Forestry Technical Work Group
Summary List of High Priority Mitigation Options

DRAFT

	Policy Option	GHG Reductions ($MMtCO_2e$)			Net Present Value 2008–2020 (Million $)	Cost-Effective-ness ($\$/tCO_2e$)	Status of Option
		2012	2020	Total 2008-2020			
F-1	Improved Forest Health	1.2	1.7	16.8	$11	0.63	In progress
F-2	Reduced Conversion to Nonforest Cover	0.9	3.8	21.6	$437	$22	In progress
F-3	Enhanced Carbon Sequestration in Forests	0.2	0.6	3.7			In progress
F-4	Enhanced Carbon Sequestration in Harvested Wood Products	0.02	0.02	0.2			In progress
F-5	Expanded Use of Wood Products for Building Materials						In progress
F-6	Expanded Use of Biomass Feedstocks for Electricity, Heat and Steam Production	0.04	0.19	1.7	-$31	-$19	In progress
F-7	Improved Commercialization of Advanced Lignocellulosic Processes						In progress
F-8	Urban and Community Forests	0.08	0.21	1.4	-$165	-$114	In progress
	Sector Total After Adjusting for Overlaps						
	Reductions From Recent Actions (table to be added below)						
	Sector Total Plus Recent Actions						

F-1. Improved Forest Health

Mitigation Option Description

Reduce catastrophic wildfire GHG emissions due to fuels buildup attributable to decades of fire suppression and related pest infestation and disease. Annually wildfire contributes at least 0.18 $MMTCO_2e$/yr, or 0.2% of the state total (Westcarb I, 2007*).

Implicit within this mitigation option is the recognition that:

- Wildfires play an important ecological function in the natural forest lifecycle yet millions of acres of Washington's forestlands are at uncharacteristic risk due to past management practices.
- Forests, depending on how they are managed, may be a net source or a net reservoir of CO2.
- Eastern and Western Washington have unique forestland types and related forest health challenges and should be treated differently.
- Implementation methods must be balanced and integrated with other policy options including those focused on carbon sequestration, biofuels and feedstocks, conversion and afforestation.

Through incentive and regulatory programs that reduce uncharacteristic wildfire this proposed option will promote hazardous fuel reduction in forests, and subsequent use of fuels in biomass power plants.

** This figure was the average for the years from 1990 through 1996, a period which preceded the larger fire seasons recently experienced. Current and projected emissions are likely to be significantly greater in the baseline case, and validation is needed for the methodology*

Mitigation Option Design

- **Goals:**
  - Reduce the rate of wildfire volatized GHG emissions through 50,000 acres/year reductions in forestland acres "at-risk" of catastrophic wildfire;

  - Restore 25% (500,000 acres) of Washington's "at-risk" state and private forestland, including 50% (XX** acres) in NE Washington, to a characteristically healthy state by the year 2020;

  - Restore 50% (1.0 million acres) Washington's "at-risk" state and private forestland to a characteristically healthy state by the year 2035;

- Restore all 2.0 million acres of Washington's "at risk" state and private forestland to a characteristically healthy state by the year 2050;

**waiting for E vs. W side statistics from DNR's Karen Ripley, or Dwayne Vaugen to fill in XX's*

- **Timing:** See goals above.
- **Coverage of parties:** Private forestland owners and managers, State-owned forest land managers, USDA Forest Service.
- **Other:** We recognize that this effort faces three classes of **limitations**:

1. Physical Limitations
    a. 35% slope or less
2. Economic Limitations
    a. Infrastructure
    b. markets
3. Policy Limitations
    a. influencing Federal lands
    b. Establishing a baseline
    c. Demonstrating additionality

While we **prioritize** recommendations focused on **thinning**, we do recognize all forms of "Forest Health Treatments" like prescribed burns, integrated pest management. We feel strategic thinning and similar treatments are most prudent in the climate policy context.

Do older trees with tight rings have more carbon?
We are also curious if there is any research on the Carbon sequestered in "dog hair" ponderosa pine—these older trees have very small diameters, and tight rings making them desirable lumber products—we are curious if there is an increased carbon per ton and a nexus with sequestration recommendations.

Implementation Mechanisms:

Jurisdiction of Implementation Mechanisms will cover private and state timberlands only, not Federal or Tribal.

Consideration will be given to opportunities to influence "forest health" on Federal Forestlands. Final recommendations should provide qualitative estimates for GHG reductions based on USFS adopting similar goals to reduce "at-risk" Federal forestland. While we **prioritize** recommendations focused on **thinning**, we do recognize all forms of "Forest Health Treatments" like prescribed burns, integrated pest management. We feel strategic thinning and similar treatments are most prudent in the climate policy context.

1. Enhanced Research and Information Dissemination*
    a. Education to landowners etc.
2. Technical Assistance*

   a. Pilot Projects
   b. Professional advise to land owner
   c. Modeling
3. Regulatory Forest Health Orders*
   a. For extreme risk situations
4. Financial Assistance
   a. For landowners to implement forest health treatments
5. Stimulate markets
   a. Seed demand for small diameter material through biomass and other markets
   b. Position forest health treatments to be sold as carbon credits in anticipated carbon cap and trade market
   c. Target areas that "pencil" in economic terms first to buy time for infrastructure and other economic limitations to be resolved
6. Public Works Project
   a. WA DNR gets into the business of improving forest health using savings from wildfire management season
7. Fire control protocols that reduce GHG emissions in fire fighting
8. Collaborative stakeholder planning processes
   a. E.g. NE WA Forestry Coalition developing consensus-based approaches to influencing policies on Federal Lands (Colville NF)

*Existing statutory authority, under way or under development but may benefit from additional resources/authority/incentives. Specifically, we recommend

- Maintaining or increasing base funding level for new forest health program at DNR.
- A broad range of pilot projects for silvicultural thinning regimes, evaluate these pilots and disseminate findings and appropriate models to landowners
- Establishing a strong staff/technical support presence in Eastern Washington

Related Policies/Programs in Place

DNR's Forest Health Program, RCW 76.06,
http://apps.leg.wa.gov/RCW/default.aspx?cite=76.06

as updated in 2007 with SSB 6141
http://www.leg.wa.gov/pub/billinfo/2007-08/Pdf/Bills/Session%20Law%202007/6141-S.SL.pdf

Types(s) of GHG Reductions

TBD

Estimated GHG Savings (in 2020) and Costs per MtCO$_2$e

- **Data Sources:** WestCarb Report, "Carbon Sequestration through Changes in Land Use in Washington: Costs and Opportunities"
- **Quantification Methods:**
    - The option seeks to treat 50,000 acres per year for a total of 500,000 acres by 2020
    - Treatment will reduce the standing carbon stocks in the forest and reduce wildfire events
    - GHG reductions will depend on the fate of biomass that is removed and on how much fires are reduced
    - Analysis of reductions will be from 2008-2020
- **Key Assumptions:**
    - Accessible forest areas that are at moderate to high risk of fires will be targeted; according to WestCarb analysis there are about 2.3 million hectares (5.7 million acres), located mainly in the West and Northeast regions of the state.
    - Treatment will be consistent with CSCH (cut-skid-chip-haul of submerchantable biomass) (see table 4-1 of WestCarb); relatively low cost with high potential GHG reductions (according to WestCarb)
    - Biomass stocks of forests at moderate to high fire risk and accessible for CSCH treatment in WA are approximately 150 dry tons per acre.
    - CSCH removes 4-8 dry tons/ac
    - Biomass removed will be used for energy or will otherwise decay. In both cases, the carbon in removed biomass is emitted to the atmosphere. **Will the biomass regenerate?** If not, this is a permanent loss and should be counted as emissions (that's how the analysis is structured now).
    - Fuel reduction treatments will lead to avoided emissions associated with reduced wildfires; i.e., treatment results in low-intensity forest fires rather than medium-intensity fires with carbon reductions on the order of 8-30 t C/ha; or treatments result in low-intensity fires, rather than high-intensity fires with reductions of 16-80 t C/ha (WestCarb Baseline report cited as source).
    - CSCH costs $34-48/dry ton of biomass removed; this is offset by cost savings from sales to biomass facilities on the order of $36/dry ton (from WestCarb, original cited source: USDA Forest Service Research & Development/Western Forestry Leadership Coalition 2003); net costs are about $5/dry ton of biomass removed (i.e., $41-$36 per dry ton), using a mid-point value for implementation costs

Initial Results:

Summary of GHG Reductions Calculation

	Acres treated with CSCH	Biomass stock (dry tons)	Biomass removed (dry tons)	Emissions* (tons C)	Avoided emissions from reduced fires (tons C)	Net reductions (tons C)	Net reduction (MMtCO2e)
2008	7,143	1,071,429	42,857	-21,429	86,755	65,327	0.24

2009	14,286	1,071,429	85,714	-42,857	173,511	130,654	0.48
2010	21,429	1,071,429	128,571	-64,286	260,266	195,980	0.72
2011	28,571	1,071,429	171,429	-85,714	347,021	261,307	0.96
2012	35,714	1,071,429	214,286	-107,143	433,777	326,634	1.20
2013	42,857	1,071,429	257,143	-128,571	520,532	391,961	1.44
2014	50,000	1,071,429	300,000	-150,000	607,287	457,287	1.68
2015	50,000	1,071,429	300,000	-150,000	607,287	457,287	1.68
2016	50,000	1,071,429	300,000	-150,000	607,287	457,287	1.68
2017	50,000	1,071,429	300,000	-150,000	607,287	457,287	1.68
2018	50,000	1,071,429	300,000	-150,000	607,287	457,287	1.68
2019	50,000	1,071,429	300,000	-150,000	607,287	457,287	1.68
2020	50,000	1,071,429	300,000	-150,000	607,287	457,287	1.68
Total	500,000		3,000,000				16.77

*Assumes biomass removed is not replaced in the future

Summary of Costs

	Biomass removed (dry tons)	Emission reduction (MMtCO2e)	Net costs ($)	Discounted costs ($)*
2008	42,857	0.24	214,286	214,286
2009	85,714	0.48	428,571	408,163
2010	128,571	0.72	642,857	583,090
2011	171,429	0.96	857,143	740,432
2012	214,286	1.20	1,071,429	881,467
2013	257,143	1.44	1,285,714	1,007,391
2014	300,000	1.68	1,500,000	1,119,323
2015	300,000	1.68	1,500,000	1,066,022
2016	300,000	1.68	1,500,000	1,015,259
2017	300,000	1.68	1,500,000	966,913
2018	300,000	1.68	1,500,000	920,870
2019	300,000	1.68	1,500,000	877,019
2020	300,000	1.68	1,500,000	835,256
Total	3,000,000	16.77		10,635,492

*5% discount rate

Cost Effectiveness = NPV (sum of discounted costs) divided by cumulative GHG reductions
Cost Effectiveness = $0.63/ton CO2e

Additional Data from TWG:

"At risk" acreage according to DNR website

www.dnr.wa.gov/htdocs/rp/forhealth.html

Total acres at risk:

2003: 1.9 million acres;

2004: 1.9 million acres;

2005: 2.5 million acres;

2006: 2.0 million acres. (The reduction from 2005 to 2006 may in part reflect fires removing "at risk" areas.)

This is about 10% of the state's roughly 21 million acres of forest land. The percentage is likely to be much higher in eastern Washington.

Forest Health Strategy Work Group reports in 2004 and 2006.

"A Desirable Forest Health Program for Washington's Forests". December, 2004

http://www.dnr.wa.gov/htdocs/rp/forhealth/fhswgc/pdf/foresthealthreport.pdf

"Forest Health Strategy Work Group Report to the Legislature". December, 2006

http://www.dnr.wa.gov/htdocs/rp/forhealth/fhswgc/fhrepttolegdec06.pdf

Contribution to Other Goals

- **Contribution to Long-term GHG Emission Goals (2035/2050):**
- **Job Creation:**
- **Reduced Fuel Import Expenditures:**

Key Uncertainties

We recognize that this effort faces three classes of **limitations**:

4. Physical Limitations
    a. 35% slope or less
5. Economic Limitations
    a. Infrastructure
    b. markets
6. Policy Limitations
    a. influencing Federal lands
    b. Establishing a baseline
    c. Demonstrating additionality

Additional Benefits and Costs

TBD

Feasibility Issues

TBD

Status of Group Approval

TBD

Level of Group Support

TBD

Barriers to Consensus

TBD

F-2. Reduced Conversion to Nonforest Cover

Mitigation Option Description

Reduce conversion of forest lands to non-forest cover and to reduce the rate at which forested tracts are parceled and/or fragmented. The conversion of forestlands to other uses is a direct cause of carbon emissions due to the loss of biomass and soil disturbance. Non-forested areas contain lower amounts of biomass and associated carbon reserves. These areas also have less capacity to sequester carbon dioxide than forested areas.

