THE BASICS – GREENHOUSE GASES AND AGRICULTURE

Climate change is linked to the emission of greenhouse gases such as carbon dioxide, methane and nitrous oxide. While some greenhouse gases are naturally occurring, it's the increased levels of emissions that are of mounting concern. Global temperatures have risen 1.6°C, and global warming is directly related to elevated greenhouse gas levels.

Agriculture is the source of 9% of the global contribution of greenhouse gas. Of this amount, at least 65% is attributed to livestock agriculture: methane from ruminants and manure, nitrous oxide from stored manure, and carbon dioxide from all livestock, livestock housing and decomposing manure.

Key gases of concern are nitrous oxide, methane and carbon dioxide. The global warming potential of each compound is:

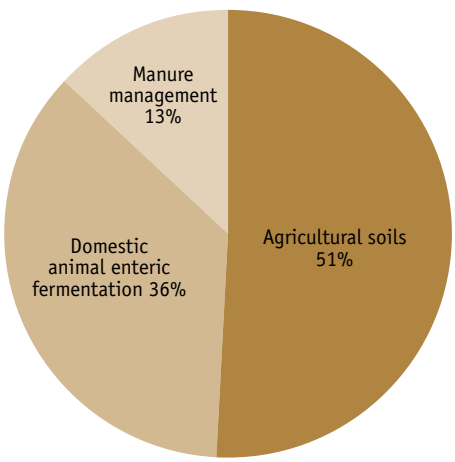
NITROUS OXIDE: METHANE: CARBON DIOXIDE (N_2O: CH_4:CO_2) = 321:21:1.

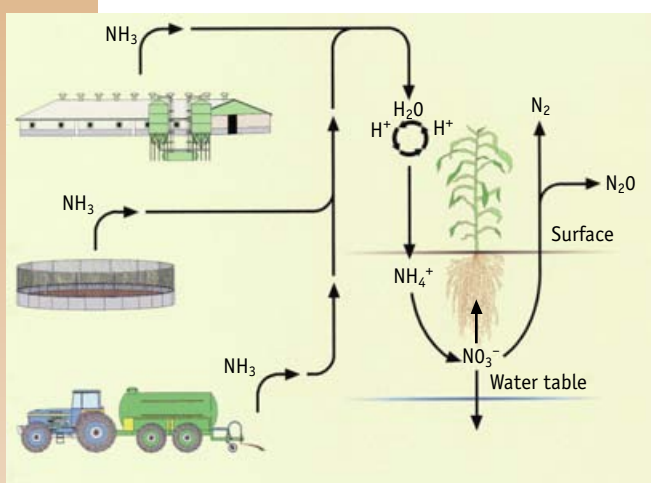
The net greenhouse gas-emissions from agriculture are usually caused by inefficient use of resources, such as feeds, energy, manure, land and water.

GREENHOUSE GAS EMISSIONS FROM THREE MAIN AGRICULTURAL SOURCES, IN CARBON DIOXIDE EQUIVALENTS

In 2003, GHG emissions from the agriculture sector contributed 8.4% of total national emissions. Total sector emissions rose 19% between 1990 and 2003. Emissions from manure management increased by 18% and from enteric fermentation by 20%. N_2O emissions from soils rose 19% over the same period.

