

**Agriculture, Forestry, and Waste Management Technical Work Group**  
**Summary List of Mitigation Options**

|        | Mitigation Option  | GHG Reductions (MMtCO <sub>2</sub> e) |       |                 | Net Present Value 2007–2020 (Million \$) | Cost-Effectiveness (\$/tCO <sub>2</sub> e) | Level of Support |
|--------|--|---------------------------------------|-------|-----------------|--|--|------------------|
|        |  | 2010                                  | 2020  | Total 2007–2020 |  |  |                  |
| AFW-1  | Agricultural Soil Carbon Management – Conservation/No-Till                             | 0.06                                  | 0.20  | 1.4             | 0  | 0  | TBD              |
|        | Agricultural Soil Carbon Management – Organic Farming                                  | nq                                    | nq    | nq              | nq                                       | nq   |                  |
| AFW-2  | Biodiesel Production (Incentives for Feedstocks and Production Plants)                 | 0.03                                  | 0.24  | 1.5             | 83                                       | 55   | 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 | 0.5                                   | 1.6   | 15              | 181                                      | 12   | TBD              |
| AFW-5  | Preserve Open Space and Working Lands – Agriculture                                    | 0.02                                  | 0.03  | 0.2             | 7  | 32   | TBD              |
|        | Preserve Open Space and Working Lands – Forests  | 0.03                                  | 0.1   | 0.9             | 3  | 3  |                  |
| AFW-7  | Expanded Use of Biomass Feedstocks for Energy Use                                      | <i>Quantified under ES/RCI</i>        |       |                 |  |  | TBD              |
| AFW-8  | Afforestation/Reforestation Programs – Restocking                                      | 0.09                                  | 0.5   | 3.4             | 41                                       | 12   | TBD              |
|        | Afforestation/Reforestation Programs – Urban Trees                                     | 0.001                                 | 0.006 | 0.04            | -0.1                                     | -3   |                  |
| AFW-9  | Improved Management and Restoration of Existing Stands                                 | 0.05                                  | 0.2   | 1.3             | 159                                      | 119  | TBD              |
| AFW-10 | Expanded Use of Wood Products for Building Materials                                   | 0.002                                 | 0.004 | 0               | 0.035                                    | 0  | TBD              |
| AFW-11 | Programs to Promote Local Food and Fiber   | 0.01                                  | 0.02  | 0.12            | 5  | 1  | TBD              |
| AFW-12 | Enhanced Solid Waste Recovery and Recycling  | 0.24                                  | 1.05  | 7.4             | 58                                       | 8  | TBD              |

| Mitigation Option  | GHG Reductions (MMtCO <sub>2</sub> e) |      |                 | Net Present Value 2007–2020 (Million \$) | Cost-Effectiveness (\$/tCO <sub>2</sub> e) | Level of Support |
|--|---------------------------------------|------|-----------------|--|--|------------------|
|  | 2010                                  | 2020 | Total 2007-2020 |  |  |                  |
| SECTOR TOTAL AFTER ADJUSTING FOR OVERLAPS                | 0.59                                  | 2.91 | 20.5            | 418                                      | 20   |                  |
| REDUCTIONS FROM RECENT ACTIONS (table to be added below) | 0                                     | 0    | 0               | 0  | 0  |                  |
| SECTOR TOTAL PLUS RECENT ACTIONS                         | 0.59                                  | 2.91 | 20.5            | 418                                      | 20   |                  |

nq – not quantified. AFW-6 was folded into AFW-7 through 9. The reductions for AFW-4 were not included in the total GHG reductions for this sector. These emissions relate to the protection of agricultural soil carbon and the potential emissions were not included in the forecast for the agricultural sector.

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 : Conservation/No-Till & Organic Farming

### 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

- **CO<sub>2</sub>:** 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<sub>2</sub> 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.
- **N<sub>2</sub>O:** To the extent that fossil fuel consumption is lowered through the cultivation methods implemented under this policy, N<sub>2</sub>O emissions from fuel combustion will be lowered. It is important to note that research also indicates the potential for higher N<sub>2</sub>O emissions as soil organic carbon levels increase.<sup>1</sup>
- **CH<sub>4</sub>:** To the extent that fossil fuel consumption is lowered through the cultivation methods implemented under this policy, CH<sub>4</sub> emissions from fuel combustion will be lowered.

## Estimated GHG Savings and Costs per MtCO<sub>2</sub>e

- **GHG reduction potential in 2010, 2020 (MMtCO<sub>2</sub>e):** 0.06, 0.20;

*The reductions reported above and costs below only cover those associated with the conservation tillage/no-till elements of this policy option. The reductions to be achieved by the organic farming element could not be quantified with available information on the net GHG reduction potential of organic farming methods on Montana crop systems.*

- **Net Cost per MtCO<sub>2</sub>e:** \$0
- **Data Sources:**

### *Conservation Tillage/No-Till*

Agricultural soil carbon accumulation levels were taken from a 2004 MontGuide Fact Sheet from the Montana State University Extension Service.<sup>2</sup> 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.<sup>3</sup> From the MT Inventory & Forecast, the fossil diesel GHG emission

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<sup>1</sup> 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.

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

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

factor is 8.37 MtCO<sub>2</sub>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.<sup>4</sup> 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.<sup>5</sup>

### *Organic Farming*

While organic farming practices are known to result in increases in soil organic carbon, the net GHG benefits overall are less certain. A new systematic study of organic farming methods in the United Kingdom<sup>6</sup> showed that with some agricultural systems organic farming can produce net GHG benefits, while under others, GHG emissions were higher than in the analogous conventional system. The higher GHG emissions from organic systems in some cases is due to the need for additional mechanical cultivation, since chemicals are not used (resulting in higher fossil fuel combustion). On the other hand, there is a reduction in chemical usage and the embedded fossil fuels used to produce and transport these products. Also, there is the potential in some cases for differing crop yields between organic and conventional systems (which leads to differing GHG emissions per ton of product).

Given these and other uncertainties, systematic studies are needed for Montana crop systems to determine where organic production methods can yield net GHG benefits. Once these systems are established, the policy calls for promoting those where net GHG benefits occur. This element of this policy proposal therefore remains unquantified.

- **Quantification Methods:**

#### *Conservation Tillage/No-Till*

Based on the policy design parameters, the schedule for acres to be put into conservation tillage/no-till cultivation is 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<sub>2</sub> equivalent yielding 0.55 MtCO<sub>2</sub>/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

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<sup>4</sup> \$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](http://www.ces.ncsu.edu/depts/agecon/Cotton_Econ/production/Economic_Comparison.ppt), accessed February 2007.

<sup>5</sup> Costs and Environmental Effects from Conservation Tillage Adoption in Iowa. Lyubov Kurkalova, Catherine Kling, and Jinhua Zhao

<sup>6</sup> *Environmental Impacts of Food Production and Consumption*, Manchester Business School, prepared for the Department for Environment, Food and Rural Affairs, December 2006, [http://www.defra.gov.uk/science/project\\_data/DocumentLibrary/EV02007/EV02007\\_4601\\_FRP.pdf](http://www.defra.gov.uk/science/project_data/DocumentLibrary/EV02007/EV02007_4601_FRP.pdf).

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 | MMtCO <sub>2</sub> e Sequestered | Diesel Saved (1,000 gal) | MMtCO <sub>2</sub> e from Diesel avoided | Total MMtCO <sub>2</sub> e 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:**

These include: the assumed carbon sequestration potential is representative across all of the crop systems to which the policy is applied; a six-year period for accumulating the soil carbon; no additional significant accumulation of soil carbon after six years; any potential increase in N<sub>2</sub>O emissions is not large enough to significantly effect the estimated benefits; the cost savings is a representative average of savings to be achieved across all crop systems.

### Key Uncertainties

Most of the conservation tillage considered business as usual (BAU) in this analysis is being done for soil conservation instead of carbon sequestration. These acres may be plowed periodically, since doing so does not significantly harm the soil conservation goal. Only around an estimated 15% of the conservation tillage reported is continuous. Periodic plowing can have a negative affect on the carbon sequestration goal badly, as the emissions in one plowing can destroy several years worth of no-till carbon sequestration. Incentives to early adopters of conservation tillage may be required to prevent periodic tillage and the resulting soil carbon losses.

**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<sub>2</sub>:** 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),<sup>7</sup> 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<sub>2e</sub> of biodiesel compared to importation of out of state vegetable oil supplies.

### Estimated GHG Savings and Costs per MtCO<sub>2e</sub>

- **GHG reduction potential in 2010, 2020 (MMtCO<sub>2e</sub>):** 0.03, 0.24
- **Net Cost per MtCO<sub>2e</sub>:** \$55
- **Data Sources:** The CO<sub>2e</sub> 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<sub>2e</sub> reductions for this option.<sup>8</sup> 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<sub>2e</sub> 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.

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, mustard and safflower oil. 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<sub>2e</sub>/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 produce greater volumes of oil per unit of energy input (e.g., canola).

Canola produces 122 gallons of oil per acre compared to soybeans at 46 gallons/acre.

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<sup>7</sup> 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.

<sup>8</sup> *Ibid*

Assuming canola production energy inputs are not significantly greater than soy, the lifecycle emission rate for canola would be  $7,261 \times 46/122$  or 2,738 MtCO<sub>2e</sub>/MMgal. Therefore, the incremental benefit of canola over soy is  $7,261 - 2,738 = 4,523$  MtCO<sub>2e</sub>/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<sub>2e</sub>/MMgal.

The mix of oil feedstocks assumed in this analysis is shown in the table below.<sup>9</sup>

| <b>Crop</b> | <b>Crop Share</b> | <b>Gallons of oil per acre</b> | <b>MMgal Biodiesel</b> | <b>Estimated Acres (1,000)</b> |
|-------------|-------------------|--------------------------------|------------------------|--------------------------------|
| <b>2010</b> |                   |                                |                        |                                |
| Canola      | 28.6%             | 122                            | 2.5                    | 21                             |
| Camelina    | 13.7%             | 60                             | 1.2                    | 20                             |
| Mustard     | 15.9%             | 59                             | 1.4                    | 24                             |
| Safflower   | 38.2%             | 80                             | 3.4                    | 42                             |
| Sunflower   | 3.6%              | 98                             | 0.3                    | 3                              |
| Total       | 100.0%            |                                | 9                      | 111                            |
| <b>2015</b> |                   |                                |                        |                                |
| Canola      | 28.6%             | 122                            | 12.7                   | 104                            |
| Camelina    | 13.7%             | 60                             | 6.1                    | 102                            |
| Mustard     | 15.9%             | 59                             | 7.0                    | 119                            |
| Safflower   | 38.2%             | 80                             | 17.0                   | 212                            |
| Sunflower   | 3.6%              | 98                             | 1.6                    | 16                             |
| Total       | 100.0%            |                                | 44                     | 554                            |
| <b>2020</b> |                   |                                |                        |                                |
| Canola      | 30.0%             | 122                            | 26.7                   | 219                            |
| Camelina    | 40.0%             | 60                             | 35.6                   | 593                            |
| Mustard     | 19.0%             | 59                             | 16.9                   | 286                            |
| Safflower   | 10.0%             | 80                             | 8.9                    | 111                            |
| Sunflower   | 1.0%              | 98                             | 0.9                    | 9                              |
| total       | 100.0%            |                                | 89                     | 1,218                          |

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.<sup>10</sup> The value of incentives needed is assumed to be equivalent to the difference

<sup>9</sup> Crop share estimates provided by Howard Haines, Montana Department of Environmental Quality.

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.<sup>11</sup> 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 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) that should be carefully considered.

### **Status of Group Approval**

TBD

### **Level of Group Support**

TBD

### **Barriers to Consensus**

TBD

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<sup>10</sup> See [www.eia.doe.gov/oiaf/analysispaper/biodiesel/index.html](http://www.eia.doe.gov/oiaf/analysispaper/biodiesel/index.html); accessed January 2007.

<sup>11</sup> Information on the Missouri Program: [www.newrules.org/agri/mobiofuels.html#biodiesel](http://www.newrules.org/agri/mobiofuels.html#biodiesel), accessed January 2007.

