Climate Change and Agriculture

CLIMATE CHANGE AND AGRICULTURE

Living Off the Land

A short drive outside any town or city in south-central Manitoba reveals where much of the province's wealth lies: in fertile farmland. Over 33,000 people are directly employed in Manitoba's agricultural industry[i]. Another 18,300 Manitobans are employed indirectly by agriculture[ii]. Farming, since the birth of our province, has continued to sustain and drive our economy.

Growing Emissions

Agriculture accounted for 33% of Manitoba's climate-changing emissions in 1999[iii]. No one agricultural sector is solely responsible for these emissions. Livestock and crop production in Manitoba both contribute to climate change.

Agricultural GHGs

The most basic agricultural activities create climate-changing emissions. Clearing forests, draining wetlands, burning stubble, raising livestock and fertilizing with nitrogen all release GHG's into the atmosphere[iv]. ***Agriculture and Agri-Food Canada*** has identified the three most important greenhouse gases produced by agriculture[v]:

- **Carbon dioxide (CO_2)**: Massive global increases have been produced from the widespread combustion of fossil fuels and other materials. It is also released by natural processes such as plant and animal respiration, and the decay of organic matter. CO2 is currently responsible for over 60% of the enhanced greenhouse effect.

- **Methane (CH_4)**: Methane is produced from the decay of organic matter without oxygen. Major sources include ruminant digestive processes, and manure storage and handling. Although there is less methane is the atmosphere, it is a more effective heat-trapping gas than CO_2.

- **Nitrous oxide (N_2O)**: Soil cultivation, fertilizer and manure application, and the combustion of fossil fuels and organic matter produce N_20 emissions. Soils and oceans naturally release N_20. It is over 300 times more effective than CO_2 in greenhouse warming.

IMPACTS ON AGRICULTURE

A Delicate Balance

Agriculture on the Canadian Prairies is sensitive to the vagaries of climate. Throughout the history of Manitoba, droughts, floods, early frosts and hail have all taken their toll on crops and livestock[vi]. It is not difficult to imagine that climate change will have a major impact the agriculture industry. **Climate change models predict an uncertain future for agriculture in Manitoba, with potential benefits offset by powerful drawbacks.**

Six Major Impacts of Climate Change[vii]

1. More carbon dioxide.

Crop Productivity Boosted

Crop species vary in their response to carbon dioxide. C_3 plants such as wheat, rice and soybeans, respond readily to increases in CO_2. They step up photosynthesis rates, converting more CO_2 to sugars, starches and cellulose. Increased CO_2 also tends to suppress photo-respiration in these plants, making them more water-efficient[viii].

Corn, sorghum and millet, plus many pasture and forage grasses are C4 plants[ix]. They are less responsive to higher levels of CO_2.

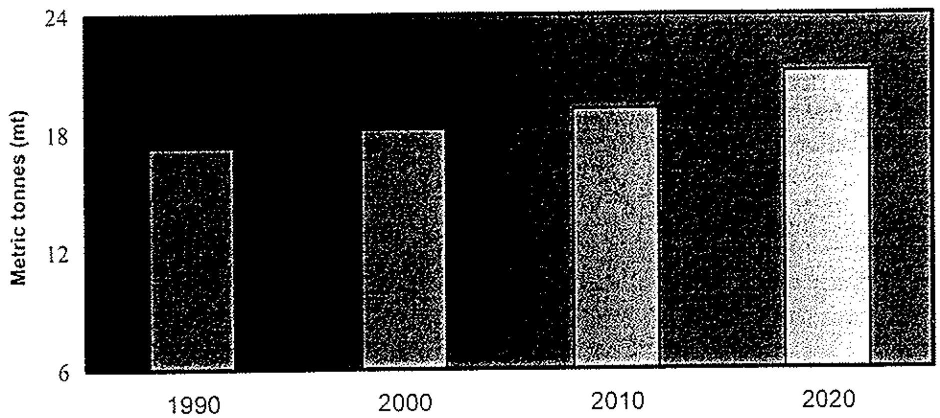

Figure 1: Past, present and projected future carbon dioxide emissions in Manitoba.
Source: Natural Resources Canada.

2. Higher temperatures.

Growing Larger
At middle and higher latitudes, climate change will extend the growing season[x]. Earlier planting and harvesting may allow for more than one cropping cycle per season. For every 1°C increase in average temperature, the growing season may lengthen by 10 days on the Canadian Prairies[xi].

