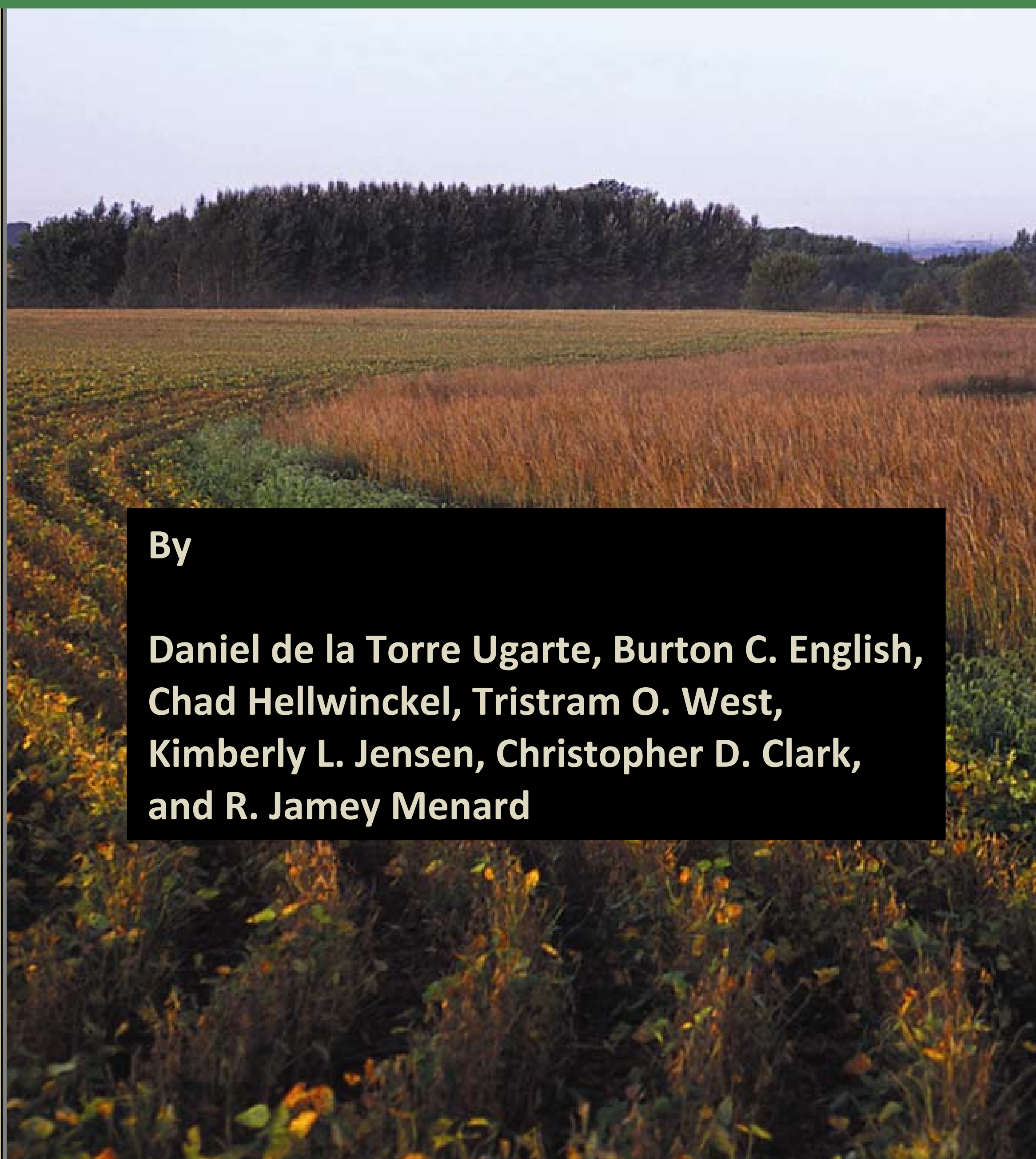
Analysis of the Implications of Climate Change and Energy Legislation to the Agricultural Sector



By

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25x'25 AMERICA'S ENERGY FUTURE

BEAG

BIO-BASED ENERGY ANALYSYS GROUP

APAC

AGRICULTURAL POLICY ANALYSYS CENTER

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BACKGROUND
Congress is currently considering energy and climate change legislation and numerous questions have arisen as to what impact various policy proposals may have on the agricultural and forestry sectors. To better assess these impacts, the 25x'25 Alliance asked the University of Tennessee's Bio-based Energy Analysis Group (BEAG) to analyze how several proposed energy/climate change policy scenarios might impact land use change, feedstock production, feedstock prices, and farm income, as well as carbon costs and payments for producers.

Results from the University of Tennessee study will be presented in four parts. This first report focuses on a detailed agricultural sector analysis evaluating the impacts on agriculture as a result of providing carbon offsets and supplying energy feedstocks from agricultural based products and by-products from crops and livestock while incorporating projected wind and solar impacts from renewable energy farms. Subsequent reports will address impacts on the forest sector and will incorporate economic analysis of the nation's economy conducted at the state and national levels.

ABOUT BEAG
The Bio-based Energy Analysis Group (BEAG), located at the University of Tennessee, is an inter-disciplinary research and outreach group which strives to provide decision makers in government and industry with the most up to date economic and environmental analysis of the bio-based energy industry at the state, regional, and national levels. In 2006, BEAG assessed the ability of the agriculture and forestry sectors to produce 25 percent of the energy consumed by the nation by 2025 while continuing to produce safe, abundant and affordable food, feed and fiber. Among the key findings, the study found that America's farms, forests and ranches can play a significant role in meeting the country's renewable energy needs, that the 25x'25 goal is achievable and that it can be met without compromising the ability of the agricultural sector to reliably produce food, feed and fiber at reasonable prices. The report can be viewed at
http://www.25x25.org/storage/25x25/documents/RANDandUT/ut_ea_report.pdf

ABOUT 25x'25
25x'25 is a renewable energy initiative backed by organizations and individuals united by a common interest in making America's energy future more secure, affordable and environmentally sustainable. Through its diverse alliance of agricultural, forestry, environmental, conservation and other organizations and businesses, 25x'25 partners have been working collaboratively since 2005 to advance the goal of securing 25 percent of the nation's energy needs from renewable sources by the year 2025. 25x'25 is led by a national steering committee composed of volunteer leaders from the agricultural, forestry and renewable energy communities. The initiative is supported by the Energy Future Coalition. More on 25x'25 can be found at www.25x25.org

The study has been funded by The Energy Foundation. An electronic copy of the report can be viewed and downloaded at www.25x25.org

(Cover photo courtesy of USDA NRCS.)

Executive Summary

This study projects how meeting several proposed energy/climate change policy scenarios might impact the U.S. agricultural sector. For the purposes of each scenario studied, it is assumed that the Renewable Fuels Standard (RFS) established by the Energy Independence and Security Act of 2007 is in play. Along with the RFS, policy scenarios that have been analyzed include a cap-and-trade regulatory system and varying treatments of agricultural offsets.

KEY FINDINGS

Under a properly constructed cap-and-trade program:

- Net returns to agriculture are projected to be positive – including up to $13 billion annually in additional revenues for agriculture and forestry – and exceed baseline projections for eight of nine crops analyzed;
- Income from offsets and from market revenues is higher than any potential increase in input cost including energy and fertilizer;
- At projected carbon prices of up to $27 per $MtCO_2e$, afforestation of cropland will not occur;
- Major shifts in commodity cropland use does not occur;
- Demand for bioenergy feedstocks will cause significant shifts to hay and dedicated energy crop acreage from pasture conversion;
- Crop and beef prices are not disrupted; and
- Biomass feedstock production creates significant direct and indirect reduction in greenhouse gases (GHG). This includes a direct reduction of an accumulated 460 million metric tons CO_2 equivalent.

