



Agriculture and Greenhouse Gases

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Summary

This report examines the implications for agriculture of the ongoing but inconclusive debate about global climate change. In that debate, agriculture's role is multifaceted. Agriculture is both a source of several greenhouse gases (GHGs) and a "sink" for absorbing carbon dioxide, the most common GHG, thereby partly offsetting emissions. Overall, agriculture is a comparatively modest source of U.S. GHG emissions: it accounts for approximately 7% of U.S. emissions, while sectors such as transportation and electricity generation account for much larger shares. Agriculture's GHG emissions are principally in the form of methane and nitrous oxides emissions.

Whatever the current or future Congresses may do regarding climate legislation, interest in existing and prospective responses by government and others will continue. Administration efforts to develop policies and strategies to address GHGs and climate change have been underway for some time. Two actions by the Environmental Protection Agency (EPA) have drawn the attention of the agriculture industry. One is regulating emissions of GHGs under the Clean Air Act (CAA) and subsequent GHG emission standards for new motor vehicles which, in turn, trigger certain CAA permitting requirements. A second, related action is a rule to require reporting of GHG emissions by certain facilities. Regarding both, EPA took steps to focus on the largest emitters and ensure that few agricultural sources would be subject to new GHG requirements. Still, EPA's overall initiatives have been widely criticized, and the 111th Congress intervened through a funding bill to largely exclude agriculture from EPA's regulatory requirements. During the 111th Congress, the House passed a comprehensive climate change bill (H.R. 2454), and a Senate committee reported a companion (S. 1733). Although no legislation was enacted, both bills included provisions excluding agriculture from regulatory requirements and promoting agricultural practices to reduce or offset emissions from regulated sources.

Traditionally, practices such as conservation tillage have been used for soil conservation and water quality improvement, but their value for climate change abatement or mitigation is receiving increased attention. A number of strategies, technologies, and practices exist to reduce methane and nitrous oxides emissions at the farm level, but implementation faces financial and monitoring challenges.

Programs administered by the U.S. Department of Agriculture (USDA) provide financial incentives and technical assistance to encourage implementation of certain farming practices. While the focus of most programs is not on GHG emission reduction, USDA is giving greater attention to GHGs in administering its suite of existing programs.

Results of the 2010 congressional elections have altered political dynamics in Congress on many issues, and leadership of both political parties have indicated that neither currently plans to pursue comprehensive approaches to addressing climate change in the 112th Congress, although some elements of previous proposals may move through the legislative process. How agriculture fits in these discussions—both as a source of GHG emissions and contributions that the sector can make to mitigating climate change—has drawn interest in the past and likely will do so again.

Contents

Introduction	1
Agricultural Emissions and Sequestration of Greenhouse Gases	2
Carbon Dioxide.....	3
Methane and Nitrous Oxides	4
Methane Emissions from Agriculture	5
Nitrous Oxides Emissions from Agriculture.....	6
Data Uncertainty and Varying Estimates.....	7
EPA Activities	8
Regulating GHGs under the Clean Air Act and the Tailoring Rule	8
Mandatory Reporting of Greenhouse Gases.....	9
Congressional Interest.....	10
Agricultural Conservation Practices and GHGs	12
USDA Activities and Programs	14
Conservation Programs	15
Environmental Services Markets	17
Other USDA Farm Programs.....	18
Conclusion.....	19

Figures

Figure 1. Estimated Emissions of Methane and Nitrous Oxides: U.S. Total and Agricultural Sector, 2008	5
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Tables

Table 1. Estimated GHG Emissions and Sequestration: U.S. Agriculture and U.S. Total, All Sources (2008).....	2
Table 2. Conservation Practices and GHGs.....	14
Table 3. Estimated GHG Mitigation Impact of USDA Conservation Programs.....	17
Table A-1. Estimated Emissions of Methane and Nitrous Oxides: U.S. Agriculture (2008).....	20
Table B-1. USDA Conservation Programs and Land Management Practices	21

Appendixes

Appendix A. Agricultural Sector Emissions of Methane and Nitrous Oxides.....	20
Appendix B. Conservation Practices and Programs Affecting GHGs	21

Contacts

Author Contact Information 23

Introduction

This report examines the implications for agriculture of the ongoing but inconclusive debate about global climate change.¹ Whatever the current or future Congresses may do regarding climate legislation, interest in existing and prospective governmental and private sector responses will surely continue. Existing governmental climate change activities affecting or potentially affecting agriculture include the Environmental Protection Agency's (EPA) initiative under the Clean Air Act to address emissions of greenhouse gases (GHGs); U.S. Department of Agriculture (USDA) conservation programs that can encourage practices affecting agriculture's emissions or sequestration of GHGs; and provisions of law encouraging the use of biofuels.² Private sector concerns about climate change also could affect agriculture. For example, some companies increase investment in drought-tolerant seed technology in response to water resource pressures and potentially longer periods of extreme temperatures resulting from a changing climate.

In the climate change debate, agriculture's role is multifaceted. Agriculture is both a source of several GHGs and a "sink" for absorbing carbon dioxide, the most common GHG, thereby partly offsetting emissions. Overall, agriculture is a comparatively modest source of U.S. GHG emissions: it accounts for approximately 7% of U.S. emissions, while transportation accounts for 27% and electricity generation for 35%. Further, it should be recognized that the data on various agriculture emissions are of varying precisions and that the implications of land use changes for emissions are not well understood and are hard to measure. Similarly, agriculture is a dynamic activity and emissions/sequestration can change and also can be manipulated to some degree.

During the 111th Congress, comprehensive climate change legislation passed the House and was reported by a Senate committee, but no comprehensive bill was enacted. At the same time, the Administration moved forward on several fronts to address climate change, including research, EPA's clean air initiative, and USDA's promotion of conservation practices that can diminish emissions. As these various initiatives progressed, the agriculture community weighed in at several points. One outcome was that the comprehensive climate change bills largely excluded agriculture from regulatory requirements, and another was that Congress through a funding bill excluded agriculture from certain EPA regulatory requirements concerning reporting of emissions (e.g., from manure management practices).

This report places in context federal agricultural policymaking with respect to the climate change debate. It describes agricultural activities involving cropland and livestock production that contribute to emissions and sequestration of GHGs; it reviews recent climate change initiatives, agricultural stakeholder responses, and current status; and it summarizes the implications of ongoing federal programs affecting agricultural emissions and sequestration.

¹ This report does not address the underlying debate over global climate change and the role of humans in contributing to it. For discussion on the science and policy of global climate change, see CRS Report RL34266, *Climate Change: Science Highlights*, by Jane A. Leggett, and CRS Report RL34513, *Climate Change: Current Issues and Policy Tools*, by Jane A. Leggett.

² Discussion of biofuels is beyond the scope of this report. However, for further information, see CRS Report R41282, *Agriculture-Based Biofuels: Overview and Emerging Issues*, by Randy Schnepf, and CRS Report RL34738, *Cellulosic Biofuels: Analysis of Policy Issues for Congress*, by Kelsi Bracmort et al..

Agricultural Emissions and Sequestration of Greenhouse Gases

Agricultural activities can be both a source and a “sink” for GHGs, releasing several GHGs through plant and animal respiration and plant decomposition and removing carbon dioxide (CO₂) through photosynthesis, thus storing/sequestering it in vegetation and soils.³ Animal agriculture contributes directly to emissions of GHGs through a variety of processes such as enteric fermentation in domestic livestock (i.e., digestion) and manure management systems and practices. Non-livestock source categories in agriculture likewise emit GHGs, including rice cultivation, agricultural soil management, and field burning of agricultural residues. A range of land management, agricultural conservation, and other farmland practices also can reduce or abate emissions and/or sequester carbon to some extent. These include soil conservation, manure and grazing management, and land retirement, conversions, and restoration.

