Montana Department of Environmental Quality

Climate Change Advisory Committee

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Agriculture, Forestry, and Waste Management Technical Work Group

Summary List of Mitigation Options

	Mitigation Option	**GHG Reductions ($MMtCO_2e$)**			**Net Present Value 2007–2020 (Million $)**	**Cost-Effective-ness ($\$/tCO_2e$)**	**Level of Support**
		2010	**2020**	**Total 2007-2020**			
AFW-1	Agricultural Soil Carbon Management – Conservation/ No-Till Agricultural Soil Carbon Management – Organic Farming	0.06	0.20	1.4	0	0	TBD
AFW-2	Biodiesel Production (Incentives for Feedstocks and Production Plants)	0.03	0.39	3.0	79	27	TBD
AFW-3	Ethanol Production	0.02	0.39	2.2	10	4	TBD
AFW-4	Incentives for Enhancing GHG Benefits of Conservation Provisions of Farm Bill Programs						TBD
AFW-5	Preserve Open Space and Working Lands						TBD
AFW-6	Forest Health Programs for Carbon Management						TBD
AFW-7	Expanded Use of Biomass Feedstocks for Energy Use						TBD
AFW-8	Afforestation and Reforestation Programs						TBD
AFW-9	Improved Management and Restoration of Existing Stands						TBD
AFW-10	Expanded Use of Wood Products for Building Materials						TBD
AFW-11	Programs to Promote Local Food and Fiber						TBD
AFW-12	Enhanced Solid Waste Recovery and Recycling	0.24	0.74				TBD
	SECTOR TOTAL AFTER ADJUSTING FOR OVERLAPS						

	Mitigation Option	GHG Reductions (MMtCO$_2$e)			Net Present Value 2007–2020 (Million $)	Cost-Effectiveness ($/tCO$_2$e)	Level of Support
		2010	2020	Total 2007-2020			
	REDUCTIONS FROM RECENT ACTIONS (table to be added below)						
	SECTOR TOTAL PLUS RECENT ACTIONS						

Note: *Italicized text* in this document is used to denote language that may be deleted pending TWG review and to highlight other pending changes or needs for further information. .

AFW–1. Agricultural Soil Carbon Management Programs

Policy Description

Use of conservation tillage/no-till and other soil management practices can increase the level of organic carbon in the soil, which sequesters carbon dioxide from the atmosphere. In addition, some practices lower fossil fuel consumption through less intensive equipment use. Other practices, such as the application of bio-char can also increase the level of soil carbon and improve the soil. Organic farming methods may tend toward an increased use of these soil management practices. This option is designed to increase the acreage using soil management practices that lead to higher soil carbon content for both conventional and organic farming.

Policy Design

Goals: Montana should adopt programs to increase the acres of cropland managed using best management practices including conservation/no tillage practices by 50%. Currently there are approximately 18 million acres of cropland in Montana. Based on 2004 data, three million acres were in the Conservation Reserve Program (CRP); 7.9 million acres were in tillage; and, the remaining 7.1 million acres are in summer fallow. A total of 5.5 million acres were in no-till (3.6 million acres were cropped and 1.9 million acres were in chemfallow). The acreage that could be used to sequester atmospheric carbon dioxide would be the remaining 9.5 million acres, including the 1.7 million acres currently managed by mulch-till practices that sequester a lesser fraction of carbon from the atmosphere.

An organic farming component is also included in this policy design pending an assessment of the GHG benefits. Compared to no tillage systems, organic farming uses higher levels of tillage to manage weeds and to terminate cover crops and in some cases results in lower yields (leading to GHG dis-benefits). However, organic farming also does not use pesticides/herbicides and synthetic fertilizers and might achieve higher soil carbon levels than conservation tillage/no-till practices (leading to GHG benefits). Organic farming acreage is increasing at the following projected rates: 126,450 acres in 2005; 215,768 acres in 2010; 305,086 acres in 2015; and, 394,404 acres in 2020. The initial goal will be to increase the organic acreage 15% above projected levels in 2015 and to 50% above 2025 levels for practices known to achieve net GHG benefits.

Timing: From 2007-2015 achieve a 15% increase in acres of cropland brought into no-till management practices, or an additional 0.9 million acres. By 2025 an additional 35% increase in acreage, or 1.9 million acres, for a total increase of 2.8 million acres in no-till/conservation tillage. This seems to be a reasonable goal considering that 1.7 million acres already in mulch-till practice could be brought into the no-till practices with incentives.

This policy also seeks an increase in organic farming acreage of 15% above the projected acreage in 2015 and 50% above the levels currently projected for 2025.

Coverage of Parties: Local Agricultural Extension Offices, Montana Conservation District Offices, USDA-NRCS field offices, Montana Salinity Control Program (Jane Holzer, who is interested in carbon credit development), National Carbon Offset Coalition (NCOC), Montana Chapter of Soil and Water Conservation Society (Tom Pick, USDA-NRCS, Bozeman), MSU Land Resource & Environmental Sciences (LRES) program, certified crop consultants, Montana Grain Growers Association, among others.

Other: Not Applicable

Implementation Mechanisms

CSP Program: Federal funding of the Conservation Security Program at levels specified in the 2002 farm bill would help provide incentives for participation in no-till and other conservation soil management strategies.

Equipment Rebate Programs: Economic incentives to go to no-till practices might include a program that gave rebates for machinery traded in for no-till machinery -- such as a 50% rebate, similar to automobile industry for replacing low-mpg older vehicles with new high-mpg vehicles.

Educational Outreach: Change the perception of no-till practices among established farmers who: 1) Use practices that continue in the manner of their ancestors; 2) Are hesitant to apply chemicals to the soil; 3) Need technical and financial assistance to become comfortable with and to acquire the new technology needed; 4) Are concerned that insect control and plant disease management strategies may be impacted; and, 5) Are wary of new practices that aren't used by neighbors and that may negatively impact income from the farming enterprise.

Other Incentives: Improve the federal and state general cost-share programs to include no-till, removing some of the special area and conditions restrictions so it can fit under Environmental Quality Incentives Program (EQUIP) and Conservation Security Program (CSP) programs.

Related Policies/Programs in Place

CRP - The Conservation Reserve Program rewards farmers financially for removing highly erodible and marginally productive land from production. CRP is currently capped at 25% of Montana cropland per county.

CSP – The Conservation Security Program

EQUIP – Environmental Quality Incentives Program

Note: Both CSP and EQUIP are relatively new programs designed to increase and cost-share implementation of Best Management Practices including, but not limited to, adoption of no-till farming practices.

MT and US Department of Agriculture program

MSU Agriculture Research and Development programs.

Types(s) of GHG Reductions

- **CO2:** Reducing tillage and soil disturbance slows the breakdown of plant material on the soil surface and in the root zone, accelerating the microbial processes that stabilize carbon and protecting carbon from oxidation, inhibiting the release of carbon back into the atmosphere. Depending on how the adoption of conservation tillage and organic production methods affects the overall crop production cycle, additional CO_2 reductions can occur through lower fossil fuel consumption in farm equipment. Note that some studies have shown higher fuel consumption using organic techniques than conventional production. Also, organic production methods reduce GHG emissions associated with the production, transport, and application of pesticides, herbicides, and other chemical treatments.

- **N2O:** To the extent that fossil fuel consumption is lowered through the cultivation methods implemented under this policy, N_2O emissions from fuel combustion will be lowered. It is important to note that research also indicates the potential for higher N_2O emissions as soil organic carbon levels increase[1]
- **CH4:** To the extent that fossil fuel consumption is lowered through the cultivation methods implemented under this policy, CH_4 emissions from fuel combustion will be lowered.

Estimated GHG Savings and Costs per MtCO$_2$e

- **GHG reduction potential in 2010, 2020 (MMtCO$_2$e):** 0.06, 0.20
- **Net Cost per MtCO$_2$e:** $0
- **Data Sources:** Agricultural soil carbon accumulation levels were taken from a 2004 MontGuide Fact Sheet from the Montana State University Extension Service.[2] This report states that no-till practices result in an increase of soil carbon of 0.45 ton/acre over 10 years.

  The reduction in fossil diesel fuel use from the adoption of conservation tillage methods is 3.5 gallons/acre.[3] From the MT Inventory & Forecast, the fossil diesel GHG emission factor is 8.37 MtCO$_2$e/1,000 gallons. Costs for adoption of conservation tillage/no-till practices are estimated to be $0 based on averaging costs from two studies. The first study from North Carolina State University on applying these practices to cotton growing in NC resulted in a range of cost savings from about $3 to $14 per acre per year.[4] CCS used the low end of the range as a conservative estimate of cost savings. The second study from Iowa found that subsidy of $3 would be required to get non-adopters to switch to no-till.[5]

[1] Li et al., "Carbon Sequestration in Arable Soils is Likely to Increase Nitrous Oxide Emissions, Offsetting Reductions in Climate Radiative Forcing" *Climate Change*, (2005) 72: 321–338.

[2] Miller, P. , Engel, R., and Brinklemyer, R., *Soil Carbon Sequestration: Farm Management Practices Can Affect Greenhouse Gases*, MontGuide Fact Sheet #200404/Agriculture from the Montana State University Extension Service

[3] Reduction associated with conservation tillage compared to conventional tillage, at http://www.ctic.purdue.edu/Core4/CT/CRM/Benefits.html, accessed August 2006.

[4] $3-$14/acre savings dependent on comparison of no-till to either strip till or conventional tillage. From: Economic Comparison of Three Cotton Tillage Systems in Three NC Regions, S. Walton and G. Bullen, NCSU, at www.ces.ncsu.edu/depts/agecon/Cotton_Econ/production/Economic_Comparison.ppt, accessed February 2007.

[5] Costs and Environmental Effects from Conservation Tillage Adoption in Iowa. Lyubov Kurkalova, Catherine Kling, and Jinhua Zhao

- **Quantification Methods:** Based on the policy design parameters, the schedule for acres to be put into conservation tillage/no-till cultivation are shown in the table below. It was further assumed that this additional carbon would be sequestered in the soil over a period of ten years (after ten years no further carbon is stored). The resulting annual carbon accumulation rate was converted into its CO_2 equivalent yielding 0.55 $MtCO_2$/acre-yr.

