Chapter 7
Agriculture and Forestry

Overview of GHG Emissions

The agriculture and forestry (AF) sectors are directly responsible for a small amount of New Mexico's current GHG emissions. For agriculture, net emissions were 6.0 MMtCO2e in 2000. Agricultural emissions include CH4 and N2O emissions from enteric fermentation, manure management, agriculture soils and agriculture residue burning. As shown in Figure 7-1, emissions from agricultural soils and enteric fermentation in cattle account for the largest portions of agricultural emissions. The agricultural soils category includes N2O emissions resulting from activities that increase nitrogen in the soil, including fertilizer (synthetic, organic and livestock) application and production of nitrogen fixing crops.

The contribution from manure management has grown significantly since 1990 and is projected to contribute nearly a third of the emissions within the next five to ten years. GHG emissions from agricultural burning are estimated to contribute a very small amount to the agricultural sector emissions. Figure 7-1 shows that little growth is expected in emissions from the agricultural sector beyond 2005.

Forestland emissions refer to the net CO2 flux[1] from forested lands in New Mexico, which account for about 27% of the state's land area. As shown in Table 7-1, US Forest Service data suggest that New Mexico forests and the use of forest products sequestered on average nearly 21 MMtCO2e per year from 1987 to 1997. The data show an accumulation of carbon in each of the forest carbon pools during this period, except for the harvested wood products and landfilled forestry waste pools.[2] These rates of sequestration are assumed to remain constant through 2020.

Opportunities for GHG mitigation in the AF sector involve measures that can reduce emissions within the sector or reduce emissions in other sectors. For example, production of liquid fuels can offset emissions in the transportation sector, while biomass energy can reduce emissions in the energy supply or RCI sectors. The primary opportunities for GHG mitigation are as follows:

- *Production of renewable fuels (in-state production from in-state feedstocks)*: production of renewable fuels, such as ethanol from crops, crop residue, forestry residue or municipal solid waste, can produce significant reductions, when they are used to offset consumption of fossil fuels (gasoline consumption in the transportation sector). This is particularly true when these fuels are produced using processes and/or feedstocks that emit much lower GHG emissions than those from conventional sources;
- *Beneficial use of forest biomass*: expanded use of biomass energy from residue removed from forested areas during treatments to reduce fire risk can achieve GHG benefits by offsetting fossil fuel consumption (either to produce electricity or heat);

[1] "Flux" refers to both emissions of CO2 to the atmosphere and removal (sinks) of CO2 from the atmosphere.
[2] This is not to say that the dead carbon pools (e.g., standing dead, forest floor) are sequestering carbon directly from the atmosphere. These pools accumulate carbon from trees/biomass that transition from a live carbon pool to a dead carbon pool.

Figure 7-1. Historical and Projected GHG Emissions from the Agriculture Sector, New Mexico, 1990 to 2020

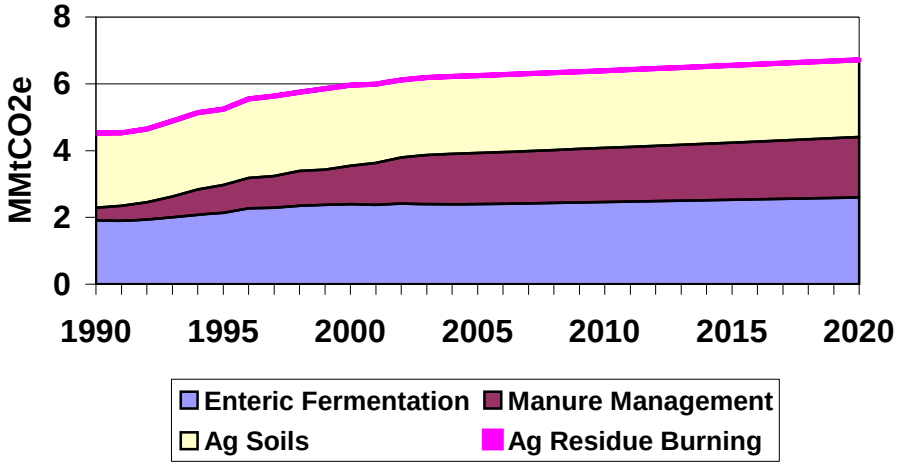

Table 7-1. GHG Emissions (Sinks) from Forestry

Forest Carbon Pool	1990 – 2020[a] MMtCO2e
Live and dead-standing trees and understory	-13.6
Forest floor and coarse woody debris	-3.1
Soils	-5.9
Wood products and landfills	1.8
Total	**-20.9**

[a] Based on USFS data from 1987-1997.

