cow/calf operations

AND GREENHOUSE GASES

Alberta

Disclaimer

The primary purpose of this Alberta Agriculture and Food publication entitled *Cow/Calf Operations and Greenhouse Gases* is to assist producers in implementing greenhouse gas management practices.

It is important to be aware that while the authors have taken every effort to ensure the accuracy and completeness of this document, it should not be considered the final word on the area of practices it covers. Producers should seek the advice of appropriate professionals and experts as the facts of individual situations may differ from those set out in this document.

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Front page photo credit: Debbie Webster

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Linking Greenhouse Gases to the Farm Gate: What Makes Sense?

Today's food and agriculture system faces ever-widening challenges as it responds and reacts to policy changes, market trends, new research, technologies and growing regulatory pressures. Industry leaders, in partnership with other stakeholders, government agencies, public representatives and the scientific community have all recognized the issue of greenhouse gases (GHGs) will continue to play an increasing role in management decisions at the farm gate. Although it is important to recognize uncertainties associated with the science surrounding greenhouse gases exist, it is equally important to recognize the science is maturing. With that maturation, policies at the local, provincial and federal level will unfold and impact future management decisions. As producers know, keeping an eye to the horizon as new information becomes available is a fundamental component of managing a successful business.

Greenhouse gas issues were brought to the forefront through Canada's involvement with, and subsequent ratification of, the Kyoto Protocol in December 2002. The Kyoto Protocol came into force on February 16, 2005. Canada was then required to reduce its emissions by six percent below its 1990 greenhouse gas levels within the period 2008-2012. However, several additional drivers have reframed this issue into one that has significance to both producers and agri-food processors as day to day business activities are carried out.

Production Efficiencies

Most agricultural activities operate with a slim profit margin. Simply put, greenhouse gas emissions represent a loss of production efficiency that translates into higher costs and lower profits. Conversely, minimizing greenhouse gas emissions may translate into reduced costs, higher productivity and increased profits.

Short-Term Opportunity

Regulation of greenhouse gas emissions in the energy, manufacturing and chemical industries has the potential to raise agricultural input costs. However, this is also creating a demand for agricultural greenhouse gas carbon or "offset" credits as a prospective means to compensate for these rising costs. Opportunities exist for the agricultural sector to create offset credits by implementing certain management practices to reduce or remove greenhouse gas emissions. In Alberta, as of January 2006, a provincial demand for offset credits will be available as regulated industries look for the opportunity to invest in offset credits as a way of meeting their Kyoto commitment.

Stewardship

Stewardship and sustainability go hand in hand on any agricultural operation that is planning for long-term viability. Many of the management practices that address emissions have a direct link to appropriate stewardship on agricultural production bases. Through the Canada-Alberta Farm Stewardship Program, in conjunction with the Alberta Environmental Farm Plan (AEFP) Company, financial incentives are provided to agricultural producers who adopt certain management practices that mitigate or minimize negative impacts and risks to the environment by maintaining or improving water, land, air quality and biodiversity.

For more information contact the Alberta Environmental Farm Plan Company, 1-866-844-2337 (www.albertaEFP.com).

Due Diligence

Due diligence is the level of judgment, care, prudence, determination and activity that would reasonably be expected of a person under particular circumstances. Like all major industries, agriculture continues to come under close public scrutiny. Although no specific compliance requirements for primary producers exist under the Kyoto Protocol, management practices that reduce or remove greenhouse gas emissions from agricultural sources and the resulting positive effects will showcase due diligence from the farm gate through the industry as a whole.

Adaptation

Weather plays a key role in how agricultural producers adapt or change their management practices to maintain productivity and sustainability. The impact of climate variability, along with changes in markets, environmental, societal and economical conditions will impact management decisions for crops, livestock, water, pests and diseases. The agricultural industry has a history of adaptation and innovation – a legacy that has producers well positioned to make the best decisions for their land, their families and their businesses. There is little choice but to respond and adapt to change, no matter what the source. Both agricultural sustainability and prosperity depend upon it.

Greenhouse gas management may not be seen as a high priority when agricultural producers are already dealing with a "full plate." However, after a closer look at the information, one may well come to see the greenhouse gas issue is more about reframing existing knowledge. Many of the management strategies associated with the reduction and removal of greenhouse gases from the atmosphere also protect the environment, improve production efficiencies and may offer a return on investment. In addition, Canada's ratification of the Kyoto Protocol and commitment to meet greenhouse gas emission reduction targets has channeled new research dollars into the agricultural industry. As the science community continues to research new technologies and strategies, this information may increase the suite of management practices currently available to agricultural producers.

What Greenhouse Gases are Produced by Agriculture?

The main greenhouse gases emitted by agriculture are carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) (Figure 1). Greenhouse gases differ in how long they remain in the atmosphere as well as in their ability to absorb energy (heat) and re-emit energy. This is known as the global warming potential and each greenhouse has a different value. While carbon dioxide is the main gas emitted by other industries, agriculture is unique in that most of the greenhouse gas emissions result from methane and nitrous oxide. These greenhouse gases have global warming potentials of 23 and 296 respectively.[1] This value is measured by comparing each gas relative to carbon dioxide and is referred to as the carbon dioxide equivalent (CO_2e).

In agriculture, the majority of on-farm carbon dioxide emissions come from:

- on farm energy use (e.g. operating equipment and heating buildings)
- intensive tillage regimes
- summerfallow and overgrazing

The primary on-farm sources of methane emissions include:

- digestive processes (enteric fermentation) from ruminant livestock (cattle, sheep, goats)
- anaerobic (in the absence of oxygen) respiration of organisms in riparian areas
- manure storage systems (stockpiled solid, liquid storage)

The primary on-farm sources of nitrous oxide emissions all involve nitrogen management practices that include:

- production of nitrogen fixing crops and forages (e.g. alfalfa and pulses)
- manure application
- inorganic fertilizer application
- water logged soils that create anaerobic conditions

Figure 1 – Farm Sources and Sinks of GHGs

Legend

1 – Soils and Crop Management
2 – Manure Management
3 – Livestock Management
4 – Land Use and Energy

What is the Greenhouse Gas Contribution from Agriculture in Alberta?

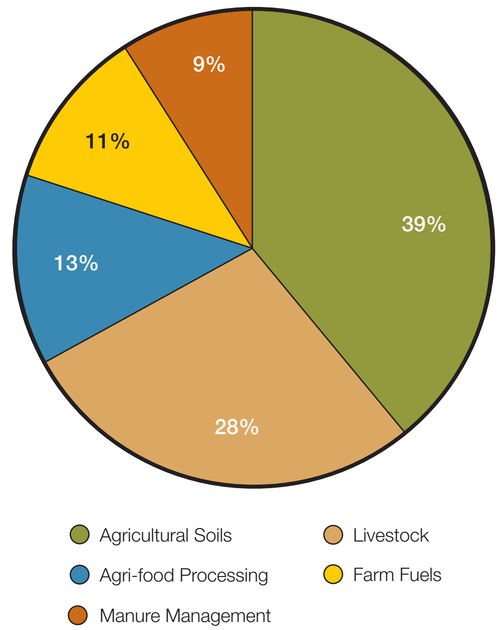
The most recent greenhouse gas inventory estimated that in 2003 nationwide, agricultural related greenhouse gas emissions contributed about 62 Mt (megatonnes) of carbon dioxide equivalents (CO_2e), which is about eight percent of Canada's emissions.[2] Of Alberta's total 2003 greenhouse gas emissions, the agricultural sector contributed about eight percent.[3]

In 2003, Alberta Agriculture and Food and the University of Alberta completed the Alberta Agricultural Greenhouse Gas Assessment Emissions Inventory (Figure 2). From this report, total greenhouse gas emissions from the agriculture sector in Alberta were estimated to be 26.3 Mt of CO_2e per year. Although the agricultural sector emits greenhouse gases, Alberta's agricultural soils, along with pastures and rangelands can sequester an estimated 5.9 Mt CO_2e and 23.4 Mt CO_2e per year, respectively. These large amounts of carbon sequestered by pasture and rangeland soils results in a net negative greenhouse gas emission estimate for Alberta's agriculture industry as a whole. The rate of carbon sequestration by these soils will continue to increase as more producers adopt sustainable management practices that reduce carbon losses associated with soil cultivation and overgrazing.[4]

What Greenhouse Gases are Produced by the Livestock Sector in Alberta?

