Forage Best Management Practices for the Reduction of GHG Emissions

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Some facts to consider

Carbon Dioxide

CO_2 (GWP 1)

Agriculture accounts for 5% of anthropogenic CO_2 emissions worldwide.

Methane

CH_4 (GWP 21)

360 Mt annually worldwide from anthropogenic sources, 50% from agriculture

Canada contributes 4.5 Mt annually, 26% of which is agriculturally based.

Nitrous Oxide

N_2O (GWP 310)

10-17.5 Mt annually worldwide from anthropogenic sources, 70% from Ag.

Canada contributes 0.17 Mt annually, 65% of which is agriculturally based.

Canada has the tenth largest GDP in the world and ranks 4th or 5th in agricultural exports.

(Methane and nitrous oxide emissions from Canadian animal agriculture, Kebreab et al. 2006)

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More facts

Globally agriculture accounts for 20% of the anthropogenic greenhouse effect. In Canada only 8% of anthropogenic GHG emissions come from agriculture.

32% of which comes from domestic animals,
17% from manure management, and
50% from soils which partly comes from manure applied to soils or pasture.

Animal products accounts for over half of Canadian Agriculture GHG emissions.

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Animal Production

Ruminant animals are the largest single source CH_4 , accounting for 16% of the worlds biogenic CH_4.

The amount of enteric CH_4 produced is influenced by dietary factors such as: level of feed intake, level of production, rate of digest passage, and level of saturated fats. Genetics and feed efficiency are also major factors.

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Reducing GHG on Farm

There is real potential for BMP's that span animal production, manure management and soils to help mitigate Canadian agricultural green house gas emissions.

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Forage Best Management Practices for the Reduction of GHG Emissions

This manual was organized and written for the Canadian Forage and Grassland Association;

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BMP's for Reduced GHG Emissions

1. **Improved Grazing Management -** Intensify Grazing Systems
   - *Intensive Rotational Grazing*
   - *Strip Grazing*
   - *Forward Creep Grazing*
   - *Mob Grazing*
2. **Improved Grazing Management** - Extended Grazing season
   - *Stockpile Forage Grazing*
   - *Bale Grazing*
   - *Swath Grazing*
3. **Forage Harvest Management** – Maximizing Productivity
   - *Moving from a 1cut system to a 2cut system*
   - *Moving from a 2cut system to 3 or more*
4. **Forage Stand Management** - Nutrient Management
   - *4R Nutrient Management Implementation for Nitrogen*
   - *Enhanced Efficiency Fertilization*
   - *Organic Amendments*
   - *Optimizing Soil Fertility*

BMP’s for Reduced GHG Emissions

5. Forage Stand Management - Systems Based Approach

- *Nutritive Additives*
- *Mould Inhibitors*
- *Bacterial Inoculants*
- *Ionophores*
- *Essential Oils*
- *Seaweed*
- *Soil pH balancing*

6. **Improved Forage Genetics**

- *Locally Adapted Genetically Advanced Cultivars*
- *Purpose Built Mixtures*
- Integration of Annuals-Perennials

7. Advanced Cropping Systems

- *Cover Crops*
- *Double Cropping*
- *Optimum Seeding Rate*
- *Integration of Annuals-Perennials (No-till seeding, Summer Fallow)*

Improved Grazing Management

Intensifying Grazing Systems & Extended Grazing Season

Intensive Rotational Grazing, Strip Grazing, Forward Creep Grazing, Mob Grazing

- By controlling both grazing and recovery periods; intensive grazing management can benefit plant growth, promote species diversity, reduce root decomposition and increase soil carbon.
- A major source of greenhouse gas emissions from ruminant livestock farms include methane from enteric fermentation and methane and nitrous oxide from stored manure. Grazing high quality forage (forages with high DMD) reduces enteric methane emission from cattle by 22% and increases feed efficiencies (Boadi & Wittenberg, 2002). There is very little methane or nitrous oxide from manure deposited during grazing.

Improved Grazing Management

Extended Grazing Season Systems

Stockpile Forage Grazing

Bale Grazing

Swath Grazing

Compared to a winter feedlot extended grazing season systems such as stockpiled pastures, swath and bale grazing decrease carbon dioxide, methane and nitrous oxide emissions per kg of forage fed (Alemu et al., 2016). Additionally, extending the grazing season reduces tractor use and more effectively recaptures nitrogen, phosphorus and other plant essential nutrients from animal excreta increasing soil fertility and reduces the need to purchased fertilizer.

