Production and Mitigation of Greenhouse Gases in Agriculture

Jenifer Wightman
Cornell University
Ithaca, NY 14853
(jw93@cornell.edu)

How much does agriculture contribute to the total greenhouse gas emissions?
Globally, agriculture is responsible for 20% of the greenhouse gas emissions. In the United States, the national average from agriculture is 8%. In the case study below, NY dairy contributes about 2% of the states greenhouse gas emissions.

What are the greenhouse gases from agriculture?
Most of the global emissions come from the combustion of fossil fuels releasing carbon dioxide (CO_2), a greenhouse gas, to the atmosphere. Agricultural emissions come from other greenhouse gases, namely methane (CH_4) and nitrous oxide (N_2O) in addition to CO_2. While CH_4 and N_2O emissions are far less in quantity in the atmosphere, they have a much more potent impact on the climate.

In an effort to make greenhouse gas accounting simpler, the different gases were given weighted values according to their potency as a greenhouse gas. This potency of a gas is referred to as a Global Warming Potential (GWP) and their common unit is referred to as a carbon dioxide equivalent or CO_2e. As you can see below, two common agricultural gases, methane and nitrous oxide are 23 and 310 times more potent than carbon dioxide.

Different gases have different Global Warming Potential (GWP):
The potency of a greenhouse gas is referred to as its global warming potential.
The common unit is referred to as a carbon dioxide equivalent or CO2e.

carbon dioxide (CO_2) = 1 CO_2e
methane (CH_4) = 23 CO_2e
nitrous oxide (N_2O) = 310 CO_2e

To convert tons of methane to CO_2e, simply multiply by 23.

In the NY Dairy case study below, the impact of methane and nitrous oxide emissions from agricultural practices far outweigh on-farm carbon dioxide emissions from fossil fuel combustion.

NY Dairy Case Study: Identifying the source of greenhouse gas emissions on farm.
Dairy is the biggest agricultural industry in NY State. In an effort to identify how agriculture could mitigate its own emissions, an analysis of climate change gas emissions from the NY dairy herd was completed. In the chart below, an inventory of energy use and greenhouse gases was compiled for the 700,000 milking dairy herd plus young replacement stock in NY State using predominantly 1997 data. The production and transport of imported feed (soybeans, corn grain) was "charged" to the NY greenhouse gas budget. We calculated the energy required for

production of inputs in British Thermal Units (BTU) and we calculated the GHG emissions in CO_2 equivalents (CO_2e) from CO_2, CH_4 and N_2O (unpublished results).

NY DAIRY INDUSTRY	ENERGY		GREENHOUSE GASES	
700,000 milking cows	10^9 BTU	%BTU	tonnes CO_2e	%CO_2e
FEED				
Nitrogen	5,174	31%	1,281,679	20%
Phosphorus	298	2%	58,571	1%
Potassium	288	2%	31,456	0%
Lime	905	5%	252,127	4%
Herbicides	663	4%	43,477	1%
Insecticides	47	0%	2,277	0%
Tractors	3,933	24%	429,226	7%
Seed	1,369	8%	85,644	1%
FEED Total	12,678	76%	2,184,457	(34%)
Feed transport[1]	1,010	6%	73,874	1%
Milk transport[2]	1,617	7%	117,121	1%
Dairy farm electricity	2,202	10%	230,172	3%
Enteric CH_4			2,446,107	38%
Manure management				(23%)
CH_4			938,277	15%
N_2O direct			297,846	5%
N_2O indirect			223,384	3%
TOTAL for dairy system	17,507	100%	6,511,238	100%

[1] transport of imported feeds from out of state [2] transport of milk to processing plant only

Figure 1. Energy use and greenhouse gas emissions from various activities on farm

Cropping Growing the crops necessary for dairy farming accounted for 76% of the total system energy use. However, cropping contributes only 34% of the dairy farm greenhouse gases. If you are a crop farmer, you'll see right away that nitrogen production is the single greatest energy consumer and greenhouse gas generator. In considering *only* the greenhouse gases associated with the cropping system, nitrogen contributes nearly 60% of the greenhouse gas emissions with field machinery coming in second contributing 20% from fuel combustion.