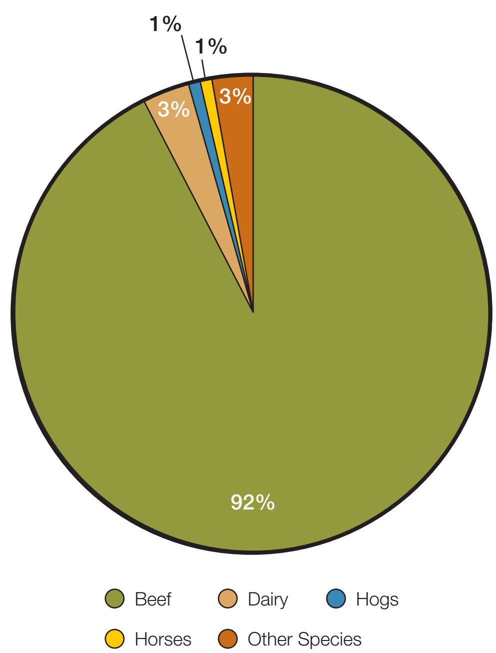
The main greenhouse gases emitted by the livestock industry are methane (CH_4) from the digestive process (enteric fermentation) and methane and nitrous oxide (N_2O) from manure. Methane produced during digestion contributes an estimated 7.4 Mt CO_2e per year, approximately three percent of Alberta's total greenhouse gas emissions. The large methane contribution may be attributed to the fact that beef cattle make up the largest portion of livestock in Alberta, producing about 92 percent of the provincial livestock sector's greenhouse gas emissions (Figure 3). This compares with greenhouse gas emissions from manure management, which contributes 2.4 Mt CO_2e per year. Because greenhouse gas emissions from all livestock represent a loss of costly feed energy and nutrient inputs, the livestock industry has an economic stake in reducing its greenhouse gas emissions.[5]

Figure 2 – Percent Contribution of GHG Emissions from Alberta's Agricultural Sector



Source: Alberta Agriculture and Food and University of Alberta 2003[2]

Figure 3 – Percent Contribution of 2001 GHG Emissions from Alberta's Livestock Sector



Source: Alberta Agriculture and Food and University of Alberta 2003[2]

How Can the Cow/Calf Sector Help to Address Greenhouse Gas Emissions?

In general, implementing certain management practices can address greenhouse gas emissions in the agricultural sector. The strategies involve management practices that would:

- **Reduce** emissions (e.g. improve feeding efficiency or manure management)
- **Remove** emissions (e.g. increase carbon in soils, pastures or trees)
- **Replace** fossil fuels (e.g. use renewable energy)

Opportunities exist for the beef sector to be a significant part of the greenhouse gas solution in agriculture and research is ongoing to determine the best methods to do this. In the meantime, a number of common sense approaches can be taken that both improve efficiency and minimize greenhouse gas emissions.

Credit: Delaney Anderson

In addition to reducing greenhouse gas emissions, the cattle industry is an integral component of the forage and rangelands that sequester carbon through photosynthesis, a natural process involving the uptake and storage of carbon carried out by both plants and trees during the growing season. According to the 2001 Agricultural Census carried out by Statistics Canada, there were 10.72 million hectares of such lands in Alberta:

- 1.98 million hectares of tame pasture
- 2.06 million hectares of hayland
- 6.68 million hectares of rangeland[6]

It is estimated that:

- tame pasture may sequester 1.10 tonnes of carbon per hectare per year
- hayland may sequester 0.9 tonnes of carbon per hectare per year
- rangeland may sequester 0.35 tonnes of carbon per hectare per year[7]

Based on these numbers, Alberta's forage and rangelands may be sequestering 23.4 Mt CO_2e per year, bearing in mind that one tonne of carbon (C) equals 3.667 tonnes of carbon dioxide equivalents. This data then suggests that in 2001 Alberta's livestock/forage systems sequestered 13.8 to 14.2 Mt CO_2e more than they emitted.[8]

Are You Familiar With These Terms?

Anthropogenic

An action or activity caused by humans.

Carbon Dioxide Equivalent (CO_2e)

A universal standard of measurement against which the impact of different greenhouse gases in the atmosphere can be evaluated. It is calculated using the global warming potential (GWP); a measurement of how much heat is retained by the earth's ecosystem through the addition of a particular gas to the atmosphere. Nitrous oxide (N_2O) and methane (CH_4) are 296 and 23 times more powerful, respectively, than carbon dioxide (CO_2) at trapping heat in the atmosphere.

Carbon Sequestration

The uptake and storage of carbon. Trees and plants, for example, absorb carbon dioxide, release the oxygen, and store the carbon through photosynthesis. Carbon is sequestered in soil organic matter (SOM). The more soil organic matter, the healthier the soil and the better the nutrient cycling capacity of the soil. This translates into better the soil quality.

Climate

The average weather for a specific region over time. Elements of climate include temperature, precipitation, sunshine, humidity, and wind velocity.

Climate Change

A slow change in the composition of the global atmosphere, caused directly and indirectly by various human activities that are additional to the natural climate variability that occurs over time.

Denitrification

A process, that occurs in the absence of oxygen, where nitrate ($N0_3$) is converted to nitrous oxide gas, a potent greenhouse gas and to dinitrogen gas (N_2).

Global Warming

An average increase in the earth's atmospheric temperature, caused by increasing levels of atmospheric greenhouse gases trapping more and more of the sun's heat energy in the atmosphere as it is reflected off the earth's surface.

Global Warming Potential

The relative potential of a specific greenhouse gas to trap the sun's heat energy in the earth's atmosphere relative to carbon dioxide. The global warming potentials of methane (CH_4) and nitrous oxide (N_2O) are 23 and 296, respectively.

Greenhouse Gases (GHGs)

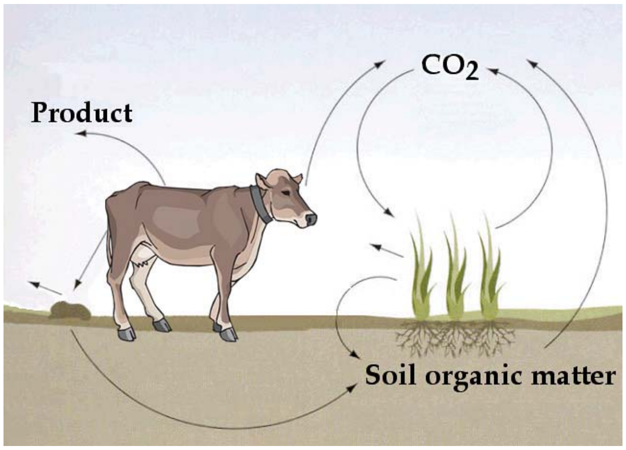
Gases that trap the sun's heat in the atmosphere, preventing its release into space, thus creating a warming effect on the surface of the earth. While greenhouse gases such as water vapour, carbon dioxide, nitrous oxide, and methane occur naturally, human activities increase the levels of these gases and are responsible for creating new ones (e.g. hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride).

