Farming in a Changing Climate in Manitoba

Climate Change Connection

A GUIDE TO SUSTAINABLE LIVESTOCK SYSTEMS - APRIL 2013

Assiniboine Credit Union
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Manitoba

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CLIMATE CHANGE CONNECTION IS A MULTI-STAKEHOLDER PROJECT, MANAGED BY THE MANITOBA ECO-NETWORK:

Our vision is for a future in which Manitobans will be aware of climate change facts related to Manitoba and will take action to reduce their greenhouse gas (GHG) emissions, both individually and as a community

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Can You Make a Difference?

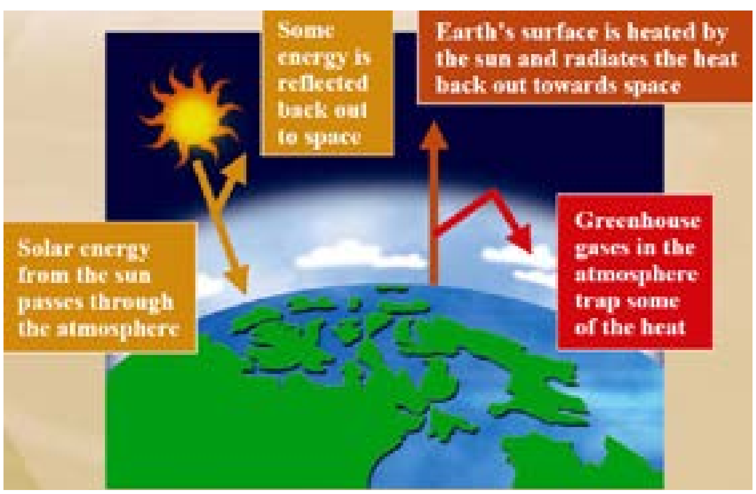
This guide is intended for Manitoba livestock producers. This guide is not meant to be prescriptive; it provides ideas to consider. This guide suggests farming practices that are practical and reduce greenhouse gas (GHG) emissions. By considering them, you will be part of a positive movement to pass on a healthier environment and healthier land to future generations

This guide includes the following topics related to crop production on the Prairies:

- A brief introduction to climate change on the Prairies
- Predicted changed for Manitoba's climate
- Impacts of climate change on crop production in Manitoba
- Farm contributions to climate change
- Recommendations on how to reduce greenhouse gas emission from crop production
- A list of information resources

What is Climate Change?

The earth has always acted as a greenhouse system, retaining some of the sun's warmth through the buildup of naturally occurring greenhouse gases (GHG), namely, carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_20) in the atmosphere. This natural greenhouse effect ensures that not all energy arriving from the sun escapes directly back into space. Without this warming effect, Earth's average temperature would be too cold to support life as we know it. The greenhouse effect is necessary for life on Earth.



"Warming of the climate system is unequivocal, as it is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level."
-Intergovernmental Panel on Climate Change, 2007

In Manitoba...

Agriculture plays a significant role in contributing emissions.

- It accounts for 33 percent of Manitoba's total greenhouse gas emissions, excluding vehicle fuel and commercial heat.
- Manitoba's agricultural emissions increased 30.7 percent between 1990 and 2010.
- Of Manitoba's agricultural emissions in 2010, 63 percent came from agricultural soils, 27 percent from enteric fermentation and 9 percent from manure management.*
- In Canada, agriculture-related GHG emissions contributed 10 percent of total emissions in 2010, an increase of 27 percent above 1990 levels. *

With the occurrence of the industrial revolution around 1750, humans began contributing to the rising amount of greenhouse gases in the atmosphere. Increased GHG sources and the removal of existing sinks (e.g. old growth forests and tall grass prairie) have increased global atmospheric GHG levels by 39 percent since the start of the Industrial Revolution.[1]

The increase in greenhouse gas emissions means a thicker blanket of greenhouse gases in the atmosphere. The "blanket" of gases traps more heat leading to global warming. Global warming leads to a changing climate. Here are some global warming facts:[2]

- Temperatures have increased by 0.76°C during the twentieth century
- The 10 hottest years in the instrument temperature record have all occurred since 1998
- A further rise of between 1.1 to 6.4°C is expected by the year 2100

Global warming, in turn, affects other aspects of the earth's climate. Here are some possible impacts of global warming on the climate and environment[3 4],

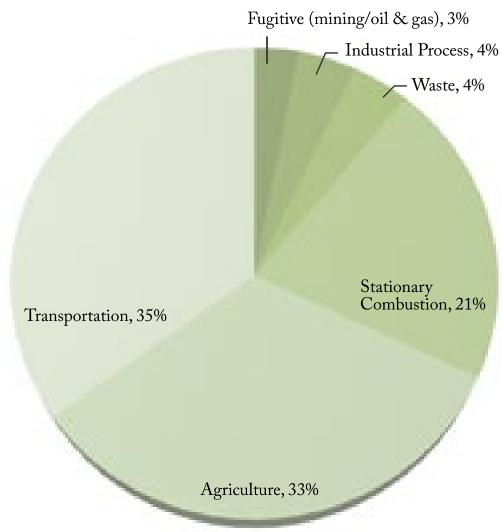
- Changing weather and rainfall patterns
- Melting polar ice cover, snow, and permafrost
- Rising sea level
- Increasing occurrence of extreme weather events, such as drought or flooding
- Habitat loss

The most significant man-made GHGs are carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). Carbon dioxide is the most common GHG, but not the most environmentally damaging. Methane and nitrous oxide have 25 and 298 times,[5] respectively, the Global Warming Potential (GWP) of CO_2. This means that these two gases have a much greater environmental impact per molecule of gas than CO_2. Greenhouse gas emissions data are usually normalized to CO_2-equivalents.[6]

How Does Agriculture Contribute to Climate Change?

