Viresco Solutions

End-to-end sustainability

Strategy for a Monitoring Network to Quantify Change in Soil Carbon for Grazing and Forage Lands in Canada

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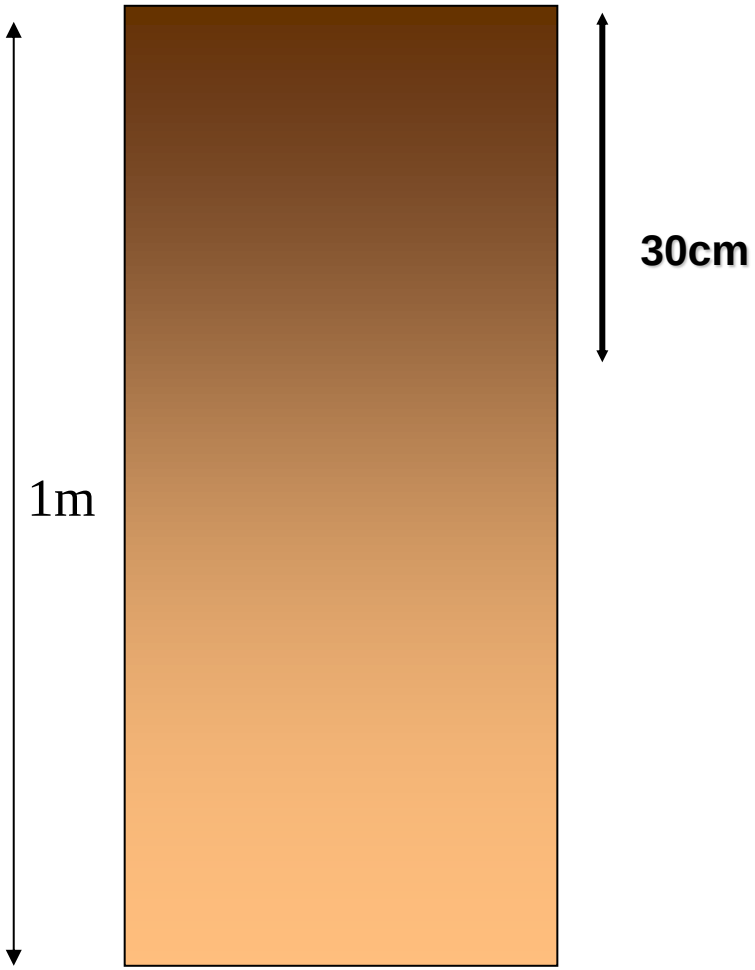
Viresco Solutions

Definitions

- Grazing Land = all land used for grazing domestic livestock
  - Range, tame pasture, naturalized grassland, bush pasture, etc.
  - Including grazing land with annual crops as part of normal rejuvenation
- Forage Land = all land used primarily for producing perennial forages for feeding domestic livestock
  - Tame forages, hayed or silage grass,
  - Including forage land with annual crops as part of normal rejuvenation
  - Does not include annual crops used for silage or hay
- Together, 43% of the land in Canada that is used directly for agricultural production in grazing land or in perennial forages

Typical Soil (Carbon) Profile



- Soil organic matter =1.72 x Soil organic carbon (SOC)
- Soil C content decreases with depth
- C content dependent on balance between decomposition and C input from plant roots and residue
  - Change in SOC requires an imbalance
- CO_2=soil C x 3.67

Carbon Stocks versus Carbon Stock Changes

- Carbon stocks are total carbon
- Carbon stock changes are the change in carbon stocks
- Carbon offset comes from carbon stock changes or the prevention of carbon stock changes.
- Carbon stock changes are typically <1% of carbon stocks per year
- Measuring carbon stocks and stock changes are related but much, much easier to estimate carbon stocks to a given accuracy than carbon stock changes to that same accuracy

Current Weaknesses

- We know very little about C change on grazing lands
  - We assume zero but could be increasing
  - For example, France measured C change on their grassland and found that average permanent grassland sequesters 0.57 t C/ha per yr. – that rate, if applicable to Canada would more than offset the greenhouse gas emission from all cattle in Canada
  - Effect of changes in management (vegetation species, grazing regime, fertilization) poorly understood
- We know very little about C change on forage land due to their management
  - Improvements in forage management would be expected to affect soil organic carbon