Forage Harvest Management

Moving from a 1 cut system to two cuts,Moving from 2 to 3 cuts or more per season

- Moving from a 1-cut to 2 or more cut system can improve forage quality and overall yield, in turn sequestering more carbon

- The extensive rooting system of a productive perennial forage stand can store up to 2.7 times more carbon than annual crops and sequester it deeper in the ground for a longer term (Manitoba Agriculture, 2008).

Forage Harvest Management

Moving from a 1 cut system to two cuts,Moving from 2 to 3 cuts or more per season

During rumen fermentation approximately 500-1500 litres of gas is produced of which 20-40% is CH_4 and CO_2. Methane and carbon dioxide production from livestock has shown to reduce when livestock are fed medium or high-quality forage diets. (Boadi & Wittenburg, 2002).

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The effect soil compaction often goes unnoticed

Travelling over fields multiple times with heavy farm equipment, especially if traveling repeatedly on the same wheel tracts can lead to soil compaction and reduced yields. **Research has shown that compaction causes between 6 and 74% loss in yield in perennial forage stands (Jorajuria & Draghi, 1997).**

Soil compaction induces major changes in the soil structure and the key variables controlling nitrous oxide emissions. Compacted, waterlogged soils can lose up to 20% of applied nitrogen through the production of nitrous oxide, a process called denitrification (Laboski, 2008). Though only 6% of annual greenhouse gas emissions, N_2O has a high global warming potential, 310 times that of CO2.

Forage Stand Management

Nutrient Management –Using 4R approach to Nitrogen

Nitrogen management on grass forage is complex and from an environmental perspective not well studied. The environmental risks associated with nitrogen fertilizer are considerable. Improper timing, rate, type and placement can result in the contamination of water with nitrates and the pollution of air with nitrous oxide. Nitrate is very mobile in the soil and under excess soil moisture can move quickly through the soil profile. Under anaerobic soil conditions (waterlogged or poorly drained soils) especially soil with high organic matter, soil nitrate can be reduced to nitrous oxide.

Using the 4R approach to nitrogen management has both environmental and economic benefits. Optimizing nitrogen management increases fertilizer efficiency resulting in increased profits and a reduction in environmental risks associated with excess soil nitrogen (Ziadi et al., 2000) (Nutrients for Life Canada, n.d.).

Forage Stand Management

Enhanced Efficiency Fertilization

By adopting technology and production methods that increase fertilizer efficiency, crop production can be increased with using the same or even less fertilizer. Enhanced fertilizer efficiency technology increases the amount of nitrogen fertilizer take up by plants, and decreases the amount lost to denitrification, volatilization and leaching.

Akiyama et al. (2010) conducted a meta-analysis on enhanced fertilizer efficiency methods and found that nitrification inhibitors were the most consistent in effectively reducing nitrous and nitric oxide emissions, polymer coated (slow/control release) fertilizers also were effective however results did vary with soil type and land use. While urease inhibitors on average did not show a reduction in emissions more research is needed for these inhibitors.

Forage Stand Management

Organic Amendments

Adding organic amendments to soil is a very good practice for soil health. Benefits include improved; soil structure, aeration, infiltration, percolation, water retention, erosion resistance and additional nutrients.

The addition of organic amendments has great potential as a climate change mitigation strategy, as they create a sink for soil carbon and nitrogen. Owen, Parton & Silver (2015) found rangelands that have received an application of manure have a mitigation potential for net GHG emissions through soil carbon sequestration. N_2O emissions are also reduced because the organic N is not immediately available for plant uptake, rather it is slowly released to plants, which maximizes plant N uptake and minimizes the potential loss of N through denitrification and leaching.

Forage Stand Management

Forage Additives

Feeds with higher palatability and digestibility increase intake (rate of passage) resulting in a lower amount of methane produced per unit of feed consumed. Forage additives that reduce storage loss, improve forage digestibility, increase feed efficiency and palatability also reduce GHG emissions. Feed additives with antimicrobial properties such as essential oils and ionophores have been shown to be effective in reducing enteric methane and ruminal ammonia (Beauchemin et al., 2003) (Strydom, 2016).