Implicit within this mitigation option is the recognition that 1) forests, depending on how they are managed, may be a net source or a net reservoir of CO2 and 2) a continuous loss of forestland regardless of the rate will ultimately lead to the loss of scale for the forest industry, wild life and WA private forests to make any significant contribution to carbon sequestration. This proposed option will promote the development of incentive programs that maintain forestland by reducing conversion and promoting forests' ability to continue to sequester carbon. This proposed option additionally aims to position Washington State forestland owners to participate in emerging carbon trading markets. This policy will include an analysis of population growth and its impact on forest land conversion and how incentives can minimize its impacts until an elimination of conversion is achieved. If these voluntary programs selected are not attaining the desired resolute, then it will be the responsibility of the state to increase or enhance the incentives so that landowners are providing the desired sequestration service.

Mitigation Option Design

- **Goals:**
  - Reduce the acres of forestland expected to be lost to non-forest uses by 70% by 2020.
- **Timing:** Policy initiation: by 2010 reduce expected loss by 10%, by 2020 reduce the expected loss by 70%.
- **Coverage of parties:**
- **Other:** It will take some time to develop and implement market initiatives and incentives programs that can stem the rate of conversion to non-forest use and for those reasons the 2010 goal is modest. But it is expected that with the full implementation of many of the mechanisms listed below dramatic decreases in the rate of conversion will be achieved. If these voluntary mechanisms are affective we hope to see an increase in forested land after 2030.

- Since the 1930's, Washington State has lost 2 million acres of timberland to other uses. But the trend has accelerated: over the next several years, 300,000 acres of Western Washington timberland is likely to be converted to other uses (Alig et al, 2003)[1].

  Two demographic surveys conducted by Washington State University (WSU) and the Washington Farm Forestry Association also revealed that the average age of small forest landowners is between 57 – 67 years old. These figures imply that a large percentage of this land base will change hands within a generation, likely leading to increased fragmentation and conversion.

Implementation Mechanisms:

1. WA to fund and perform a study on current rates of private forest land conversion to other uses, including data on geography and demographics of landowners. These numbers will help to prioritize conservation efforts by the state and others in order to achieve the goals of this mitigation option.
2. The state to provide more analysis to help identify rates of conversion on a county by county level and credit the amount of carbon associated with maintaining the forest land cover as a percentage of the rate of conversion in the area (see CA Forest Protocols as reference).
3. WA to participate in the development of a regional regulatory Cap and Trade system that recognizes forestry projects that could provide carbon sequestration offsets, including avoided deforestation of forestland.
4. Make environmental mitigation more efficient for developers and effective for conservation to reduce negative environmental impacts of development.
5. Accelerate the development of conservation markets in order to create new income streams to landowners for conservation actions.
6. Encourage conservation easements used to maintain working forestland that are threatened with conversion
7. Expand the use of transfer of development rights (TDR) in areas facing rapid development through regional markets, incentives to receiving areas for increased density, and capacity building for financially constrained local governments (this mechanism linked with Transportation option 4 and Residential, Commercial and Industrial option 3.)
8. Implementation of the Conservation Villages concept will provide an alternative to large lot development. Each Conservation Village, a receiving site for development right transfers, will permanently protect working forests by transferring currently allowed development potential to compact, green-build developments.

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[1] Alig, R. J., A. J. Planting, S. Ahn, and J. Kline. 2003. *Land use changes involving forestry in the United States: 1952 to 1997, with projections to 2050*. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: Portland, Oregon.

9. Working Lands Revolving Loan Fund will provide government entities access to low or no-interest loans for transactions that permanently keep land in economically active forestry through TDR. Local bodies then resell to private market, having removed real estate development value. Greater affordability of working forests will help transfer Washington's resource legacy to the next generation.
10. New tax incentives that encourage forest management for greater forest sequestration and avoid conversion, including the development of an Anti-Forest Conversion designation that works similarly to open space designations for agriculture. This designation would allow forest landowners to avoid paying specific state taxes as long as the forest lands remained as working forests. At the point of conversion, past taxes would have to be re-paid.
11. Washington will undergo a study to determine inadvertent regulatory or tax disincentives to forestry, including inheritance taxes laid on next generation foresters.
12. (Changes to project environmental review requirements (e.g. SEPA) to require analysis and mitigation of climate impacts, including those related to possible depletion of forest carbon stocks.) *Consensus has not been reach among F-2 Members.*
13. Educate Washington citizens on the importance of working lands and the quality environmental stewardship performed by our landowners in order to increase the value of forest lands to the public beyond their value as real estate. (Does not have direct emissions benefits, may want to move it another section.)

Related Policies/Programs in Place

Examples of Direct Payment Incentive Programs

Program	Program Implementer	Type of Action	Benefits	Acres protected	Program support
Forest Legacy Program	U.S. Forest Service & WA DNR	**Grant program** funds up to 75% of project costs, typically a conservation easement.	Private landowner	~15,000	$6.2 million
Conservation Reserve Enhancement Program	Farm Services Agency & Washington State Conservation Commission	**Cost share** covers up 50% of the eligible costs to reforest riparian areas.	Private landowner	8,100	$1.3 million
Conservation Innovation Grants Program	Natural Resource Conservation Service (NRCS)	**Cost share** transfers conservation technologies, management systems, and innovative approaches (i.e. market-based systems).	Organizations or academic institutions		
Healthy Forests Reserve Program	NRCS	**Cost share** funds 50-100% of the costs of voluntary easement program established to restore/enhance forest ecosystems & promote recovery of threatened and endangered species, enhance carbon sequestration.	Private landowner		Not in WA; was a pilot program in FY 06 in Arkansas, Maine, and Mississippi
Landowner Incentive Program	WA Department of Fish and Wildlife (WDFW)	**Grant program** supplements the protection & restoration of federally listed, proposed or candidate species on private lands.	Private landowner		Up to $50,000 for individual landowners
Wildlife Habitat Incentives Program	NRCS	**Cost share** provides technical and financial assistance to landowners to restore native vegetation and habitat for threatened and endangered species.	Private landowner		
Forestry Riparian Easement Program	WA DNR - Small Forest Landowner Office (SFLO)	**Grant program** compensates eligible small forest landowners in exchange for a 50-year easement on "qualifying timber" within riparian areas.	Private landowner	1,813	$5.2 million
Family Forest Fish Passage Program	WA DNR - SFLO, WDFW, Salmon Recovery Funding Board	**Cost share** provides 75-100% of the cost of correcting a barrier; also provides technical assistance.		236 miles of stream opened	$4.3 million
Forest Land Enhancement Program	U.S. Forest Service & Washington DNR	**Cost share** provides for technical, educational, and cost-share assistance to promote sustainability of non-industrial private forests.	Private landowners (small)		
Riparian Open Space Program	WA DNR	**Grant program** qualifying landowners can donate or sell their land and/or timber in designated forest land that exists along migrating stream channels. There are also options to sell the state permanent conservation easements covering the timber and/or forest land provide.	Private landowners	584	$1.47 million
Conservation Easements	Land conservation organizations, state agencies, counties	**Direct payment** voluntary legal agreement that restricts the development and future use of a piece of property, transfers those rights to qualified conservation organization or agency.	Private landowners		
Transfer Development Rights	King County, in development elsewhere in the state	**Direct payment** trading of zoning privileges from areas with low population needs, such as forest land, to areas of high development needs, such as urban core areas. Typically includes a conservation easement on sending site.	Private landowners	92,000	$22 million in value

Acres protected and program support are best available estimates as of 2006 and are not complete for all programs.

Source: Bradley, G, A. Erickson, A. Robbins, G. Smith, L. Malone, L. Rogers, and M. Connor. 2007. Future of Washington's Forest and Forest Industries Study. Final Report 2007. Study 4: Land Conservation. http://www.ruraltech.org/projects/fwaf/final_report/pdfs/05_Study4_LandConv.pdf

Types(s) of GHG Reductions

- Avoided CO_2 emissions from carbon stock losses that occur when forests are converted to other uses
- Maintenance of annual carbon sequestration potential in forests that are not converted to development

Estimated GHG Savings (in 2020) and Costs per MtCO$_2$e

- **GHG reduction potential in 2012, 2020 (MMtCO$_2$e):** 0.9, 3.8
- **Cumulative GHG reduction potential, 2007-2020 (MMtCO2e):** 21.6
- **Net Cost per MtCO$_2$:** $22.42 (based on Westside analysis only)
- **Data Sources:** Data on rates of forest conversion to development from NRCS National Resource Inventory; forest carbon densities from the CCS Inventory and Forecast Appendix H on Forestry; forest sequestration rates calculated from PNW defaults in the 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 distribution of forest types in eastern and western WA from USFS Forest Inventory Analysis; Assumptions about carbon losses from (a) Strong, T.F., 1997 "Harvesting Intensity Influences the Carbon Distribution in a Northern Hardwood Ecosystem," USFS Research Paper NC-329 and (b) "The Intersection of Land Use History and Exurban Development: Implications for Carbon Storage in the Northeast" Master's Thesis, K. Austin, 2006); cost data are derived from the Multiple Listing Service and from The Future of Washington's Forests and Forest Industry Study 1: Timber Supply and Forest Structure (http://www.ruraltech.org/projects/fwaf/final_report/index.asp#toc).
- **Quantification Methods:**

  GHG Benefits
  This option maintains a certain percentage of forest land that would otherwise be converted to development, assuming current rates of forest conversion continue out into the future. The carbon savings are estimated from two sources: the amount of carbon that would be lost as a result of forest conversion to developed uses (i.e., "avoided emissions"); and the amount of annual carbon sequestration in the forest area that is not converted to development under this option (i.e., "protection of carbon sequestration potential"). Data are available to allow for separate estimates for the East- and Westside of WA, which allows the analysis to take into account different underlying forest conversion trends, predominant forest species, and carbon densities between these regions.

  Baseline future rates of forest conversion (in State and private ownership) were calculated from land use change data reported by the Natural Resources Inventory (NRI). NRI is one of the few available sources of land use data that provides information on specific land use changes. NRI data are for Non-Federal lands (although the amount of Non-Federal land moving into Federal ownership is also tracked). In addition, NRI provided CCS with separate West- and Eastside estimates for WA. The 1992-1997 time period is the most recent for which NRI data are available for specific land use conversions (i.e., from forests to urban land uses). Thus, for this analysis, the baseline future rate of forest conversion to development is based on the 1992-1997 NRI data shown in Tables 1a and 1b below.

The annual average rate of forest conversion to development is calculated as the number of forest acres converted to urban land uses from 1992-1997 divided by 5 years. This value divided by the initial forest area in 1992 yields the percent change per year. Estimated annual average rates of forest conversion to development for Western WA are 19,500 acres/yr, or 0.25%/yr, and for Eastern WA are 3,560 acres/yr, or 0.07%/yr.

Table 1a. Trends in Forest Conversion, Westside of WA, 1982-1997

	1982-1987	**1987-1992**	**1992-1997**
Initial Non-Federal Forest Acres	7,995,000	7,931,700	7,789,800
Final Non-Federal Forest Acres	7,904,200	7,780,800	7,663,300
Change	90,800	150,900	126,500
Non-Federal Forests Converted to:			
Cropland	0	1,200	0
Conservation Reserve Program	0	0	0
Pastureland	2,400	17,600	17,100
Rangeland	0	0	0
Minor land cover/uses	4,300	6,400	8,400
Urban land use	**43,500**	**124,800**	**97,500**
Water	1,300	900	2,300
Federal land	39,300	0	1,200

Table 1b. Trends in Forest Conversion, Eastside of WA, 1982-1997

	1982-1987	**1987-1992**	**1992-1997**
Initial Non-Federal Forest Acres	5,102,300	5,093,600	5,134,600
Final Non-Federal Forest Acres	5,079,900	5,082,000	5,098,300
Change	22,400	11,600	36,300
Non-Federal Forests Converted to:			
Cropland	2,200	0	0
Conservation Reserve Program	0	0	0
Pastureland	0	1,000	0
Rangeland	9,100	2,900	15,000
Minor land cover/uses	100	900	3,300
Urban land use	**2,100**	**5,600**	**17,800**
Water	200	100	200
Federal land	8,700	1,100	0

At the goal levels specified by this option, the baseline rates of forest conversion to development would be reduced by 10% by 2010 and 70% by 2020. This amounts to the avoided conversion of 1,950 acres/yr by 2010 and 13,650 acres/yr by 2020 on the Westside, and 356 acres/yr by 2010 and 2,492 acres/yr by 2020 on the Eastside.

Loss of forests to developed uses typically results in the near complete removal of forest trees as well as significant soil disturbance, causing a substantial one-time loss of carbon stocks stored in forest biomass and soils. For this analysis, 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).

Average forest carbon stocks (tons carbon per acre) are multiplied by the anticipated percentage loss of carbon due to development to yield avoided emissions coefficients. Average forest carbon stocks are provided in the WA Inventory and Forecast report Appendix H, which is the source for the biomass and soil carbon stocks used in this analysis and shown in Table 2 below. To estimate avoided emissions, the avoided emissions coefficients for biomass and soils are multiplied by the acres of forests that avoid conversion each year.

Table 2. Avoided emissions coefficients (tons C/ac).

