of areas with greatest sink/reduction potential and providing better information on emission inventories for national and international accounting.

1. Evaluation and Assessment of Data collected from Farm Environmental Management Survey

Acquire the rights to use the federal "Farm Environmental Management Survey" for the years 2001, 2003 and 2005. Evaluate, assess and manage the Land Use Management Database gathered through the federal Farm Environment Management survey for Alberta on an annual basis.

2. Development of subset of questions based on Federal Survey

In conjunction with staff from Statistics Canada, develop a sub-set of questions needed from the federal survey (as well as determine if any additional questions are required) that can be tested in Alberta for the interim years 2002, 2004 and 2006.

3. Conduct Survey (2002, 2004 and 2006)

The questionnaire developed above will be used to conduct an annual survey in 2003 and 2005. Testing will involve the interviewing of about 1,000 farmers in order to provide a statistically significant sample. The majority of farmers interviewed will likely be in the cropland areas of the province. The independent test may also serve to provide an assessment of annual land use changes in the years between Statistics Canada Surveys.

4. **Comparative analysis of census data from 2002 and 2006**

Statistics Canada data from 2001 and 2006 will be independently tested to determine its level of accuracy. Compare and analyze the data collected over the five year period with census data collected in 2001 and 2006.

5.4 Communication of Results.

Results of this project will be forthcoming over the period 2002 to 2008. It will be important to communicate both general progress of the project, and results as they emerge to a variety of audiences, including: peers in the science community, potential users of the information (farmers, provincial and federal policy makers), project investors, and the general public. This can and will be done in several ways, including the use of workshops, conferences, meetings with potential users and investors, regular newsletters, Internet communications and media releases.

6. Personnel Needed to Implement Plan.

The following table summarizes the proposed team to find cooperators, set up the benchmark sites, collect the soil carbon, farm management, nitrous oxide and methane flux, and changes due to landscape data.

Objective	**Activity**	**Responsibility/Expertise**	**Time requirement Person Year (py)**
Support Existing BM Sites	Develop Partnership, Ongoing Liaison, Exchange and distribute results to team	Project Manager	0.1
Set up New Benchmark Sites (40)	Select Potential Cooperators	ARAs/RTLs	5*0.05=0.25
	Select field sites and describe	Pedologist	0.2
	Sample and Measure Soil Carbon	Pedologist	0.2
	Measure N2O/CH4	Scientist – Nitrogen and methane flux specialist	0.6
	Gather Management and yield data	ARAs/RTLs	0.25
Support Long Term Plots	Develop Partnership Ongoing liaison with Plot managers Gather results and distribute to team	Project Manager	0.1
Evaluate and Summarize Site Data	Coordinate Data evaluation and reporting Prepare integrated summary reports Distribute reports	Project Manager and technical team selected from above.	0.2
Develop Land Use Database	Ranking Criteria Data sources and methods Audit Evaluate costs/benefits	Senior Argolist	.5
	Rank Alternatives Design/Implement Pilot Evaluate Pilot Implement Province wide	Technical Team	1.5
Communications	Coordinate and conduct communications plan	Communications specialist	0.5
Project Management	Coordinate all activities Manage budget and schedules Report progress to partners and steering committee	Project Manager Steering Committee	0.7

To insure consistency of the data, it is proposed to use one analytical laboratory to conduct all the soil carbon, soil bulk density, and methane and nitrous oxide analyses. Additional analyses may be conducted at the detailed benchmark sites as needed. It is proposed that either the University of Alberta or Lethbridge Research Centre Soils laboratory be used.

The data evaluation team will pull together the data gathered in this project as well as relevant data from the Saskatchewan Benchmark site network. The evaluation team will also provide input to the AAFC team, which plans to develop national scale up and modeling methodologies.

7. Budget Estimate.

7.1 Budget Calculations for Benchmark Sites

Objective	Activity	Time requirement Person Year (py)	No.	Unit Cost	Sub-Total	py cost	Sampling Year Total	Non-sampling Year Total
Support existing BM Sites (Gov't. of Saskatchewan Partner)	Develop Partnership, Ongoing Liaison, Exchange and distribute results to team	0.1	137	200	27,400	7,000	34,400	
Set up New Benchmark Sites (40)	Select Potential Cooperators	5*0.05=0.25	40			17,500	17,500	
	Cooperator Stipend		40	100	4,000		4,000	4,000
	Select field sites and describe	0.2	40	500	20,000		20,000	
	Sample and Measure Soil Carbon	0.2	40	500	20,000		20,000	
	Measure N3O/CH4	0.6	12	100	1,200	42,000	43,200	
	Gather Management and yield data	0.25				17,500	17,500	17,500
Support Long Term Plots	Develop Partnership Ongoing Liaison with Plot managers Gather results and distribute to team	0.1	5	15,000	75,000	7,000	82,000	
Evaluate and Summarize Site Data	Coordinate Data evaluation and reporting Prepare integrated summary reports Distribute reports	0.2				14,000	14,000	14,000
Land Use Database	Subtotal	See Section	5.3					
Communications	Coordinate and conduct	Budget to be						

	communications plan	determined						
Lab Analyses	soil C N2O, CH4		400 900	100 50	40,000 45,000		40,000 45,000	
Project Management	Coordinate all activities Manage budget and schedules Report progress to partners and steering committee	0.7				49,000	49,000	14,000
TOTALS							386,600	49,500

