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Projected impact of future climate conditions on the agronomic and environmental performance of Canadian dairy farms

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Why is this important?

Agriculture is a contributor to greenhouse gas emissions (GHG), thereby impacting climate change potential. In addition to GHG emissions, the dairy industry significantly impacts the environment through nitrogen (N) and phosphorus (P) losses contributing to air and water pollution. Interestingly, climate change may positively impact crop productivity in Canada due to the expected increase in CO_2 concentration, warmer temperatures, and a longer growing season. However, climate change is likely to have a net negative impact through: 1) increased N air pollution from crop production due to higher nitrogen rates required for greater crop yields, 2) increased N water pollution from agricultural watersheds due to increased precipitation, 3) increased ammonia and methane emissions from manure storage due to higher temperatures, and 4) increased P losses due to increased intensity of precipitation. A dairy farm is complex, requiring comprehensive whole-farm simulations to account for internal cycling of nutrients on-farm and nutrient exchange with the environment. This study used the Integrated Farm System Model (IFSM), a model providing an assessment of the economic and environmental sustainability of dairy farms. The objective of this study was to examine the impact of climate conditions in the near and distant future on the performance of dairy farms.

What did we do?

A virtual dairy farm was created for Central Alberta. The farm housed 140 lactating cows (8,610 L milk/cow/year), 88 ha of perennial forages for silages, 65 ha for barley grain, and 35 ha for barley silage. A reference period was created using current data for all variables measured in the study. The impact of climate change on dairy farms was then studied by comparing IFSM predictions from the reference period with predictions made for the near future (NF; 2020 to 2049) and distant future (DF; 2050 to 2079). For both of these future periods, two different atmospheric GHG concentration scenarios were applied:

- 4.5 - GHG emissions increase slightly until 2040 and then decline
- 8.5 - GHG emissions keep increasing over time

The IFSM includes several major processes on the farm: crop and soil, grazing, machinery, tillage and planting, crop harvest and storage, herd and feeding, and manure storage and handling.

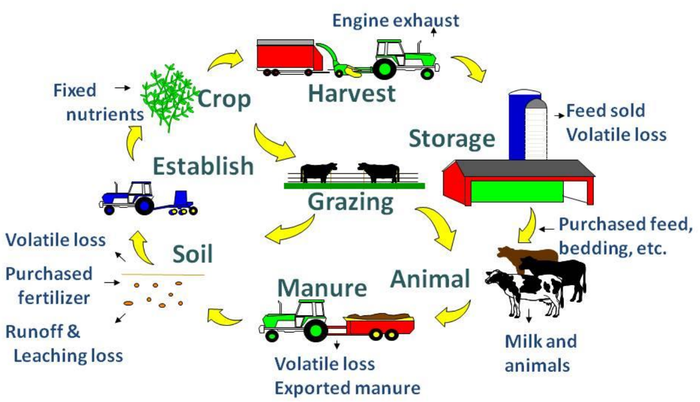

Table 2. Climate characteristics of a virtual dairy farm in Alberta for the reference period (1971-2000) and projected changes (increase [+] or decrease [-] relative to the reference period) in near future (NF; 2020-2049) and distant future (DF; 2050-2079) periods under representative concentration pathways of 4.5 and 8.5.

Climate characteristics	Ref.	NF4.5	NF8.5	DF4.5	DF8.5
	Value		Change from ref. (+ / -)		
Temperature (average, Apr. to Oct.), °C	10.5	2.3	2.3	3.5	4.8
- April, °C	4.1	2.1	1.7	2.5	3.6
- May, °C	10.4	1.4	1.7	2.3	3.4
- June, °C	14.0	2.0	2.2	3.7	4.5
- July, °C	15.9	2.7	2.9	4.6	6.1
- August, °C	14.8	3.0	3.2	4.8	6.6
- September, °C	10.3	2.4	2.2	3.6	5.1
- October, °C	4.0	2.2	2.2	3.0	4.4
High temp. days[a] (Apr. to Oct.), #	7	15	17	34	47
First fall frost (< 0 °C), day of the year	252	14	13	19	24
Precipitation (annual), mm	486	45	31	43	74
Precipitation (Apr. to Oct.), mm	398	35	23	23	44
Crop heat unit accumulation, CHU	1884	623	658	970	1319
Growth start for perennial forages, day of the year	111	- 10	- 8	- 13	- 17
Beginning of planting date – barley, day of the year	131	- 9	- 6	- 12	- 18
Beginning of planting date – corn, day of the year	133	- 6	- 11	- 7	- 16

[a] Number of days when the maximum temperature reached at least 28 °C

What did we find?

Of benefit to producers, this study found that the yield of all silage crops (corn, barley, and perennial forage) increased in all future scenarios, with pure alfalfa increasing most (from +30 to +62%). The barley grain yield decreased in all future scenarios (from -5% to -11%), thus causing producers to purchase additional grain or to select grain crops with greater yields in the future. With respect to environmental performance, total farm ammonia emissions increased in all future scenarios. In the future, fossil fuel CO_2 emissions and methane emissions from stored manure will increase (+23 to +36% and +4 to +26%, respectively). Losses of N and P in water through runoff and leaching will also increase (largely due to increased fertilization of corn). Overall, the N footprint will increase (+15% to +46%), but the C footprint will remain relatively stable (+1% to +4%).

What does it mean?

Increased yields for silage crops (particularly corn silage and alfalfa) may be beneficial to producers in the future, as silage sales may increase or producers may consider expanding their herds due to greater availability of feed. However, decreased barley yields in the future mean that producers will need to rely on purchased grain to meet animal requirements and/or consider other grain sources (such as corn). Producers should consider increasing the proportion of alfalfa in their forage mixtures, given that N-fixing species respond well to increased atmospheric CO_2. Despite these potential improvements in feed production, there is also the potential for increased pollution on-farm, an issue that will need to be managed and is likely to result in additional costs to producers.

Summary Points

- Yields of perennial forages and corn silage will increase, while yields of barley will decrease in the future.
- Ammonia and methane emissions from manure, field-related P losses, and field-related N losses through nitrification are all projected to increase.

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