REPORT TO STAKEHOLDERS FROM THE AGRICULTURE AND FORESTRY WORKING GROUP

Date: June 21, 2004
To: GHG Stakeholder Advisory Group
From: Agriculture and Forestry Working Group
Re: Recommendations regarding Options to reduce GHG emissions from Agriculture and Forestry

---

This is a report to the SAG on the status of the work completed by the AF Working Group with respect to reviewing and revising the Agriculture and Forestry sectors baseline forecasts and the lists of potential sector greenhouse gas mitigation options, as provided by the SAG to the Working Group after the December 17, 2003 meeting. The following are included:

- A summary of the process and decisions to date of the AF Working Group.
- A summary of the findings from the agriculture and forestry sectors baselines and mitigation results (some pending) regarding the Greenhouse Gas (GHG) savings and costs of mitigation options.
- A summary table of the agriculture and forestry options combined, and a separate summary for agriculture and forestry.
- A summary of attendance at the Working Group meetings.
- The technical Working Group background report, June 18 version, with a complete discussion of all baselines and options.

The AF Working Group's Process and Major Outcomes

The AF Working Group met three times—on January 29, March 19 and May 27, 2004. In addition, a special forest experts meeting was held March 4 to review technical work on the FORCARB inventory and to provide technical guidance on forest management options. At the time of this Working Group's first meeting, an effort was about to begin to investigate revisions to the forest sector baseline forecast (based largely on the USFS FORCARB model with adjuncts such as HARVCARB) to better meet Maine conditions where possible, as a result of SAG review of that baseline in December, 2003 and concerns expressed. No analyses were available for any of the options as to Carbon saved and cost of Carbon saved (CSC). During the first two meetings in January and March, and in between, sector experts reviewed assumptions and data sources relevant to the remodeling effort, including the forest experts meeting March 4. The entire Working Group reviewed the options forwarded by the SAG last December, eliminating some options in both sectors that had little applicability to Maine conditions, consolidating or redefining some options, and, significantly, identifying the need to articulate a more specific set of "forest management" options under that initial generic category of action. Work continued on defining that set of forest management options (for analysis and

Working Group review) after Meeting #2. A set of forest sector options was available with analyses for the first time at Meeting #3. One option defined in sketch form by Working Group members NRCM and The Nature Conservancy was submitted only a few days before the May 27 meeting and could not be analyzed, but is included tentatively in the list of options reported here subject to any further preparation and review.

By Meeting #3, all Agriculture Sector baseline and option analysis work was ready for final review and action; A just-completed revised Forest Sector baseline forecast was ready for review, and; A complete set of Forest Sector mitigation options was ready for review for the first time. The Ag Sector baseline and options package were recommended to the SAG by consensus with minor final revisions. Table 1 here and (and the corresponding table in the complete AF Working Group Technical Document—a separate attachment) provides a summary of how the Ag and Forestry options lists have been revised by the AF Working Group since the initial December 17, 2003 SAG lists.

At AF Working Group Meeting #3 the Forest Sector baseline forecast was also recommended to the SAG by consensus with one specific dissent by NRCM's representative. This dissent concerned doubts about whether Carbon storage in the wood products sub sector is appropriately credited to Maine when wood is grown in another state but later imported (or counted as an emission from Maine when Maine exports). NRCM believes this issue should be addressed in how wood products are accounted for, including the fate of biomass emissions, and included in the industry/manufacturing greenhouse gas accounts. (Import and export effects were included at the request of the Working Group based on the availability of state data (Maine Wood Processor Reports), a desire for consistency across options and emissions sources, and significant l import/export activity in the region. (Biomass can be imported or exported at various stages of its life cycle, including growth, processing, use and waste.)

Finally, two of the forest sector options were reviewed and recommended by consensus to the SAG: AF 5.4 Forest Land Protection and Forest Management Option AF 5.2 c Improved Stocking. There was not time to review the remaining 5 options under consideration, for which analyses were being presented for the first time. These will be reviewed at a technical Working Group meeting to be held in late July, with results directly reported to Maine DEP. Initial analysis of these options is provided in the tables that follow, with the exception of the late submission by NRCM for increased harvest rotation length.

<u>The Agriculture Sector Results Baseline and Options Package</u>

The baseline forecast of carbon flux for the Maine Ag Sector to 2010 and 2020 shows a declining trend—this is the only sector in which this was the case. As a result, the baseline falls over time naturally (due primarily to declines in agricultural land and livestock numbers). Because the Maine Legislative Target is based on 1990 levels, the targets are actually above baseline levels. The final mitigation options package (Table 1) recommended reduces agriculture emissions below targets and below baselines, although the magnitude of reductions is small compared to total state Carbon emissions.

The Forestry Sector Results Baseline and Options Package

The baseline forecast of carbon flux for the Maine Forestry Sector to 2010 and 2020 shows a flat trend—this is the only sector in which this was the case. This is due to two decisions by the Working Group: 1) to calculate average forest emissions and storage over a 20-year period (1982-2002) to smooth anomalous data points in particular years, and reflect a longer-term picture of forest carbon change in Maine; and 2) to assume a linear trend forward to years 2010 and 2020 in lieu of dynamic modeling that would require significant additional resources and time. During the inventory period net forest emissions are slightly positive (a net source), primarily due to land cover change (with net losses of carbon) and declining age of forest stands of all types. This static baseline does not reflect some of the shorter-term changes in this period, particularly those related to forest health.

The baseline has no effect on the overall degree of difficulty in meeting the Maine Legislative Target because it is flat, with equal effects on the overall baseline at the 1990, 2010 and 2020 intervals. The baseline is comprised of several carbon accounts for the forest system (live and dead trees, understory, debris and soils) and wood products (wood products and landfill storage). Emissions associated with energy recapture from biomass (for direct heat or power) are included in the Maine FORCARB inventory (standard procedure) and are significant. Calculations of the net carbon impact of land use change were included and significantly affected baseline results. Import and export effects were included but had a minor effect. The creation of a detailed, comprehensive forest inventory calibrated specifically to Maine allowed the Working Group to develop and review very specific mitigation options and net measurements of carbon impacts in the state -- the primary technical use of the revised baseline.

The final mitigation options package (Table 2) recommended reduces forestry emissions below targets and baselines under two scenarios for analysis as requested by the Working Group: 1) measurement of carbon storage through *2020* for actions taken by 2020; and 2) measurement of carbon storage through *2100* for actions taken by 2020. This longer-term calculation attempts to address full life cycle replacement of biomass removed during the 2005-2020 time period but replaced and or stored far beyond 2020. Long-term storage of carbon is included in levelized annual emissions rates for 2010 and 2020 in table 2 below under both scenarios. The value of carbon storage and replacement *beyond 2020* for actions taken *by 2020* is substantial for some options. When compared to analysis that measures only carbon storage and replacement to the year 2020, full life cycle analysis changes the direction and magnitude of some options. The Working Group did not recommend one time horizon for analysis versus another, and did not discard any options based on differential effects of the time period of analysis.

Combined Agriculture & Forestry Progress Toward Targets

Table 1 provides GHG savings data for agriculture and forestry options with combined Baselines, Maine Legislative Targets, and the GHG savings. Cost figures are not available for forestry options at this time.

Table 1.

MAINE AGRICULTURE & FORESTRY GHG SAVINGS

	KMTCO2e Reduced			
	Avg Annual Reductions 2005-2020 15 yr		**Avg Annual Reductions 2005-2020** 100 yr	
	2010	2020	2010	2020
Agriculture Options				
Maine Biodiesel	5.47	5.48		
Soil Carbon Buildup	15.35	31.02		
Organic Farming#	4.38	8.86		
Nutrient Management	1.80	1.81		
Farmland Protection	15.89	22.71		
Local Grown Produce	34.90	52.09		
Total Agriculture Options GHG Savings	73.43	113.10		
# not added to the total to avoid double counting				
Forestry Options				
Forestland Protection	458.64	458.64	477.02	477.02
Increased Stocking With Fast Growing Trees	172.14	172.14	737.04	737.04
Early Commercial Thin+	-129.39	-129.39	283.39	283.39
More Light Harvests+	-1.66	-1.66	3.31	3.31
Active Softwood Increase+	-7.65	-7.65	20.75	20.75
Increased Harvest Rotation Length+	TBD	TBD	TBD	TBD
Biomass Electricity Feedstocks+#	-139.25	-139.25	474.83	474.83
Expanded Use Of Wood Products+#	137.87	137.87	19.12	19.12
Total Forestry Options GHG Savings	492.09	492.09	1,521.51	1,521.51
+ Option not yet fully discussed				
Agriculture & Forestry Combined				
Maine Agriculture & Forest Baseline	1,030.50	1,001.84	1,030.50	1,001.84
Maine Legislative Targets	1,030.50	901.65	1,030.50	901.65
Net Emissions After Baseline and Progress	464.97	396.64	-564.44	-632.77

Summary Of Agriculture Progress Toward Targets

Table 2 compares GHG savings and cost effectiveness of proposed policy actions.

Table 2.

Maine Agriculture GHG Savings	KMTCO2e Reduced*		$/MTCO2e
	2010	2020	
Maine Biodiesel	5.47	5.48	$40
Soil Carbon Buildup	15.35	31.02	$2-28
Organic Farming (savings included in Soil Carbon Buildup)	4.38	8.86	$2-28
Nutrient Management	1.80	1.81	$0
Farmland Protection	15.89	22.71	TBD
Local Grown Produce	34.90	52.09	TBD
Total Agriculture Options GHG Savings	73.43	113.10	
Maine Agriculture Baseline	313.90	285.24	
Maine Agriculture Targets	313.90	256.71	
Net Emissions After Baseline and Progress	240.47	172.14	

* GHG savings calculated through levelized annual net emissions reduction over 15 years, including savings from 2005 to 2020

Summary Of Forestry Progress Toward Targets

Table 3 compares GHG savings and cost effectiveness of proposed policy actions.

Table 3.

Maine Forestry GHG Savings	**KMTCO2e Reduced**			
	Avg Annual Reductions 2005-2020 15 yr*		**Avg Annual Reductions 2005-2020** 100 yr**	
	2010	2020	2010	2020
Current Consensus Options				
Forestland Protection	458.64	458.64	477.02	477.02
Increased Stocking With Fast Growing Trees	172.14	172.14	737.04	737.04
Still To Be Discussed				
Early Commercial Thin+	-129.39	-129.39	283.39	283.39
***More Light Harvests*+**	-1.66	-1.66	3.31	3.31
Active Softwood Increase+	-7.65	-7.65	20.75	20.75
Increased Harvest Rotation Length+	TBD	TBD	TBD	TBD
Biomass Electricity Feedstocks+	-139.25	-139.25	474.83	474.83
Expanded Use Of Wood Products+	137.87	137.87	19.12	19.12
Total Forestry Options GHG Savings	492.09	492.09	1,521.51	1,521.51
Maine Forest Baseline	716.60	716.60	716.60	716.60
Maine Legislative Targets	716.60	644.94	716.60	644.94
Net Emissions After Baseline and Progress	224.50	224.50	-804.91	-804.91

* GHG savings calculated through levelized annual net emissions reduction over 15 years, including savings from 2005 to 2020
** GHG savings calculated through levelized annual net emissions reduction over 15 years, including savings from 2005 to 2100
+ Option not yet fully discussed

Table 4.

Attendance List Maine AF Working Group

Affiliation	Name	1/29/04	3/19/04	5/27/04
-MEMBERS				
Maine Farm Bureau Association	Jon Olson	X		
International Paper	Chuck Kraske	X	X	X
The Nature Conservancy	Kate Dempsey	X	X	X
Maine Forest Service	Donald Mansius	X	X	X
MOFGA	Russell Libby	X	X	X
Wild Blueberry Commission of Maine	David Bell	X		X
Maine State Legislature	Rep. Raymond Pineau			
Environment Northeast	Dan Sosland	X	X	X
DEP	Kevin McDonald	X		X
Mainewatch Institute	Sherry Huber			X
Lincoln Pulp & Paper	Neil Brackley			
Maine Potato Board	Timothy Hobbs	X		X
Small Woodlots Owners of Maine	Judith Merck	X	X	X
J.D. Irving, Ltd.	Walter Emrich	X	X	X
NRCM	Sue Jones	X		X
Maine Pulp & Paper Association	John Williams	X		X
-Facilitators/Technical Consultants				
Thomas D. Peterson/Penn State	Tom Peterson	X	X	X
Muskie School – USM	Jack Kartez	X	X	X
Muskie School – USM	Hugh Coxe		X	X
-DEP Staff				
DEP	Malcolm Burson	X		
DEP	Mike Karagiannes	X	X	X
-Others (Science Advisors)				
Maine Forest Service	Ken Laustsen	X		
Maine Forest Service	Alec Giffen			
Maine Forest Service	David Struble			
Bowdoin College	Dr. Mark Battle	X		X
University of Maine	Dr. Ivan Fernandez	X	X	X
NRCM	Melissa Carey		X	X
US Forest Service	Dr. Jim Smith	X	X	
US Forest Service	Dr. Linda Heath			
Me Department of Agriculture	Jonathan Chalmers	X	X	
-Guests				
Ind Energy Prod Me, and MeGHG-SAG	Dave Wilby			X

Maine Greenhouse Gas Action Plan Development Process

Agriculture and Forestry Greenhouse Gas Baseline and Reduction Options

Agriculture and Forestry Technical Working Group Meeting

Revised June 18, 2004 Version Of The May 27th Document

CONTENTS

Combined Agriculture & Forestry Baselines, Targets & Progress

Figure 1 below shows combined Baselines, Maine Legislative Targets and Progress from mitigation options under consideration by the Agriculture and Forestry Working Group (hereafter referred to as the "Working Group"). Agriculture and forestry baselines and options will be addressed separately in the report that follows. The cumulative effect of both sectors includes a slightly declining baseline (forecast) of greenhouse gas (GHG) emissions through 2020, and steeply declining emissions relative to the baseline that would potentially result from adoption of options that have been quantified. In forestry two time horizons for analysis were used to address carbon storage that occurs *after 2020* as a consequence of actions taken *by 2020*. Time horizons ending in 2020 and 2100 were used (see later discussion in the Forestry section).

Figure 1.

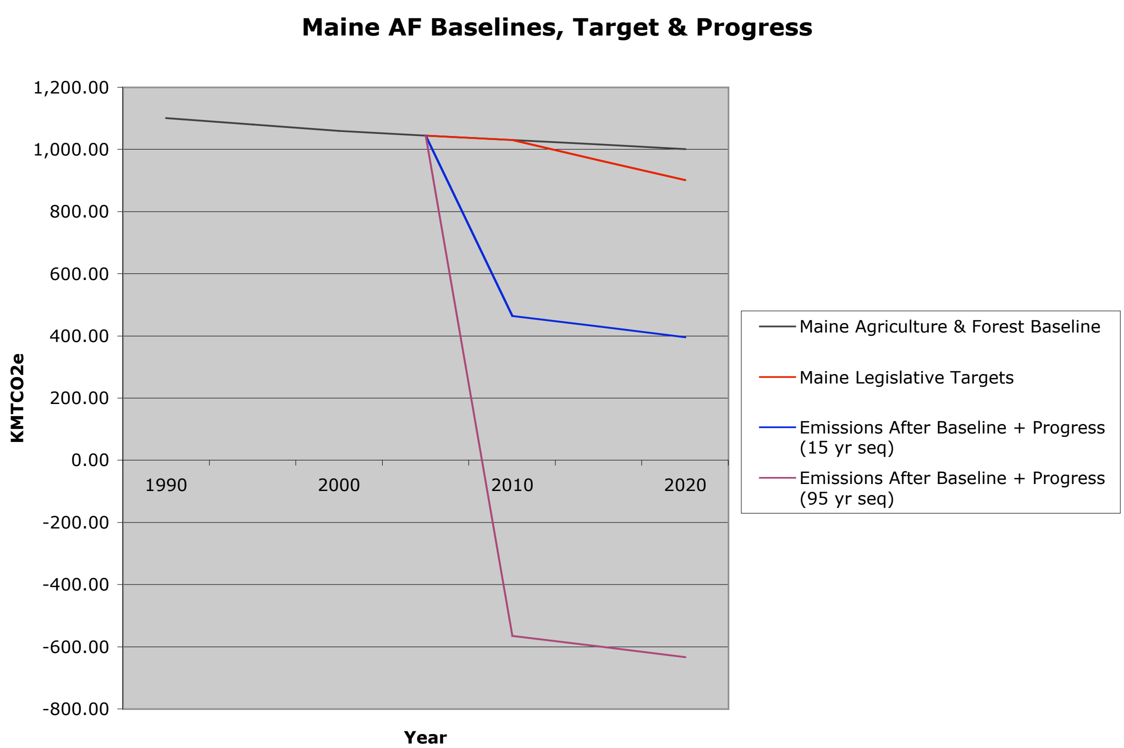


Table 1 below provides GHG savings data for each of the agriculture and forestry options under consideration by the Working Group, with combined Baselines, Maine Legislative Targets, and the combined GHG savings (Progress) for all options. These options are discussed individually in the report. Cost figures are provided separately for agriculture options and are not available for forestry options at this time.

Table 1.

MAINE AGRICULTURE & FORESTRY GHG SAVINGS				
	KMTCO2e Reduced			
	Avg Annual Reductions 2005-2020 15 yr*		Avg Annual Reductions 2005-2020 100 yr**	
	2010	2020	2010	2020
Agriculture Options				
Maine Biodiesel	5.47	5.48		
Soil Carbon Buildup	15.35	31.02		
Organic Farming#	4.38	8.86		
Nutrient Management	1.80	1.81		
Farmland Protection	15.89	22.71		
Local Grown Produce	34.90	52.09		
Total Agriculture Options GHG Savings	73.43	113.10		
Forestry Options				
Forestland Protection	458.64	458.64	477.02	477.02
Increased Stocking With Fast Growing Trees	172.14	172.14	737.04	737.04
Early Commercial Thin+	-129.39	-129.39	283.39	283.39
More Light Harvests+	-1.66	-1.66	3.31	3.31
Active Softwood Increase+	-7.65	-7.65	20.75	20.75
Increased Harvest Rotation Length+	TBD	TBD	TBD	TBD
Biomass Electricity Feedstocks+#	-139.25	-139.25	474.83	474.83
Expanded Use Of Wood Products+#	137.87	137.87	19.12	19.12
Total Forestry Options GHG Savings	492.09	492.09	1,521.51	1,521.51
Agriculture & Forestry Combined				
Maine Agriculture & Forest Baseline	1,030.50	1,001.84	1,030.50	1,001.84
Maine Legislative Targets	1,030.50	901.65	1,030.50	901.65
Net Emissions After Baseline + Progress	464.97	396.64	-564.44	-632.77

* GHG savings calculated through levelized annual net emissions reduction over 15 years, including savings from 2005 to 2020
** GHG savings calculated through levelized annual net emissions reduction over 15 years, including savings from 2005 to 2100
+ Option not yet fully discussed

Option not added to the total to avoid double counting

Agriculture Inventory and Baselines

The following section of this background document contains a summary of updates to the agriculture baselines, including data sources, methods and assumptions, and a series of graphs with related explanation of results.

Land Cover Change

From 1990 to 2000 the acreage of land in farms and forests in Maine changed for a variety of reasons, including conversion to urban development and conversions to and from other land uses (such as forests). Because total acreage and acreage changes affect emissions from agriculture and forestry, an inventory of land cover change was provided to the working group and used in calculations of baselines and calculations for certain options.

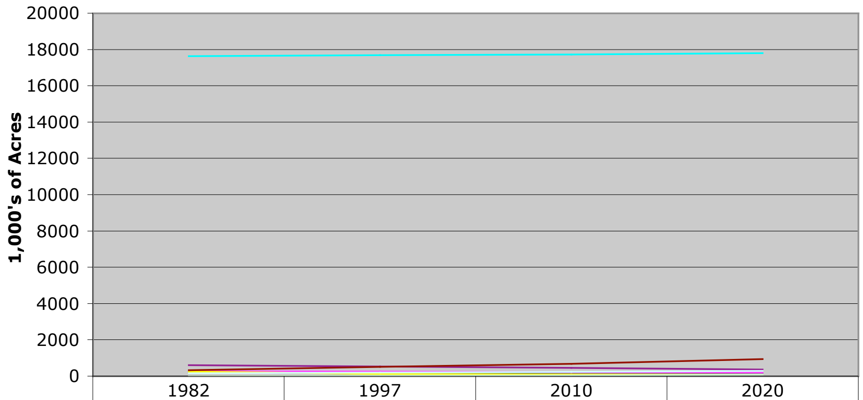
Figure 1 below shows historical and projected land cover change in Maine from the Natural Resource Inventory (NRI) from 1982-2020, using Working Group forecast assumptions. Wetlands are not included as a separate category and are embedded partially in the forest and agriculture categories. A comprehensive inventory of wetlands acreage changes was not available.

A simple linear extrapolation of historical trends in agricultural land from 1997 to 2010 and 2020 would show a complete loss of pasture in Maine and a very step decline of cultivated cropland. These trends were considered unlikely by the working group, and an alternate baseline method was constructed with the following assumptions:

- Conversion of forestland and other natural lands to urban land continues at a historical rate (196,000 acres over 15 years)
- Conversion of pasture to other uses occurs at one percent per year consistent with working group assumptions on livestock animal units (slower than historical rates of 142,000 acres per year that result in total loss of pasture land by 2010)
- Conversion of non cultivated cropland to other uses occurs at the historical rate (30,000 acres per 15 years)
- Conversion of cultivated cropland to other uses drops to zero after reaching a base acreage of 150,000 acres (slower than historical rates of 78,000 acres over 15 years that result in base acreages of 87,400 acres by 2010 and 35,400 acres in 2020)

Figure 2.

Maine Land Cover 1982-2020 (NRI, WG Adjusted)



	1982	1997	2010	2020
Cropland, cultivated	233	155	150	150
Cropland, noncultivated	288	258	232	212
Pastureland	265	123	107	99
Forest Land	17640	17691	17736	17804
Minor Land Cover/uses	610	537	474	376
Urban Land	332	528	697	956
Federal Land (cover/use not recorded)	168	207	241	293
Conservation Reserve Program	0	30	55	95

Years

Agriculture Greenhouse Gas Emissions

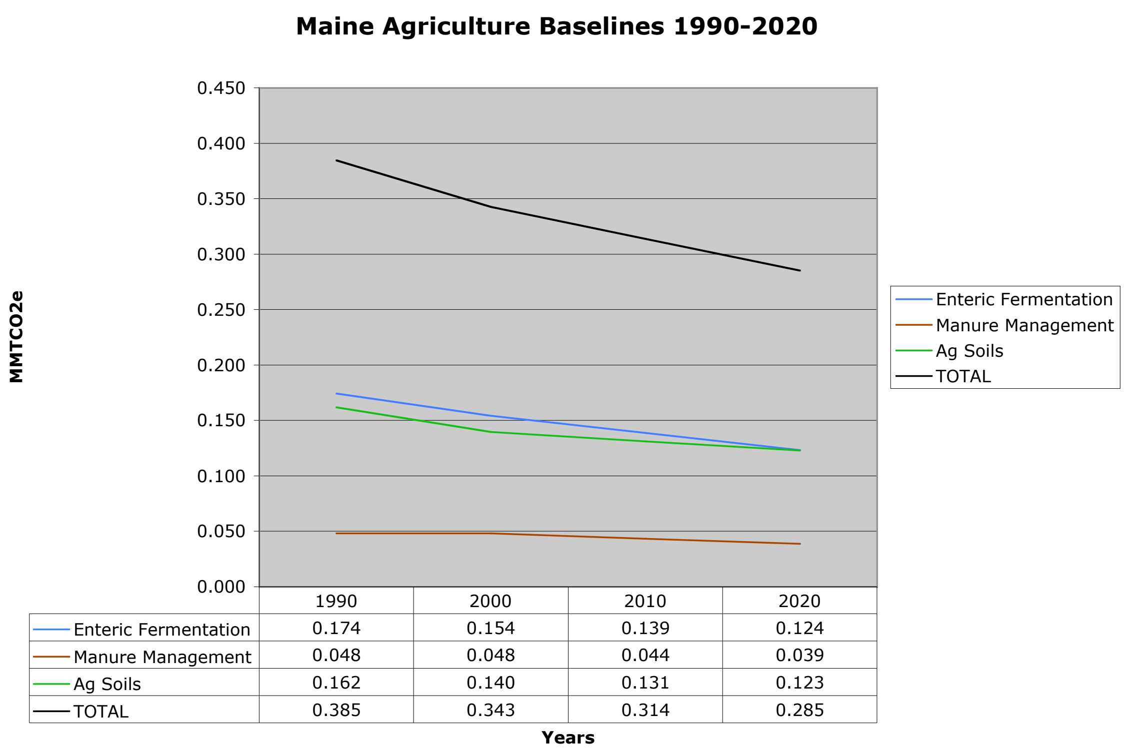
Greenhouse gas emissions from agriculture include carbon dioxide, methane and nitrous oxide. Estimates are based on the flow of emissions from agricultural activities, including livestock and poultry management, fertilizer application, manure management, soil management, and crop residue burning. Under the EPA inventory methodology used in Maine, indirect sources of emissions are not included, such as transportation fuel use for product distribution or energy inputs to fertilizer production.