Mold inhibitors

Bacterial Inoculants

Exogenous fibrolytic enzymes

Ionophores

Essential Oils

Seaweed supplements

Cover Crops

Research estimates that cover crops have a global potential soil organic carbon sequestration rate of 0.12 ± 0.03 Pg C yr^{-1}, which is a mitigation of approximately 8% of greenhouse gas emissions from agriculture (Poeplau & Don, 2015). This study did not include any nitrous oxide emissions which may occur; however, it provides evidence for how cover crops offset greenhouse gas emissions through carbon sequestration (Poeplau & Don, 2015).

If a grazed cover crop is integrated into an annual cropping system, nutrients are returned directly to the soil through livestock excreta reducing the nutrient loss and greenhouse gas emissions that occurs from manure handling (Thiessen-Martens & Entz 2011).

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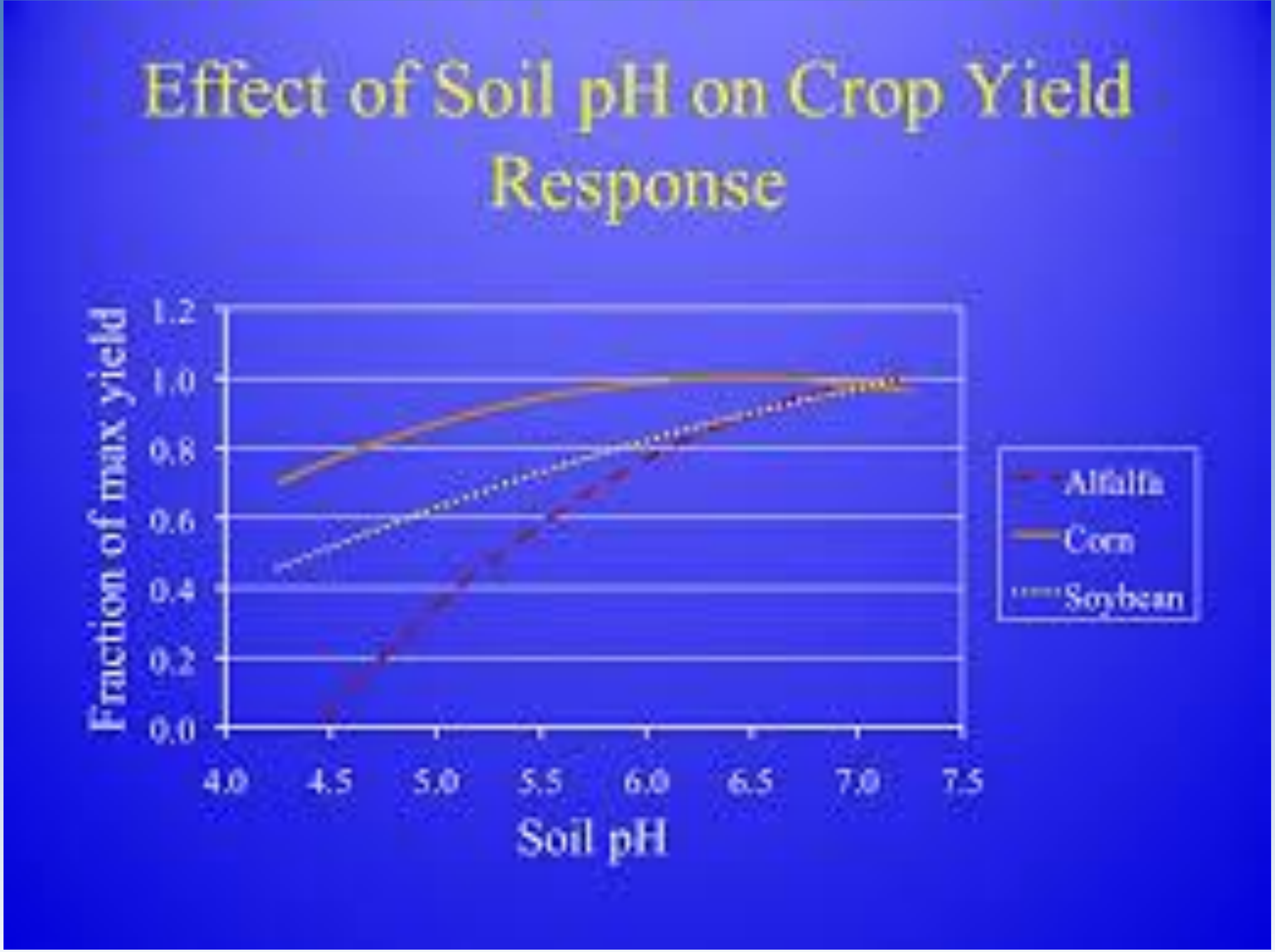
Benefits of Liming

