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Net Farm Income and Land Use under a U.S. Greenhouse Gas Cap and Trade

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During recent years, the U.S. agricultural sector has experienced high prices for energy-related inputs and commodities, and a rapidly developing bioenergy market. Greenhouse gas (GHG) emissions mitigation would further alter agricultural markets and increase land competition in forestry and agriculture by shifting input costs, creating an agricultural GHG abatement market, and expanding bioenergy demand. The potential effects of these events on the agricultural sector are being hotly debated. We use a multi-sector model (FASOM-GHG, Adams et al, 2009) to estimate the potential implications of these developments on net farm income and the U.S. agricultural sector.

Current Policy Landscape and Understanding

Numerous policies to reduce U.S. GHG emissions are either in place, being developed, or being debated. Thirty-four states have enacted GHG emissions reduction efforts, including the Western Climate Initiative, the Regional Greenhouse Gas Initiative in the northeast, and the Midwest Greenhouse Gas Reduction Accord (Adams, 2009). Comprehensive federal cap-and-trade legislation was passed in June 2009 by the U.S. House of Representatives and is being considered in the U.S. Senate. The House bill is known formally as HR 2454 the “American Clean Energy and Security Act” (ACES) and informally as the Waxman-Markey climate bill. In HR 2454, the agricultural sector is not included as a sector that must comply with the GHG emissions cap and that situation is not expected to change under any bill that gets through the Senate. Nonetheless, even if agriculture is uncapped, the sector will likely be affected directly by the implementation of a Renewable Energy Portfolio Standard (RPS) and the creation of a market for the sale of GHG emission offsets. Offsets are GHG mitigation activities in uncapped sectors, such as agriculture, that can be purchased by capped entities to meet their compli-

ance obligations in lieu of further emissions cuts at their own facilities. Potential climate mitigation efforts will accompany the Renewable Fuels Standard established by the Energy Independence and Security Act of 2007 (referred to as RFS2), which increases the required volume of U.S. biofuel production, and has already affected commodity markets and production patterns.

These policies could have significant impacts on net farm income via the following:

- Higher production costs due to higher prices for fossil fuels, fertilizer, and other energy-intensive inputs
- Additional income opportunities with increased demands for agricultural biofuel and bioelectricity feedstocks
- Additional income opportunities from the demand for GHG offsets, where agriculture can generate offsets through a variety of changes in production practices and land use, including:
 - sequestering carbon through cropland tillage change
 - reducing nitrous oxide emissions from fertilizer and manure/livestock
 - abandoning use of histosols
 - reducing methane emissions from livestock, manure handling, and rice cultivation
 - sequestering carbon by diverting land to forests and grasslands
 - sequestering additional carbon by modifying existing forest management practices
- Higher agricultural output prices as farm-gate commodity prices will likely rise in response to increased energy and energy intensive input costs, increased competition for land, and shifts in management towards GHG abatement.

Given the many potential effects on income, it is important to evaluate the net implications for both net farm income and the agricultural sector as a whole.

The U.S. Environmental Protection Agency (EPA) assessed HR 2454, and estimated that gasoline prices could rise 15% above baseline levels by 2050 under the policy from a base level of approximately \$4.50/gallon in 2050, with electricity and natural gas prices rising 30% and 35%, respectively from base levels of approximately \$0.10 per kilowatt hour (kwh) and \$10/MM British thermal units (Btu) in 2050 (EPA, 2009). Such energy price increases would impose an additional cost burden on agriculture. A preliminary study by the USDA (2009a) on HR 2454 estimated a small increase in agricultural operating costs in the short-term of less than 2% per acre, and relatively modest increases in the medium and long-terms of around 4% and 10% per acre, respectively. However, this USDA study did not account for potentially important factors, such as changes in agricultural production practices, a number of offset opportunities in agriculture and forestry, and bioenergy as an abatement activity. Such omissions are likely significant. For example, McCarl and Schneider (2001) show that considering bioenergy likely makes carbon policies beneficial to agriculture, as energy feedstock markets could alter production practices, output prices, and farm income. We use a U.S. agriculture and forestry sector model that accounts for these many factors in order to evaluate the combined implications of the various impacts of GHG mitigation on U.S. net farm income and the agricultural sector. This model, described below, was used in part by the USDA (2009b) in a revised study on HR 2454 that found significant economic gains to the U.S. agricultural sector under cap-and-trade.