Crop-producing areas may expand northward, though yields will be lower due to less fertile soils. Many crops are adapted to specific growing-season daylengths of middle and lower latitudes. These plants may respond poorly to the longer days of high-latitude summers.

Too Hot To Grow
At lower latitudes, increased temperatures may exceed optimal conditions for growth. In the same way that overheated people become sluggish and unproductive, plants respond with a steep drop in net growth and yield. High temperatures also accelerate development, resulting in early maturation and reduced yield.

Overheated Livestock
Livestock would also be more susceptible to the effects of high temperatures. Heat stressed dairy cattle produce less milk and are less fertile[xii]. Hogs and fowl are especially susceptible to heat-related injury and death because they have no sweat glands. The demand – and cost - for water and cooling systems will grow.

Cows sweat at only 10 percent the rate of humans[xiii].

3. Less water.

Feast or Famine
Climate change models predict 10 to 20 percent declines in summer precipitation in Manitoba[xiv]. What rain does fall will more likely be released during intense weather events. The duration of dry periods between deluges is predicted to increase[xv]. Coupled with warmer temperatures, Prairie farmers can expect more droughts[xvi].

Thirsty Crops
In addition to rainfall, evaporation, runoff and soil moisture will also be influenced by climate change. Warmer temperatures will increase the rate of evapotranspiration, draining both the soil and crops of water. Wheat, corn and soybeans are very sensitive to moisture stress – particularly during flowering, pollination and grain-filling[xvii]. A greater demand for irrigation would place a strain on limited water supplies and increase N_2O emissions.

4. Extreme weather events.

Hold on to Your Hat
Climate change will affect the frequency, severity and duration of extreme weather events[xviii]. Spells of high temperature, heavy rainfall, high winds and droughts disrupt crop production. The ***International Institute for Sustainable Development*** has projected possible increases in the following weather events:

- prolonged heat spells
- thunderstorms and straight-line winds
- hailstorms
- tornadoes
- heavy rainfall
- intense winter storms.

Hail is the most destructive weather event in Canada, causing an average of $450 million dollars a year in damage[xix].

Winds of Change
Long terms changes in the pattern of water and air movement may change as the greenhouse gases alter the dynamics of the atmosphere. Major changes in atmospheric circulation could occur, altering storm tracks, rainfall distribution and wind patterns. In turn, climate change would affect the way that rivers and streams run. Lake levels would either rise or fall dramatically with alterations in input.

As greenhouse gas concentrations continue to rise – doubling, tripling and quadrupling current values – climate patterns would not have a chance to stabilize. **Climate-changing emissions would constantly alter the flow of air and water through the atmosphere.** Things would never be the same.

5. Soil fertility and erosion

Less Soil Organic Matter

Climate change will also impact soil quality. Warmer temperatures increase soil respiration[xx], speeding the natural breakdown of organic matter and other processes that affect fertility. Adequate soil organic matter is critical to fertility, water retention, crop production and carbon sequestration[xxi].

More chemical fertilization may offset soil quality losses, but at a cost to air and water quality. Nitrogen-based fertilizers are also a chief source of N_20 emissions, another important greenhouse gas.

The Root of the Problem

Plants take up nitrogen, a key nutrient, through their roots. Greater root development indicates healthy rates of nitrogen uptake. If soil moisture is not limiting, warmer air temperatures will increase nutrient uptake.

Unfortunately, climate change models predict hotter, dryer summers. Increases in evapotranspiration and evaporation will remove water from soil. Nitrogen uptake will be suppressed, slowing root growth and decomposition. Without the anchor of well-developed root systems, fertile Prairie soils will be more vulnerable to wind erosion. Dry spells broken up by heavy rainfall increase the likelihood of water erosion as well.

Yields from severely eroded soils may be *50-100% lower* than those from stable soil in the same field[xxii].

6. Pests and diseases

What is Good for the Goose…

Agricultural pests, pathogens and weeds are all affected by climate[xxiii]. Warming can affect the range of pest species, while extreme weather events provide opportunity for infestation[xxiv]. They will respond in a variety of undesirable ways to climate change events:

1. **Longer growing seasons** – insects such as grasshoppers and flies will be able to complete a greater number of reproductive cycles during the spring, summer and autumn. Warm-season weed species may also benefit from balmier weather[xxv].
2. **Warmer winter temperatures** – the range of many pest species is limited by cold temperatures. With milder winters, larvae could survive overwintering, causing greater infestation the following spring.
3. **Altered wind patterns** – different wind patterns could change the spread of wind-borne pest insects, bacteria and fungi that cause crop and livestock disease.
4. **Elevated CO_2 levels** – crops aren't the only plants that will increase productivity. Many weed species would benefit from carbon dioxide fertilization.

