Greenhouse Gas Mitigation Potential in U.S. Forestry and Agriculture

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Executive Summary

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Forestry and agricultural activities are widely recognized as potential greenhouse gas (GHG) mitigation options. Activities in forestry and agriculture can reduce and avoid the atmospheric buildup of the three most prevalent GHGs directly emitted by human actions: carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). The removal of atmospheric CO_2 through sequestration in carbon "sinks" is a mitigation option in forestry and agriculture that has received particular attention.

Currently in the United States, forest and agricultural lands comprise a net carbon sink of almost 830 teragrams (Tg or million tonnes[1]) of CO_2 equivalent (or nearly 225 Tg of carbon equivalent) per year, according to the U.S. GHG inventory (EPA 2005). Removal of atmospheric CO_2 through carbon sequestration is greater than CO_2 emissions from events such as forest harvests, land conversion to other uses, or fire. The U.S. net carbon sink—over 90 percent of which occurs on forest lands—currently offsets 12 percent of U.S. GHG emissions from all sectors of the economy on an annual basis (EPA 2005). The agriculture sector, however, is a net emitter of GHGs. Agricultural CH_4 and N_2O emissions are responsible for over 6 percent of all annual U.S. GHG emissions (EPA 2005). After accounting for both carbon sequestration and non-CO_2 emissions, the forest and agriculture sectors comprise a net GHG sink that offsets almost 6 percent of total U.S. GHG emissions.

This report evaluates the potential for additional carbon sequestration and GHG reductions in U.S. forestry and agriculture over the next several decades and beyond. It reports these reductions as changes from baseline trends, starting in 2010 and projected out 100 years to 2110. The report employs the Forest and Agriculture Sector Optimization Model with Greenhouse Gases (FASOMGHG). FASOMGHG is a partial equilibrium economic model of the U.S. forest and agriculture sectors, with land use competition between them, and linkages to international trade. FASOMGHG includes most major GHG mitigation options in U.S. forestry and agriculture; accounts for changes in CO_2, CH_4, and N_2O from most activities; and tracks carbon sequestration and carbon losses over time. It also projects a dynamic baseline and reports all additional GHG mitigation as changes from that baseline. FASOMGHG tracks five forest product categories and over 2,000 production possibilities for field crops, livestock, and biofuels for private lands in the conterminous United States broken into 11 regions. Public lands are not included.

FASOMGHG evaluates the joint economic and biophysical effects of a range of GHG mitigation scenarios, under which costs, mitigation levels, eligible activities, and GHG coverage may vary. The six scenarios evaluated in this report are constant GHG prices, rising GHG prices, fixed national mitigation levels, inclusion of selected mitigation activities only, incentive payments for

[1] A tonne is a metric ton, which equals one megagram (Mg). 1 tonne CO_2 = 0.27 tonnes of carbon. 1 tonne of carbon = 3.67 tonnes of CO_2.

CO_2 only, and payments on a per-acre versus per-tonne basis. GHG mitigation incentives are estimated by dollars per tonne of CO_2 equivalent (\$/t CO_2 Eq.) payments for four of the six scenarios above. The model and analysis cover the 100 years from 2010 to 2110, but three focus dates are highlighted: 2015, 2025, and 2055. FASOMGHG's standard GHG accounting and payment approach is a comprehensive, pay-as-you-go system, for all applicable GHGs and activities over time.

The analysis reported here is unique from other studies conducted on forestry and agricultural mitigation options on a number of fronts. First, the range of covered activities across the sectors is wide. Most comparable studies look at just one of the sectors or at one or a small subset of activities within each sector, while this report examines a fairly comprehensive set of activities across the two sectors covering a vast majority of all GHG effects. Of particular note are the inclusions of biofuels and non-CO_2 mitigation options in agriculture. Second, the intertemporal dynamics of the economic and biophysical systems within FASOMGHG allow for an accounting of mitigation over time and by region, and for quantification of leakage effects that other studies generally have not produced. And third, the inclusion of non-GHG co-effects allows insights into the multiple environmental and economic tradeoffs that pertain to GHG mitigation in these sectors.