  To estimate carbon stored each year, the annual accumulation rate was multiplied by the number of acres in the policy program each year. After ten years, the crop acres that entered the program were assumed to not store additional carbon. Results are shown in the table below. Additional GHG savings from reduced fossil fuel consumption were estimated by multiplying the fossil diesel emission factor and diesel fuel reduction per acre estimate provided above. Results are shown in the table below along with a total estimated benefit from both carbon sequestration and fossil fuel reductions.

Year	Acres in Program	Acres still accumulating carbon	MMtCO2e Sequestered	Diesel Saved (1,000 gal)	MMtCO2e from Diesel avoided	Total MMtCO2e saved
2006	0	0	0.00	0	0.00	0.00
2007	0	0	0.00	0	0.00	0.00
2008	103,125	103,125	0.02	361	0.00	0.02
2009	206,250	206,250	0.03	722	0.01	0.04
2010	309,375	309,375	0.05	1,083	0.01	0.06
2011	412,500	412,500	0.06	1,444	0.01	0.07
2012	515,625	515,625	0.08	1,805	0.02	0.09
2013	618,750	618,750	0.09	2,166	0.02	0.11
2014	721,875	618,750	0.09	2,527	0.02	0.11
2015	825,000	618,750	0.09	2,888	0.02	0.12
2016	953,333	643,958	0.10	3,337	0.03	0.12
2017	1,145,833	733,333	0.11	4,010	0.03	0.14
2018	1,338,333	822,708	0.12	4,684	0.04	0.16
2019	1,530,833	912,083	0.14	5,358	0.04	0.18
2020	1,723,333	1,001,458	0.15	6,032	0.05	0.20
2021	1,915,833	1,090,833	0.16	6,705	0.06	0.22
2022	2,108,333	1,155,000	0.17	7,379	0.06	0.23
2023	2,300,833	1,155,000	0.17	8,053	0.07	0.24
2024	2,493,333	1,155,000	0.17	8,727	0.07	0.25
2025	2,750,000	1,219,167	0.18	9,625	0.08	0.26

- **Key Assumptions:** To be determined (TBD)

Key Uncertainties

TBD

Additional Benefits and Costs

TBD

Feasibility Issues

TBD

Status of Group Approval

TBD

Level of Group Support

TBD

Barriers to Consensus

TBD

AFW–2. Biodiesel Production
(Incentives for Feedstocks and Production Plants)

Policy Description

Use of biodiesel offsets the consumption of diesel fuel produced from oil (fossil diesel). Since biodiesel has a lower GHG content than fossil diesel (being derived from biogenic sources), overall GHG emissions are reduced. By producing biodiesel in the state for consumption within the state, the highest benefits can be achieved, since the fuel is transported over shorter distances to the end user. This option covers incentives needed to increase biodiesel production in Montana.

Policy Design

Goals: Produce sufficient biodiesel from Montana feedstocks, to meet 2-, 10-, and 20-percent of 2004 Montana petroleum diesel consumption by 2010, 2015 and 2020, respectively.

Timing: See above.

Parties Involved: MT DEQ, MT Department of Agriculture, MT Farmers Union, Resource Conservation and Development, MT Grain Growers, MT State University, MT Livestock Associations.

Other: Not Applicable

Implementation Mechanisms

TBD

Related Policies/Programs in Place

15-70-601 (incentive for incremental production increases over first 3 years); 15-32-702 (production facility tax credit); 15-32-703 (blending and storage tax credit); 15-70-369 (tax refund to distributor/retailer); 15-32-701 MCA (Oil Seed Crushing Facility Credit); and 15-32-702 (Biodiesel Production Facility Credit).

Types(s) of GHG Reductions

- **CO_2**: Lifecycle emissions are reduced to the extent that biodiesel is produced with lower embedded fossil-based carbon than conventional (fossil) diesel fuel. Feedstocks used for producing biodiesel can be made from crops or other biomass, which contain carbon sequestered during photosynthesis (e.g., biogenic or short-term carbon). The primary feedstocks for biodiesel are vegetable oils (soy, canola, sunflower, algal, etc.) and alcohols (either methanol or ethanol). From a recent report (Hill et al., 2006),[6] biodiesel from soybeans contains 93% more useable energy than its petroleum equivalent and reduces lifecycle GHG emissions by as much as 41%. Higher oil production potential of different feedstocks (e.g., other oil crops, algae) will likely adjust the lifecycle GHG emissions further downward as they are developed as biodiesel sources. Local production of biodiesel also decreases the embedded CO_2e of biodiesel compared to importation of out of state vegetable oil supplies.

Estimated GHG Savings and Costs per $MtCO_2e$

- **GHG reduction potential in 2010, 2020 ($MMtCO_2e$):** 0.03, 0.39
- **Net Cost per $MtCO_2e$:** $27
- **Data Sources:** The CO_2e emission factor for fossil diesel used in the inventory and forecast is 10.04 Mt/1,000 gallons. The lifecycle fossil diesel emission factor is 12.3 Mt/1,000 gallons (Hill et al., 2006; cited in the footnotes).
- **Quantification Methods:**

  GHG Reductions
  A new study on lifecycle GHG benefits for biodiesel production and use was used to estimate the CO_2e reductions for this option (Hill et al, 2006; cited in footnotes to this option). This study covered biodiesel production from soybean production, which is currently the predominant feedstock source for biodiesel production in the US and is assumed to remain that way for the purposes of this analysis. Lifecycle CO_2e reductions (via displacement of fossil diesel with soybean-derived biodiesel) were estimated by Hill et al to be 41%. This value is being used by the TLU TWG to estimate the benefit of the biodiesel component of the TLU biofuels option. Hence, this analysis focuses on incremental benefits of in-state feedstocks production with the focus on vegetable oils and algal oil.

  When combined with the other feedstocks needed to produce biodiesel (e.g., either methanol or ethanol), a gallon of vegetable oil will produce slightly more than one gallon of biodiesel. For the purposes of this estimate, each gallon is assumed to produce one gallon of biodiesel.

  Feedstocks included in this analysis include canola, camelina, sunflower, and algal oils. For oil sources other than soybean oil, the benefit for substituting in-state biodiesel for fossil diesel is estimated starting with the lifecycle soybean emission factor (7,261 $MtCO_2e$/MMgal from the Hill et al study). As mentioned previously, the benefits of the biodiesel component of the TLU biofuels option is based on displacement with soybean-based biodiesel. Hence, this analysis was designed to only account for the incremental benefit of in-state feedstock (oil) production using GHG preferential feedstocks. These include vegetable oils that

[6] Hill et al, 2006, "Environmental, economic, and energetic costs and benefits of biodiesel and ethanol biofuels," Proceedings of the National Academy of Sciences, volume 103, pp. 11206-11210, July 25, 2006.

produce greater volumes of oil per unit of energy input (e.g., canola), and, in the future, algal oils.

Canola produces 122 gallons of oil per acre compared to soybeans at 46 gallons/acre. Assuming canola production energy inputs are not significantly greater than soy, the lifecycle emission rate for canola would be 7,261 x 46/122 or 2,738 $MtCO_2e/MMgal$. So the incremental benefit of canola over soy is 7,261 - 2,738 = 4,523 $MtCO_2e/MMgal$. Camelina produces 60 gallons of oil per acre and sunflower produces 98 gallons of oil per acre resulting in incremental benefits of camelina and sunflower over soy of 1,694 and 3,453 $MtCO_2e/MMgal$. For algal oils, CCS assumes that these have negligible embedded energy. So, the incremental benefit over soy equals the lifecycle fossil diesel EF (12,306 $MtCO_2e/MMgal$) minus the soybean based EF (7,261 $MtCO_2e/MMgal$), which is 5,045 $MtCO_2e/MMgal$.

The mix of oil feedstocks assumed in this analysis was based on 2006 production of canola, camelina, and sunflower in Montana, shown in the table below. This mix was assumed to remain constant until 2015. After 2015, all additional production is assumed to be based on new technologies (e.g., algal oil) to produce feedstocks.

Crop	2006 Acres	Potential Gallons of Oil Per Acre	Potential Oil Production (1,000 gallons)	Potential Oil Percentage of Oil Production
Canola	10,000	122	1,220	26%
Camelina	10,000	60	600	13%
Safflower	3,5000	80	2,800	61%

GHG reductions were estimated by multiplying the production of each oil feedstock by the applicable incremental benefit (e.g., by oil type). Total reductions in each year were estimated by summing the incremental benefit for each oil type.

Costs

Costs were estimated using information from an analysis of biodiesel production costs from the US DOE.[7] The value of incentives needed is assumed to be equivalent to the difference in the costs of producing fossil diesel and soy-based biodiesel ($0.34/gallon). This value is very close to the incentive offered in a State of Missouri incentives program.[8] This program offers production incentives of $0.30/gallon to producers up to 15 million gallons of production/yr. The incentive grants last for five years. CCS assumed a similar incentive structure and that these would cover the costs of all grants or tax incentives associated with this policy (all other implementation mechanisms are assumed to be achieved within existing programs). The cost estimates are based on multiplying the amount of biodiesel produced in each year by the production incentive. This assumes that all production occurs at production facilities

[7] See www.eia.doe.gov/oiaf/analysispaper/biodiesel/index.html; accessed January 2007.
[8] Information on the Missouri Program: www.newrules.org/agri/mobiofuels.html#biodiesel, accessed January 2007.

of less than 15 million gallons/yr. The production incentive runs out after five years of production.

- **Key Assumptions:** Life-cycle GHG emission factors utilized/derived for this analysis are representative for each feedstock and for fossil diesel. Production incentives offered by this option are sufficient to drive production of GHG-superior feedstocks (e.g., superior to soybeans) and to increase the level of research and development needed for non-crop based feedstocks (e.g., algal biodiesel, Fischer- Tropsch biodiesel).

Key Uncertainties

TBD

Additional Benefits and Costs

Increased in-state economic activity, oilseeds as rotational crop, reduced herbicide/pesticide and fertilizer use on traditional crops; increased transportation energy security; reduced reliance on imported petroleum.