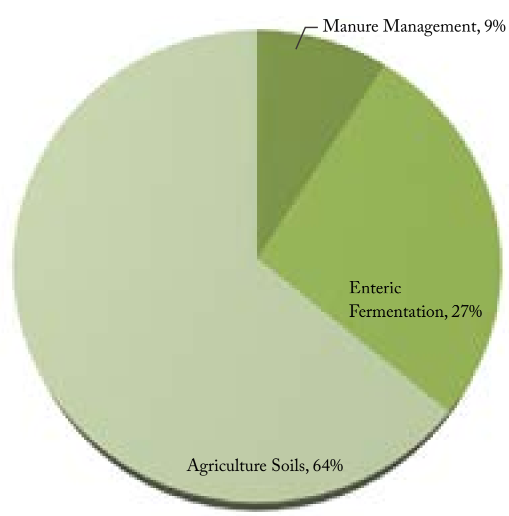
Farming activities such as manure storage, use of nitrogen fertilizers, and ruminant enteric fermentation (i.e. livestock burps), account for one-third of Manitoba's total greenhouse gas emissions. This is about equal to the contribution from burning fossil fuels for transportation. Although carbon dioxide (CO_2) is the primary gas emitted by fossil fuel combustion, the main greenhouse gases (GHG) from agriculture are nitrous oxide (N_20) and methane (CH_4).[7 8]

FIGURE 1: MANITOBA GHG EMISSIONS



In Manitoba, enteric fermentation of ruminant livestock (sheep, goat, and cow burps) emits about 27 percent of the provincial agricultural GHG emissions, mostly in the form of methane (CH_4). Anaerobic (without oxygen) decomposition of organic matter in wet soils and riparian zones, as well as manure storage, also contributes CH_4 in lesser amounts. Manure storage and management contributes both nitrous oxide (N_2O) and CO_2 at about 9 percent.[9]

FIGURE 2: MANITOBA AGRICULTURAL GHG EMISSIONS



Nitrous oxide is created by the denitrification (anaerobic microbial respiration in wet soils) of synthetic fertilizers and soil nitrogen, as well as from the nitrification of ammonium nitrate. Together these add up to about 64 percent of Manitoba's agriculturally-produced gases.

With the proper techniques and crop production practices, farmers have the potential to improve their economic and production efficiency, and reduce the amount of GHGs going into the atmosphere.

Table 1 gives a handy breakdown of greenhouse gases and some of the ways that agricultural practices contribute them. Home heating and farm machinery are still considered sources of CO_2 but are categorized separately from agricultural emissions in Manitoba GHG statistics.

TABLE 1: GHG SOURCES FROM AGRICULTURE

GREENHOUSE GAS	GLOBAL WARMING POTENTIAL	AGRICULTURAL SOURCE	CAUSES
Carbon dioxide (CO_2)	1:1 (CO_2 equivalent)	• Soils • Fossil fuel combustion	• Tillage, which accelerates organic matter decomposition • Clearing woodlots and soil drainage • Operating farm machinery • Heating farm buildings • Crop residue burning
Methane (CH_4)	21:1 (21 times more potent than CO_2)	• Ruminant livestock (the major source) • Manure • Soils	• Digestion of feeds by ruminants • Decomposition of manure during storage and application • Methane production by bacteria in poorly drained soils
Nitrous oxide (N_2O)	310:1 (310 times more potent than CO_2)	• Manure storage • Nitrification (oxidation of ammonia) • Denitrification (conversion of plant-available nitrate-nitrogen to gases) in the soil	• Saturated soil conditions with warm soil temperatures and the presence of carbon • Production of N_2O during manure storage • Immediate loss to atmosphere shortly after fertilizer application • Use of excess amounts of nitrogen fertilizers • No or delayed incorporation of manure

Source: Ontario Ministry of Agriculture, Food and Rural Affairs
100-year Global Warming Potential (GWP)

What Changes are Predicted for Manitoba?

As every farmer knows, it's difficult to predict weather for any given day. So how can scientists possibly predict climate change?

Climate and weather are two very different things. Weather is the specific condition of the atmosphere at a particular place and time. Climate, in contrast, is much less specific. It refers to weather patterns and probabilities averaged over a long period.

Manitoba's central location in North American, combined with its northerly latitude, means that climate change affects are likely to be felt sooner and more severely than in other parts of the world. [10]

Predicted changes for Manitoba's agricultural regions over the next century include the following: [11]

- Not much change in average annual precipitation in Manitoba's south-west
- Slightly more annual average precipitation in Manitoba's far north-east
- A shift in when precipitation occurs - slightly more in winter and less in summer
- More extreme weather, including droughts, heat waves, heavy precipitation events and flooding
- Fewer extreme cold spells
- More intense winter storms
- More winter precipitation falling as rain and freezing rain rather than snow

How Will Climate Change Affect Manitoba Livestock Production?

A changed climate will significantly impact agriculture in Manitoba. Higher levels of carbon dioxide (CO_2), changing rain patterns, higher temperatures and greater occurrence of extreme weather events will all modify livestock production in Manitoba.

Climate change is in the forecast however, detailed predictions about how livestock production will be affected are unclear. Higher temperatures may increase heat stress for animals and the lack of precipitation will most likely limit access to good quality water. Changes to temperature and precipitation will most likely lower feed quality, adding to animal stress. The diseases and insect pests found in Manitoba may also change, negatively affecting animals.[12] Generally, climate change models predict an uncertain future for agriculture in Manitoba, with potential benefits most likely being offset by major drawbacks.[13]

The following sections will help clarify the potential benefits and drawbacks of climate change on livestock production in Manitoba.

HEAT STRESS

As seasonal temperatures rise with the changing climate, livestock will be more vulnerable to heat stress during the warmest months.[14] Animals tend to eat less when under heat stress, resulting in less weight gain and decreased performance and reproduction.[15] Heat stress models have predicted that by 2040 in the central US, swine may take 1.5 to 3.7 days longer to reach slaughter weight. In cattle, it could take 2.8 to 4.8 days longer, and milk production could be reduced up to 2.9 percent.[16] Hogs and poultry are especially susceptible to heat stress because they have no sweat glands. Increased demand for water and barn cooling systems may result.[17] Stressed animals also have a weaker immune system, making them more susceptible to diseases.[18]

However, because winters are predicted be less extreme, over-wintering cattle will probably face a less harsh environment, and will most likely gain more weight over the winter.[19] In an effort to maintain optimum levels of animal production, climate change may result in some livestock producers selecting breeds that are genetically adapted to the current climatic conditions.[20]

INSECTS AND DISEASE

The exact impacts of climate change on insects and pathogens are somewhat uncertain; some changes may be favourable, while others may be negative.

