Maine Forest Service Assessment of Sustainable Biomass Availability

July 17, 2008

Absolute Supply is not the Issue. Improving Utilization and Silviculture While Keeping Costs Low Are

Executive Summary

Maine Forest Service (MFS) was asked by the Governor's Wood-to-Energy (WTE) Task Force to develop an estimate of wood supply to support the emerging wood pellet industry as well as current and other potential new users.

Key Finding – An analysis of highly reliable existing information on Maine's forest resources indicates that, **with improvements in forest utilization and silviculture, Maine's forests are capable of producing substantially more wood than they do currently,** while at the same time retaining the number of den trees, snags, large dead logs, and limbs and tops needed to maintain or improve site fertility, wildlife populations, and biodiversity. Increased imports of wood from states nearby are also possible.

- MFS developed its estimate of available wood taking into account concerns for **soil productivity, water quality protection, and biodiversity** based on Maine's "benchmarks of sustainability." As a result, the maximum quantities available were discounted significantly.
- Based on this analysis, MFS identified four potential sources of "new" wood:
  1. **Improved harvest/utilization of wood from currently harvested stands** – Considerable residual material is left on harvest sites that could provide additional biomass (not just limbs and tops, but previously unmerchantable trees as well). MFS estimates that, **if these opportunities are pursued, an additional 3.8 million green tons of wood could be supplied annually**, of which 1.8 million green tons are of a quality for making premium grade wood pellets.
  2. **Harvest in stands not previously considered commercially viable** – Thinning overstocked stands could provide several million green tons of wood of varying quality. These operations could provide an additional 1.4 million tons of wood per year.
  3. **Increasing productivity (and allowable cut) through more intensive management** – Investing in intensive silviculture on the most productive sites could double the potential growth on these sites and yield approximately 600,000 tons per year of additional sustainable annual harvest.
  4. **Increased imports from outside Maine's borders** – Wood flows back and forth across the region. Neighboring states have growth rates well in excess of harvest; opportunities abound to import high-quality wood to support the emerging pellet industry. The amounts of surplus plus pulpwood grade material available from just 2 neighboring states is approximately 3.8 million tons.

All told, if all these opportunities are pursued and prove to be financially feasible, the amount of wood available for energy purposes could be increased by approximately 9.7 million tons per year. This represents a 50-60% increase over current levels of harvest.

NOTE: **Realizing the opportunities from these four potential sources requires operating beyond "business-as-usual" in the Maine woods.** The Maine's forest industry currently harvests 15-17.5 million green tons annually. Harvest and growth under current practices are in balance at 1:1. We have specifically not determined the economic feasibility of extracting, transporting, and utilizing these potential sources of supply. Our analysis only deals with potential supply. Constraining factors include logging capacity, need for new logging technologies to harvest smaller material, fuel costs (and distance to some markets), and new market entrants competing directly with existing users for the same supply base.

The Analysis

Based on annual harvest reports from Maine's forest landowners (and substantiated by Forest Inventory and Analysis [FIA] removal data), timber harvesting currently occurs on about 530,000 acres annually, and generates 15 to 17.5 million green tons of product (sawlogs, pulp, biomass chips, firewood) annually. This level of harvest has been relatively stable for the past 21 years. During this period, the inventory of merchantable trees on Maine timberlands has also remained stable – indicating that, as a statewide average, current harvest levels of what is currently considered merchantable are sustainable.

If we assume that current harvest will remain stable and committed to existing markets, then any expanding biomass-using industry would have to access new sources. While not differentiating between hardwood and softwood components or determining the economic feasibility of extracting, transporting and utilizing these potential sources of biomass, this report shows that Maine's forest products industry could access additional biomass, mostly low grade (pulpwood, pellet quality wood, biomass chips) from four potential sources:

1. Improved harvest/utilization of wood from currently harvested stands.
2. Harvest in stands not previously considered commercially viable.
3. Increasing productivity (and allowable cut) through more intensive management.
4. Increased imports from outside Maine's borders.

1. Improved Harvest/Utilization of Wood From Currently Harvested Stands

Current harvest practices leave considerable residual material on site after harvest (limbs, tops, snags, cull trees, and trees that should be removed for proper spacing, etc.). At little additional cost, some of this material could be extracted while the underlying harvest was being conducted and then utilized for its highest and best use.

If all residual, above-ground woody biomass were removed on these harvest sites, it could provide an additional 11.58 million green tons of biomass annually. However, this estimate must be constrained to account for biodiversity conservation measures. Therefore, a more realistic figure is derived by discounting this upper bound to maintain a minimum population of existing dead trees and large living trees, and restrict removal of saplings to those in the skid trails. With these deductions, we estimate that stands currently harvested could yield an additional 3.8 million green tons of residuals annually, of which 1.8 million green tons are of sufficient quality to be used for production of premium pellets.

2. Harvest in Stands not Previously Considered Commercially Viable

Analysis conducted as part of the federal "Billion Ton Report" (BTR) estimates that there are 13.1 million acres of "overstocked" stands in Maine that are viable candidates for thinning. This acreage matches that occupied by "fully stocked" and "overstocked" stands as defined by FIA stocking algorithms in 1995. Treating this acreage over a 30-year rotation would result in an annual thinning of approximately 437,000 acres. The authors of the BTR estimated that such thinnings could provide 11.9 million green tons annually of "merchantable" material and 5.1 million green tons of residuals that could be used as biomass chips.