- ***Carbon Dioxide (CO_2)***
  The most common greenhouse gas that is produced from respiration (Figure 4) and when any carbon-containing compound is burned. Its atmospheric levels have increased by 30 percent above levels known to exist before the industrial revolution.[9]
- ***Methane (CH_4)***
  A greenhouse gas produced by bacteria when organic matter decomposes in the absence of oxygen (anaerobic). Some of the main sources of methane include wetlands, digestion of livestock feed (Figure 4), and fossil fuel extraction. Methane is 23 times more potent a greenhouse gas than carbon dioxide and its atmospheric levels have increased by 145 percent above pre-industrial levels.[10]
- ***Nitrous Oxide (N_2O)***
  A greenhouse gas produced naturally in soils and water without the presence of oxygen through incomplete denitrification (Figure 5). Humans contribute to nitrous oxide through the application of nitrogen fertilizers and manure. Nitrous oxide is 296 times more potent a greenhouse gas than carbon dioxide. Its atmospheric levels have increased by 17 percent above pre-industrial levels.[11]

Greenhouse Effect

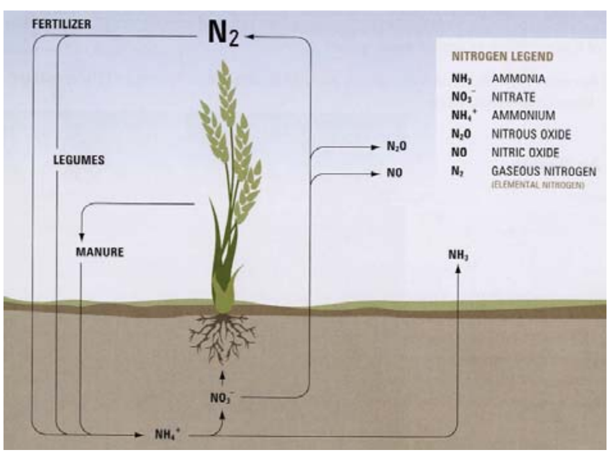
The warming of the earth's atmosphere caused by the presence of greenhouse gases in the atmosphere that trap the sun's heat energy. This effect is responsible for maintaining the earth's surface at a temperature that makes it habitable for life, as we know it. However, the concentrations of greenhouse gases in the atmosphere lare increasing and as such, they are preventing more heat from escaping meaning the earth slowly heats up. This is called the enhanced greenhouse effect, which causes global warming and it is changing our climate.

Figure 4 – The Carbon Cycle



Credit: Adapted from: Figure 9 in Janzen, H.H., Desjardins, R.L., Asselin, J.M.R., and Grace B. (eds). 1999. The Health of Our Air: Toward Sustainable Agriculture in Canada. Agriculture and Agri-Food Canada, Publication 1981/E. Reproduced with the permission of the Minister of Public Works and Government Services Canada, 2005.

Figure 5 – The Nitrogen Cycle



Credit: Adapted from: Figure 21 in Janzen, H.H., Desjardins, R.L., Asselin, J.M.R., and Grace B. (eds). 1999. The Health of Our Air: Toward Sustainable Agriculture in Canada. Agriculture and Agri-Food Canada, Publication 1981/E. Reproduced with the permission of the Minister of Public Works and Government Services Canada, 2005.

Net Feed Efficiency (NFE)

The difference between an animal's actual feed intake and its expected feed requirements for maintenance and growth. NFE has been proposed as a measure of feed efficiency that is moderately heritable and independent of growth and body size. It is used to select beef cattle for improved efficiency of feed utilization.

Offsets

Greenhouse gas reductions and/or removals arising from an eligible beneficial management practice that a producer has implemented (e.g. conservation tillage).

Removal

The process of removing greenhouse gases from the atmosphere and storing them long term in sinks. An example would be planting tree shelterbelts, which would remove some carbon dioxide out of the atmosphere.

Sinks

A process that removes greenhouse gases from the atmosphere, either by destroying them through chemical processes or storing them long term in another form. As an example, carbon dioxide is often stored in ocean water, plants or soils.

Sources

Any process or mechanism which release greenhouse gases into the atmosphere; the opposite of sinks.

Weather

The state of the atmosphere with respect to temperature, moisture, sunshine and wind velocity for a certain period of time at a specific location.

Volatilization

A process where a substance is converted from liquid to a gaseous state. For example, nitrogen exists in the liquid ammonium (NH_4+) form in liquid livestock manure but can be given off, or volatilized as ammonia gas (NH_3) when liquid manure is surface applied.

how to use this booklet

This booklet provides information on various management strategies associated with the reduction and removal of greenhouse gases from the atmosphere. A decrease in an agricultural operation's production of greenhouse gases can help to reduce its environmental footprint, improve production efficiencies, and may offer a return on investment. The following tables allow a producer to evaluate different management practices that could be implemented. Section references are supplied indicating where additional details about the management strategy can be located within the booklet. It is important to note that while many of these practices are already in use within the cow/calf sector and have the potential to improve production efficiency, they also have positive results in the removal or reduction of agricultural greenhouse gas emissions. Please note the management strategies are listed in no particular order in terms of their efficacy or efficiency.

As you proceed through the booklet you will make several observations:

- the cow/calf sector is already making a significant contribution to the removal and reduction of greenhouse gases, both within the agricultural industry and the greater global arena
- there are numerous ways to reduce and remove greenhouse gases that will show positive results on the bottom line
- no single producer can make a huge difference in the overall reduction or removal of greenhouse gases but each producer can be part of the solution
- no single management practice can make a huge difference in the overall reduction or removal or greenhouse gases, but each one can factor into the solution
- research is ongoing on a variety of fronts within the cow/calf sector with potentially new and exciting results becoming available on a regular basis

Table 1 – Management Practices that Reduce Greenhouse Gases and/or Sequester Carbon

Put a check (✓) in the box that best reflects your management strategy.