Figure 3 below shows historical and projected agricultural greenhouse gas emissions for Maine from 1990-2020 using the EPA inventory tool with working group forecast assumptions. This includes carbon dioxide, methane and nitrous oxide. Enteric fermentation, manure management and soil carbon are included, but rice the categories of rice cultivation and agricultural residue burning showed no data for Maine and were excluded. Forecasted emissions from 1997 to 2010 and 2020 were developed using similar assumptions as indicated for NRI land cover data in Figure 1 above, as follows:

- Methane emissions from enteric fermentation declined at one percent per year consistent with working group assumptions on animal units

- Methane and nitrous oxide emissions from manure management (fertilizer management of agricultural soils) declined at one percent per year consistent with working group assumptions on animal units
- Soil carbon losses declined at a rate of 0.6 percent per year consistent with the combined rate of acreage decline for cultivated and non-cultivated cropland, and pasture.

Figure 3.



	1990	2000	2010	2020
Enteric Fermentation	0.174	0.154	0.139	0.124
Manure Management	0.048	0.048	0.044	0.039
Ag Soils	0.162	0.140	0.131	0.123
TOTAL	0.385	0.343	0.314	0.285

Figure 3 uses units of MMTCO2e from the EPA inventory as opposed to units of kMTCO2e used hereafter for agriculture mitigation analysis.

Summary Of Agriculture Progress Toward Targets

Table 2 below compares the GHG savings of each proposed policy action and provides simple cost effectiveness estimates where data was available. These estimates have not been discounted and assume level annual reductions for each policy. They begin in 2005 and continue through 2020. No ramp-up periods are assumed. Other, specific working group assumptions for each of these options are described in individual policy descriptions in the section of the document that follows.

The Maine legislative target does not require sector-based targets. For illustration we have provided a graph in Figure 4 below that summarizes the cumulative effects of all proposed agricultural mitigation policies in Maine.

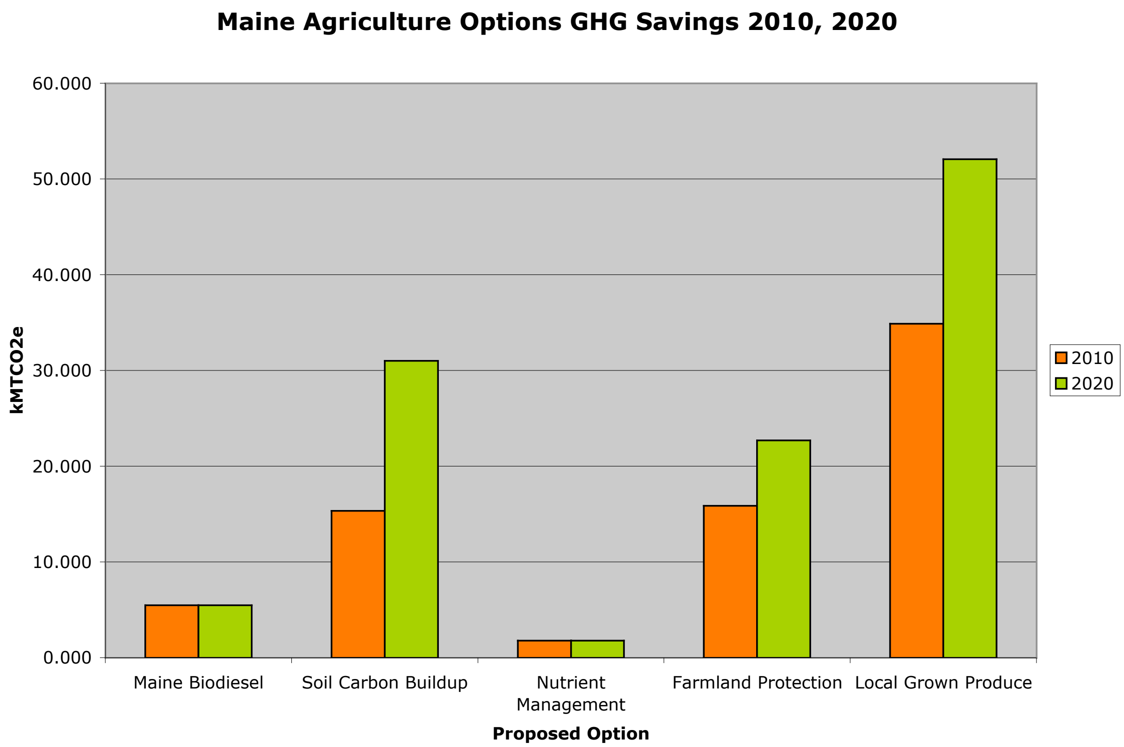
Table 2.

Maine Agriculture GHG Savings	KMTCO2e Reduced*		$/MTCO2e
	2010	2020	
Maine Biodiesel	5.47	5.48	$40
Soil Carbon Buildup	15.35	31.02	$2-28
Organic Farming (savings included in Soil Carbon Buildup)	4.38	8.86	$2-28
Nutrient Management	1.80	1.81	$0
Farmland Protection	15.89	22.71	TBD
Local Grown Produce	34.90	52.09	TBD
Total Agriculture Options GHG Savings	73.43	113.10	
Maine Agriculture Baseline	313.90	285.24	
Maine Agriculture Targets	313.90	256.71	
Net Emissions After Baseline + Progress	240.47	172.14	

* GHG savings calculated through levelized annual net emissions reduction over 15 years, including savings from 2005 to 2020

* Working group assumptions for each of these options are described in the sections on mitigation options that follow.

Figure 4.



Columns in the figure 4 above represent greenhouse gas savings in 2010 and 2020, respectively. The 2020 figures are higher in some cases due to ramp up periods.

Figure 5.

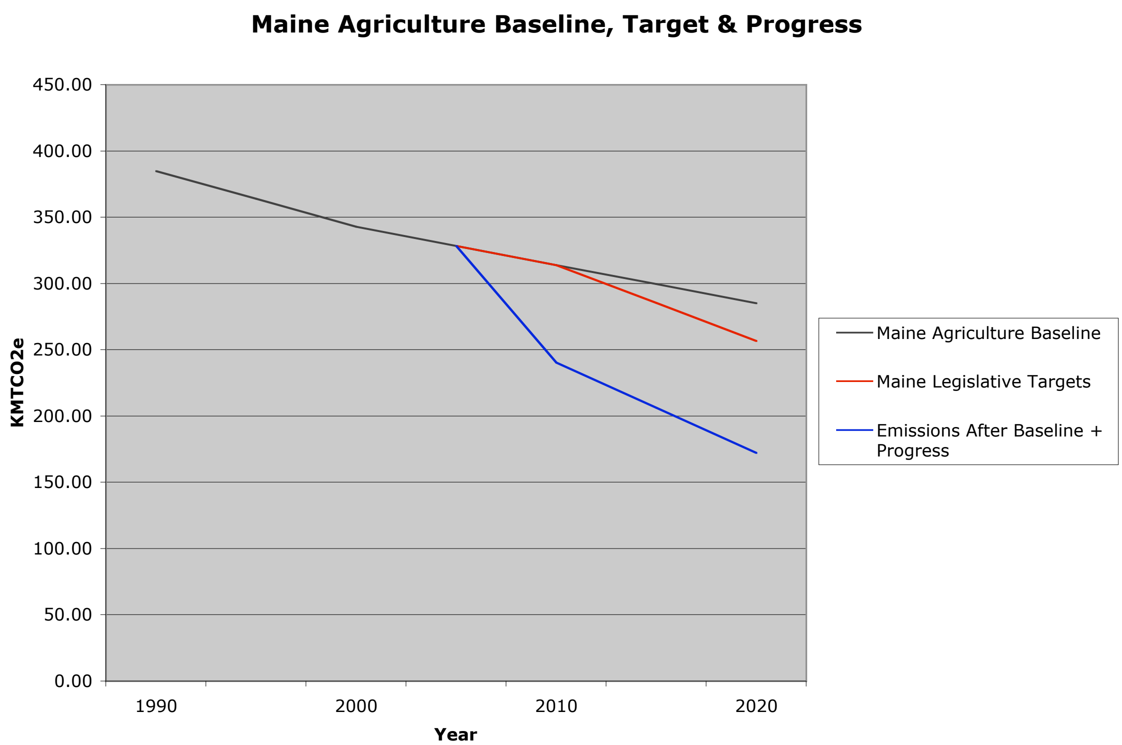


Figure 5 above shows progress against the Maine agriculture baseline and legislative target if it was applied proportionately to the sector. Note that baselines are downward sloping due to declining farm acreage and animal units. Progress exceeds baseline and target levels. The chart above reverses the signs for credits and debits so that emissions are shown as positive numbers, and emissions reductions or carbon storage is shown as a negative number (as depicted in previous stakeholder advisory group presentations of Maine's baseline and targets).

Agriculture Mitigation Options

The following potential mitigation options were developed by the working group from a longer initial list (see past working group documents for the initial list):

- Biodiesel Fuel for Farm Equipment
- Nutrient Management
- Soil Carbon Buildup (Reduced Till, Cover Crops, Organic Farming)
- Agricultural Land Protection
- Support Local Farming/Buy Local

The following sections of this document present information about each of the proposed forestry policy options, including:

- A description of the policy
- A description of some key business as usual policies and programs
- A listing of key data sources, methods and assumptions
- A summary table of estimated greenhouse gas reductions and costs
- A worksheet of calculations
- References and background materials

In developing agriculture options the Working Group noted the importance of ancillary issues that are included in decision criteria for the stakeholder advisory group. Specifically, they felt the following considerations should be made:

- All options should be reviewed for potential impacts to biodiversity and the options adopted should do no harm to biodiversity.
- The planting of exotic species of trees should not be precluded as long as impacts to biodiversity have been considered and shown to have no harm.
- All options should create a net benefit to the atmosphere in the form of reduced land use, reduced sulfur emissions, and/or increased carbon sequestration.
- A meaningful and credible dialogue should be created with decision makers in order to give them a better understanding of the options developed by the Working Group.
- Implementation of the options should be in the context of an adaptive management stance, recognizing and providing for new data and understandings of the systems involved.

Biodiesel Fuel for Farm Equipment

Policy Description: The working group did not develop a detailed policy proposal for this potential action, and instead suggested a general proposal that assumed expanded use of biodiesel in farm equipment and off road diesel vehicles.

BAU Policy/Program: Two pilot programs exist for biodiesel in Maine: 1) the Chewonki Foundation has a small-scale demonstration pilot underway; and 2) a cooperative exists in Hancock County to promote use of biodiesel through existing equipment. Neither program has a significant rate of market penetration at present. L.L. Bean Company recently began testing of B20 in its fleet with purchases of biodiesel from a plant owned by Frontier Energy in South China, Maine. A graduate program at USM is exploring establishment of a biodiesel fund to support fuel needs of campus VIP fleets. The Alternative Fuels Data Center (http://www.afdc.doe.gov/refuel/state_tot.shtml) lists three biodiesel fueling locations in Maine.

Data Sources, Methods and Assumptions:

Table 3 below provides a worksheet calculation of potential GHG savings and costs. This used static linear equations for supply sources. No demand response function was included.

- 4,000 acres of soybeans per year from Maine growers were assumed at a yield of 38 bushels per acre, and 1.4 gallons biodiesel per bushel
- 1,000 acres of rapeseed per year from Maine growers were assumed with a yield of 110 gallons of oil per acre, with a 1:1 conversion to biodiesel
- Full life cycle carbon emissions impacts were assumed at 78 percent of conventional diesel based on data from the National Biodiesel Board
- Biodiesel prices were assumed to include a $1 per gallon price premium over conventional diesel prices (Transport Working Group assumption)
- No ramp up period was assumed
- Nitrous oxide emissions were not considered, but may increase as nitrogen fixing crops are grown (soybeans)
- Cellulosic alcohol was not evaluated, but could be a promising option

Estimated GHG Savings and Costs:

Table 3 below provides a worksheet calculation of potential GHG savings and costs.

Table 3.

Biodiesel Fuel for Farm Equipment	
Acres Soybeans per year	4,000
Bushels Soybeans	152,000

Gallons Biodiesel	108,571
Acres Rapeseed (Canola oil)	1,000
Gallons canola oil	110,000
Gallons Biodiesel per year total	218,571
Annual kMTCO2 Displaced Diesel Emissions	7.024
kMTCO2 With Lifecycle Displacement Adjustment (78%) 2010, 2020	5.479
Incremental costs per gallon	$1.00
Annual Cost per MTCO2e	$39.90

Option Summary-Biodiesel for Farm Equipment	GHG savings 2010 (kMTCO2e)*	GHG savings 2020 (kMTCO2e)*	$/MTCO2e
	5.479	5.479	$39.90

Key Uncertainties:

- Acres of soybeans and rapeseed economically available for biodiesel production in Maine
- Life cycle emissions rates
- Incremental price per gallon in Maine
- Effective incentive systems

References:

L.L. Bean Biodiesel announcement:
http://www.afdc.doe.gov/documents/altfuelnews/7_1states.html

USM Biodiesel Initiative: http://www.megreencampus.com/USMbiodisel.html

National Biodiesel Board: http://www.biodiesel.org/resources/fuelfactsheets/

Nutrient Management

Policy Description: Improve efficiency of fertilizer application by reducing over application resulting from incorrect timing. A portion of nitrogen applied to the soil and not incorporated into plants and soil organic material is emitted as N_2O (a GHG); therefore, a reduction in the quantity of fertilizer applied or measures that improve uptake can reduce N_2O emissions. This can be accomplished by substituting organic fertilizer (primarily manure) for synthetic fertilizer, by altering the timing of applications, by altering cover crops and rotational schemes, or by increasing soil testing to improve efficiency (and reduce unnecessary applications).

The working group formulated a specific proposal for fertilization of Potatoes: Alter nitrogen application by applying 40 pounds initially, then waiting six to eight weeks for second application of 80 pounds as opposed to applying 120 pounds at the outset. This process does not reduce the net amount of fertilizer applied, but increases use in the crop and soil organic layer versus over application in one large dose.

The working group assumes that 50 percent of the current acreage of 65,000 acres uses traditional methods, and that 25 percent of the total acreage could be brought into the new application practice (16,500 acres). The result is a savings of 40 pounds per acre of fertilizer that will be fully incorporated by crops and not applied in excess (660,000 pounds nitrogen saved).

BAU Policy: Maine passed a Nutrient Management Law in 1998 (7 M.R.S.A. Chapter 747, Nutrient Management Act) that prevents winter manure spreading and requires a nutrient management plan. Maine also has an Agriculture Compliance program that requires plans and implementation of certain best management practices in order to quality for certain support payments. The Environmental Quality Incentives Program (EQIP) was reauthorized in the US Farm Security and Rural Investment Act of 2002 (Farm Bill) to provide a voluntary conservation program for farmers and ranchers that promotes agricultural production and environmental quality as compatible national goals. EQIP offers financial and technical help to assist eligible participants install or implement structural and management practices on eligible agricultural land. The Conservation of Private Grazing Land (CPGL) initiative ensures that technical, educational, and related assistance is provided to those who own private grazing lands. The USDA Conservation Security Program provides security payments to farmers in exchange for adoption of environmentally beneficial best management practices. The Agricultural Management Assistance Program provides cost share payments for land and water conservation to 15 states where federal crop insurance levels have been historically low, including Maine.

Data Sources, Methods and Assumptions:

No ramp up period was assumed.

EPA conversion factors were used, as noted below:

EPA Inventory Tool:

Maine Potato growers could potentially reduce losses of 299,371 kg N as synthetic fertilizer during the calendar year 2005.

296,377 kg N x (1 – 0.1) = 265,351 kg unvolatilized N/yr

Convert emissions to N_2O-N using the 0.0125 emission factor, and then to units of N_2O using the molecular weight ratio, 44/28.

296,377 kg N/yr x 0.0125 N_2O-N/N x 44/28 = 5,822 kg N_2O per year

5,822 kg N_2O x 310 Global Warming Potential (GWP) = 1.805 kMTCO2e per year

Estimated GHG Savings and Costs:

Table 4 below provides a worksheet calculation of potential GHG savings and costs.

Table 4.

Nutrient Management	
Acres per year Maine Potatoes under BMP	16500
Pounds N not emitted per acre under BMP	40
Statewide kg N not over applied under BMP	299,371
Statewide kg N not volatized under BMP	296,377
Statewide kg N20 not emitted under BMP	5,822
Statewide kg CO2e not emitted	1,804,724
Statewide kMTCO2e not emitted 2010. 2020	1.805

Option Summary - Nutrient Management – Organic And Synthetic	**GHG savings 2010 (kMTCO2e)***	**GHG savings 2020 (kMTCO2e)***	**$/MTCO2e**
	1.805	1.805	$0

Key Uncertainties:

- Acreage that can be brought into new BMP
- Cost per acre of new BMP

Build Up Of Soil Organic Carbon

Policy Description: Practices that result in less disruption of the soil or increase organic content through carbon deposition can increase the carbon content (stock) of soil or reduce its rate of loss (flow) to the atmosphere. The working group did not identify a specific implementation program for reduced tillage, and instead recommended a general program goal based on 140,000 acres of cropland brought into new management practices, and per acre soil carbon storage rate improvements from1.5 percent to 3.5 percent over a 10 year time period. This includes 100,000 acres of conventional cropland and 40,000 acres of organic farms. In the conventional cropland category, 16,500 acres use cover crops and the remainder use reduced tillage.

BAU Policy/Program: A variety of support programs exist to encourage conservation tillage or no till agriculture. Maine has an Agriculture Compliance program that requires plans and implementation of certain best management practices in order to quality for certain support payments. The Environmental Quality Incentives Program (EQIP) was reauthorized in the US Farm Security and Rural Investment Act of 2002 (Farm Bill) to provide a voluntary conservation program for farmers and ranchers that promotes agricultural production and environmental quality as compatible national goals. EQIP offers financial and technical help to assist eligible participants install or implement structural and management practices on eligible agricultural land. The Conservation of Private Grazing Land (CPGL) initiative ensures that technical, educational, and related assistance is provided to those who own private grazing lands. The USDA Conservation Security Program provides security payments to farmers in exchange for adoption of environmentally beneficial best management practices. The Agricultural Management Assistance Program provides cost share payments for land and water conservation to 15 states where federal crop insurance levels have been historically low, including Maine.

Organic farms do not participate in most subsidy programs that provide production support or conservation payments.

Data Sources, Methods and Assumptions:

- 100,000 acres of conventional cropland
- 40,000 acres of organic farms
- A ramp up period is assumed whereby one third of the total acreage goal is reached by 2010, and 100 percent by 2020
- Ten years of soil management practice are required to fully stock soils with carbon; therefore one all acres put into practice by 2010 have been saturated by 2020 and are not counted in that period

Soil content and improvement statistics were provided by Dr. Ivan Fernadez, as follows:

- Soil carbon content under conventional tillage in Maine = 1.5 percent
- Soil carbon content under conservation tillage in Maine = 3.5 percent

- Cropland averages 2 million pounds of soil in the carbonaceous layer (top six inches)
- Other assumptions are noted in Table 4 below.

Estimated GHG Savings and Costs:

Table 5 below provides a worksheet calculation of potential GHG savings and costs. This used static linear equations for supply sources. No demand response function was included. Calculations are based on data and assumptions provided by Ivan Fernandez of UM except as otherwise noted.

Table 5.

Build Up Of Soil Organic Carbon	
Acres of cropland potential	140,000
Cultivated cropland	100,000
Organic farms	40,000
Potential percent increase in soil organic matter	2.00%
Potential percent increase in organic content	1.75%
Pounds soil per acre	2,000,000
Percent soil organic matter	1.00%
Pounds soil organic matter per acre	20,000
Percent SOM that is Organic Carbon	50.00%
Potential annual rate of SOM increase	2.00%
Pounds OC sequestered per acre per year	200
kMTCO2e sequestered per acre per year	0.000332
kMTCO2e soil carbon buildup 2010 (33% of goal)	15.354
kMTCO2e soil carbon buildup 2020 (100% of goal)	31.107
Cost per acre BMP	?
Cost per MTCO2e BMP - low (ERS)	$2.10
Cost per MTCO2e BMP - high (ERS)	$27.90

Option Summary - Reduced Till	**GHG savings 2010 (kMTCO2e)***	**GHG savings 2020 (kMTCO2e)***	**$/MTCO2e**
	15.354	31.107	$2-28

Key Uncertainties:

- Acreage that can be brought into new BMP
- Type and effectiveness of BMP
- Cost per acre of new BMP
- Retention of soil carbon increases over time

Agricultural Land Protection

Policy Description: Preservation of agricultural land can retain the ability of land to store carbon (particularly through protection of soils and cover crops) and may also reduce transportation emissions by directing growth to more efficient locations. The working group did not formulate a specific implementation proposal and instead suggested a goal of saving ten percent of projected farmland loss by 2010, and 20 percent by 2020. This translated into savings of 950 acres per year over 15 years. A number of potential implementation mechanisms exist, including regulatory and market based land use standards and goals; direct incentive payments (easements and acquisitions); cluster zoning requirements or incentives (also known as conservation design or low impact development); revised transportation infrastructure investments; improvements to farm profitability; and education.

BAU Policy/Program: A variety of programs exist that potentially affect land conversion rates. The Land for Maine's Future Program (LMFP) was developed in 1987 to protect natural and working lands through financing of easements or fee title; 33 percent of funds must be matched. The USDA Farm and Ranchland Protection Program (FRPP) also provides limited cost sharing for land protection. Maine's Farm and Open Space Tax Law was developed in 1975 to provide tax relief to farm and forestland owners. The Maine Tree Growth Tax Law was enacted to provide property tax relief to owners of woodlots and forestlands. The USDA Farm and Ranch Land Protection Program (FRPP) provides matching funds to help purchase development rights to keep productive farm and ranchland in agricultural uses. The USDA Wetlands Reserve Program is a voluntary program offering landowners the opportunity to protect, restore, and enhance wetlands on their property. The Wildlife Habitat Incentives Program (WHIP) is a voluntary program for people who want to develop and improve wildlife habitat primarily on private land. Growth management policies and programs also significantly affect farmland protection, including zoning, property taxation, and infrastructure funding (particularly transportation) as well as private preservation actions by land trust organizations.

Data Sources, Methods and Assumptions:

- The rate of projected farmland loss was developed by using historical land cover conversion rates from the 1997 Natural Resource Inventory (NRI), with a simple linear extrapolation. USDA provided average soil carbon levels for farmland.
- Average housing density figures of one home per acre for new single family homes from the American Housing Survey were replaced by a one home per two-acre suggestion.
- Suggested VMT reduction rates are based on literature reviews (see Transportation Working Group, and see also CCAP White Paper on Transportation and Climate Policy, 2003) that show 2-10 percent VMT reduction for regional smart growth policies. A five percent average was used. Much higher ranges of VMT reductions (above 50 percent) exist for specific VMT reduction

projects within a regional drive shed. Fuel use and conversion figures for gasoline are provided by EIA.

- Soil loss was estimated based on 10,000 square feet of disrupted subsurface area per acre developed, or 0.23 acres.
- Soil loss was assumed to occur in the year of development.

Estimated GHG Savings and Costs:

Table 6 below provides a worksheet calculation of potential GHG savings and costs. This used static linear equations for supply sources. No demand response function was included.

Table 6.

