Chapter 6
Agriculture, Forestry, and Waste Management

Overview of GHG Emissions

The agriculture and waste management sectors together are directly responsible for about 9% of Colorado's current GHG emissions in 2005. For agriculture, gross emissions were 9.6 million metric tons (MMt) of carbon dioxide equivalent (CO_2e) in 2000 (8.8% of Total Gross Emissions). Agricultural emissions include methane (CH_4) and nitrous oxide (N_2O) emissions from enteric fermentation, manure management, agriculture soils and agriculture residue burning. As shown in Figure 6-1, emissions from agricultural soils and enteric fermentation in cattle account for the largest portions of agricultural emissions. The agricultural soils category includes N_2O emissions resulting from activities that increase nitrogen in the soil, including fertilizer (synthetic, organic and livestock) application and production of nitrogen fixing crops. The evaluation of emissions from the agriculture sector includes a study of the net soil carbon flux.[1] Carbon dioxide is either emitted or sequestered as a result of agricultural practices. Net carbon fluxes from agricultural soils have been estimated by researchers at the Natural Resources Ecology Laboratory at Colorado State University, and are reported in the United States (US) Inventory of Greenhouse Gas Emissions and Sinks[2] and the US Agriculture and Forestry Greenhouse Gas Inventory. For Colorado, Table 6-1 below shows a summary of the latest estimates available from the USDA.[3] These data show that changes in agricultural practices are estimated to result in a net sink of –2.0 MMtCO_2e/year in Colorado. Since data are not yet available from USDA to make a determination of whether the emissions are increasing or decreasing, the net sink of –2.0 MMtCO_2e/year is assumed to remain constant.

Although manure management and enteric fermentation comprise a significant portion of the gross agriculture emissions, the contribution of these sources to the total gross agriculture emissions is not projected to increase substantially through 2020. GHG emissions from agricultural burning are estimated to contribute a very small amount to the agricultural sector emissions. Figure 6-1 shows that little growth is expected in emissions from the agricultural sector beyond 2005.

Forestland emissions refer to the net CO_2 flux from forested lands in Colorado, which account for about 34% of the state's land area. As shown in Table 6-2, US Forest Service (USFS) data

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[1] "Flux" refers to both emissions of CO_2 to the atmosphere and removal (sinks) of CO_2 from the atmosphere.

[2] US Inventory of Greenhouse Gas Emissions and Sinks: 1990–2004 (and earlier editions), US Environmental Protection Agency, Report # 430-R-06-002, April 2006. Available at: http://www.epa.gov/climatechange/emissions/usinventoryreport.html

[3] *US Agriculture and Forestry Greenhouse Gas Inventory: 1990–2001*. Global Change Program Office, Office of the Chief Economist, US Department of Agriculture. Technical Bulletin No. 1907. 164 pp. March 2004. http://www.usda.gov/oce/global_change/gg_inventory.htm; the data are in Appendix B table B-11. The table contains two separate IPCC categories: "carbon stock fluxes in mineral soils" and "cultivation of organic soils." The latter is shown in the second to last column of Table F1. The sum of the first nine columns is equivalent to the mineral soils category.

suggest that Colorado forests and the use of forest products sequestered on average nearly 25 $MMtCO_2e$ per year from 1983 to 1997. An accounting of forest carbon flux is done within several carbon pools: live trees; dead-standing trees; live understory; forest floor; coarse woody debris; forest soil organic carbon; landfills; and harvested wood products. 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.[4] These rates of sequestration are assumed to remain constant through 2020. Note that based on the recommendations of the USFS, carbon storage estimates for the forest soil organic carbon pool are not included in the statewide totals because of the considerable uncertainty associated with the estimates.

Figure 6-2 shows estimated historical and projected emissions from the management and treatment of solid wastes and wastewater. Emissions from waste management consist largely of CH_4 emitted from landfills, while emissions from wastewater treatment include both CH_4 and N_2O. In 2000, the waste management sector accounted for 1.7% of total gross emissions in Colorado. Overall, the sector accounts for 2.1 $MMtCO_2e$ in 2005. By 2020, emissions are expected to grow to 3.5 $MMtCO_2e$/year. The growth in emissions is driven largely by the solid waste management sector, in particular uncontrolled landfills. In 2005, over 45% of the emissions were contributed by the uncontrolled landfills sector. By 2020, the contribution from these sites is expected to be over 50% of the sector totals.