Warmer, longer growing seasons will most likely increase insect life cycles with the early onset of spring.[21] Climate change may also increase the transfer potential of diseases and infections between animals and possibly humans.[22] Almost certainly, climate change will enhance insect development rates, create new diseases, and alter animal husbandry techniques. Changes to livestock feeding and rearing practices will be necessary. The increased use of medication on sick animals may potentially lead to more chemicals in food.[23]

ANIMAL HUSBANDRY

Climate-induced changes will influence how livestock are reared. Certain species or breeds of animals may need to spend more time inside to avoid heat exposure. A similar situation may occur if there is limited access to adequate amounts of water. Confined spaces and overcrowding indoors could lead to faster disease transmission. The overcrowding of livestock at watering sources could result in animal stress, greater pathogen output in one area of the paddock and reduced water quality.[24] It will become increasingly important to ensure livestock have sufficient access to shade, to minimize pen overcrowding, and to provide indoor ventilation to limit heat stress.[25]

WATER RESOURCES

Although overall growing season precipitation on the Prairies is expected to decrease, precipitation is anticipated to occur in intense events.[26] Warmer temperatures combined with longer dry spells between rain events will likely increase drought severity and frequency.[27] Water-stressed areas will expand to include drier areas of the province where seasonal lack of water is already a concern.[28]

Lack of water will place increased demands on available water resources affecting water quality and quantity on a seasonal basis.[29] Mild winters and limited snowfall may decrease water availability. Water stress may lower water basin and lake levels, decreasing water quality with the possibility of increasing toxin and pathogen concentrations in water supplies.[30] Algal blooms may also become a problem affecting water quality.[31] Water storage systems will become important for access to clean drinking sources.

Recommendations on How to Reduce Greenhouse Gas Emissions from Livestock Production

Because some degree of climate change is now inevitable, sustainable agricultural practices are critical to climate change adaptation. A focus needs to be on the implementation of farming practices that limit or reduce direct and indirect greenhouse gas (GHG) emissions from livestock production. Modifications to current practices will be necessary with environmental sustainability as the top priority.

Livestock production contributes 27 percent of overall agricultural GHGs in Manitoba[32], making this agriculture sector an important target for climate change adaptation. Livestock produce the largest amount of methane (CH_4) in Manitoba. The gas is produced both directly and indirectly by animals. Animals directly produce emissions in the form of burps, a product of enteric fermentation. Indirect emissions are a result of manure storage practices. Manure storage and spreading also releases nitrous oxide (N_2O), another potent GHG.

Manitoba's agriculture is in a good position to influence GHG emissions[33], because farming practices can be modified to become part of the climate change solution. There are practical on-farm techniques that can be implemented to help reduce GHG emissions from livestock production. Management strategies can include improving pasture and forage quality, using efficient feed rations to lower fermentation losses, following proper manure storage and spreading regulations and enhancing carbon (C) sequestration and storage on pastures. [34]

This section includes suggestions on how you can:

- Maintain or improve your pasture quality,
- Influence digestion and feed use efficiency in livestock,
- Improve manure storage and limit GHGs produced,
- Use trees to enhance soil carbon storage,
- Reduce emissions from farm vehicles and equipment use, and
- Increase the energy efficiency of farm buildings.

HEALTHY GRASSLAND AND PASTURE MANAGEMENT

The key to preventing GHG creation (and ensuring a healthy herd) is to maintaining healthy, high quality pastures. High quality feed, whether in the form of pasture grazing or baled hay, means higher feed efficiency and more nutrients absorbed by the animal. The rate of consumption by cattle is improved with high quality forage, increasing the efficiency of digestion and reducing the amount of time needed to graze. Faster digestion and greater feed use efficiency means less creation of GHG emissions.

Pastures also have numerous indirect benefits to reduce GHG production from animal production. Perennial forages trap atmospheric CO_2 with their extensive roots systems, storing carbon (C) meters below ground.[35] Grasses and alfalfa not only improve the soil by increasing organic C, but are capable of absorbing excess water, lowering the water table and helping to control soil salinity.[36] Reducing soil moisture also limits the risk of N losses by denitrification, cutting down the amount of nitrous oxide (N_2O) creation. Pastures also provide soil cover, protecting against erosion, and maintain or improve water quality.

Here are some keys management techniques to ensure high quality forage, while protecting the land from degradation.

PROMOTE HIGH QUALITY FORAGES & LEGUMES

The type of plants grown will have a big impact on pasture health. A diversity of native, deep-rooted, and productive plant species are needed for good quality pastures. These vigorous plants will ensure adequate vegetative cover to protect against erosion, will be able to handle frequent grazing, and will sequester atmospheric CO_2 to store as C in their roots.[37] Using multi-species crop mixtures, such as alfalfa-brome grass[38], will help the pasture mimic a natural system. A natural ecosystem will be able to use soil nutrients more efficiently and reduce the potential of loss to the environment.[39]

Integrating perennial legume forages, such as clover or alfalfa, into pasture mixes can help improve overall plant and pasture health.[40] The carrying capacity (amount of animals a system can support) of a pasture was increased by 28 percent when alfalfa was grown with the grass stand. When combined with fertilizer, the grazing system was able to support 57 percent more animals.[41] Younger forage stands provide better feed value and tend to have lower CH_4 emissions than more mature stands. Methane emissions were reduced by half when grazing animals had access to high quality feed, when compared to reduced quality pastures.[42] Legumes also help to increase the nitrogen (N) and C content of the soil. Although perennial legumes can help sequester soil C, perennial grasses have been found to store more C than legumes in a pasture setting.[43]

ADOPT ROTATIONAL OR BALE GRAZING

Grazing allows animals to harvest their own feed during the summer months, reducing GHG emissions emitted from fuel use (created when making and using hay bales).[44] Grazing is natural for cattle and helps spread manure around a paddock[45], limiting the CH_4 and CO_2 created by manure storage. Manure nutrient build-up occurs around water troughs and bale feeders when animals are brought feed, increasing likelihood of nutrient loss and GHG creation.

Compared to continuous grazing, where livestock graze uncontrolled in one big paddock, rotational grazing divides a paddock into several small ones, with animals strategically moved every few days between paddocks.[46] Alternating between periods of grazing and rest helps maintain forage health by reducing weed competition and allowing plant recovery. Any excess N left behind in the manure and urine can be utilized by the plants or lost as ammonia or nitrous oxide. Rotational grazing is more efficient and productive because livestock are only in the paddock for a short period of time. Cattle are selective eaters and rotational grazing encourages animals to consume all plant material, preventing under- or over-grazed areas and reducing wastage.[47] Rotational grazing is also environmentally friendly by limiting soil compaction and reducing soil erosion through the presence of continuous ground cover. Benefits for the producer include a longer grazing season because of shorter forage recovery periods, improved animal productivity and better nutrient distribution.[48]

Grazing can be extended into the cold winter months using 'bale grazing'. Bale grazing is similar in concept to rotational grazing. Feed bales are set in the pasture and livestock allowed access to new bales every 2 to 5 days throughout the fall and winter.[49] This grazing technique allows the animals to feed themselves, reduces GHG emissions and distributes nutrients around a paddock.[50] Though this type of grazing does reduce the amount of manure that is concentrated in one area of the pasture, nutrient management is still necessary to remove excess manure from the feeding areas.