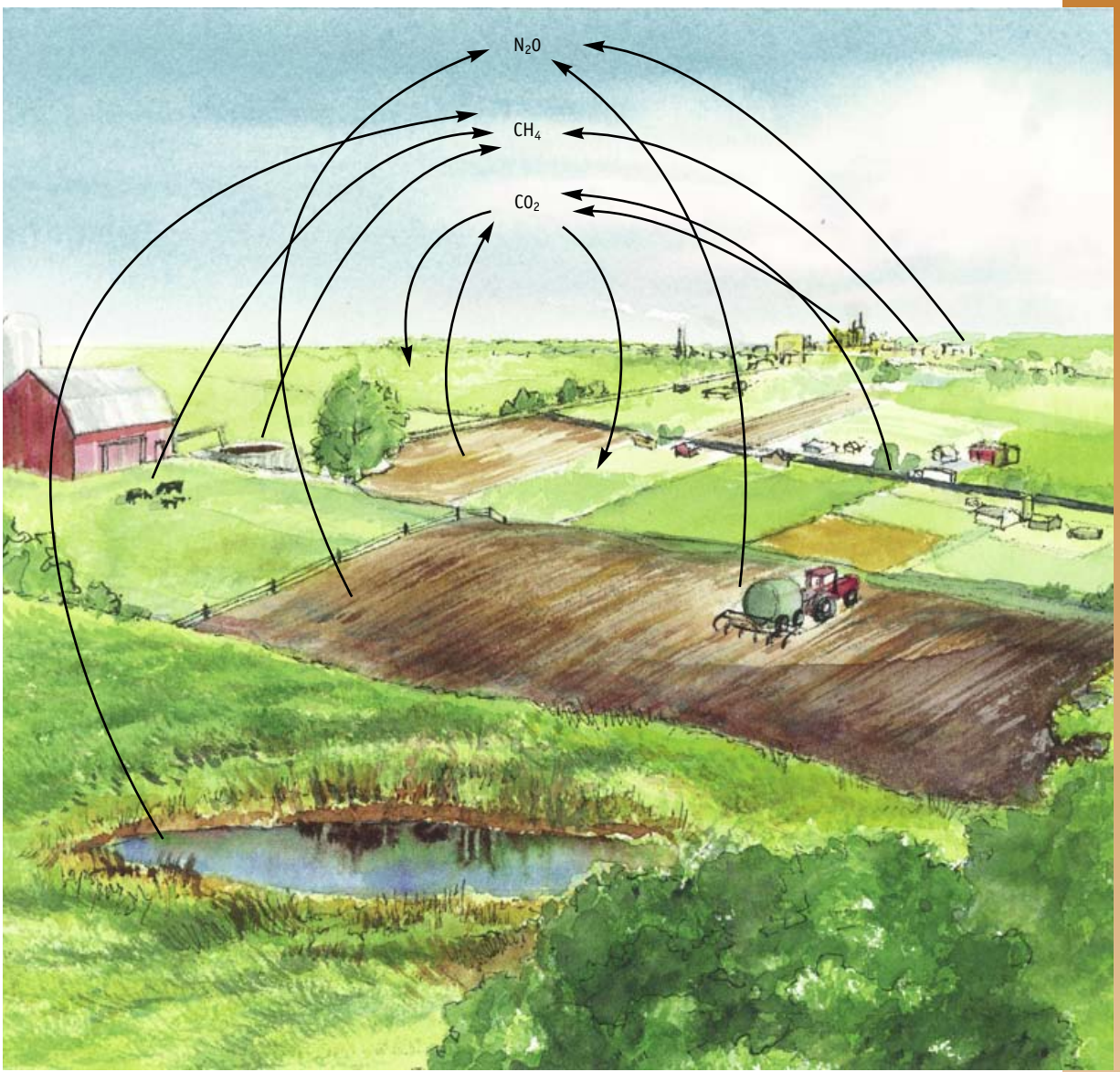
From Environment Canada Information on Greenhouse Gas Sources and Sinks, October 2005





Ammonia gas (NH_3) can indirectly contribute to the generation of nitrous oxide (N_2O) gas. Volatilized ammonia from barns, manure storages and applied manure will convert to ammonium (NH_4^+) as it reacts with moisture in the atmosphere. The NH_4^+ is redeposited throughout the landscape with precipitation. Most of this NH_4^+ will nitrify to nitrate (NO_3^-) in the soil.

The risk is that a significant amount of the nitrate will be converted (denitrified) to nitrogen gas (N_2) and nitrous oxides – particularly if deposition is NOT on cropland and NOT during the growing season.



Greenhouse gases (GHGs) are atmospheric gases that reflect heat energy released by Earth back to the surface. GHGs – water vapour, ozone, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) – are necessary for life on Earth. Without this natural greenhouse effect that "holds" some of the heat in our atmosphere, the average temperature on Earth would be too cold for life as we know it.

However, excessive increases in GHG levels can lead to a warming of Earth's surface. Some industrial, transportation, residential and agricultural activities accelerate the production of the three main GHGs (CO_2, CH_4 and N_2O), and therefore increase the risk of upsetting the atmospheric balance of GHGs.

