Estimating U.S. Forest-Agriculture Climate Change Mitigation: Summary of Report "Greenhouse Gas Mitigation Potential in U.S. Forestry and Agriculture"

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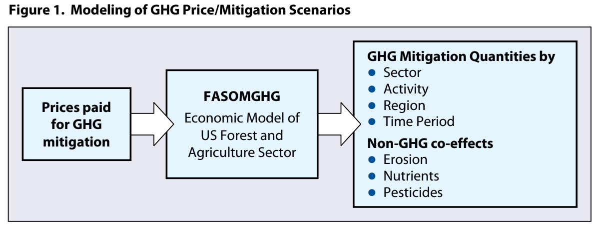
1. Problem Statement

The land-based sectors of forestry and agriculture can contribute to GHG mitigation efforts by incorporating practices that sequester and maintain carbon in terrestrial pools and by reducing the emissions of greenhouse gases (GHGs) (primarily CO_2, CH_4, and N_2O) from production activities. U.S. forest and agricultural lands currently comprise a net carbon sink of 830 Tg CO_2 equivalent per year (for 2003), 90 percent of which is in forests, and offer significant potential for further GHG mitigation. The purpose of this study is to estimate the magnitude, location, timing, cost, and non-GHG environmental co-effects of the key forest and agricultural sector GHG mitigation options within the conterminous United States over the next 50–100 years.

2. Methods for Estimating Competitive Economic Mitigation Potential in Forestry and Agriculture

The Forest and Agricultural Sector Optimization Model (FASOMGHG) is used to assess net GHG mitigation potential through the lens of economic, climate policy (e.g., baseline, leakage), and co-benefit (e.g., water quality) factors. Results for 2010–2110 (and focus years 2015, 2025, and 2055), are presented for six scenarios covering constant and rising GHG prices; fixed national mitigation levels; selected mitigation activities; and various incentive payment systems. The FASOMGHG model is a price endogenous dynamic optimization model of the US forest and agricultural sectors with greenhouse gas quantification that has been developed by a team of researchers from Texas A&M University, Oregon State University, USDA Forest Service, and RTI International. More information on the FASOMGHG model can be found at (http://agecon2.tamu.edu/people/faculty/mccarl-bruce/FASOM.html)

Figure 1. Modeling of GHG Price/Mitigation Scenarios



3. Mitigation Results at the National Level

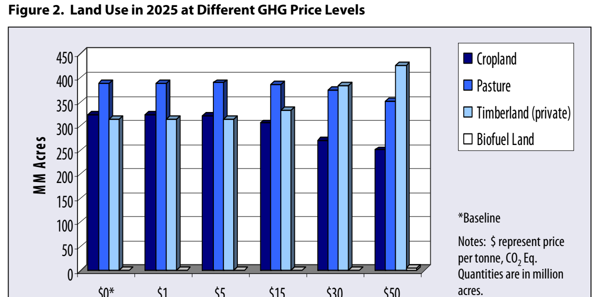
Core Price Scenarios. FASOMGHG evaluates mitigation potential from these sectors at cost scenarios of \$1-50 per tonne (Mg) of CO_2 equivalent, subject to constant and rising prices over time.

Table 1. Cost Price Scenarios

Scenario	Initial Price in 2010 ($/t CO_2 Eq.)	Annual Price Growth	Price Cap
Constant Prices	\$1	0	None
	\$5	0	None
	\$15	0	None
	\$30	0	None
	\$50	0	None
Rising Prices	\$3	1.5%/yr	None
	\$3	4%/yr	\$30
	\$20	\$1.30/yr	\$75

The price incentives change the way land is allocated across the major uses tracked in the model. Land is shifted from land uses that emit more carbon and GHGs (e.g., cropland) to those that sequester more carbon and emit less GHGs (timberland). At high GHG prices, changes in land use (e.g., afforestation) can be significant (over 100 million acres).