Agricultural Land Protection	
Acres of land cover saved 15 years	47,500
Acres of land cover saved per year - 30% of base	950
Annual new SF homes affected (one home per 2 acres)	475
VMT per household before	22,000
VMT per household after	20,900
Total annual gallons fuel reduction from land conservation	24,302
kMTCO2e avoided from VMT annual	0.216
kMTCO2e from avoided VMT 2010	0.216
kMTCO2e from avoided VMT 2020	0.216
MTC Soil carbon saved/acre (0.23 acres per 2 acre lot)	4.51
kMTCO2e avoided per acre from soil loss annual	0.02
kMTCO2e savings from avoided soil loss 2010	15.674
kMTCO2e savings from avoided soil loss 2020	15.674
Total GHG savings for saved land 2010	15.891
Total GHG savings for saved land 2020	22.705
Total carbon costs per acre saved land	TBD

Option Summary - Agricultural Land Preservation	GHG savings 2010 (kMTCO2e)*	GHG savings 2020 (kMTCO2e)*	$/MTCO2e
	15.891	22.705	TBD

Key Uncertainties:

- Location of saved land relative to existing housing and service areas
- Changes in housing density and location resulting from land savings

- Impact on VMT rates of changes in housing density and proximity
- Degree of soil disturbance per acre from conversion to developed uses
- Soil carbon levels per acre
- Soil carbon emission rates per acre from development

Organic Farming

Policy Description: Organic farming techniques can build up soil carbon levels in farmed acreage. Consistent with the broader policy option to increase soil carbon, the working group did not formulate an implementation mechanism for increased acreage in organic farming, and instead suggested simple acreage goals. About 20,000 acres of farmland in Maine are presently in organic farming out of 155,000 acres of total cultivated cropland. The Maine Organic Farming Association expects this to grow to 30,000 acres by 2010 and then cease to increase. They believe that aggressive public policy could increase this acreage level to 70,000 acres by 2020 (a 40,000 acre increase). Some existing state and federal programs could assist in this effort, including the USDA Resource Conservation and Development (RC&D) program and recently promulgated organic food standards by USDA.

BAU Policy/Program: Federal regulatory standards for organic foods were promulgated starting in 1997, but organic farming otherwise does not participate in federal production or conservation payment systems.

Data Sources, Methods and Assumptions:

- The group recommended analyzing a scenario in which 40,000 acres of cropland was brought into organic farming using conservation tillage and or cover crops at the same effectives as calculated for these programs as they are separately applied to other conventional cropland. Note: this acreage is included in the previous option to build up soil carbon, and not double counted.
- Soil carbon assumptions are the same as those used in analysis of conservation tillage and cover crop options.
- Acreage brought into organic farming by 2010 is not counted in 2020 because soil has saturated carbon levels by then.

Estimated GHG Savings and Costs:

Table 7 below provides a worksheet calculation of potential GHG savings and costs. This used static linear equations for supply sources. No demand response function was included.

Table 7.

Organic Farming	
Acres of cropland converted - potential	40,000
Acres of cropland converted 2010	13,200
Acres of cropland converted 2020	40,000
Potential percent increase in soil organic matter	2.00%
Potential percent increase in organic content	1.75%
Pounds soil per acre	2,000,000
Percent soil organic matter	1.00%
Pounds soil organic matter per acre	20,000
Percent SOM that is Organic Carbon	50.00%
Potential annual rate of SOM increase	2.00%
Pounds OC sequested per acre per year	200
kMTCO2e soil carbon build up per acre per year	0.000332
kMTCO2e soil carbon build up 2010	4.387
kMTCO2e soil carbon build up 2020	8.862
Cost per acre BMP	TBD
Cost per MTCO2e BMP - low (ERS)	$2.10
Cost per MTCO2e BMP - high (ERS)	$27.90

Organic Farming	**GHG savings 2010 (kMTCO2e)***	**GHG savings 2020 (kMTCO2e)***	**$/MTCO2e**
	4.387	8.862	$2-28

* These savings are included in the broader option “Build Up Of Soil Carbon.”

Key Uncertainties:

- Amount of cropland that can be converted to organic farming
- Soil carbon savings of organic farming
- Reduced fuel use from organic farming
- Costs of converting to and practicing organic farming (above cost figures are based on conservation tillage adoption but not other changes in management)

References:

- Maine organic farmers and gardener’s association: http://www.mofga.org/
- Rodale Institute Study: http://www.newfarm.org/depts/NFfield_trials/1003/carbonsequest.shtml

Support Local Farming/Buy Local

Policy Description: Increased purchase of locally grown produce can potentially reduce emissions associated with the transport of agricultural products by ground or airfreight. Modification of haul distances and freight modes (air to ground) can reduce diesel fuel use.

The working group suggested a shift of ten percent above baseline to local grown food by 2010, and 15 percent above baseline by 2020. This goal is based on an Iowa study that evaluated shifting ten percent of produce to local grown sources, and has been adjusted by population factor to Maine.

BAU Policy/Program: The purpose of the USDA Resource Conservation and Development (RC&D) program is to accelerate the conservation, development and utilization of natural resources, improve the general level of economic activity, and to enhance the environment and standard of living in designated RC&D areas. These programs can, potentially, be used to encourage local farming.

Data Sources, Methods and Assumptions:

- All data sources, methods and assumptions are based on the Iowa study cited below, and were scaled to Maine using state population adjustments. The study analyzed the feasibility and effects of shifting transportation distance and mode.
- Only diesel fuel savings from freight transport are included (no air transport savings).

Estimated GHG Savings and Costs:

Table 8 below is based on a study that partially evaluated dynamic effects of shifting production location and transportation demand. It is not a full market simulation.

Table 8.

Support Local Farming/Buy Local	
Gallons of fuel saved per year Iowa/10% policy	8,800,000
Pounds CO2 saved per year	172,480,000
kMTCO2e reduced per year from fuel savings	78.31
Iowa population 2003	2,944,062
Maine population 2003	1,305,728
Population adjusted Maine kMTCO2e savings per year	34.730
Maine kMTCO2e savings per year - 15% state goal	52.094
Maine kMTCO2e savings 2010 (10% goal)	34.903
Maine kMTCO2e savings 2020 (15% goal)	52.094

Costs per MTCO2e TBD

Option Summary - Support Local Farming/Buy Local	GHG savings 2010 (kMTCO2e)*	GHG savings 2020 (kMTCO2e)*	$/MTCO2e
	34.903	52.094	TBD

Key Uncertainties:

- Percent of food categories that can be shifted to locally grown
- Relative mix of food categories compared to Iowa
- Travel distance of food under present (conventional) circumstances
- Cost of growing food locally vs. elsewhere (as determined by market)
- Incentive system required to make producer and consumer shifts viable

References:

- Food, Fuel, and Freeways: An Iowa perspective on how far food travels, fuel usage, and greenhouse gas emissions. Leopold Center for Sustainable Agriculture 209 Curtis Hall Iowa State University Ames, Iowa 50011-1050 Website: http://www.leopold.iastate.edu/

Forestry Inventory and Baselines

The following section of this background memo contains a summary of updates to the FORCARB model, including data sources, methods and assumptions, and a series of graphs with related explanation of results.

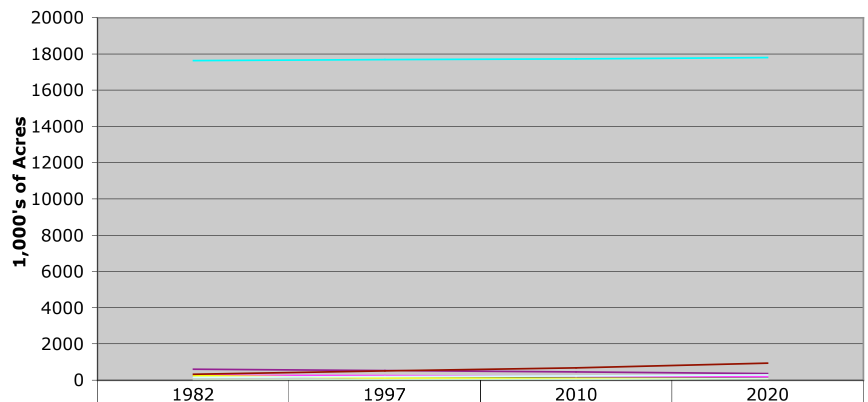
Land Cover Change

From 1990 to 2000 the acreage of land in farms and forests in Maine changed for a variety of reasons, including conversion to urban development and conversions to and from other land uses (such as forests). In the case of forestland, acreage was converted to forest from pasture, cropland and other minor land uses as well the reverse. The largest single source of conversion of forest to nonforest land was urban development, at a rate of 141,600 acres from 1982-1997 estimated by NRI. (The NRI showed a lower rate from 1982-92 compared to the period of 1992-97. This analysis assumes a future rate equal to the average rate over the 1982-97 period. This could be affected by changes in expected population, economic growth, and public policy related to growth management.) Wetlands are not included as a separate category and are embedded partially in the forest and agriculture categories. A comprehensive inventory of wetlands acreage changes is not currently available.

Because total acreage and acreage changes affect emissions from agriculture and forestry, an inventory of land cover change was provided to the working group and used in calculations of baselines and calculations for certain options. Figure 6 below shows historical and projected land cover change in Maine from the Natural Resource Inventory (NRI) from 1982-2020, using Working Group forecast assumptions as noted in earlier discussion of agriculture land cover baselines.

Figure 6.

Maine Land Cover 1982-2020 (NRI, WG Adjusted)



	1982	1997	2010	2020
Cropland, cultivated	233	155	150	150
Cropland, noncultivated	288	258	232	212
Pastureland	265	123	107	99
Forest Land	17640	17691	17736	17804
Minor Land Cover/uses	610	537	474	376
Urban Land	332	528	697	956
Federal Land (cover/use not recorded)	168	207	241	293
Conservation Reserve Program	0	30	55	95

Years

FORCARB2: Maine Forest Carbon Account

The forestry greenhouse gas baseline for Maine was originally based on FORCARB results for Maine first published in 1997 and updated in 2003 by the USFS (second column in Table 9 below). At the request of stakeholders and Maine DEP a new baseline was calculated with several modifications (first column in Table 9) in a joint effort by the USFS, Maine Forest Service, the forest experts group, and the forestry Working Group technical consultant (Tom Peterson). These modifications are noted below and in previous working group documents that were discussed and approved in Working Group meetings.

FORCARB is a national forest carbon model that can be applied at the regional and state level due to the large number of regularly sampled Forest Inventory Assessment (FIA) plots in each state. The model estimates carbon emissions/storage from state forestland by measuring forest carbon stocks (forest ecosystem and soils) in two periods and comparing the difference to create a flow calculation. If net carbon is lost (stocks decline) it is assumed that the lost carbon becomes an emission to the atmosphere unless it is stored in wood products or landfills. If the net change is positive it is assumed that the forest is storing carbon in addition to storage also occurring in wood products and landfills.

According to the US Forest Service (Birdsey and Lewis, 2003) "Ecosystem carbon is divided into biomass, forest floor, and soil. Harvested carbon is treated separately. Biomass includes all aboveground and belowground portions of all live and dead trees and understory vegetation, including the merchantable stem, limbs, tops, cull sections, stump, foliage, bark and rootbark, and coarse roots (larger than 2 mm). The forest floor includes all dead organic matter above the mineral soil horizons except standing dead trees: litter, humus, and other woody debris. The soil component includes all organic carbon in mineral horizons to a depth of 1 m (excluding coarse roots). Harvested carbon includes carbon removed from the forest for wood products and fuelwood. Each of the component pools is related through transfers of carbon."

Wood products and landfill storage and decay are estimated with the HARVCARB model (see appendix 1 for storage rates used in Maine by the USFS). Biomass that does not become wood products or landfill storage is either burned for energy recapture (heat and power) or allowed to burn or decay openly. In both cases these biomass emissions are immediately released to the atmosphere. In the future this emitted biomass may or may not be replaced by new growth in the forest and soils (forest "sustainability" assumptions generally assume full replacement at some point). Biomass burned for energy capture may also displace fossil emissions from other power supply sources (such as natural gas and coal).

The revised version of FORCARB our effort has developed accounts for both imports and exports of wood products. This is possible through new data from the Maine Wood Processor Reports that replace earlier regional default estimates without state level import/export data.

Typically emissions from biomass combustion are counted either in the forestry sector (in FORCARB) or in the power generation sector, but not both in order to avoid double counting. Since biomass emissions are not counted in the ESW Working Group in Maine there is not an overlap. The industry sector counts emissions from wood processing, but not life cycle wood product emissions in Maine. A similar issue exists with waste, and FORCARB is counting these in Maine.

A key decision of the working group in modifying the FORCARB model was use of two time period measurements to establish an annual flow figure. The group was interested in using the longest time period possible to reduce effects of inter-temporal variation. In addition, data collected in 1995 was not regarded as reliable due to collection problems. As a result, carbon stocks measurements were used from 1982 and 2003. The 2003 data was collected on a five year rolling plan and averaged 2001 in vintage, so the time period between the two measures was 20 years.

Because only two time periods were used for comparison (a simple before and after measure) the difference between the two was divided by 20 years to provide a single annual carbon flow number. This approach allows annual emissions reporting consistent with other sectors. However, the simple before and after comparison of long term snapshots for forest carbon results in a static (straight line) annual emissions estimate. The working group also decided to forecast emissions forward to 2010 and 2020 at the long-term historic rate. As a result emissions are flat at a static growth rate for the entire inventory and baseline period.

In the original and forestry baselines emissions outweigh carbon storage, indicating a decline in carbon stocks in the forest system that is not completely offset by storage in wood products and landfills, or additions of new land from nonforest uses. In the revised baseline, this remains true but to a lesser extent due to crediting of carbon retained on lands converted to nonforest uses. The revised inventory is very close to neutral (zero emissions). (The original FORCARB estimate records certain land use change effects, but does not include them in calculations.)

It is important to recognize that multiple processes are in play across several forest carbon accounts, and that the acreage amount of forestland is also very dynamic (e.g. forests enter and leave the system). The interplay between these many factors results in both positive and negative forest emissions. The net effects of these are captured in the inventory *flow* results reported in the revised Maine FORCARB inventory. It also important to note that FORCARB combines stock and flow measurements into a single flow-based accounting system.

Because the forest emissions number is static in the baseline period it has no effect on the overall degree of difficulty in meeting Maine legislative targets. The extent to which the state is able to meet targets beyond baseline is determined by mitigation options that create emissions reductions beyond the level of baseline emissions anticipated. Mitigation option estimates are provided and summarized in later discussion of mitigation options.

Specific data breakdowns are provided in a later series of graphs that show declines in average stand age for all tree species in Maine, substantial variation in per acre and total carbon for different tree species, forest ecosystem sub accounts for live trees vs. forest floor, etc, and land use change.

Table 9 compares the original FORCARB baseline with the revised FORCARB baseline (all units in MMTC). Key revisions in the new baseline include:

- Use of Maine biomass tree equations in lieu of regional equations
- Revised coefficients for forest floor and soils accounts
- Credit for retention of biomass in lieu of an implied loss of 100 percent of forest biomass when land exits the forest inventory
- Use of 1982 as the initial carbon stock period, and 2003 as the only other and final carbon stock period, in lieu of previous measures at 1987 and 1997
- Exclusion of storage and emissions effects of wood exports, and inclusion of wood imports as opposed to inclusion of all wood products produced in state (no exports)

The USFS is working on revisions to its national model that will better address state level boundary, timing and accounting issues. The output of this Maine Working Group is being considered as a meaningful input to these revisions.

Table 9.

Sub Account	New/Revised Version*	Original Version**
Live Trees	Data Sources: Maine Tree Equations provided by USFS/Maine FS for forest types, carbon stock data from Maine FIA samples, land use change rates from Maine FS using FORCARB Methods: Carbon stock changes from FIA-defined forest lands, including partial credit for retention of forest cover on lands converted to non forest uses Key assumptions: Average stand ages and sites (new stands are reflected in FIA data) Outgoing forest land loses 67% of tree carbon and 33% of soil carbon (rough NRI/AHS comparison of developed acres v. land cover change)	Data Sources: FORCARB2 default coefficients based on regional data, no land use change credits (although land use change is reported separately) Methods: No partial credit for outgoing forest lands, single step functions for changes in forest types Key assumptions: Outgoing forest stands lose 100% of forest and soil carbon when land use changes
Understory	Data Sources: FORCARB2 default coefficients for forest types (regional), carbon stock data from Maine FIA samples, land use change rates from Maine FS using FORCARB Methods: Same as above. Key assumptions: Same as above.	Same as above.
FORCARB Results For Live Tree And Understory	-0.796 Before LUC 0.379 With LUC	-1.96 - 1987-92 4.13 - 1992-97
Standing Dead Trees	Same as above.	Same as above.
Coarse Woody Debris	Data Sources: FORCARB2 default coefficients for forest types (regional), carbon stock data from Maine FIA	Same as above.

(Down Dead)	samples, land use change rates from Maine FS using FORCARB Methods: Same as above. Key assumptions: Same as above.	
Forest Floor	Data Sources: FORCARB2 default coefficients for forest types (regional), carbon stock data from Maine FIA samples, land use change rates from Maine FS using FORCARB Methods: Forest floor to live tree ratios were calculated by volume and type with Weibull coefficients from USFS. Key assumptions: Same as above.	Same as above.
FORCARB Results For Standing Dead, CWD, Forest Floor	-0.396 Before LUC 0.187 LUC Credit	-0.57 - 1987-92 -2.01 - 1992-97
Soils	Data Sources: Coefficients from Amichev and Galbraith (in press), forest type acreage from Maine FIA samples, land use change rates from Maine FS using FORCARB Methods: Carbon flow rates applied annually, with separate calculations for base acres, incoming and outgoing acres Key assumptions: Average stand ages and sites No harvest or age effects Outgoing forest land loses 33% of soil carbon (soil disturbance on 33% of land cover acres converted)	Same as above. Key Assumptions: Soil storage equations do not vary by stand age or harvest practices.
FORCARB Results For Soils	-.206 Before LUC -0.71 With LUC	-3.26 - 1982-97 -1.43 - 1992-97
Wood Products	Data Sources: Maine FS product volume and mix data, including imports and	Data Sources: Same as above.

And Landfills	exports from 1990-2000 Methods: Ten year averages calculated with USFS HARVCARB (Skog and Nicholson) regional coefficients applied to Maine product mix, imports are added and exports are subtracted from Maine GHG accounts Key assumptions: Regional product carbon storage rates apply to Maine	above. Methods: No correction for imports/exports Key assumptions: All wood products produced in Maine are consumed in Maine
FORCARB Results For Wood Products And Landfills	0.708	1.51 – 1982-92 1.58 – 1992-1997

* Maine AF Working Group revisions as suggested by the Forest Experts subgroup. See working group summaries available at: http://maineghg.raabassociates.org/grpsfo.asp

** Birdsey and Lewis 2003, Maine forest inventory with Northeast Regional assumptions, available at: http://www.fs.fed.us/ne/global/pubs/books/epa/states/ME.htm

Table 10.

FORCARB sub accounts	Mmtc	Kmtco2e	Kmtco2e	Kmtco2e	Kmtco2e	Kmtco2e	No LUC Credits
	Annual Flux	Annual Flux	1990	2000	2010	2020	2,020
Live Forest	-0.796	-2,913	-2,913	-2,913	-2,913	-2,913	**-2,913**
Live trees	-0.813	-2,974	-2,974	-2,974	-2,974	-2,974	**-2,974**
Understory	0.017	60	60	60	60	60	**60**
Non-live forest	-0.396	-1,451	-1,451	-1,451	-1,451	-1,451	**-1,451**
Standing dead	-0.065	-236	-236	-236	-236	-236	**-236**
Coarse woody debris	0.019	70	70	70	70	70	**70**
Forest floor	-0.351	-1,285	-1,285	-1,285	-1,285	-1,285	**-1,285**
Total Base Acres Live + Dead	-1.193	-4,365	-4,365	-4,365	-4,365	-4,365	**-4,365**
Nonforest Conversion Live 1/3 Credit	0.379	1,386	1,386	1,386	1,386	1,386	**0**
Nonforest Conversion Dead 1/3 Credit	0.187	684	684	684	684	684	**0**
Total Trees Base + Nonforested	**-0.627**	**-2,295**	-2,295	-2,295	-2,295	-2,295	**-4,365**
Soils							
Soil - Base	-0.206	-754	-754	-754	-754	-754	**-754**
Soil Nonforest Conversion (25% loss of 1/3 of land base)	-0.071	-259	-259	-259	-259	-259	**-259**
Total Soils Base + Nonforest Conversion	**-0.277**	**-1,013**	-1,013	-1,013	-1,013	-1,013	**-1,013**
Wood products - Base Volume							
Products in use	0.167	611	611	611	611	611	**611**
Landfills	0.372	1,362	1,362	1,362	1,362	1,362	**1,362**
Burned with energy capture	-1.493	-5,464	-5,464	-5,464	-5,464	-5,464	**-5,464**
Total Base Wood Products Flux	0.539	1,973	1,973	1,973	1,973	1,973	**1,973**
Products in use - import	0.122	447	447	447	447	447	**447**
Landfills - import	0.047	172	172	172	172	172	**172**
Burned with energy capture - import	-0.414	-1,515	-1,515	-1,515	-1,515	-1,515	**-1,515**
Total Imported Wood Products Flux	0.169	619	619	619	619	619	**619**
Total Wood Products Base + Imports	**0.708**	**2,591**	2,591	2,591	2,591	2,591	**2,591**
Maine Forest Carbon Baseline	**-0.196**	**-717**	-717	-717	-717	-717	**-2,786**

*** Emissions (sources) are denoted as negative numbers, and emissions reductions and storage (sinks) as positive numbers to follow an accounting system with consistent debits and credits.**

Table 11.

Total Carbon Stock On Forestland, Including Soil (MMTC)

Type	**1982**	**2003**
White/Red/Jack Pine	98.9	100.7
Spruce/Fir	506.3	381.5
Softwood Plantation	0.0	0.9
Oak/Pine	18.5	25.4
Oak/Hickory	18.5	22.1
Oak/Gum/Cypress	0.8	0.9
Elm/Ash/Cottonwood	32.2	24.9
Maple/Beech/Y. Birch	456.1	554.7
Aspen/W. Birch	135.6	131.7
Nonstocked	2.7	1.5
Total	**1,269.7**	**1,244.4**

Carbon in trees is based on the individual-tree equations for Maine
Soil estimates assume no LUC effect

Table 12.

Maine Forestland Change 1982-2003	**Total Acres**	**Acres/Year**
Nonforested >Aspen/W. Birch	197,331	9,867
Aspen/W. Birch >Nonforested	44,859	2,243
Nonforested >Elm/Ash/Cottonwood	10,485	524
Maple/Beech/Y. B >Nonforested	159,503	7,975
Nonforested >Maple/Beech/Y. B	333,586	16,679
Nonforested >Oak/Pine	40,972	2,049
Oak/Hickory >Nonforested	19,500	975
Nonforested >Spruce/Fir	261,032	13,052
Spruce/Fir >Nonforested	388,554	19,428
Nonforested >White/Red/Jack P	56,731	2,837
White/Red/Jack P >Nonforested	124,631	6,232
Timberland – Non >Nonforested	69,910	3,496
Nonforested >Nonforested	1,226,891	61,345

Figure 7.

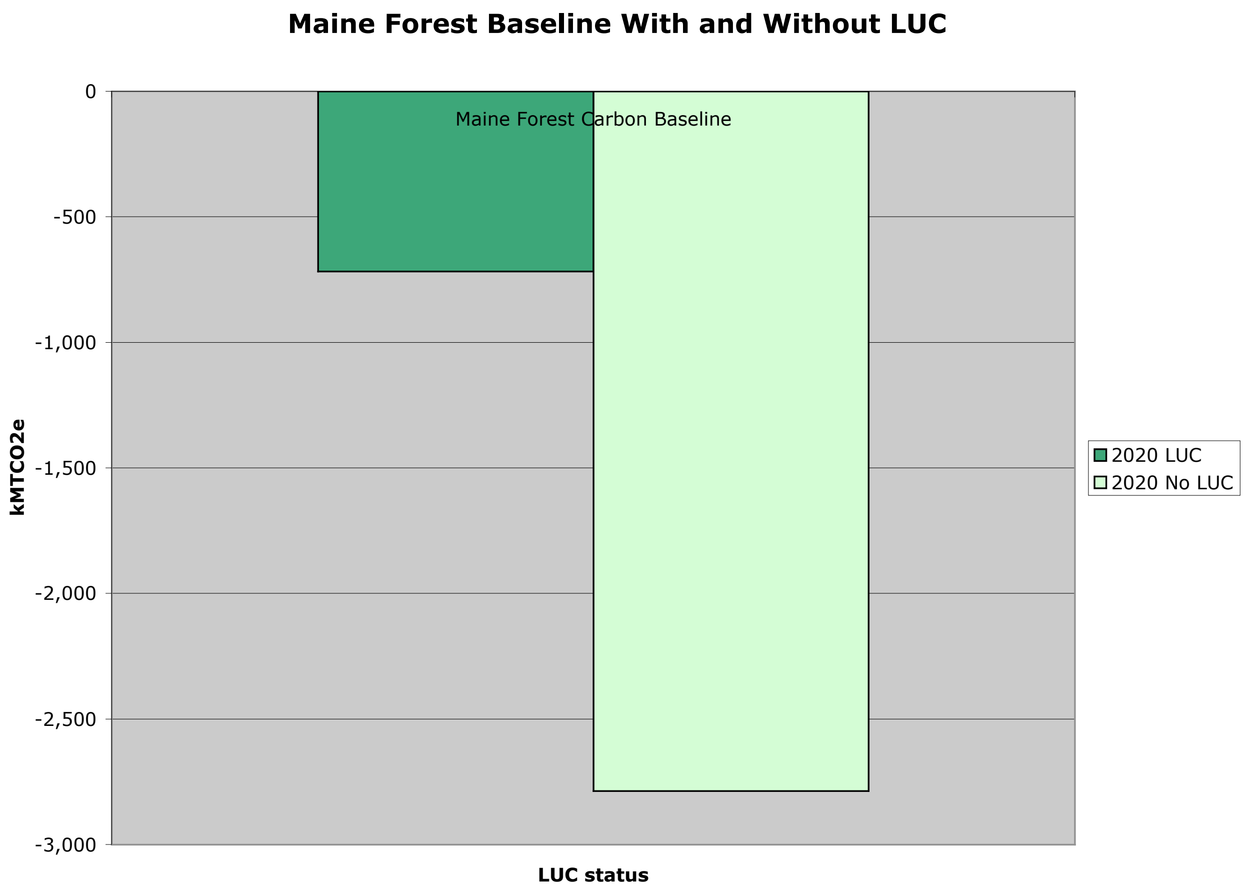


Figure 7 above shows the significant effect of land use change on total forest carbon. Partial credit was given to forest land converted to non forest uses at the rate of 33 percent retention of forest biomass, and 91.75 percent credit for retention of soil carbon on converted lands (100 percent - (25 percent soil loss x 33 percent of site disturbed).