Source: Greenhouse Gases and Ontario Agriculture, Infosheet #1, OMAF. AF095

IMPLICATIONS FOR AGRICULTURE

Climate change could lead to crop losses and shortages.

Prolonged drought could lead to fewer acres of sustainable pasture for grazing livestock.

Climate change could lead to long-term losses of readily accessible sources of drinking water.

Hotter summers could lead to increased incidence of heat stress for confined livestock.

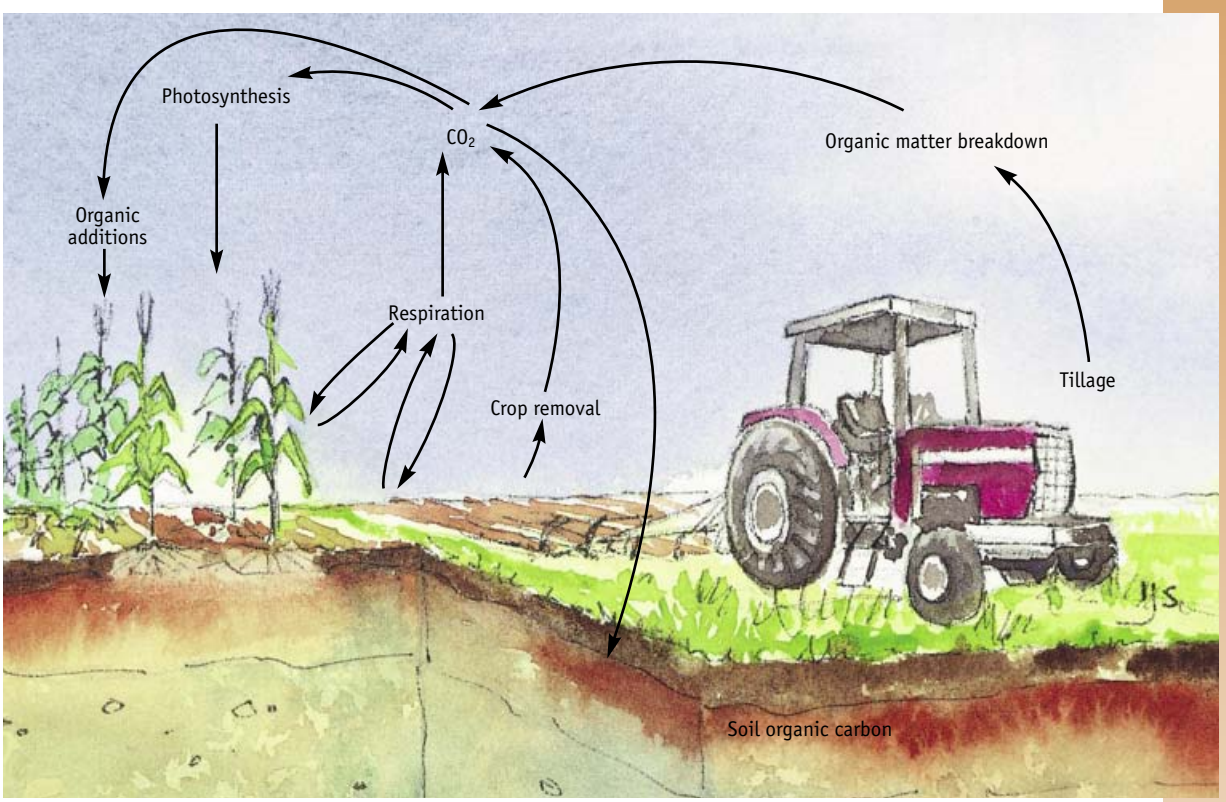
Impact of GHG Emissions on Livestock

- ▶ Global warming will mean higher temperatures and more drought
- ▶ Incidence of livestock heat stress will increase
- ▶ Pests and diseases will diversify and pressure will increase
- ▶ Feed prices will rise
- ▶ Pasture may be more difficult to establish and manage
- ▶ Drinking water will continue to be scarce in some regions
- ▶ Water quality will suffer in areas with low water levels