Description of Management Practice	Is this a Current Management Practice?	Is this a Management Practice to Consider?	For More Information See
Herd Health • Implement strategies to: - Increase the percentage of live births and weaned calf survival rates; - Pregnancy test cows; - Evaluate bulls for breeding soundness; - Adopt a strict culling program, and - Implement a cow/calf vaccination program.			***Section 1*** Page 10
Grazing Management • Improve your grazing management			***Section 2*** Page 12
• Reduce or eliminate cultivation on pasture lands			Page 13
• Incorporate legumes into tame pasture mixes			Page 14
• Maintain a litter cover			Page 15
• Extend your grazing season: - Stockpile perennial forage; - Swath graze; or - Seed annuals.			Page 16
• Carefully manage riparian areas			Page 19
Feed Management • Feed high quality feeds and balance rations			***Section 3*** Page 21
• Chop, grind or pellet low quality feeds			Page 21
• Use genetics to select for feed efficiency			Page 22
• Feed silage rather than dry feed			Page 22
• Add grain to the diet			Page 23
• Add lipids to the diet			Page 23
Manure Management • Recognize the nutrient value of manure			***Section 4*** Page 24
• Fertilize tame pasture using manure or compost			Page 25
• Encourage healthy populations of beneficial insects that breakdown manure			Page 26
• Carefully select wintering sites: - Feed rations over a large area; - Frequently move the bedding pile/area; - Feed on level ground or gentle slopes; and - Ensure adequate protection from the elements.			Page 27

Section 1
Herd Health

Implement strategies to:

- increase percentages of live births and weaned calf survival rates
- pregnancy test cows
- evaluate bulls for breeding soundness
- adopt a strict culling program
- implement a cow/calf vaccination program

Greenhouse Gas Benefit

Cow/calf producers are continually striving for optimal herd health and increased production efficiency. When this goal is achieved by improving the survival rate of calves from birth through to weaning, adopting a comprehensive vaccination program for all classes of livestock and the appropriate culling of both cows and bulls through pregnancy testing and breeding soundness respectively, the greenhouse gas emissions per pound of liveweight produced is reduced. It follows, that an inefficient livestock operation will require more units of livestock to produce the equivalent output of an efficient operation. There is a definite relationship between increasing production efficiency and reduced methane emissions per unit of calf weight.[12]

Current Research

Increased productivity and efficiency in production may offer some of the highest overall benefits. From the standpoint of reducing greenhouse gas emissions, the best practices are those which reduce emissions per unit of product (e.g. per litre of milk, per kilogram of beef). The objective is complementary to producers' goal of high efficiency and reduced costs.[13]

Credit: Vicky Spenst

Section 2
Grazing Management

Greenhouse Gas Benefit

According to *Beneficial Management Practices: Environmental Manual for Alberta Cow/Calf Producers*, grazing management is the care and use of range and pasture to obtain the highest sustainable yield of animal products without endangering forage plants, soil, water resources and other important land attributes. Accomplishing these goals require maintaining an adequate leaf area on desirable plants in order to intercept the sunlight on which photosynthesis depends. Animal grazing must also be controlled so that plant vigour is maintained, and water and nutrient cycles are enhanced. Grazing systems that control where and for how long the cattle graze, result in healthier pastures, higher productivity and potentially, a longer grazing season. Given the number of acres dedicated to livestock grazing in Alberta, improvements in grazing management could have a positive impact on provincial soil carbon sequestration while contributing to improved production and profitability.

Current Research

Significant gains in soil carbon may be achievable on grazing lands that are intensively managed (e.g. via nutrient amendment, irrigation, re-vegetation). But most grazing lands in Canada are subject to only minimal management (primarily through control of grazing intensity); while some opportunities for further carbon storage may exist, especially on degraded lands, the rates and amounts of carbon gain have not been established, widely and unambiguously, by analyses of rangeland soils.[14]

Increases in soil carbon are often associated with other benefits, notably preserved or enhanced productivity. Often these other benefits are sufficient to warrant the adoption of carbon-conserving practices, even apart from carbon sequestration benefits. Indeed, decisions to adopt carbon-conserving practices are often driven more by considerations other than sequestration.[15]

Credit: Duane McCartney

Improve your grazing management

Greenhouse Gas Benefit

A grazing system that shifts between use and recovery increases productivity and improves the quality of the forage. Healthy forage stands can increase the level of carbon sequestered in the soil. Although both rotational and intensive grazing systems require more management, labour and a potential increase in costs, subsequent increases in stocking rates, returns per animal, forage production, number of grazing days, net income and improved herd health are among the reported benefits.[16]

Generally speaking, most people that seek out grazing courses or consult with experienced graziers will make some changes to their management strategy. To see what these changes mean to pasture yield and species potential may take at least three years of improved grazing management to realize. Primary factors influencing that rate of change include moisture conditions and the extent of the management change that has been undertaken.

Alberta provides a wide range of training opportunities and print material that offer a greater understanding of grazing principles. For more information on the details of grazing, obtain a copy of *Beneficial Management Practices: Environmental Manual for Alberta Cow/Calf Producers* from Alberta Agriculture and Food, Ag-Info Centre: 310-FARM (310-3276) or Publications: 1-800-292-5697 (www.agric.gov.ab.ca). In addition, you can consult with an experienced grazier by contacting the Agriculture and Research Extension Council (780) 416-6046 (www.areca.ab.ca) and inquiring about the Grazing Mentor Program.

Current Research

There are a lot of misconceptions about what happens with carbon. Carbon is always in a state of flux. Sometimes it is being stored or sequestered and sometimes it is being released. Nature's goal is to reach an equilibrium – strike a balance to match the amount of carbon stored with the amount being released. That would be success…Carbon dioxide in the atmosphere is captured by plants and stored as carbon in plant tissue and in the soil…If there is a net carbon gain over a year the crop-soil continuum is a carbon sink. Healthy, vigorous growing forage stands, annual crops and land that is not cultivated have the greatest potential to store or sequester carbon. Overgrazed pastures, for example, and traditional summerfallow will release more carbon to the atmosphere than is saved and are known as sources of carbon. Several factors affect the amount of carbon returned to the atmosphere. Soil moisture, temperature, length of the dormant periods and health of the plant are all part of the equation…Field cultivation, pastures that are continually overgrazed or forage and crop stands under drought conditions are prime for net carbon respiration (i.e. carbon loss). Overgrazing and drought [create] conditions [under which] a forage stand has reduced ability to store carbon because photosynthesis is limited… Improved forage and grazing management often increases the equilibrium point for carbon storage or the amount held in the carbon account. Sequestration rates increase for a period of years until a steady state carbon-equilibrium is reached (the sink is full, based on prevalent conditions)… Small improvements to carbon sequestration rates over the large area of pasture and rangeland in western Canada could have a large impact.[17]

Reduce or eliminate cultivation on pasture lands

Greenhouse Gas Benefit

Many producers consider it necessary to break up a pasture thinking it has become “root bound” and therefore lost its productivity. However, whenever you cultivate you lose a portion of soil carbon. Historically cultivation has been employed to control weeds, prepare seedbeds and ultimately, to release nutrients stored in the soil organic matter. Over time, as the soil nutrients become exhausted, there comes a greater dependence on inorganic fertilizers to encourage plant growth. Under good pasture management perennial forages can be long lived at the same time maintaining or increasing soil carbon levels.[18] In the event that a stand has to be terminated, herbicide application may be considered rather than cultivation. The process of reestablishment provides an ideal opportunity to evaluate the makeup of the forage stand. Choosing the correct plant mix can make a significant difference in both productivity and sustainability. A large amount of carbon is stored in plant root systems and ultimately in the soil. Using a minimum disturbance seeding method will reduce the amount of carbon lost in the seeding process.[19]

Current Research

Breaking up and reseeding [perennial] forage [pastures] should be looked at as a last resort. Using tillage is expensive, leaves the soil prone to erosion and generally means losing one year of production.[20]

Planting adapted and improved species on tame pasture could increase the rate of carbon sequestration over pastures by 100 to 300 grams per square meter per year until a new equilibrium is reached.[21]

Credit: Gwen Doran

Incorporate legumes into tame pasture mixes

Greenhouse Gas Benefit

When considering a pasture mix, look to a grass/legume combination. Legumes provide grasses with nitrogen, creating a more balanced system. Adding legumes to pastures can actually improve animal performance by increasing feed intake, providing greater feed efficiency and by fostering a better use of forage nitrogen content. Grazing legumes improves feed efficiency and reduces methane emissions because they are more easily digested. This allows for quicker digestion and shifts the fermentation process towards lower methane production.