The largest contribution to emissions from the waste management sector comes from landfills (LFs), which fall into one of four categories in Colorado Inventory & Forecast: uncontrolled LFs, flared LFs, Industrial LFs, and landfill gas-to-energy (LFGTE) LFs. Also considered is municipal solid waste (MSW) combustion. However, the Colorado Department of Public Health and the Environment (CDPHE) indicated that no MSW combustion took place between 1990 and 2005. Growth rates for landfill emissions in both controlled and uncontrolled landfill categories were estimated by using the historic (1995–2005) growth rates.[5]

GHG emissions (N_2O and CH_4) from municipal and industrial wastewater treatment were also estimated. Due to data availability, only emissions from meat and poultry processing in the industrial wastewater treatment sector were estimated (and these emissions were held constant at 2005 levels for the forecast). Only about 2% of the emissions were contributed by the industrial wastewater treatment sector in 2005. In 2005, about 13% of the waste management sector emissions were contributed by municipal wastewater treatment systems. By 2020, the contributions from municipal wastewater treatment are expected to remain about the same (at about 11% of the waste management sector emissions).

Overall, gross GHG emissions in the agricultural sector were estimated at 8.9 $MMtCO_2e$ in 2005 and are expected to grow to 9.1 $MMtCO_2e$ by 2020 (an increase of 2.2%). For forestry, the CO_2

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[4] 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.

[5] The period from 1995 to 2005 was used since there were a large number of landfill closures during the period from 1987 to 1995 (which could have affected waste management practices). Hence, the post-1995 period is thought to be most representative of waste emplacement rates in the future and subsequent emissions.

sink of –25 $MMtCO_2$ was forecasted to remain constant through 2020 (due to significant uncertainties surrounding future development patterns, wildfire activity, and near-term effects of climate change and their impacts on forest size and health). For waste management, 2005 emissions were estimated to be 2.1 $MMtCO_2e$, and these were forecasted to grow to 3.5 $MMtCO_2e$ by 2020 (an increase of 67%).

Figure 6-1. Historical and projected GHG Emissions from the agriculture sector, Colorado, 1990 to 2020

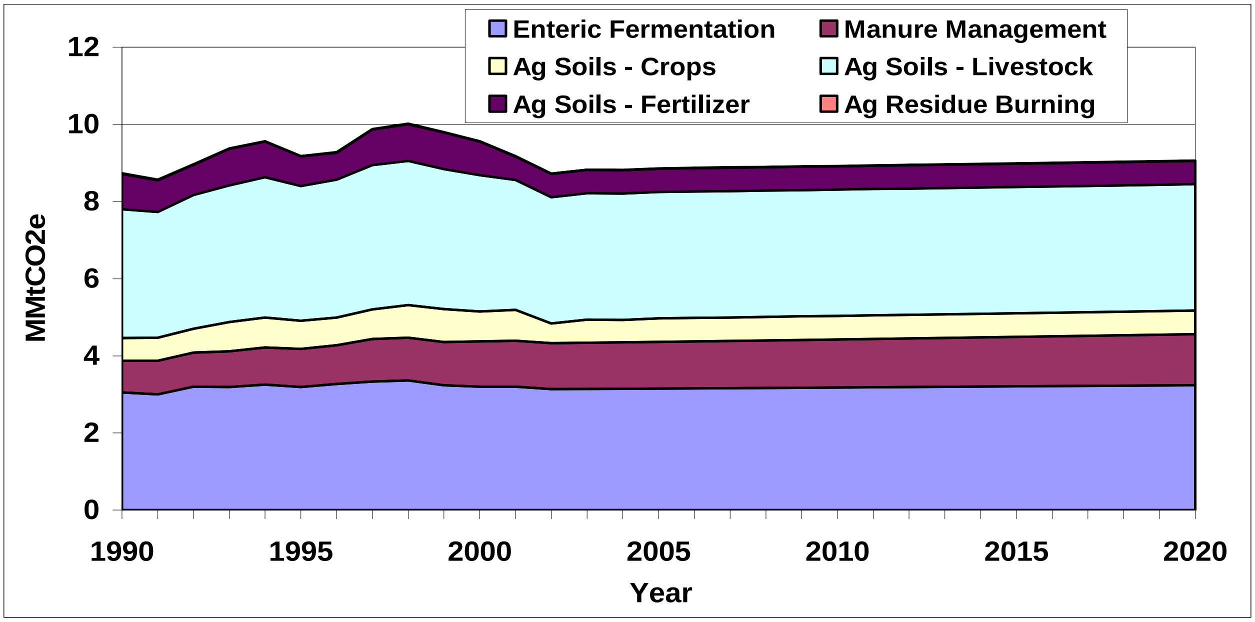


Table 6-1. GHG emissions from soil carbon changes due to cultivation practices ($MMtCO_2e$)

Changes in Cropland			Changes in Hayland				Other			Total[4]
Plowout of grassland to annual cropland[1]	Cropland manage-ment	Other cropland[2]	Cropland converted to hayland[3]	Hayland manage-ment	Cropland converted to grazing land[3]	Grazing land manage-ment	CRP	Manure application	Cultivation of organic soils	Net soil carbon emissions
0.77	–0.15	0.00	–0.55	–0.04	–0.26	0.00	–1.25	–0.53	0.00	–2.00

Based on USDA 1997 estimates. Parentheses indicate net sequestration.