Simulation Analysis

To examine the effects of cap and trade provisions like those in HR 2454 on agricultural and forestry income, we simulate agricultural and forestry production and market responses to GHG prices using FASOM-GHG, an economic model of the U.S. forest and agricultural sectors. The model has been applied in numerous previous studies of renewable energy and GHG mitigation policy (for example see McCarl and Schneider, 2001; EPA, 2005; Alig et al. 2010; EPA 2009), and has been further updated and enhanced. We simulate the effects of a U.S. GHG cap-and-trade program on the agricultural and forestry sectors over an 80-year time horizon (2000-2080) by using alternative GHG prices. Our baseline scenario with no GHG incentive models levels of biofuels production consistent with RFS2 mandates, export commodity prices that follow recent trends of high average prices, agricultural yield and demand growth trends consistent with USDA historical data and projections extrapolated out to 2080, and energy prices consistent with projections by the U.S. Energy Information Administration. We compare four alternative GHG price scenarios to the baseline and to each other: \$0 (baseline), \$15, \$30, and \$50 per metric ton of carbon dioxide equivalent (tCO₂e).

We note that this analysis does not explicitly evaluate a specific U.S. GHG cap-and-trade proposal, we instead model low to high GHG incentives for changing agricultural and forestry practices that might arise under different proposals. This analysis is also not the same as modeling an entire GHG cap-and-trade policy. Among other things, agriculture is just one part of the GHG mitigation portfolio. Also, we model the full set of agricultural GHG abatement options, where the proposed bills may exclude some items. For example, unlike HR 2454, we do not exempt fertilizer manufacturing from needing

emissions permits through 2025 or omit consideration of fertilizer based nitrous oxide emissions, which adds an additional cost component to the agricultural sector. As such, our estimates slightly overstate cost increases and underestimate offset revenues, but these impacts do not affect our core findings. Offset payments are limited to activities currently allowed under ACES—afforestation, tillage change, nitrogen fertilizer reduction, manure management, and improved enteric fermentation—and bioenergy; and assumed sequestration rates differ for pasture and cropland.

Results and Discussion

Key results include GHG mitigation potential, net income, consumer and producer economic welfare changes, important commodity price impacts, and land use changes. Data are expressed mostly in annualized net present values (annuities) calculated using a 4% discount rate.

The GHG mitigation levels displayed in Figure 1 are the annualized difference in emissions from the baseline, aggregated to three main GHG accounts—agriculture, forestry, and bioenergy. Agriculturally generated offsets include afforestation by planting trees on crop or pasture land, reduced CO₂ emissions from energy/other input use, soil carbon management, reductions in N₂O emissions from crop and livestock production, and reductions in methane from rice cultivation and livestock. Forestry offsets include altered forest management practices to increase carbon sequestration potential—including changes in harvest timing, management intensity, and species mix—plus forest product sequestration and forest fossil fuel use emissions reduction. Bioenergy is the net change in emissions from the replacement of liquid fossil fuels and coal generated electricity, though biofuel levels are locked in to EISA-RFS2 levels. The bulk of abatement potential comes from forest manage-

Figure 1: GHG Emissions Flux from Base (Annuity)

