Potential Implications of a Carbon Offset Program to Farmers and Landowners

-name redacted-
Specialist in Agricultural Policy

-name redacted-
Specialist in Environmental Policy

-name redacted-
Specialist in Natural Resources Policy

-name redacted-
Analyst in Agricultural Conservation and Natural Resources Policy

February 26, 2010

Congressional Research Service
7-....
www.crs.gov
R41086

CRS Report for Congress
Prepared for Members and Committees of Congress

Summary

Numerous studies have attempted to estimate the economic effects of potential climate legislation currently being considered by Congress. These studies have examined both the economy-wide effects, as well as the effects to specific sectors. Two principal reports on the economic effects to the U.S. agriculture and forestry sectors were conducted by the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Agriculture (USDA). As described by USDA, these studies generally concluded that the overall economic costs to the agricultural community of the proposed legislation would be modest. Both studies further suggested that farm revenues from carbon offsets could result in net economic gains for the U.S. agricultural sectors.Concerns have been raised regarding the results of the EPA and USDA analyses, as well as the potential effects of a carbon offset market established by a cap-and-trade system. Many in the U.S. farming community have expressed concern that these analyses estimate that 60 to 65 million acres of U.S. agricultural land could be converted to woodlands by 2050. This conversion would be the result of farmers and landowners choosing to participate in the emerging carbon markets through additional tree-planting, in response to expected high carbon prices. Some believe this could take land out of crop production, removing farmers from the business of food production, and raising food prices to consumers. In addition, some in the farming community have expressed concern that only certain landowners and agricultural producers might benefit in the carbon offset market. Some worry that only larger landowners and farmers might benefit from a carbon offset program, which could result in further industry consolidation in the farming sectors, exacerbating difficult business conditions for smaller, traditional farmers. Others worry that only certain crop producers will benefit, resulting in inequities across all crop producers.

Given the general uncertainty about the possible outcomes of a likely regulatory process, following the still uncertain passage of climate legislation in Congress, it is not possible to definitively predict or provide a quantitative assessment of the potential implications or participation rates within a future carbon offset program. Regarding available economic modeling projections of land-use changes, many variables and factors complicate the analyses and projections of cropland conversion rates should be regarded with caution. Among the types of factors are: assumptions in the models of high and rising carbon prices that substantially influence the modeling results; missing farm-level costs, such as transaction costs associated with the future regulatory regime and possible foregone revenue from farm support programs; regional and biological variability that might not be precisely reflected in the model; possible physical capacity constraints and limitations to support substantial afforestation efforts; and possible legal and contractual constraints that might affect participation in the carbon market, given differences in the U.S. crop sectors between farmland ownership and leasing in the United States.

The available economic models are even more limited in their ability to predict land-use changes or other potential changes under a carbon offset market, differentiating among producers and production areas. Anecdotally, the evidence about whether or not some operations and production regions might benefit more than others is mixed. Some evidence suggests that larger landowners and farming operations may have greater opportunities to participate in carbon markets, because of their economies of scale and their likely lower transactions costs compared to smaller landowners and farmers. Alternatively, smaller-sized operations might have greater opportunities to participate in carbon offset projects, because they are more likely to own their land and generally tend to be more operationally diverse, and the expected continued role of designated middlemen in generating and marketing carbon offsets.

Contents

Figures

Tables

Appendixes

Contacts

Introduction

Congress is currently debating climate legislation which could affect the U.S. agriculture and forestry sectors. In June 2009, the House passed H.R. 2454, the American Clean Energy and Security Act of 2009. In November 2009, the Senate Committee on Environment and Public Works completed markup of S. 1733, the Clean Energy Jobs and American Power Act, by approving a "Manager's Amendment" as a substitute, and ordered S. 1733 reported. Both the House-passed and the Senate-reported bills would establish cap-and-trade systems to regulate greenhouse gas (GHG) emissions, as well as address energy efficiency, renewable energy, and other energy topics. Both bills would require major reductions in GHG emissions from entities comprising roughly 85% of current U.S. GHG emissions. Covered sectors would include electricity production, natural gas distribution, petroleum refining, and specific industrial sectors. These and related bills and issues are currently being debated in Congress. For more detailed information see CRS Report R40896, *Climate Change: Comparison of the Cap-and-Trade Provisions in H.R. 2454 and S. 1733*.

Numerous studies have attempted to estimate the economic effects of potential climate legislation currently being considered by Congress. These studies have examined both the economy-wide effects, as well as the effects to specific sectors, such as the U.S. agriculture and forestry sectors. Some of these studies have also examined the potential market and industry effects from the proposed climate legislation, including possible resource shifts such as land use conversions and related crop production changes. Some studies further examine the potential economy-wide market effects, such as possible changes to retail food prices and supplies.

This first section of this report describes results from some of the studies and discusses limitations and uncertainties associated with the economic models and their results. The second and third sections examine two particular concerns raised by the modeling results, involving (1) lands converted from agriculture to forestry, and (2) potential unequal opportunities and costs of carbon markets in various sectors of the agricultural community. The final section provides some conclusions.

Economic Analyses: Results and Considerations

The leading House and Senate climate proposals would not require GHG emission reductions in the agriculture and forestry sectors. However, provisions in these bills could potentially raise farm costs for energy, fertilizers, and other production inputs, while also providing opportunities for additional farm income. These potential effects have been estimated by various governmental agencies, including the U.S. Department of Agriculture (USDA) and the U.S. Environmental Protection Agency (EPA), as well as by several universities and farm industry groups.

Many of these studies examine the possibility that higher costs may be alleviated by possible farm revenue increases from other provisions of the bills. Primarily, higher costs might be countered by possible revenues for farmers who participate in carbon offset programs. Costs might also be balanced by tradable allowances that could be provided at no cost to certain agricultural industries, such as fertilizer manufacturers. In addition, the renewable energy provisions in these bills could potentially expand the market for farm-based biofuels, biomass residues, dedicated energy crops, and other renewable energy production. Both bills also provide incentives for international forestry and related land-based activities.

This section describes these analyses in some detail and puts their results in perspective by discussing limitations and uncertainties inherent in all models, as well as constraints specific to the EPA and USDA studies.

Economic Analyses

The principal reports on the economic effects for the U.S. agriculture and forestry sectors were conducted by EPA and USDA:

- EPA studies: *The United States Environmental Protection Agency's Analysis of S. 1733 in the 111th Congress, the Clean Energy Jobs and American Power Act of 2009,* October 2009; and *The United States Environmental Protection Agency's Analysis of H.R. 2454 in the 111th Congress, the American Clean Energy and Security Act of 2009,* June 2009.[1]
- USDA studies: *The Impacts of the American Clean Energy and Security Act of 2009 on U.S. Agriculture,* December 18, 2009; and *A Preliminary Analysis of the Effects of H.R. 2454 on U.S. Agriculture, USDA,* July 22, 2009.[2]

The core modeling work underlying these analyses relies on a version of a longstanding economic and market model, called the Forest and Agriculture Sector Optimization Model (FASOM) with Greenhouse Gases (FASOMGHG). An overview of this model is provided in the text box below.

Both studies took a comprehensive approach to assess the potential costs and economic effects of the legislative proposals. EPA conducted its review of the potential economic effects of the energy and climate legislation throughout the U.S. economy, including the agriculture and forestry sectors. USDA also conducted analyses of the effects to agricultural producers from expected higher production and input costs under the legislation, expanding on some of the simulation results generated by EPA and further disaggregating some of the estimated effects to the farming sector.

In addition to the USDA and EPA analyses, several other groups, including universities, non-governmental organizations, industry groups, and other advocacy groups also have published studies and estimates. Many have focused specifically on the economic effects on the agricultural and forestry sectors. A list of these studies is provided in **Appendix A**. These economic studies show a wide range of possible effects, often with conflicting conclusions.

General Study Conclusions

The EPA and USDA studies generally concluded that the overall economic costs of the proposed climate legislation to farmers and landowners would be "modest" and that "agriculture will benefit from energy and climate legislation if it includes a robust carbon offset program and other helpful provisions."[3] Indeed, both the USDA and EPA studies indicate that the U.S. agricultural

---

[1] http://www.epa.gov/climatechange/economics/economicanalyses.html.

[2] http://www.usda.gov/oce/newsroom/archives/releases/ 2009files/ImpactsofHR%202454.pdf; and http://www.usda.gov/oce/newsroom/archives/.

[3] See USDA press release No. 0622.09, "Statement of Secretary of Agriculture Tom Vilsack on Release of USDA Climate Change Analysis," December 18, 2009.

sectors—in aggregate—would experience net economic *gains*, since farm revenues generated by participating in carbon offset programs would more than counter the potentially higher production costs resulting from higher energy and energy-based input costs. The USDA analysis further considered the possibility that increases in farm production costs would be mitigated by freely distributed tradable allowances (akin to currency) to U.S. fertilizer manufacturers under the legislative proposals' allowances for "energy-intensive and trade-exposed" industries.[4] Both EPA and USDA projected economic gains from the possible resource shifts in changing agricultural markets, including land use conversions and related crop production and market changes. In particular, the results showing substantial possible conversion of cropland to forestland under a carbon offset program have stirred some controversy in the agricultural community. (This is discussed further under "Potential Land Conversion," below.)

Overview of FASOM

The core modeling work underlying these analyses relies on a version of a longstanding economic and market model called the Forest and Agriculture Sector Optimization Model (FASOM) with Greenhouse Gases (FASOMGHG). This model depicts land use and production competition among the agriculture and forestry sectors within 10 specified crop production regions, with linkages to international trade. The model currently covers roughly 80 agricultural commodities, and depicts production possibilities for field crops, livestock, and biofuels for private lands (excluding public lands). It also tracks about 50 forestry and 30 bioenergy product categories. The model simulates changes across a range of prices over a 100-year period from afforestation, forest management, changes in tillage practices, energy substitution, livestock management and fertilizer applications, and biofuel offsets of fossil fuels derived from crops. Biological variability and diversity is specified within productivity growth functions developed for each of the 10 production regions, accounting for differences in biological productivity and yields, and sequestration potential, among other factors.

To depict future conditions under a possible carbon offset program, the model simulates landowners decision-making from payments for increasing sequestration and/or reducing emissions relative to a baseline scenario. The model assumes that perfectly competitive market conditions prevail, and that economic agents are profit maximizing and act with perfect foresight of future demands, yields, technologies, and GHG and other prices. The model does not take into account any transaction costs of participating in or complying with a regulatory regime governing a new carbon offset program, nor does it account for government payments under existing farm support programs. The model also cannot account for various non-economic considerations that may influence farm decision-making. In general, all economic models are subject to such limitations.

Previous economic analyses by USDA and EPA (see, e.g., EPA, *Greenhouse Gas Mitigation Potential in U.S. Forestry and Agriculture*, Nov. 2005) were developed following a period of generally declining agricultural prices, stable net farm income, and a reduction in land devoted to agricultural production. These analyses also used data and assumptions of farm production prior to 2003 and did not include the effects of increasing federal support for farm-based bioenergy production in subsequent omnibus farm bills. They were completed before the enactment of the Energy Policy Act of 2005 (P.L. 109-58) and the Energy Independence and Security Act (EISA) of 2007 (P.L. 110-140). Thus, the earlier models did not include the effects of the Renewable Fuel Standard. In 2009, the FASOM creators updated their modeling assumptions and baseline conditions to take these factors into account.

More detailed information on the FASOM model is available from Texas A&M University and supporting documentation prepared by Dr. Bruce McCarl (http://agecon2.tamu.edu/people/faculty/mccarl-bruce/FASOM.html). For more Information on the updated FASOMGHG used by EPA for the climate change legislation, see EPA, "Updated Forestry and Agriculture Marginal Abatement Cost Curves," March 31, 2009, available in EPA's data annex for its H.R. 2454 analysis, at http://epa.gov/climatechange/economics/economicanalyses.html.

[4] See "Attachment A" of the testimony of John J. McMackin, Energy-Intensive Manufacturers' Working Group on Greenhouse Gas Regulation, House Committee on Energy and Commerce Subcommittee on Energy and Environment, "Hearing on Competitiveness and Climate Policy: Avoiding Leakage of Jobs and Emissions," March 18, 2009.