- *Control and utilization of methane at dairies*: methane emissions from manure management can be reduced through the use of anaerobic digesters or other technology. The methane captured can then be used to create electricity, steam, or heat to offset fossil fuel use;
- *Protection of forest and agricultural land from conversion to developed use*: by protecting these areas from development, the carbon in above-ground biomass and below-ground soil organic carbon can be maintained and additional emissions of CO2e to the atmosphere can be avoided;
- *Support of local farming and food networks*: by offsetting a portion of imported food with locally grown and produced food, GHG reductions can be achieved by reducing the emissions associated with food transportation;
- *Utilize crop residues for heat or electricity production:* crop residues that currently have no significant market (e.g. as animal feed) can be used as an energy source for commercial, industrial or residential applications;
- *Support of organic farming*: organic farming has been shown to result in significant increases in soil carbon as compared to conventional cultivation. Additional GHG

reductions are also possible to the extent that organic techniques reduce fossil fuel consumption due to less intensive use of farm equipment; and

- *Retention of agricultural soil carbon*: programs that incentivize growers to keep lands in conservation programs, instead of returning them to active cultivation, will retain the soil carbon in these lands. This issue is especially important given the number of acres due to expire from the federal Conservation Reserve Program in upcoming years.

Additional opportunities for reducing GHGs include: nutrient management to reduce the amount of nitrogen applied and subsequent GHG emissions; and application of conservation tillage/no-till practices on additional croplands in New Mexico. Conservation tillage/no-till practices, as practiced in organic farming, increase the levels of organic carbon in the soil, which indirectly sequesters carbon from the atmosphere.

Key Challenges and Opportunities

In the agricultural sector, production of ethanol and biodiesel were found to offer substantial GHG reduction potential with an estimated 2020 reduction of 1.25 MMtCO2e (combined benefit of Options A-3 and A-11). This is the benefit from in-state production using New Mexico grown feedstocks and/or lower GHG production methods. The benefit is incremental to the benefit achieved via the renewable fuels standards incorporated in TLU Option 6. The benefits for both biodiesel and ethanol are based on production methods and feedstocks that have lower GHG emissions than conventional processes. For ethanol, this means processes that achieve much better GHG reductions than the production from conventional corn-based ethanol. These processes could include cellulosic hydrolysis, biomass gasification combined with biofuels production, or alternative starch-based production (fermentation processes fueled by renewable fuels). For biodiesel, crop production should be promoted that results in significantly better vegetable oil yields than soybean oil, which is currently the most prominent feedstock in the US. Candidates include vegetable oil crops like canola, sunflower, or jatropha that have much higher yields or emerging technologies like algal oil production that could be particularly well-suited to portions of the state.

For biofuels, challenges in New Mexico will be to identify and promote appropriate feedstocks for the production of these fuels. Limited analysis by the CCAG suggests that sufficient feedstock for cellulosic ethanol is available to meet the increased consumption to result from the TLU renewable fuels standard (without affecting existing markets for these materials). There is limited capacity within the state for crop production to support biodiesel production without the use of cropland that is currently used for other purposes or is part of the Conservation Reserve Program. Funding and/or incentives will be needed to support the development of biofuels production capacity, including research and development (for production processes and feedstocks) and scale-up of production facilities.

As shown in the policy option descriptions in Appendix XX, the implementation mechanisms developed for the agricultural sector should focus on methods that avoid conflict with potential future market-based GHG reduction programs. These include GHG credits that could be generated in the agricultural sector through renewable fuels projects, soil carbon projects, and possibly other project types. New regulations that mandate emission reductions or specific

agricultural practices could limit NM agriculture from taking part in emerging carbon markets. Implementation mechanisms that are incentive and education based can avoid these conflicts.