To assure that production attainable from this source was sustainable and additional to current harvests, MFS took the BTR results and further adjusted the acreage annually available for thinning by discounting for the current average annual harvest on FIA-defined fully stocked and overstocked stands. This reduced the average candidate acres for thinning to 37,600 acres per year. Using BTR extraction estimates, this acreage could generate 1.0 million green tons of "merchantable" material and 0.4 million green tons of residuals, annually. This production would be additional to existing harvest. This is a sustainable addition to current harvest levels

3. Increasing Productivity (and Allowable Cut) Through More Intensive Management

Currently, Maine's timberlands grow approximately 1 green ton (0.4 cords) per acre of merchantable material per year. The University of Maine and others (e.g., Seymour, Greenwood) have conducted studies that estimate the potential increased productivity which could be realized through intensive forest management (site preparation, planting, competition control, thinning). Projected increases range from 88% to 273% (depending on the level of intensification practiced). Even if such intensive management was focused on only the most productive sites, approximately 450,000 acres of forest lie within in the top quartile of productivity. A twofold increase in growth on such sites over time could translate into approximately 0.6 million green tons per year of additional sustainable harvest of which 0.4 million would be "merchantable" and 0.2 million would be residue.

4. Increased Imports from Outside Maine's Borders

Maine imports a net of 350,000 green tons per year of biomass chips from neighboring jurisdictions. Current import levels provide strong evidence of the existence of commercial relationships and infrastructure to access and transport additional resources. Import is a viable option for increasing raw material supplies.

All neighboring states have a surplus growth/harvest ratio. Accessing just the surplus pulpwood grade growth from New Hampshire and Massachusetts (Maine's nearest neighbor states) potentially could provide up to 3.83 million green tons of premium pellet grade material. Potentially, there is also additional tonnage of associated biomass chip grade material available that is not currently being accessed.

Table 1. Total Additional Available Biomass

	Million Green Tons		
Source	**Pellet Quality Feedstock**	**Biomass Residues**	**Total Available**
1 - Additional Utilization from Existing Harvests	1.79	2.01	3.8
2 - Fuel Treatment Thinnings	1.02	0.44	1.47
3 - Intensive Management	0.42	0.18	0.61
4 - Import Pulp Quality from Tier 1 States (NH and MA)	3.83		3.83
Grand Total	**7.06**	**2.63**	**9.69**
Note: Columns and rows may not add up due to rounding			

In total, Sources #1, 2, and 4 identified above could provide 9.0 million green tons of biomass annually (70% of which would be potential premium pellet stock). Of this, 5.2 million green tons come from increased sustainable harvest in Maine; the rest comes from similar removals from neighboring states. In either case, such increases could be realized relatively rapidly and would amount to a 50-60% increase over the current total harvest volumes.

The return from intensified management (Source #3) would be more delayed but could, after 25 years, realistically add an additional 0.61 million green tons annually.

In summary, Maine and the surrounding region have considerable opportunity for increased harvest and utilization of native biomass. Raw supply is not a constraint on potential industrial expansion.

Appendix 1. Additional Sustainable Biomass Extraction from Current Maine Harvests.

To: Alec Giffen
From: Dave Struble
Date: May 1, 2008
Re: Assessment of Sustainable Biomass Availability

Alec- Per your instruction, I have investigated various datasets and approaches to generate an estimate of available resource to support “biomass to energy” initiatives. I settled on using the three most current state-level estimations of biomass availability to generate an average value. Where these three independent assessments generate very similar results (standard deviation down around 8% of the mean), I think we have a very robust/defensible estimate of additional underutilized resource streams that could be practically accessed to provide a sustainable source material. I have attempted to assure that this analysis does not present an overly optimistic assessment of availability. Although the results depart greatly from some anecdotal accounts of local conditions, I believe that as a calculated statewide average, they are a good approximation of the current overall situation.

Caveats:

- No attempt was made to factor in location of source and potential market. This could be a huge factor regarding what actually comes to market.
- The assumptions regarding a balanced growth to harvest ratio are based on current conditions. There are many stands where current measured growth rates could increase markedly as trees reach merchantability. Conversely, impacts of pest populations exacerbated by climate change may largely offset or reverse this anticipated influx.
- No attempt to analyze the effects of competition and possible diversion of resource streams from/to current wood processing facilities.
- Utilization by the current wood processing industry was assumed to be static; this is likely to be a very simplistic assumption.
- Current import/export patterns are assumed to be unaffected by development of new biomass markets (i.e., all increased use would need to come from utilization of residues currently left on site).
- In calculating the final figure for available material, the allowable extraction levels for certain environmentally critical sources of potential biomass were discounted. This was done to assure minimum residual materials were left on site to maintain the health and sustainability of the Maine’s forest resource and associated ecological processes.

Analyses used in constructing the final number:

- “Billion Tons Report” published by Oak Ridge National Laboratory (2005).
- Biomass Availability analysis conducted by Maine Forest Service (2006).
- “Biomass and Biofuels in Maine” report conducted by the University of Maine, Forest Bioproducts Research Initiative and the Margaret Chase Smith Policy Center (2007).

The Billion Tons Report was a national analysis constructed from state-specific 2002 RPA data For the purpose of this comparison, the Maine-specific data were parsed out and utilized. The other two analyses were specifically focused on Maine-based data (2003 FIA for MFS analysis; 2007 RPA for the Biomass/Biofuels Report).

Because the analyses were conducted at slightly different times, the datasets regarding growth and removals differ slightly (i.e., overlapping but different time periods). However, all are predicated on then current growth and removals rates; none make any assumptions regarding possible improved growth/extraction rates resulting from more intensive management practices. And, where Maine’s current level of harvest activities already extract an amount equal to the annual growth (i.e., a balanced growth/removal ratio), no attempt was made to assess potential cost/benefit resulting from additional stand entries and increased removals. For the purposes of this analysis, the only materials considered as potential additions were those that could reasonably be expected to be available on-site during current harvests.

No attempt was made to calculate possible additional material available from surrounding jurisdictions or from municipal waste wood streams.