There are many greenhouse gas benefits in utilizing grass/legume forage mixes:

- the reduction in the amount of time it takes cattle to digest their feed results in decreased methane emissions
- soil carbon sequestration is increased as the amount of land in perennial forages increases
- legumes fix their own nitrogen from the atmosphere and do not require the addition of nitrogen fertilizer (In addition, grasses will utilize the nitrogen produced by the legumes reducing the possibility of nitrous oxide emissions.)

Current Research

Adding as little as 25 percent legume in the forage mix may result in significant drops in methane production because it greatly improves the efficiency of fermentation in the rumen. [22]

There are compounds, e.g. tannins, saponins and flavonoids, found in some animal feeds, particularly forages, that do reduce methane output…The challenge of research into these compounds is to find the level in the diets that might reduce methane output without having negative effects on the animal elsewhere. Some quite encouraging results are evident with tannins…Sainfoin is a tanniniferous legume of potential in Western Canada…It can be concluded that tanniniferous forages, such as sainfoin in western Canada or trefoil in eastern Canada, could be used to reduce methane output by grazing cattle. Unfortunately sainfoin many not have longevity or other attributes to make it adaptable in all regions of western Canada. It is too early to prescribe specifically how much tannin could be added to cattle feed to reduce methane output... [23]

Credit: Alberta Agriculture and Food

Maintain a litter cover

Greenhouse Gas Benefit

Litter, also known as mulch, is old grass residue left from previous plant production. It performs several important functions that contribute to the health of grazing lands while reducing and/or removing greenhouse gases:

- as the litter breaks down, plants use the available nutrients, increasing soil carbon content and reducing the need for the application of additional fertilizer
- litter conserves moisture by reducing evaporation thereby encouraging plant growth
- litter shades and cools the soil surface, traps snow, increases water infiltration and reduces raindrop impact

Litter cover and distribution is one of several factors taken into account in determining the overall health of grazing land. The *Rangeland Health and Assessment for Grassland, Forest and Tame Pasture Field Book* published by, and available through Public Lands Division – Alberta Sustainable Resource Development, is a comprehensive tool that one might use to assess the condition of specific grazing sites. To obtain a copy, contact Public Lands Division, Alberta Sustainable Resource Development. (On the Rite Line, dial: 310-0000).[24]

Note: The term "range health" refers to the ability of rangelands to perform certain key functions including net primary production, maintenance of soil/site stability, capture and beneficial release of water, nutrient and energy cycling and functional diversity of plant species.[25]

Credit: Kelly Montgomery

Extend your grazing season:

• Stockpile perennial forage;
• Swath graze; or
• Seed annuals.

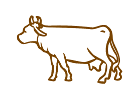
Greenhouse Gas Benefit

Many livestock producers have determined that it is possible to extend their grazing season. Successfully doing so will see a decrease in financial costs and carbon dioxide emissions through the reduction or possible elimination of the fossil fuel required to put up and deliver forages to the livestock. Nitrous oxide and methane emissions may be reduced when the manure is directly deposited on carefully selected winter-feeding sites rather than stored in piles that may encourage anaerobic decomposition. Overall workload and fossil fuel use associated with hauling and spreading manure from confined areas will also decrease. Each strategy has both benefits and cautions. In all cases, remember to:

- determine sources of water and shelter
- recognize that snow conditions may hamper access to the feed
- consider the additional costs of checking cattle and developing and managing a fencing system
- be prepared for potential conflicts with wildlife

Stockpile Perennial Forage

To bank or stockpile pasture for use in the dormant season, plan a recovery period that is appropriate for the pasture type and growing conditions. In moist areas, cutting or grazing in early July followed by a pasture re-growth period for the remainder of the growing season may provide the best balance between quality and quantity. In drier areas, an entire year's growing season may be required. These strategies have the potential to result in an adequate quantity of high quality pasture for use in the fall or the following spring.[26] Species that are suitable for stockpiling must retain yield and feed value well enough to supply the cow's nutritional needs. When frost causes leaf loss or when rain and snow melt leach sugars out of frozen and dead plant cells, both yield loss and feed value loss can occur.[27] Dormant pasture may not contain an adequate quantity or balance of nutrients. Feed tests, monitoring animal condition and supplementing as required are necessary to maintain herd health and productivity.



Current Research

With a winter feeding period on the Canadian prairies that may last 200 days, winterfeed and feeding costs of beef cows are the largest costs in beef calf production. By stockpiling perennial forages, feed and feed costs may be reduced by 46 percent. This happens because baling, hauling, feeding and manure removal are eliminated from the traditional winterfeeding practice… The Alberta Agriculture Research Initiative funded a stockpiled perennial forage research project in Central Alberta. Scientists at Lacombe monitored yield and nutritive losses from the fall until spring of nine adapted forage species. This was repeated over three years from the fall of 1998 until spring of 2001. It was found that species choice is the first step in a successful stockpiled grazing program. The legume alfalfa lost leaves after frost and had more rapid yield and nutritive loss than all of the grass species. Grass species commonly found in permanent pastures, such as creeping red fescue and Kentucky bluegrass had the disadvantages of relatively low yields to begin winter. Quackgrass yielded well in years with average to above average rainfall and had below average yield loss due to weathering. Meadow bromegrass had stable and relatively high yields during all years of the study. What separated meadow bromegrass and creeping red fescue from the other species was their ability to resist the weathering process. In spite of frost, snow, snowmelt and rain, they retained their nutritive value longer than all other forage species. Their nutritional value maintained beef cows well into the winter months.[28]

Credit: Duane McCartney

Swath Graze

Swath grazing involves leaving swathed, late seeded annuals for cattle to graze during the dormant season. One additional consideration that needs to be taken into account with swath grazing involves the residue remaining in the field if the cattle have not made good utilization of the feed. Addressing this in the spring may require an increase in time, money and greenhouse gas emissions.

For more information on the details of swath grazing, obtain a copy of *An Introduction to Swath Grazing in Western Canada* Agdex 420/56-1 by contacting Alberta Agriculture and Food, Ag-Info Centre: 310-FARM (310-3276) or Publications 1-800-292-5697 (www.agric.gov.ab.ca).