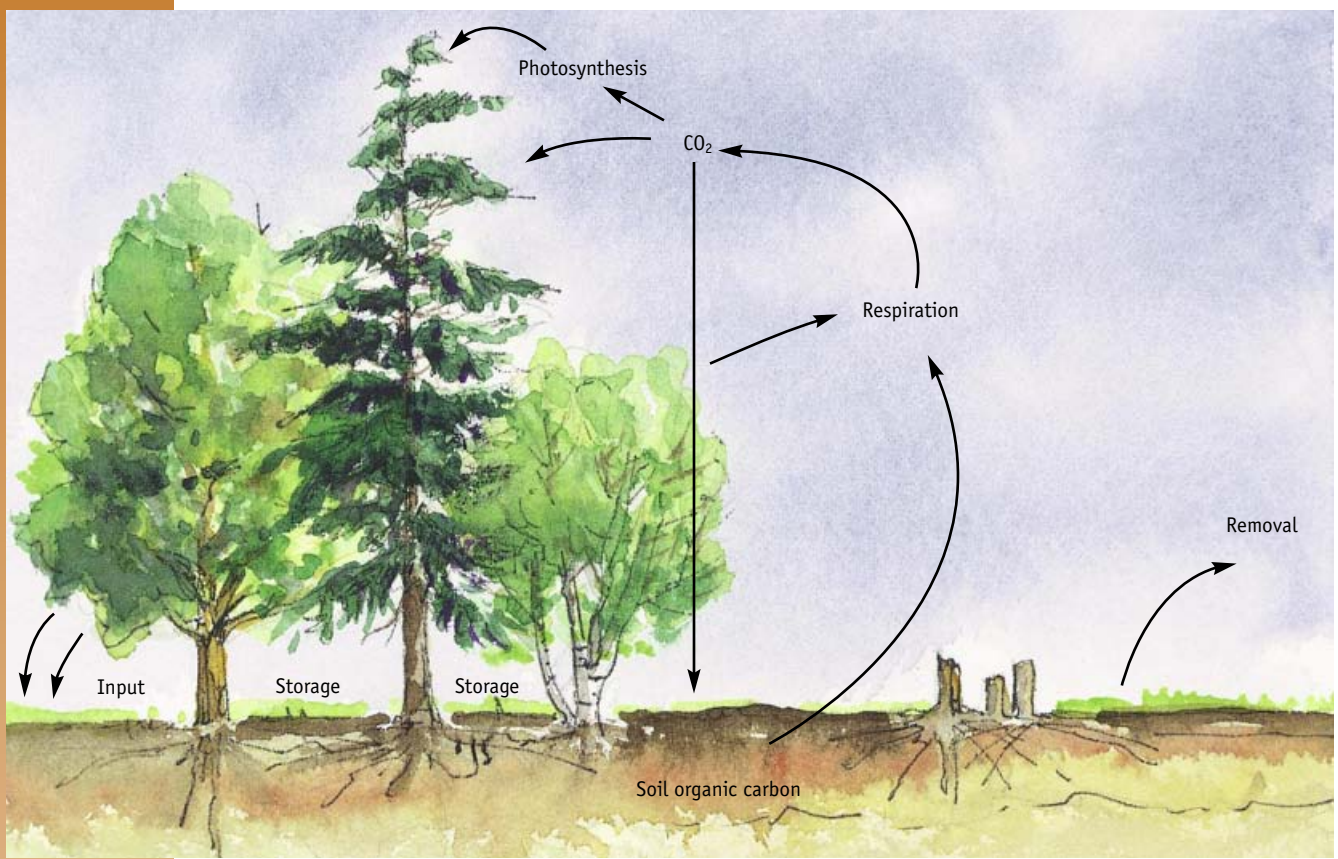
Agriculture and Agri-Food Canada

A sink is an invisible reservoir that absorbs released carbon. Trees, soils and wetlands are examples of potential sinks.

CARBON DIOXIDE (CO_2) GENERATION



Farming systems can be both a "sink" and a direct source for carbon dioxide. Crops and soils fix carbon dioxide. Tillage action and fuel consumption during field operations are a source of CO_2.

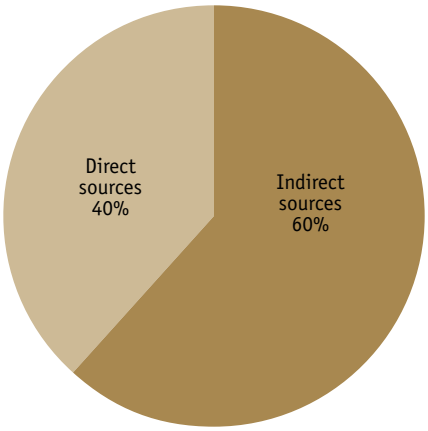


Farm woodlands are important sinks for carbon dioxide. Carbon is sequestered in woody plant material and woodland soils.