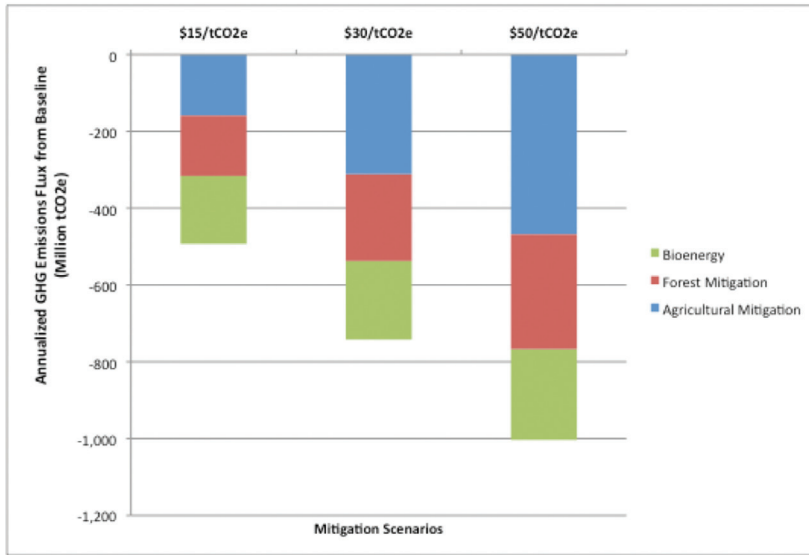


Figure 2: Gain in Agricultural Producer Surplus (PS) across Mitigation Schemes (Annuity)

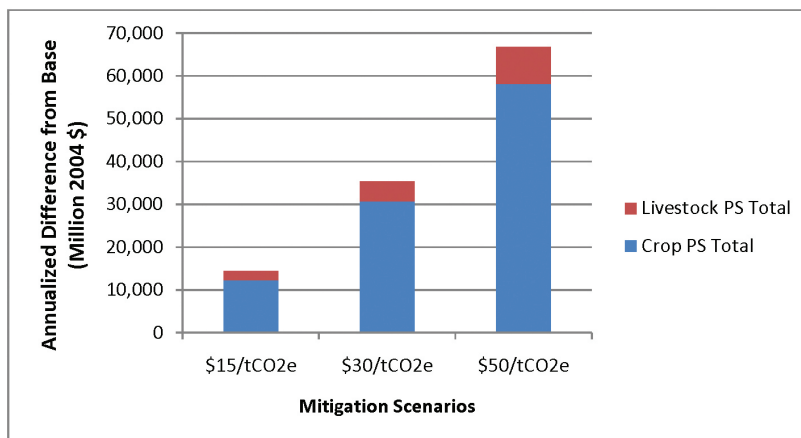
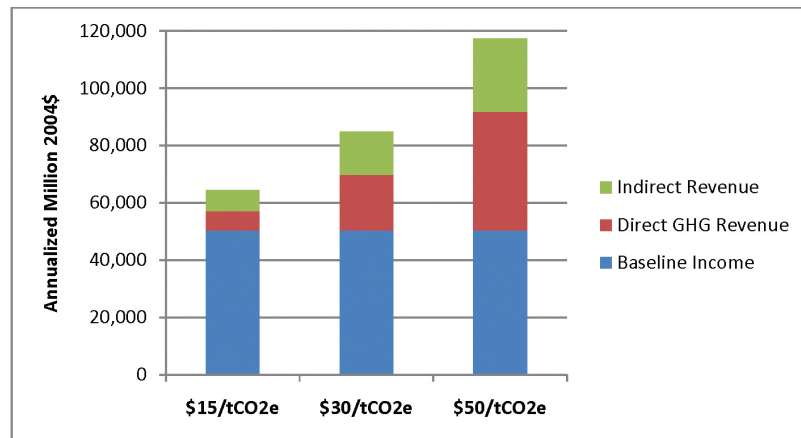


Figure 3: Direct and Indirect Income Effects on Agricultural Income (Annuity)



ment, afforestation, and bioelectricity. Changes in agricultural emissions that do not come from afforestation or bioelectricity play a limited role in the overall mitigation portfolio, including soil carbon sequestration and N₂O reductions.