Almost all of the studies predict that energy costs would rise under a GHG cap-and-trade system, though the estimated magnitudes vary widely. Several studies also examine the potential harm to the U.S. agriculture sectors from climate change, absent policy changes designed to mitigate such effects, as part of efforts to evaluate the possible economy-wide benefits of climate change legislation. (See **Appendix B.**)

The general economic conclusions of the potential for net agricultural sector gains have been supported by some additional economic studies.[5] Various studies conclude that, despite higher energy and farm-level input costs, the expected gains to the U.S. farming sector from a cap-and-trade system will result in net benefits to the entire sector.[6] Among the predicted gains are expected higher commodity prices, due to modest consumer response and potential short crop supplies, and alternative sources of farm revenue from increasing bioenergy demand and offset income opportunities. New markets for carbon offsets via afforestation and bioenergy crops would increasingly compete for available land, raising farmland values. Also, producers shifting land out of crop production to participate in biofuels or carbon offset markets, thus raising crop prices, would likely present additional production opportunities to farmers that might not be willing or able to participate in the emerging biofuels or carbon offset markets. These benefits would generally accrue to all U.S. crop and animal producers.

Nonetheless, some are worried about the possible implications for crop production, food prices, and trade. In response to concerns, USDA has indicated that it would re-examine its model, modeling assumptions, and results regarding cropland conversion.[7] Concerns also have been raised about the possibility that any potential benefits that might accrue to farmers in a carbon offset program may not be evenly distributed and might disproportionately favor larger-sized farming operations or farmers in certain regions. These issues, along with some additional analysis results, are discussed further throughout this report.

Role of Offsets in Economic Analyses

Economic models cannot reliably predict the future.[8] If cap-and-trade legislation eventually allows substantial use of offsets for compliance (as recent proposals would do), its potential economic impacts are diverse and debatable. The quantity and type of domestic offsets that might be available and used in a cap-and-trade system are subject to considerable uncertainty. It is difficult to estimate the supply of offsets, mainly because the supply is determined by many variables, most of which are fraught with uncertainty. These include:

- **Mitigation potential.** Mitigation potential estimates are the raw data, without economic and implementation limitations, that are inputs into models estimating

[5] **Appendix A** provides a list of additional economic studies of the proposed legislation.

[6] See, for example, Justin S. Baker, Bruce A. McCarl, Brian C. Murray, et al., "The Effects of Low-Carbon Policies on Net Farm Income," WP 09-04, Nicholas Institute for Environmental Policy Solutions, November 2009, http://nicholas.duke.edu/institute/ni.wp.09.04.pdf.

[7] USDA press release No. 0622.09, "Statement of Secretary of Agriculture Tom Vilsack on Release of USDA Climate Change Analysis," December 18, 2009, http://www.usda.gov. Also see December 2009 issues of the Farmpolicy.com blog (http://www.farmpolicy.com/?m=200912).

[8] For a comprehensive discussion of the uncertainty surrounding the economic analyses of H.R. 2454, see CRS Report R40809, *Climate Change: Costs and Benefits of the Cap-and-Trade Provisions of H.R. 2454.*

offset use in a cap-and-trade program. For example, recent FASOM estimates contain considerable uncertainty.

- **Policy choices.** The design and implementation of the cap-and-trade system would be critical to offset supply. Particularly relevant design choices include: which sources are covered; which types of offset projects are allowed; whether or not offset use is limited; and the degree to which set-aside allowances are allotted to activities that may otherwise qualify as offsets. Policymakers' treatment of international offsets also would have a substantial effect on domestic offset development.
- **Technological development.** The development and market penetration of low- and/or zero-carbon technologies in both covered and non-covered sectors would likely have substantial effects. These technologies could lower the costs of the cap-and-trade program, making fewer (in covered sectors) or more (in non-covered sectors) offset projects cost effective.
- **Carbon market price.** The market price of carbon emissions reductions would determine the supply and type of offsets that would be economically competitive in a cap-and-trade system. As the price increases, more (and different types of) projects would become cost effective. Future carbon prices are difficult to predict, as they depend on numerous variables, including offset treatment (i.e., the policy choices described above).
- **Other factors.** Non-market factors, such as social acceptance, may influence offset use. In addition, information dissemination would likely be an issue, because some of the offset opportunities exist at smaller operations, such as family farms.

This uncertainty of offset supply is especially relevant in analyses of cap-and-trade proposals, because offsets play an integral role in determining the overall cost of the cap-and-trade program. Indeed, multiple economic analyses[9] of H.R. 2454 have shown that assumptions regarding offset availability and use significantly impact program cost. For example, as shown in CRS Report R40809, *Climate Change: Costs and Benefits of the Cap-and-Trade Provisions of H.R. 2454*, sensitivity analyses from various economic models of H.R. 2454 indicate that prohibiting international offset projects could raise the carbon price by 65% to 180%; another analysis that prohibited all offset projects (domestic and international) found a price increase of 250%.

Offset uncertainty also raises questions regarding estimates of potential benefits for the agriculture and forestry sectors under a cap-and-trade program. The quantity and type of offsets eligible for development would affect the degree to which landowners will be able to recoup financial losses associated with cap-related costs.

Uncertainty in Economic Modeling

Various factors lead to uncertainty in economic modeling results. Three particular factors are important in understanding this uncertainty: general limitations of simulation models; uncertainty

[9] Conducted by EPA, the U.S. Energy Information Administration, the Congressional Budget Office (CBO), the Massachusetts Institute of Technology, the Heritage Foundation, Charles River Associates International, the American Council for Capital Formation/National Association of Manufacturers, and others.

over the future carbon regulatory regime; and non-economic factors. These factors are discussed below.

General Limitations of Simulation Models

Simulation models are useful analytic tools to assess possible effects of policy changes. However, differences in methodological approaches and underlying assumptions and data lead to a wide range of reported economic effects across the studies. Thus, the results and generalizations derived from economic studies based on simulation models require some qualification.

A general caveat about any simulation model is that it is necessarily limited in the extent to which it is able to reflect all real-world interactions precisely and to predict future conditions accurately. Simulation models are theoretical constructs designed to represent a system or group of functionally interrelated elements forming a complex whole. At best, simulation models provide a simplified framework to illustrate highly complex spatial and temporal dynamics, interrelationships, and processes. They depend highly on available data and, inevitably, on the simplifying assumptions necessary to depict the underlying relationships and processes of complex systems. This complexity can be attributed to a number of factors that are difficult to quantify, including resource limitations, environmental and geographical constraints, site-specific conditions, individual and cooperative decision processes, institutional and legal requirements, and general uncertainty and variability. Consequently models often rely on simplistic assumptions, such as perfect market competition (e.g., assuming theoretical supply and demand conditions) or optimum behavioral outcomes (e.g., assuming that all farmers and landowners are profit maximizers, and follow required protocols to manage their operations to maximize on-site carbon sequestration). Moreover, it is difficult to compare the results across various studies, given differences in modeling approach and methodology, scope (geographic region, commodity sector activities, assumptions about adoption of certain mitigation strategies, etc.), and other underlying assumptions.

Uncertainty about Future Regulatory Regime

Simulation models are also limited in their ability to reflect future conditions. Congress is still debating the design for a cap-and-trade program. If Congress does enact legislation, how it specifies the program's underlying requirements and protocols for any participating sector will substantially affect the availability and cost of offsets as well as the direct economic impacts. Likewise, there is uncertainty regarding how the regulatory agencies would implement and oversee a carbon offset program and how sequestration from agricultural and forestry systems would be priced in the marketplace. This is a general shortcoming of most economic models.[10] Indeed, in previous reports USDA readily acknowledged the potential for "upward bias" in its reported estimates, because the models were limited in the treatments of permanence, carbon-stock equilibrium, and leakage.[11]

[10] CBO, *The Potential for Carbon Sequestration in the United States*, Sept. 2007, p.8, http://www.cbo.gov/ftpdocs/86xx/doc8624/09-12-CarbonSequestration.pdf.

[11] Jan Lewandrowski, Mark Peters, and Carol Jones et al., *Economics of Sequestering Carbon in the U.S. Agricultural Sector*, USDA Economic Research Service (ERS), Technical Bulletin (TB) No. 1909, Washington, DC, April 2004, Table 2.2, http://www.ers.usda.gov/Publications/TB1909/.

Regulatory requirements would likely be relatively complex and need to address various methodological, measurement, verification, monitoring, and programmatic issues, as well as additionality, permanence, and leakage issues associated with agriculture and forestry offsets.[12] Various design and implementation elements could affect offset supply in several ways, from the overall structure of the cap and of program scope (e.g., which sources are covered) to specific logistical details (e.g., monitoring and measuring protocols). The supply of offsets would also be beset by similar issues of competition for resources and land, and questions about how to treat biofuels, among other constraints. These factors would be subject to their own regulatory protocols and implementation practices, adding another layer of uncertainty.

Other Non-Economic Considerations

Simulation models are limited also in their necessary several simplifying assumptions of the motivations of economic agents and underlying conditions in economic markets, even though such assumptions might not apply in all cases. Most economic models are developed assuming that markets are perfectly competitive and all producers (consumers) are profit-maximizing (cost minimizing). See also the discussion in the text box below.

Some behavioral and/or institutional economists point out that economic decision-making processes are not always so straightforward and that some choices are not based solely on profit maximization. They contend that additional social, psychological, or emotional factors are necessary to understand actions, rather than simple assumptions of economic behavior. Myriad non-economic reasons also explain why farmers regularly remain in business despite financial hardship. These include factors such as lifestyle choice, pride in owning a business, inter-generational transfer of farm, farm operations also serving as homes, and off-farm income supplementing family income. Standard economic models, such as those developed by EPA and USDA, cannot capture such nuances in the U.S. farming sectors.

In addition, other aspects of U.S. agricultural production could limit participation in an emerging carbon offset program. These include concerns about the inherent risks of participating in a new market compared to the certainty of maintaining existing government payments under U.S. farm support programs, as well as other concerns related to perceptions that inequities exist among producers and that imperfect market conditions prevail.[13] These types of considerations further raise questions about whether some of the simplifying assumptions in most economic models accurately characterize conditions in the U.S. farming sectors.

[12] For a discussion of these issues, see CRS Report RS22964, *Measuring and Monitoring Carbon in the Agricultural and Forestry Sectors* and CRS Report RL34560, *Forest Carbon Markets: Potential and Drawbacks.*

[13] See, for example, work by Richard J. Sexton at the University of California-Davis; William H. Nicholls, "Imperfect Competition in Agricultural Processing and Distributing Industries, *The Canadian Journal of Economics and Political Science*, v. 10, no. 2 (May 1944): 150-164; Steve McCorriston, "Why Should Imperfect Competition Matter to Agricultural Economists?" *European Review of Agricultural Economics*, v. 29, no. 3 (2002): 349-371; and also Arne Hallam, "Economies of Size and Scale in Agriculture: An Interpretive Review of Empirical Measurement," *Review of Agricultural Economics*, v. 13, no. 1 (January 1991): 155-172.

Economic Model Assumptions versus Other "Real World" Considerations

Most economic models generally presume that consumers and businesses always make decisions that are perfectly rational, with perfect knowledge and foresight. Businesses are generally assumed to be guided by "profit-maximizing" decision-making behavior, with the goal of selling products at a price that generates the most profit (generally where marginal costs meet marginal revenue). Businesses are also assumed to have precise, exact knowledge of future productivity and prices for all possible products and services, and will automatically choose to produce and sell those goods that will yield the greatest financial return. Under such conditions, the decision to change production from one product to another will be immediate in response to conditions in the market. In contrast, consumers are assumed to be guided by cost-minimizing behavior, and ready to switch from one product to another competing substitute product.

Economic models also assume "perfect competition" characterized by many buyers and sellers (consumers and businesses) who are subject to the prices determined by supply and demand. The market is comprised of many products that are similar in nature (homogenous) with many substitutes (e.g., competing products). All sellers are price takers and have a relatively small market share (i.e., cannot leverage their market power to influence the market); also, sellers face few, if any, barriers to entering or exiting the market (i.e., open to competition from new suppliers). In a perfectly competitive market, both buyers and sellers have perfect information about the market: consumers have information about all market prices for a product and may choose a substitute product if prices get too high; businesses have equal access to resources (technology, other factor inputs) and improvements in production technologies achieved by one business are available to other sellers in the market. Most economic models also do not reflect potential "externalities" of an economic transaction (i.e., either a positive or negative spillover effect that may not be fully accounted in the market prices, possibly resulting in a divergence between private and social costs and benefits).