Carbon dioxide (CO_2) comes from direct and indirect sources. In the agriculture sector, direct sources account for 40% of the emissions – mostly from soil and fossil-fuel burning. Indirect sources account for the balance – mostly as energy used to develop inputs and as fuel for transportation.

Agricultural "gains" (meaning retention of carbon) are from photosynthesis. Carbon is fixed to form plant materials. Some plant materials go for human/livestock consumption, are respired to atmosphere, add to the soil organic carbon (SOC) or remain as plant tissue (fibre, wood). A significant proportion of agricultural crops – forages, pasture and grains – go to livestock feed.

"Losses" (meaning lost to the atmosphere as a greenhouse gas) are due to respiration by plants and livestock, methane emissions from livestock and soil loss (soil degradation), and fossil fuel combustion.



Direct sources – such as soil degradation (organic matter depletion) and fossil fuel use – contribute to approximately 40% of the CO_2 emissions from agriculture.

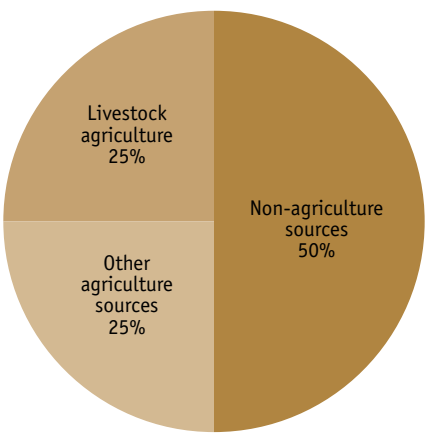
METHANE (CH_4) GENERATION

Methane is the principal component of natural gas. Because it has a short shelf life in the atmosphere, remedial measures can have a rapid impact.

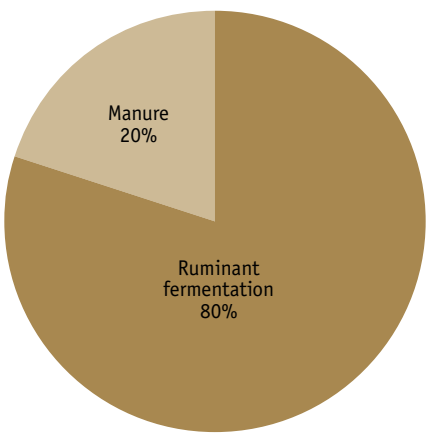
Seventy per cent of methane comes from human activities. The remaining 30% is from natural sources. Half of the 70% is from agriculture, and half of that is from livestock agriculture.

Of livestock methane, 80% comes from ruminant fermentation and 20% from manure.

Approximately half of the methane from agriculture comes from livestock operations.



