Soil Management Protocols and Projects for Greenhouse Gas Offsets in Canada

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Abstract

Agricultural activities contribute to sources, sinks, and reductions of greenhouse gases (GHG) in Canada. There is considerable producer interest in generating and selling carbon or offset credits through GHG sinks and reductions. During the development of a potential Canadian offset system by Environment Canada from 2003 to 2006, a number of technical working groups were established to generate standardized protocols. These protocols were intended to streamline project development by providing specific guidance for quantification, monitoring, and verification of GHG reductions or removals for specific activities. In 2005/06 the Soil Management Technical Working Group (SMTWG) developed protocols and guidelines involving no tillage, nitrogen fertilizer reduction, and other soil carbon and nutrient management related practices. Considerable effort was required to develop scientifically based solutions for policy driven challenges such as baselines and maintenance of soil carbon through a liability period. Other important aspects of protocol development included assessing quantification methodologies (eg. coefficients versus soil carbon measurements), developing appropriate activity definitions and regional stratification for coefficient based approaches, and evaluating various options for monitoring and verification of specific soil management practices to ensure GHG assertions at reasonable cost. While the applicability of these protocols may be uncertain during the current policy vacuum (2006/07), they should prove valuable as a base from which to refine or develop new protocols at a time when GHG offset program and policy issues are resolved.

Background and Introduction

Agriculture is both a source and sink for greenhouse gases (GHG). Prime examples of sources are methane (CH_4) from cattle ruminant digestion and nitrous oxide (N_20) release from soils. Soil carbon sequestration provides a large potential sink for carbon dioxide (CO_2), and beneficial management practices (BMPs) such as no till, reduced fallow, and perennial forage have been demonstrated to increase soil organic carbon (SOC). There are also opportunities to reduce CH_4 and N_2O emissions through improved feeding strategies and nutrient management, respectively.

The quest for improved knowledge of specific agricultural impacts on GHG has been driven by the need for many countries including Canada to provide accurate inventories of GHG emissions through the United Nations Framework Convention on Climate Change (UNFCCC). The emergence of the Kyoto protocol in 1997 and the provision for large final emitters (LFE's) to attain part of their GHG emission reduction requirements by purchasing offset credits, led to discussions about a potential offset system in Canada. Farmers have been involved in these discussions, as they recognized the potential to generate and sell credits to LFE's by implementing BMPs.

Considerable effort for developing a Canadian offset system occurred from 2003 to early 2006. This effort was initially led by a federal interdepartmental Working Group on Offsets (WGO). Later a program authority was formed under Environment Canada (EC). EC published a technical background document in September, 2005 (EC, 2005), which proposed specific guidance for project development. Much of this guidance was based on ISO 14064-2 (Canadian Standards Association, 2006).

Development of an offset system involved consultation with provinces, industry groups, non government organizations (NGOs), and other federal departments including Agriculture and Agri-Food Canada (AAFC). A multi-agency group called the National Offset Quantification Team (NOQT) was formed and led to the establishment of technical working groups (TWGs) tasked with developing standardized protocols. Protocols were intended to streamline project development by providing specific guidance with regard to quantification, monitoring, and verification of GHG reductions or removals. The proposed system also envisioned the opportunity for project proponents to develop their own methodology from scratch if so desired. A number of agricultural TWGs were established to investigate specific BMPs as shown in Table 1.

Table 1. BMPs investigated by Agricultural Technical Working Groups

TWG	BMPs
Pork	Feeding strategies, manure storage, timing of manure application
Beef	Feeding strategies
Manure Treatment	Anaerobic digestion
Agroforestry	
Soil Management	No till, nitrogen fertilizer reduction, other soil carbon enhancements and nutrient management

Also around 2003, EC launched a pilot GHG emissions trading project called the Pilot Emissions Reductions, Removals, and Learnings Initiative (PERRL). While a number of other pilots had been launched previously, this was the first one that specifically included agricultural projects in Canada as part of its target. An interdepartmental federal working group developed coefficients for no till, reduced till, and conversion of annual cropland to perennial forage. They also provided specific definitions, and monitoring/verification requirements associated with these BMPs. Through a proposal based system two projects were approved in 2005, one involving no till by the Saskatchewan Soil Conservation

