The Impacts of the American Clean Energy and Security Act of 2009 On U.S. Agriculture

Office of the Chief Economist

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Executive Summary

Our preliminary analysis of H.R. 2454, published in July[1], focused on the economic impacts of changes in energy prices associated with the cap imposed on domestic emissions. We have refined and expanded that analysis. The focus of this report is on how higher energy prices as well as the ability to generate and sell offsets resulting from a GHG emissions cap-and-trade system would affect the agriculture sector. In addition to national sector impacts, we present detailed regional impacts on both the effects of higher energy prices as well as the income potential from the sale of offsets. Our analysis finds that H.R. 2454 would benefit the agricultural sector. While higher energy prices are projected to increase farm expenses, when considered in conjunction with commodity price increases and revenues from offsets and biofuel production, the impact on net farm income is positive.

The economic impacts of climate change legislation on the farm sector are broad, complex, and will evolve slowly over the next decades. Impacts will be influenced by the timing and extent of changes in temperature and precipitation, the efficacy of actions to mitigate emissions and adapt to changes, the form of the actions taken within the United States and in other countries, and the extent to which mitigation within the farm sector can be compensated through greenhouse gas (GHG) offsets or other mechanisms. We have not been able to quantify all of these factors and their influence on the farm economy.

In particular, because of the time horizons considered in the medium and long term analyses there is much uncertainty surrounding the estimated effects. Factors such as yield productivity, development of energy-saving technologies and weather can all have major effects on supply, demand and price outcomes. Predictions far out into the future are inherently more uncertain than nearer term estimates. USDA typically only forecasts agricultural prices and incomes ten years into the future. As such, results – particularly for 2030 and beyond - should not be interpreted as precise estimates but rather as indications of the direction and magnitude of the expected effect.

The immediate implications are that higher energy prices will increase the prices paid for energy-related agriculture inputs and therefore increase agricultural production costs. Energy-related inputs include direct energy use, such as for diesel, natural gas, and electricity, and indirect use, such as for fertilizer. Our findings suggest that under the energy price scenario estimated by the Environmental Protection Agency (EPA), price and income effects due to higher production costs will be relatively small, particularly over the short run (2012-18). Impacts on production costs are also mitigated by provisions in H.R. 2454 that would provide allowance rebates to "trade-vulnerable" industries, including fertilizers. When production cost impacts considered in conjunction with likely commodity price

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[1] U.S. Department of Agriculture, Office of the Chief Economist and Economic Research Service. "A Preliminary Analysis of the Effects of H.R. 2454 on U.S. Agriculture" July 22, 2009. Available at http://www.usda.gov/oce/newsroom/archives/releases/2009files/HR2454.pdf We acknowledge the contribution of the Economic Research Service in providing data and analysis used in this paper.

increases and possible revenues from offsets and increased biofuel production, the impact on net farm income is positive.

The ability to generate and sell offsets provides an additional source of farm income which can compensate for any loss in income due to higher energy costs. Gross income associated with offsets could be as high as $30 billion by 2050 (Table ES-1). In addition to offset revenues, providing offsets through afforestation will also take land out of agricultural production. As a result, the impact of less land in agricultural production leads to higher overall returns to agricultural producers. The effect of higher prices received outweighs the effect of less production and, on average, net returns to agricultural producers are about 12 percent higher, with an annuity value in excess of $20 billion if we count change in producer surplus through 2080. This excludes the revenue earned from afforestation offsets.

Consumers will likely feel the effect of higher commodity prices through increases in the prices paid for food. The overall impact on the Food CPI is estimated to be an increase of about 0.1 to 0.2 percentage points above the expected historical trend in the Food CPI in 2015 and 1.2 to 2.1 percentage points above the expected historical trend in the Food CPI in 2050 with the years in between showing steady increases in the index.

While we are confident that the level of offsets will be significant, it is possible that the level and mix of offsets especially with respect to afforestation will differ as a result of changes in model assumptions. This suggests continued work to refine model assumptions. For example, it is important to recognize that our analysis does not account for all potential offset categories. The exclusion of other sources in the modeling does not imply that those sources would not be eligible to receive offsets (e.g. management of peatland or wetland). Similarly, H.R. 2454 requires the Secretary to develop methodologies for domestic agricultural and forestry offsets which establish activity baselines, a standardized approach for determining additionality and leakage, and methods for monitoring and accounting for uncertainty. To the extent that the methods developed are different than those assumed in the models, both the amount and mix of offset activities can be different than our estimates. In addition, we assume the structure of government programs remains fixed over the entire time period. For example, we assume the Conservation Reserve Program is maintained at 32 million acres, the structure of current farm programs remains unchanged, and there are no changes to current trade agreements. Again, changes to these or other policy variables can affect both the level and distribution of offsets by changing agricultural market conditions.

Table ES 1: Effects of H.R. 2454 on Net Farm Income (billion 2005$)

	2015	2020	2025	2030	2035	2040	2045	2050
Gross income associated with offsets	$0.8	$2.4	$3.5	$5.2	$11.6	$18.1	$23.7	$29.7
Change in producer surplus 1/	$1.4	$2.0	$2.8	$3.9	$5.5	$7.7	$10.8	$15.1

From USDA analysis based on FASOM simulations provided by EPA and other data provided to USDA by Bruce McCarl at Texas A&M University. FASOM estimates are based on 5-year averages (e.g., 2015 is reflects average over 2015-19). 1/ Excludes revenues from offsets.

I. Introduction

In June 2009, the U.S. House of Representatives passed the American Clean Energy and Security Act of 2009 (H.R. 2454), which included a cap-and-trade system for greenhouse gas (GHG) emissions from 2012 to 2050. The legislation assigns responsibility for emissions across fuels and production sectors.

When fully implemented, covered emissions will represent about 85 percent of total GHG emissions in the United States. From this reference level, the legislation specifies the reduction in GHG emissions each year, thus establishing the emissions cap. All entities responsible for emissions subject to the cap must hold allowances for those emissions or purchase offsets from uncovered sectors. Under this legislation, producers of some fuels may also incur responsibility for "attributable" GHG emissions that would occur when that fuel is ultimately used.

Agriculture and forestry are not covered sectors under the cap-and-trade system of H.R. 2454 (Title V, Sec. 501). Therefore, these producers are not required to hold allowances for GHG emissions. Nonetheless, production sectors not covered under the emissions cap may still be affected by higher energy prices. For example, the agricultural sector is expected to see higher prices of fossil fuels and fertilizer.

Agriculture may also benefit by generating and selling emission offsets. The term *offset* describes a reduction in emissions or increase in sequestration of GHGs produced by one entity that is sold to and used by another entity to offset its own emissions. Offsets provide a way to bring uncovered entities into an emissions trading system.

Agricultural producers are not affected uniformly by the rise in energy prices and not all agricultural producers have the same opportunities to provide offsets. How changes in energy prices and the ability to provide offsets affect different parts of the agricultural sector relates to the relative and absolute magnitudes of the changes in production costs and ability to change farming practices. Energy-related inputs and the ability to generate and provide offsets have a different importance across the sector and impacts reflect those different roles, both by commodity and region of the country. Section II of the paper presents an overview of energy use in U.S. agriculture. Section III presents a discussion of the impacts higher energy costs will have on crop production costs. Section IV identifies the role offsets can play in improving farm income and Section V presents some concluding remarks.

II. An Overview of Energy Use by U.S. Agriculture

Agriculture is an energy intensive sector, with row crop production particularly affected by energy price increases. Energy consumption in the agricultural sector can be either direct or indirect. Direct energy consumption in the agricultural sector includes use of gasoline, diesel fuel, liquid petroleum, natural gas, and electricity. Indirect use involves agricultural inputs such as nitrogen and other fertilizers which have a significant energy component associated with their production. Over 2005-08, ERS data show that expenses from direct energy use averaged about 6.7 percent of total production expenses in the sector, while fertilizer expenses represented another 6.5 percent. With the

more recent increases in energy costs, the combined share of these inputs reached nearly 15 percent in 2008.

However, the importance of energy and the effects of energy price changes are not uniform across commodities, as the energy intensity in production varies considerably. Table 1 shows the per-acre costs and their share of total operating costs represented by total energy inputs (direct energy and fertilizer) for 2007-08 for several agricultural commodities.[2] In general, energy costs as a percent of total operating costs are highest for wheat and feed grains. Based on cost of production data for 2007 and 2008, wheat, sorghum, corn, barley and oats have energy input shares between 55 and 60 percent. Cotton and soybeans are among the least energy intensive crops, with total energy costs representing only about 30 percent of total production costs.

A somewhat different distribution of energy costs by commodity results if looked at in terms of per-acre costs for energy-related inputs rather than shares of operating costs. Rice, peanuts, corn, and cotton have the highest per-acre expenses for these inputs. Again, energy-related costs for soybean production are low among these crops.

There is also variation in the regional distribution of energy-input costs. Figure 1 illustrates this for wheat and soybeans, two sectors at the opposite end of the energy-input share spectrum. For wheat, the regions with the largest share of input costs allocated to energy are the Fruitful Rim and the Heartland (71 percent), followed by the Prairie Gateway (69 percent).

Wheat production cost relationships for the Northern Great Plains and the Prairie Gateway, where the majority of the crop is grown, present an interesting contrast in operating expenses. While the 2 regions have a similar share of production costs attributable to fertilizer expense in 2008 (44-45 percent), the shares of costs that are for fuel, lubrication, and electricity are much different (25 percent for the Prairie Gateway, while only 11 percent for the Northern Great Plains). This is likely due to the high level of irrigation used in the Prairie Gateway.

For soybeans, the region with the largest share of input costs allocated to energy is the Southern Seaboard (54 percent), followed by the Eastern Uplands (45 percent). The region with the largest soybean plantings is the Heartland, which has the second lowest share of energy inputs in total operating expenses, at 36 percent. Regional energy costs for selected agricultural commodities are provided in appendix tables A1-A4. In addition, appendix tables A5-A6 show the energy-related expenses as a share of total production costs by State, by North American Industry Classification from the 2007 Census of Agriculture.

Direct energy costs make up a small share of total operating costs on livestock operations, comprising less than 10 percent of total operating costs for dairy, hogs and cow-calf operations (table 2). However, these operations experience higher energy costs indirectly through higher feed costs. Feed costs ranged from less than 11 percent of a cow-calf operator's total operating costs to almost 77 percent for dairy.

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[2] *Operating costs* are the out-of-pocket cash expenses paid for inputs unique to the commodity being produced. Operating expenses depend on production practices and on quantities and prices of inputs. These include inputs such as seed, fertilizer, feed, chemicals, and interest on operating capital.

III. Effects of Higher Energy Costs on Crop Production Costs

To represent the effects on the U.S. agricultural sector of higher energy costs resulting from the emissions cap-and-trade system in H.R. 2454, estimated energy price changes from EPA's (June 2009) and EIA's (August 2009) analyses were used to derive implications for crop-specific production costs.[3] Cost categories in the USDA-ERS cost of production framework included in this analysis were fertilizer and fuel, lube, and electricity. As shown in the previous section, these production inputs represent a significant portion of operating expenses for major field crops. We then apply changes in agricultural production costs arising from higher energy prices as inputs to the Food and Agricultural Policy Simulator Model (FAPSIM) to analyze the effect of these energy price changes under H.R. 2454 on national level production costs. This model allows farmers to change acreage decisions in response to higher energy prices, but does not allow for changes in production practices or technology. We know this is not the case due to changes in productivity over time as well as farmers ability to adapt to higher energy prices by shifting away from energy-intensive inputs. Regional effects are also discussed.

Agricultural sector impacts were derived for 2012-18 based on energy price changes from the EPA and EIA analyses. While most of the direct energy price increases would be felt immediately by the agricultural sector, impacts on fertilizer costs would be significantly mitigated due to provisions in H.R. 2454 that would rebate specific quantities of emissions allowances to "trade-vulnerable" industries.[4] Based on these considerations, we assume H.R. 2454 imposes no uncompensated costs on nitrogen fertilizer manufacturers related to increases in the price of natural gas through 2024. We assume for modeling purposes that these allocations are terminated beginning in 2025. This assumption is inconsistent with the provisions of H.R. 2454, which would continue to provide allocations to trade-vulnerable industries through at least 2035 (at a rate that could begin phasing down in 2026). This assumption will lead in the medium-term scenario to an over-estimate of the impact of H.R. 2454 on the cost of fertilizer and therefore on the production costs of agriculture (See Appendix B for discussion of medium and long term effects).

As emission caps become more stringent over time, allowance prices and corresponding energy price impacts become larger. Results for these scenarios illustrate some of these larger impacts. Table 3

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[3] For the June EPA H.R. 2454 analysis, scenario 2 was used. The EPA analysis of H.R. 2454 can be found at: http://www.epa.gov/climatechange/economics/economicanalyses.html. For the EIA analysis, the basic case was used. The EIA analysis of H.R. 2454 can be found at: http://www.eia.doe.gov/oiaf/servicerpt/hr2454/index.html .

[4] Subtitle A of Title IV of H.R. 2454 would provide "allowance rebates" to firms within industrial sectors that have: 1) an energy or greenhouse gas intensity of at least 5% and a trade intensity of at least 15%; or 2) an energy or greenhouse gas intensity of at least 20%. Without these allocations, firms in these energy-intensive, trade-exposed (EITE) industries would incur costs related to their compliance with the cap-and-trade program that competitors in foreign countries without comparable greenhouse gas regulations would avoid, and hence be at a market disadvantage relative to such foreign competitors. The bill sets aside a maximum number of allowances that can be rebated to EITE industries each year: this number is 2% of the overall cap for 2012 and 2013, 15% of the overall cap in 2014, and after 2014 a number of allowances that declines annually from 2014 in proportion with the cap through 2025. Beginning in 2026, H.R. 2454 specifies a default phase-out schedule for the number of allowance rebates. This default schedule would lead to a complete phase-out of these allocations by 2035, but this phase-out schedule may be delayed by the President based on a determination related to the state global action to reduce greenhouse gas emissions.

shows selected energy-related impacts from the EPA and EIA analyses of H.R. 2454 that were used for the agricultural sector scenarios across each of the time periods. EIA results were available on an annual basis out to 2030.

Using the EPA and EIA results shown in table 3, changes in measures of energy-related agricultural inputs were estimated. Fuel price impacts are based on the EPA petroleum price changes and the EIA diesel fuel (transportation) price changes. Fertilizer price impacts in the EPA scenarios reflect price changes for natural gas and petroleum, while those in the EIA scenarios are based on price changes for natural gas (feedstock) and industrial distillate fuel oil. Fertilizer price impacts under both the EPA and EIA price scenarios reflect EITE rebates.

Table 4 shows the average percent changes in the indexes of prices paid by farmers for fuels and fertilizer across the various time periods and scenarios analyzed. Reflecting the differences in the relative sizes of the EPA and EIA energy price impacts, effects on producer input prices during 2012-18 are about twice as large for the EIA-based scenarios compared to the EPA scenarios. The exception is the net fertilizer cost increase, reflecting in part different assumptions about the size of the EITE rebate and EPA projections of declining near-term natural gas demand under H.R. 2454.[5]

The discussion of national impacts on the agricultural sector resulting from higher energy prices associated with the proposed emissions cap-and-trade policy is divided into two parts. First, an assessment of the impacts on major field crops and the livestock sector over 2012-18 is discussed. This is followed by a discussion of impacts of higher energy costs on production expenses for the fruit and vegetable sector. It does not include the effect of other countries enacting policies mitigate GHG emissions. The analysis and discussion in this section below do not include the effects of GHG offsets or other mechanisms to compensate farmers for emissions reductions and carbon sequestration. However, when revenues from offsets are considered in conjunction with production costs, net farm income is expected to be positive.

To assess impacts on major field crops and the livestock sector, changes in agricultural production costs arising from higher energy prices are used as inputs to the Food and Agricultural Policy Simulator Model (FAPSIM). FAPSIM covers commodity markets for corn, sorghum, barley, oats, wheat, rice, upland cotton, soybeans (including product markets for soybean meal and soybean oil), cattle, hogs, chickens, turkeys, eggs, and dairy. Fruit and vegetables are not modeled in FAPSIM but are analyzed using a separate model. FAPSIM calculates the impacts of changes in production costs on supply, demand, and prices in each of these markets over 2009-18. At the aggregate level, the model also computes associated changes in production expenses in the sector and net farm income. FAPSIM allows farmers to change acreage decisions in response to higher energy prices, but does not allow for changes in input mix. The model simulations for the different scenarios and time periods assume no changes in technology or production practices (such as fertilizer application rates) beyond those implicit in the reference scenario's trends.

Higher prices for energy-related agricultural inputs (fertilizer and fuel) raise the cost of production for all major crops. Table 5 shows the average impacts on variable production costs per acre for major field crops over 2012-18. For the EPA energy price scenario (with average fuel and fertilizer

[5] Feedstock prices do not include impact of allowance allocations to local distribution companies. To the degree that such allowances lower feedstock prices to industrial users, the impacts on price paid by farmers could be overstated.

price increases over 2012-18 of 2.6 percent and 0.3 percent, respectively), the largest changes in per-acre production costs from baseline levels are for crops that use more energy-related inputs, most notably rice, corn, and cotton. However, compared with overall crop-specific production costs, high-cost rice and cotton are relatively less affected by the energy-related input changes (each up by less than 2 percent), while sorghum production costs are relatively more affected at 2.2 percent. This is due to the lower energy-input share relative to production costs for rice and cotton producers (as shown earlier in table 1). Whether looked at on a cost per acre basis or on a cost as share of production costs basis, soybean production costs are less affected than those of most other crops.

For the EIA energy price scenario, energy-related production cost impacts for all crops are generally on the order of twice as large as those for the EPA energy price scenario. However, the relative impacts among the crops are similar to those identified for the EPA scenario. For both price scenarios, the EITE rebates for fertilizer producers result in a significant reduction in potential costs since most of the impacts are limited to the increase in fuel costs.

Acreage effects, without offsets, are modest (table 6). Under the EPA energy price scenario, overall acreage planted to major field crops decreases by 133,000 acres, a less than 0.1 percent change from baseline levels over 2012-18. However, relative net returns among cropping alternatives, along with differences in producer responses to changes in economic incentives, result in varying impacts for each crop. Wheat acreage is down the most at 63,000 acres. While corn acreage also declines (less than 0.1 percent decline), its impacts are sharply reduced because of the importance of the EITE rebates in determining fertilizer costs. Also, the net shift of acres to soybean production is reduced relative to baseline levels as the relative cost advantage of the low-fertilizer input crop is diminished with the rebate.

Similarly, for the EIA energy price scenario, a larger absolute decline in total acreage results, though still modest, with planted acreage down 354,000 acres. This represents a 0.1 percent decline in planted acreage. Wheat and corn acreage still experience the largest reductions. Again, there is a net switch in acreage to soybeans as their returns are affected the least among crops.

In general, crop production is down slightly, leading to higher prices (table 7). However, since production changes are small, price impacts are minimal; with no price change greater than 0.4 percent (0.2 percent and 0.4 percent are the highest price changes under the EPA and EIA energy price scenarios, respectively). Under both energy price scenarios, slightly higher corn prices, which are partially offset by lower soybean meal prices, lead to a small increase in feed costs for the livestock sector (table 8). As a result, livestock production declines slightly. The impacts on livestock production vary across livestock species reflecting the relative shares of corn and soybean meal in the typical feed ration. Because corn is large part of their feed ration, pork and beef are affected more than poultry. Feed costs under the EIA energy price scenario experience a larger increase than those from the EPA energy price scenario, resulting in slightly larger livestock production declines. It is worth noting that at the time EPA conducted its analysis, it assumed that allowance allocations to local distribution companies of electricity only used these to offset higher prices to residential customers. If this were extended to industrial customers as well, farmers could also experience lower electricity prices. We expect this to have a relatively small effect on estimated production cost impacts. However, since the largest energy costs for agricultural producers are fuel and fertilizer.

Net farm income in the agricultural sector declines from the FAPSIM baseline on average by 0.9-2.1 percent over 2012-18 (table 9). This change is due primarily to higher production expenses, although higher cash receipts partly offset the increases in production expenses. These income effects do not reflect revenues from GHG offsets or changes in biofuel production nor do they reflect the related effects of land use changes associated with GHG offsets.

Effects on Production Expenses for the Fruit and Vegetable Sector

Fruits and vegetables are not included in FAPSIM. Instead, data from USDA's 2007 Agricultural Resources Management Survey (ARMS) were used to estimate the effects of H.R. 2454 on costs of production in the fruit and vegetable sector. Average per farm effects on variable costs of production were estimated based on the increased input prices for fuels, electricity, and fertilizer estimated under the FAPSIM runs described above.

Unlike for most row crops and livestock production, labor is the single largest variable cost for vegetable, melon, fruit and tree nut farms. However, the second largest expense component is fertilizer and agricultural chemicals. In 2007, fertilizer and agrichemicals accounted for about 18 percent of the variable cash expenses for specialized vegetable and melon farms and 13 percent for specialized fruit and tree nut farms. Motor fuels and oil used to run tractors, generators, and irrigation pumps accounted for 5 percent of vegetable cash costs and 4 percent of cash costs for fruits and tree nuts. In this analysis, per-acre fertilizer application rates are assumed to remain unchanged. Over the medium- and long-run, most growers would adjust application methods, amounts, timing, or the mix of crops produced to reduce expenses.

In addition, electricity is required by these farms to run irrigation pumps, ice makers, lights, and sorting and packing equipment in packing sheds. Electricity is the largest component of the public utility expense (which also includes telephone, water, and internet access). According to ARMS data, electricity accounts for 2-3 percent of cash costs for fruit and vegetable farms. This analysis for the fruit and vegetable sector assumes that the entire utility expense category consists of electricity costs since there was no way to break out electric costs from telephone, water, and other utility expenses. Like fertilizer and other fuel expenses, no adjustments were assumed in electricity use; thus, the results for energy costs assumed here are likely high estimates. As with the previous results, this estimate also assumes that allowances allocated to local distribution companies are not used to keep prices to industrial customers low.

Impacts of higher fertilizer, fuel, and electricity prices on variable costs within the fruit and vegetable complex are generally small in terms of percentages (table 10). Across the EPA and EIA short-term energy price scenarios, impacts on costs for all fruits and vegetables were 2 percent or less. Over the long-term, the total impact on variable costs of production under the EPA energy price scenario was estimated to be 3.8 percent per farm that specializes in fruits and vegetables (farm for which more than half of all sales come from fruits and vegetables).

Impacts across Farm Types and Regions

Regional and farm type impacts are based on results from the Farm-Level Partial Budget Model. The model operates on individual farm data for farm businesses from ARMS. The model reflects

historic production patterns and farm structure within each region. Any potential structural or production responses by farms are not included within the model.

The model uses results from the FAPSIM scenarios discussed earlier as inputs to derive regional and farm type impacts consistent with the national outcomes. Results can be summarized across various groupings of farms such as by resource region, commodity specialization, or farm size categories. Nonetheless, since farm business performance varies within these groupings, results do not indicate performance of individual farms within a group.

The overall impacts reported in this section can differ from those in the national farm income accounts due to a number of factors. This section reflects, in part, on farm businesses[6] so the concentration of expenses is higher than for all farms. Further, part of the differences relates to the treatment of rent—the national accounts use net rent, while rent comes directly out of net cash income at the farm level.

A simulation of how the legislation will impact agriculture by farm type reveals that some segments of agriculture will be more impacted by the legislation than others. The analysis focuses on results for 2014 and this one year analysis serves as an example of regional and commodity differences in the short-run.