Feasibility Issues

Sourcing of feedstocks and the size and location of facilities (both crushing and biodiesel production) must be addressed for optimization and planning. There will be interaction with potential ethanol production crops and carbon sequestration, although expanded use of biodiesel will continue to replace/reduce greenhouse gas emissions beyond the ability of the land to sequester carbon. There may be an overlap among TWGs (especially AFW-1 through 3) which should be carefully considered.

Status of Group Approval

TBD

Level of Group Support

TBD

Barriers to Consensus

TBD

AFW–3. Ethanol Production

Policy Description

Offset fossil fuel use (gasoline) with production and use of starch-based and cellulosic ethanol. Offsetting gasoline use with ethanol can reduce GHGs to the extent that the ethanol is produced with lower GHG content than gasoline. Provide incentives for the production of ethanol from crops, forest sources, animal waste, and municipal solid waste. Also encourage cellulosic ethanol production research and development already initiated by the MT Department of Agriculture

Policy Design

Goals: By 2010, achieve in-state production levels of 50 million gallons/year (mgy) of starch-based ethanol production capacity and 2 mgy of cellulosic production; by 2015, achieve in-state production of 110 mgy of starch-based and 25 mgy of cellulosic production; by 2020, achieve in-state production levels of 250 mgy starch-based and 50 mgy of cellulosic production.

Timing: see above.

Parties Involved: DEQ, Dept. of Ag, MT Farmers Union, MT Association of Ethanol Producers, Farm Bureau, Conservation Districts, MT Extension Service, MT Stock Growers and Wool Growers Associations, MT Grain Growers Association and MT Co-op Development Center.

Other:

Implementation Mechanisms

TBD

Related Policies/Programs in Place

The major sections of Montana's laws for ethanol are mostly tax related and are listed in sections of the Montana Code Annotated (MCA):

- 15-70-522 MCA provides tax incentives for the production of alcohol to be blended for gasohol and other laws provide for the proper administration and enforcement of the tax incentive. The incentive on each gallon of alcohol is 20 cents for each gallon that is 100% produced from Montana products to an ethanol producing facility.
- 5-70-204 MCA states that gasohol is subject to 85% of the tax imposed in subsection (1)(b) which is 27 cents for each gallon of all other gasoline distributed by the distributor within the state.

- 15-70-221 MCA states that a person who purchases and uses any gasoline on which the Montana gasoline license tax has been paid for denaturing alcohol to be used in gasohol is eligible for a refund or credit on the gasoline license tax.
- 15-6-220 MCA provides that all manufacturing machinery, fixtures, equipment, and tools used for the production of ethanol from grain during the course of the construction of an ethanol manufacturing facility and for 10 years after completion of construction of the manufacturing facility is exempt from property taxation.
- 15-30-164 MCA provides a tax credit against taxes for equipment and labor costs incurred to convert a motor vehicle licensed in Montana to operate on alternative fuel. For the purposes of this section, "alternative fuel" includes fuel that is at least 85% methanol, ethanol or other alcohol, ether, or any combination of them.
- 2-17-414 MCA states that state government and a state institution of higher education owning or operating a motor vehicle capable of burning ethanol-blended fuel shall take all reasonable steps to ensure that the operators of those vehicles use ethanol-blended fuel (90% gasoline and 10% anhydrous ethanol produced from agricultural products) in the vehicles.

Types(s) of GHG Reductions

CO_2: Lifecycle emissions are reduced to the extent that ethanol is produced with lower embedded fossil-based carbon than conventional (fossil) fuel. Feedstocks used for producing ethanol can be made from crops or other biomass, which contain carbon sequestered during photosynthesis (e.g., biogenic or short-term carbon). There are two different methods for producing ethanol based on two different feedstocks. Starch-based ethanol is derived from corn or other starch/sugar crops. Cellulosic ethanol is made from the cellulose contained in a wide variety of biomass feedstocks, including agricultural residue (e.g., corn stover), forestry waste, purpose grown crops (e.g., switchgrass), and municipal solid waste. Local production of ethanol also decreases the embedded CO_2e of ethanol compared to importation from the current U.S. primary ethanol producing regions. Current research indicates cellulose-based ethanol production provides up to 72-85% reduction in GHGs compared to gasoline, whereas an 18-29% reduction is measured from starch-based ethanol production compared to gasoline.

Estimated GHG Savings and Costs per $MtCO_2e$

- **GHG reduction potential in 2010, 2020 ($MMtCO_2e$):** 0.02, 0.39
- **Net Cost per $MtCO_2e$:** $4
- **Data Sources:** See below
- **Quantification Methods:**

  GHG Reductions

  The benefits for this option are dependent on developing in-state production capacity that achieves benefits above the levels of existing and planned (BAU) starch-based production in the U.S. Emission factors for reformulated gasoline, starch-based ethanol, and cellulosic ethanol were taken from a General Motors/Argonne National Lab study.[9] These emission factors incorporate the GHG emissions during the entire life-cycle of fuel production (e.g., for gasoline: extraction, transport, refining, distribution, and consumption; for ethanol: crop production, feedstock transport, processing, distribution, and consumption). These life-cycle emission factors are referred to as "well-to-wheels" emission factors:

Reformulated gasoline: 552 grams CO_2e/mi

Starch-based ethanol: 451 grams CO_2e/mi

Cellulosic ethanol: 154 grams CO_2e/mi

Based on the emission factors shown above, the incremental benefit of the production targeted by this policy over conventional starch-based ethanol is 66% (reduction of CO_2e by offsetting gasoline consumption). This value was used along with the lifecycle emission factor for gasoline[10] and the production in each year to estimate GHG reductions.

Costs

Costs for the incentives needed by this policy option are based on the difference in estimated production costs between conventional starch-based ethanol and cellulosic ethanol. The DOE EIA estimated that the cost to produce starch-based ethanol is \$1.10/gal compared to \$1.29/gal, or a difference of \$0.19/gal (in \$1998).[11] In 2006 dollars, the difference is \$0.23/gal. These incentives are considered necessary in the near term (up to 2015) to help commercialize technologies that produce ethanol from cellulose or produce starch-based ethanol using renewable fuels. The incentives should also help to establish the infrastructure to deliver biomass to bio-refineries, since producers will seek the local feedstocks or renewable fuels for their operations.

By 2015, it is assumed that advances in cellulosic ethanol production (e.g., enzyme costs, production processes) will make cellulosic ethanol production cost competitive with starch-based production. Hence, the incentives are discontinued beginning in 2015. Note that there is currently federal legislative proposal to offer cellulose an incentive of \$0.765/gallon compared to the \$0.51/gallon currently offered for ethanol production.[12] If enacted, this \$0.255/gallon premium could cover the additional incentives that are assumed to be needed

[9] Well-to-Wheels Analysis of Advanced Fuel/Vehicle Systems—A North American Study of Energy Use, Greenhouse Gas Emissions, and Criteria Pollutant Emissions, General Motors, Argonne National Lab, and Air Improvement Resource, Inc., May 2005.

[10] In the study mentioned above, the average fuel economy used was 21.3 miles/gallon or 100 miles/4.7 gallons. Multiplying this value by the emission factor of 552 grams/mile yields 11,745 grams/gallon.

[11] DOE EIA analysis can be found at www.eia.doe.gov/oiaf/analysispaper/biomass.html, accessed January 2007.

[12] D. Morris, *Making Cellulosic Ethanol Happen: Good and Not So Good Public Policy*, Institute for Local Self-Reliance, January 2007, at www.newrules.org/agri/cellulosicethanol.pdf, accessed January 2007.

by the State of Montana. Obviously, the federal incentives do not assure that production facilities would locate in MT. These federal incentives have not been factored into the cost estimates for this option.

The costs for this option were estimated using the $0.23/gal incentive multiplied by the production needed in each year. By 2015, it is assumed that these incentives will no longer be needed as cellulosic ethanol technologies become fully commercialized.

- **Key Assumptions:** Starch-based ethanol production using renewable fuels achieves equivalent GHG lifecycle benefits as cellulosic ethanol; cellulosic production or starch-based production with renewable fuels can achieve the production levels in the near term (2014 production of 310 MMgal/yr) required by this policy option; Federal tax incentives do not preclude the need for the additional state incentives assumed for the cost estimate.

Key Uncertainties

Oil market volatility; favorable federal legislation for ethanol; Federal support for cellulosic R&D;

Additional Benefits and Costs

Increased value-added farm products.

Feasibility Issues

TBD

Status of Group Approval

TBD

Level of Group Support

TBD

Barriers to Consensus

TBD

AFW–4. Incentives for Enhancing GHG Benefits of Conservation Provisions of Farm Bill Programs

Policy Description

Agricultural lands that have been placed into conservation programs such as those in the US Farm Bill may sequester carbon dioxide by implementing practices that build soil carbon over time. For example, land in the Conservation Reserve Program (CRP) is taken out of production and in the absence of tillage practices, soil carbon is sequestered over time. This option seeks to extend the GHG benefits of current Farm Bill programs, looking particularly at land that is scheduled to retire from Farm Bill programs and potentially go back into production.

Policy Design

Goals: For acreage that is being retired from conservation programs, retain these crop acres in some type of management program that protects the soil carbon.

Timing: Achieve no net conversion of acreage in conservation programs to conventional tillage by 2010. Retain no net conversion through 2020.

Parties Involved: Implementation of this option would require Governor's Office leadership in directing state conservation programs administered by the Conservation Districts Division of the Montana Department of Natural Resources and Conservation, to include USDA approved carbon sequestration planning criteria in their program literature and training of staff in order to provide technical assistance to landowners desiring to develop a carbon sequestration projects for entry into the NCOC portfolio.

Additionally, the Governor's Office should seek the cooperation of federal agency staff from USDA agencies such as the Natural Resources Conservation Service, the Farm Services Agency, and the Forest Service state and private forest staff.

Other: This strategy would be a low-cost option which would bring to bear the existing federal and state staff and programs in a focused approach unlike any other in the U.S.