[1] Losses from annual cropping systems due to plow-out of pastures, rangeland, hayland, set-aside lands, and perennial/horticultural cropland (annual cropping systems on mineral soils, e.g., corn, soybean, cotton, and wheat).

[2] Perennial/horticultural cropland and rice cultivation.

[3] Gains in soil carbon sequestration due to land conversions from annual cropland into hay or grazing land.

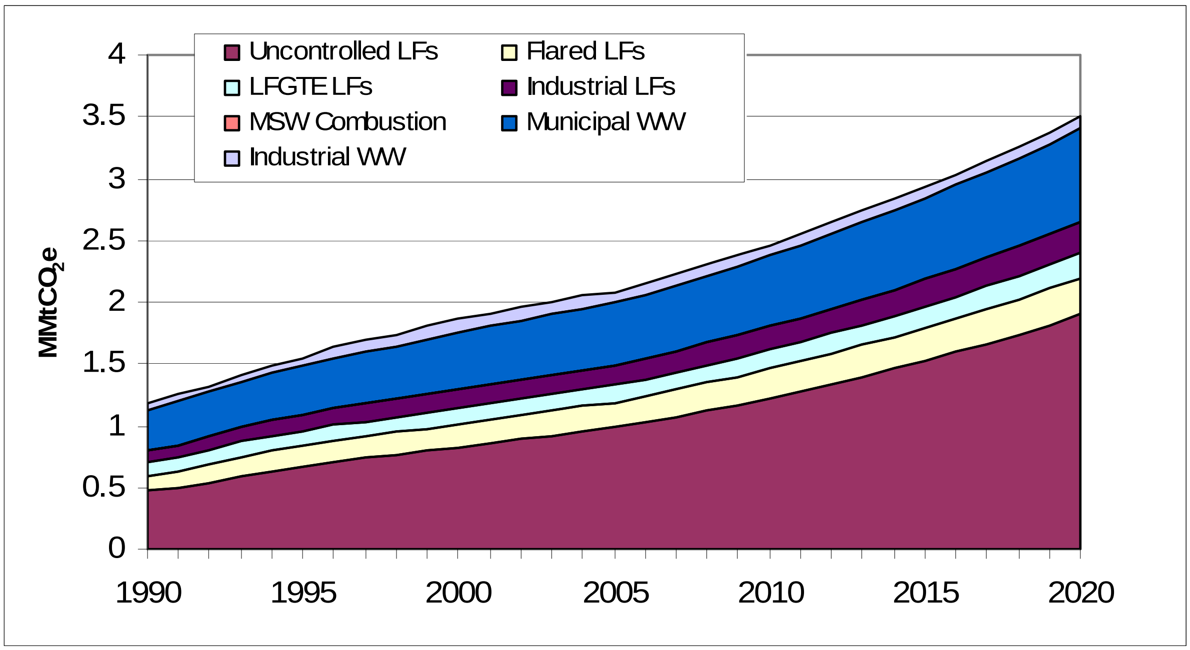
[4] Total does not include change in soil organic carbon storage on federal lands, including those that were previously under private ownership, and does not include carbon storage due to sewage sludge applications

Table 6-2. GHG emissions (sinks) from forestry

Forest Carbon Pool	1990–2020* $MMtCO_2e$/year
Live and dead-standing trees and understory	–17.7
Forest floor and coarse woody debris	–6.2
Soils	–7.1
Wood products and landfills	–0.8
Total	**–31.8**

***Based on USFS data from 1987–1997. Flux held constant for the rest of the inventory and forecast period.

Figure 6-2. Estimated historical and projected emissions from waste and wastewater management in Colorado



Key Challenges and Opportunities

Opportunities for GHG mitigation in the AFW sector involve measures that can reduce emissions within the sector or reduce emissions in other sectors. For example, production of liquid biofuels can offset emissions in the transportation or RCI sectors, while biomass energy can reduce emissions in the energy supply or RCI sectors.

In the agricultural sector, the implementation mechanisms for the CAP recommendations 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 Colorado agriculture from taking part in emerging carbon markets. Implementation mechanisms that are incentive- and education-based can avoid these conflicts.