Net cash income in 2014 for all farm businesses is estimated to be 1-4 percent lower than in the 2014 baseline level compared to the 1-2 percent decline in net farm income presented in the previous section under the FAPSIM analysis. Wheat, cotton, rice, and "other crop" producers have a decrease in net income of 2-8 percent across the EPA-based and EIA-based energy price scenarios (figure 2). Except for "other livestock" producers, most other farm types have a net income decrease of around 1-3 percent. Impacts on net income across all farm types are significantly mitigated by provisions in H.R. 2454 that provide allowance rebates to trade-vulnerable industries, including fertilizers. As in the previous sections, these impacts do not include revenue from GHG offsets or increased biomass production.

The impact of higher energy prices is not evenly distributed. Other cash grains, wheat, corn, soybeans, cotton, rice, specialty crops, and hogs account for nearly 49 percent of all farms, but these farms also account for over 63 percent of the projected decrease to net cash income relative to 2014 baseline levels. As was the case in analyzing farm types, net cash farm business incomes under both the EPA- and the EIA-energy price scenarios are reduced across all regions. All regions can expect a decrease in net cash income, ranging from less than 2 percent to about 7 percent (figures 3 and 4), with the biggest decrease in the Mississippi Portal region under the EIA energy price scenario. Again, it is important to note that these estimated income effects do not reflect management decisions about changes in inputs, revenues from GHG offsets nor do they reflect the related effects of land use changes.

IV. The Role of Offsets

The role of offsets is important for agriculture as well as to the rest of the economy. First, offsets provide a potential low-cost option for compliance to GHG emissions reduction targets for covered

[6] Farm businesses are defined as family and non-family operations that report farming as their principal occupation.

sectors under a cap-and-trade system. Offsets reduce the costs of compliance for covered entities which results in smaller increases in allowance prices that are then passed on to consumers—including farmers—as increased energy prices. Conversely, limited offset availability could result in higher costs to the economy. In its analysis of H.R. 2454, the EPA estimates that allowance prices would be almost 90 percent higher if international offset markets were not allowed.[7] In a similar analysis, the EIA estimates that allowance prices would be 64 percent higher with no international offsets market.[8] These analyses do not consider how allowance prices would change if both international and domestic offsets were not available, but the effect would likely be magnified. When international offsets are not available, demand for domestic offsets increases substantially and acts as a limiting factor on allowance price increase. The Congressional Budget Office (CBO) estimates that if no offsets were allowed, allowance prices would more than triple.[9]

Second, offsets are a potential income source for agricultural producers and forest landowners through changes in land management practices (e.g., reduced tillage, increased fertilizer efficiency, afforestation/tree planting), animal management (e.g., dietary modifications), and manure management (e.g., biogass capture). And while the profitability of management practices varies widely by region, as does the amount of carbon storage attainable, net revenues from agricultural offsets can mitigate the effects of higher production costs due to higher energy costs.

Lastly, a carbon offsets program could affect land use and agricultural production and prices. If afforestation is the primary source of carbon offsets, for example, cropland and pastureland would be converted to forests which would raise farm prices and increase farm income, but also result in higher food prices for both domestic and foreign consumers. Other sources of possible offsets such as conservation tillage and other agricultural management practices that reduce nitrous oxide (N_20) and methane (CH_4) emissions could have potentially smaller effects on land use and agricultural production and prices but would be more difficult to monitor and verify.

The analysis presented here does not examine the impacts of international offsets on the U.S. farm sector. International offsets, particularly reduced deforestation offsets that limit agricultural expansion globally can also affect U.S. farmers by raising farm prices. As found in the EPA, EIA, and CBO analyses, international offsets are important for avoiding high allowance prices, which will lead to more moderate energy price increases but also result in lower prices for domestic offsets.

Agriculture and forestry have a wide variety of production and land management practices that can lower GHG emissions and/or increase the quantity of carbon stored in soils and vegetation. These include shifting cropland into trees or permanent grasses, managing existing forests to store additional carbon, adopting no-till or reduced tillage systems on a long-term basis, eliminating fallow periods, planting cover crops, changing nitrogen fertilizer management practices (including rates, application method, timing, and use of inhibitors), altering livestock feed mixes, and changing manure management practices.

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[7] The EPA analysis of H.R. 2454 can be found at http://www.epa.gov/climatechange/economics/economicanalyses.html

[8] The EIA analysis of H.R. 2454 can be found at: http://www.eia.doe.gov/oiaf/servicerpt/hr2454/index.html

[9] Congressional Budget Office. *CBO Cost Estimate: H.R. 2454 American Clean Energy and Security Act of 2009*, June 5, 2009. p.18.

A number of recent economic studies have focused on how farmers and forest land owners would respond to various incentives designed to increase the use of production practices and land uses that increase carbon sequestration and/or reduce emissions associated with commodity production. For six of these studies, table 11 details the types of mitigation activities assessed, the regional and sector coverage, and the quantity of GHG mitigation achieved by specific activities at selected prices.

The studies summarized in table 11 employ different methodologies and make alternative assumptions regarding key underlying variables, trends, and other factors. Additionally, the studies were designed to look at different research questions and so differ with respect to geographic focus, sector coverage, activity coverage, inclusion of relevant federal policies and measures and time period considered. When viewed collectively, however, several overall conclusions emerge regarding the potential of the U.S. agriculture and forestry sectors to supply greenhouse gas mitigation within the context of a cap-and-trade system.

Collectively, the studies found, depending on the CO_2 price, farmers and forest land owners generate measurable amounts of greenhouse gas mitigation through changes in tillage practices, crop rotations, elimination of fallow periods, switching marginal cropland to permanent grassland, reducing CH_4 and N_2O emissions from agricultural sources, making changes in forest management, and afforestation.

While not presented in the table, the offset supply curves from these studies indicate than even at low CO_2 prices, the domestic agriculture and forestry sectors could supply a significant amount of GHG offsets to entities covered under a cap-and-trade system. At very low CO_2 prices (e.g., under $10 per ton), these offsets would be generated mostly by changes in agricultural production practices. Lewandrowski et al (2004), EPA (2005), and Antle et al. (2001, 2007) found some shifting to less GHG intense production practices (such as increased adoption of no-till, elimination of fallow periods, and shifts to less energy intensive rotations) at CO_2 prices of $5 per ton or less. In many areas no-till, conservation tillage, and conventional tillage systems are practiced in relatively close geographic proximity. This suggests the economic returns to different tillage systems are often relatively similar. Where this is the case, a relatively small economic incentive favoring one system over another – such as a carbon market could provide for no-till, would be sufficient to induce some farmers to change tillage systems. Similar reasoning applies to increases in the use of other less GHG intense production practices and rotations.

Results in the two studies that include forest management as a mitigation option (EPA 2005, 2006) suggest these activities would also start generating significant offsets at a CO_2 price as low as $5 per ton. At a CO_2 price of about $10 per ton, afforestation becomes economically attractive and dominates mitigation activities in the agricultural sector. Across studies, afforestation accounts for an increasing share of total offsets as CO_2 prices rise – at least through the price ranges considered ($33.1 per ton in Lewandrowski et al., $50 per ton in EPA (2005), and $54.4 per ton in Lubowski et al.). Opportunities to generate offsets from reducing N_2O and CH_4 emissions from agricultural sources appear positive but relatively modest through the range of CO_2 prices considered (EPA, 2005 and 2006).

Finally, the studies by Lewandrowski et al. and EPA (2005) discuss the difference between the technical and economic potentials of the agriculture and forestry sectors to mitigate GHG emissions

through changes in production and land management practices. As with the empirical results, these discussions are not directly comparable. Lewandrowski et al. combine published technical assessments of the carbon sequestering potential of various crop and livestock activities with published estimates of the total land suitable for each practice to develop a table describing the aggregate technical potential of specific farm sector activities to sequester carbon (see Lewandrowski et al., table 2.2, page 5). The discussion in EPA (2005) is conceptual and drawn from an earlier paper McCarl and Schneider (2001). Also, the studies differ in terms of evaluation period, as the EPA 2005 results are from 2010-2100 while the Lewandrowski et al. study evaluates a shorter, 15 year time period.

It is also important to understand the regional economic implications of a national cap-and-trade framework such as contained in H.R. 2454. Insights regarding these impacts can be developed from the studies by Lewandrowski et al. (2004) and EPA (2005). Although the studies vary significantly in timeframe and other underlying assumptions, this brief synopsis highlights the regional difference in adoption rates of offset options, using afforestation as an example.

Regional results of offset potential by source from Lewandrowski et al. with GHG mitigation priced at $34 per ton CO_2, and, EPA (2005) with GHG mitigation priced at $30 per ton CO_2 are shown in figures 5a and 5b. In both cases, afforestation is the largest potential source of offsets[10]. In the EPA (2005) study, 90 percent of the 434.9 million metric tons (MMT) of CO_2 sequestered by afforestation occurs in the Corn Belt and South Central regions. The remainder occurs in Southeast, Lake States, and Rock Mountain regions. In the Lewandrowski et al. study, over 60 percent of the CO_2 sequestered by afforestation occurs in Appalachia, the Southeast, Delta States, Lake States, and Corn Belt. One region where the afforestation results differ significantly between the two studies is the Pacific Northwest and California. In Lewandrowski et al, these areas sequester 160 MMT CO_2 via afforestation (all from conversion of pasture to trees). In this study, afforestation in the Pacific Northwest (PNW) region requires a relatively high price for CO_2 before it is economically attractive. At prices below $15 per ton CO_2 virtually no afforestation occurs. In the EPA (2005) analysis the PNW and California sequester only 4.7 MMT CO_2 from afforestation.

Agricultural Offsets in H.R. 2454

The economic profitability to supply offsets depends on the price that industries in covered sectors are willing to pay for offsets. The June EPA analysis of H.R. 2454 (2009) estimates the real ($2005) price of allowances to increase from about $13 per ton of carbon dioxide equivalent (CO_2eq) in 2015 to over $70 per ton CO_2eq by 2050; an increase of 5 percent per year[11] (table 14).

To estimate the economic potential for agriculture and forestry to supply offsets we rely on EPA allowance prices and detailed modeling provided by EPA.[12] The results presented are similar to but not

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[10] In the Lewandrowski et al. study, afforestation was assumed to be zero in the North Plains, South Plains and Mountain regions.

[11] For the June EPA H.R. 2454 analysis, scenario 2 was used. The EPA analysis of H.R. 2454 can be found at: http://www.epa.gov/climatechange/economics/economicanalyses.html.

[12] To estimate the economic potential of the agriculture and forestry sectors in the United States to provide carbon offsets, EPA (2009) used an economic model, the Forest and Agricultural Sector Optimization Model (FASOM), developed by Bruce McCarl at the Texas A&M University. The results presented in this paper reflect simulations during March 2009. A more

identical to the results provided in the EPA (2009) analysis of H.R. 2454 or our preliminary analysis of H.R. 2454 (USDA, OCE, 2009). The results presented in this analysis reflect the estimates from the Forest and Agricultural Sector Optimization Model (FASOM) based on an average of two scenarios: an inflation adjusted carbon allowance price of $5 per ton in 2010 and increasing at 5 percent per year over time and an inflation adjusted carbon allowance price of $15 per ton in 2010 and increasing at 5 percent per year over time. The average of these carbon prices paths generates a carbon price path that approximates the carbon price allowance path estimated by EPA. FASOM values are given as net average annual emissions/sequestration for the half-decade following the date, e.g., 2015 represents 2015-2019. Therefore the comparison in the short-term here is FAPSIM's 2012-18 and FASOM's 2015-2024. This difference in timeframes considered accounts for some of the variance in results between the models. In addition, in this paper we focus exclusively on agricultural activities and include afforestation as an agricultural activity.[13]

It is important to note that results from economic models – including both FAPSIM and FASOM – should not be interpreted as precise estimates but rather as indications of the direction and magnitude of the expected effect.

FASOM captures the increases in energy prices evaluated earlier in the report. Because it relies on a different modeling framework – one that encompasses fuel and commodity price increases, changes in input mix and land use change, and revenues from offset and biofuel activities – one should not add the impacts form the FASOM and FAPSIM models together. The FASOM modeling results already account for energy price rises. However, the FASOM results do not include adjustments for EITE or local distribution company allowances. Therefore, the FASOM results over-estimate the costs on agricultural production.

The categories of domestic offsets modeled in FASOM represent sources that have significant supply in the model at the relevant allowance prices. The exclusion of other sources in the modeling results does not imply that those sources would not be eligible to receive offsets credits. Per this operating criteria, FASOM does not account for several categories of GHG reductions, including: improvements in organic soil management; advances in feed management of ruminants; changes in the timing, form, and method of fertilizer application; and alternative manure management systems other than anaerobic digesters.[14] The model only evaluates additional no-till adoption relative to a historic baseline. To the extent legislation awards offsets to no-till prior to the start of the program, it is not accounted for here. It is important to note that these emissions reductions would not be additional relative to the baseline.

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complete description of FASOM modeling framework and a complete list of commodities can be found at: http://agecon2.tamu.edu/people/faculty/mccarl-bruce/FASOM.html

[13] The EI A prices were not used in this analysis because they only extended to the year 2030.

[14] Because of how it is handled in FASOM, agricultural soil sequestration does not show significant supply. However, detailed FASOM output indicates a 50 percent increase in the percent of cropland using conservation tillage and no-till by 2050 in response to a $15/ton CO_2 incentive payment. Because overall land area in crops declines due to afforestation, the modeling indicates a net decrease in total agricultural soil carbon storage as carbon is transferred from the agricultural soils pool to the afforestation carbon pool.

In addition, FASOM accounts for implementation of the renewable fuel standard mandated in the Energy Independence and Security Act of 2007 in the baseline. As such, it contains various assumptions about biofuels and when new biofuels (e.g., biomass for electricity generation and cellulosic ethanol for transportation) become commercially viable.[15] Changes in these (or other) assumptions can significantly alter the simulation results. Under a cap-and-trade policy, demand for biomass feedstocks used for biofuels and bioelectricity could increase beyond baseline levels, providing additional revenues to the farm sector.

FASOM assumes economic entities – including farmers and forest landowners - have perfect foresight with respect to the future. This feature crucially affects the quantity of offsets supplied by the agriculture and forestry sector because in making management decisions with respect to production and land management – say to afforest additional cropland land at a given point in time - farmers know exactly what future commodity and CO_2 prices will be in certainty. In reality, a number of the offset generating activities, both inside and outside of FASOM, involve resource commitments that can run for years or decades (including investments forest management, afforestation, new livestock waste management systems, renewable energy systems, and energy efficiency technologies). Accounting for uncertainty in these investment decisions could reduce the supply of agriculture and forestry offsets.

Unlike FAPSIM, FASOM generates baseline estimates for the medium and longer term. However, predictions far out into the future are inherently more uncertain than nearer term estimates. USDA typically only forecasts agricultural prices and incomes 10 years into the future. As such, results, particularly for 2030 and 2050, should not be interpreted as precise estimates but rather as indications of the direction and magnitude of the expected effect.

From 2015 to 2050, the total amount of offsets that would be supplied by the agricultural sector increases from 59 million metric tons of carbon equivalent ($MMTCO_2eq$) per year to over 420 $MMTCO_2eq$ by 2050 (table 13). With allowance prices increasing over time, the real gross revenues resulting from agricultural offsets increases from about $800 million per year in 2015 to almost $30 billion per year by 2050.

Overall, the primary source of agricultural offsets would be increased carbon sequestration through afforestation of crop and pastureland.[16] The gross revenues (before accounting for the cost of the offset-generating activity) associated with offsets from afforestation account for about 85 percent of the total agricultural offset revenues from 2015 to 2050 (table 13). Reductions in CH_4 and N_2O emissions account for second largest share of agricultural offsets. These offsets total about 11 MMT CO_2eq in 2015 and 78 MMT CO_2eq in 2050. Many of the opportunities to generate these offsets would be concentrated among specific groups of producers. Examples include changes in manure management practices for confined dairy, hog, and poultry operations, changes in diet for confined cattle operations, changes in fertilizer management for nitrogen intensive commodities such as corn and cotton, and, changes in rice production practices.

[15] In the FASOM baseline, total ethanol production is projected to increase from 15 billion gallons per year in 2010 to 47 billion gallons per year by 2050.

[16] This includes soil carbon sequestration on afforested agricultural lands, in addition to carbon sequestered from new trees.

At the time the EPA-provided FASOM simulations were conducted regional break downs of the agricultural offsets by time period were not estimated. To address this issue, additional simulations were conducted at a later date and provided by FASOM modelers (not from EPA). Therefore, these results use a slightly different version of the March model which produces estimates of regional agricultural offsets by activity. Results from this simulation were used to develop regional offset shares that were then applied to the aggregate agricultural offsets presented in the earlier FASOM simulations.

The Corn Belt region is the largest supplier of GHG offsets across time periods and the Lake States region is the second largest supplier (table 14).[17] In each 5-year period between 2015 and 2050, the Corn Belt region accounts for between 30 and 50 percent of all agricultural sector offsets supplied while the Lake States region account for between 20 and 30 percent of the total supply of agricultural offsets. The South Central, Northeast, and Rocky Mountain regions account for, on average and respectively, 11, 8, and 6 percent of all agricultural offsets supplied between 2015 and 2050.

Implications for Land Use

Providing offsets through afforestation has clear land use implications. As the value of carbon allowances increase, FASOM estimates provided by EPA show that afforestation occurs on larger amounts of crop and pastureland (table 15). In 2015, when the price of carbon allowances is about $13 per ton of CO_2eq, additional afforestation occurs on about 8 million acres. This represents a 3 percent increase in forestland against the projected baseline. By 2030, when the price of carbon allowances increases to almost $27 per ton of CO_2eq, additional afforestation occurs on almost 27 million of acres. By 2050, when the price of carbon allowances increases to $70 per ton of CO_2eq, additional afforestation occurs on almost 60 million acres, 35 million acres of which comes from cropland (14 percent decline from baseline) and 24 million acres from pasture (almost 9 percent decline from baseline).

The source of land being used for afforestation matters as well. In the early periods, more pastureland is converted to forests than cropland. For example, in 2015, when the price of carbon allowances is relatively low, almost all the afforestation occurs on pastureland. As the value of carbon allowances increase, the share of cropland used for afforestation increases. By 2030, when price of carbon allowances rises to about twice the price in 2015, slightly more than half of the additional afforestation occurs on cropland. By 2050, when the price of carbon allowances increases to over $70 per ton of CO_2eq, about 60 percent of the afforestation occurs on cropland compared to about 40 percent for pastureland. A study by de la Torre Ugarte et al. (2009) has shown a greater portion of mitigation coming from pasturelands, which results in smaller aggregate impacts on commodity production and food prices. However, that study also shows considerably less GHG reductions.

The amount of land where additional afforestation occurs also varies by region. As shown in table 16, in 2015, almost all of the additional afforestation occurs in four regions of the country: the Corn Belt, Lake States, Rocky Mountains, and South Central. While most of the additional afforestation occurs in the Corn Belt, there is also a growing concentration of afforestation over time. In 2015, for example, about 55 percent of the afforestation occurs in the Corn Belt and Lake States. By 2050, almost 65 percent of the additional afforestation in the United States occurs in those two regions.

[17] FASOM regions are presented in figure 6.

Impacts on Offset-Related Land Use Change on Crop Production and Prices

Land use decisions such as afforestation of cropland, other agricultural offsets, bioenergy feedstock production, and energy price increases will have production and price impacts. As carbon allowance prices increase, the magnitude of the impact compared to baseline production and prices grows. In 2015, the commodity production impacts are relatively modest except for rice (table 17). Corn and soybean production are 3.5 and 1.4 percent lower, respectively, compared to baseline production levels.[18] By 2030, corn and soybean production are about 7 and 9 percent lower, respectively, when compared to baseline levels of production in 2030. By 2050, corn and soybean production are 22 and 29 percent lower than baseline levels.

Under the FASOM baseline, crop production generally increases over time due to yield growth. Thus, the impacts of higher carbon allowance prices on future production relative to current levels are less than the impacts compared to baseline levels. For example, while corn production is 22 percent less than baseline production levels for 2050, this lower level of production is 13 percent higher than baseline levels of production in 2015. Only for soybeans and sorghum are 2050 levels of production under cap-and-trade less than baseline levels of production in 2015.

Lower levels of production relative to baseline levels translate into higher real prices. As shown in table 18, by 2030, corn, rice, and wheat prices are 15, 5.5, and 3 percent higher compared to baseline prices. By 2050 corn, rice, wheat prices are 28, 8, and 13 percent higher, respectively, compared to baseline prices. In addition, soybean, cotton, sorghum, and barley prices are 21, 25, 40, and 57 percent higher compared to baseline prices. While baseline yield growth mitigates increases in corn, wheat, rice and oat prices over time, crop prices in real terms are higher in 2050 under cap-and-trade compared to current prices for sorghum, barley, cotton and soybeans.

Lower domestic crop production and higher prices could spur increases in agricultural production abroad as producers make up for reductions in U.S. crop exports relative to the baseline (table 19). These trade impacts could moderate the anticipated rise in crop prices over the baseline. At the same time, expansion of agricultural production abroad could lead to emissions leakage if forests and grasslands are cleared to produce crops. However, international offset programs, such as reducing deforestation, could limit this effect.

Implications for Livestock

Higher real commodity prices also affect livestock production and prices through higher production costs. Hog slaughter is estimated to fall by about 7 percent in 2030 and fed beef slaughter is estimated to fall by about 3 percent compared to 2030 baseline production levels (table 20). As greater and greater amounts of cropland are afforested and crop prices rise, the impacts on livestock producers increase. By 2050, hog slaughter is 23 percent lower compared to baseline levels while fed beef slaughter is estimated to fall by almost 10 percent compared to baseline levels. Milk production is estimated to fall by about 7 and 17 percent compared to baseline levels in 2030 and 2050, respectively. Chicken, turkey, and egg production appear to be relatively less impacted.

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[18] FASOM estimates differ from the short-run FAPSIM results discussed in tables 5-9 and show the impact of GHG offsets and related land use change.

Lower livestock supplies will cause real prices to increase relative to baseline levels (table 21). Those livestock categories which showed the largest production impacts translate into the smallest price changes. For example, for 2030, the 7 and 3 percent declines in hog and fed beef slaughter result in price increases of 12 and 4 percent, respectively; by 2050, the decline in hog and fed beef slaughter result in price increases of 27 and 14 percent, respectively. However, while egg, broiler, and turkey production are only 2, 7, and 8 percent lower than baseline production levels in 2050, respectively; egg, broiler, and turkey prices are 20, 16, and 15 percent higher, respectively. The prices for eggs, broilers, and turkeys are far more responsive to a change in production relative to the prices for beef and hogs. Similarly, milk prices are expected to increase by 33 percent in 2050 compared to the baseline in response to the 17 percent decline in production. The relatively larger price impacts for eggs, broilers, turkeys, and milk compared to beef and pork reflects the availability of alternatives in consumers food spending. Price increases for beef and pork are limited because consumers can switch to relatively lower priced alternatives such as chicken and turkey. However, there are few alternatives in the consumer food basket to chicken, turkey, and milk.

While livestock producers will see an increase in feed costs, they are expected to pass a portion of these higher costs onto consumers by reducing herd size, yielding increased income after accounting for demand reductions. Price increases in livestock due to cap-and-trade could be mitigated in part if foreign producers increase their production of livestock beyond baseline levels in response to higher prices. Similar to the trade impacts associated with changes in crop production, increase in foreign livestock production could lead to increases in GHG emissions abroad if producers clear native ecosystems to expand pastureland. As with crop production, well designed international offset programs could limit this effect.

