A Template for a Strategy for Monitoring Carbon Stock Change on Grazing Lands and Forage Lands In Canada

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Purpose

This document describes a basic template for a strategy for monitoring the soil organic carbon (SOC) change on grazing and forage lands. The monitoring strategy would fill the critical data gap that has prevented reliable estimates of the carbon stock change on these lands. The strategy thus enables the SOC change to be quantified so that the livestock industry can obtain credit for SOC increases on grazing and forage lands. Further, SOC increases will lower the carbon footprint of products from cattle and other ruminants and thereby help change the perception of the environmental sustainability of these livestock products among consumers and policy makers.

The template is for a strategy of periodic measurement of SOC across a network of monitored fields or paddocks to support a process-model based quantification system. The primary objective of the strategy is to cost-effectively quantify farm-scale carbon sequestration on grazing and forage lands for use as a potential carbon offset that, insofar as feasible, accounts for farm-specific conditions. The target user for the network are farmers and ranchers who want to quantify SOC change on their land to gain a credit for the SOC increase or to use that data to gain a market advantage. Only a small proportion of farms or ranches who want the data on the SOC for their land would be in the monitoring network. Most farmers and ranchers would have the SOC change on their land modeled based on their weather, production system, and management. Depending on data needs for the desired scope of geography and practices, the monitoring network could be as small as a few farms in one province or as large as about 50 to 100 farms across the whole of Canada.

The basic strategy will be able to address other SOC change quantification objectives. However, the strategy would need to be modified to optimize for a different objective such as making a comprehensive estimate across all of Canada's grazing and forage land for reporting in Canada's National Inventory Report.

This template is intended to encourage discussion among stakeholders about the value they place and requirements they have for the proposed strategy. There is further work necessary to develop specific projects based on the template to realize the strategy and quantify SOC change for individual landowners/land managers of Canada's grazing and forage lands.

Background

(There are accompanying notes available for this template that provide more depth).

Grasslands, pastures, and forage lands account for 46% of total agricultural land in Canada in 2016 – 14.3 M ha of natural land used for grazing, 5.1 M ha of tame pasture, and 6.7 M ha for forage.

Currently there is inadequate data to develop estimates of the effect of the management of grazing and forage lands on SOC. There are many practices for which we do not have good knowledge on SOC changes from grazing and forage lands. Without that knowledge to quantify the SOC change, it is not possible for landowners and managers to obtain credit for SOC increases. Examples of practices that we expect will increase SOC but for which we do not know adequately the effect of management to quantify precisely include: use of locally adapted genetically advanced cultivars, intensive forage harvest management, improved grazing management and extended grazing season management, high performance forage fertility management, systems-based approaches to forage stand management.

Given the amount of grazing and forage land involved in cattle production in Canada, increases in carbon stocks on that land would greatly decrease the carbon footprint of that production that is important to buyers who value food with a lower footprint. To illustrate the importance of SOC change, based on measurements, France uses a constant C sequestration rate of 0.57 t C/ha/yr (Dolle *et al.*, 2013; Institut de l'elevage, 2019) for all normally managed permanent grassland for the purpose of estimating the carbon footprint of French beef. There is strong evidence that normally managed North American grasslands also sequester carbon (USGCRP, 2018) but the rate is uncertain for Canada. If the French grassland SOC change rate applied to Canada, it would represent of sink of 30 Mt CO_2/yr, which exceeds the 24 M t CO2 eq calculated global warming potential for all Canadian livestock in 2017. France is not alone in wanting to use C sequestration on grazing lands as an offset to other GHG emissions. Based on measurements of SOC change on grazing land across southern South America, one estimate puts C sequestration on Brazil's grazing land at 2200 Mt CO_2/yr (Viglizzo *et al.*, 2019), roughly equivalent to that nation's total GHG emissions including those from deforestation in the Amazon watershed.

A Template to Monitor SOC change on grazing and forage lands

Measurements of SOC change over time on grazing and forage land are essential to understand and quantify SOC change. However, given the amount and heterogeneity of land involved and the variation of management practices, a SOC change quantification system based solely on measurements has been shown to be uneconomical to quantify SOC change at the farm or field level. Instead, there is growing consensus that modelling SOC with process models having a strong underpinning of measurements of SOC change to calibrate and validate modes is the most practical approach to make estimates of SOC over both large areas and individual farms (Smith *et al.*, 2012; Paustian *et al.*, 2019). The model can account for much of site-specific influences on SOC including those independent of management (weather, soil type, and initial SOC content) and those depending on management (pasture utilization, renovation practices, vegetation species, fertilization, etc.). A strategic SOC change monitoring system cost-effectively provides the necessary measurements to support the model results. Monitoring at the farm-scale also ensures that the C stock estimates are relevant of commercial scale operations. Continued ongoing measurements as a monitoring approach to provide assurance that the model continues to provide accurate estimates of SOC change is sensible. Importantly, the major SOC process models only estimate SOC change in the upper 20 to 30 cm of soils and so measurements are needed to estimate SOC change deeper in the soil based on observed relationships between SOC change near the soil surface and that in the subsoil. This is necessary for grazing and forage lands since SOC change below 30 cm is particularly important for perennial vegetation (Beniston *et al.*, 2014).

Fig. 1 provides a general schema of the proposed quantification system to provide estimates of SOC change at farm scale. The basis of quantification of SOC change itself is by computer model that simulates SOC processing based on input data of soils, weather, remotely sensed information such as vegetation indices, and management information. The specific on-farm management information is provided by those who participate in the system with agreed-upon limitations to uses and distribution of that data.