Association and the other involving perennial forage by Horizon Vert in Quebec. Since one of the goals of the PERRL is to learn from experience, there has been some opportunity to develop additional guidance and flexibility to refine or adjust monitoring / reporting requirements. These changes have occurred as a result of collaboration between the program authority and the project proponents. Currently these projects are slated for one more year of activity in 2007.
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In early 2006 work on the offset system ceased with the change in federal government. . At that time any new work on protocol development also ceased, however, protocols in the midst of development were completed albeit with minimal stakeholder review. The remainder of this paper deals with the development and status of soil management protocols as coordinated by the Soil Management Technical Working Group (SMTWG). At present the status of a Canadian offset system is uncertain

Methodology

The SMTWG was initiated in July, 2005. It was led by AAFC and including provincial soil specialists, AAFC and university soil scientists, and NGO, industry, and farmer representatives. (see Appendix I for list of members). In October 2005 three consultants were contracted to work on three separate aspects of protocol development, as outlined in Table 2.

Table 2. SMTWG Consultant Contracts

Consultant	Protocol Area
Agrologics Consulting, Coaldale, AB	No Till and Reduced Till using Default Coefficients
Paragon Soil & Environmental Consulting, Edmonton, AB	Soil Carbon Measurement
The Soil Resource Group, Guelph, ON	Nutrient Management

The SMTWG met with the consultants in November, 2005 to provide more detailed direction for protocol development. The consultants were also guided by the technical background document developed earlier by the program authority. A core group from the SMTWG had regular communication with the consultants from November 2005 to March 2006. In December 2005 this group also met and exchanged information with several companies that were interested in being project proponents or aggregators for pools of farmers under an offset system. In late March 2006 a stakeholder workshop was conducted with a broader audience of 45 people in Ottawa, to provide presentations on draft protocols from each of the consultants and receive feedback.

Just prior to the March 2006 workshops, the SMTWG received more specific guidance from the EC program authority in a protocol template document entitled “Guide to Quantification Methodologies and Protocols” (EC, 2006). Unfortunately, the consultants were not able to feasibly utilize the template due to their March 31, 2006 contract deadline. As a result of the shutdown in offset development in early 2006, it was not possible for the SMTWG to continue functioning. The SMTWG received direction from the EC program authority to put off further protocol development work, but complete documentation for any protocols that were well developed. Therefore, it was decided to rewrite two of the protocols that were well developed using more specific guidance provided in the template document. This rewrite was completed by the SMTWG Lead in the fall of 2006. A summary of all document titles are provided in Table 3. At present none of these have been widely circulated due to the uncertain policy issues surrounding the offset system. It is important to note that the rewritten documents did not result in any significant changes in protocol methodology and GHG emission factors, but rather provided more detailed explanation and justification of the quantification, monitoring, and verification requirements within the policy context provided in the technical background document.

Table 3. Titles of Soil Management Protocol Documents

Consultant Document	**Rewritten to Fit Quantification Template**
Tillage System Default Coefficient Protocol – Final Report, Agrologics Consulting, March 31, 2006, 29 pages	Tillage System Default Coefficient Protocol based on Canada's Offset System for Greenhouse Gases Technical Background Document 2005, D. Haak, SMTWG, October 2006, 70 pages
Draft Quantification Methodology for a Nitrogen Reduction Protocol, The Soil Resource Group, March 31, 2006, 21 pages	Nitrogen Fertilizer Reduction in Corn Production Protocol based on Canada's Offset System for Greenhouse Gases Technical Background Document 2005, D. Haak, SMTWG, October 2006, 64 pages
Guide to Development of Customized Agricultural Soil Carbon Sink, Paragon Soil and Environmental Consulting Inc., March 31, 2006, 71 pages	
Exploring New Soil Management Protocols: Nutrient Management Protocol Options, The Soil Resource Group, March 31, 2006, 42 pages	
Workshop Report: Developing The Soil Management GHG Quantification Protocol, Toma and Bouma Management Consultants, March 31, 2006, 23 pages	

The intent of this paper is not to present a detailed description of these protocols, but rather discusses some of the major results, issues, and proposed recommendations regarding potential offset system protocols and projects involving soil management practices.