	Westside		Eastside	
	Avg. Carbon Stock	Avoided Emissions Coefficient	Avg. Carbon Stock	Avoided Emissions Coefficient
Biomass	81.58	43.24	47.11	24.97
Soils	40.72	14.25	29.26	10.24

Forests that are protected from conversion in one year continue to sequester carbon in subsequent years, which is carbon sequestration that would not have occurred if the forest were converted to development. This is estimated and included as an additiona GHG benefit using average annual carbon sequestration rates for Western and Eastern WA, calculated from published carbon yield tables (USFS GTR NE-343). These data were combined with FIA data on acres by forest type and region of WA to calculate an area-weighted average carbon sequestration rate for Eastern and Western WA (Table 3). Annual sequestration rates were based on a 65-yr average and calculated by subtracting biomass carbon stocks in 65 yr old stands from biomass carbon stocks in new stands and dividing by 65. Sixty-five years was chosen to approximate the average stand age distribution in WA. Soil carbon stocks are constant across stand age in the published yield tables, therefore, sequestration in soils is assumed to be zero in the analysis.

Annual sequestration is calculated by multiplying the cumulative forest acres that avoided development each year by the appropriate average carbon sequestration rate. Cumulative acres are used because forests that are protected from conversion in one year continue to sequester carbon in subsequent years.

Table 3. Weighted average annual carbon sequestration rates for WA

Region	Forest Type	Area (acres)	Biomass	Biomass	Sequestration (tons

			Stocks (tons C/ac) for new stands (0 yrs)	Stocks (tons C/ac) for 65 yrs old stands	C/ac/yr)
Eastside	Douglas-fir	3,564,564	27.4	86.4	0.91
	Fir-spruce-mountain hemlock	1,575,167	23.7	58.6	0.54
	Lodgepole pine	622,528	17	45.3	0.44
	Ponderosa pine	2,101,228	15.6	34.9	0.30
	Area-weighted average				**0.63**
Westside	Alder-maple	1,847,329	18.7	138.8	1.85
	Douglas-fir	4,920,078	33.3	183.9	2.32
	Fir-spruce-mountain hemlock	1,795,660	23.5	114.2	1.40
	Hemlock-sitka spruce	3,074,643	30.5	116.1	1.32
	Area-weighted average				**1.84**

All estimates are converted from tons carbon to million metric tons of CO_2 equivalent ($MMTCO_2e$). Result for both avoided emissions and protected sequestration capacity are shown in Tables 4a and 4b.

Table 4a. GHG Benefits of Avoided Forest Conversion to Development in Western WA

	Forest Acres Avoiding Conversion	Total Avoided Emissions (tons C)	Protected Sequestration Capacity (tons C)	Total (MMtCO2e)
2008	650	37,369	1,193	0.14
2009	1,300	74,739	3,580	0.29
2010	1,950	112,108	7,161	0.44
2011	2,340	134,529	11,457	0.54
2012	3,510	201,794	17,902	0.81
2013	4,680	269,059	26,494	1.08
2014	5,850	336,323	37,235	1.37
2015	7,020	403,588	50,124	1.66
2016	8,190	470,853	65,161	1.97
2017	9,360	538,117	82,347	2.28
2018	10,530	605,382	101,681	2.59
2019	11,700	672,647	123,162	2.92
2020	13,650	784,754	148,224	3.42
Total	80,730	4,641,261	5,791,857	19.50

Table 4b. GHG Benefits of Avoided Forest Conversion to Development in Eastern WA

	Forest Acres Avoiding Conversion	Total Avoided Emissions (tons C)	Protected Sequestration Capacity (tons C)	Total (MMtCO2e)

2008	119	4,178	75	0.02
2009	237	8,356	225	0.03
2010	356	12,535	451	0.05
2011	427	15,042	721	0.06
2012	641	22,562	1,126	0.09
2013	854	30,083	1,667	0.12
2014	1,068	37,604	2,343	0.15
2015	1,282	45,125	3,154	0.18
2016	1,495	52,645	4,100	0.21
2017	1,709	60,166	5,182	0.24
2018	1,922	67,687	6,398	0.27
2019	2,136	75,208	7,750	0.30
2020	2,492	87,742	9,327	0.36
Total	14,738	518,934	669,862	2.06

Cost Analysis

Cost data were available for Western WA only. Therefore the cost analysis is limited to this region. The GHG benefits are largely attributed to Western WA due to the relatively large baseline rate of forest conversion in the Western region. Thus, the analysis is believed to be a good representation of the overall costs.

Both costs and cost savings are taken into account in this analysis. Costs are approximated as the market price of forest land, which is assumed to reflect the minimum amount of compensation needed to prevent a decision to sell to developers. An average market price of $12,381/acre was calculated from the forest land sale prices (for parcels >10 acres) in Western WA as listed in the MLS database. The specific mechanism for compensating land owners is not prescribed here as there are several potential vehicles (e.g., conservation easements, carbon offsets markets, etc.)

The net loss of working forest land in WA has implications in terms of lost forest revenue from multiple revenue streams, including for example state taxes. Researchers at the University of Washington have estimated the net economic impact of preventing forest conversion by comparing the present value of forest revenues under two future scenarios, one with and one without forest conversion to other uses (see tables 1.16 and 1.17 in the Future of Washington's Forests and Forest Industry: Study 1). The report shows net economic benefits to eliminating conversion of industrial forests to other non-forest uses and projects that both the total and per acre present value of industrial forests goes up when forest conversion ceases. The study estimates that the present value of industrial forests increases by about $1.169 million overall if conversion of 272,000 acres of industrial forests is prevented. These statistics were used to calculate a potential cost savings based on the forest revenues saved per acre of forest that is not converted of $4,298/acre ($1.169 million in savings divided by 272,000 acres not converted yields $4,298 per acre not converted).

Costs minus cost savings yield a net cost per acres of $8,083 per acre not converted (i.e., $12,381 minus $4298). Net costs per acre are multiplied by the forest acres that avoid conversion each year to yield annual costs. Annual discounted costs are then estimated using a 5% interest rate. The sum of annual discounted costs provides an estimate of the Net Present Value (NPV) of this option, which amounts to $437 million. The cumulative cost effectiveness of the total program was calculated by dividing the NPV by cumulative carbon benefits of this option for Western WA, yielding $22/ton CO2e.

Table 5. Summary of Cost Calculation, for Western WA only

	Acres Protected	Carbon Savings (MMtCO2e)	Cost	Discounted costs
2008	650	0.14	$5,254,084	$5,254,084
2009	1,300	0.29	$10,508,168	$10,007,779
2010	1,950	0.44	$15,762,251	$14,296,827
2011	2,340	0.54	$18,914,702	$16,339,231
2012	3,510	0.81	$28,372,053	$23,341,758
2013	4,680	1.08	$37,829,404	$29,640,328
2014	5,850	1.37	$47,286,754	$35,286,104
2015	7,020	1.66	$56,744,105	$40,326,976
2016	8,190	1.97	$66,201,456	$44,807,751
2017	9,360	2.28	$75,658,807	$48,770,342
2018	10,530	2.59	$85,116,158	$52,253,937
2019	11,700	2.92	$94,573,509	$55,295,172
2020	13,650	3.42	$110,335,760	$61,439,080
Total	80,730	19.50		$437,059,368

- **Key Assumptions:**
  - Baseline rate of forest conversion to developed uses for Westside is assumed to be 19,500/yr, or 0.25%/yr (NRI 1992-1997, non-federal land)
  - Baseline rate of forest conversion to developed uses for Eastside is assumed to be 3,560/yr, or 0.07%/yr (NRI 1992-1997, non-federal land)
  - 53% of biomass carbon stocks are lost/emitted during conversion (Strong 1997)
  - 35% of soil carbon stocks are lost/emitted during conversion (Austin 2006)
  - Net costs are estimated at $8,083/acre, using land value to approximate costs of $12,381/acre and potential lost forest revenues to approximate cost savings of $4,298/acre

Contribution to Other Goals

- **Contribution to Long-term GHG Emission Goals (2035/2050):**
- **Job Creation:**
- **Reduced Fuel Import Expenditures:**

Key Uncertainties

[Insert text here]

Additional Benefits and Costs

TBD

Feasibility Issues

TBD

Status of Group Approval

TBD

Level of Group Support

TBD

Barriers to Consensus

TBD

F-3. Enhanced Carbon Sequestration in Forests

Mitigation Option Description

Washington forests have a significant role to play in decreasing net emissions of carbon dioxide (CO2) by removing CO2 from the atmosphere. Our forests are among the most productive in the world, and programs designed to encourage management of our forests for increased overall forest carbon stocks can be an important part of the state's climate action strategy. Special programmatic emphasis should be placed on opportunities to increase and maintain overall carbon storage in the most stable reservoirs in the forest environment, especially stems, roots, and soils.

This mitigation option is designed to promote the removal of additional CO2 from the atmosphere by increasing and maintaining overall carbon stocks in Washington forests relative to an established baseline. The baseline should not be established solely on the basis of the estimated amount of carbon sequestered in Washington forests at a single point in time. The baseline should also take into account projected trends in sequestered forest carbon levels, particularly as those levels are expected to be affected by factors such as current regulatory requirements and forest management practices and by projected forest losses from fire resulting from unnatural fuel loading.

Net storage of forest carbon is influenced by many factors, including the conversion of forests to non-forest uses, forest health, and the wood products manufacturing process. These and other important issues related to enhanced carbon sequestration in Washington forests are addressed in other forestry mitigation options (e.g. F-1 addresses forest health, F-2 addresses forest conversion and F-4 addresses wood product carbon storage). In addition other important policy goals (e.g. preservation of natural habitat and species biodiversity), this mitigation option includes as a policy goal the preservation of our state's public and private working forests. In support of these goals, this option aims to position our state's public and private working forests to participate meaningfully in emerging carbon trading markets.

Mitigation Option Design

- **Goals:** Help position Washington forest landowners to participate meaningfully in emerging carbon offset markets by implementing voluntary programs and incentives which, together with emerging market opportunities, will increase absolute levels of sequestered carbon relative to an established baseline in Washington forests (exclusive of Federal and Tribal forestlands) by 10% by 2020 and 40% by 2050.
- Undertake and complete analysis necessary to determine baseline net forest carbon stocks by the end of 2008.
- Develop accounting protocols to measure changes in forest carbon stocks by the end of 2009.

- Adopt legislation, rules, or other measures as necessary to implement voluntary programs and incentives for achieving increases in net forest carbon stocks, consistent with maintaining or enhancing healthy native forests that support environmental values by 2011.
- [Implement afforestation on X% of available land by 2020. (Text added/suggested by CCS)]
- [Implement forest management to improve productivity on 50% of available forest acres by 2020. (Text added/suggested by CCS)]
- **Coverage of parties**: Washington Governor; Washington Legislature; Executive Departments (e.g. Ecology, DNR, CTED; OFM; Revenue); Climate Action Challenge stakeholders; large and small forest landowners; foresters and climate scientists; and general public.
- **Other:**

Implementation Mechanisms:

The design for this mitigation option includes the development of greenhouse gas accounting protocols to quantify and verify real, additional and durable emission reductions that provide emissions reductions exceeding those anticipated under the established baseline. The accounting protocols used to quantify emissions reductions should 1) quantify annual increases and decreases in forest carbon stocks above the baseline (live and dead carbon pools, including wood product carbon), 2) secure/account for the protection (i.e. "permanence") of overall carbon stocks and 3) quantify and verify removals/reductions of CO2 based on stock change accounting.

Any or a combination of the following (or other identified) forest management practices could be implemented to increase and maintain overall forest carbon stocks in Washington forests:

- Programs, incentives and development of new markets (e.g. increasing demand for large solid wood beams) for increased lengths of harvest rotation.
- Programs, incentives and development of new markets for harvest limitations.
- Improved restocking of under-stocked areas/Reforestation of non-forested areas that were historically in forest cover, both utilizing native tree species.
- Silvicultural techniques to improve carbon sequestration rates
- Appropriate thinning of over-stocked areas.
- Avoidance of conversion to non-forest uses.
- Widening of forested riparian corridor buffers.

Programs and incentives in support of these methods of practice could include:

- Participation in the development of regional and national carbon markets that allow participation by large and smaller forest landowners.
- Increased use of conservation easements to maintain working forests managed for enhanced carbon sequestration and environmental values (see e.g. F-2 for more details on the use of conservation easements).
- New tax incentives or tax relief that encourage forestry and management for greater forest carbon stocks and that avoid conversion.
- Other identified forest landowner incentives and technical assistance programs that

protect and preserve our forests and address the reality of increased ownership fragmentation.
- **[**Changes to development project environmental review requirements (e.g. SEPA) to require analysis and mitigation of climate impacts, including those related to possible depletion of forest carbon stocks.**]**
- Development fees that fund on-site and/or off-site mitigation for identified climate impacts of projects.
- New "Green Building" (e.g. LEED) standards that require use of wood products from managed and sustainable forestland sources that store additional carbon (see e.g. F-5 and RCI-3 for more details on how to include life cycle impacts in green building standards).

Additional analysis is needed to determine which combination of these or other programs and incentives would yield the most cost effective and environmentally sound absolute increases to levels of sequestered carbon in Washington forests.