As shown in **Table 1**, agriculture is estimated to have emitted 6.9% of total U.S. greenhouse gas emissions in 2008, including CO₂, methane (CH₄), and nitrous oxides (N₂O). Conversely, agriculture is estimated to have been a sink for 5.4% of total GHG emissions that were sequestered in the United States. Unlike other prominent economic sectors (e.g., electricity generation and transportation), agriculture sector emissions are dominated by CH₄ and N₂O, not CO₂.⁴

Table 1. Estimated GHG Emissions and Sequestration: U.S. Agriculture and U.S. Total, All Sources (2008)

Million Metric Tons of CO₂ equivalent (MMTCO₂e)

Source	Emissions ^a	Sequestration ^b	Net
Agriculture CO ₂	59.9	(51.0)	8.9
Agriculture CH ₄	194.0	—	194.0
Agriculture N ₂ O	233.2	—	233.2
Agriculture Subtotal	480.5	(51.0)	429.5
U.S. Total, All Sources	6,956.8	(940.3)	6,016.4
% U.S. Total, Agriculture	6.9%	5.4%	—

Source: U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008*, April 15, 2010, EPA 430-R-10-006, Tables ES-7, 7-1, 2-12; calculations by CRS.

- a. Includes CO₂, CH₄, and N₂O emissions attributable to the agriculture sector, including land use/land use changes and fossil fuel combustion from transportation and other on-farm activities. Excludes emissions from forestry activities and emissions allocated to electricity generation for agricultural activities.

³ Forestry activities, although not a focus of this report, also can be both a source and a sink of GHGs, releasing GHGs through plant decomposition and removing CO₂ through photosynthesis, storing (sequestering) it in trees, vegetation, and soils.

⁴ U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008*, April 15, 2010, EPA 430-R-10-006, <http://www.epa.gov/climatechange/emissions/usinventoryreport.html>. Hereafter, Greenhouse Gas Inventory.

- b. Measured agricultural sequestration categories include cropland remaining as cropland, grassland remaining as grassland, land converted to cropland, and land converted to grassland. Excludes sequestration by forestry activities.

Carbon Dioxide

Billions of tons of carbon in the form of CO₂ are emitted to the atmosphere annually from anthropogenic sources and natural processes. Some agricultural land management uses and practices involve both emissions and removal of CO₂ from the atmosphere, a combination that is referred to as CO₂ flux. Agriculture directly emits CO₂ from fossil fuel combustion by transportation and other on-farm activities; fossil fuel combustion by agricultural sources accounted for an estimated 45.4 million metric tons of CO₂ equivalent (MMTCO₂e) in 2008, or 76% of the CO₂ emissions shown in **Table 1**.

Agriculture soils also emit relatively small amounts of carbon through the application of liming and urea fertilizer (7.6 MMTCO₂e in 2008). The U.S. agricultural sector is a minor source of CO₂ emissions—1% in 2008—while electricity generation accounts for 40%, and transportation accounts for 30%. On the other hand, agricultural soils sequester nearly nine times more carbon than they emit. Soil carbon sequestration is largely due to conversion of cropland, an increase in adoption of conservation tillage practices that preserve soil carbon, and an increase in the amount of organic fertilizer (manure and sewage sludge) that farmers apply to croplands in place of synthetic fertilizers.⁵

EPA's Greenhouse Gas Inventory reports on four categories of agricultural land use practices. Three of these categories—cropland remaining as cropland, grassland remaining as grassland, and land converted to grassland—demonstrated carbon sequestration in 2008, while the fourth—land converted to cropland—contributed emissions of about 6 MMTCO₂e, not sequestration. Carbon sequestration on farm lands is currently estimated to contribute more than 5% of total sequestration by all sources (which occurs principally through forested lands remaining forest land) and to mitigate less than 1% of total annual GHG emissions in the United States (forested lands mitigate about 11% of total annual GHG emissions in the United States).

There is ongoing debate about the permanence, or duration, of many carbon sequestration practices. Permanence depends on the practice itself and such site-specific factors as location, climate and land condition. For example, reforestation and similar forestry activities may be capable of long term emission reduction (from 20 to 200 years). However, cropping practices such as conservation tillage or other cropland changes (e.g., transitioning to improved pasture) may or may not be long term, depending on how long a farmer maintains the practice, whether a farmer receives and continues to receive financial or technical assistance as incentive for maintaining the practice, whether the farmer is able to withstand lower yields in the near-term, or whether high prices shift idle land back into production.⁶

⁵ Ibid., p. ES-12.

⁶ For further information, see CRS Report RS22964, *Measuring and Monitoring Carbon in the Agricultural and Forestry Sectors*, by Ross W. Gorte and Renée Johnson.

Methane and Nitrous Oxides

The two principal GHGs emitted by agricultural sources are CH₄ and N₂O. An estimated one-half of global CH₄ comes from anthropogenic sources (i.e., from human activities), of which agriculture is the largest source; livestock production is a major component within the sector.⁷ EPA estimates that nearly one-third of U.S. CH₄ emissions come from livestock. Agricultural CH₄ is produced by ruminant animals, but it also is emitted during microbial degradation of organic matter under anaerobic conditions. Nitrous oxides are formed as a result of crop fertilization practices, directly via the microbial processes of nitrification and denitrification, and indirectly via volatilization and surface water runoff and leaching into ground water.

In 2008, total anthropogenic emissions of CH₄ and N₂O from all U.S. sectors were 885.8 MMTCO₂e, while total agricultural sector GHG emissions of these two GHGs totaled 427.5 MMTCO₂e, or 48% of total U.S. emissions of both GHGs.⁸ As shown in **Figure 1**, agricultural emissions of CH₄ are predominantly from enteric fermentation in domestic livestock, with lesser contributions by livestock manure management, rice cultivation, and field burning of agricultural residues. Over 90% of agricultural emissions of N₂O are from agricultural soil management, with small contributions by livestock manure management and field burning of agricultural residues.⁹

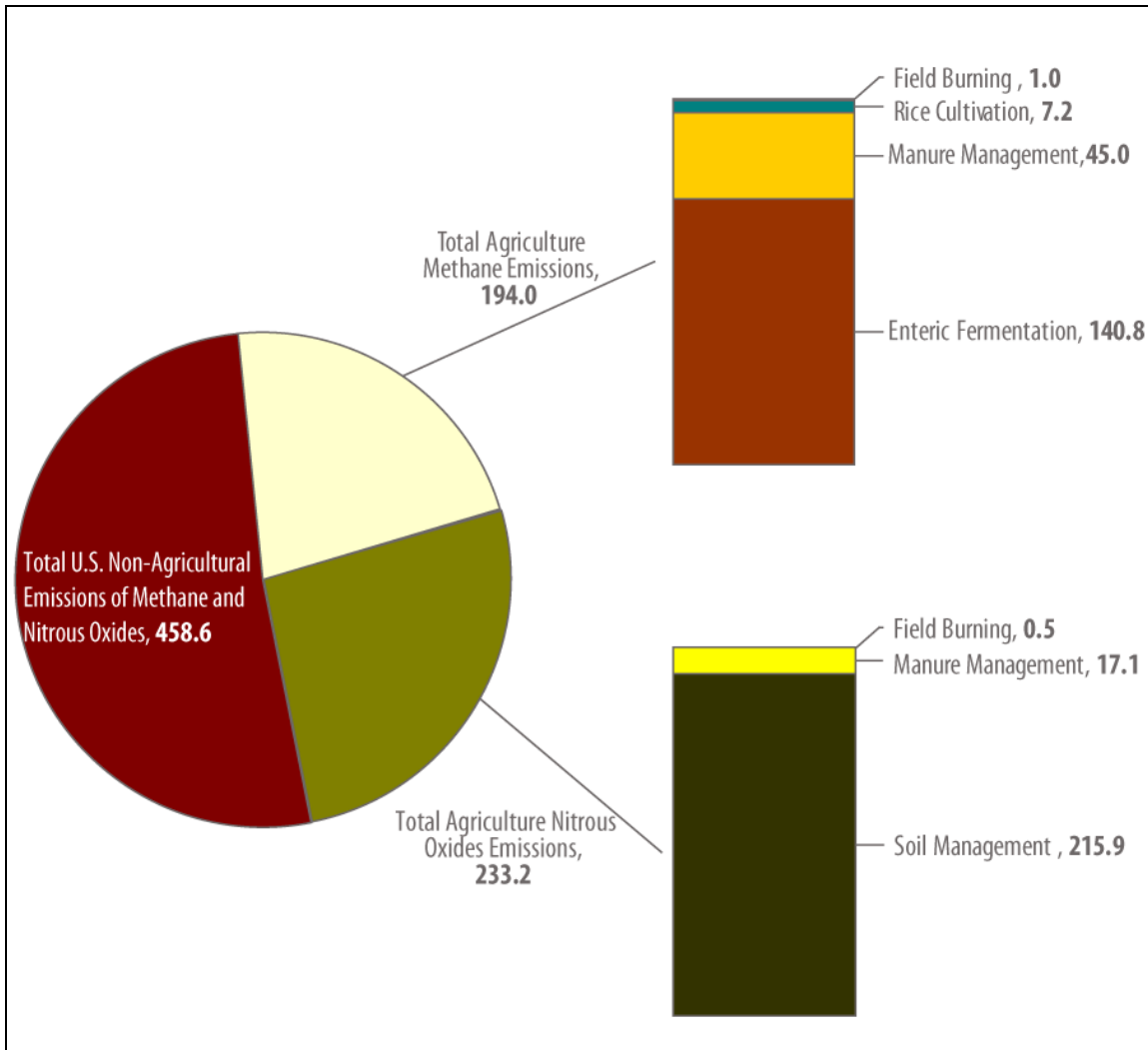
⁷ Ibid. Also see CRS Report R40813, *Methane Capture: Options for Greenhouse Gas Emission Reduction*, by Kelsi Bracmort et al.

