Cornell University

Introduction to Farm & Forest Greenhouse Gas Mitigation Opportunities

Information Sheet #1: OVERVIEW

Jenifer Wightman & Peter Woodbury
Soil and Crop Sciences Section, School of Integrative Plant Science
College of Agriculture and Life Sciences, Cornell University

Fast Facts

- **Trends**: While carbon dioxide (CO_2) from fossil combustion accounts for about 80% of global greenhouse gas (GHG) emissions, methane (CH_4) and nitrous oxide (N_2O) are the primary source of GHG emissions on farms.
- **An imperative to act:** Methane impact on the atmosphere is 34 times more potent than CO_2 over 100 years (86 times more potent over 20 years). Nitrous oxide is 298 times more potent than CO_2 over 100 years. Small changes in these gases can have large impact.
- **A concern for implementation:** Climate change is changing temperature and weather with likely increase of rainfall intensity and droughts that affect agriculture.
- **An opportunity for proactive change:** While farms contribute GHG emissions, farms also have great potential to mitigate these emissions while providing other benefits such as energy savings, reduced air and water pollution, and increased profitability.

Introduction

Climate change caused by increased emission of greenhouse gases (GHG) to the atmosphere is an important issue that affects agriculture. Some agricultural practices emit GHG, while others reduce GHG emissions. Globally, agriculture is responsible for 20% of annual GHG emissions (IPCC, 2014). In the United States, agriculture is responsible for 8.3% of GHG emissions (US EPA, 2016). Agriculture can continue to advance management for reduced greenhouse gas emissions as a part of the global effort to curb climate change. For example, improving dairy diets has reduced enteric (methane-based) GHG emissions from dairy cows, and improved management of nitrogen fertilizer has reduced nitrous oxide emissions (a very potent GHG). Additionally, some agricultural practices have the potential to reduce GHG emissions from other sectors (e.g. bioenergy reducing emissions from fossil fuel electric generation, agricultural practices absorbing existing emissions by sequestering carbon in forests and soils).

Agricultural GHG emissions come primarily from three gases: methane (CH_4), nitrous oxide (N_2O), and carbon dioxide (CO_2). While CH_4 and N_2O emissions are much lower in volume than CO_2, these GHGs have a much greater ability to trap heat in the atmosphere. To simplify GHG accounting, each gas is assigned a value called the Global Warming Potential (GWP) that shows its ability to trap heat in the atmosphere compared to CO_2. The common unit for GWP is the carbon dioxide equivalent (CO_2e). Over a 100-year period, CH_4 and N_2O are 34 and 298 times more potent than CO_2, so they have GWP values of 34 and 298, respectively. Farms interested in mitigating emissions should focus on these three gases.

Concerns

Climate change, as a result of human activity (primarily fossil fuel energy use which releases carbon dioxide, or CO_2, into the atmosphere), has been observed globally and is projected to become more apparent throughout the next several decades. New York State agriculture is vulnerable to changing climate and market conditions, including:

- Crop responses to changes in regional temperature (frosts & heat waves)

- Variation in seasonal precipitation, including extreme weather events (floods & droughts)
- Distribution and variety of pests and pathogens in response to weather changes
- Increased temperatures affect crop and livestock production (including meat, eggs, dairy)
- Energy price fluctuations as a function of increased regulation of fossil CO_2 emissions

Summary of Regulation of GHG Emissions

While there are regulations on GHG emissions from the electric sector, there are no regulations of GHG emissions from agriculture. Action in this arena continues a tradition of farm stewardship. There are many exciting and pragmatic mechanisms for agriculture and forestry to proactively reduce GHG emissions, and government programs to assist in stewardship.

Goal

This Information Sheet is an introductory overview to help farmers, conservationists, educators, and farm advisors navigate voluntary methods for reducing GHG emissions from a variety of practices across different types of farms. We focus on key opportunities that have substantial co-benefits like improved profitability and yield (summarized below). There is a glossary and a variety of introductory Information Sheets across several area. For More In Depth information, please visit: http://blogs.cornell.edu/woodbury/publications/

A Selection of Potential On-Farm GHG Mitigation Strategies

Description of Strategy	Opportunities	Considerations
Dairy Feed and Manure Management (see Information Sheet #2)	Feed: Reduce nitrogen in animal feed to reduce N_2O emissions from manure storage, and improve diet efficiency to reduce total inputs and potentially reduce the enteric emissions of CH_4 from the cow. Manure: Cover, capture, & flare CH_4 produced by anaerobic storage of manure; consider improving livestock diet to reduce precursors for N_2O and CH_4 production.	Feed: Requires animal diet planning and testing of diet and manure. Manure: Cover and flare systems as well as Anaerobic Digester Systems have high capital costs and need maintenance.
Energy Conservation & Efficiency (see Information Sheet #4)	Energy conservation and improved efficiency reduce fossil fuel GHG emissions, and often reduce costs and increase profits.	Improvements may pay for themselves over a few years, but upfront costs may include a professional energy audit, capital & labor costs; some practices may increase energy use to achieve other types of profit & benefit.
N Fertilizer Management (see Information Sheet #5)	Precision N application (of manure and synthetic N) reduces N_2O emissions while maintaining crop yields if timing, source, and rate of application are carefully managed.	Requires careful record-keeping to account for past and current manure application rates, soil N supply potential, cropping history, yields, etc.
Soil Carbon Management (see Information Sheet #6)	Perennial crops, pasture, and forest root systems sequester soil carbon and use nutrients more efficiently than annual crops, reducing GHG emissions. Healthier soils retain more water, a benefit in both drought and flood conditions.	Soil carbon should not be considered permanent storage as it can be lost quickly with tillage, and GHG mitigation benefits are quickly lost if a long-term sod is plowed.
Forest Management (see Information Sheet #7)	Managing a forest sustainably for long-lived timber products and/or bioenergy can reduce GHG emissions by sequestering carbon in the forest, replacing high GHG-emitting concrete and steel with wood and/or replacing fossil fuels with bioenergy.	A forest management plan should be prepared by a professional forester, which costs money and requires management. The plan should be updated every 10 years.

Funders: This work was supported in part by the USDA National Institute of Food & Agriculture Project 2011-67003-30205, Hatch Projects 223995 and 1004302, McIntire Stennis Project 1000999, and by the NYS Soil & Water Conservation Committee's Climate Resilient Farming program.