Production of renewable fuels, such as ethanol or biodiesel from crops, crop residue, forestry residue or MSW, can produce significant reductions when they are used to offset consumption of fossil fuels (gasoline and diesel fuels 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 (e.g., conventional corn-based ethanol and soybean-based biodiesel). For ethanol, this means the benefits are dependent on developing in-state production capacity that achieves benefits above the levels of existing and planned (business-as-usual [BAU]) starch-based production. GHG-superior feedstocks/processes could include cellulosic hydrolysis, biomass gasification combined with biofuels production, or alternative starch-based production (fermentation processes fueled by renewable fuels). For biodiesel, the analysis focuses on the incremental benefits of in-state production derived from in-state lower carbon content feedstocks (vegetable oil and algal oil) compared to the importation of out of state feedstock supplies (soybean oil).

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. In addition to vegetable oil, sufficient planning is needed to promote in-state production for the other primary feedstock to biodiesel (methanol or ethanol).

Agricultural crop management programs that incentivize growers to improve crop management practices can result in gains in soil carbon sequestration and reductions in additions of the nutrients that produce N_2O emissions as well as in emissions from fossil fuel combustion used during application. On-farm energy efficiency programs to reduce fossil fuel and electricity use can also provide significant GHG reductions. Improving the availability of information to farm operators is crucial for the success of these policies. Additionally, some of the strategies that require initial capital investments may prove difficult to implement if financing and/or incentives are not made available.

Source reduction, enhanced recycling and composting reduces future landfill CH_4 emissions potential, while source reduction and recycling reduces emissions associated with the manufacturing of products and packaging from raw materials, as well as their distribution. While the reduction benefits from the goal of 75% less materials being landfilled is relatively ambitious, it is attainable, as evidenced by the results of aggressive programs nationwide. A broad suite of implementation mechanisms will be needed to achieve this goal, which include education and public involvement; economic support; technical research and assistance; legislative actions; and state “lead by example” actions.

By protecting high carbon value forested lands and grasslands from conversion to developed uses, the carbon in above-ground biomass and below-ground soil organic carbon can be maintained and additional emissions of CO_2e to the atmosphere can be avoided. 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. A related challenge is that there is limited capacity within the state for crop production to support biofuels feedstock production without the use of cropland that is currently enrolled in the federal Conservation Reserve Program.

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). Success can be achieved through close cooperation between Colorado, federal agencies (USFS), and private industry to identify biomass resources and effective end uses for the resource.

The recommendation for significant expansion of urban tree planting and maintenance programs in the state could achieve higher levels of carbon sequestration in the urban forest, as well as provide energy savings in residential and commercial buildings (e.g. from shading and wind protection). Attaining the goal of 4.4 million trees planted by 2020 will require a commitment from municipalities and promotion by the state.

Overview of Policy Recommendations and Estimated Impacts

The CAP adopted by unanimous consent of those present and voting a set of ten policy recommendations for the AFW sector that offer the potential for major economic benefits and emissions savings. For each of four recommendations (AFW-2, AFW-4, AFW-5, and AFW-10), at least one CAP member expressed qualifications about support for the recommendation, but did not object to it. The explanations of the qualified votes of approval are included in the detailed policy recommendations in Appendix H.

The total GHG reductions from reference case projections are estimated to be 11.5 $MMtCO_2e$ per year by 2020, a cumulative savings of 66 $MMtCO_2e$ from 2007 to 2020. The net present value of the costs is approximately $252 million over the same period.[6] The weighted average cost of saved carbon from the policies for which quantitative estimates of both costs and savings were prepared was $4 per metric ton of CO_2 equivalent.

The estimated impacts of the individual recommended policies are shown in Table 6-3. This summarizes the effects of the AFW policies within the AFW sectors, but it should be noted that these policies achieve emission reductions not only from the AFW source sectors, but in other source sectors as well (e.g., transportation sector due to consumption of biofuels produced; energy supply or RCI from biomass energy production).

Improving agricultural crop management methods (AFW-1) has been estimated to result in significant benefits by 2020 (0.78 $MMtCO_2e$/year). Improved cultivation methods can provide increases in soil carbon, reductions in nutrient-related emissions, and will reduce all GHG emissions that result from the combustion of fossil fuels in farm equipment. This final reduction is captured under AFW-1, rather than AFW-3 (Reductions in On-Farm Energy Use).

AFW-3 examines on-farm energy efficiency measures. The GHG benefit associated with the implementation of policy AFW-3 is estimated to be 0.64 $MMtCO_2e$ in 2020. This policy also has significant cost savings due to more efficient farming practices.