Acute Challenges to Quantify SOC Change on Grazing Land

- Huge variation among grazing approaches
  - Vegetation types
  - Heterogeneity of grazing land within the operation
  - Grazing practices
  - Availability of and choices for supplemental feed
  - Individual manager's response to the situation and perceived risk of market, weather, and other influences
- It is difficult to represent real world within controlled experiments
  - Scale and the conglomeration of pasture types and productivities can't be easily included
- We need a method that works at the scale of individual farm/ranches

Other Challenges

- Fewer challenges for quantifying SOC on forage land than grazing land
  - Some challenges similar such as possible heterogeneity of forage land within the operation
  - Important part of cattle production system so we need to improve data to include effect of improved management on SOC change
- Currently C change on grazing or forage land is only estimated in Canada's national inventory based on conversion to or from annual crop production
  - The effect of grazing and forage land management not estimated within Canada's national inventory
  - Management effects will be most important to any market to pay farmers for ecological goods and services including carbon offsets
  - Therefore, management effects on SOC will be under the highest scrutiny

Strategy Objective

- Monitoring Strategy to underpin quantifying SOC change for individual farms to benefit from carbon offset and/or market advantages of a lower carbon footprint from increasing SOC

Basic Features of Proposed Strategy

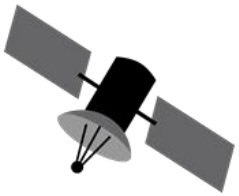
- Uses process models of SOC dynamics to estimate SOC stocks and their change from farm specific situation
- Models are underpinned by monitoring network that calibrates and validates the model estimates of SOC change
- Uses current and historical vegetation analysis by remote sensing from satellites as one input

Why Based on Models?

- Estimates based entirely on measurement will be too costly
- Models make effective and efficient use of existing data
- Models can capture many farm-specific influences
    - Weather
    - Soil type
    - Pasture and/or forage vegetation type
    - Amount and timing of grazing land utilization
    - Fertilization and other amendments
    - Seeding and termination practices

- Data required needs to cover the range of geographical and management conditions that models will be applied but does not need to be representative
- Entering new era of climate change concern in which stakeholders will demand estimates of the future performance and consequences of current actions
    - Measurements of backward looking and can only be used directly to make projections for the same conditions that existed in past
    - Models can make predictions for very different future scenarios

Overview



Soils and Weather Data

Remotely Sensed Data

Farm Management Data

Quantification Platform using Process Models of SOC

Process Model

Validated Estimates of Farm-scale C stock changes (and GHG Emissions) for grazing and forage lands

Monitoring Network of Measurements of C Stocks To Validate and Improve Model and to Validate farm-scale estimates

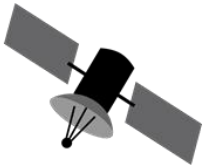
Monitoring Network

- Calibrate model parameters so that modeled results better represent observed behaviour
- Validate the model
  - assess the agreement between modelled and observed results
- Based on observed relationships, extend the modelled results that are limited to 20-30 cm to deeper depths

What is the monitoring network

Experiments/Demonstrations
(use/add C stock measurements)

Soils and Weather Data



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Chosen Farm-scale Comparisons to Determine Effect of Time and Production System

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Validated Estimates of Farm-scale C stock changes (and GHG Emissions) for grazing and forage lands

Select Appropriate Sites to add to Network

Select Farms for Monitoring Network

Monitoring Network of Farm-Scale C stock Changes on Grazing and Forage Lands

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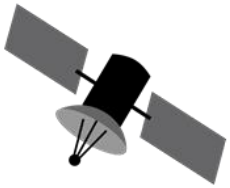

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Monitoring Network

- Set of data to calibrate and validate SOC models
- Match the geographical and management scope of interest
- Lowest hanging fruit
  - Published results relevant to Canadian conditions of interest
    - Canada or northern US
- Low hanging fruit
  - Using (adding or improving) SOC measurements to demonstrations or research sites underway or planned

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Experiments/Demonstrations
(use/add C stock measurements)

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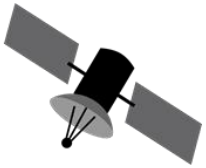

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Chronosequence

- Set of parcels (fields or paddocks) separated in space that represent different durations of land use or management
  - Often described as "across the fence" comparisons
- Assumed that parcels at a specific time in past had the same SOC due to the same land use and management history
- Difference in SOC at present then represents the difference between effects of land use or management since the parcels were assumed to have the same SOC
- Major weakness is the assumption that the parcels had the same SOC at a specific time in the past
  - Only protection is to have as many as feasible parcel comparisons so that assumption, across all comparisons, is likely