Although grazing limits GHG production by lowering fuel consumption, grazed cattle are found to emit more emissions than feedlot cattle. Grains fed to feedlot livestock are digested easier and more efficiently than grass.[51] The downfalls of grazing for the farmer include more active livestock management, such as labour for rotating livestock, paddock set-up planning and bale placement.[52] Despite a few minor disadvantages, almost all cattle farmers, with the exception of feedlot operations, graze their cattle during the summer months. Community pastures are still frequently used during the summer when a farmer does not have enough acres to support his grazing herd.[53]

AVOID OVERGRAZING PASTURES

It is important to avoid overgrazing a pasture. Overgrazing may expose the soil, increasing the risk of soil C mineralization or erosion. Overgrazing occurs when a plant is not given adequate time to re-grow or replenish its root reserves before it is grazed again. Livestock demands should be balanced with the available forage supply, so that enough plant material is left between grazing periods or over winter to keep plants healthy and limit soil erosion. Short grazing phases provide rest periods and allow plants to recover from the stress of grazing and reduce the likelihood of plant death.[54] Removing cattle from pastures in early fall is other way to maintain high quality forage pastures.[55]

FERTILIZE TAME PASTURES

Livestock return between 25 and 60 percent of consumed C to the soil in their feces and urine.[56] When the natural distribution of nutrients is not enough to maintain pasture health, it may be necessary for farmers to supplement with fertilizer. Pasture fertilization can be done with synthetic fertilizers, manure or compost. These nutrient forms encourage vegetative growth and improve pasture productivity. Fertilizers also encourage C sequestration in the soil. Using legumes in a pasture mixture is a natural method of improving feed quality and increasing soil N and C levels.[57]

Barry Lowes: Increased Legume Use

Barry Lowes loves the way his pasture grass grows with a healthy mix of legumes added to it. "You get good growth in spring. You get good growth late into the summer. And you don't have to use commercial fertilizer because the legumes supply the nitrogen for the grass," he marvels.

In the last four years, each time he's sown down a pasture he's put alfalfa into it. Usually about 15 percent of the grass mix he seeds is alfalfa, working out to about 25 percent alfalfa actually growing in the pasture.

Barry runs an 800 cow-calf operation on 6000 acres near McAuley, Manitoba, and the majority of that is pasture.

He knows legumes are good for pasture health and good for the environment. But he also suspects it's doing his cows good. "I would say it probably helps quite a bit in terms of weight gain, because there's higher protein in legumes."

Brian Harper: Intensive Rotational Grazing

It may seem counter-intuitive that increasing the density of cows on a pasture can lead to healthier pastures and environmental benefits, but that's just what Brian Harper has learned in his Brandon cow-calf operation.

Over the last 10 years he has gradually divided his 360 acres of pasture into 8–15-acre paddocks. He puts his cows onto each paddock for short intensive amounts of grazing—the length dependent on stock density.

"I usually try to be out of a paddock within five days," he explains. "And if it's especially high density we're out after a day. We've only really gone that intensive in the last couple of years and we're seeing the benefits."

He says new growth on the pasture is noticeably abundant. Wean weights on his animals stay the same, but he's carrying more animals per acre. "As your carrying capacity goes up you get better return per acre. We're just starting to get into that. It definitely pays off," he says.

Harper wasn't thinking about environmental benefits when he adopted intensive rotational grazing. But he does now. "My new philosophy is to take care of the soil and it will take care of the calves."

Livestock Feed (Nutrient) Management

Sustainable livestock management does not only revolve around the proper management of grassland and pasture. Improving animal nutrition and feed efficiency will also help to reduce methane (CH_4) emissions. Advancing the production efficiency of livestock feeds should lower feed costs, while reducing the amount of biological waste and enteric fermentation produced by cattle and hogs. Improving animal nutrition and feed efficiency will also cut greenhouse gas emissions.

The following nutrient management suggestions relate specifically to lowering enteric fermentation and subsequent greenhouse gas (GHG) emissions in cattle and swine. Enteric fermentation is the microbial breakdown of feed components in ruminants, causing CH_4 production in the intestines.[58] The amount of gas produced by animals can be strongly influenced by the quality of foodstuffs ingested. Up to 12 percent of feed energy can be converted into CH_4 gas when low quality feed is used in rations.[59]

A better quality feed, such as grain or feed with low fibre (fresh grass, alfalfa), will digest easier, increase feed efficiency and lower CH_4 and waste production.[60] Research in Manitoba found that there were 50 percent less CH_4 emissions from grazing steers with access to high quality pastures.[61] Low fibre diets were also shown to lower CH_4 emissions in a swine dietary study in Denmark.[62] The loss of feed energy into excrement or GHGs represents lost profit for farmers since the energy is not being converted into animal protein.

Nutrient management techniques in cattle and hogs can include:

- Improving production efficiency,
- Improving feed efficiency,
- Feeding a balanced diet,
- Aiding digestion in hogs.

IMPROVING PRODUCTION EFFICIENCY

Any practice that reduces the number of livestock needed to meet demand will reduce overall GHG emissions. Such steps include accelerated growth, improved reproduction, selective breeding[63] and improved herd health. Improving animal performance and genetics can lower CH_4 emissions from dairy and beef cattle by 3 percent. Emissions per pound live weight gain are reduced as production efficiencies increase.[64]

Allowing animals to graze and harvest their own forage throughout the year can also reduce production costs and GHG emissions. Options include season-long grazing, swath grazing and bale grazing.