[6] 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 6-3. CAP-recommended policies and results for the agriculture, forestry, and waste management sectors

	Policy Recommendation	GHG Reductions ($MMtCO_2e$)			Costs (Savings) 2007–2020 (Million $)	Cost-Effective-ness ($\$/tCO_2e$)	Climate Action Panel Action
		2012	2020	Total 2007–2020			
AFW-1	Achieve no-till operation of half of croplands by 2020 and increase nitrogen fertilizer efficiency by 20%.	0.57	0.78	7.7	–$57	–$7/ton	Unanimous Consent
AFW-2	Implement methane capture and energy recovery on manure management projects on 80% of animal feeding operations by 2020.	0.01	0.32	1.8	$66	$36/ton	Unanimous Consent (1 qualified approval)
AFW-3	Reduce on-farm petro-diesel use 20% by 2020, and reduce electricity use from fossil fuels 40% through energy efficiency and on-site renewable sources generation.	0.14	0.64	3.8	–$150	–$40/ton	Unanimous Consent
AFW-4	Incentives for the production of biodiesel fuel from oilseed crops, waste vegetable oil, or other sources to offset 40% of fossil diesel fuel use by 2020.	0.02	0.22	1.1	$13	$12/ton	Unanimous Consent (3 qualified approvals)
AFW-5	Increase in-state ethanol production, using GHG-superior feedstocks and production methods, to 400 million gallons per year above BAU by 2020.	0.39	3.1	15	$58	$3/ton	Unanimous Consent (3 qualified approvals)
AFW-6	Preserve forest lands (line 1) and grasslands (line 2) to reduce the rate of conversion to developed uses by 25% by 2020.	0.10 0.05	0.24 0.14	1.7 1.0	$44 $31	$26/ton $32/ton	Unanimous Consent
AFW-7	Increase the use of biomass from forest health and fire risk treatment for energy production, using 20% of harvested wood by 2020.	0.08	0.20	1.4	–$104	–$75/ton	Unanimous Consent
AFW-8	Divert 75% of wastes from landfills by 2020 through source reduction, enhanced recycling, and composting programs.	0.48	4.6	24	$311	$13/ton	Unanimous Consent
AFW-9	Control or capture landfill methane to achieve 50% reduction from BAU by 2020.	0.33	1.2	7.5	–$0.1	–$0.02/ton	Unanimous Consent
AFW-10	Plant 3.4 million new trees statewide by 2020 through expanded urban forestry programs.	0.03	0.08	0.59	$40	$79/ton	Unanimous Consent (1 qualified approval)
	Sector Total of Analyzed Policies After Adjusting for Overlaps	2.2	11.5	66	$252	$4/ton	

Negative numbers indicate cost savings.

The cost (savings) shown are calculated as in terms of net present value in constant 2005 dollars using a 5% annual real discount rate for the period 2008 through 2020. Capital investments are represented in terms of levelized or amortized costs through 2020.

Control and utilization of methane is addressed in two policies. Methane can be collected from manure management through the use of anaerobic digesters or other technology (AFW-2). Collection and utilization of CH_4 from landfills (AFW-9) reduces GHG emissions directly from control of CH_4 emissions and indirectly by offsetting fossil fuel use. The CH_4 captured in either policy can then be used to create electricity, steam, or heat to offset fossil fuel use.

Production of ethanol and biodiesel were found to offer substantial GHG reduction potential with an estimated 2020 reduction of 3.32 $MMtCO_2e$ (combined benefit of AFW-4 and AFW-5). This is the benefit from in-state production using Colorado grown feedstocks and GHG-superior production methods (superior to current conventional methods of biofuel production). The benefit is incremental to the benefit achieved via the renewable fuels standard incorporated in TLU Policy 5 (Low Carbon Fuels Standard).

Combining the GHG benefits from the grasslands and forested land preservation policies (AFW-6), 0.38 $MMtCO_2e$/year in GHG emissions are estimated to be saved in 2020. Also in the forestry sector is AFW-7, which recommends the utilization for energy of biomass feedstocks from forest treatment projects (to reduce fire risk), resulting in a significant potential for GHG benefits (0.2 $MMtCO_2e$/year by 2020).