Figure 8.

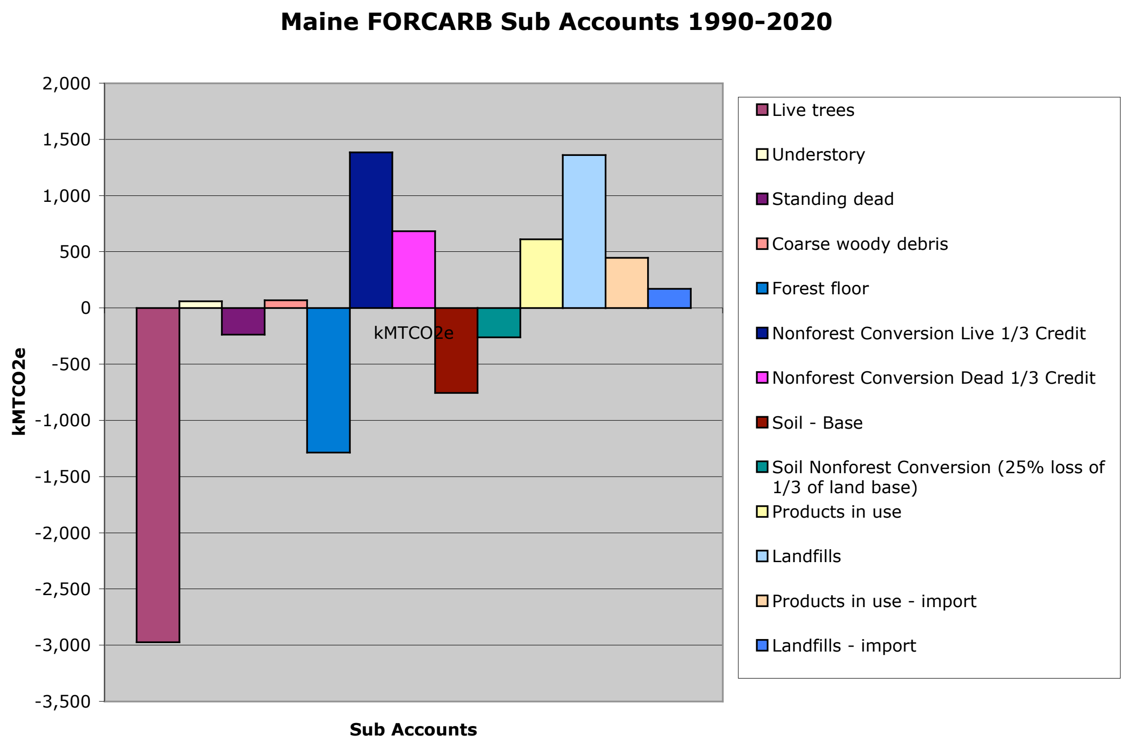


Figure 8 above shows the differential effects of FORCARB sub accounts on overall carbon flow. Each of these accounts is an individual baseline. Their effects are additive, and net to a source of carbon emissions in Maine. Note the significant effect of land use credits.

Figure 9.

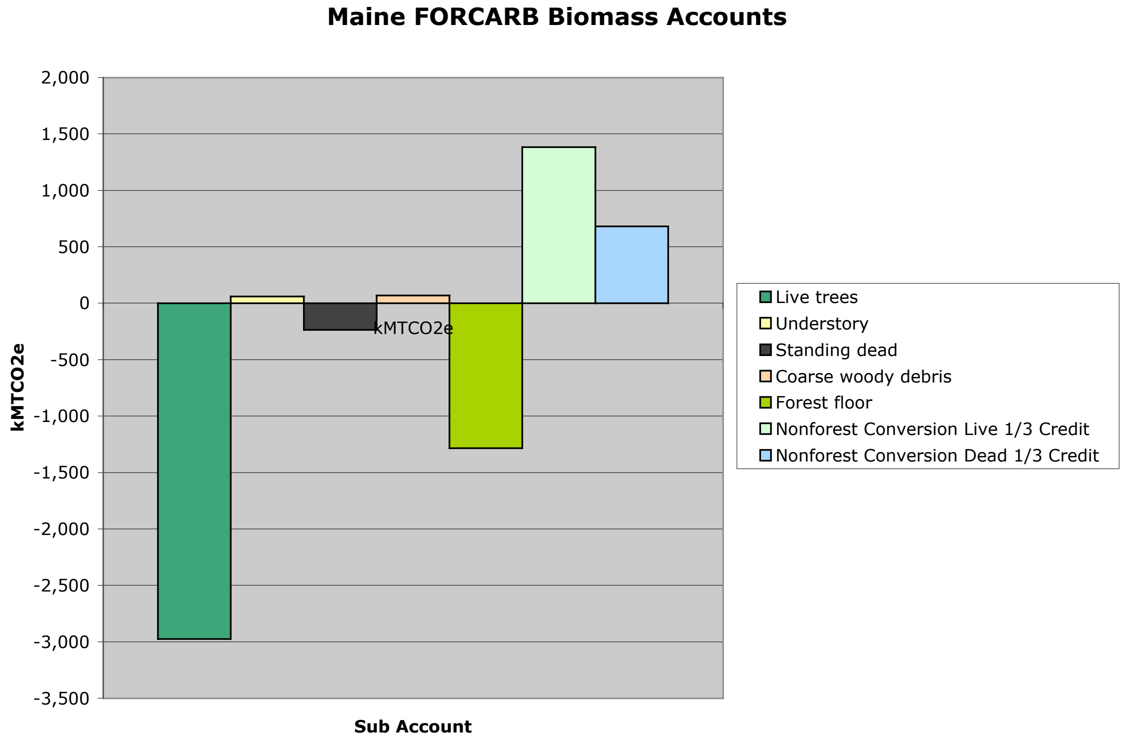


Figure 9 above shows the differential effects of FORCARB biomass sub accounts. Live trees and forest floor show negative values because carbon stocks in 1982 were higher than 2003, implying a loss of carbon in the intervening period. Positive credit values for land use change are significant. New biomass stock data will be available in 2005 and may alter these numbers (FIA data is collected at the rate of 20 percent of statewide sample plots per year over five years, and the fifth year of collection in this cycle is now in progress).

Figure 10

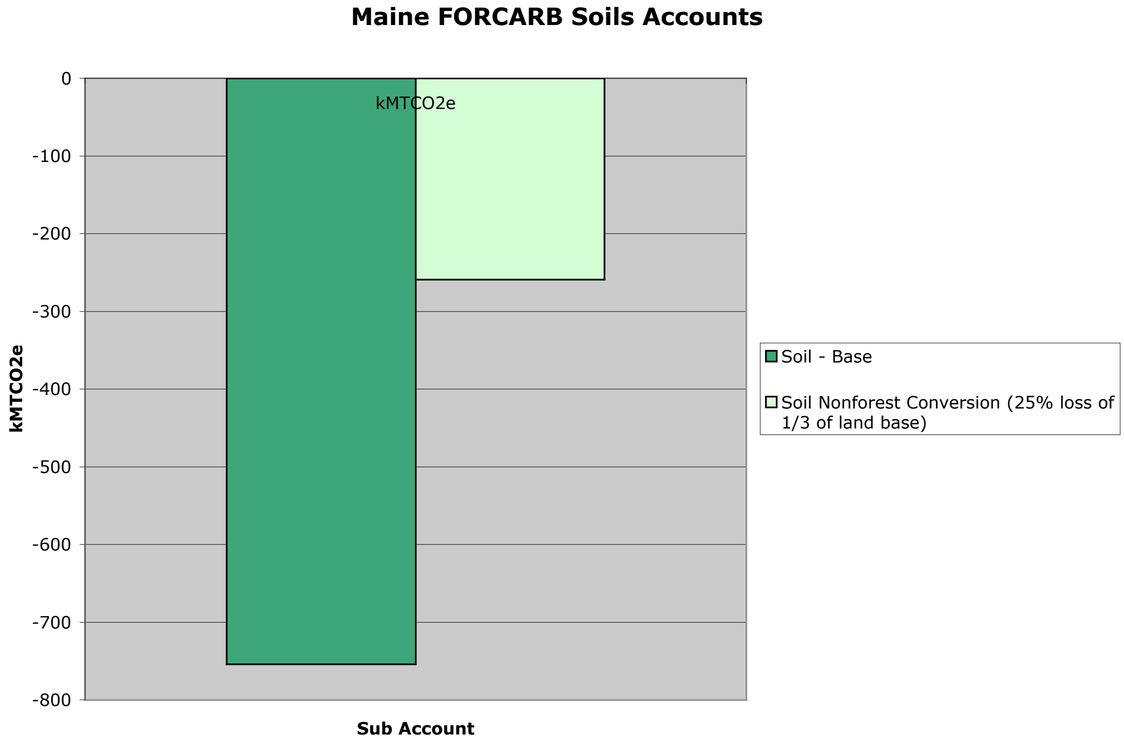


Figure 10 above shows soil carbon flow accounts in FORCARB. Soil carbon is calculated on a flow basis, and is determined by forest type. Changes in forest soil carbon levels in FORCARB result from shifts in forest types on base acres, and acres converted to and from forestland.

Figure 11

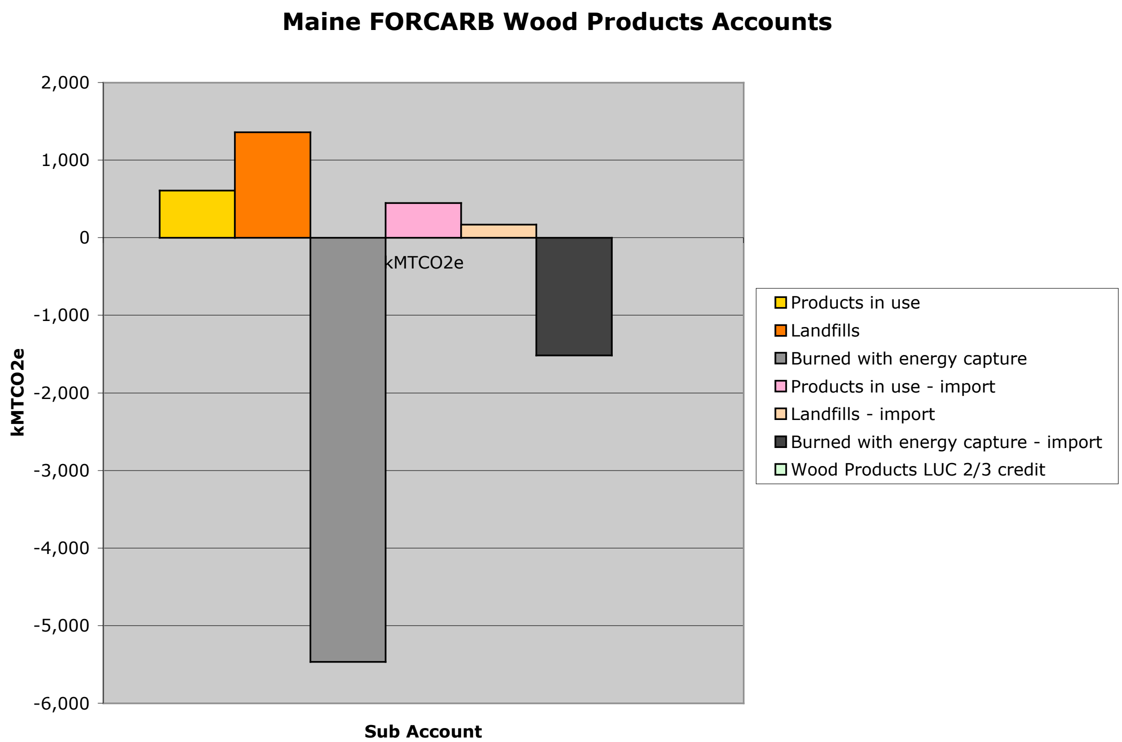


Figure 11 above shows the differential effects of wood products and landfill storage in FORCARB wood products accounts calculated by HARVCARB. In this graph emissions from biomass burning for energy recapture are reported to illustrate their magnitude, but they are not counted separately in the FORCARB inventory because they are included in carbon lost from reductions in live tree stocks.

Figure 12.

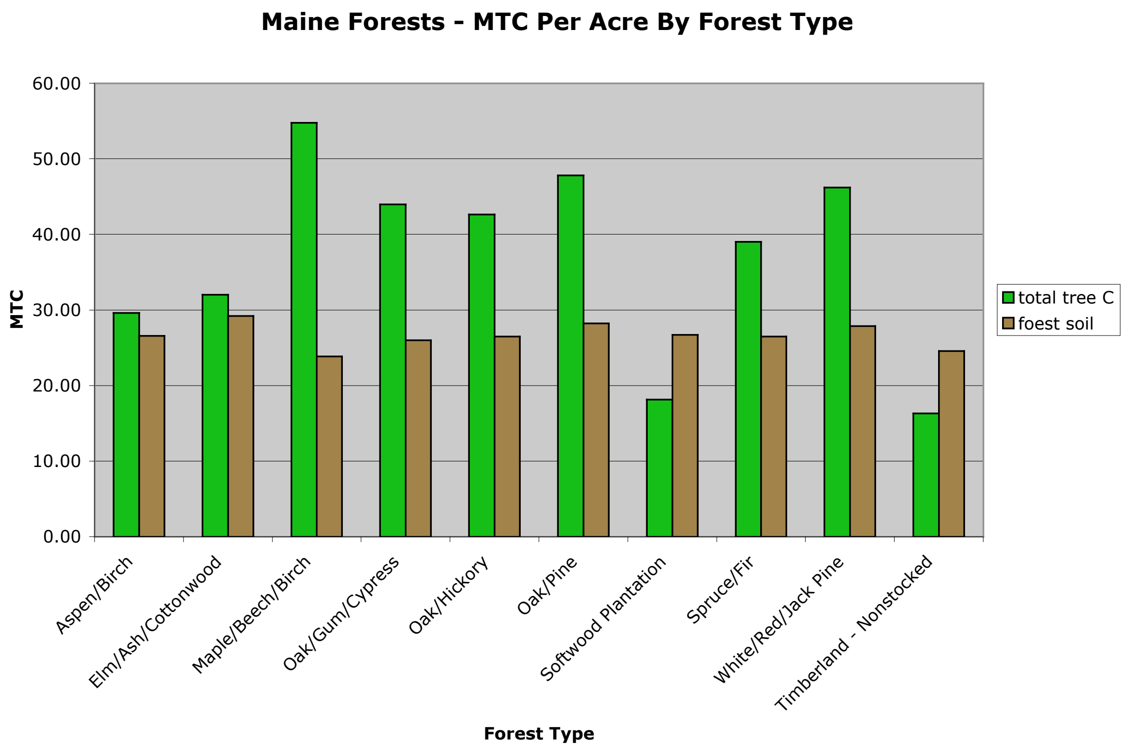


Figure 12 above shows differentials in biomass and soil carbon for different forest types in Maine on a per acre basis. With respect to carbon, not all trees are created equal.

Figure 13.

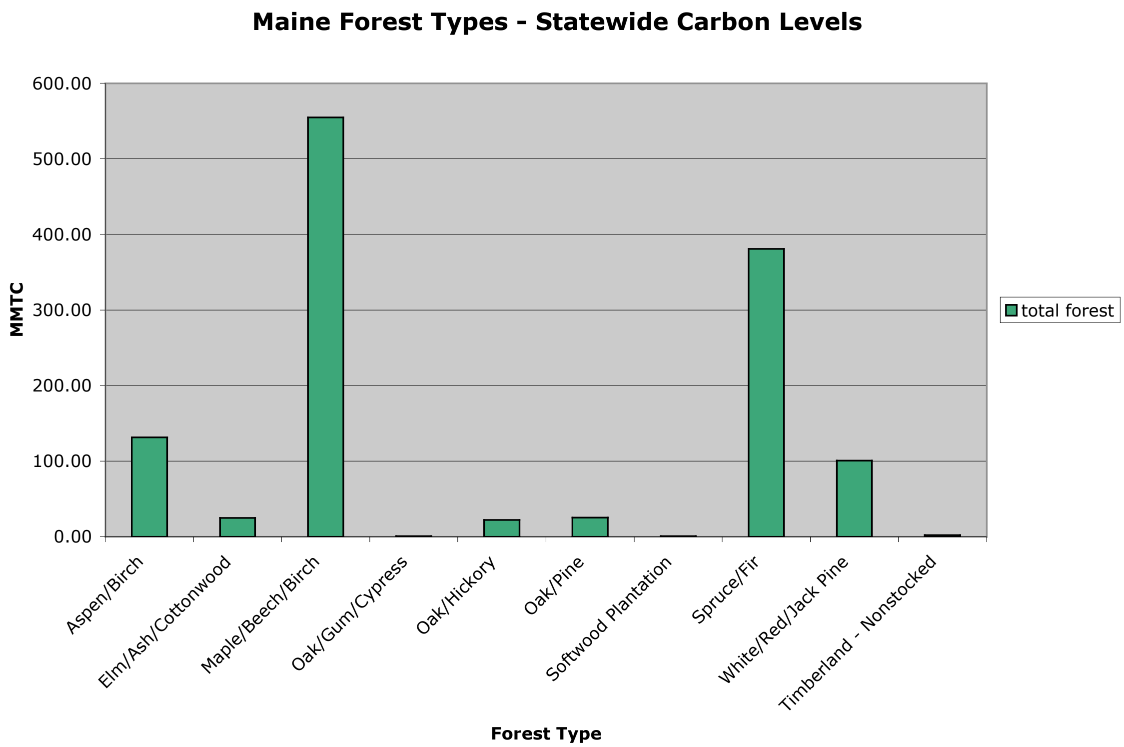


Figure 13 above shows the significant differences in total carbon levels by forest type in Maine, with domination by Maple/Beech/Birch, Spruce/Fir, Aspen/Birch, and White/Red/Jack Pine. Total carbon levels include biomass and soil carbon for total statewide acres for each forest type.

Figure 14.

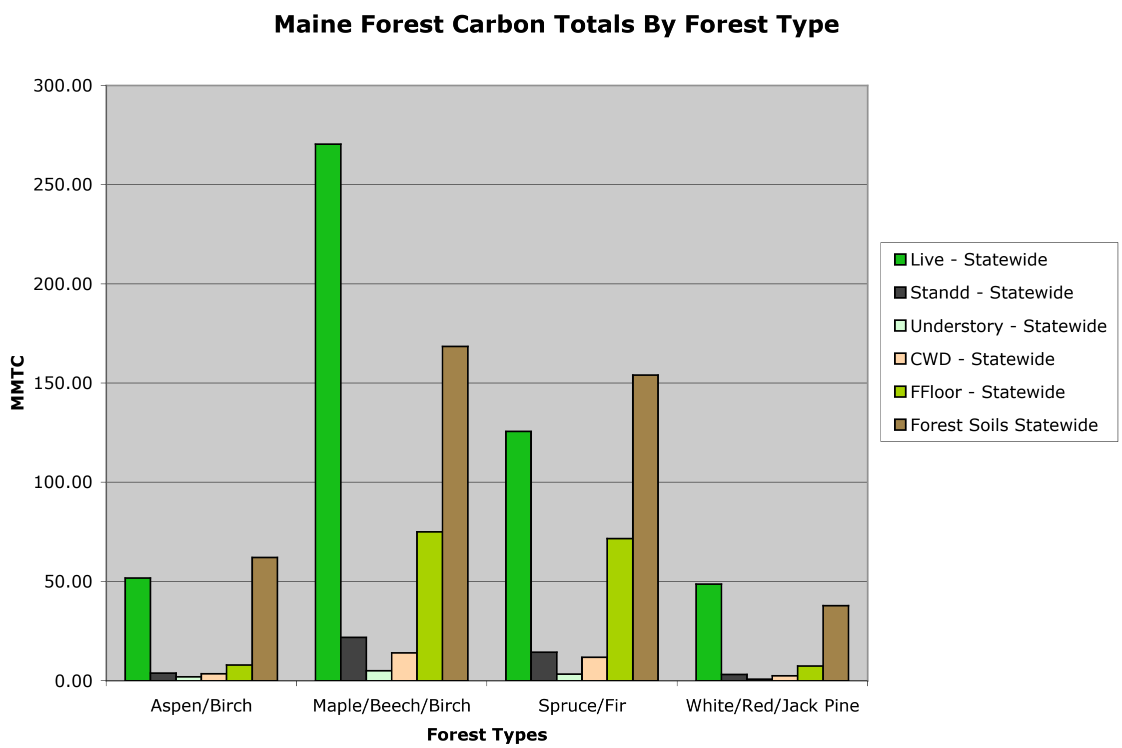


Figure 14 above shows differentials in biomass and soil carbon sub accounts for total carbon statewide (total acres times per acre carbon rates) for major forest types in Maine. Note the dominance of Maple/Beech/Birch and the comparative size of soil carbon and forest floor sub accounts.

Figure 15.

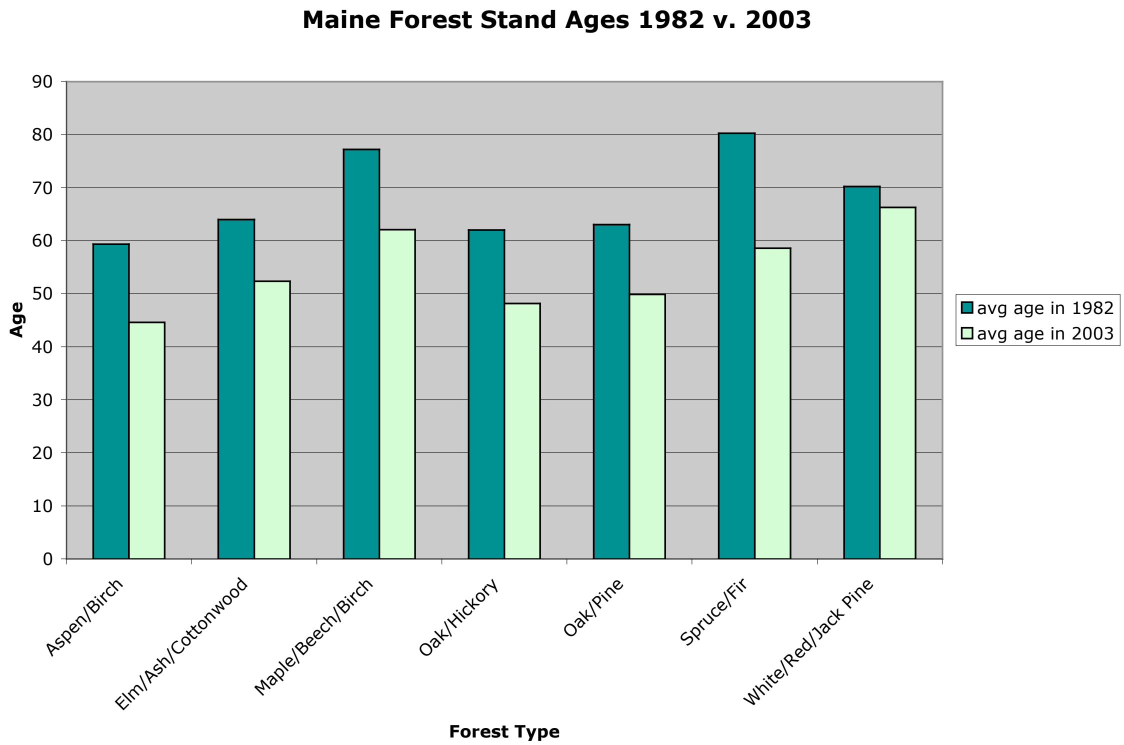


Figure 15 above shows a significant decline in stand age for all forest types in Maine from an un-weighted average of 68 years 1982, to 55 years in 2003. Decline in stand age is due to combined effects of harvest, forest health, and conversions from and to forest from other land uses. Forestlands that are converted to nonforest contain 24.67 MTC per acre of mature *live trees, dead trees, and understory* on average compared to incoming stands at 14.52 MTC per acre with younger trees.