## 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<sub>2</sub>:** 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<sub>2e</sub> 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<sub>2e</sub>

- **GHG reduction potential in 2010, 2020 (MMtCO<sub>2e</sub>):** 0.02, 0.39
- **Net Cost per MtCO<sub>2e</sub>:** \$4
- **Data Sources:** The computation of the GHG reduction potential and cost effectiveness of this option is based upon the following data:
  - Emissions factors for gasoline and ethanol varieties were taken from a General Motors/Argonne National Lab Study.
  - Research completed by the Energy Information Administration (EIA) provided the cost of production for starch-based and cellulosic ethanol.
- **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.<sup>12</sup> 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<sub>2</sub>e/mi
- Starch-based ethanol: 451 grams CO<sub>2</sub>e/mi
- Cellulosic ethanol: 154 grams CO<sub>2</sub>e/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<sub>2</sub>e by offsetting gasoline consumption). This value was used along with the lifecycle emission factor for gasoline<sup>13</sup> and the production in each year to estimate GHG reductions. The table below gives the amount of cellulosic ethanol and feedstock needed for each year.

| <b>Year</b> | <b>MMGal EtOH Capacity Needed</b> | <b>Cellulosic Feedstock Needed (dry tons)</b> |
|-------------|-----------------------------------|---|
| 2008        | 0.7                               | 9,524   |
| 2009        | 1.3                               | 19,048  |
| 2010        | 2.0                               | 28,571  |
| 2011        | 6.6                               | 94,286  |
| 2012        | 11.2                              | 124,444                                       |
| 2013        | 15.8                              | 175,556                                       |
| 2014        | 20.4                              | 226,667                                       |
| 2015        | 25.0                              | 277,778                                       |
| 2016        | 30.0                              | 333,333                                       |
| 2017        | 35.0                              | 388,889                                       |
| 2018        | 40.0                              | 444,444                                       |
| 2019        | 45.0                              | 500,000                                       |
| 2020        | 50.0                              | 500,000                                       |

<sup>12</sup> 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.

<sup>13</sup> 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.

### 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).<sup>14</sup> 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.<sup>15</sup> If enacted, this \$0.255/gallon premium could cover the additional incentives that are assumed to be needed 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

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<sup>14</sup> DOE EIA analysis can be found at [www.eia.doe.gov/oiaf/analysispaper/biomass.html](http://www.eia.doe.gov/oiaf/analysispaper/biomass.html), accessed January 2007.

<sup>15</sup> 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](http://www.newrules.org/agri/cellulosicethanol.pdf), accessed January 2007.

**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 that 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<sub>2e</sub>

- **GHG reduction potential in 2010, 2020 (MMtCO<sub>2e</sub>):** 0.50, 1.61
- **Net Cost per MtCO<sub>2e</sub>:** \$12
- **Data Sources:** Data on the number of acres expiring from CRP as of 2007 were obtained from a USDA monthly CRP acreage report for May 2007.<sup>16</sup> Estimates of the percentage of expiring acres offered extensions or re-enrollment were taken from USDA CRP state data tables<sup>17</sup> and a report from Ducks Unlimited.<sup>18</sup> Average annual CRP rental payments were taken from USDA state data tables.<sup>14</sup>

The change in soil carbon due to CRP acres returned to conventional tillage or development was taken from a report from the Food and Agricultural Policy Research Institute. This report shows that the effects of conventional crop production in Montana is in the range of -3.9 to -2.0 tons C/acre and the effects of the CRP in Montana is 1.1 to 5.0 tons C/acre over 10 years. Adding the midpoint of these two ranges results in 6 tons C/acre (20 MtCO<sub>2e</sub>/acre).

- **Quantification Methods:** The acres leaving the CRP program for each year was estimated using the number of acres expiring for 2008-2020 as of 2007. These acreages do not include extensions and re-enrollments. Therefore, 91.6% of expiring acres were assumed to be offered extensions or re-enrollments with 93.3% accepting the offers (based on USDA data for 2006). For the acres accepting offers, 32.2% are assumed to be re-enrollments (10 year contract) and 67.8% are assumed to be extensions (based on data in the Ducks Unlimited report cited above). The contract extensions are divided equally between 2, 3, 4, and 5 year extensions. The table below shows the estimated number of acres leaving CRP for 2001-2020. The number of acres leaving CRP was then multiplied by the soil carbon change between conventional crop production and CRP management.

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<sup>16</sup> U.S. Department of Agriculture, Farm Service Agency, Monthly CRP Acreage Report, <http://content.fsa.usda.gov/crpstorpt/rmepegg/MEPEGGR1.HTM>.

<sup>17</sup> U.S. Department of Agriculture, Farm Service Agency, Conservation Reserve Program State Tables, [http://www.fsa.usda.gov/Internet/FSA\\_File/aug2006statetables.xlw](http://www.fsa.usda.gov/Internet/FSA_File/aug2006statetables.xlw).

<sup>18</sup> Ducks Unlimited, "Conservation Reserve Program: Critical Waterfowl Nesting Habitat at Risk in the Prairie Pothole Region" [http://www.ducks.org/media/Conservation/Farm%20Bill/documents/CRP\\_021007.pdf](http://www.ducks.org/media/Conservation/Farm%20Bill/documents/CRP_021007.pdf).

| Year | CRP acres set to expire (2007) | Acres Expiring Including Re-enrollments and Extensions | Active Acres Estimate | Acres Leaving Program |
|------|--------------------------------|--|-----------------------|-----------------------|
| 2007 | 618,435                        | 618,435  | 3,387,546             | 89,903                |
| 2008 | 190,425                        | 190,425  | 3,359,863             | 27,682                |
| 2009 | 307,871                        | 397,457  | 3,302,084             | 57,779                |
| 2010 | 409,680                        | 526,851  | 3,225,495             | 76,589                |
| 2011 | 493,060                        | 667,806  | 3,128,414             | 97,080                |
| 2012 | 645,081                        | 896,147  | 2,998,140             | 130,275               |
| 2013 | 362,907                        | 621,124  | 2,907,846             | 90,294                |
| 2014 | 235,108                        | 595,556  | 2,821,268             | 86,577                |
| 2015 | 115,767                        | 508,615  | 2,747,330             | 73,938                |
| 2016 | 40,814                         | 443,614  | 2,682,841             | 64,489                |
| 2017 | 332                            | 550,260  | 2,602,848             | 79,992                |
| 2018 | 23,234                         | 389,825  | 2,546,179             | 56,670                |
| 2019 | 1,778                          | 415,076  | 2,485,838             | 60,340                |
| 2020 | 26,312                         | 445,415  | 2,421,087             | 64,751                |
| 2021 | 6,646                          | 450,989  | 2,355,526             | 65,561                |
| 2022 | 0                              | 507,441  | 2,281,758             | 73,768                |

Costs were estimated by applying the cumulative number of acres leaving CRP by the annual rental payment (\$34/acre).

- **Key Assumptions:** No new acres will be enrolled into CRP and that the current level of re-enrollment and extensions will continue.

**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: Agriculture & Forests

### 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

- **CO<sub>2</sub>:** Avoided emissions from carbon sequestered in biomass and soils that sequester carbon, so long as they are not disturbed by development and conversion to developed uses. The conversion of existing forests and agricultural lands to developed use releases carbon that has previously been sequestered, as well as hindering future sequestration.

## Estimated GHG Savings and Costs per MtCO<sub>2</sub>e

### I. Agriculture

- **GHG reduction potential in 2015, 2020 (MMtCO<sub>2</sub>e):** 0.02, 0.03.
- **Net Cost per MtCO<sub>2</sub>e:** \$32

*Note: The reductions and cost per Mt estimated for this option only refer to the direct benefits and costs associated with the estimated loss of soil carbon from agricultural soils due to development. They do not include the indirect benefits that occur as a result of more efficient development patterns that could result from this option (see TLU Option 5).*

- **Data Sources:**

The annual rate of agricultural land conversion in MT is 7,200 acres per year.<sup>19</sup> The typical level of soil carbon in agricultural soils is estimated by comparing soil carbon and cropland maps from USGS. These maps show that the areas of Montana with the most agriculture

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<sup>19</sup> NRI data provided by Julie Tesky, State Resource Inventory Coordinator, USDA, NRCS, Montana State Office. Includes agriculture and range lands.

have soil carbon stocks ranging from 0.1-4.0 kg C/m<sup>2</sup> in the top 20 cm. About half of the area in the 0.1-2.0 kg C/m<sup>2</sup> range and about half is in the 2.1-4.0 kg C/m<sup>2</sup> range. The midpoint of this range 2.0 kg C/m<sup>2</sup> is equivalent to 0.008 MMtC/1,000 acres. The cost of establishing conservation easements on agricultural lands surrounding developing areas was estimated by dividing the total costs for eight easements preserved through the Montana Agricultural Heritage Program by the total acreage for these easements.<sup>20</sup> The resulting average net policy cost is \$730 per acre.

- **Quantification Methods:**

- GHG Benefits*

- Studies are lacking on the changes in below and above-ground carbon stocks when agricultural land is converted to developed uses. For some land use changes, carbon stocks could be higher in the developed use relative to the agricultural use (e.g., parks). In other instances, carbon stocks are likely to be lower (graded and paved surfaces). CCS assumed that the agricultural land would be developed into typical tract-style suburban development. It was further assumed that 50% of the land would be graded and covered with roads, driveways, parking lots, and building pads. The final assumption was that 75% of the soil carbon in the top eight inches of soil for these graded and covered surfaces would be lost and not replaced. CCS assumed no change in the levels of above-ground carbon stocks.

- The benefit in each year was determined by: (1) determining the amount of land protected in each year by multiplying the annual rate of agricultural land lost by the percent of agricultural land protected; (2) multiplying the soil carbon content on the protected land by 50% (representing graded and covered areas) and by 75% (fraction of soil carbon lost); (3) converting the soil carbon lost to CO<sub>2</sub> by multiplying by 44/12.

- Costs*

- To estimate program costs in each year, CCS used multiplied the estimated agricultural acres protected from development by the conservation cost (\$730/acre) and an assumed cost share of 50%. This cost share is assumed to be available from the NRCS or other sources (e.g., city or county governments, or non-government organizations). The resulting cost effectiveness is \$32 per MtCO<sub>2</sub>e. This estimate only accounts for the direct reductions associated with soil carbon losses estimated above and does not include potentially much larger indirect benefits associated with reductions in vehicle miles traveled (see TLU Option 5).

- Note that the availability of this cost share is a significant assumption for this policy option, since the number of acres to be protected is substantially higher than the average protected during the 1996-2001 period (about 200 acres/year). Without the cost share, the cost effectiveness would be twice the value presented here.

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<sup>20</sup> The Montana Agricultural Heritage Program approved eight landowner grant applications totaling \$888,000. This figure is to be matched by \$6.36 million additional dollars from various federal, local, and private sources, including the participating landowners. The corresponding easements preserve 9,923 acres.  
<http://www.westgov.org/wga/publicat/pdr.pdf>

- **Key Assumptions:** No change in above-ground carbon stocks; 75% loss of soil carbon on 50% of developed land; 50% cost share available from NRCS, city/local governments, or other sources.

## II. Forests

- **GHG reduction potential in 2010, 2020 (MMtCO<sub>2</sub>e):** 0.03, 0.14
- **Cumulative GHG reduction potential (MMtCO<sub>2</sub>e, 2007-2010):** 0.9
- **Net Cost per MtCO<sub>2</sub>e:** \$3.05
- **Data Sources:**

Forestry: US Forest Service Methods for Calculating Forest Ecosystem and Harvested Carbon with Standards Estimates for Forest Types of the US, General Technical Report NE-343 (also published as part of the Department of Energy Voluntary GHG Reporting Program). Data on forest conversion to developed uses from NRCS National Resource Inventory data (1987-2003). Data on forest types from FIA, 2003-2005. Strong, T.F., 1997 “Harvesting Intensity Influences the Carbon Distribution in a Northern Hardwood Ecosystem,” USFS Research Paper NC-329; “The Intersection of Land Use History and Exurban Development: Implications for Carbon Storage in the Northeast” Master’s Thesis, K. Austin, 2006).