Implications for Farm Income/Producer Surplus

Higher real commodity prices coupled with lower production, changes in input costs, and offset net revenues will have an impact on net farm income or producer surplus. FASOM modeling results provided by EPA show the annuity value of changes in producer surplus over the entire simulation period.[19] The annuity value measures the annual change in producer surplus relative to baseline producer surplus over time. The annual changes in producer surplus are then discounted to reflect differences in the value of current earnings compared to future earnings (net present value calculations). These annuity values, which were not included in the June EPA H.R. 2454 analysis, include changes in farm income through 2080.

The annuity value of the change in producer surplus is expected to be almost $22 billion higher; an increase of 12 percent compared to baseline producer surplus (table 22). Almost 30 percent of the gains would occur in the Corn Belt followed by the South East region (16 percent of the gains), Great Plains region (13 percent), and South Central region (10 percent).

The producer surplus impacts exclude earnings from the sale of carbon from afforestation. USDA estimates the annuity value of the gross revenues associated with the sale of afforestation offsets

[19] FASOM estimates the impact on producer surplus, a measure of farm income. The annuity value is calculated over the period 2015-2075. FASOM estimates differ from the short-run net farm income effects presented in table 9 estimated by FAPSIM and reflect the impacts of GHG offsets and related land use change.

would result in approximately $3 billion of additional farm revenue.[20] About 90 percent of that additional revenue would be generated in four regions of the country: the Corn Belt (40 percent), Lake States (25 percent), South Central (14 percent), and Northeast (11 percent). However, part of that increase in revenue will be offset by the continued costs associated with maintaining afforestation projects.

One would expect a relative increase in producer surplus in the Lake States if income from afforestation was included in the estimates provided in table 22. Alternatively, because afforestation is assumed not to occur in the Great Plains and Southwest regions, one would expect a relatively smaller increase in producer surplus in those regions.

Impacts on Consumer Food Prices

In addition to the primary crop and livestock commodities, FASOM also incorporates the processing of primary commodities into secondary commodities. Table 23 shows the percentage change in prices compared to baseline prices over time. The changes in secondary commodity prices reflect the changes in the price of primary commodities. For example, the 23 and 38 percent increase in soybean meal and oil prices for 2050 shown in table 23 reflect the lower soybean production and higher soybean prices. Similarly, the beef, pork, chicken, and turkey price increases of 12, 32, 16, and 17 percent in 2050 shown in table 25 reflect the 14, 27, 16 and 15 percent price increases in 2050 for fed beef, hogs, broilers, and turkeys.

FASOM does not estimate the impact of changes in primary and secondary commodity prices on the consumer prices index (CPI). To estimate the impacts on the CPI, USDA's Economic Research Service matched the FASOM results to analogous categories of Producer Price Index (PPI) food items. Most of the FASOM estimates were used to make direct inferences as to the possible change in their comparable PPI series[21]. The analysis assumes that consumer spending patterns remain relative constant over time. To the degree to which there may be shifts in consumption patterns due changes in tastes and preferences, the effects may be overstated or understated.

The CPI categories chosen to represent the retail prices were selected so they were either a direct retail representation of the input product (e.g. the Pork CPI to the Pork PPI) or an aggregate category where the farm or wholesale product could be seen as a principal component of the retail product (e.g. the Bakery Products CPI to the Flour and Flour Base Mixes and Doughs PPI). In general, indirect relations and cases in which information was unknown about other principal components of a retail category were not considered. In total, 27 predicted changes in FASOM farm or wholesale food prices were reflected in 14 Food-at-Home (FAH) CPI categories or subcategories. These CPI items represent approximately 47.3 percent of the FAH CPI[22].

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[20] The annuity value of afforestation offsets were not directly taken from model results but estimated based on the EPA allowance prices, the amount of offsets in each region, and a real discount rate of 5 percent.

[21] When both a farm product and its wholesale or processed form were given, the downstream product was used and was assumed to be representative of changes both at the farm and wholesale or processed levels.

[22] The percentage of the FAH CPI value not represented is due to the previously stated reason of indirect relationships, a lack of predicted change values for some products (e.g. most fruits and vegetables), and a number of products which would likely have no change from their baseline (e.g. seafood, bananas).

The overall impact of the considered predicted price changes on the FAH CPI is estimated to be an increase of about 0.2 percentage points above what the expected historical trend in FAH price inflation would be in 2015 and up to 2.1 percentage points above what the expected historical trend in FAH price inflation would be in 2050 with the years in between showing steady increases in the index (table 24). This trend increase across years is likely due to the predicted input price change estimates consistently increasing, as the pass-through rates are fixed across years. The underlying cause for these increases is mainly from the estimated changes in the retail prices of certain food categories. The significance of these categories appears to be from a combination of a relatively high pass-through rate, a large predicted farm or wholesale price increase, and a relatively high degree of importance in the FAH CPI. This is exemplified in products such as beef, pork, refined sugar, and ice cream.

In addition, table 24 shows the impact of a higher FAH CPI on the overall Food CPI. The predicted effect on the overall Food CPI is dependent upon the assumed relationship between the FAH and Food Away from Home (FAFH) price indices. An upper and lower bound estimate is presented based on the following two possible assumptions: a lower bound estimate which assumes the FAFH index is not changed by higher costs and an upper bound estimate which assumes that FAFH effects are the same as the FAH effects. Combining the FAH and FAFH results to the overall CPI for Food implies that the changes in food costs due to higher commodity prices will increase the Food CPI by 0.1 to 0.2 percentage points above the expected inflation trend in 2015 and 1.2 to 2.1 percentage points in 2050. In comparison, the average annual food inflation rate has been 3.1 percent over the past 20 years. Adding the impact of higher energy costs could add an additional 0.4 to 0.8 percentage points to the Food CPI in 2015 and an additional 1.4 to 2.5 percentage point to the Food CPI by 2050.

V. Conclusions

Higher energy prices under H.R. 2454 will increase the prices paid for energy-related agriculture inputs and therefore increase agricultural production costs. Overall, impacts on net farm income could be 1-2 percent in the short-term (2012-18) across the EPA and EIA energy price scenarios analyzed. This amounts to a loss in net farm income of $760 million per year compared to baseline levels of net farm income. However, this is before accounting for the effects of allowance prices on commodity prices, as well as offset and biofuel production revenues that will benefit farmers.

Across all scenarios analyzed and for each time period, impacts are not uniform across commodity or regional segments of the agricultural sector. Limited effects in the fruit and vegetable sectors would be expected as cost increases would likely be passed through the marketing chain with little change in production, similar to what occurred in 2008 when much higher changes in energy costs occurred.

The ability to generate and sell offsets provides an additional source of farm income which can more than compensate for any loss in income due to higher energy costs. In addition to offset revenues, providing offsets through afforestation will take land out of agricultural production. As a result, the impact of less land in agricultural production leads to higher commodity prices and higher overall returns to agricultural producers. The effect of higher prices received outweighs the effect of less production and, on average, net returns to agricultural producers are about 12 percent higher, with an annuity value in excess of $20 billion if we look out to 2080. The producer surplus impacts exclude

earnings from the sale of carbon from afforestation. USDA estimates the annuity value of the gross revenues associated with the sale of afforestation offsets would result in approximately $3 billion of additional farm revenue.

Consumers will likely feel the effect of higher commodity prices through increases in the prices paid for food. The overall impact on the Food CPI is estimated to be an increase of about 0.1 to 0.2 percentage points above the expected historical trend in the Food CPI in 2015 and 1.2 to 2.1 percentage points above the expected historical trend in the Food CPI in 2050 with the years in between showing steady increases in the index.

Table 1. Energy related inputs relative to total operating expenses for selected crops, 2007-08

Commodity	Fuel		Fertilizer	
	$/acre	Percent of operating costs	$/acre	Percent of operating costs
Corn	37.11	14.1	116.16	44.3
Soybeans	17.71	15.1	20.22	17.2
Wheat	22.51	20.6	42.60	39.0
Cotton	54.98	12.6	76.88	17.6
Rice	122.28	27.7	93.35	21.2
Sorghum	48.83	34.3	38.02	26.7
Barley	26.06	20.5	44.31	34.8
Oats	20.26	20.8	38.97	40.0
Peanuts	76.88	16.6	88.04	19.0

Source: Economic Research Service. Available at http://www.ers.usda.gov/data/CostsandReturns/

Table 2. Energy related inputs relative to total operating expenses for selected livestock, 2007-08

Commodity	Unit	Fuel		Feed	
		$/unit	Percent of operating costs	$/unit	Percent of operating costs
Milk	Per cwt sold	0.76	5.2	11.16	76.5
Hogs	Per cwt gain	1.81	3.5	29.61	57.6
Cow-calf	Per bred cow	66.42	10.1	71.52	10.8

Source: Economic Research Service.

Table 3. Estimated Impacts of H.R. 2454 on Energy Prices

	2015	2020	2025	2030	2035	2040	2045	2050
	$ per ton CO_2e (2005 $)							
Allowance price: EPA 1/	12.64	16.31	20.78	26.54	33.92	43.37	55.27	70.40
EIA 2/	20.96	29.95	42.80	61.16				
	Percent change from baseline							
Electricity price EPA	10.7	12.7	14.0	13.3	16.9	24.0	29.1	35.2
EIA	14.0	12.2	20.7	18.9				
Natural gas price EPA	7.4	8.5	8.6	10.4	14.3	18.9	24.1	30.9
EIA	19.7	12.6	16.2	23.0				
Petroleum price EPA	3.2	4.0	4.7	5.6	7.2	9.0	11.4	14.6
EIA	7.8	9.6	11.2	16.5				

1/ Source: EPA, June 23, 2009. The EPA analysis of H.R. 2454 can be found at: http://www.epa.gov/climatechange/economics/economicanalyses.html.
2/ Source: EIA, August 4, 2009. The EIA analysis of H.R. 2454 can be found at: http://www.eia.doe.gov/oiaf/servicerpt/hr2454/index.html

Table 4. Prices paid by farmers, energy related agricultural inputs, various scenarios (average annual percent change from reference scenario)

Item	EPA short term (2012-18)	EIA short term (2012-18)
Fuel	2.6	5.3
Fertilizer	0.3	1.7

Source: Economic Research Service

Table 5. Effects of energy price increases on per-acre costs of production, 2012-18 averages (2005$, percent change shown in parentheses)

Commodity	EPA price scenario	EIA price scenario
Corn	1.15 (0.4%)	3.94 (1.5%)
Sorghum	1.29 (0.9%)	3.05 (2.2%)
Barley	0.70 (0.6%)	2.00 (1.6%)
Oats	0.56 (0.6%)	1.63 (1.7%)
Wheat	0.65 (0.6%)	1.92 (1.7%)
Rice	3.16 (0.7%)	7.53 (1.8%)
Upland cotton	1.47 (0.3%)	3.77 (0.9%)
Soybeans	0.46 (0.4%)	1.18 (1.0%)

Source: Economic Research Service

Table 6. Effects of energy price increases on planted acres, 2012-18 averages (in 1,000 acres, percent change shown in parentheses)

Commodity	EPA price scenario	EIA price scenario
Corn	-27 (-0.0%)	-89 (-0.1%)
Sorghum	-26 (-0.3%)	-48 (-0.7%)
Barley	-2 (-0.1%)	-6 (-0.1%)
Oats	-10 (-0.3%)	-25 (-0.7%)
Wheat	-63 (-0.1%)	-176 (-0.3%)
Rice	-3 (-0.1%)	-8 (-0.3%)
Upland cotton	-7 (-0.1%)	-20 (-0.2%)
Soybeans	4 (0.0%)	19 (0.0%)
Total	-133 (-0.1%)	-354 (-0.1%)

Source: Economic Research Service

Table 7. Effects of energy price increases on farm level prices, 2012-18 averages (2005$, percent change shown in parentheses)

Commodity	EPA price scenario	EIA price scenario
Corn ($/bu)	0.00 (0.1%)	0.01 (0.3%)
Sorghum ($/bu)	0.00 (0.2%)	0.01 (0.4%)
Barley ($/bu)	0.00 (0.1%)	0.01 (0.3%)
Oats ($/bu)	0.00 (0.1%)	0.01 (0.4%)
Wheat ($/bu)	0.00 (0.1%)	0.01 (0.3%)
Rice ($/cwt)	0.01 (0.1%)	0.03 (0.3%)
Upland cotton (cents/lb)	0.03 (0.1%)	0.10 (0.2%)
Soybeans ($/bu)	0.00 (0.0%)	0.00 (0.0%)
Soybean meal ($/ton)	0.00 (0.0%)	0.02 (0.0%)
Soybean oil (cents/lb)	0.00 (0.0%)	0.01 (0.0%)

Source: Economic Research Service. Price effects do not reflect the effects of land use changes associated with GHG offsets.

Table 8. Effect of energy price increase on feed costs and livestock production, 2012-18 average (percent change from baseline)

Commodity	EPA price scenario	EIA price scenario
Beef		
Feed costs	0.1%	0.3%
Production	-0.0%	-0.1%
Pork		
Feed costs	0.1%	0.2%
Production	-0.0%	-0.0%
Young chickens		
Feed costs	0.0%	0.2%
Production	-0.0%	-0.0%
Milk		
Feed costs	0.1%	0.3%
Production	-0.0%	-0.0%

Source: Economic Research Service

Table 9. Effects of energy price increase on farm income, 2012-18 average (billion 2005$, with percent change from baseline in parentheses)

Commodity	EPA price scenario	EIA price scenario
Cash receipts:		
Crops	0.02 (0.0%)	0.07 (0.0%)
Livestock	0.02 (0.0%)	0.10 (0.1%)
Total cash Receipts	0.04 (0.0%)	0.16 (0.1%)
Total production expenses	0.65 (0.3%)	1.57 (0.6%)
Net farm income	-0.62 (-0.9%)	-1.42 (-2.1%)

Source: Economic Research Service. Income effects do not reflect revenues from GHG offsets or changes in biofuel production nor do they reflect the related effects of land use changes associated with GHG offsets.

Table 10. Percent increase in per-farm variable cash production expenses for fruit and vegetable sector due to increased energy costs

Scenario	Vegetable and melons	Fruit and tree nuts	Fruits, tree nuts, and vegetables
	Percent	Percent	Percent
Short term: EPA, with rebate	0.44	0.45	0.44
EIA, with rebate	0.91	0.82	0.86
Medium term	2.13	1.72	1.89
Long term	4.29	3.42	3.78

Source: Economic Research Service

Table 11. GHG offset potential for selected practices and CO_2 prices from recent studies*

GHG Mitigation Practice	Study	Coverage	Potential GHG mitigation($MMTCO_2e$/yr @ $ per ton CO_2)
Tillage			
Conservation tillage (primarily no-till)	Lewandrowski et al. (2004)	US agriculture sector	31 @ $13.62 101 @ $34.06
	EPA (2005)	US agriculture and forestry sectors	In 2015: 194 @ $15.00 191 @ $30.00 In 2025: 204 @ $15.00 187 @ $30.00
	Antle et al. (2007)	Central US cropland	No-till corn-soy-feed systems 14.6 @ $16.4 18.6 @ $27.3 No-till wheat systems 1.9 @ $16.4 2.2 @ $27.3
Other Agricultural Management Practices			
All Agricultural CH4 and N2O	EPA (2005)	US agriculture and forestry sectors	In 2015: 28 @ $15.00 48 @ $30.00 In 2025: 36 @ $15.00 76 @ $30.00
	EPA (2006)	Global Agriculture US Cropland sources US Livestock sources	In 2020 (Base = 200 MMT CO2) 21% Reduction @ $15 26 % Reduction @ $30 In 2020 (Base = 171 MMT CO2) 11.8% Reduction @ $15 19.8% Reduction @ $30
Reduced fossil fuel use	EPA (2005)	US agriculture and forestry sectors	In 2015: 35 @ $15.00 46 @ $30.00 In 2025: 32 @ $15.00 49 @ $30.00

Biofuel Offsets (primarily biomass for power generation)	EPA (2005)	US agriculture and forestry sectors	In 2015: 0 @ $15.00 16 @ $30.00 In 2025: 0 @ $15.00 21 @ $30.00
Cropland to permanent grass	Antle et al. (2001)	Northern US Great Plains	8.7 @ $24.9 13.6 @ $49.2
Continuous cropping (reducing fallow)	Antle et al. (2001)	Northern US Great Plains	44.9 @ $14.4 63.4 @ $28.7
	Antle et al. (2007)	Central US	2.23 @ $16.35 2.85 @ $27.25
Afforestation			
Afforestation	Lewandrowski et al. (2004)	US agriculture sector	265.7 @ $13.62 74.1 from cropland 191.6 from grassland 488.8 @ $34.06 147.2 from cropland 341.7 from grassland
	EPA (2005)	US agriculture and forestry sectors	In 2015: 145 @ $15.00 557 @ $30.00 In 2025: 228 @ $15.00 806 @ $30.00
	Lubowski et al. (2006)	US land base	734 – 917 @ $13 2,110-2,899 @ $27.2 (range shows with & without harvests)
Forest Management			
Forest management (e.g., extend rotations, thin, and fertilize)	EPA (2005)	US agriculture and forestry sectors	In 2015: 227 @ $15.00 271 @ $30.00 In 2025: 156 @ $15.00 250 @ $30.00

* Some values have been derived from numerical results or interpreted off of graphs in associated publications. Some studies report results in units of carbon. In this table, all GHG values have been converted to metric tons of CO_2.

Table 12. EPA Estimated Allowance Prices

Year	2015	2020	2025	2030	2035	2040	2045	2050
Allowance Price ($2005 per ton CO_2eq)								
	$12.64	$16.31	$20.78	$26.54	$33.92	$43.37	$55.27	$70.40

Source: USEPA. EPA Analysis of the American Clean Energy and Security Act of 2009 H.R. 2454 in the *111th Congress.* June 23, 2009.

Table 13. Agricultural Offsets - by Source, Quantity, and Gross Offset Revenue 1/

	2015	2020	2025	2030	2035	2040	2045	2050
Agricultural Offsets (MMT CO_2eq per year)								
Afforestation	48	132	146	170	307	372	368	344
Animal Wastes CH4	3	4	6	8	10	12	17	25
Other Ag CH4 & N2O	8	12	15	19	26	35	44	53
Ag Soils	0	0	0	0	0	0	0	0
Total	**59**	**148**	**167**	**197**	**342**	**419**	**429**	**422**
Annual Gross Offset Revenue ($2004 billion)								
Afforestation	0.6	2.1	3.0	4.5	10.4	16.1	20.3	24.2
Animal Wastes CH4	0.0	0.1	0.1	0.2	0.3	0.5	1.0	1.8
Other Ag CH4 & N2O	0.1	0.2	0.3	0.5	0.9	1.5	2.4	3.8
Ag Soils	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	**0.8**	**2.4**	**3.5**	**5.2**	**11.6**	**18.1**	**23.7**	**29.7**

USDA analysis based on FASOM simulations provided by EPA, and other data provided to USDA by Bruce McCarl at Texas A&M University.

1/ Because of how it is handled in FASOM, agricultural soil sequestration does not show significant supply. However, detailed FASOM output indicates a 50 percent increase in the percent of cropland using conservation tillage and no-till by 2050 in response to a $15/ton CO_2 incentive payment. Because overall land area in crops declines due to afforestation, the modeling indicates a net decrease in total agricultural soil carbon storage as carbon is transferred from the agricultural soils pool to the afforestation carbon pool.

Table 14. Annual Agricultural Offsets and Gross Offset Revenue by Region

Year	2015	2020	2025	2030	2035	2040	2045	2050
Agricultural Offsets (MMT CO_2eq per year)								
U.S. Total	59.0	148.4	167.5	197.4	342.4	419.0	429.0	422.0
Corn Belt	26.5	70.8	82.4	79.3	109.0	138.0	127.1	141.7
Great Plains	5.4	7.5	8.5	8.8	10.3	20.0	28.6	37.0
Lake States	16.8	36.4	48.5	47.7	70.4	96.0	92.0	108.9
Northeast	1.5	6.4	10.4	15.0	35.7	53.0	49.4	45.0
Rocky Mountains	4.9	6.2	9.6	10.0	13.5	19.6	24.2	39.2
Pacific Southwest	1.9	2.1	3.4	1.3	2.1	2.2	1.6	2.4
Pacific Northwest	0.7	0.8	0.7	0.7	1.0	1.3	1.2	3.0
South Central	0.1	15.9	0.9	24.4	86.0	68.7	69.9	15.4
Southeast	0.0	0.9	1.0	7.7	9.9	17.1	32.1	25.0
South West	1.3	1.4	2.0	2.5	4.3	3.1	3.0	4.4
Annual Gross Offset Revenue ($2004 billion)								
U.S. Total	$0.8	$2.4	$3.5	$5.2	$11.6	$18.1	$23.7	$29.7
Corn Belt	0.3	1.2	1.7	2.1	3.7	6.0	7.0	10.0
Great Plains	0.1	0.1	0.2	0.2	0.4	0.8	1.6	2.6
Lake States	0.2	0.6	1.0	1.3	2.4	4.1	5.1	7.7
Northeast	0.0	0.1	0.2	0.4	1.2	2.3	2.7	3.2
Rocky Mountains	0.1	0.1	0.2	0.3	0.5	0.9	1.3	2.8
Pacific Southwest	0.0	0.0	0.1	0.0	0.1	0.1	0.1	0.2
Pacific Northwest	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2
South Central	0.0	0.3	0.0	0.7	2.9	3.0	3.9	1.1
Southeast	0.0	0.0	0.0	0.2	0.3	0.7	1.8	1.8
South West	0.0	0.0	0.0	0.1	0.2	0.1	0.2	0.3

USDA analysis based on annual U.S. totals from FASOM simulations provided by EPA, and other data provided to USDA by Bruce McCarl at Texas A&M University.

Totals may not add due to rounding.

Table 15. Net National Changes in Land Use.

	2015	2020	2025	2030	2035	2040	2045	2050
Million Acres								
Forest	8.3	16.6	20.3	26.6	34.4	43.6	55.4	59.0
Percent change	2.6%	5.2%	6.4%	8.5%	11.1%	14.3%	18.4%	19.7%
Cropland	0.1	-6.0	-10.2	-14.6	-21.0	-28.3	-32.5	-35.0
Percent change	0.3%	-2.3%	-4.0%	-5.7%	-8.3%	-11.3%	13.2%	-14.4%
Pasture	-6.7	-8.5	-9.7	-12.0	-13.3	-15.3	-22.8	-24.0

Percent change	-2.5%	-3.1%	-3.5%	-4.4%	-4.9%	-5.6%	-8.3%	-8.7%

USDA analysis based on FASOM simulations provided by EPA.

Table 16. Regional Changes in Acres.