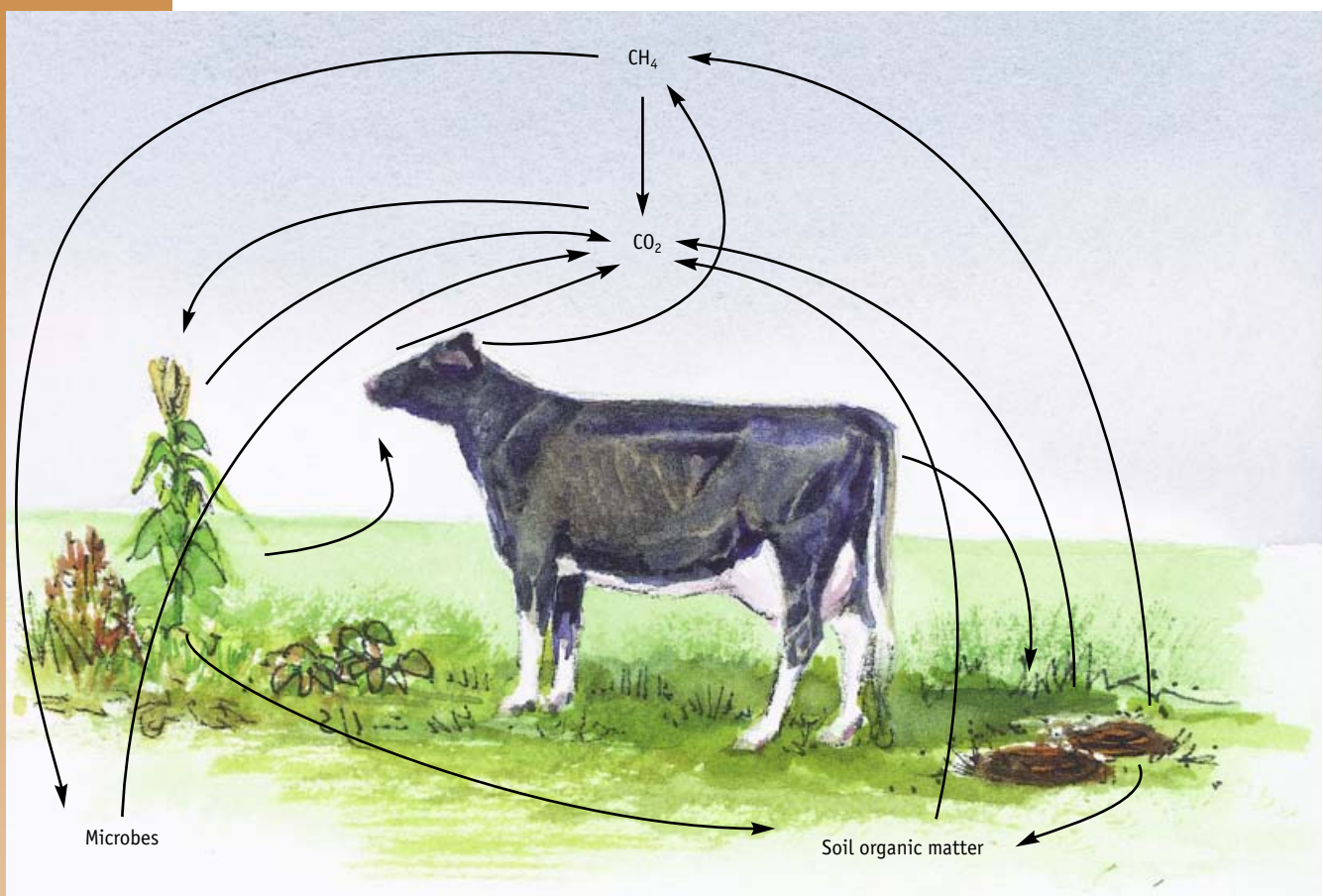
Livestock agriculture is the source of 25% of the methane emissions from human activities.



Eighty per cent of livestock methane emissions is from ruminant fermentation and 20% is from manure.

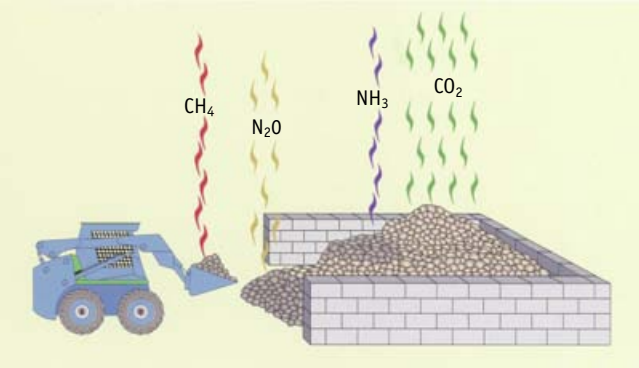
Microbes in the soil can convert up to 10% of atmospheric methane to carbon dioxide.

All types of livestock and poultry produce methane. Methane is a by-product of digestion – microbes that break down feed roughage emit methane. The greatest single source is ruminant livestock, e.g., cattle, sheep and goats. Their rumen, or fore stomach, ferments feeds, releasing methane and other gases. Cattle – by belching – generate most of the rumen-sourced methane from Ontario farms.