- **Quantification Methods:**

Carbon savings from this option were estimated from two sources: A. the amount of carbon that would be lost as a result of forest conversion to developed uses (i.e., “avoided emissions”); and B. the amount of annual carbon sequestration in protected forest area. The area of forestland protected annually is based on a gradual implementation of the goals outlined above, so that a 25% reduction in forest conversion rates is achieved by 2015, and a 50% reduction by 2020. A current conversion rate of 2,000 ac/yr was assumed based on NRI data from 1987-2003. The percentages in the goals represent a decrease from the current conversion rate of 500 acres/yr in 2015 and 1,000 acres/yr in 2020. Table 1 shows the assumptions about the types of forests protected under this option, based roughly on relative abundances of three common forest types in Montana. Table 1 also provides values for forest carbon stocks and annual carbon flux used to calculate total carbon savings under this option.

**Table 1. Input Data, by Forest Type**

| Forest Type    | Percent of Protected Acres | Annual C Flux (tons C/acre/yr) | Biomass Carbon Stocks (tons C/ac/yr) | Soil Carbon Stocks (tons C/acre/yr) |
|----------------|----------------------------|--------------------------------|--------------------------------------|-------------------------------------|
| Douglas Fir    | 52%                        | 0.573                          | 66.0                                 | 15.7                                |
| Lodgepole Pine | 26%                        | 0.388                          | 44.0                                 | 15.0                                |
| Ponderosa Pine | 22%                        | 0.368                          | 45.0                                 | 13.9                                |

The forest carbon stocks (tons carbon per acre) and annual carbon flux (annual change in tons carbon per acre) data are based on default carbon sequestration values for Douglas Fir, Lodgepole Pine, and Ponderosa Pine forest types in the Northern Rocky Mountain Region of the United States (USFS GTR-343, Tables A30, A32, and A33). Values for forest carbon stocks (including biomass and soils) in each of the three forest types represent the average for typical mature forests and are based on coefficients for 65-yr old stands. Annual rates of carbon sequestration (tons carbon sequestered per year) were calculated by subtracting total carbon stocks in forest biomass of 125 yr old stands from total carbon stocks in forest biomass of new stands and dividing by 125. A long-term average was used to implicitly take into account the relatively fast rate of carbon accumulation in young stands and slower rates in older stands. Soil carbon density was assumed constant and is not included in the annual carbon flux calculations because default values for soil carbon density are constant over time in USFS GTR-343.

*A. Avoided Emissions*

Loss of forests to development results in a large one-time surge of carbon emissions. In this case, it was assumed that 53% of carbon stocks in biomass and 35% of carbon stocks in soils would be lost in the event of forest conversion, with no appreciable carbon sequestration in soils or biomass following development. The biomass loss assumption is based on research that shows heavy levels of individual tree removal results in the harvesting of 53% of carbon in aboveground biomass (Strong 1997). The soil carbon loss assumption was based on a study that shows about a 35% loss of soil carbon when woodlots are converted to developed uses (Austin, 2006). Therefore, to estimate avoided emissions, the total number of acres protected in a year for each forest type was multiplied by the percent-adjusted carbon stock value for loss of biomass and soil carbon stocks. Results were converted to units of million metric tons CO<sub>2</sub> equivalent (MMtCO<sub>2</sub>e) and are provided in Table 2.

**Table 2. Emissions Avoided by Protecting Forest Lands in Montana**

| Year         | Acres Protected | Avoided emissions (MMtCO <sub>2</sub> e) |                       |                       |               |
|--------------|-----------------|--|-----------------------|-----------------------|---------------|
|              |                 | <i>Douglas Fir</i>                       | <i>Lodgepole Pine</i> | <i>Ponderosa Pine</i> | <i>Total</i>  |
| 2007         | 56              | 0.0043                                   | 0.0015                | 0.0013                | 0.007         |
| 2008         | 111             | 0.0086                                   | 0.0030                | 0.0026                | 0.014         |
| 2009         | 167             | 0.0129                                   | 0.0045                | 0.0039                | 0.021         |
| 2010         | 222             | 0.0171                                   | 0.0061                | 0.0051                | 0.028         |
| 2011         | 278             | 0.0214                                   | 0.0076                | 0.0064                | 0.035         |
| 2012         | 333             | 0.0257                                   | 0.0091                | 0.0077                | 0.043         |
| 2013         | 389             | 0.0300                                   | 0.0106                | 0.0090                | 0.050         |
| 2014         | 444             | 0.0343                                   | 0.0121                | 0.0103                | 0.057         |
| 2015         | 500             | 0.0386                                   | 0.0136                | 0.0116                | 0.064         |
| 2016         | 600             | 0.0463                                   | 0.0163                | 0.0139                | 0.077         |
| 2017         | 700             | 0.0540                                   | 0.0191                | 0.0162                | 0.089         |
| 2018         | 800             | 0.0617                                   | 0.0218                | 0.0185                | 0.102         |
| 2019         | 900             | 0.0695                                   | 0.0245                | 0.0208                | 0.115         |
| 2020         | 1000            | 0.0772                                   | 0.0272                | 0.0232                | 0.128         |
| <b>Total</b> | <b>6,500</b>    | <b>0.5016</b>                            | <b>0.1770</b>         | <b>0.1506</b>         | <b>0.8292</b> |

*B. Annual Sequestration in Protected Forests*

The results for annual sequestration are given in Table 3. Forests preserved in one year continue to sequester carbon in subsequent years. Thus, annual sequestration includes benefits from acres preserved cumulatively under the program. It was calculated each year by multiplying the cumulative acres protected by the percentage of each forest type, and by the average annual carbon flux for each forest type.

**Table 3. Annual Carbon Sequestered in Protected Forest Lands**

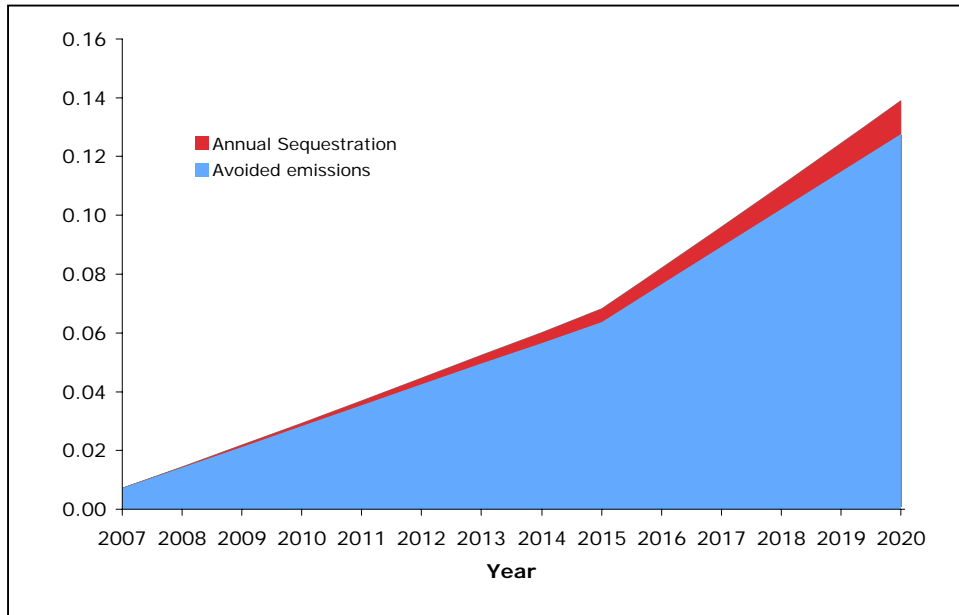
| Year         | Acres protected | Annual C Sequestered (MMtCO <sub>2</sub> e) |                       |                       |              |
|--------------|-----------------|---|-----------------------|-----------------------|--------------|
|              |                 | <i>Douglas Fir</i>                          | <i>Lodgepole Pine</i> | <i>Ponderosa Pine</i> | <i>Total</i> |
| 2007         | 56              | 0.0001                                      | 0.0000                | 0.0000                | 0.0001       |
| 2008         | 167             | 0.0002                                      | 0.0001                | 0.0000                | 0.0003       |
| 2009         | 333             | 0.0004                                      | 0.0001                | 0.0001                | 0.0006       |
| 2010         | 556             | 0.0006                                      | 0.0002                | 0.0002                | 0.0010       |
| 2011         | 833             | 0.0009                                      | 0.0003                | 0.0002                | 0.0015       |
| 2012         | 1167            | 0.0013                                      | 0.0004                | 0.0003                | 0.0021       |
| 2013         | 1556            | 0.0017                                      | 0.0006                | 0.0005                | 0.0027       |
| 2014         | 2000            | 0.0022                                      | 0.0007                | 0.0006                | 0.0035       |
| 2015         | 2500            | 0.0027                                      | 0.0009                | 0.0007                | 0.0044       |
| 2016         | 3100            | 0.0034                                      | 0.0011                | 0.0009                | 0.0055       |
| 2017         | 3800            | 0.0042                                      | 0.0014                | 0.0011                | 0.0067       |
| 2018         | 4600            | 0.0050                                      | 0.0017                | 0.0014                | 0.0081       |
| 2019         | 5500            | 0.0060                                      | 0.0020                | 0.0016                | 0.0097       |
| 2020         | 6500            | 0.0071                                      | 0.0024                | 0.0019                | 0.0114       |
| <b>Total</b> | <b>6,500</b>    | <b>0.036</b>                                | <b>0.012</b>          | <b>0.0097</b>         | <b>0.058</b> |

*C. Total Carbon Savings*

Total carbon savings achieved by protecting forest lands from development are illustrated in Figure 1. Figure 1 shows that the bulk of carbon savings under this option arise from avoiding emission that occur during forest conversion.

The cost of protecting forest land was estimated at \$635/acre using expert input from the Montana land trust community. This value assumes that 20% of forests under this option will be acquired at \$2500/ac, 10% of forests will be preserved with conservation easements costing \$1,000/ac, and 70% of forests will be preserved with donated conservation easements at \$50/ac. The analysis does not take into account potential cost savings from forest products revenue on working forest lands that are protected under this policy. Annual costs were estimated by multiplying the number of acres protected by the cost per acre. Annual discounted costs were then estimated using a 5% interest rate. The cumulative cost effectiveness of the total program was calculated by summing the annual discounted costs and dividing by cumulative carbon sequestration, yielding \$3.05/tCO<sub>2</sub>e. The sum of annual discounted costs also provides an estimate of the Net Present Value of this option of \$2.7 million dollars.

**Figure 1. Total Carbon Savings from Protecting Forest Lands**



- **Key Assumptions:** Forestry: 53% and 35% of biomass and soil carbon, respectively, is lost when forests are converted to developed uses; no appreciable carbon sequestration occurs post-development. Distribution of forest types protected is assumed based on forest dominance.

#### Key Uncertainties

TBD

#### Additional Benefits and Costs

Supporting intact rural communities in traditional land uses; maintaining land for recreational opportunity (hunting and fishing), critical wildlife habitat, productive timberland, and water quality.

Potential to enhance smart-growth objectives.

Potential loss of commercial income generating activity.

#### 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-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). The later is covered by this option. 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 electricity, heat and steam generation by 200,000 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, 200,000 of which would be used under this option and the remaining would go to liquid fuels production (covered by AFW-3). 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 public 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.

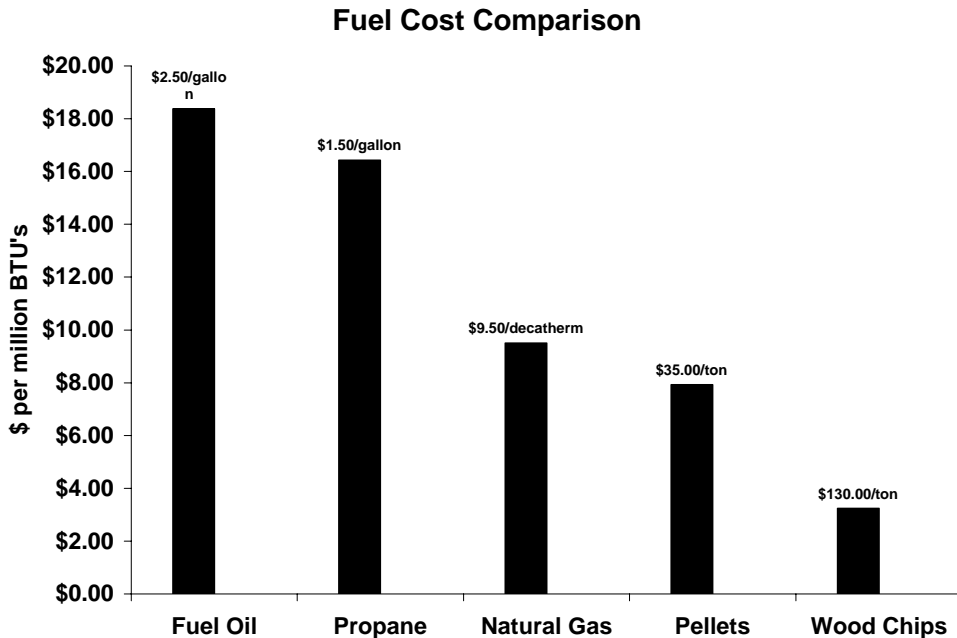
**Types(s) of GHG Reductions**

Avoided fossil fuel emissions.