Related Policies/Programs in Place

TBD

Types(s) of GHG Reductions

Increased carbon sequestration and storage in forest biomass and soils.

Estimated GHG Savings (in 2020) and Costs per $MtCO_2e$

- **Data Sources:** Forest carbon stocks, sequestration rates, and growing stock volume from PNW defaults in the 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 distribution of forest types in eastern and western WA from USFS Forest Inventory Analysis; Assumptions about carbon removals during harvesting from Strong, T.F., 1997 "Harvesting Intensity Influences the Carbon Distribution in a Northern Hardwood Ecosystem," USFS Research Paper NC-329

- **Quantification Methods:**

  The Forestry Technical Working Group identified two primary opportunities in WA for increasing net forest carbon stocks (beyond what can be accomplished with avoided forest conversion, which is covered by option F-2). Those are afforestation in industrial forests and riparian areas; and changes in forest management. The GHG benefits and costs/cost savings are quantified separately for each of these actions.

  Afforestation

  TBD

  Need estimates of available acreage as a starting point

  Will use default carbon stocks from USFS to estimate carbon stock increases from afforestation.

  Costs? Cost Savings?

Forest Management

The net change in carbon stocks in forest biomass and soil is influenced by growth, mortality and decay processes, as well as the amount of carbon removed during harvest. The potential exists to increase net forest and harvested wood carbon stocks on working forests in WA through a number of management practices that, in effect, either extend harvest rotations or increase stand productivity (or both). The later can be accomplished through, for example, stand fertilization, using genetically improved trees, and changes in stocking and thinning practices. These practices have the potential to increase the amount of carbon sequestered and stored in forest biomass (live trees, understory vegetation, standing and down dead trees, and small diameter debris on the forest floor), soils, and harvested wood products (HWP).

Increasing harvest rotations allows more time for forest growth before harvest, which can increase the volume of forest biomass, some portion of which is eventually harvested. The net impact of this practice on forest and HWP carbon stocks is complex and difficult to quantify, and is still an evolving area of study.

Increasing productivity involves increasing the rate at which forests accumulate biomass; i.e., a high productivity stand accumulates more carbon in biomass over the same amount of time as an otherwise equivalent low productivity stand. This leads to a relatively higher growing stock volume (i.e., the volume of living trees above the ground), some portion of which is harvested at periodic intervals (providing for potentially greater harvest volumes). Data are available to estimate the carbon stock changes associated with increasing forest productivity in WA, thus the analysis of GHG benefits of forest management is based on this process, and it is intended to represent at least the partial potential for increasing net carbon stocks in WA forests.

The net impact of a shift from low to high productivity forests involves both forest carbon and HWP pools. From a carbon accounting perspective, harvested carbon represents a carbon stock loss to the forest and a carbon stock gain into the HWP pool, with only a portion of the carbon that is shifted into the HWP pool at harvest remaining stored for long periods of time. Options F-3 and F-4 are essentially divided along the accounting boundary between the forest and HWP carbon pools, with F-3 focusing on gains in forest carbon stocks (biomass and soils) and F-4 focusing on gains in HWP carbon stocks. The change in carbon stocks in both forest and HWP pools are quantified below, with the carbon stock increases within the forest boundary reported under F-3 and the carbon stock changes in HWP reported under F-4.

The potential increase in net carbon stocks resulting from improving stand productivity on timberlands in WA is estimated below using the following key factors calculated from published carbon stocks and growing stock volumes (USFS GTR NE-343):

- Incremental increase in carbon stocks when stand productivity increases (0.3 tons C/ac/yr)
- Incremental increase in growing stock volume when stand productivity increases (4,083 cubic feet/ac)

These values, combined with assumptions about harvest rates, are used to estimate the incremental increase in forest carbon and harvested carbon removed from forests in stands that have been treated with management practices that increase productivity. In addition, the amount of carbon remaining stored in the increased portion of harvested carbon is tracked using established accounting methods for estimating long-term carbon storage in durable HWP.

These factors are applied to an approximate area of forestland in WA where the potential exists to increase forest productivity, based on the area of timberlands that are currently classified as having relatively low productivity (as measured by site productivity index).

Increases in Carbon Sequestration Rates and Growing Stock Volumes

The USFS publishes carbon stock tables for forest types by region for the entire US. In some regions, for some forest types, the USFS provide tables for both average and high productivity stands. Such tables are available for Douglas fir forests in the western region of the Pacific Northwest ("PNW W"). Douglas fir forests are the most abundant type in Washington, distributed close to evenly between east- and west-sides of the state, and an analysis of this forest group alone is believed to be a good approximation of the overall potential GHG benefits of forest management in WA. Given the available data for the PNW W and the abundance of Douglas fir forests, the analysis focuses on the impacts of increasing productivity of Douglas fir in western WA.

Carbon stock and growing stock volume data in the USFS tables (see Tables 1a and 1b below) were used to calculate an annual carbon sequestration rate for average and high productivity Douglas fir forests in western WA (carbon stocks in 75 yr old stands were subtracted from carbon stocks in new stands and divided by 75). An average over 75 years is assumed to encompass the range of actual age classes for this forest type in western WA, thereby providing a representative average (in reality, sequestration rates vary by stand age). Note that soil carbon stocks are constant over time and between productivity classes, so carbon stock gains occur only in biomass pools. The high productivity stands sequester approximately 0.3 tons more carbon per acre per year. Therefore, regardless of the initial carbon stock levels, a forest stand that moves to higher productivity status will gain roughly 0.3 more tons C per acre per year than it would if left as is.

Table. 1a Carbon stocks and mean growing stock volumes by selected age class for Douglas fir forests in the PNW W (USFS GTR NE-343, Table A22)

Age	Mean volume (cf/ac)	Soils (tC/ac)	Biomass (tC/ac)	Total (tC/ac)
0	0	38.3	33.3	71.6
35	5600	38.3	105.5	143.8
55	9981	38.3	160.9	199.2
75	13432	38.3	204.4	242.7
95	16213	38.3	239.5	277.8
Average annual sequestration (75 year average) (tC/ac/yr)				2.3

Table. 1b Carbon stocks and mean growing stock volumes by selected age class for High Productivity Douglas fir forests in the PNW W (USFS GTR NE-343, Table A23)

Age	Mean volume (cf/ac)	Soils (tC/ac)	Biomass (tC/ac)	Total (tC/ac)

0	0	38.3	32.9	71.2
35	6370	38.3	104.9	143.2
55	13207	38.3	180.9	219.2
75	17518	38.3	228.9	267.2
95	20756	38.3	265.2	303.5
Average annual sequestration (75 year average) (tC/ac/yr)				2.6

In addition, the growing stock volume is greater in all age classes of high productivity Douglas fir stands. Assuming that, on average, stands are harvested at 75 yrs (CCS chose this assumption, to be reviewed by the TWG), USFS HWP accounting methods were used to convert the 4,086 cubic feet per acre incremental increase in growing stock volume into the equivalent carbon volume of 47.2 tons C/ac (see Table A2 and Appendix below for explanation of this calculation). Note that this is the carbon stored in the incremental increase in growing stock, only a portion of which is removed during harvest (this analysis assumes 35% is removed, see below).

Forestland with the Potential to Increase Productivity

Data on the area of Douglas fir timberlands in WA by site productivity class where collected from the USFS Forest Inventory Analysis database for 2005 and used to approximate the potential acreage on which productivity can be improved (Table 2). The potential acreage is based on the number of acres of Douglas fir on the Westside in site productivity classes less than 120 board feet per acre (need to double-check units for site class). These data suggest a potential of approximately 1,086,464 acres.

Table 2. Area of Douglas fir timberlands in WA, by region and site productivity class.

Site productivity class (board feet/ac?)	Eastside (acres)	Westside (acres)	Total (acres)
225+	13,806	204,183	217,989
165-224	53,501	1,434,749	1,488,250
120-164	237,556	1,873,005	2,110,561
85-119	512,208	698,235	1,210,443
50-84	1,454,295	314,283	1,768,578
20-49	942,830	73,946	1,016,776
Total	3,214,195	4,598,401	7,812,596

It was assumed that productivity could feasibly be increased on only 50% of these acres by 2020 and that an equal portion (41,787 acres) would be treated each year from 2008 to 2020 (CCS made this assumption as a starting point, for further review by the TWG).

Calculation of Net Carbon Stock Change in Forests and HWP

The calculation of net forest carbon stock change takes into account that each year gains in biomass carbon stocks from higher accumulation rates are offset by the removal of larger volumes of carbon during harvest (Table 3). The incremental increase in biomass carbon stocks is calculated by multiplying the cumulative number of acres treated by 0.3 tons C/ac/yr (Table 3, Column A). Cumulative acres are used because once an area is treated it continues to sequester carbon at a higher rate in subsequent years.

The incremental increase in carbon removed during harvest is calculated by multiplying the number of acres harvested each year by 35% of the carbon in the growing stock volume (i.e., 35% of 47.2 tons C/ac) (Table 3, Column B). This assumes that 35% of the growing stock volume is removed during a harvest (Strong 1997, for intermediate harvest levels). The number of acres harvested is calculated by assuming 3% of the 41,787 acres treated each year are harvested the following year. The carbon removed during harvest is subtracted from the carbon gains in biomass due to sequestration to yield a net change in forest carbon stocks each year (Table 3, Column C). If the calculation stopped here, then this would imply that all carbon removed is essentially emitted to the atmosphere. Therefore, a subsequent step is taken to account for the portion of carbon that remains stored in HWP for a total carbon stock balance.

Standard USFS HWP accounting methods were used to estimate the incremental increase in carbon that remains stored in HWP in definitely. The amount of carbon stored in HWP carbon stocks is time dependent relative to the year of harvest (carbon stocks are high initially and decrease over time), making carbon stock accounting for HWP complex. Therefore, an approach has been developed to standardize and simplify HWP carbon accounting, which applies the amount of carbon still stored in HWP 100-yrs after harvest as the estimated net change in HWP carbon stocks attributable in the year of harvest.

Using the USFS methods, a coefficient of 10.06 tons C/acre was calculated for the amount of carbon that remains stored in HWP 100-yrs after harvest of the increased growing stock volume due to higher productivity (see Table A5 and Appendix below for calculation details). For this analysis it is assumed that 35% of the growing stock volume is harvested, which would lower the actual amount of additional carbon stored to 3.5 tons C/acre (35% of 10.06 tons C/ac). The net annual carbon stock increase in HWP attributable to increased productivity was calculated by multiplying the number of acres harvested annually (3% of 41,787 acres) by 3.5 tons C/acre (Table 3, Column D). For standardization across all policy options, units are converted to million metric tons carbon dioxide equivalent (MMtCO2e) in Table 4.

Table 3. Summary of Calculated Net Changes in Forest and HWP Carbon Stocks (in units of tons C)

			Column A	**Column B**	**Column C (A minus B)**	**Column D**	**Column E (C plus D)**
Year	Acres/yr	Cumulative Acres	Increased C Stocks in Forest Biomass (tons C)	Increased C Stocks Removed at Harvest (tons C)	Net Change in Forest Carbon Stocks (tons C)	Net Increase in HWP C Stocks (tons C)	Combined Carbon Change of F-3 and F-4 (tons C)
2008	41,787	41,787	13,873	0	13,873	0	13,873
2009	41,787	83,574	27,747	20,709	7,037	4,413	11,451
2010	41,787	125,361	41,620	20,709	20,911	4,413	25,324
2011	41,787	167,148	55,493	20,709	34,784	4,413	39,197
2012	41,787	208,935	69,367	20,709	48,657	4,413	53,070
2013	41,787	250,723	83,240	20,709	62,531	4,413	66,944
2014	41,787	292,510	97,113	20,709	76,404	4,413	80,817
2015	41,787	334,297	110,987	20,709	90,277	4,413	94,690

2016	41,787	376,084	124,860	20,709	104,151	4,413	108,564
2017	41,787	417,871	138,733	20,709	118,024	4,413	122,437
2018	41,787	459,658	152,606	20,709	131,897	4,413	136,310
2019	41,787	501,445	166,480	20,709	145,771	4,413	150,184
2020	41,787	543,232	180,353	20,709	159,644	4,413	164,057
Total	543,232		1,262,472	248,510	1,013,961	52,957	1,066,918

Table 4. Summary Table: Results in Million Metric Tons Carbon Dioxide Equivalent (MMtCO2e)

	Net Change in Forest Carbon Stocks (MMtCO2e)	Net Increase in HWP C Stocks (MMtCO2e)	Combined Carbon Change of F-3 and F-4 (MMtCO2e)
2008	0.05	0.00	0.05
2009	0.03	0.02	0.04
2010	0.08	0.02	0.09
2011	0.13	0.02	0.14
2012	0.18	0.02	0.19
2013	0.23	0.02	0.25
2014	0.28	0.02	0.30
2015	0.33	0.02	0.35
2016	0.38	0.02	0.40
2017	0.43	0.02	0.45
2018	0.48	0.02	0.50
2019	0.53	0.02	0.55
2020	0.59	0.02	0.60
Total	3.72	0.19	3.91

The results suggest potential net carbon stock increases in forest biomass of 0.18 MMtCO2e in 2012, increasing to 0.59 MMtCO2e in 2020 as more acres are treated, with a cumulative gain in forest biomass carbon stocks of 3.72 MMtCO2e from 2008-2020. In addition, the analysis suggests a net carbon stock increase in HWP of 0.02 MMtCO2e each year, for a cumulative gain of 0.19 MMtCO2e from 2008-2020.