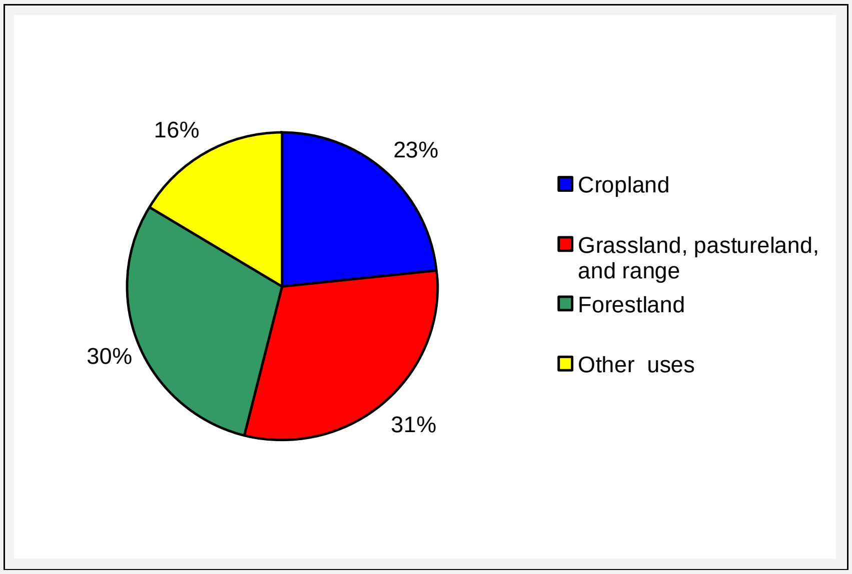
However, in reality, most buyers and sellers (including farmers) do not always operate under such perfect market conditions. This may be particularly true under an alternative emerging market involving agricultural and forestry carbon offsets. In the case of farmers as sellers in the marketplace, their choices are based on economic projections and best guesses about costs, yields, and returns. While farmers undoubtedly are influenced by a desire to grow crops that will generate high farm incomes and profit, their production decisions and knowledge base are influenced by their past actions (since their history affects their knowledge base); by their family and neighbors (since they often cooperate with equipment and support); by their willingness to try new opportunities or their desire to avoid change or uncertainty; and by various financial aspects that cannot be adequately captured in economic models, such as likely transaction costs and existing agricultural programs (e.g., price supports and conservation payments). Because of such factors, farmers are likely to respond to a host of other factors and may be slow to adapt to a changing marketplace and therefore unwilling to shift available land and resources away from traditional crop mixes. In addition, farmers might also seek to remain within programs and production practices they are more familiar with, working with USDA programs rather than switching over to over to a program that could involve oversight and administration by other federal agencies (e.g., EPA) or other state or local agencies and constituency groups.

Potential Land Conversion

Both the USDA and EPA models have projected the conversion of substantial U.S. agricultural land to tree plantings in response to expected favorable conditions in future carbon offset markets However, many in the U.S. agricultural community are concerned that this could take millions of agricultural acres out of production, removing farmers and employees from the business of food production and raising food prices to consumers. Others question whether such scenarios will actually materialize. Farmers may be unwilling to participate in a regulatory program that could involve significant administrative and other transaction costs, as well as for other reasons.

Land Area and Land Use in the United States

Total land area in the United States covers about 2.3 billion acres. The figure below indicates the different uses of land for the contiguous 48 U.S. states, approximately 1.9 billion acres. Cropland acres include cropland used for crops (cropland harvested, cropland failure, and cultivated summer fallow), cropland used for pasture, and cropland classified as idle (such as acreage enrolled in the Conservation Reserve Program (CRP)). Other uses include urban uses, so-called "special" uses, and miscellaneous uses.



Source: Prepared by CRS with data from R. N. Lubowski, M. Vestrby, S. Bucholtz, et al., Major Uses of Land in the United States, 2002, USDA, ERS, EIB-14, May 2006, http://www.ers.usda.gov/publications/ eib14/; and USDA's periodic Agricultural Resources and Environmental Indicators series.

Considering the general uncertainty about the possible outcomes of a regulatory process, following the still-uncertain passage of climate legislation in Congress, it is not possible to confidently predict or quantify the extent to which available U.S. cropland might be converted to woodlands. Following is a discussion of the potential for land conversion in the U.S. agricultural sectors. This includes information suggesting that U.S. cropland would be converted to woodlands, as farmers' respond to expected favorable market conditions and prices under a future carbon offset market. Other considerations might possibly temper such a response by U.S. farmers and result in possibly lower land conversion rates than predicted in various models.

Future Carbon Market Prices

The EPA and USDA economic analyses project that, under the types of carbon offset programs proposed in the House and Senate climate bills—which would likely involve sequestration efforts as well as other GHG mitigation activities—farmer and landowner participation could result in U.S. agricultural land being converted to forest production, particularly at higher market prices for carbon.[14] At certain rising price levels, the FASOM model projects that a total of 60 to 65

[14] In this context, the carbon price refers to the assumed payment for carbon credits in the marketplace established by a GHG cap-and-trade program. Carbon price levels are in dollars per metric ton of CO_2 equivalent ($ per MT CO_2-Eq.). (continued...)

million agricultural acres could be converted to woodlands by 2050, including 35 to 50 million acres of cropland. (See **Table 1**.) Compared to current estimates of total cropland acres (about 406 million acres in 2007), this would mean that cropland acres could drop by more than 11% below current levels. Projections beyond 2050 indicate continued conversion. These results have caused some concern about the possible implications for crop production, food prices, and international trade. Specifically, some speculate that cropland conversions of this magnitude could reduce crop production and, in turn, raise food prices. Opportunities for export might also be reduced, given expected reduced overall food supplies.[15] To put this projected decrease into perspective, however, it is worth noting that cropland acres decreased by 28 million acres—more than 6%—in the five years between the two most recent *Census of Agriculture* periods (2002 and 2007).[16] Under the USDA-administered voluntary land retirement program, the Conservation Reserve Program (CRP), a total of 31 million acres are enrolled nationally.[17]

Table 1. Net Cumulative National Changes in Land Use, 2020-2050

(millions of acres)

Land Use Change	2020	2030	2040	2050
EPA's Analysis (July 2009): Constant $15/MT CO_2-Eq. price				
Changes in forestland	+18	+16	+16	+15
Changes in cropland	-8	-8	-9	-9
Changes in pastureland	-10	-8	-7	-6
EPA's Analysis (July 2009): Rising $15/MT CO_2-Eq. price (5% annual growth)				
Changes in forestland	+22	+33	+50	+65
Changes in cropland	-14	-23	-35	-49
Changes in pastureland	-8	-10	-15	-16
USDA's Analysis (Dec. 2009): Rising $13 MT CO_2-Eq. price, (5% annual growth)				
Changes in forestland	+17	+27	+44	+59
Changes in cropland	-6	-15	-28	-35
Changes in pastureland	-9	-12	-15	-24

Sources: EPA's modeling output provided to CRS by EPA staff, July 31, 2009; and USDA, *The Impacts of the American Clean Energy and Security Act of 2009 on U.S. Agriculture*, December 18, 2009.

Notes: USDA analysis is based on FASOM simulations provided by EPA, further expanded on and disaggregated by USDA. EPA and USDA used different starting prices and starting times for their rising price scenarios. USDA based its price on EPA's June 2009 analysis of H.R. 2454, which estimated an allowance price of approximately $13 MT CO_2-Eq. that began in 2015, reaching $70 by 2050. EPA's July 2009 analysis used a starting price of $15 MT CO_2-Eq. that began in 2010, reaching $106 in 2050. EPA prices are in 2004 dollars; USDA prices are 2005.

(...continued)

For modeling purposes, carbon offsets are often priced at the same level as allowances. For more information, see CRS Report R40809, *Climate Change: Costs and Benefits of the Cap-and-Trade Provisions of H.R. 2454*.

[15] See, for example, comments made by Members during hearings by the Senate Committee on Agriculture, Nutrition, and Forestry, *The Role of Agriculture and Forestry in Global Warming Legislation*, July 22, 2009.

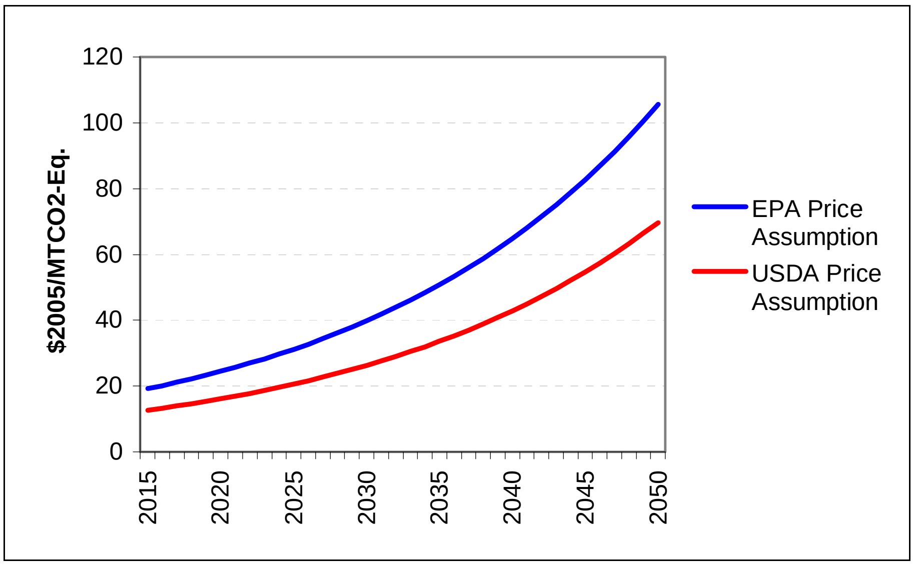
[16] USDA, National Agricultural Statistics Service (NASS), *Census of Agriculture*, http://www.agcensus.usda.gov/.

[17] For information about CRP, see CRS Report RS21613, *Conservation Reserve Program: Status and Current Issues*. Further discussion is provided in the section titled "Lessons from Existing Farmland Retirement Programs."

As shown in **Table 1**, the assumed carbon price (or emission allowance price) in the simulation model greatly influences the extent to which these models predict the conversion of croplands to woodlands. Under a modeling scenario where the carbon price begins in 2010 and remains constant at $15 per MT CO_2-Eq. (metric tons of CO_2-equivalent), the predicted land conversion grows markedly at the onset of the new market, but then remains more or less constant over the modeling period (shown for 2020-2050). However, under a scenario where the base carbon price starts in 2010 at $15 per MT CO_2-Eq. and rises at 5% per year, land conversion would nearly triple from 2020-2050. Note also that EPA and USDA used different price paths to generate their land conversion estimates. As **Figure 1** illustrates, EPA's price path was higher, starting at $15 per MT CO_2-Eq. (2004 dollars) and reaching $106 per MT CO_2-Eq. by 2050. USDA's price path assumed a price of $13 (2005 dollars) per MT CO_2-Eq., rising to $70 per MT CO_2-Eq. in 2050.

Figure 1. EPA and USDA Emission Allowance Price Assumptions

(used to generate land conversion estimates)



Source: EPA, *The United States Environmental Protection Agency's Analysis of H.R. 2454 in the 111th Congress, the American Clean Energy and Security Act of 2009*, June 2009. Reported by USDA as the underlying price assumption in EPA's modeling scenarios for agricultural and forestry offsets (see USDA, *The Impacts of the American Clean Energy and Security Act of 2009 on U.S. Agriculture*, December 18, 2009).

Notes: EPA and USDA used different starting prices and starting times for their rising price scenarios. USDA based its price path on EPA's June 2009 analysis of H.R. 2454, which estimated an allowance price of approximately $13 MT-CO2 equiv. that began in 2015, reaching $70 by 2050. EPA's July 2009 analysis used a starting price of $15 MT-CO2 equiv. that began in 2010, reaching $19 in 2015 and $106 in 2050. EPA prices are in 2004 dollars; USDA prices are 2005.

These assumed prices do not account for possible program discounts, unintentional reversals, possible error margins related to measurement and sequestration potential, or discounting due to other types of transaction costs. Nevertheless, these results illustrate the importance of the underlying assumptions about the market carbon price in influencing the modeling results within the agricultural and forestry offset market.