Implementation Mechanisms

- **Leverage existing federal and state conservation cost share programs**: The proposed program would require Montana Conservation Districts to include terrestrial carbon sequestration benefits, emerging carbon market information, and established state or national carbon sequestration planning criteria in their program literature. Conservation District staff would be trained in to provide such information and technical assistance to landowners desiring to develop carbon sequestration projects for entry into emerging voluntary or federally mandated carbon markets. Such a program would assist Montana landowners and tribal government's use of existing federal and state conservation practice standards, and cost share programs when entering into private carbon credit trades, thus increasing incentives for conservation and carbon sequestration practices.

- **Education and Training:** Implementation of this strategy would include a series of training workshops and development of literature for inclusion in existing public affairs materials.

Related Policies/Programs in Place

TBD

Types(s) of GHG Reductions

TBD

Estimated GHG Savings and Costs per $MtCO_2e$

TBD

- **Data Sources:** TBD
- **Quantification Methods:** TBD
- **Key Assumptions:** TBD

Key Uncertainties

TBD

Additional Benefits and Costs

TBD

Feasibility Issues

TBD

Status of Group Approval

TBD

Level of Group Support

TBD

Barriers to Consensus

TBD

AFW–5. Preserve Open Space and Working Lands

Policy Description

Reduce the rate at which existing crop/pasture, rangeland, and forests are converted to developed uses. The carbon sequestered in the soils and aboveground biomass of these open spaces and working lands is often much higher than in developed land uses. Policies that preserve open space and working lands provide additional GHG benefits by reducing the vehicle miles traveled that would otherwise occur from unwise or unplanned development.

Policy Design

Goals: By 2020, reduce the rate that forest and agricultural lands are converted to developed use by 50% from current levels.

Timing: By 2015, reduce the rate of conversion by 25%; achieve full 50% by 2020.

Parties involved: Montana Department of Natural Resources and Conservation, Montana Fish, Wildlife, and Parks, USDA Forest Service, USDA Natural Resources Conservation Service; county governments and other political subdivisions of the state, private non-profit land trusts, non-profit organizations; AERO; MT Farmers Union and other farm groups.

Other: NRCS National Resource Inventory data (1987-2003) shows that Montana is losing (on average) over 2,000 acres of forest land and over 34,000 acres of rangeland on an annual basis. While some of that rangeland is turning into pastureland, more than 13,000 acres a year (on average) are being developed or becoming other rural lands. There is potential for divestiture of over 1 million acres of industrial forestland and loss of over 5 million acres of ranchlands, with some proportion of those lands being converted to development. There were more than 14,500 new subdivisions approved by local governments over past 10 years, resulting in over 1.1 million acres of new development. Many of these (e.g., Yellowstone Mountain Club in Madison County) occur on former forest and agricultural lands. Projections are 200,000 more people in next 20 years, with more than 100,000 additional homes in western Montana by 2025.

Implementation Mechanisms

- Develop a mitigation fund where developers would contribute and funds would be used to offset impacts;
- Engage local/county planning boards and zoning departments;
- Engage tourism departments and land trusts in the solution.

Related Policies/Programs in Place

There are several existing state programs aimed at conserving lands that provide important wildlife habitat. The Habitat Montana program administered by FWP uses hunting license fees to protect threatened wildlife habitats. Montana's Fish Wildlife and Parks (FWP) Wildlife Mitigation Program aims to replace wildlife and habitat lost during the development of Libby and Hungry Horse Dams. FWP state wildlife grants use federal funding through the Land and Water Conservation Fund for projects involving species of special concern and can potentially be used for land and easement acquisitions. The Natural Resource Damage Program under the Montana Department of Justice (DOJ) uses funds recovered from an environmental lawsuit to fund restoration in the Clark Fork Drainage area. The funds can be used for land and easement acquisitions.

There are also several federal programs that have been critical for funding land conservation through fee or easement purchases. The Forest Legacy Program provides funding to protect environmentally sensitive forest lands. The Habitat Conservation Plan Land Acquisition Grants Program provides funding for acquisition of vital habitat for threatened and endangered fish, wildlife and plants. At the county level, Gallatin, Ravalli, and Missoula counties have passed $40 million in bonds to protect open space, particularly agricultural land that is rapidly being converted for subdivisions.

Types(s) of GHG Reductions

TBD

Estimated GHG Savings and Costs per MtCO_2e

TBD

- **Data Sources:** TBD
- **Quantification Methods:** TBD
- **Key Assumptions:** TBD

Key Uncertainties

TBD

Additional Benefits and Costs

TBD

Feasibility Issues

Lack of funding at federal, state, and local level.

Lack of support for increased federal or state ownership.

Status of Group Approval

TBD

Level of Group Support

TBD

Barriers to Consensus

TBD

AFW–6. Forest Health Programs for Carbon Management

Policy Description

This policy seeks to increase forest carbon stocks through changes in management practices on existing forestland. The focus for this option is to identify elements within existing forest health programs that can be enhanced to achieve carbon benefits. These program elements would increase tree density, enhance forest growth rates, alter rotation times, or decrease the chances of biomass loss from fires, pests, and disease. Existing forest health programs could include the following: Ecosystem Health Risk Reduction Programs; Drought Management Programs; Flood and Riparian Management Programs; Watershed Management Programs; Habitat Management Programs; and Fire Management and Risk Reduction Programs. Note that there is a companion policy option (AFW-9. Improved Management and Restoration of Existing Stands) which promotes new programs for enhancing the GHG benefits on existing forested lands in Montana.

Policy Design

Goals: The TWG recommends that the elements of this option be incorporated into AFW-7 through AFW-9. This is due to the large overlap of the options. Originally, the TWG had felt that policy to enhance the GHG benefits of existing forest programs could be looked at separately from policy aimed at new forest programs. After further analysis and discussion, the TWG feels that it does not make sense to have separate policies for existing forest programs and for new programs.

Timing: See AFW-7 through AFW-9.

Parties involved: See AFW-7 through AFW-9.

Other: See AFW-7 through AFW-9.

Implementation Mechanisms

- **Voluntary / Negotiated Agreements:** Provide landowners and/or corporations with opportunity to enter into agreements to better utilize biomass energy and/or increase the productivity of carbon sequestered on the landscape.
- **Information and Education/ Research and Development:** Development of a carbon sequestration assessment program that would assess and assign carbon sequestration value to the state's natural, working agricultural, as well as to rangelands and grasslands. This carbon sequestration program could support a variety of GHG reduction policies. The reporting mechanism would enable reporting from the agricultural and forestry sectors, widening market participation in a carbon restricted economy.

- **Technical Assistance:** Public education and outreach to land owners regarding existing federal and state programs.
- **Funding Mechanisms and or Incentives:** Enhancement of incentives for placement of no-development easements on private land through existing or future programs. Possibly through establishment of limited-term carbon sequestration leases whose cost is linked to the "carbon sink" value of natural lands.
- **Establishment of an "Agricultural / Conservation Land Reserve":** This would establish a pool of permanently protected forest, agricultural or other conserved lands. Owners of natural/agricultural land would be provided with tax incentives to join the reserve.
- **Enhancement of the Existing Programs:** This would allow purchase and trade of development rights between high density and low density areas to conserve open space, agricultural land and forest land on the margins of growing urban areas.

Related Policies/Programs in Place

- **Department of Environmental Quality (DEQ) Open Burning Program:** The Montana / Idaho State Airshed Group was formed in 1978 to minimize or prevent the accumulation of smoke from prescribed fires and to protect state and federal air quality standards and visibility in federal Class I areas. This is accomplished, in part, through DEQ restricting open burning when atmospheric dispersion is not acceptable.

  The state of Montana has open burning regulations under the Administrative Rules of Montana (ARM) 17.8.601 et. seq. DEQ annually issues permits to major open burners allowing them to burn under the regulations. A major open burner is defined as any person, agency, institution, business, or industry conducting open burning that emits more than 500 tons of carbon monoxide or 50 tons of any other pollutant except hydrocarbons per calendar year.

  Minor burners contribute emissions to airsheds - but pay no fees. Minor open burners are not required by DEQ to obtain an air quality open burning permit, but must follow other BACT procedures that include calling the smoke management hotline and obtaining a burning permit from their local forestry office.

Types(s) of GHG Reductions

TBD

Estimated GHG Savings and Costs per $MtCO_2e$

TBD

- **Data Sources:** TBD
- **Quantification Methods:** TBD
- **Key Assumptions:** TBD

Key Uncertainties

TBD

Additional Benefits and Costs

TBD

Feasibility Issues

TBD

Status of Group Approval

TBD

Level of Group Support

TBD

Barriers to Consensus

TBD

AFW–7. Expanded Use of Biomass Feedstocks for Energy Use

Policy Description

This policy seeks to expand the use of biomass energy sources (from forests, agriculture, and other biomass resources). Biomass can be used to generate renewable energy in the form of liquid fuels (such as cellulosic ethanol), or through direct combustion to generate electricity, heat, or steam (through biomass combustion). Carbon in biomass is considered biogenic under sustainable systems; carbon dioxide emissions from biomass energy combustion are replaced by future carbon sequestration. Expanded use of biomass energy in place of fossil fuels results in net emissions reductions by shifting from high to low carbon fuels (when sustainably managed), provided the full lifecycle of energy requirements for producing fuels does not exceed the energy content of the renewable resource. Expanded use of biomass energy can be promoted through increasing the amount of biomass produced and used for renewable energy, and providing incentives for the production and use of renewable energy supplies.

Policy Design

Goals: Increase usage of woody biomass residue for renewable energy and heat generation by 450,000 tons/year above 2006 levels by 2020. To use 10% of agricultural waste for energy production by 2020.

Timing: see above.

Parties Involved: Department of Natural Resources and Conservation (DNRC), Department of Environmental Quality (DEQ), U.S. Forest Service (USFS), Bureau of Land Management (BLM), Montana State University (MSU) Cooperative Extension, University of Montana College of Forestry and Conservation, Public Service Commission, industrial/commercial energy providers and consumers, livestock and poultry producers, farmers, private landowners, forest products manufacturers, and logging companies.

Other: The current estimated amount of biomass used in Montana is 2 million dry tons, with 1.95 million derived from primary and secondary mill waste and only 85,000 tons from logging residue. It is estimated that there is 2.76 million dry tons of woody biomass available in Montana (NREL), with 704,000 dry tons available from logging residue. Therefore, the goal will be to increase the accessibility and utilization of woody biomass from logging residue to 450,000 dry tons. As the acreage being treated to reduce fire hazard in the state increase, the total amount of available biomass will also increase.