Results and Discussion

The length of each protocol document does not permit an exhaustive discussion in this paper. The level of detail provided below is intended to give the reader a basic understanding of the key decision areas and rationale for these decisions. Individuals interested in developing protocols for similar activities should refer to the detailed protocol and guidance documents to fully understand the methodologies used and their justification.

A. Application of Guidance to Protocol Development

While much of the information provided in this section was provided in the Offset System technical background document, its current applicability is uncertain due to the current shutdown of offset system development at the federal level. Nevertheless, this information provides necessary context to the development of protocols discussed in this paper.

1. Project Requirements

The guidance documents specified that GHG emission reductions or removals must be quantifiable; real; verifiable; unique (not counted more than once); and surplus to any federal GHG regulation, program, or incentive. Projects receive credits for activities undertaken for up to eight years, beginning after project registration. Credits are not provided for activities undertaken before project registration, however projects which initiated their activity on or after January 1, 2000 are still eligible.

2. Level of Detail and Rigour

Much of protocol documentation focuses on the rationale or justification for all decisions made, and is based on the ISO 14064 quantification principles such as relevance, completeness, consistency, accuracy, and transparency. This requires a significant level of detail and rigour. It is also important to note that if a project proponent utilizes a standardized protocol, the level of detail and rigour required in a specific project proposal and its implementation may be significantly less because the justification has already been dealt with in the protocol.

3. Protocol Elements

The key elements of protocols are quantification, monitoring, and verification. Quantification determines what scientific methodology will be used to measure or accurately estimate GHG emission reductions. Important sub-elements within quantification include:

- Assessing various baseline approaches and scenarios
- Choosing and providing justification for the most appropriate baseline scenario
- Identifying all sources, sinks, and removals (SSRs) for GHG

- Choosing relevant SSRs for inclusion in the quantification and providing justification
- Assessing various quantification approaches and methodologies for relevant SSRs
- Choosing and providing justification for the most appropriate quantification methodology

The strict definition of baseline as provided in most guidance documents is the level of activity that would have occurred during the registration period without the project. Often this is difficult to determine, as one is not able to forecast the future. Another possibly more feasible definition is the level of activity that actually occurred at a past reference point. It could be inferred that an appropriate reference point is January 1, 2000, the eligibility date noted in section A1. The program guidance stated that after the initial eight year registration period projects would have to reapply, and this would include a reassessment of baseline.

Monitoring is the means whereby a project proponent calculates GHG emission reductions or removals on specific land parcels for specific years, and ensures good data management and quality control procedures. Verification is a process whereby a third party audits a project's activities to ensure that GHG emission reductions or removals have taken place. Some of the specific tasks that an auditor performs may be the same as what a project proponent would do during the monitoring process, but on a smaller scale. However, it is important to note that monitoring is done by a project proponent, and verification by a third party auditor.

3. Guidance for Sink Projects

The Offset System technical background document provided additional guidance for sink projects. A sink project is defined as one that stores GHG removals in reservoirs. Two primary examples are soil organic carbon and woody biomass, which are associated with agricultural and forestry practices, respectively. Specific items related to sinks include the following:

- sinks are subject to non permanence or reversals through practices such as tillage and harvesting of trees
- the requirement for a liability period which extends beyond the crediting period. (the length to be set by the program authority but never finalized)
- the requirement for reversal coefficients to quantify carbon losses during the crediting (ie. registration) and liability periods
- reversal coefficients need to consider baseline or business as usual circumstances, in the same way coefficients used to generate offset credits also need to consider baseline.
- the provision for generating either permanent and temporary credits. Permanent credits are associated with removals that must be maintained through a liability period and are subject to a reversal. Temporary credits do not have these obligations, and are thus considered as a lower risk option. However, they are of lower value. The actual or relative values of permanent versus temporary credits are determined by the marketplace and not the project methodology or protocol.

- the provision for a default and customized approach for quantifying agricultural soil sinks. A default approach would involve the use of regional coefficients and be applicable to all regions within Canada, while a customized approach could involve various methodologies and be targeted for specific regions.