	2015	2020	2025	2030	2035	2040	2045	2050
Forest (million acres)								
Corn Belt	2.9	4.9	6.9	9.7	13.5	16.3	20.1	22.5
Great Plains	--	--	--	--	--	--	--	--
Lake States	1.7	3.1	4.9	7.0	8.7	10.6	13.4	15.1
Northeast	-0.1	1.1	1.9	2.5	3.2	3.2	3.2	2.4
Rocky Mountains	2.3	3.4	4.0	4.7	5.5	6.2	7.0	7.7
Pacific Southwest	0.2	0.2	0.2	0.2	0.2	0.0	0.0	0.0
Pacific Northwest	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
South Central	1.2	3.3	2.1	2.0	2.8	6.0	10.4	10.0
Southeast	-0.1	0.4	0.2	0.3	0.4	1.2	1.2	1.1
South West	--	--	--	--	--	--	--	--
Cropland (million acres)								
Corn Belt	-2.3	-4.2	-6.3	-8.5	-12.2	-15.5	-18.1	-20.6
Great Plains	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	1.7	1.7
Lake States	-1.2	-2.2	-4.0	-5.2	-6.9	-8.7	-10.5	-12.1
Northeast	0.6	0.0	-0.7	-1.2	-1.5	-1.5	-1.5	-1.9
Rocky Mountains	-0.4	-1.0	-1.6	-2.3	-3.1	-3.8	-4.6	-5.3
Pacific Southwest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pacific Northwest	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2
South Central	-0.2	-2.0	-2.1	-2.1	-2.1	-3.1	-7.0	-6.4
Southeast	0.6	0.3	1.4	1.7	1.7	1.1	1.2	1.2
South West	3.1	3.1	3.1	3.1	3.1	3.1	6.0	8.2
Pasture (million acres)								
Corn Belt	-0.5	-0.4	-0.4	-1.1	-1.0	-0.6	-1.8	-1.8
Great Plains	-1.9	-1.9	-1.9	-1.9	-1.9	-1.9	-3.8	-3.8
Lake States	0.0	-0.2	-0.2	-1.1	-1.1	-1.2	-2.2	-2.2
Northeast	-0.5	-1.1	-1.2	-1.2	-1.7	-1.7	-1.7	-0.5
Rocky Mountains	-1.2	-1.7	-1.7	-1.7	-1.7	-1.7	-1.7	-1.7
Pacific Southwest	-0.2	-0.2	-0.2	-0.2	-0.2	0.0	0.0	0.0
Pacific Northwest	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2
South Central	0.7	0.4	0.4	0.2	-0.7	-3.0	-3.4	-3.6
Southeast	0.3	0.1	-1.1	-1.6	-1.7	-1.9	-2.0	-1.9
South West	-3.1	-3.1	-3.1	-3.1	-3.1	-3.1	-6.0	-8.2

USDA analysis based on annual U.S. totals from FASOM simulations provided by EPA, and other data provided to USDA by Bruce McCarl at Texas A&M University.

Note: FASOM does not model afforestation in the Great Plains and Southwest regions and does not model agriculture in the west side of the Pacific Northwest region.

Table 17. Crop Production Impacts

Crop (unit)		2015	2020	2025	2030	2035	2040	2045	2050
		millions							
Cotton (bales)	Baseline	16.1	18.0	18.6	18.6	19.6	19.9	20.6	20.8
	Scenario	16.3	17.3	17.9	18.3	19.1	18.8	17.7	18.2
	% Change	1.2	-3.9	-3.6	-1.5	-2.7	-5.3	-14.1	-12.5
Corn (bushels)	Baseline	14,222	14,619	15,585	16,520	17,536	17,547	18,274	20,627
	Scenario	14,022	14,212	14,735	15,326	15,852	16,003	15,794	16,109
	% Change	-1.4	-2.8	-5.5	-7.2	-9.6	-8.8	-13.6	-21.9
Soybeans (bushels)	Baseline	2,609	2,671	2,734	2,777	2,888	2,818	2,861	2,848
	Scenario	2,518	2,539	2,534	2,527	2,481	2,319	2,126	2,028
	% Change	-3.5	-5.0	-7.3	-9.0	-14.1	-17.7	-25.7	-28.8
Wheat (bushels)	Baseline	2,433	2,509	2,601	2,660	2,795	3,108	3,212	3,412
	Scenario	2,433	2,498	2,563	2,611	2,724	2,988	3,059	3,065
	% Change	0.0	-0.4	-1.5	-1.8	-2.6	-3.8	-4.8	-10.2
Sorghum (bushels)	Baseline	522	317	300	289	307	304	315	333
	Scenario	588	325	304	297	303	262	262	251
	% Change	12.7	2.6	1.3	2.8	-1.4	-13.7	-16.9	-24.5
Rice (cwt)	Baseline	273	346	391	444	484	536	590	632
	Scenario	237	306	334	359	397	419	440	474
	% Change	-13.1	-11.4	-14.5	-19.2	-18.0	-21.7	-25.3	-25.1
Oats (bushels)	Baseline	114	96	104	114	134	190	212	217
	Scenario	127	102	100	108	110	140	154	149
	% Change	11.4	6.0	-3.8	-5.1	-18.1	-26.1	-27.2	-31.5
Barley (bushels)	Baseline	310	283	296	312	342	398	400	428
	Scenario	324	285	293	309	314	358	375	363
	% Change	4.8	0.8	-1.1	-1.0	-8.4	-10.1	-6.2	-15.2

USDA analysis based on FASOM simulations provided by EPA.

Table 18. Crop Price Impacts

		2015	2020	2025	2030	2035	2040	2045	2050
	$2004 per unit								
Cotton ($/bale)	Baseline	273.45	241.60	241.60	258.62	249.79	263.67	267.94	278.53
	Scenario	267.71	259.38	260.11	264.20	264.20	287.80	339.60	347.10
	% Change	-2.1	7.4	7.7	2.1	5.8	9.2	26.8	24.6
Corn ($/bu)	Baseline	4.03	4.03	3.63	3.26	2.97	2.72	2.61	2.50
	Scenario	4.32	4.50	4.05	3.77	3.53	3.19	3.14	3.21
	% Change	7.2	11.5	11.4	15.4	19.0	17.3	20.6	28.1
Soybeans ($/bu)	Baseline	9.04	9.03	9.01	9.00	8.85	8.83	8.71	8.79
	Scenario	9.04	9.03	9.02	9.06	9.07	9.06	9.81	10.63
	% Change	0.0	0.0	0.1	0.7	2.5	2.6	12.7	20.9
Wheat ($/bu)	Baseline	5.40	5.10	5.03	4.80	4.59	4.50	4.31	4.11
	Scenario	5.35	4.85	4.95	4.94	4.76	4.94	4.78	4.66
	% Change	-0.9	-4.9	-1.6	3.0	3.7	9.8	10.9	13.4
Sorghum ($/bu)	Baseline	7.73	5.99	6.27	5.98	5.92	7.39	7.97	8.12
	Scenario	7.77	5.96	6.01	6.17	6.02	8.13	9.68	11.35
	% Change	0.5	-0.5	-4.2	3.2	1.6	10.0	21.4	39.8
Rice ($/cwt)	Baseline	7.30	6.87	6.51	6.24	5.97	5.80	5.57	5.29
	Scenario	7.42	6.97	6.77	6.58	6.29	6.14	5.89	5.72
	% Change	1.6	1.5	4.0	5.5	5.3	5.9	5.8	8.1
Oats ($/bu)	Baseline	1.35	1.96	1.41	1.01	0.47	1.15	0.47	0.72
	Scenario	1.42	1.43	1.49	1.10	0.95	1.44	1.04	1.04
	% Change	5.5	-27.1	5.9	8.9	100.5	25.3	120.0	45.1
Barley ($/bu)	Baseline	2.92	3.24	3.32	3.53	3.76	3.36	4.78	5.50
	Scenario	2.99	2.80	3.28	3.53	4.33	4.51	5.32	8.61
	% Change	2.5	-13.6	-1.1	0.0	15.0	34.2	11.3	56.5

USDA analysis based on FASOM simulations provided by EPA.

Table 19a. Impact on Domestic Demand

Crop (unit)		2015	2020	2025	2030	2035	2040	2045	2050
		millions							
Cotton (bales)	Baseline	9.4	9.8	10.1	10.1	10.5	10.7	11.0	11.2
	Scenario	9.4	9.7	9.9	10.1	10.4	10.6	10.5	10.7
	% Change	0.0	-1.5	-1.5	0.0	-1.0	-1.1	-4.1	-3.6
Corn (bushels)	Baseline	14,222	14,600	15,098	15,713	16,306	15,927	16,453	18,606
	Scenario	14,022	14,212	14,680	15,037	15,421	15,021	14,731	15,068
	% Change	-1.4	-2.7	-2.8	-4.3	-5.4	-5.7	-10.5	-19.0
Soybeans (bushels)	Baseline	2,357	2,305	2,403	2,406	2,479	2,404	2,433	2,420
	Scenario	2,329	2,312	2,410	2,404	2,405	2,259	2,126	2,028
	% Change	-1.2	0.3	0.3	-0.1	-3.0	-6.1	-12.6	-16.2
Wheat (bushels)	Baseline	1,911	1,935	2,014	2,056	2,148	2,428	2,504	2,657
	Scenario	1,912	1,913	1,974	2,008	2,099	2,354	2,402	2,398
	% Change	0.0	-1.1	-2.0	-2.3	-2.3	-3.0	-4.1	-9.7
Sorghum (bushels)	Baseline	475	249	238	222	228	248	264	280
	Scenario	541	245	240	234	233	212	220	216
	% Change	13.9	-1.3	0.9	5.6	2.1	-14.4	-16.6	-23.0
Rice (cwt)	Baseline	150	140	143	148	152	158	161	167
	Scenario	137	139	143	147	151	165	161	165
	% Change	-8.8	-0.5	0.0	-1.0	-0.5	4.7	-0.5	-1.4
Oats (bushels)	Baseline	207	195	198	203	213	280	295	301
	Scenario	221	195	194	198	198	234	243	238
	% Change	6.5	-0.1	-1.7	-2.4	-7.2	-16.4	-17.7	-20.8
Barley (bushels)	Baseline	306	280	292	307	337	390	395	423
	Scenario	321	280	289	304	310	353	371	364
	% Change	4.9	0.2	-1.1	-1.0	-8.1	-9.5	-5.9	-14.0

Domestic demand includes all domestic uses.
USDA analysis based on FASOM simulations provided by EPA.

Table 19b. Impact on Net Exports (Exports less Imports)

Crop (unit)		2015	2020	2025	2030	2035	2040	2045	2050
		millions							
Cotton (bales)	Baseline	6.8	8.2	8.5	8.5	9.1	9.1	9.6	9.6
	Scenario	7.0	7.6	8.0	8.2	8.7	8.2	7.1	7.4
	% Change	2.8	-6.8	-6.0	-3.3	-4.7	-10.2	-25.5	-22.7
Corn (bushels)	Baseline	0	19	487	808	1,230	1,620	1,821	2,021
	Scenario	0	0	55	289	431	982	1,063	1,041
	% Change	--	-100.0	-88.7	-64.3	-64.9	-39.4	-41.6	-48.5
Soybeans (bushels)	Baseline	253	366	331	371	409	413	428	428
	Scenario	189	227	123	123	76	60	0	0
	% Change	-25.3	-38.2	-62.7	-66.9	-81.4	-85.5	-100.0	-100.0
Wheat (bushels)	Baseline	522	574	588	604	647	680	708	755
	Scenario	522	585	589	603	624	634	657	667
	% Change	0.0	1.9	0.2	-0.2	-3.5	-6.7	-7.2	-11.7
Sorghum (bushels)	Baseline	47	68	63	67	79	56	51	52
	Scenario	47	80	64	63	70	50	42	35
	% Change	0.0	17.0	2.7	-6.4	-11.3	-10.5	-18.4	-32.4
Rice (cwt)	Baseline	123	206	247	295	332	378	428	465
	Scenario	100	167	191	212	246	254	280	309
	% Change	-18.4	-18.8	-22.9	-28.4	-26.1	-32.7	-34.7	-33.5
Oats a/ (bushels)	Baseline	-93	-99	-94	-88	-79	-90	-84	-84
	Scenario	-94	-93	-94	-89	-88	-94	-89	-89
	% Change	0.5	-6.0	0.6	1.1	11.2	4.2	6.2	6.7
Barley (bushels)	Baseline	3	3	4	5	5	8	5	5
	Scenario	3	5	4	5	4	5	4	-1
	% Change	-8.3	54.1	-1.0	0.0	-31.2	-42.0	-24.4	-115.6

a/ Negative numbers in the baseline and scenario implies the United States is a net importer. A positive percentage change implies greater imports.
USDA analysis based on FASOM simulations provided by EPA.

Table 20. Livestock Production Impacts

		2015	2020	2025	2030	2035	2040	2045	2050
	Million cwt except eggs (million dozen)								
Fed Beef	Baseline	510	525	547	555	560	614	640	649
	Scenario	508	507	523	536	546	576	591	587
	% Change	-0.4	-3.5	-4.4	-3.4	-2.6	-6.1	-7.7	-9.6
Hogs	Baseline	453	474	518	555	615	647	674	699
	Scenario	427	437	481	500	525	547	557	541
	% Change	-5.7	-7.9	-7.2	-9.9	-14.6	-15.3	-17.3	-22.7
Milk	Baseline	2,017	2,153	2,243	2,420	2,547	2,654	2,773	2,911
	Scenario	2,005	2,095	2,181	2,255	2,329	2,427	2,410	2,418
	% Change	-0.6	-2.7	-2.8	-6.8	-8.6	-8.6	-13.1	-16.9
Eggs	Baseline	7,506	7,749	8,000	8,259	8,615	8,803	9,088	9,480
	Scenario	7,467	7,629	7,945	8,212	8,483	8,696	8,994	9,285
	% Change	-0.5	-1.6	-0.7	-0.6	-1.5	-1.2	-1.0	-2.1
Broilers	Baseline	471	484	514	540	568	596	618	643
	Scenario	466	481	506	531	557	579	593	596
	% Change	-1.0	-0.7	-1.6	-1.6	-1.8	-2.8	-4.1	-7.3
Turkeys	Baseline	92	105	111	124	130	137	146	154
	Scenario	92	102	109	114	122	133	136	142
	% Change	0.1	-3.1	-2.1	-8.2	-6.3	-2.7	-6.9	-7.6

USDA analysis based on FASOM simulations provided by EPA.

Table 21. Livestock Price Impacts

Product		2015	2020	2025	2030	2035	2040	2045	2050
	$2004 per unit								
Fed Beef ($/cwt)	Baseline	57.60	58.57	57.91	60.24	62.07	58.12	58.10	60.17
	Scenario	58.29	61.07	61.53	62.58	64.30	63.45	65.04	68.79
	% Change	1.2	4.3	6.3	3.9	3.6	9.2	11.9	14.3
Hogs ($/cwt)	Baseline	41.77	40.42	38.73	37.43	36.44	36.97	35.29	36.19
	Scenario	43.60	44.08	42.38	41.96	41.64	41.29	43.13	45.94
	% Change	4.4	9.0	9.4	12.1	14.3	14.8	22.2	26.9
Milk ($/cwt)	Baseline	15.51	14.78	14.65	13.90	13.45	13.41	12.98	12.98
	Scenario	15.72	15.49	15.44	15.51	15.68	15.58	16.21	17.27
	% Change	1.4	4.8	5.4	11.5	16.6	16.2	24.9	33.1
Eggs ($/dz)	Baseline	0.92	0.96	0.90	0.94	0.88	0.92	0.89	0.87
	Scenario	0.96	1.02	1.01	0.97	0.97	1.03	1.03	1.05
	% Change	4.2	6.3	12.1	2.6	10.8	12.5	15.3	19.9
Broilers ($/cwt)	Baseline	49.01	49.23	47.63	46.56	45.16	44.56	44.65	44.06
	Scenario	49.65	50.30	48.88	47.79	47.05	46.77	48.54	51.09
	% Change	1.3	2.2	2.6	2.6	4.2	5.0	8.7	16.0
Turkeys ($/cwt)	Baseline	46.03	39.21	38.96	33.40	32.56	31.00	31.00	28.96
	Scenario	46.03	41.28	39.25	38.21	36.14	33.46	33.85	33.29
	% Change	0.0	5.3	3.4	14.4	11.0	8.0	9.2	14.9

USDA analysis based on FASOM simulations provided by EPA.

Table 22. Annuity Impacts on Producer Surplus/Farm Income, by Region.

	$2004 billion annualized annuity value	% of total
Corn Belt	6.4	29.3
Great Plains (no forestry)	2.9	13.3
Lake States	1.6	7.3
Northeast	0.4	1.8
Rocky Mountains	1.5	6.7
Pacific Southwest	0.7	3.3
Pacific Northwest	0.7	3.3
South Central	2.3	10.4
Southeast	3.4	15.6
South West (no forestry)	1.9	8.9
U.S. Total	22	100

USDA analysis based on annual U.S. totals from FASOM simulations provided by EPA, and other data provided to USDA by Bruce McCarl at Texas A&M University.

Table 23. Percentage Change in Secondary Commodity Prices over Time

	2015	2020	2025	2030	2035	2040	2045	2050
Processed Citrus Products								
Orange Juice	-2.0	-3.5	-4.2	-8.6	-16.7	-13.1	-17.0	-17.2
Grapefruit Juice	-1.4	-0.3	-2.5	-4.9	-4.2	-4.4	-4.4	-1.0
Crushed Soybean Products								
Soybean Meal	-0.8	-1.5	-0.8	-0.1	-0.1	0.2	12.8	23.3
Soybean Oil	1.3	2.5	1.4	2.5	9.8	11.2	26.3	37.7
Corn Milling Products								
HFCS	2.8	7.0	6.4	8.1	8.9	7.6	7.1	9.2
Gluten Meal	-0.1	-0.5	-0.4	0.3	0.1	-6.9	11.8	31.2
Gluten Feed	5.0	12.7	12.1	16.4	20.3	18.6	22.1	43.6
Corn Starch	3.1	7.6	7.0	8.9	9.9	8.5	7.9	10.3
Corn Oil	1.3	2.5	1.5	2.5	9.7	11.2	30.2	36.8
Corn Syrup	2.5	6.2	5.7	7.1	7.8	6.7	6.2	8.0
Dextrose	2.5	6.1	5.6	7.0	7.7	6.5	6.1	7.9
DDGs	0.8	-3.1	6.0	4.1	2.3	11.2	7.9	18.2
Sweetened Products								
Beverages	0.1	0.2	0.2	0.3	0.3	0.3	0.4	0.5
Confection	0.3	0.7	0.8	1.0	1.5	1.5	2.8	4.2
Baking	0.3	0.6	0.7	0.9	1.3	1.4	2.6	3.8
Canning	0.1	0.1	0.1	0.2	0.2	0.2	0.4	0.6
Refined Sugar	9.5	18.5	20.4	24.2	33.7	32.7	55.2	75.2
Refined Potato Products								
Frozen Potatoes	1.2	1.9	3.4	5.8	9.6	10.7	19.1	26.5
Dried Potatoes	2.1	3.5	6.1	10.5	17.2	18.5	33.8	45.4
Potato Chips	0.6	1.0	1.8	3.1	5.1	5.8	10.3	14.6
Meat Items								
Fed Beef	1.0	3.7	5.5	3.3	3.0	7.9	10.2	12.3
Pork	5.1	10.7	11.2	14.5	17.0	17.6	26.6	32.0
Chicken	1.3	2.2	2.6	2.6	4.2	4.9	8.7	15.9
Turkey	0.0	5.7	3.7	15.8	12.1	8.8	10.2	16.7
Dairy Products								
Fluid Milk (whole)	0.0	1.7	1.7	1.7	5.2	5.2	6.9	8.6
Fluid Milk (low fat)	1.8	1.8	1.8	1.8	5.6	5.6	5.6	5.6
Skim Milk	0.0	0.0	0.0	9.1	9.1	9.1	9.1	9.1
Butter	1.8	8.2	10.5	21.5	32.9	31.5	58.5	82.0
American Cheese	1.5	4.2	4.5	9.8	13.9	14.0	21.6	28.4
Other Cheese	0.8	3.1	3.7	7.6	10.4	10.8	14.9	19.5
Cottage Cheese	0.0	1.0	1.0	1.7	2.8	2.8	4.2	5.6
Ice Cream	1.7	5.7	7.7	15.8	22.9	21.9	36.3	47.8

USDA analysis based on FASOM output provided by EPA.

Table 24. Estimated Impact of Predicted Changes on the Food at Home CPI (%)

Exogenous Variable	Dependent Variable	2015	2020	2025	2030	2035	2040	2045	2050
Cereals PPI	Cereals CPI	0.003	-0.001	0.004	0.006	0.022	0.009	0.025	0.015
Pasta PPI	Cereals CPI	0.000	-0.001	-0.001	0.000	-0.001	0.001	0.002	0.002
Flour PPI*	Bakery Products CPI	-0.005	-0.016	-0.014	-0.006	-0.019	0.017	0.023	0.027
Cottage Cheese PPI	Cheese CPI	0.000	0.003	0.003	0.005	0.008	0.008	0.013	0.017
Natural, Processed, & Imitation Cheese PPI	Cheese CPI	0.008	0.027	0.031	0.065	0.090	0.093	0.132	0.172
Ice Cream PPI	Ice Cream CPI	0.015	0.050	0.067	0.138	0.200	0.191	0.317	0.417
Whole Milk PPI	Milk CPI	0.000	0.015	0.015	0.015	0.046	0.046	0.062	0.077
Skim Milk PPI	Milk CPI	0.000	0.000	0.000	0.025	0.025	0.025	0.025	0.025
Low Fat Milk PPI	Milk CPI	0.005	0.005	0.005	0.005	0.016	0.016	0.016	0.016
Beef PPI	Beef CPI	0.020	0.066	0.097	0.060	0.056	0.143	0.186	0.224
Pork PPI	Pork CPI	0.073	0.153	0.160	0.207	0.244	0.252	0.381	0.459
Chicken PPI	Poultry CPI	0.011	0.018	0.021	0.021	0.034	0.040	0.071	0.130
Turkey PPI	Poultry CPI	0.000	0.010	0.006	0.027	0.021	0.015	0.017	0.029
Eggs PPI	Eggs CPI	0.003	0.005	0.010	0.003	0.009	0.010	0.012	0.016
Citrus PPI	Citrus CPI	-0.001	0.002	0.002	0.002	0.002	-0.001	0.010	0.009
Potatoes PPI	Potatoes CPI	0.002	0.003	0.005	0.009	0.014	0.015	0.028	0.036
Tomatoes PPI	Tomatoes CPI	-0.001	0.005	-0.007	-0.009	-0.022	-0.025	-0.006	0.000
Corn Sweetners PPI	Bakery Products CPI	0.008	0.020	0.019	0.024	0.026	0.022	0.021	0.027
Corn Sweetners PPI	Sugar & Sweets CPI	0.006	0.015	0.014	0.017	0.019	0.016	0.015	0.020
Ref Sugar PPI	Sugar & Sweets CPI	0.028	0.054	0.059	0.071	0.099	0.096	0.161	0.220
Butter PPI	Butter & Margarine CPI	0.003	0.014	0.018	0.037	0.057	0.054	0.101	0.141
Margarine PPI	Butter & Margarine CPI	0.001	0.002	0.001	0.002	0.006	0.007	0.016	0.023
Total Change to Food at Home CPI		0.2	0.4	0.5	0.7	1.0	1.1	1.6	2.1
Total Change to Food CPI (lower bound)		0.1	0.2	0.3	0.4	0.5	0.6	0.9	1.2
Total Change to Food CPI (upper bound)		0.2	0.4	0.5	0.7	1.0	1.1	1.6	2.1

Source: Economic Research Service calculations based on FASOM output provided by EPA. Notes: Cells shaded in grey represent a multistage pass-through relationship, farm to wholesale to retail. *Represents PPI for flour, flour base mixes, and doughs.

Figure 1. Total energy input costs as a percentage of total operating costs, 2008, by ERS Farm Resource Region (soybeans and wheat).