- Increased yield
- Increases fertilizer efficiency
- increased stand establishment and persistence
- Increased legume content

- more activity of nitrogen-fixing *Rhizobium* bacteria
- added calcium and magnesium
- improved soil structure and tilth
- increased availability of phosphorus and molybdenum
- decreased manganese and aluminum toxicity



From slide set of Paulo , Department of Soil, Water and Cilmate, University of Minnesota

Fertilizing Legumes

Where there is sufficient crude protein and minerals in the diet, voluntary intake is linearly related to the proportion of legume in the forage mix.

Improved Forage Genetics

Canada is a vast country with varying climate and soils. Choosing forage species and cultivars most suitable to climate and soil conditions is an important component of a successful forage production system.

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Growing genetically superior
cultivars of well adapted species
increases productivity, reduces
cost of production and increases
soil organic carbon sequestration.

Improved Forage Genetics

The use of highly digestible forage species and cultivars and species with tannins can increase feed efficiency and reduce carbon dioxide and methane emissions during digestion.

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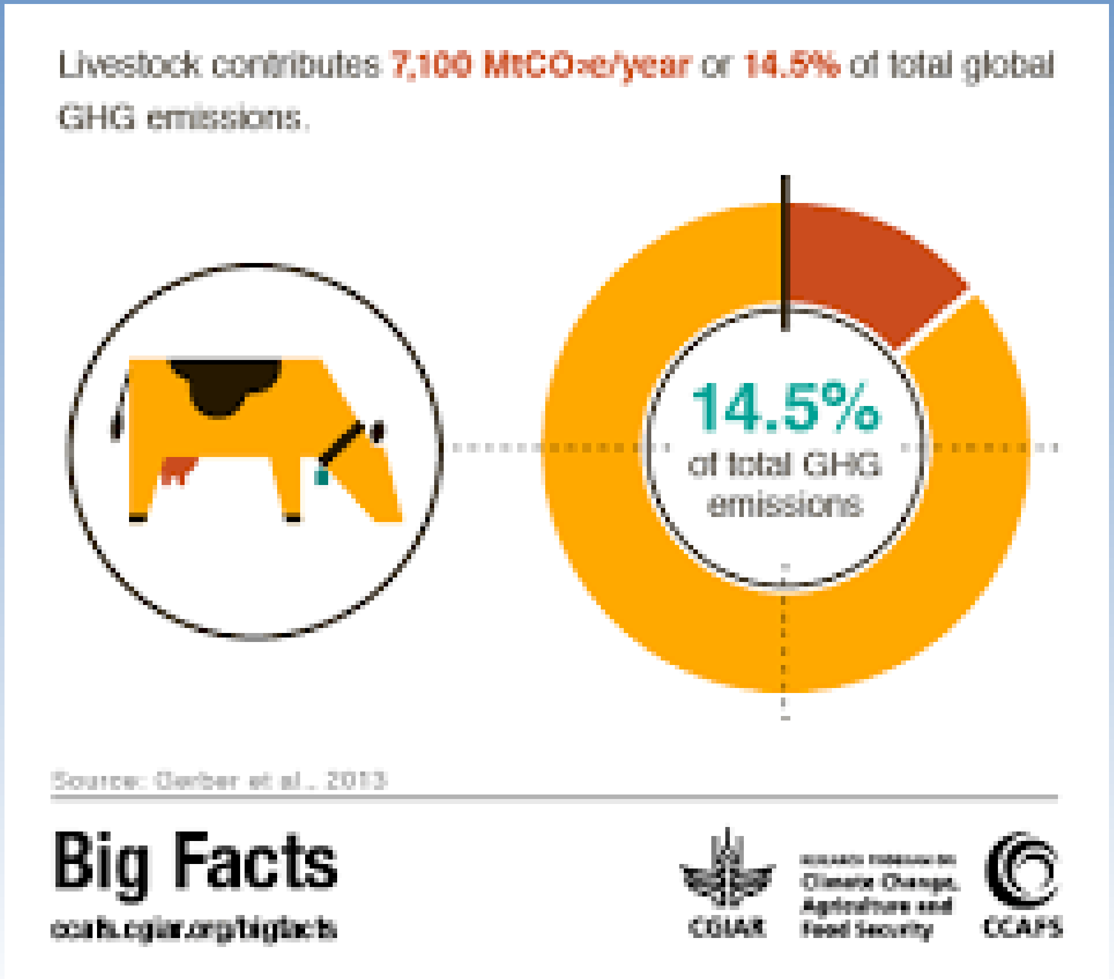
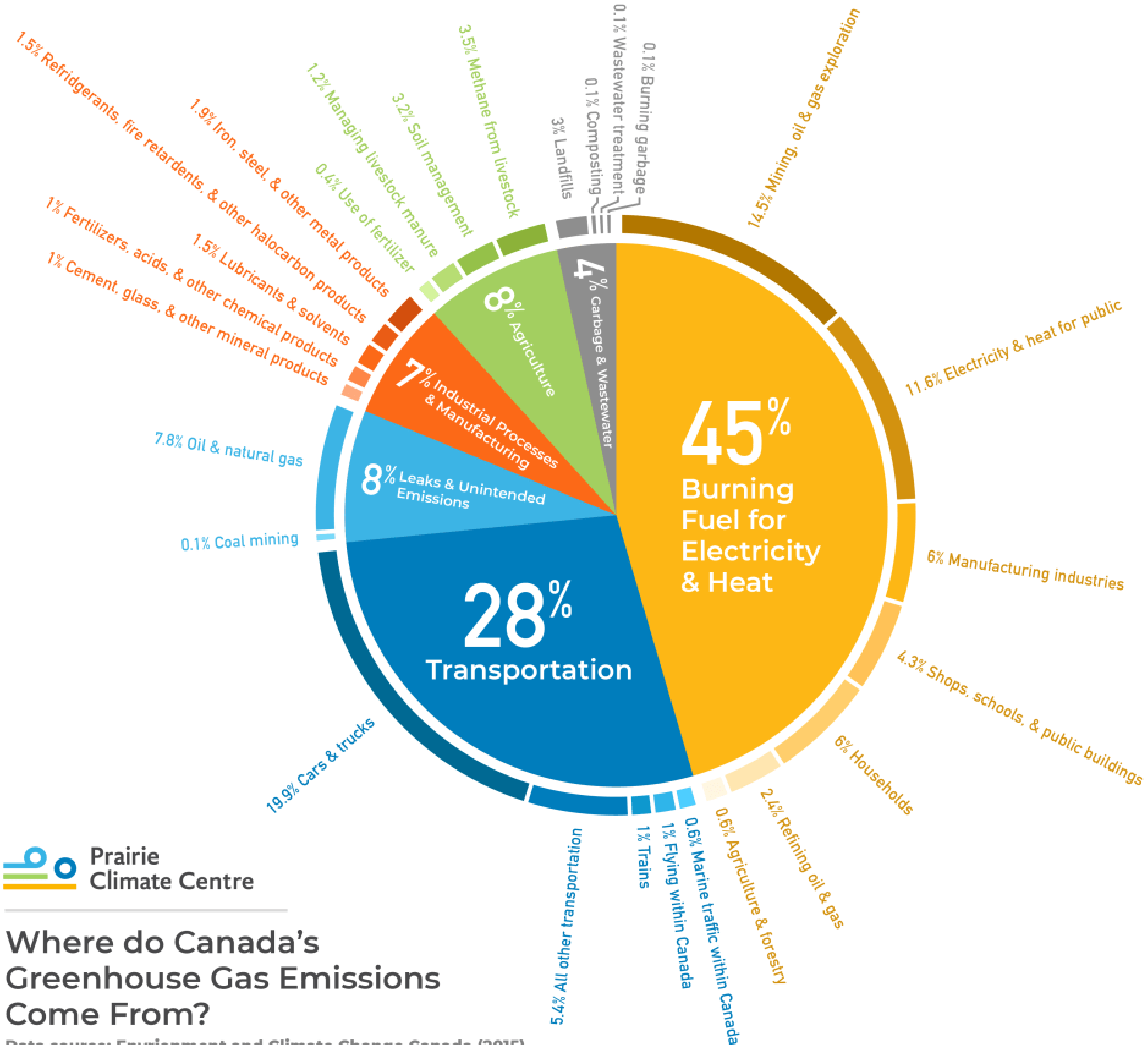
Questions and Discussion

More Facts?