B. Tillage System Default Coefficient Protocol

The SMTWG identified no till and reduced till as key practices and a first priority for development within a default coefficient approach protocol. It was decided to utilize the quantification methodologies developed by the National Carbon and Greenhouse Gas Accounting and Verification System (NCGAVS) that was developed for Canada's GHG reporting requirement under the UNFCCC. The rationale for using this methodology is that it utilizes a coefficient approach, is national in scope, and is based on the best available peer reviewed science. NCGAVS has a number of working groups that quantify GHG emissions for various ag sector components. This protocol utilized coefficients from two groups that have documented soil organic carbon (SOC) changes and N_2O emissions from soils in recent papers (McConkey, et al, 2006 and Rochette, et al, 2006). In addition, GHG emission reductions associated with change in energy use were derived from the GHG Model Farm (Helgason, et al, 2005), as this was the only available peer reviewed data source for these emission reductions.

A critical question was the appropriate level of regionalization for this protocol. It was decided to utilize the regions developed for the soil organic carbon component (SOC) of NCGAVS, since SOC is the dominant contribution to generating offset credits under this protocol (see Figure 1). This regionalization for SOC uses a well established national ecological framework which is based on key biophysical drivers that have been demonstrated through research to impact SOC change.

Considerable work was required to develop an appropriate baseline scenario for this protocol. A baseline based on historical adoption rates of no till and reduced till practices was deemed as the only option, since there is no data on actual soil carbon sequestered across Canada from no till or reduced till. The only adoption rate dataset with national coverage is the Census of Agriculture. The NCGAVS also uses this dataset to establish national estimates of GHG from no till and reduced till.

It was deemed appropriate to use adoption for the 1999 crop year, since this most closely aligned with the January 1, 2000 project start date. However, since Census data is only collected once every five years (eg. 1996 and 2001) it was necessary to estimate this adoption through interpolation. Also, since the Census data is based on a question that is answered by farmers, there is a degree of uncertainty due to varying perceptions and possible misinterpretation. These uncertainty issues were resolved by analyzing additional regional datasets on tillage systems. These regional datasets were able to link more objective definitions used in the NCGAVS with the more subjective definitions used in the Census. This analysis proved that the definitions were in fact consistent and therefore assured the validity of the Census adoption data. The adoption rates for the three tillage systems are shown in Table 4.

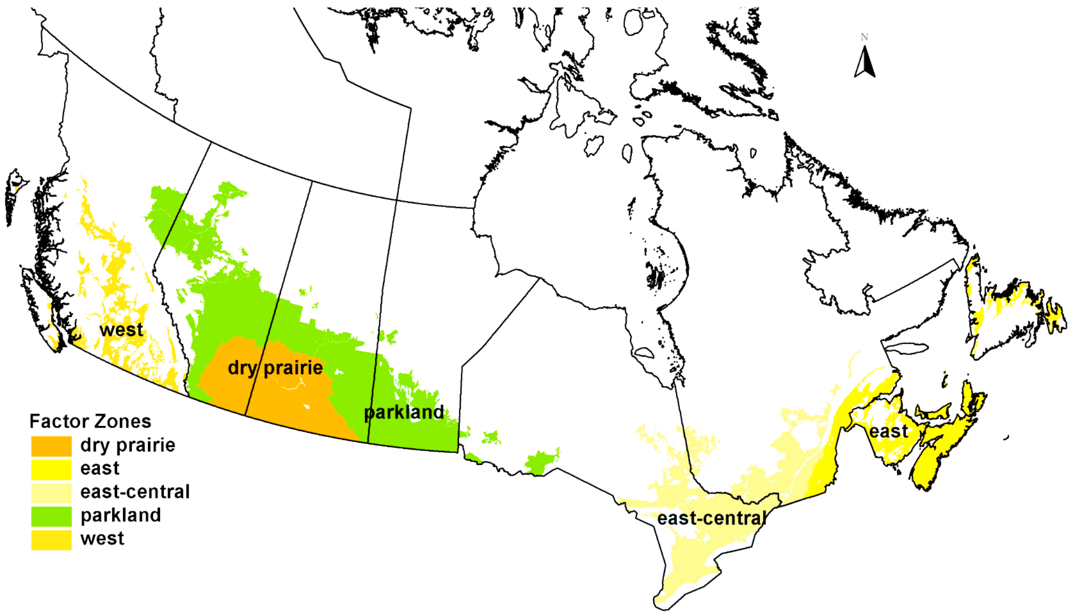

Figure 1. Biophysical regions used in the Default Protocol based on Canada's National Ecological Framework