Some 500 insect pests, 270 weed species and 150 plant diseases are now resistant to one or more pesticides[xxvi]

REDUCING AGRICULTURAL EMISSIONS

Soils As Sinks for Carbon

Carbon – in the form of organic matter – is a key element to healthy soil. Some of the carbon previously stored in fertile Manitoban soils has been lost. The conversion of natural habitats to cropland and pasture, and unsustainable land practices such as excessive tillage, frees carbon from organic matter, releasing it to the atmosphere as CO_2 [xxvii]. Depleted of organic carbon, soils develop a "carbon deficit".

Soils can regain lost carbon by reabsorbing it from the atmosphere. This process is called "carbon sequestration". Through photosynthesis, plants convert CO_2 to sugars, starch and cellulose, also known as carbohydrates. These are organic forms of carbon. In natural habitats, carbon from plants is deposited in the soil through roots and plant residues, such as fallen leaves.

Carbon-Friendly Farming

When crops are harvested, much of the carbon-containing plant mass is removed. How can farmers refill the soil carbon sink and still produce crops for food and industry?

The following farming practices can slow carbon loss and increase long-term soil organic carbon (SOC):

1. **Conservation tillage or no-till farming** - reduces soil disturbance and fossil fuel emissions from farm machinery[xxviii].
2. **Regrowth of native or perennial vegetation** – increases SOC in previously cultivated soils[xxix]. Converted marginal croplands can also act as shelterbelts and oases of natural habitat.
3. **Reducing summer fallow** – continuous cropping leaves soils with a higher SOC than those with a high frequency of fallow[xxx].
4. **Including perennial forages** –they have longer growing seasons than annual crops. Regularly including perennial forages in crop rotations increases SOC[xxxi].

Benefits Beyond Climate Change

Many of these practices produce benefits beyond reducing GHG emissions and increasing SOC. They also contribute to environmental sustainability and economic savings. ***Agriculture and Agri-Food Canada*** have identified the extra perks of climate-friendly farming practices:

- Increased water conservation
- Reduced wind and water erosion

- Enhanced wildlife habitat and protection
- Increased biodiversity
- Reduced machinery use and fuel consumption
- Improved yields

Less Nitrogen is Better

Nitrogen (N) is the fourth most common element in living tissues and necessity for life[xxxii]. Earth's atmosphere is 78% nitrogen (N_2). However, most plants and animals cannot use N gas directly from the air like oxygen or carbon dioxide. They must wait for nitrogen to be "fixed" – pulled from the air and bonded into molecules with hydrogen or oxygen – before they can use it[xxxiii].

Before human activities began to alter the release of nitrogen into the atmosphere, nitrogen was a rare and precious commodity. It served as an important limiting resource that controlled the biodiversity and function of many ecosystems[xxxiv].

Double Trouble

Nitrous oxide (N_2O) is a powerful greenhouse gas, with a global warming potential 310 times that of carbon dioxide[xxxv]. **It also long-lived in the atmosphere, trapping Earth's heat for about 120 years once released.** It eventually converts to nitric oxide (NO), a gas that breaks down ozone (O_3) in the upper stratosphere. Ozone filters out harmful UV radiation from the sun.

Fertile Grounds for Change

Almost 70% of N_2O released is from agricultural activities[xxxvi]. The inefficient use of nitrogen-based fertilizers is greatest source of GHG emissions. Plant uptake is often only 50% of the nitrogen (N) applied – a huge economic loss for producers[xxxvii]. Such poor uptake is caused by leaching, runoff, erosion and gaseous emissions[xxxviii].

Timing and technique of fertilizer application can help dramatically reduce rates of N_2O release to the atmosphere[xxxix].