If emissions are regulated by EPA without the benefit of multiple offsets:

- Net farm income is projected to fall below baseline projections;
- Agriculture is subjected to higher input costs with no opportunity to be compensated for the GHG reduction services the sector provides;
- Impacts to beef production are uncertain; and
- If afforestation and grassland sequestration are the only offsets allowed, and carbon prices are as high as $160 per $MtCO_2e$, sixty million acres of cropland could be converted to forests and grasslands.

The study looks at a "baseline" policy scenario, which is an extension of the USDA agricultural baseline through 2030. Four other scenarios are then compared with the *Baseline Scenario*.

Among the other four scenarios is one in which emissions, including those from the agricultural sector, are regulated by the EPA in accordance with a 2007 Supreme Court ruling holding the agency responsible for regulating greenhouse gas emissions under the Clean Air Act (*EPA Led Scenario*). No legislative guidance is presumed for this scenario.

Another scenario limits the offsets available to agriculture to methane capture, afforestation, and conservation tillage (*Limited Offsets Scenario*). Crop residue removals under this limited offset scenario must be carbon neutral.

A third scenario allows for many agricultural offsets, including those for bioenergy crop production and grassland sequestration, but there is no requirement that the removal of crop residues at harvest be carbon neutral (*Multiple Offsets Scenario*). However, crop residue removal must be held at acceptable levels for erosion.

The final scenario also allows many offsets, but the removal of crop residues at harvest must be carbon neutral (*Multiple Offsets/RCN Scenario*). For this final scenario, the effects of pasture conversion and forage replacement on the cattle industry were estimated.

The study used POLYSYS, an agricultural policy simulation model of the U.S. agricultural sector, to project the impacts to the agricultural sector from these potential policy scenarios. The results show impacts on economic returns, climate benefits, feedstock prices, and land use impacts.

The *Multiple Offsets/RCN Scenario* is projected to produce the highest net returns to agriculture and the greatest climate benefits, but ranks third in terms of biomass price. Because this scenario performs well in meeting three important objectives (net returns, environmental performance, and biomass prices), the study devotes further analysis to it, using the *Baseline* and *EPA Led Scenarios* as reference points. The *Multiple Offsets/RCN Scenario* provides nearly $209 billion more in net returns than the *Baseline Scenario* and $364 billion more than the *EPA Led Scenario*. The *Multiple Offsets/RCN Scenario* also provides an additional 463 million metric tons of reduced CO_2 equivalent, and 31 million metric tons more in reductions when measured against projections made for the *EPA Led Scenario*.

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Study Purpose and Background

The purpose of this study is to project how existing and proposed energy and climate change policies that increase the use of renewable energy and reduce greenhouse gas emissions might affect the U.S. agricultural sector. At the time of our analysis, these policies included the Energy Independence & Security Act of 2007 (EISA), which established a renewable fuels standard (RFS) requiring the production of 36 billion gallons of renewable fuels by 2022 (U.S. Congress, 2007), and the American Clean Energy Security Act (ACES), which includes a renewable electricity standard (RES) and a cap-and-trade program to reduce greenhouse gas (GHG) emissions. Additionally, the Supreme Court recently ruled that the Environmental Protection Agency (EPA) has the authority to regulate GHGs under the Clean Air Act (CAA). Although the Senate is now working on climate legislation, it was not available during the time of this analysis.

The June 26, 2009 passage of ACES by the U.S. House of Representatives—representing the first time that either chamber of Congress has passed legislation to regulate GHG emissions—suggests that Congressional action to address climate change is possible. ACES sets targets to reduce national GHG emissions from high-emitting industries to 3 percent below 2005 levels by 2012, 17 percent by 2020, 42 percent by 2030, and 83 percent by 2050. The reduction would occur under a cap-and-trade program to be administered by EPA and USDA. Regulated sources would be required to obtain "allowances" from EPA to emit a specified amount of emissions with EPA reducing the total amount of allowances distributed each year in order to meet the reduction targets. However, the U.S. Supreme Court's decision in Massachusetts v. Environmental Protection Agency, 549 U.S. 497 (2007) and the Environmental Protection Agency's response (EPA, 2009b), suggest that, absent Congressional action, EPA will regulate GHG emissions under the CAA.

A cap-and-trade program is a market mechanism to reduce emissions. Regulated sources with excess allowances (i.e., sources with more allowances than emissions) would be allowed to trade or sell them to other regulated or non-regulated entities. Initially, about 85 percent of the allowances would be given away with the remaining 15 percent auctioned off, although the amount auctioned would increase over time. Regulated sources would be prohibited from emitting more GHG than they had allowances for, unless they purchased offset credits from projects that would result in reductions of GHG emissions or sequestration of GHG (House of Representatives, 2009).

In its current form, ACES specifically excludes the agricultural and forestry sectors from the industries to be regulated under the GHG cap and allows for the production of offsets from agricultural and forestry sources. Although the "Peterson Amendment" to

ACES provides some guidance on what agricultural practices would qualify as an offset, uncertainty remains. Offset project eligibility is a critical issue for determining how the legislation might affect agriculture and its ability to meet the existing RFS and the proposed RES. For example, if practices related to bioenergy crop production are not included in the list of approved offset practices, then it might become prohibitively expensive for agriculture to produce enough feedstocks to meet the RFS and RES.

This study seeks to project how varying specifications for allowable offsets in a cap-and-trade program might impact the agricultural sector and generate climate benefits, as measured by changes to net carbon flux. (Net carbon flux represents the amount of carbon leaving a system). We modeled how sector changes will impact land use change, feedstock production, feedstock prices, and farm income, as well as carbon costs and payments for producers.

Study Assumptions and Methods

The Renewable Fuels Standard (RFS) set forth in EISA is assumed to continue in this study. The RFS requires 36 billion gallons of renewable fuels by 2022, with 16 billion gallons coming from cellulosic ethanol and one billion gallons from biodiesel by 2012. Along with the RFS, policy scenarios analyzed include cap-and-trade and varying treatments of agricultural offsets. The most restrictive treatment, called the *EPA Led Scenario*, enforces the Supreme Court verdict for EPA to regulate GHG emissions under the Clean Air Act, which does not allow for the creation of an offsets market.[1] To account for this lack of offsets coupled with carbon regulation, this study uses the EPA estimated equivalent carbon price (EPA, 2009).

The second most restrictive treatment of offsets, the *Limited Offsets Scenario*, only allows for methane capture, afforestation, and conservation tillage, but does not include the production of bioenergy crops or grasslands sequestration.[2] In this treatment, crop residues are harvested for bioenergy production, but removals must be carbon neutral. Although crop residues are often left on the field to prevent soil erosion, additional material must be left to replenish soil carbon.

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[1] Title V of the Clean Air Act (CAA) requires that any entity with the potential to emit more than 100 tons per year of a regulated pollutant must obtain a permit in order to operate. As USDA points out in its comments to the Advance Notice of Proposed Rulemaking for Regulating Greenhouse Gas Emissions under the Clean Air Act: "If GHG emissions from agricultural sources are regulated under the CAA, numerous farming operations that currently are not subject to the costly and time-consuming Title V permitting process would, for the first time, become covered entities. Even very small agricultural operations would meet a 100-tons-per-year emissions threshold. For example, dairy facilities with over 25 cows, beef cattle operations of over 50 cattle, swine operations with over 200 hogs, and farms with over 500 acres of corn may need to get a Title V permit" (EPA, 2008). If so, this would mean that a large share of the nation's livestock operations and other large farms would need to get a Title V permit and pay the requisite permitting fee. The New York Farm Bureau has calculated that the permitting fee imposed by EPA for Title V permits could amount to as much as $175 per dairy cow, $87.50 per head of beef cattle, $20 per hog." (New York Farm Bureau, 2008).

[2] Most bioenergy crops are perennials with long-lived, deep root stocks that build carbon into soil organic matter.