Implementation Mechanisms

- **State Lead by Example**: Require consideration of renewable resource systems (including biomass heat/energy) in all new state building constructions/renovations; Provide state support to the DNRC Biomass Utilization Fuels For Schools Program and

Beyond which identifies financially viable biomass heating opportunities and assists facilities in securing funding, supply and installation. State lands should incorporate biomass recovery objectives during program implementation

- **Source Reduction**: Reduce the amount of open slash pile burning on all lands and/or provide viable alternatives to open burning. Revise DEQ Air Quality permits to discourage open burning.
- **Voluntary / Negotiated Agreements**: Voluntary, incentive based programs should be used to foster the development of the industry and associated economic markets. Provide landowners and/or corporations with opportunity to enter into agreements to better utilize biomass energy and/or increase the productivity of carbon sequestered on the landscape.
- **Funding Mechanisms**: Provide tax incentives to reduce the capital costs of biomass energy production, including electricity generation and heating of residences and public buildings; establish utility "Buyback Rates" for biomass derived energy where utilities offer a standard rate for which they purchase biomass generated energy (electricity and/or heat.) Expand/develop renewable energy tax credits to develop new incentives for smaller distributed biomass generation.
- **Codes and Standards**: Increase efficiency standards for wood burning equipment and appliances (e.g., wood burning furnaces and stoves). Develop or expand existing net-metering regulations to enable smaller projects to net-meter at retail energy rates. (Net metering enables customers to use their own generation to offset their consumption over a billing period by allowing their electric meters to turn backwards when they generate electricity in excess of the their demand, feeding it back to the grid.)
- **Pilots and Demonstrations**: Pilot projects on the use of different forestry and agriculture residues for energy production are needed.
- **Research and Development**: Research is needed on techniques for collecting and processing forestry and agriculture residues, as well as markets for these materials.
- **Market-Based Mechanisms**: Incentives (e.g., preferential tax rates) may be needed to spur the use of biomass energy.
- **Provide Tax Incentives**: Incentives to reduce the capital costs of biomass energy production and transport for use in electricity generation and the heating of residences and public buildings. This could include tax reductions in state sales tax for a wide variety of biomass-related equipment, including but not limited to biomass harvesting/collection equipment, biomass gasification equipment, biomass electricity generation equipment, and high efficiency wood pellet stoves. Gross receipts exemptions for biomass generation facilities, project construction and related equipment and materials are also recommended.
- **Establish Utility "Buyback Rates" for "Feed-in-Tariffs"**: Applicable to biomass-derived energy where utilities offer a standard rate at which they purchase biomass generated energy (electricity and/or heat). Buyback rates for biomass projects in other regions of the country generally range from 6-7 ¢ / kWh.

- **Expand the MT Renewable Energy Tax Credit**: Lower the eligible threshold capacity from 10 MW down to 1 MW as well as expanding the classification of corporate taxpayers and including general income taxpayers.
- **Codes and Standards**: Work with local communities to develop responsible ordinances that allow the use of EPA-certified wood / pellet burning equipment (instead of broad burn bans that apply to all wood-burning equipment). Expand existing net-metering regulations to enable projects up to 2 MW in size to net-meter at retail energy rates.

Related Policies/Programs in Place

- **Renewable Portfolio Standards**: Requires public utilities to obtain 15% of their retail electricity sales from eligible renewable resources by 2015.
- **Renewable Energy Credits**: Create market for clean power generated by biomass. Western Governor's Association and California Energy Commission are currently working together to develop Western Renewable Energy Generation Information System (WREGIS), a regional renewable energy tracking and registry system.
- **Alternative Energy Revolving Loan Program**: Provides loans to individuals, small businesses, local government agencies, units of the university system, and nonprofit organizations to install alternative energy systems that generate energy for their own use. Max loan amount is $40,000 with a fixed interest rate and must be paid back within 10 years.
- **Montana Electric Cooperatives - Net Metering**: Under the model policy, customers generating their own electricity using (but not limited to) wind, solar, geothermal, hydro, biomass or fuel cells may participate in net metering.
- **Mandatory Green Power Program**: NW Energy offers its customers the option of purchasing a product composed of or supporting power from certified environmentally preferred resources generated by renewables including biomass.
- **DNRC Forestry Assistance Programs**: Maintain and improve the health of Montana's forests, forested watersheds and the communities that depend on them. Tools include Information and Education, Technical Assistance and Financial Assistance.
- **Biomass Utilization Fuels for Schools and Beyond Program**: Promoting the use of forest biomass as an energy source for heating schools and other pubic facilities. Utilization of biomass energy for heat and energy creates carbon offsets when compared to utilization of fossil fuels.
- **USFS Woody Biomass Utilization Policy**: Recently implemented, it requires that contractors doing work on federal lands, haul and pile slash at landings to help facilitate removal of biomass during forest operations for utilization.
- **Trust Land Forest Management Program**: Recently implemented, the Forestry Management Bureau has recently changed the timber bid sale process for state trust lands to encourage removal of residues for pulp and biomass.

Types(s) of GHG Reductions

TBD

Estimated GHG Savings and Costs per $MtCO_2e$

TBD

- **Data Sources:** TBD
- **Quantification Methods:** TBD
- **Key Assumptions:** TBD

Key Uncertainties

Amount of biomass residues generated is dependant on the number of forest acres and trees that are treated. This can be greatly impacted by budget limitations, state and federal forest policies, and forest management litigation or appeals.

Additional Benefits and Costs

- Encourages management of forested lands by contributing to economically viable ways to remove hazardous fuels and maintain healthy forests.
- Opportunity for local forest-dependent economies to supplement their businesses based on supplying woody biomass to users.
- Reduced risk of severe wildfires and their negative impacts on habitats, homes, communities and watersheds.
- Forest carbon sequestration potential is improved with the thinning-treatments of forests.
- Reduced emissions from open-pile slash burning (reductions in particulate matter, CH4, NOx, SOx, CO.
- Displace the emissions associated with the combustion of traditional fossil fuels of natural gas, propane, fuel oil).
- Reduce dependence on foreign fossil fuels.
- Emissions associated with collection and transport
- Distributed heat and energy sources for national security.
- Economic and efficient recovery and transportation of forest biomass feedstock.
- Forest management litigation or appeals on state and federal lands.
- Long-term availability of biomass feedstock supplies at low costs.
- Challenges in permitting facilities in air quality non-attainment areas.

Feasibility Issues

TBD

Status of Group Approval

TBD

Level of Group Support

TBD

Barriers to Consensus

TBD

AFW–8. Afforestation and Reforestation Programs

Policy Description

Increase carbon stored in forests through expanding the forestland base. Establishing new forests, either on historically non-forested land ("afforestation") or on land that has not been managed as forest land for some time ("reforestation") increases the amount of carbon in biomass and soils compared to pre-existing conditions. Afforestation and reforestation accomplished with stocking/planting and other practices (e.g., soil preparation, erosion control, etc.) can increase carbon stocks above baseline levels and ensure conditions that support forest growth.

Policy Design

Goals: Ensure re-stocking on 20% of the accessible forest lands impacted by stand replacement fires since year 2000 (estimated at 70,000 acres) to stocking rates of 200-400 trees/acre (depending on forest type). For future lands impacted by wildfire, re-stock 30% of the forest lands impacted by stand replacement fires within 5 years post-fire.

Plant 1,300 new trees in Montana communities within 5 years through programs such as DNRC's Urban Forestry program.

Timing: By 2010, ensure re-stocking on 15,000 acres of accessible lands impacted by stand replacement fires since year 2000; by 2020, ensure restocking on the remaining 55,000 acres. As stated in the goal above, for future fires, re-stock 30% of the high severity burned forest lands within 5 years post-fire. For the urban area goals, achieve these by 2013.

Parties involved: Montana Department of Natural Resources and Conservation, USDA Forest Service, UM School of Forestry & Conservation, Conservation Districts, watershed management groups, Bureau of Land Management, Bureau of Indian Affairs, Confederated Salish and Kootenai Tribe, USDA Natural Resources Conservation Service; private industry, non-industrial private landowners.

Other: Since 2000, over 3.3 million acres have burned in Montana. It is roughly estimated that one-third of these have been forested acres and of the forested acres about one third have been high severity burns that require some level of restocking. Some of these areas have been replanted; however there are an estimated 70,000 acres still requiring replanting. In addition, each year there are an estimated 20,000 acres per year of forests burned with high severity (stand replacement fires). Together, there is a need for re-stocking on about 25,000 acres/yr on federal, state, and private lands in Montana between 2007 and 2020 to meet the goals of this policy. Reforestation costs are roughly $180 per acre.

A 2007 study (Potter et al.) estimates there are over 69 million acres of low-production rangelands in Montana that could be afforested to result in carbon gains. More realistically, only 8.9 million acres are available for afforestation due to precipitation and soil nutrient limitations.

The potential results of afforesting 8.9 million acres could be the sequestration of over 15 million tons of carbon annually.

However, a question remains on the efficacy of afforestation in Montana. The best possible means for afforestation could remain with the development of wind break, shelter belts, and riparian areas. As currently envisioned, this policy only covers reforestation efforts on high severity burned areas and some urban forestry goals.