Whole dairy system Combining the crops with the dairy, nitrogen emissions still contribute significantly with 20% of the total greenhouse gas emissions. However, when we add in dairy, the majority of the greenhouse gases are coming from enteric methane production followed by methane and nitrous oxide emissions from manure handling. It should be noted that different manure handling systems produce different amounts of greenhouse gas emissions, lagoons being the biggest producer of greenhouse gases and daily spread generating the least amount.

Nitrogen, Manure Management and Enteric Methane emissions are the major sources of GHGs.
The much greater global warming potential (GWP) from methane and nitrous oxide account for 75% of the overall farm accounting of GHG emissions as measured in CO_2equivalents.

Nitrogen Nitrogen is a significant source of GHG for two main reasons.
1) Producing commercial nitrogen is a very energy intensive process
2) After nitrogen is applied to the field, either as synthetic fertilizer or as manure, a certain percentage of it is volatilized off the field as N_2O at the time of application, this is referred to as

direct emissions. Indirect N_2O emissions are a fraction of the nitrogen that has leached through the ecosystem to another site. Limiting N in a cow's diet (and therefore manure) and conserving synthetic N applied to fields reduce N_2O emissions from agriculture (see Nitrogen Management by John Duxbury).

Enteric methane The gut of the cow is full of bacteria that produce methane. About 6% of the energy source of the cow is released as methane gas from the cow. Optimizing the diet not only improves the efficiency of the cow but also reduces the methane emissions.

Manure management, methane According to data from the US EPA, 20% of NY dairy manure was stored as liquid/slurry (lagoon) in 1992. This produced 16,067 metric tons of methane (CH_4) and accounted for 47% of NY state dairy manure methane emissions. To compare, daily spread which accounts for 70% of dairy manure handling, produced 14,058 metric tons of methane and accounted for 41% of the dairy manure methane emissions. Different manure management strategies address different environmental problems. See nitrogen section above for manure N emissions. For mitigation of lagoon methane, see *Anaerobic Digester: Methane Emissions and Carbon-Trading Opportunities* in Chapter 5.

Unlike society at large which contributes most of the anthropogenic greenhouse gases in the form of CO_2 from the combustion of fossil fuels, this study shows that 75% of emissions from NY Dairy is coming from CH_4 (53%) and N_2O (22%) and the remaining 25% is from energy-based CO_2.

~2% of NY's GHGs come from agriculture; ~90% come from fossil fuel combusted for energy. Mitigate farm GHG? Or displace fossil fuels with carbon neutral biofuels?

What can farmers and landowners do to mitigate their own emissions?
When it is all said and done, reducing nitrogen and energy use is the greatest way to save money and also mitigate climate change. Improving dairy cow diet will also improve methane and nitrous oxide emissions. Capturing and destroying methane created in manure lagoons would also reduce emissions. However, the greatest opportunity may be to farm for biofuels and displace the emissions from fossil fuel used by other sectors of society.

Summary
NY dairy contributes 6.5 Million Metric Tons of CO_2e to the atmosphere:

- 53% comes from CH_4, 22% from N_2O and 25% from CO_2.
- NY dairy accounts for ~2% of NY State Greenhouse Gas emissions.

To mitigate emissions from farm activities :

- Reduce nitrogen use
- Avoid anaerobic conditions for manure storage unless you can capture/destroy the CH_4
- Reduce energy demand and increase energy efficiency
- Regulate dairy diet to reduce N released in the manure, and reduce enteric CH_4

To mitigate emissions created off farm (90% of NY emissions come from burning fossil fuels):

- Crop biomass to displace fossil fuels used by society at large
- Manage woodlots for maximum forest growth and carbon sequestration and biomass fuel