**Estimated GHG Savings and Costs per MtCO<sub>2</sub>e**

ES and RCI options related to increasing energy generation from renewable energy sources include biomass energy generation. GHG reductions from avoided fossil fuel use associated with this AFW option are nearly entirely accounted for in quantification of ES-1, ES-4/RCII-7, RCII-5/RCII-12. The total inferred biomass tonnage included in the quantification of the relevant ES/RCII options is approximately 161,000 dry tons, which is 40,000 tons short of the goal for wood biomass envisioned under this option by 2020. Thus, the potential benefits of this option are slightly underestimated within the ES/RCI options.

A full cost analysis was not completed for this option. Costs would be incurred through a need to increase collection and utilization infrastructure. The up-front cost of a biomass system can be greater than a traditional system, however the fuel is far less expensive, such that over time fuel savings can more than offset upfront costs. Net cost savings are more likely in certain circumstances, in particular: 1) when the price of fossil fuel options are relatively expensive; and 2) in larger, heat-using facilities whose unit savings on heat fuel costs result in a better payback on the up-front investment. Figure below shows costs relative to heat generation for various fuel sources (source Angela Farr, Fuels for Schools Program Coordinator, DCNR).



- **Data Sources:** see ES-1, ES-4/RCII-7, RCII-5/RCII-12
- **Quantification Methods:** see ES-1, ES-4/RCII-7, RCII-5/RCII-12.
- **Key Assumptions:** see ES-1, ES-4/RCII-7, RCII-5/RCII-12

### **Key Uncertainties**

Amount of biomass residues generated is dependent 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, CH<sub>4</sub>, NO<sub>x</sub>, SO<sub>x</sub>, CO).
- Displace the emissions associated with the combustion of traditional fossil fuels of natural gas, propane, and fuel oil).
- Reduce dependence on foreign fossil fuels.
- Emissions associated with collection and transport
- Distributed heat and energy sources for national security.

### **Feasibility Issues**

- 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.

### **Status of Group Approval**

TBD

### **Level of Group Support**

TBD

### **Barriers to Consensus**

TBD

## AFW-8. Afforestation and Reforestation Programs: Restocking & Urban Trees

### 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 forest lands impacted by stand replacement fires (estimated at 20,000 ac/yr) within 5 years post-fire.

Plant 42,250 new trees in Montana communities by 2020 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 at a pace of 3,521 trees per year.

**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 urban forestry goals.

The Montana DNRC urban and community forestry program has a goal to plant 3,250 trees (250 trees/yr) during 2008-2020. There is the potential for more trees to be planted each year by cities, counties, and local organizations. A rough estimate of this potential was used in combination with the DCNR goal to arrive at the goal level for urban tree planting. Montana has 129 incorporated cities, towns and county governments and an additional 100 communities receiving some or all of their technical assistance from the Montana U&CF Program to build the necessary infrastructure to achieve Tree City USA designation and sustainable community forestry programs. The goal stated above assumes that each of these 229 communities plants 10 trees per year, leading to roughly 3,000 trees planted per yr (recognizing that number will range from 0 to 100+, e.g., The Growing Friends of Helena plant roughly 100 trees/yr). This in combination with the DNRC urban and community forestry program would be 3,250 trees/yr or 42,250 by 2020.

### Implementation Mechanisms

- **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.
- **Technical Assistance:** 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.
- **Market-based Incentives:** Support and engage in private sector markets for carbon sequestration that recognize the carbon benefits of forest management, urban forestry, and afforestation/reforestation (e.g., Chicago Climate Exchange). State participation further enhances state lead by example as an implementation mechanism.
- **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:** 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: Promote the use of forest biomass as an energy source for heating schools and other public 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

Carbon sequestered in forest biomass

Carbon sequestered in urban/suburban trees

Displaced fossil emissions from reduced heating/cooling needs (as a result of increased shade and reduced wind impacts from urban/suburban trees)

### Estimated GHG Savings and Costs per MtCO<sub>2e</sub>

- **GHG reduction potential in 2010, 2020 (MMtCO<sub>2e</sub>):** (A) Restocking: 0.09, 0.51; (B) Urban Trees: 0.0014, 0.0059
- **Cumulative GHG reduction potential (MMtCO<sub>2e</sub>, 2007-2010):** (A) Restocking 3.4; (B) Urban Trees: 0.04
- **Net Cost per MtCO<sub>2e</sub>:** (A) Restocking: \$12; (B) Urban Trees: -\$3.20

- **Data Sources:** US Forest Service Methods for Calculating Forest Ecosystem and Harvested Carbon with Standards Estimates for Forest Types of the US, General Technical Report NE-343 (also published as part of the Department of Energy Voluntary GHG Reporting Program); US Forest Service Effects of Urban Forests and their Management on Human Health and Environmental Quality (<http://www.fs.fed.us/ne/syracuse/Data/data.htm>; Carbon Dioxide Reduction Through Urban Forestry, USFS PSW-GTR-171, McPherson and Sampson, 1999; Northern Mountain and Prairie Community Tree Guide: Benefits, Costs and Strategic Planning, McPherson et al. 2003.
- **Quantification Methods:** Analysis of this option includes two parts: (A) restocking of forests impacted by wildfires, and (B) urban tree planting.

*Part A: Restocking of Forests Impacted by Wildfires*

Goal levels require replanting on 5,000 acres/yr from 2008-2010 and 5,500/yr from 2011-2020 to restock a total of 70,000 acres of previously burned sites by 2020. In addition, each year there will be an estimated 20,000 acres of forests burned at high severity, stand replacement intensities and this policy aims to restock all of those future burn sites as well. Thus, another 20,000 ac/yr of future burns are assumed starting in 2009.

Assumptions used to calculate the carbon benefits achieved through restocking are shown in Table 1. The proportions of area restocked with each species type are based on the approximate relative distributions of these three forest types in Montana. Carbon sequestration rates of restocked forests are from USFS GTR NE-343 tables B30, B32, and B33, which contain carbon densities on Northern Rocky Mountain forests that have been afforested. Carbon sequestration rates were calculated by subtracting carbon stocks in fifteen-year old stands from carbon stocks in new stands and dividing by fifteen. These rates are intended to reflect growth rates in young, recently established stands. It was assumed that in the absence of this restocking program that no carbon sequestration would occur on these sites (i.e., the baseline rate is assumed to be zero).

**Table 1. Restocking Assumptions**

| Forest Types Restocked | Proportion of Area Restocked with This Species | C Sequestration Rate (tons C/acre/yr) |
|------------------------|--|---------------------------------------|
| Douglas Fir            | 50%  | 0.56                                  |
| Lodgepole Pine         | 25%  | 0.32                                  |
| Ponderosa Pine         | 25%  | 0.39                                  |

Forests restocked in one year continue to sequester carbon in subsequent years. Thus, the calculation of carbon sequestration each year is based on annual benefits from acres restocked cumulatively under the program. Annual carbon sequestration was calculated for each forest type, based on the proportions provided in Table 1, and summed to achieve the total carbon benefits. Units were converted from tons carbon (tons C) to million metric tons of carbon dioxide equivalent (MMtCO<sub>2e</sub>). Table 2 shows the acreage treated under goal implementation and resulting carbon sequestration benefits. Figure 1 illustrates the projected carbon benefits by forest type.

**Table 2. Acres Restocked and Resulting Carbon Sequestration**

| Year         | Acres Replanted |                | Carbon Sequestered (MMtCO <sub>2</sub> e/yr) |                |                |               |
|--------------|-----------------|----------------|--|----------------|----------------|---------------|
|              | Previous Burns  | Future Burns   | Douglas Fir                                  | Lodgepole Pine | Ponderosa Pine | Total         |
| 2008         | 5,000           |                | 0.0051                                       | 0.0015         | 0.0018         | 0.0084        |
| 2009         | 5,000           | 20,000         | 0.0308                                       | 0.0088         | 0.0106         | 0.0502        |
| 2010         | 5,000           | 20,000         | 0.0565                                       | 0.0161         | 0.0195         | 0.0921        |
| 2011         | 5,500           | 20,000         | 0.0826                                       | 0.0236         | 0.0285         | 0.1348        |
| 2012         | 5,500           | 20,000         | 0.1088                                       | 0.0311         | 0.0376         | 0.1775        |
| 2013         | 5,500           | 20,000         | 0.1350                                       | 0.0386         | 0.0466         | 0.2202        |
| 2014         | 5,500           | 20,000         | 0.1612                                       | 0.0461         | 0.0556         | 0.2629        |
| 2015         | 5,500           | 20,000         | 0.1874                                       | 0.0535         | 0.0647         | 0.3056        |
| 2016         | 5,500           | 20,000         | 0.2135                                       | 0.0610         | 0.0737         | 0.3483        |
| 2017         | 5,500           | 20,000         | 0.2397                                       | 0.0685         | 0.0828         | 0.3910        |
| 2018         | 5,500           | 20,000         | 0.2659                                       | 0.0760         | 0.0918         | 0.4337        |
| 2019         | 5,500           | 20,000         | 0.2921                                       | 0.0835         | 0.1008         | 0.4764        |
| 2020         | 5,500           | 20,000         | 0.3183                                       | 0.0909         | 0.1099         | 0.5191        |
| <b>Total</b> | <b>70,000</b>   | <b>240,000</b> | <b>2.0970</b>                                | <b>0.5991</b>  | <b>0.7240</b>  | <b>3.4201</b> |

Costs were estimated based on a restocking cost of \$180/acre (Whitney, pers com). Annual costs were calculated by multiplying the number of acres restocked that year with the cost per acre for restocking. Costs were discounted in future years using a 5% interest rate. A levelized cost effectiveness (CE) of \$12.11/MtC was calculated based on cumulative discounted costs divided by cumulative carbon sequestered through 2020. The total discounted costs from 2007-2020 yields a Net Present Value for this option of \$41 million.

*Part B: Urban Tree Planting*

Two types of emissions reductions were calculated separately below for this goal: carbon sequestration in trees and CO<sub>2</sub> savings from reduced heating and cooling costs.

Carbon sequestration in urban trees was calculated at 0.0076 tons C/tree/year (0.028 tons CO<sub>2</sub>e/tree/yr), based on the average for Montana in the USFS assessment of urban forests resources (Nowak et al., 2001). Using this value, total annual carbon sequestration from urban tree planting was calculated each year, including sequestration in trees planted that year and in prior years under the program.

A CO<sub>2</sub> savings factor for reduced heating and cooling needs was calculated for Montana using default factors published in USFS PSW-GTR-171. An average factor was calculated from defaults for the Northern region of the US, across three vintages of housing classes (pre-1950, 1950-1980, and post 1980). Separate factors for the shade effects of urban trees on cooling and heating demands and the wind effects on heating demands were calculated and then combined by adding them together for a single composite factor reflecting the net impacts. Default data for medium evergreen trees were used as a proxy for the types of trees planted. Table 1 shows the default factors by vintage and effects category as well as the final composite, which indicates each tree planted will result in CO<sub>2</sub> savings of 0.1125 tons CO<sub>2</sub> per tree per year.