IMPROVING FEED EFFICIENCY

The easiest way to improve livestock feed efficiency is to avoid overfeeding animals. Feeding excessive nutrients results in more nutrients excreted in manure. In cattle, excessive nutrient intake increases rumen CH_4 emissions and wastes money on additional feed. Formulating diets based on the physical requirements of the animal will prevent overfeeding and ensure the animal is accessing the proper amounts of vitamins, minerals, protein and fibre. Animal nutritionists can analyze the nutrient content of feed and formulate diets with an ideal mix of protein, minerals and other essential nutrients.[65]

Lowering GHG emissions due to poor feed efficiency can also be done by grinding or pelleting feed to lower the amount of digestion performed by the animal. Research shows that between 20 and 40 percent of total CH_4 emissions were reduced when feed size was decreased. Maintaining proper animal health will also ensure that the animal is prime condition for digesting and absorbing nutrients and reduce likelihood of feed energy loss.[66]

Adding fats or vegetable oils to grain diets can improve feed efficiency by reducing the amount of feed that is fermented. However, no more than 6 percent of a daily ration can be fat, otherwise the digestion of fibre is compromised. A study in Alberta found that CH_4 emissions were reduced by 33 percent when 4 percent canola oil was added to a feedlot diet.[67]

Improving feed efficiencies in poultry rations can be controlled with enzymes to enhance nutrient retention and lower nutrient excretion. Enzymes such as amylase and B-glucanase have been found to lower methane emissions in studies.[68]

FEEDING A BALANCED DIET OF HIGH QUALITY FEEDS

Feeding animals a balanced diet of high quality feeds is important for both livestock health and feed efficiency. Farmers should make sure that animals are fed a balanced ration with a good mixture of protein, energy, minerals and vitamins. The type and quantity of feed stuffs in a diet will vary depending on species, breed, body weight, production stage, age and reproductive stage.[69]

High fibre diet research showed an improvement in the well-being of animals and digestion and a reduction of stomach ulcers. However, too much dietary fibre can lead to reduced available energy for the animal if no high energy ingredients (animal fat or vegetable oil) are included in the diet. High fibre diets also mean high enteric fermentation and increased methane (CH_4) emissions.[70]

Formulating diets based on animal requirement and using a variety of feedstuffs is the best way to lower CH_4 emissions without harming livestock performance. For pigs, diets rich in fat, starch and protein with low fibre are best for lowering CH_4 emissions and excrement. For many cattle producers, testing winter rations for nutrient levels is hard, and many farmers feed whatever is available. Ensuring a varied winter diet of energy, protein, minerals and vitamins for beef cattle will maintain animal health and could cut GHG emissions by 15 percent.[71]

Low quality feeds will produce elevated levels of methane. Limiting straw intake and increasing higher quality feeds in rations will reduce methane emissions. For instance, straw intake could be lowered from 24 pounds (lbs) to 18 lbs and an additional 1 lb of barley added to an 8 lb/day barley ration. A small addition of one pound higher quality feed is all that is needed to replace the lost straw. The daily ration of 18 lbs straw and 9 lbs barley would reduce CH_4 emissions without compromising nutrition. While there could be some increase in feed costs, the added benefit of energy and better utilization could outweigh the added cost of grain.[72]

AGING DIGESTION IN SWINE

Pigs struggle to digest phytate in cereal grains. Adding phytase to the feed can help pigs break down the phytate. Not only does adding phytase reduce phosphorus (P) excretion, it also increases feed use efficiency and decreases nitrogen (N) output in manure. A study at the University of Manitoba found that completely removing inorganic P from pig diets while supplementing phytase improved digestibility and reduced excretion losses.[73]

REDUCE DIETARY PROTEIN IN SWINE RATIONS

Although pig diets are highly formulated to supply nutrient at the specific levels needed by the animal, actual nutrient requirements vary between individual pigs. Rations usually oversupply protein, causing an excess of N and C excretion. Reducing protein levels and including a proper balance of amino acids in the diet is a cost-effective means to reduce GHG emissions from hogs. There will be little impact on performance and little or no cost added to the farmer.[74]

Nutrient (Manure) Management

Nutrient management is particularly important in Manitoba due to the large expansion of the hog industry over the last few decades. Although manure is an excellent source for plant nutrients, the expansion to more than 8 million hogs in 2010 has resulted in the challenge of too much manure and not enough land-base for spreading.[75] The large amount of manure created and the resulting nitrous oxide (N_2O) should make manure management a priority when trying to reduce greenhouse gas (GHG) emissions from farms. Approximately 9 percent of Manitoba's agricultural GHG emissions are created due to manure storage and management.[76]

Major emissions from manure come in the form of methane (CH_4) from the anaerobic decomposition of manure during storage, and N_2O formed during storage and application. The creation of these gases is influenced by a variety of factors: temperature, oxygen level, moisture or amount of nutrients. In turn, these factors are affected by manure type, animal diet, the type of manure storage and handling, and manure application techniques.[77] To help reduce GHG creation and work with large amounts of excess manure, it is important that manure management in the province concentrates on disposing manure in an environmentally and economically friendly manner.

Objectives for manure management should focus on maintaining or improving local water and air quality by limiting unpleasant odors, reducing nitrogen (N) and phosphorus (P) concentrations in manure and efficiently spreading manure. Although many management technologies exist, not all are realistic or cheap enough for farmers to implement. Different nutrient management strategies will work better for different farms.

Available management technologies include[78]:

- Manure handling and storage systems
- Testing manure
- Proper manure application
- Composting manure
- Anaerobic digesters

A great resource to understanding everything about manure are the *Tri-Provincial Manure Application and Use Guidelines*, available on the internet.[79]

MANURE HANDLING SYSTEMS

Emissions from manure handling systems are released when favourable conditions are met for gas creation. Warm, wet conditions tend to create higher amounts of both CH_4 and N_2O. To reduce greenhouse emissions when handling manure ensure that manure is not left in the barn environment for extended periods of time. Manure kept in a barn will tend to be warmer than manure stored outdoors and will produce more methane. Keeping barns clean and dry will help lower the loss of ammonia, reducing N_2O production.[80] Barn scraper systems can provide regular manure removal from the barn and store waste in proper storage areas. Solid manure management systems, where poultry and livestock are housed on dry bedded manure packs of straw or sawdust were found to have lower CH_4 emissions when compared to liquid or slurry handling systems.[81]

MANURE STORAGE SYSTEMS

Manure storage is one of the main areas where a farmer can control how many nutrients remain in or are lost from the manure. It is in the best interest of the farmer to focus on what method of storage system is best for the farm and type of livestock. Certain manure storage systems are more environmentally friendly than others, but may not be the best fit for the type of livestock the farmer is raising. The following practices are encouraged.