Highlights of the analysis include the following:

GHG reduction incentives can generate substantial mitigation from the U.S. forest and agriculture sectors especially in the first few decades. Total national mitigation annually is estimated to average almost 630 Tg CO_2/yr (170 Tg C) in the first decade and 655 Tg CO_2/yr (180 Tg C) by 2025, under one of the moderate GHG prices considered (\$15 t/CO_2 Eq, or \$55/t C, remaining constant over time). Mitigation then declines to about 85 Tg CO_2/yr (23 Tg C) by 2055. The rate of annual mitigation (i.e., occurring in a given year) declines over time, as the result of saturating carbon sequestration (to a new equilibrium) in forestry and agriculture and carbon losses after timber harvesting. Cumulative GHG mitigation (i.e., achieved in the years up to a given year), however, steadily increases for constant price scenarios.

If GHG prices rise over time, however, GHG mitigation is shown to start low and increase over time. Farmers and foresters who want to optimize their returns from any GHG payments are assumed to know that GHG prices will rise in future decades and may delay mitigation practices until prices rise. The mitigation timing results, however, are sensitive to the FASOMGHG model's assumptions about landowner knowledge of future price behavior, known as perfect foresight.

The optimal portfolio and timing of mitigation strategies are affected by the GHG price levels. At relatively low GHG prices (≤\$5/t CO_2 Eq.) and in early years, carbon sequestration in agricultural soils and carbon sequestration in forest management (i.e., harvest and regrowth practices) are the dominant mitigation strategies. Afforestation becomes the leading strategy at middle to higher prices (≥\$15/t CO_2 Eq.) in the early to middle years to 2050, but both afforestation and sequestration in agricultural soils get reversed by 2055, because of carbon saturation, harvesting, and practice reversion. Biofuels dominate the portfolio at the highest prices (\$30 and \$50/t CO_2 Eq.) and in later years beyond 2050.

Agricultural CH_4 and N_2O mitigation is a relatively small but steady part of the mitigation portfolio. Biofuels and agricultural CH_4 and N_2O mitigation are permanent emissions reductions (i.e., they do not face the risk of GHG benefit reversal).

Mitigation potential is likely to have a regional, uneven distribution. The South-Central, Corn Belt, and Southeast regions possess the largest competitive potential to generate GHG mitigation, while the Rockies, Southwest, and Pacific Coast regions generate the least mitigation. Forest management in the South-Central region generates the most GHG mitigation, followed by agricultural soil carbon seques¬tration in the Corn Belt, Lake

States, and Plains, in low, constant price scenarios. Afforestation in the South-Central and Corn Belt regions is dominant at higher price scenarios. Biofuels become a significant part of the mitigation portfolio at high prices and occur primarily in the Northeast, Southeast, and South-Central regions.

If a national GHG mitigation quantity in a given year is an objective, but economic incentives do not continue after that date, then carbon sequestered in previous decades is likely to be reversed. Landowners return to other, more economically attractive land management choices when GHG incentives disappear.

Leakage of GHG benefits from management activities in one region to other regions may be significant in scenarios where only selected activities (e.g., afforestation) are eligible for inclusion in a mitigation scheme. This leakage may vary by activity, by region, and over time. Agricultural activities, including soil carbon sequestration, appear to have minimal leakage, however (less than 6 percent).

Large changes in land use and production due to mitigation activities can have substantial non-GHG environmental co-effects. Even a low GHG price (e.g., $5/tonne) can induce changes in tillage practices and promote agricultural soil carbon sequestration at a significant scale. Tillage practice changes also reduce erosion and nutrient run-off into waterways as a co-benefit, but can lead to a modest increase in pesticide use as a co-cost. Taking environmental co-effects into consideration could affect the relative attractiveness of competing mitigation options. In general, the more aggressive the mitigation action, the more likely that co-effects may factor into the net benefits of GHG mitigation.

Several key issues related to the design of an incentive system can affect the magnitude, timing, and duration of GHG benefits and cost. These issues include if, and how, baseline setting, leakage of GHG benefits, and the risk of reversal of carbon management mitigation are addressed. Another key issue is how mitigation is quantified and reported. Use of cumulative mitigation (i.e., total mitigation to some future date) rather than annual mitigation (i.e., in a given year) may more accurately summarize the net GHG contribution of forest or soil carbon management activities that face some risk of reversal. Other considerations include which activities are eligible for inclusion, payment options (per acre versus per tonne), and the potential adjustment of mitigation benefits to account for reversal risk, leakage, and baseline additionality.