The most liberal treatment analyzed, *Multiple Offsets Scenario*, allows methane capture, afforestation, conservation tillage, production of bioenergy crops, and grasslands sequestration, but does not require that crop residue removal be carbon neutral. Crop residue removal must still be held at acceptable erosion levels.

The final treatment evaluated, *Multiple Offsets/RCN Scenario*, allows many agricultural offsets, including methane capture, afforestation, conservation tillage, production of bioenergy crops, and grasslands sequestration, but still requires that removal of crop residues be carbon neutral. For the *Multiple Offsets Scenario/RCN Scenario*, the effects of pasture conversion and animal unit replacement on the beef cattle sector are evaluated.

These policy scenarios are compared with the *Baseline Scenario*, which is an extension of the USDA agricultural baseline through 2030 assuming continuance of the EISA RFS. A summary table of the scenarios evaluated is presented below in Table 1.

Agricultural Sector Modeling

Key Biomass Sources

The key biomass sources considered as part of this study are corn grain, soybeans, switchgrass, hybrid poplar, willow, crop residues (corn stover and wheat straw), wood residues (forest residues, mill wastes, fuel treatments and forestland thinnings), and animal manure (beef, dairy, hogs, and poultry). Switchgrass is a perennial native grass that can be grown from Colorado to the East Coast of the United States and from the Gulf Coast into Canada. Switchgrass yields in some areas can exceed ten dry tons per acre and, as a native grass, does not require large amounts of inputs (Bransby). Hybrid poplars are fast growing trees that can easily be propagated from stem cuttings. As with switchgrass, chemical and fertilizer applications for hybrid poplars are lower than many row crops. Except for arid regions, hybrid poplar can be grown throughout most of the United States and can produce up to ten dry tons per acre (Tuskan). Willow is often found in wetlands and near water sources but can also grow in a variety of well-drained soils in areas with regular rainfall. Willow propagates well with seedlings or with cuttings and yields can exceed eight dry tons per acre (Abrahamson, et al., 1998). Other crops such as Energy Cane, Giant Reed, Giant Miscanthus, and Napier Grass could provide higher yields at a lower cost in some areas of the country. For this study, dedicated energy crop baseline yields are assumed to be equal to levels provided by Perlack (2009).

Forest residues, wood from fuel reduction, and mill wastes are included in the analysis. However, the potential for forestry is understated in this analysis as standing timber is not incorporated into the potential supplies of cellulosic materials. Thus, the nation's over 400 million acres of privately owned forest land, over forty million of which are plantation forests (Smith, Miles, Perry, and Pugh, 2008), are not considered as a source of additional woody feedstocks. A summary of the bioenergy sources is presented in Figure 1.

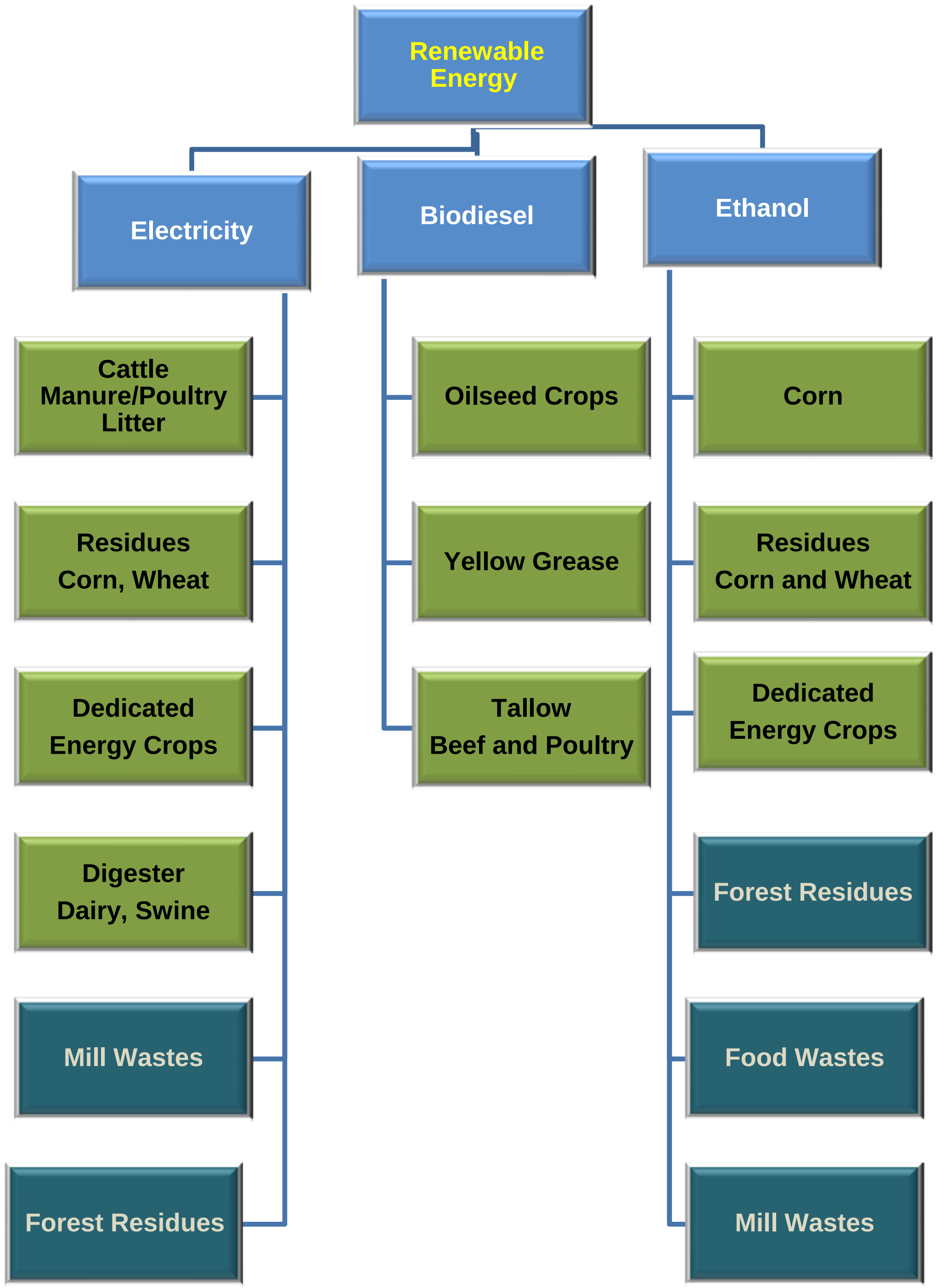


Figure 1. Bioenergy Sources

Table 1. Climate Change and Energy Legislation Scenarios Analyzed and Key Assumptions

	Scenario	Attributes/Offsets	Crop Residues Constrained at Soil Carbon Neutral Levels	Pasture Conversion/ Livestock	Fertilizer Exempt from Regulation	Carbon Price per Ton CO_2 Eq.
1.	*Baseline*	USDA baseline extended to 2030/Continuance of EISA RFS	No	No pasture conversion	N/A	None
2.	*EPA* (Supreme Court/EPA)	No cap-and-trade Legislation EISA RFS /High energy Costs with no offsets	No	Pasture conversion allowed 1. With AUM replacement[a] 2. Without AUM replacement	No	Up to $160
3.	*Limited Offsets*	Cap-and-trade Legislation with EISA RFS/ High energy Costs with offsets conservation tillage, afforestation, and methane capture	Yes	Pasture conversion allowed 1. With AUM replacement 2. Without AUM replacement	No	Up to $27
4.	*Multiple Offsets*	Cap-and-trade Legislation with EISA RFS /High energy Costs with multiple offsets including conservation tillage, afforestation, methane capture, grassland sequestration, and bioenergy crops	No	Pasture conversion allowed 1. With AUM replacement 2. Without AUM replacement	Yes	Up to $27
5.	*Multiple Offsets/ RCN*	Same as Scenario 4 but with residues at carbon neutral levels after harvest	Yes	Pasture conversion allowed 1. With AUM replacement 2. Without AUM replacement	Yes	Up to $27

[a]An animal unit month (AUM) is the amount of forage required by an animal unit (AU) for one month.