- Avoid liquid or slurry handling systems. Methane production takes place when manure decomposes in the absence of oxygen (anaerobic conditions). Therefore, CH_4 production is higher in liquid manure.[82]
- Use manure storage covers – roofs for solid, covered tanks for liquid – to trap manure gases. In liquid systems, covers may reduce methane emissions by up to 95 percent.[83] Covers also have the added benefit of controlling odour. Odour means that gas and money is being lost.
- Avoid disturbing liquid manures in lagoons. Aerating lagoons increases oxygen and can eliminate CH_4 emissions, but increase N_2O emissions.[84]
- Avoid straw covers. Using a straw cover may be an effective odour barrier, but when the straw sinks into the liquid manure it adds C, which can substantially increase CH_4 production.[85]
- Avoid stockpiling manure for long periods. Stockpiling can lead to anaerobic decomposition, resulting in both CH_4 and N_2O emissions.[86]

MANURE TESTING

Manure testing should be done routinely to determine the amount of plant-available nutrients, particularly N and P. Current legislation states that manure application be based on soil phosphorus levels. When soil Olsen-P levels are between 60 and 180 ppm, manure can be applied no more than five times the annual crop removal rate of phosphate (P_2O_5). Additionally, nitrate-N levels can be no more than 140 lbs per acre (157.1 kg/ha) of soil class 1 to 3.[87] Because both nutrient levels are important in terms of the amount of applied manure, manure testing is a cost-effective farming practice.

PROPER MANURE APPLICATION

Timing is everything when it comes to properly applying manure to fields. To ensure that crops receive the most nutrients possible, manure should be applied when crops will use it. If manure is not taken up by plants, losses will occur through greenhouse emissions, leaching or by surface run-off.[88] The following strategies can help improve manure nutrient use by crops and result in less GHG emissions.

- Apply manure to fields as soon as possible after removal from storage. Storing manure for long periods can encourage anaerobic decomposition and lead to increased CH_4 emissions.
- Inject or incorporate manure as soon as possible after application to reduce N loss.
- Avoid applying manure in areas where soil can become saturated, as this leads to anaerobic decomposition and increased N_2O emissions.
- Eliminate winter applications to reduce the risk of run-off, and reduce the amount of nitrate-N in soils during spring snowmelt when risk of N_2O loss is greatest.[89]
- Spread manure uniformly around pasture to reduce N losses.
- Move winter feeding and bedding areas around pastures so manure is more evenly distributed. This will result in better decomposition.
- Station winter feeding areas on level ground away from riparian areas. This will reduce the risk of manure run-off entering surface watercourses.[90]

TABLE 2: MANURE HANDLING & STORAGE AND GHG REDUCTION

BEST MANAGEMENT PRACTICE	RATIONALE
MANURE HANDLING • Contain all runoff • Remove manure from barn floor promptly	• Reduces NH_3 loss, retains nutrients for crops, and prevents water pollution
MANURE STORAGE • Use covered storage (roofs for solid; covered tanks for liquid) • Use bottom-filling tanks • Maintain low temperatures with below-ground tanks, and reduce summer storage with late-summer application • Keep poultry manure dry	• Prevents direct losses of N_2O and CH_4 to the air • Reduces loss of CH_4 to air • Limits the biological activities that produce CH_4 and N_2O • Produces fewer GHGs in dry form

Source: Ontario Ministry of Agriculture, Food and Rural Affairs
100-year Global Warming Potential (GWP)

ELIMINATE WINTER SPREADING

Winter manure application should be eliminated to prevent manure runoff at spring-thaw and to reduce spring-thaw N_2O emissions. Effective November 10, 2013, the spreading of livestock manure between November 10 and April 10 in Manitoba will be prohibited under The Environment Act: Livestock Manure and Mortalities Management Regulation, unless otherwise noted.[91] Applying manure after April 10 encourages farmers to apply manure at a time when their crops are just beginning to grow. The developing crop uses the nutrients as they become plant-available, minimizing the risk of loss to the environment.[92] Should moving manure during the winter be necessary, it is recommended that the manure be stock-piled in the field and spread following spring-melt.

COMPOSTING MANURE

Composting breaks manure into a more stable organic form, slowly releasing nutrients over time. Compost is rich in C, free from most pathogens and weed seeds, and improves soil nutrient status. Because compost reduces the amount of synthetic fertilizer needed on fields, composting manure helps lower net GHG emissions from livestock systems. The aerobic (with air) method of decomposing manure is also thought to lower CH_4 and N_2O creation.[93] However, more research is needed to determine the exact benefit of composting manure net GHG reduction.

CONSIDER ANAEROBIC DIGESTERS

Anaerobic digestion is the oxygen-free process through which manure is broken down by microbes. The microbes produce a mix of CH_4 and CO_2, called biogas. This biogas can be cleaned and used as a natural gas replacement, burned as fuel or used by a generator to produce electricity or heat.[94] The remaining organic material left after the digestion process has some nutritional value, very little odor and can be applied to fields as fertilizer.

Current anaerobic digesters on the market are much too expensive for most farmers to own. Research continues at the University of Manitoba to determine the benefits of digesters on manure management.[95] This digestion system works better for dairy and cattle manure, as poultry and swine manure presents more of a challenge due to their higher nitrogen levels.[96] Anaerobic digestion is known to reduce pathogens, odour and weed seeds in the digested manure, reduce GHG emissions and provides an alternative fuel source.[97] Digesters may be the technology of the future to lower farm fuel consumption or provide alternative energy creation.

Larry Schweitzer: Composting Manure

At the Hamiota Feedlot, home to upwards of 13,000 head of beef feeder cattle, manure is in plentiful supply. In summer and winter, when that manure can't be spread on fields, composting becomes the best way to store it.

Larry Schweitzer says they pile the manure in pens and roll it over two or three times a summer, based on the manure's temperature. "It's pretty much compost by the time we put it on the field," he says. "It cuts down on the volume we have to take out on the field too, meaning we're spending less on diesel fuel."

Sieg Peters: Manure Injection

As far as Sieg Peters is concerned, manure is a precious commodity. “We have a lot of land, so we want to get as much coverage out of our manure as possible,” he says. “We need the nitrogen so there’s no point losing half of it. That’s why we directly inject it into the ground.”

Sieg, who farms with his brother and their sons near Steinbach, was never that impressed with sprinkler systems. There was too much nitrogen loss. And the odours and view weren’t pleasant. So seven years ago he started hiring a custom applicator to come in and inject the manure directly—some of which is pumped through hoses from his storage lagoon three to four miles away.

As part of a large farm—they crop about 3000 acres, and have a 12,000 feeder hog operation—they use all the manure they produce. That means they’re reluctant to see any go to waste.

But the environment ranks high on their priorities too. “We know if we put it in the ground it’s less likely to leach off, to run off the field. That’s a huge consideration.”