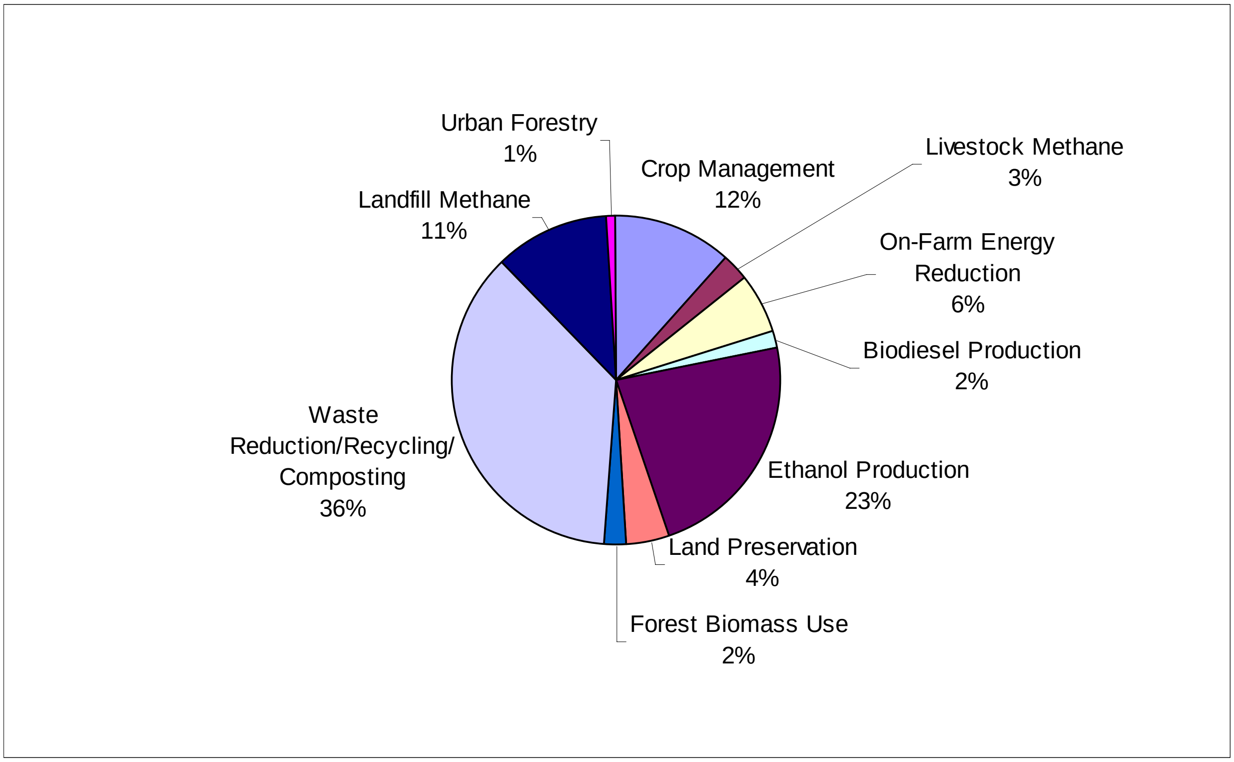
In the waste management sector, the CAP is recommending a strong goal for solid waste diversion: 75% overall reduction in landfilling through source reduction, recycling and composting by 2020 (AFW-8). The resulting 4.6 $MMtCO_2e$ per year reduction by 2020 makes this one of the most effective CAP recommendations for GHG reductions.

There is overlap in the expected emissions reduction and cost between AFW-9 and ES-2 (Increase renewable portfolio standards) and the quantification of the emission reductions and costs for AFW-9 account for this overlap to eliminate potential double counting. See Appendix D, Methods of Quantification, for additional description of overlaps among sectors and of analyses of the cumulative GHG reductions from the combined effects of the CAP policy recommendations that were quantified.

The CAP policy recommendations described briefly here (and in more detail in Appendix H to this report) result not only in significant emissions savings, but offer a host of additional benefits as well. These benefits include (but are by no means limited to): 1) Support of Colorado agricultural producers in the production of biofuels crops, development of new markets for agricultural byproducts, and training/outreach covering energy production and energy efficiency; 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) Lower air and water pollution from implementation of several policies in both the agriculture and waste management sector.

Figure 6-3 shows the breakdown of the emission reductions (2007–2020) anticipated from the recommended actions in the AFW sector. The greatest emission reductions achieved (36%) come from implementation of enhanced waste management programs. Under AFW-8, these programs cover source reduction, recycling, and composting. It is important to note that these emission reductions are lifecycle GHG reductions that occur both within and outside of Colorado (resulting from lower energy use and GHG emissions to create, transport, and dispose of new products and packaging that are avoided through source reduction and recycling). In-state production of ethanol using technologies and feedstocks (e.g., cellulosic hydrolysis) that have superior GHG benefits to conventional starch-based ethanol production is also estimated to produce substantial benefits during the policy period. Improvements to crop management that result in higher levels of carbon sequestration in soils and lower amounts of nutrients applied will provide 12% of the total AFW GHG reductions through 2020. Finally, landfill methane collection and control/use will provide another substantial portion of the overall AFW sector benefit (11%). As with the livestock methane under AFW-2, the reductions under AFW-9 come not only from control of the methane emitted by landfills, but also utilization of this methane as an energy source.