Modeling Process

The methodology for modeling the agricultural sector's response to meeting energy requirements under EISA's RFS with varying provisions for GHG regulation is schematically displayed in Figure 2. The schematic of the process starts with the definition of the energy targets for biofuels under the RFS and for renewable energy under the RES. As can be seen from the figure, additional feedstock materials beyond what are needed to meet biofuels targets under the RFS are then used toward meeting the RES. The information and data on conversion costs for agricultural and forest feedstocks are introduced into POLYSYS to estimate the quantity and type of energy to be produced from agriculture, as well as prices, farm income, and government payments.

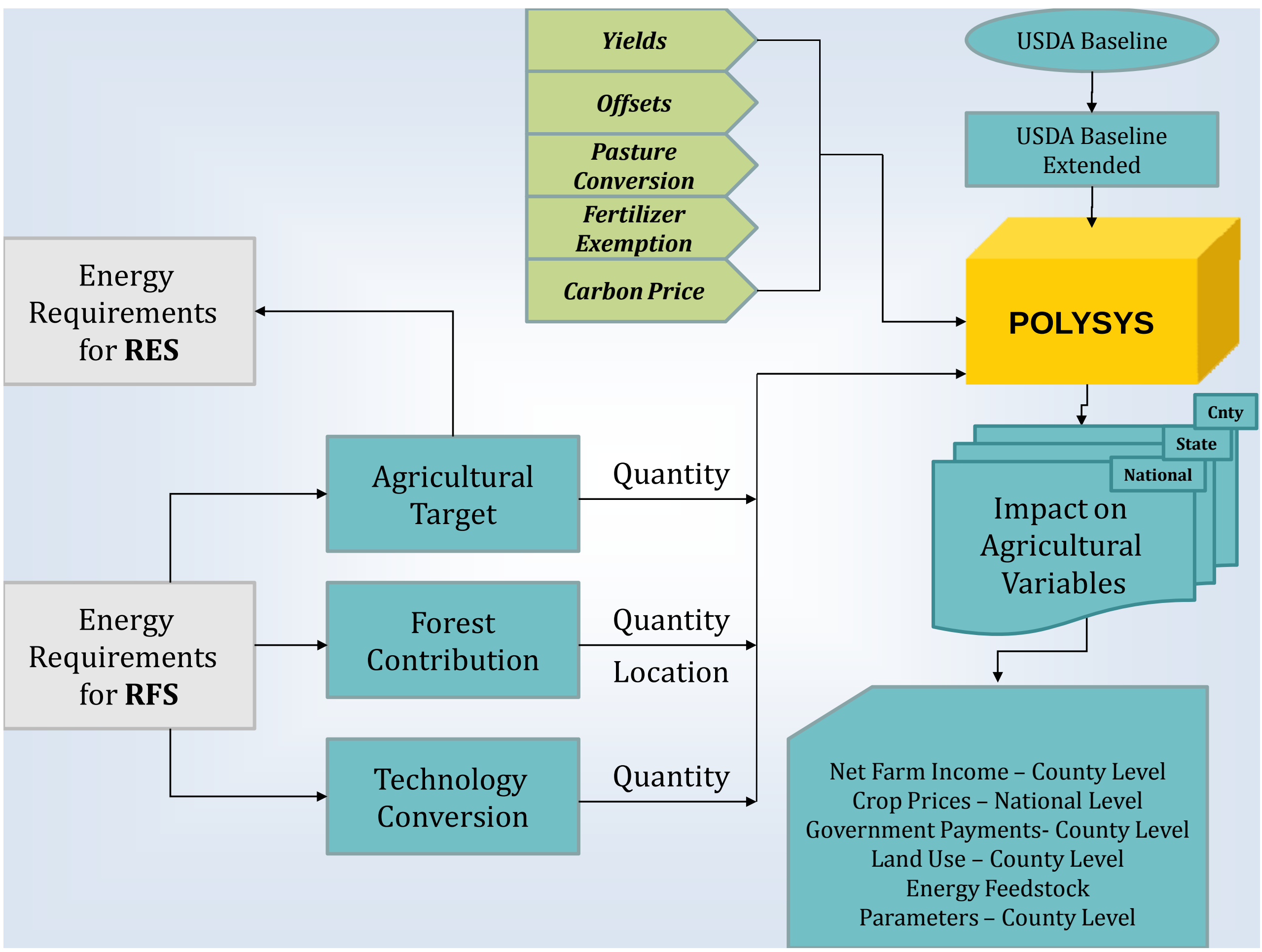


Figure 2. Process for Modeling Impacts on Agricultural Variables

POLYSYS

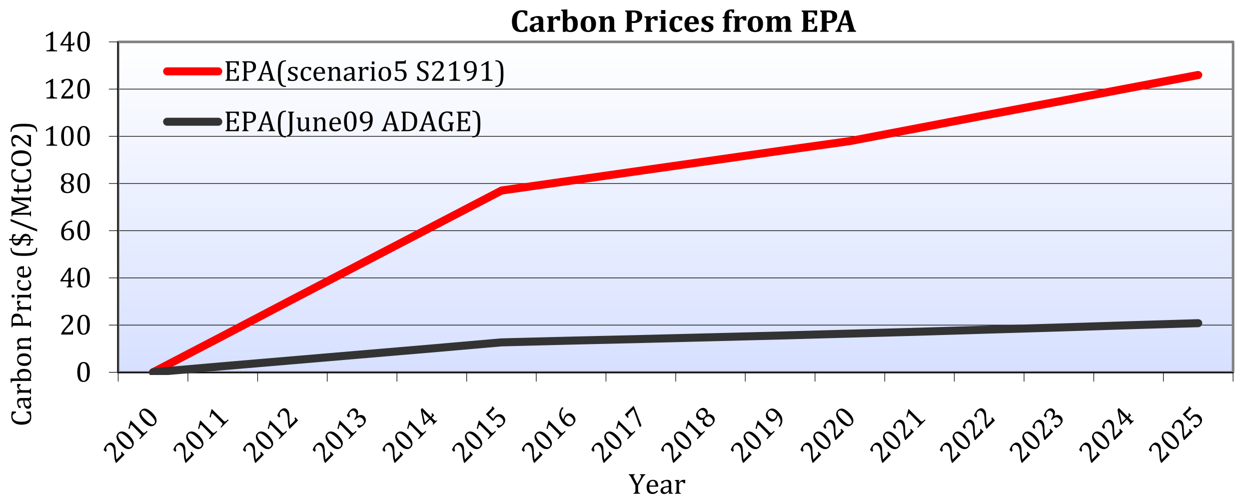
We used POLYSYS to project agriculture sector impacts from potential climate and energy policies. POLYSYS is a robust agricultural policy simulation model of the U.S. agricultural sector that includes national demand, regional supply, livestock, and aggregate income modules (De La Torre Ugarte, Ray, and Tiller, 1998). POLYSYS is anchored by published baseline projections for the agricultural sector and simulates deviations from the baseline. The projected impacts obtained from POLYSYS include impacts to net farm income, government payments, and energy feedstock parameters. These impacts can be obtained at the county, state, and national level. The projected impacts also include changes in crop prices. These impacts are available at the national level.

The POLYSYS model includes the eight major U.S. crops (corn, grain sorghum, oats, barley, wheat, soybeans, cotton, and rice), as well as switchgrass, hybrid poplar, willow, and hay (alfalfa and other hay included). Corn and wheat residue costs and returns are added to the corresponding crop returns, if profitable. POLYSYS is structured as a system of interdependent modules of crop supply, livestock supply, crop demand, livestock demand and agricultural income. The supply modules are solved first, then crop and livestock demand are solved simultaneously, followed by the agricultural income module. This project includes a bioproducts module that fills exogenous demands from the feedstock sources. The bioproducts module captures the dynamics of corn grain and cellulosic feedstocks competing to fill ethanol demand by using a search by iteration method to find the optimal allocation of feedstocks to satisfy these demands.

