WORKING PAPER

The Effects of Low-Carbon Policies on Net Farm Income

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NICHOLAS INSTITUTE
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Texas A&M System

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Contents

Abstract

Concerns about expected increases in energy and other agricultural input costs have led some to oppose greenhouse gas cap-and-trade legislative proposals. However, these policies could result in significant revenue for U.S. agriculture, which is a potential source of low-carbon bioenergy and low-cost abatement alternatives to fossil fuel emission reductions (i.e., offsets) through terrestrial sequestration, afforestation, and reductions in nitrous oxide and methane emissions. It is important to simultaneously model these factors in order to properly assess the net impacts for U.S. agriculture. Existing studies of the impacts of low-carbon policies on the agricultural sector have generally not accounted for changes in production practices, demand responses, or commodity and offset revenues. In this study, we estimate the U.S. net farm income implications of moving to a low-carbon economy. We find higher input costs, higher output prices, modest consumer response, increased bioenergy supply, and offset income opportunities. On net, we find that the U.S. agricultural sector would benefit from a U.S. climate policy.

1. Introduction

Over the last few years the agricultural sector has experienced higher energy prices, export market price increases, and a rapidly developing market for bioenergy. Current efforts to reduce greenhouse gas (GHG) emissions can further alter the agricultural landscape through changes in input costs, the emergence of a potential carbon offset market, expanded bioenergy demand, and a resulting increase in land competition (and land prices) for forestry and agriculture.

This paper examines how a GHG reduction program in the form of a cap-and-trade policy could affect agricultural net farm income by considering input cost effects and new revenue opportunities. We base our discussion on policy simulations using an economic model of the U.S. forest and agricultural sectors.

Current policy landscape

Multiple policy efforts that aim to reduce GHG emissions in the U.S. are currently in place or under debate. The Energy Independence and Security Act of 2007 substantially increases the required volume of biofuels established under the 2005 Renewable Fuels Standard (RFS), calling for the production of 36 billion gallons of biofuels annually by 2022, establishing specific mandates for the use of "advanced" biofuels (e.g., cellulosic ethanol), and adding GHG emission reduction thresholds for several classes of biofuels. Research suggests that this mandate will boost commodity prices and net farm income (Biomass Research and Development Board 2008; Fortenberry and Park 2008; EPA 2009).

Looming are policy proposals directly focused at reducing GHG emissions. The most recent is H.R. 2454, the American Clean Energy and Security Act (ACES), also known as the Waxman-Markey Bill, which as of this writing, has passed the House and is awaiting consideration in the Senate. H.R. 2454 establishes a cap-and-trade program that limits GHG emissions to 17% below current levels by 2020 and 83% below by 2050. The agricultural sector is excluded from the emissions cap, but is affected by provisions of the bill that affect other capped sectors. The capped sectors provisions covering the transportation and electricity sectors will affect energy costs and the cost of energy-intensive products, such as fertilizer. H.R. 2454 also establishes a Renewable Energy Standard (RES) that mandates that a percentage of U.S. electricity be produced with renewable generation. This would present a new market for agricultural residues or dedicated energy crops as inputs for co-fired electricity generation, along with promoting other renewables such as wind and solar power.

Finally, the cap-and-trade provisions of H.R. 2454 also allow domestic and international offsets to be sold to capped entities. Offsets arise from mitigation activities outside of the capped emissions sectors and which can be purchased by capped entities to offset emissions.

Although it is not completely clear how renewable energy mandates and climate offset mitigation opportunities will function together, both policies could provide additional sources of revenue to agricultural producers. This study examines how these benefit flows balance against higher input costs for U.S. agriculture that could result from the effects of the policies on energy and energy-intensive input costs.

2. Mitigation Activities and Implications for Farm Income

The net farm income effects of GHG policy are tied to a number of factors, including effects of policies through commodity and input factor markets. Although GHG policy could cause input costs to increase, revenues from commodity markets and offset sales must be considered as well. Consumer effects are also relevant.

GHG policy, fossil fuel costs, and farm income

The U.S. Environmental Protection Agency (EPA) recently assessed H.R. 2454, and found that it could cause petroleum prices to rise 15% above baseline levels by 2050, with electricity and natural gas prices rising 30% and 35%, respectively.

Recent studies have estimated the direct impact of GHG policy on production costs to agricultural producers, producing estimates of a substantial total cost burden imposed on the agricultural sector (Doane Advisory Committee 2008). However, these results did not fully consider commodity market and offset revenue effects. The Doane results arose from a farm budgeting approach that did not allow for changes in input use and crop mix strategies, nor for commodity markets and offset revenues. Additional commentary on the Doane study can be found in Murray, McCarl, and Baker 2009. Commodity market effects are expected to be particularly important as recent history has shown that higher fuel prices and a biofuels boom led to a substantial increase in agricultural commodity prices (see Abbott, Hurt, and Tyner 2009 for discussion), while net farm income estimates went up.

A recent (2009) USDA analysis of H.R. 2454 shows a small increase in operating costs in the short term of less than 2% per acre, and relatively modest increases in the medium and long terms of less than 4% and 10% per acre, respectively. Additionally, the USDA analysis indicates that a portion of the increased cost will be passed through to consumers in the form of higher commodity prices. Overall, the USDA analysis shows a net income loss to the agricultural sector over time, but does not account for changes in production practices, input substitution, or potential offset and bioenergy revenue. It also ignores market effects caused by pursuit of GHG offsets that move land out of conventional agricultural production.