⁸ Different GHGs have varying potential to impact climate change by trapping heat in the atmosphere. In particular, CH₄ and N₂O have greater potency, relative to CO₂. Over a 100-year time horizon, CH₄ emissions have 21 times more potency than equivalent tonnage of CO₂, and N₂O emissions are 310 times more potent than CO₂. To correct for these differences, actual emissions of each GHG are converted to the equivalent amount of CO₂ emissions, based on how potent the substance is compared to CO₂, giving rise to the term “CO₂-equivalent.” This measure allows for a comparison of the impacts of emissions of different gases. The figures throughout this report are expressed in carbon equivalents. Greenhouse Gas Inventory, Table ES-1, page ES-3.

⁹ See **Table A-1** in the Appendix of this report for more detail.

Figure 1. Estimated Emissions of Methane and Nitrous Oxides: U.S. Total and Agricultural Sector, 2008

Million Metric Tons of CO₂ equivalent (MMTCO₂e)



Source: Prepared by CRS from U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008*, April 15, 2010, EPA 430-R-10-006, Tables 6-1, 2-1.

Methane Emissions from Agriculture

Livestock sources were responsible for one-third of all U.S. CH₄ emissions in 2008. More than three-quarters of CH₄ emissions from livestock resulted from normal digestive processes (i.e., enteric fermentation¹⁰) in ruminant animals such as cattle, sheep, and goats. Cattle account for the majority of CH₄ emissions from U.S. livestock (because of their large population, large animal size, and particular digestive characteristics), and emissions changes over time tend to track

¹⁰ Enteric fermentation is the production and release of CH₄ via eructation (burping) and flatulence as ruminant animals digest their feed.

changes in beef and dairy cattle populations. Feed quality and the amount of feed intake by animals also affect CH₄ emissions.¹¹

The management of livestock manure also can produce CH₄. Methane is produced from the decomposition of liquid-based livestock manure that is stored or treated in lagoons, ponds, tanks, or pits. Factors that affect the amount of CH₄ produced include temperature, moisture, and storage time, because they influence the growth of bacteria that are responsible for CH₄ formation. An animal's feed also can be a factor: in general, the greater the energy content of the feed, the greater the potential for methane emissions.

When manure is handled as a solid or deposited on pasture, range, or paddock lands, it produces little or no CH₄, and in fact, the majority of manure in the United States is handled as a solid. However, the general trend in manure management, particularly for dairy and swine, is towards use of liquid systems. According to EPA, states such as California, New Mexico, and Idaho have seen increases in dairy populations as the industry becomes more concentrated, along with greater use of liquid-based systems to manage and store manure. A consequence of the dairy industry's shift toward larger facilities translates into an increasing use of liquid manure management systems, which have higher potential CH₄ emissions than dry systems. Between 1990 and 2008, methane emissions from manure management increased on average 2.5% annually. The majority of this increase was from swine and dairy cow manure, where emissions increased 50% and 91%, respectively.¹²

Rice cultivation and field burning of agricultural residues also contribute CH₄ emissions, but they are small contributors of U.S. emissions (1.5% of all CH₄ emissions). Crop residue burning also produces small amounts of both CH₄ and N₂O (see **Figure 1** and **Table A-1**). Although field burning is not a widely used practice of farmers for disposing of crop residues, it is used throughout the United States for disposal of about 3% of the residue of wheat, rice, sugarcane, corn, barley, soybeans, and peanuts. According to EPA, annual emissions from this source have remained relatively constant since 1990.¹³

Nitrous Oxides Emissions from Agriculture

Nitrous oxides emissions are produced by biological processes that occur in soil and water and by a variety of human activities involving agriculture, energy, industry, and waste management. Agricultural soil management practices (e.g., fertilizer application and other cropping practices) produce the majority of N₂O emissions in the United States and accounted for nearly 68% of U.S. N₂O emissions in 2008.¹⁴ Year to year fluctuations in agricultural soil emissions of N₂O reflect variations in weather patterns, synthetic fertilizer use, and crop type.¹⁵

A number of agricultural activities increase mineral nitrogen availability in soils, thereby increasing the amount available for the microbial processes that produce nitrous oxide. Direct increases in soil mineral nitrogen occur as a result of practices such as fertilization, application of

¹¹ Lower feed quality and/or higher feed intake leads to higher emissions. *Ibid.*, p. 6-2.

¹² Greenhouse Gas Inventory, p. 6-7.

¹³ Greenhouse Gas Inventory., p. 6-27.

¹⁴ For more information, see CRS Report R40874, *Nitrous Oxide from Agricultural Sources: Potential Role in Greenhouse Gas Emission Reduction and Ozone Recovery*, by Kelsi Bracmort.

¹⁵ Greenhouse Gas Inventory, pp. 6-16 – 6-19.

manure on soils, and production of nitrogen-fixing crops and forages such as clover and alfalfa. Direct N₂O emissions from croplands tend to be high in the Corn Belt states where highly fertilized corn and nitrogen-fixing soybean crops are grown. Direct emissions also tend to be high from grasslands in the central and western states where a high proportion of land is used for cattle grazing (e.g., emissions by grazing animals whose manure is not managed and from retention of crop residues).

Indirect emissions, which occur when mineral nitrogen is transported from the soil either in gaseous or aqueous forms and later is converted into N₂O, comprise about 25% of emissions from agricultural soil management activities. These types of emissions occur in many of the same U.S. regions as direct emissions (e.g., central and western United States). There are two pathways leading to indirect emissions. The first results from volatilization of nitrogen to the atmosphere (e.g., from nitrogen fertilizer). Indirect emissions also occur through surface transport and runoff from farmland into nearby streams and lakes.

Livestock manure management activities produce N₂O emissions, as well as CH₄. Direct N₂O emissions are released from dry manure handling systems, pasture, solid storage, and—similar to agricultural soil management activities—indirect emissions result from volatilization of nitrogen or runoff of nitrogen during manure treatment, storage, and transportation. Both direct and indirect emissions of N₂O have remained fairly steady since 1990, according to EPA.¹⁶

Data Uncertainty and Varying Estimates

Scientists have considerable confidence in characterizing U.S. GHG emissions, particularly for major industrial sectors where statistics such as fossil fuel consumption are relatively accurate. At the same time, EPA and others recognize that there are uncertainties associated with some of the emission estimates data, especially for sectors that are smaller contributors of emissions, due to a lack of data or an incomplete understanding of how emissions are generated or may be measured.