Figure 2. Land Use in 2025 at Different GHG Price Levels



Material in this poster is derived from the report, *US Environmental Protection Agency. 2005. Greenhouse Gas Mitigation Potential in U.S Forestry and Agriculture*, EPA 430-R-05-006. Office of Atmospheric Programs, Washington DC. Soon available at: www.epa.gov/sequestration.

3. Mitigation Results at the National Level (cont'd)

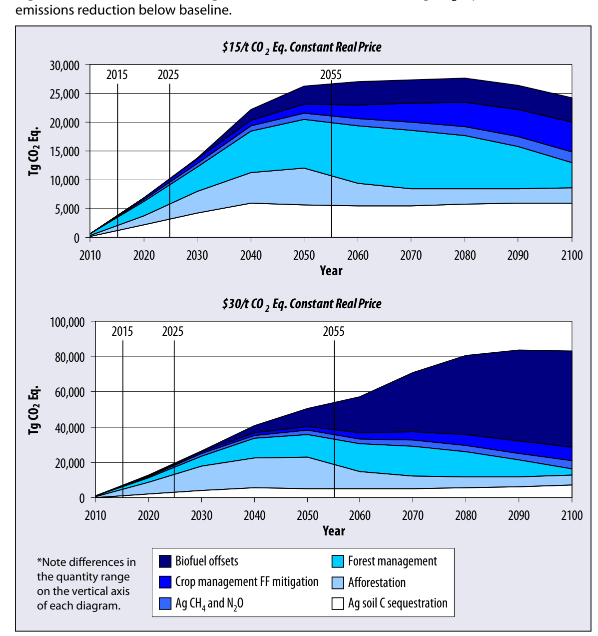
The magnitude and activity composition of the mitigation portfolio varies with the size of the GHG reduction incentive. Mitigation quantities range from just over 100 million tonnes (Tg) of CO_2 equivalent per year (annualized) at a GHG price of \$1 per tonne, to over 2 billion tonnes of mitigation (over one-quarter of net US GHG emissions) at a GHG price of \$50. Agricultural soil carbon sequestration dominates the mitigation portfolio at the lowest prices (costs), forest management takes over at middle prices, and afforestation and biofuels are the most effective option at the high end of the incentive price spectrum.

Table 2. National GHG Mitigation Totals by Activity: Annualized Averages, 2010–2110. Quantities are Tg CO_2 Eq. per year net emissions reduction below baseline, annualized over the time period 2010–2110.

	Constant Prices Over Time				
Activity	\$1	\$5	\$15	\$30	\$50
Afforestation	0.0	2.3	137.3	434.8	823.2
Forest management	24.8	105.1	219.1	314.2	384.8
Agricultural soil carbon sequestration	62.0	122.7	168.0	162.4	130.6
Fossil fuel mitigation from crop production	20.5	31.9	53.1	77.6	95.7
Agricultural CH_4 and N_2O mitigation	9.4	15.2	32.0	66.8	110.2
Biofuel offsets	0.0	0.1	57.2	374.6	560.9
All Activities	116.8	277.3	666.7	1,430.4	2,105.4

Effects vary over time. GHG mitigation benefits accumulate steadily for several decades, then taper off as sequestration potential "saturates" toward a new biophysical equilibrium, and timber harvests reintroduce sequestered carbon to the atmosphere. Non-CO_2 reductions, however, do not reverse and are thereby viewed as "permanent" reductions.

Figure 3. Cumulative GHG Mitigation over Time. Quantities are Tg CO_2 Eq. cumulative net emissions reduction below baseline.



Rising vs Constant Price Incentives. When GHG price incentives rise, this means reductions are more valuable in the future than today. This provides an incentive for delayed mitigation actions. Under rising GHG prices, mitigation effects rise over time rather than saturate and reverse as can be found under constant price scenarios.