Figure 6-3. Percent of avoided greenhouse gas emissions by policy



Agriculture Forestry and Waste Management Sector Policy Descriptions

The Agriculture, Forestry, and Waste Management Sectors include emissions and mitigation opportunities related to use of biomass energy, protection and enhancement of forest and grassland carbon sinks, control of agricultural CH_4 emissions, production of renewable fuels, methods to increase soil carbon, and source reduction/recycling/composting programs.

AFW-1 Agricultural Crop Management

The amount of carbon (C) stored in the soil can be increased by crop management practices that increase C inputs to soil and/or reduce soil organic matter decomposition rates. Adoption of conservation tillage, in particular no-till, can increase soil C stocks. Reducing mechanical soil disturbance reduces the oxidation of soil carbon compounds and allows more stable aggregates to form. Other benefits of conservation tillage include reduced wind and water erosion, improved soil structure and crop water use, reduced fuel consumption, and improved wildlife habitat. On non-irrigated cropland, increased cropping frequency to reduce or eliminate summer fallow goes hand in hand with adopting no-till practices. Application of biochar (i.e., stable organic residues from biomass pyrolysis) to soils is a potential practice to capture and sequester atmospheric CO_2.

Improved nutrient management (i.e., better timing, application rates based on soil testing, advanced fertilizer formulations, etc.) of both fertilizer and manure can increase nutrient use efficiency and reduce addition rates, thereby reducing N_2O emissions and potentially fossil fuel use. For some production systems, organic farming practices result in lower net GHG emissions.

The CAP recommends, by unanimous vote of those members present and voting, that Colorado achieve 50% no-till cultivation and increase nitrogen fertilizer efficiency by 20% by 2020.

AFW-2 Manure Management and Energy Programs

The CH_4 emissions inherent from the anaerobic decomposition process of manure and other wastes may be captured and used as an energy source. Methane and N_2O emissions can occur at several different places in the manure management process. Management techniques can also reduce GHG emissions and, with energy recovery, offset fossil-based energy. This policy covers producer incentives to adopt programs to increase the number of CH_4 capture and energy recovery projects or other manure management techniques that reduce CH_4 and N_2O emissions.

The CAP recommends, by unanimous vote of those members present and voting, with one qualified vote of approval, that by 2020 Colorado implement manure management and energy utilization programs on 80% of all animal feeding operations where the application of such technology is feasible and cost-effective.

AFW-3 Reductions in On-Farm Fossil Energy Use

This policy seeks to develop and implement cost-effective programs for renewable energy (solar thermal, solar photovoltaic or PV electricity) and energy efficiency technologies for farmers and ranchers. Reductions in fossil fuel consumption reduce emissions of CO_2, CH_4, and N_2O.

The CAP recommends, by unanimous vote of those members present and voting, that Colorado achieve a 40% reduction of on-farm grid-based electricity use and a 20% reduction in petro-diesel use by 2020.

AFW-4 Biodiesel Production

Provide incentives for the production of biodiesel from oilseed crops, waste vegetable oil, or other sources. Biodiesel use will offset diesel fuel derived from petroleum and will lead to decreased fossil fuel-based CO_2 emissions. This policy emphasizes the supply of biodiesel, accounting for the incremental benefit of using in-state, GHG-superior feedstocks (superior to the conventional national soybean oil feedstock).

The CAP recommends, by unanimous vote of those members present and voting, with three qualified votes of approval, that Colorado produce enough biodiesel using in-state GHG-superior feedstocks to offset 20% of the State's diesel fuel demand by 2020. Recognizing limitations on the amount of cropland that can be devoted to oilseed crops, the assessment of the policy benefits included the need to develop and commercially deploy advanced technologies for feedstock production (e.g. algal oil).

AFW-5 Ethanol Production

Trees, crops and other plants convert atmospheric carbon to carbohydrate or fiber stocks that can be converted to liquid fuels, such ethanol. The use of these renewable, biological fuels can offset fossil fuel use and reduce associated net CO_2 emissions. Production incentives for the conversion of crops, forest sources, animal waste and other sources to ethanol through existing or new technologies can increase the level of ethanol use in future markets. In-state production of ethanol using GHG-superior feedstocks and processes (e.g., cellulosic technologies) offer the highest GHG benefits and complement policies to increase ethanol consumption as part of a low carbon fuels standard (e.g., TLU-5).

The CAP recommends, by unanimous vote of those members present and voting, with three qualified votes of approval, that Colorado increase in-state ethanol fuel output to 400 million gallons per year above business-as-usual (BAU) by 2020. Adoption and deployment of these methods to produce ethanol using GHG-superior methods (superior to conventional corn-based ethanol) will position Colorado's biofuel industry to better meet the fuel needs associated with emerging low carbon fuel standards in the state and region.

