Soil carbon monitoring to detect changes due to grazing management

2019 INT 8

Soil carbon monitoring to detect changes in soil carbon due to implementation of planned and rotational grazing, and comparison between these two systems

Project Lead:	**Matthew Wiens**, Land Management Specialist – Climate Change, Manitoba Agriculture and Resource Development (ARD)
MBFI Location(s):	Brookdale Farm
Collaborating Partners:	Pamela Iwanchysko, Farm Production Extension Specialist – Livestock (MARD) and Marla Riekman, Land Management Specialist - Landscape
Start Date:	2016 Status: In Progress

Introduction

Soil sampling to monitor changes in soil carbon occurred in May 2016 and again in May 2019 on paddocks under two distinct grazing systems at the Manitoba Beef & Forage Initiative's Brookdale Farm on land that had previously been either annually cropped or sporadically grazed. The Planned Grazing system employs a documented plan at the beginning of the season to guide when and where cattle are as the grazing season progresses. Cattle are moved quickly during fast growth in early spring and more slowly during slowed growth in late summer, and forage plants are observed to ensure full recovery before they are grazed a second time. In contrast, the Continuous Grazing system allows cattle free access to the entire pasture area for the entire grazing season.

Objectives

To monitor for a minimum of three years, the impact on soil organic carbon of two grazing systems: Planned Grazing and Continuous Grazing. The intention is to seek further support to continue monitoring every three years beyond the first three years to monitor longer-term changes on soil organic carbon.

Project Design and Methods

Based on the Soil Carbon Coalition guide, '*Measuring soil carbon change'*[1], six - 4 x 4 m plots were established in total, as three across-the-fence paired samples for the two grazing systems. They were sampled mid-May 2016 (May 12 and 18) and mid-May 2019 (May 9 and 10). Future sampling is planned for the same time of year in 2022 and 2025 to detect any changes in soil carbon. During sampling, eight- 40 cm soil cores are taken at predetermined locations within the 4 x 4 m grazed plots. Core samples were taken using a step-in soil probe in 2016 and a truck-mounted probe in 2019. Soil samples were collected from the zero to 10 cm soil layer, as well as the 10 to 25 cm and 25 to 40 cm layers. An additional sample depth of 40 to 70 cm was added in 2019. The eight samples from a soil depth were bulked and one sub-sample was collected for drying and storage. Bulk density samples were collected from each depth in 2016 and were collected again in 2019. Bulk density samples were taken for each of the six 4 x 4 m plots, just outside of the plot at one of the corners; a different corner being used for each sampling time (i.e. 2016, 2019). One bulk density sample was collected for each soil layer for each plot. Soil samples for carbon analysis from 2016 and 2019 were sent to the Agriculture and Food Laboratory at the University of Guelph and analyzed by a combustion and elemental analysis method for total carbon, organic carbon and inorganic carbon. Samples taken in 2016 were air dried and stored at room temperature until 2019 and then sent for laboratory analysis along with the 2019 samples in June of 2019. At that, time sub-samples from the 2019 sampling were air dried and stored at room temperature along with 2016 sub-samples and stored to maintain the potential for re-analysis of these samples along with samples to be taken in 2022 and 2025.

The Microsoft Excel Analysis ToolPak add-in was used for statistical analysis. The Anova: Two-Factor With Replication test was used to determine whether or not significant differences in soil organic carbon, bulk density, and soil organic carbon stocks could be detected between grazing treatment (Planned vs. Continuous) and between year (2016 vs. 2019), and whether any interaction was occurring between grazing treatment and year. On all three parameters the anova test was run for all three soil depths (0-10 cm, 10-25 cm, 25-40 cm), and for the entire soil profile (0-40 cm) for soil organic carbon stocks.

Visual assessments of plant community composition, ground cover, and litter layer were done at two locations for each plot; one being the centre of the plot and one 8 to 12 meters away from the plot. Visual assessments were done using a 1 meter diameter hoop and identifying all plant species present, estimating the proportion of bare soil, and estimating the thickness of the litter layer.