Implementation Mechanisms

- *This paragraph marked for deletion.* **Voluntary / Negotiated Agreements**: Provide landowners and/or corporations with opportunity to enter into agreements to better utilize biomass energy and/or increase the productivity of carbon sequestered on the landscape.
- **Information and Education**: Work through the Montana State University extension forestry program and DNRC's Forest Stewardship Program to educate private forest landowners on the importance and practice of stand regeneration, post-fire reforestation, and restocking. *Rest of paragraph marked for deletion.* Development of a carbon sequestration assessment program that would assess and assign carbon sequestration value to the state's natural, working agricultural, as well as to rangelands and grasslands. This carbon sequestration program could support a variety of GHG reduction policies. The reporting mechanism would enable reporting from the agricultural and forestry sectors, widening market participation in a carbon restricted economy. Provide information and education programs to private landowners (DNRC, NRCS, USDA).
- **Technical Assistance**: *First sentence marked for deletion* Public education and outreach to land owners regarding existing federal and state programs. Develop interagency partnerships with Natural Resource Conservation Service, USDA State and Private Forestry, Conservation Districts, and the Montana DNRC to deliver comprehensive private forest landowner assistance and cost-share programs for forest management and post-fire rehabilitation. Develop interagency site-specific reforestation plans post-burn with planting targeted for stand replacement fires.
- *This paragraph marked for deletion* **Funding Mechanisms and or Incentives**: Enhancement of incentives for placement of no-development easements on private land through existing or future programs. Possibly through establishment of limited-term carbon sequestration leases whose cost is linked to the "carbon sink" value of natural lands.
- *This paragraph marked for deletion.* **Establishment of an "Agricultural/Conservation Land Reserve:"** This would establish a pool of permanently protected forest, agricultural or other conserved lands. Owners of natural/agricultural land receive tax incentives to join the reserve.
- **Enhancement of the Existing Programs**: Utilize DNRC Conservation Seedling Nursery to provide locally adapted and native seedlings for private forest and riparian area reforestation projects. Provide additional support and resources to this program in order increase the capacity for program delivery.

- **State Lead by Example**: Plant 1,300 new trees in Montana Communities within 5 years through programs such as DNRC's Urban Forestry program. On state trust lands, DNRC generally plants 700-1,000 acres per year. In 2007 that level will increase to 1,700 acres due largely to areas impacted by wildland fires.

Related Policies/Programs in Place

- **Forestry Best Management Practices:** Montana has no regulations that direct landowners to replant stands post-harvest or post-burn. However, Forestry Best Management Practices encourage rapid reforestation post-harvest.
- **USFS/BLM Policies:** Pending
- **Long Term Maintenance Goals:** On state trust lands there are general rules to maintain long-term productivity of forest lands, but no specific rules aimed at reforestation. However, DNRC has an active reforestation program focused in areas where natural regeneration is not occurring or where there are issues with tree species composition.
- **DNRC Forestry Assistance Programs:** Maintain and improve the health of Montana's forests, forested watersheds and the communities that depend on them. Tools include Information and Education, Technical Assistance and Financial Assistance.
    1. Urban and Community Forestry: Provide Montana's urban communities with assistance in establishing and maintaining healthy, productive and financially beneficial urban forestry programs and urban forests.
    2. Conservation Seedling Nursery: Produce and distribute seedlings for conservation plantings to private landowners, state federal and tribal landowners and other conservation organizations
    3. Forest Pest Management: Provide non-industrial forest landowners, and others, assistance in the identification and management of forest insects and diseases.
    4. Biomass Utilization: Promoting the use of forest biomass as an energy source for heating schools and other pubic facilities.
    5. Forest Stewardship: Promote forest stewardship by assisting non-industrial forest landowners in acquiring personal knowledge about their forest resources and in developing and implementing a forest management plan for their property.

Types(s) of GHG Reductions

TBD

Estimated GHG Savings and Costs per $MtCO_2e$

TBD

- **Data Sources:** TBD
- **Quantification Methods:** TBD
- **Key Assumptions:** TBD

Key Uncertainties

TBD

Additional Benefits and Costs

TBD

Feasibility Issues

Nursery Capacity: Consider logistics and funding associated with the existing state nursery capacity and ability to respond to increased seedling demand.

Availability of Seed Source Funding

Status of Group Approval

TBD

Level of Group Support

TBD

Barriers to Consensus

TBD

AFW– 9. Improved Management and Restoration of Existing Stands

Policy Description

This policy seeks to increase forest carbon stocks through changes in management practices on existing forestland. In contrast to the companion policy AFW-6, this policy is not restricted to working through existing forest health programs to promote new practices that increase tree density, enhance forest growth rates, alter rotation times, or decrease the chances of biomass loss from fires, pests, and disease. In addition, increasing the transfer of biomass to long-term storage in wood products can increase net carbon sequestration, provided a proper balance is maintained where enough biomass remains on site as residues serving as nutrient inputs to the forest. Practices may include management of rotation length, biomass density, biomass energy use, and sustainable use of wood products.

Policy Design

Goals: Initiate programs to increase forest productivity by 20% on 1 million acres of private and state forest lands by 2020.

Timing: Accelerate private forest landowner education programs by 2010; Implement forest improvement projects on 77,000 acres of state and private forest lands per year.

Parties Involved: Montana Department of Natural Resources, Montana Fish, Wildlife, and Parks, UM School of Forestry and Conservation, USDA Forest Service, USDA Natural Resources Conservation Service; Bureau of Land Management, Bureau of Indian Affairs and Tribal Governments, county governments and other political subdivisions of the state, private non-profit land trusts, non-profit organizations.

Other: A 2001 study (Fiedler et al.) estimated that 7.5 million acres of Montana's forestlands should be considered for treatment because they are in the moderate or high fire hazard condition in short-term fire-adapted ecosystems. Treating these stands would reduce fire hazard potential, improve forest health and diversity, and restore stand conditions. In 2005, over 1.2 million acres of Montana's forestlands (all ownerships) were impacted by insect and diseases.

Implementation Mechanisms

- *This paragraph marked for deletion* **Voluntary / Negotiated Agreements:** Provide landowners and/or corporations with opportunity to enter into agreements to better utilize biomass energy and/or increase the productivity of carbon sequestered on the landscape.
- **Information and Education:** Work through the MSU extension forestry program and DNRC's Forest Stewardship Program to educate private forest landowners on the forest health and hazardous fuels mitigation benefits of implementing proper forest management and silvicultural practices. In turn, this will increase forest productivity and

improve stand health. Use success stories from state trust lands to inform private landowners on the benefits of forest management. *Rest of paragraph marked for deletion* Development of a carbon sequestration assessment program that would assess and assign carbon sequestration value to the state's natural, working agricultural, as well as to rangelands and grasslands. This carbon sequestration program could support a variety of GHG reduction policies. The reporting mechanism would enable reporting from the agricultural and forestry sectors, widening market participation in a carbon restricted economy. Increase private forest landowner forest stewardship education workshops and incorporate GFG reduction education and strategies into its curriculum. Provide GHG information and education to Montana urban forest managers to increase carbon sequestration in urban forests.

- **Technical Assistance:** Public education and outreach to land owners regarding existing federal and state programs. Continue DNRC Service Forester assistance to non-industrial private forest landowners, targeting stewardship program graduates with current Stewardship Management Plans and private land management efforts such as The Blackfoot Challenge.
- **Funding Mechanisms and or Incentives:** Utilize Natural Resource and Conservation Service and USDA State and Private Forestry cost-share programs to assist private forest landowners. Timber management focused on stagnant, overstocked, over-aged, or debilitated stands of trees would provide increased carbon sequestration. Incentives for this management would be ecologically improved and more productive forestlands and the sale of the harvested logs earnings enough to, at a minimum, pay for the cost of the work. *Rest of paragraph marked for deletion* Enhancement of incentives for placement of no-development easements on private land through existing or future programs. A possible approach is establishment of limited-term carbon sequestration leases whose cost is linked to the "carbon sink" value of natural lands.
- *Paragraph marked for deletion* **Establishment of an "Agricultural/Conservation Land Reserve":** This would establish a pool of permanently protected forest, agricultural or other conserved lands. Owners of natural/agricultural land would be provided with tax incentives to join the reserve. Forestlands managed to provide improved carbon sequestration would be described as natural.
- **Enhancement of the Existing Programs:** *first sentence marked for deletion* . This would allow purchase and trade of development rights between high density and low density areas to conserve open space, agricultural land and forest land on the margins of growing urban areas. Provide increased guidance and expertise to forestland owners to promote the implementation of proper forest management. DNRC currently has urban, non-industrial private forest landowner and forest health programs which provide to landowners and urban forest managers, information/education, technical and, when available, financial assistance.

  These programs are predominately federally funded through USDA Forest Service State and Private Forestry and the Farm Bill. These programs are targeted for significant reduction in the Presidents 2008 budget proposal. Continuation of these federal programs through State efforts in Washington DC and program enhancement through State of Montana legislative and fiscal support for these programs with a new focus on GHG reduction and carbon sequestration strategies.

- **Hazard Identification:** Identify areas of high hazard within the wildland-urban interface and other high-risk areas (high fire hazard, severe overstocking, insect & disease attacks, etc) to target for accelerated treatments to improve stand conditions, which will also result in improved stand productivity.
- **Improve Inventory:** Collect stand data on 10% of forest stands on state trust lands within 10 years. Educate private non-industrial landowners to do the same.
- **Increase Forest Productivity:** On state trust lands, increase forest productivity on 12,000 to 15,000 acres per year through active forest management.
- **Sustained Yield Calculation:** Consider statewide coarse filter sustained yield calculation across all land ownerships.

Related Policies/Programs in Place

- **Fire Risk and Forest Health Initiatives:** Current fire risk and forest health initiatives directed towards density reduction include the multi-agency National Fire Plan and the Western Governor's Association 10-year Comprehensive Strategy for Implementation of the National Fire Plan.
- **Cost-Share Assistance Programs:** Cost-share assistance for fuels treatment on private lands is provided through Community Protection Fuels Mitigation Grant Program and Western Wildland Urban Interface Grant Program. Utilize Natural Resource Conservation Service and USDA State and Private Forestry cost-share programs to assist private forest landowners.
- **DNRC Forest Management Goals and Objectives:** On state trust lands the DNRC forest management objectives through the State Forest Land Management Plan and the current Administrative Rules are to move stands towards desired future conditions that are based on historical cover type distributions. More specific goals for state lands include thinning overstocked stands, reducing fire hazard, and managing for forest health and biodiversity.
- **Department of Environmental Quality (DEQ) Open Burning Program:** The Montana / Idaho State Airshed Group was formed in 1978 order to minimize or prevent the accumulation of smoke from prescribed fire to protect state and federal air quality standards and visibility in federal Class I areas. This is accomplished, in part, through DEQ restricting open burning when atmospheric dispersion is not acceptable. *This bullet marked for deletion*

  As noted above in AFW-6, Montana has open burning regulations under ARM 17.8.601 et. seq. It focuses on large open burners (those emitting more than 500 tons of carbon monoxide or 50 tons of other pollutants per calendar year).