AFW-6 Preserve Lands with Carbon Storage Value

The CAP recommends, by unanimous vote of those members present and voting, that the rate at which high carbon lands (i.e., existing grassland and forested land) are converted to developed uses be reduced by 25% by 2020. The carbon stored in soils and aboveground biomass is typically higher in these lands than in developed land uses. Each year, developed areas also typically sequester less CO_2 than high carbon lands. Policies are needed to protect working farms and forests from unwise and unplanned development. Indirectly, this policy also supports important policies in the transportation and land use sector by promoting more efficient development patterns (e.g., TLU-1).

Another element of this policy is to reduce the rate at which permanent grassland in the USDA Conservation Reserve Program is converted to cultivated cropland. Soil carbon stored in retired agricultural land that has been maintained as grassland is reversed when lands are put back to cultivation, resulting in net carbon emissions. Since these *potential* emissions were not included in the reference case forecast of GHG emissions, the benefits for this policy element were not quantified.

The CAP discussed that infestations by mountain pine beetles could affect the extent to which Colorado's forested lands store carbon in the future, but did not have sufficient data to be able to analyze that possible effect.

AFW-7&8 Forest Health and Biomass Feedstocks for Energy Production

A specific focus of this policy is on the potential synergistic objectives of forest fire risk management and bioenergy production. Forest management methods that decrease wildfire risk to communities remove biomass from forests to reduce biomass density or dead/diseased trees. The biomass harvested is typically of low economic value and therefore generally is underutilized (e.g. burned on-site or left to decompose). This policy proposes using this biomass as a feedstock for energy production to yield GHG reduction benefits. Woody biomass feedstocks may also come from other types of forest health management programs such as pest and disease prevention.

Based on data availability, the analysis of this policy focused on forest fire risk mitigation in communities at risk of wildfires in the wildland-urban interface (WUI) of the Front Range Region of Colorado (although the recommended goals apply statewide). The focus on WUI areas was chosen in part because of the significant potential benefits, in terms of avoided costs and other losses, from preventing wildfires in communities. Also, the best available information is for this region of Colorado.

The CAP recommends, by unanimous vote of those members present and voting, that Colorado increase the use of biomass from fire risk treatments to produce energy (specifically institutional heating) to 20% of harvested wood by 2020.

AFW-9 Source Reduction, Enhanced Recycling and Composting Programs

Solid waste that is normally buried in landfills generates CH_4 through decomposition processes. By preventing this source of CH_4, GHG emissions are reduced. Waste can be diverted through a variety of actions including composting, source reduction, recycling, and re-use. Alternatives to landfilling unprocessed organic material (food wastes, agricultural wastes, biosolids, lawn & garden wastes, or other organic materials) include composting and anaerobic digestion. Both alternatives reduce net GHG emissions and anaerobic digestion can also provide a source of renewable energy (CH_4). Source reduction and recycling also reduce product life cycle GHG emissions, including extraction and processing of raw materials, product & packaging manufacture, transport, and final disposal.

The CAP recommends, by unanimous vote of those members present and voting, that through the implementation of additional recycling, organic composting, and source reduction programs, Colorado divert 75% of waste from landfilling by 2020.

AFW-10 Landfill Methane Reduction Programs

Provide incentives that will result in an increase in the recovery of landfill CH_4 for use as an energy source. Increasing the recovery of landfill CH_4 will reduce emissions of this GHG and will offset the use of fossil fuels for commercial/industrial heat/steam generation or electricity production.

The CAP recommends, by unanimous vote of those members present and voting, with one qualified vote of approval, that Colorado implement controls or waste management practices at municipal solid waste landfills such that 50% of the CH_4 emissions that would be generated under business as usual conditions are avoided by 2020.

AFW-11 Urban Forestry Programs

Urban forest enhancement and management offers a potentially cost effect mechanism to reduce energy use and to store/sequester carbon. Strategic planting of trees to shade houses and air conditioning units can yield energy savings of 15% to 50% on cooling costs.[7] Planting of shade trees can reduce summer cooling costs, with only marginal increases in winter heating costs, particularly in mild climates. In addition, depending on local conditions, tree planting can reduce wind-speed and further reduce energy costs. This policy seeks to expand existing urban tree planting and maintenance programs, such as Denver's Tree Initiative.[8]

The CAP recommends, by unanimous vote of those members present and voting, that Colorado expand urban tree planting and maintenance programs statewide, such that 3.4 million new trees are planted by 2025.

[7] Cooling Our Cities, US Environmental Protection Agency PM-221.

[8] More information on this program can be found at: http://www.greenprintdenver.org/trees/index.php