Results:
Regarding in-woods residues (tops/branches; cull trees; standing dead trees): the three analyses provide similar estimates of total biomass availability

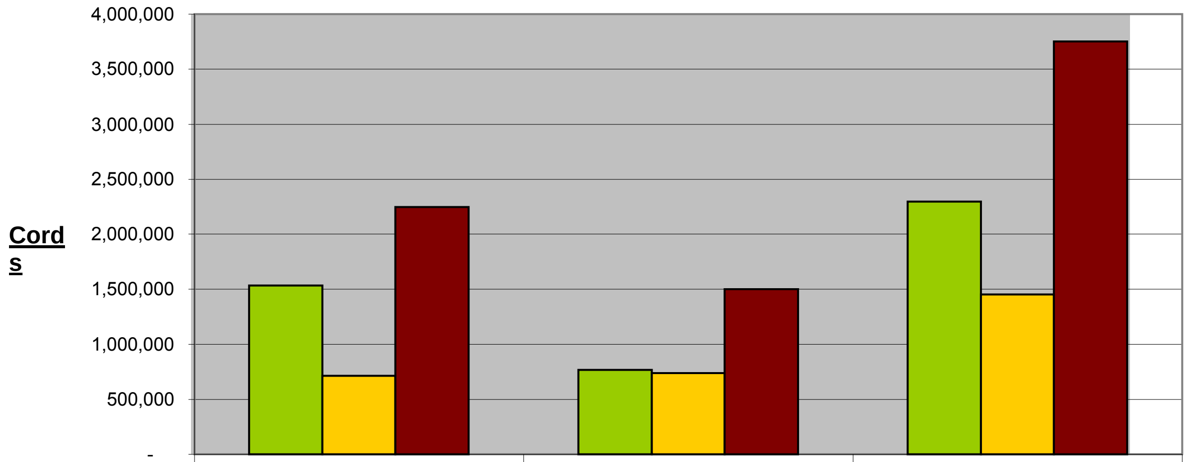
Source Analysis	mm green tons	
Billion Ton Report	4.50	
MFS analysis	5.56	(4.28 if adjusted for current harvest)
UMO Biomass/Biofuels analysis	5.20	
Average	**4.66**	

The table below expands the MFS-generated values to apportion the various components of residues and then discount the individual figures to allow for materials that should be left on site (e.g., tops in skid trails; minimum numbers of den trees). Additionally, this analysis assumes that during harvest the saplings that occupy the skid trails and are being destroyed during harvest are also available to be merchandised.

	million green tons		million green tons		million green tons
	Initial Biomass Vol.	Resource Retained	Harvest Area Retained Vol	Resource Removed	Harvest Area Extracted Vol.
Branches & Tops	2.68	33%	0.88	67%	1.80
Cull Trees 5.0 - 12.9" DBH	1.59	0%		100%	1.59
Cull Trees 13.0-14.9" DBH	0.27	25%	0.07	75%	0.20
Cull Trees 15.0"+ DBH	0.57	100%	0.57	0%	
Salvable Dead Trees 5.0"-14.9" DBH	0.4	0%		100%	0.40
Salvable Dead Trees 15.0"+ DBH	0.05	100%	0.05	0%	
Total Residues	5.56		1.57		3.99
Discount for current harvest:					
Avg Biomass Harvest (1996 - 2006)					-1.28
Available Residues					2.71
Saplings	7.3	85%	6.21	15%	1.10
Additional Biomass Harvest Available					**3.80**
note: columns and rows may not add up due to rounding					

Final estimate of additional available biomass chip grade material: 3.80 million green tons. Of this estimate, approximately 1.79 mm green tons (that derived from cull grade bole wood) is estimated to be of sufficient quality to be used in the manufacture of pellets. This number, although very defensible, is a static/trailing estimate. It does not address possible future conditions or predict the amounts of biomass that might be come available under alternative management. If we are to answer those sorts of questions we will need to conduct a full reanalysis of current FIA data to generate computer modeled projections of timber and biomass supply under various future conditions.

Appendix 2 - Excess Annual Net Growth above Current Annual Removals from Tier 1 States (MA and NH) and Tier 2 States (CT, RI, VT, and selected NY eastern counties)



	Tier 1 States	Tier 2 States	Grand Total
Pulpwood Quality	1,532,827	765,050	2,297,877
Sawlog Quality	714,955	737,710	1,452,665
Total Volume	2,247,782	1,502,760	3,750,543

The above estimates were derived using Mapmaker 3.0, a FIA-Tools and Data online retrieval system (http://fia.fs.fed.us/tools-data/other/default.asp), accessed on January 31, 2008. The most recent inventory data set for each state was selected:

- CT (2005)
- MA (2005)
- NH(2005)
- NY (2003) – for just the counties of Clinton, Columbia, Dutchess, Essex, Putnam, Rensselaer, and Washington
- RI (2005)
- VT (2005)

Attribute of interest selected:

- Net growth of growing stocking stock on timberland (cubic feet)
- Removals of growing stock on timberland (cubic feet)

Difference between the two attributes is excess growth which was partitioned by 2" DBH class to these products:

- Pulpwood Quality
  - 5.0 – 8.9" DBH for Softwood species
  - 5.0 – 10.9" DBH for hardwood species
- Sawlog Quality
  - 9.0"+ DBH for Softwood species
  - 11.0"+ DBH for Hardwood species

Appendix 3 - Fuel Treatment Thinning Analysis and Sustainable Estimates
Maine, 2003 (Revised 05-29-08)