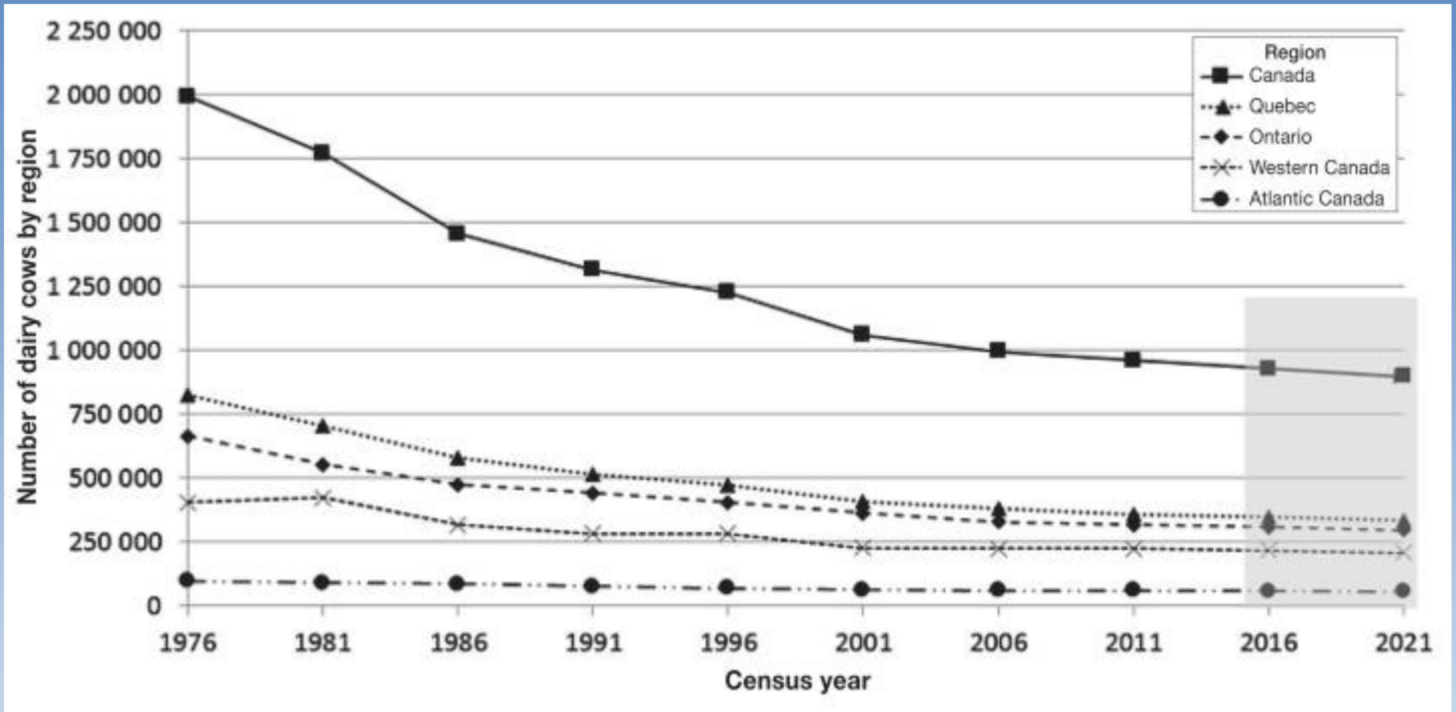

Livestock contributes 7,100 MtCO2e/year or 14.5% of total global GHG emissions.
14.5%
of total GHG emissions
Source: Gerber et al., 2013
Big Facts
ccafs.cgiar.org/bigfacts
CGIAR
Climate Change, Agriculture and Food Security
CCAFS