**Table 1. CO<sub>2</sub> Savings factor for shading and wind reduction effects of urban trees.**

| Housing Vintage              | Shade-Cooling | Shade-Heating | Wind-Heating | Net effect |
|------------------------------|---------------|---------------|--------------|------------|
| pre 1950                     | 0.122         | -0.0227       | 0.1006       | 0.1999     |
| 1950-1980                    | 0.0079        | -0.0141       | 0.0658       | 0.0596     |
| post 1980                    | 0.0089        | -0.0198       | 0.0889       | 0.078      |
| Average                      | 0.0463        | -0.0189       | 0.0851       | 0.1125     |
| Average (tCO <sub>2</sub> e) |               |               |              | 1.125E-07  |

Carbon sequestration and CO<sub>2</sub> savings were calculated by multiplying the factors above by the cumulative number of trees planted under the program each year, taking into account that carbon sequestration and energy savings continue every year after a tree is planted. Table 2 shows the results of this analysis.

**Table 2. Carbon Benefits and Program Costs of Urban Tree Planting**

|      | Number of trees planted | Cumulative number of trees in program | Carbon sequestered (MMtCO <sub>2</sub> e/yr) | CO <sub>2</sub> savings from shading & wind effects (MMtCO <sub>2</sub> e/yr) | Total Carbon Savings (MMtCO <sub>2</sub> e/yr) |
|------|-------------------------|---------------------------------------|--|---|--|
| 2008 | 3,250                   | 3,250                                 | 0.0001                                       | 0.0004  | 0.0005   |
| 2009 | 3,250                   | 6,500                                 | 0.0002                                       | 0.0007  | 0.0009   |
| 2010 | 3,250                   | 9,750                                 | 0.0003                                       | 0.0011  | 0.0014   |
| 2011 | 3,250                   | 13,000                                | 0.0004                                       | 0.0015  | 0.0018   |
| 2012 | 3,250                   | 16,250                                | 0.0005                                       | 0.0018  | 0.0023   |
| 2013 | 3,250                   | 19,500                                | 0.0005                                       | 0.0022  | 0.0027   |
| 2014 | 3,250                   | 22,750                                | 0.0006                                       | 0.0026  | 0.0032   |
| 2015 | 3,250                   | 26,000                                | 0.0007                                       | 0.0029  | 0.0037   |
| 2016 | 3,250                   | 29,250                                | 0.0008                                       | 0.0033  | 0.0041   |
| 2017 | 3,250                   | 32,500                                | 0.0009                                       | 0.0037  | 0.0046   |
| 2018 | 3,250                   | 35,750                                | 0.0010                                       | 0.0040  | 0.0050   |
| 2019 | 3,250                   | 39,000                                | 0.0011                                       | 0.0044  | 0.0055   |
| 2020 | 3,250                   | 42,250                                | 0.0012                                       | 0.0048  | 0.0059   |

A cost of \$14.56/tree was estimated using a 40-yr average for small/medium/large conifer trees in Northern Mountain and Prairie communities (McPherson et al). Net cost savings were estimated at \$28.26/tree, considering energy conservation, storm water interception, clean air, and higher property values. Taken together, each tree yields a net cost savings of \$13.70. Using this value, total cost savings, cost effectiveness (cost per ton of GHG reduced), and discounted costs (assuming a 5% interest rate) were calculated. Cost effectiveness (cost per metric ton of carbon) improves through the duration of the timeframe as the cumulative number of trees planted continues to accrue carbon sequestration and CO<sub>2</sub> savings without any additional costs. Un-discounted net annual costs are -\$44,525/yr (negative indicates cost savings), i.e., -\$13.70/tree times 3,250 trees. The net present value for this option (sum of the discounted annual

costs from 2008-2020) is estimated at -\$132,880. Overall cost effectiveness is estimated at - \$3.20/ton CO<sub>2</sub>e, based on cumulative discounted costs divided by cumulative GHG savings.

- **Key Assumptions:** (1) Restocking Goal: the carbon sequestration rate in non-restocked forests in zero; forest types burned are proportional to dominant forest types; future annual rate of stand replacement fires of 20,000 ac/yr; (2) Urban Trees Goal: state-wide and regional carbon sequestration and CO<sub>2</sub> savings coefficients are representative of trees planted under the program. Costs and costs savings were based on 40-yr averages for conifers.

### Key Uncertainties

The number of acres that will burn in the future

### Additional Benefits and Costs

Increased wildlife habitat and ecosystem health

Erosion control and water quality

Increasing productive forestland more quickly

Potential small business growth, e.g., contracting out restocking services

### 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 :** Pending

### 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 700,000 acres of private and state forest lands by 2020.

**Timing:** Accelerate private forest landowner education programs by 2010; Implement forest improvement projects on 53,846 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

- **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.

- **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.
- **Market-based Incentives:** Support and engage in private sector markets for carbon sequestration that recognize the carbon benefits of forest management, urban forestry, and afforestation/reforestation (e.g., Chicago Climate Exchange). State participation further enhances state lead by example as an implementation mechanism.
- **Enhancement of the Existing Programs:** 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.

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 public facilities.

### Types(s) of GHG Reductions

Carbon stored in forest biomass and soils

Carbon stored in harvested wood products

### Estimated GHG Savings and Costs per MtCO<sub>2e</sub>

- **Forest Carbon GHG reduction potential in 2010, 2020 (MMtCO<sub>2e</sub>):** 0.04, 0.2
- **Forest Carbon Cumulative GHG reduction potential (MMtCO<sub>2e</sub>, 2007-2010):** 1.2
- **Harvested Wood Carbon GHG reduction potential in 2010, 2020 (MMtCO<sub>2e</sub>):** 0.01, 0.01
- **Harvested Wood Cumulative GHG reduction potential (MMtCO<sub>2e</sub>, 2007-2010):** 0.14
- **Net Cost per MtCO<sub>2e</sub>:** \$120
- **Data Sources:**

US Forest Service Methods for Calculating Forest Ecosystem and Harvested Carbon with Standards Estimates for Forest Types of the US, General Technical Report NE-343 (also published as part of the Department of Energy Voluntary GHG Reporting Program), US Forest Service Forest Inventory Analysis Program; Strong, T.F., 1997 “Harvesting Intensity Influences the Carbon Distribution in a Northern Hardwood Ecosystem,” USFS Research Paper NC-329

- **Quantification Methods:**

This option aims to increase production in terms of harvest volumes (i.e., cubic feet per acre) by 20% on 700,000 acres of forestland in Montana through stand improvement treatments including density reduction treatment such as pre-commercial thinning, commercial thinning, intermediate harvests, and selection harvests.

For the purposes of estimating the GHG benefits, it was assumed that three dominant forest types in Montana would be targeted for treatment. Specifically, this analysis assumes 280,000 acres each of Douglas fir and Ponderosa Pine, and 140,000 acres of Lodgepole pine will be treated by 2020, for a total of 700,000 acres (Table 1).

**Table 1. Total Acres Targeted by the Policy by 2020, by Forest Type**

| Forest Type    | Acres treated by 2020 |
|----------------|-----------------------|
| Doug Fir       | 280,000               |
| Lodgepole Pine | 140,000               |
| Ponderosa pine | 280,000               |
| Total          | 700,000               |

Stand improvement treatments are anticipated to impact carbon sequestration in two ways. First, they will enhance forest growth and carbon sequestration in forest biomass by 15%. Second, they will yield a 20% increase in harvest volumes, which will increase the amount of carbon stored in durable wood products. These impacts are quantified separately below: (1) net forest carbon sequestration is calculated as carbon sequestration due to growth minus carbon losses from removals (harvests); (2) amount of carbon remaining stored in durable wood products post-harvest is estimated using regional default coefficients for the use and disposal of wood products and corresponding carbon decay.

*Forest Carbon Sequestration*

Forest carbon sequestration rates under baseline conditions (no stand improvement treatments) were based on published carbon stocks (tons carbon per acre in forest biomass) for Douglas fir, Lodgepole pine, and Ponderosa pine stands in the Northern Rocky Mountain region (USFS GTR-343). Annual rates of carbon sequestration from forest growth (tons carbon sequestered per year) were calculated by subtracting total carbon stocks in forest biomass of 125 yr old stands from total carbon stocks in forest biomass of new stands and dividing by 125. A long-term average was used to implicitly take into account the relatively fast rate of carbon accumulation in young stands and slower rates in older stands.

It was assumed that improved forest management would increase forest growth and carbon sequestration by 15%, based on expert opinion from Montana Department of Forestry. USFS estimates of soil carbon stocks are constant over time. Therefore, this analysis assumes no net carbon sequestration in forest soils occurs under the baseline or policy scenarios. Carbon sequestration rates under baseline and policy implementation are shown in Table 2.

**Table 2. Forest Biomass Carbon Sequestration Rates**

|                | Baseline     | With Stand Improvement Treatments |
|----------------|--------------|-----------------------------------|
|                | Tons C/ac/yr |                                   |
| Doug Fir       | 0.57         | 0.66                              |
| Lodgepole Pine | 0.39         | 0.45                              |
| Ponderosa pine | 0.37         | 0.42                              |

The analysis assumes that approximately 53,846 acres of forests are treated each year, starting in 2008 until 2020, when a total of 700,000 acres will have been treated. Table 3 shows the cumulative acres treated per year by forest type as modeled in this analysis: starting in 2008, 21,538 acres each of Douglas fir and Ponderosa pine, and 10,769 acres of Lodgepole pine are treated. This same amount of area is treated each year thereafter until the total number of acres treated in 2020 is 280,000 acres each of Douglas fir and Ponderosa pine and 140,000 acres of Lodgepole pine.

Annual carbon sequestration under policy implementation was calculated by multiplying the cumulative number of acres treated each year by the annual carbon sequestration rate for Stand

Improvement Treatments in Table 2. This accounts for annual carbon sequestration benefits beginning in the first year that an area of forest is treated and continuing through the duration of the timeframe of analysis. Annual removals were also calculated assuming a harvest rate of 1.3%/yr, i.e., by multiplying the number of acres treated each year by 1.3%, which yields approximately 700 ac/yr, and multiplying 700 ac/yr by biomass carbon stocks in 65-yr old stands. The biomass carbon stocks were then multiplied by 39% to account for the amount of biomass removed during harvest. Strong (1997) estimates that a “light” harvest removes approximately 39% of forest carbon. The net change in growth (positive value) and removals (negative value) was calculated to yield a net annual carbon flux (note: removals in are shown as negative values to indicate that biomass is lost from the forest). Annual sequestration, removals, and net carbon flux under baseline conditions were calculated using the same area data and applying the baseline annual sequestration and 65-yr carbon stocks values. The difference in net carbon flux between the policy and baseline cases is the total additional carbon sequestered within forests under this option. Results are shown in Table 3.

