Farm Foundation

Issue Report

Agriculture, Forestry and Greenhouse Gases

Research provides insights for public policy

Climate change and policy options to mitigate climate change have the potential to affect agriculture, forestry and their land-use interrelationships. Climate change may influence future U.S. production conditions, potentially shifting optimal production regions north, and causing wider variability in annual weather conditions.

Policies adopted to reduce greenhouse gas (GHG) emissions could also influence land use, and the availability or desirability of a number of current management practices in forestry and agriculture. Both climate change impacts and mitigation policies will impact the agriculture and forestry sectors in the near and long term.

Since 1900, the earth's climate has warmed by about 1°F and may warm by as much as 10°F over the next 100 years, according to projections by international scientific bodies, such as the Intergovernmental Panel on Climate Change. The scientific community attributes this climate change to increases in GHG emissions, such as carbon dioxide (CO_2), florinated gases (e.g., HFCs), methane (CH_4), and nitrous oxide (N_2O).

Currently, most human-generated GHG emissions are the result of electricity generation and petroleum consumption. According to the U.S. Environmental Protection Agency, 86% of U.S. GHG emissions in 2003 were from electricity generation and petroleum. About 6% of total emissions were emitted from agricultural practices and soils. Forest ecosystems provide substantial sinks for carbon dioxide, i.e. withdrawing and storing atmospheric carbon dioxide in biomass and soils.

Agriculture and forestry mitigation alternatives to reduce or offset GHG emissions are appealing because they are more cost-effective than many current options in other sectors. Agricultural and forestry activities can reduce atmospheric buildup of carbon dioxide, methane and nitrous oxide in three basic ways:

- *Sequestration:* Carbon dioxide can be removed from the atmosphere and sequestered, or stored, in soils, biomass and harvested products, which can act as carbon sinks.

- *Emissions reduction:* Carbon sequestered in soils and biomass can be protected and preserved instead of emitted to the atmosphere. Agricultural methane and nitrous oxide emissions can be reduced with modifications in livestock and cropland management, such as feed management, manure management, fertilizer use,

tillage practices, crop selection and water management. Emissions of CO_2 can be indirectly avoided by reducing the use of energy-intensive inputs.

- *Fossil fuel substitution:* In the production of electricity, net CO_2 concentrations can be lowered by replacing fossil fuels with biofuels produced in the agricultural and forest sectors. When biofuels are used, CO_2 is essentially recycled in the atmosphere—carbon is stored in biomass throughout its growth stage and released during energy production. In contrast, fossil fuel combustion releases energy that would otherwise be stored below ground in coal, gas and petroleum deposits.

Mitigation strategy	Strategy type	GHG affected CO_2	CH_4	N_2O
Afforestation	Sequestration	X		
Rotation length	Sequestration	X		
Timberland management	Sequestration	X		
Deforestation (avoided)	Sequestration	X		
Biofuel production	Fossil fuel substitution	X	X	X
Crop mix alteration	Emission reduction, Sequestration	X		X
Rice acreage reduction	Emission reduction		X	
Crop fertilizer rate reduction	Emission reduction	X		X
Other crop input alteration	Emission reduction	X		
Crop tillage alteration	Sequestration	X		
Grassland conversion	Sequestration	X		
Irrigated/dry/land conversion	Emission reduction	X		X
Livestock management	Emission reduction		X	
Livestock herd size alteration	Emission reduction		X	X
Livestock system change	Emission reduction		X	X
Liquid manure management	Emission reduction		X	X

Source: "Overview of Agricultural and Forestry GHG Offsets on the U.S. Landscape," *Choices*, 3rd Quarter 2004.

Mitigation Programs

In North America, a variety of mitigation policies and programs are being developed. These include state and private-sector GHG reduction and trading programs, recognition of climate benefits in federal conservation programs, and the Bush Administration's current revision of rules for the Department of Energy's (DOE) 1605(b) Voluntary Greenhouse Gas Registry Program. The Canadian government is developing an emissions offset credit system, including forestry and agriculture, to help meet its international GHG reduction commitments in the Kyoto Accords.

The United States is not part of the Kyoto Accords, but has incorporated GHGs into USDA conservation programs, for example, through the Conservation Security Act. USDA provides targeted incentives to encourage wider use of land management practices that remove carbon from the atmosphere or reduce emissions of GHG. USDA's forest and agriculture conservation programs, such as the Environmental Quality Incentives Program (EQIP) and Conservation Reserve Program (CRP), encourage the increased use of biomass energy, crop and grazing land conservation actions, practices to reduce emissions from agriculture, and sustainable forest management.

The DOE's 1605(b) Voluntary Greenhouse Gas Registry Program guidelines is a voluntary tool landowners can use to quantify and record the benefits of actions they take to reduce GHG emissions or increase carbon uptake. Those may include:

- Using no-till or low-tillage cropping practices to increase soil carbon sequestration;
- Installing methane digesters to capture and use methane gas from stored manure for electricity production, rather than fossil fuels;
- Improving nutrient management and lowering fertilizer use through precision cropland application techniques to reduce nitrous oxide emissions; and
- Managing forestland harvests and tree growth to reduce carbon dioxide emissions and increase sequestration in both soil and tree biomass.