Combining the agricultural and forestry land protection options (F-1 and A-8), 0.33 MMtCO2e/yr in GHG savings is estimated to be saved in 2020. To achieve these reductions, the state will need to work closely with local planning agencies, land owners, and non-governmental organizations to identify lands suitable for acquisition/conservation easements and funding mechanisms. Another benefit to these options, which was not quantified, is the reduction in vehicle-miles traveled due to more efficient development patterns.

Adoption of organic farming methods (Option A-9) has been shown to result in significant benefits by 2020 (0.4 MMtCO2e/yr). Only the reductions achieved through increases in soil carbon have been quantified. The challenges in New Mexico will be to identify and communicate opportunities for growers to adopt these methods in order to achieve the levels of participation envisioned in the policy design (352,000 acres by 2020, which represents 70% of vegetable and field crop production). A strong educational and outreach program will be needed. Closely associated with the organic farming option is the conservation tillage/no-till option (A-6). This option will also result in increases in soil carbon, thereby sequestering carbon dioxide (0.13 MMtCO2e sequestered in 2020 or 0.08 MMtCO2e after accounting for the overlap with Option A-9).

Option A-10 seeks to promote local farming programs and food systems that achieve significant reductions in food transportation-related GHG emissions. The CCAG estimates that if 25% of food consumed in New Mexico is supplied by in-state production by 2020, then over 1 MMtCO2e/yr could be avoided. Challenges for the state will be to develop new programs and/or enhance existing programs to the levels needed to achieve the policy's goals. Methods to better characterize the existing food distribution system in New Mexico are needed, as well as methods to monitor a transition of the system toward more locally produced products.

Option A-7 seeks to retain cropland that is about to expire from the Conservation Reserve Program in an uncultivated state, thereby preventing the oxidation of soil carbon and subsequent CO2 emissions. The CCAG recognizes that additional work is needed to identify appropriate implementation approaches for this option.

In the forestry sector, restoration of forested areas has the potential for GHG benefits (0.1 MMtCO2e/yr by 2020). However, the CCAG recognizes that restoration projects in many cases could be limited by available precipitation. Additional analysis is needed to identify areas where restoration programs are likely to be successful. Fairly significant GHG benefits were also estimated for utilization of biomass energy from forest treatment projects (to reduce fire risk). These benefits totaled nearly 0.7 MMtCO2e/yr in 2010 and 2020 based on current levels of treatment. Success will be achieved through close cooperation between AZ, federal agencies (USFS), and private industry to identify biomass resources and effective end uses for the resource. Through recommendation of the option to support development of biomass gasification and combined cycle technology (BGCC), the CCAG recognized the need to promote efficient biomass energy resource utilization.

Overview of Policy Recommendations and Estimated Impacts

The CCAG recommends a set of 11 policy options for the AF sector that offer the potential for major economic benefits and emissions savings. Figure 7-2 shows the estimated impacts of the

emissions savings on the AF sector emissions. As summarized in Table 7-2, the AF policy recommendations could lead to emissions reductions from reference case projections of 4.8 $MMtCO_2e$ per year by 2020, cumulative savings of over 41 $MMtCO_2e$ from 2007 through 2020, and net cost savings of over 198 million through the year 2020 on a net present value basis (NPV).[3] The weighted average cost of saved carbon from the policy options for which quantitative estimates of both costs and savings were prepared was -$5 per metric ton of CO_2 equivalent, meaning that there is a net savings to the New Mexico economy in implementing this package of options.