How cap-and-trade affects agricultural producers

Now let us turn attention to the effects of a cap-and-trade policy as it is employed in H.R. 2454 and in the international Kyoto arena. We can expect several agricultural sector effects of such a program:

- There will be additional costs for fossil fuels, fertilizer, and other inputs as their effective prices will rise due to contained GHG emissions.
- Higher effective fossil fuel prices will raise demand and prices for biofuel and bioelectricity feedstocks, providing additional income opportunities to agriculture.
- Through the domestic offsets program, producers could receive incentives to

- divert land to forests and grasslands,
- cease use of histosols,
- modify existing forest management to increase carbon sequestration,
- reduce methane emissions from livestock, manure handling, and rice cultivation,
- sequester carbon through cropland tillage change, and
- reduce nitrous oxide from fertilizer and manure/livestock.

These opportunities and the added cost of production are likely to divert land and shift up the supply curve, thus reducing the amount of agricultural production entering traditional markets. Additionally, new production opportunities could arise in the agricultural sector if forests are managed for carbon (including short-rotation woody crops, such as hybrid poplar). These opportunities will raise conventional crop prices as well as land values.

3. Simulation Analysis of GHG Offset Prices and Opportunities

Below we quantitatively look at what might happen with GHG prices using a model called FASOMGHG. FASOMGHG (Forest and Agricultural Sector Optimization Model with Greenhouse Gases) is a partial equilibrium economic model of the U.S. forest and agricultural sectors, and can simulate agricultural and forestry production responses to carbon prices. The model has been applied in numerous previous studies of renewable energy and GHG mitigation policy (Murray et al. 2005; Schneider and McCarl 2005; McCarl and Schneider 2001). The model has recently been updated and enhanced (see the appendix for additional information).

The model represents many activities that produce emissions or emissions reductions. To simulate the effects of cap-and-trade on the agricultural sector, we present those activities with a carbon equivalent price to see how production practices, land use, and markets will respond. Our method assigns the carbon price to all GHG flows within the sector (carbon sequestration, bioenergy offsets, or changes in GHG emissions from altered management practices and land use). All effects of implementing carbon prices are measured relative to the baseline. Responses are estimated over an 80 year horizon (2000–2080) to fully capture changes in forestry investment decisions and the dynamic interactions of forest and agricultural land use.

4. Description of Scenarios

Before simulating GHG policy we first need to simulate a base or “baseline” case. This baseline incorporates contemporary data on the renewable fuel standard, energy prices (AEO 2009), demand and yield productivity growth, exports, land use, land-use changes, and technological progress in bioenergy processing. We add to the baseline by shifting export demands to be consistent with contemporary market conditions. The level of U.S. exports that we saw in 2001 was virtually unchanged in 2007 despite much higher commodity prices; thus we calibrated demand parameters accordingly to represent this reality. This essentially allows export markets to exist at current levels even under higher commodity prices brought on by the RFS. Additionally, the latest version of the EISA-RFS rules (referred to as RFS2) are incorporated into the model by setting minimum biofuel production requirements for ethanol, cellulosic ethanol, and biodiesel at mandated levels. Requirements are phased in over time until reaching a total of 36 billion gallons of biofuels annually in 2022. Note that these serve as a minimum constraint that can be moved upward if biofuels become economically competitive with conventional fuels. For this analysis we lock in ethanol production at RFS-mandated levels beyond 2022 to be consistent with energy demand projections and the current transportation sector infrastructure.

FASOMGHG solves under baseline conditions for market-clearing levels of production, consumption, feedstock use, and net GHG emissions associated with all commodities modeled within the U.S. agricultural and forestry sectors.

Meeting the RFS requires that a significant portion of land resources be allocated to the production of bioenergy. Additionally, emphasis on cellulosic ethanol creates a new market for agricultural residues (e.g., corn stover, wheat straw) and dedicated energy feedstocks (e.g., switchgrass, hybrid poplar). This gives producers more marketable alternatives for managing their land. Additionally, these mandates indirectly boost farm income by increasing conventional commodity prices as land is allocated to energy production. Following the baseline RFS scenario, we consider alternative carbon dioxide equivalent (CO_2e) pricing schemes (using the 100-year global warming potential for methane and nitrous oxide), with prices of $15, $30, and $50 per ton[1] (t) of CO_2e. These prices give us a comprehensive range of CO_2e prices in line with those projected by the EPA under the two most comprehensive climate bills (H.R. 2454 Waxman-Markey in 2009 and S. 2191 Lieberman-Warner in 2008).

5. Results

The GHG price is imposed on an economy with the baseline as described above. Figure 1 displays net mitigation potential for several important categories of emissions by annualizing deviations from the baseline (calculated for time periods beyond 2010).[2] Under baseline conditions, agriculture produces a large source of emissions, but the mitigation scenarios suggest that the forestry and agricultural sectors have the potential to produce significant GHG offset benefits. Annualized mitigation potential rises monotonically across the constant price scenarios. This figure represents an expected GHG mitigation flux from aggregate emissions categories that can be disaggregated to represent viable offset activities in forest and agriculture. The bulk of the offset potential comes from afforestation, forest management, and bioelectricity.[3,4] It is important to note that under simulations, offset potential from modified agricultural production activities plays only a limited role in the overall mitigation portfolio. However, as afforestation occurs on agricultural lands, substantial offset revenues are accrued to agricultural producers, in addition to payments for nitrogen fertilizer reductions, soil carbon sequestration, and animal agriculture offsets.

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[1] All tons (t) referenced in this paper are metric tons (1 metric ton = 1,000 kg = 2,204.62 lbs.).

[2] The net present value of emissions, by category and for all periods beyond 2010, is converted to an annuity using a 4% discount rate.