**Table 3. Acres Targeted and Estimate Annual Carbon Sequestration (“Seq.”), Removals, and Net Carbon Flux under Baseline and Policy Scenarios**

|           | Cumulative Acres Treated | Baseline        |                     |                       | Policy Scenario |                     |                       | GHG Savings                 |  |
|-----------|--------------------------|-----------------|---------------------|-----------------------|-----------------|---------------------|-----------------------|-----------------------------|--|
|           |                          | Annual Seq. (A) | Annual Removals (B) | Net Carbon flux (A+B) | Annual Seq. (D) | Annual Removals (E) | Net Carbon flux (D+E) | Additional Seq. (D+E)-(A+B) | Additional Seq., converted to MMtCO <sub>2</sub> e |
| Tons C/yr |                          |                 |                     |                       |                 |                     |                       |                             | MMtCO <sub>2</sub> e                               |
| 2008      | 53,846                   | 24,441.8        | -14,523.6           | 9,918.2               | 28,108.1        | -15,249.8           | 12,858.3              | 2,940.1                     | 0.011  |
| 2009      | 107,692                  | 48,883.7        | -14,523.6           | 34,360.1              | 56,216.2        | -15,249.8           | 40,966.5              | 6,606.4                     | 0.024  |
| 2010      | 161,538                  | 73,325.5        | -14,523.6           | 58,801.9              | 84,324.4        | -15,249.8           | 69,074.6              | 10,272.7                    | 0.038  |
| 2011      | 215,385                  | 97,767.4        | -14,523.6           | 83,243.8              | 112,432.5       | -15,249.8           | 97,182.7              | 13,938.9                    | 0.051  |
| 2012      | 269,231                  | 122,209.2       | -14,523.6           | 107,685.6             | 140,540.6       | -15,249.8           | 125,290.8             | 17,605.2                    | 0.065  |
| 2013      | 323,077                  | 146,651.1       | -14,523.6           | 132,127.5             | 168,648.7       | -15,249.8           | 153,399.0             | 21,271.5                    | 0.078  |
| 2014      | 376,923                  | 171,092.9       | -14,523.6           | 156,569.3             | 196,756.9       | -15,249.8           | 181,507.1             | 24,937.8                    | 0.091  |
| 2015      | 430,769                  | 195,534.8       | -14,523.6           | 181,011.2             | 224,865.0       | -15,249.8           | 209,615.2             | 28,604.0                    | 0.105  |
| 2016      | 484,615                  | 219,976.6       | -14,523.6           | 205,453.0             | 252,973.1       | -15,249.8           | 237,723.3             | 32,270.3                    | 0.118  |
| 2017      | 538,462                  | 244,418.5       | -14,523.6           | 229,894.9             | 281,081.2       | -15,249.8           | 265,831.5             | 35,936.6                    | 0.132  |
| 2018      | 592,308                  | 268,860.3       | -14,523.6           | 254,336.7             | 309,189.4       | -15,249.8           | 293,939.6             | 39,602.9                    | 0.145  |
| 2019      | 646,154                  | 293,302.2       | -14,523.6           | 278,778.6             | 337,297.5       | -15,249.8           | 322,047.7             | 43,269.1                    | 0.159  |
| 2020      | 700,000                  | 317,744.0       | -14,523.6           | 303,220.4             | 365,405.6       | -15,249.8           | 350,155.8             | 46,935.4                    | 0.172  |

*Carbon Sequestered in Harvested Wood Products*

*Note: Metric units are used in this portion of the analysis because default coefficients in the USFS methodology for quantifying carbon sequestration in harvested wood products are in metric units.*

Stand improvement treatments are expected to enhance the amount of biomass available for harvest. The removal of biomass through harvesting transfers carbon stored in forest biomass to

carbon stored in harvested wood products (HWP). Increased levels of production under this option will lead to more carbon transferred into HWP. The analysis below estimates the amount of additional carbon stored in HWP as a result of a 20% increase in productivity on treated forests.

Carbon sequestration in harvested wood products (HWP) was calculated following guidelines published by the US Forest Service. Details on each step of the analysis can be found in the guidelines, following the methodology referred to as “Land-based estimation.” In general, forest productivity is used as a starting point and regional patterns in the disposition of carbon through various HWP pools are used to model carbon stock changes in HWP over time. The methodology calculates the transfer of carbon through four pools over time: wood in use (i.e., building materials, furniture), wood in landfills (i.e., products that were previously in use and have been discarded), wood burned for energy capture, and wood that has decayed or burned without energy capture. The difference in the amount of carbon entering the “in use” and “landfill” pools at the beginning of a year and the amount remaining one year later equals total net annual carbon flux (i.e., “sequestration”) in harvested wood products (HWP).

Data from the US Forest Service Forest Inventory Analysis program in 2005 were used to estimate current levels of productivity for Douglas fir, Lodgepole pine, and Ponderosa pine in Montana. Average productivity was calculated separately for each forest type by dividing the total growing stock volume in timberlands by the total area of timberland in 2005. Average productivity in Douglas fir, Lodgepole pine, and Ponderosa pine stands in Montana was calculated to be 125, 162, and 72 cubic meters per hectare, respectively. Under implementation of this policy option, productivity is expected to increase by 20%, therefore, productivity on forests with improved forest management was calculated as a 20% increase over current levels (i.e., 150, 194, and 86 m<sup>3</sup>/ha on Douglas fir, Lodgepole pine, and Ponderosa pine, respectively).

**Table 4. Background Information on Forest Production by Forest Type (FIA 2005)**

| <b>Species</b> | <b>Area of timberlands (ha)</b> | <b>Growing stock volume (m<sup>3</sup>/yr)</b> | <b>Baseline Average Production (m<sup>3</sup>/ha/yr)</b> | <b>Average Production with Improved Forest Management (m<sup>3</sup>/ha/yr)</b> |
|----------------|---------------------------------|--|--|---|
| Douglas fir    | 2,751,891                       | 344,580,115                                    | 125.22   | 150.26  |
| Lodgepole pine | 1,439,387                       | 232,661,602                                    | 161.64   | 193.97  |
| Ponderosa Pine | 1,189,055                       | 85,327,889                                     | 71.76  | 86.11   |

There are several steps in the analysis where default coefficients for the Northern Rocky Mountain region are applied to the starting point of average productivity. First, for each forest type, average productivity (m<sup>3</sup>/ha/ys) is apportioned into classes of wood harvested (i.e., softwood sawlog, softwood pulpwood, hardwood sawlog, hardwood pulpwood) and the per-area carbon volumes of each class are calculated. Next, the quantity that is processed into primary wood products is calculated (factoring out carbon in logging residue, fuelwood, and waste), using the following ratios: ratio of industrial roundwood to growing stock volume removed as roundwood; ratio of carbon in bark to carbon in wood; fraction of growing stock volume

removed as roundwood; and the ratio of fuelwood to growing stock volume removed as roundwood. The results are approximate per-area carbon stocks (tons carbon per hectare) in industrial roundwood, excluding bark and fuelwood. Carbon stocks in industrial roundwood were estimated for the baseline case using current levels of production as the starting point, and for the policy scenario using levels of production under improved forest management as the starting point (Table 5).

**Table 5. Calculated Carbon Stocks in Industrial Roundwood**

| <b>Product Pool</b>                              | <b>Baseline<br/>(tC/ha)</b> | <b>Improved Forest<br/>Management<br/>(tC/ha)</b> |
|--|-----------------------------|---|
| Softwood saw log carbon in industrial roundwood  | 43.97                       | 52.76   |
| Softwood pulpwood carbon in industrial roundwood | 48.97                       | 58.76   |
| Hardwood saw log carbon in industrial roundwood  | 0.08                        | 0.10  |
| Hardwood pulpwood carbon in industrial roundwood | 0.49                        | 0.59  |

The average disposition pattern of HWP over time in the Northern Rocky Mountain Region is provided by the USFS methodology. The disposition pattern is the flow of HPW between four pools over time: carbon in HWP in use, carbon in HWP in landfills, carbon emitted with energy capture, and carbon emitted without energy capture. Because there is not much hardwood in the Northern Rocky Mountain region, as reflected in the relatively low carbon stocks for hardwood classes in Table 5, the disposition patterns only include softwood categories of industrial roundwood. Thus, the remainder of the analysis only includes softwood.

Table 6, on the next page, shows the disposition pattern used in this analysis for a single harvest. According to Table 6, in the year following harvest, 70% of the carbon in softwood goes into use, 21% is emitted with energy capture, 9% is emitted without energy capture, and none is placed in landfills. Over time the amount of carbon in use declines as it is transferred into the categories of carbon in landfills and carbon emitted to the atmosphere, such that by 100 years after harvest, approximately 11% of carbon remains in HWP in use, 26% is in landfills, and 63% has been emitted (note: carbon emissions from HWP are considered biogenic and are not counted as direct emissions).

The disposition over time of carbon stocks was modeled using the carbon stocks in Table 5 (separately for the baseline and policy cases) and the disposition pattern in Table 6 (same pattern used in baseline and policy case). This provides per-acre estimates of carbon stocks (tC/ha) remaining in each pool over time starting from a single harvest for both the baseline and policy scenarios. The total amount of carbon stocks, and their disposition over time, from a single harvest was calculated by multiplying the per-acre carbon stocks mentioned above by an average annual harvested area of 283 ha/yr (i.e., 700 ac/yr, which is 1.3% of the annual area of treated forest). The net impact of carbon storage in HWP as a result of regular annual harvests over the period of analysis was modeled for the baseline and policy cases. The incremental increase in carbon stocks was calculated as the difference between the two scenarios.

**Table 6. Disposition pattern of carbon in HWP as a fraction of industrial roundwood for the Northern Rocky Mountain Region of the US**

| Year after harvest | Fraction In use | Fraction in landfill | Fraction emitted with energy capture | Fraction emitted w/o energy capture |
|--------------------|-----------------|----------------------|--------------------------------------|-------------------------------------|
| 0                  | 0.704           | 0                    | 0.209                                | 0.087                               |
| 1                  | 0.664           | 0.019                | 0.223                                | 0.094                               |
| 2                  | 0.628           | 0.036                | 0.235                                | 0.101                               |
| 3                  | 0.595           | 0.051                | 0.247                                | 0.107                               |
| 4                  | 0.567           | 0.065                | 0.256                                | 0.112                               |
| 5                  | 0.541           | 0.077                | 0.265                                | 0.118                               |
| 6                  | 0.517           | 0.088                | 0.273                                | 0.122                               |
| 7                  | 0.495           | 0.098                | 0.28                                 | 0.127                               |
| 8                  | 0.474           | 0.107                | 0.287                                | 0.131                               |
| 9                  | 0.455           | 0.116                | 0.294                                | 0.135                               |
| 10                 | 0.438           | 0.124                | 0.3                                  | 0.139                               |
| 15                 | 0.373           | 0.152                | 0.32                                 | 0.154                               |
| 20                 | 0.33            | 0.171                | 0.333                                | 0.165                               |
| 100                | 0.112           | 0.255                | 0.373                                | 0.26                                |

The results of the analysis are summarized in Table 7, next page, which show the amount of carbon stored in landfills and products in-use each year above what would have happened in the baseline, spanning the time period 2008-2020. While the amount of additional carbon in landfills and in products from a given harvest decreases each year (as it is emitted through decay or energy capture), additional wood is harvested each year, adding new carbon stocks to total HWP stream. Thus for every year in the time series, the carbon stocks in the wood products pool are increasing. This analysis is carried out until 2020 and does not capture the continued disposition of carbon through the wood products pools in time.

The values in the table are incremental increases in HWP carbon stocks, with annual totals shown at the bottom. Carbon sequestration is calculated as the annual change in carbon stocks (subtracting stocks in year 2 from stocks in year 1). The net sequestration rate (last row) is sensitive to the year of analysis because the transfer of carbon between HWP pools is dynamic over time.

An alternative approach for estimating carbon stored in wood products is to estimate the amount of carbon remaining in products and landfills after 100 years and to apply that value to the year of harvest as an annual sequestration rate (GTR NE-343, 1605b technical guidelines). This approach essentially accounts for emissions occurring during 100 years after a harvest in the year of the harvest and assumes that the carbon remaining after 100 years is stored permanently. This approach was developed to simplify annual reporting of carbon stored in wood products and to account for the long term dynamics of carbon flows in harvested wood products pools.