Results and Discussion

Figure 1 shows the locations of the 4m x 4m plots at the MBFI Brookdale farm, and in which grazing system they sit.

<u>No Significant Differences Detected</u>

For all three of the parameters that were analyzed (soil organic carbon, bulk density, soil organic carbon stocks), there were no significant differences found between grazing treatment or year. Neither was any interaction effect found of grazing treatment x year.

<u>Means and Standard Deviation</u>

Given that no statistically significant difference was detected between and continuous grazing and planned grazing, or between years, it makes sense to report soil organic carbon concentration, bulk density, and soil carbon stocks as averages of all measurements taken on all six plots over the two sampling campaigns (i.e. the average of 12 measurements). Table 1 shows averages and standard deviations across grazing treatments and years for soil organic carbon concentration, bulk density and soil organic carbon stocks.

Table 1. Averages and standard deviations (SD) for soil organic carbon (SOC) concentration, bulk density, and soil organic carbon stocks for the 0-10, 10-25, and 25-40 cm layers under grazing at Brookdale, Manitoba.

Soil layer	SOC concentration, %		Bulk Density, g/cm3		SOC stocks, kg/ha	
	Average	SD	Average	SD	Average	SD
0-10 cm	4.49	0.91	1.04	0.16	45300	5400
10-25 cm	2.02	0.84	1.16	0.17	34000	11000
25-40 cm	1.12	0.46	1.15	0.10	19000	6900
0-40 cm	-not applicable		-not applicable		98300	17800

<u>Plant species present, soil cover and litter layer</u>
No consistent differences were obvious between years or grazing treatments for the types of plant species present, the percentage of bare ground or the thickness of the litter layer. For both 2016 and 2019 the assessments were done in early to mid-May. At this time of year plant growth was only just beginning. If assessments had been done two to three weeks later in the growing season it is possible that differences would have been detected.

<u>Inorganic C and Total C Measurements</u>
Lab analyses on the soil samples included inorganic carbon concentration and total carbon concentration, in addition to the organic carbon concentration described above. Statistical analysis has not been done fully on the impact of year or grazing treatment on inorganic soil carbon concentration or total soil carbon concentration. However, given that no differences were found for soil organic carbon concentration it is unlikely that differences will be found for inorganic or total carbon concentrations.

<u>Discussion</u>
The lack of difference detected between grazing systems or between years may indicate that the planned grazing system has not yet been in place long enough to influence soil carbon concentrations substantially enough to be measured. Re-sampling in 2022 and 2025 may tell a different story.

Besides the null hypothesis that there were in fact no differences, there are other possible reasons why we did not detect differences between grazing systems or between years. One reason would be that sampling errors masked true differences. Compaction is one type of sampling error that may have masked true differences. Compaction of soil cores occurred occasionally, particularly in the soil layers below the 0 to 10 cm layer. In both 2016 and 2019 the most compaction occurred at sites five and six. Compaction may have resulted in carbon rich soil from a shallower soil layer being accidentally included in a deeper soil layer.

There is a possibility that one or more sites in 2019 had sampling locations outside of the intended grid and so rather than all 2019 samples being done only 0.5 m from the original 2016 locations, one or more may have been taken approximately 8.5 meters from original sampling locations. While not likely, this possibility cannot be ruled out as notes taken in 2016 did not always clearly identify which of the two hoop locations the sampling grid was centered upon. The assumption was that if the notes did not state otherwise, the original sampling grid had been centered at the Hoop location 1. If at one or more plots sampling occurred 8.5 meters from the original sampling location rather than the intended 0.5 meters it may help explain why no statistical differences were detected in soil organic carbon concentrations.