[3] Biofuels production doesn't increase with the GHG price because of demand-side constraints associated with ethanol blending limits and E85 vehicle and infrastructure penetration limits. Nonetheless, we see mitigation due to changes in the mix of biofuel feedstocks at higher GHG prices as the model favors feedstock processes that provide the greatest GHG reduction benefit.

[4] Forest management can include changes in harvest timing, management intensity, species mix, etc.

Figure 1. Annualized emissions flux across mitigation scenarios.

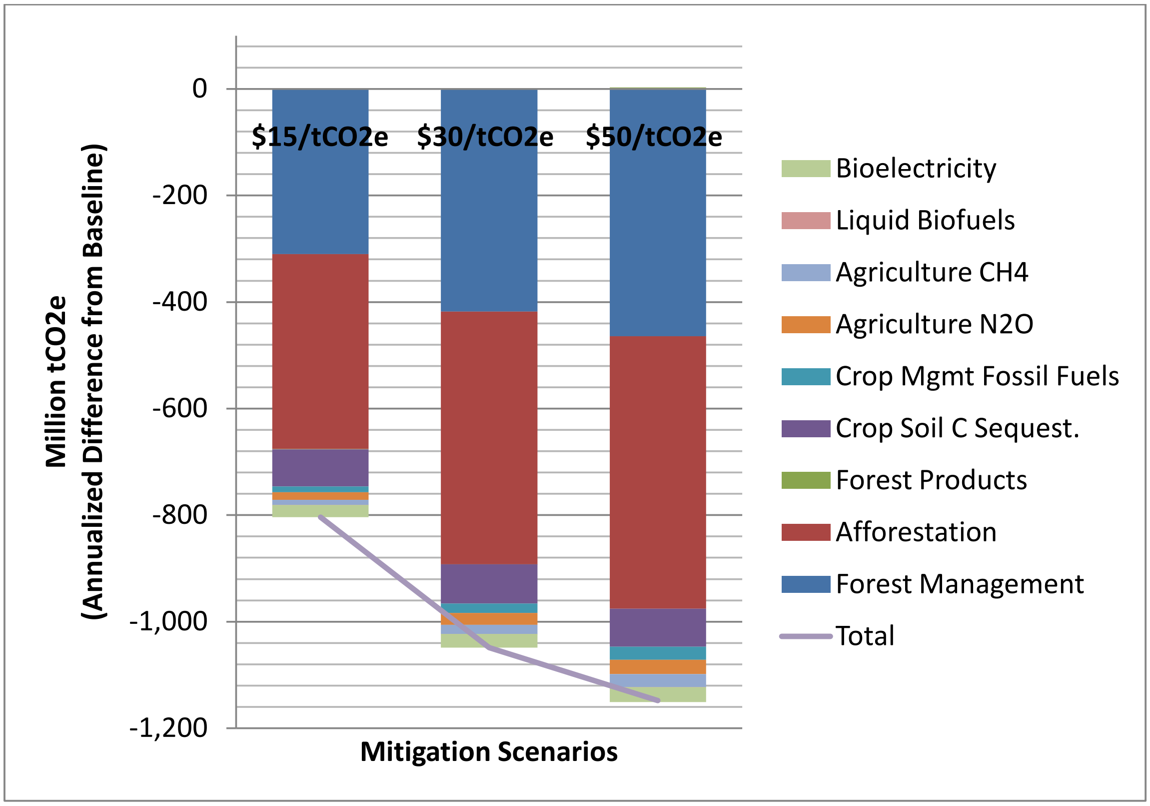
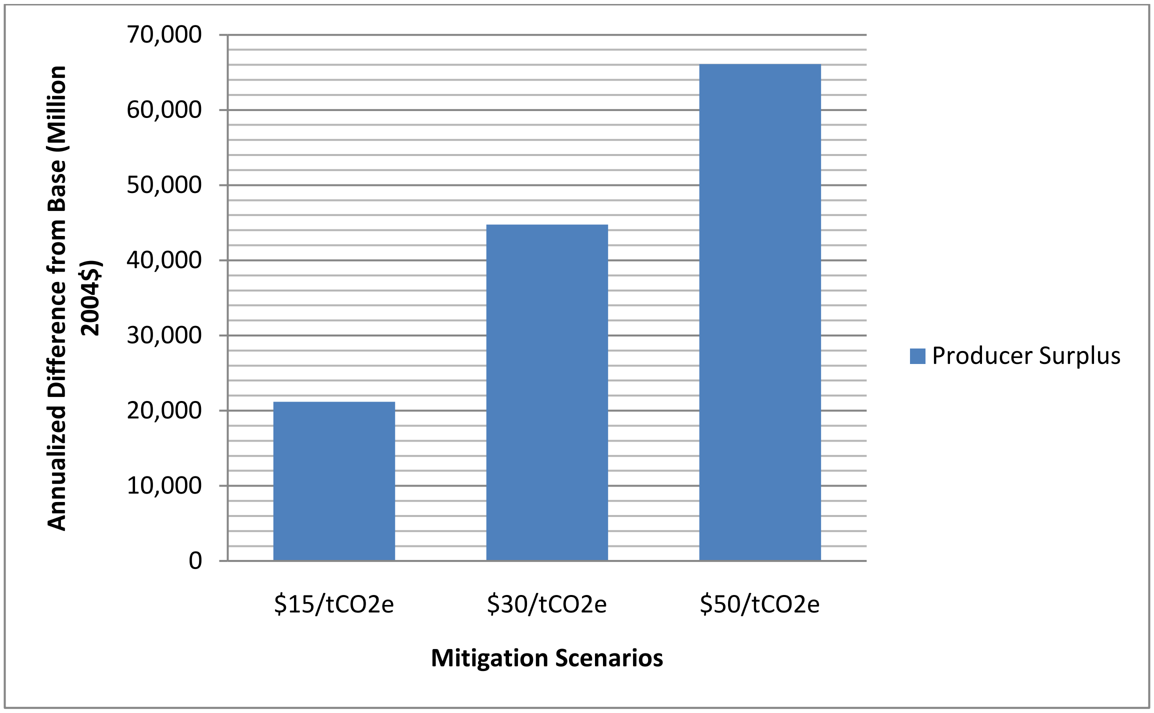