Additional Key Assumptions

Carbon Prices and Offsets

Carbon prices are those assumed by EPA in its analysis of ACES. The carbon price levels considered are up to \$27 per Mt of CO_2 and up to \$160 per Mt of CO_2 (EPA, 2009). The carbon price level of up to 160 per Mt of CO_2 was estimated by EPA to be the price equivalent for carbon when no domestic offsets are allowed. Offsets are priced at the same level as allowances, but after discounts for transaction costs and the expected program discounts for unintentional reversals, the net receipts per ton will be reduced. The net receipts as a portion of the carbon prices employed for each activity type are: 40 percent for a change in tillage practices, 30 percent for afforestation, 20 percent for methane capture, and 20 percent for production of bioenergy crops. For the change in tillage practices, a level of 40 percent reflects the high degree of uncertainty regarding what rate of sequestration will be recognized, the term of contract issue interaction with a significant amount of land that is farmed on one-year renewable leases, and a high degree of uncertainty on how the duration/permanence issue will be addressed by policymakers. For the planting of herbaceous energy crops, the level of 20 percent reflects that perennials are less likely to be planted on land operated with one-year leases, lowered likelihood of reversal, but potentially higher costs of quantification and verification. With respect to afforestation, the level of 30 percent reflects higher costs of quantification and verification, higher probability of leakage, and higher probability of reversal risk due to natural events (disease and fire). The 20 percent rate for methane capture reflects the high initial cost of verification and documentation, low opportunity for aggregation, and high documentation and monitoring requirements specific to each project. The carbon price and offset value assumptions are illustrated in Figure 3.



Offsets Transaction Cost Discounts			
Change in tillage practices	**40%**	**Afforestation**	**30%**
Planting herbaceous energy crops	**20%**	**Methane capture**	**20%**

Figure 3. Carbon Prices (from EPA) and the Value of Offsets

Pastureland Conversion

One of the key interests of this study is land use, and especially the use of cropland to produce energy feedstocks. Another use is pastureland. Cropland "in pasture" is defined as land that previously has been used for crop production but has since shifted to pasture use. An increase in the intensity of the management of this pastureland could free a significant portion of the acreage for crop or dedicated energy crop production. However, not all of these lands will be available for conversion to cropland. In regions where irrigated hay production exceeds dryland hay production, it is assumed that irrigation would be needed to convert these lands to cropland. Hence, in these areas, an increased level of inputs would be required. Since the analysis assumes energy crop production will be undertaken using few inputs, pasture/range lands are constrained from being converted to energy crop production in these areas. In addition, if pastureland is converted to energy crops rather than to hay, then additional hay production must occur to produce an equivalent of feed, reflecting an increase in intensity on hayland. This requirement results in the same amount of roughage being available for the livestock sector and assumes that current pasture/range land is utilized for roughage. Additional reductions to pastureland available for conversion were made in response to environmentally sensitive lands identified by 25x'25 state alliances.

Afforestation and Grassland Sequestration

Afforestation and grassland sequestration were considered as offsets in all scenarios except the *EPA Led Scenario*. Although the *EPA Led Scenario* does not explicitly allow offsets, we use EPA's estimated carbon price equivalent to regulation to analyze the sensitivity of afforestation and grassland sequestration to carbon prices.

Livestock Sector

The analysis includes two "extreme" treatments for the cattle industry to project the outer bounds of potential impacts to that sector. The first treatment of the livestock sector allows that there is forage replacement, where forage productivity in permanent pasture makes up for any forage losses due to shift of hay or cropland in pasture to dedicated energy crops. The second assumes that head reduction occurs. In this case, loss of forage due to shifting land use to energy crop production can only be met by reduction in the total number of animals.

Limitations in Modeling Offsets

The study uses a conservative approach in modeling potential offsets. Several types of offsets could be incorporated into policies; however, not all could be modeled due to a lack of data. Examples of unmodeled crop offsets include those increasing nitrogen efficiency, alternative nitrogen application methods, biochar utilization, and seed improvements. Those for livestock could include changes in diet, improvements in diet efficiency, alternative management systems, or intensive grazing.

Key Drivers

Our model results are driven by key factors. These drivers include:

- *the demand for bioenergy crops generated from continuance of EISA;*
- *availability of carbon credits for dedicated energy crops;*
- *transactions costs for offsets;*
- *the cost of carbon, and, more specifically whether or not fertilizer will be exempted from the cap;*
- *and constraints on harvesting of crop residues at carbon neutral levels.*

Results

Overview

The performance of the policy scenarios can be evaluated in terms of each scenario's ability to meet policy objectives. The objectives considered in this analysis are represented in Table 2 and include net returns to agriculture, net carbon flux, and biomass price. As can be seen in Table 2, the *Multiple Offsets/RCN Scenario* is projected to produce the highest net returns to agriculture and the lowest net carbon flux, but ranks third in terms of biomass price. Because this scenario performs well in terms of these three potential policy program objectives, further analysis focuses on this scenario along with the *Baseline Scenario* and the *EPA Led Scenario* as reference points. The *Multiple Offsets/RCN Scenario* provides nearly $209 billion more in accumulated net returns than the *Baseline* and over $364 billion more than the *EPA Led Scenario* over the period 2010-2025.

Table 2. Ranking of Scenarios by Potential Program Objectives

	Objective [a]					
	Economic Indicator		Climate Benefits		Low Cost Feedstock	
Scenario	Ag Net Returns		Net Carbon Flux		Max Biomass Price	
	Billion $		MMt CO_2		$/dt	
Baseline	4,067	(4)	1,820	(5)	49.00	(1)
Multiple Offsets	4,134	(3)	1,527	(4)	49.00	(1)
Multiple Offsets/RCN	4,276	(1)	1,357	(1)	59.00	(3)
Limited Offsets	4,226	(2)	1,418	(3)	61.00	(5)
EPA Led	3,912	(5)	1,388	(2)	60.00	(4)

[a]Accumulated values for 2010-2025

Crop Net Returns are Positive Under a Well-Constructed Cap-and-Trade Program

Contrary to previous studies, our results show that the agricultural economy is not negatively impacted by a well-constructed cap-and-trade policy. The net crop returns under the *Multiple Offsets/RCN Scenario* are greater than *Baseline* and *EPA Led Scenarios,* as shown in Figure 4. By 2025, not only does the *Multiple Offsets/RCN Scenario* outperform the *EPA Led Scenarios* by nearly $27 billion, but it is also exceeds the *Baseline Scenario*.