Costs Analysis

TBD

Appendix: Calculations of HWP assumptions

Two key HWP coefficients were calculated using standard USFS methods:

- incremental increase in carbon in the growing stock volume of forests treated to improve productivity (47.2 tons C/ac, see Table A2)
- of this, the amount of that carbon that remains stored in products in use and landfills 100-years after harvests (10.1 tons C/ac, see Table A5)

The USFS methodology uses growing stock volume in metric units as a starting point. The incremental increase in growing stock volume of high productivity stands was used as a starting point for this analysis: 4,086 cubic feet per acre converts to 281 cubic meters per hectare (m3/ha). Thus, all factors calculated below represent increases above baseline productivity levels.

A series of default coefficients for the PNW W region were applied to the 281 m3/ha to apportion the fraction of growing stock volume into classes of softwoods and hardwoods (Table A1). The specific gravity of hardwoods and softwoods are combined with the carbon content in biomass to calculate separate per-area carbon volumes for hardwood and softwood classes (Table A2).

Table A1. Softwood and Hardwood fractions in Douglas fir PNW W growing stock (US GTR NE-343 Table 4)

	Factor
Incremental increase in growing stock volume (m3/ha) (i.e., 4,086 cuft/ac converted to metric units)	281
Fraction of growing stock volume that is softwood	0.959
Fraction of softwood growing stock volume that is sawtimber-size	0.914
Fraction of hardwood growing stock volume that is sawtimber-size	0.415
Specific gravity of softwoods	0.44
Specific gravity of hardwoods	0.426
Carbon content in biomass	0.5

Table A2. Calculated Carbon Content of Softwood and Hardwoods Harvested from Douglas fir Forests in the PNW W

	Tons C/ha
Softwood saw log carbon in growing-stock volume	54.21
Softwood pulpwood carbon in growing-stock volume	59.31
Hardwood saw log carbon in growing-stock volume	1.02
Hardwood pulpwood carbon in growing-stock volume	1.44
Total (tC/ha)	115.97
Total (tons C/ac)	47.20

The quantity of carbon in hardwoods and softwoods that is processed into primary wood products was calculated next (factoring out carbon in logging residue, fuelwood, and waste), using the ratios in Table A3 for the Pacific Coast region of the US. The results are approximate per-area carbon stocks (tons carbon per hectare) in industrial roundwood, excluding bark and fuelwood (Table A4).

Table A3. Ratios of Industrial Roundwood produced from Hardwood and Softwood classes in the Pacific Coas Region of the US (USFS GTR NE-343 Table 5)

	Ratio of industrial RW to growing stock volume removed as RW	Ratio of carbon in bark to carbon in wood	Fraction of growing stock volume removed as roundwood	Ratio of fuelwood to growing stock volume removed as RW
Softwood Saw log	0.965	0.181	0.929	0.096
Softwood Pulpwood	1.099	0.185	0.929	0.096

Hardwood Saw log	0.721	0.197	0.947	0.957
Hardwood Pulpwood	0.324	0.219	0.947	0.957

Table A4. Calculated Carbon Content of Harvested Wood that Produces Industrial Roundwood

	(tons C/ha)
Softwood saw log carbon in industrial roundwood	48.60
Softwood pulpwood carbon in industrial roundwood	60.55
Hardwood saw log carbon in industrial roundwood	0.70
Hardwood pulpwood carbon in industrial roundwood	0.44

The average disposition pattern of HWP over time in the PNW W is provided by the USFS methodology. The disposition pattern tracks the flow of softwood and hardwood classes of industrial roundwood through four "pools" over time: carbon in HWP in use, carbon in HWP in landfills, carbon in HWP emitted with energy capture, and carbon in HWP emitted without energy capture. Disposition patterns are provided separately for softwood and hardwood categories and are represented by the fraction of carbon remaining in each pool over time.

Table A5 shows the fraction remaining 100-years after harvest for the PNW W by softwood and hardwood classes. These fractions were multiplied by the corresponding initial carbon contents shows in Table A4 to yield the carbon content remaining 100-yrs post harvest in each pool. The net carbon stock change in HWP is calculated as the total amount of carbon remaining in HWP in use or landfills after 100-yrs.

Table A5. Fraction of Carbon in HWP Pools 100-yrs Post Harvest (USFS GTR NE-343 Table 6) and Corresponding Calculated Per-area Carbon Stock.

	Disposition Factor for 100-yrs	**Carbon Stock (tons C/ha)**
Softwoods-Sawlog		
in use	0.13	6.32
landfill	0.279	13.56
energy	0.242	11.76
emitted w/o energy	0.349	16.96
Softwoods-Pulpwood		
in use	0	0.00
landfill	0.076	4.60
energy	0.569	34.45
emitted w/o energy	0.355	21.50
Hardwoods-All		
in use	0.03	0.03
landfill	0.177	0.20
energy	0.448	0.51
emitted w/o energy	0.345	0.39
Total stored C 100 yrs post harvest (tons C/ha)		24.71
Total stored C 100 yrs post harvest (tons C/ac)		10.06

- **Key Assumptions:**

Contribution to Other Goals

- **Contribution to Long-term GHG Emission Goals (2035/2050):**
- **Job Creation:**
- **Reduced Fuel Import Expenditures:**

Key Uncertainties

[Insert text here]

Additional Benefits and Costs

TBD

Feasibility Issues

TBD

Status of Group Approval

TBD

Level of Group Support

TBD

Barriers to Consensus

TBD

F-4. Enhanced Carbon Sequestration in Harvested Wood Products

Mitigation Option Description

This policy is focused on recognizing and improving the climate benefits of managing forests for wood production. Washington State is uniquely positioned to take advantage of the climate benefits of wood production- the native Douglas-fir forests have high productivity rates and extremely desirable structural characteristics for long-lived wood products. Washington State is in strategic location to provide efficient sources of raw materials and has the infrastructure to manufacture these materials into products. The long-term carbon storage contribution of Washington State's wood product production is roughly 11.7 million metric tons CO2e/yr, which offsets more than 10 percent of Washington's greenhouse gas emissions. Climate improvements can be made by incentives for increasing stand productivity to increase the amount of wood products that can be produced while maintaining carbon storage in the forest.

Mitigation Option Design

- **Goals:** To increase the production of durable wood products from Washington forests by 10% by 2050.
- **[Replace w/ the following Goal:** Implement forest management to improve productivity on 50% of available forest acres by 2020. (Text added/suggested by CCS, identical to an F-3 goal)]
- Timing: See goals above. The demand for wood products should increase as the climate benefits of using a product with low embodied energy (in many cases a negative carbon footprint) is realized. See F-5 for more information on the expanded use of wood product for building materials.
- **Coverage of parties:** Washington State Department of Natural Resources, University of Washington (Rural Technology Initiative), Washington State University (RTI, WSU Forestry Extension Program), USDA Forest Service, forest landowners (non-industrial, industrial, state, tribal, and federal), wood product manufacturing facilities.
- **Other:** The long-term carbon storage contribution of Washington State's wood product production is roughly 11.7 million metric tons CO_2e/yr, which offsets more than 10 percent of Washington's greenhouse gas emissions. This does not include the avoided emissions of using wood products instead of more energy intensive substitute materials.

Implementation Mechanisms:

- Full carbon accounting: all forestry carbon assessments should include wood product carbon storage as a mandatory pool along with above and below-ground biomass, litter, and soil carbon. It is an extension of the live tree carbon pool, just as litter and soil carbon is built upon the transfer of carbon from a formerly live tree. Without recognizing wood product storage as a carbon pool, an incomplete picture of the carbon cycle is given. Harvested wood product carbon storage can be calculated following guidelines published by the US Forest Service (Forestry Appendix, 1605b technical guidelines). Briefly, the guidelines lay out methodology starting from either a land-base (particular species and location) or a wood product. These methods use U.S. statistics to calculate a decay rate based on the proportion of a harvested log that goes into various forest and wood products, the half-life of different types of housing and other wood product end-uses, and the distribution of different kinds of wood products across these end-use categories. The portion of product (or log if starting from the forest) that remains "in-use" after 100 years can be considered long-term carbon storage, as described in the "100-Year Method" (Miner 2006).

- Incentives for increasing productivity on Washington timberlands. These can include:
  - Increasing technical assistance for small family forest landowners, including funding for writing forest management plans. Currently about 10% of the 96,000 small family forest owners have a written management plan. The Department of Natural Resources Small Forest Landowner Office (SFLO) houses the Forest Stewardship Program, which is uniquely suited to assist landowners in the development of Forest Stewardship plans. Currently the need for assistance, e.g. field foresters who can assist landowners in developing Stewardship plans, far exceeds the existing staffing capacity. Sufficient funds should be directed to the SFLO so that proper staffing is available to meet the planning needs of small family forest landowners. Technology assistance can also be achieved through re-funding the Rural Technology Initiative at the University of Washington. This program helps rural forest resource-based communities and landowners manage their forestlands using updated technology. The federal grant has recently run out, but the state could re-fund this program to continue the development of a mechanism that allows the transfer of technology to small family forest landowners.
  - Encouraging smart application of silvicultural treatments such as planting genetically improved seedlings, fertilization, thinning, and pruning. Management techniques can improve stand productivity for west-side Douglas fir forests by 30% (see yield tables B22 and B23 of the forestry appendix to DOE's 1605b technical guidelines for comparison). This increase in productivity could increase the amount of timber available for harvest without reducing the carbon storage on the landscape. Incentives for active forest management can be achieved by including forest management in a voluntary carbon offset program in addition to conservation forestry, afforestation/reforestation, and avoided deforestation.
- Incentives for increasing recovery rates at mills. This would result in more carbon storage in long-term wood products with the same input of raw material. The wood products that result from improvements in recovery rates should be considered additional carbon storage.

Related Policies/Programs in Place

- Forest Stewardship Program, run by the Department of Natural Resources Small Forest Landowner Office, offers advice and assistance to landowners with over 5 acres to help improve forests for timber production, forest health, wildlife and fish habitat, special forest products, water quality, aesthetics and fire safety. In addition to free on-site forest management advice from a Stewardship Forester, the program offers Forest Stewardship Planning Courses, cost-share programs to help with forest stewardship projects, and other educational programs and materials in cooperation with Washington State University Extension. See http://dnr.wa.gov/base/education.html#stewardship for more information.

- The Forest Stewardship Coached Planning short course is one of the planning courses offered by the Forest Stewardship Program. A recent report noted that 96% of King County small landowner participants had a better understanding of forest management options, 72% implemented a forestry practice they would not have done otherwise, and 63% completed a written plan as a result of the course (see http://king.wsu.edu/forestry/documents/ForestStewardshipImpacts.pdf for full report).
- The Rural Technology Initiative at the University of Washington was established in 2000 by a federal grant to accelerate the implementation of new technologies in rural forest resource-based communities, such as GPS, GIS, and forest growth simulation models.

Types(s) of GHG Reductions

GHG reductions would be in the form of increased long-term storage of carbon in the form of wood products. In addition, GHG reductions would be achieved in the form of avoided emissions for using a wood product that take less energy to manufacture than an alternative material such as concrete or steel. See F-5 for more information on the climate benefits of wood product consumption.

Estimated GHG Savings (in 2020) and Costs per $MtCO_2e$

See F-3 Estimated GHG Savings and Costs per MtCO2e for Forest Management

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

Contribution to Other Goals

- **Contribution to Long-term GHG Emission Goals (2035/2050):**
- **Job Creation:**
- **Reduced Fuel Import Expenditures:**

Key Uncertainties

[Insert text here]

Additional Benefits and Costs

TBD

Feasibility Issues

TBD

Status of Group Approval

TBD

Level of Group Support

TBD

Barriers to Consensus

TBD

F-5. Expanded Use of Wood Products for Building Materials

Mitigation Option Description

This policy seeks to enhance the use of long-lived wood products as a strategy for reducing GHG emissions. Wood products not only store significant amounts of carbon but they are also less energy intensive to manufacture than substitute materials. The climate benefits of using wood products as opposed to substitute materials have been documented in numerous life cycle assessments.

Enhancement of wood product use can be achieved through transparent inclusion of carbon footprint/embodied energy information in green building standards and in consumer literature. Any increase must be done with consideration of practical use of the material and of material costs.