	Million Dry Tons (MMDT)			Million Dry Tons (MMDT)	
Fuel Treatment Thinnings from Timberlands	Public	Private	**Annual Harvest Acreage**	**Total Biomass Residues (1)**	**Total Merchantable Material**
BTR Acreage in Minimally Fully Stocked Stands (1995 FIA) **(C)**			**13,121,200**		
Total Available Fuel Treatment Thinnings Resource	16.1	363			
Accessible Timberland (%)	60%	80%			
Recoverable Volume (%)	85%	85%			
Biomass Residue Fraction (%) **(B)**	30%	30%			70%
Composite Fraction (%) **(A)**	15%	20%			
Biomass Residues Available	2.5	74.0			178.4
Harvest Frequency Rotation (Years)	30	30	30		30
Annual Availability of from Fuel Treatment Thinnings	0.1	2.5	437,373	**2.55**	5.95
***Fuel Treatment Thinnings from Other Forestlands* (2)**					
Total Available Fuel Treatment Thinnings Resource		1.59			
Accessible Timberland (%)		80%			
Recoverable Volume (%)		85%			
Biomass Residue Fraction (%)		90%			
Composite Fraction (%)		61.2%			
Biomass Residues Available		1.0			
Harvest Frequency Rotation (Years)		30			
Annual Availability of Biomass Residues from Fuel Treatment Thinnings		0.0		**0.03**	
Grand Total of Potential Annual Availability from Fuel Treatment Thinnings			**437,373**	**2.58**	**5.95**
1995 - 2003 Average Annual Harvest within Fully/Overstocked Stands (FIA Data)			**399,694**		
Additional Acreage Available for Fuel Treatment Thinnings and Proportioned Additional Volume Availability			**37,679**	**0.22**	**0.51**
Conversion to Million Green Tons ***These volumes are now additive to those derived and estimated from existing harvests***				**0.44**	**1.02**

note: column and row totals may not add up due to rounding

[1] This estimate is derived from the tops and limbs of 7.0"+ DBH trees and total biomass of small diameter trees (<7.0" DBH)

[2] Source is Non-Reserved Unproductive forested areas

[A] Total available estimate is discounted for known efficiencies

[B] BTR Report, page 13, "The conventional forest products fraction assumed is 70 percent, and the resdiue of bioenergy and biobased product fraction is 30%, see footnote [1]

[C] BTR Report, page 10, "The FTE (Fuel Treatment Evaluator) uses a stand density index approach to identify stands that are minimally fully stocked. Stands that exceed this threshold are identified as potential candidates for fuel treatment thinnings

[D] 530,000 acres in current operational harvesting plus 38,000 acres in new fuel treatment thinnings is a total of 568,000 acres harvested per year 568,000 acres divided into 17.1 Million acres of timberland, calculates to a 30 year rotation

Appendix 4 - Intensive Management

Timberland Acreage within the Top Quartile of Site Index (76 - 99) (1995 FIA Data)	455,936
[(1)] Current Custodial Yield (Site Index = 50) (Cords/Acre)	18.6
MFS predicts a doubling of existing Yield thru Intensive Management (Cords/Acre)	37.2
Increased Yield over Custodial (Cords/Acre)	18.6
Total Potential Increased Yield from Top Quartile of Site Index (Cords)	8,480,410
Annualized Potential Increased MerchantableYield (50 year Rotation) (Cords)	169,608
Merchantable Wood - Conversion to Million Green Tons	0.42
Additional Residues derived from this Merchantable Wood (Million Green Tons)	0.18
Total Annual Additional Volume from Intensive Management	0.61

Note: columns and rows may not add up due to rounding

[(1)] Source - Greenwood, Michael; Seymour, Robert S.; and Blumenstock, Marvin W.
"Productivity of Maine's Forest Underestimated - More Intensive Approaches are Needed"
Maine Agricultural Experiment Station Miscellaneous Report No. 328

Appendix 5. Forest Sustainability Standard Criterion 5: Biodiversity (DRAFT)

Goal: Maintain healthy, well-distributed populations of native flora and fauna and a complete and balanced array of different types of ecosystems.

Indicator 5.1: Number and distribution of large diameter trees, snags, and down logs (≥ 15.0 in DBH)

Benchmark 5.1.1: The number of rough and rotten, large diameter trees in Maine's timberland should increase gradually over time to at least 68 million (4 stems per acre), well distributed on the landscape. At least 17 million of these trees (1 stem per acre) should be ≥ 21.0 in DBH.

Benchmark 5.1.2: The number of large diameter dead trees and snags in Maine's timberland should increase gradually over time to at least 68 million (4 stems per acre), well distributed on the landscape. At least 17 million of these trees (1 stem per acre) should be ≥ 21.0 in DBH.

Benchmark 5.1.3: The number of large diameter, down dead trees in Maine's timberland should increase gradually over time to at least 68 million (4 stems per acre), well distributed on the landscape. At least 17 million of these trees (1 stem per acre) should be ≥ 21.0 in DBH.

Table 5.1.1. Number of large diameter trees in Maine's timberland, 1959-2003 (millions of trees)

		1959	1971	1982 (2003 Restated)	1995 (2003 Restated)	2003
Growing Stock	**Mean**	62.0	68.8	82.1	103.1	104.6
	Sig. Diff.			A	B	B
Rough & Rotten	**Mean**		33.0	24.7	18.9	14.7
	Sig. Diff.					
All Live	**Mean**		101.7	106.8	122.0	119.4
	Sig. Diff.			A	A	A
Dead & Snags	**Mean**				17.1	18.2
	Sig. Diff.				A	A
All Standing	**Mean**				139.1	137.6
	Sig. Diff.				A	A
Down & Dead	**Mean**				39.8	4.0
	Sig. Diff.					

Table 5.1.2. Distribution[1] of large diameter trees in Maine's timberland, 1995 and 2003

Tree Class	1995	2003	% Change
Growing Stock Trees	43%	39%	-4%
Rough/Rotten Live Trees	15%	10%	-5%
Dead Trees and Snags	17%	11%	-6%
Down dead trees	n.a.	n.a.	n.a.