Figure 7-2. Impact of Policy Recommendations on GHG Emissions from the Agriculture and Forestry Sector, New Mexico

[INSERT FIG]

The estimated impacts of the recommended policies are shown in Table 7-2. The CCAG policy recommendations described briefly here (and in more detail in Appendix XX to this Report) result not only in significant emissions and costs savings, but offer a host of additional benefits as well. These benefits include (but are by no means limited to): 1) Support of New Mexico agricultural producers in the production of biofuels crops, development of new markets for agricultural byproducts, production of crops to support locally consumed foods, and training/outreach covering energy production and organic farming; 2) Creation of jobs in the biomass energy and liquid biofuels feedstock/production industries; 3) Healthier forests with lower fire risk through the development of markets for forestry residue; and 4) Research and development work to be conducted by New Mexico universities to support many of the policies for this sector.

[3] The net cost savings are based on fuel expenditures, operations, maintenance, and administrative costs, and amortized, incremental equipment costs. All NPV analyses here use a 5% real discount rate.

Table 7-2. CCAG Recommended Policy Options and Results for the Agriculture and Forestry Sector

Agriculture and Forestry Sector Summary of Results						
Option Number	**Policy Name**	**Estimated 2010 GHG Reduction ($MMtCO_2e$)**	**Estimated 2020 GHG Reduction ($MMtCO_2e$)**	**Cumulative 2007-2020 GHG Reduction ($MMtCO_2e$)**	**Estimated Cost or Cost Saving ($/tCO_2e$)**	**Level of CCAG Support**
F-1	Forestland Protection from Developed Uses	0.08	0.13	1.2	22	*Pending*
F-2a	Forest Health & Restoration - Residential Lands	0.18	0.18	2.5	-46	*Pending*
F-2b	Forest Health & Restoration - Other Lands	0.45	0.45	6.3	-15	*Pending*
A-1	Manure Energy Utilization	0.31	0.75	6.3	3	*Pending*
A-2	Biomass Feedstocks for Electricity or Steam Production	0.16	0.32	2.6	-77	*Pending*
A-3	Ethanol Production	0.5	1.0	7.5	3	*Pending*
A-4	Nutrient Management	0.004	0.012	0.08	-46	*Pending*
A-5	Manure Management - Land Application	nq[a]	nq[a]	nq[a]	nq[a]	*Pending*
A-6	Conservation Tillage/No-Till	0.06[b]	0.13[b]	0.60[b]	15	*Pending*
A-7	Convert Agricultural Land to Grassland or Forest	0.36[c]	0.36[c]	4.0[c]	7	*Pending*

A-8	Reduce Permanent Conversion of Agricultural Land and Rangeland to Developed Uses	0.12	0.20	1.6	62	*Pending*
A-9	Programs to Support Organic Farming	0.21	0.40	4.4	0.5	*Pending*
A-10	Programs to Support Local Farming/Buy Local	0.32	1.1	5.9	0.2	*Pending*
A-11	Biodiesel Production	0.10	0.25	2.3	nq[d]	*Pending*
Accounting for Overlap Among Options		2.5	4.8	**41**	**-4.80**	
Net Total All Options		**2.5**	**4.9**	**45**	**-3.80**	
Additional Emissions Savings from Recent Actions (not included in forecast or in policy options above)						
Net Total All Options Plus Recent Actions						

[a] Not quantified due to a lack of information on the GHG benefits associated with different land application and composting techniques.

[b] The GHG benefits for this option overlap with the soil carbon benefits derived from Option A9 on Organic Farming. The overlap has been adjusted in the first set of totals.

[c] Emission reductions are taken against emissions that have not been built into the existing forecast for NM. They refer to emissions associated with acreage assumed to be coming out of the Conservation Reserve Program and returned to active cultivation. Since they aren't included in the baseline, these reductions are left out of the totals.

[d] Not quantified. Information on funding levels needed to promote biodiesel feedstock production was not identified.

Agriculture and Forestry Sector
CCAG Policy Descriptions

The Agriculture and Forestry Sectors include emissions and mitigation opportunities related to use of biomass energy, protection and enhancement of forest and agricultural carbon sinks, control of agricultural methane emissions, production of renewable fuels, and reducing transport emissions from imported agricultural commodities. As described in the options descriptions in Appendix XX, the CCAG recommends policies in the agriculture featuring implementation methods that are voluntarily implemented by individual producers.