Summary Of Forestry Options Progress Toward Targets

Table 13 below compares the GHG savings of each proposed policy action and provides simple cost effectiveness estimates where data was available. These estimates are not discounted, assume level annual reductions for each policy, and begin in 2005 and continue through 2020. No ramp-up periods are assumed. Other, specific working group assumptions for each of these options are described in individual policy descriptions in the next section of the document.

Table 13.

Maine Forestry GHG Savings	**KMTCO2e Reduced**			
	Avg Annual Reductions 2005-2020 15 yr*		**Avg Annual Reductions 2005-2020** 100 yr**	
	2010	2020	2010	2020
Forestland Protection	458.64	458.64	477.02	477.02
Increased Stocking With Fast Growing Trees	172.14	172.14	737.04	737.04
Early Commercial Thin+	-129.39	-129.39	283.39	283.39
More Light Harvests+	-1.66	-1.66	3.31	3.31
Active Softwood Increase+	-7.65	-7.65	20.75	20.75
Increased Harvest Rotation Length+	TBD	TBD	TBD	TBD
Biomass Electricity Feedstocks+#	-139.25	-139.25	474.83	474.83
Expanded Use Of Wood Products+#	137.87	137.87	19.12	19.12
Total Forestry Options GHG Savings	492.09	492.09	1,521.51	1,521.51
Maine Forest Baseline	716.60	716.60	716.60	716.60
Maine Legislative Targets	716.60	644.94	716.60	644.94
Net Emissions After Baseline + Progress	224.50	224.50	-804.91	-804.91

* GHG savings calculated through levelized annual net emissions reduction over 15 years, including savings from 2005 to 2020
** GHG savings calculated through levelized annual net emissions reduction over 15 years, including savings from 2005 to 2100
+ Option not yet fully discussed
# Option not added to the total to avoid double counting

* Working assumptions for each policy proposal are included in the option descriptions that follow. The Maine legislative target does not require sector-based targets.

Figure 16.

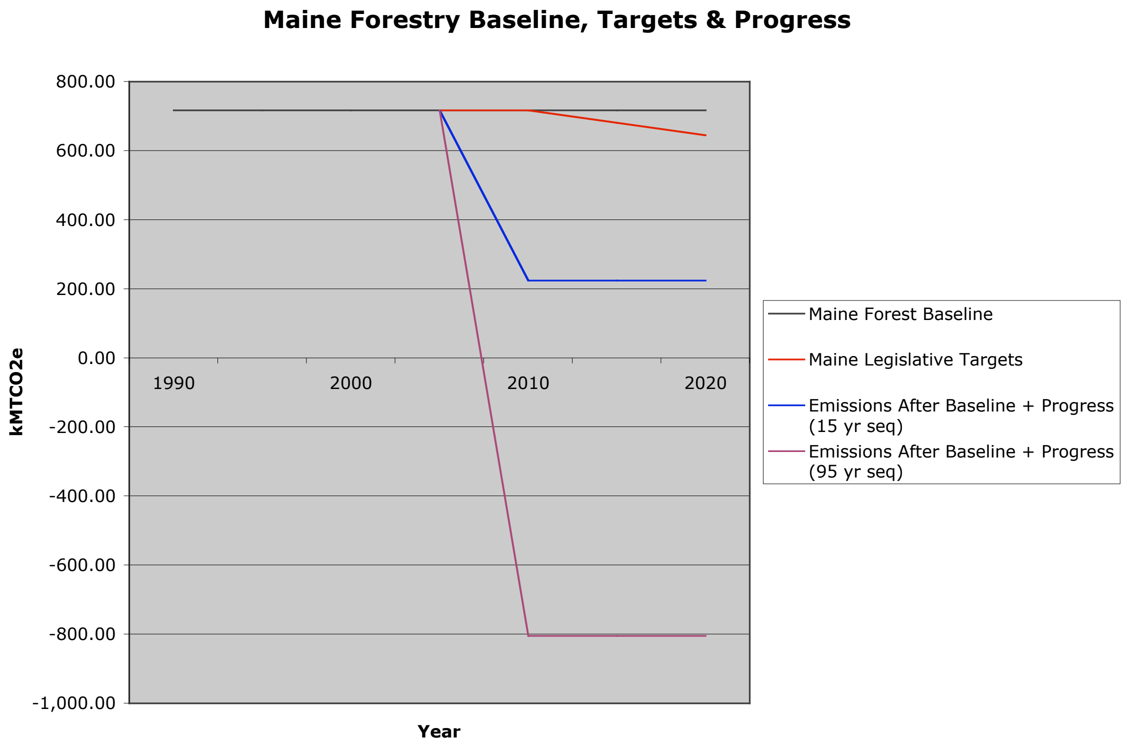


Figure 16 above shows progress toward Maine legislative targets under two scenarios: 1) 15 year sequestration; and 2) 95-year sequestration (approximate full life cycle growth of trees to 2100). Negative numbers represent emissions and positive numbers represent carbon storage or emissions reductions. In both scenarios the Maine Legislative targets in red are surpassed by options in blue. Note that this chart records greenhouse gases emissions as positive numbers, and storage and reductions as a negative number.

Figure 17.

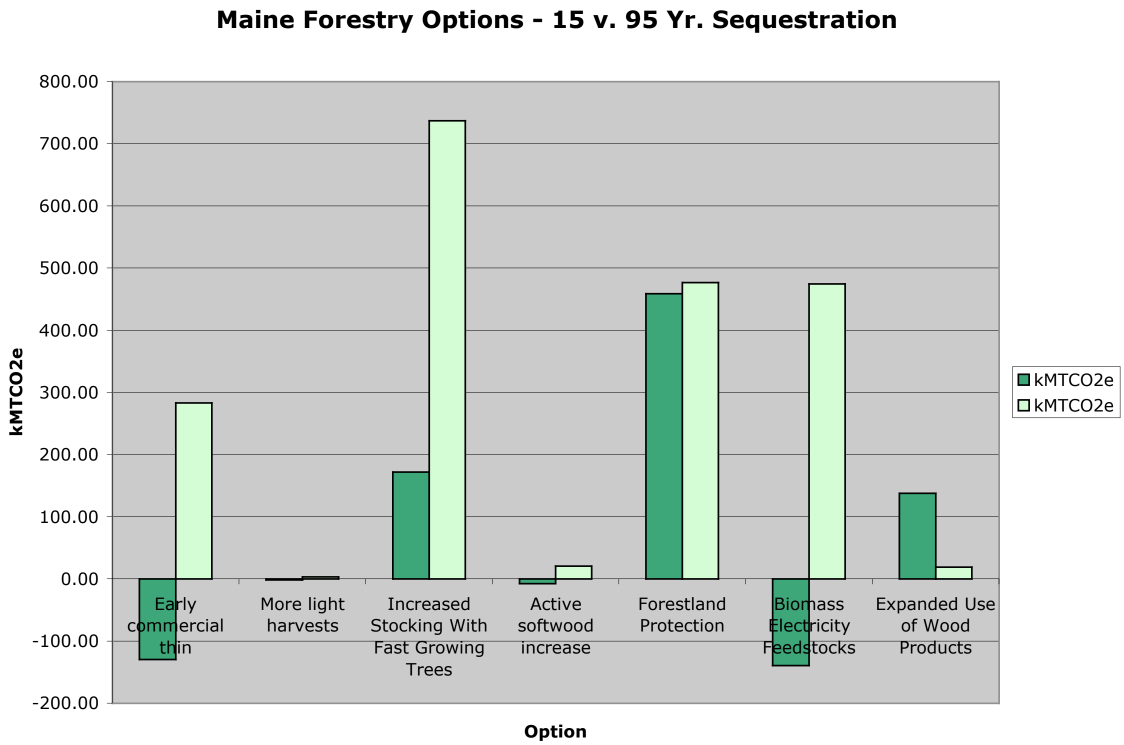


Figure 17 above shows greenhouse gas reductions from each forestry option proposed by the working group under two scenarios: 1) 15 year sequestration; and 2) 95 year sequestration (forest management options use a 55 year grow back period based on average age of Maine forest stands in 2001). Note the relatively smaller columns for 15-year sequestration v. 95-year sequestration and the impact of time horizon on analysis. Positive numbers represent emissions reductions or carbon storage.

Forestry Mitigation Options

Potential options for analysis were developed by the working group through two processes: Options not directly classified as forest management (forest land protection, biomass electricity feedstocks, and increased use of wood products) were developed in early reviews of potential options. Forest management options were subsequently developed by working group development of a general framework, followed by review and refinement by a forest experts Working Group. The working group then reviewed this broader list with a request for six specific proposals (see earlier Working Group summaries for details of these discussions). Specific options for analysis were submitted by: 1) the Maine Forest Service and Environment Northeast, and 2) Irving Company, and 3) Environmental Defense (late submission) (see appendix 2 for full descriptions of these proposals). Based on these submissions the following options list was formulated.

- Early Commercial Thinning
- More Regular, Lighter Harvests
- Increased Stocking
- Increased Stocking Of Genetically Improved Species
- Active Management To Maintain And Increase The Softwood Component Of Forest Stands
- Increased Harvest Rotation Length

The following sections of this document present information about each of the proposed forestry policy options, including:

- A description of the policy
- A description of some key business as usual policies and programs
- A listing of key data sources, methods and assumptions
- A summary table of estimated greenhouse gas reductions and costs
- A worksheet of calculations
- References and background materials

In developing forestry options the Working Group noted the importance of ancillary issues that are included in decision criteria for the stakeholder advisory group. Specifically, they felt the following considerations should be made:

- All options should be reviewed for potential impacts to biodiversity and the options adopted should do no harm to biodiversity.
- The planting of exotic species of trees should not be precluded as long as impacts to biodiversity have been considered and shown to have no harm.
- All options should create a net benefit to the atmosphere in the form of reduced land use, reduced sulfur emissions, and/or increased carbon sequestration.
- A meaningful and credible dialogue should be created with decision makers in order to give them a better understanding of the options developed by the Working Group.

- Implementation of the options should be in the context of an adaptive management stance, recognizing and providing for new data and understandings of the systems involved.

Early Commercial Thinning

Policy Description: Over the next 5 years, treat 50% of the 400,000 acres (40,000 acres per year) estimated to be available for ECT. Apply to all forest types and all landowner classes. Treat an additional 50% of a new subset of 400,000 acres over the subsequent 5-year period. Estimated Forest Product Output: 20% durable wood products; 60% pulp/OSB ("oriented strand board"), and 20% biomass energy. Assume 8 cords per acre per year harvest.

BAU Policy/Program: Early commercial thinnings are not required but are often practiced for silviculture reasons. Costs and undervalued benefits often prohibit broader application of this practice.

A number of existing programs support improved management of private non-industrial forests in Maine. The Maine Forest Service, with some financial support from the USDA Forest Service, provides technical and financial assistance to encourage non-industrial private forest landowners to keep their lands and natural resources productive and healthy. Qualifying land includes rural lands with existing tree cover or land suitable for growing trees and which is owned by a private individual, group, association, corporation, Indian tribe, or other legal private entity. Eligible landowners must have an approved Forest Management Plan and own 1,000 or fewer acres of qualifying land. Authorization may be obtained for exceptions of up to 5,000 acres.

The Tree Growth Tax Law provides for the valuation of enrolled forest lands according to the land's productivity instead of its just value (ad valorem). This provides an incentive for forest landowners to hold and manage their lands for long term. Substantial withdrawal penalties ensure the program's credibility. Enrolled acreage has remained relatively stable at around 11.7 million acres for many years.

Data Sources, Methods and Assumptions:

Analysis of this proposal is based on baseline data from the modified USFS FORCARB as described in an earlier discussion of the forestry baseline. Forest carbon measurements for average and specific stands are based on 2003 FORCARB data (average collection date of 2001). Specific proposed action levels, timing, acreages, and the Maine Forest Service and Environment Northeast provided yields per acre. Specific coefficients for emissions and storage from wood products are based on USFS HARVCARB data (appendix 1). Electricity emissions are based on HARVCARB allocations of biomass energy use from durable wood products and pulp, and emissions factors for marginal displaced power provided by Synapse, Inc. (ISO New England rates of 950 pounds CO2 per Mwh in appendix 5). All HARVCARB data are for the Northeast.

Analysis of these assumptions was conducted by spreadsheet analysis (static model) that assumed changes in biomass from policy would not be offset by demand responses (dynamic model). Cost figures were not available.

Greenhouse gas savings numbers were calculated by creating levelized annual actions assuming all 15 years (2005-2020) undergo equal actions and no ramp up period is involved. Savings numbers are not discounted. The levelized calculation is based on a stylized stand of all 15 years worth of acres grown in the average year (7.5 years from 2005), divided by the 15 year budget period (2005-2020) to simplify timing issues associated with biomass growth.

Calculations for net effects of biomass energy emissions and storage were made under two scenarios: 1) carbon sequestration of 15 years (the 2005-2020-target period), and 2) carbon sequestration of 95 years (2005-2100). The latter scenario is generally defined as "carbon neutral" by allowing full life cycle growth of biomass supplies to replace current biomass combustion. Both scenarios were calculated using a simple levelized annual number based on total years of carbon sequestered (7.5 or 87.5) divided by 15. Unless otherwise noted sequestration levels are based on statewide biomass growth rates for a mixture of stand types. Carbon sequestration rates for specific tree species were provided by the USFS (Jim Smith, appendix 4). Wood products and landfill emissions and storage are based on the HARVCARB model. Biomass conversions from cords per acre to carbon and dry tons wood biomass were calculated using coefficients provided by the Maine Forest Service (appendix 5).

Other details are noted in the worksheet in Table 13 below.

Estimated GHG Savings and Costs:

Table 14 summarizes results of analysis for the proposed option under two carbon sequestration scenarios for biomass that is directed to durable wood products, pulp and biomass energy. Note that HARVCARB estimates a certain percentage of biomass directed to wood products will be allocated over time for products, landfill storage, biomass energy and direct emissions (waste). Consequently the categories of durable wood products (saw timber) and pulp also include subcategories of biomass energy from mill residue. A separate biomass category exists for live tree chips used solely for biomass energy recapture. As a result multiple calculations are made under the option for biomass electricity feedstocks.

Table 14.

Early Commercial Thin		**Kmtco2e**	**Kmtco2e**	**Kmtco2e**	**Kmtco2e**
		2010	2020	2010+	2020+
Acres treated per year (avg forest)	40,000				
Cords removed per acre	8				
Cft removed per acre	1,024				
Pounds removed per acre (5000 short pounds/cord)	40,000				
Wet Tons removed per acre (2.5 short	20				

tons/cord)					
Dry Tons removed per acre (.5)	10				
MT removed per acre	9.07				
MTC removed per acre (.50 conversion)	4.54				
MTCO2e removed per acre (2.079 MT CO2e/cord)	16.632				
Total KMTCO2e removed yr 0-15	9,979				
% to durable wood	20%				
kMTCO2 to durable wood (yr 0-15)	1,996				
kMTCO2 Products in use - storage (yr 7.5)		31.63	31.63	7.32	7.32
kMTCO2 Landfill - storage (yr 7.5)		6.73	6.73	14.70	14.70
kMTCO2 Biomass energy - annual emission		-57.48	-57.48	-59.21	-59.21
Mbtus biomass energy (17.0 Mbtus per dry ton)	8,812,800				
Mwh biomass energy (11550 btu per Kwh)	763,013				
kMTCO2 displaced (950 lbs CO2 per Mwh) annual	329	21.94	21.94	21.94	21.94
kMTCO2 Other WP - emission (yr 7.5)		-40.52	-40.52	-51.83	-51.83
kMTCO2 Forest Sequestration (stand replacement) (yr 7.5)	544	18.14	18.14	133.06	133.06
Total GHG Savings		**-19.55**	**-19.55**	**65.98**	**65.98**
% to pulp	60%				
kMTCO2 to pulp (yr 0-15)	5,988				
kMTCO2 Products in use - storage (yr 7.5)		94.04	94.04	9.78	9.78
kMTCO2 Landfill - storage (yr 7.5)		31.53	31.53	41.71	41.71
kMTCO2 Biomass energy - annual emission		-166.73	-166.73	-172.64	-172.64
Mbtus biomass energy (17.0 Mbtus per dry ton)	25,563,240				
Mwh biomass energy (11550 btu per Kwh)	2,213,268				
kMTCO2 displaced (950 lbs CO2 per Mwh) annual	955	63.64	63.64	63.64	63.64
kMTCO2 Other WP - emission (yr 7.5)		-122.62	-122.62	-175.04	-175.04

kMTCO2 Forest Sequestration (stand replacement) (yr 7.5)	1,633	54.43	54.43	399.17	399.17
Total GHG Savings		**-45.71**	**-45.71**	**166.62**	**166.62**
% to elec gen	20%				
kMTCO2 Biomass energy - annual emission	1995.84	-133.06	-133.06	-133.06	-133.06
Mbtus biomass energy (17.0 Mbtus per dry ton)	20,400,000				
Mwh biomass energy (11550 btu per Kwh)	1,766,234				
kMTCO2 displaced (950 lbs CO2 per Mwh) annual	762	50.79	50.79	50.79	50.79
kMTCO2 Forest Sequestration (stand replacement) (yr 7.5)	544	18.14	18.14	133.06	133.06
Total GHG Savings		**-64.13**	**-64.13**	**50.79**	**50.79**
Option Total GHG Savings		**-129.39**	**-129.39**	**283.39**	**283.39**

Option Summary - Early Commercial Thinning	GHG savings 2010 (kMTCO2e)*	GHG savings 2020 (kMTCO2e)*	$/MTCO2e
15 Yr Seq	**-129.39**	**-129.39**	TBD
95 Yr Seq	**283.39**	**283.39**	TBD

Key Uncertainties:

- Feasibility of treating 40,000 acres per year (a potentially aggressive goal)
- Growth rates of restocked species following thinning; growth rates may be not be the same following thins as for restocking following clear cut harvest (assumed in this analysis)
- Emissions factors for electricity supplies displaced by biomass power
- Sequestration rates for average forest stands
- The volume of non merchantable harvest residue left on site
- Waste emissions (biomass not used for energy recapture) from biomass conversion during processing
- The percentage of biomass used for heat versus power production, and the relevant displacement rates for direct heat
- Time periods of analysis

More Regular, Lighter Harvests

Policy Description: This option is intended to remove standing biomass from the forest with minimal impact on the forest floor and soils, and to apply biomass to energy saving uses to reduce carbon dioxide emissions. Apply to all forest types and all landowner classes on 1,700,000 total acres over a 15-year period (113.333 acres per year). Goal: within 10 years capture 50% of biomass that otherwise is thinned by natural mortality and becomes decay on forest floors. This would yield approximately 4,000 cords of wood annually, or 3 cubic feet of wood per acre per year. Estimated Forest Product Output: 45% saw logs; 48% pulpwood and 7% biomass chips (the average mix of the reported harvest of forest products over the past 7 years).

BAU Policy/Program: A number of existing programs support improved management of private non-industrial forests in Maine. The Maine Forest Service, with some financial support from the USDA Forest Service, provides technical and financial assistance to encourage non-industrial private forest landowners to keep their lands and natural resources productive and healthy. Qualifying land includes rural lands with existing tree cover or land suitable for growing trees and which is owned by a private individual, group, association, corporation, Indian tribe, or other legal private entity. Eligible landowners must have an approved Forest Management Plan and own 1,000 or fewer acres of qualifying land. Authorization may be obtained for exceptions of up to 5,000 acres.

The Tree Growth Tax Law provides for the valuation of enrolled forest lands according to the land's productivity instead of its just value (ad valorem). This provides an incentive for forest landowners to hold and manage their lands for long term. Substantial withdrawal penalties ensure the program's credibility. Enrolled acreage has remained relatively stable at around 11.7 million acres for many years.

Data Sources, Methods and Assumptions:

Analysis of this proposal is based on baseline data from the modified USFS FORCARB as described in an earlier discussion of the forestry baseline. Forest carbon measurements for average and specific stands are based on 2003 FORCARB data (average collection date of 2001). Specific proposed action levels, timing, acreages, and the Maine Forest Service and Environment Northeast provided yields per acre. Specific coefficients for emissions and storage from wood products are based on USFS HARVCARB data (appendix 1). Electricity emissions are based on HARVCARB allocations of biomass energy use from durable wood products and pulp, and emissions factors for marginal displaced power provided by Synapse, Inc. (ISO New England rates of 950 pounds CO2 per Mwh in appendix 3). All HARVCARB data are from the Northeast.

Analysis of these assumptions was conducted by spreadsheet analysis (static model) that assumed changes in biomass from policy would not be offset by demand responses (dynamic model). Cost figures were not available.

Greenhouse gas savings numbers were calculated by creating levelized annual actions assuming all 15 years (2005-2020) undergo equal actions and no ramp up period is involved. Savings numbers are not discounted. The levelized calculation is based on a stylized stand of all 15 years worth of acres grown in the average year (7.5 years from 2005), divided by the 15 year budget period (2005-2020) to simplify timing issues associated with biomass growth.

Calculations for net effects of biomass energy emissions and storage were made under two scenarios: 1) carbon sequestration of 15 years (the 2005-2020-target period), and 2) carbon sequestration of 95 years (2005-2100). The latter scenario is generally defined as “carbon neutral” by allowing full life cycle growth of biomass supplies to replace current biomass combustion. Both scenarios were calculated using a simple levelized annual number based on total years of carbon sequestered (7.5 or 87.5) divided by 15. Unless otherwise noted sequestration levels are based on statewide biomass growth rates for a mixture of stand types. Carbon sequestration rates for specific tree species were provided by the USFS (Jim Smith, appendix 4). Wood products and landfill emissions and storage are based on the HARVCARB model. Biomass conversions from cords per acre to carbon and dry tons wood biomass were calculated using coefficients provided by the Maine Forest Service (appendix 5).

Other details are noted in the worksheet in Table 14 below.

Estimated GHG Savings and Costs:

Table 15 summarizes results of analysis for the proposed option under two carbon sequestration scenarios for biomass that is directed to durable wood products, pulp and biomass energy. Note that HARVCARB estimates a certain percentage of biomass directed to wood products will be allocated over time for products, landfill storage, biomass energy and direct emissions (waste). Consequently the categories of durable wood products (saw timber) and pulp also include subcategories of biomass energy from mill residue. A separate biomass category exists for live tree chips used solely for biomass energy recapture. As a result multiple calculations are made under the option for biomass electricity feedstocks.

Table 15.