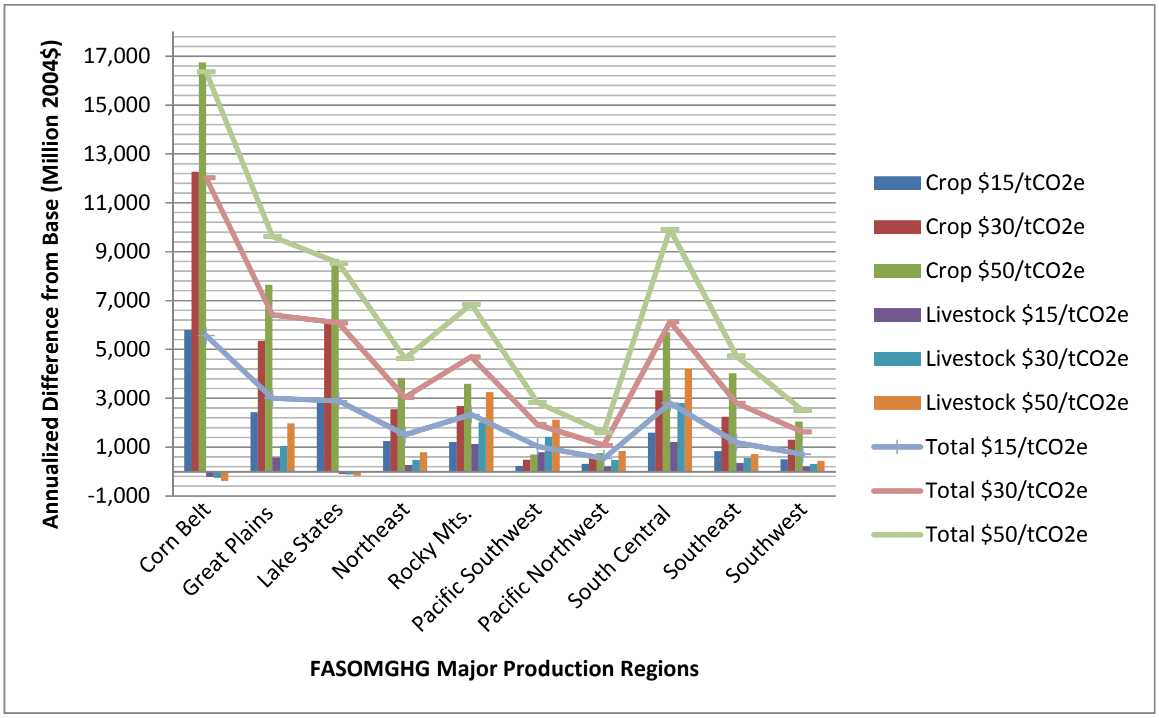
Figure 2. Gain in agricultural producer surplus (net income) across mitigation schemes (annuity).



As shown in Figure 2, producer surplus, which reflects net producer income (converted to an annual annuity at 4%), increases $20–$66 billion (2004$).

The distribution of annualized welfare impacts by region are shown on Figure 3. Certain regions and producer groups experience a net loss in welfare. However, the lines illustrating total agricultural producer surplus (the sum of crop and livestock producer surplus) show a net gain for each region and CO_2e pricing scheme. This result indicates that even regions without afforestation opportunities or biofuel production possibilities, or that lack soil carbon or animal offset potential, can still benefit under low-carbon policies due to higher commodity prices. For instance, the Southwest and Great Plains regions, which we model as agricultural regions only (that is, with no forest production possibilities) still receive a net income boost even without afforestation revenues.

Figure 3. Regional crop and livestock producer surplus across mitigation scenarios (annualized difference from base).



Where do the producer surplus gains come from? We decompose total income into the baseline income, input cost impacts from GHG pricing, direct revenue from GHG payments (for offsets and bioenergy), and indirect revenues from changes in commodity prices and land rents. We begin with baseline agricultural income for several representative periods then examine total income under mitigation schemes, decomposing the difference into direct GHG payments and indirect revenue.

Direct GHG payments include direct revenue for offset activities (including afforestation, tillage change, nitrogen fertilizer reduction, manure management, and improved enteric fermentation) above the marginal cost of implementing those strategies, as well as a direct payment for additional bioenergy GHG reductions. GHG payments for afforestation are allocated to crop or livestock producers, depending on whether the activity occurs on cropland or pasture. Indirect revenues are the net income changes from commodity price and land value adjustments that are triggered by the carbon policy.