1. **Match fertilizer additions to plant needs** – apply just enough N so crops reach maximum yield without leftovers.
2. **Cut the poop** – heavily manured lands emit a lot of N_2O. Like nitrogen-based fertilizers, manure should be applied only as needed.
3. **Perfect timing**– fertilizers and manure should be applied as quickly as possible just prior to the maximum uptake by the crop[xl].
4. **Improve soil aeration** – the chemical reactions that produce N_2O occur in low-oxygen conditions. Managing soils prone to water logging, avoiding excess irrigation and using tillage practices that improve soil structure will reduce emissions.
5. **All fertilizers are not created equal** – some forms of fertilizers emit more GHG's than others. Anhydrous ammonia produces the highest emissions[xli], whereas forms containing NO_3 produce the lowest.
6. **Lime acid soils** - emissions can be suppressed by applying neutralizing lime to acid soils, which favour the production of N_2O.

Livestock and GHG Emissions

Methane is responsible for about 18% of the enhanced greenhouse effect [xlii]. Its concentration in the atmosphere is increasing[xliii]. Although there is considerably less methane than CO_2 in the atmosphere, it is still a serious problem. **Methane is 21 times more effective than CO_2 at trapping heat.**

> **According to the *Intergovernmental Panel on Climate Change*, methane concentrations now are at their highest levels in 420 000 years.**

Something to Chew On

The majority of methane emissions are from the digestive processes of ruminant livestock, such as cattle, sheep, buffalo and goats. These animals have a rumen or large "fore-stomach". Microorganisms live in the rumen and break down food into nutrients the animal can absorb. This is called enteric fermentation. During microbial fermentation, methane is produced, which is exhaled or burped up by the animal.

A variety of climate-friendly livestock feed management practices decrease enteric methane production[xliv]:

1. **High quality forages** –steers grazing on high-quality pasture emit 50% less methane than those feeding on matured pastures[xlv].
2. **Legumes in grazing rotations** – fewer methane emissions were observed from animals grazing alfalfa-grass pastures than grass-only pastures[xlvi].
3. **Feed additives** –use of ionophores can reduce methane emissions by 28%[xlvii], but only in the short-term, as digestive microbes adapt to the additives.
4. **Adding fat to grain diets** – methane emissions can drop by one-third when canola oil is added to feed[xlviii]. However, fat should not comprise more than 5% of the diet. Too much fat depresses fibre digestion.
5. **Feed and animal management** –methane released from an animal represents lost energy. Improved efficiency reduces methane emissions and improves a farm's bottom line:
    - Rotational grazing instead of continuous grazing
    - Penning and grouping strategies to meet nutrient needs (age, sex, etc.)
    - Grinding and pelleting food
    - Use of high grain to forage ratios
    - Formulate diets to avoid overfeeding and underfeeding of nutrients
    - Adjust diet to life cycle stage to reduce excess nutrients and manure volume.

Nothing to Sniff At

Manure in storage and on land is also a significant source of methane emissions. If manure decomposes in the absence of oxygen – such as in stockpiling or liquid storage – much of the carbon in the manure is converted to methane gas[xlix]. When oxygen is present, decomposing manure releases nitrous oxide (N_2O), another potent greenhouse gas.

A full-grown pig produces 4.5 kg or 10 lbs of manure a day, while a cow produces 54. 5 kg or 120 lbs!

Manitoba's livestock industry is growing. The sale of Manitoban hogs alone increased from 4.3 million to 5.3 million head from 1999 to 2000. To do their bit, farmers can use the following management options to reduce methane and nitrous oxide emissions from manure[li]:

1. **Reduced dietary protein** – about 50% of the total nitrogen excreted by pigs can be reduced by adjusting amino acid composition of the diet[lii].
2. **Improved feed efficiency** – better quality nutrition means less manure and less nitrogen excreted in the manure. Easy as pie…
3. **Manure handling systems** – liquid or slurry systems support anaerobic (oxygen-free) decomposition, producing more methane than other systems.
4. **Manure storage systems** – composting is the most climate-friendly method of storing manure. It emits up to 17 times less GHG's than slurry storage, and 2-3 times less than stockpiling.
5. **Type of land application** –Injecting manure directly into the soil or cultivating directly after surface spreading reduces nitrogen release compared to other application techniques.[liii].

DOING OUR BIT

Over one third of Manitoba's greenhouse gas emissions are produced by agricultural activities. These emissions will ultimately force farmers to change the way they produce food and agricultural products. As the climate changes, Manitoban farmers will have to adapt to new conditions – for better or for worse.

To avoid such a scenario, Manitobans must do their bit to reduce climate-changing emissions from the agriculture sector today. It is far easier to make sustainable farm management choices now instead of waiting for the inevitable losses that will accompany a changing, unpredictable climate.

Rachel Van Caeseele. September 2002.

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