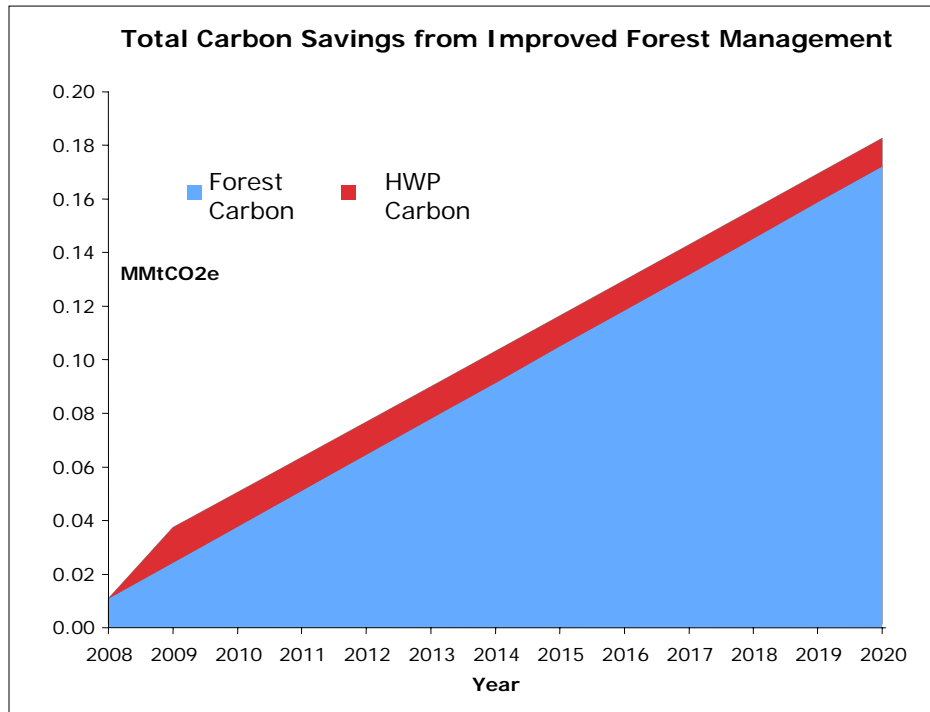
**Table 7. Disposition of Carbon in HWP over time, Shown by Tracking Individual Annual Harvests from 2008-2020.**

| Year of harvest                                       | Carbon in use or landfill by the end of this year |       |       |       |       |       |       |       |       |       |       |       |       |
|---|---|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|   | 2008  | 2009  | 2010  | 2011  | 2012  | 2013  | 2014  | 2015  | 2016  | 2017  | 2018  | 2019  | 2020  |
| 2008  | 0.014   | 0.013 | 0.013 | 0.012 | 0.012 | 0.012 | 0.012 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 |
| 2009  |   | 0.014 | 0.013 | 0.013 | 0.012 | 0.012 | 0.012 | 0.012 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 |
| 2010  |   |       | 0.014 | 0.013 | 0.013 | 0.012 | 0.012 | 0.012 | 0.012 | 0.011 | 0.011 | 0.011 | 0.011 |
| 2011  |   |       |       | 0.014 | 0.013 | 0.013 | 0.012 | 0.012 | 0.012 | 0.012 | 0.011 | 0.011 | 0.011 |
| 2012  |   |       |       |       | 0.014 | 0.013 | 0.013 | 0.012 | 0.012 | 0.012 | 0.012 | 0.011 | 0.011 |
| 2013  |   |       |       |       |       | 0.014 | 0.013 | 0.013 | 0.012 | 0.012 | 0.012 | 0.012 | 0.011 |
| 2014  |   |       |       |       |       |       | 0.014 | 0.013 | 0.013 | 0.012 | 0.012 | 0.012 | 0.012 |
| 2015  |   |       |       |       |       |       |       | 0.014 | 0.013 | 0.013 | 0.012 | 0.012 | 0.012 |
| 2016  |   |       |       |       |       |       |       |       | 0.014 | 0.013 | 0.013 | 0.012 | 0.012 |
| 2017  |   |       |       |       |       |       |       |       |       | 0.014 | 0.013 | 0.013 | 0.012 |
| 2018  |   |       |       |       |       |       |       |       |       |       | 0.014 | 0.013 | 0.013 |
| 2019  |   |       |       |       |       |       |       |       |       |       |       | 0.014 | 0.013 |
| 2020  |   |       |       |       |       |       |       |       |       |       |       |       | 0.014 |
| <b>Total HWP Stocks (MMtCO<sub>2</sub>e)</b>          | 0.014   | 0.027 | 0.040 | 0.052 | 0.064 | 0.076 | 0.088 | 0.099 | 0.111 | 0.122 | 0.132 | 0.143 | 0.154 |
| <b>Annual Change in Stocks(MMtCO<sub>2</sub>e/yr)</b> |   | 0.013 | 0.013 | 0.012 | 0.012 | 0.012 | 0.012 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 |

For comparison to the analysis shown in Figure 1, below, which tracks actual annual stocks and carbon sequestration during 2008-2020, the additional amount of carbon stored permanently above baseline levels 100-years after a single annual harvest is estimated to be 0.007 MMtCO<sub>2</sub>e. Using the 100-yr method, the total amount of incremental carbon permanently stored from harvests during 2008-2020 is 0.09 MMtCO<sub>2</sub>e. This can be compared to the cumulative amount of carbon sequestration during 2008-2020 as shown in Table 7 of 0.14 MMtCO<sub>2</sub>e.

Total carbon savings, includes forest carbon sequestration and carbon stored in harvested wood products are shown in Figure 1. The majority of carbon sequestration occurs from increased forest growth. HWP carbon storage makes small contribution to the overall benefit.

**Figure 1**



HWP – Harvested Wood Products

### Cost Analysis

The costs per acre to implement stand improvement treatments were assumed to be \$300/acre based on expert opinion of the technical working group. Costs were multiplied by the number of acres treated annually, yielding an annual cost of \$16 million per year. Annual discounted costs were then estimated using a 5% interest rate. Cost effectiveness (\$/tCO<sub>2</sub>e) was calculated by summing the annual discounted costs and dividing by cumulative GHG benefits (including forest and HWP carbon) during 2008-2020. (The annual accounting method for HWP was used in the analysis). Cost effectiveness is estimated at \$120/MtCO<sub>2</sub>e. The sum of annual discounted costs also provides an estimate of the Net Present Value of this option of \$160 million dollars. This analysis does not take into account the additional revenue generated from enhanced harvest volumes, which would be a cost savings.

- **Key Assumptions:**

Stand improvement treatments increases carbon sequestration by 15% and harvest volumes by 20%; harvest rates are 1.3%/yr; regional patterns in the disposition of HWP represent conditions in MT; stand improvement treatments result in instantaneous increases in growth and volumes harvested.

### Key Uncertainties

Actual forest carbon sequestration will vary by site conditions, species classes, and specific management practices implemented. The analysis uses average values representative of the

Northern Rocky Mountain region for three common forest types and therefore does not take into account site-specific conditions.

Both HWP accounting approaches involve simplifying assumptions that in one case may overestimate carbon storage (annual accounting with instantaneous benefits) and in the other case, may underestimate carbon storage (100-yr accounting approach). The real benefits probably lie somewhere in between.

### **Additional Benefits and Costs**

Increased timber yields and revenues

Reduce pest, disease, and fire risk

Potential increased public exposure to smoke and increased trace greenhouse gas emissions

Treating these stands would reduce fire hazard potential, improve forest health and diversity, and restore stand conditions

### **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. Input from TWG is requested.]*

### 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.
- **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.

#### 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.

#### Types(s) of GHG Reductions

Displacement of lifecycle emissions associated with production and use of industrial building materials (e.g., steel and concrete)

#### Estimated GHG Savings and Costs per MtCO<sub>2e</sub>

**Estimated GHG Savings in 2010 and 2020: 0.002, 0.004**

**Cost Effectiveness: \$0**

- **Data Sources:**

The Consortium for Research on Renewable Industrial Materials (CORRIM, Inc.) Phase I Research Report provided the GHG reduction potential for substituting steel frames for wood frames in residential structures, as well as physical characteristics in wood typically used in the West region.<sup>21</sup> Data provided by the Montana Department of Environmental Quality (DEQ), along with population projections from the MT I&F project the number of residential structures

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<sup>21</sup> J. Bowyer, D. Briggs, B. Lippke, J. Perez-Garcia, J. Wilson. *Life Cycle Environmental Performance of Renewable Materials in the Context of Residential Building Construction*. Prepared for CORRIM, Inc. [http://www.corrim.org/reports/2006/final\\_phase\\_1/index.htm](http://www.corrim.org/reports/2006/final_phase_1/index.htm)

per year will be built in Montana.<sup>22</sup> Data and GHG reduction estimates for industrial and commercial structures, as well as long-lived consumer products were not available at the time of this analysis.

- **Quantification Methods:**

The CORRIM Phase I report modeled the life-cycle Global Warming Potential (GWP) for a steel-framed and wood-framed house in Minneapolis. Based on personal communication with an author of this report, it is reasonable to assume that a Montana residential structure can be represented by the Minneapolis houses modeled by CORRIM.<sup>23</sup> The GHG reduction for a wood-frame house is shown to be 25%, compared to a steel-frame house. This accounts for the difference in embedded energy in all building supplies necessary for steel and wood-framed structures.

The baseline (BAU) GHG emissions for residential construction in Montana were estimated based on the assumption that all new houses utilized 15 thousand board feet (Mbf), which is equal to approximately 13 Mt of wood fiber. Then, based on the targets of 2% increase in wood products by 2010 and 5% by 2020, the incremental increase in wood used for residential construction was calculated. After calculating the incremental increase in wood use needed to meet the target, the GHG emissions reduction was calculated by multiplying the target incremental increase in wood use by the assumed carbon content (50%), the multiplier converting elemental carbon to carbon dioxide (44/12), and the GHG benefit accrued from the replacement of non-renewable building materials (1.25). The resulting GHG reductions are 0.002 MMtCO<sub>2</sub>e in 2010 and 0.004 MMtCO<sub>2</sub>e in 2020, for a cumulative reduction of 0.035 MMtCO<sub>2</sub>e.

The cost of this option is currently estimated to be zero, as a key assumption of the CORRIM study is that the construction costs a wood-framed house and the baseline house are equal. The net present value of the life-cycle energy costs is also expected to be equal, since the costs are discounted over the long life of the house (75 years). Likely costs of this option include incentives necessary to offset up-front cost premiums on solid wood products, as well as incentives to increase the production of finished wood products.

Further data input are needed to accurately and comprehensively quantify the environmental and economic impacts of this option. It is clear that the current model, representing only the residential building sector, does not encapsulate the benefits that can be realized by increasing the use of wood products in all sectors. Also, the assumption that the costs effectiveness is zero (based on CORRIM model) is misleading, since a homebuilder is not likely to annualize the cost of inputs over the entire life of the home (75 years). Rather, it is more likely that the cost of inputs will be annualized over the expected residency of the initial occupant or the length of the mortgage.

- **Key Assumptions:**

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<sup>22</sup> US Census Bureau, *Vermont: Selected Housing Characteristics: 2005*.  
[http://factfinder.census.gov/servlet/ADPTable?\\_bm=y&-geo\\_id=04000US50&-qr\\_name=ACS\\_2005\\_EST\\_G00\\_DP4&-ds\\_name=ACS\\_2005\\_EST\\_G00\\_-&-\\_lang=en&-\\_sse=on](http://factfinder.census.gov/servlet/ADPTable?_bm=y&-geo_id=04000US50&-qr_name=ACS_2005_EST_G00_DP4&-ds_name=ACS_2005_EST_G00_-&-_lang=en&-_sse=on)

<sup>23</sup> B. Lippke, CORRIM, personal communication with B. Strode, CCS, May 31, 2007

The default assumption for carbon content in wood products used in residential construction is 50% carbon by weight.<sup>24</sup>

By only quantifying the residential construction sector, it is implicitly assumed that, due to fire and insurance codes, there is a minimal possibility for a significant increase in the use of wood products in commercial and industrial construction. It is also assumed that AFW-9 adequately captures carbon sequestered in non-construction wood products. However, the estimates in AFW-9 are based on production data, whereas consumption data would be more appropriate for the quantification of this option.

### **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

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<sup>24</sup> R. Miner. "Characterizing Carbon Sequestration in Forest Products Along the Value Chain." *Prepared for the Climate Change Working Group of the International Council of Forest and Paper Associations*. Available online at <http://www.resourcesaver.org/file/toolmanager/CustomO16C45F64210.pdf>.