  Minor burners contribute emissions to airsheds - but pay no fees. Minor open burners are not required by DEQ to obtain an air quality open burning permit, but must follow other best available control technology (BACT) procedures that include calling the smoke management hotline and obtaining a burning permit from their local forestry office.

- **DNRC Forestry Assistance Programs:** Maintain and improve the health of Montana's forests, forested watersheds and the communities that depend on them. Tools include Information and Education, Technical Assistance and Financial Assistance. Supporting programs could include:

  — Forest Stewardship: Promote forest stewardship by assisting non-industrial forest landowners in acquiring personal knowledge about their forest resources and in developing and implementing a forest management plan for their property.

  — Urban and Community Forestry: Provide Montana's urban communities with assistance in establishing and maintaining healthy, productive and financially beneficial urban forestry programs and urban forests.

  — Forest Pest Management: Provide non-industrial forest landowners, and others, assistance in the identification and management of forest insects and diseases.

  — Conservation Seedling Nursery: Produce and distribute seedlings for conservation plantings to private landowners, state federal and tribal landowners and other conservation organizations.

  — Biomass Utilization: Promoting the use of forest biomass as an energy source for heating schools and other pubic facilities.

Types(s) of GHG Reductions

TBD

Estimated GHG Savings and Costs per $MtCO_2e$

TBD

- **Data Sources:** TBD
- **Quantification Methods:** TBD
- **Key Assumptions:** TBD

Key Uncertainties

TBD

Additional Benefits and Costs

TBD

Feasibility Issues

- Loss of cost-share assistance or state budget cuts
- Loss of forest industry
- Litigation/appeals for state projects

- Poor timber product markets will reduce financial incentives for management on non-industrial private lands.
- Loss of productive forestland

Status of Group Approval

TBD

Level of Group Support

TBD

Barriers to Consensus

TBD

AFW–10. Expanded Use of Wood Products for Building Materials

Policy Description

This policy seeks to enhance the use and lifetime of durable wood products. Durable products made from wood prolong the length of time forest carbon is stored and not emitted to the atmosphere. Following their useful life which could last for decades, wood products disposed of in landfills may store carbon for long periods under conditions that minimize decomposition. Additional GHG benefits can be achieved when methane gas is captured from landfills and used as an energy source. (Carbon originally stored in wood products becomes methane during decomposition.) Increasing carbon stored in the wood products pool increases carbon sequestration from forests. This can be achieved through improvements in production efficiency, product substitution, expanded product lifetimes, and other practices. In addition, increasing the efficiency of the manufacturing lifecycle for wood products enhances greenhouse gas benefits.

Policy Design

Goals: The CCAC recommends that Montana adopt programs to expand use of wood products by 5% over current baseline rates of use.

Timing: Increase usage by 2% by 2010 and 5% by 2020, above current trends.

Parties involved: Building material suppliers, wood product industries, and recycled building materials sellers, etc., UM School of Forestry & Conservation, All state agencies lead through example.

Other: As needed, identify incentives that encourage expanded use of wood products for building, such as giving state tax credits for the use of wood products in building "good sense" homes. Conduct an inventory of needs for durable wood product utilization in Montana. *[Note: need to add data on current levels]*.

Implementation Mechanisms

- **State Adopted Policies**: The state should adopt policies that require wood products in the construction and maintenance of all state buildings when those products are feasible and relatively close in price (within 5%) to the alternative.
- **Product Substitution**: Promote using wood products whenever and wherever feasible, instead of metal or synthetic building materials. Also promote replacing petroleum thinners and solvents with those derived from wood and tree sap / pitch (i.e., naval stores)..
- **Tax Incentives**: Giving tax incentives or low costs loans for the development and production of new wood products and derivatives. Montana state tax credits for the use of wood product in building energy efficient homes.

- **Expanded Product Lifetimes**: Activities that expand lifetimes through preservatives – these can also be derived from wood.
- **New Products**: Developing wood as fuel, filler for organic composting, bedding for livestock, and creating grants or support for research and development of new products. The Montana University System would be an excellent vehicle for such research and development.
- *This paragraph marked for deletion* **Voluntary / Negotiated Agreements**: Provide landowners and/or corporations with opportunity to enter into agreements to better utilize biomass energy and/or increase the productivity of carbon sequestered on the landscape.
- **Education / Outreach**: Develop information and education program to promote product substitution (using wood products whenever and wherever feasible, instead of metal or synthetic building materials) and the benefits gained through carbon sequestration.
- *This paragraph marked for deletion* **Identify Incentives**: Encourage the expanded usage of wood products for building through non-tax incentives like low-cost, long-life, give-a-ways, etc.
- *This paragraph marked for deletion* **Forest Residue Alternative Use**: Create incentives through low-interest loans or tax incentives to encourage alternative uses for forest residues. Alternative uses may include energy production and/or building materials.

Related Policies/Programs in Place

- **State Hazard Reduction Regulations**: State forest hazard reduction law and administrative rules require the reduction of timber slash during harvest projects. Although not required the current law and rules structure makes burning slash the most feasible method of reducing the hazard.
- **Forest Service**: USFS has recently implemented a policy to require contractors to haul and pile slash as landings to help facilitate removal of biomass during harvest operations.
- **DNRC Logging Contracts**: Slash treatment requirements are currently part of all DNRC logging contracts.
- **Trust Land Forest Management Program**: Recently implemented, the Forestry Management Bureau has recently changed the timber bid sale process for state trust lands to encourage removal of residues for pulp and biomass.
- *This paragraph marked for deletion* **Timber Sale Process**: DNRC forestry bureau has changed the timber sale bid process for state trust lands to encourage the removal of pulp and biomass as a condition of the sale.

Types(s) of GHG Reductions

TBD

Estimated GHG Savings and Costs per $MtCO_2e$

TBD

- **Data Sources:** TBD
- **Quantification Methods:** TBD
- **Key Assumptions:** TBD

Key Uncertainties

TBD

Additional Benefits and Costs

TBD

Feasibility Issues

Cost effectiveness of non-wood alternatives

Availability of wood products to substitute for non-wood alternatives

Quality/durability of wood versus the alternatives

Status of Group Approval

TBD

Level of Group Support

TBD

Barriers to Consensus

TBD

AFW–11. Programs to Promote Local Food and Fiber

Policy Description

Programs that promote the production, distribution and consumption of locally-grown food and fiber products reduce transportation and manufacturing emissions by offsetting the consumption of products with higher embodied energy. Food and fiber products consumed in the U.S. can travel thousands of miles before reaching a grocery or clothing store in the form of a final product (on average a typical food product travels 1,500 miles and changes hands 33 times). Increasing the percentage of locally grown food and fiber consumed in Montana will significantly reduce fossil fuel use and its associated GHG emissions.

Policy Design

Goals: 30% of food consumed in Montana is grown, harvested and processed in Montana.

Timing: For food, by 2010, 20%; by 2020, 30%**.**

Parties involved: Promotion by MT Dept of Ag, Farm Bureau, Stock Growers, Montana Cattlemen's Association, Grow Montana, AERO, NCAT, sheep producers, wool growers, grain growers, etc.

Tracking by MT Dept of Ag.

Other: Montana-based food systems are a realistic vision.

- In 1950, 70% of the food Montanans ate was grown in Montana.
- Through the 1930's, food processing was our state's number one employer.
- In the spring of 2003, The University of Montana-Missoula responded to student demand by launching the Farm to College Program, purchasing safflower oil, beef, bread, dairy products, and fruits and vegetables from Montana producers. In the past two years, the program bought more than $500,000 from in the state. In the same period, the University's overall food costs—as a percentage of its food service budget—decreased.

Notes to reviewers: I'm suggesting a food goal based on historic information. In 1950, 70% of the food Montanans ate was grown in Montana. Today it is 15%. If we sourced 30% instead of 15% of our food in-state, an additional $450 million would go directly to our food producers and the associated carbon dioxide burned as a result of transportation of these products would be saved.

Implementation Mechanisms

TBD

Related Policies/Programs in Place

Grow Montana Program (http://growmontana.ncat.org/). Goal is strengthening our food and agricultural economy. **Grow Montana** is a broad-based coalition whose common purpose is: To promote community economic development policies that support sustainable Montana-owned food production, processing, and distribution, and that improve all of our citizens' access to Montana foods. Other initiatives:

2005 State Legislature passed:
Legislation to authorize the Montana Department of Livestock to inspect mobile meat slaughter units. By harvesting animals on-farm in an inspected mobile unit, farmers and ranchers can sell meat at any Montana retail, restaurant or direct market. Read bill text.

Introduced in the 2007 State Legislature
SB 328 Montana Food to Institutions: Optional Procurement Exception by Sen. Donald Steinbeisser (R-Sidney) allows institutions to buy Montana grown or processed food, even if it costs a little more.

The UM Farm to College Program (http://ordway.umt.edu/SA/UDS/index.cfm/page/917)
University Dining Services and four UM graduate students teamed-up in the spring of 2003 to create the UM Farm to College Program, dedicated to buying more food locally and regionally to feed the campus community.

Agriculture Marketing & Business Development Bureau, Montana Department of Agriculture promotes local Farmers Markets (http://www.agr.state.mt.us/business/farmersMkts06.pdf)

Abundant Montana, the Alternative Energy Resources Organization's **(AERO's) Directory to Sustainably Grown Montana Food**. Over 80 sustainable farms, ranches, and retailers are listed by region and by farm name, in the 5th edition of *Abundant Montana*, published in 2005. Products range from fruits and vegetables to processed foods, to meat products and grains. The directory gives consumers who value sustainability and community the means to express their values through their food purchases while supporting the growers, processors and retailers who share their values. (http://www.aeromt.org/publications.php)

Types(s) of GHG Reductions

TBD

Estimated GHG Savings and Costs per $MtCO_2e$

TBD

- **Data Sources:** TBD
- **Quantification Methods:** TBD
- **Key Assumptions:** TBD

Key Uncertainties

TBD

Additional Benefits and Costs

TBD

Feasibility Issues

TBD

Status of Group Approval

TBD

Level of Group Support

TBD

Barriers to Consensus

TBD

AFW–12. Enhanced Solid Waste Recovery and Recycling

Policy Description

Programs are needed to increase the quantity of materials recovered for recycling with specific attention given to materials with the greatest ability to reduce energy consumption during the manufacturing process and to materials that may be used as a fuel source (e.g., clean wood waste). Reducing the quantify of materials being landfilled reduces future landfill methane emissions potential, while recycling reduces emissions associated with the manufacturing of products from raw materials.