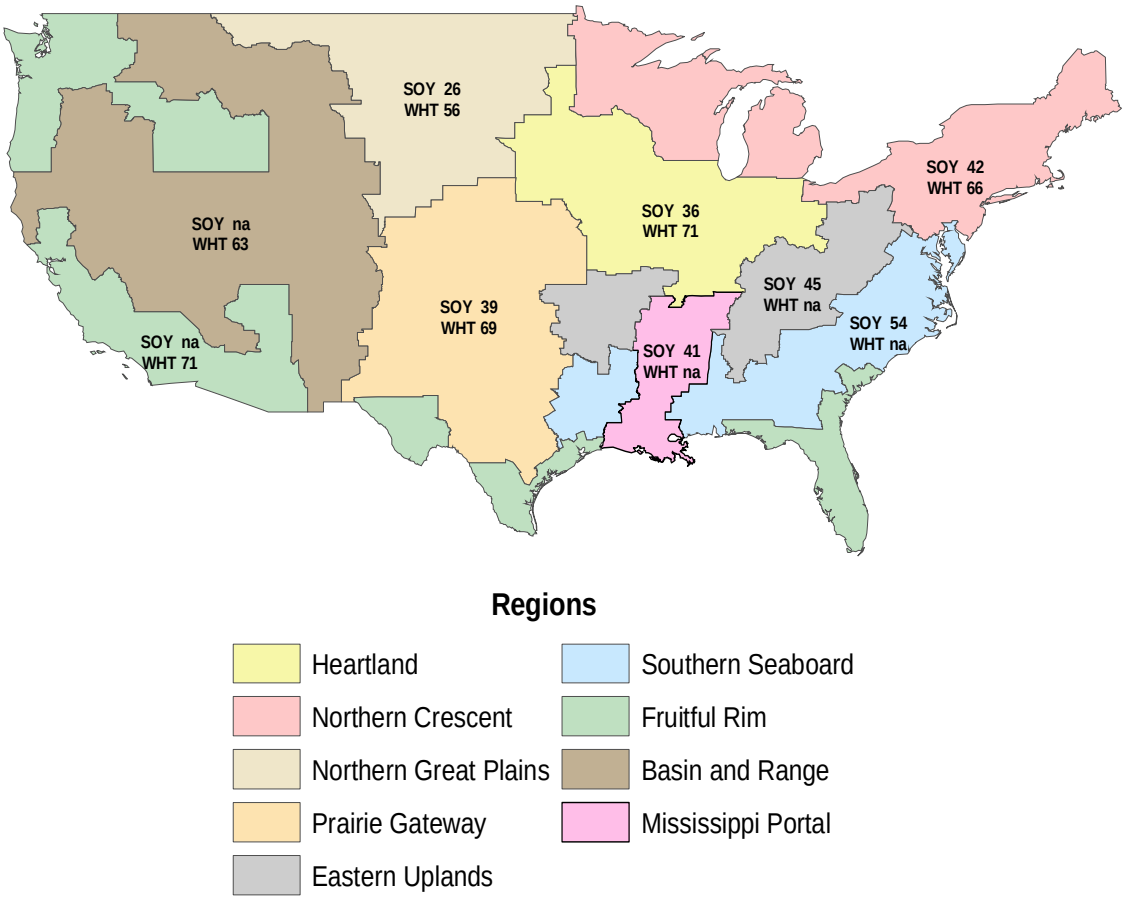


Figure 2—Reduction in farm business net cash income by farm production specialty, 2014, with EITE rebate

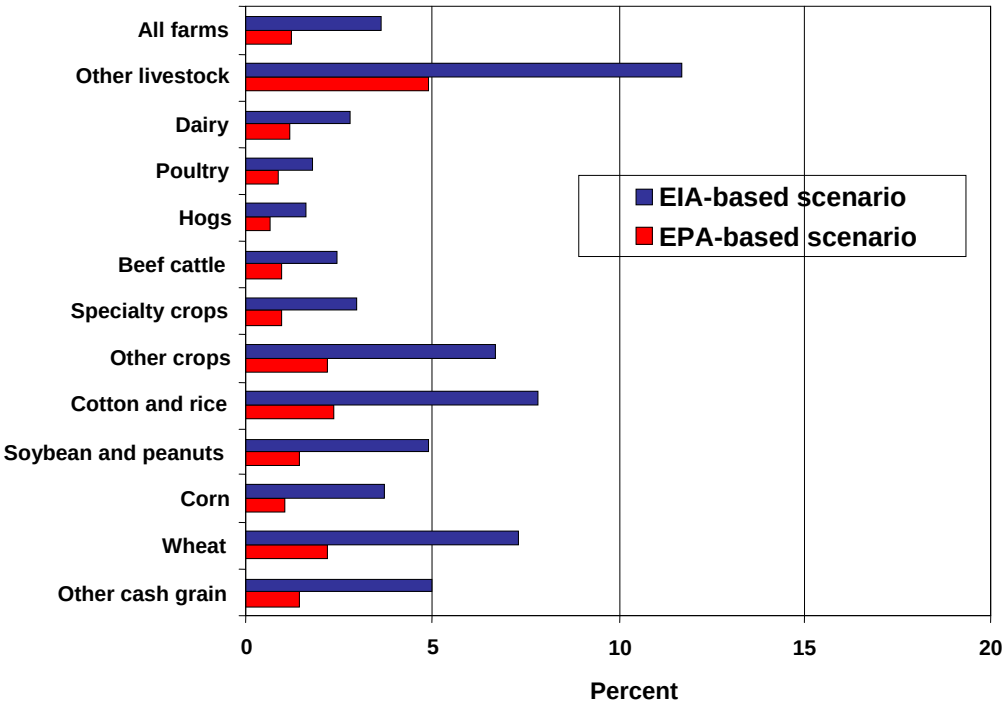


Figure 3--Reduction in farm business net cash income by resource region, EPA-based energy prices, 2014, with EITE rebates.

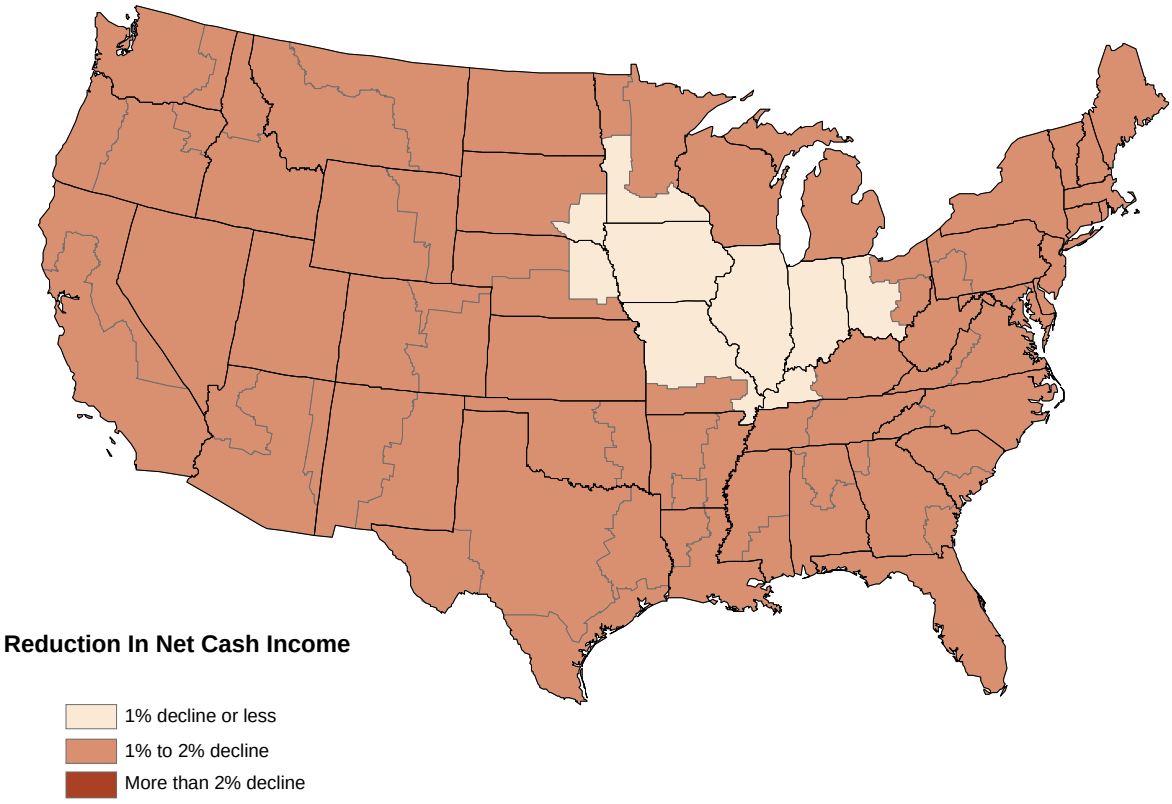


Figure 4-Reduction in farm business net cash income by resource region, EIA-based energy prices, 2014, with EITE rebates

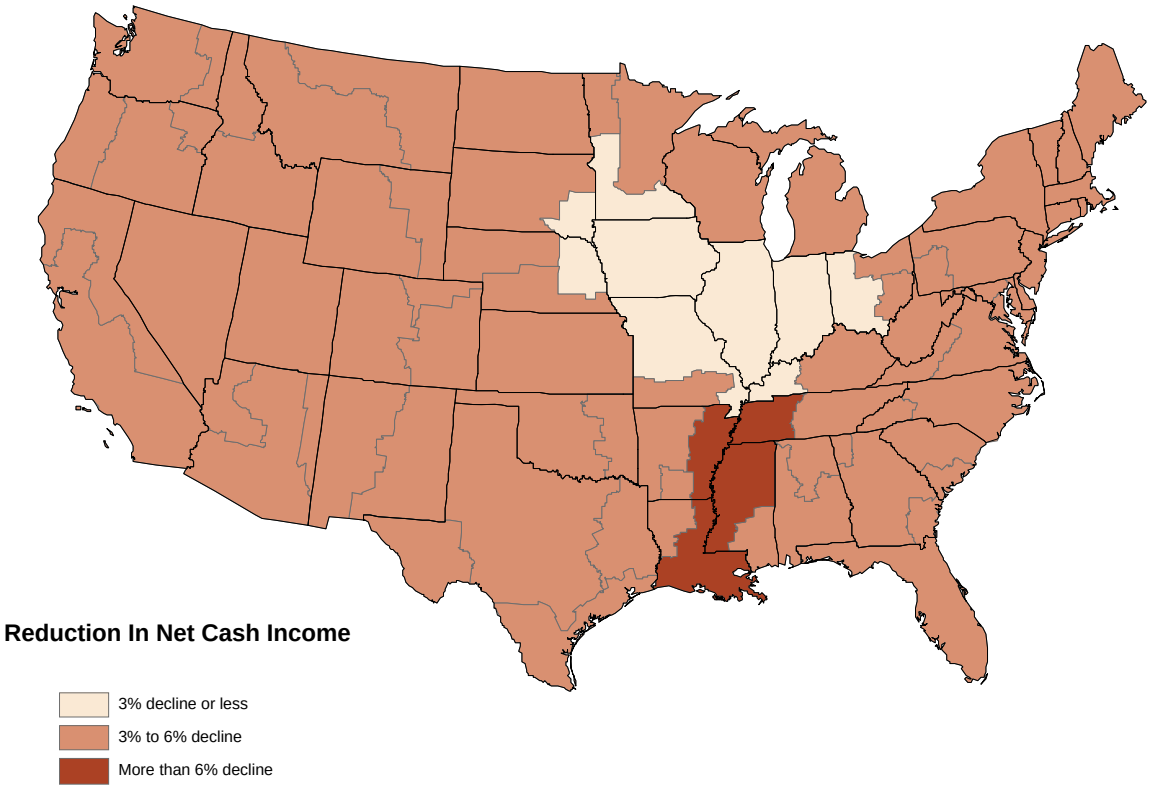
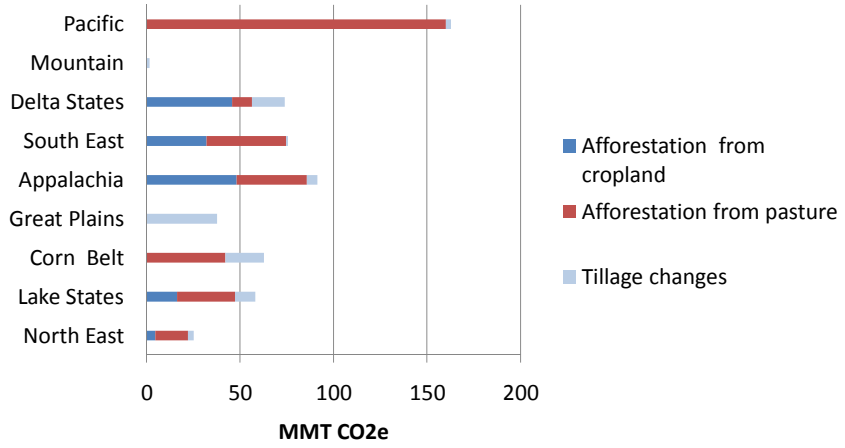


Figure 5a--Regional Potential

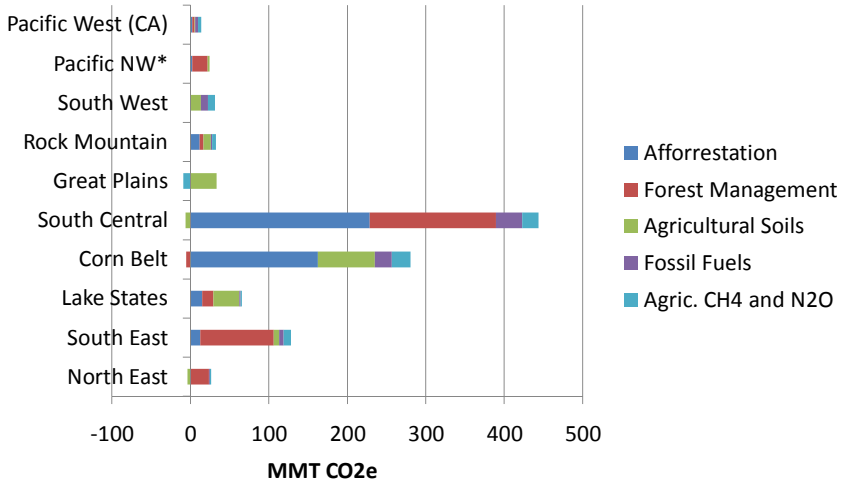
(carbon price of $34/MT CO2e)



Source: Lewandrowski et al. 2004

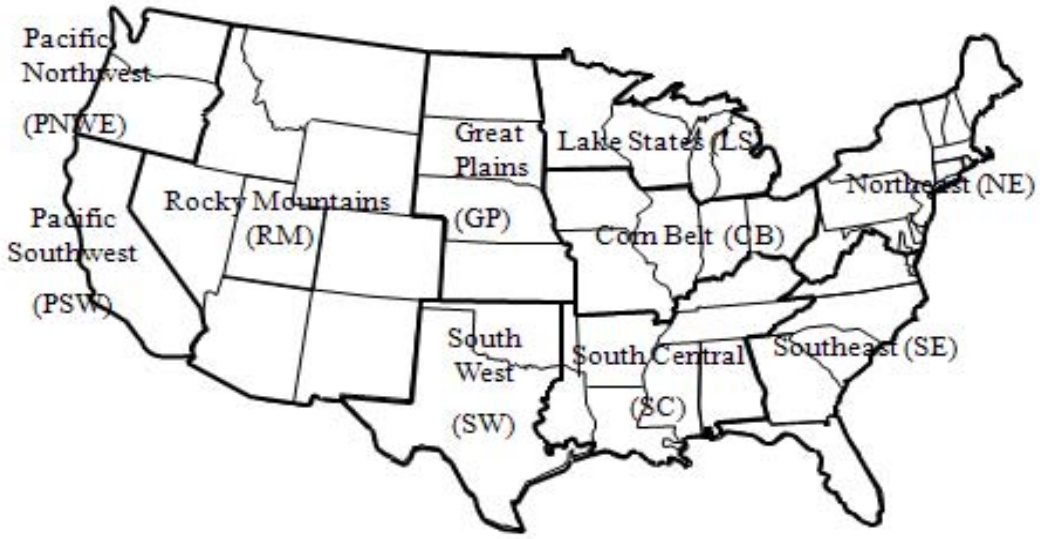
Figure 5b--Regional Potential

(carbon price of $30/MT CO2e)



Source: EPA 2005

Figure 6. FASOM Regions.



Appendices

Appendix Table A1--Energy-related expenses as percent of total farm production expenditures, 2007-08 average

State and Region1/	Total Production Expenditures	Fertilizer, Lime & Soil Conditioners	Percent of Total	Fuels	Percent of Total
	Million $			Million $	
Atlantic					
North Carolina	8,780	375	4.3%	400	4.6%
Other States	28,635	1,480	5.2%	1,470	5.1%
Total	37,415	1,855	5.0%	1,870	5.0%
South					
Arkansas	6,640	500	7.5%	455	6.9%
Florida	6,725	430	6.4%	285	4.2%
Georgia	5,845	375	6.4%	345	5.9%
Other States	13,645	870	6.4%	775	5.7%
Total	32,855	2,175	6.6%	1,860	5.7%
Midwest					
Illinois	13,595	1,725	12.7%	675	5.0%
Indiana	7,855	1,005	12.8%	400	5.1%
Iowa	20,895	1,605	7.7%	855	4.1%
Minnesota	13,500	1,160	8.6%	790	5.9%
Missouri	7,490	720	9.6%	430	5.7%
Wisconsin	8,890	545	6.1%	470	5.3%
Other States	13,725	1,295	9.4%	675	4.9%
Total	85,950	8,055	9.4%	4,295	5.0%
Plains					
Kansas	13,700	910	6.6%	665	4.9%
Nebraska	16,250	1,050	6.5%	670	4.1%
Texas	23,280	1,000	4.3%	1,185	5.1%
Other States	20,550	1,920	9.3%	1,210	5.9%
Total	73,780	4,880	6.6%	3,730	5.1%
West					
California	30,130	1,305	4.3%	1,230	4.1%
Washington	7,025	375	5.3%	310	4.4%
Other States	28,115	1,455	5.2%	1,455	5.2%
Total	65,270	3,135	4.8%	2,995	4.6%
United States	295,270	20,100	6.8%	14,750	5.0%

Source: NASS, *Farm Production Expenditures 2008 Summary*, August 2009.

Appendix Table A2--Energy costs as percent of total operating costs, 2007-08 average

Region	Item	Corn		Soybeans		Wheat		Cotton	
		$/acre	Percent of total costs	$/acre	Percent of total costs	$/acre	Percent of total costs	$/acre	Percent of total costs
United States	Fertilizer	116.16	44.3%	20.22	17.2%	42.60	39.0%	76.88	17.6%
	Fuel	37.11	14.1%	17.71	15.1%	22.51	20.6%	54.98	12.6%
Heartland	Fertilizer	121.38	46.8%	18.82	17.5%	83.97	57.7%	95.34	17.6%
	Fuel	28.87	11.1%	13.98	13.0%	11.05	7.6%	55.66	10.3%
Northern Crescent	Fertilizer	130.87	47.3%	29.00	23.1%	87.32	52.3%	na	na
	Fuel	36.08	16.8%	15.84	12.6%	13.91	8.3%	na	na
Northern Great Plains	Fertilizer	77.25	35.9%	9.09	9.2%	36.16	37.4%	na	na
	Fuel	36.80	17.1%	12.88	13.0%	11.57	12.0%	na	na
Prairie Gateway	Fertilizer	80.00	28.7%	11.28	8.9%	36.96	36.7%	43.78	13.1%
	Fuel	87.33	31.4%	33.51	26.3%	28.11	27.9%	56.70	17.0%
Eastern Uplands	Fertilizer	146.91	53.9%	31.20	26.2%	na	na	na	na
	Fuel	24.59	9.0%	14.83	12.4%	na	na	na	na
Fruitful Rim	Fertilizer	na	na	na	na	47.71	27.0%	99.09	14.6%
	Fuel	na	na	na	na	70.53	40.0%	102.21	15.0%
Basin and Range	Fertilizer	na	na	na	na	58.38	44.1%	na	na
	Fuel	na	na	na	na	17.29	13.1%	na	na
Mississippi Portal	Fertilizer	na	na	19.22	13.2%	na	na	101.20	19.2%
	Fuel	na	na	33.91	23.3%	na	na	41.83	7.9%
Southern Seaboard	Fertilizer	122.84	47.6%	51.37	37.3%	na	na	118.39	24.9%
	Fuel	30.23	11.7%	12.69	9.2%	na	na	45.33	9.5%

Source: Economic Research Service.

Appendix Table A2--Energy costs as percent of total operating costs, 2007-08 average, continued

Region	Item	Sorghum		Barley		Oats		Peanuts	
		$/acre	Percent of total costs	$/acre	Percent of total costs	$/acre	Percent of total costs	$/acre	Percent of total costs
United States	Fertilizer	38.02	26.7%	44.31	34.8%	38.97	40.0%	88.09	19.0%
	Fuel	48.83	34.3%	26.06	20.5%	20.26	20.8%	76.88	16.6%
Heartland	Fertilizer	74.69	49.1%	42.87	40.4%	33.42	33.6%	na	na
	Fuel	20.89	13.7%	16.68	15.7%	20.59	20.7%	na	na
Northern Crescent	Fertilizer	na	na	47.93	39.2%	52.53	43.4%	na	na
	Fuel	na	na	22.19	18.1%	25.24	20.8%	na	na
Northern Great Plains	Fertilizer	32.17	38.5%	35.65	35.1%	19.28	29.5%	na	na
	Fuel	9.99	12.0%	16.85	16.6%	16.26	24.9%	na	na
Prairie Gateway	Fertilizer	36.89	24.1%	na	na	58.28	59.8%	83.05	16.1%
	Fuel	56.39	36.9%	na	na	14.39	14.8%	158.29	30.6%
Fruitful Rim	Fertilizer	40.34	34.1%	59.45	31.3%	na	na	113.55	23.2%
	Fuel	32.50	27.5%	52.27	27.6%	na	na	60.53	12.4%
Basin and Range	Fertilizer	na	na	53.59	39.0%	na	na	na	na
	Fuel	na	na	25.06	18.2%	na	na	na	na
Southern Seaboard	Fertilizer	na	na	na	na	na	na	101.06	21.5%
	Fuel	na	na	na	na	na	na	77.69	16.5%

Source: Economic Research Service.

Appendix Table A3--Energy costs as percent of total rice operating expenses, 2007-08 average.

Region	Item	$/acre	Percent
United States	Fertilizer	93.35	21.2%
	Fuel	122.28	27.7%
Arkansas Non-Delta	Fertilizer	79.39	20.4%
	Fuel	130.58	33.5%
California	Fertilizer	106.25	19.7%
	Fuel	81.05	15.0%
Mississippi River Delta	Fertilizer	90.62	22.7%
	Fuel	123.68	31.0%
Gulf coast	Fertilizer	114.76	22.8%
	Fuel	141.41	28.1%

Source: Economic Research Service.