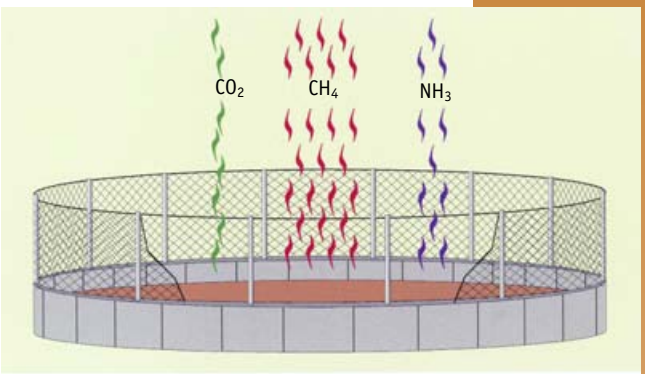
Carbon, in the forms of CH_4 and CO_2, is released by ruminants, decomposing manure, and decomposing soil organic matter. These losses can be reduced through improved management practices such as feeding strategies, as well as better manure handling and storage techniques.

Manure can decompose with or without oxygen. Either way, gases are released. With oxygen (i.e., aerobic environments such as solid manure stacks), microbes release carbon dioxide during decomposition. Without oxygen (i.e., anaerobic environments such as liquid storages, runoff storages and the wetter portions of solid manure stacks), methane is produced during decomposition.



Generally, the microbes in solid manure are aerobic and generate carbon dioxide. Methane and nitrous oxide are emitted from the wetter parts of solid manure piles.

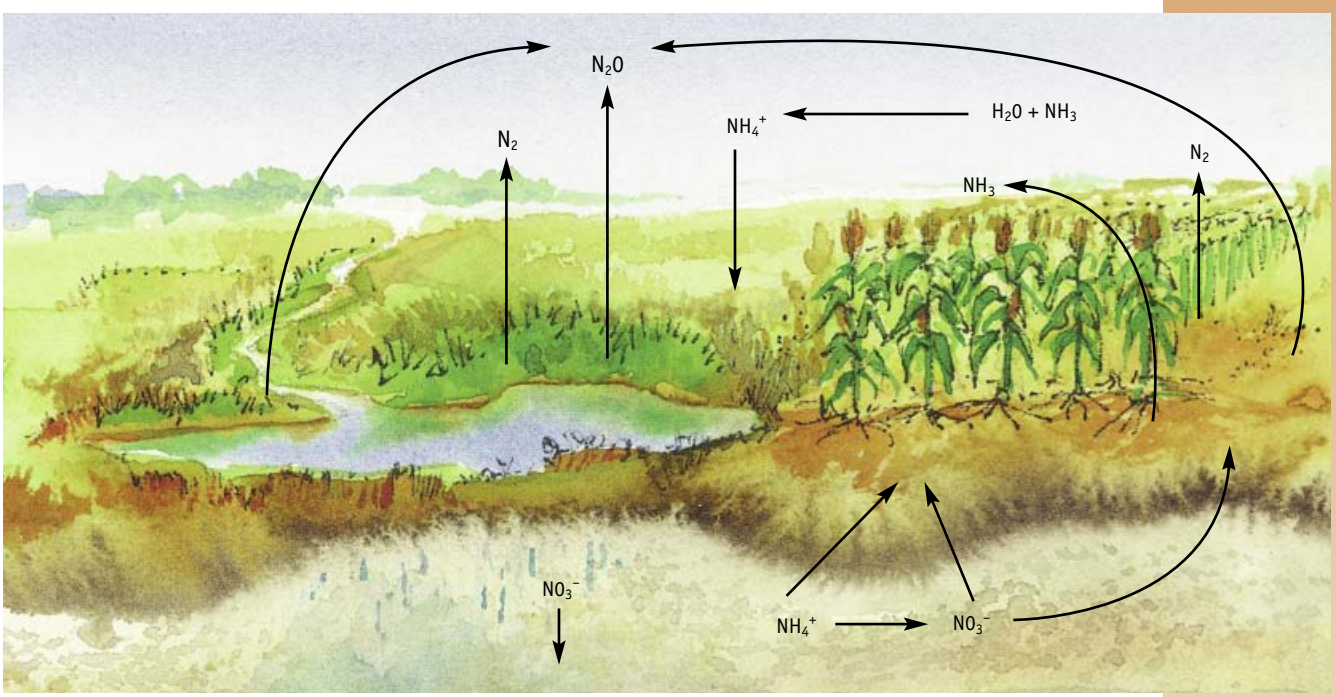
Methane and ammonia are emitted from liquid manure systems, which are mostly anaerobic.