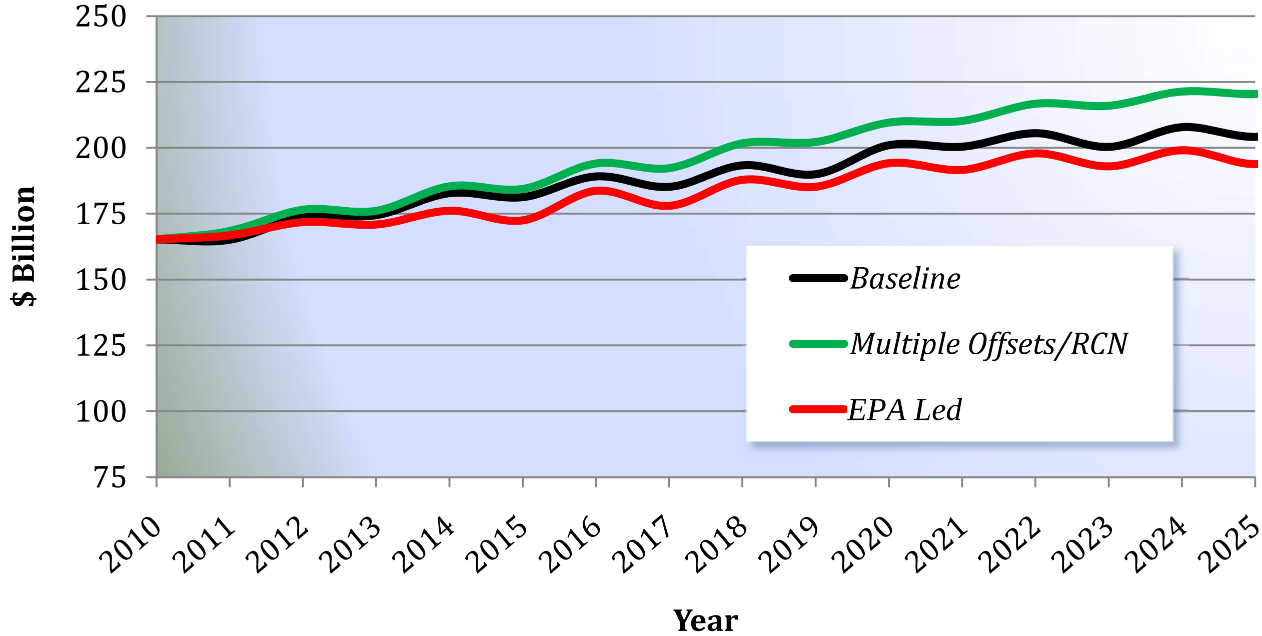


Figure 4. Net Crop Returns by Selected Scenario: 2010-2025

Similarly, average crop returns would increase for eight of nine major crops under the *Multiple Offsets/RCN Scenario* as can be seen in Table 3; however, under the *EPA Led Scenario*, all major crops, except corn and barley, are projected to experience a negative change in net returns compared to the *Baseline*. The decline in rice crop net returns under the *Multiple Offsets/RCN Scenario* of approximately $2 million per year constitutes less than .1 percent decline. In the case of bioenergy crops, the *Multiple Offsets/RCN Scenario* yields a higher average change in crop returns than did the *EPA Led Scenario.* The *Multiple Offsets/RCN Scenario* results in just over $4 billion average annual change in net returns compared with the *Baseline*.

Table 3. Average Change in Net Returns and Carbon Payments by Scenario and Crop: 2010-2025

Crop	Baseline +EISA Net Returns	Multiple Offsets/RCN Average Change Crop Returns	Net Carbon Receipts	EPA Led Average Change Crop Returns	Net Carbon Payments
			(Million $)		
Corn	31,713	1,937	131	336	-
Grain Sorghum	438	40	4	(53)	-
Oats	73	11	5	(33)	-
Barley	511	36	7	3	-
Wheat	7,726	210	91	(494)	-
Soybeans	21,736	680	196	(411)	-
Cotton	451	20	3	(177)	-
Rice	2,811	(2)	1	(121)	-
Energy Crop	737	4,764	819	2,807	-

Carbon Payments for Dairy and Hogs Methane Capture

In addition to changes in net crop returns, net agricultural returns would be supplemented with carbon payments for methane capture.[3] The level of net returns for hog and dairy producers are shown in Figure 5. Projected net returns for methane from hogs exceed $120 million by 2025 and for dairy exceed $208 million by 2025.

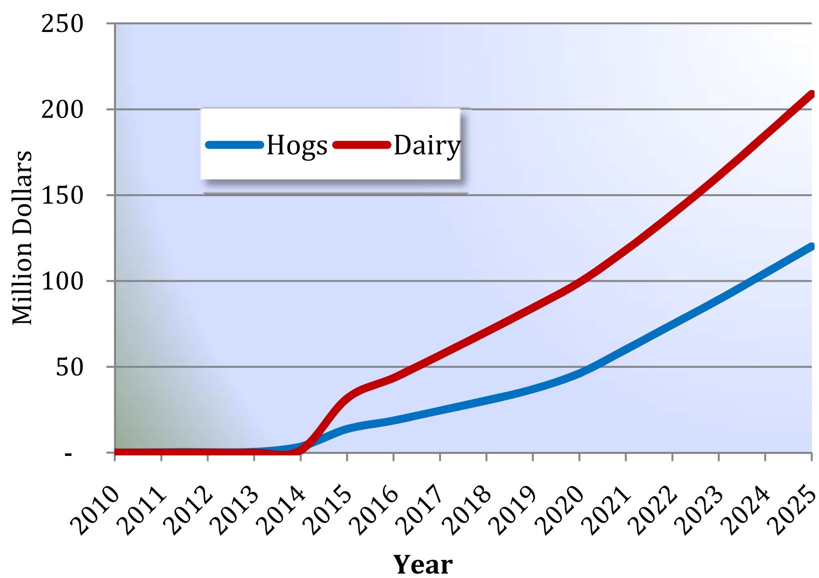


Figure 5. Net Returns of Carbon Credits To Methane Production for Hogs and Dairy Under the Multiple Offsets/RCN Scenario: 2010-2025

[3] Net returns for dairy and hog digesters incorporate both an electricity credit and a bedding credit in addition to the carbon payment.

Cropland Use Remains Stable

During consideration of climate legislation in the Congress, concerns have been raised that an agriculture offsets program could unintentionally drive afforestation on prime cropland. Our findings, which use EPA's carbon price projections for the cap-and-trade program of up to $27 per Mt$CO_2$, show that both crops and herbaceous perennial grasses outcompete afforestation at these prices. Therefore, the agricultural sector is able to achieve significant food and biomass production goals, resulting in positive income. Table 4 shows only 5.3 million acres shift for corn, soybeans, and wheat combined, which is typical of shifts that occur as a result market forces. The main land use changes come from the conversion of pasture into hay and dedicated energy crop production.

Table 4. Estimated Land Use by Scenario, 2025

	Baseline	*Multiple Offsets / RCN*	*EPA Led*
		(million acres)	
Corn	90.5	89.3	90.2
Soybeans	65.9	63.0	62.9
Wheat	52.0	50.8	50.5
Hay	75.8	91.0	85.0
Ded. Energy Crops	49.5	76.4	66.9
Pasture	355.1	318.7	334.2
Total Land	**688.8**	**689.2**	**689.6**
(Pasture Converted)	50.1	84.3	68.8

Crop and Bioenergy Feedstock Prices Remain Stable

Cap-and-trade legislation would not create major disruptions in crop or bioenergy feedstock prices, and would enhance price returns to producers. Changes to crop prices are all within 10 percent of the *Baseline*, which are of a magnitude typical to those caused by normal market forces. For corn and wheat, the *Multiple Offsets/RCN Scenario* is projected to produce higher crop prices than the other two scenarios by the year 2025. Under all three scenarios, cotton prices are nearly equal. For soybeans, the *EPA Led Scenario* results in the highest price by 2025. These crop price projections are shown in Table 5.

Table 5. Crop Prices by Scenario, 2015-2025

	Corn ($/bushel)		
	2015	**2020**	**2025**
Baseline	3.60	4.16	3.91
Multiple Offsets /RCN	3.64	4.45	4.08
EPA Led	3.73	4.65	4.06
	Soybeans ($/bushel)		
	2015	**2020**	**2025**
Baseline	10.64	9.47	10.32
Multiple Offsets /RCN	10.75	9.49	11.30
EPA Led	10.71	9.36	11.42
	Wheat ($/bushel)		
	2015	**2020**	**2025**
Baseline	5.87	6.59	7.04
Multiple Offsets / RCN	5.95	7.00	7.57
EPA Led	5.90	7.07	7.52
	Cotton (cents/pound)		
	2015	**2020**	**2025**
Baseline	0.63	0.69	0.71
Multiple Offsets / RCN	0.64	0.70	0.73
EPA Led	0.65	0.71	0.73

Increasing the Allowed Agricultural Offsets Provides Largest Climate Benefits

The changes in net carbon flux under the three policy scenarios are displayed in Figure 6. As can be seen in this figure, carbon emissions decline under all three scenarios. The largest climate benefits, however, come from the scenario with the greatest number of offsets that also keeps residue harvest carbon neutral (the *Multiple Offsets/RCN Scenario)*. Because they are perennials, have deep root structures, and require fewer inputs, herbaceous dedicated energy crops contribute significantly to sequestering carbon and reducing GHG emissions from agriculture. Further reductions in GHG under the *Multiple Offsets/RCN Scenario* result from methane capture.