7.2 Budget Summary by Year.

Objective	Activity	Year								Project Totals
		2002	2003	2004	2005	2006	2007	2008	2009	
Support Existing BM Sites (Gov't. of Saskatchewan Partner)	Develop Partnership, Ongoing Liaison, Exchange and distribute results to team		34,400	0	34,400	0	0	34,400		103,200
Set up New Benchmark Site (40)	Select Potential Cooperation	17,500	0	0	17,500	0	0	17,500		52,500
	Cooperator Stipend		4,000	4,000	4,000	4,000	4,000	4,000		24,000
	Select field sites and describe		20,000	0	20,000	0	0	20,000		60,000
	Sample and Measure Soil Carbon		20,000	0	20,000	0	0	20,000		60,000
	Measure N2O/CH4		43,200	0	43,200	0	0	43,200		129,600
	Gather Management and yield data		17,500	17,500	17,500	17,500	17,500	17,500		105,000
Support Long Term Plots	Develop Partnership Ongoing Liaison with Plot managers Gather results and distribute to team	82,500	0	0	82,000	0	0	82,000		246,000
Evaluate and Summarize Site Data	Coordinate Data evaluation and reporting Prepare integrated summary reports Distribute reports		14,000	14,000	14,000	14,000	14,000	14,000	14,000	98,000
Land Use	Subtotal	115,400	115,000	115,000	115,000	115,000	115,000	115,000		805,400

Database										
Communications	Coordianate and conduct communications plan	Budget to be determined								
Lab Analyses	soil C		40,000	0	40,000	0	0	40,000		135,000
	N2O, CH4		45,000	0	45,000	0	0	45,000		
Project Management	Coordinate all activities Manage budget and schedules Report progress to partners and steering committee	49,000	49,000	14,000	49,000	14,000	14,000	49,000	14,000	252,000
TOTALS		263,900	402,100	164,500	501,600	164,500	164,500	501,600	28,000	2,190,700

7.3 Budget Summary for Land-use Database.

Task	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Use of federal data	$10,000		$10,000		$10,000	
Evaluation/ Assessment/Project Management	$40,000	$40,000	$40,000	$40,000	$40,000	$40,000
Development of sub-set questionnaire	$10,000		$10,000		$10,000	
Interim Survey	$35,000		$35,000		$35,000	
Custom Run Data – Statistics Canada	$8,000		$8,000		$8,000	
Total	$103,000	$40,000	$103,000	$40,000	$103,000	$40,000

8. Potential Funding Partners.

Potential Funding Partners include:

- Alberta Government (Alberta Environment and/or AAFRD),
- Agriculture and Agri-Food Canada (AAFC),
- Climate Change Central,
- Saskatchewan Government,
- Biocap
- Potential purchasers of soil carbon offsets
- Other federal funding agencies

AAFC has a matching fund initiative (MII), which could provide the basis for negotiating a federal funding share.

APPENDIX A

Monitoring, Measuring and Verifying (MMV) Team

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Henry Janzen……...Agriculture and Agri-Food Canada
Ben Ellert…….Agriculture and Agri-Food Canada
Tony Brierley…….……..Agriculture and Agri-Food Canada
Shannon Flint……...Climate Change Central
Shane Chetner……..Alberta Agriculture, Food and Rural Development
Andy Ridge……..Alberta Environment
Noorallah Juma……University of Alberta
Al Fedkenheuer……TransCanadaPipelines
Les Fuller……..University of Alberta
Elston Solberg……..Alberta Agriculture, Food and Rural Development
Mingchu Zhang Zhang…….Alberta Agriculture, Food and Rural Development
John Zylstra……..Alberta Agriculture, Food and Rural Development
Les Wetter…….Ducks Unlimited
John Hastie……Valdrew Environmental Services

APPENDIX B

Priority Management Changes and Locations

The MMV team developed and discussed a matrix of changes in farm practices, the potential amount of carbon which might be sequestered as a result of such changes, the potential adoption of such changes by Alberta farmers, the potential for associated emission reductions from fuel savings and the potential for changes in nitrous oxide emissions. The team then listed the following changes in farm practices in order of priority for measuring monitoring and verification in the benchmark project:

1. reduced tillage/no-till from annual cultivation,
2. conversion of marginal cropland to perennial vegetation,
3. native range management to change pasture productivity from poor to good,
4. reduce summerfallow frequency from one year in two to one year in five,
5. rotational/managed grazing of grassland from annual grazing,
6. fertilization of grassland from no fertilization,
7. others including planting shelterbelts on land instead of cropping, block afforestation from annual cropping, changes in management of irrigated crop and pasture lands, changes in residue management and slough margin restoration (wetlands) where the margins have been cleared and cultivated,
8. other overlap items with the livestock measuring monitoring and verification proposal including changes in manure management, and winter grazing methods (this last item was not specifically prioritized by the team as it should either be included as high priority in the livestock MMV proposal or incorporated into items 1,2,3,5, and 6 above).