F-1 Forestland Protection from Developed Uses

Reduce the rate at which existing forestlands and forest cover are cleared and converted to developed uses or damaged by development that reduces productivity.

The CCAG recommends that policies be developed to decrease the conversion of forest and woodlands to urban and other developed uses to 30 percent or less of the rates of loss to these uses during the 1987-1997 period by 2012 and to 50 percent or less by 2020. A 50% reduction would decrease the conversion rate from 3,900 acres/year to about 1,900 acres/year. By reducing the rates of conversion, both above- and below-ground carbon can be retained, the sequestration potential of these lands is retained, and GHG emissions associated with travel are indirectly reduced via reducing commute distances.

F-2a and b Forest Health & Restoration

Manage sustainable thinning or biomass reduction from residential forestlands (intended to address fire and forest health issues) so that harvested biomass is directed to wood products and renewable energy instead of open burning or decay. F-2a is directed at residential lands (the wildland-urban interface or WUI) and F-2b is directed at non-WUI areas.

Some efforts to reduce biomass in residential forests and woodlands for forest health/sustainability and wildfire suppression include some emphasis on using the extracted woody biomass for wood products and/or energy production (e.g. local residential firewood). However, a large portion of these materials are managed through open burning, or storage or decay off site. The CCAG recommends placing a greater emphasis on wood products and/or energy production, through appropriate mechanisms, incentives, etc. More specifically, the CCAG recommends utilizing 50% or more of the biomass extracted from both WUI and non-WUI areas for wood products and/or energy production by 2012 and continuing through 2020.

A-1 Manure Energy Utilization

Reduce methane emissions from livestock manure through the use of manure digesters installed at dairies. Energy from the manure digesters is used to create heat or power, which offsets fossil

fuel-based energy production and the associated GHG emissions. The goal is to manage dairy manure using anaerobic digesters or other energy capture technology (e.g. biomass gasification) covering 15% of the state-wide dairy population by 2012, 35% by 2020, and 50% by 2050. The policy reduces emissions by offsetting fossil fuel consumption, as well as direct reduction of methane emissions.

A-2 Biomass Feedstocks for Electricity or Steam Generation

Displace fossil fuel usage through the use of agricultural byproducts (e.g., orchard trimmings, other crop residue) as a feedstock for electricity or steam production. The CCAG recommends a goal of using 25% of available biomass by 2012, 50% of available agricultural biomass by 2020, and 75% by 2050. The GHG savings occur as a result of displacing fossil fuel use in the production of electricity or steam. The CCAG recognizes that available biomass is limited to agricultural byproducts that are both technically and economically feasible to recover.

A-3 Ethanol Production

The CCAG recommends that New Mexico adopt programs that align in-state production with the TLU Option 6 ethanol renewable fuels consumption goals of 10% of New Mexico gasoline consumption by 2012, 20% of gasoline consumption by 2020, and 50% of gasoline consumption by 2050. The CCAG recognizes that in-state production goals could be limited by available cropland and waste feedstocks. Careful planning and monitoring of the ethanol production industry will be needed. State incentives should be directed at in-state feedstocks and production methods that achieve much better lifecycle GHG emission reductions than conventional starch-based ethanol production (the benefits of which have already been accounted for under TLU Option 6).

A-4 Nutrient Management

Agronomic practices that tighten the coupling between soil nitrogen availability and crop growth will improve nutrient use efficiency and reduce the likelihood that nitrogen will escape as N_2O, leach as nitrate into groundwater systems, or be transported to surface water systems. Better synchronization of nutrient applications with active crop needs can be achieved with improved nutrient management. The CCAG recommends the development and promotion of '*nutrient management guidelines and strategies*' along with support for enhanced extension and outreach of these guidelines can increase adoption of improved nutrient planning and practices, leading to both lower N_2O emissions and lower fertilizer costs. The initial goal of the policy is to reduce nitrogen fertilizer application rates by at least 10% by 2020.