More Light Harvest		**Kmtco2e** 2010	**Kmtco2e** 2020	**Kmtco2e** 2010+	**Kmtco2e** 2020+
Acres treated per year (avg forest)	113,333				
Cords removed per acre	0.04				
Total cords removed per year	4,000				
Cft removed per acre	3.00				

Pounds removed per acre (5000 short pounds/cord)	176				
Wet Tons removed per acre (2.5 short tons/cord)	0.088				
Dry Tons removed per acre (.5)	0.044				
MT removed per acre	0.040				
MTC removed per acre (.50 conversion)	0.020				
MTCO2e removed per acre (2.079 CO2e/cord)	0.073				
Total KMTCO2e removed yr 0-15	125				
% to durable wood	45%				
kMTCO2 to durable wood (yr 0-15)	56				
kMTCO2 Products in use - storage (yr 7.5)		0.89	0.89	0.21	0.21
kMTCO2 Landfill - storage (yr 7.5)		0.30	0.30	0.39	0.39
kMTCO2 Biomass energy - annual emission		-1.56	-1.56	-1.62	-1.62
Mbtus biomass energy (17.0 Mbtus per dry ton)	136,380				
Mwh biomass energy (11550 btu per Kwh)	11,808				
kMTCO2 displaced (950 lbs CO2 per Mwh) annual	5	0.34	0.34	0.34	0.34
kMTCO2 Other WP - emission (yr 7.5)		-1.15	-1.15	-1.64	-1.64
kMTCO2 Forest Sequestration (stand replacement) (yr 7.5)		0.51	0.51	3.74	3.74
Total GHG Savings		**-0.68**	**-0.68**	**1.42**	**1.42**
% to pulp	48%				
kMTCO2 to pulp (yr 0-15)	60				
kMTCO2 Products in use - storage (yr 7.5)		0.94	0.94	0.10	0.10
kMTCO2 Landfill - storage (yr 7.5)		0.07	0.07	0.42	0.42
kMTCO2 Biomass energy - annual emission		-1.67	-1.67	-1.73	-1.73
Mbtus biomass energy (17.0 Mbtus per dry ton)	255,632				
Mwh biomass energy (11550 btu per Kwh)	22,133				
kMTCO2 displaced (950 lbs CO2 per Mwh) annual	10	0.64	0.64	0.64	0.64

kMTCO2 Other WP - emission (yr 7.5)		-1.23	-1.23	-1.75	-1.75
kMTCO2 Forest Sequestration (stand replacement) (yr 7.5)	16	0.54	0.54	3.99	3.99
Total GHG Savings		**-0.70**	**-0.70**	**1.67**	**1.67**
% to elec gen					
kMTCO2 Biomass energy - annual emission	-8.73	-0.58	-0.58	-0.58	-0.58
Mbtus biomass energy (17.0 Mbtus per dry ton)	89,250				
Mwh biomass energy (11550 btu per Kwh)	7,727				
kMTCO2 displaced (950 lbs CO2 per Mwh) annual	3	0.22	0.22	0.22	0.22
kMTCO2 Forest Sequestration (stand replacement) (yr 7.5)	2	0.08	0.08	0.58	0.58
Total GHG Savings		**-0.28**	**-0.28**	**0.22**	**0.22**
Option Total GHG Savings		**-1.66**	**-1.66**	**3.31**	**3.31**

Option Summary - More Regular, Lighter Harvests	GHG savings 2010 (kMTCO2e)*	GHG savings 2020 (kMTCO2e)*	$/MTCO2e
15 Yr Seq	**-1.66**	**-1.66**	TBD
95 Yr Seq	**3.31**	**3.31**	TBD

Key Uncertainties:

- Emissions factors for electricity supplies displaced by biomass power
- Sequestration rates for average forest stands
- The volume of non merchantable harvest waste left on site
- Waste emissions (biomass not used for energy recapture) from biomass conversion during processing
- The percentage of biomass used for heat versus power production, and the relevant displacement rates for direct heat
- Time periods of analysis

Increased Stocking Of Poorly Stocked Forest Stands With Fast Growing Trees

Policy Description: This measure focuses on increasing overall stand stocking, by management practices that promote current Poorly Stocked Stands (10% - 34% stocked) into Moderately Stocked Class Stands (35% - 64% stocked). Goal: Manage and promote 25,000 acres per year from the Poorly Stocked Class to Moderately Stocked Class over the next 15 years. Apply to all forest type groups, focusing on desirable species, and available to all landowner classes. Faster growing trees are to be used in restocking. The Working Group recommended a rate eight percent higher than average spruce fir restocking. Commercial restocking operations can use select seedlings with a 12 to 20 percent increased growth rate following clear cut harvest, but the group was concerned about the feasibility of this growth rate following less intensive harvests.

BAU Policy/Program: Public and private reforestation is required on many lands and practiced routinely in the state, but does not always result in full stocking of all stands.

Data Sources, Methods and Assumptions:

Analysis of this proposal is based on baseline data from the modified USFS FORCARB as described in an earlier discussion of the forestry baseline. Forest carbon measurements for average and specific stands are based on 2003 FORCARB data (average collection date of 2001). Specific proposed action levels, timing, acreages, and the Maine Forest Service and Environment Northeast provided yields per acre.

Analysis of these assumptions was conducted by spreadsheet analysis (static model) that assumed changes in biomass from policy would not be offset by demand responses (dynamic model). Cost figures were not available.

Greenhouse gas savings numbers were calculated by creating levelized annual actions assuming all 15 years (2005-2020) undergo equal actions and no ramp up period is involved. Savings numbers are not discounted. The levelized calculation is based on a stylized stand of all 15 years worth of acres grown in the average year (7.5 years from 2005) divided by the 15 year budget period (2005-2020) to simplify timing issues associated with biomass growth.

Carbon sequestration rates for specific tree species were provided by the USFS (Jim Smith, appendix 4). Growth rates were based on standing live and understory biomass.

Wood products and landfill emissions and storage are based on the HARVCARB model. An increase of eight percent over normal growth was added to reflect selection of fast growing trees.

One forest type was evaluated for spruce/fir stocking, using trees selected for fast growth (eight percent higher than average wild stands). Two time horizons were used for counting the benefits of future sequestration, one ending in 2020, and one ending in 2100.

Other details are noted in the worksheet in Table 16 below.

Estimated GHG Savings and Costs:

Table 16 summarizes results of analysis for the proposed option fewer than two carbon sequestration scenarios.

Table 16.

Increased Stocking Poorly Stocked Lands With Fast Growing Trees		**Kmtco2e** 2010	**Kmtco2e** 2020	**Kmtco2e** 2010+	**Kmtco2e** 2020+
Acres 15 years (25,000 treated per year)	375,000				
MTC per acre biomass nonsoil (Spruce fir 7.5 yrs)	8.71				
kMTCO2e per acre biomass nonsoil (Spruce fir 7.5 yrs)	0.032				
MTC per acre biomass nonsoil (Spruce fir 87.5 yrs)	37.29				
kMTCO2e per acre biomass nonsoil (Spruce fir 87.5 yrs)	0.136				
kMTCO2e total avg annual acres w 8% adder (Spruce fir 7.5 yrs)	860.72	860.72	860.72		
kMTCO2e total avg annual acres w 8% adder (Spruce fir 87.5 yrs)				3,685.20	3,685.20
Option Total GHG Savings - 20%> Spruce Fir		**172.14**	**172.14**	**737.04**	**737.04**

Option Summary - Increased Stocking	**GHG savings 2010 (kMTCO2e)***	**GHG savings 2020 (kMTCO2e)***	**$/MTCO2e**
15 Yr Seq	**172.14**	**172.14**	TBD
95 Yr Seq	**737.04**	**737.04**	TBD

Key Uncertainties:

- Biomass growth rates for new trees on partially stocked sites versus clear cut or intensively harvested sites
- Tree mortality for seedlings
- Feasibility of increasing the rate of stocking on poorly stocked stands to the moderate stocking class; it may be possible to increased stocking from poor to fully stocked conditions under intensive restocking
- Length of biomass replacement period for restocked stands; current calculations use two time periods: 15 years and 95 years

Active Management To Maintain And Increase The Softwood Component Of Forest Stands

Policy Description: Significant percentages of Maine's original softwood forests have shifted to hardwoods as a result of forest practices. With long-term forest succession they are likely to return to softwoods in the very long term, but this process can be accelerated with practices that remove hardwood stocks by thinning or harvest and replace them with longer-lived softwoods. In the process significant biomass could be generated for wood products and energy use, carbon sequestration rates may be improved by stimulating biomass growth response in the forest, and spruce budworm risks may be reduced along with emissions associated with decomposition of dead or dying wood.

Two million acres of spruce-fir forests, predominately located in northern Maine, transitioned from a softwood forest type to a hardwood forest type as a combined result of the spruce budworm epidemic in the 1970's and 1980's and subsequent salvage harvesting. Softwood Forest types have soil carbon sequestration rates significantly higher than for hardwood forests (for example, the Spruce-Fir forest type group has an associated value of 193 tons of organic carbon tons/hectare, compared to an associated value of 140 for the maple/beech/birch forest type group).

The working group proposed implementing a structured conversion process back to an assignment as a softwood forest type will increase the soil sequestration values of a substantial portion of Maine timberlands. Goal: transition 85% of 2 million acres (113,333 acres per year over 15 years) currently classified as a hardwood forest type to a softwood forest type by 2020. This includes removal of two cords of harvested biomass per acre through one time removals over the 15-year period from ten percent of these stands, with restocking of softwood species.

BAU Policy/Program: A number of existing programs support improved management of private non-industrial forests in Maine. The Maine Forest Service, with some financial support from the USDA Forest Service, provides technical and financial assistance to encourage non-industrial private forest landowners to keep their lands and natural resources productive and healthy. Qualifying land includes rural lands with existing tree cover or land suitable for growing trees and which is owned by a private individual, group, association, corporation, Indian tribe, or other legal private entity. Eligible landowners must have an approved Forest Management Plan and own 1,000 or fewer acres of qualifying land. Authorization may be obtained for exceptions of up to 5,000 acres.

The Tree Growth Tax Law provides for the valuation of enrolled forest lands according to the land's productivity instead of its just value (ad valorem). This provides an incentive for forest landowners to hold and manage their lands for long term. Substantial withdrawal penalties ensure the program's credibility. Enrolled acreage has remained relatively stable at around 11.7 million acres for many years.

Data Sources, Methods and Assumptions:

Analysis of this proposal is based on baseline data from the modified USFS FORCARB as described in an earlier discussion of the forestry baseline. Forest carbon measurements for average and specific stands are based on 2003 FORCARB data (average collection date of 2001). Specific proposed action levels, timing, acreages, and the Maine Forest Service and Environment Northeast provided yields per acre. Specific coefficients for emissions and storage from wood products are based on USFS HARVCARB data (appendix 1). Electricity emissions are based on HARVCARB allocations of biomass energy use from durable wood products and pulp, and emissions factors for marginal displaced power provided by Synapse, Inc. (ISO New England rates of 950 pounds CO2 per Mwh in appendix 3). All HARVCARB are from the Northeast.

Analysis of these assumptions was conducted by spreadsheet analysis (static model) that assumed changes in biomass from policy would not be offset by demand responses (dynamic model). Cost figures were not available.

Greenhouse gas savings numbers were calculated by creating levelized annual actions assuming all 15 years (2005-2020) undergo equal actions and no ramp up period is involved. Savings numbers are not discounted. The levelized calculation is based on a stylized stand of all 15 years worth of acres grown in the average year (7.5 years from 2005), divided by the 15 year budget period (2005-2020) to simplify timing issues associated with biomass growth.

Calculations for net effects of biomass energy emissions and storage were made under two scenarios: 1) carbon sequestration of 15 years (the 2005-2020 target period), and carbon sequestration of 95 years (2005-2100). The latter scenario is generally defined as "carbon neutral" by allowing full life cycle growth of biomass supplies to replace current biomass combustion. Both scenarios were calculated using a simple levelized annual number based on total years of carbon sequestered (7.5 or 87.5) divided by 15. Unless otherwise noted sequestration levels are based on statewide biomass growth rates for a mixture of stand types. Carbon sequestration rates for specific tree species were provided by the USFS (Jim Smith, appendix 1). Wood products and landfill emissions and storage are based on the HARVCARB model. Biomass conversions from cords per acre to carbon and dry tons wood biomass were calculated using coefficients provided by the Maine Forest Service (appendix 6).

Other details are noted in the worksheet in Table 17 below.

Estimated GHG Savings and Costs:

Table 17 summarizes results of analysis for the proposed option under two carbon sequestration scenarios for biomass that is directed to durable wood products, pulp and biomass energy. Note that HARVCARB estimates a certain percentage of biomass directed to wood products will be allocated over time for products, landfill storage, biomass energy and direct emissions (waste). Consequently the categories of durable wood products (saw timber) and pulp also include subcategories of biomass energy from mill residue. A separate biomass category exists for live tree chips used solely for biomass energy recapture. As a result multiple calculations are made under the option for biomass electricity feedstocks.

Table 17.

Active Softwood Increase		**Kmtco2e** 2010	**Kmtco2e** 2020	**Kmtco2e** 2010+	**Kmtco2e** 2020+
Acres treated per year (avg forest)	11,333				
Cords removed per acre	2				
Cft removed per acre	256				
Pounds removed per acre (5000 short pounds/cord)	10,000				
Wet Tons removed per acre (2.5 short tons/cord)	5.000				
Dry Tons removed per acre (.5)	2.500				
MT removed per acre	2.268				
MTC removed per acre (.50 conversion)	1.134				
MTCO2e removed per acre (2.079 CO2e/cord)	4.158				
Total kMTCO2e removed yr 0-15	707				
% to durable wood	45%				
kMTCO2 to durable wood (yr 0-15)	318				
kMTCO2 Products in use - storage (yr 7.5)		5.04	5.04	1.17	1.17
kMTCO2 Landfill - storage (yr 7.5)		1.19	1.19	2.34	2.34
kMTCO2 Biomass energy - annual emission		-9.16	-9.16	-9.44	-9.44
Mbtus biomass energy (17.0 Mbtus per dry ton)	1,404,540				
Mwh biomass energy (11550 btu per Kwh)	121,605				
kMTCO2 displaced (950 lbs CO2 per Mwh) annual	52	3.50	3.50	3.50	3.50
kMTCO2 Other WP - emission (yr 7.5)		-6.46	-6.46	-8.26	-8.26
kMTCO2 Forest Sequestration (stand replacement) (yr 7.5)		2.89	2.89	21.21	21.21
Total GHG Savings		**-3.00**	**-3.00**	**10.52**	**10.52**
% to pulp	48%				
kMTCO2 to pulp (yr 0-15)	339				
kMTCO2 Products in use - storage (yr 7.5)		5.33	5.33	0.55	0.55
kMTCO2 Landfill - storage (yr 7.5)		1.79	1.79	2.36	2.36
kMTCO2 Biomass energy - annual emission		-9.45	-9.45	-9.78	-9.78
Mbtus biomass energy (17.0 Mbtus per	1,448,584				

dry ton)					
Mwh biomass energy (11550 btu per Kwh)	125,418				
kMTCO2 displaced (950 lbs CO2 per Mwh) annual	54	3.61	3.61	3.61	3.61
kMTCO2 Other WP - emission (yr 7.5)		-6.95	-6.95	-9.92	-9.92
kMTCO2 Forest Sequestration (stand replacement) (yr 7.5)		3.08	3.08	22.62	22.62
Total GHG Savings		**-2.59**	**-2.59**	**9.44**	**9.44**
% to elec gen	7%				
kMTCO2 Biomass energy - annual emission	-49.48	-3.30	-3.30	-3.30	-3.30
Mbtus biomass energy (17.0 Mbtus per dry ton)	505,750				
Mwh biomass energy (11550 btu per Kwh)	43,788				
kMTCO2 displaced (950 lbs CO2 per Mwh) annual	12	0.79	0.79	0.79	0.79
kMTCO2 Forest Sequestration (stand replacement) (yr 7.5)	13	0.45	0.45	3.30	3.30
Total GHG Savings		**-2.06**	**-2.06**	**0.79**	**0.79**
Option Total GHG Savings		**-7.65**	**-7.65**	**20.75**	**20.75**

Option Summary - Active Management To Maintain And Increase The Softwood Component Of Forest Stands	GHG savings 2010 (kMTCO2e)*	GHG savings 2020 (kMTCO2e)*	$/MTCO2e
15 Yr Seq	**-7.65**	**-7.65**	TBD
95 Yr Seq	**20.75**	**20.75**	TBD

Key Uncertainties:

- Emissions factors for electricity supplies displaced by biomass power
- The capacity of industry to produce and plant softwood seedlings
- Sequestration rates for average forest stands
- The volume of non merchantable harvest residue left on site
- Waste emissions (biomass not used for energy recapture) from biomass conversion during processing
- The percentage of biomass used for heat versus power production, and the relevant displacement rates for direct heat
- Time periods of analysis

Biomass Electricity Feedstocks

Policy Description: This option is the simple addition of biomass energy sub options evaluated under forest management options, including: early commercial thins, more lighter harvests, and active management of stands for softwood reestablishment.

Incentives to make greater use forest products or forest waste as a fuel (in solid or gas form) or for co-firing with fossil fuels may reduce net emissions from power supply if it replaces higher emissions supply sources. In addition, removals of overstocked trees may improve forest health and reduce emissions from dead and dying trees.

BAU Policy/Program: Presently biomass is used for about 24 percent of the state's power generation, and is also a significant source of combined heat and power for wood products manufacturing facilities. Biomass is heavily used for home heating with wood stoves. (Reference Energy Supply and Waste Working Group for Updated Heat and Electric Power Demand for Biomass.)

Data Sources, Methods and Assumptions:

Same assumptions as used in forest management options that include biomass energy recapture. No dynamic effects of markets, all new supplies assumed to be additive to the market and not lost to export.

Other details are noted in the worksheet in Table 18 below.

Estimated GHG Savings and Costs:

Table 18 summarizes results of analysis for the proposed option under two carbon sequestration scenarios consistent with forest management options from which they are derived.

Table 18.

Biomass Electricity Feedstocks	Kmtco2e	Kmtco2e	Kmtco2e	Kmtco2e
	2010	2020	2010+	2020+
Early commercial thin	-130.19	-130.19	436.74	436.74
More light harvests	-1.48	-1.48	5.59	5.59
Active softwood increase	-7.59	-7.59	32.50	32.50
Option Total GHG Savings	**-139.25**	**-139.25**	**474.83**	**474.83**

Option Summary - Biomass Electricity	GHG savings 2010	GHG savings 2020	$/MTCO2e

Biomass Electricity Feedstocks	**2010 (kMTCO2e)***	**2020 (kMTCO2e)***	
15 Yr Seq	**-139.25**	**-139.25**	TBD
95 Yr Seq	**474.83**	**474.83**	TBD

Key Uncertainties:

- Emissions displacement factors
- Forest sequestration rates
- Supply responses from competing fuel sources
- Demand responses from expanded supply options
- Price requirements for biomass to effectively enter the power market
- Future subsidies for biomass, including production tax credits, portfolio standards and other incentives

Increase Wood Products Use

Policy Description: This option is the simple addition of biomass to wood products sub options evaluated under forest management options, including: early commercial thins, more lighter harvests, and active management of stands for softwood reestablishment.

Durable wood products in construction of furnishings and buildings can sequester carbon for long periods of time depending on the type of harvesting practices and end use of the wood products. Wood products may be less energy-intensive in production and use than other materials.

BAU Policy/Program: None to date.

Data Sources, Methods and Assumptions:

Same assumptions as used in forest management options that include biomass to wood products. No dynamic effects of markets, all new supplies assumed to be additive to the market and not lost to export.

Other details are noted in the worksheet in Table 19 below.

Estimated GHG Savings and Costs:

Table 19 summarizes results of analysis for the proposed option under two carbon sequestration scenarios consistent with forest management options from which they are derived.

Table 19.

Expanded Use Of Wood Products	**Kmtco2e**	**Kmtco2e**	**Kmtco2e**	**Kmtco2e**
	2010	2020	2010+	2020+
Early commercial thin	125.67	125.67	17.10	17.10
Regular light harvests	1.83	1.83	0.30	0.30
Active softwood increase	10.37	10.37	1.72	1.72
Option Total GHG Savings	**137.87**	**137.87**	**19.12**	**19.12**

Option Summary - Increased Use Of Wood Products	**GHG savings 2010 (kMTCO2e)***	**GHG savings 2020 (kMTCO2e)***	**$/MTCO2e**
15 Yr Seq	**137.87**	**137.87**	TBD
95 Yr Seq	**19.12**	**19.12**	TBD

Key Uncertainties:

- Dynamic effects of wood product markets, including imports and exports
- Potential variation in Maine versus the Northeast

Forest Land Protection

Policy Description: Protection of forestland cover from conversion to developed uses significantly reduces the atmospheric conversion of carbon stored in biomass and soils on undeveloped lands. It may also have the effect of directing growth to more efficient locations and reduce transportation emissions. The working group did not recommend an implementation program for this option but instead agreed to an option that would reduce ten percent of forestland conversion by 2010, and 20 percent by 2020 (against a baseline rate of 141,600 acres projected loss from 2005-2020). This translated into a savings of 2832 acres of natural forest cover per year. No geographic targets were included. A number of potential implementation mechanisms exist, including regulatory and market based land use standards and goals; direct incentive payments (easements and acquisitions); cluster zoning requirements or incentives (also known as conservation design or low impact development); revised transportation infrastructure investments; improvements to forest management profitability; and education.

BAU Policy/Program: The Forest Legacy Program of USDA is an incentive-based and strictly voluntary program that conserves working forests through financial support of land acquisition. The Land for Maine's Future Program (LMFP) was developed in 1987 to protect natural and working lands through financing of easements or fee title; 33 percent of funds must be matched. The USDA Farm and Ranchland Protection Program (FRPP) also provides limited cost sharing for land protection. Maine's Farm and Open Space Tax Law was developed in 1975 to provide tax relief to farm and forestland owners. The Maine Tree Growth Tax Law was enacted to provide property tax relief to owners of woodlots and forestlands. The Wetlands Reserve Program is a voluntary program offering landowners the opportunity to protect, restore, and enhance wetlands on their property. The USDA Natural Resources Conservation Service (NRCS) provides technical and financial support to help landowners with their wetland restoration efforts. Growth management policies and programs also significantly affect forestland protection, including zoning, property taxation, and infrastructure funding (particularly transportation) as well as private preservation actions by land trust organizations. The USDA Wildlife Habitat Incentives Program (WHIP) is a voluntary program for people who want to develop and improve wildlife habitat primarily on private land. Through WHIP USDA's Natural Resources Conservation Service provides both technical assistance and up to 75 percent cost-share assistance to establish and improve fish and wildlife habitat.

Data Sources, Methods and Assumptions:

Analysis of this proposal is based on baseline land cover conversion data from NRI.

Forest carbon measurements for average and specific stands are based on 2003 FORCARB data (average collection date of 2001).

Specific coefficients for emissions and storage from wood products are based on USFS HARVCARB data (appendix 1). Based on the US Forest Service estimates a 45 percent ratio was derived for the merchantable portion of live tree carbon for deforested stands. When harvested, HARVCARB coefficients forwood products, landfill storage and energy recapture were applied to this merchantable fraction of stand biomass to determine the level of biomass stored and not emitted by 2020, and by 2100. This is represented as a wood products credit in the worksheet below.

Analysis of these assumptions was conducted by spreadsheet analysis (static model) without demand responses (dynamic model). The analysis assumes an program that achieves 2832 acres of land cover savings net above any dynamic land use responses (additionality and leakage).

Cost figures were not available.

Greenhouse gas savings numbers were calculated by creating levelized annual actions assuming all 15 years (2005-2020) undergo equal actions and no ramp up period is involved. Greenhouse gas savings numbers are not discounted.

Unless otherwise noted sequestration levels are based on statewide biomass growth rates for a mixture of stand types. Biomass conversions from cords per acre to carbon and dry tons wood biomass were calculated using coefficients provided by the Maine Forest Service (appendix 5).

Other details are noted in the worksheet in Table 20 below.

Estimated GHG Savings and Costs:

Table 20 summarizes results of analysis for the proposed option fewer than two carbon sequestration scenarios.

Table 20.

Forest Land Protection **Forest Savings**		**Kmtco2e** 2010	**Kmtco2e** 2020	**Kmtco2e** 2010+	**Kmtco2e** 2020+
Baseline Forest Cover Acres Lost per year (NRI)	9,440				
30% Land Savings Target over 15 years, annual acres saved	2,832				
MTC per acre saved forest biomass (nonsoil)	44.602				
MTC per acre forest soil saved - 25% loss on 2/3 acres, 100% loss 0.1155 acres	8.752				
kMTCO2e per acre saved forest (nonsoil)	0.163				
kMTCO2e per acre saved forest (soil)	0.032				

kMTCO2e saved per acre per year total	0.195				
kMTCO2e total acres saved per year total biomass and soil	553.019				
kMTCO2e credit for wood products & landfills (7.5 yr)	-95.34				
kMTCO2e credit for wood products & landfills (87.5 yr)	-76.96				
Total GHG savings from forest cover and soils	457.68	**457.68**	**457.68**	**476.06**	**476.06**

Transportation Savings					
Acres of land cover saved 15 years	42,480				
Acres of land cover saved per year	2,832				
Housing units affected (3 home per acre LC average)	2,113				
Density increases resulting from land conservation	144.12%				
VMT per household before	22,000				
VMT per household after	20,900				
Gallons fuel reduction per HH from land conservation	51				
KMTCO2e avoided per HH from land conservation/VMT annual	0.000455				
KMTCO2e avoided all HH from land conservation/VMT annual	0.96				
Total GHG Transportation Savings	**0.96**	**0.96**	**0.96**	**0.96**	**0.96**
Option Total GHG Savings	458.64	**458.64**	**458.64**	**477.02**	**477.02**

Option Summary - Forest Land Protection	GHG savings 2010 (kMTCO2e)*	GHG savings 2020 (kMTCO2e)*	$/MTCO2e
15 Yr Seq	**458.64**	**458.64**	TBD
95 Yr Seq	**477.02**	**477.02**	TBD

Key Uncertainties:

- Retention rates for biomass, soil and wood products carbon for forestland that is developed for urban/suburban land use.