NITROUS OXIDE (N_2O) GENERATION

Nitrous oxide or N_2O is the source of the largest share of greenhouse gas produced by agriculture. It's also the production component with the greatest opportunity for reductions.

There are two key sources of nitrous oxides from livestock production systems: **manure** and **soils**.



In agriculture, nitrous oxide (N_2O) is the greenhouse gas that has the most profound effect on climate change. There are two key sources: wet solid manure and partially denitrified N in soils.

NITROGEN (N) CYCLE

As nutrients, nitrogen and carbon are indispensable agents for promoting crop growth and soil health. Depending on how they're managed, nitrogen and carbon can also be significant sources of emissions.

As nitrogen cycles through the environment, some of it will be released as nitrous oxide. As carbon cycles through the environment, it can become either methane or carbon dioxide.

Nitrous oxide can be produced directly from decomposing manure – in storage and on the field. It can also be produced indirectly. Large amounts of N are lost as ammonia gas when manure is exposed to the air, either on the barn floor or in the field. Part of this ammonia can be converted to N_2O. Indirect losses also result from runoff to surface and ground water systems.

Wet, stacked solid manure is a source of nitrous oxides.

N_2O is produced in cropland soils as well. Denitrification – the conversion of plant-available nitrogen to nitrogen gases (including N_2O) – is caused by soil microbes in moist soils. Limiting excess available nitrogen in soils at any time is a key factor in limiting denitrification.

The rate of N_2O production from manure depends on storage system, temperature and manure type. The highest rates of nitrous oxide from manure come from a wet manure stack, with a large proportion of bedding, piled outdoors in warm weather.

The rate and extent of denitrification from soil depends on the concentration of oxygen in the soil. In stored manure, the rate and extent are determined by the amount of plant-available N and the amount of carbon.

When manure N is applied, it has two forms: organic N and inorganic N (NH_4^+). The organic N fraction is mineralized to form ammonium (NH_4^+), which can be used by the plant or nitrified. (Nitrification can also be a source of N_2O.)

In warm weather, nitrates in wet topsoil will emit nitrous oxides.

Nitrified N (NO_3^-) can be used by a crop or soil microbes, or lost from the system through leaching or runoff as NO_3^-. This nitrate can enter ground or surface water, directly or indirectly, only to be denitrified to nitrous oxide or nitrogen gas.

N_2O fluxes are sporadic. Much of the nitrous oxide from cropland and manure piles comes from thawing conditions of late winter and early spring.

AMMONIA (NH_3) GENERATION

Agriculture, especially livestock, is a significant source of ammonia (NH_3):

- ▶ livestock is the source of 81%
- ▶ fertilizers account for 19%.

Ammonia is reactive in the atmosphere:

$NH_3 + H_2O = NH_4^+ + OH^-$ (hydroxide)

NH_3 can be added to any moist surface or surface water (in acidic conditions) to form ammonium. In both soils and water, dissolved ammonium can be nitrified (i.e. changed to nitrate or NO_3^-) and then denitrified (source of greenhouse gas, N_2O).

In pig farms, up to 95% of the ammonia can be lost before reaching the field. Up to 40% can be lost in liquid storages.

THE KYOTO PROTOCOL

In December 1997, more than 160 countries negotiated binding limitations on greenhouse gases for the advanced industrialized nations. The outcome of the meeting was the Kyoto Protocol, which sets targets to reduce greenhouse gas emissions by at least 6.0% before 2012. It also describes several options available for signatories to meet the targets.

To meet the Kyoto Protocol, over 80% of the feasible potential improvements (at 10% adoption rates) are possible by the year 2010 in the livestock and poultry sector alone, according to climate change studies conducted by Agriculture and Agri-Food Canada.

Approximately 50% of the reductions could come from the adoption of BMPs for comprehensive manure and nutrient management, due to reduced methane and nitrous oxide emissions – as opposed to carbon sinks in cropland and forest conditions.

The sooner action is taken, the sooner positive impact will be realized. Waiting too long may make any action inconsequential!