A-5 Manure Management

Reduce N2O emissions from daily spread and other land application of dairy and feedlot cattle manure through the use of better application methods. These application methods are designed to reduce contact of manure nitrogen with air (lowering the rate of nitrification) and the amount of manure nitrogen loss via leaching and runoff. The policy also seeks to reduce CH4 emissions from dry manure storage by promoting composting of these wastes. The CCAG was unable to identify studies to support the quantification of benefits and costs for this option.

A-6 Conservation Tillage/No-Till

The amount of carbon stored in the soil can be increased by the adoption of conservation tillage. Reducing mechanical soil disturbance reduces the oxidation of soil carbon compounds and

allows more stable aggregates to form. In addition to soil carbon benefits, conservation tillage has numerous co-benefits including reduced wind and water erosion, reduced fuel consumption and improved wildlife habitat. The CCAG's goal is to bring an additional 650,000 acres into conservation tillage/no-till production by 2015 and 1,300,000 acres by 2025. Note that this option has overlap with Option A-9 on Organic Farming (no-till is a common organic farming technique). The overlap in the benefits for these options have been addressed in Table 7-2.

A-7 Convert Agricultural Land to Grassland or Forest

Increase carbon sequestration in agricultural land by converting marginal land used for annual crops to permanent cover (grassland/rangeland or orchard). Also, prevent the loss of soil carbon in the future associated with cropland currently in the Conservation Reserve Program (CRP). Adopt mechanisms to either keep these cropland acres in the CRP or prevent them from either returning to conventionally tilled production or to suburban/urban development.

The CCAG did not identify significant opportunities for conversion of marginal agricultural land in NM; however the protection of CRP acres and their associated soil carbon, is a significant issue. Since the conversion of the expiring CRP acres into cultivated acres was not built into the forecast of emissions, the reductions associated with this option (i.e. those associated with the protection of soil carbon) were not included in the summary totals for the AF sector.

A-8 Reduce Permanent Conversion of Agricultural & Rangeland to Developed Uses

The CCAG recommends that New Mexico adopt programs to reduce the rate at which agricultural lands are converted to developed uses. These recommendations are aligned with the goals of the analogous option for forested lands (F1). The policy should be initiated by 2010 and it should achieve a 30% reduction by 2012; a 50% reduction should be achieved by 2020. By 2020, achieving these goals would save 8,600 acres of land per year from being converted to developed use. This would retain the above- and below-ground carbon on these lands, as well as the carbon sequestration potential of these lands. Transportation emissions would be reduced indirectly through more efficient development and lower vehicle use.

A-9 Programs to Support Organic Farming

The CCAG recommends that New Mexico adopt programs to achieve a long-range goal of increasing organic-certified and non-certified-organic acreage to approximately 70% of the cropland used for vegetable and field crop production in the state by 2050. The organic production acreage could therefore increase to 352,000 acres by 2020 depending on drought impacts and the availability of water. The GHG benefits of organic production are due to its higher levels of soil carbon (indirectly sequestering CO2 from the atmosphere). It also uses fewer chemical inputs, which reduces the GHG emissions associated with the production and transport of these products.

A-10 Programs to Support Local Farming/Buy Local

The CCAG recommends that New Mexico adopt programs to increase the amount of food consumed in the state to be produced locally. From today's approximate 3 percent consumption of local food (much of this is dairy products), by the year 2012, local food systems need to be constructed to shift to 8 percent local food consumption, and to 25% by 2020. Reductions in GHG emissions occur through offsetting imported foods with high embedded GHG with local foods that have significantly lower embedded GHG.

A-11 Biodiesel Production

The CCAG recommends that New Mexico adopt programs to increase the amount of biodiesel produced within the state. The goals are to produce enough biodiesel to meet 10% of New Mexico diesel consumption by 2012, 20% by 2020, and 50% by 2050. This option is paired with TLU Option 6, which targets methods to increase biodiesel consumption in the state. Optimum GHG benefits are achieved when the biodiesel consumed in the state is produced in-state from crops that are much more efficient than conventional crops (i.e. soybean oil). This option includes incentives for research and development of cropping systems and emerging technologies (e.g. algal biodiesel), as well as scale-up of these cropping/production systems to commercial scale.