The cost impacts of climate mitigation are estimated by pricing the GHG content of nitrogen fertilizer, pesticide, and fossil fuel use directly and then estimating the behavioral response. Figure 4 illustrates the total revenue implications. Notice that although the unit cost of GHG-intensive inputs increases, the additional cost burden changes very little across mitigation scenarios with it decreasing slightly. In our analysis, producers adopt management decisions accordingly when faced with higher input costs and

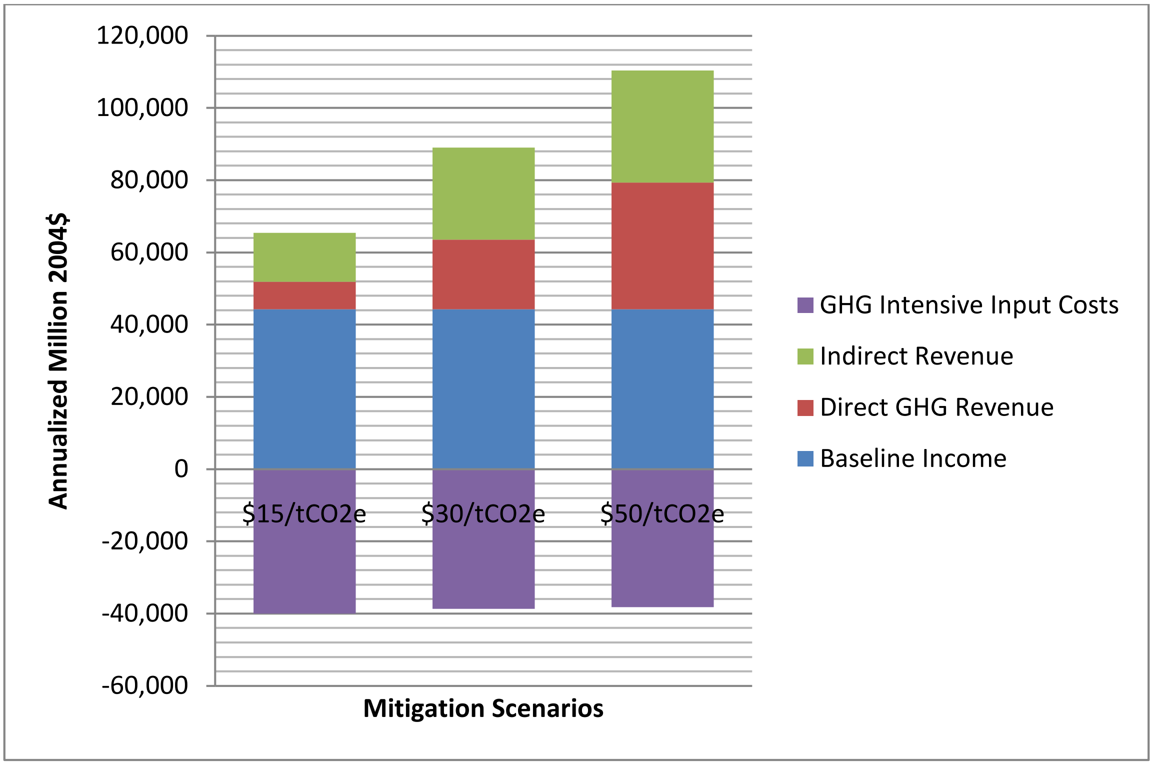
GHG-offsetting alternatives to traditional crop management. Thus, the total cost burden decreases as the agricultural land base shrinks and producers use less nitrogen and fossil fuels in the production process.

However, the higher costs of energy signal greater per-acre costs of production. Results indicate that the average per-acre cost of GHG-intensive input use would increase 1.40%, 2.30%, and 4.10% per acre across the price scenarios, respectively. These input cost increases are in line with those forecast in the USDA 2009 analysis (which did not allow for changes in input use).

Despite the fact that production costs are rising, both from the higher costs of inputs as well as the cost of emissions, indirect and direct revenues more than compensate. The gains in indirect revenues are the largest component of additional revenue, amounting to approximately $13.5–$31 billion per year.

Direct GHG payments generate annualized revenues of $7.6–$35 billion per year. Overall, the gain in net income could be substantial.

Figure 4. Annualized direct and indirect revenue effects on agricultural income.



Decomposing the payments by mitigation activity, we find that forest management incentives to landowners and afforestation offset payments to agricultural producers dominate other mitigation options in terms of annualized offset revenues and mitigation potential. Again, afforestation payments are accrued to crop and livestock producers, depending on whether the afforestation takes place on crop or pasture land. Forest management payments are shown as managing forests for carbon has significant indirect benefits on the agricultural sector by keeping land from converting to agriculture (thereby shrinking the cropland trajectory), and by providing marketable production opportunities to farmers (e.g., short-rotation woody crops).

Figure 5. Annualized GHG offset payments across mitigation schemes to forestry and agricultural sectors.