Table 4. 1999 Tillage System Adoption Rates (Source: Derived from Statistics Canada 1996 & 2001)

Region	No Till	Reduced Till	Conventional Till
East	4.48	18.02	77.50
East-Central	18.42	20.85	60.72
Parkland	18.61	33.50	47.89
Dry Prairie	29.65	30.96	39.39
West	13.63	18.68	67.69

In order to maintain simplicity and minimize administration costs, this protocol was designed for all producers in a particular region to use the same coefficients regardless of their tillage system history. However, the credits provided could only be for activity that was in addition to the baseline condition. This was accomplished by applying a coefficient deduction. This can best be explained through a simple example. If the baseline adoption rate of no till was 30%, then the coefficient was reduced by 30%. The

actual formulas used to make this calculation were more complex due to the consideration of reduced till as a transition between conventional and no till.
Table 5 provides raw coefficients for no till GHG emission reductions or removals associated with SOC, N_2O, and energy. These are totaled and the baseline deduction is applied to show the net coefficient for each region. Similar coefficients were generated for reduced till but are not shown here.

It is important to note that the SOC change methodology is based on a non linear relationship over time, but also provides constant linear coefficients for various sequestration periods. The shortest period is 10 years and has the largest coefficient values. With an eight year registration period and the likely requirement for baseline reassessment after this period, the SMTWG assumed that project feasibility would not extend beyond this eight year period because of the high anticipated rates of no till and reduced till adoption by this time. Therefore, 10 year coefficients were chosen.

Table 5. No Till and Full Till Coefficients for Default Protocol

	No Till Coefficients					Full Till Coefficients	
	SOC 10 yr	N_2O	Energy	Total	Net	Net	Stored SOC Reversal
Region	tonnes CO2 equiv / ha / year						
East	0.25		0.16	0.42	0.34	-0.08	-0.21
East/Central	0.41		0.16	0.58	0.41	-0.16	-0.30
Parkland	0.59	0.05	0.11	0.74	0.49	-0.24	-0.39
Dry Prairie	0.41	0.01	0.06	0.48	0.26	-0.20	-0.22
West	0.20		0.11	0.31	0.26	-0.05	-0.17

Table 5 also provides coefficients for full till or conventional till. The net full till coefficients quantify the impact for the year that this activity takes place and are a reflection of the baseline condition. Therefore, higher negative values are associated with regions where there is a higher adoption of no till and/or reduced till in the baseline. A reversal coefficient must also be applied in the event of full till to account for loss of previous sequestered SOC. This is based on the scientific evidence that the rate of SOC loss due to full till is similar to the rate of gain from no till. In this case the reversal is equal to the negative value of the 10 year SOC coefficient deducted for baseline.

A final quantification requirement was to develop specific tillage activity definitions that were consistent with the NCGAVS and baseline methodologies. This definition also needed to be clearly understood and feasible for producer implementation, proponent monitoring, and third party verification. These definitions are provided in Table 6.

Table 6. Tillage System Definitions used in Default Protocol

Region	Tillage System	Description
East	Full Till	More fall tillage than a single pass with HD cultivator [5]
	Reduced Till	One fall tillage with HD Cultivator, or < tillage
	No Till [2]	Up to two passes with low-disturbance openers (up to 33%) or 1 pass with a slightly higher disturbance opener (up to 40%) [3], discretionary tillage of up to 10% [4], no fall tillage
East-Central	Full Till	More fall tillage than a single pass with a HD cultivator
	Reduced Till	One fall tillage With HD Cultivator, or < tillage
	No Till [2]	Up to two passes with low-disturbance openers (up to 33%) or 1 pass with a slightly higher disturbance opener (up to 40%) [3], discretionary tillage of up to 10% [4], no fall tillage
Parkland	Full Till	Fall Tillage > 40% [3] soil disturbance, > 2 cultivations on summerfallow.
	Reduced Till	Fall tillage limited to injection of manure or fertilizer with <40% [3] soil disturbance, 1 to 2 cultivations on summerfallow.
	No Till [2]	Up to two passes with low-disturbance openers (up to 33%) or 1 pass with a slightly higher disturbance opener (up to 40%)[3], discretionary tillage of up to 10%[4] , no cultivations on summerfallow, no fall tillage.
Dry Prairie	Full Till	Fall Tillage > 40% [3] soil disturbance, > 2 cultivations on summerfallow.
	Reduced Till	Fall tillage limited to injection of manure or fertilizer with < 40% [3] soil disturbance, 1 to 2 cultivations on summerfallow.
	No Till [2]	Up to two passes with low-disturbance openers (up to 33%) or 1 pass with a slightly higher disturbance opener (up to 40%)[3], discretionary tillage of up to 10%[4] , no cultivations on summerfallow, no fall tillage.
West [1]	Full Till	More fall tillage than a single pass with a HD
	Reduced Till	One fall tillage With HD Cultivator or < tillage.
	No Till [2]	Up to two passes with low-disturbance openers (up to 33%) or 1 pass with a slightly higher disturbance opener (up to 40%) [3], discretionary tillage of up to 10% [4], no fall tillage.