The USDA analysis further refers to other studies that examined alternative assumptions, including lower estimates for future market prices. These studies show that at price levels of less than $10 per MT CO_2-Eq., offsets would be generated mostly by changes in agricultural production practices, rather than by afforestation.[18] Accordingly, given the opportunity costs of land used in crop production, conversion of pasture land and cropland to forestland is mostly viable at higher price levels.

Farmer Response and Behavior

With increasing prices in the GHG cap-and-trade market, EPA's economic model projects U.S. farmers responding to such favorable market conditions and willingly participating in offset opportunities. Motivated by the possibility of additional farm-level profits and revenues from sources other than the more traditional food, fiber, and fuel markets, it seems likely that farmers would convert their land holdings. Accordingly, participation in carbon offset market would merely be a response to an alternative financial venture available to farmers and landowners, who are simply responding to favorable market incentives. In other words, at some carbon price, the return on investment on afforestation and other offset activities is greater than that for conventional crop mixes, and the model reflects these market changes through projected higher afforestation and land-use changes that could lower total farmed acres. These results are consistent with simplifying assumptions built into most economic models, including that used by EPA to evaluate the proposed climate legislation. (For additional background on these assumptions and related topics, see discussion in the text box titled "Economic Model Assumptions versus Other "Real World" Considerations.")

However, farmers and landowners may not behave in a purely economically rational, profit-maximizing manner. As discussed previously, farmers face many non-economic incentives that may influence their behavior. Converting cropland to forestland could meet social and/or cultural hurdles. For example, fourth-generation grain farmers may not wish to participate in an emerging carbon offset market, regardless of the perceived market incentives; they might be motivated by other social factors not related strictly to profits, such as transferring the farm to their children.

In addition, while crop production is subject to natural hazards (insects, diseases, severe storms, etc.), the longer-term commitment for forests exacerbates the risk from natural hazards and adds at least one hazard—wildfire— not typically faced in crop production. On the other hand, some risks might be ameliorated, as forests are less susceptible to catastrophic failures from short-term drought or individual storms. Nonetheless, considering these additional risks and the time commitment involved, some landowners may decide to continue with their current operations.

Moreover, a future carbon market would be inherently uncertain, as the implementation details of the program are unknown and would follow future EPA and/or USDA rulemaking processes. Once the program is established, the requirements would become more predictable, but the initial startup would involve adjustment and transition among farmers and landowners. During this transition, landowners might not be readily willing to risk such uncertainty; they might also be skeptical of participating in a market that might be strictly regulated by governmental authorities. EPA's and USDA's models cannot account for these factors.

---

[18] For example, USDA, *Economics of Sequestering Carbon in the Agriculture Sector*, TB-1909; EPA, *Greenhouse Gas Mitigation Potential in U.S. Forestry and Agriculture*, EPA 430-R-05-006, Washington, DC, November 2005, Table 2-1, http://www.epa.gov/sequestration/greenhouse_gas.html; John M. Antle, Susan M. Capalbo, Siân Mooney, et al., "Economic Analysis of Agricultural Soil Carbon Sequestration: An Integrated Approach," *Journal of Agricultural and Resource Economics*, v. 26, no. 2 (2001): 344-367; and John M. Antle, Susan M. Capalbo, Keith Paustian, et al., "Estimating the Economic Potential for Agricultural Soil Carbon Sequestration in the Central United States Using an Aggregate Econometric Process Simulation Model," *Climatic Change*, v. 80 (2007): 145-171.

Another consideration is the potential learning-curve of education and experience. Although some farmers and landowners may be more familiar with agroforestry activities and land set-aside programs, some are not. Converting cropland to forestland substantially alters the day-to-day, on-the-ground practices of the landowner, and requires a different set of tools and equipment. Such changes, combined with the longer-term commitment for forests, could meet resistance from landowners. Further, technical assistance and educational outreach may be required in areas where forestry is not commonly practiced.

Studies evaluating the socioeconomic impacts of land use changes (primarily agricultural to urban) have found communal pressures against conversion, due to the cooperative nature of production agricultural activities, such as equipment sharing, land renting, custom work, and irrigation system development.[19] Dramatic land-use changes would potentially eliminate or reduce these benefits for traditional cropland owners. Conversely, farmers may continue to benefit from the traditional information sharing and formal and informal business relations that currently exist among neighboring farms. Multiple landowners converting to forestry may create a network of support that could expand afforestation in some areas. In addition, farmers could also benefit from the additional environmental services that forests can provide (e.g., clean water and wildlife habitat for hunting).

Limited Accounting of All Financial Costs

Participating in and complying with the new carbon market would not be costless to farmers. The EPA and USDA economic analyses of agricultural and forest land activities do not fully account for certain costs that would likely be associated with participating in a carbon market program. Among these are transaction costs required to develop offset projects and possible foregone revenue from agriculture and farm support programs associated with crop production. The failure of the model to account for these types of costs is problematic.

The definition of transaction costs can vary widely, but in general transaction costs would likely include (1) administrative costs, such as project registration or document preparation (e.g., project petitions) needed for compliance; and (2) measuring, monitoring, and verifying costs. Transaction costs would likely involve upfront, one-time costs to get the project up and running as well as annual or periodic costs to assure the project is performing as intended.

Because of general uncertainty about the possible carbon market structure, as well as information and data limitations, the FASOM model does not include transaction costs associated with the regulatory regime that would cover offset development.[20] Moreover, given the initial uncertainty of participating in such an emerging market, there will likely be a period of uncertainty and information limitations, as well as certain administrative or regulatory barriers to participating in this market. (See, for example, the discussion in "Land Tenure," below.) Other studies that try to account for transaction costs note that these can often be key factors in driving the results.[21]

The FASOM model also does not adjust for government support programs and subsidy payments to farmers, in part, because of the inherent complexity of incorporating such information into an

[19] JunJie Wu, "Land Use Changes: Economic, Social, and Environmental Impacts," *Choices*, 4th Quarter 2008.

[20] Based on CRS staff communications with EPA staff and modeling personnel/experts.

[21] See, for example, 25x'25 Carbon Work Group, "Summary of Recent Cost Impact Data, American Clean Energy Security Act of 2009, H.R. 2454," August 2009, http://www.25x25.org/storage/25x25/documents/Carbon_Subcommittee/aces_cost_summary_final_08-15-09.pdf.

economic model and also because of information and data limitations.[22] However, farm support payments can make up a substantial share of overall annual farm income for some operations and are an important part of the business decision-making process for some farmers. U.S. farm programs are governed by laws and regulations periodically reviewed and updated by Congress in omnibus "farm bill" legislation.[23] Since the 2002 farm bill, USDA reports that farm payments have totaled, on average, about $15 billion per year; government payments are estimated at $12.5 billion in 2009.[24] About 40% of farms receive government payments. In 2007, farm payments averaged nearly $9,800 for those farms receiving government payments, accounting for about 5% of gross cash income and about 22% of net cash income.[25] The exclusion of such a potentially significant component of a farm's financial accounting, and basing economic decision-making only on commodity price and market conditions, does not accurately portray the behavior of many farming operations. Whether or how participation in a new carbon offset program would affect a farm's continued participation in farm commodity support programs remains unclear.

Regional and Biological Variability

The biological variability that exists across different regions presents a challenge when estimating land use changes. The FASOM model's ability to account for site-specific baseline conditions is limited, because the model's biological differentiation is specified only for 10 production regions (regions are shown in **Figure 2**).[26] Specifying conditions at the regional level is a reasonable approach to account for underlying conditions, but does not provide a full accounting of the scope of biologic diversity and differences across the United States and within regions and microclimates. This limitation adds uncertainty to the land use change projections.

The FASOM model presumes forestry offsets through afforestation of softwood (e.g., pine) plantations in each agricultural region. However, most temperate forests contain a variety of tree species, which vary in size, form, growth, and rate of carbon sequestration. One study of U.S. forests reported carbon storage in existing tree stands[27] ranging from 40 MT CO_2-Eq. of carbon per acre in longleaf-slash pine forests of the Southeast to 377 MT CO_2-Eq. per acre in hemlock-Sitka spruce forests of the Pacific Northwest.[28] Even within each U.S. region, there was substantial variation, with carbon storage in the most carbon-intensive ecosystems double or triple the storage in the least carbon-intensive ecosystems.

[22] Based on CRS staff communications with EPA staff and modeling personnel/experts.

[23] The most recent omnibus farm bill (Food, Conservation, and Energy Act of 2008, P.L. 110-246) was enacted in June 2008. See CRS Report RL34696, *The 2008 Farm Bill: Major Provisions and Legislative Action.*

[24] USDA, "Agricultural Income and Finance Outlook," AIS-88, December 2009.

[25] USDA, ERS, "Farm and Commodity Policy: Government Payments and the Farm Sector," *ERS Briefing Rooms*, http://www.ers.usda.gov/Briefing/FarmPolicy/Gov-Pay.htm.

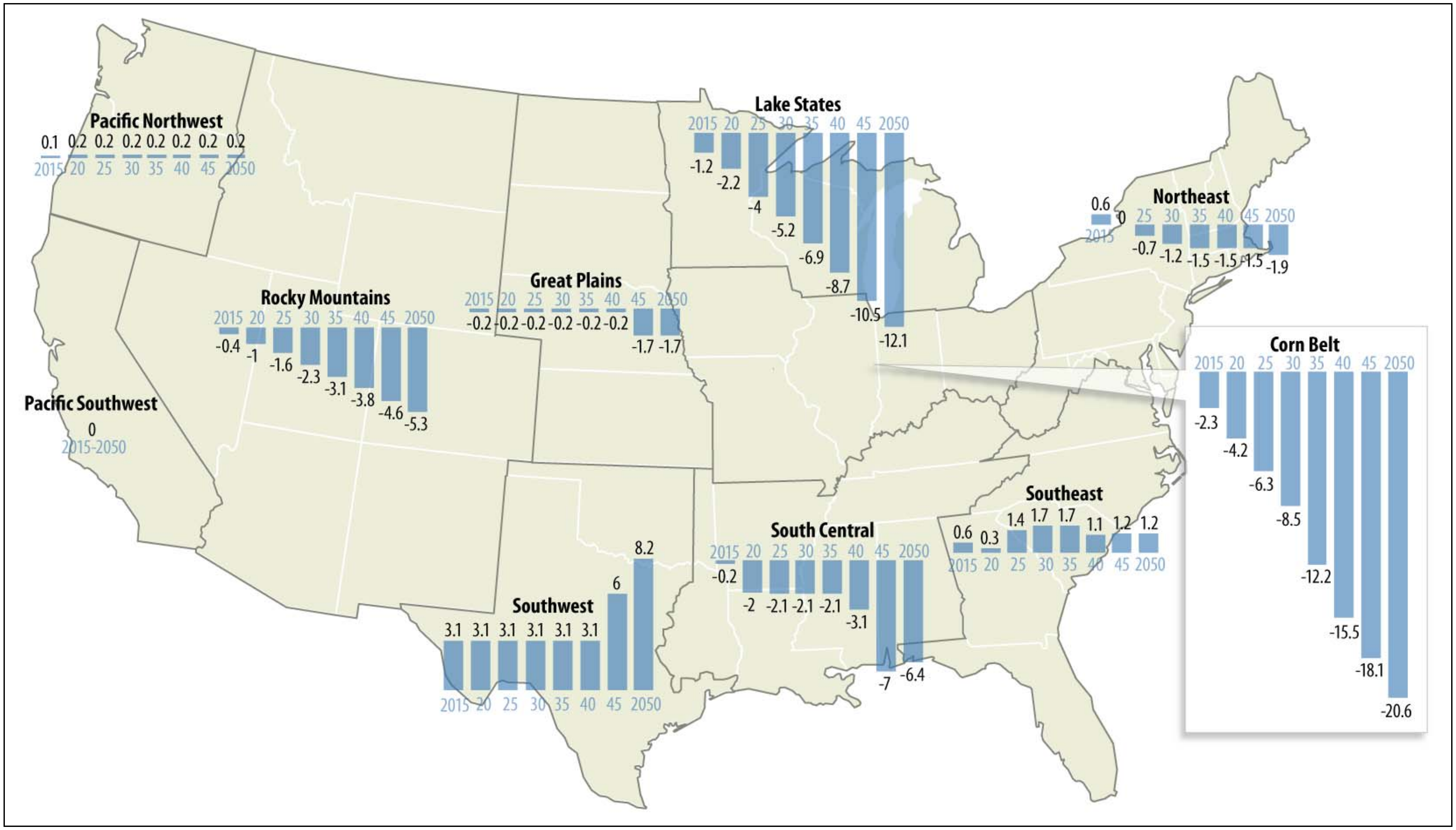
[26] Based on CRS staff communications with EPA staff and modeling personnel/experts. In the model, biological variability and diversity is specified within productivity growth functions developed for each region, accounting for differences in biological productivity and yields, and sequestration potential, among other factors.