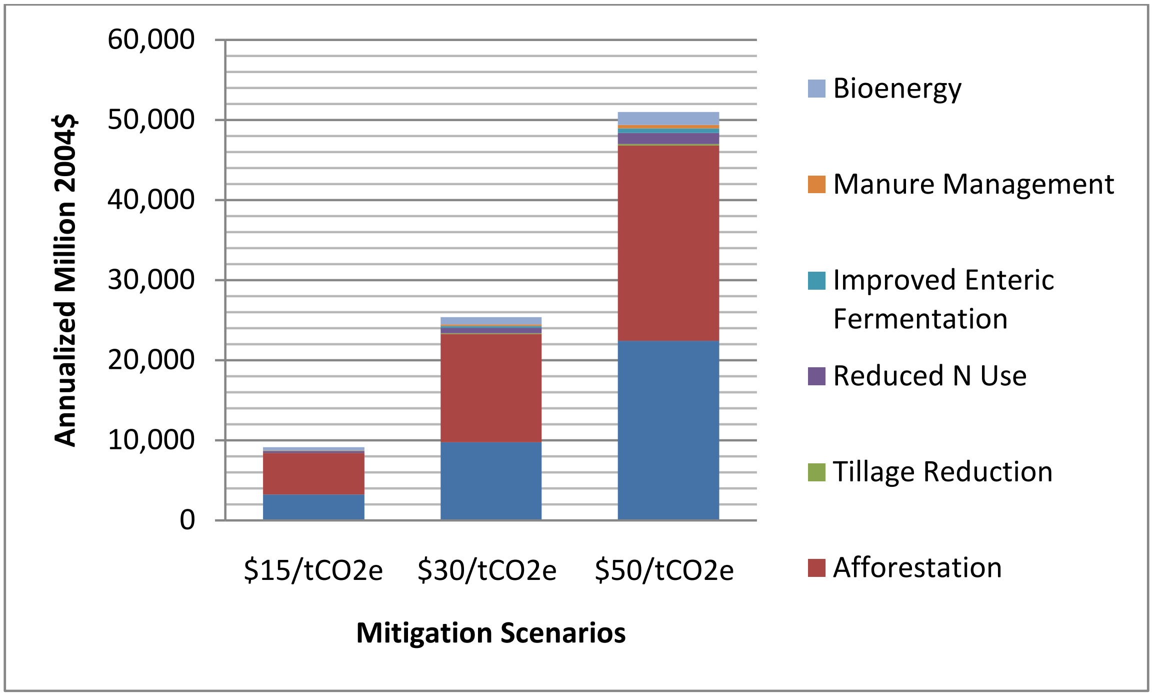
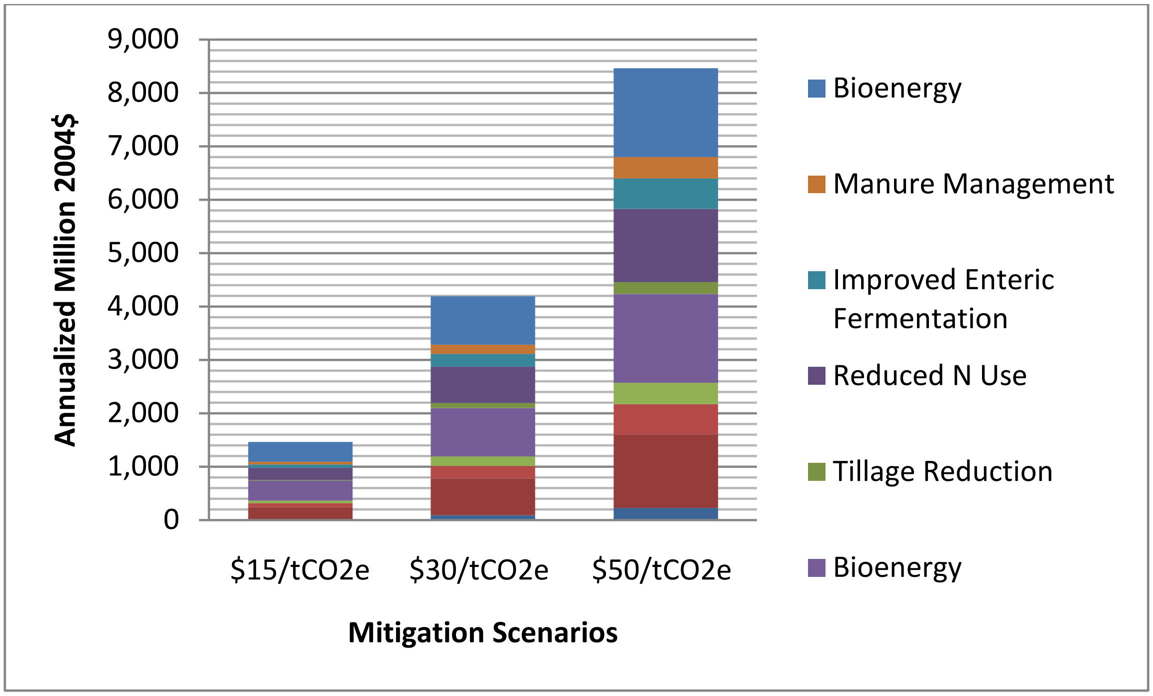


Figure 6 highlights the payments for the more agricultural mitigation activities estimated to have more modest roles. Although these activities represent a small component of the cost-effective abatement portfolio (relative to forest management and afforestation), they are still a significant revenue opportunity for agricultural producers.

Figure 6. Annualized GHG offset payments (without forest management or afforestation).



To better understand the gains in indirect revenue, we examine the commodity price implications. presents average price differences for several important commodities in the period 2010–2060, presented in percentage terms. Prices increase significantly for most commodities under the mitigation scenarios. Corn prices, in particular, show significant movement, rising 12%–50%. Although higher grain prices would impose additional costs on livestock producers, results indicate that livestock producers will be able to pass on a portion of the higher costs of feed to consumers, as is also possible with primary and secondary crop commodities. Price increases outpace quantity demand reductions in yielding increased revenue.

Also, it is noted that equilibrium commodity prices generally decrease under FASOMGHG baseline assumptions in the long term. After peaking around 2020 (where the RFS reaches maturity), prices begin to decline as exogenous technological growth rates in the model typically outpace demand growth. For instance, in the baseline corn prices peak at $3.59/bushel in 2015, before averaging $1.87/bushel in 2060. We raise this issue to point out that the relative magnitude of price increases essentially stabilizes commodity prices at similar levels to those induced by the EISA-RFS2. Thus, while we forecast significant increases in commodity prices, these shifts are no larger in relative magnitude than those brought on by the RFS in earlier time periods.

Table 1. Commodity price impacts of mitigation scenarios.