- The acreage that can effectively be protected without offsetting development in other areas.
- VMT effects of land cover savings programs that may increase housing density and proximity to existing service areas

Appendix 1 – Draft Estimates Of Carbon Stocks And Stock Changes For Harvested Wood In Maine 1990 And 2000

James Smith
USDA Forest Service
Northeastern Research Station

Overview. Draft estimates of carbon flux associated with harvested wood are provided in Tables 1, 2, and 3, which represent carbon harvested and processed in Maine, carbon harvested elsewhere and imported to Maine, and carbon harvested in Maine and then exported, respectively. The sum of fluxes for carbon harvested and processed in Maine and imported carbon represents stock change within the state. Overall, fluxes for stock changes of carbon in products in use and products in landfills show no consistent trends, or change, through the 1990's (Figure 1). A total for 1990 is not included in Figure 1 because imports are not included in flux for products in use and in landfills for (see discussion below).

The estimates of carbon flux associated with harvested wood provided in this draft report are part of a set of three reports prepared for the Maine Greenhouse Gas Initiative. The other two reports address (1) flux of soil organic carbon associated with forest type and land-use change, and (2) forest ecosystem carbon stocks and stock changes, including effects of land use change. The purpose of these reports is to provide estimates of net annual carbon flux associated with forestry for the years 1990 and 2000. Methods are based on those used to report forest carbon estimates for the U.S. as provided to the U.S. Environmental Protection Agency (EPA) for the Land-Use Change and Forestry chapter of the U.S. Greenhouse Gas Emissions and Sinks: 1990-2002 (U.S. Environmental Protection Agency 2004). Methods are consistent with recommendations of the Intergovernmental Panel on Climate Change (1997) for reporting greenhouse gas inventories and modified according to the availability of data specific to Maine's forests.

Estimates of stocks and stock changes of carbon in harvested wood are based on a model of harvested carbon flows and annual reports of wood processed in Maine. Stocks are estimated for two major pools of harvested wood carbon: products in use and in landfills. Flux is simply the net annual change, or the annual balance of carbon gained and lost from each pool. Annual net flux reflects the cumulative effects of all previous harvests. Additional flux estimates are provided for carbon reemitted to the atmosphere either with or without some form of energy recapture with combustion. Note that the sign convention used in this draft report is that a positive flux represents net sequestration in a particular pool.

Model of carbon in harvested wood. The model of harvested carbon flows (HARVCARB) was developed to estimate the disposition of carbon in harvested timber by tracing removals through transformation phases (Row and Phelps 1996). In these transformations, round wood is processed into primary products such as lumber, plywood, paper and paperboard; these primary products are then transformed into end-use products such as housing, packaging, and newsprint. Processing generates substantial amounts of byproducts, used primarily in energy cogeneration. The final disposition of end-use products reflects the length of time products remain in use and patterns of disposal. Disposition patterns in HARVCARB reflect regional differences in the diameters of logs harvested and end-use patterns; coefficients used here are for the Northeastern U.S.

The model estimates the percentage of carbon remaining in harvested wood for a 100-year period following harvest using four disposition categories: wood in use (durable wood products), wood products disposed in landfills, wood products and residues burned for energy, and wood products and byproducts that have decayed and returned carbon to the atmosphere. The first two categories (wood remaining in products and landfills) represent harvested carbon remaining in solid materials. Wood used for energy, although emitted to the atmosphere, may also contribute to carbon storage by displacing carbon in fossil fuels that would have would have otherwise been used for energy and emitted. Total harvested carbon for each pool at each year after harvest is based on the proportions of harvested wood in each of the four categories—softwood pulpwood, softwood saw timber, hardwood pulpwood, and hardwood saw timber. These data are supplied by the Maine Wood Processor Reports.

Harvest information for Maine. The Maine Forest Service publishes annual Wood Processor Reports for the state; these provide volumes harvested and serve as the source of inputs for HARVCARB. Annual Wood Processor Reports used for the estimates provided here include the years 1965, 1970, 1975, 1980, 1985-88, 1990, 1993, 1994, and 1996-2002. Summaries of total volumes harvested according to species groups are provided for saw logs and pulpwood; volumes are reported as cords. Additionally, green weight of biomass chips was provided, starting in 1990. Cords to green weight conversion factors are provided in the 2002 report.

Distinct categories of imports and exports can be important in accounting for carbon in harvested wood products. Not all logs harvested in the state are also process in the state; similarly, not all logs processed in state were also harvested there. Starting in 1990, three distinct categories were specified for all harvest data: logs harvested and processed in state; logs harvested in state but exported for processing, and logs harvested out of state but imported for processing. No information on imports is included in the reports prior to 1990. Most reports before 1990 did not specify exports for pulpwood, only total production for Maine.

Developing estimates for Maine. Coefficients from HARVCARB, which allocate carbon in harvested wood over time for the Northeast, are provided in Table 4 and are taken from Birdsey (1996). Coefficients were linearly interpolated to provide estimates for all years. Harvest data were converted from cords to green weight according to factors provided in the 2002 Wood Processor Report. Green weight to dry weight conversion was according to information in an unpublished guide to the 1997 National RPA Forest Database, which cites Smith (1991) as the source of the information; these dry-to-green ratios are reproduced as Table 5. Finally, carbon mass is assumed to be 50 percent of dry weight for wood and bark (Matthews 1993). Harvested carbon is then summarized according to softwood versus hardwood and saw logs versus pulpwood. Estimates of carbon harvested in Maine (including exports) as pulpwood, saw logs, and biomass chips are shown in Figure 2. Carbon harvested in years since 1965 where an annual report was not available were estimated by linearly interpolating estimated carbon mass by species group.

Estimates of carbon stocks are simply the product of the HARVCARB coefficients and the mass of carbon harvested in a particular year. Figure 3 illustrates the fate of carbon over 32 years since harvest as softwood saw timber in 1970; this example is for timber harvested and processed in state, that is excluding exports. Total carbon stocks for a given year are the sum of all such annual estimates prior to that time. Net annual flux is simply the change in stock.

Biomass chips are not included in the HARVCARB estimates. Results presented here assume that all carbon in biomass chips is associated with combustion and energy capture in same year as the report. Therefore, these values are reported in a separate energy capture category.

Harvests from years prior to 1965 can affect flux estimates for 1990 and 2000 because flux is based on the cumulative effect of harvests from all previous years. Without specific information, estimated levels of pre-1965 harvests need to be assumed. The sensitivity of flux to three relatively simple alternate assumptions about pre-1965 values is illustrated in Table 6. Harvested carbon for the 50 years prior to 1965 was simulated according to relatively extreme assumptions: harvests were constant at 1965 levels from 1915 through 1965, harvests linearly increased from 1915 through 1965, or there were no harvests before 1965. Each simulation began in 1915. These fluxes are included as examples of the long-term effect of harvested wood products. The reason that fluxes in Table 6 are reduced by the additional harvests many years before the 1990's is that small amounts of carbon are still being lost from older pools still in products and landfills. Adding to the uncertainty about the effect of past harvest is the fact that utilization, half-life, and disposition of harvested wood are each very likely different now than 50 years ago, for example. Additionally, the transition in disposal of harvested wood products from dumps to landfills can also have a small effect on estimates of current fluxes.

The base estimates of carbon flux associated with harvested wood are in Tables 1, 2, and 3 for carbon harvested and processed in Maine, imported, and exported, respectively. Note that the flux estimates for imports begin in 1991 because 1990 was the first year imports were reported. The first reported import of biomass chips was in 1993, and flux for chips is listed in the same year as the report. These simulations should be considered draft estimates; they were based on a simple assumption that harvests in each year prior to 1965 were 2 percent lower than the succeeding year. Thus, the simulations began with zero harvest for 1915 and then ramp up to 1965.

A number of assumptions built into the model can affect the estimates presented here. As discussed above, filling in pre 1965 harvest information can affect fluxes in the 1990's, generally by 10 to 15 percent. Interpolating harvests to fill the few gaps since 1965 assumes linear year-to-year changes, years where this is not true can affect results. Estimates also depend on the applicability of the HARVCARB coefficients to Maine and to the entire interval of the simulation. The process used to convert harvests from cords to tons of carbon can affect flux in subsequent years, especially where harvests tend to increase from year to year. Since imports do not have a history prior to 1990, flux rates are probably overestimates of sequestration because decay, or loss, from older harvests is not accounted for. Similarly, the in-Maine flux estimates for pulp (but not separately identified in Table 1) are probably underestimates of sequestration because exports prior to 1990 were not separately identified, and thus, flux includes effects of decay from older harvests, some of which were actually exported.

Literature Cited

Birdsey, R.A. 1996. Carbon storage for major forest types and regions in the coterminous United States. P. 1-25 and Appendix 2-4 *in* Sampson, N. and D. Hair, (eds.) Forests and Global Change. Volume 2: Forest management opportunities for mitigating carbon emissions. American Forests. Washington, DC.

Intergovernmental Panel on Climate Change, Organization for Economic Cooperation and Development, and International Energy Agency. 1997. Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Volumes 1-3. Bracknell, UK: IPCC WGI Technical Support Unit.

Maine Forest Service. 2002 Wood Processor Report, Department of Conservation, Maine Forest Service, Forest Policy and Management Division. Published October 2003 and updated March 2004. Also annual Wood Processor Reports from 1965, 1970, 1975, 1980, 1985-88, 1990, 1993, 1994, and 1996-2001.

Matthews, G. 1993. The carbon content of trees. Forestry Commission Technical paper 4, Forestry Commission, Edinburgh. 21p.

Row, Clark and Robert B. Phelps. 1996. Wood carbon flows after timber harvest. P. 27-58 *in* Sampson, N. and D. Hair, (eds.) Forests and Global Change. Volume 2: Forest management opportunities for mitigating carbon emissions. American Forests. Washington, DC.

Smith, W. Brad. 1991. Assessing removals for North Central forest inventories. USDA Forest Service. North Central Forest Experiment Station, Research Paper NC-299. 48p.

U.S. Environmental Protection Agency. 2004. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2002. Annual EPA GHG reports, which are submitted to the United Nations Framework Convention on Climate Change, are available at: http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterPublicationsGHGEmissions.html.

Table 1. Estimated net annual flux of carbon in harvested wood that is both harvested and processed in Maine. A positive value indicates net increase in carbon, such as increased sequestration in products in use or in landfills or net emission to atmosphere.

Year	Products in use	Landfills	Pulp and saw energy capture	Biomass chips energy capture	Emitted, no energy capture
			Million tonnes carbon per year		
1990	0.178	0.387	1.199	0.420	1.036
1991	0.156	0.386	1.168	0.441	1.025
1992	0.136	0.385	1.136	0.462	1.014
1993	0.118	0.381	1.105	0.483	1.002
1994	0.134	0.376	1.122	0.396	1.012
1995	0.165	0.371	1.160	0.357	1.051
1996	0.194	0.367	1.198	0.317	1.091
1997	0.254	0.366	1.275	0.326	1.152
1998	0.200	0.366	1.197	0.288	1.100
1999	0.145	0.362	1.118	0.245	1.040
2000	0.166	0.357	1.143	0.219	1.068
2001	0.146	0.353	1.124	0.259	1.058
2002	0.137	0.352	1.113	0.393	1.050

Table 2. Estimated net annual flux of carbon in harvested wood that is imported to Maine, that is, harvested elsewhere but processed in state. A positive value indicates net increase in carbon, such as increased sequestration in products in use or in landfills or net emission to atmosphere.

Year	Products in use	Landfills	Pulp and saw energy capture	Biomass chips energy capture	Emitted, no energy capture
			Million tonnes carbon per year		
1990					
1991	0.145	0.008	0.229		0.154
1992	0.123	0.016	0.213		0.151
1993	0.103	0.023	0.196	0.089	0.147
1994	0.133	0.030	0.262	0.038	0.195
1995	0.146	0.039	0.294	0.086	0.224
1996	0.158	0.048	0.326	0.133	0.254
1997	0.154	0.059	0.336	0.118	0.269
1998	0.105	0.071	0.305	0.178	0.241
1999	0.056	0.081	0.255	0.100	0.207
2000	0.093	0.089	0.314	0.282	0.260
2001	0.064	0.091	0.298	0.066	0.241

2002	0.121	0.093	0.366	0.077	0.294

Table 3. Estimated net annual flux of carbon in harvested wood that is exported from Maine, that is, harvested in state but processed elsewhere. A positive value indicates net increase in carbon, such as increased sequestration in products in use or in landfills or net emission to atmosphere.

Year	Products in use	Landfills	Pulp and saw energy capture	Biomass chips energy capture	Emitted, no energy capture
			Million tonnes carbon per year		
1990	0.002	0.030	0.072	0.014	0.068
1991	0.035	0.029	0.113	0.015	0.099
1992	0.067	0.030	0.155	0.016	0.131
1993	0.098	0.031	0.197	0.017	0.163
1994	0.074	0.034	0.174	0.012	0.145
1995	0.111	0.036	0.225	0.012	0.183
1996	0.146	0.039	0.277	0.012	0.222
1997	0.127	0.044	0.260	0.015	0.214
1998	0.098	0.049	0.246	0.007	0.199
1999	0.084	0.054	0.229	0.024	0.193
2000	0.095	0.058	0.259	0.015	0.212
2001	0.125	0.063	0.301	0.017	0.248
2002	0.129	0.068	0.315	0.055	0.261

Table 4. Disposition of harvested wood by harvest type for a 100-year period. Coefficients from HARVCARB (Birdsey 1996).

Harvest Type/ Disposition	Years After Harvest										
	0	10	20	30	40	50	60	70	80	90	100
	(Proportion of Initial Carbon Harvested)										
Softwood Pulpwood											
Products	0.300	0.067	0.046	0.039	0.034	0.031	0.029	0.028	0.026	0.025	0.024
Landfills	0.000	0.161	0.164	0.157	0.150	0.143	0.135	0.127	0.121	0.114	0.109
Energy	0.448	0.464	0.466	0.466	0.467	0.467	0.467	0.467	0.467	0.467	0.467
Emissions	0.252	0.308	0.324	0.337	0.349	0.360	0.369	0.378	0.386	0.393	0.400
Softwood Saw timber											
Products	0.330	0.193	0.166	0.147	0.125	0.114	0.105	0.097	0.091	0.086	0.083
Landfills	0.000	0.096	0.111	0.119	0.129	0.130	0.130	0.129	0.128	0.126	0.124
Energy	0.376	0.386	0.388	0.389	0.391	0.391	0.392	0.393	0.393	0.394	0.394
Emissions	0.293	0.324	0.336	0.346	0.356	0.364	0.373	0.380	0.387	0.394	0.400
Hardwood Pulpwood											
Products	0.291	0.064	0.047	0.040	0.035	0.032	0.030	0.028	0.027	0.025	0.025
Landfills	0.000	0.153	0.154	0.147	0.141	0.133	0.125	0.119	0.112	0.106	0.100
Energy	0.379	0.395	0.396	0.397	0.397	0.397	0.398	0.398	0.398	0.398	0.398
Emissions	0.330	0.388	0.403	0.416	0.428	0.438	0.448	0.456	0.464	0.471	0.477
Hardwood Saw timber											
Products	0.218	0.092	0.064	0.054	0.046	0.041	0.037	0.034	0.031	0.029	0.028
Landfills	0.000	0.091	0.107	0.110	0.111	0.109	0.107	0.105	0.103	0.100	0.097
Energy	0.483	0.491	0.493	0.494	0.495	0.495	0.495	0.495	0.496	0.496	0.496
Emissions	0.299	0.325	0.335	0.342	0.349	0.355	0.361	0.366	0.371	0.375	0.379

Table 5. Green weight to dry weight conversion factors (based on Smith, 1991).

Species group	Ratio of dry weight to green weight
Spruce – Fir	0.54
Pine	0.55
Hemlock	0.48
Cedar	0.54
Tamarack	0.48
Other Softwoods	0.56
Beech	0.59
Birch	0.56
Maple	0.56
Oak	0.56
Ash	0.60
Aspen/Poplar	0.49
Other Hardwoods	0.56

Table 6. Sensitivity of calculated flux (million metric tons per year) to estimates of pre 1965 harvests.

Assumed harvest 1915-1964	Products in use		Landfills	
	1990	2000	1990	2000
	Million tonnes carbon per year			
Set constant at 1965 level	0.164	0.135	0.365	0.332
Ramp up to 1965 level (see Table 1)	0.178	0.166	0.387	0.357
Set at zero	0.202	0.183	0.403	0.376

Figure 1. Estimates of net annual carbon flux into landfills and products in use through the 1990's. Estimates include carbon in wood harvested and processed in state as well as wood harvested out of state and imported to Maine for processing.

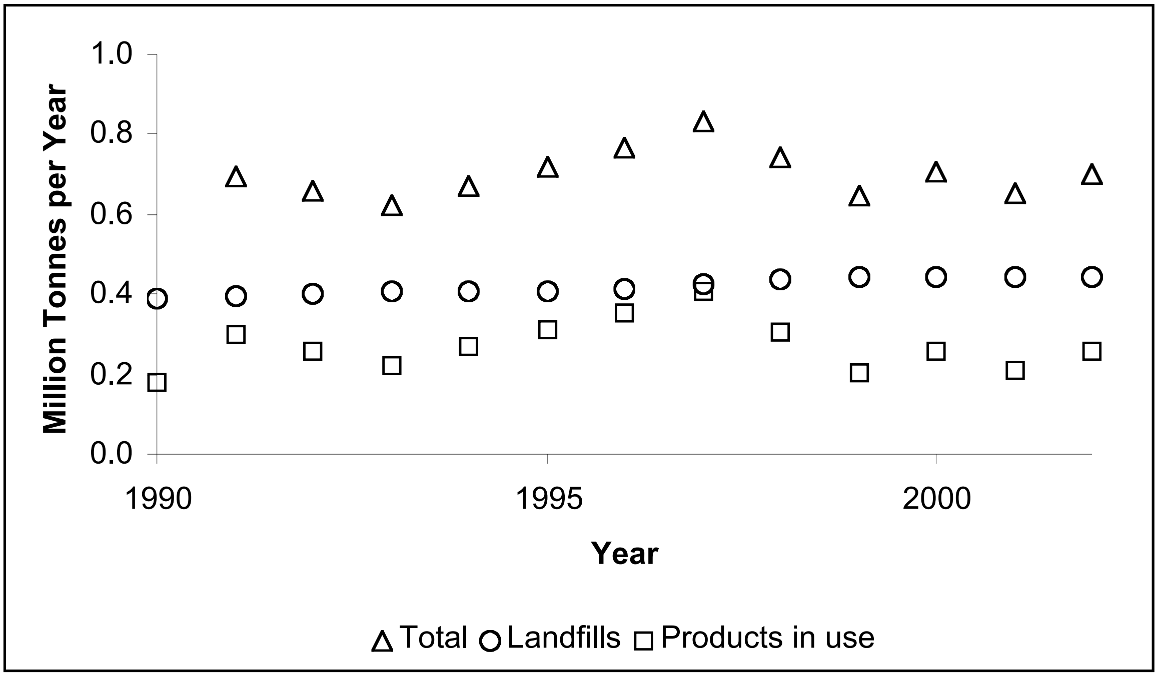


Figure 2. Estimates of carbon harvested in Maine, including exports. Symbols represent direct conversions from cords as reported in the Wood Processor Reports, and lines represent interpolation for intervening years.

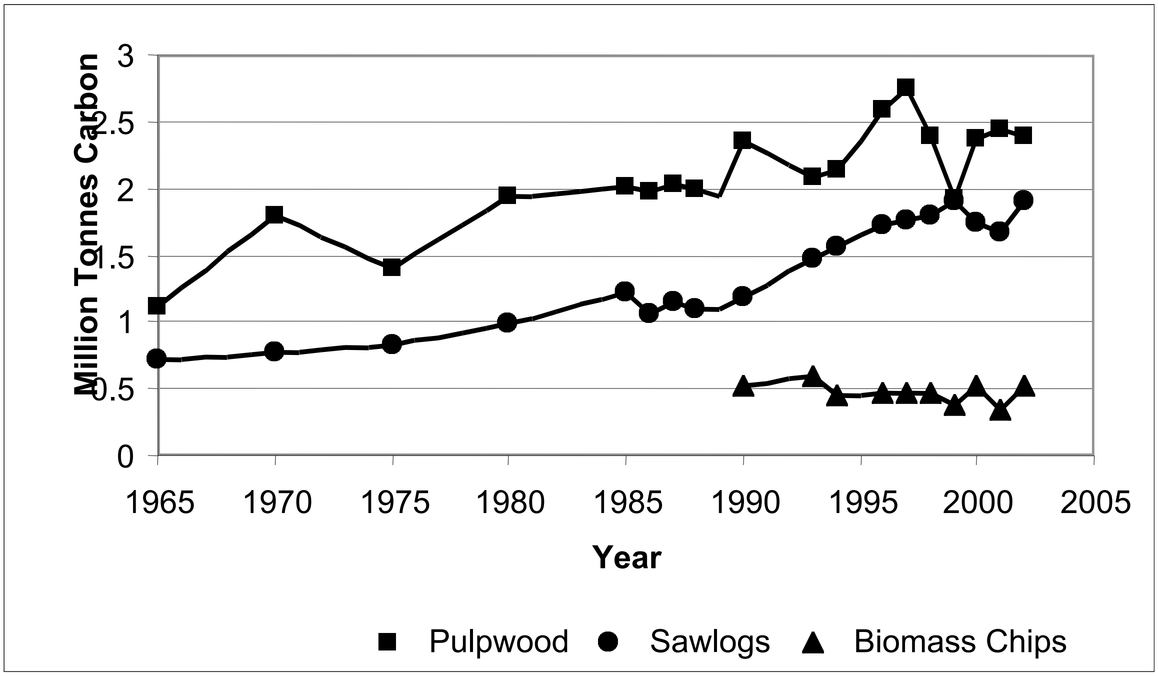
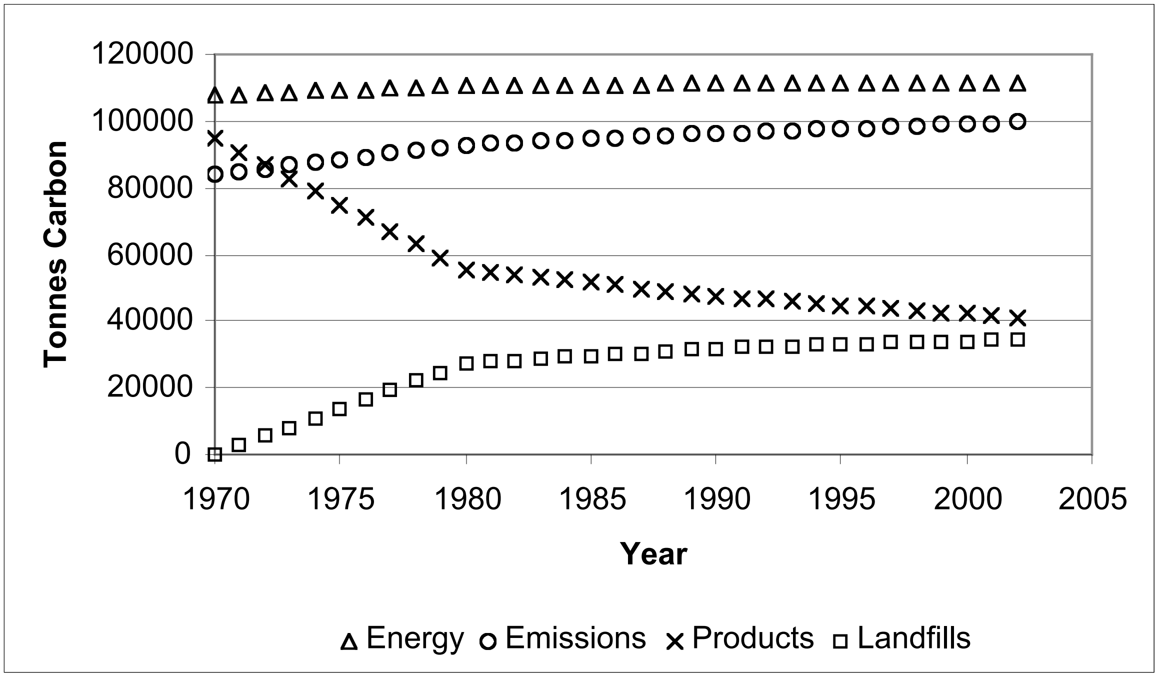


Figure 3. Allocation of carbon in softwood saw timber harvested and processed in Maine over a 32-year interval following harvest in 1970.