Chronosequence Example

AMP from continuous 2011

Continuous continuous

AMP from continuous 2010

AMP from continuous 1996

AMP from continuous 1998

AMP from continuous 2013

AMP from continuous 2016

Continuous continuous

Continuous continuous

SOC differences between land parcels provide a relationship between the time of adoption of adaptive multi-paddock grazing (AMP) relative to continuous grazing

On-farm monitoring locations

- Goal to have the range of management in the data set that covers the range of real management
- Essential that the managers are completely free to do what they want to ensure true validation
  - Inclusion in network and sampling location do not impede free choice of cooperator
- Having management information over time is critical
  - Land managers need to be adequately compensated for their contributions at a amount acceptable to (reluctant) managers that become part of the network from assuming management of the monitored site

What is the monitoring network

Experiments/Demonstrations
(use/add C stock measurements)

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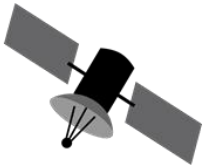

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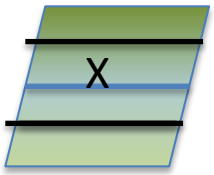
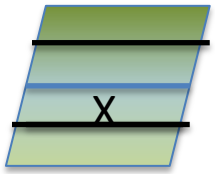
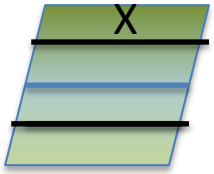
One Farm – Grazing Land



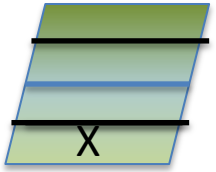
Type 1
(e.g. spring)



Type 2
(e.g. summer)



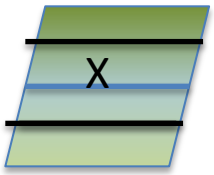
Type 3
(e.g. fall)



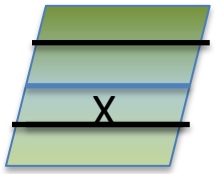
Type 4
(e.g. winter)

Represent the temporal-vegetation variation within the farm

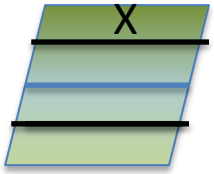
One Farm – Forage Land



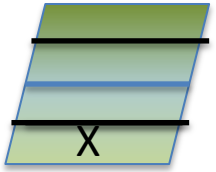
Type 1
(establishment)



Type 2
(production)



Type 3
(underseeding)



Type 4
(termination)

Represent the temporal-vegetation variation within the farm

Site vs Location

- Location is specific soil and climate (weather)
- Site is a combination of soil-climate-management
  - Generally, there are multiple sites within a location
  - In experiments or demonstrations, each treatment is a site
  - A farm is a location and each measured paddock or field is a site

SOC measurements over time essential

- Time sequence of SOC measurements has most value for both calibration and validation of models
  - Agreement at one time mostly dependent on the model initialization procedure
- Measurements every 3 to 5 years have good potential to detect differences
- Once measured twice, the intensity of measurement at one location can be reduced.

How many locations?

- An offset system that requires estimate of SOC change that would have occurred without intervention is challenge
  - What would have occurred is hypothetical
  - Data from past experiments can be sufficient for validating "what-would-have-been" model based estimates
- Want four or more locations to represent an important management-soil-climatic combination
  - Example four locations of adaptive multi-paddock grazing in Atlantic Canada
  - Allows for some sites to be removed for calibration and for some sites to be lost do to cooperator choice.
  - Depending on the nee for and data available, the "what would have been" could require an additional 4 locations.

How many locations? - 2

- About 50 locations across Canada should be sufficient for an adequate monitoring network
- Logically the network would be built piecemeal based on the geographical and management scope of interest of the funders.
- The space between enough and none is a bad place, especially when only occupied by single on-farm locations
  - Idiosyncrasies for one or two sites can prevent validation of model without enough data to provide an alternative empirical estimate or indicate how the model is wrong.
  - Have sufficient number of locations before advertising a monitoring network.

Building a Monitoring Network

- Build network piecemeal to cover geographical and management range of interest to stakeholders

Summary

- Pressing need to fill gaps in knowledge on the C stock change of grazing and forage lands in Canada.
- A well designed monitoring system enables producers to capitalize of market opportunities from C stock increases.
- A process model-based estimate of SOC that is well validated by independent measurements of C change is most cost effective.
- On farm SOC change monitoring sites are necessary for an effective monitoring network
  - Do well or go home

Thank You!

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