Notes:

1 The Peace River Lowland ecoregion is contained within the Parkland zone.

[2] Additional operations with harrows, packers, or similar non soil disturbing implements are accepted. Where a second low soil disturbance operation is performed it is normally for injection of fertilizer or manure.
[3] Percentage values associated with openers are based on average opener width (below ground) divided by row or shank spacing of the implement.
[4] Discretionary tillage of up to 10% means that up to 10% of the surface area of a single agricultural field may be cultivated to address specific management issues. These areas are determined on an annual basis, meaning that specific areas may change from year to year.
[5] A heavy duty cultivator or chisel plow is usually capable of primary tillage in annual crop stubble.

The protocol also developed guidance and rationale for the treatment of a variety of management scenarios. The goal was to permit a reasonable level of flexibility for no till farmers but at the same time maintain integrity to quantification principles. This additional guidance is not provided in this paper, but the management scenarios included the following:

- Crop Types (rotations, fall seeded crops, perennial forages)
- Nutrient Management (fertilizer and manure application)
- Irrigation
- Crop Utilization (grain, hay, silage)
- Crop Residue Management (spreading, harvesting, grazing, burning)
- Crop Failures, Unseeded Land, & Cover Crops

Monitoring involves collecting data on project location, size (area of land), and adherence to no till or reduced till activity; and calculating GHG emission reductions and removals from this data. Verification involves providing a high level of assurance that these data and calculations are correct. Various approaches, methodologies, and tools were considered and evaluated within this protocol. These included the following:

- Farmer contract and sworn affidavit certifying project size, location, and adherence to activity
- Farmer generated field records, GPS coordinates, etc.
- Crop Insurance records (normally includes location, size, crop, but not tillage activity)
- Remote sensing to determine project location, size, and activity. Generally activity is difficult to determine, but continued research and development may provide future opportunities
- Farmyard inspection to determine seeding, tillage, fertilizer, manure application equipment
- Field inspection to assess anchored or standing stubble, row spacing, seed spread, and crop residue cover

Generally, as one moves down this list the level of assurance increases but the cost of data collection also increases. Therefore, there is a need to find the correct balance to achieve both project integrity and feasibility. Normally, one would use lower cost methodologies on all project sites as part of a monitoring program, and higher cost methodologies on a small percentage of sites as part of a verification process.

One of the primary conclusions of this protocol was the small coefficients, and perceived low value of credits generated, despite the relatively low cost approach to implement. One of the recommendations for future protocol development was to develop other practices such as reduced fallow and inclusion of perennial forages in rotation with annual crops into this default approach. This would add value, since the ability to use much of the same data collection and analysis techniques would result in only a slight increase in monitoring and verification costs

C. Customized Approaches for Quantifying Soil Organic Carbon

The SMTWG conducted a literature review and analysis to determine the potential for quantifying SOC using a measurement approach. While a number of measurement approaches are being researched, the only established system involves taking soil samples for SOC analysis in a laboratory. It was determined that a large number of soil samples are required to detect significant changes in SOC, for the following reasons:

- SOC changes due to practice change are small and slow
- There is high spatial variability of SOC levels over short distances within individual fields due to inherent differences in soil and landscape characteristics
- There is significant variability inherent in sampling and lab analysis processes

The main conclusion is that the cost of sampling and analysis would be too high to quantify significant differences at the field or even farm level. However, there may be opportunity to pool lands from multiple farms that have similar soil, landscape, climate, and management practices, and use soil measurements to develop custom coefficients for this pool of producers. Lands with low starting SOC would be most feasible, due to decreasing ability to detect SOC changes as SOC levels rise.