Use Trees to Make Your Farm More Climate- Friendly

Trees can be extremely valuable resources to farmers, although over the last couple decades many trees have been torn down on the Prairies to enlarge fields.

When trees are grown together with crops and livestock, as an integrated production unit, numerous benefits can be observed. Trees have been shown to indirectly increase crop yields, improve soil and water quality, better protect livestock, reduce greenhouse gas emissions (GHGs) and increase carbon (C) sequestration.[98] Trees, shrubs, or bushes act as natural buffers, filtering the air and water, reducing blowing wind and can even minimize the spread of airborn crop diseases and pests.[99] These plants can be easily incorporated onto your farm and are aesthetically pleasing as well.

PLANT SHELTERBELTS

Shelterbelts consist of one or more rows of strategically planted trees and/or bushes. Traditionally, shelterbelts were found around farmyards to shelter farm buildings and livestock, but they are also now used along highways or between fields. They reduce wind, limit soil erosion and nutrient loss, control and trap blowing snow and conserve water.[100] For livestock, shelterbelts reduce high wind speeds, keeping animals warmer during winter months. Warmer animals mean lower winter feed requirements, faster growth rates and increased reproductive potential.[101] Shelterbelts also help to contain barnyard odours.

Shelterbelts can also help fight climate change because they remove carbon dioxide (CO_2) from the atmosphere and store the GHG as C. Studies at the Agroforestry Development Centre, formerly known as the Prairie Farm Rehabilitation Administration (PFRA) Shelterbelt Centre, show that the leaves and branches of a mature poplar tree in a shelterbelt can store about 970 kg of CO_2.[102] The leaves and branches alone can save the equivalent amount of a car driving approximately 4600 kilometres![103] Tree roots are thought to store 50 to 75 percent more C than that stored above ground.[104]

The potential drawbacks of shelterbelts are increased shade and competition with crops for water and nutrients.[105] Wildlife may also find a home in the trees, which can be an unwanted nuisance.

PLANT RIPARIAN BUFFERS

Riparian buffers consist of trees, shrubs or grasses planted between cultivated crop land and a waterway, such as river, pond, or dug-out. The main benefits of these buffers are to filter surface run-off before it enters the water, to protect water edges from erosion, and to sequester C.[106] Run-off may contain sediments, nutrients, and/or pesticides, which can be damaging to the water quality and the animals that live in waterways.[107]

Livestock should be closely monitored or restricted from access to riparian areas so that adequate vegetation can grow and the area remains stabilized against erosion. Without proper riparian management, natural nutrient and sediment filtering will not take place. Improper sediment filtering encourages the eutrophication (algal blooms) and sedimentation of local waterways.[108]

CONSIDER SILVOPASTURE OR ALLEY CROPPING

Silvopasture combines trees with pastures, fields and livestock production in an effort to reduce heat and cold stress on animals.[109] Less stress enhances animal health and results in higher feed conversion rates and weight gain.[110] Properly managed silvopasture systems can also lead to an increase in net C storage.[111]

Alley cropping is another form of tree production that mixes trees with agricultural crops. The trees are planted in widely-spaced rows with agricultural crops in alleys between the trees. The shelterbelts minimize soil erosion and nutrient loss, trap snow, and create warmer microclimates for both crops and livestock.[112]

DIVERSIFY INTO AGRO WOODLOTS

Growing trees is a fairly recent farming practice that provides a timber crop in as little as 20 years. Fast growing wood crops, such as hybrid poplars, provide environmental benefits to the land, increasing soil organic matter and providing atmospheric oxygen. Trees have high rates of nutrient uptake and can store large amounts of C over rotation lengths as short as 15 years. The Agro Woodlot Program of Manitoba recommends growing a combination of fast and slow growing trees to provide monetary benefits over a longer time period.[113] Biomass from the trees can be used as timber or as an alternative fuel (bioenergy).

Michelle McMechan: Shelterbelts

Michelle and Tim McMechan's farm lies on the western edge of the Lyleton Shelterbelt in southern Manitoba. Over two million trees were planted in the area from the 1930s to '50s as part of a PFRA program. The McMechans have a full 20 miles of multi-rowed shelterbelts on their 3000 acres—some from the original shelterbelt program and others they planted themselves in the 1980s.

"In the winter our trees hold the snow on the land, thereby increasing soil moisture in the spring. In the summer, the shelter means less moisture loss from evaporation and more protection for emerging crops," explains Michelle.

"Our livestock benefit too. Although the trees are fenced off from the livestock, they can always find shelter from a storm. Tim will feed them on the sheltered side, causing less stress for the cows."

And shelterbelts near the house mean fuel savings in winter. Michelle can go from wearing a t-shirt on her sheltered yard to needing a good jacket outside the shelterbelts. "I know it's making a difference on our fuel bills."

Cut Greenhouse Gas Emissions from Vehicles and Equipment

Farm practices that reduce the need for equipment and vehicles without productivity losses, have benefits for both farm budgets and the environment. Rationalizing the use of vehicles and equipment and making fuel-efficient choices will reduce GHGs and improve profits. Enhancing the energy efficiency of farm homes and buildings can also reduce demand for fossil fuels. Some suggestions for alternative energy management are outlined below.

FUEL-SAVING STRATEGIES

Adopting fuel-saving strategies can be a huge step towards lowering GHG emissions from farms. In 2009, almost 5 percent of all GHGs created in Canada were from off-road gasoline and diesel transportation.[114] In 2003, Manitoba passed the Biofuels Act, mandating the availability of at least 8.5 percent of gasoline sold to be an ethanol blend. Similar legislation came into effect for biodiesel in 2009, where 2 percent of all diesel fuel must be biodiesel.[115] Because agriculture is highly dependent on fuel consumption, using biofuels are already helping to reduce GHG emissions created by the province. The Biofuel Acts are thought to have reduced GHG emissions by the equivalent of taking more than 63,000 vehicles off the road every year.[116]

Regular machinery maintenance will ensure that equipment is operating at peak efficiency. Correct tire pressure can use up to 20 percent less fuel and improve productivity by more than 5 percent. Keeping fuel and air systems clean, and selectively using the throttle during farm operations can also help with fuel efficiency. Limiting idling times will save fuel and cut emissions.