Appendix Table A4--Energy costs as percent of total operating costs, 2007-08 average

Region	Item	Milk 1/		Hogs 2/		Cow-calf 3/	
		$/cwt	Percent of operating costs	$/cwt	Percent of operating costs	$/cwt	Percent of operating costs
United States	Feed	11.16	76.5%	29.61	57.6%	71.52	10.8%
	Fuel	0.76	5.2%	1.81	3.5%	66.42	10.1%
Heartland	Feed	10.775	73.1%	27.75	57.1%	105.61	14.2%
	Fuel	0.805	5.5%	1.65	3.4%	58.37	7.9%
Northern Crescent	Feed	10.615	72.8%	39.84	66.7%	na	na
	Fuel	0.89	6.1%	2.17	3.6%	na	na
Northern Great Plains	Feed	na	na	na	na	108.23	16.4%
	Fuel	na	na	na	na	65.25	9.9%
Prairie Gateway	Feed	9.35	78.6%	32.15	65.6%	60.11	8.8%
	Fuel	0.56	4.7%	2.41	4.9%	79.05	11.6%
Eastern Uplands	Feed	12.57	75.8%	28.24	56.0%	56.25	8.9%
	Fuel	0.92	5.5%	3.71	7.4%	49.42	7.8%
Fruitful Rim	Feed	12.13	81.5%	na	na	36.25	6.1%
	Fuel	0.62	4.2%	na	na	63.29	10.7%
Basin and Range	Feed	na	na	na	na	20.49	3.4%
	Fuel	na	na	na	na	61.21	10.1%
Mississippi Portal	Feed	na	na	na	na	59.09	9.6%
	Fuel	na	na	na	na	69.81	11.4%
Southern Seaboard	Feed	11.54	75.3%	31.98	52.0%	na	na
	Fuel	0.86	5.6%	1.71	2.8%	na	na

Source: Economic Research Service.
1/ Costs per hundredweight sold.
2/Costs per hundredweight gain.
3/ Costs per bredcow.

Appendix Table A5. Energy-related expenses as a percentage of total farm production costs, 2007.

		Total	Oilseeds and grains	Vegetables and melons	Fruit and tree nut	Greenhouse, nursery, and floriculture	Tobacco	Cotton	Sugarcane, hay, and all other crops
Alabama	Share of total costs	10.9	33.5	24.9	25.2	16.3	--	28.3	27.1
	Fertilizer	4.3	24.9	13.2	11.5	6.8	--	20.2	14.1
	Gasoline, fuels, and oils	4.2	7.5	8.8	9.4	5.6	--	7.1	10.8
	Utilities	2.4	1.2	2.9	4.3	3.9	--	0.9	2.2
Alaska	Share of total	18.0	41.4	28.7	--	17.7	--	--	37.3
	Fertilizer	4.6	23.0	10.1	5.0	2.9	--	--	20.2
	Gasoline, fuels, and oils	7.5	18.4	9.0	10.0	7.4	--	--	13.7
	Utilities	5.9	--	9.7	--	7.3	--	--	3.4
Arizo--	Share of total	14.9	0.0	21.2	21.5	14.5	--	30.6	31.2
	Fertilizer	5.9	--	14.2	7.8	3.6	--	13.2	11.6
	Gasoline, fuels, and oils	5.3	--	4.7	6.6	8.4	--	8.4	9.2
	Utilities	3.8	--	2.3	7.2	2.5	--	9.0	10.5
Arkansas	Share of total	16.1	34.3	21.5	18.8	18.5	--	27.1	27.4
	Fertilizer	7.1	18.5	9.7	6.7	5.5	--	17.0	10.0
	Gasoline, fuels, and oils	6.4	12.7	8.7	8.3	8.1	--	8.6	14.7
	Utilities	2.5	3.1	3.0	3.7	5.0	--	1.5	2.7
California	Share of total	13.6	26.3	18.0	15.6	11.6	--	28.9	27.9
	Fertilizer	4.9	12.6	8.4	5.9	3.8	--	11.5	11.2
	Gasoline, fuels, and oils	4.2	8.3	4.9	3.8	4.2	--	9.9	8.8
	Utilities	4.6	5.4	4.7	5.9	3.6	--	7.5	7.9
Colorado	Share of total	11.0	32.5	22.7	11.9	10.8	--	--	29.0
	Fertilizer	3.7	16.2	12.1	3.0	3.0	--	--	7.2
	Gasoline, fuels, and oils	4.7	10.6	5.2	4.7	3.9	--	--	15.3
	Utilities	2.6	5.7	5.3	4.2	4.0	--	--	6.5

		Total	Oilseeds and grains	Vegetables and melons	Fruit and tree nut	Greenhouse, nursery, and floriculture	Tobacco	Cotton	Sugarcane, hay, and all other crops
Connecticut	Share of total	12.3	--	16.4	10.1	11.4	16.0	--	20.8
	Fertilizer	3.2	--	6.2	2.1	2.3	8.1	--	7.5
	Gasoline, fuels, and oils	6.3	10.6	7.3	3.8	6.9	6.9	--	10.0
	Utilities	2.7	2.9	2.9	4.2	2.2	1.1	--	3.2
Delaware	Share of total	8.4	31.2	24.8	14.5	12.7	--	--	17.4
	Fertilizer	4.3	21.7	18.0	3.4	4.3	--	--	7.5
	Gasoline, fuels, and oils	2.5	7.9	5.3	3.4	6.0	--	--	7.6
	Utilities	1.6	1.6	1.5	7.7	2.5	--	--	2.3
Florida	Share of total	14.1	35.8	16.9	15.9	11.6	47.9	27.9	23.5
	Fertilizer	7.6	20.0	9.5	10.3	5.7	21.8	20.3	16.1
	Gasoline, fuels, and oils	4.6	11.3	5.6	4.5	3.8	23.1	6.4	6.4
	Utilities	1.9	4.5	1.8	1.1	2.2	3.1	1.2	1.1
Georgia	Share of total	13.1	36.4	23.3	21.4	16.0	35.7	31.3	29.4
	Fertilizer	5.9	23.2	14.1	10.4	6.4	16.5	20.3	16.6
	Gasoline, fuels, and oils	5.0	10.6	6.7	7.7	6.0	15.1	9.2	10.6
	Utilities	2.2	2.5	2.5	3.3	3.5	4.1	1.8	2.2
Hawaii	Share of total	16.4	8.7	20.8	18.5	12.2	--	--	22.5
	Fertilizer	6.1	4.7	9.3	8.3	4.2	--	--	8.9
	Gasoline, fuels, and oils	5.0	2.9	5.0	5.2	3.9	--	--	6.4
	Utilities	5.2	1.1	6.6	5.0	4.1	--	--	7.3
Idaho	Share of total	16.6	36.2	32.0	8.8	11.5	--	--	30.8
	Fertilizer	8.0	22.7	20.3	1.8	2.8	--	--	14.3
	Gasoline, fuels, and oils	4.8	8.7	5.8	3.3	5.9	--	--	8.2
	Utilities	3.8	4.8	6.0	3.6	2.8	--	--	8.2
Illinois	Share of total	24.2	29.1	17.9	11.8	11.3	--	--	21.5

		Total	Oilseeds and grains	Vegetables and melons	Fruit and tree nut	Greenhouse, nursery, and floriculture	Tobacco	Cotton	Sugarcane, hay, and all other crops
	Fertilizer	16.4	21.0	8.6	2.7	3.2	16.6	--	6.2
	Gasoline, fuels, and oils	6.2	6.7	6.7	5.2	5.3	7.4	--	12.9
	Utilities	1.6	1.3	2.6	3.9	2.8	--	--	2.4
India--	Share of total	21.3	29.9	21.3	12.6	12.5	29.4	--	21.8
	Fertilizer	14.1	22.1	13.3	3.7	2.7	18.4	--	7.6
	Gasoline, fuels, and oils	5.5	6.6	6.2	5.0	7.0	8.1	--	12.2
	Utilities	1.7	1.3	1.8	3.9	2.8	2.9	--	2.0
Iowa	Share of total	14.5	25.0	18.0	16.4	15.4	--	--	19.8
	Fertilizer	8.7	17.2	7.8	4.0	3.0	--	--	5.1
	Gasoline, fuels, and oils	4.3	6.3	6.9	7.1	8.3	--	--	12.7
	Utilities	1.5	1.5	3.3	5.2	4.2	--	--	2.0
Kansas	Share of total	12.6	34.5	18.8	23.5	15.2	--	35.8	27.0
	Fertilizer	6.8	21.0	9.2	12.3	3.1	--	24.4	10.1
	Gasoline, fuels, and oils	4.6	11.5	6.5	7.9	7.6	--	10.0	14.5
	Utilities	1.1	2.1	3.1	3.3	4.5	--	1.4	2.4
Kentucky	Share of total	15.1	32.9	19.4	15.2	15.9	26.4	--	23.9
	Fertilizer	7.9	24.6	8.2	4.1	3.5	15.9	--	9.3
	Gasoline, fuels, and oils	5.2	7.0	7.6	6.3	7.7	8.4	--	11.7
	Utilities	2.0	1.3	3.6	4.8	4.7	2.1	--	2.9
Louisia--	Share of total	21.2	31.2	18.7	19.4	16.9	--	23.7	25.9
	Fertilizer	10.8	19.4	9.0	7.0	8.1	--	15.9	10.9
	Gasoline, fuels, and oils	8.5	10.2	6.8	8.8	5.0	--	6.9	13.9
	Utilities	2.0	1.7	2.9	3.5	3.9	--	0.9	1.1
Maine	Share of total	15.9	34.8	23.0	15.8	22.2	--	--	21.0
	Fertilizer	4.9	10.6	12.2	5.6	3.6	--	--	4.1

		Total	Oilseeds and grains	Vegetables and melons	Fruit and tree nut	Greenhouse, nursery, and floriculture	Tobacco	Cotton	Sugarcane, hay, and all other crops
	Gasoline, fuels, and oils	7.2	20.6	7.5	8.8	11.4	--	--	13.7
	Utilities	3.7	3.6	3.3	1.3	7.2	--	--	3.2
Maryland	Share of total	13.0	31.9	19.5	10.6	13.0	28.6	--	21.1
	Fertilizer	6.4	22.4	10.0	2.2	3.7	16.8	--	9.5
	Gasoline, fuels, and oils	4.4	7.9	6.4	5.1	6.6	8.5	--	9.4
	Utilities	2.3	1.6	3.1	3.3	2.7	3.3	--	2.3
Massachusetts	Share of total	13.5	32.8	15.3	13.8	13.2	25.6	--	18.1
	Fertilizer	3.2	18.5	5.7	4.0	2.4	11.7	--	5.4
	Gasoline, fuels, and oils	6.7	10.6	5.7	6.2	7.5	12.3	--	9.6
	Utilities	3.6	3.7	3.8	3.6	3.3	1.6	--	3.2
Michigan	Share of total	18.2	32.1	20.0	11.8	12.1	--	--	21.6
	Fertilizer	9.5	22.1	10.8	4.0	2.4	--	--	9.6
	Gasoline, fuels, and oils	6.3	8.2	6.1	5.4	6.1	--	--	10.0
	Utilities	2.4	1.8	3.1	2.4	3.6	--	--	2.0
Minnesota	Share of total	17.5	26.9	19.9	12.2	13.8	--	--	22.0
	Fertilizer	9.7	17.8	12.7	3.5	3.0	--	--	10.5
	Gasoline, fuels, and oils	6.0	7.6	4.8	5.1	7.2	--	--	9.7
	Utilities	1.8	1.5	2.3	3.5	3.6	--	--	1.7
Mississippi	Share of total	13.6	25.9	18.5	18.0	18.0	--	21.8	23.8
	Fertilizer	6.2	15.0	9.7	8.2	8.9	--	13.8	7.1
	Gasoline, fuels, and oils	5.3	9.0	6.6	6.1	6.2	--	6.9	15.1
	Utilities	2.2	1.9	2.2	3.7	2.9	--	1.1	1.6
Missouri	Share of total	19.6	31.5	21.6	16.2	11.9	20.9	26.0	25.7
	Fertilizer	10.9	21.4	12.3	5.8	2.5	12.1	17.7	9.3
	Gasoline, fuels, and oils	6.7	8.6	6.9	6.5	5.7	6.4	7.3	13.3

		Total	Oilseeds and grains	Vegetables and melons	Fruit and tree nut	Greenhouse, nursery, and floriculture	Tobacco	Cotton	Sugarcane, hay, and all other crops
	Utilities	1.9	1.5	2.4	3.9	3.8	2.5	1.1	3.1
Monta--	Share of total	21.7	32.5	24.9	--	14.5	--	--	27.7
	Fertilizer	9.4	20.7	14.1	7.2	2.2	--	--	8.4
	Gasoline, fuels, and oils	9.2	9.6	5.9	--	5.6	--	--	14.9
	Utilities	3.0	2.2	4.9	3.2	6.7	--	--	4.4
Nebraska	Share of total	14.1	29.5	14.1	14.9	13.3	--	--	23.7
	Fertilizer	7.4	17.3	6.2	3.0	1.8	--	--	8.0
	Gasoline, fuels, and oils	4.9	9.1	4.2	5.8	7.5	--	--	11.5
	Utilities	1.8	3.1	3.7	6.2	3.9	--	--	4.2
Nevada	Share of total	19.8	--	--	18.7	15.4	--	--	33.3
	Fertilizer	5.2	--	--	5.3	4.1	--	--	9.3
	Gasoline, fuels, and oils	7.4	--	4.7	4.8	6.2	--	--	10.3
	Utilities	7.2	--	9.8	8.7	5.2	--	--	13.7
New Hampshire	Share of total	12.6	--	13.5	10.7	13.4	--	--	17.5
	Fertilizer	2.4	--	4.9	1.9	1.6	--	--	4.9
	Gasoline, fuels, and oils	6.7	--	4.6	4.2	9.1	--	--	9.4
	Utilities	3.5	--	4.0	4.6	2.7	--	--	3.3
New Jersey	Share of total	14.5	30.8	18.3	10.6	12.6	--	--	20.4
	Fertilizer	5.3	18.7	9.4	3.2	3.2	--	--	8.6
	Gasoline, fuels, and oils	6.1	9.7	6.2	4.1	6.7	--	--	8.8
	Utilities	3.1	2.4	2.6	3.3	2.8	--	--	3.0
New Mexico	Share of total	12.6	34.6	22.9	23.7	14.3	--	29.1	28.9
	Fertilizer	3.0	14.4	9.5	10.3	2.5	--	9.5	9.8
	Gasoline, fuels, and oils	5.9	10.8	7.9	7.2	6.0	--	12.8	12.0

		Total	Oilseeds and grains	Vegetables and melons	Fruit and tree nut	Greenhouse, nursery, and floriculture	Tobacco	Cotton	Sugarcane, hay, and all other crops
	Utilities	3.7	9.4	5.5	6.1	5.8	--	6.8	7.2
New York	Share of total	14.9	31.7	17.9	10.8	15.6	--	--	19.9
	Fertilizer	4.9	19.0	8.1	3.0	2.8	--	--	5.4
	Gasoline, fuels, and oils	6.5	10.1	6.6	5.1	8.5	--	--	11.0
	Utilities	3.5	2.6	3.2	2.7	4.2	--	--	3.5
North Caroli--	Share of total	10.2	33.5	19.7	--	14.0	33.6	26.0	27.4
	Fertilizer	4.5	23.4	10.7	4.4	5.7	14.3	17.9	15.1
	Gasoline, fuels, and oils	4.0	8.6	6.5	--	5.9	15.7	7.1	10.2
	Utilities	1.6	1.5	2.5	--	2.4	3.6	1.0	2.1
North Dakota	Share of total	26.3	29.4	22.1	19.3	13.9	--	--	23.3
	Fertilizer	15.9	19.3	12.2	5.9	2.1	--	--	9.9
	Gasoline, fuels, and oils	8.8	8.7	7.7	11.1	7.5	--	--	11.6
	Utilities	1.6	1.3	2.1	2.2	4.3	--	--	1.8
Ohio	Share of total	19.7	31.8	14.7	13.1	13.0	28.3	--	21.4
	Fertilizer	12.0	23.1	7.1	2.8	2.6	16.0	--	7.2
	Gasoline, fuels, and oils	5.9	7.3	5.1	5.6	6.9	9.4	--	11.4
	Utilities	1.9	1.4	2.4	4.6	3.6	2.9	--	2.8
Oklahoma	Share of total	13.4	36.1	20.3	21.4	15.1	--	28.8	27.2
	Fertilizer	5.5	21.2	8.2	8.2	4.3	--	15.2	9.8
	Gasoline, fuels, and oils	6.1	12.7	9.4	9.4	7.4	--	11.0	14.5
	Utilities	1.9	2.2	2.6	3.8	3.5	--	2.7	3.0
Oregon	Share of total	14.7	30.1	24.5	11.2	9.1	--	--	27.3
	Fertilizer	6.6	17.2	13.8	4.4	3.7	--	--	16.0
	Gasoline, fuels, and oils	5.1	9.6	5.0	4.0	3.2	--	--	7.4
	Utilities	3.1	3.2	5.7	2.7	2.3	--	--	3.9

		Total	Oilseeds and grains	Vegetables and melons	Fruit and tree nut	Greenhouse, nursery, and floriculture	Tobacco	Cotton	Sugarcane, hay, and all other crops
Pennsylvania	Share of total	12.2	30.2	17.4	9.9	12.6	11.8	--	20.2
	Fertilizer	4.2	19.4	7.9	2.7	1.5	7.4	--	7.5
	Gasoline, fuels, and oils	5.0	8.8	6.6	4.9	5.6	3.6	--	10.4
	Utilities	3.0	2.1	2.9	2.3	5.6	0.8	--	2.3
Rhode Island	Share of total	13.9	--	--	17.5	13.8	--	--	12.6
	Fertilizer	4.9	--	12.1	4.3	5.5	--	--	4.4
	Gasoline, fuels, and oils	6.1	--	7.3	6.0	5.7	--	--	6.0
	Utilities	3.0	--	--	7.2	2.6	--	--	2.2
South Caroli--	Share of total	14.3	36.0	19.0	16.5	12.8	40.7	32.6	30.7
	Fertilizer	7.1	25.0	9.9	7.2	5.1	20.2	24.0	17.4
	Gasoline, fuels, and oils	5.1	8.9	6.5	6.0	4.2	17.4	7.7	11.1
	Utilities	2.1	2.1	2.6	3.2	3.5	3.1	0.9	2.2
South Dakota	Share of total	18.6	26.9	15.0	17.6	12.1	--	--	20.7
	Fertilizer	10.5	18.3	3.7	2.0	1.4	--	--	5.9
	Gasoline, fuels, and oils	6.2	6.9	6.2	11.0	7.8	--	--	12.0
	Utilities	1.9	1.6	5.1	4.5	2.9	--	--	2.7
Tennessee	Share of total	19.7	33.0	19.2	16.5	14.6	25.1	29.5	25.2
	Fertilizer	11.5	25.6	10.6	5.2	6.5	15.6	23.1	11.7
	Gasoline, fuels, and oils	6.1	6.4	6.2	6.5	5.2	7.6	5.5	11.2
	Utilities	2.1	1.0	2.4	4.8	2.9	1.9	0.9	2.3
Texas	Share of total	12.6	36.2	19.2	17.7	14.2	--	30.5	27.4
	Fertilizer	4.8	18.9	9.2	7.0	5.0	--	13.0	10.4
	Gasoline, fuels, and oils	5.5	13.0	6.5	7.0	5.3	--	11.5	12.8
	Utilities	2.3	4.3	3.4	3.6	4.0	--	6.0	4.1
Utah	Share of total	13.1	--	23.0	15.3	12.6	--	--	30.1

		Total	Oilseeds and grains	Vegetables and melons	Fruit and tree nut	Greenhouse, nursery, and floriculture	Tobacco	Cotton	Sugarcane, hay, and all other crops
	Fertilizer	2.8	17.0	10.8	4.1	3.2	--	--	9.1
	Gasoline, fuels, and oils	6.8	13.7	9.2	6.1	4.8	--	--	12.4
	Utilities	3.5	--	3.0	5.1	4.5	--	--	8.5
Vermont	Share of total	12.9	--	--	10.6	16.2	--	--	17.9
	Fertilizer	3.6	18.7	5.3	3.2	2.7	--	--	3.8
	Gasoline, fuels, and oils	5.9	10.2	5.6	4.5	7.9	--	--	10.8
	Utilities	3.4	--	--	2.9	5.6	--	--	3.3
Virginia	Share of total	14.7	34.5	20.0	9.7	10.2	34.2	29.5	23.2
	Fertilizer	7.0	26.1	10.3	3.3	3.3	13.6	21.4	11.8
	Gasoline, fuels, and oils	5.8	7.3	6.7	4.3	4.9	17.1	7.0	9.3
	Utilities	2.0	1.1	2.9	2.0	2.1	3.5	1.1	2.1
Washington	Share of total	15.4	34.1	27.1	9.6	10.4	--	--	28.2
	Fertilizer	7.1	21.6	16.3	3.0	2.4	--	--	13.5
	Gasoline, fuels, and oils	4.9	9.8	4.5	3.7	4.9	--	--	8.3
	Utilities	3.5	2.8	6.3	2.9	3.2	--	--	6.5
West Virginia	Share of total	12.4	29.7	22.0	8.8	18.5	29.4	--	24.6
	Fertilizer	3.5	20.0	7.6	2.2	2.8	12.4	--	7.4
	Gasoline, fuels, and oils	6.9	7.9	10.4	4.5	10.3	13.4	--	14.4
	Utilities	2.0	1.8	3.9	2.2	5.4	3.6	--	2.8
Wisconsin	Share of total	16.7	27.2	20.3	14.1	13.3	18.2	--	19.4
	Fertilizer	7.3	17.6	12.0	4.1	3.0	6.7	--	5.6
	Gasoline, fuels, and oils	6.3	7.7	5.6	7.0	7.1	8.6	--	10.9
	Utilities	3.0	2.0	2.8	2.9	3.2	2.9	--	2.9
Wyoming	Share of total	13.5	29.6	--	--	11.0	--	--	25.9
	Fertilizer	3.3	14.9	--	1.8	1.7	--	--	9.4

		Total	Oilseeds and grains	Vegetables and melons	Fruit and tree nut	Greenhouse, nursery, and floriculture	Tobacco	Cotton	Sugarcane, hay, and all other crops
	Gasoline, fuels, and oils	6.8	10.3	4.1	--	4.3	--	--	10.3
	Utilities	3.4	4.4	3.1	7.9	5.0	--	--	6.1
United States	Share of total	15.3	29.9	20.5	14.7	12.5	30.9	28.5	26.2
	Fertilizer	7.5	19.6	11.0	5.9	3.9	14.8	15.2	11.2
	Gasoline, fuels, and oils	5.4	8.3	5.4	4.2	5.3	13.2	9.3	10.7
	Utilities	2.5	2.0	4.1	4.6	3.4	3.0	3.9	4.3

Source: 2007 Census of Agriculture.

Appendix Table A6. Energy-related expenses as a percentage of total farm production costs, 2007.