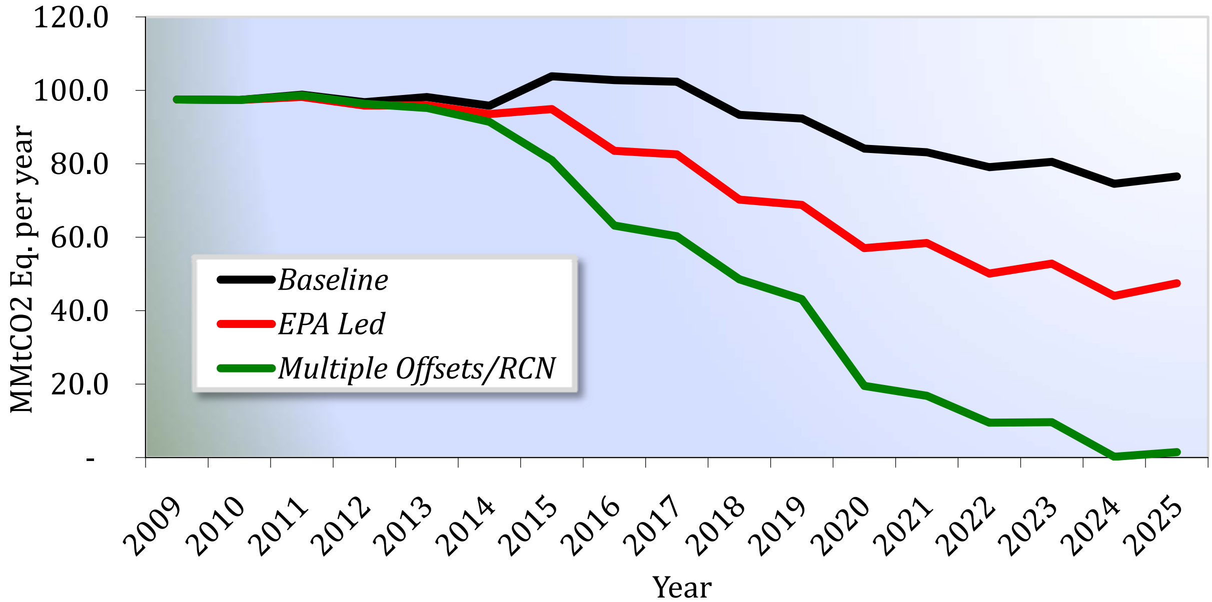


Figure 6. Net Carbon Flux by Scenario: 2009-2025

Afforestation on Cropland Only Occurs at High Carbon Prices

The only scenario with carbon prices high enough to lead to significant conversion of cropland to forest or grasslands occurs under a price line that allows carbon prices rising to \$160 per $MtCO_2$. At these prices, significant land use changes are projected to occur. About forty million acres of cropland could convert to forests, 75 million acres of pasture could convert to forests, and twenty million acres of cropland could convert to grasslands. As can be seen in Figure 7, greater afforestation only occurs at higher carbon prices, and significant shifts of cropland to forest begin to occur at \$80/$MtCO_2$.

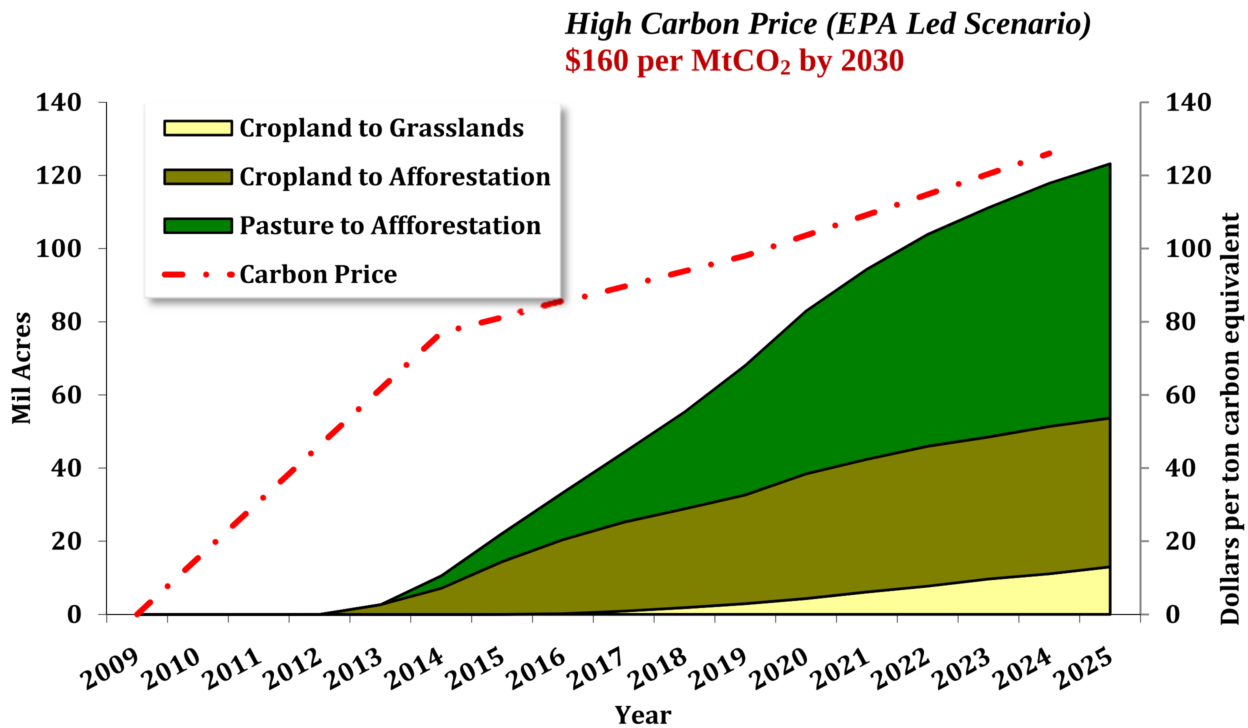


Figure 7. Afforestation Under the *EPA Led Scenario*: 2009-2025

Livestock Sector Impacts

To conduct a sensitivity analysis for the livestock sector, we considered two "extreme" treatments. As was previously noted, the main land use change will be a conversion of pasture to hay or dedicated energy crops. The first treatment assumes total forage replacement and the second assumes that the only way for the sector to adjust is to undergo herd reduction. Under forage replacement, increased forage productivity in permanent pasture makes up for any losses due to shifts of hay or cropland in pasture to dedicated energy crop production. Under a herd reduction treatment, loss of forage due to land use shifts can only be met by reduction in the total number of animals. We compare the beef sector impacts under the *Multiple Offsets/RCN Scenario* relative to the *Baseline* under these two treatments in Table 6. Notably, the beef cattle sector does not experience major net return disruptions under either treatment. Instead, the forage replacement treatment is projected to result in an overall slight increase in net returns to the sector.