Mitigation Option Design

- **Goals:** To expand the use of wood products for building materials, where appropriate, by 10% over current levels
- **Timing:** Increase usage by 5% by 2010 and 10% by 2020, above current trends
- **Coverage of parties:** Builders, building material suppliers, wood product industries, recycled building material sellers, home improvement stores and consumers. All state agencies should lead through example.
- **Other:** Wood products not only serve as long-term carbon storage but also require much less energy to manufacture than substitute materials such as concrete or steel. This difference in energy use is so significant that one study found a substitution for steel and concrete framing representing 6 to 8 percent of the total house weight resulted in an increase in greenhouse gas emissions of 26 to 31 percent respectively[2]. Other studies have echoed these same results. Eriksson's (2003) compilation of building life cycle assessments (LCAs) concluded that using wood-framed housing in the 1.7 million housing starts in Europe[3] would save 35-50 MMtCO2e, which would be enough to contribute 11-16% of the emissions reduction needed for Europe to meet the Kyoto requirement. Buchanon and Levine (1999) report that a 17% increase in wood usage in the New Zealand building industry could result in a reduction of 484,000 MMtCO2e.

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[2] Taken from the CORRIM study, Perez-Garcia, Bruce Lippke, David Briggs, James Wilson, James Bowyer and Jaime Meil. 2005. The Environmental performance of renewable building materials in the context of residential construction. *Wood and Fiber Science* 37, CORRIM Special Issue: 3-17.

[3] Currently only 5% of new construction in Europe uses wood framing

This reduction is equivalent to a 20% reduction in carbon emissions from the New Zealand building industry and roughly a 1.8% of New Zealand's total GHG emissions. Miner et al (2006) report that, according to the CORRIM work, if 1.5 million housing starts in the U.S. used wood framed houses rather than non-wood building systems, 9.6 MMtCO2e per year would be kept out of the atmosphere. This savings is equivalent to keeping roughly two million cars of the road for one year.

Implementation Mechanisms:

- **Green building standards**: Support green building standards that include embodied energy/carbon footprint/life cycle assessment (LCA) differentiation for building materials[4].The information can be included can through the deployment of material selection LCI tools, such as the ATHENA® EcoCalculator for Assemblies or BREEAM's Green Guide to Building Assemblies. The ATHENA® EcoCalculator compiles greenhouse gas emissions for different material building assemblies (e.g. exterior walls, roofs, windows, floors, interior walls) based on detailed life cycle assessments using the ATHENA® Impact Estimator for Buildings. The ATHENA® Impact Estimator, in turn, uses data from the US Life Cycle Inventory Database and ATHENA®'s own datasets (see http://www.athenasmi.ca/tools/docs/EcoCalculatorFactSheet.pdf for more detail). The EcoCalculator tool is the free generic version of a tool commissioned by the Green Building Initiative (GBI) for use in the Green Globes™ environmental assessment and rating system for commercial buildings. It is used by architect firms and universities and can be used for new construction, retrofits and major renovations in industrial, office or residential designs. BREEAM's Green Guide to Building Assemblies is used in BREEAM's Ecohomes program, which is the United Kingdom's predominant green building standard. Like the EcoCalculator, it uses LCA information to grade material assemblies. Building assemblies that have a high grade are awarded points towards the green building scheme. Note: this implementation mechanisms complements the life cycle emissions implementation mechanism explained in RCI-3.
- **Carbon footprint literature**: Include carbon footprint information/literature on materials in building supply and home improvement stores. This information would show the consumer the total GHG emissions associated with a particular product. Life cycle assessments have already been done on many building materials (e.g. see ATHENA's EcoIndicator calculator) and these results can be included in the literature without having to do extensive LCAs on individual products. Note: this mechanism complements the carbon labeling mechanism explained in the RCI-8 straw proposal; however this method may be less costly than instituting a comprehensive carbon labeling scheme and can be used as an interim program while the rules of carbon labeling are developed.
- **Product life-time**: Provide incentives to increase salvage of reusable building materials. Washington State has a number of used building material stores. The Northwest Building Salvage Network estimates that its four member stores in Seattle and Bellingham divert 1800-3600 tons of reusable building materials from the waste stream each year. Incentives, in the form of tax breaks or grants, should be put in place to encourage more

[4] There are currently a number of green building programs, such as LEED, Architecture 2030, National Association of Home Builders (NAHB) Green Home Building Guidelines, Built Green, Energy Star Homes Northwest and Green Globes.

building salvage material stores and online exchanges and to promote the use of existing stores with architects, builders and do-it-yourself home remodelers.
- **State adopted policies**: the state should adopt policies that require the use of climate friendly materials in the construction and maintenance of all state buildings when those products are feasible and relatively close in price (within 5%) to the alternative.
- **Education/Outreach**: Develop information and education programs to promote product substitution (using wood products wherever feasible) and the benefits gained through carbon sequestration and avoided emissions.

Related Policies/Programs in Place

Green Building Standards
The state has adopted a number of green building standard bills. Executive Order 05-01 directs the adoption of green buildling practices in the construction of new or renovated state buildings (>25,000 ft2) and requires the achievement of LEED silver standards for WA public buildings. The High-Performance Public Buildings bill (Chapter 39.35D RCW) requires all new state-funded facilities over 5,000 ft2 to meet green building standards. Specifically, major office and higher education facilities will be required to achieve LEED Silver certification. However, because the LEED standards do not yet include embodied energy/carbon footprint consideration for material selection, other building materials, such as steel, are more favorable in the LEED point system. These current bills may not achieve the desired results of promoting the use of building materials with low carbon footprints.

The High-Performance Public Buildings bill does prioritize the use of locally extracted and manufactured products in all state building products. This emphasis may encourage the use of wood products produced in Washington State.

Reusable Building Materials
The Northwest Salvage Buildings Network, http://www.nwubm.net, has partnerships with Seattle Public Utilities, The Seattle Fleets and Facilities Department, the Seattle Department of Planning and Development and the Department of Ecology. NBSN's web site has useful information on salvage building product stores and on-line exchanges by city and region, http://www.nwubm.net/links.htm. In September 2007, the Department of Ecology Green Building Group and the City of Seattle Department of Planning and Development published a guide to Salvage and Reuse as part of a series on green home remodeling, http://www.ecy.wa.gov/pubs/0704017.pdf.

Types(s) of GHG Reductions

TBD

Estimated GHG Savings (in 2020) and Costs per $MtCO_2e$

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

Contribution to Other Goals

- **Contribution to Long-term GHG Emission Goals (2035/2050):**
- **Job Creation:**

- **Reduced Fuel Import Expenditures:**

Key Uncertainties

[Insert text here]

Additional Benefits and Costs

TBD

Feasibility Issues

TBD

Status of Group Approval

TBD

Level of Group Support

TBD

Barriers to Consensus

TBD

F-6. Expanded Use of Biomass Feedstocks for Electricity, Heat and Steam Production

Mitigation Option Description

This policy option seeks to expand the combined heat and power production (CHP) at forest product manufacturing facilities, including pulp and paper mills and lumber mills. The expanded use of CHP can reduce greenhouse gas emissions by displacing the use of fossil energy in two ways: using waste heat or steam that is a combustion by-product, and powering CHP with woody biomass. Many forest product manufacturing facilities have the co-generation capability to produce steam for industrial processes and electricity for both on-site use and off-site export to the electrical grid system. Potential exists to more fully use existing capacity, improve the efficiency of existing CHP facilities through the replacement of aged recover furnaces with high pressure systems or combined cycle gasification units, and expand new CHP capacity at forest product facilities. CHP can provide a low cost opportunity for new renewable energy investment and a means to utilize woody biomass harvested from forest fuel reduction treatments. Increased utilization of biomass generated from forest fuel reduction treatments will help to achieve the forest restoration goals identified in policy option F-1 to reduce forest fire risk. Prioritizing the use of local forest residues has the added benefits of reducing transportation related emissions and providing revenue to the local forest economy.

Mitigation Option Design

- **Goals:** Achieve 76 MW of additional CHP production at Washington State forest products facilities (paper and lumber/wood) by 2020, 50% of the identified economic potential. Achieve 152 MW of additional CHP production at Washington State forest products facilities (paper and lumber/wood) by 2035, 100% of the identified economic potential.
- **Timing:**
- 2010: Complete assessment of biomass generation capability for Washington State forest products facilities.
- 2020: Achieve 50% of identified economic potential for CHP capacity at Washington State forest products facilities (paper and lumber/wood).
- 2035: Achieve 100% of CHP technical market potential at Washington State forest products facilities (paper and lumber/wood).
- **Coverage of parties:**
- **Other:**

Implementation Mechanisms:

Incentives to Develop Biomass CHP

- Provide technical assistance in assuring adequate biomass fuel supply to biomass plants such as business and technical assistance in reclaiming urban wood through building demolition and reclaim of waste wood, and utilization of other waste biomass streams for biomass fuel.
- Provide incentives for business in economically depressed counties with biomass availability to use local and regional biomass supplies to develop biomass renewable energy projects. Incentives could be community assistance grants, technical assistance grants, etc.
- Leveraging of attractive financing arrangements, tax benefits such as the existing sales and use tax incentive for machinery and equipment used for biomass cogeneration facilities (RCW 82.08.02565[5] and RCW 82.12.02565[6]), extending the existing sales an tax incentive for renewable energy to include biomass renewable energy (RCW 82.08.02567), and other incentives to promote biomass technologies.
- Recognition of pulp mill recovery boiler power as a renewable biomass energy resource.

Interconnection issues:

- Removing high interconnection cost and regulatory access barriers similar to OR Public Utility Commission ruling under UM 1129.

Permitting and siting

- Supporting state, county and city land use prescreening efforts to support siting.

Related Policies/Programs in Place

TBD

Types(s) of GHG Reductions

TBD

Estimated GHG Savings (in 2020) and Costs per $MtCO_2e$

The quantification for F-6 is based on the quantification methods for ES-7

[5] http://apps.leg.wa.gov/RCW/default.aspx?cite=82.08.02565

[6] http://apps.leg.wa.gov/RCW/default.aspx?Cite=82.12.820

			Reductions	(MMtCO$_2$e)*			
	Policy	Scenario	2012	2020	Cumulative Reductions (2008–2020)	NPV (2008–2020) $ millions	Cost-Effective-ness $/tCO$_2$
F-6	CHP	76 MW by 2020	0.04	0.19	1.7	-$31 (-$59, -$1)*	-$19 (-$35, -$1)*

***Cost range based on maximum and minimum biomass cost estimates. See Table 1. below.**

- **Data Sources:**

CHP market potential

- **Combined Heat and Power in the Pacific Northwest: Market Assessment** This 2004 report provides: 1) A comprehensive review of current CHP capacity in the Pacific Northwest including a database by each state; 2) A review of the economic and technical market potential for additional CHP; 3) A review of barriers and incentives to CHP; and 4) Recommended actions to increase CHP deployment. http://www.chpcenternw.org/NwChpDocs/Chp_Market-Assessment_In_PNW_EEA_08_2004.pdf

Washington State Estimated Economic Potential (using 10-year payback):

- **Total Washington State Economic Potential**

Two estimates of total economic potential for CHP in Washington were provided by a recent report, based on two sets of assumptions on technology costs and performance, including assumptions on stand-by charges and financial incentives (see below). The assumptions for the Accelerated Case more closely reflect the policy design described above, so the quantification was based on the total economic potential of 2,847 MW in 2007.

731 MW (Business as Usual assumptions – current cost and performance specs, $3-4 /kW/month CHP Stand-by charges, no financial incentives)

2,847 MW (Accelerated Case assumptions – 2020 cost and performance specs, no stand-by charges, financial incentives equal to about 15% of capital costs)

- **Washington Forest Product Facilities Economic Potential**

The report estimates the technical potential for both on-site and export CHP production from paper and lumber/wood industries to be 412 MW, 5.3% of the total technical potential for CHP in Washington. Paper and lumber/wood industries were assumed to make up the same relative contribution to the economic potential for CHP **152 MW** (5.3% of the total economic potential 2847 MW).

Source: *Combined Heat and Power in the Pacific Northwest: Market Assessment* (Energy and Environmental Analysis Inc. 2004)

Heat Rate for Biomass

- **Northwest Power Council 5th Power Plan**

- 14,500 Btu/kWh for electricity generation for a wood residue steam-electric system

CHP

- **Quantification Methods :** Starting with an estimate for forest product facilities share of Washington's CHP potential in the Pacific Northwest, as provided in the *Market Assessment* report (Energy and Environmental Analysis Inc. 2004) referenced above, assumptions regarding the penetration of and fuel shares for new CHP systems, and estimates of future capacity of CHP developed under the policy, are generated. Estimates of CHP cost and performance for different kinds of systems are then used to estimate the overall net GHG emissions reduction and net cost of the policy.
- **Key Assumptions:** Key assumptions are the CHP potential in Washington, the analysis is based on a potential of 152 MW (per the *Market Assessment* source above)[7]; this potential grows with commercial and industrial loads; and the potential and can be realized at a rate of 2.5 – 4.9% [2.5% per year through 2012, increasing linearly to reach 4.9% in 2020] of total potential per year to reach the goals outlined in this policy option to achieve 50% of economic potential in forest product facilities by 2020.
- **Biomass Cost:**

Table 1. Delivered biomass cost estimates.