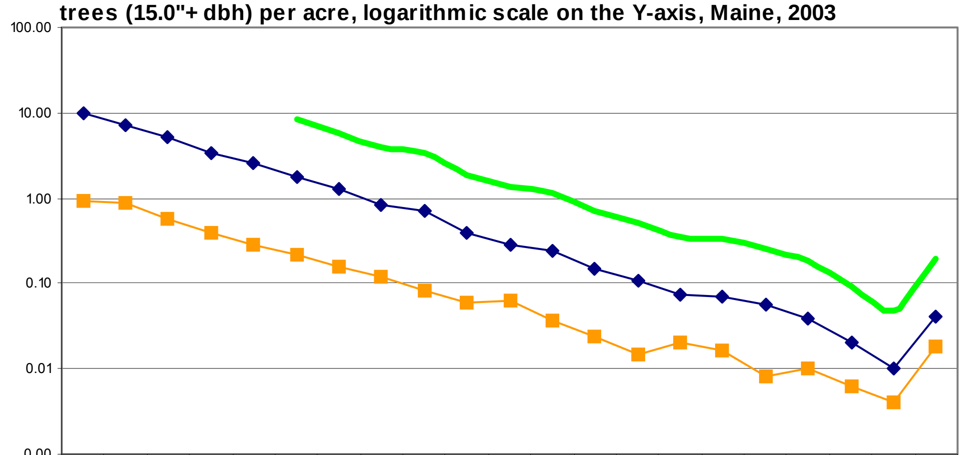
[1] Distribution expressed as a percentage of timberland inventory plots on which at least one large diameter tree (≥ 15.0 inches DBH) is recorded compared to all inventory plots.

Status and trend for this indicator: The number of large diameter, rough and rotten live trees, dead trees, snags, and down dead trees does not attain the minimum levels recommended in "Biodiversity in the Forests of Maine: Guidelines for Land Management" (Elliott, ed., 1999). However, the potential exists to reverse this trend through active planning and management.

The number of large diameter live trees increased at a decreasing rate from 1971 to 1995 and has been stable since then. The number of large diameter, rough and rotten trees has decreased by 55% since the 1971 forest inventory; however, the statistical significance of this change is unknown. Trend data is unavailable for large diameter dead trees, snags, and down dead trees. In Table 5.1.2, the distribution of large diameter trees of various qualities decreased slightly between 1995 and 2003.

The decline in the number and distribution of rough and rotten live trees, dead trees, and snags poses dilemmas for policy makers. On one hand, the decline can be seen as a positive, because it indicates that landowners are removing the legacies of past high grading operations and focusing future growth on quality trees. Quality trees provide landowners with many more marketing options than rough and rotten trees, and increase the financial viability of forest management. Snags present real dangers to timber harvesters, particularly hand crews. About 16 percent of all logging fatalities in the U.S. result from falling limbs, logs, or snags (American Pulpwood Association, 1996). The US Occupational and Health Administration's regulations for managing snags may conflict with wildlife habitat management guidelines in some circumstances.

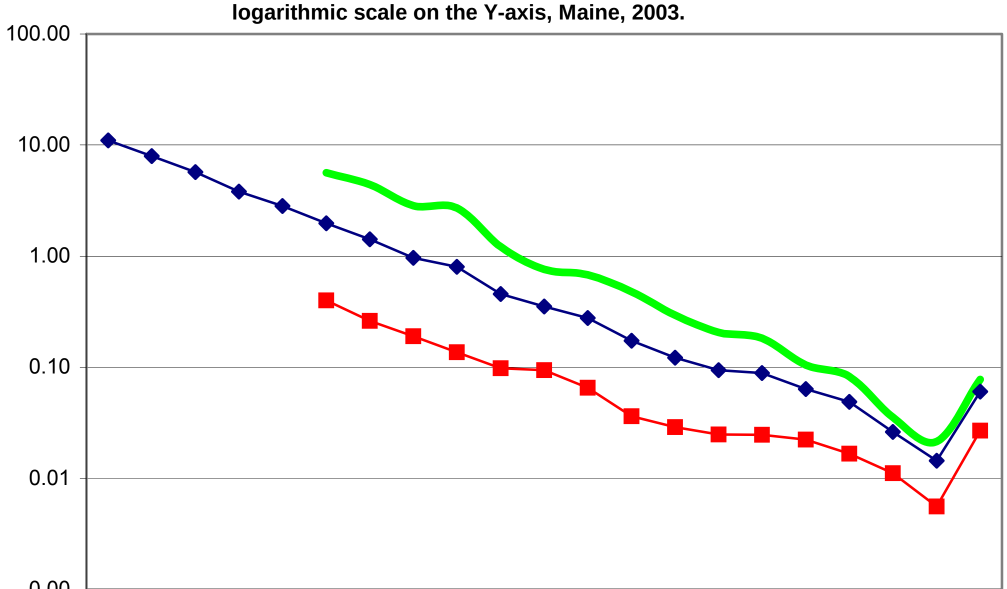
Figure 5.1.1. Current growing stock trees per acre by dbh class and the projected distribution needed to produce an average of 4 rough & rotten trees (15.0"+ dbh) per acre, logarithmic scale on the Y-axis, Maine, 2003



	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30+
Projected GS TPA						8.21	5.86	3.97	3.37	1.84	1.35	1.13	0.70	0.50	0.34	0.34	0.26	0.18	0.09	0.05	0.20
ActualGS	10.05	7.03	5.13	3.43	2.54	1.76	1.26	0.85	0.72	0.39	0.29	0.24	0.15	0.11	0.07	0.07	0.06	0.04	0.02	0.01	0.04
ActualR&R	0.95	0.89	0.58	0.39	0.29	0.21	0.16	0.12	0.08	0.06	0.06	0.04	0.02	0.01	0.02	0.02	0.01	0.01	0.01	0.00	0.02

On the other hand, the minor decline in large diameter, rough and rotten trees and dead trees and snags could be seen as a negative for those concerned about biodiversity. Rough and rotten live trees provide the future wildlife trees, snags, and downed logs that many species need for food and shelter. DeMaynadier (2002) indicates that the percentage of dead trees and snags greater than 10 cm (4 in) in relatively unmanaged stands in the Northeast ranges from 11-13% in hardwood stands to 16% in softwood stands, up to 30% in high elevation stands. Active management and planning, including careful harvest planning and supervision, will be needed to attain minimum acceptable levels of large diameter trees destined for wildlife habitat functions. Closer examination of forest inventory data (live tree distribution by DBH class, Tables 5.1.1 and 5.1.2) indicates that under even the most optimistic scenarios, achieving the benchmarks will be a very long-term process that spans several decades.