Table 6. Beef Sector Impacts, 2025 and 2010-2025 Average

	Percent Changes from the *Baseline*			
	Forage Replacement		Herd Reduction	
Variable	2025	Average 2010-2025	2025	Average 2010-2025
Inventory	0.0	-0.0	-14.1	-4.0
Production	-0.1	-0.1	-8.4	-2.1
Beef Cattle Farm Price	0.9	0.5	6.0	1.6
Net Returns	1.1	0.6	-0.5	0.2

Regional Impacts of Cap-and-Trade Predominantly Positive

Figures 8 and 9 show the regional distribution of net returns changes from the *Baseline* under the *Multiple Offsets/RCN Scenario* in 2025. The net returns in these maps include crop prices and carbon payments, livestock returns, forest residue payments, and methane capture payments. Figure 8 assumes forage replacement for livestock, while Figure 9 assumes herd reduction. The green to blue shaded areas denote positive returns, while the orange to red areas indicate negative returns compared with the *Baseline*. As can be seen in the figures, the majority of the nation will experience positive returns under this scenario. In the second figure, Figure 9, there are increased losses in areas that have cow-calf operations, but greater gains in other areas.

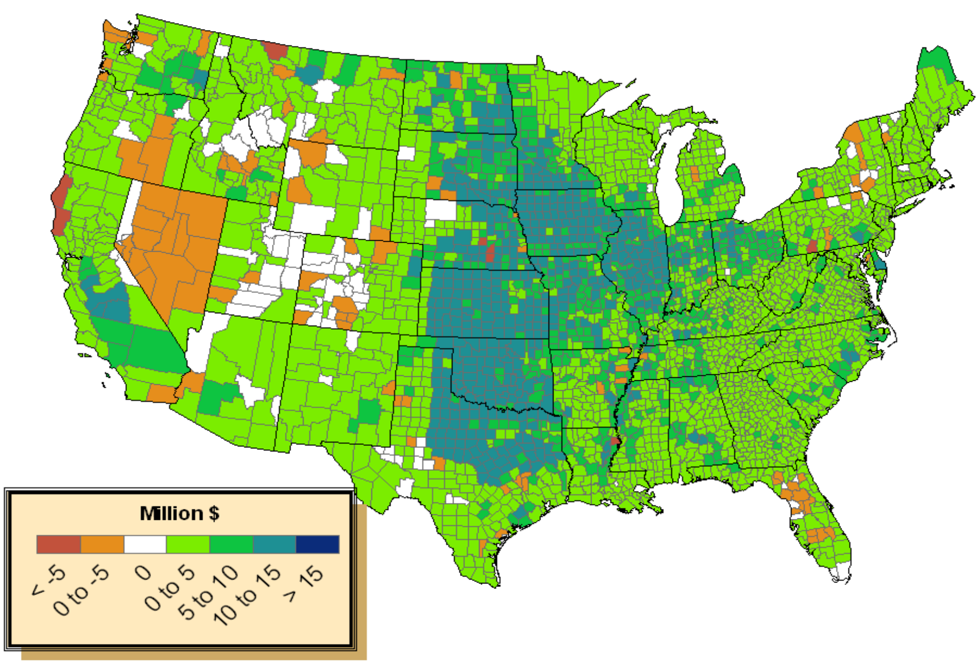


Figure 8. Regional Effects of the *Multiple Offsets/RCN Scenario* on Net Returns to Agriculture, <u>With Forage Replacement</u>: 2025

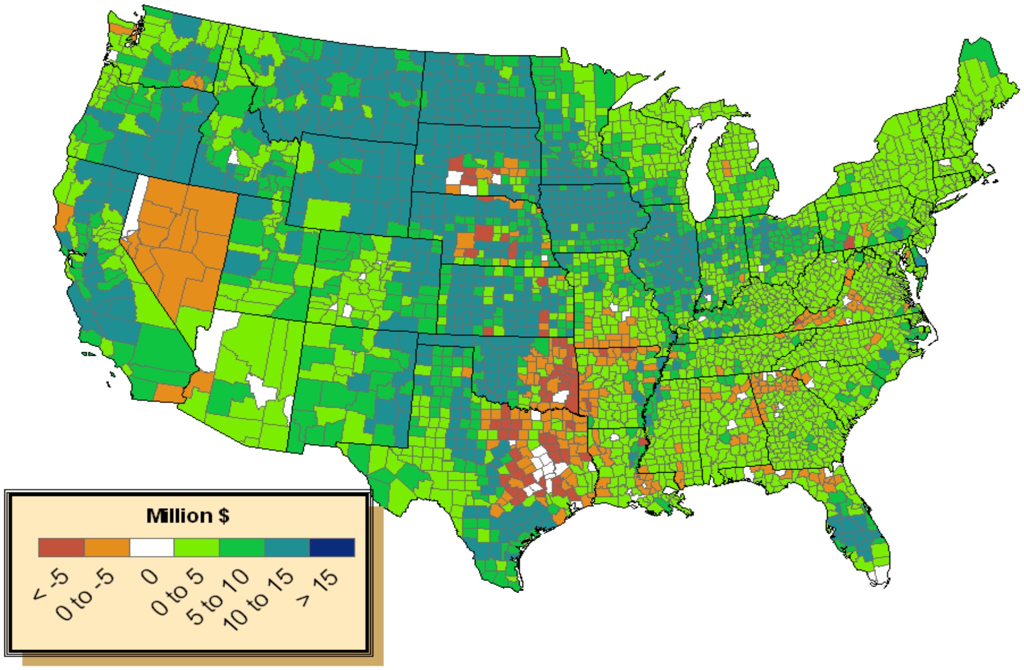


Figure 9. Regional Effects of the *Multiple Offsets/RCN Scenario* on Net Returns to Agriculture, With Herd Reduction: 2025

Conclusions and Implications

The impacts of cap-and-trade policies upon the agricultural sector could have dramatically different outcomes depending upon how the policy is constructed. However, a well-constructed cap-and-trade program that allows multiple offsets for agriculture (including bioenergy crop production) and manages residue removal to be carbon neutral, can generate positive net returns to agriculture while yielding carbon benefits. Such a policy is projected to provide nearly $209 billion more in net returns by 2025 than the baseline. Such a policy also is projected to provide over $364 billion more net returns than a policy where EPA regulates carbon without the benefit of multiple offsets.

The net returns under our optimized cap-and-trade scenario are positive for most major crops (eight out of nine analyzed). Afforestation of cropland does not occur at projected carbon prices of $27 per $MtCO_2$, a reasonable price assumption and within the "price collar" recently proposed by the Senate. Additionally cap-and-trade under such a policy scenario does not result in major shifts in commodity crop land use. The demand for bioenergy feedstocks, however, is projected to result in significant shifts in hay and dedicated energy crop acreage via pasture conversion. In addition, crop and beef prices are not majorly disrupted.

Climate benefits are also greatest under our optimized cap-and-trade scenario. Emissions are projected to be lower over time compared with the baseline or even an EPA regulated scenario. Herbaceous dedicated energy crops contribute significantly to sequestering carbon and to reducing GHG emissions from agriculture. Further reductions in GHG result from methane capture. Climate benefits from biomass feedstock production and methane capture include significant direct and indirect reductions (from substituting renewable fuels for fossil fuels) in GHG emissions. However, the benefits of indirect GHG emission reductions for biofuels are not considered in this study.

However, if carbon emissions are regulated by EPA as prescribed under the Supreme Court ruling, net farm income is projected to fall below baseline projections. Furthermore, 60 million acres of cropland could be converted to forests and grasslands. Under this type of policy scenario, agriculture is subjected to higher input costs with no opportunity to be compensated for the GHG reduction services the sector provides, and the impacts to beef production are uncertain.

The results from this study demonstrate how the effects of policies on agriculture and GHG emissions dramatically change given provisions in these policies. Policy provisions that do not take in account the role that agriculture has in providing environmental services will increase production costs and decrease net returns to the agricultural sector. However, provisions that sufficiently credit the role of environmentally sound agricultural management practices and carbon sequestration benefits of bioenergy crop production can benefit both agriculture and the environment. Legislative approaches under debate in Congress should carefully consider the potential environmental benefits that agriculture can provide.

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