Current Research

Plot research at Lacombe showed that there was potential for wintering cows on meadow brome and alfalfa regrowth. [During the winter of 2004/05], a research trial was established to evaluate cows grazing this type of perennial pasture. The meadow brome/alfalfa pastures were cut for hay in mid-July and the regrowth was then available for grazing during November, December and January. This growth was left standing for grazing through the snow. Winterkill was a major question and it was felt that trampling and smothering problems could occur if the perennial crop was swathed. By leaving the stockpiled forage standing, we also eliminated the swathing cost. The cows were strip grazed using an electric fence which was moved every two to three days depending on snow conditions…The forage was still green and the nutritional quality met the cows requirements…All cows performed well under these conditions. In fact they wintered in the same body condition as cows on oat swaths or fed a straw silage ration in the wintering facility. Cows appeared to be content during the winter grazing period. The cows on the meadow brome would graze the standing alfalfa stems first, (there were some alfalfa leaves remaining on the stems), followed by grazing the meadow bromegrass. The grass was flat to the ground. The cows would break through the snow and graze the meadow brome completely to the ground… We intentionally did not regraze the perennial fields in the early spring after calving as we were concerned about grazing the new growth too early in the spring before the plants had reached the three leaf stage. The alfalfa stand in the spring showed no visible signs of winterkill damage. The previous fall had been quite cold before the snowfall and the alfalfa plants had ample time to harden off prior to freeze up. This study continued for the winter of 2005/06.[29]

Current Research

Swath grazing of oats or barley can be used to pasture cows from mid-November to early spring depending on the calving season. Research at the Lacombe Research Centre has shown that swath grazing can reduce the traditional winter feeding and yardage costs by up to 50 percent with cows coming through the winter in the same body condition as those wintered on stored feed.[30]

Credit: Kelly Montgomery

Seed Annuals

In special circumstances when grazing options are limited, both spring and winter cereal crops can be used to provide productive annual pasture crops. Annual crops such as the ryegrasses can be utilized as well, although they do require a higher level of moisture to properly establish and be productive. Spring seeded oats and barley tend not to regrow as well as spring-seeded cereals such as fall rye, winter triticale and winter wheat. Winter cereals grow and stay green well into the fall for grazing. Fall rye and winter triticale are more productive at that time of year, whereas research has shown that winter wheat can be slightly more productive during the summer months.[31] Intercropping systems involving oats or barley interseeded with Italian ryegrass, fall rye, winter wheat or winter triticale have the potential to provide additional fall grazing as well as a silage crop. This system allows for dual use of your land base. However, to make this system functional, the crops need to be seeded as early as possible and cut for silage earlier than normal in order to provide enough growing days for the fall crop to grow.[32]

Current Research

Research out of Brooks has shown that if the spring cereals are clipped on a monthly basis, they are more productive than if they are clipped weekly or biweekly. This indicates that a rotation grazing system will increase production of the spring seeded winter cereals. Other research has shown that growing spring cereals and winter cereals in a mixture will increase the grazing days of the pasture. The early growth of spring cereals generally allows grazing seven to ten days earlier. In most instances, half a bushel of oats or barley mixed with a normal rate of winter cereals is a good mix... Winter cereals are a very effective source of pasture in the fall and provide a high quality productive pasture that can be used to extend the grazing season. Winter cereals have been shown to be a versatile crop that can be used for supplement pasture to reduce the overgrazing on perennial pastures.[33]

Credit: Vicky Spenst

Carefully manage riparian areas

Greenhouse Gas Benefit

Riparian areas are zones of vegetation along-side streams and around water bodies where the vegetation and soils are strongly influenced by the presence of water. In terms of greenhouse gas emissions, cattle managed improperly in these areas tend to overgraze the vegetation, negatively impacting soil carbon reserves and cause additional physical damage through soil compaction. The mismanagement of livestock can increase the amount of nitrous oxide emitted through the addition of manure to the system (Photo A). Riparian areas are recognized as having numerous important ecological functions (Photo B) that include:

- water filtration, which controls salinity and siltation
- water flow control, allowing for groundwater recharge
- flood regulation
- excellent source of clean water
- reliable source of pasture
- reduction and dissipation of stream energy
- maintenance of biodiversity[34]

Riparian area resources and functions are different from those of surrounding lands and require specific management techniques. Implementation of an appropriate grazing plan will take into account such specifics as controlling access, choosing alternate watering points, fencing, and utilization of distribution tools such as salt and mineral. Assessing riparian health can be achieved with the aid of *Caring For The Green Zone: Riparian Health Assessment for Streams & Small Rivers Field Workbook*, available through the Cows and Fish Program. To obtain a copy, visit their website at www.cowsandfish.org and follow the links to Community Tools and an online order form, or you can call the Cows and Fish Program Manager at (403) 381-5538.

Photo A Credit: Jeannette Austin

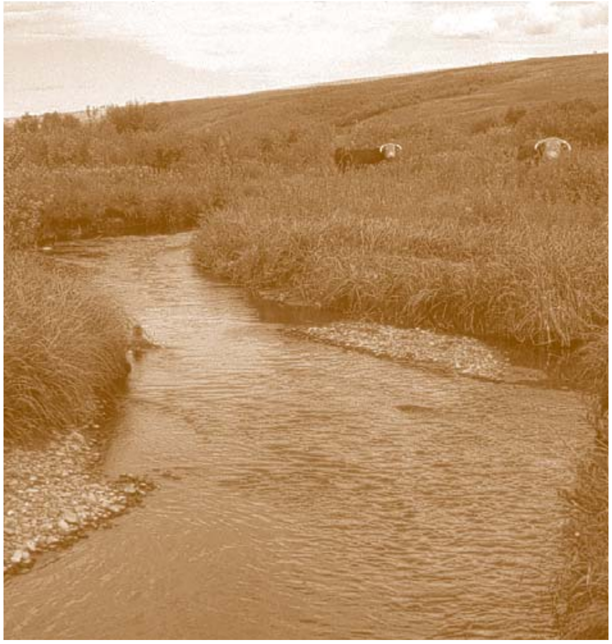


Photo B Credit: Cows and Fish

Section 3: Feed Management

Greenhouse Gas Benefit

Improved feed efficiency increases productivity and reduces greenhouse gas emissions. Methane, released primarily by belching, represents a loss of dietary energy and feed inefficiency. It is a byproduct of enteric digestion by microbes known as methanogens. Rumen microbe species are specialized in their ability to breakdown either cellulose from forages or starch from grains. Changes in the composition of a ration need to be made gradually to allow time (about two weeks) for the rumen microbe population to adapt. In general, the faster feed passes through a ruminant, the less methane is produced. Changes in feed management that lessen the amount of feed utilized by the animal also reduce methane emissions. Because this results in a decrease in the amount of manure produced, both methane and nitrous oxide emissions are also reduced. Even small changes in management practice can increase feed efficiency and cut back on greenhouse gas emissions.

Current Research

Methane produced comes at a cost to the animal in energy used and represents a substantial loss in efficiency of animal production. Methane emissions from cattle range from 2 to 12 percent of the gross energy intake and translate to emissions of 150 to over 300 litres per day. It also contributes about 16-20 percent of global atmospheric methane. One of the main factors which effects methane production is the efficiency of feed used by cattle...[35]

Dietary strategies to reduce methane emission by beef cattle [have been reviewed]; fumarate, ionophores, tannins, oils, forage species, increasing grain content, feed particle size reduction and inclusion of brewers or distillers grain were considered the most promising strategies…Legumes generate less methane than grasses. Feeding grain reduces methane emissions relative to feeding forages but there is a need for more research to understand some of the variation in this response and how it is affected by feed processing.[37]

Ruminant livestock are the largest source of methane emissions from Canadian agriculture. Because methane generation from ruminants is closely linked to the efficiency of feed use, the factors affecting the rates of emission are reasonably well understood.[36]

Credit: Phil Boehme

Feed high quality feeds and balance rations

Greenhouse Gas Benefit

On pasture, a high rate of gain or high production per cow will result in less methane produced per acre and per unit of production. Improved feed quality creates an environment in a ruminant's digestive system that is not conducive to methane producing fermenters. The higher the quality of feed supplied, the greater the reduction in methane production. Providing rations balanced for energy, protein, minerals and vitamins results in greater feed efficiency and ultimately lower methane emissions per kilogram of live weight gain. Alternatively, an unbalanced diet will lead to a loss of nutrients through urine and manure outputs, reduced herd productivity, increased methane emissions and increased manure output.