Table 5.1.2. Current all live trees per acre by dbh class and the projected distribution needed to produce an average of 4 dead & snag trees (15.0"+ dbh) per acre, logarithmic scale on the Y-axis, Maine, 2003.



	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30+
Projected ALL LIVE TPA						5.62	4.42	2.84	2.72	1.21	0.76	0.68	0.48	0.30	0.21	0.18	0.11	0.08	0.04	0.02	0.08
Actual ALL LIVE	11.00	7.93	5.72	3.82	2.82	1.97	1.42	0.97	0.80	0.46	0.35	0.28	0.17	0.12	0.09	0.09	0.06	0.05	0.03	0.01	0.06
Actual Dead & Snag						0.40	0.26	0.19	0.14	0.10	0.09	0.07	0.04	0.03	0.02	0.02	0.02	0.02	0.01	0.01	0.03

Rationale for this indicator: Large diameter trees provide important support functions for many species, particularly species that spend a large portion of their lives in older forests and/or require older forest structures at some point during their lives, such as some lichens and some ground beetles. A widespread decline in the density of large diameter trees might cause currently well-distributed species to become limited to ecological reserves. Large diameter live trees, particularly those with injuries and diseases that allow the creation of cavities, are highly preferred by a number of species. Every stand, even those managed as even-aged, should contain some large diameter, living and dead, standing and down trees to serve as a biological legacies and to provide some habitat continuity between harvests.

The density of large diameter, living, dead, standing, and down trees needed to support different biodiversity values is unknown. However, in forested landscapes with long histories of intensive silviculture, such as Scandinavia and the Pacific Northwest, policy makers and land managers are struggling to avoid extirpating forest species. In Sweden, one hundred years of increasingly intensive forestry has reduced the density of big trees and the volume of snags (Linder and Ostlund 1992). Many of Sweden's Red-Listed species (the equivalent of our threatened and endangered species) are associated with big trees, big snags, and logs. Reduction of these important components of forest structure through forest management may be extirpating many forest species from large areas of Sweden. Nearby Finland may lose up to 5% of its forest species (~1000 species) due to the loss of these features (Hanski 2001) that are commonly found in late-successional and old growth forests. Many of these are small, inconspicuous, and hard to identify species such as insects, fungi, lichens, and mosses. Harvesting can affect poor dispersers at the stand level by temporarily changing structure and eliminating critical habitat features, and at the landscape level by creating large areas of unsuitable habitat for years or decades.

The following table illustrates the values of large diameter trees at all stages of growth and decomposition.

Values and beneficiaries of large diameter trees[2]		
Value	**Beneficiaries**	
Super canopy trees	Raptors, songbirds, lichens, bryophytes, fungi	Kuusinen, 1996; Newton *et al*, 2002
Cavity trees	Large bodied mammals, woodpeckers, bats, owls, bryophytes, secondary cavity nesting birds, invertebrates	Ranius, 2002; DeGraaf and Yamasaki, 2001
Large snags	Flying squirrels, bats, woodpeckers, lichens, invertebrates	Selva, 1994; DeGraaf and Yamasaki, 2001
Logs	Lichens, mosses, invertebrates, fungi, birds, mammals, amphibians	Ódor and Standovár, 2001; Sippola, 2001; Sverdrup-Thygeson, 2001; DeGraaf and Yamasaki, 2001; deMaynadier and Hunter, 1995

Indicator 5.3: Forest stand structure

Benchmark 5.3.1: Maine's forests should be managed to attain over time a structural distribution that matches the following ideal (well distributed among forest types and across the state):

Table 5.3.1. Idealized structure[3]			
Stand size class	**Stand structure**		
	Single storied	**Two storied**	**Multi-storied and mosaic**
High basal area in large sawtimber only[4]		at least 15%	
At least sawtimber[5]		at least 25%	
At least poletimber[6]	at least 50%		
Seedling/sapling/nonstocked[7]	no more than 30%		

Benchmark 5.3.2.1: The percentage of Forest Health Monitoring plots with old forest macrolichens present should not decrease below the current level of approximately 75%.

Benchmark 5.3.2.2: The percentage of Forest Health Monitoring plots with 3 or more old forest macrolichen species should not decrease below the current level of approximately 25%.

[2] Adapted from deMaynadier, 2002.
[3] Adapted from DeGraaf, *et al* (1992), Maine Council on Sustainable Forest Management (1996) and technical working group discussions.
[4] Stands ≥ 100 ft^2 basal area in which trees ≥ 15.0 in DBH comprise at least 50% of the basal area. The idealized percentage is included in "at least sawtimber" category; it is not additive.
[5] Softwood stands 9.0+ in DBH; hardwood stands 11.0+ in, and the plurality of the crown cover is in trees of this size or larger.
[6] Softwood stands 5.0 in – 8.9 in DBH; hardwood stands 5.0 in – 10.9 in DBH, and the plurality of the crown cover is in trees of this size or larger.
[7] Stands 1.0 in – 4.9 in DBH, and plurality of the crown cover is in trees of this size.

Status and trend for this indicator: Maine's forest appears to be fairly well distributed in terms of stand size. Using FIA protocols and algorithms, sawtimber stands represent 33% of the total acreage; poletimber stands 37%; and seedling/sapling 29%. However, the distribution of stand structural characteristics falls short of the ideal, particularly in high basal area sawtimber stands.

Table 5.3.2. 2003 Actual Stand Structure			
	Stand structure		
Stand size class	**Single-storied**	**Two-storied**	**Multi-storied & mosaic**
High basal area in large sawtimber only	0.9%	0.8%	
At least sawtimber	11.3%	20.4%	
At least poletimber	70.6%		
Seedling/sapling/nonstocked	29.4%		

Most individual forest type groups do not attain this relatively even distribution. Some forest type groups are quite unbalanced. For example, the White/Red/Jack Pine group is deficient in the seedling/sapling classes. The Spruce/Fir group is skewed the opposite way, with an overrepresentation of 40% in the seedling/sapling class. The other major type group, Maple/Beech/Birch, approaches the idealized structure, being just slightly deficient in the combined sawtimber size and two-story/multi-story and mosaic structural grouping.