	ITEM	Beef cattle ranching	Cattle feedlots	Dairy cattle and milk	Hogs and pigs	Poultry and eggs	Sheep and goats	Animal aquaculture and other animals
Alabama	Share of total	24.5	8.3	--	--	4.8	20.0	14.3
	Fertilizer	13.4	5.1	4.0	0.9	0.3	4.1	2.4
	Gasoline, fuels, and oils	8.7	2.6	4.1	1.5	2.3	11.9	7.1
	Utilities	2.4	0.6	--	--	2.3	3.9	4.8
Alaska	Share of total	21.1	30.7	--	17.2	12.9	--	11.8
	Fertilizer	11.1	14.9	--	4.7	0.6	--	0.4
	Gasoline, fuels, and oils	6.8	8.8	--	7.8	7.9	--	5.8
	Utilities	3.2	7.0	--	4.7	4.3	--	5.6
Arizo--	Share of total	14.6	--	4.9	--	4.1	26.2	15.4
	Fertilizer	1.0	--	0.3	--	0.1	0.2	0.6
	Gasoline, fuels, and oils	10.1	0.9	1.9	--	2.5	22.5	10.8
	Utilities	3.4	--	2.7	--	1.5	3.6	4.1
Arkansas	Share of total	16.3	10.8	12.6	6.4	4.5	15.1	17.4
	Fertilizer	6.8	4.5	3.7	0.6	0.2	2.1	1.5
	Gasoline, fuels, and oils	7.6	4.9	5.2	2.9	2.2	9.8	8.2
	Utilities	1.9	1.5	3.7	2.9	2.1	3.2	7.7
California	Share of total	7.7	1.5	6.7	7.0	5.6	10.2	11.7
	Fertilizer	1.0	0.0	1.1	0.5	0.1	0.9	0.4
	Gasoline, fuels, and oils	4.3	0.7	2.5	3.3	2.8	6.4	6.9
	Utilities	2.4	0.8	3.1	3.2	2.6	2.8	4.4
Colorado	Share of total	12.4	1.4	4.8	5.5	4.6	6.8	18.3
	Fertilizer	2.5	0.3	0.3	0.2	0.1	0.7	0.8
	Gasoline, fuels, and oils	6.8	0.6	2.1	2.8	2.3	4.1	13.7

	ITEM	Beef cattle ranching	Cattle feedlots	Dairy cattle and milk	Hogs and pigs	Poultry and eggs	Sheep and goats	Animal aquaculture and other animals
	Utilities	3.0	0.5	2.4	2.5	2.2	2.0	3.8
Connecticut	Share of total	14.9	--	13.9	17.3	5.0	11.5	10.9
	Fertilizer	4.0	--	4.6	2.1	0.2	0.8	0.7
	Gasoline, fuels, and oils	6.6	6.0	5.8	9.4	2.6	7.9	6.0
	Utilities	4.4	1.8	3.5	5.9	2.3	2.8	4.2
Delaware	Share of total	14.0	--	17.8	--	3.7	9.3	14.4
	Fertilizer	5.0	--	8.9	--	0.9	0.9	3.8
	Gasoline, fuels, and oils	6.0	2.7	5.4	6.6	1.3	7.2	7.1
	Utilities	3.0	2.2	3.6	2.6	1.5	1.2	3.5
Florida	Share of total	17.1	19.6	6.6	17.0	4.0	12.6	9.9
	Fertilizer	8.7	7.6	1.6	1.7	0.3	1.8	1.0
	Gasoline, fuels, and oils	6.5	8.5	2.2	12.3	1.9	7.7	5.4
	Utilities	2.0	3.6	2.8	2.9	1.8	3.2	3.5
Georgia	Share of total	21.3	23.0	11.0	6.8	4.7	16.3	15.8
	Fertilizer	11.3	11.6	4.1	1.9	0.3	4.4	2.5
	Gasoline, fuels, and oils	7.7	8.8	3.5	2.6	2.5	8.2	10.2
	Utilities	2.3	2.7	3.3	2.3	1.9	3.7	3.1
Hawaii	Share of total	9.6	--	--	--	4.4	13.8	14.9
	Fertilizer	0.5	0.5	--	--	0.3	0.9	0.3
	Gasoline, fuels, and oils	6.1	--	--	--	1.3	9.8	3.8
	Utilities	3.0	--	--	--	2.7	3.1	10.8
Idaho	Share of total	11.0	1.7	5.7	11.0	7.3	14.0	11.8
	Fertilizer	2.4	0.3	1.1	1.1	0.2	3.3	0.8
	Gasoline, fuels, and oils	5.6	1.0	2.4	5.4	4.4	7.8	7.8

	ITEM	Beef cattle ranching	Cattle feedlots	Dairy cattle and milk	Hogs and pigs	Poultry and eggs	Sheep and goats	Animal aquaculture and other animals
	Utilities	3.0	0.5	2.1	4.6	2.7	3.0	3.3
Illinois	Share of total	14.4	8.7	16.3	8.1	4.6	17.2	13.3
	Fertilizer	5.8	4.7	6.8	3.0	0.4	1.5	3.8
	Gasoline, fuels, and oils	6.5	3.1	6.0	3.1	2.4	12.3	6.5
	Utilities	2.0	0.8	3.5	2.0	1.8	3.4	2.9
India--	Share of total	11.8	13.3	11.1	8.3	6.1	12.9	11.6
	Fertilizer	4.8	6.4	4.4	3.8	0.8	1.7	3.3
	Gasoline, fuels, and oils	5.4	5.3	4.1	2.8	2.3	8.2	5.9
	Utilities	1.6	1.7	2.6	1.7	2.9	3.0	2.3
Iowa	Share of total	12.5	5.7	11.7	5.3	4.5	10.7	10.6
	Fertilizer	5.5	2.9	3.8	1.7	0.3	2.0	4.9
	Gasoline, fuels, and oils	5.1	2.2	4.9	2.0	2.0	5.6	4.2
	Utilities	1.9	0.6	3.1	1.5	2.1	3.1	1.6
Kansas	Share of total	11.8	1.3	7.9	4.1	6.4	14.1	17.4
	Fertilizer	5.5	0.3	1.8	1.2	1.0	2.2	4.5
	Gasoline, fuels, and oils	5.0	0.6	3.3	1.4	3.3	8.6	10.0
	Utilities	1.3	0.3	2.8	1.5	2.1	3.3	3.0
Kentucky	Share of total	17.7	20.0	17.6	9.3	4.5	14.8	4.6
	Fertilizer	8.2	8.5	8.0	3.9	0.5	2.7	0.7
	Gasoline, fuels, and oils	7.1	8.3	5.5	2.4	2.1	8.5	2.5
	Utilities	2.3	3.2	4.2	2.9	1.8	3.5	1.4
Louisia--	Share of total	22.5	--	15.6	14.4	3.7	18.8	17.5
	Fertilizer	10.2	--	8.2	3.3	0.1	3.2	1.5
	Gasoline, fuels, and oils	9.8	--	4.2	8.4	1.8	12.3	11.2

	ITEM	Beef cattle ranching	Cattle feedlots	Dairy cattle and milk	Hogs and pigs	Poultry and eggs	Sheep and goats	Animal aquaculture and other animals
	Utilities	2.5	--	3.2	2.7	1.7	3.3	4.7
Maine	Share of total	16.3	17.3	12.6	12.0	5.6	11.7	8.9
	Fertilizer	2.4	5.0	3.0	0.7	0.1	1.4	0.3
	Gasoline, fuels, and oils	10.0	9.3	6.2	5.9	1.7	6.8	4.7
	Utilities	3.8	3.0	3.3	5.4	3.9	3.5	3.9
Maryland	Share of total	18.4	14.8	15.1	7.1	4.8	10.0	8.8
	Fertilizer	8.3	7.2	6.9	0.9	1.1	1.8	1.1
	Gasoline, fuels, and oils	7.3	5.2	4.9	3.7	1.6	5.9	4.3
	Utilities	2.7	2.4	3.3	2.4	2.0	2.3	3.4
Massachusetts	Share of total	15.6	10.5	15.8	13.4	8.1	9.8	9.7
	Fertilizer	3.5	2.1	4.9	2.1	0.4	1.3	0.3
	Gasoline, fuels, and oils	9.1	7.0	6.4	9.1	4.4	5.5	5.2
	Utilities	3.0	1.5	4.5	2.2	3.3	3.0	4.2
Michigan	Share of total	14.8	12.3	11.8	7.4	5.2	13.0	13.0
	Fertilizer	6.0	6.6	4.2	2.4	0.9	2.5	1.3
	Gasoline, fuels, and oils	6.7	4.4	4.9	3.2	1.9	7.7	8.2
	Utilities	2.2	1.2	2.6	1.8	2.4	2.8	3.5
Minnesota	Share of total	15.5	9.1	13.9	5.9	7.2	12.9	12.5
	Fertilizer	5.9	4.5	4.7	2.0	0.6	2.0	3.4
	Gasoline, fuels, and oils	7.0	3.6	5.7	2.4	5.0	7.0	6.3
	Utilities	2.6	1.0	3.4	1.5	1.6	4.0	2.7
Mississippi	Share of total	21.6	--	16.3	4.1	4.0	18.3	15.7
	Fertilizer	11.8	--	8.3	0.5	0.2	3.4	1.6
	Gasoline, fuels, and oils	7.9	--	4.2	2.0	1.9	11.0	7.4

	ITEM	Beef cattle ranching	Cattle feedlots	Dairy cattle and milk	Hogs and pigs	Poultry and eggs	Sheep and goats	Animal aquaculture and other animals
	Utilities	1.8	--	3.8	1.7	1.9	3.9	6.7
Missouri	Share of total	19.0	12.4	14.4	5.7	5.1	14.5	16.7
	Fertilizer	9.3	6.5	6.2	1.1	0.3	2.6	4.4
	Gasoline, fuels, and oils	7.6	4.4	5.1	2.8	3.0	8.3	9.0
	Utilities	2.1	1.4	3.1	1.9	1.8	3.6	3.3
Monta--	Share of total	14.9	4.2	12.1	--	--	13.9	20.9
	Fertilizer	3.6	1.0	2.3	--	--	1.2	4.0
	Gasoline, fuels, and oils	8.2	2.3	5.7	--	12.2	8.3	12.7
	Utilities	3.1	0.9	4.1	5.7	4.7	4.4	4.2
Nebraska	Share of total	12.6	2.7	9.9	5.6	2.8	12.4	15.6
	Fertilizer	4.4	1.1	2.8	1.3	0.4	1.1	5.4
	Gasoline, fuels, and oils	6.2	1.2	4.2	2.7	1.3	7.6	7.6
	Utilities	2.0	0.4	2.9	1.6	1.0	3.7	2.7
Nevada	Share of total	15.2	--	--	--	--	14.5	15.0
	Fertilizer	2.0	--	0.3	--	--	0.4	0.3
	Gasoline, fuels, and oils	8.7	--	--	9.4	7.0	8.6	9.6
	Utilities	4.6	--	2.5	6.5	6.0	5.4	5.0
New Hampshire	Share of total	16.1	25.0	12.5	--	--	8.4	9.9
	Fertilizer	4.0	12.5	3.0	--	0.3	1.2	0.7
	Gasoline, fuels, and oils	9.2	8.3	5.0	--	--	5.0	6.1
	Utilities	2.8	4.2	4.6	--	2.7	2.3	3.1
New Jersey	Share of total	13.7	10.5	18.6	14.1	6.9	12.9	9.4
	Fertilizer	4.9	2.8	7.9	2.2	0.6	1.6	0.9
	Gasoline, fuels, and oils	6.2	5.3	6.2	8.8	2.5	8.4	4.4

	ITEM	Beef cattle ranching	Cattle feedlots	Dairy cattle and milk	Hogs and pigs	Poultry and eggs	Sheep and goats	Animal aquaculture and other animals
	Utilities	2.6	2.4	4.4	3.0	3.7	2.9	4.2
New Mexico	Share of total	13.8	4.8	4.9	15.4	9.8	23.7	21.4
	Fertilizer	1.6	0.6	0.5	0.7	0.5	0.6	0.7
	Gasoline, fuels, and oils	8.7	2.9	2.2	10.6	4.8	17.5	15.6
	Utilities	3.5	1.3	2.1	4.1	4.5	5.6	5.1
New York	Share of total	15.0	10.9	13.5	7.8	7.5	12.7	11.2
	Fertilizer	4.1	3.1	4.3	1.0	0.6	1.4	0.6
	Gasoline, fuels, and oils	7.6	5.7	5.5	4.6	3.7	6.9	6.3
	Utilities	3.2	2.0	3.7	2.2	3.2	4.4	4.3
North Caroli--	Share of total	20.9	--	13.4	--	4.1	--	12.4
	Fertilizer	11.1	--	6.5	--	0.6	--	3.0
	Gasoline, fuels, and oils	7.9	--	3.8	1.4	2.1	--	6.3
	Utilities	2.0	--	3.1	1.2	1.4	--	3.1
North Dakota	Share of total	17.0	6.0	13.8	--	--	14.1	19.5
	Fertilizer	4.7	1.7	3.1	--	--	0.7	2.1
	Gasoline, fuels, and oils	9.9	3.4	7.1	4.3	8.1	9.2	13.9
	Utilities	2.4	0.9	3.6	3.7	1.7	4.2	3.5
Ohio	Share of total	14.1	11.3	13.7	7.0	3.8	13.4	11.2
	Fertilizer	5.7	6.1	5.6	2.8	0.5	1.6	2.3
	Gasoline, fuels, and oils	6.4	3.9	5.4	2.7	1.8	8.9	6.1
	Utilities	2.0	1.3	2.8	1.5	1.5	2.9	2.8
Oklahoma	Share of total	14.9	1.8	11.3	3.5	5.6	15.2	16.5
	Fertilizer	6.3	0.5	3.4	0.1	0.2	2.0	2.1
	Gasoline, fuels, and oils	6.9	0.8	4.3	1.7	2.9	9.8	10.7

	ITEM	Beef cattle ranching	Cattle feedlots	Dairy cattle and milk	Hogs and pigs	Poultry and eggs	Sheep and goats	Animal aquaculture and other animals
	Utilities	1.7	0.5	3.6	1.8	2.5	3.4	3.7
Oregon	Share of total	12.6	2.3	6.1	10.9	5.4	11.8	14.1
	Fertilizer	2.7	0.4	0.6	1.1	0.3	2.2	1.2
	Gasoline, fuels, and oils	6.8	1.3	2.8	5.9	2.9	6.2	9.0
	Utilities	3.2	0.6	2.8	3.8	2.2	3.3	3.9
Pennsylvania	Share of total	12.0	9.7	13.4	5.3	4.6	11.5	9.6
	Fertilizer	4.5	4.2	5.0	1.2	0.5	2.3	1.4
	Gasoline, fuels, and oils	5.7	4.1	5.1	2.3	2.2	6.5	5.2
	Utilities	1.8	1.4	3.3	1.9	1.9	2.7	3.1
Rhode Island	Share of total	12.4	--	14.6	--	--	6.1	9.8
	Fertilizer	3.2	--	6.0	--	0.4	0.4	0.6
	Gasoline, fuels, and oils	7.7	4.8	4.9	--	--	3.6	6.1
	Utilities	1.6	2.6	3.8	--	--	2.0	3.1
South Caroli--	Share of total	27.0	24.4	14.3	6.5	4.2	18.4	15.0
	Fertilizer	15.5	14.6	6.4	1.9	0.7	6.2	2.8
	Gasoline, fuels, and oils	9.3	7.7	4.4	2.8	2.0	9.9	9.1
	Utilities	2.2	2.1	3.5	1.9	1.5	2.3	3.1
South Dakota	Share of total	14.3	6.3	8.8	7.7	9.8	14.6	18.7
	Fertilizer	4.8	3.1	2.2	2.1	1.6	2.7	5.8
	Gasoline, fuels, and oils	7.2	2.5	3.9	3.2	3.8	7.9	9.5
	Utilities	2.3	0.7	2.7	2.4	4.5	4.0	3.4
Tennessee	Share of total	22.0	10.6	15.2	9.8	5.1	14.8	13.8
	Fertilizer	11.6	6.6	7.6	3.6	0.4	3.1	3.0
	Gasoline, fuels, and oils	8.1	3.0	4.3	4.2	2.7	8.6	7.2

	ITEM	Beef cattle ranching	Cattle feedlots	Dairy cattle and milk	Hogs and pigs	Poultry and eggs	Sheep and goats	Animal aquaculture and other animals
	Utilities	2.3	1.1	3.2	2.0	1.9	3.1	3.6
Texas	Share of total	14.9	1.5	6.5	6.2	4.3	14.0	16.1
	Fertilizer	5.6	0.1	1.6	0.9	0.2	1.5	1.9
	Gasoline, fuels, and oils	7.0	0.9	2.3	3.1	2.2	9.1	10.5
	Utilities	2.3	0.5	2.5	2.2	1.9	3.4	3.7
Utah	Share of total	15.3	11.4	8.8	--	4.4	17.2	17.2
	Fertilizer	2.8	2.2	1.3	0.1	0.1	1.5	1.0
	Gasoline, fuels, and oils	9.5	8.0	4.1	1.7	2.5	12.4	12.2
	Utilities	3.0	1.3	3.4	--	1.8	3.3	3.9
Vermont	Share of total	12.5	7.0	12.4	15.7	--	8.8	13.9
	Fertilizer	3.5	0.9	3.8	2.4	0.2	0.8	0.6
	Gasoline, fuels, and oils	6.3	5.0	5.3	10.7	4.7	4.7	8.2
	Utilities	2.7	1.1	3.3	2.6	--	3.2	5.1
Virginia	Share of total	19.2	14.2	14.7	6.9	5.2	11.6	11.4
	Fertilizer	10.0	6.9	7.1	1.2	0.4	2.7	1.9
	Gasoline, fuels, and oils	7.7	5.9	4.9	3.0	3.2	6.7	6.5
	Utilities	1.6	1.3	2.8	2.6	1.6	2.3	3.0
Washington	Share of total	12.9	2.2	6.0	12.0	4.6	12.9	10.6
	Fertilizer	3.3	0.6	1.2	1.7	0.1	1.0	0.7
	Gasoline, fuels, and oils	6.5	1.0	2.6	7.1	3.0	8.5	6.7
	Utilities	3.1	0.7	2.2	3.2	1.4	3.4	3.3
West Virginia	Share of total	19.3	15.4	14.9	12.3	5.4	14.8	13.1
	Fertilizer	7.6	6.6	5.7	1.3	0.2	2.9	1.6
	Gasoline, fuels, and oils	9.9	7.1	5.8	8.6	3.8	9.3	8.3

	ITEM	Beef cattle ranching	Cattle feedlots	Dairy cattle and milk	Hogs and pigs	Poultry and eggs	Sheep and goats	Animal aquaculture and other animals
	Utilities	1.8	1.7	3.5	2.5	1.4	2.7	3.1
Wisconsin	Share of total	15.9	15.4	14.5	12.0	6.8	11.5	10.6
	Fertilizer	6.0	7.1	5.3	3.4	0.6	1.3	1.2
	Gasoline, fuels, and oils	7.0	6.0	5.6	5.3	4.2	6.6	6.5
	Utilities	2.9	2.3	3.6	3.4	1.9	3.6	3.0
Wyoming	Share of total	11.4	4.9	9.4	--	9.5	11.9	15.5
	Fertilizer	2.0	1.2	1.7	--	1.0	1.3	1.4
	Gasoline, fuels, and oils	6.4	2.4	4.2	--	6.1	7.1	10.3
	Utilities	3.0	1.3	3.6	2.8	2.5	3.4	3.8
United States	Share of total	15.0	2.8	10.1	5.5	4.7	13.2	12.4
	Fertilizer	5.8	1.0	3.1	1.6	0.4	1.7	1.9
	Gasoline, fuels, and oils	6.9	1.2	4.0	2.3	2.4	8.2	7.1
	Utilities	2.2	0.5	3.1	1.6	1.9	3.2	3.4

Source: 2007 Census of Agriculture.

Appendix B—Medium and Long Run Impacts on Production Costs using FAPSIM

Though FAPSIM is only designed to examine short-term impacts, we extrapolate to the intermediate and long-term to make an initial assessment of how higher energy prices in those years would affect farmers if they made identical decisions to those modeled in the short term. These effects are already integrated into the results reported by FASOM, but it is difficult to glean the separate effect on production prices. Unlike FASOM, the FAPSIM model simulations for the different scenarios and time periods assume no changes in technology or production practices (such as fertilizer application rates) beyond those implicit in the reference scenario's trends.[23] In addition, trends in energy-related inputs could themselves change in the future in response to climate change impacts, as shifts in temperature and precipitation alter the need for fertilizer, pesticides, and irrigation. FAPSIM does not reflect these future changes in agroclimatic conditions. As such, these impacts likely substantially over estimate the impact of higher energy prices on farmers' production costs. Further, medium-term impacts are also likely significantly over-stated as this analysis disregards the mitigating impact that allowance rebates to trade vulnerable industries would have on fertilizer costs.

As cap levels become more stringent over time, allowance prices and corresponding energy price impacts become larger. FAPSIM is designed to evaluate short-term impacts. It is therefore difficult to make accurate statements about the medium and longer-term. Nonetheless, to make some initial assessment of the effects of higher energy prices on agriculture beyond the initial short-term focus, the estimated impacts of energy prices for selected periods from the EPA analysis were used to look at the potential price effects from 2 additional time periods using the FAPSIM framework. First a medium-term scenario was based on EPA estimated changes in energy prices for 2027-33. Then a long-term assessment was based on EPA energy price results for 2042-48.

The methodological approach used is similar to that used to evaluate short-term impacts. However, given the assumptions necessary to extrapolate beyond the FAPSIM time frame, these should be viewed with full acknowledgement of the limitations of this analysis. Since these two additional time periods are beyond the horizon of FAPSIM, results were generated within the FAPSIM time horizon based on percent changes for affected variables and then inflated to the medium- and long-term time periods based on the annual inflation rate from the EPA analysis, 1.8 percent. This implies a constant real price assumption for those two additional time periods. Additionally, no additional changes in production practices beyond those implicit in underlying trend yields between now and these time periods is assumed. While these assumptions are analytical simplifications, they provide a vehicle for simulating representative impacts were they to occur in the short run. For the medium-term and long-term periods, we assume there are no allowance rebates provided to trade-vulnerable industries, including fertilizer production. As noted previously, this assumption will lead to an over-estimate of impacts on fertilizer prices and farm production costs in the medium-term scenario, as H.R. 2454 would continue to provide these allowance rebates to trade-vulnerable industries through

[23] A more detailed description of FAPSIM is given in Appendix C.

at least 2035. For comparison purposes, results shown in this section repeat some of the earlier short-term impacts.

This approach has limitations given the observation that energy per unit of output has drastically declined over the last several decades. These estimates are likely an upper bound on the costs because they fail to account for farmer's proven ability to innovate in response to changes in market conditions.

Table B1 presents the impacts of higher energy prices on average annual production costs in the medium- and long-term along with those from the short-term discussed earlier. The medium- and long-term impacts on production costs have a relatively larger impact on fertilizer intensive crops such as corn compared to less fertilizer intensive crops such as soybeans. In the long-term, corn production costs are estimated to increase by more than $25 per acre (in $2005), representing an increase of almost 10 percent. In comparison, soybean production costs rise by $5.19 per acre, on average, 4.6 percent. Wheat, sorghum, barley, and oats would see increases similar to corn in percentage terms. Rice is estimated to have the largest average per-acre increase in the long term at $28.08 per acre, although its percentage increase would be less than that for wheat, corn, and the other feed grains. Likewise, cotton has a relatively high absolute increase in production costs, but this represents a smaller share of operating expenses. Soybean production costs remain the least affected.

Resulting adjustments in the agricultural sector to these higher production expenses follow the same dynamics as discussed earlier for the short-term results. Acreage shifts would lead to changes in commodity prices and adjustments through the livestock sector.

Table B2 presents the projected impacts of the higher energy costs across the different time periods for farm cash receipts, production expenses, and net farm income. In the long-term results, fuel, oil, and electricity expenses are estimated to increase, on average, 22 percent above baseline levels, while fertilizer and lime expenses are estimated to rise, on average, by almost 20 percent. While total receipts increase marginally—due to higher crop and livestock prices—they only partly offset the increase in expenses. As a result, higher energy prices associated with H.R. 2454 would lower net farm income by as much as 7.2 percent from baseline levels in the long term scenario. These results do not include the effects of GHG offsets, nor the mitigating influence of allowance rebates for fertilizers in the medium-term scenario.