However, no cohesive vision has emerged as to how the activities of forestry and agriculture might be consistently included in voluntary registries or emissions trading regimes. If forestry and agriculture are to meaningfully participate in mitigation, a number of policy issues and concerns need to be addressed.

Canada and the United States are working through related issues of their respective climate policies. For example, Canada's Large Final Emitters (LFEs) in energy and industry are responsible for about one-half of Canada's GHG emissions. To provide LFEs with flexibility in meeting emissions reduction requirements, Canada is developing an offset system that would allow LFEs to develop mitigation projects in agriculture, forestry or land fill to offset emissions.

The DOE's 1605(b) guidelines also provide opportunities for agriculture and forestry to: partner with industry GHG emitters seeking emissions offsets; establish a documented report of GHG mitigation activities that may be used in future registry or reduction programs; and link reporting with conservation programs. Creating a new market to trade emissions has proven complex, however, progress has benefited from scientific research and modeling.

Modeling Policy Options

The 2004 Forestry and Agriculture Greenhouse Gas Modeling Forum (See *Source*, page 4) used a case study approach to examine how to integrate biophysical, economic and policy analyses into credible mitigation programs. Three case studies of varying combinations of GHG mitigation activities and locales were developed: cropland soils in Canadian Prairies; soils in the U.S. Corn Belt; and afforestation—establishing forests on land that previously was not forests—in the Mississippi Alluvial Valley. Each case assumed a hypothetical scenario of a large program, e.g., portfolio of individual field-level mitigation projects. For each case study, teams of scientific and policy experts identified and evaluated the technical, economic and implementation aspects of mitigation activities, and identified research and data gaps. Five key issues emerged:

1) Forests and agriculture have a potentially promising role in mitigating climate change in the U.S. and Canada. Field-level observation and modeling of biophysical processes have successfully defined physical relationships between GHG emissions and land management activities, and identified key variable.

These variables include soil carbon responses to tillage practices, nitrous oxide responses to synthetic and organic fertilizer use, and forest biomass carbon dynamics by species and age. Economic modeling of direct and indirect land-use revenues and costs has used this biophysical information to estimate regional and national aggregate emissions and mitigation opportunities.

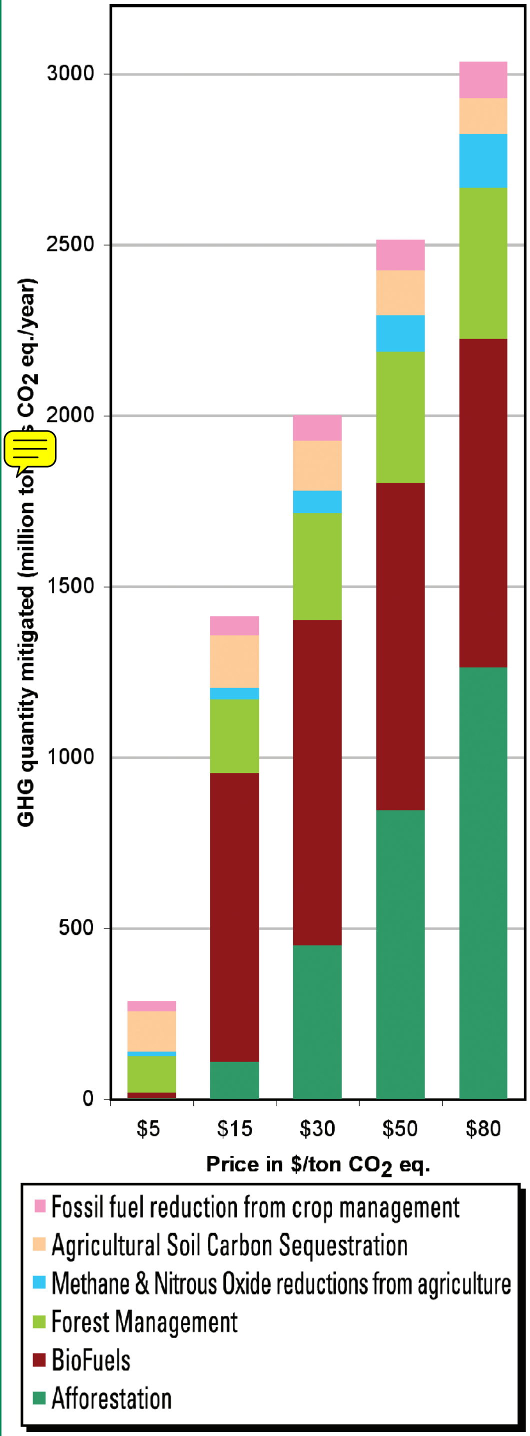
Multiple private and public land-based mitigation approaches are technically feasible and could be economically viable. Agricultural and forest land could play a fairly important role in U.S. and Canadian climate policies. That role is dependent on the eventual market value of carbon in an emerging market, with estimates ranging from $1 to $80 per metric ton of CO_2, or about $4 to $300 per ton of carbon.