[27] 50th percentile for existing stands, where the *average* age ranges from less than 15 years to more than 50 years (and all stand ages range from 1 year to more than 125 years).

[28] James E. Smith, Linda S. Heath, and Kenneth E. Skog et al., *Methods for Calculating Forest Ecosystem and Harvested Carbon with Standard Estimates for Forest Types of the United States*, USDA, Forest Service, Northeastern Research Station, General Technical Report NE-343, Newton Square, PA, April 2006, pp. 40-43. The data were converted from metric tons of carbon per hectare to MT CO_2-Eq. per acre by first multiplying the carbon quantity by 3.67 (MT CO_2-Eq. per metric ton of carbon) and dividing by 2.47 (acres per hectare).

Figure 2. USDA's Regional Analysis of Net Cropland Changes, 2050

(in millions of acres)



Source: CRS. Map generated from data in USDA's analysis, *The Impacts of the American Clean Energy and Security Act of 2009 on U.S. Agriculture*, December 18, 2009, Table 16 and Figure 6.

Notes: Each bar represents five-year increments beginning with 2015 to the left through 2050 on the right. The FASOM does not model agriculture in the west side of the Pacific Northwest region. The data only cover the contiguous United States.

Studies that have examined afforestation and reforestation for carbon sequestration have shown a similarly broad range of possibilities. The EPA study estimated 2.2 to 9.5 MT CO_2-Eq. per acre per year sequestered in afforestation (planting trees on previous cropland or pasture)—an average of 5.85 MT CO_2-Eq., plus-or-minus 62%—and 1.1 to 7.7 MT CO_2-Eq. sequestered per acre per year in reforestation (planting trees on areas recently cleared of trees)—an average of 4.4 MT CO_2-Eq., plus-or-minus 75%.[29] The USDA study estimated 2.7 to 7.7 MT CO_2-Eq. sequestered per acre per year in afforestation—an average of 5.2 MT CO_2-Eq., plus-or-minus 48%.[30]

The FASOM model also essentially presumes a linear rate of carbon sequestration from tree planting in each region, based on managed softwood forests relevant for that region. Such an assumption would likely lead to imprecise estimates of the conversion acreage. While the least productive (or currently unused) land for crops would likely be the first converted, it might (or might not) be the least productive for forest carbon. Also, different lands within a region undoubtedly vary significantly in forest carbon productivity. Thus, the conversion is not likely to be evenly distributed geographically or temporally within each region.

To date, the FASOM model results have not been reported by region, disaggregating land use changes and the effects of agricultural offset supplies. However, USDA's analysis expands upon EPA's model simulations to disaggregate the national data to provide regional breakouts of potential land use changes and farm revenue gains from offsets. USDA's regional analysis projects that the majority of offset supply from afforestation of croplands and pasturelands would occur in the Corn Belt region and Lake States regions (**Figure 2**). For further discussion about USDA's regional analysis results, see the section of this report titled "Regional Differences."

Capacity Constraints in Land Availability

It is unclear whether the capacity exists to afforest 1 million to 1.5 million acres annually. Historically, two federal programs provided assistance in establishing forests on private lands—the Forestry Incentives Program (FIP) and the Stewardship Incentives Program (SIP).[31] In 1994 (the last published report), FIP accomplishments included 188,017 acres of tree planting; the 2003 SIP accomplishments (the last published report) included 3,144 acres of tree planting. The last report on tree planting on all (public and private) lands in the United States (1997) showed 2.6 million acres planted in 1997.[32] The peak in tree planting—nearly 3.4 million acres—occurred in 1988. This was partly due to tree planting under the Conservation Reserve Program (CRP), the largest federal tree planting program for private land in U.S. history, with 2.2 million acres of trees on the more than 30 million CRP acres under contract.[33] Though high prices for forest carbon offsets may well be much greater incentives for tree planting than the CRP or other programs, planting an additional million acres (or more) of private forest annually would still be a significant increase in tree planting in the United States.

[29] EPA, *Greenhouse Gas Mitigation Potential in U.S. Forestry and Agriculture*, EPA 430-R-05-006.

[30] USDA, *Economics of Sequestering Carbon in the U.S. Agricultural Sector*, TB-1909.

[31] FIP was created in the Cooperative Forestry Assistance Act of 1978 (P.L. 95-313, 16 U.S.C. §2101, et seq.). SIP was added to that act in the 1990 farm bill (P.L. 101-624). Both were replaced by the Federal Land Enhancement Program (FLEP), created in the 2002 farm bill (P.L. 107-171), but no reports were published on FLEP accomplishments. About half of the FLEP funding was subsequently diverted to other purposes (fighting wildfires) and not replaced, and the program expired and was not renewed in the 2008 farm bill.

[32] Robert J. Moulton, "Tree Planting in the United States-1997," *Tree Planters' Notes*, USDA Forest Service, v. 49, no. 1 (1999), pp. 5-11.

[33] USDA Farm Service Agency, *Conservation Reserve Program: Monthly Summary—March 2009*, Washington, DC, http://www.fsa.usda.gov/Internet/FSA_File/mar2009.pdf.

Shifts in Land Use Throughout U.S. History

The potential shift of 60 million to 65 million acres of agricultural land into forests would represent a very large change in forest acreage, even spread over 40 years. Large shifts in forest acreage have occurred in the past. It was estimated that, in 1630, what would become the 48 states had 907 million acres of forest land. (W. Brad Smith, Patrick D. Miles, and Charles H. Perry, et al., *Forest Resources of the United States, 2007*, USDA Forest Service, General Technical Report WO-78, St. Paul, MN, 2004, pp. 157-159, Table 3.) Because of clearing for agriculture and other development, forest land declined about 30%, to about 624 million acres, by 1907. Over the past century, however, forest acreage has been relatively stable, peaking at 626 million acres in 1963 and dropping to a low of 601 million acres in 1987, before recovering to 623 million acres in 2007 (the most recent data available). Thus, in the past 44 years, only 26 million acres have shifted into or out of forest. An increase of 60 million to 65 million acres of forest would be a significant change from historical trends of the past century.

Land Tenure: Ownership versus Leased Land

Legal or social constraints associated with land tenure could affect the likelihood of land conversion. USDA researchers have noted that the potential complexity of future land leasing and land retirement agreements under an emerging carbon offset program would likely present certain challenges and act as a deterrent to participation.[34] Such agreements and contractual negotiations might also present certain barriers to exiting this market, given that there would likely be contractual timeframes that would need to be complied with in order to ensure the overall validity of the carbon emission reduction program. Thus, the mix of farmland ownership and leasing in the United States might constrain efforts to shift land uses, despite a willingness by farmers to participate in an emerging carbon market program. The EPA or USDA models, as designed, cannot reflect such effects.

Some farm groups have expressed concerns that extended contract periods (between 5 and 30 years) could create a barrier to farmer participation in a carbon offset program. They argue that because many farmers rent at least some of the land they farm, they might not be in a position to enter into multi-year contracts under a carbon offset program. Although the exact contract period for various offset projects would be determined through rulemaking after the laws are enacted, Congress has provided some stipulations in the House-passed bill (H.R. 2454): contract periods would be limited to 5-10 years (for various agricultural projects) and 20 years (for forestry projects).[35] Some environmental groups are continuing to push for extended crediting periods for certain offset projects because of concerns about permanence issues as well as the overall credibility of carbon emission reduction goals.

A recent USDA report also acknowledges that farmers who own the land may be in a better position to generate offsets than those who rent their land.[36] The report builds off previous studies showing that farmers that rent land may be more reluctant to make long-term conservation investment. The report states that farmers that rent land might be unable to obtain a long-term land lease and therefore have less flexibility to enter into the types of long-term investments and/or farming practice commitments that would be required in a carbon offset market. Moreover,

[34] Roger Claassen, and Mitch Morehart, *Agricultural Land Tenure and Carbon Offsets*, USDA, ERS, Economic Brief (EB) No. 14, September 2009, http://www.ers.usda.gov/Publications/EB14/EB14.pdf.

[35] Although not a comprehensive climate bill, Senator Stabenow's agriculture offset bill, S. 2729, specifies crediting periods of 5-10 years, except for forestry activities, which cannot exceed 30 years.

[36] *Agricultural Land Tenure and Carbon Offsets*, USDA, ERS, EB-14.

"the complexity of the associated lease agreements and negotiation challenges will continue to act as a deterrent" to their participation in the carbon market, compared to landowners.[37]

Concerns among farm groups about land tenure issues raise important programmatic and policy considerations. Renting land is commonplace in the U.S. farming sector. USDA identifies three groups related to farm tenure: full owners, who own all the land they operate; part owners, who own at least 1% of the land they operate, but also rent land; and tenants, who own less than 1% of the land they farm and who rent the rest. The most recent available USDA survey of land ownership characteristics in the United States farming sector (1997 data) reported that less than 30% of all farmed acres are owned by their operators.

Carbon offset markets could alter the incentives for landowners to lease their lands. Currently, landowners lease land to farmers, because often few other marketable opportunities for the land exist. High and rising carbon prices under a cap-and-trade, however, would create additional competition for land and raise land values. On one hand, offsets could provide additional financial incentives for farmers, which could lead to additional farm income. On the other hand, higher land values might entice current farmer-landowners to sell their land or abandon its current use for the more lucrative alternative in afforestation. For example, absentee-landowners might be induced to consider terminating their leases with farmers, both affecting the livelihood of the farmer and taking land out of production for up to 20-30 years.

Lessons from Existing Farmland Retirement Programs

Existing USDA land retirement programs provide insights into the possible effects of removing cropland from agricultural production. The CRP, authorized in 1985, is a voluntary land retirement program intended to encourage landowners to establish long-term, resource-conserving covers on eligible farmland.[38] Under the program, landowners enroll in contracts for 10-15 years and receive annual rental payments as well as cost-share assistance (of up to 50% of the cost) for approved conservation practices. When the program was originally established, authorized enrollment allowed for up to 45 million acres; this limit was reduced in subsequent legislation. The authorization allowed for the removal of over 10% of the nation's cropland at that time. Current CRP enrollment is at 31 million acres,[39] or about half of EPA's and USDA's projected land conversion estimates of 60 million to 65 million acres for 2050.

In the 1980s, while CRP reduced the principal crop acreage, average annual yields continued to climb.[40] This observation may be explained by the types of land that typically participate in CRP. Lands retired under CRP are largely associated with marginal or idle lands and generally are not considered to be taking productive cropland out of production. Similarly, incentives encouraging afforestation under a carbon offset program are likely to first take less productive and idled lands, as is reflected in EPA's and USDA's models. Which lands are taken out of production for

[37] Ibid.

[38] For information about CRP, see CRS Report RS21613, *Conservation Reserve Program: Status and Current Issues*.

[39] CRP was modeled after another land retirement program that was established in the 1956 Soil Bank Act (P.L.84-540) that was repealed in 1965. That program removed land from production and converted it to grass or trees, and had a significant effect on tree planting on private lands in the United States. Enrollment in that program reached a peak of 28.6 million acres in 1960.

[40] B. C. Darst and L. S. Murphy, "Keeping Agriculture Viable: Industry's Viewpoint," *Journal of Soil and Water Conservation*, v. 49, no. 2 (March/April 1994): 11.

afforestation will largely depend on the opportunity cost of the land. As long as crop production remains more profitable than participation in the carbon market, productive lands would likely remain in crop production. At higher offset prices, however, the tradeoffs between returns and profits in the two markets would become more competitive, and afforestation could eventually outweigh opportunities from growing crops.

CRP rules require landowners to offer farmers who rent their land the opportunity to participate in CRP contracts and receive payments under the program. Similar requirements under a carbon offset program might help address land tenure issues, in particular the willingness of the lessee to participate in the program. CRP rules also limit enrollment within a county to no more than 25% of its total acres to prevent significant disruptions to local input industries, such as the manufacturers and sellers of seed, chemicals, and farm equipment.