Cattle use feed most efficiently when the nutrients in the daily feed match their daily requirements, hence the term, balanced rations. Producers know they can't "eyeball" feed value but they sometimes use traditional or book values to estimate feed quality against their livestock feed requirements. These can be useful guides but the quality of individual feed supplies can vary widely from the average. Not knowing the exact nutritional value of feeds can lead to underfeeding or overfeeding, both of which cost money. Nutrient content of feeds vary greatly from year to year because of differences in growing conditions, method of harvest, stage of maturity at harvest, storage and processing. Roughage mixtures of unknown proportions or use of unusual feedstuffs or screenings increases the need for precise information. A little time and a few dollars spent planning can lead to satisfactory performance on minimum feed while limiting the risks associated with thin cows, poor calves, low fertility and/or wasted feed resources. Adding the necessary protein supplements, vitamins, minerals, and grain to meet, but not exceed nutrient requirements, lowers production costs by optimizing performance and feed efficiency.[38]

To balance or check cattle rations, consider using Cowbytes, an easy to use computer software program available from Alberta Agriculture and Food Ag-Info Centre at 310-FARM (310-3276) (www.agr.gov.ab.ca). In addition there are professional nutritionists within the industry to assist with the development of an appropriate formulation.

Current Research

The quality of feed is one of the most important factors affecting methane emission. The amount of methane produced can be significantly reduced by improving animal diets, though many livestock operations already use high quality feeds, limiting the mitigative benefits from further improvements. Changes in feeding practices (e.g., increased grinding of feeds, lower feeding frequency or increased feeding level) may also reduce methane emissions somewhat, though many producers may already employ near-optimal practices.[39]

Chop, grind or pellet low quality feeds

Greenhouse Gas Benefit

When straw or low quality hay is utilized as part of the ration, grinding or chopping will make it more easily digestible. This leads to quicker digestion and reduces the amount of time food remains in the rumen, causing a reduction in the amount of methane produced.

Current Research

The chewing time required per unit of dry matter (DM) is influenced by many factors, including proportions, lignification and anatomy of leaf and stem, particle moisture in the rumen and feed processing. Feed processing reduces both time and energy required for eating, but may not affect the amount of rumination required unless the feed is finely ground. Total chewing time per kilogram DM ranges from 20-40 minutes for pelleted forages to 70-100 minutes for long forages and from 100-220+ minutes for straws. In one study, mature cattle ate 0.84 percent DM from long straw, needing 212 minutes to chew each kilogram. Chopping the straw reduced chewing time per kilogram, enabling the animals to increase their intake to 0.95 percent. Chewing costs energy. Energy lost to chew feed is lost as heat, reducing the net energy available for maintenance.[40]

SECTION 3
Feed Management

Use genetics to select for feed efficiency

Greenhouse Gas Benefit

In the early to mid 1990s Australian researchers identified net feed efficiency (NFE) as a trait that was independent of body size and growth. This trait is moderately inheritable. This implies that improvements could be made in feed efficiency through properly designed genetic selection programs. Net feed efficiency in simple terms can be defined as the difference between an animal's actual feed intake and its expected feed requirements for maintenance and growth. Some animals eat less than expected and are efficient (negative NFE). Other animals eat more than expected and are inefficient (positive NFE)…[41] In recent years, results from a research team headed by Dr. John Basarab of the Western Forage/Beef Group have clearly indicated that net feed efficiency is a trait that is independent of body size and growth. Since it reflects the maintenance requirements of individual animals, it was thought that cattle with low or negative NFE would produce less methane than cattle with high or positive NFE. …Results of the research suggested that the NFE trait as a selection tool for cattle would lead to savings in feed costs and also lead to a reduction in methane emission by cattle.[42]

Current Research

A preliminary study from the University of Alberta in conjunction with the Western Forage/Beef Group showed results indicating that low NFE cattle produced about 20 percent less heat and retained about 35 percent more of the energy consumed than the cattle with high NFE. Other differences included the production of 20 percent more manure, the loss of 18 percent more energy in feces and 21 percent more urinary energy loss in the high NFE compared to the low NFE cattle. In addition, methane production was approximately 6 percent or 14 percent higher as a percent of gross and digestible energy intake respectively in high as compared to low NFE steers… If accurate, these results indicate that differences in NFE in cattle may be partly due to differences in maintenance requirements, the efficiency of energy usage, methane production and energy retention.[43]

The Bovine Genome Project, led by Dr. Moore at the University of Alberta, is identifying genetic markers for net feed efficiency (NFE) that will have commercial application. Improving NFE will reduce methane and manure emissions from cattle. This may generate new agricultural investment due to greenhouse gas credits.[44]

Feed silage rather than dry feed

Greenhouse Gas Benefit

Silage is an effective method of preserving feed with minimum nutrient loss. During the fermentation process, the plant carbohydrates are broken down, resulting in lower methane emission as compared to feeding dried forages. This reduces the amount of fermentation time required in the rumen; the less time feed remains in the rumen, the fewer methane emissions result. More research is required in this area to fully evaluate this feeding strategy. The costs of growing, putting up and properly storing the silage would need to be carefully evaluated, both in financial terms and in greenhouse gas terms.

Credit: Duane McCartney

Add grain to the diet

Greenhouse Gas Benefit

Livestock diets high in grain tend to reduce methane production. However, the costs of growing, putting up and properly storing the grain would need to be carefully evaluated, both in financial terms and in greenhouse gas terms.

Current Research

Calculations showed that placing calves directly on a grain ration after weaning resulted in only 34 percent as much methane being emitted compared to a calf that goes through a backgrounding program before finishing. There is need for further work to estimate the impact of these systems on total greenhouse gas production and at the same time taking their economics and sustainability into account before conclusions on which is the best system to adopt. As improvements in feeding and management efficiency are associated with reduced methane emissions, methods to predict outcome from these approaches accurately still needs to be evaluated.[45]

Add lipids to the diet

Greenhouse Gas Benefit

Plant derived edible oils fed in appropriate amounts, add energy to the diet and inhibit methane production. Again, the costs of growing, putting up and potentially processing the oilseed would need to be carefully evaluated, both in financial terms and in greenhouse gas terms.

Current Research

Fatty acids [a component of oilseeds] are quite toxic to methanogenic bacteria. Free fatty acids, fats and oils are alternatives to decrease methane production by cattle and other ruminants. Unsaturated fatty acids act as sinks for metabolic hydrogen in the rumen, although it is generally agreed in the literature that toxicity on methanogenic bacteria, rather than a sink for hydrogen, is the major reason why these fatty acids inhibit methane output. Other organisms, besides the methanogens, can also be affected negatively by fatty acids. In particular, fibre digestion is often, but not always, negatively affected by them. The result is that in moderate or high fibre diets, this negative effect of the fat or oil implies that the theoretical energy value of the fat for cattle is not altogether recovered through improved performance, i.e. in energetic and gross feed efficiency. As many of the feed sources of fats are expensive relative to other feeds, the economic incentive to include oil or fat in ruminant diets may not exist. On the other hand, oils and fats can be used to enrich beef with nutraceuticals, such as conjugated linoleic acid (CLA) and omega-3 fatty acids. This acts as a counter to their negative impact on energetic efficiency and economics...[46]

Section 4: Manure Management

Greenhouse Gas Benefit

Beef manure is largely composed of carbon, nitrogen and other organic materials. The main greenhouse gases emitted from manure are carbon dioxide, nitrous oxide and methane. Methane is formed during the anaerobic (in the absence of oxygen) decomposition of manure. The amount of methane emitted from manure is influenced by various management strategies (e.g. stockpiling, composting, storage and spreading). Feed management strategies, as well as animal size, impact both the amount of manure and the amount of methane produced. Because nitrous oxide is the most potent greenhouse gas emitted by livestock operations, appropriate manure management is an important consideration. Specific management practices can ensure the nutrients in the manure make their way into the soil where plants can use them rather than have them volatilize into the atmosphere.