## 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: The suggested food goal is 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/>). Its 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 5<sup>th</sup> 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<sub>2e</sub>

- **GHG reduction potential in 2010, 2020 (MMtCO<sub>2e</sub>):** 0.005, 0.02.
- **Net Cost per MtCO<sub>2e</sub>:** \$5
- **Data Sources:** U.S. per capita food consumption was taken from the USDA Economic Research Service (ERS) Food Availability (Per Capita) Data System. Per capita consumption

of each food type is shown in the table below. The average travel distance of imported food was taken from an Iowa study of food miles.<sup>25</sup>

| <b>Food Category</b>            | <b>US per capita consumption (lbs)</b> |
|---------------------------------|--|
| Red meat                        | 116                                    |
| Chicken                         | 86                                     |
| Turkey                          | 17                                     |
| Fish                            | 12                                     |
| Eggs                            | 33                                     |
| All dairy                       | 601                                    |
| Fats and oils                   | 87                                     |
| Peanuts                         | 7                                      |
| Tree nuts                       | 3                                      |
| Coconut                         | 1                                      |
| Fresh fruit                     | 122                                    |
| Canned fruit                    | 15                                     |
| Dried fruit                     | 2                                      |
| Frozen fruit                    | 5                                      |
| Fruit juice                     | 72                                     |
| Fresh vegetables                | 184                                    |
| Canned vegetables               | 108                                    |
| Frozen vegetables               | 75                                     |
| Legumes                         | 6                                      |
| Dehydrated vegetables           | 14                                     |
| Potatoes for chips, shoestrings | 16                                     |
| Grains                          | 192                                    |
| Coffee, tea, cocoa              | 20                                     |
| Spices                          | 3                                      |
| Beverages                       | 116                                    |
| <b>Total</b>                    | <b>1,911</b>                           |

- **Quantification Methods:** Total consumption of food was estimated for each year by multiplying projected population by the per capita consumption data referenced above. The table below shows the estimated food consumption and the amount of food imported from out-of-state sources. The BAU percentage of out-of-state food was estimated by assuming that existing programs (UM Farm to College Program) targeting institutional food, which accounts for about 10% of Montana’s total consumption, achieves 30% consumption of in-

<sup>25</sup> Pirog, R., “Checking the food odometer: Comparing food miles for local versus conventional produce sales to Iowa institutions”. Leopold Center for Sustainable Agriculture, 2003, [http://www.leopold.iastate.edu/pubs/staff/files/food\\_travel072103.pdf](http://www.leopold.iastate.edu/pubs/staff/files/food_travel072103.pdf)

state food by 2020. Hence, 90% of MT food consumption has a 15% in-state content, while 10% of MT consumption has a 30% in-state content).

| Year | MT Food Consumption (tons) | % Locally Purchased Food | BAU % Locally Purchased Food | Food from out-of-state (tons) | BAU Food from out-of-state (tons) |
|------|----------------------------|--------------------------|------------------------------|-------------------------------|-----------------------------------|
| 2007 | 905,345                    | 15%                      | 15%                          | 769,543                       | 769,543                           |
| 2008 | 912,073                    | 17%                      | 15%                          | 760,061                       | 774,209                           |
| 2009 | 918,801                    | 18%                      | 15%                          | 750,354                       | 778,861                           |
| 2010 | 925,529                    | 20%                      | 15%                          | 740,423                       | 783,496                           |
| 2011 | 930,702                    | 21%                      | 15%                          | 735,255                       | 786,801                           |
| 2012 | 935,875                    | 22%                      | 16%                          | 729,983                       | 790,095                           |
| 2013 | 941,048                    | 23%                      | 16%                          | 724,607                       | 793,376                           |
| 2014 | 946,221                    | 24%                      | 16%                          | 719,128                       | 796,645                           |
| 2015 | 951,394                    | 25%                      | 16%                          | 713,546                       | 799,903                           |
| 2016 | 956,567                    | 26%                      | 16%                          | 707,860                       | 803,149                           |
| 2017 | 961,740                    | 27%                      | 16%                          | 702,070                       | 806,382                           |
| 2018 | 966,913                    | 28%                      | 16%                          | 696,177                       | 809,604                           |
| 2019 | 972,086                    | 29%                      | 16%                          | 690,181                       | 812,814                           |
| 2020 | 977,259                    | 30%                      | 17%                          | 684,081                       | 816,011                           |

The reduction of food miles was estimated by taking the difference between the BAU food from out-of-state and the food from out-of-state under this policy and multiplying by average difference in miles traveled by in-state and out-of-state food. The average miles by out-of-state food was assumed to be 1,500 miles plus and additional 25% to account for trucks returning to their points of origin empty (1,825 miles). Since Montana is a relatively large and sparsely populated state, in-state food was assumed to travel 200 miles plus 25% (250 miles), for a difference of 1,575 miles between in-state and out-of-state food. The food transport emission factor (0.162 lb CO<sub>2</sub>/ton-mile) was estimated by assuming 23 ton payload trucks, 6 truck miles/gal diesel, and 22.4 lb CO<sub>2</sub>/gal diesel.

*Cost*

The development of a local food advocacy program is expected to help reach the 2020 target that requires 30% of food consumed in Montana to be grown, harvested, and processed in-state. The cost of such a program is expected to equal the cost of one half of a full-time senior-level program development employee. The Full Time Equivalent (FTE) of such an employee is assumed to be \$75k per year. The cost of the implementation program is therefore \$37,500 in the first year, increasing by 5% per year through the end of the target period. The resulting NPV (in \$2007) is \$0.5 million and the levelized cost-effectiveness is \$5/MtCO<sub>2e</sub>.

• **Key Assumptions:**

The assumption that 25% of out-of-state trucks return from their delivery point empty is a standard assumption. Although the low density of food processors and markets may increase the

probability that these trucks return empty, there is an absence of sufficient data that would support amending this assumption.

It is assumed that all private costs associated with the implementation of this option will be recovered through market mechanisms. Therefore, no subsidies for locally produced food products are necessary to include in the cost analysis of this option.

### **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 quantity 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, 22% by 2011, 25% by 2015, (targets from the Montana Integrated Waste Management Plan) and 28% 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.<sup>26</sup>

### 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”).

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<sup>26</sup> MT DEQ 2005 Recycling Summary, [http://deq.mt.gov/Recycle/2005Recy\\_Summary\\_01-11.htm](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

**CO<sub>2</sub>:** 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<sub>2e</sub>

**Estimated GHG Savings in 2012 and 2020:** 0.02, 1.04

**Cost Effectiveness:** \$8/MtCO<sub>2e</sub>

- **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         | 29.6         | 8.7%        |
| Newspaper         | 49.8         | 14.6%       |
| Office Pack       | 255.1        | 74.9%       |
| Phone Books       | 1.7          | 0.5%        |
| Magazines         | 4.0          | 1.2%        |
| Aluminum          | 0.2          | 0.1%        |
| <b>Total</b>      | <b>340.4</b> | <b>100%</b> |

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.<sup>27</sup> The wastes in the table above were aggregated into the applicable WARM material categories (initial estimates based on

<sup>27</sup> The WARM model and associated documentation can be downloaded from: [www.yosemite.epa.gov/oar/globalwarming.nsf/content/ActionsWasteWARM.html](http://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.

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 2010 and 2020 was then determined by inputting the additional quantities of waste that would be recycled in each year (21% in 2010 and 28% 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) | 257,545   | 307,823   | 343,755   | 399,196   | 478,930   |
| Organics Composted            | 13,462    | 16,090    | 17,968    | 20,866    | 25,034    |
| Recycle Rate                  | 17.7%     | 19.9%     | 21.5%     | 23.8%     | 26.6%     |
| Diversion Rate                | 18.7%     | 21.0%     | 22.7%     | 25.0%     | 28.0%     |

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

| Scenario                       | MtCO <sub>2</sub> e |
|--------------------------------|---------------------|
| Baseline WARM GHG Reduction    | 1,188,863           |
| 2012 Incremental GHG Reduction | 1,424,021           |
| 2020 Incremental GHG Reduction | 2,236,034           |

*Composting of Organic Material*

By composting organic material, the CH<sub>4</sub> 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 (UNFCCC).<sup>28</sup>

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<sub>4</sub> as it diffuses through the landfill soil cover is applied. The baseline landfill methane avoided is (see footnote for additional details):

$$\begin{aligned} \text{Baseline CH}_4 &= (64,524 \text{ ton organics}) \times (0.21) \times (0.50) \times (0.907 \text{ Mt/ton}) \times (16/12) \times 21 \times (1-0.75) \times (1-0.10) \\ &= 38,713 \text{ MtCO}_2\text{e} \end{aligned}$$

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<sub>2</sub>e and 50,640 MtCO<sub>2</sub>e 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<sub>4</sub> emission factor of 1.12 lb/ton material from tests conducted by the South Coast Air Quality Management District in California.<sup>29</sup> CH<sub>4</sub> emissions from the incremental composting in 2012 are estimated to be 99 MtCO<sub>2</sub>e and in 2020 to be 540 MtCO<sub>2</sub>e. Nitrous oxide emissions were estimated from tests done on composting of cattle manure<sup>30</sup> (no data on MSW organic materials were identified). The average N<sub>2</sub>O 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<sub>2</sub>e and 11,154 MtCO<sub>2</sub>e, respectively. Hence, the net GHG benefits for the incremental organics composting are:

| Estimate                 | 2012 MtCO <sub>2</sub> e | 2020 MtCO <sub>2</sub> e |
|--------------------------|--------------------------|--------------------------|
| Landfill methane avoided | 16,188                   | 50,640                   |
| Composting methane       | 288                      | 900                      |
| Composting nitrous oxide | 3,566                    | 11,154                   |
| <b>Net GHG Benefit</b>   | <b>12,334</b>            | <b>38,586</b>            |

<sup>28</sup> UNFCCC, 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<sub>4</sub> 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.

<sup>29</sup> 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.

<sup>30</sup> 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).

Therefore, the overall emission reductions for the policy option are 236,496 MtCO<sub>2</sub>e in 2012 and 739,810 MtCO<sub>2</sub>e in 2020.

### Costs

*Non-organics recycling.* CCS assumed that the policy would be applied to households in three counties in Montana with the highest population density: Yellowstone County (52,084 households, 49.09 people/mi<sup>2</sup>), Silver Bow County (14,432 households, 48.18 people/mi<sup>2</sup>), and Missoula County (38,439 households, 36.88 people/mi<sup>2</sup>).<sup>31,32</sup> Single-stream recycling service would cost \$3.50 per pick-up with each pick-up occurring every 2 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 \$91. The total annual cost for all households is \$9.6 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 are \$25.38 per ton. Using an EPA estimate of waste density (0.05 ton/yd<sup>3</sup>), the volume of the recycle container, the number of annual pick-ups, and the number of households, the maximum amount of total waste to be diverted was estimated to be 754,809 tons/yr, assuming that all collection containers are full. Using the mid-point of the range in tipping fees and 25% of the maximum waste avoided, the avoided landfill cost is \$4.8 million/yr. The net cost for the non-organics recycling is \$5.1 million/yr. Using the GHG reduction estimates derived above, the cost effectiveness in 2020 is \$7.86/MtCO<sub>2</sub>e.

### *Organics Composting*

The cost of organics composting is based on the total quantity of organic material composted under the business as usual (BAU) scenario, less the total quantity of organics composted after the adoption of the targets imposed by this action. The per-ton cost was largely derived from capital and operation and maintenance (O&M) cost estimates provided via personal communication.<sup>33</sup> The cost estimates used in this analysis are provided in the table below.

| Annual Volume (tons) | Capital Cost (2007\$,000) | Operating Cost (\$/ton) |
|----------------------|---------------------------|-------------------------|
| <1,500               | 75                        | 25                      |
| 1,500-10,000         | 200                       | 50                      |
| 10,000-30,000        | 2,000                     | 40                      |
| 30,000-60,000+       | 8,000                     | 30                      |

<sup>31</sup> Montana County Population; Population Density 2000. Accessed on June 20, 2007 from [http://ceic.commerce.state.mt.us/graphics/Data\\_Maps/Densitymap.pdf](http://ceic.commerce.state.mt.us/graphics/Data_Maps/Densitymap.pdf).

<sup>32</sup> US Census Bureau; Montana State and County Quickfacts. Accessed on June 20, 2007 from <http://quickfacts.census.gov/qfd/states/30000.html>.

<sup>33</sup> P. Calabrese, Cassella Waste Management, personal communication with S. Roe, CCS, June 5, 2007. Transmitted via e-mail to B. Strode by S. Roe.

The capital costs were annualized using the cost recovery factor method. This method takes the product of the total annual capital cost and a factor that includes assumptions of a 15 year project life and a 5% interest rate. The annualized capital cost is added to the annual O&M cost and the tipping fee is subtracted to determine the total annualized composting costs. This value does not take into account any revenue raised from the sale of compost.

As reported above, the current average tipping fee in Montana is \$25 per ton. Therefore, since the total annual cost-per-ton is greater than the tipping fee, composting projects are expected to have a net cost. The net present value of costs – assuming a constant \$25 tipping fee - related to composting is \$4.82 million.

- **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<sub>2</sub>O 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