Response of greenhouse gas emission and soil carbon storage to cattle grazing practice on a rough fescue grassland

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1. Background

- Cow-calf grazing on rangeland generates 80% and feedlot only 20% of total greenhouse gas emissions from beef production in Western Canada.
- Rangeland soils are small sinks for methane (CH$_4$) and a source of nitrous oxide (N$_2$O).
- Emissions associated with livestock grazing excreta on rangeland are uncertain.
- Very little data are available for native rangelands on the Canadian prairies.
2. Objectives

- Determine the GHG emission from cow-calf production on rangeland as influenced by management practices
- Explore potential to increase soil C sequestration and storage in rangeland
3. Experimental Approach

Four experiments were conducted

- **Expt 1**: Effect of long-term cattle stocking on GHG emission and soil C storage (Stavely)
- **Expt 2**: GHG emission from producer site (Little Bow)
- **Expt 3**: Effect of soil texture on GHG emission under rotational grazing system (Duchess)
- **Expt 4**: Contribution of dung and urine on tame pasture (Lethbridge)
3.1 Cattle stocking rate

- Three years study (2013 to 2016)
- Four non-replicated cattle stocking rates on the rough fescue grassland established at Stavely in 1949
- The adjacent fields (C and D) with 2.4 (MG) and 4.8 AUM ha\(^{-1}\) (HG) stocking rates, and nearby field at 1.2 AUM ha\(^{-1}\) (LG)
- A permanent exclosure since 1949, 0 AUM ha\(^{-1}\) (CK)
- April 1998, three *exclosures* were installed in each of the adjacent fields (C and D)
3.1 Cattle stocking rate – Rangeland recovery

Chambers placement at Stavely
3.2 Producer site - Piosphere

Chamber placement at the Little Bow producer site
3.3 Rotational grazing - Soil texture

Duchess Chamber set:
- E5E: 1-8;
- E3NE: 9-16;
- Inside the exclosure:
  - 1, 3, 5, 7, 9, 11, 13, 15;
- Outside the exclosure:
  - 2, 4, 6, 8, 10, 12, 14, 16;
- Chamber

Exclosure 2010

Exclosure 2010
Urine = 75 tonne/ha = 750 kg N/ha
Dung = 65 tonne DM/ha
DI water = 75 tonne/ha

3.4 Tame Pasture - Dung & urine

When compost applied
4. Measures

- Weekly gas sampling (May to Oct)
- Monthly surface soil (0-15 cm) sampling:
  - For analysis of available N and P, and microbial assessment,
- One-time soil profile sampling:
  - 0-15, 15-30 and 30-60 cm
  - macro organic matter (MOM),
  - bulk density (BD)
  - TOC, TN and TP
  - Water-OC and soluble ions
- Annual herbage sampling (peak NPP)
## 5. Key Outcomes

### Cumulative GHG emission (Stavely site)

<table>
<thead>
<tr>
<th></th>
<th>CO$_2$ (kg C ha$^{-1}$ yr$^{-1}$)</th>
<th>CH$_4$ (kg C ha$^{-1}$ yr$^{-1}$)</th>
<th>N$_2$O (kg N ha$^{-1}$ yr$^{-1}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CK</td>
<td>3,308</td>
<td>3,408</td>
<td>-1.6</td>
</tr>
<tr>
<td>1.2 AUM</td>
<td>4,793</td>
<td>5,297</td>
<td>-0.9</td>
</tr>
<tr>
<td>2.4 AUM Inside</td>
<td>3,123</td>
<td>4,094</td>
<td>-1.0</td>
</tr>
<tr>
<td>2.4 AUM Outside</td>
<td>4,362</td>
<td>4,593</td>
<td>-1.0</td>
</tr>
<tr>
<td>4.8 AUM Inside</td>
<td>3,569</td>
<td>4,208</td>
<td>-1.0</td>
</tr>
<tr>
<td>4.8 AUM Outside</td>
<td>4,276</td>
<td>5,451</td>
<td>-1.0</td>
</tr>
</tbody>
</table>

* Gas flux was measured from May 28 to September 17 in 2013 (113 days) and from May 15 to October 22 in 2014 (160 days).
# Key Outcomes

## Carbon storage on a rough fescue grassland at Stavely site (2014)

<table>
<thead>
<tr>
<th></th>
<th>Aboveground Plant carbon (kg ha(^{-1}))</th>
<th>Macro organic carbon (kg ha(^{-1}))</th>
<th>Soil organic carbon (kg ha(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>CK</td>
<td>1,240</td>
<td>4,093</td>
<td>96,156</td>
</tr>
<tr>
<td>1.2 AUM</td>
<td>1,634</td>
<td>4,893</td>
<td>97,380</td>
</tr>
<tr>
<td>2.4 AUM</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inside</td>
<td>1,351</td>
<td>6,092</td>
<td>105,990</td>
</tr>
<tr>
<td>Outside</td>
<td>1,884</td>
<td>6,199</td>
<td>82,200</td>
</tr>
<tr>
<td>4.8 AUM</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inside</td>
<td>1,600</td>
<td>4,526</td>
<td>73,157</td>
</tr>
<tr>
<td>Outside</td>
<td>1,295</td>
<td>4,614</td>
<td>88,824</td>
</tr>
</tbody>
</table>

* Macro organic carbon (85%) and soil organic carbon (51%) are located in the 0-15 cm depth
Acknowledgements

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Thank you!