The monitoring network is a strategic set of sites on which SOC is measured periodically. These measurements are used to validate the process model. They also validate the ability of the model-based quantification system to estimate SOC change over the interrelated set of farm fields and paddocks that are affected by the farm management for which the quantification system is intended to be applied.

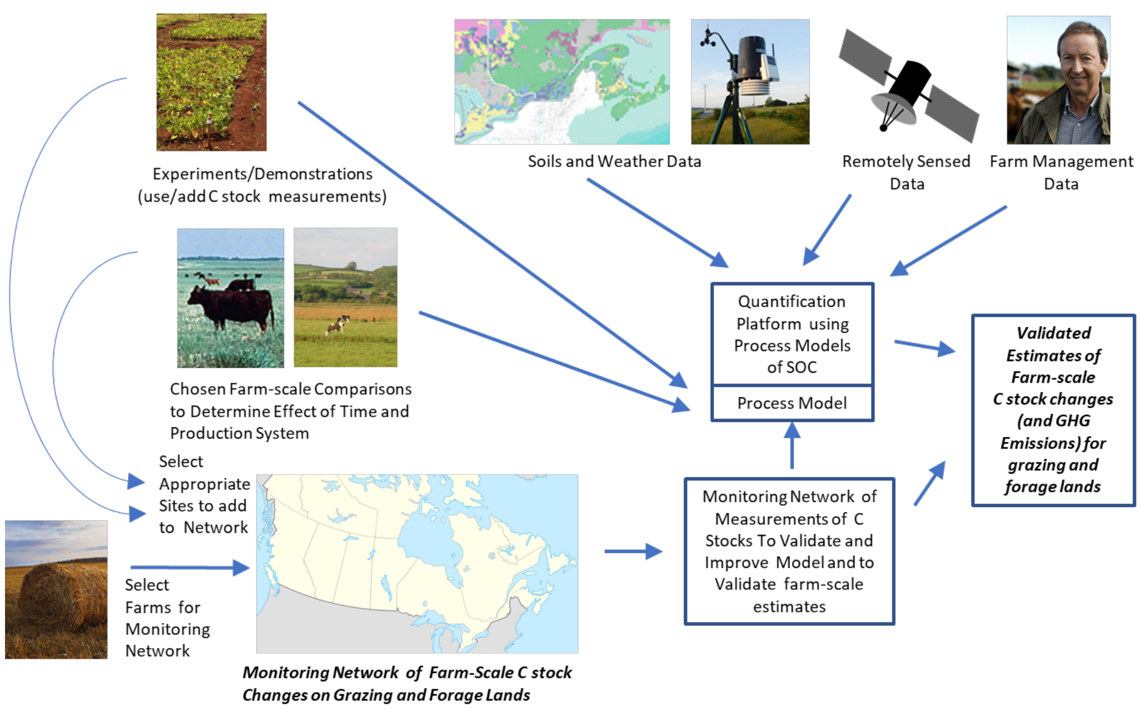

Figure 1. General approach to estimate C stock changes on Canadian grazing and forage lands

Generally, three to five years is a reasonable interval between measurements to detect differences. So, a comprehensive national monitoring network of 50 locations would require about 10 to 33 locations be sampled in any one year. The basic requirements for successful process model validation (see notes on model validation) require that the locations cover the range of situations of soils, weather and climate, vegetation and production practices over which the model will be used to make estimates of SOC change. Therefore, the locations are chosen to meet that objective. Some of the locations may be existing controlled experiments and well managed demonstrations to leverage some of the resources already dedicated to operate those sites. In fact, SOC change data from terminated experiments/demonstrations that cover needed situations would become valuable but no-cost part of the data required from the monitoring network and reduce the need to have those situations among new monitoring sites. To meet objectives for monitoring performance relevant to commercial farms, the locations need to be largely composed of actual farm situations. Some of these locations could be carefully selected neighbouring farms to get more rapid estimates of the effects of different management and/or different duration under specific management practices (see accompanying notes).

The cooperator is fundamental to the monitoring network. So that the locations represent commercial farm practice, it is important that the cooperator not manage the land in the monitoring network differently than what they would do if it was not in the monitoring network. That includes fundamental changes to management or productions system if that was what they see as best for their operation. The cooperator needs to provide data on how the sites within a location were managed annually and deal with the hassles of periodic resampling. Compensation to the cooperators for their contributions to the network is expected.

To implement the strategy outlined in this template, the next step is to engage the various stakeholders in a discussion about the benefits and requirements for good estimates of SOC change on Canada's grazing and forage lands and the interest in resourcing the strategy. Assuming there is sufficient initial interest in a monitoring network, it would be worthwhile to fund the modest analytical work early (see sampling protocol in notes for more information) to firm up the design details for the potential monitoring network options to better estimate the its potential resource requirements.

The monitoring network itself is probably mostly effectively constructed piecemeal as a coordinated set of individual projects that each address a specific province/region and/or types of management systems for grazing and/or forage lands. This approach will be more acceptable to some funders and so work better than a single national project to secure the contributions and involvement of provincial/regional/sectoral organizations in project delivery. Including some initial nearby farm chronosequence comparisons within these projects provides some early information to knowledge of SOC change on grazing and forage lands (see accompanying notes for more explanation).

The quantification system also is well suited to a set of coordinated projects. The validation and calibration are periodic exercises that best involves a number of experts across forage and grazing system and regions of Canada. Close coordination across the validation/calibration is necessary for finalizing the model version, input data choices, and parameters for use in quantification. The quantification needs to be both transparent and reproducible. Therefore, the quantification operation needs to be standardized and automated as far as practical. Operation has to be designed so that there is no expected need for decisions requiring expert scientific knowledge. Once operation is standardized, it is sensible that actual estimation with the system can be distributed for stakeholders to use.

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