Baseline assessment is a significant challenge for a customized approach. Historical baselines for individual land parcels are conceptually possible, but in most cases not feasible because of a lack of verifiable records on soil management and SOC change. A concurrent baseline may be possible, but adds significant soil sampling and analysis cost. It was concluded that a default coefficient type baseline deduction (similar to that described in section B) would be the only option. However, because SOC can be enhanced through a number of practices it would be necessary to capture coefficients for as many practices as possible. At present the NCGAVS methodology only provides coefficients for tillage system, fallow management, and inclusion of perennial crops in rotation with annuals, but these are probably the most dominant practices that influence SOC in cropping systems. Fortunately, there is reasonable baseline adoption data available for these practices, so this approach may be feasible for future consideration.

Another challenge relates to the handling of manure and other soil amendments that can significantly enhance SOC. There is a naturally tendency for projects to target this practice due to its relatively large short term impact. However, one needs to consider manure application in a broader context than a project field. For example, if a project simply involves transferring manure application from one field to another, there may be no real net change in SOC. The increase on the project field may be negated by a similar increase that would have otherwise occurred in the other field in the baseline. These types of project boundary issues may not necessarily be limited to a farm but could be extended to a sector. The SMTWG concluded that more study of this issue was required.

It was recognized that the policy of reversals and liability would represent a significant cost for a customized approach, due to the need to continue monitoring SOC change after the crediting period.

Finally, it was noted that another possible customized approach is the application of SOC models at the farm and field level. At least two models are being developed and tested for this purpose in the USA (Zimmerman et al, 2005, and Colorado State University et al, 2005). The SMTWG noted that while models may have potential, considerably more work to develop and validate these was necessary. It was not possible to do this work within the resource and time constraints of the SMTWG's mandate.

D. Nutrient Management Protocol Opportunities

The SMTWG explored a considerable number of other potential practices for protocol development, relating to soil nutrient management. These included:

- Timing of fertilizer and manure application
- Rate of fertilizer and manure application
- Placement of fertilizer and manure application
- Altered manure forms such as anaerobic digestates
- Fertilizer enhancement products such as slow release granules (eg. ESN)

It was concluded that protocol development was currently not feasible for most practices, for one or more of the following reasons:

- The practice has not demonstrated significant GHG emission reductions or removals
- There is insufficient research information to support real reductions
- Much of the potential reductions associated with these practices is related to N_2O emissions, which is currently less understood than SOC impacts.

Nevertheless, the SMTWG identified one practice as having potential for protocol development, namely, nitrogen reduction in corn production. This protocol was developed and is described briefly in section F.

E. Grazing and Forage Management Protocol Opportunities

A number of grazing management practices were also considered for protocol development. These included

- Rotational grazing systems
- Extended grazing systems (including swath and bale grazing)
- Improved fertilizer and manure application to forage land

It was recognized that the above practices could result in increased SOC, especially in the prairie region, and the potential for reduced methane emissions from cattle on an intensity basis. The rationale for the latter is that improved grass and forage quality will result in reduced emissions for beef herds on a per kilogram of animal weight gain basis and for dairy herds on a per kilogram of milk produced. However, this will be counteracted by an overall increase in methane and possibly N_2O emissions as a result of a significantly larger cattle herd required to utilize the increased forage production.

The development of these protocols was not pursued at this time partly due to the uncertainty of capacity for the Canadian cattle herd to increase, and the offset system policy to base emissions on real reductions, not intensity based reductions.

F. Nitrogen Fertilizer Reduction in Corn Production Protocol

Improvements in soil and crop productivity, specifically nitrogen (N) use efficiency, has resulted in the lowering of recommended N fertilizer rates for corn production in Ontario and Quebec in recent years. However, many producers have not lowered their N application rates. The desire to maintain N.rates is primarily to capitalize in the event of optimal growing conditions, despite considerable research that average yields can be maintained with lower N rates.