We have also estimated changes in producers' surplus—equivalent to agricultural producers' net income, or profits. GHG prices create an increase in U.S. crop and livestock net income (Figure 2). We find that net producer income increases \$14.3-\$66.8 billion per year (2004 \$). Most of this accrues to crop producers who nationally receive 85.6-87.0% of the net income gain, while livestock (e.g., dairy and beef cattle) producers receive approximately 13-14.4%, with the highest proportionate gains from the \$15/tCO₂e scenario. Net crop and livestock producer income changes differ by U.S. region, but are positive for all. While not displayed, U.S. forest producers receive \$0.76-\$3.6 billion per year in combined offset revenues and bioenergy revenue.

Net income varies according to changes in input costs, direct revenue from offset payments and bioenergy production, and indirect revenue from changes in commodity prices (Figure 3). Higher energy prices result in greater per-acre costs of production, which increase 2.0%, 3.4%, and 5.8% per acre across the GHG price scenarios, respectively. These findings are consistent with USDA estimates (USDA, 2009). Despite the added costs of production, indirect revenue and offset payments more than compensate. Annualized offset payments and new bioenergy revenue range from \$6.8-\$41.4 billion, and indirect revenue from commodity price increases range from \$7.2-\$25.5 billion.

Recall that afforestation, forest management, and bioelectricity dominated mitigation potential. Afforestation alone accounts for direct revenues of \$2.3-\$19.5 billion per year, and bioelectricity from agricultural sources ranges from \$4.5-\$19 billion per year

based on annualized GHG revenue calculations.

However, other agricultural mitigation activities could also offer significant revenue opportunities for agricultural producers. Annualized payments for carbon sequestration through reduced tillage practices provide \$58-1,124 million. Improved livestock enteric fermentation and manure management practices provide offset revenues of \$342-2,243 million per year. N₂O emissions reductions from changes in nitrogen (N) fertilizer use through an overall change in crop mix and land-use and reductions in on-farm N use levels provide payments of \$37-922 million per year. There are some scientific uncertainties about the potential GHG benefits of these activities. We currently model livestock emissions mitigation in accordance with EPA GHG inventory methods and mitigation cost estimates, while changes in cropland fertilizer emissions fluxes and crop yields are based on the CENTURY model (Ogle et al 2009), which is used for the U.S. annual GHG inventory.

Commodity price increases differ by crop and offset price, but most commodities experience price increases from 2010 to 2060 (Table 1). For example, although higher grain prices would impose additional costs on livestock producers, livestock producers will be able to pass-through a portion of the higher costs of feed to consumers. Commodity price increases reflect

higher production costs due to higher fuel and intermediate input costs, increased land prices, and decreased agricultural production relative to the baseline.

With offset payments available, deforestation for agriculture use declines compared to the baseline trajectory and agricultural lands are afforested. Cumulative afforestation of cropland by 2030 ranges 8.3-39 million acres, with pasture afforestation ranging 15-16.5 million acres. Reductions in cumulative cropland deforestation by 2030 range 5.5-11.5 million acres relative to the baseline. This result suggests that offset and timber revenues from afforestation outweigh baseline land rents from crop production on the same parcel, where baseline land rents are consistent with regional estimates from USDA-NASS in the baseline, and vary endogenously in the mitigation scenarios.

Two additional points are worth noting. First, commodity price impacts could be reduced and mitigation potential improved if idle or conservation cropland re-enters production, specifically lands currently enrolled in the conservation reserve program (CRP). CRP lands represent a large source of potential additional cropland that we currently keep fixed in our modeling at the 2008 Farm Bill target of 32 million acres. Second, we might observe lower U.S. afforestation than suggested by our results if there is an international offset market

that brings, among other things, less expensive international supplies of afforestation/reforestation, and avoided deforestation projects into the market.