Biomass Type	Delivered Cost ($/dry ton)	Source
Pulpwood	35	D. Vaagen. 2007. Personal Communication
Chipwood	60	D. Vaagen. 2007. Personal Communication
Sawdust	33	D. Vaagen. 2007. Personal Communication
Shavings	24	D. Vaagen. 2007. Personal Communication
Bark	18.5	D. Vaagen. 2007. Personal Communication
Mill Chips	32	McNeil Technologies, Inc. 2003.
Forest biomass	72	McNeil Technologies, Inc. 2003.
National Average	51	Walsh, M. 1999. 2000 Update.
Total Average	40.7	

Source:

- D. Vaagen. 2007. Personal Communication.
- Walsh, M. et al. 1999. Update 2000. Biomass Feedstock Availability in the United States: 1999 State Level Analysis.
- McNeil Technologies, Inc. 2003. Biomass Resource Assessment and Utilization Options for Three Counties in Eastern Oregon. Oregon Department of Energy, Contract number: C03057, December 31, 2003.
  - Estimates are from E. Oregon and given as delivered price per green ton.

Table 1. Technology characteristics of new CHP equipment.

Technology	Capital Cost ($/kW)		Fraction of New CHP capacity	
	2012	2020	2012	2020

[7] An alternate estimate of CHP potential is 1092 MW from a 2004 analysis by the Western Resource Advocates, *A Balanced Energy Plan for the Interior West*. http://www.westernresourceadvocates.org/energy/clenergy.php

Biomass	$896	$845	0%	0%

Source: Energy and Environmental Analysis, Inc for Oak Right National Laboratory (2004) *Combined Heat and Power in the Pacific Northwest: Market Assessment*, based on average costs of 40MW and 260MW gas turbine; biomass assumed to be $250 higher; coal assumed to be equal to gas turbine

- **Avoided costs:** $43.5/MWh Based on analysis from NW Power and Conservation Council.
- **Avoided electricity emissions:** 0.5 metric ton CO_2/MWh, placeholder value (reflecting largely avoidance of natural gas) awaiting further consultation with NW Power and Conservation Council and TWG as analysis proceeds.

Contribution to Other Goals

- **Contribution to Long-term GHG Emission Goals (2035/2050):**
- **Job Creation:**
- **Reduced Fuel Import Expenditures:**

Key Uncertainties

[Insert text here]

Additional Benefits and Costs

TBD

Feasibility Issues

TBD

Status of Group Approval

TBD

Level of Group Support

TBD

Barriers to Consensus

TBD

F-7. Improved Commercialization of Advanced Lignocellulosic Processes

Mitigation Option Description

This policy option seeks to develop and improve the implementation of technology to convert wood biomass to biofuels. Current research has identified underutilized forest biomass as one of the largest potential sources for in-state biofuel feedstocks. Wood biomass can be converted into biofuels and used for transportation or other uses, offsetting the use for fossil fuels. While advanced lignocelluslosic technology for wood biomass conversion to biofuels is believed to be feasible, further research and development are needed for full scale commercialization of these conversion processes. This option, in collaboration with the policy option AW-2, aims to increase the production of biofuels from biomass feedstocks and improve the commercialization of the conversion process. Biorefinery facilities which produce both biofuels and chemicals from wood biomass feedstocks may provide a means of production with the great economic potential. Estimates of biomass supply from logging residues, mill residues, pre-commercial thinning, and forest fuel treatments suggest that 5.6 Mt of dry biomass are potentially available annually in Washington. Biomass harvested from forest fuel treatment thinnings make up the largest fraction of potential biomass with estimates up to 3.7 Mt/yr in Washington. Increasing the utilization of biomass harvested from restoration treatments to reduce forest fire risk, similar to policy option F-6, will help to achieve the goals outlined in policy option F-1. This policy option will aim to promote sustainable forest management strategies which provide wood biomass for biofuels production while maintaining forest productivity, carbon storage, and integrity of forest ecosystems.

Mitigation Option Design

- **Goals:** Increase utilization of waste biomass for biofuels by 3 million dry tons per year for the production of 250 million gallons of biofuels per year by 2020.
- Note: Policy options F-7 and AW-2 will be quantified together incorporating waste biomass from agricultural and wood biomass sources.

Road map to first commercial biorefinery.

- Research and analysis to support construction of 1st Washington State biorefinery.
    - Identify and assess lignocelluloses conversion technologies on Washington State biomass.
    - Perform techno- economic analysis of most promising candidates to assess technical economic feasibility
    - Assess broad environmental impact by means of life-cycle analysis or other encompassing mechanism

Start 2008 – Complete 2011

- Construct demonstration scale biorefinery facility with best technology – 100 tons/day biomass (~ 3 million gallons fuel year)

  Start 2010 – Complete 2012

- Construction commercial scale biorefinery (3500 tons/day biomass) 100 million gallons of fuel/ year

  Start 2012 – Complete 2015

- **Timing**: See goals above
- **Coverage of parties:**
- **Other:** New conversion technology that is optimized for Washington State biomass may need to be developed. The timing for this type of development work would be longer than the horizon presented above.

Implementation Mechanisms:

Analysis work required prior to building the 1st biorefinery can be accomplished with grants to Universities and engineering firms. An industrial partner would need to take the lead on building the demonstration and commercial scale biorefinery. Universities and engineering firms engaged in the assessment would be part of the consortium to build and operate the demonstration unit.

Incentives may be required construct initial biorefineries. Two significant barriers for constructing a commercial facility are concerns about availability and cost of biomass feedstock and the risk of constructing the first facility running on the biomass mix unique to Washington State. Incentives that could overcome these barriers include the following:

- Support for research and development of biorefinery technologies – especially as it pertains to use of Washington State biomass feedstock.
- Incentive grants for construction of initial biorefineries
- Tax break for biorefinery operations
- Long term contracts with the state and federal government guaranteeing supply of biomass.
- Support of biomass cost that recognizes environmental benefit of using biomass for fuel.
- Subsidy of transportation fuel produced from biomass. Federal government is considering $1.06/gallon subsidy of ethanol produced from lignincellulosics.

Related Policies/Programs in Place

Policies:
http://www.sccd.org/policy/WashingtonBiofuelsIncentives.shtml
http://www.sccd.org/policy/RenewableFuelRequirement.shtml

Types(s) of GHG Reductions

TBD

Estimated GHG Savings (in 2020) and Costs per MtCO$_2$e

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

Contribution to Other Goals

- **Contribution to Long-term GHG Emission Goals (2035/2050):**
- **Job Creation:**
- **Reduced Fuel Import Expenditures:**

Key Uncertainties

[Insert text here]

Additional Benefits and Costs

TBD

Feasibility Issues

TBD

Status of Group Approval

TBD

Level of Group Support

TBD

Barriers to Consensus

TBD

F-8. Urban and Community Forests

Mitigation Option Description

Option F-8 seeks to establish and maintain a net increase of urban and community forest in Washington. Tree planting and maintenance in urban and suburban areas has multiple benefits, including reducing greenhouse gas emissions due to energy conservation (primarily reduced demand for cooling in hot weather), offsetting greenhouse gas emissions due to enhanced C sequestration, and reducing urban sprawl by providing desirable living spaces.

Other benefits of urban and community forests (i.e. improving air quality, reducing storm water runoff, improving aesthetics) make it a highly desirable community investment for reasons beyond the benefits to climate change.

Mitigation Option Design

Goals: ***By the year 2020, enable Washington's local governments, utilities and large urban landowners to protect, plant and maintain an <u>additional</u> 3 million trees, and increase the quality of urban forests to***

- conserve energy
- reduce greenhouse gas emissions
- offset green house gases (and tapping emerging carbon markets)
- benefit healthy neighborhoods and business districts, and to
- reduce sprawl

By 2035, protect, plant and maintain 6 million trees, and

By 2050, protect, plant and maintain 12 million trees.

Achieve or exceed prescribed municipal canopy goals for all cities by 2050

Suggested municipal canopy goals:[8]

West of the Cascades
For metropolitan areas east of the Mississippi and in the Pacific Northwest:

Average tree cover counting all zones	40%

[8] http://www.americanforests.org/resources/urbanforests/treedeficit.php

Suburban residential zones	50%
Urban residential zones	25%
Central business districts	15%

East of the Cascades
For metropolitan areas in the Southwest and dry West:

Average tree cover counting all zones	25%
Suburban residential zones	35%
Urban residential zones	18%
Central business districts	9%

- **Timing:** Dependent on funding available and timing of The Carbon Registry timing for development / adoption of urban forest greenhouse gas reporting protocols.

- **Coverage of parties:**

Affected parties, end users--Municipalities and local governments, utilities, large urban/suburban landowners, private business and homeowners.

Implementing parties--DNR, CTED, DOT, local governments.

- **Other:**

Trees of the **urban forest modify climate and conserve building-energy** use in three principle ways:

- Shading—reduces the amount of radiant energy absorbed and stored by built surfaces.
- Transpiration—converts moisture to water vapor and thus cools by using solar energy that would otherwise result in heating of the air.
- Wind speed reduction—reduces the infiltration of outside air into interior spaces and conductive heat loss where thermal conductivity is relatively high (e.g. glass windows)[9]

Urban Forests can reduce atmospheric CO_2 in two ways:

[9] Mcpherson, E.G.; Maco, S.E.; Simpson, J.R.; Peper, P.J.; Xiao, Q.; VanDerZanden, A.M.; Bell, N.; 2002. **Western Washington and Oregon Community Tree Guide: Benefits, Costs and Strategic Planting**. Center for Urban Forest Research, USDA Forest Service, Pacific Southwest Research Station. http://www.fs.fed.us/psw/programs/cufr/products/5/CUFR_164_Western_WA_OR_Tree_Guide.pdf

- Trees directly sequester CO_2 as woody and foliar biomass while they grow, and
- Trees near buildings can reduce the demand for heating and air conditioning, thereby reducing emissions associated with electric power production. [6]

Treed Communities can concentrate consumers and residents:

- Consumers shop longer, more frequently and are willing to pay more for goods/services in well-landscaped business districts
- Well maintained trees maintain the "curb-appeal" of properties
- Treed cities are desirable communities with stronger communities, less crime, cleaner air, less noise, more wildlife and improved aesthetics. [6]

Why Set Tree Canopy Goals?[10]
"Tree cover in urban areas east of the Mississippi has declined by about 30% over the last 20 years while the foot print of the urban areas has increased by 20%. With this decline in tree cover, significant air and water management costs have increased.

Tree cover is directly related to environmental quality. Maintaining a robust enough tree cover to function as green infrastructure reduces the need and expense of building infrastructure to manage air and water resources. Local agencies can use CITYgreen software to calculate the environmental and economic values of the ecosystem services that trees provide. American Forests' intent is to help communities calculate the value of their trees so that city leaders can make better decisions about integrating "green" into their urban infrastructure."

- **Definitions: (place holder)**
    - *Urban Forest:*
    - *Community Forest:*
    - *Exurban Forest:*
- **Community & Urban Forest fragmentation/conversion rates: (place holder)**

Implementation Mechanisms:

[10] http://www.americanforests.org/resources/urbanforests/treedeficit.php

- **Energy Conservation / Emissions Reduction**
  - Incentivize / require local ordinances that plant the right trees in the right place to conserve energy (heating and cooling) in new homes and businesses built after 20XX
  - Incentivize & educate home and business owners to position the right trees in the right place to conserve energy (heating and cooling)
  - Incentivize / require local municipalities to develop and implement forest management plans that include goals and strategies to increasing number of trees to reduce "heat island" effect and reduce heating/cooling costs around public buildings, businesses and homes.
  - Require / encourage urban forest byproducts to manage, minimize or slow rate of CO_2 volatility (feasibility unlikely—may not pencil out)
    - No burning
    - Solid fuels / biofuels?
    - Recycled (mulch?)

- **Carbon Sequestration**
  - Establish statewide inventory and baseline of community and urban forests in WA.
  - Require state to begin using emerging Urban Forest Greenhouse Gas reporting protocols for sectors or projects voluntarily "reporting" to DNR.
  - Establish state goal for increasing number of additional trees in urban and suburban settings – xx million trees by year 20XX.
  - Establish sub-goals for maintenance of existing trees/forests, additionality of protecting trees otherwise slated for removal and preparation of planting sites—esp. removal of invasive species.
  - Enable municipalities, utilities, and large urban landowners to help meet that goal through state "seed grants."
  - Require "reporting" to DNR for eligibility to "seed grants".
  - Position Washington's additional urban trees for carbon offset markets.
  - Establish disincentives ($ civil penalties) for violations of local ordinances or permits requiring tree retention.
  - Consider impact fees and or 4:1 tree mitigation requirements for trees lost in cities and communities from development or other permanent conversion of forested land.
  - Fees above local component go into "seed grant" account.