BIOGAS USE

Biogas is the use of organic wastes, such as manure, to produce gas for generating heat and power. On-farm biogas production offers the benefits of nutrient management, odour control and pathogen reduction. However current biogas creation technologies are expensive and not a practical alternative for most farmers. Research is being undertaken by the University of Manitoba to further education and implementation opportunities in the province.[117]

ENERGY EFFICIENCY FOR FARM BUILDINGS

Energy efficiency in farm homes, work sheds or barns can reduce energy demands, saving money and lowering carbon dioxide emissions. Farm yards and livestock holding facilities can easily be protected from cold winter winds by shelterbelts or windbreaks, reducing heating costs by as much as 25 percent.[118] Alternate energy sources, such as geothermal heat, solar, wind, biogas, or waste heat can also be used to heat farm buildings and lower heating demands.

John Popp: Cutting Vehicle Emissions

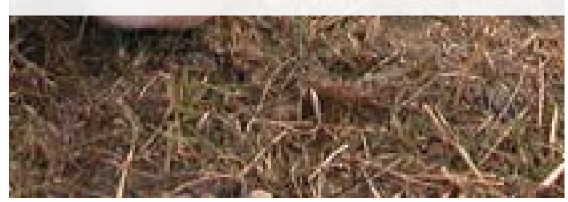
In years past, John Popp would pile his bales for winter grazing into one huge tower and then slowly divvy out the bales as his 200 cows required. That meant firing up the tractor on a regular basis and burning costly fossil fuels.

Now he uses a simple bale grazing system that cuts fuel use substantially on his Erickson farm—and reduces greenhouse gas emissions while he's at it.

John sets out enough bales for four months of winter feeding at the start of winter. Then every four days he moves the wires on his pasture to open up a new feeding area for his cows.

"I have not started a tractor to feed my cows all winter," he says. "I'm pretty confident I've saved $4000 in terms of equipment use."

While he hasn't calculated how much he's reduced vehicle emissions, he's confident he has put 100 fewer hours on his tractor this winter than in past winters.



Information and Opportunities

For more information on climate change and sustainable farming practices in Manitoba, please check out the following Web sites:

GOVERNMENT OF MANITOBA WEB SITES

Environmental Farm Plan
http://www.gov.mb.ca/agriculture/soilwater/farmplan/index.html
Environmental farm planning is a voluntary, self-assessment process designed to help farm managers identify the environmental strengths and weaknesses of their operations.

Growing Forward
http://www.gov.mb.ca/agriculture/growingforward/index.html
Agreement among federal-provincial-territorial governments to build an innovative and profitable agriculture and agri-food sector.

Manitoba Agriculture, Food and Rural Initiatives
http://www.gov.mb.ca/agriculture/index.html
For all things agricultural in Manitoba

Manitoba Agricultural Sustainability Initiative
http://www.gov.mb.ca/agriculture/research/asi/index.html
The program provides funding to Manitoba producer groups and provincial commodity organizations to carry out sustainable agriculture demonstration or technology transfer projects throughout the province.

Manitoba Conservation – Livestock Manure and Mortalities Management Regulation
http://www.gov.mb.ca/conservation/envprograms/livestock/pdf/livestock_manure_and_mortality_management_mr04298.pdf

Tomorrow Now – Manitoba's Green Plan
http://gov.mb.ca/conservation/tomorrownowgreenplan/pdf/tomorrowNowBook.pdf

OTHER USEFUL SITES

Acres USA
http://www.acresusa.com/magazines/magazine.htm

Agriculture and the Environment
http://www4.agr.gc.ca/AAFC-AAC/display-afficher.do?id=1166717071446&lang=eng
Agriculture and Agri-Food Canada's guide to farming and climate change.

Agriculture in the Classroom
http://www.aitc.ca/

Agroforestry Development Centre
http://www4.agr.gc.ca/AAFC-AAC/display-afficher.do?id=1186517615847&lang=eng
Shelterbelt research, programs and numerous resources.

Canadian Cattlemen's Association
http://www.cattle.ca/cattle-producers-and-the-environment
The Canadian Cattlemen's Association guide to greenhouse gases.

Carbon Farming: Workshops in Regenerative Agriculture
http://carbonfarmingcourse.com/

C-CIARN Agriculture
http://www.c-ciarn.uoguelph.ca
Clearinghouse of current information on climate change risks and adaptation for the Canadian agri-food sector.

Climate Change and Agriculture
http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/cl9706
Alberta's guide to farming and climate change.

Climate Change Connection
http://www.climatechangeconnection.org/
Public education and outreach on climate change issues for Manitoba.

Climate and Farming
http://www.climateandfarming.org/
Resource materials to help farmers make practical and profitable responses to climate changes.

Farm Credit Canada
http://www.fcc-fac.ca/en/

Green Action Centre
http://www.greenactioncentre.ca/
Information on the principles of composting.

Holistic Management International
http://www.holisticmanagement.org/

Keystone Agricultural Producers
http://www.kap.mb.ca/

Manitoba Alternative Food Research Alliance
http://www.localandjust.ca/

Manitoba Agricultural Services Corporation
http://www.masc.mb.ca/masc.nsf/index.html

Manitoba Conservation Districts Association
http://www.mcda.ca/

Manitoba Hydro – PowerSmart for Farms
http://www.hydro.mb.ca/your_business/farm/index.shtml
Information on energy efficiency for farm owners.

Manitoba Farm Mentorship
http://organicfoodcouncil.org/manitoba-farm-mentorship/55-manitoba-farm-mentorship.html

Manitoba Zero Tillage Research Association
http://mztra.ca/
Farmer-directed research information on zero tillage production systems.

National Centre for Livestock and the Environment
http://www.umanitoba.ca/afs/ncle/index.html
Research furthering the economic and environmental sustainability of integrated livestock and crop production systems

Organic Agriculture Centre of Canada
http://www.organicagcentre.ca/

PAMI (Prairie Agricultural Machinery Institute)
http://www.pami.ca
An applied research, development, and testing organization serving manufacturers and farmers.

Rural Development Institute
http://www.brandonu.ca/rdi/

Soil Conservation Council of Manitoba
http://www.soilcc.ca/
Wide-ranging producer information from the Greenhouse Gas Mitigation Program for Canadian agriculture, as well as soil conservation knowledge.

Soil Food Web
http://www.soilfoodweb.ca/

The National Farmers Union
http://www.nfu.ca/

The Stockman Grass Farmer
http://www.stockmangrassfarmer.com/index.php

University of Manitoba – Natural Systems Agriculture
http://umanitoba.ca/outreach/naturalagriculture/
Info on cropping systems based on processes found in nature-specifically the natural grassland ecosystem of prairie Canada

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