Table 5.3.2a. Stand Structure, White/Red/Jack Pine Forest Type Group, 2003			
	Stand structure		
Stand size class	**Single-storied**	**Two-storied**	**Multi-storied & mosaic**
High basal area in large sawtimber only	6.5%	2.9%	
At least sawtimber	27.5%	36.3%	
At least poletimber	95.6%		
Seedling/sapling/nonstocked	4.4%		

Table 5.3.2b. Stand Structure, Spruce/Fir Forest Type Group, 2003			
	Stand structure		
Stand size class	**Single-storied**	**Two-storied**	**Multi-storied & mosaic**
High basal area in large sawtimber only	0.0%	0.5%	
At least sawtimber	11.2%	19.2%	
At least poletimber	60.3%		
Seedling/sapling/nonstocked	39.7%		

Table 5.3.2c. Stand Structure, Sugar Maple/Beech/Yellow Birch Forest Type Group, 2003			
	Stand structure		
Stand size class	**Single-storied**	**Two-storied**	**Multi-storied & mosaic**
High basal area in large sawtimber only	0.6%	1.0%	
At least sawtimber	11.5%	23.5%	
At least poletimber	79.7%		
Seedling/sapling/nonstocked	20.3%		

Phase 3 plots monitor the lichen community in order to assess air pollution impacts and spatial and temporal trends in biodiversity. For the period 1999 - 2003, the sample of approximately 150 plots identified 42 lichen genera through specimen collection. Over 35 percent of the specimens collected are in genera that may represent late successional forests (A. Whitman, 2004, personal communication).

Rationale for this indicator: Sound management of the working forest matrix is essential to the conservation of Maine's forest biodiversity. While ecological reserves and other lands reserved from management can protect some elements of biodiversity, the reality is that reserves will never be large enough, connected enough, or located to protect all biodiversity (J. Franklin, 2002, personal communication).

For the purposes of this indicator, "large sawtimber" trees and stands are used as a proxy for late successional forests. Late successional forests provide a number of goods, services, and values to society, including large, often high-value sawtimber, watershed protection, recreation, spiritual renewal, and, in some cases, a reference point against which to measure the effects of more intensive forest management.

Late successional forests are not necessarily unmanaged. In fact, active management can accelerate the development of late successional functions and structures in forests.

However, late successional forests of all types are becoming less common in Maine. Older forests support some plant and animal habitat specialists, in part due to their heterogeneity and structural complexity, but also due to the relatively long time elapsed since a stand-replacing disturbance (Gawler, *et al*, 1996).

Lichens serve a number of functions in temperate forests, including nutrient cycling and as components of food webs. Epiphytic lichens are an important component of the biodiversity of many forest types. Late successional epiphytes can be dispersal limited and are often sensitive to the impacts of forest management activities. Other factors, including atmospheric deposition, also affect these organisms. The presence of adequate populations of late successional epiphytes provides evidence of the continuity of the functions and processes of late successional forests (Selva, 1994; McCune, 2000).

Indicator 5.6: Degree to which forest management is consonant with natural forest dynamics

Forest ecosystems have evolved with natural disturbances, such as fire, windthrow, and pest epidemics. Forest ecosystems generally are considered resilient in the aftermath of such disturbances within the range of natural variation. Many scientists and forest managers have begun to embrace management strategies modeled on natural disturbance regimes (Crow and Perera, 2004). Maine's forests evolved within a pattern of "relatively frequent, partial disturbances that produced a finely patterned, diverse mosaic dominated by late-successional species and structures." Disturbances creating small canopy gaps were frequent. Large-scale, catastrophic (stand-replacing) disturbances were quite rare (Seymour *et al*, 2002).

Whereas Maine's natural forest dynamics tend to create a complex mosaic of species, types, and size classes across the landscape, timber harvesting - no matter how well planned and implemented - tends to simplify forest composition and structure (Crow and Perera, *op. cit.*). Most notable is the paucity of large trees, both living and dead, and other structural features that characterize unmanaged forests (McGee *et al*, 1998; Crow *et al*, 2002).

Notwithstanding the often significant differences between current forest management and natural forest dynamics, Foster (1997, 1998, 2000, and 2004) and Oliver and Larson (2004) remind us that while history can inform us about the conditions and disturbances that created today's conditions, we are now confronted with a suite of "novel environmental stresses [that] may surpass the ability of forests to control important ecosystem processes (Foster, 1997, *op. cit.*). Examples of such stressors include invasive and exotic species (e.g. hemlock woolly adelgid), air pollution, and abrupt climate change. These stresses are overlaid on past harvesting and land clearing patterns, and past disturbances to create a complex situation for which Foster (2000, *op. cit.*) suggests "there [is] no fixed 'original' landscape" against which to refer. Forest management can rarely - if ever - satisfy all interests and conserve all values; therefore, management involves tradeoffs among interests and values. The challenge to policy makers and land managers in the context of forest biodiversity is to design management strategies that involve the fewest tradeoffs (Oliver and Larson, *op. cit.*) and minimizing the risks of species loss.

No formal benchmarks are presented for this indicator. The indicator is presented to inform public discussion about the topic.

