TITLE

What does agriculture have to do with climate change?

ABSTRACT PAGE

The Issue

Agriculture is a major contributor of greenhouse gases, Certain management practices can substantially reduce greenhouse gas emissions, but these practices are not always economically viable for farmers.

Ecological Content

Oxidation of soil organic carbon due to agricultural management, sources of methane in agriculture, conversion of soil nitrogen to nitrous oxide, radiative forcing of greenhouse gases, carbon sequestration in agricultural soils, global warming potential from agricultural ecosystems. Other key words include carbon cycle, fertilizer, organic agriculture, no-till, carbon sources and carbon sinks.

Student-active Approaches

Turn to your Neighbor, Think Pair Share, Guided Class Discussion, Paired Think Aloud, Citizen's Argument

Student Assessments

Short Essay, Minute Paper, Land Management Activity

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Relevant Cover Image
Cover Image LTER Image Landscape

Cover Image Caption
Agricultural management practices in the Long Term Ecological Research (LTER) experiment at the W.K. Kellogg Biological Station (KBS) range from high intensity (Conventional Row Crop Management) to low intensity (Old Growth Forest). Many of these practices are visible in this mid-summer photo. Alfalfa, which will be harvested for animal feed, is growing in the foreground. Corn harvested for grain is growing on the right side of the photo while an old field successional plot is on the left side. Poplar trees, which are harvested for biomass, and hardwood forests are visible in the background. Photo taken from the W.K. Kellogg Biological Station Long Term Ecological Research website (www.lter.kbs.msu.edu).

OVERVIEW PAGE

What Is the Ecological Issue?
Agriculture provides important ecosystem services in the forms of food and fiber, but can also convey many disservices to agroecosystems themselves and to the ecosystems affected by agricultural practices. In particular, agricultural activities contribute substantial amounts of greenhouse gases, including more methane and nitrous oxide than any other human activity. For example, Duxbury (1994; PDF included) estimated that agriculture contributes 25%, 65% and 90% of all anthropogenic emissions of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), respectively.

Several processes identified below are responsible for greenhouse gas emissions in production agriculture:

- Fossil fuels are oxidized to provide energy for machinery involved in tilling, planting and harvesting.
- Initial cultivation of previously untilled soil results in substantial losses of carbon previously stored in soil organic matter (Robertson and Grace 2004). This occurs because tillage increases oxygen supply to soil organisms and exposes previously protected soil organic matter to decomposers.
- Inputs such as nitrogen fertilizer, irrigation and manure can increase plant productivity and soil carbon sequestration, but don't necessarily result in a net decrease in carbon dioxide emissions due to the fossil fuel energy requirements to provide these inputs (Schlesinger 1999; PDF included).
- Nitrogen fertilization and tillage decrease the amount of CH_4 sequestered by soils because of a decrease in the abundance of methanotrophic bacteria in soil (Goulding et al. 1995).
- Nitrogen fertilization and tillage increase the amount of N_2O given off to the atmosphere through the processes of nitrification and denitrification (Mosier et al. 1991).
- Nitrogen fertilizer is produced using energy from fossil fuels, and applications of nitrogen fertilizer can result in high nitrous oxide emissions.

Certain management activities have been shown to reduce agricultural greenhouse gas emissions after accounting for all inputs and emissions (i.e., Net Global Warming Potential) (Robertson et al. 2000; pdf included). For example, no-till agriculture reduces soil disturbance, thus increasing soil aggregation and decreasing available oxygen for decomposition. Growing winter cover crops increases net primary productivity and inputs of organic carbon to the soil. Perennial plants have expansive root systems and have long growth periods, thus increasing soil carbon storage (Cox et al. 2006).

In this activity, students investigate three sources of greenhouse gas emissions from agriculture, and how different cropping methods, including no-till, organic and perennialization, affect global warming potential. In addition, students will discuss potential trade-offs that limit the broad application of these practices and identify tactics that may aid in the reduction of global warming potential from agriculture. The PDFs of several articles are included as resources with this Figure Set.

These Figure Sets have been developed over a period of time when they were used to teach high school ecology students, incoming first year college students and high school science teachers. We believe that these activities could be used in a range of classes, from high school biology up to graduate level biogeochemistry. Material is presented in a format that can be used directly in class, but instructors may need to modify the Figure Sets to better fit their objectives.

References

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FIGURE SETS PAGE

Figure Set and Ecological Question	**Student-active Approach**	**Cognitive Skill**	**Class Size/Time**
1 Cultivation and Soil Carbon losses (Robertson and Grace 2004)	Turn to Your Neighbor	Knowledge, interpretation, application	Any / Moderate
2 Methane Emissions from Agriculture (Moss et al. 2000; IPCC 2007)	Think Pair Share	Knowledge, interpretation	Any / Short
3 Nitrogen Fertilizers Increase Nitrous Oxide Emissions (McSwiney and Robertson 2005; IPCC 2007)	Guided Class Discussion	Knowledge, interpretation, synthesis	Any / Short
4 Carbon Sequestration in Degraded Agricultural Soils (Robertson et al. 2000)	Paired Think Aloud	Knowledge, interpretation, synthesis	Any / Short
5 Global Warming Potential – Temperate Agriculture (Robertson et al. 2000)	Citizens Argument	Knowledge, interpretation, analysis, synthesis	Small (can be adapted to large classes) - Long

Resources

Suggested Textbook

Schlesinger, W. H. 1997. *Biogeochemistry: An analysis of global change*. Academic Press, San Diego.

Online resources

Chicago Climate Exchange:
http://www.chicagoclimatex.com/

Ecological Society of America - Issues in Ecology:
http://www.esa.org/science_resources/issues.php

Intergovernmental Panel on Climate Change Website
http://www.ipcc.ch/

Michigan Greenhouse Gas Emissions Calculator for agroecosystems:
http://lter.kbs.msu.edu/carboncalculator/

- The W.K. Kellogg Biological Station is in Kalamazoo County

Purdue University - Using Agricultural Land for Carbon Sequestration:
http://www.agry.purdue.edu/soils/Csequest.PDF

USDA NRCS Global Climate Change Website
http://soils.usda.gov/survey/global_climate_change.html

U.S. Environmental Protection Agency Climate Change website:
http://www.epa.gov/climatechange/index.html

U.S. Environmental Protection Agency Methane website:
http://epa.gov/methane/

U.S. Environmental Protection Agency Nitrous Oxide website:
http://www.epa.gov/nitrousoxide/index.html

W.K. Kellogg Biological Station Long Term Ecological Research website:
http://lter.kbs.msu.edu/