	$\$15/tCO_2e$	$\$30/tCO_2e$	$\$50/tCO_2e$
Cotton ($/bale)	3.80%	15.40%	29.75%
Corn ($/bushel)	15.94%	31.84%	41.77%
Soybeans ($/bushel)	11.61%	24.18%	33.12%
Wheat ($/bushel)	3.70%	9.12%	14.53%
Sorghum ($/cwt)	0.57%	5.97%	8.80%
Rice ($/cwt)	1.5%	2.75%	2.67%
Fed beef ($/100 lbs.)	5.21%	8.88%	13.55%
Non-fed beef ($/100 lbs.)	1.65%	2.56%	3.51%
Pork ($/100 lbs.)	7.22%	15.38%	22.68%
Chicken ($/100 lbs.)	5.26%	12.87%	10.96%

The commodity price increases reflect higher production costs due to a variety of factors—higher fuel and intermediate input costs, emissions costs, and higher land costs due to the increased opportunity cost for agricultural land. Forest-based GHG offset opportunities increase the opportunity cost of current and additional crop and pasture land and result in decreased acreage relative to the baseline. With GHG payments available, deforestation for agriculture use slows and agricultural lands are afforested.

Under the baseline approximately 16.9 million cumulative acres of private forest in the U.S. are deforested to agriculture and converted to cropland or pasture uses by 2030; this is due to the bioenergy mandates and increased agricultural commodity demand. However, cropland deforestation beyond 2010 is almost completely absent at $\$15/tCO_2e$.

Meanwhile, afforestation is profitable even at $\$15/tCO_2e$. We show a cropland afforestation potential of 26 million, 39 million, and 44.4 million acres. Cropland pasture afforestation occurs on approximately 28 million acres.[5] Even if the cropland converted to forest is marginally productive in agricultural use, it still affects supply and increases pressure on commodity markets. Overall, climate mitigation opportunities

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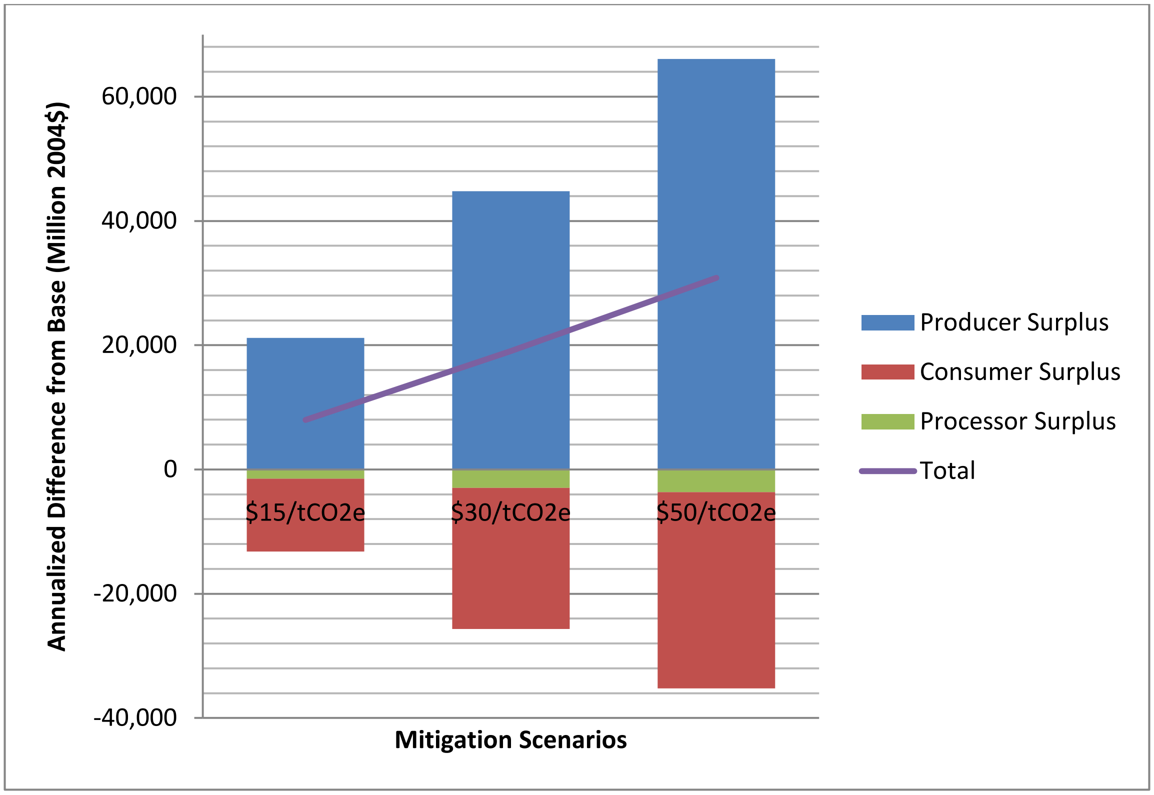
[5] These values represent cumulative land use change, converted to an annuity using a 4% discount rate.

increase the demand for land, reduce commodity supply, and can result in significant commodity market impacts.

6. Total Agricultural Welfare Accounting

Above we have shown that commodity prices will likely increase with GHG mitigation policies. This result logically raises concerns of the increased burden of higher food prices for households. We look at the loss in consumer surplus to estimate this effect (Figure 7), where consumer surplus is the value of purchased commodities to consumers above their costs. It is important to weigh potential gains to producers with the potential losses in consumer welfare. Figure 7 does just that in providing estimated changes to U.S. total agricultural welfare, which is the sum of changes in domestic producer, consumer, and processor surplus. In the figure, we see the decline of household consumer surplus and processor surplus associated with the higher commodity and energy prices. However, we also see the larger increases in producer surplus. Therefore, the agricultural sector as a whole benefits from the GHG policy, with net gains of approximately $7.9 billion, $19.0 billion, $30.8 billion per year, respectively, across mitigation scenarios.