Status and trend: Total acreage harvested increased from 470,599 acres in 1995 to 511,070 acres in 2003. Clearcut acreage declined from 39,295 acres to 18,389 acres during the same period. Part of the increased total harvest acreage reported may be due to better reporting and compliance; however, the trend for total acres harvested is definitely upward (notwithstanding a decline from 2002 to 2003). Harvest levels remained remarkably stable during the period, indicating that landowners have increased non-clearcut harvesting to compensate for the reduction in volume obtained by clearcutting. Total acres treated since the 1980's to improve future forest productivity (site preparation, planting, competition control, and spacing) are estimated at over 1.2 million. The total acres adjusted for treatment overlap are approximately 850,000.[8]

The current harvest footprint covers approximately 3% of the state's forestland area each year. Of the annual harvest footprint (2003 figures), approximately 51% of the acres are harvested by a partial harvest method (either individual trees or small groups of trees). The remainder is harvested using either the shelterwood (43%) or clearcut (5%) methods. About 5% of the state's land area currently is managed under intensive silvicultural regimes that approximate the effects of a major or catastrophic disturbance on forest succession (effectively reset to zero every 50-70 years). The "return time" and patch size of land managed under such regimes, however, does not match that of the natural forest (Seymour *et al*, 2002). The annual percentage increase in this acreage is small.

Rationale for this indicator: This indicator allows us to assess roughly the level of correlation between current forest management strategies and natural disturbance regimes.

[8] Lloyd Irland, 2000, personal communication, and Kenneth Laustsen, 2002, personal communication, adjusted to reflect new information. Excerpted from: **Department of Conservation, Maine Forest Service. 2005. The 2005 Biennial Report on the State of the Forest and Progress Report on Sustainability Standards. Report to the Joint Standing Committee of the 122nd Legislature on Agriculture, Conservation and Forestry. Maine Department of Conservation: Augusta. 124 pp.**

Appendix 6. Response to concerns expressed about MFS's June 10, 2008 "Assessment of Sustainable Biomass Availability"

The Governor's Wood-to-Energy (WTE) Task Force requested that the Maine Forest Service (MFS) develop an estimate of the amount of woody biomass in the region which could be used to support an emerging pellet fuel industry. MFS developed its estimate using Forest Inventory and Analysis data as its base; these are the most reliable figures available. Further, MFS developed its estimate from the perspective of its legislative mandate to promote sustainable forest management, with sustainability defined in its broadest sense: ecological, economical, and social.

Since the June 10, 2008 release of MFS's "Assessment of Sustainable Biomass Availability", some parties have questioned the validity of the estimates presented. Comments were received in writing from Rob Bryan, formerly of Maine Audubon, and orally from others. In response to such concerns it is important to reemphasize what the estimates are and are not.

The assessment estimates the amount of biomass that could be accessed for use in Maine. Sources include:

1. Improved harvest/utilization of wood from currently harvested stands.
2. Harvest in stands not previously considered commercially viable.
3. Increasing productivity (and allowable cut) through more intensive management.
4. Increased imports from outside Maine's borders.

Realizing the increased amount of wood which could be supplied by Maine's forest will require going beyond "business-as-usual" management and improving utilization as well as silviculture.

Further, these estimates specifically do not address the economic feasibility of extracting, transporting and utilizing these potential sources of biomass. This analysis deals only with potential supply.

In developing its estimates, MFS considered – based on Maine's benchmarks of sustainability – the amount of material that should be left on site to assure that sites were not degraded. The raw numbers of available material also were discounted to account for the need to maintain critical ecological functions and structures, e.g. snags, large woody material (see Point 2 below).

1. Regarding Improved harvest/utilization of wood from currently harvested stands

There are three sources of difference between the MFS estimates and those generated by Rob Bryan:

- The first difference deals with the amount of branches and tops from harvested trees that should be retained on site. MFS estimates are based on retaining 33% of this volume; Mr. Bryan's estimates are based on retaining 79% of this volume. Mr. Bryan references the proposed Minnesota and Wisconsin draft biomass retention guidelines; MFS's proposal meets both states' proposed guidelines. Further, none of the MFS estimates assumed any recovery of existing fine or coarse woody material; all calculations were based on standing biomass. There is no indication that the process used by the MFS does not address slash retention concerns, or that the estimates need to be reduced.
- The second difference deals with retention of large trees and snags. Mr. Bryan suggests that MFS revise its assumptions to retain more cull trees and snags on harvest sites. MFS assumptions regarding the number of large trees, snags, and down logs to retain on site are derived from a thorough process that began with the Maine Forest Biodiversity Project – a consensus effort – and were refined by a highly competent group of people widely recognized and respected as top shelf in this state: Phillip DeMaynadier, Andy Cutko, Gary Donovan, Ken Elowe, Dan Harrison, Barbara Vickery, and Andy Whitman, with additional review by Mac Hunter, Mr. Bryan, and Ken Laustsen. Absent new scientific information that would lead us to a different conclusion, we stand by those assumptions.

– The third difference concerns the estimation of biomass currently being removed. MFS estimates were derived from a ten-year average, while Mr. Bryan's estimates are based only on the last two years.

2. Regarding harvest in stands not previously considered commercially viable:

These numbers were directly extracted from national analyses which the MFS then further discounted to assure we were not double counting existing operations in Maine. These numbers too are sound.

3. Regarding increasing productivity (and allowable cut) through more intensive management:

We agree with Mr. Bryan's skepticism regarding the probability under current conditions of additional investments in intensive silviculture by current landowners; however, as the demand for timber supplies increase, the viability of silviculture which has been infeasible in the past and landowners attitudes may change as well. Further, the fact is that the potential for increased forest productivity exists. Further, the MFS analysis was quite conservative in discounting productivity assumptions developed by the University of Maine.

In the final analysis, we believe that the amount of biomass that we have identified as available on a sustainable basis - without depleting harvest sites or compromising biodiversity - is a reliable estimate.

4. Regarding increased imports from outside Maine's borders:

The estimates of imported biomass material are sound. We made no assumptions regarding cost or transport, only that the material exists and is excess to current local market usage. That raw material will go to whoever has built the processing mills and is buying. If Maine is too late in putting in a bid for the material, it will go somewhere else - but it doesn't have to. We already are a net importer of biomass chips, and there is no reason to doubt that pulp grade material could be purchased and imported. MFS estimates were built utilizing material from only adjacent jurisdictions; one could make the case that wood already is being transported longer distances and that our estimates of available resource are understated. For example, we understand that pulpwood is currently being shipped to Maine from as far away as Wisconsin.