In summary, climate mitigation opportunities increase the demand for land for nonfood benefits, reduce commodity supply, and result in significant commodity market impacts.

Net Agricultural Sector Welfare

Higher commodity prices also impact consumers and agricultural processors (Figure 4). Here, we include changes in agricultural processors' surplus in the total producers' surplus account. Compared to the baseline, domestic (U.S.) household consumers' surplus—net benefit of consumption—falls. However, these losses are offset by much larger net gains to producers. When taken together, the U.S. agricultural sector as a whole experiences net gains of approximately \$4.7-\$37.6 billion per year. Consumer and producer surplus changes will occur internationally as well, but that is beyond the scope of this manuscript. It is also valuable to note that U.S. agricultural GHG abatement could help reduce the overall economic cost of GHG cap-and-trade compliance, while agricultural and forestry mitigation activities can generate potential benefits from air quality improvements and other environmental benefits—for example, wildlife habitat conservation and water quality.

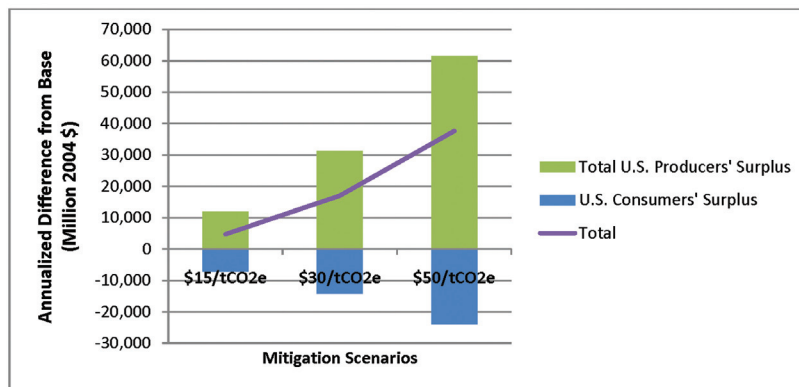
Concluding Observations

Our analysis suggests that the agricultural sector would benefit from a GHG cap-and-trade policy. In particular, despite higher production input costs, producers would benefit from higher commodity prices and additional revenues from offsets and increased demand for bioenergy feedstocks. However, we caution that our modeling assumptions may not reflect some features of an eventual federal GHG cap-and-trade program. For example, we assume a well-functioning, comprehensive offset program for the

Table 1: Average Annual Percentage Increase in Commodity Prices from Baseline (2010-2060) under GHG price Scenarios

	\$15/tCO ₂ e	\$30/tCO ₂ e	\$50/tCO ₂ e
Cotton (\$/bale)	1.83%	7.83%	10.79%
Corn (\$/bushel)	6.71%	18.15%	39.47%
Soybeans (\$/bushel)	4.38%	9.66%	16.47%
Wheat (\$/bushel)	3.51%	6.52%	11.15%
Sorghum (\$/cwt)	3.34%	7.25%	13.94%
Rice (\$/cwt)	1.26%	2.09%	3.01%
Fed Beef (\$/100 lb)	5.09%	8.84%	14.61%
Nonfed Beef (\$/100 lb)	7.92%	14.54%	18.71%
Pork (\$/100 lb)	2.54%	5.46%	10.62%
Chicken (\$/100 lb)	1.45%	4.21%	7.60%

Figure 4: Total Agricultural Welfare Change in Mitigation Scenarios Relative to Baseline (Annuity)



agriculture and forest sectors. The delays and transaction costs associated with developing and administering the offsets program, including protocol development, project aggregation, monitoring, and enforcement of offset activities, could reduce the economic appeal of agricultural and forestry GHG mitigation. Also, the impacts of a cap-and-trade program may differ, particularly in the early years, as a result of policymakers allocating GHG pollution permits to capped industries. Additional work is needed to consider other carbon price trajectories and offset program assumptions.

For More Information

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