Figure 7. Total agricultural welfare change in mitigation scenarios relative to baseline.



7. Conclusions

Our simulation results suggest that the agricultural sector would be placed in a favorable position by a GHG cap-and-trade policy. While agricultural producers will feel the input price ramifications of restrictions on fossil fuel–intensive input suppliers (energy, fuels, and fertilizers in particular), they can benefit in several ways. First, a portion of production cost increases can be passed on to consumers in the form of higher prices. Second, new revenue opportunities may exist for bioenergy feedstocks. Third, by being outside the cap, agriculture and forestry are a considerable potential source of offsets for sale to the capped sectors. Using an economic model of the U.S. forestry and agricultural sectors, we show that policies that support bioenergy and terrestrial GHG mitigation efforts could stimulate agricultural income significantly despite higher input costs and could lead to a net welfare increase for the agricultural sector as a whole.

We note that in this analysis the GHG payment component also debits the system for the CO_2e value of its emissions. This adds an additional cost component to the use of fossil fuels, nitrogen fertilizer, land-use change, or other emitting activities. Current climate mitigation policy proposals are not designed this way, as emissions from agriculture remain outside the cap and therefore mitigation is voluntary. However, since we do price these emissions, it is likely that we are understating the additional GHG revenue potential available to producers, while overstating the emissions reduction benefits, as emitting activities would be costless.

We should also note that while the welfare gains to agricultural producers are just one of the many other costs and benefits in the general economy from both GHG-induced emissions prices and from an atmosphere with less GHG content. An economy-wide analysis is needed to fully evaluate potential economic tradeoffs, but such an analysis is beyond the scope of this study.

Finally, the levels of the welfare effects illustrated here will depend on the GHG price trajectory and specific mitigation program design. For example, rising GHG prices will reduce annualized mitigation, while payment eligibility restrictions (such as discounting) for particular mitigation activities could modify mitigation potential for all activities. Also, the transaction costs associated with aggregation, monitoring, and enforcement of offset activities could reduce the economic appeal of agricultural and forestry GHG mitigation. Future research will consider production and welfare responses for different GHG price trajectories and offset program designs.

Appendix – About the Forest and Agricultural Sector Optimization Model with Greenhouse Gases (FASOMGHG)

We use the Forest and Agricultural Sector Optimization Model with Greenhouse Gases (FASOMGHG) for this analysis. FASOMGHG has been applied to a wide range of policy settings. It allows evaluation of GHG mitigation strategies in the agricultural and forestry sectors and the impact of renewable energy standards on the agricultural supply chain (Murray et al. 2005; Schneider and McCarl 2003). Additionally, the model has been used to examine environmental impacts of land-use decisions influenced by the aforementioned GHG mitigation alternatives.

FASOMGHG portrays a full suite of GHG mitigation options, including biological sequestration of carbon in agricultural soils and forest stands, alternative crop and livestock production practices to reduce emissions, and bioenergy feedstock substitutes for fossil fuels. The gases represented are carbon dioxide, methane, and nitrous oxide. The model is particularly unique in its ability to evaluate a full suite of biofuel feedstocks for processing ethanol, cellulosic ethanol, and biodiesel. In addition to biofuels, FASOMGHG contains a set of activities for replacing coal with biomass in electricity production. The full set of bioenergy activities is more comprehensive than other modeling efforts.

FASOMGHG contains comprehensive GHG accounting across management activities. This includes detailed biophysical data used to model the dynamics of soil and forest carbon balances in different regions of the United States. In addition, the model simulates explicit competition between competing uses of land (forest, cropland, pasture, and conservation land). This competition is modeled endogenously, such that whenever one land use increases in value relative to the other two, more land is allocated to that specific use over time (however, not all land is classified as freely transferable between uses). Between its capabilities of modeling explicit land-use competition and comprehensive terrestrial carbon accounting over time, FASOMGHG provides a tool for evaluating GHG mitigation alternatives in the agricultural and forestry sectors and the associated sectoral economic impacts. FASOMGHG was recently updated (from the version used in Murray et al. 2005) to provide a better portrayal of contemporary forestry and agriculture and increase capability. Advances include additional bioenergy activities representing new marketable alternatives for food and timber commodities, as well as residual by-products of harvest and production. The model now contains more than 20 alternative biofuel feedstocks for processing starch- or sugar-based ethanol, cellulosic ethanol, and biodiesel. In addition, biomass from a variety of sources can be used for bioelectricity production. Updated technological growth assumptions offer the most up-to-date picture of when advanced biofuel technologies will be economically feasible. Commodity demand, energy market, and input cost growth assumptions have also been updated to accurately represent current and future market conditions. The forestry sector has also been updated to five-year time steps (previously the model was solved in 10-year intervals), recent timberland inventory, distribution of ownership, and harvest schedules with an extensive processing sector and the addition of many manufactured product forms. The forest carbon accounting was also redone to match USDA Forest Service procedures. Additional forest management options were also introduced.

The model now accounts for a broader range of land-use categories. In addition to cropland, forest, and pasture land, FASOMGHG now has explicit spatial representations of rangeland, Conservation Reserve Program acreage, privately owned-grazed forest, grazed public forest, cropland pasture, and forest-pasture that is grazed only (and freely transferable with private timberland). Improved land-use dimensions allow us to capture land-use change patterns in a detailed manner. This categorization also allows for improved GHG accounting among different land uses.

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the Nicholas Institute

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