Uncertainty is apparent in much of the data on agriculture's emissions that are presented in EPA's Greenhouse Gas Inventory. Emissions estimated in the Inventory may vary from year to year based on new data and changes in assumptions and methodology. Regarding CH₄ emissions from enteric fermentation, which are the main agricultural source of those emissions, the Inventory states that the lower- and upper-bound uncertainties are -11% and +18%. However, regarding other emissions, such as N₂O emissions from soil management, which is the main agricultural source of those emissions, there is greater uncertainty. For example, direct emissions, which account for the majority of N₂O emissions from agricultural soil management, have lower- and upper-bound uncertainties of -24% and +63%, while indirect emissions (i.e., from volatilization) have greater uncertainties due to lack of data, as well as uncertainties regarding major crops and application of manure and other organic fertilizer amendments: the uncertainty range in the report is -48% and +142%.¹⁷

Notwithstanding specific uncertainties, whether agriculture's emissions are 7% of the U.S. total, as reported in EPA's Inventory, or 3%, or 11%, is not especially critical to policy debates about GHG emissions and climate change. What is evident in the data is that agriculture is a much

¹⁶ *Ibid.*, pp. 6-6 – 6-7.

¹⁷ *Ibid.*, pp. 6-5, 6-25. To account for data uncertainty and methodological changes in the Inventory, some analysts report emissions averages (e.g., from 2004-2008) rather than single year estimates that are used in this report.

smaller source of emissions than other economic sectors—especially electricity generation and transportation. Thus, while policy debate about climate change continues to occur internationally, nationally, and regionally, one question is where does agriculture fit in those discussions. Broadly speaking, there are three distinct policy tracks that could define agriculture’s role. One option would be to regulate agriculture and other sources of GHGs in order to mitigate or abate emissions. A second would be to promote practices by agricultural sources that may diminish or mitigate the sector’s emissions voluntarily. A third option would be to do nothing.

EPA Activities

Efforts have been underway in the Administration to develop policies and strategies to address GHGs and climate change. The 111th Congress, too, considered legislation in this area: comprehensive climate and energy legislation passed the House in July 2009 and was reported by a Senate committee, but no comprehensive bill was enacted. Agriculture generally has been a major part of these discussions, but so far the agriculture sector has been largely excluded from regulatory and legislative proposals. Two sets of actions by the EPA concerning GHG emissions have drawn stakeholders’ attention.

Regulating GHGs under the Clean Air Act and the Tailoring Rule

First, in July 2008, the Bush Administration published an Advance Notice of Proposed Rulemaking (ANPR) in connection with its consideration of how it should comply with *Massachusetts v. EPA*, in which the Supreme Court held that the Clean Air Act (CAA) authorizes EPA to regulate emissions from new motor vehicles on the basis of their climate change impacts. The Court held that the EPA Administrator must determine whether or not emissions of GHGs from new motor vehicles cause or contribute to air pollution which may reasonably be anticipated to endanger public health or welfare (i.e., an endangerment finding), or whether the science is too uncertain to make a reasoned decision.¹⁸ Responding to this ruling with the ANPR, EPA discussed a wide range of CAA authorities and programs that could potentially be used to address climate change, including the permitting provisions in Title V of the act.¹⁹ The ANPR did not propose or recommend the use of any particular CAA authority, or commit to specific next steps to address GHGs from any category of emission sources.

Agricultural sources were not specifically referenced in any of this ANPR discussion; nevertheless, agriculture stakeholders—especially many representing livestock operations—were highly critical of potential economic impacts on their operations and the possibility that Title V permits might be required. In the months following the ANPR, EPA officials said that the agency had no plans to tax livestock or pursue other “doomsday scenarios” for new regulations.²⁰ The public comment period on the ANPR ended in November 2008; no further action on it occurred.

¹⁸ 549 U.S. 497 (2007). For information, see CRS Report RS22665, *The Supreme Court’s Climate Change Decision: Massachusetts v. EPA*, by Robert Meltz.

¹⁹ Title V requires major industrial sources of air pollutants to obtain permits which detail all of the federal emission control requirements that apply to the facility.

²⁰ EPA Administrator Lisa P. Jackson, “Address, 2009 USDA Agricultural Outlook Forum,” Feb. 26, 2009, http://www.usda.gov/oce/forum/2009_Speeches/Speeches/Jackson.pdf.

However, in December 2009, EPA Administrator Jackson signed two endangerment findings about GHGs. First, the Administrator found that the current and projected concentrations of six GHGs in the atmosphere (including CH₄ and N₂O) threaten the public health and welfare of current and future generations. Second, the Administrator found that GHG emissions from motor vehicles contribute to the atmospheric concentrations of the six key GHGs and hence to the threat of climate change.²¹ The endangerment finding does not itself impose any CAA requirements on industry or other entities or trigger regulation under the entire act. However, the endangerment finding is a prerequisite to finalizing proposed greenhouse gas emission standards for light-duty vehicles, which EPA proposed jointly with the Department of Transportation in September 2009. When EPA's proposed light-duty vehicle rule takes effect (expected to be January 2011), other CAA requirements will be triggered. In particular, stationary sources that emit any of the six GHGs covered by the endangerment finding will be subject to certain permitting requirements under the Title V operating permit and New Source Review (NSR) provisions in the law.²²

Related to the CAA requirements that are triggered by the endangerment finding and light-duty vehicle rule, on May 13, 2010, EPA issued a rule specifying thresholds for GHG emissions that define when Title V and NSR permits would be required. In the absence of the rule, called the GHG Tailoring Rule, sources that emit as little as 100 tons per year of CO₂ equivalent of GHGs would be subject to CAA permits. In order to limit the number of facilities that would be required to obtain permits, in the Tailoring Rule EPA established a threshold of 100,000 tons per year of CO₂ equivalent of GHG emissions. EPA estimates that the rule will cover 67% of the nation's largest stationary source GHG emitters, while shielding small businesses and agriculture operations from new permitting requirements.²³ EPA believes that livestock and production agriculture operations will not be subject to CAA permitting as a result of the Tailoring Rule, because of the high threshold in the rule and because the rule does not apply to so-called "fugitive emissions" from sources of enteric fermentation and animal manure management systems.²⁴

The Tailoring Rule does apply to GHG emissions from internal combustion diesel engine generators, including those used on farms. However, because of the 100,000 tpy threshold in the rule, EPA estimates that no farm stationary fuel combustion sources emit GHGs (i.e., CO₂) at levels that would be subject to the rule.

Mandatory Reporting of Greenhouse Gases

A second EPA action that drew agriculture's attention was an April 2009 EPA proposal to require reporting by certain facilities that emit GHGs and by suppliers of fossil fuels and industrial GHGs. The proposal responded to a congressional directive in the FY2008 Consolidated Appropriations Act (P.L. 110-161) for EPA to develop a comprehensive national system for reporting emissions of CO₂ and other GHGs produced by major U.S. sources. Included in the categories of sources that would be subject to the proposed rule were manure management systems that emit, in the aggregate, methane and nitrous oxide in amounts equivalent to 25,000

²¹ For additional information, see <http://www.epa.gov/climatechange/endangerment.html>.

²² For additional information, see CRS Report R40984, *Legal Consequences of EPA's Endangerment Finding for New Motor Vehicle Greenhouse Gas Emissions*, by Robert Meltz. New Source Review (NSR) is a CAA program designed to minimize emissions from new sources and existing sources that are making major modifications.

²³ See "Final GHG Tailoring Rule" at <http://www.epa.gov/NSR/actions.html#may10>.

²⁴ Fugitive emissions are generally defined as emissions which are not released, or could not be reasonably collected and released, through a stack or vent.

metric tons of CO₂ equivalent or more per year. Because of the proposed reporting threshold, EPA initially estimated that fewer than 50 beef cattle, dairy cattle, and swine operations would be subject to the rule; an unknown number of poultry operations also would be covered.²⁵

A number of agriculture stakeholders criticized the proposal. Many noted that agriculture as a whole is responsible for only a small percentage of total GHGs and questioned why manure management systems in particular were included in the proposal, since they are responsible for less than 1% of total U.S. GHGs (see **Table A-1**). Other categories of agricultural sources, such as livestock enteric fermentation and soil management, emit larger amounts of CH₄ and N₂O, but were not included in the proposal. EPA explained that the proposal did not include reporting by the other agriculture categories such as field burning of agricultural residues because, for those sources, there are no direct GHG emission measurement methods available except for expensive and complex equipment. Using emissions estimates for such sources, instead of direct measurement, would have a high degree of uncertainty and likely would burden a large number of small emitters, EPA said. Some who commented on the proposal said that similar concerns—about a lack of accurate measurement methods and the costly burden of compliance with only very small benefits—apply equally to reporting by manure management systems.