For detailed information on manure management, obtain a copy of *Beneficial Management Practices: Environmental Manual for Alberta Cow/Calf Producers* and/or *Code of Practice for Responsible Livestock Development and Manure Management* from Alberta Agriculture and Food Ag-Info Centre: 310-FARM (310-3276) or Publications: 1-800-292-5697 (www.agric.gov.ab.ca).

Credit: Alberta Agriculture and Food

Recognize the nutrient value of manure

Greenhouse Gas Benefit

Not only can proper manure management capture the value of manure as a resource, but it also reduces nitrogen loss. Nitrogen is a valuable component of manure, and the less that is volatilized, the more that remains available for growing crops and pastures. When manure is properly applied, improvements are seen in soil tilth, structure, aeration and water-holding capacity. In turn, plant production increases and more carbon is sequestered. Manure is a source of nutrients that can be used to replace some of the commercial fertilizer an agricultural operation may be required to purchase. However, if livestock manure is stockpiled, stored in liquid form or submerged during snowmelt or times of high precipitation, the lack of oxygen forces the decomposition process to produce methane.

For detailed information on nutrient content of livestock manure, obtain a copy of *Code of Practice for Responsible Livestock Development and Manure Management* from Alberta Agriculture and Food Ag-Info Centre: 310-FARM (310-3276) or Publications: 1-800-292-5697 (www.agric.gov.ab.ca).

Fertilize tame pastures using manure or compost

Greenhouse Gas Benefit

To maintain or increase forage production, both manure and compost are recognized as valuable sources of nutrients. Inorganic fertilizers can be utilized as well. Fertilization increases both plant growth and the amount of plant cover, increasing the amount of carbon retained in the soil profile. Other environmental benefits from improved soil fertility include reduced soil erosion, a reduction in opportunities for invader species and decreased soil moisture losses.

In well-managed grazing situations cattle will evenly spread the manure around the pasture, potentially reducing the cost for any additional fertilizer and minimizing greenhouse gas emissions. To encourage this even distribution, manage livestock for uniform grazing, control watering sites and utilize salt, mineral, shade and shelter as tools to regulate cattle lounging in a particular area for extended periods of time.

To minimize greenhouse gas emissions and maximize the time and financial investment of fertilizing pastures with manure, compost or inorganic fertilizer, consider the following:

- Before beginning any fertilizer program, take samples of both soil and manure for nutrient analysis. Properly managed pastures have lower fertilizer requirements that forages used for hay or silage as more nutrient cycling occurs in a grazing situation; and
- The timing of fertilizer application is crucial. To reduce nitrous oxide emissions, apply manure or fertilizer when pastures are actively growing. It is during this active growth period that plants will most effectively use the available nitrogen and emissions (losses) due to volatilization will be minimized.

To obtain a copy of *The Manure Composting Manual*, contact Alberta Agriculture and Food Ag-Info Centre: 310-FARM (310-3276) or Publications at 1-800-292-5697, and request Agdex #400/27-1 or download a copy at (www.agric.gov.ab.ca).

Current Research

The best approach for reducing nitrous oxide emissions is to avoid surplus plant-available N, by precisely matching available N to plant needs. A variety of tools are available to help meet this objective: soil testing, precision farming, nutrient budgeting, reducing summerfallow and others...[47]

Timing *of N application is often as important as the* amount *of N applied in controlling nitrous oxide emissions emissions. For example some N fertilizers and manures are applied in fall, after crop uptake has ceased, leaving the N susceptible to losses throughout winter and early spring. Eliminating fall applications may appreciably reduce nitrous oxide emissions though this may result in higher costs for fertilizer and problems associated with manure storage.*[48]

Practices that reduce nitrous oxide emissions often also result in more efficient use of nitrogen, an input that is expensive and also a source of carbon dioxide (during fertilizer manufacture). Consequently, some of these mitigation practices may also have economic and other environmental benefits.[49]

Encourage healthy populations of beneficial insects that breakdown manure

Greenhouse Gas Benefit

Dung pats that have not broken down represent a loss of soil nitrogen as well as grazing area. When the dung is incorporated back into the soil, the nitrogen is available for plant growth rather than volatilized into the atmosphere in the form of nitrous oxide and carbon dioxide. Although several other factors play a role in pat degradation (e.g. foraging by birds, trampling by cattle, frost, rain and vegetation), insects are important components of the recycling process.[50] Benefits of manure breakdown include:

- nutrient recycling including significant amounts of nitrogen
- increased grazing and forage production
- soil aeration, water retention, root penetration and reduction of run-off
- reduced pest flies and parasitism
- reduced disease
- cost savings

To encourage healthy populations of beneficial insects, choose agricultural and animal health products recognized to be safe for dung inhabiting insects and determine the safest time of year to apply them.

Credit: Kevin Floate, AAFC

Carefully select wintering sites:

- **Feed rations over a large area;**
- **Frequently move the bedding pile or area;**
- **Feed on level ground or gentle slopes; and**
- **Ensure adequate protection from the elements.**

Greenhouse Gas Benefit

Livestock wintering sites include the feeding area, a sheltered area and the water source. On many operations, livestock movement is minimal during the winter resulting in the buildup of manure in specific areas. This can lead to increased greenhouse gas emissions and the potential contamination of nearby water sources. If winter rations are fed over a large area and the winter bedding pile/area is frequently moved, it is easier for the elements, insects and microbes to break down the manure (including feces, urine soaked straw and bedding) when the weather warms. The nutrients derived from the breakdown of manure will improve soil health, increase organic matter and ultimately increase soil carbon levels. Feeding on level ground or gentle slopes will reduce manure runoff or run-on and minimize the greenhouse gas emissions associated with the nitrogen loss. In addition to providing another tool for manure management, adequate natural or man-made (preferably portable) windbreaks help to reduce the amount of feed required by livestock to maintain body condition. Supplying more feed or nutrients than are needed results in unnecessary rumen methane emissions and increased manure output.

For detailed information on site management, obtain a copy of *Beneficial Management Practices: Environmental Manual for Alberta Cow/Calf Producers* from Alberta Agriculture and Food Ag-Info Centre: 310-FARM (310-3276) or Publications: 1-800-292-5697 (www.agric.gov.ab.ca).

Current Research

It can be concluded that environment, particularly ambient [immediate surrounding area] temperature, should be considered as a factor that could be causing variation in methane emissions from cattle during the year in locations within Alberta and Canada.[51]

[When] feeder calves and/or over wintering cows are exposed to wind during cold winter months the result is average to below average feed conversion and average daily gain as more feed is used by the animal for maintenance and growth. [Adequate shelter] allows more feed to be converted to body mass with less given off as methane and manure.[52]

Credit: Jeannette Austin

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