2) Important implementation issues may impact forest and agricultural mitigation opportunities and policy effectiveness. A critical next step is to understand how forestry and agriculture can fit into voluntary GHG registries or emissions trading schemes. A variety of project and policy design implementation issues affect the marketability of mitigation projects and quantification of marketable GHG commodities. Additional modeling could generate more information to aid policy design and analyze alternatives, including:

- Select sets of eligible activities and GHGs for mitigation programs.
- Account for net GHG effects for activities that affect multiple GHGs.
- Distinguish between mitigation emission reductions and emission changes that would occur anyway, i.e., the baseline or business as usual.
- Identify and quantify leakage effects where mitigation leads to increased emissions elsewhere.
- Estimate mitigation project activity transaction costs and barriers to adoption.
- Characterize the precision and cost implications of emissions measurement and monitoring alternatives
- Identify key biophysical variability and define acceptable confidence intervals for market quantification.
- Characterize the risks of sequestered carbon loss.
- Assign long-term maintenance responsibility for sequestered carbon.

3) *Emerging carbon markets are likely to require project-level analysis tools, guidance and methods to assure credible offsets.* The DOE 1065(b) program has taken significant steps to collect market-appropriate data by developing a project scale registry. Additional work is needed on measurement, monitoring and reporting programs that can generate estimates of mitigation benefits sufficient for the requirements of investors in a carbon market.

New on-line tools are also being developed that use large-scale biophysical modeling to provide landowners with estimates of the GHG emissions and sequestration effects from changes in management activities. For example, USDA's Voluntary Reporting of Greenhouse Gases-CarbOn Management Evaluation Tool (COMET-VR) calculates annual carbon fluxes, given historic and



Source: "Overview of Agricultural and Forestry GHG Offsets on the U.S. Landscape," *Choices*, 3rd Quarter 2004.

projected land conditions and management *(http://www.cometvr.colostate.edu/)*. USDA Forest Service's Carbon On Line Estimator (COLE) can estimate forest carbon for any area of the continental United States *(http://ncasi.uml.edu/COLE/index.html)*. Other national models appear to have the potential to be down-scaled to sub-regional levels to provide additional biophysical and economic data for more comprehensive project evaluation.

4) *Evaluation of non-GHG benefits and non-climate policies will be important to forest and agricultural climate policy.* Researchers have begun to develop biodiversity indicators on sequestration projects. Tools are also being developed to evaluate the GHG implications of non-climate land management policies, such as fire and water quality management. Policy makers need the capacity to evaluate the interaction between climate and non-climate policies, and the effects on both GHG and non-GHG benefits, such as soil erosion, water quality and biodiversity.

5) *Climate change impacts on forest and agricultural productivity will alter mitigation opportunities.* Climate change has implications for GHG mitigation alternatives. Climate change could redefine the opportunity costs of land management alternatives and the environmental emissions conditions; resulting in changes in the costs and effectiveness of mitigation actions. Studies indicate that climate change may alter the productivity of agriculture and forests, shifting resource management, and ultimately production nationally and regionally as landowners adapt to the changing environmental and economic conditions. For example, in areas where climate change increases timber growth, larger timber volumes will be available for harvest in existing forest stands and those regenerated in the future. This might affect the direction and rates of land-use change across the two sectors.

The Source

This *Issue Report* is a summary of the 2004 Forestry and Agriculture Greenhouse Gas Modeling Forum. The forum, first organized in 2001, is a means for researchers, analysts and policy-makers to exchange information, and to develop enhanced approaches for modeling agricultural and forestry land use, land-use change, and activities to reduce GHG emissions and/or preserve and sequester carbon. The Forum works to provide North American policy makers with science-based information from modeling economic and biophysical processes related to GHG mitigation. Farm Foundation, the U.S. Environmental Protection Agency, the U.S. Department of Agriculture's Forest Service, and Agriculture and Agri-Food Canada sponsor the forum *(foragforum.rti.org)*. Contributing authors for this *Issue Report* are Kenneth Andrasko, Steven Rose, Ralph Alig, Jan Lewandrowski, Robert MacGregor and Brian Murray.

Summary

Significant biophysical potential exists for U.S. forest and agricultural mitigation options such as cropland soil carbon management, development of new forests, forest management, and the reduction of methane and nitrous oxide emissions from livestock and fertilizer use. A key question is how, through specific regional and national mitigation programs, to accurately integrate forest and agricultural mitigation into broader climate change policy in energy and other sectors. Research is needed on forest and agriculture mitigation implementation issues; integration and evaluation of carbon and non-carbon benefits under climate and non-climate policies; and forest and agricultural responses to potential climate changes.

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Farm Foundation's mission is to improve the economic and social well-being of U.S. agriculture, the food system and rural communities by serving as a catalyst to assist private- and public-sector decision makers in identifying and understanding forces that will shape the future.

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This publication is intended to be a vehicle to stimulate discussion and debate about challenges facing agriculture and rural America.