The EPA Administrator signed the final reporting rule on September 22, 2009.²⁶ As in the proposal, the final rule applies to manure management facilities with the same reporting threshold of 25,000 metric tpy of CO₂ equivalent of GHGs, but not to other agricultural sources or agricultural land uses. In response to comments about the burden of the rule, EPA removed manure sampling requirements and instead will allow facilities to use default values for estimating emissions. EPA also made certain recalculations of affected facilities and now estimates that approximately 107 livestock facilities will be subject to the reporting rule. The final rule identifies population threshold levels below which facilities are not required to report emissions, such as fewer than 29,300 beef cattle and fewer than 3,200 dairy cattle. These thresholds would exclude 99% of beef feedlots, dairy farms, and others operations with manure management systems.²⁷ Facilities subject to the rule would report annually beginning in January 2011. However, as discussed below, in passing EPA's FY2010 appropriations legislation (P.L. 111-88), Congress included bill language barring EPA from using funds under that act to implement mandatory GHG reporting by manure management facilities.

Congressional Interest

The 111th Congress showed interest in several aspects of issues concerning agriculture and GHGs, acting mainly to exempt or relieve agriculture from potential regulation of sources' GHG emissions.

²⁵ U.S. Environmental Protection Agency, "Mandatory Reporting of Greenhouse Gases; Proposed Rule," 74 *Federal Register* 16562, April 9, 2009.

²⁶ U.S. Environmental Protection Agency, "Mandatory Reporting of Greenhouse Gases," 74 *Federal Register* 56260-56519, October 30, 2009.

²⁷ U.S. Environmental Protection Agency, Office of Atmospheric Programs, Climate Change Division, *Technical Support Document for Manure Management Systems: Proposed Rule for Mandatory Reporting of Greenhouse Gases*, February 4, 2009, p. 6.

First, legislation was introduced in the 111th Congress in response to concerns raised by EPA's July 2008 ANPR that the agency might require CAA permits for GHG emissions from agriculture, which some groups characterized as a "cow tax proposal." The legislation, S. 527 and H.R. 1426, would have amended the Clean Air Act to mandate that no Title V permit be issued for controlling carbon dioxide, nitrogen oxide, water vapor, or methane emissions "resulting from biological processes associated with livestock production." In addition, in the FY2010 appropriations bill for EPA (P.L. 111-88), Congress included a provision similar to the prohibitory language of S. 527 and H.R. 1426. As adopted, the measure prohibits EPA from using funds under the act to promulgate or implement any rule requiring the issuance of CAA Title V permits for GHG emissions associated with livestock production.

Second, also in final action on P.L. 111-88, Congress blocked EPA from using funds in the bill to implement any rule that would require mandatory reporting of GHG emissions from manure management operations. This bill language applies to manure management systems of all sizes, not just to those that emit more than 25,000 metric tons of CO₂ equivalent per year, as contained in EPA's mandatory reporting rule. As noted previously, EPA's rule excludes reporting by 99% of farms with manure management systems; P.L. 111-88 excluded the other 1% of operations.

Third, the 111th Congress debated comprehensive climate change bills and in that context considered whether or how to include agriculture and other sources of GHGs in the legislation. In July 2009, the House passed the American Clean Energy and Security Act of 2009 (H.R. 2454), legislation that covers clean energy, energy efficiency, reducing global warming pollution, transitioning to a clean energy economy, and agriculture and forestry related offsets. The complex and controversial legislation reflected compromises on various issues, including a number of negotiated changes sought by agriculture interests.²⁸ A key feature of the House-passed bill was an economy-wide cap-and-trade system designed to reduce GHG emissions from covered entities. As passed, the legislation excluded any agricultural enterprise or any small business enterprise that emits less than 25,000 tons of CO₂ equivalent of GHG emissions per year. Animal agriculture sources were excluded entirely from the definition of "covered entities" in H.R. 2454, because of their *de minimis* impact on the climate; thus, they would not have been subject to the cap or other mandatory provisions of the bill.²⁹

A key feature of H.R. 2454, as passed by the House, was the creation of a carbon offset provision for agriculture. The so-called "Peterson Amendment" was added to H.R. 2454 just prior to the floor debate, following negotiations between the Chairmen of the House Energy and Commerce Committee and the House Agriculture Committee. Among other provisions, the Peterson Amendment allowed for certain agricultural and forestry activities to become eligible to participate in a carbon offset program. Offsets (emission reductions from non-covered sources) could be purchased by covered entities and used to meet their compliance obligations. Thus, the agricultural and forestry sectors could earn income for any emission reductions that it undertakes, provided that the reductions are measurable and verifiable. The legislation also would have established the offset program under USDA (rather than EPA), a key difference sought by agriculture stakeholders.³⁰

²⁸ "Climate Bill Slated for House Vote June 26; Waxman, Peterson Announce Deal on Offsets," *Daily Environment Report*, June 26, 2009, p. A-11.

²⁹ For information, see CRS Report R40643, *Greenhouse Gas Legislation: Summary and Analysis of H.R. 2454 as Passed by the House of Representatives*, coordinated by Mark Holt and Gene Whitney.

³⁰ For additional information, see CRS Report R40994, *Agriculture and Forestry Provisions in Climate Legislation in* (continued...)

Comprehensive climate change legislation was reported from the Senate Environment and Public Works Committee in February 2010 (S. 1733, the Clean Energy Jobs and American Power Act). Regarding agriculture, this bill was similar to H.R. 2454 in that it used the same emissions threshold (25,000 metric tons of CO₂ equivalent per year) applicable to the cap-and-trade and other mandatory provisions and would exclude animal agriculture from the definition of “covered entities.” Like H.R. 2454, S. 1733 would have allowed for agriculture and forestry offsets as part of a cap-and-trade scheme. Also in the Senate, the Clean Energy Partnerships Act of 2009 (S. 2729) was introduced by Senator Stabenow shortly after the Senate Environment and Public Works Committee completed work on S. 1733. This bill (often referred to as the “Stabenow Amendment”) would have expanded the agricultural and forestry carbon offset provisions in the comprehensive climate bills (e.g., S. 1733) and also would have allowed for certain other provisions benefitting U.S. farmers and landowners.

Agricultural Conservation Practices and GHGs

Some degree of GHG emissions reduction from agricultural activities can be achieved with existing conservation and land management practices, which also conserve and improve the quality of soil, water, air, energy, and plant and animal life.³¹ Thus, in addition to or in place of regulating agricultural emissions, another policy option could be to promote various voluntary on-farm practices—ranging from reduced tillage to prescribed grazing—that could mitigate emissions. The effectiveness, complexity, cost, and break-even point of the conservation practice varies based on the farm type, farm size, land management, and agricultural commodity, among other factors. A list of selected conservation practices that can reduce agricultural GHG emissions is displayed in **Table 2**.

Typically, conservation practices have been used for soil conservation and water quality improvement, not climate change abatement or mitigation. However, recent investigations have shown certain conservation practices can significantly reduce agriculturally based GHG emissions. Ideal conservation practices that also could reduce GHG emissions are associated with the primary agricultural sources of these emissions (described previously)—enteric fermentation, manure management, and agricultural soil management—or more simply, croplands and livestock. Conservation practices that fall under the domains of nutrient management, tillage operations, field management, precision agriculture, manure management, and dietary management will likely have the most influence on decreasing agricultural GHG emissions. A combination of practices may be necessary in some cases to significantly reduce GHG emissions. However, certain conservation practices may decrease a single GHG while simultaneously increasing others.³²

(...continued)

the 111th Congress, by Renée Johnson and CRS Report RL34436, *The Role of Offsets in a Greenhouse Gas Emissions Cap-and-Trade Program: Potential Benefits and Concerns*, by Jonathan L. Ramseur.

³¹ Federally supported conservation practices for environmental improvement and agricultural productivity originated with the Soil Conservation and Domestic Allotment Act (P.L. 74-46, 49 Stat. 163) in April 1935, establishing the Soil Conservation Service (SCS) within the USDA. The USDA Natural Resources Conservation Service (NRCS, formally SCS) currently maintains standards for more than 150 conservation practices. A conservation practice standard contains information on why and where the practice is applied, and sets forth the minimum quality criteria that must be met during the application of that practice in order for it to achieve its intended purpose(s).