In 2019 a truck mounted-probe was used instead of the step-in probe used in 2016. This shift to the truck-mounted probe was motivated by our desire to sample deeper in the soil profile in 2019 than the 40 cm that we were able to achieve with the step-in probe in 2016. Our goal for 2019 was to sample down to 1 meter. However, we were not consistently able to get deeper than 70 cm. It is possible that frost had not completely melted out of the ground when we sampled on May 09, 2019 and that frozen soil was preventing the probe from going deeper than about 70 cm. The 2019 soil samples from the 40-70 cm depth were air-dried and archived along with the other samples; however, these were not sent away for soil carbon analyses. We plan to soil sample again in 2022 and plan to include the 40-70 cm layer from 2019 and 2022 for analysis at that time.

Another reason for using the truck mounted probe rather than the step-in probe was to avoid compaction of the cores. The larger diameter of the truck mounted probe may have reduced the severity of compaction, but compaction did still occur on some cores.

Summary

I found no significant differences in soil organic carbon concentration, soil bulk density, or soil organic carbon stocks between planned grazing and continuous grazing or between the sampling years of 2016 and 2019. While the lack of significant differences may have been caused by sampling error (e.g. compaction of cores), it is more likely that the variation in soil organic carbon concentration was simply too large to enable detection of significant differences. It may be that three years of contrasting grazing management at Brookdale was not yet enough time to result in soil carbon differences large enough to detect with the Soil Carbon Coalition approach to soil carbon monitoring.
The author recommends sampling again in 2022 in order to monitor any differences that may yet emerge between grazing systems after an additional three years of grazing.

Acknowledgements

I thank Mr. Blain Hjertass for his assistance with the sampling in both 2016 and 2019 and for demonstrating the Soil Carbon Coaltion methods while sharing of both his experience and knowledge.
I thank MBFI staff and summer students for providing invaluable assistance, including Kristelle Harper, Leah Rodvang, Andrea Hamilton, Kathleen Holweger, Emily Pearson and others.
I thank the staff at Guelph Agricultural Laboratories for their soil carbon testing services.
I thank the department of Agriculture and Resource Development and Dr. Francis Zvoyuma for giving a statistics refresher course on February 20, 2020. Dr. Zvoyuma guided me to the two-way factorial test.

References

[1]Donovan, P. Soil Carbon Coalition guide: Measuring soil carbon change [Internet]. 2013. Available from: http://soilcarboncoalition.org/files/MeasuringSoilCarbonChange.pdf