Appendix 2 – Forest Management Options Proposals

Maine Forest Service, Environment Northeast:

In response to the memo dated April 22, 2004 from Jack Kartez and Tom Peterson, MFS and ENE propose the following priorities for forest management options. Reference is made to the variables outlined in the Kartez/Peterson memo: type of action; forest type; landownership type; levels and timing; and type of biomass use.

1. **Early Commercial Thinning (ECT).** Apply to all forest types and all landowner classes. Over the next 5 years, treat 50% of the 400,000 acres estimated to be available for ECT. Treat an additional 50% of a new subset of 400,000 acres over the subsequent 5-year period. Estimated Forest Product Output: 20% durable wood products; 60% pulp/OSB ("oriented strand board"), and 20% biomass energy.

2. **More regular, lighter harvesting.** Apply to all forest types and all landowner classes. Goal: capture 50% of current decay on forest floors within 10 years. This would yield approximately 2 cubic feet of wood per acre per year. Estimated Forest Product Output: 45% saw logs; 48% pulpwood and 7% biomass chips (the average mix of the reported harvest of forest products over the past 7 years).

3. **Increased Stocking**. This measure focuses on increasing overall stand stocking, by management practices that promote current Poorly Stocked Stands (10% - 34% stocked) into Moderately Stocked Class Stands (35% - 64% stocked).

4. **Active management to maintain and increase the softwood component of forest stands.** Two million acres of spruce-fir forests, predominately located in northern Maine, transitioned from a softwood forest type to a hardwood forest type as a combined result of the spruce budworm epidemic in the 1970's and 1980's and subsequent salvage harvesting. Softwood Forest types have soil carbon sequestration rates significantly higher than for hardwood forests (for example, the Spruce-Fir forest type group has an associated value of 193 tons of organic carbon tons/hectare, compared to an associated value of 140 for the maple/beech/birch forest type group). Implementing a structured conversion process back to an assignment as a softwood forest type will increase the soil sequestration values of a substantial portion of Maine timberlands. Goal: transition 85% of 2 million acres currently classified as a hardwood forest type to a softwood forest type by 2020.

J. D. Irving, Limited

(1) Increase mixed plantation forestry on the industrial forest
in Maine to ensure prompt regeneration of harvest sites and to increase

Spruce stocking (and reduce fir), increase growth rates and improve quality of the spruce-fir forest type. Planted species will include genetically Improved black, red, white and Norway spruce that will improve volume growth rates from 12 to 20%. Investigate the impact of doubling and tripling the present annual planting levels for the state. Plantation rotations of 50 - 60 years will include 1 to 3 commercial thinnings (25-30% volume removals) beginning at 25 to 30 years of age, that will serve to capture mortality, manage density and provide a source for solid wood products and biomass for electricity generation. Harvesting methods will involve processing the trees at the stump (cut, delimb and slash), leaving branches, tops, leaves and cull in the woods providing a source of forest floor carbon.

(2) Increase density management of the naturally regenerating Spruce-fir forest to promote continued vigorous growth of the desired crop trees on all forest ownerships. Treatments over the life of the stand will Include pre-commercial and commercial thinning harvests. Early treatments will favor the retention of longer-lived spruce species over fir. Investigate increasing the levels of precommercial thinning to 90% of The stands that would be eligible for this treatment. Commercial thinning In these stands would be limited to the estimated 40% of the stands that Would have a high enough spruce content to warrant the treatment. Harvesting methods will involve processing the trees at the stump (cut, delimb And slash), leaving branches, tops, leaves and cull in the woods providing A source of forest floor carbon. Rotations for stand undergoing this Option would be similar to plantations (50 -60 years), but would not reach the Same volume levels.

(3) Increase the use of selective harvest methods in the uneven aged management of the tolerant hardwood forest with the goal of improving the quality of the trees and maintaining a continuous presence of large trees in the stand. By improving the quality we will increase the percentage of future harvests that will go into long lasting solid wood products, sequestering more carbon. The lighter (25-35%) harvests will reduce the impact to the forest floor and soil carbon pools. Stands would be re-entered on a 30-35 year cycle. Not all northern (tolerant) hardwood stands would be suitable for this type of treatment, but we could assume that we might be able to manage 40% of them over the next 30 years.

NRCM/Environmental Defense (late submission):

"Increase harvest rotation by 50 percent by 2010 and 100 percent by 2020 in Spruce/fir forests and by 50 percent in 2010 and 25 percent in 2020 in Hardwood forests on industrial, private non-industrial, and public lands."

Appendix 3 – ISO New England Marginal Electricity Displacement Factors

Displaced CO_2 rates (lb/Mwh)

Year	Rate
2002	1000
2003	1000
2004	960
2005	930
2006	940
2007	940
2008	950
2009	950
2010	950
2011	950
2012	950
2013	950
2014	950
2015	950
2016	950
2017	950
2018	950
2019	950
2020	950

Appendix 4 – Reforestation, Or Regrowth After Harvest, USFS

List of tables

R1. Northeast, Aspen & Birch

Age	Mean Volume	Mean Carbon Density						
		Live tree	Standing dead tree	Under-story	Down dead wood	Forest floor	Soil organic	Total nonsoil
Years	m^3/ha	Metric tons carbon per hectare						
0	0	0.0	0.0	1.0	10.5	10.2	237	22
5	0	16.0	0.5	2.2	7.4	7.5	237	33
15	13	22.5	1.5	2.1	4.4	6.0	237	37
25	34	32.9	2.2	2.1	3.7	6.5	237	47
35	58	45.0	2.9	2.1	4.0	7.5	237	61
45	85	57.7	3.5	2.1	4.7	8.5	237	76
55	112	70.8	4.2	2.1	5.6	9.3	237	92
65	142	84.4	4.8	2.0	6.6	10.1	237	108
75	173	98.3	5.4	2.0	7.7	10.7	237	124
85	205	112.7	5.9	2.0	8.8	11.3	237	141
95	239	127.4	6.3	2.0	9.9	11.8	237	157
105	274	142.4	6.7	2.0	11.1	12.2	237	174
115	311	157.6	7.1	2.0	12.3	12.5	237	191
125	350	173.1	7.3	2.0	13.5	12.9	237	209
135	390	188.7	7.5	2.0	14.7	13.2	237	226
145	432	204.5	7.7	2.0	15.9	13.4	237	243
155	475	220.3	7.8	2.0	17.1	13.7	237	261
165	520	236.3	7.8	2.0	18.4	13.9	237	278
175	566	252.2	7.8	2.0	19.6	14.1	237	296

R2. Northeast, Elm, Ash, Red Maple

Age	Mean Volume	Mean Carbon Density						
		Live tree	Standing dead tree	Under-story	Down dead wood	Forest floor	Soil organic	Total nonsoil
Years	m^3/ha	Metric tons carbon per hectare						
0	0	0.0	0.0	0.8	10.9	27.7	134	39

5	0	22.1	0.8	1.9	7.8	20.3	134	53
15	31	38.2	2.4	1.8	5.4	16.3	134	64
25	62	54.4	3.5	1.8	5.0	17.6	134	82
35	97	72.7	4.6	1.7	5.7	20.3	134	105
45	133	90.7	5.6	1.7	6.7	23.0	134	128
55	166	107.2	6.4	1.7	7.7	25.3	134	148
65	196	122.4	7.0	1.7	8.7	27.4	134	167
75	225	136.1	7.2	1.7	9.7	29.2	134	184
85	251	148.6	7.2	1.6	10.5	30.7	134	199
95	274	159.9	7.0	1.6	11.3	32.0	134	212
105	296	169.9	6.7	1.6	12.0	33.1	134	223
115	314	178.7	6.2	1.6	12.7	34.2	134	233
125	331	186.4	5.7	1.6	13.2	35.1	134	242
135	345	192.9	5.3	1.6	13.7	35.9	134	249
145	357	198.3	4.9	1.6	14.0	36.6	134	255
155	367	202.6	4.5	1.6	14.3	37.3	134	260
165	374	205.9	4.3	1.6	14.6	37.9	134	264
175	378	208.0	4.1	1.6	14.7	38.4	134	267

R3. Northeast, Maple, Beech, Birch

Age	Mean Volume	Mean Carbon Density						
		Live tree	Standing dead tree	Under-story	Down dead wood	Forest floor	Soil organic	Total nonsoil
Years	m^3/ha	Metric tons carbon per hectare						
0	0	0.0	0.0	0.8	9.9	27.7	140	38
5	0	22.1	0.8	1.9	7.1	20.3	140	52
15	28	36.9	2.4	1.8	5.0	16.3	140	62
25	58	52.6	3.4	1.8	4.8	17.6	140	80
35	90	68.9	4.4	1.7	5.3	20.3	140	101
45	119	83.9	5.3	1.7	6.1	23.0	140	120
55	147	97.7	6.0	1.7	7.0	25.3	140	138
65	172	110.4	6.6	1.7	7.9	27.4	140	154
75	196	122.0	7.0	1.7	8.7	29.2	140	168
85	217	132.5	7.2	1.7	9.4	30.7	140	181
95	237	141.9	7.3	1.7	10.1	32.0	140	193
105	254	150.3	7.2	1.6	10.6	33.1	140	203
115	270	157.7	7.1	1.6	11.2	34.2	140	212
125	283	164.1	6.9	1.6	11.6	35.1	140	219
135	295	169.4	6.7	1.6	12.0	35.9	140	226
145	304	173.9	6.5	1.6	12.3	36.6	140	231
155	312	177.4	6.3	1.6	12.6	37.3	140	235
165	317	180.0	6.1	1.6	12.7	37.9	140	238
175	321	181.6	6.0	1.6	12.9	38.4	140	241

R4. Northeast, Oak & Hickory

Age	Mean Volume	Mean Carbon Density

		Live tree	Standing dead tree	Under-story	Down dead wood	Forest floor	Soil organic	Total nonsoil
Years	m³/ha	Metric tons carbon per hectare						
0	0	0.0	0.0	0.9	12.9	8.2	85	22
5	0	22.2	1.0	2.0	9.1	5.7	85	40
15	55	52.0	3.0	1.9	6.9	4.1	85	68
25	96	74.1	4.0	1.8	6.5	4.5	85	91
35	135	94.8	4.7	1.8	7.1	5.3	85	114
45	173	114.4	5.1	1.8	8.1	6.3	85	136
55	210	132.7	5.1	1.8	9.2	7.3	85	156
65	244	149.9	5.0	1.8	10.3	8.1	85	175
75	277	166.0	4.7	1.8	11.4	8.9	85	193
85	309	181.1	4.2	1.8	12.4	9.7	85	209
95	339	195.3	3.8	1.8	13.4	10.3	85	224
105	367	208.4	3.3	1.8	14.3	10.9	85	239
115	394	220.6	2.9	1.7	15.1	11.5	85	252
125	419	232.0	2.4	1.7	15.9	12.0	85	264
135	442	242.4	2.1	1.7	16.6	12.5	85	275
145	464	252.1	1.8	1.7	17.2	12.9	85	286
155	484	260.9	1.5	1.7	17.8	13.3	85	295
165	502	268.9	1.3	1.7	18.4	13.7	85	304
175	519	276.2	1.1	1.7	18.9	14.1	85	312

R5. Northeast, Oak & Pine

Age	Mean Volume	Mean Carbon Density						
		Live tree	Standing dead tree	Under-story	Down dead wood	Forest floor	Soil organic	Total nonsoil
Years	m³/ha	Metric tons carbon per hectare						
0	0	0.0	0.0	1.1	8.2	29.7	82	39
5	0	18.6	0.8	3.6	6.5	20.2	82	50
15	37	37.3	2.3	3.0	5.3	15.3	82	63
25	71	54.6	3.3	2.8	5.1	17.1	82	83
35	103	70.4	4.2	2.6	5.3	20.3	82	103
45	133	84.9	4.8	2.5	5.8	23.6	82	122
55	161	98.1	5.3	2.4	6.3	26.6	82	139
65	187	110.2	5.6	2.4	6.9	29.3	82	154
75	210	121.0	5.7	2.3	7.5	31.6	82	168
85	232	130.7	5.7	2.3	8.1	33.6	82	180
95	251	139.4	5.5	2.2	8.6	35.4	82	191
105	268	147.0	5.4	2.2	9.0	37.0	82	201
115	283	153.5	5.2	2.2	9.4	38.4	82	209
125	295	159.1	4.9	2.2	9.7	39.7	82	216
135	306	163.7	4.8	2.1	10.0	40.9	82	222
145	314	167.3	4.6	2.1	10.2	42.0	82	226
155	321	170.0	4.5	2.1	10.4	43.0	82	230
165	325	171.7	4.4	2.1	10.5	43.9	82	233
175	327	172.5	4.3	2.1	10.6	44.7	82	234

R6. Northeast, Spruce & Balsam Fir

Age	Mean Volume	Mean Carbon Density						
		Live tree	Standing dead tree	Under-story	Down dead wood	Forest floor	Soil organic	Total nonsoil
Years	m^3/ha	Metric tons carbon per hectare						
0	0	0.0	0.0	0.6	9.6	33.7	193	44
5	0	19.3	1.0	1.6	7.7	23.6	193	53
15	11	24.3	3.1	1.5	5.6	18.6	193	53
25	29	31.9	4.0	1.5	4.9	20.7	193	63
35	52	41.5	5.1	1.5	4.9	24.2	193	77
45	77	52.0	6.2	1.4	5.4	27.7	193	93
55	103	62.6	7.1	1.4	6.1	30.7	193	108
65	126	72.2	7.8	1.4	6.9	33.3	193	122
75	149	81.3	8.2	1.3	7.6	35.5	193	134
85	171	89.9	8.6	1.3	8.4	37.4	193	146
95	192	97.9	8.7	1.3	9.1	39.1	193	156
105	211	105.4	8.8	1.3	9.7	40.6	193	166
115	230	112.3	8.8	1.3	10.4	41.9	193	175
125	247	118.9	8.7	1.3	11.0	43.0	193	183
135	264	125.0	8.6	1.3	11.5	44.0	193	190
145	279	130.7	8.4	1.3	12.1	45.0	193	197
155	294	136.0	8.2	1.3	12.5	45.8	193	204
165	310	142.0	7.9	1.3	13.1	46.6	193	211
175	326	147.7	7.6	1.2	13.6	47.3	193	217

R7. Northeast, White, Red & Jack Pine

Age	Mean Volume	Mean Carbon Density						
		Live tree	Standing dead tree	Under-story	Down dead wood	Forest floor	Soil organic	Total nonsoil
Years	m^3/ha	Metric tons carbon per hectare						
0	0	0.0	0.0	0.8	5.9	13.8	196	20
5	0	19.9	0.5	1.9	4.7	10.7	196	38
15	30	33.1	1.5	1.8	3.9	9.4	196	50
25	54	43.6	2.0	1.8	3.6	10.1	196	61
35	78	53.6	2.5	1.7	3.6	11.2	196	73
45	101	63.1	2.9	1.7	3.9	12.2	196	84
55	123	72.2	3.3	1.7	4.2	13.1	196	94
65	142	80.2	3.7	1.6	4.5	13.7	196	104
75	161	87.7	4.0	1.6	4.9	14.2	196	112
85	178	94.7	4.3	1.6	5.3	14.7	196	121
95	195	101.1	4.5	1.6	5.6	15.0	196	128
105	210	107.1	4.8	1.6	5.9	15.4	196	135
115	224	112.5	4.9	1.6	6.2	15.6	196	141
125	237	117.5	5.1	1.6	6.5	15.9	196	146
135	249	122.1	5.2	1.6	6.7	16.1	196	152
145	260	126.2	5.3	1.6	7.0	16.2	196	156
155	270	130.0	5.3	1.5	7.2	16.4	196	160

165	282	134.3	5.4	1.5	7.4	16.5	196	165
175	293	138.5	5.4	1.5	7.6	16.7	196	170

Appendix 5 - Biomass Conversion Factors

Maine Forest Service:

Conversions:

1 cord	= 5,000 pounds of biomass chips / 2,000 pounds
	= 2.5 short tons green weight X 0.5 to remove moisture
	= 1.25 short tons dry weight X 0.5 carbon share of weight
	= 0.625 short tons of carbon X 0.907148
	= 0.567 metric tons of carbon X 3.667
	= 2.079 metric tons of Carbon Dioxide Equivalent

If I one is interested in the all the timber components that might be captured in standing inventory then 1 cord = 3.17 Metric Tons of Carbon Dioxide Equivalent (MTCO2E).

Beech, Birch, Oak, and Pine at Kiln dried moisture contents (~12%) are around 7,500 BTU per pound.

Average annual harvest is on the order of 500 - 600,000 acres per year, so capturing an additional 2 cubic feet on these acres will result in an additional annual harvest of 12,000 cords of wood products.

Tellus Institute:

Woody material content	17.0 Mbtu/dry ton (source, Michael Lazarus)
Ag material content	15.0 Mbtu/dry ton (source, Michael Lazarus)

Heat rates

co-firing	11550 BTU/kWh
Biomass GCC	8911 BTU/kWh

Appendix 6 – Initial List of Mitigation Options

POTENTIAL AGRICULTURE AND FORESTRY MITIGATION OPTIONS		
Original "Long" Option List December 2003		**Current Working Group Proposal & Status (see Key)**
Key: R-Recommended by Consensus; Dropped – little potential; Not Yet Reviewed * Identified as a potential priority at the December SAG meeting. ? Identified as a potential priority at the December SAG meeting, pending resolution of key questions about the policy definition and prospects.		
AF 1	**Agriculture: Production of Fuels and Electricity**	
AF 1.1	**Ethanol production** – Incentives to grow crops and/or create ethanol (for fuel or fuel additive).	**Dropped**
AF 1.2	**Biodiesel production** – Incentives to grow crops and/or create biodiesel (for fuel or fuel additive).	**Biodiesel Fuel for Farm Equipment R**
AF 1.3	*? **Install Manure Digesters** - Install anaerobic digesters to process agriculture manure into energy (e.g., heat, hot water, or electricity). Also produces digested manure, which can contain more valuable nitrogen for crop production.	**Dropped**
AF 1.4	* **Ag Biomass Feedstocks for Electricity** – Incentives to grow crops or use crop waste for use as a fuel or for co-firing with fossil fuels.	**Dropped**
AF 1.5	**On-Farm Wind Production** – Support the development of wind resources on farms (often smaller size installations than commercial wind farms).	**Dropped**
AF 2	**Agriculture: Fertilizer, Manure, and Livestock Management**	
AF 2.1	* ***Nutrient Management*** - Improve	

	efficiency of fertilizer use. A portion of nitrogen applied to the soil is subsequently emitted as N_2O (a GHG); therefore, a reduction in the quantity of fertilizer applied can reduce N_2O emissions.	**Nutrient Management** **R**
AF 2.1.a	**Reduce non-farm fertilizer use** – See 2.1	**Incorporated in AF 2.1**
AF 2.2	***Manure Management*** – Improve the handling of manure to reduce methane and N_2O.	**Dropped**
AF 2.2.a	**Composting** – Compost manure instead of alternative handling techniques such as slurry or stockpiling.	**Dropped**
AF 2.2.b	**Change feedstocks** – Alter the feed to animals to lower the manure's nitrogen levels.	**Dropped**
AF 2.2.c	*? **Install Manure Digesters** – Capture methane for use as an energy source (see 1.3 above)	**Dropped**
AF 2.3	**Livestock Management** – Alter livestock management practices to reduce methane and N_2O emissions.	**Dropped**
AF 3	**Agriculture: Soil Carbon Sequestration** – The following are some measures that increase the amount of carbon contained in soil or prevent carbon from being released from soil.	
AF 3.1	* **Conservation tillage/No-till** – Practices that utilize less carbon can increase the carbon content of soil; therefore, sequestering carbon from the atmosphere.	**Renamed "Build Soil Carbon--Organic Matter"; Includes Organic Farming** **R**
AF 3.2	**Reduce summer fallow** – Reducing the amount of land left fallow (vegetation free) can increase the soil carbon content and reduce N_2O emissions.	**Dropped**
AF 3.3	* **Increase cover crops** – Increasing the use of cover crops can increase the soil carbon content and potentially increase the nitrogen content of soil and reduce fertilizer need (see 2.1).	**Increase Cover Crops** **R**
AF 3.4	**Improve water & nutrient use** - The water content of soil affects the potential for GHG emissions.	**Dropped**
AF	**Rotational grazing/Improve grazing**	**Dropped**

3.5	**crops**	
AF 3.6	**Converting land to grassland, forests, or wetland** – Converting farmland to other types of land can lead to increased sequestration of carbon from the atmosphere.	**Dropped**
AF 3.7	* ***Agricultural Land Preservation*** – Preservation of agricultural land can retain ability of land to sequester carbon from the atmosphere.	**Agricultural Land Protection (renamed)** **R**
AF 3.7.a	**Promote "no net loss" of agricultural land**	**Incorporated in 3.7**
	AF 4 **Agriculture: Energy Use**	
AF 4.1	* **Conservation tillage/No-till** – Reduces farm fuel consumption and related emissions as well as increasing the amount of carbon sequestered in soil.	**Incorporated in 3.1**
AF 4.2	*! Use biodiesel or ethanol blended fuel in farm equipment, and/or hybrid-electric engines –tax credit incentive	**Incorporated in 1.2**
AF 4.3	* **Nutrient Reduction** – Using less fertilizer can reduce the related production, transportation, and application emissions.	Same as AF 2.1
AF 4.4	*! **Organic Farming** – Utilizing organic farming techniques can reduce the on-farm energy uses (e.g., reduced tractor use) by reduced tillage (see 3.1) and off-farm energy (e.g., reduced transportation of fertilizer and pesticides).- growing interest.	**Organic Farming (incorporated into 3.1 Build Soil Carbon)** **R**
AF 4.5	* **Support Local Farming/Buy Local** - Reduces emissions associated with the transport of agricultural products.	**Support Local Farming/Buy Local** **R**
	AF 5*! **Forest carbon sequestration**	
AF 5.1	**Afforestation** (1st time planting) **and Reforestation** –replanting previously forested area **(in-state)**	**Dropped**

AF 5.2	**Forest Management** - Forest management programs to protect the productivity of existing forest and reduce or prevent the loss of forest due to fires, storms, diseases, or pests; implementation of reduced-impact logging regimes to minimize the damage to non-harvested trees; actions to increase biomass stocks through activities such as planting, thinning, and fertilizer application; and prolonged rotation periods in harvested forests.	**a Early Commercial Thinning – Not Yet Reviewed** **b More Regular, Lighter Harvests – Not Yet Reviewed** **c Increased Stocking -- R** **d Increased Stocking Of Genetically Improved Species (R - incorporated into 5.2c)** **e Active Management To Maintain And Increase The Softwood Component Of Forest Stands – Not Yet Reviewed** **f Lengthened Harvest Rotation – Not Yet Discussed/Analyzed**
AF 5.3	* ***Urban Forestry*** **-** Planting urban trees to reduce the consumption of energy for heating and cooling buildings, thereby helping to avoid fossil fuel emissions in the energy sector. Also increases the carbon stock of non-forest land.	**Dropped**
AF 5.3.a	**Support tree planting on residential properties**	**Dropped**
AF 5.4	***Forest preservation*** **-** Preservation of forestland avoids the loss of carbon sequestered in forestlands.	**Forest Land Protection R**
AF 5.4.a	**Support "no net loss" of existing forests**	**Incorporated in 5.4**
AF 5.5	***Promote Use of Wood Products*** **-** Durable wood products/construction sequesters carbon for long periods of time, as long as the timber is produced as a result of certified sustainable harvesting practices. Wood products/construction is also much less energy-intensive than other materials.	**Increased Use Of Wood Products – Not Yet Reviewed**
AF 5.5.a	**State procurement of locally grown wood products** – Incentives or requirements for state government procurement.	**Dropped**
AF 6	**Forestry: Energy Production**	
AF	* **Forest products biomass**	

6.1	**feedstocks for electricity -** Incentives to use forest products or forest waste for use as a fuel or for co-firing with fossil fuels.	**Biomass Electricity Feedstocks – Not Yet Reviewed**
AF 6.2	**Improve efficiency of wood burning stoves –** Using more efficient wood burning stoves can reduce the need for fuel by increasing the efficiency of burning.	**Dropped**
AF 7	**Cross-Cutting**	
AF 7.1	* **Carbon Offsets from Ag/For Activities (in state and out of state) –** Create a program to reduce GHG emissions from sources not covered by specific recommendations from the Stakeholders and outside the State or the country (i.e., "offsets").	**Referred to SAG**