³² For example, restoring a wetland would sequester CO₂, but could also release CH₄.

Depending on the agricultural source of GHG emissions, different conservation practices would likely need to be used to obtain desired reductions. For instance, GHG control strategies for cropland differ from those used for livestock. Cropland GHG emissions generally are distributed over a vast area of land. Land management practices, sometimes referred to as “non-structural practices,” work well to reduce GHG emissions from cropland.³³ On the other hand, livestock GHG emissions may be widely dispersed (emissions originate from a herd of cattle grazing) or may emanate from a point-source (emissions originate from the manure handling system). A mixture of feed management, nonstructural practices, and structural practices may be used to reduce livestock GHG emissions.

In addition to reducing GHG emissions directly, some conservation practices provide another climate change benefit: carbon sequestration (storage), which takes carbon out of the atmosphere. Wetland restoration is a prime example of a conservation practice that sequesters carbon by re-establishing a sustainable ecosystem that provides a relatively greater degree of permanence in CO₂ sequestration than some other practices.³⁴

Strategies, technologies, and practices to reduce CH₄ and N₂O emissions at the farm level are not mandated by federal policies. As discussed further below, current federal policies are voluntary and offer incentives for reducing GHG emissions. Absent mandates or increased incentives, financial and monitoring challenges have stalled large-scale adoption of certain practices and technologies. For example, CH₄ emitted from a dairy farm via enteric fermentation (i.e., digestion) and manure management can be reduced by feeding dairy cows a high-quality forage and using an anaerobic digestion system to capture methane from the manure. However, the high cost of anaerobic digestion systems is a significant barrier to their widespread use for methane capture.³⁵ Similarly, N₂O emitted from corn fields due to nutrient and soil management efforts (e.g., fertilization and tillage) can be reduced with efficient application of fertilizer and conservation tillage, but costs of adopting appropriate technologies and practices can be prohibitive. Overall, problems of quantifying, monitoring, and verifying emission reduction or carbon storage may make it impracticable to include many agricultural activities in some GHG reduction programs, such as trading, because they might not meet credible standards.³⁶

³³ Examples of non-structural practices include crop residue management, nutrient management, and precision agriculture.

³⁴ As noted previously, there is ongoing debate about the permanence, or duration, of many carbon sequestration practices, depending on the practice itself and such site-specific factors as location, climate and land condition. For information, see CRS Report RS22964, *Measuring and Monitoring Carbon in the Agricultural and Forestry Sectors*, by Ross W. Gorte and Renée Johnson.

³⁵ For more information on challenges to widespread implementation of anaerobic digestion systems, including the difficulty of quantifying their benefits, see CRS Report R40667, *Anaerobic Digestion: Greenhouse Gas Emission Reduction and Energy Generation*, by Kelsi Bracmort.

³⁶ For information, see CRS Report RS22964, *Measuring and Monitoring Carbon in the Agricultural and Forestry Sectors*, by Ross W. Gorte and Renée Johnson.

Table 2. Conservation Practices and GHGs

Category	Practice		GHGs Affected		
	Activity	Description	CO ₂	CH ₄	N ₂ O
Cropland	Nutrient management planning	Timing, rate, and type of fertilizer applications	X	X	X
	Fertilizer land application	Incorporating manure fertilizer, synchronizing N supply with plant need through timing and placement (e.g., precision agriculture)		X	X
	Proper nutrient crediting (manure/crops)	Crediting nutrient inputs from prior year amendments or legumes		X	X
	Residue management	Using reduced or no-till practices reduces	X		X
	Pasture and hay planting	Planting high nutrient species and maintaining permanent, vigorous plant growth	X	X	X
Livestock	Manure management	Relocating manure fertilizer from crop land with nutrient excesses to crop land with nutrient deficiencies; anaerobic digestion technology; covered lagoon with flaring		X	X
	Dietary management	Managing animal diets effectively (e.g., feed additives)		X	X
	Conservation crop rotation	Using legume crops in rotation	X		

Source: Adapted by CRS from Solomon Haile, Clyde Fraisse, and P.K. Ramachandran Nair, et al., *Greenhouse Gas Mitigation in Forest and Agricultural Lands: Reducing Emissions*, University of Florida IFAS Extension, AE443, December 2008, <http://edis.ifas.ufl.edu/pdffiles/AE/AE44300.pdf>. The table reflects no relative order of importance of the cited control strategy or activity.

USDA Activities and Programs

Existing conservation and farmland management programs administered at the federal and state levels often encourage agricultural practices that can reduce GHG emissions and/or sequester carbon (see **Table 2**). Most of these programs are voluntary and were initiated mainly for other production or environmental purposes (such as soil fertility and water quality improvement). Few existing programs specifically address GHG emission concerns in the agriculture and forestry sectors. However, USDA and some states have started to focus additional attention on the

potential for emissions reduction and carbon storage under certain existing programs.³⁷ These include conservation, forestry, energy, and research programs within existing farm legislation.

In general, conservation programs administered by USDA and state agencies encourage farmers to implement certain farming practices and often provide financial incentives and technical assistance to support their adoption. Participation in these programs is voluntary, and long-term maintenance of implemented practices is not mandatory following the completion of a contract. The effectiveness of these practices depends on the type of practice, how well it is maintained, and also on the length of time a practice is undertaken. These programs are generally designed to address site-specific improvements based on a conservation plan developed with the assistance of USDA technical field staff, state extension services, or private technical service providers. Conservation plans consider the goals and land resource base for an individual farmer or landowner and are typically a necessary precursor to participating in USDA's conservation programs.³⁸ This section describes relevant USDA programs that can provide financial and/or technical assistance for the types of on-farm practices described above to mitigate agriculture's GHG emissions.

Conservation Programs

Most conservation programs administered by USDA are designed to take land out of production and improve it (i.e., land retirement/easement programs) or to improve management practices on land in production (working lands programs).³⁹ Programs include some level of technical assistance to assist implementation and typically offer a cost-share contract to producers to implement practices necessary to achieve conservation goals. Many of these programs are provided for in Title II of the 2008 farm bill (P.L. 110-246, the Food, Conservation, and Energy Act of 2008).⁴⁰

USDA has expanded some of its existing farmland conservation programs to further encourage agricultural emission reductions and carbon sequestration.⁴¹ As described previously, a number of conservation and land management practices can reduce net emissions directly, and many of the practices are encouraged under working lands programs, such as the Environmental Quality Incentives Program (EQIP) and the Conservation Stewardship Program (CSP). USDA has provided additional technical guidance to make GHG a priority resource concern in working lands programs by giving greater weight to projects that promote anaerobic digestion, nutrient management plans, and other types of cropland practices, such as installing shelter belts and

³⁷ For additional information on state-level agricultural programs, see CRS Report RL33898, *Climate Change: The Role of the U.S. Agriculture Sector*, by Renée Johnson.

³⁸ Non-industrial private forestland and some forestry activities are eligible under most all conservation programs within USDA. Unlike agroforestry practices, which are used to benefit agriculture production, forestry practices are for the benefit of timber production. While these practices may reduce GHG emissions and increase carbon sequestration, they are not discussed here. For more information on programs that support forestry, see CRS Report RL31065, *Forestry Assistance Programs*, by Ross W. Gorte.

³⁹ For more information on agriculture conservation programs, see CRS Report R40763, *Agricultural Conservation: A Guide to Programs*, by Megan Stubbs.

⁴⁰ For more information on conservation programs in the 2008 farm bill, see CRS Report RL34557, *Conservation Provisions of the 2008 Farm Bill*, by Tadlock Cowan, Renée Johnson, and Megan Stubbs.

⁴¹ For additional discussion on forestry and agricultural activities for carbon sequestration and emissions reduction, see CRS Report RS22964, *Measuring and Monitoring Carbon in the Agricultural and Forestry Sectors*, by Ross W. Gorte and Renée Johnson.

windbreaks, encouraging conservation tillage, and providing resources for biomass energy projects. Several working lands programs list a reduction in emissions as a national priority for the program, which affects the overall funding and ranking of projects. USDA has modified how it scores and ranks offers to enroll land in the Conservation Reserve Program (CRP) in order to place greater weight on installing vegetative covers that sequester carbon. USDA also has an initiative under CRP's continuous enrollment provision to plant up to 500,000 acres of bottomland hardwoods, which are among the most productive U.S. lands for sequestering carbon.