Figures

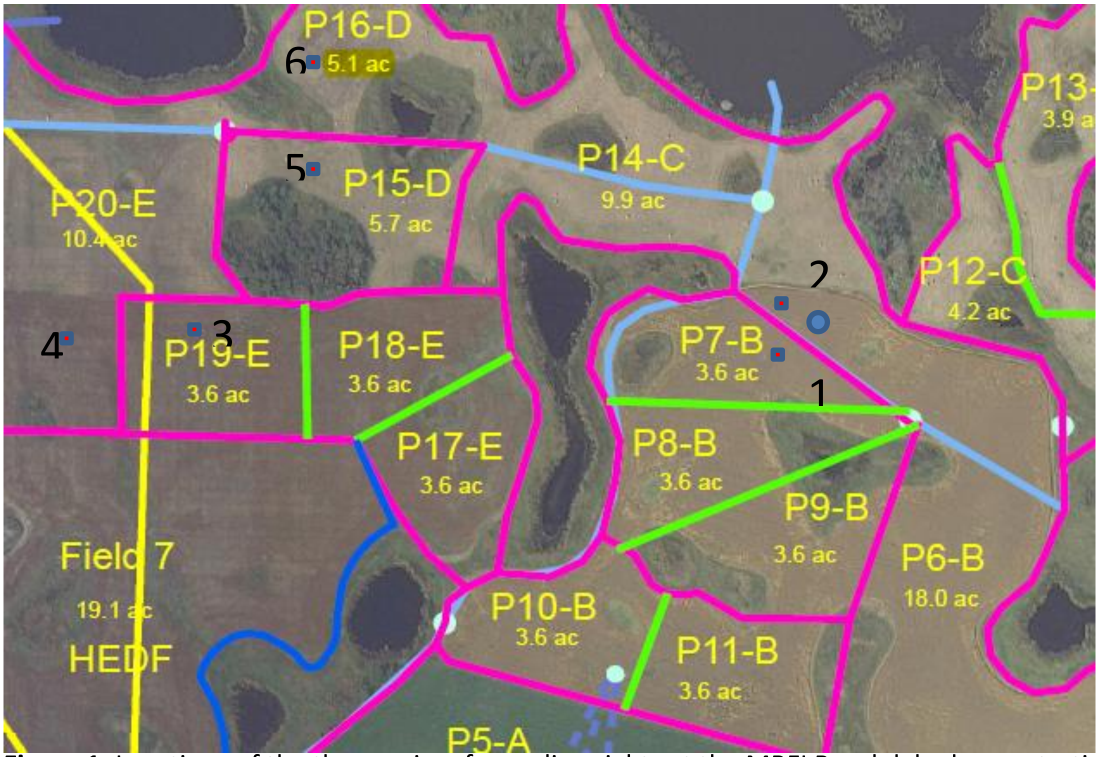

Figure 1. Locations of the three pairs of sampling sights at the MBFI Brookdale demonstration farm.

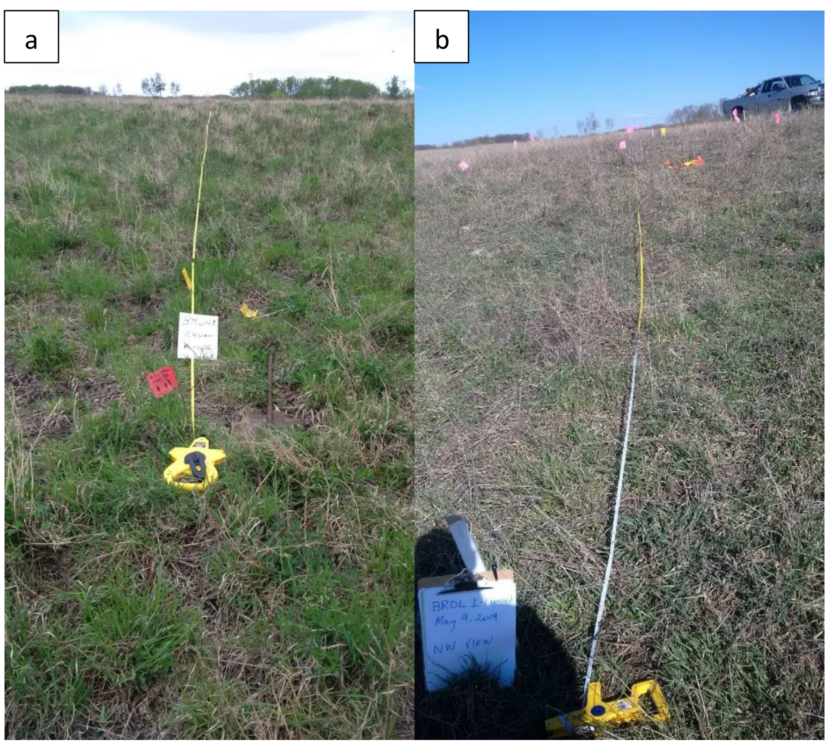

Figure 2. Planned grazing monitoring site, Brookdale Farm, May 12, 2016 (frame a) and May 09, 2019 (frame b); photos by Matthew Wiens.

Figure 3. One meter diameter hoop placed along Site #2 transect at the same location in 2016 (frame a) and 2019 (frame b).

Figure 4. Sampling with the truck-mounted soil probe on May 10, 2019. We were able to sample down to 70 cm.

Figure 5. Step-in probe used in 2016 down to 40 cm.

Figure 6. Bulk density ring and hammer head used to collected bulk density samples.