Lastly, it is important to note that the medium- to long-term analyses are conservative given that energy use per unit of output has declined significantly over the past several decades. Because of this, the estimates in table B2 are likely an upper bound estimate on the costs because they fail to account for farmers' ability to fully respond to changes in market conditions. In addition, the analysis is also conservative because it does not account for revenues provided by GHG offsets, expanded renewable energy markets, or the effects GHG offsets and biofuel production have on land use, production and prices. Table 22 shows the effects of offsets on net farm income.

Table B1. Estimated impacts on per acre variable costs of production of higher energy prices under an emissions cap-and-trade system ($2005/acre, percent change from baseline in parentheses)

Crop	Short-term (with rebate)	Medium-term (no rebate)	Long-term (no rebate)
Corn	1.19	12.02	25.19
	(0.4%)	(4.6%)	(9.6%)
Sorghum	1.26	5.45	11.30
	(0.9%)	(3.9%)	(8.0%)
Barley	0.70	5.00	10.44
	(0.6%)	(4.1%)	(8.5%)
Oats	0.57	4.12	8.66
	(0.6%)	(4.4%)	(9.3%)
Wheat	0.66	4.94	10.34
	(0.6%)	(4.5%)	(9.5%)
Rice	3.09	13.48	28.08
	(0.7%)	(3.1%)	(6.5%)
Upland cotton	1.46	7.90	16.44
	(0.3%)	(1.8%)	(3.7%)
Soybeans	0.45	2.50	5.19
	(0.4%)	(2.2)	(4.6%)

Source: Economic Research Service

Table B2. Estimated impacts on net farm income of higher energy prices under an emissions cap-and-trade system ($2005 billion, percent change from baseline in parentheses)

Item	Short-term	Medium-term	Long-term
Total receipts	0.0	0.4	0.9
	(0.0%)	(0.2%)	(0.3%)
Total expenses	0.7	2.7	5.6
	(0.3%)	(1.1%)	(2.2%)
Fuel, oil and electricity	0.7	1.3	2.6
	(6.4%)	(11.1%)	(22.2%)
Fertilizer and lime	< 0.1	2.0	4.3
	(0.3%)	(9.5%)	(19.9%)
Net farm income	-0.6	-2.4	-4.9
	(-0.9%)	(-3.5%)	(-7.2%)

Source: Economic Research Service. Effects do not reflect revenues from GHG offsets or changes in biofuel production, nor do they reflect the related effects of land use changes associated with GHG offsets.

Appendix C -- The Food and Agricultural Policy Simulator (FAPSIM)

The Food and Agricultural Policy Simulator (FAPSIM) is an annual, dynamic econometric model of the U.S. agricultural sector. The model was originally developed at the U.S. Department of Agriculture during the early 1980s.[24] Since that time, FAPSIM has been continually re-specified and re-estimated to reflect changes in the structure of the U.S. food and agricultural sector. The model includes over 800 equations.

The model contains four broad types of relationships: definitional, institutional, behavioral, and temporal. Definitional equations include identities that reflect mathematical relationships that must hold among the data in the model. For example, total demand must equal total supply for a commodity at any point in time. The model constrains solutions to satisfy all identities of this type.

Institutional equations involve relationships between variables that reflect certain institutional arrangements in the sector. Countercyclical payment rates calculations are example of this type of relationship.

Definitional and institutional equations reflect known relationships that necessarily hold among the variables in the model. Behavioral equations are quite different because the exact relationship is not known and must be estimated. Economic theory is used to determine the types of variables to include in behavioral equations, but theory does not indicate precisely how the variables should be related to each other. Examples of behavioral relationships in FAPSIM are the acreage equations for different field crops. Economic theory indicates that production should be positively related to the price received for the commodity and negatively related to prices of inputs required in the production process. Producer net returns are used in the FAPSIM acreage equations to capture these economic effects. Additionally, net returns for other crops that compete with each other for land use are included in the acreage equations. While the model covers the U.S. agricultural sector, trade for each commodity is included through econometrically-based export equations.

For the most part, FAPSIM uses a linear relationship to approximate the general functional form for each behavioral relationship. Generally, the parameters in the linear behavioral relationships were estimated by single equation regression methods. The large size of the model precludes the use of econometric methods designed for systems of equations. Ordinary least squares was used to estimate the majority of the equations. If statistical tests indicated the presence of either autocorrelation or heteroscedasticity in the

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[24] Salathe, Larry E., Price, J. Michael, and Gadson, Kenneth E. "The Food and Agricultural Policy Simulator." *Agricultural Economics Research*, (34(2)): 1-15, 1982.

error structure of an equation, maximum likelihood methods or weighted least squares were used.

Temporal relationships are empirical equations that describe the inter-relationships between variables measured using different units of time. For example, not all of the variables in FAPSIM are measured using the same concept of a year. Commodity data are reported on a marketing year basis; budgetary data are reported on a fiscal year basis; and farm income data are reported on a calendar year basis. As a result, empirical equations are sometimes needed to establish relationships among variables in these different temporal categories. For example, cash receipts for crops are reported on a calendar year basis, but production and price information for crops are on a marketing year basis. Equations are used in FAPSIM to estimate cash receipts using information from both marketing years that overlap the calendar year.

Commodities included in FAPSIM are corn, sorghum, barley, oats, wheat, rice, soybeans, (including product markets for soybean meal and soybean oil), upland cotton, cattle, hogs, broilers, turkeys, eggs, and dairy. The dairy model contains submodels for fluid milk, evaporated and condensed milk, frozen dairy products, cheese, butter, and non-fat dry milk. Each commodity submodel contains equations to estimate production, prices, and different demand components. FAPSIM also includes submodels to estimate the value of exports, net farm income, Government outlays on farm programs, retail food prices, and consumer expenditures on food. All of the submodels are linked together through the variables they share in common.

Appendix D--FASOM Baseline and other Model Details

Figures D1 and D2 show how crop yields are projected to changes under the baseline. Figures D1 and D2 are indexed so that 2010 yields are equal to 1.0. The indexing shows how yields for various crops are projected to change in relation to 2010 as well as in relation to one another. The projected yield changes for each crop are listed in Table D1. Figure D1 shows that the index value for corn yields is expected to double from 2010 to 2050, increasing from 1.0 in 2010 to 2.0 in 2050. This corresponds to a projected annual growth rate of about 1.8 percent per year from 2010 to 2050, with a projected increase in corn yields from 164.1 bushels per acre in 2010 to 330.0 bushels per acre by 2050 (Table D1). The rate of growth for wheat yields are projected at about 1.0 percent per year, while the growth rate for soybean yields are projected at about 0.4 percent per year over the same time period. In comparison, the USDA baseline projects corn yields increasing by 1.2 percent per year, soybean yields increases by about 1.0 percent per year, and wheat yields increasing by about 0.7 percent per year from 2010/11 to 2018/19 (USDA Agricultural Projections to 2018).[25] Figure D2 shows the index values for cotton, sorghum, rice, oats, barley, silage, and hay. As shown in Figure D2, not all crops are projected to significantly increase yields. Sorghum yields are projected to increase by about 0.2 percent per year while barely yields are projected to remain relatively flat.

Due in part to yield increases, the FASOM baseline also projects declining real (inflation adjusted) prices over time for most commodities. As presented in Table D2, the real price of corn falls from $4.03 per bushel in 2010 to $2.50 per bushel by 2050, or about 38 percent. Similarly, wheat prices fall by between 15 and almost 60 percent between 2010 and 2050, depending on the class of wheat. The prices for those commodities with lower projected yield increases, in general, exhibit relatively smaller declines in prices. For example, the real price of soybeans is projected to decline by only about 3 percent from 2010 to 2050 while the real price of sorghum is projected to increase by almost 10 percent and barley prices are projected to almost double.

Greater yields and lower real prices translate into less land in crop production. As shown in Table D3, the total amount of land devoted to crop production declines by about 12 million acres (5 percent) from 2010 to 2050. For some crops, the decline is quite dramatic. For example, the amount of acres devoted to corn production declines by about 17 million acres (23 percent) from 2010 to 2050, while the amount of acres planted to hard red winter wheat declines by about 4 million acres (15 percent), and the amount of soybean acres falls by about 2.4 million acres (4 percent). Land enrolled in the Conservation Reserve Program (CRP) is not included in Table D3. The CRP is fixed at 32 million acres throughout the projection period.

FASOM simulations also include payments to farmers and forest land owners when they reduce GHG emissions or increase carbon sequestration and corresponding charges when they take actions that increase GHG emissions. In the model, this prevents

[25] The USDA Agricultural Projections to 2018 can be accessed at: http://www.ers.usda.gov/Publications/OCE091/.

farmers from switching practices to generate offsets that produce little or no GHG mitigation. For example, without a charge on CO_2 emissions, farmers might shift a large quantity of cropland to pasture – thus generating offsets – but simultaneously shift a similar amount of pasture to cropland – thus maintaining commodity income but negating the GHG benefits of the offsets. Imposing the CO_2 charge prevents the agriculture sector from generating offsets in this manner but with the consequence that the simulation effectively brings agriculture and forestry under the cap (i.e., with an obligation to maintain emissions at current levels).

A similar issue arises with GHG offsets that are generated within FASOM by reducing farm output. For example, in FASOM livestock producers can generate offsets by reducing herd or flock sizes. In a cap-and-trade system, it is not clear that farmers would be awarded emissions offsets simply for decreasing output. For a many reasons farm output can fluctuate from year to year, often significantly. It would be a challenge to determine when a decrease in farm output is in response to a GHG mitigation incentive and when it is related to another factor. Additionally, in the absence of a financial penalty for increasing emissions, farmers could create offsets simply by redistributing production across farms. Such offsets would have no GHG mitigation value.

Figure D1. Index of Crop Yields over Time (2010 = 1.0)

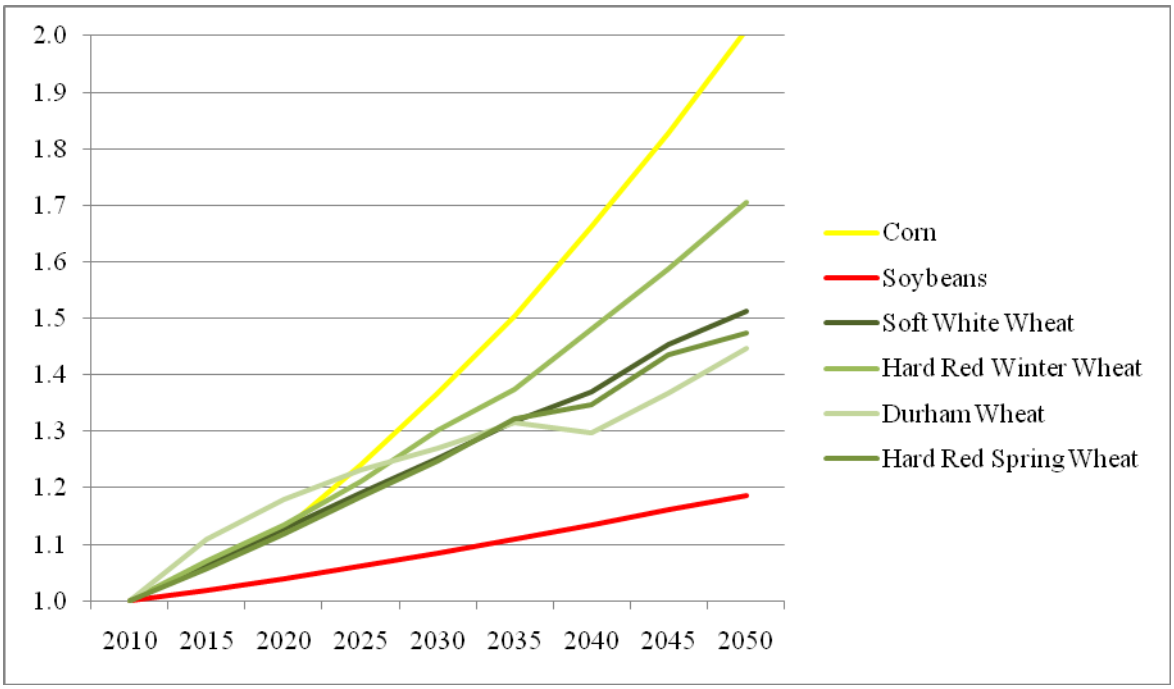

Figure D2. Index of Crop Yields over Time (2010 = 1.0)

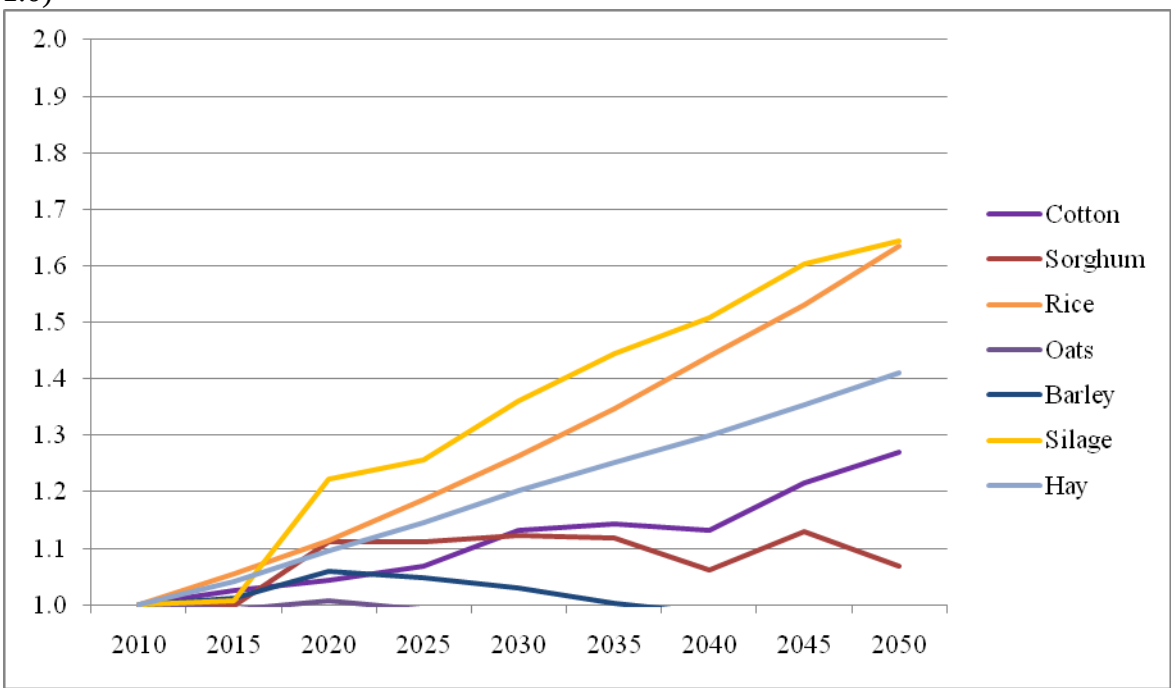

Table D1. Crop Yields Over Time.

	2010	2015	2020	2025	2030	2035	2040	2045	2050
	Yields (bushels per acre unless otherwise noted)								
Cotton (480-lb. bales/acre)	1.7	1.7	1.8	1.8	1.9	1.9	1.9	2.1	2.2
Corn	164.1	174.5	184.7	203.5	224.4	246.8	272.7	300.0	330.0
Soybeans	44.5	45.4	46.3	47.2	48.3	49.3	50.5	51.7	52.8
Soft White Wheat	68.3	72.7	77.1	81.5	85.6	90.0	93.6	99.4	103.3
Hard Red Winter Wheat	69.0	73.9	78.3	83.7	89.9	94.9	102.2	109.6	117.8
Durham Wheat	32.3	35.9	38.1	39.8	41.0	42.5	42.0	44.2	46.8
Hard Red Spring Wheat	38.9	41.2	43.5	46.1	48.6	51.5	52.4	55.9	57.4
Sorghum	59.5	59.5	66.2	66.2	66.9	66.6	63.2	67.3	63.6
Rice (cwt/acre)	72.6	76.6	80.9	86.1	91.7	97.8	104.5	111.1	118.7
Oats	61.8	61.3	62.3	61.2	60.5	58.7	61.2	61.1	60.6
Barley	59.5	60.2	63.1	62.3	61.2	59.6	58.5	59.0	59.0
Silage (tons/acre)	15.1	15.2	18.4	19.0	20.5	21.8	22.7	24.2	24.8
Hay (tons/acre)	3.0	3.2	3.3	3.5	3.6	3.8	3.9	4.1	4.3

Table D2. Real (2004) Crop Prices Over Time.

	2010	2015	2020	2025	2030	2035	2040	2045	2050
	$ per bushel (unless otherwise noted)								
Cotton ($/bale)	280.49	273.45	241.60	241.60	258.62	249.79	263.67	267.94	278.53
Corn	4.03	4.03	4.03	3.63	3.26	2.97	2.72	2.61	2.50
Soybeans	9.05	9.04	9.03	9.01	9.00	8.85	8.83	8.71	8.79
Soft White Wheat	4.21	4.19	3.68	3.43	2.76	2.50	2.86	1.90	1.81
Hard Red Winter Wheat	5.38	5.31	5.08	5.01	4.82	4.64	4.50	4.34	4.21
Durham Wheat	8.75	8.15	7.56	8.41	8.24	8.07	7.80	7.64	7.44
Hard Red Spring Wheat	6.10	6.05	5.53	5.47	5.29	5.06	5.17	5.01	4.82
Sorghum	7.40	7.73	5.99	6.27	5.98	5.92	7.39	7.97	8.12
Rice ($/cwt)	7.71	7.30	6.87	6.51	6.24	5.97	5.80	5.57	5.29
Oats	1.27	1.35	1.96	1.41	1.01	0.47	1.15	0.47	0.72
Barley	2.87	2.92	3.24	3.32	3.53	3.76	3.36	4.78	5.50
Silage ($/ton)	4.68	4.28	4.74	4.09	4.00	3.84	3.13	3.07	2.89
Hay ($/ton)	137.98	134.83	130.06	130.31	135.68	127.15	133.30	140.99	140.29

Table D3. Acres Devoted to Crop Production Over Time.

	2010	2015	2020	2025	2030	2035	2040	2045	2050
	Acres (1,000)								
Cotton	8,933	9,266	10,134	10,235	9,673	10,078	10,285	9,936	9,615
Corn	75,345	75,157	73,778	72,008	69,558	67,430	60,734	57,219	58,006
Soybeans	56,433	57,507	57,745	57,886	57,504	58,555	55,838	55,378	53,941
Soft White Wheat	2,795	2,887	2,625	2,574	2,568	2,531	3,635	2,941	3,763
Hard Red Winter Wheat	23,995	23,362	22,364	21,906	21,084	21,391	21,383	20,711	20,280
Durham Wheat	1,048	1,140	1,164	1,101	1,011	924	1,554	1,537	1,538
Hard Red Spring Wheat	10,142	11,078	11,727	11,169	10,343	9,672	9,843	10,406	9,786
Sorghum	8,544	8,867	4,782	4,714	4,537	4,822	8,782	7,976	8,420
Rice	2,951	3,558	4,275	4,535	4,842	4,953	5,124	5,308	5,325
Oats	1,868	1,867	1,538	1,698	1,890	2,290	3,099	3,465	3,584
Barley	5,182	5,140	4,486	4,753	5,095	5,745	6,800	6,774	7,246
Silage	5,013	5,147	4,474	4,502	4,454	4,358	4,298	4,161	4,297
Hay	49,043	48,208	47,798	47,389	46,848	46,747	46,513	45,600	45,157
Switchgrass	0	0	0	0	2,864	358	1,490	3,868	2,751
Other Crops	4,694	4,802	4,973	5,084	5,188	5,281	5,357	5,372	5,463
Cropland Used	255,987	257,985	251,863	249,554	247,458	245,134	244,737	240,653	239,173
Idled Cropland	814	76	7,216	6,629	6,427	6,328	6,226	6,089	4,647
Total Cropland	256,801	258,061	259,079	256,183	253,885	251,462	250,963	246,742	243,820

Primary livestock and milk production also increase under the FASOM baseline (Table D4). For example, fed beef slaughter is up by about 25 percent from 2010 to 2050 while hog slaughter is up by about 60 percent and broiler and turkey production grow by 43 percent, and 69 percent, respectively over the same time period. Milk production increases by almost 50 percent from 2010 to 2050. While livestock and milk production increases over time, the real prices for those commodities except for fed beef, declines. The real prices for hogs, broilers, and turkeys fall by 12 percent, 11 percent, and 35 percent, respectively from 2010 to 2050 while the real milk price falls by about 16 percent.

Table D4. Primary Livestock and Milk Production and Real (2004) Prices Over Time.

		2010	2015	2020	2025	2030	2035	2040	2045	2050
Fed Beef	$/cwt	54.4	57.6	58.6	57.9	60.2	62.1	58.1	58.1	60.2
Fed Beef	mil.cwt	517	510	525	547	555	560	614	640	649
Hogs	$/cwt	41.2	41.8	40.4	38.7	37.4	36.4	36.0	35.3	36.2
Hogs	mil.cwt	437	453	474	518	555	615	647	674	699
Broilers	¢/lb.	49.8	49.0	49.2	47.6	46.6	45.2	44.6	44.6	44.1
Broilers	mil.cwt	449	471	484	514	540	568	596	618	643
Eggs	¢/dz.	0.94	0.92	0.96	0.90	0.94	0.88	0.92	0.89	0.87
Eggs	mil.dz.	7,271	7,506	7,749	8,000	8,259	8,615	8,803	9,088	9,487
Turkey	¢/lb.	44.9	46.0	39.2	38.0	33.4	32.6	31.0	31.0	29.0
Turkey	mil.cwt	91	92	105	111	124	130	137	146	154
Milk	$/cwt	15.5	15.5	14.8	14.6	13.9	13.5	13.4	13.0	13.0
Milk	mil.cwt	1,945	2,017	2,153	2,243	2,420	2,547	2,654	2,773	2,911

The implication of higher yields coupled with advanced technology is also important for the production of biofuels such as ethanol. Under the FASOM baseline, total ethanol production is projected to increase from about 15 billion gallons per year in 2010 to 47 billion gallons per year by 2050 (Table D5). However, advances in cellulosic technologies create an environment where crops for ethanol represent a declining share of the feedstock used in ethanol production. For example, in 2010 all ethanol production is based on corn starch as a feedstock. However, by 2050 corn starch represents only 38 percent of total ethanol production. By 2050 cellulosic based ethanol is projected to grow to almost 30 billion gallons per year, representing over 60 percent of total ethanol production. The use of corn residues is projected to contribute 15 billion gallons of ethanol per year.

Table D5. Ethanol Production Over Time.

	2010	2015	2020	2025	2030	2035	2040	2045	2050
Feedstock	billion gallons								
Corn	13	15	15	15	15	15	12	12	17
Other Crops	1	1	0	0	0	0	2	1	1
Starch Total	14	16	15	15	15	15	14	13	18
Crop Residues	0	0	6	7	6	8	11	15	17
Switchgrass	0	0	0	0	2	0	1	3	3
Bagasse	0	1	1	1	1	1	1	1	1
Woody Biomass	0	4	6	6	5	5	8	8	8
Cellulosic Total	0	5	14	14	14	14	21	28	29
Total Ethanol	15	21	29	29	29	29	35	41	47

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