Some programs offer only technical assistance to producers and no financial assistance. USDA has also expanded these programs to encourage GHG emission reductions. For example, the Conservation Technical Assistance (CTA) program lists a reduction in GHG emissions as a national priority. Also, many CTA activities support the scientific underpinnings of the conservation practices that are encouraged by the financial assistance programs, as well as providing the conservation planning requirement for program participation. Compliance programs⁴² such as conservation compliance, sodbuster, and swampbuster do not always require specific practices; however, conservation plan requirements under these programs include land management components that could have significant GHG benefits (e.g., tillage requirements, cover crops, and land conversion requirements). Similar to the conservation programs offering financial assistance, technical assistance programs are voluntary and were initiated predominantly for other production or environmental purposes. **Table B-1** highlights conservation practices affecting GHG emissions and USDA programs that offer possible financial or technical assistance for implementation.

USDA recognizes that conservation practices implemented through many of these programs reduce GHG emissions. It estimates that select conservation programs mitigated as much as 68 MMTCO₂e of GHG in 2007 and could potentially mitigate over 81 MMTCO₂e of GHG by 2020 (see **Table 3**). USDA also recognizes that marketable credits may be generated by these conservation programs. Consequently, USDA has recently changed many of its conservation program rules to remove any claim on these credits.⁴³

⁴² Compliance provisions prohibit a producer from receiving many federal farm program benefits (including conservation assistance) when conservation program requirements for highly erodible lands and wetlands are not met.

⁴³ The following program rules include a section recognizing the credits generated by programs and asserting no direct or indirect claim on these credits: EQIP (7 CFR §1466.36), WRP (7 CFR §1467.20), AMA (7 CFR §1465.36), GRP (7 CFR §1415.10), FPP (7 CFR §1491.21), WHIP (7 CFR §636.21), CRP (7 CFR §1410.63(6)), and HFRP (7 CFR §625.8). Also see CRS Report R40692, *Agricultural Conservation Issues in the 111th Congress*, by Megan Stubbs.

Table 3. Estimated GHG Mitigation Impact of USDA Conservation Programs
(Tons of CO₂ equivalent)

Program	2007	2012	2020
CRP	59,600,000	57,140,000 ^a	53,000,000
EQIP	3,938,900	7,877,100	14,178,200
CTA	3,927,600	7,264,000	12,602,300
GRP	7,400	15,400	27,700
WRP	184,000	200,000	250,000
WHIP	251,900	347,800	501,200
CSP	25,400	508,000	685,800
Total	67,935,200	73,352,300	81,245,200

Source: U.S. Department of State, *U.S. Climate Action Report 2010*, Fifth National Communication of the United States of America Under the United Nations Framework Convention on Climate Change, Washington, DC, June 2010, <http://www.state.gov/g/oes/rls/rpts/car/index.htm>, and Richard Swenson, "Conservation Programs that Can be Used to Mitigate Climate Change," Presentation at the Soil and Water Conservation Society Annual Conference, St. Louis, MO, July 20, 2010.

Notes: CRP = Conservation Reserve Program; CSP = Conservation Stewardship Program; CTA = Conservation Technical Assistance; EQIP = Environmental Quality Incentives Program; GRP = Grassland Reserve Program; WRP = Wetlands Reserve Program; and WHIP = Wildlife Habitat Incentives Program. Estimates of the mitigation impacts of programs are provided by USDA, based on the agency's experience and assumptions related to the implementation of voluntary programs. These estimates may include assumptions about the continued or increased participation of partners, development and deployment goals, and/or whether the necessary commercialization or significant market penetration is achieved.

a. Figure represents a 2010 estimate for CRP. A 2012 estimate is not available.

Environmental Services Markets

In addition to expanding several existing conservation programs that were created mainly for purposes other than GHG emission reduction, the 2008 farm bill also included a new conservation provision intended to facilitate the participation of farmers and ranchers in emerging carbon and emissions trading markets. Section 2709 of the bill directed USDA to establish guidelines for standards, accounting procedures, reporting protocols, and verification processes for carbon storage and other types of environmental services markets.⁴⁴ This provision was also intended to help address some of the measurement and quantification issues surrounding agricultural and forestry carbon credits, as well as to expand existing voluntary conservation and other farm bill programs, providing incentives that could accelerate opportunities for agriculture and forestry to reduce emissions associated with climate change, adopt energy efficiency measures, and produce renewable energy feedstocks.

In response to the farm bill provision, USDA created a federal "Conservation and Land Management Environmental Services Board" to assist USDA with the "development of new

⁴⁴ Section 2709 of P.L. 110-246 amended Section 1245(f) of the Food Security Act of 1985. Ecosystem services refers to the environmental goods and services and other benefits that society obtains from the environment and ecosystems, both natural and managed. Examples include water filtration, flood control, provision of habitat, carbon storage, and many others. For more information, see CRS Report RL34042, *Provisions Supporting Ecosystem Services Markets in U.S. Farm Bill Legislation*, by Renée Johnson.

technical guidelines and science-based methods to assess environmental service benefits which will in turn promote markets for ecosystem services including carbon trading to mitigate climate change.”⁴⁵ A federally chartered public advisory committee, consisting of farmers, ranchers, forest landowners, and tribal representatives, as well as representatives from state natural resource and agriculture departments, plus public members, was set up to advise the board. USDA also established an Office of Ecosystem Services and Markets to provide administrative and technical assistance in developing the uniform guidelines and tools needed to create and expand markets for ecosystem services in the farming and forestry sectors. Activities of this Office or the Board cannot be identified.⁴⁶

Other USDA Farm Programs

In addition to USDA’s conservation programs, several farm bill programs are intended to encourage renewable energy projects and activities that can reduce GHG emissions and/or sequester carbon.

Renewable energy projects received additional program funding in three titles of the 2008 farm bill: Title II (Conservation), Title IX (Energy), and Title VII (Research).⁴⁷ One provision in the energy title, the Rural Energy for America Program (REAP), provides mandatory funding for grants for energy audits, renewable energy development, and financial assistance to promote energy efficiency and renewable energy development for farmers and rural small businesses.⁴⁸ This program also provides funding to support construction of anaerobic digesters in the livestock sector. Limited information is available regarding the current number of anaerobic digesters⁴⁹ installed through REAP. According to a USDA report, since 2003, the Section 9006 grants (precursor to REAP) funded approximately \$26 million for anaerobic digesters and have leveraged \$123 million in private investment. Over 90 digesters have been funded, of which 19 are operational, 6 are near completion, and 66 are under development.⁵⁰

Renewable energy funding also is available through other federal programs.⁵¹ The 2008 farm bill created the Biomass Crop Assistance Program (BCAP) to assist in the development of renewable energy feedstocks, including cellulosic ethanol, and to provide incentives for producers to harvest, store, and transport biomass.⁵² BCAP incentivizes the conversion to dedicated energy

⁴⁵ USDA, “USDA Announces New Office of Ecosystem Services and Markets,” Release No. 0307.08, Dec. 18, 2008.

⁴⁶ In March 2010, USDA announced that the Office’s title was changed to the Office of Environmental Markets (OEM) and its functions were moved to the USDA Natural Resources and Environment (NRE) mission area. In addition to OEM, USDA’s NRE mission area oversees the USDA Forest Service and the Natural Resources Conservation Service.

⁴⁷ For additional information on renewable energy provisions in the 2008 farm bill, see CRS Report RL34130, *Renewable Energy Programs in the 2008 Farm Bill*, by Megan Stubbs.

⁴⁸ Previously referred to as Section 9006 (Renewable Energy Systems and Energy Efficiency Improvements) in the 2002 farm bill. Section 9007 of the 2008 farm bill amended the 2002 provision and renamed the program the Rural Energy for America Program.

⁴⁹ For additional information on anaerobic digesters, see CRS Report R40667, *Anaerobic Digestion: Greenhouse Gas Emission Reduction and Energy Generation*, by Kelsi Bracmort.