Prairie Climate Centre

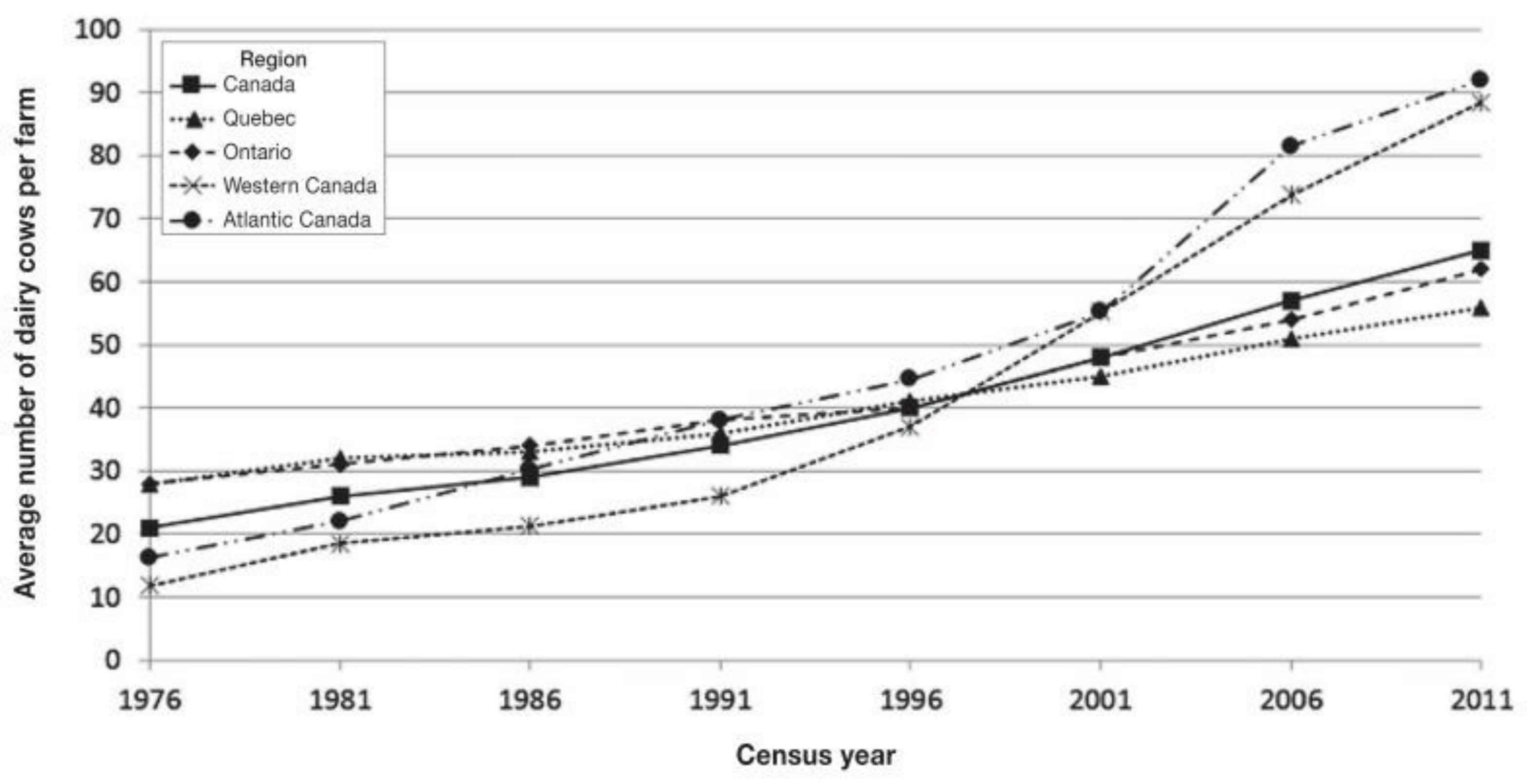
Where do Canada's Greenhouse Gas Emissions Come From?