Other provisions might be considered to ensure that contractual obligations are met. As an example, under USDA's Environmental Qualities Incentives Program (EQIP), farmers who lease land are required to show proof of control of the land for the duration of the contract period. These types of requirements might also be required for farm and forestry carbon offset projects, either through statutory provisions or through rulemaking.

Existing programs provide an indication of the potential willingness of farmers to participate in multi-year contracts. Under CRP, participants enroll in contracts for 10 to 15 years. EQIP contracts range from 1 to 10 years in length. Participation in each of these programs continues to increase despite these types of obstacles. However, a study by USDA shows that farmers who own 80% or more of the land they farm are more likely to enroll in CRP and account for the bulk (about two-thirds) of all CRP enrolled acres.[41] While CRP does have a provision that requires landowners to offer tenants the opportunity to participate in CRP and receive payments, the USDA study also found that few farmers that mostly lease land (defined as those who own less than 60% of the land they farm) tend to focus more on crop production and are reluctant to retire land.[42] In most cases, leaseholders are more likely to lease productive lands, if intended for growing marketable crops.

Forestry Projects in the Clean Development Mechanism

The inclusion of forestry and other land-based offsets with a carbon reduction program has remained controversial since the Kyoto Protocol negotiations during the 1990s.[43] As a result, the development of a carbon offset program with credible and certifiable forestry practices and protocols could slow implementation and adoption of afforestation and other related forestry offset projects. This has been the case within the Clean Development Mechanism (CDM), which was developed as part of the Kyoto Protocol of the United Nations Framework Convention on Climate Change (UNFCCC). CDM is a project-based mechanism that permits Annex I countries under the Kyoto Protocol to earn credits for use in achieving their emission targets.[44] It is the only

[41] *Agricultural Land Tenure and Carbon Offsets,* USDA, ERS, EB-14.

[42] Ibid.

[43] See, for example, E. Boyd, E. Corbera, B. Kjellén, M. Guitiérrez, and M. Estrada, "The Politics of 'Sinks' and the CDM: A Process Tracing of the UNFCCC Negotiations (pre-Kyoto to COP-9)," Feb. 2007, draft submitted for International Environmental Agreements; also see two articles in Nature, no. 6812, Nov. 2000, "Deadlock in the Hague, but Hope Remains for Spring Climate Deal," and "Critical Politics of Carbon Sinks."

[44] The United States originally signed the Kyoto Protocol, but later rejected participation and is not bound by its goals.

mechanism that allows developed countries (e.g., European Union nations) to earn credits for actions in developing countries (e.g., India or China). The CDM is the largest compliance offset market in the world. Both the trading volume and market value of the CDM have grown substantially in recent years.

The only land-use change offset projects allowed in the CDM are afforestation (planting trees where none were previously growing) and reforestation (replanting trees on recently cleared forest sites).[45] Although the forestry sector was initially expected to play a significant role in the CDM,[46] forestry-based projects have not played a large role to date. Indeed, no forestry-related offset credits have been issued through the CDM (as of February 1, 2010); and of the 2,029 registered projects (i.e., in development), only 13 are forestry-related.[47] A report by the Intergovernmental Panel on Climate Change (IPCC) stated that although the forestry sector can make a "very significant contribution to a low-cost mitigation portfolio ... this opportunity is being lost in the current institutional context and lack of political will to implement and has resulted in only a small portion of this potential being realized at present."[48] However, the primary compliance market that uses the CDM—the European Union's Emission Trading System (EU-ETS)—is relatively new, and the EU-ETS carbon prices may not have reached sufficient levels to stimulate forestry projects.

Potentially Disproportionate Benefits

Some in the U.S. farming community have expressed concern that only certain landowners and agricultural producers might be able to participate in the carbon offset market. They suggest that only larger landowners and farming operations would benefit from a carbon program, and this may result in further industry consolidation in the farming sectors, exacerbating difficult business conditions for smaller, traditional farmers. Others are concerned that if only certain crop producers in some regions benefit from participating in the new carbon offset market, this could result in inequities across all crop producers, benefitting some while not benefitting others.

Differences by Farm Size

The FASOM simulation model cannot depict differences in farm size, nor can it fully differentiate results by operation type. Evidence and speculation are mixed on whether larger landowners and farming operations will benefit more than smaller-sized operations. Some evidence suggests that larger landowners and farming operations may have greater opportunities to participate in carbon markets, because of their economies of scale and their likely lower transactions costs compared to smaller landowners and farmers. Alternatively, smaller-sized operations might have greater opportunities to participate in carbon offset projects, because they are more likely to own their land and generally tend to be more operationally diverse, and because given the expected continued role of designated middlemen in generating and marketing carbon offsets.

[45] See UNFCCC, Conference of the Parties, Seventh Session—"the Marrakesh Accords"—2001, Decision 11.

[46] M. Webb and R. Godfrey, "Financing the Protection of Forests Around the World," *Fiscal Pulse*, January 9, 2009.

[47] United Nations Environment Programme, *Capacity Development for the Clean Development Mechanism ("CDM Pipeline")*, at http://cd4cdm.org/index.htm.

[48] IPCC, *Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report*, 2007, p. 543.

Economies of Scale in Larger Operations

In general, businesses that operate more efficiently and are more productive than their competitors receive greater rewards in the marketplace. Economies of scale refer to the ability of a business (farm) to reduce its cost per additional unit of output (or its average unit costs) by increasing total production. This can be the result of improved productivity (e.g., through more specialization among workers), increased operational efficiency (e.g., equipment operating a larger percent of the time), or spreading fixed costs over greater total production. Economies of size, specialization, and relative market power also play a role, allowing some larger-sized operations to lower their overall production or input costs. Evidence in the agricultural sector suggests that these market forces have led to farm consolidation (fewer small farms). See the text box below for more information. Accordingly, larger-sized operations could benefit from economies of scale in carbon offset markets; having more land to work with might provide greater opportunities to participate in carbon projects while maintaining basic agricultural operations. Thus, larger-sized operations might potentially have access to greater benefits than smaller-sized operations.

Consolidation in the Agricultural Sector

The U.S. agricultural industry is marked by ongoing consolidation, with a decline in the number of farms and an increase in average farm size. The number of farms in the United States has declined from an historic high of 6.8 million farms in 1935 to 2.2 million in 2007. At the same time, the number of larger farms (sales of $250,000 or more) grew steadily between the 1982 and 2002 *Censuses of Agriculture*. Also, overall production has increased, evidence that farms have become, on average, larger as well as more efficient and specialized. Increasingly, larger, more industrialized, and highly specialized operations now account for a greater share of all crop and animal production.

The most recent USDA data grouped by farm typology include the following statistics: as of 2004, small family farms (sales of less than $250,000) accounted for more than 90% of U.S. farms, held about 60% of the land owned by farms, and accounted for less than 25% of the value of production. USDA reports that large farms are more viable businesses than small family farms, based on more favorable and mostly positive average operating profit margins and rates of returns on assets and equity. These same measures for small farms were mostly negative; also average net income for each small-farm type was low compared with large-scale farms. Small farm households often must rely on off-farm income.

Historically, the number of farm operations has been steadily declining, especially smaller operations that cannot compete with large-scale, highly specialized, often lower cost producers. (The most recent *Census of Agriculture*, however, reported a net increase in the number U.S. farms, breaking with this longstanding trend.) USDA reports that, in a normal year, 3-4% of all farm operators discontinue farming for a variety of financial and personal reasons. Of these, about 2-3% of farm exits are "involuntary" (i.e., due to bankruptcies, foreclosures, debt repayment problems, or inadequate farm incomes). Involuntary farm exits caused by financial stress vary considerably by farm size and production region, and commodity produced. High-value crops (e.g., vegetables, orchards, and greenhouse products) and livestock production are particularly dominated by larger operations, although these operations constitute a small share of the total number of operations.

Economies of size and scale account for much of the growth in farm size. At the same time, cost and efficiency considerations are pushing farms to become more specialized and intensive. These trends are especially evident in the U.S. livestock and poultry sectors. Marked gains in production efficiency have allowed farmers to produce more with fewer animals because of higher per-animal yields and quicker turnover of animals between farm production and consumer market. As a result, annual production and sales have increased, even though the number of animals on farms at any one time has declined (i.e., an increase in the number of marketing cycles over the course of the year allows operators to maintain production levels with fewer animals at any given time, although the total number of animals produced by the facility over the year may be greater).

Source: R.A. Hoppe, et al., "Structure and Finances of U.S. Farms: Family Farm Report," 2007 Edition, USDA, ERS, EIB-24, June 2007; J.M. Stam and B.L. Dixon, "Farmer Bankruptcies and Farm Exits in the United States, 1899-2002," USDA, ERS, AIB-788, March 2004; J.M. MacDonald, et al., "Consolidation in U.S. Meatpacking," USDA, ERS, AER-785, March 1999; and W.D. McBride, "Changes in U.S. Livestock Production, 1969-92," USDA, ERS, AER-754, July 1997.

Transaction and Regulatory Costs

The impact of transactions costs on small farms/landowners versus large farms/landowners is largely unknown. Under a federal cap-and-trade program, offset transaction costs would probably disproportionately affect small-scale offset projects, because some of the costs of creating and obtaining project approval are essentially fixed (i.e., not affected by the size of the project). A related and important consideration is how the transaction costs would affect the break-even prices for offset projects—would the magnitude of transaction costs make only the largest farm operations and land plots economically viable for offset projects?

Transaction costs would likely present a disproportionate challenge to smaller-scale offset projects, because of economies of scale: as more and/or larger projects generate more offset credits, the transaction costs (as a percentage of MT CO_2-Eq. reduced or sequestered) generally decrease. Research assessing existing offset projects has demonstrated that measurement costs account for a larger percentage of total costs for smaller projects than for large-area projects.[49] Observations from the Chicago Climate Exchange (CCX)[50] confirmed these findings: verification costs vary by an order of magnitude between small ($1/MT) and large ($0.10/MT) agricultural soil sequestration projects.[51]

Although this disparity would seem to favor larger projects, smaller projects may still be economically viable, depending on the magnitude of the transactions costs relative to the estimated offset revenue and depending on the nature of the project. Evidence indicates that the cost calculation would vary substantially under different offset protocols (e.g., the CCX, the Voluntary Carbon Standard,[52] or the 1605(b)[53] requirements).[54] Studies have shown that different offset protocols produce a wide spectrum of break-even prices (the carbon price needed to make a project economically viable); for example, a 2009 study found that the break-even prices for a 246-acre (100-hectare) afforestation project ranged from $10 per MT to approximately $50 per MT.[55] Different protocols affect not only the transaction costs, but the number of offset credits that would be generated, an integral figure in a break-even price assessment. A 2008 study estimated the offset credits that a hypothetical afforestation project would generate under several

[49] Siân Mooney, Sandra Brown, and David Shoch, *Measurement and Monitoring Costs: Influence of Parcel Contiguity, Carbon Variability, Project Size and Timing of Measurement Events*, Winrock International, January 2004.

[50] In terms of trading volume, CCX accounts for a substantial portion of the global voluntary offsets market. In 2008, CCX offsets represented more than 50% of the traded volume. In terms of market value, CCX offsets have historically accounted for a smaller market share, but this shared has increased in recent years. In 2008, the market value of CCX offsets accounted for approximately 44% of value in the voluntary market (Ecosystem Marketplace, *Fortifying the Foundation: State of the Voluntary Carbon Markets 2009*, figures 3 and 4). Between 2004 and 2009, CCX reports that approximately 32% of its registered offsets were agricultural soil carbon projects (CCX, "CCX Offsets Report," September-December 2009, at http://theccx.com/docs/offsets/Reports/CCX_Offsets_Report_Vol1No5_Sept_Dec.pdf).

[51] Per conversation with official from the Iowa Farm Bureau, a group closely involved in offset development in the CCX (January 28, 2009).

[52] See http://www.v-c-s.org/.

[53] Section 1605(b) of the Energy Policy Act of 1992 (P.L. 102-486; 42 U.S.C. §§ 13201, et seq.) created a program of voluntary reporting of GHG emissions, reductions, and sequestration.

[54] Timothy R.H. Pearson, Sandra Brown, and Kenneth Andrasko, "Comparison of Registry Methodologies for Reporting Carbon Benefits for Afforestation Projects in the United States," *Environmental Science and Policy*, vol. 11 (2008): 490-504.