⁵⁰ William F. Lazarus, Farm-Based Anaerobic Digesters as an Energy and Odor Control Technology: Background and Policy Issues, USDA Office of the Chief Economist Office of Energy Policy and New Uses, Agricultural Economic Report Number 843, February 2008, <http://www.usda.gov/oce/reports/energy/AnerobicDigesters0308.pdf>, p. 6.

⁵¹ See CRS Report RL34130, *Renewable Energy Programs in the 2008 Farm Bill*, and CRS Report R40110, *Biofuels Incentives: A Summary of Federal Programs*.

⁵² For additional information on BCAP, see CRS Report R41296, *Biomass Crop Assistance Program (BCAP): Status* (continued...)

crops, which is suggested to help mitigate the negative effects of GHG emissions.⁵³ Concerns remainder, however, regarding the impact of energy crops on other aspects of the environment (e.g., biodiversity and wildlife habitat).⁵⁴ The farm bill's Title VII (Research) also provides for research on renewable fuels, feedstocks, and energy efficiency and for competitive grants for on-farm research and extension projects.

Conclusion

Questions of whether and how to address human-induced climate change have been widely debated in recent times. Issues of science, economics, values, geopolitics and a host of other concerns have been contentious. The economic stakes in these debates are potentially large—with both the costs of controls and the “costs of inaction” ranging, by some estimates, into trillions of dollars over several decades.

Results of the 2010 congressional elections have altered political dynamics in Congress on many issues, and leaders of both political parties have indicated that they currently do not plan to pursue comprehensive approaches to addressing climate change in the 112th Congress, although some elements of previous proposals may move through the legislative process—for example, certain energy policy elements. How agriculture fits in these discussions has drawn interest in the past and likely will do so again.

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and Issues, by Megan Stubbs.

⁵³ USDA, FSA, *Biomass Crop Assistance Program Programmatic Environmental Impact Statement*, Final, June 2010.

⁵⁴ Les G. Firbank, “Assessing the Ecological Impacts of Bioenergy Projects,” *Bioenergy Research*, vol. 1, no. 1 (March 2008), pp. 12-19.

Appendix A. Agricultural Sector Emissions of Methane and Nitrous Oxides

As shown in **Table A-1**, agricultural activities contributed an estimated 34.2% of all CH₄ emissions and 73.3% of all N₂O emissions in the United States in 2008. Livestock-related categories (enteric fermentation and manure management) were 32.7% of total U.S. CH₄ emissions and 5.4% of total N₂O emissions in 2008, while various land management practices were 8.2% of total U.S. CH₄ emissions and 68% of total N₂O emissions. Between 1990 and 2008, estimated CH₄ emissions from agricultural activities increased by 14.4%, while estimated N₂O emissions fluctuated from year to year, but overall increased by 7.0%.

Table A-1. Estimated Emissions of Methane and Nitrous Oxides: U.S. Agriculture (2008)

Million Metric Tons of CO₂ equivalent (MMTCO₂e)

	MMTCO ₂ e	Percentage of Total
Total anthropogenic GHG emissions, all sectors	6,956.8	100% of all GHG emissions
Total U.S. methane (CH ₄) emissions, all sources	567.6	8.1% of all GHG emissions
Total agriculture CH ₄ emissions, all categories	194.0	34.2% of all CH ₄ emissions
Enteric Fermentation in Domestic Livestock	140.8	24.8% of all CH ₄ emissions
Livestock Manure Management	45.0	7.9% of all CH ₄ emissions
Rice Cultivation	7.2	1.3% of all CH ₄ emissions
Field Burning of Agricultural Residues	1.0	0.2% of all CH ₄ emissions
Total U.S. nitrous oxides (N ₂ O) emissions, all sources	318.2	4.6 % of all GHG emissions
Total agriculture N ₂ O emissions, all categories	233.2	73.3% of all N ₂ O emissions
Agricultural Soil Management	215.9	67.9% of all N ₂ O emissions
Livestock Manure Management	17.1	5.4% of all N ₂ O emissions
Field Burning of Agricultural Residues	0.5	0.1% of all N ₂ O emissions

Source: U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008*, April 15, 2010, EPA 430-R-10-006, Tables 2-1, 6-1; calculations by CRS.

Note: Greenhouse gas emissions also may be measured in teragrams of CO₂ equivalent (Tg CO₂e). One teragram is equal to one million metric tons. The level of certainty for the emissions data varies by source category. Uncertainty rates are more pronounced for the methane and nitrous oxide agricultural source categories due to limited site, crop, and manure management information (see discussion of “Data Uncertainty and Varying Estimates” in the text.)

Appendix B. Conservation Practices and Programs Affecting GHGs

Table B-1. USDA Conservation Programs and Land Management Practices

Conservation Effort	GHG Objectives	General Ecosystem Benefits	USDA Programs
Crops			
Conservation tillage and reduced field pass intensity	Sequestration and emissions reduction	Improves soil, water, and air quality. Reduces soil erosion and fuel use.	AMA, CB, CCPI, CSP, CTA, EQIP, Compliance, Sodbuster ^a
Efficient nutrient management	Sequestration and emissions reduction	Improves water quality. Saves expensive, time, and labor.	AMA, AWEP, CB, CCPI, CSP, CTA, EQIP
Crop diversity through rotations and cover crops	Sequestration	Reduces erosion and water requirements. Improves soil and water quality.	AMA, CB, CCPI, CSP, CTA, EQIP, Compliance, Sodbuster ^a
Livestock			
Manure management	Emissions reduction	On-farm sources of biogas fuel and possibly electricity for large operations. Provides nutrients for crops.	CB, CCPI, CSP, CTA, EQIP, Other ^b
Rotational grazing and improved forage	Sequestration and emissions reduction	Reduces water requirements. Helps withstand drought. Increases long-term grassland productivity.	AMA, CCPI, CSP, CTA, EQIP, GLCI, ^c GRP
Feed management through raising feed efficiency and dietary supplements	Emissions reduction	Reduces quantity of nutrients. Improves water quality. Increases efficient use of fuel.	AMA, CB, CCPI, CSP, CTA, EQIP, Other ^b
Agroforestry^d			
Windbreaks for crops and livestock	Sequestration and emissions reduction	Improves crop and livestock protection and wildlife habitat. Provides alternative income sources (e.g., specialty crops and hunting fees).	AMA, CB, CCPI, CRP, CSP, CTA, EQIP, WHIP
Silvopasture with rotational grazing and improved forage	Sequestration and emissions reduction	Provides annual income from grazing and long-term income from wood products.	CRP, CSP, CTA, EQIP, GLCI, ^c GRP, WHIP, Other ^b
Riparian forest buffer	Sequestration	Improves water quality and wildlife habitat. Provides alternative income source (e.g., specialty crops and hunting fees).	CRP, CSP, CTA, EQIP, GRP, WHIP
Land Use Change			
Conversion of cropland to grassland, wetland, or forestland	Sequestration and emissions reduction	Improves soil, water, and air quality. Reduces soil erosion and fuel use. Improves wildlife habitat.	CRP, CTA, GRP, HFRP, WRP, Compliance, Sodbuster, Swampbuster ^a

Source: Compiled by CRS from USDA/NRCS information including USDA, NRCS, *Conservation Practices and Programs for Your Land: 2008 Farm Bill*, Climate Change Insert, Washington, DC, November 2009.

Notes: Some programs such as CCPI and the Chesapeake Bay Watershed Program (CB) offer additional financial assistance through existing programs like EQIP and WHIP, but are targeted at specific resource concerns or geographic areas.

- a. Conservation compliance, sodbuster, and swampbuster do not always require specific practices; however, conservation plans under these programs could include some of these land management activities.
- b. Renewable energy projects receive additional program funding under titles IX (Energy) and VI (Rural Development) in the 2008 farm bill, as well as other state and federal programs. See CRS Report RL34130, *Renewable Energy Programs in the 2008 Farm Bill*.
- c. Grazing Lands Conservation Initiative (GLCI) is a USDA initiative that utilizes NRCS technical assistance funds to support private grazing conservation.
- d. Although forestry is not the focus of this report, agroforestry encourages the use of forestry in farming operations to create integrated and sustainable land-use systems. Agroforestry practices are implemented for agriculture production benefits, rather than traditional timber production. Because agroforestry practices can reduce GHG emissions and/or sequester carbon, they are included in this table.

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