In the event of average growing conditions, higher N fertilizer rates can result in increased losses of N to environment. This includes not only N_2O emissions, but also nitrates in surface and ground waters and volatilization of ammonia and N_2 gas.

The NCGAVS methodology for N_2O soil emissions (Rochette et al, 2006) is based on the best available science at this time. The coefficient for N_2O emission reduction is directly proportional to a reduction of N fertilizer applied. There are many other factors that also affect N_2O emissions, such as timing and placement of fertilizer, soil texture, slope position, climate factors, etc. The NCGAVS methodology addresses many of these factors in an aggregate way, since there is often not enough research to understand these impacts at a local or even regional level. Assuming that this protocol would be used by projects involving pools of producers, the level of accuracy is considered reasonable.

There are a number of factors that are included in this quantification, but the relationship can be consistently simplified as follows:

$$N_2O_{FERT} = N_{FERT} * 0.0105$$

where N_2O_{FERT} is expressed as tonnes CO_{2equiv} / ha / year
and N_{FERT} is expressed as kg actual N / ha / year

The SMTWG chose a baseline scenario based on historical individual producer records. Other baseline options such as an aggregate baseline based on historical adoption or a projection based baseline were rejected due to lack of aggregate historical data and uncertainty regarding future projections. The baseline required that producers provide three consecutive years of nitrogen fertilizer records on corn fields. As an example, if the average N fertilizer rate for the historical period was 180 kg / ha, and the anticipated average N fertilizer rate for the project was 150 kg / ha, then the reduction of N fertilizer of 30 kg / ha would result in an emission reduction of 0.315 tonnes CO_2 equiv / ha / yr.

This protocol is applicable to all of Canada, but most uptake would likely occur in Ontario and some parts of Quebec. The protocol is currently limited to corn, but could conceivably be developed for other crops. However, at present there are few other crops that could maintain yields and profitability with a N fertilizer reduction.

The protocol is also limited to lands receiving only commercial sources of N in the year of corn production. Lands receiving manure and other organic amendments are not eligible for a number of reasons including the difficulty in obtaining historical records, uncertainties of N content in manure, and uncertainty of other GHG impacts of manure such as soil organic carbon. Nevertheless, project lands receiving manure in other years when corn is not grown would remain eligible for the corn growing years, since multiple year impacts of manure on corn N requirements are negligible.

It is important to note that future protocols could consider other management factors such as manure management, timing and placement of nutrients, etc., but these would have a higher degree of complexity. Due to time constraints the SMTWG was only able to develop a protocol based on a single practice that could be quantified using a reasonably simplified methodology.

Conclusions

A significant number of agricultural practices have been demonstrated to reduce GHG emissions. However, the potential for these practices to generate carbon credits may be constrained by a number of factors that impact project feasibility. For example, project requirements such as baseline and maintaining GHG sinks may reduce net coefficients or increase project costs.

Protocol development involves the application of science and technical information on specific practices. While it does not involve policy development, it is dependant on the provision of clear policies that can be consistently interpreted. These policies provide the context in determining how to apply science. In the absence of clear policy it is still possible to conduct basic science and technical information development to better quantify GHG emission reductions or removals. However, without policy it is not possible to properly quantify the impact of baseline, maintenance of soil carbon sinks, and other project requirements.

Current international guidance for GHG protocols and projects, such as ISO 14064-2, requires a high degree of rigor and detail to rationalize quantification, monitoring, and verification requirements. This translates into significant costs for project development and validation. Standardized protocols that are used by many project proponents should be viewed as an effective way of reducing these costs. Therefore, it is anticipated that the development of standardized protocols will resume once policy direction becomes clearer. The value and acceptance of standardized protocols will depend significantly on the extent to which policy guidance can be developed and consistently applied nationally and even internationally.

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Appendix I – Soil Management Technical Working Group Members

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	Nancy Lease	Quebec
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	John Bennett	Saskatchewan Soil Conservation Association
Other Agency Reps	Stephen Hairsine	Environment Canada
	Cheryl Arkison	Climate Change Central
	Susan Wood	BIOCAP
	Gordon Fairchild	Eastern Canada Soil and Water Conservation Centre