[55] Christopher S. Galik, Justin S. Baker, and Joseph L. Grinnell, *Transaction Costs and Forest Management Carbon Offset Potential*, Climate Change Policy Partnership, Duke University, July 2009.

offset protocols, finding that the offsets generated over a 60-year period under different protocols would range from 118 million MT CO_2-Eq. to 300 million MT CO_2-Eq.[56]

In addition, different types of offset projects could have radically different transaction costs. For example, agricultural soil sequestration projects would likely require annual monitoring, possibly at several sites, depending on the size of the project. In contrast, afforestation might need only periodic monitoring, perhaps every 5 years, to assure that carbon sequestration is occurring. In addition, afforestation carbon is above ground and can be estimated rather simply, with measurements of tree height and diameter. Soil carbon would likely require soil samples be taken and analyzed, with the number of samples depending on the heterogeneity of the soils on the site.

Diversification among Smaller-Sized Operations

While economies of scale often drive farm consolidation, smaller producers might be more responsive to non-economic incentives. In particular, many small producers emphasize organic products, sustainability, and other "green" aspects of agricultural production that may be of less concern to larger, consolidated operations. As a result, the smaller operators might well be interested in participating in carbon sequestration efforts and programs despite the potentially higher transaction costs for small operators. This innate interest might be more significant in determining participation than the economic incentives, especially in the early stages of implementation.

USDA's 2007 *Census of Agriculture* reports that the number of U.S. farms increased (net) by more than 76,000 farms compared to the 2002 census, breaking with historical trends showing a steady decline on the total number of farming operations. Compared to all farms nationwide, these new farms tend to have more diversified production, fewer acres, lower sales, and younger operators who also work off-farm. Smaller operations fitting this demographic could find additional benefits by participating in a carbon offset program. Increased diversification through forestry combined with the non-economic considerations mentioned above—the "green" aspects of sequestration—could provide sufficient incentives for smaller producers.

The role of additional outreach, education, and technical assistance could also have a greater impact on small-scale projects with smaller operators. A lack of personal experience and local support for afforestation might be seen as too significant a risk, despite favorable economic incentives. The knowledge and skills required to convert cropland to forestland would likely be greater than that required merely to retire the land, such as under the CRP or other related USDA programs, and would likely require additional extension services and technical resources to entice producers to absorb this extra risk. Neither this risk nor the possible adjustments that outreach and technical assistance could have on participation can be accounted for within economic models.

Land Tenure

A recent USDA study projects that the largest share of sequestration potential is on larger-sized farms.[57] Half of this potential is reportedly concentrated on farms located in the Northern Plains and Rocky Mountain regions. (See the discussion in "Regional Differences," below.)

In contrast, as discussed in "Land Tenure: Ownership versus Leased Land" in a previous section of this report, farmers that own the land are more likely to enter into multi-year contracts and thus

[56] Pearson, Brown, and Andrasko, "Comparison of Registry Methodologies for Reporting Carbon Benefits."

[57] *Agricultural Land Tenure and Carbon Offsets*, USDA, ERS, EB-14.

would appear more likely to participate in carbon markets. As noted above, small family farms own 60% of the agricultural acres in the United States.[58] Furthermore, small family farms have been more likely to enter into CRP contracts, accounting for nearly 82% of CRP and Wetland Reserve Program acreage.[59] Thus, small family farm operators might be more likely to create carbon offset projects than larger farm operators and especially than leased land operators.

Role of Aggregators

As discussed above, small-scale projects may be cost prohibitive at certain carbon prices, but if similar projects could be pooled together and sold as a larger unit (i.e., aggregated), participation from small-scale projects may increase. *Aggregators* often serve as middle-men, linking landowners with the offset markets. Offset project aggregators have played a key role in developing offsets, particularly agricultural sector offsets in the CCX, and many of the offsets sold on the CCX are developed via aggregators.[60] The U.S. Department of Energy's National Energy Technology Laboratory described the role of aggregators in the CCX as follows:

> From inception, Chicago Climate Exchange has found the inclusion of aggregators to be an extremely effective model in developing participation in the carbon market from the agricultural sector. The need for aggregators has increased entrepreneurial activity in the carbon markets. In some cases, established membership organizations and cooperatives have created new departments in order to offer this additional category of service to their members. Other times, new companies have been created to aggregate projects, with the primary mission one of marketing these "environmental services". This increase in competition is a benefit to both the market in general, and project/land owners specifically.[61]

In a federal cap-and-trade system, aggregators would likely continue to play a role by offering participation opportunities to small landowners. However, the level of aggregation/small-scale participation may depend, in part, on the offset protocols established in legislation or through subsequent rulemakings. For example, a protocol with more rigorous sampling and verification requirements would discourage aggregation.

Profile of Participants in Voluntary Carbon Markets

Neither the size nor the value of the voluntary offset market is known, because no registry or tracking system follows exchanges in the voluntary market.[62] Therefore, comprehensive data regarding the participants in the voluntary carbon market are limited. However, the Chicago Climate Exchange (CCX), which accounted for more than half of the estimated global voluntary carbon market in 2008,[63] provided CRS with estimates for soil sequestration projects. According to the CCX, approximately 65% percent of the 6,000 farms enrolled in the CCX conservation tillage program had less than 450 acres and could thus be considered small farms.

In addition, Point Carbon, a private company that tracks and analyzes carbon markets, provided data for domestic forestry projects. Point Carbon data include 86 forestry projects that have been

[58] *Structure and Finances of U.S. Farms: Family Farm Report, 2007 Edition*, USDA, ERS, EIB-24.

[59] Ibid.

[60] Ecosystem Marketplace, *Fortifying the Foundation: State of the Voluntary Carbon Markets 2009*.

[61] Joel R. Brown and Kellee James, *Rangeland Soil Carbon Sequestration in the Chicago Climate Exchange*, http://www.netl.doe.gov/publications/proceedings/07/carbon-seq/data/papers/tue_082.pdf.

[62] See CRS Report RL34241, *Voluntary Carbon Offsets: Overview and Assessment*.

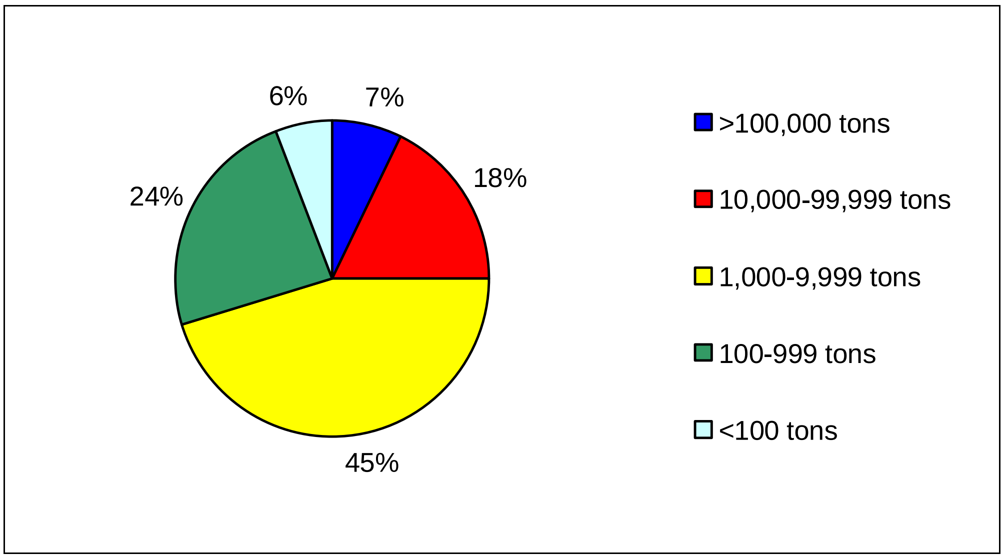
[63] Ecosystem Marketplace, *Fortifying the Foundation: State of the Voluntary Carbon Markets 2009*.

developed since 1999. **Figure 3** shows a breakdown of these projects by size. The size categories indicate the MT CO_2 emissions mitigated per year. For example, 6% of the projects each mitigate less than 100 MT per year; 24% of the projects each mitigate between 100 and 999 MT per year.[64]

Whether these data are a useful indication of offset projects that would result under a federal cap-and-trade program is an open question. The protocols used to develop the projects cited above may well differ from the protocols established in a federal system. Moreover, offsets created in the voluntary market may have originated for non-economic reasons, such as personal desires or public relations. Further, studies indicate that the economic incentives (i.e., the carbon price) in a compliance market would likely be much higher than in the voluntary market. These factors make a comparison between voluntary offset data and predictions for compliance offsets problematic.

Figure 3. Domestic Forestry Offset Projects from Point Carbon, by Project Size

(in metric tons per year)



Source: Prepared by CRS; data provided by Point Carbon.

Regional Differences

Although the EPA and USDA analyses (as well as other studies) found that the agricultural sector as a whole would experience net gains under a cap-and-trade program with offset opportunities, the benefits and costs imposed by the program would likely vary across regions. The EPA analysis did not disaggregate land use changes and the effects of agricultural offset supplies by region. The USDA analysis, however—expanding upon EPA's FASOM model simulations—disaggregated the national data to provide regional breakouts of potential land use changes and farm revenue gains from offsets.

USDA's regional analysis projects the majority of offset supply to come from afforestation of croplands and pasturelands. The results indicate that farmers and landowners in the Corn Belt

[64] Some of the projects listed in the larger size categories may include aggregated land parcels. For example, if a project is listed as having generated 1,000 MT in offsets per year, this project could be two land plots that each generate 500 MT per year. This is a limitation of the data provided.

region—comprising Iowa, Missouri, Illinois, Indiana, and Ohio—would be the largest suppliers of agriculture- and forestry-based carbon offsets under a cap-and-trade program. The Lake States—comprised of Michigan, Minnesota, and Wisconsin—would also be a large offset supplier. As shown in **Figure 2**, these regions would experience an increase in afforestation primarily through the conversion of cropland. This reduction of cropland by afforestation within these regions is expected to be concentrated over time. In 2015, for example, USDA projects that about 55% of the additional afforestation will occur in the Corn Belt and Lake States. By 2050, these two regions would account for almost 65% of additional afforestation.

Most agree that certain regions of the country are geographically better equipped to grow trees. While other regions could be aided by irrigation and fertilizers, the additional expense and technical feasibility could prevent such efforts from being sustainable over time. The land use shifts shown by USDA's analysis highlight some of these feasibility assumptions, though the analysis does not discuss them in detail. For example, USDA's analysis does not project substantial land shifts in California (shown as the Pacific Southwest in **Figure 2**). Presumably this is because that state's production of higher value crops, such as fruits and vegetables, could out-compete the carbon market for land use. Other areas such as the Great Plains show less afforestation and more land remaining in cropland production. This is possibly related to that region's limited ability to grow trees. Other areas, such as the Southwest, show pastureland moving to cropland rather than afforestation (shown as an increase in cropland in **Figure 2**).

As the Corn Belt and Lake States regions are projected to be the largest suppliers of offsets, USDA's analysis also projects these regions will have the highest annual gross revenue from offsets (**Table 2**). Other areas showing high annual gross revenue from offsets in the Northeast, South Central, and Rocky Mountain states also show revenue gains from afforestation.

Table 2. Annual Gross Agricultural Revenue from Carbon Offsets

($ billions)

	2020	2030	2040	2050
Corn Belt	1.2	2.1	6.0	10.0
Great Plains	0.1	0.2	0.8	2.6
Lake States	0.6	1.3	4.1	7.7
Northeast	0.1	0.4	2.3	3.2
Rocky Mountains	0.1	0.3	0.9	2.8
Pacific Southwest	0.0	0.0	0.1	0.2
Pacific Northwest	0.0	0.0	0.1	0.2
South Central	0.3	0.7	3.0	1.1
Southeast	0.0	0.2	0.7	1.8
Southwest	0.0	0.1	0.1	0.3
Total	**$2.4**	**$5.2**	**$18.1**	**$29.7**

Source: USDA, *The Impacts of the American Clean Energy and Security Act of 2009 on U.S. Agriculture*, USDA, December 18, 2009, Table 14. Estimated in 2004 dollars.

Note: Totals may not add due to rounding. The data only cover the contiguous United States.