1. Reduced tillage/no-till from annual cultivation

The change from conventional annual cultivation of crop fields to prepare the seedbed for the next crop, to reduced tillage (one fall tillage or one spring tillage before seeding) or no tillage at all, has the potential in Alberta to sequester about 13 million tonnes of carbon dioxide equivalents per year for at least 15 years. Many Alberta farmers have already adopted this change to make their farm operations more sustainable. The potential for more farmers to adopt this change is high. In addition, the team concluded that there is a high potential for associated fuel savings (and the resultant reduction in carbon dioxide emissions) and a high potential for small reductions in nitrous oxide emissions associated with the change.

Priority locations for benchmark sites include the Gray Luvisols in the Peace River district (10), and the Chinook Belt (10) in Alberta. The Black, Dark Brown and Brown soil zones are somewhat lower priority, as benchmark sites have already been established in Saskatchewan to adequately cover these soil zones and the data from these can be directly applied to the same zones in Alberta.

Conversion of marginal cropland to perennial vegetation

The conversion of marginal cropland to perennial grassland or trees has the potential to sequester carbon in soils at a high rate per hectare, and with a program such as the federal Permanent Cover Program, there is potential in Alberta to sequester about 600,000 tonnes of carbon dioxide equivalents per year, for at least 15 years. The potential for farmers to adopt such a change is moderate to high, and there is high potential for associated fuel savings.

Priority locations for benchmark sites include marginal cropland, where the soil has been degraded or eroded, and where a farmer is prepared to convert such land to permanent cover for a minimum of 10 years. It is anticipated that marginal cropland work will be conducted at AAFC Swift Current, Saskatchewan.

2. Native range management to change pasture productivity from poor to good condition

There are some six million hectares of native rangeland in Alberta. A significant portion (30 per cent) of this rangeland is in poor condition as a result of past management practices on the rangeland. Range improvement practices to bring the range into good condition have the potential to sequester carbon in the soil, although the rate of sequestration is uncertain given the lack of measurements up until now. Even at a low rate of sequestration of 0.1 tonnes per hectare per year there is potential in Alberta to sequester in the order of 600,000 tonnes carbon dioxide equivalents per year.

Priority locations for benchmark sites include representative rangeland sites in poor condition where the management changes are being implemented to improve the range condition. Such sites may be found in the short grass prairie and in the fescue grasslands of the foothills in Alberta.

It is recommended that 10 benchmark sites be located where changes in range management are being undertaken, both in the short grass prairie and in the fescue grasslands of the foothills.

3. Reduce summerfallow from 1 year in 2 to 1 year in 5

There are over one million hectares of farmland under mechanical (tillage) summerfallow in Alberta currently. The potential exists to sequester about one half million tonnes carbon dioxide equivalents per year if the frequency of summerfallowing is reduced from every second year to every fifth year. There is also high potential for reducing fuel use with this change, and low potential for reducing nitrous oxide emissions.

The priority for benchmark sites is in the Brown and Dark Brown soil zone where much of the summerfallow operations still occur, and where farmers are prepared to reduce the frequency of summerfallow on an ongoing basis. It is anticipated that sites in Saskatchewan will address this priority.

4. Rotational/managed grazing of grassland from annual grazing

It has been estimated that some 100,000 hectares of seeded pasture land could be improved by adopting rotational grazing instead of allowing unmanaged grazing of the entire pasture for the whole growing season. This change in management could result in the sequestration of about 100,000 tonnes of carbon dioxide equivalents per year, some of which could be offset by additional fuel use. There is significant uncertainty about the potential given the lack of past measurements of carbon change associated with pasture management.

It is recommended that five benchmark sites be established at locations where this change in management will take place for a period of at least five years.

6. Fertilization of grassland from no fertilization

The same potential for sequestering carbon (100,000 tonnes CO2e/yr) exists on seeded pasture and hay land where the management change is to provide fertilizer nutrients where none have conventionally been applied. Some of this potential sequestration may be offset by the need for additional fuel for spreading fertilizer. There is also low potential for additional nitrous oxide emissions associated with the use of nitrogen fertilizers on the pastures.

It is recommended that five benchmark sites be established at locations where this change in management will take place for a period of at least five years.

7. Other land management changes

There is limited information on the potential of the management changes itemized under priority 7 above to sequester carbon, or what the net effect will be when taking into account methane and nitrous oxide. In many cases research is under way or will be initiated in the near future to improve our understanding of the greenhouse gas emission processes associated with shelterbelts, wetland restoration, changes in residue management and changes in irrigation management.

It is not recommended that benchmark sites be established to measure, monitor and verify carbon changes in soils associated with these management changes until further research provides an indication of the potential of these changes to sequester carbon and which is not significantly offset by additional emissions of methane and/or nitrous oxide.