- **Averting Sprawl – Livable Cities**
  - Transportation Mitigation
    - Establish / require tree-lined streets protocols based on road traffic capacity
    - Establish greenways and urban forest corridors
    - Require "mitigation" for deforestation and traffic impacts

        - Implement within urban growth boundaries. Developers to replace trees either within the UGB or by establishing trees outside the UGB and putting them under a conservation easement.
        - Establish Highway Greenway stem/easement requirements for WSDOT and other road builders.
    - Transfer of Development Rights
        - Prioritize Municipalities utilizing Transfer of Development Rights from working exurban forestland to secure seed grants
    - Require local governments to establish urban forestry (stem and canopy) goals and strategies in their comprehensive plans—as part of larger greenhouse gas reduction plans.
    - Establish Community Forests of Long Term Significance.

Related Policies/Programs in Place

RCW 76.15 – enabling legislation for the state's Community and Urban Forestry Program and Community Forest Council. http://apps.leg.wa.gov/RCW/default.aspx?cite=76.15

Types(s) of GHG Reductions

TBD

Estimated GHG Savings (in 2020) and Costs per $MtCO_2e$

- **Data Sources:**
- Nowak (USDA-FS), State Urban Carbon Summary data (http://www.fs.fed.us/ne/syracuse/Data/State/data_WA.htm)
- Carbon Dioxide Reduction Through Urban Forestry, USFS PSW-GTR-171, McPherson and Sampson, 1999
- McPherson, E.G.; Maco, S.E.; Simpson, J.R.; Peper, P.J.; Xiao, Q.; VanDerZanden, A.M.; Bell, N.; 2002. Western Washington and Oregon Community Tree Guide: Benefits, Costs and Strategic Planting. Center for Urban Forest Research, USDA Forest Service, Pacific Southwest Research Station. http://www.fs.fed.us/psw/programs/cufr/products/5/CUFR_164_Western_WA_OR_Tree_Guide.pdf
- **Quantification Methods:**
- This option seeks to add 3 million trees total by 2020, or 230769 trees/ yr beginning in 2008 and continuing through to 2020 (230772 trees in 2020 to get to 3 million trees even)
- Goals are articulated to 2035 and 2050 but not quantified past 2020
- C sequestration per year per tree is calculated as 0.006 t C per tree per year. This is based on statewide average data reported by Nowak, USDA-FS, and is the result when the total

estimated urban forest C storage (572000 t C/ yr) is divided by the total number of urban trees in WA (93.272 million).

- Offsets from avoided fossil fuel use for heating and cooling are the sum of three different types of savings: avoided emissions from reduced cooling demand, avoided emissions from reduced demand for heating due to wind reduction, and enhanced fossil fuel emissions needed for heat due to wintertime shading. This is based on calculations presented by McPherson et al. in GTR-PSW-171. It is assumed that the trees planted are evenly split among residential settings with pre-1950, 1950-1980, and post-1980 homes.
- For fossil fuel offset calculations, it is assumed that 80% of the new urban trees are planted in the PNW climate region and 20% are planted in the "Northern Tier" region. These climate regions follow those presented by McPherson et al. (GTR-PSW-171). The proportions of 80% and 20% are the relative proportions of WA residents living in each half of the State.
- For fossil fuel reduction calculations, it is assumed that all planted trees are medium-sized evergreens.
- Net cost is found as the difference between cost of planting + maintenance and economic benefit of tree planting, including reduced energy cost, provision of clean water, aesthetic enhancement, etc.
- Cost of planting and maintenance for first three years is assumed to be $125 (midpoint of $50-200, G. McPherson, pers. comm. with H. Packard).
- After the first three years the annual maintenance cost per tree is estimated as $16.30 per tree (McPherson et al. ,Western WA and OR tree planting guide CUFR 164 publication), which is the average public/ private maintenance cost for a medium-sized tree.
- Net cost savings of tree planting is calculated from McPherson et al. ,Western WA and OR tree planting guide CUFR 164. This economic benefit assumes trees are planted on west side in optimal position for shading in a residential yard setting in PNW. Average annual net cost savings of -$40.58 per tree is the average of small, medium, and large trees under public and private management.

Initial Results:

Table 1. C sequestered by urban trees between 2008 and 2020.

	Trees planted this year	Trees planted in previous years	Carbon sequestered (MtC/yr)	Carbon Sequestered (MMtCO2e/yr)
2008	230769		1415.21	0.005189119
2009	230769	230769	2830.43	0.010378238
2010	230769	461538	4245.64	0.015567357
2011	230769	692307	5660.86	0.020756476
2012	230769	923076	7076.07	0.025945595
2013	230769	1153845	8491.29	0.031134715
2014	230769	1384614	9906.50	0.036323834
2015	230769	1615383	11321.71	0.041512953
2016	230769	1846152	12736.93	0.046702072

2017	230769	2076921	14152.14	0.051891191
2018	230769	2307690	15567.36	0.05708031
2019	230769	2538459	16982.57	0.062269429
2020	230772	2769228	18397.80	0.067458616
cumulative totals		3000000		0.472209905

Table 2. Fossil fuel savings per tree per year (from McPherson et al. GTR-171) in Northern Tier and PNW Communities.

Northern Tier	(Eastside Communities)			t CO2 saved per tree per year
Housing vintage	shade-cooling	shade-heating	wind-heating	net effect
pre-1950	0.0122	-0.0227	0.1006	0.0901
1950-1980	0.0079	-0.0141	0.0658	0.0596
post-1980	0.0089	-0.0198	0.0889	0.078
Average	0.0097	-0.0189	0.0851	0.0759
Average (MMtCO2e)				7.59E-08

PNW Tier	(Westside Communities)			t CO2 saved per tree per year
Housing vintage	shade-cooling	shade-heating	wind-heating	net effect
pre-1950	0.0012	-0.0282	0.0786	0.0516
1950-1980	0.0014	-0.0239	0.0646	0.0421
post-1980	0.0031	-0.0213	0.0414	0.0232
Average	0.0019	-0.0245	0.0615	0.0390
Average (MMtCO2e)				3.89667E-08

Table 3. Fossil fuel savings from planting trees in WA.

	Trees planted this year	Trees planted in previous years	annual MMtCO2e saved by planting trees
2008	230769		0.0107
2009	230769	230769	0.0214
2010	230769	461538	0.0321
2011	230769	692307	0.0428
2012	230769	923076	0.0535
2013	230769	1153845	0.0642
2014	230769	1384614	0.0749
2015	230769	1615383	0.0856
2016	230769	1846152	0.0963
2017	230769	2076921	0.1070
2018	230769	2307690	0.1177
2019	230769	2538459	0.1284
2020	230772	2769228	0.1391

cumulative totals	3000000	0.9734

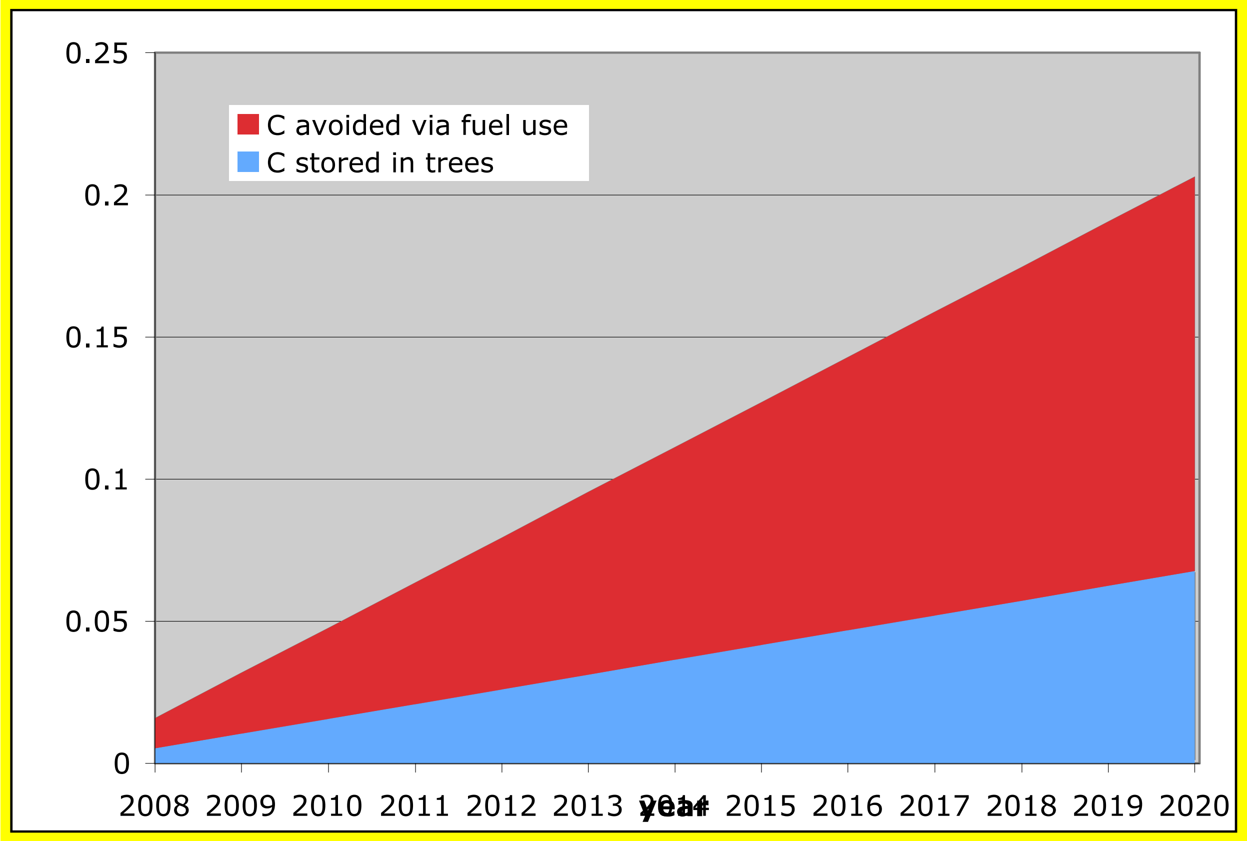

Figure 1. C sequestered in urban trees and C avoided from reduced fossil-fuel emissions due to urban tree planting activities in WA, 2008-2020.

Table 4. Costs of planting and maintenance for urban tree planting efforts in WA, 2008-2020.

	Trees planted this year	Trees planted in previous years	Cost of planting + three years maintenance	Annual maintenance cost after 3 years	Annual cos ($$/yr)
2008	230769		$28,846,125.00		$28,846
2009	230769	230769	$28,846,125.00		$28,846
2010	230769	461538	$28,846,125.00		$28,846
2011	230769	692307	$28,846,125.00	$3,761,534.70	$32,607
2012	230769	923076	$28,846,125.00	$7,523,069.40	$36,369
2013	230769	1153845	$28,846,125.00	$11,284,604.10	$40,130
2014	230769	1384614	$28,846,125.00	$15,046,138.80	$43,892
2015	230769	1615383	$28,846,125.00	$18,807,673.50	$47,653

2016	230769	1846152	$28,846,125.00	$22,569,208.20	$51,415
2017	230769	2076921	$28,846,125.00	$26,330,742.90	$55,176
2018	230769	2307690	$28,846,125.00	$30,092,277.60	$58,938
2019	230769	2538459	$28,846,125.00	$33,853,812.30	$62,699
2020	230772	2769228	$28,846,500.00	$37,615,347.00	$66,461
cumulative totals		3000000	$375,000,000.00	$206,884,408.50	$581,884

Table 5. Net economic costs of tree planting in WA communities, 2008-2020.

	Total $$ benefit	Net benefit (costs minus benefits)	Discounted net benefits
2008	$9,363,836.79	$19,482,288.21	$19,482,288.21
2009	$18,727,673.58	$10,118,451.42	$9,636,620.40
2010	$28,091,510.37	$754,614.63	$684,457.71
2011	$37,455,347.16	-$4,847,687.46	-$4,187,614.69
2012	$46,819,183.95	-$10,449,989.55	-$8,597,232.26
2013	$56,183,020.74	-$16,052,291.64	-$12,577,390.53
2014	$65,546,857.53	-$21,654,593.73	-$16,158,991.25
2015	$74,910,694.32	-$27,256,895.82	-$19,370,966.98
2016	$84,274,531.11	-$32,859,197.91	-$22,240,398.55
2017	$93,638,367.90	-$38,461,500.00	-$24,792,625.83
2018	$103,002,204.69	-$44,063,802.09	-$27,051,352.10
2019	$112,366,041.48	-$49,666,104.18	-$29,038,742.48
2020	$121,730,000.00	-$55,268,153.00	-$30,775,375.62

Net result: Planting trees in WA communities has a net economic benefit of $30.8 million in 2020 and a cumulative cost savings (or Net Present Value) of -$165 million from 2008-2020, for an estimated cost effectiveness of -$114.13 per ton of CO_2e

- **Key Assumptions: see quantification methods above.**

Contribution to Other Goals

- **Contribution to Long-term GHG Emission Goals (2035/2050):**
- **Job Creation:**
- **Reduced Fuel Import Expenditures:**

Key Uncertainties

[Insert text here]

Additional Benefits and Costs

TBD

Feasibility Issues

TBD

Status of Group Approval

TBD

Level of Group Support

TBD

Barriers to Consensus

TBD