USDA's analysis shows some areas, such as the Pacific Northwest, Southwest, and Pacific Southwest regions, receiving little annual gross revenue from offsets (**Table 2**). These regions are projected to provide fewer carbon offsets. This does not necessarily indicate a reduction in overall gross revenue in these regions. Although some regions are projected to gain from participating in a carbon market, potentially higher commodity prices from reduced supply could benefit regions remaining in cropland. If an increase in afforestation occurred, as the USDA model projects, regions remaining in crop production could see higher prices and increased demand for their crops. Some studies argue that this overall effect could benefit all regions not just those participating in a carbon market.[65]

Conclusions

When assessing climate change legislation such as a cap-and-trade program, it is difficult for economic models to forecast costs and associated impacts several decades into the future, much less beyond. Assumptions such as regulatory requirements become more fragile as time goes forward, and unforeseen events (such as technological breakthroughs) and unpredictable behavior similarly threaten the basic structure of the model. Hence, long-term projections are at best speculative and should be viewed with attentive skepticism. The finer and more detailed the estimate (e.g., land use changes in specific regions), the greater the skepticism should be.

The economic impact estimates of H.R. 2454 offered by EPA and USDA are not unique in this regard. Although both EPA and USDA concluded that the overall costs of the GHG cap-and-trade program established by H.R. 2454 would be "modest"—indeed finding that carbon offsets revenue could yield *net economic gains* for the U.S. agricultural sectors—these conclusions are rife with uncertainty. However, the uncertainty does not necessarily suggest that the economic impacts would turn out to be dramatically different than predicted, simply that they are unknowable.

Other models support the EPA and USDA conclusions of agriculture sector-wide benefits. Many stakeholders are concerned that smaller-sized operations and some regions might not be able to participate, and thus share in these benefits. The details of such participation rates are discussed below. However, even if their participation rates are low, they might still benefit from land conversions and carbon offsets by larger operations. With some land shifting out of crop production, commodity prices are likely to rise, which benefits all farmers. Similarly, alternative sources of farm revenue raise land values, thus benefitting all landowners, even if they do not or cannot participate in carbon offset markets.

Projected Land Conversion

Many variables complicate the economic analyses and related estimates. In particular, the projections of land-use changes are debatable, considering the following factors:

- Offset Prices—Prices are the key driver of EPA simulation results regarding land conversion rates. Assumed high and rising prices substantially influence modeling results, showing increasing land conversion and afforestation. At

[65] See, for example, "The Effects of Low-Carbon Policies on Net Farm Income," WP 09-04, Nicholas Institute.

constant or less sharply increasing prices, projected land conversion rates are much lower.

- Farmer Response—EPA and USDA analyses cannot estimate the effects of various non-economic and social norms within the farming sectors. This could influence actual program participation and land conversion, likely overstating the modeling results.
- Missing Costs—EPA and USDA analyses do not account for all likely farm-level costs, such as transaction costs associated with the future regulatory regime and possible foregone revenue from farm support programs associated with commodity crop production if farmers chose to participate in a carbon market. If these costs were taken into account, land conversion rates would likely be lower.
- Regional and Biological Variability—EPA and USDA analyses are not able to fully account for precise site-specific baseline conditions, and biological differentiation is specified only at the regional level. It is unclear how this could influence the results of the modeling analyses.
- Capacity Constraints—EPA and USDA analyses may not reflect actual physical capacity constraints and limitations to support substantial afforestation efforts that will also ensure that carbon sequestration potential meets the full set of requirements in the carbon reduction program. This could overstate the modeling results.
- Land Tenure—EPA and USDA analyses do not reflect possible legal and contractual constraints that might affect participation in the carbon market, given differences in the U.S. crop sectors between farmland ownership and leasing in the United States. As landowners would likely be in a better position to participate in a carbon market program than renters, this could overstate the modeling results.

Potentially Disproportionate Benefits

Some are concerned that the cap-and-trade offset market would disproportionately favor larger producers or certain crop producers. The FASOM simulation model cannot depict differences in farm size in their models. The evidence and speculation on the possibly inequitable distribution of benefits is mixed. On one hand, market forces and trends within the farming sectors suggest that larger operations would likely benefit more relative to smaller farms because of their economies of scale. Also the relative ability of smaller-sized operations to be able to cover various transaction costs of participating in the new carbon market (but not captured in the simulation model) is also unknown, but may favor larger-sized operations.

On the other hand, smaller-sized operations might also benefit from the developing carbon markets. Smaller-sized operations are commonly more diversified, and many are more responsive to non-economic influences than larger-sized operations. In addition, smaller-sized farms are more likely to be owner-operated, rather than leased, which may make a shift in operations to carbon offset projects more feasible. Smaller-sized operators have shown a marked willingness to participate in conservation-payment programs, such as CRP. Finally, *aggregators* have emerged to develop projects for the voluntary carbon markets, and seem likely to continue and even expand their role in assisting smaller-sized farming operations to participate in carbon markets.

Modeling efforts are not able to differentiate by type of operation or region. USDA expanded upon EPA's model simulations to disaggregate the land conversion data to the regional level. This analysis shows that most carbon offset supplies, and the largest offset benefits, will originate in the Corn Belt and Lake States, with lesser benefits in the Northeast, South Central, and Rocky Mountain states. It is unclear whether these results would differ under alternative assumptions. These results also do not mean that other regions receive no benefits. The Southwest, for example, shows an *increase* in cropland, while most other regions are showing conversions of cropland to forestland; the likely explanation is that higher crop values, and higher land values generally, due to the carbon offset program increase farm revenues sufficiently to expand crop production in areas where crop production currently cannot cover operating costs.

Appendix A. Selected Studies of Potential Economic Impacts of Carbon Offset Programs

EPA, *Analysis of S. 1733 in the 111th Congress, the Clean Energy Jobs and American Power Act of 2009*, October 2009; and *Analysis of H.R. 2454 in the 111th Congress, the American Clean Energy and Security Act of 2009*, June 2009, http://www.epa.gov/climatechange/economics/economicanalyses.html.

USDA, *The Impacts of the American Clean Energy and Security Act of 2009 on U.S. Agriculture*, December 18, 2009, http://www.usda.gov/oce/newsroom/archives/releases/2009files/ImpactsofHR%202454.pdf; and *A Preliminary Analysis of the Effects of H.R. 2454 on U.S. Agriculture*, July 22, 2009, http://www.usda.gov/oce/newsroom/archives/.

Congressional Budget Office (CBO), "The Estimated Costs to Households From the Cap-and-Trade Provisions of H.R. 2454," June 19, 2009, http://www.cbo.gov/ftpdocs/103xx/doc10327/06-19-CapAndTradeCosts.pdf.

Agricultural Carbon Market Working Group, "The Value of a Carbon Offset Market for Agriculture," http://www.farmland.org/programs/environment/workshops/documents/TCGWhitePaper_ValueofOffsets_Final.pdf.

25x'25 Carbon Work Group, "Summary of Recent Cost Impact Data, American Clean Energy Security Act of 2009, H.R. 2454," August 2009, http://www.25x25.org/storage/25x25/documents/Carbon_Subcommittee/aces_cost_summary_final_08-15-09.pdf.

Kansas State University (Golden, B. et al.), "A Comparison of Select Cost-Benefit Studies on the Impacts of H.R. 2454 on the Agriculture Sector of the Economy," December 8, 2009, http://www.farmland.org/documents/A-Comparison-of-Select-Cost-Benefit-Studies-HR2454-Impacts-On-Agriculture-Sector.pdf.

Duke University's Nicolas Institute for Environmental Policy Solutions (Baker, J.S. et al.), "The Effects of Low-Carbon Policies on Net Farm Income," WP 09-04, September 2009, http://www.nicholas.duke.edu/institute/ ni.wp.09.04.pdf; and http://www.nicholas.duke.edu/agmeeting/Potential_Economic_Effects.pdf.

Food and Agriculture Policy Research Institute (FAPRI), "The Effect of Higher Energy Prices from H.R. 2454 on Missouri Crop Production Costs," FAPRI-MU Report #05-09, July 2009, http://www.fapri.missouri.edu/outreach/ publications/2009/FAPRI_MU_Report_05_09.pdf.

Texas A&M University's Agricultural and Food Policy Center (AFPC), "Economic Implications of the EPA Analysis of the CAP and Trade Provisions of H.R. 2454 for U.S. Representative Farms," AFPC Research Paper 09-2, August 2009, http://www.afpc.tamu.edu/pubs/2/526/rr%2009-2%20paper%20-%20for%20web.pdf.

Iowa State University, Center for Agricultural and Rural Development (CARD), Bruce Babcock, "Costs and Benefits to Agriculture from Climate Change Policy," Summer 2009, http://www.card.iastate.edu/iowa_ag_review/.

Iowa State University, CARD, Tristan Brown et al., "Market Impact of Domestic Offset Programs," Working Paper 10-WP 502, January 2010, http://www.econ.iastate.edu/research/webpapers/paper_13154.pdf.

University of Tennessee (de la Torre Ugarte, D. et al.), "Analysis of the Implications of Climate Change and Energy Legislation to the Agricultural Sector," Department of Agricultural Economics, Institute of Agriculture, November 2009, http://www.25x25.org/storage/25x25/documents/ut_climate_energy_report_25x25_november.pdf.

University of Arkansas (Nalley, Lanier, et al.), "How a Cap-and-Trade Policy of Green House Gases Could Alter the Face of Agriculture in the South: A Spatial and Production Level Analysis, Department of Agricultural Economics and Agribusiness," http://purl.umn.edu/55717.

Informa Economics, "Potential Impacts of Cap and Trade Policy on U.S. Corn, Soybean, and Wheat Producers," prepared for the National Corn Growers Association (NCGA), December 2009, http://www.fb.org/newsroom/fbn/2009/FBN_07-06-09.pdf.

American Farm Bureau Federation (AFBF), "'Flawed' Cap-and-Trade Bill Goes to Senate," *FB News*, July 6, 2009 Vol. 88 No. 13, http://www.fb.org/newsroom/fbn/2009/FBN_07-06-09.pdf.

Fertilizer Institute (commissioned study), "Climate Change, Effects of Cap and Trade Legislation on U.S. Agriculture," Doane Advisory Services, http://tfi.org/issues/climatechange.cfm.

Brookings Institution, "Consequences of Cap and Trade," June 2009, http://www.brookings.edu/~/media/Files/events/2009/0608_climate_change_economy/20090608_climate_change_economy.pdf.

CRA International, "Impact on the Economy of the American Clean Energy and Security Act of 2009," May 2009, http://www.crai.com/uploadedFiles/Publications/impact-on-the-economy-of-the-american-clean-energy-and-security-act-of-2009.pdf.

Appendix B. Selected Studies of Potential Economic Impacts of Unmitigated Climate Change

USDA, *The Effects of Climate Change on U.S. Ecosystems*, December 2009, http://www.usda.gov/img/content/EffectsofClimateChangeonUSEcosystem.pdf.

USDA, *The Effects of Climate Change on Agriculture, Land Resources, Water Resources, and Biodiversity in the United States*, May 2008, http://www.climatescience.gov/Library/sap/sap4-3/final-report/default.htm.

Massachusetts Institute of Technology, "Agriculture: The Potential Consequences of Climate Variability and Change for the United States," June 2002, Joint Program on the Science and Policy of Global Change.

Institute for Policy Integrity, "The Other Side of the Coin: The Economic Benefits of Climate Legislation," Policy Brief 4, September 2009, http://www.policyintegrity.org/documents/OtherSideoftheCoin.pdf.

J. Bloomfield and T. Francesco, "Agriculture: The Potential Impacts of Global Warming on U.S. Agriculture," *First National Assessment of the Potential Consequences of Climate Variability and Change*, 2000, http://www.climatehotmap.org/impacts/agriculture.html.

Environmental Working Group, *Crying Wolf: Climate Change Will Cost Farmers Far More Than a Climate Bill*, October 2009, http://www.ewg.org/agmag/2009/10/climate-change-will-cost-farmers-far-more-than-a-climate-bill/.

Author Contact Information

(name redacted)
Specialist in Agricultural Policy
#redacted#@crs.loc.gov, 7-....

(name redacted)
Specialist in Environmental Policy
#redacted#@crs.loc.gov, 7-....

(name redacted)
Specialist in Natural Resources Policy
#redacted#@crs.loc.gov, 7-....

(name redacted)
Analyst in Agricultural Conservation and Natural Resources Policy
#redacted#@crs.loc.gov, 7-....