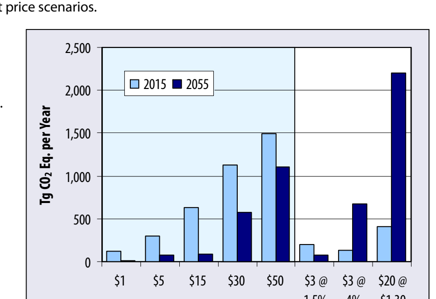
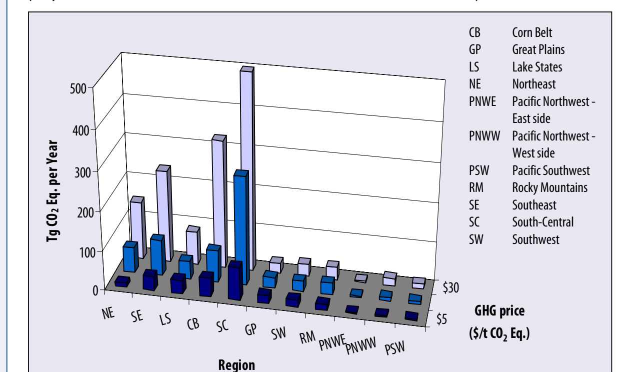


Figure 4. Constant-Price Scenarios vs. Rising-Price Scenarios and GHG Mitigation. Quantities are Tg CO_2 Eq. per year net emissions reduction below baseline for 2015 and 2055.

4. Regional Results

Mitigation potential is not regionally uniform. The FASOMGHG model separates results across 11 regions within the conterminous United States. South-Central, Corn Belt, and Southeast regions possess the largest GHG competitive potential; Rockies, Southwest, and Pacific Coast the least.

Figure 5. Total Forest and Agriculture GHG Mitigation by Region. Quantities are Tg CO_2 Eq. per year net emissions reduction below baseline, annualized over the time period 2010–2110.



5. Leakage Potential

Project-based mitigation approaches run the risk that some of the direct GHG benefits of these efforts will be undercut by leakage of emissions outside the boundaries of the project. Leakage is relevant for assessing the effectiveness of programs that target a subset of land-based activities such as afforestation, biofuels, or agricultural soil carbon sequestration. Leakage is calculated as a percentage of the direct benefits, accordingly:

$$\text{Leakage percent} = \frac{\text{Indirect GHC emissions from nontargeted activity}}{\text{Direct GHC emissions from targeted activity}} * 100.$$

At an aggregate level, leakage affects are of greatest concern for afforestation activity, a modest concern for agricultural soil carbon sequestration, and of little concern for other activities.

Table 3. Leakage Estimates by Mitigation Activity at a GHG Price of \$15/t CO_2 Eq. All quantities are on an annualized basis for the time period 2010–2110.

Selected Mitigation Activities	A GHG Effects of Targeted Payment (Tg CO_2 Eq.)	B Net GHG Effects of All Activities (Tg CO_2 Eq.)	C Indirect GHG Effects from Nontargeted Activity[a] (Tg CO_2 Eq.)	D Leakage Rate[b] (%)
Afforestation only	137	104	–33	24.0
Afforestation + forest management	338	348	10	–2.8
Biofuels	84	83	–1	0.2
Agricultural management	230	231	1	–0.1
Agricultural soil carbon	154	145	–9	5.7

[a]Indirect effects: C = (B – A). [b]Leakage rate: D = –(C/A) * 100; rounding occurs in table.

Note: Negative leakage rate in D refers to beneficial leakage (i.e., additional mitigation outside the selected activity region, also called positive leakage).

6. Non-GHG Environmental Co-effects

GHG mitigation can have substantial non-GHG environmental co-effects. Even a low GHG price (e.g., \$5/tonne) can induce changes in tillage practices and soil carbon sequestration, and thus significantly reduce erosion and nutrient run-off.

Figure 6. Pollutant Loading Effects Over Time of a \$15/t CO_2 Eq. GHG Price