Policy Design

Goals: Increase Montana solid waste recycling rates to 17% by 2008, 19% by 2011, 22% by 2015, (targets from the Montana Integrated Waste Management Plan) and 25% by 2020 using a variety of methods including source reduction, reuse, recycling and composting.

Timing: see above.

Parties involved: DEQ, Montana Association of Counties (MACo), MSU Extension, local governments, other landfill operators (private), recycling firms.

Other: Based on DEQ estimates, the current recycling rate overall was 14.3% in 2005. Total diversion was 18.7%, which includes composted material.[13]

Implementation Mechanisms

- Educational outreach.
- Local market development for recycled materials.
- Encourage inter-county cooperation using the Headwaters Recycling model.
- Increased recycling of waste wood to composting and biomass energy.
- Develop better tracking methods for recycling volumes.
- Encourage integration of waste-to-energy in sewage treatment plant upgrades.
- Encourage composting of biosolids over landfilling.
- Encourage Montana landfills to participate in the EPA Methane Outreach Program.
- Implement programs whereby manufacturers are given the responsibility to take products back for recycling ("cradle to cradle responsibility").

[13] MT DEQ 2005 Recycling Summary, http://deq.mt.gov/Recycle/2005Recy_Summary_01-11.htm.

Related Policies/Programs in Place

- Montana Integrated Waste Management Act and Plan.
- No cost licenses from DEQ for small composters, recyclers, and small biodiesel producers.
- Tax credit for purchase of recycling equipment.
- Tax deduction for purchase of recycled products.

Types(s) of GHG Reductions

Net reduction in CO_2 and methane emissions.

CO_2: Upstream Energy Use Reductions – The energy and GHG intensity of manufacturing a product is generally less using recycled feedstocks than from using virgin feedstocks.

Methane: Diverting organic wastes from landfills will result in a decrease in methane gas releases from landfills.

Estimated GHG Savings and Costs per $MtCO_2e$

Estimated GHG Savings in 2012 and 2020: 0.24, 0.74

Cost Effectiveness: $x

- **Data Sources:** These include information from DEQ's 2005 Recycling Summary cited above and EPA's WAste Reduction Model (WARM). 2005 DEQ recycling data are as follows (initial modeling conducted using WARM "mixed recyclables"):

Recycled Material	2005 Tons	% of Total
Cardboard		
Newspaper		
Office Pack		
Phone Books		
Magazines		
Aluminum		
Total	**208,399**	**100**

In addition, there was a total of 64,524 tons of material composted.

- **Quantification Methods: GHG Reductions**

Non-Organics Recycling

WARM was used to estimate GHG reductions achieved via recycling.[14] The wastes in the table above were aggregated into the applicable WARM material categories (initial estimates based on mixed recyclables): mixed paper waste (fibers in the table above), mixed metals (scrap metals in the table above), and mixed recyclables (containers and miscellaneous in the table above). A baseline estimate of waste recycling and associated GHG reductions for 2005 (representing a 14% MSW diversion rate) was established by inputting the diverted quantities for each waste material.

The incremental benefit for 2012 and 2020 was then determined by inputting the additional quantities of waste that would be recycled in each year (18% in 2012 and 25% in 2020). These additional quantities of recycled materials excluded organic materials (addressed below). CCS assumed that the fractions of materials diverted remained the same as in 2005 (initial estimates based on mixed recyclables): mixed paper (0.56); mixed metals (0.23); and mixed recyclables (0.21). CCS also grew the waste generation in each future year using the 0.6%/yr population growth as used in the GHG inventory and forecast. Finally, the volume of organic material composted is assumed to rise at the same rate as recycled materials. The table below shows the resulting waste recycling amounts and rates in each year.

Table 1. Waste Diversion Rates

Year	2005	2010	2012	2015	2020
MSW Landfilled	1,184,198	1,220,153	1,234,839	1,257,199	1,295,371
MSW Recycled (minus organics)	208,399	253,377	295,543	360,631	481,003
Organics Composted	64,524	78,450	91,505	111,658	148,927
Recycle Rate	14.3%	16.3%	18.2%	20.9%	25.0%
Diversion Rate	18.7%	21.4%	23.9%	27.3%	32.7%

For the incremental tons recycled, WARM provided the following results:

Scenario	$MtCO_2e$
Baseline WARM GHG Reduction	536,069
2012 Incremental GHG Reduction	224,162
2020 Incremental GHG Reduction	701,224

[14] The WARM model and associated documentation can be downloaded from: www.yosemite.epa.gov/oar/globalwarming.nsf/content/ActionsWasteWARM.html. Note that CCS excluded organic materials diverted for composting from the recycled amounts in this analysis.

Composting of Organic Material

By composting organic material, the CH_4 emissions that would have been generated via anaerobic decomposition in a landfill are avoided. Landfill methane avoided for the baseline (2005) organics material diversion was estimated using an estimate of the degradable organic carbon (DOC) content from the United Nations Framework Convention on Climate Change (UNFCC).[15]

For this assessment, landfill gas generated at the applicable landfills in MT is assumed to be collected and controlled. The EPA default methane collection efficiency of 75% is applied. Also, the default assumption of 10% oxidation of CH_4 as it diffuses through the landfill soil cover is applied. The baseline landfill methane avoided is (see footnote for additional details):

$$\text{Baseline } CH_4 = (64{,}524 \text{ ton organics}) \times (0.21) \times (0.50) \times (0.907 \text{ Mt/ton}) \times (16/12) \times 21 \times (1-0.75) \times (1-0.10)$$
$$= 38{,}713 \text{ MtCO}_2\text{e}$$

Using this method for calculating the GHG reductions and the tons of organics to be recycled in 2012 (91,505) and in 2020 (148,927) as shown in Table 1 above, the incremental benefit of increased organic material composting in 2012 is 16,188 $MtCO_2e$ and 50,640 $MtCO_2e$ in 2020.

Because GHG emissions also occur as a result of composting, these emissions need to be factored in to obtain a net GHG benefit for organics recycling. CCS used an average CH_4 emission factor of 1.12 lb/ton material from tests conducted by the South Coast Air Quality Management District in California.[16] CH_4 emissions from the incremental composting in 2012 are estimated to be 99 $MtCO_2e$ and in 2020 to be 540 $MtCO_2e$. Nitrous oxide emissions were estimated from tests done on composting of cattle manure[17] (no data on MSW organic materials were identified). The average N_2O emission factor was 0.94 lb/ton of manure. Applying this emission factor to the incremental organic materials composted in 2012 and 2020 yielded: 3,566 $MtCO_2e$ and 11,154 $MtCO_2e$, respectively. Hence, the net GHG benefits for the incremental organics composting are:

[15] UNFCC, CDM – Executive Board, "Approved baseline and monitoring methodology AM0039", September 29, 2006. The average DOC content for lawn & garden, food, and wood/straw waste is 21%. Default CH_4 content of landfill gas is 50%. 16/12 is the ratio of molecular weights of carbon and methane. 21 is the global warming potential of methane.

[16] Average of three facilities conducting composting of a variety of organic materials – digested biosolids, manure, wood waste, rice hulls, and green waste. Documented in Roe et al, 2004, *Estimating Ammonia Emissions from Anthropogenic Nonagricultural Sources*, Final Report, prepared for the U.S. EPA, Emission Inventory Improvement Program, April 2004.

[17] X. Hao, C. Chang, F.J. Larney, and G.R. Travis, "Greenhouse Gas Emissions during Cattle Feedlot Manure Composting", *Journal of Environmental Quality*, 30:376-386 (2001).

Estimate	2012 $MtCO_2e$	2020 $MtCO_2e$
Landfill methane avoided	16,188	50,640
Composting methane	288	900
Composting nitrous oxide	3,566	11,154
Net GHG Benefit	**12,334**	**38,586**

Therefore, the overall emission reductions for the policy option are 236,496 MtCO2e in 2012 and 739,810 $MtCO_2e$ in 2020.

Costs

Non-organics recycling. CCS assumed that the policy would be applied to households in X County (x households), X County (x households), and X County (x households). Single-stream recycling service would cost $x per pick-up with each pick-up occurring every x weeks. Further, it is assumed that households would fill a 96-gallon container with mixed recyclables. This resulted in an annual average cost per household of $x. The total annual cost for all households is $x.x million.

There are also societal cost savings associated with this option in that landfill tipping fees are avoided for the waste that is diverted. Tipping fees in MT range from $x to $x per ton. Using an EPA estimate of waste density (0.05 ton/yd^3), the volume of the recycle container, the number of annual pick-ups, and the number of households, the total waste to be diverted was estimated to be xx,xxx tons/yr. Using the mid-point of the range in tipping fees, the avoided landfill cost is $x.x million/yr. The net cost for the non-organics recycling is $x.x million/yr. Using the GHG reduction estimates derived above, the cost effectiveness in 2020 is $x.x million/xxx,xxx Mt = $x.xx/$MtCO_2e$.

Organics Composting

Note: Information to be added.

- **Key Assumptions:** Assumptions used in the EPA WARM modeling include the use of the “current mix” of recycled and virgin material inputs to production (i.e. new products are not produced with 100% virgin materials); landfill gas is flared; 75% collection efficiency for LFG; distance to the landfill and recycling facilities (50 miles). Another key assumption is how representative the N_2O composting emission factor is in representing emissions from MSW organic materials composting.

Key Uncertainties

TBD

Additional Benefits and Costs

TBD

Feasibility Issues

TBD

Status of Group Approval

TBD

Level of Group Support

TBD

Barriers to Consensus

TBD