Data source: Envrionment and Climate Change Canada (2015)

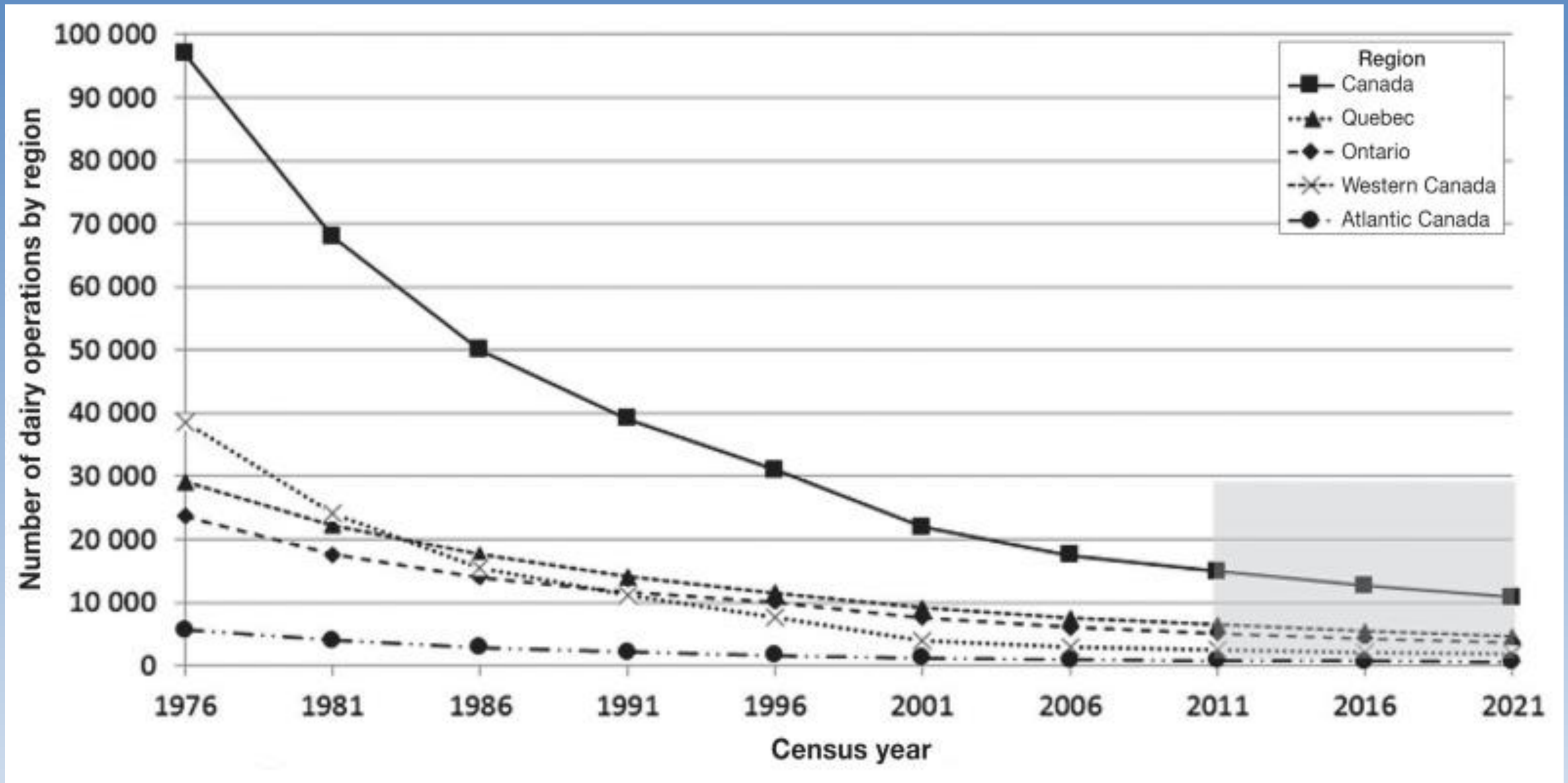


Number of dairy cows (excluding replacement heifers) by region and census year. Shaded area represents extrapolated data for the census years 2016 and 2021. All data were extracted from Statistics Canada's online databases.

Demographics of the Canadian dairy industry from 1991 to 2011
Murray D. Jelinski, Stephen LeBlanc, and Richard Kennedy Canadian Journal of Veterinary Science 015 Jul; 56(7): 701–708.



Average number of dairy cows (excluding heifers) per herd by region and census year. All data were extracted from Statistics Canada's online databases.



Number of dairy operations by region and census year. Shaded area represents extrapolated data for the census years 2016 and 2021. All data were extracted from Statistics Canada’s online databases.

More Facts

1975

Average milk per cow/day 16.5 litres

2019

Average milk per cow/day 32.5 litres

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