

# Vermont's Forest Resources, 2007

Research Note NRS-54

This publication provides an overview of forest resource attributes for Vermont based on an annual inventory conducted by the Forest Inventory and Analysis (FIA) program at the Northern Research Station of the U.S. Forest Service. These estimates, along with web-posted core tables, will be updated annually. For more information please refer to page 5 of this report.

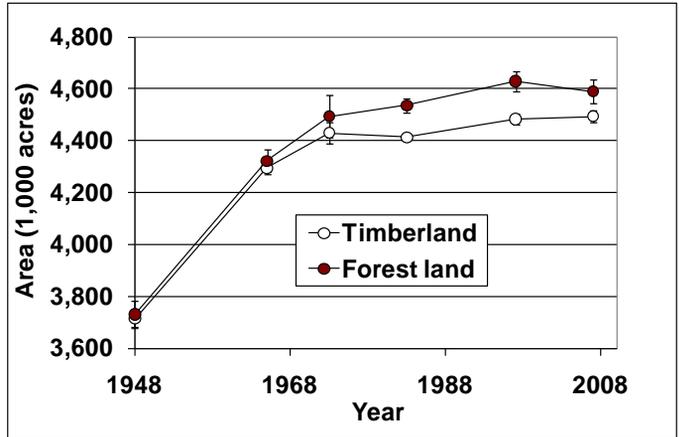


Figure 1. – Area of timberland and forest land by year.

Table 1. – Annual estimates and uncertainty		
	Estimate 2007	Sampling error (%)
<b>Forest Land Estimates</b>		
Area (1,000 acres)	4,588.6	1.0
Number of live trees 1-inch diameter or larger (million trees)	3,511.1	2.6
Dry biomass of live trees 1-inch diameter or larger (1,000 tons)	273,298.0	1.7
Net volume in live trees (1,000,000 ft <sup>3</sup> )	10,111.3	1.8
<b>Timberland Estimates</b>		
Area (1,000 acres)	4,493.3	1.1
Number of live trees 1-inch diameter or larger (million trees)	3,426.4	2.7
Dry biomass of live trees 1-inch diameter or larger (1,000 tons)	268,850.6	1.7
Net volume in live trees (1,000,000 ft <sup>3</sup> )	9,953.9	1.9
Net volume of growing-stock trees (1,000,000 ft <sup>3</sup> )	8,961.5	2.0

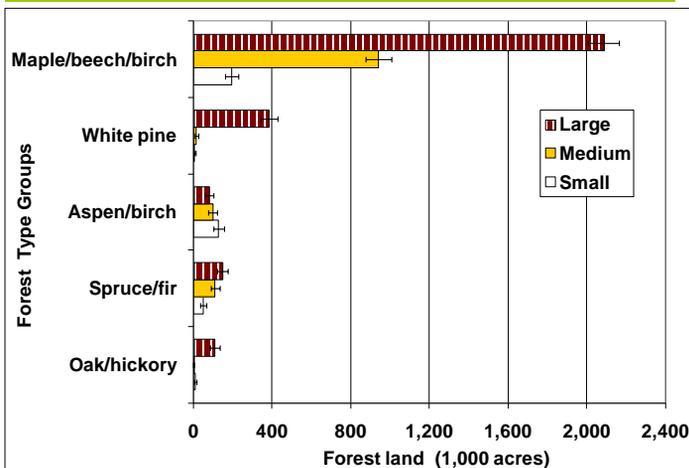


Figure 2. – Area of forest land area by top five forest type groups and stand size class, 2003-2007.

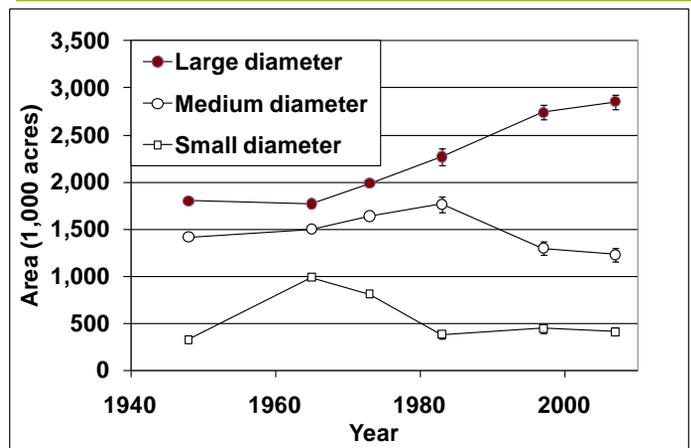
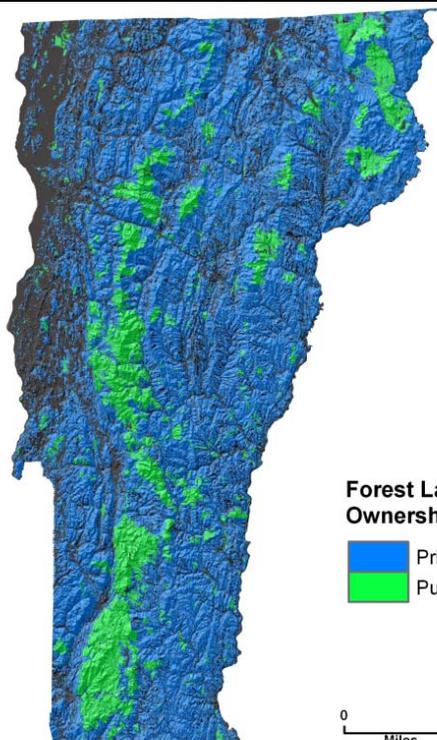


Figure 3. – Area of timberland by stand size class and year.

Note: When available, sampling errors/bars provided in figures and tables represent the approximate error interval at the 68 percent confidence level

**Table 2. – Top 10 tree species by statewide volume estimates, 2003-2007**

Rank	Species	Volume of live trees on forest land (1,000,000 ft <sup>3</sup> )	Sampling error (%)	Proportion of total live tree volume (%)	Volume of sawtimber trees on timberland (1,000,000 bdf <sup>t</sup> )	Sampling error (%)	Proportion of total sawtimber volume (%)
1	Sugar maple	2,385.2	4.7	23.6	6,654.0	6.1	24.5
2	Red maple	1,226.3	5.7	12.1	2,766.9	7.8	10.2
3	Eastern hemlock	1,037.4	8.6	10.3	2,841.5	10.0	10.5
4	Eastern white pine	955.6	9.7	9.5	3,924.4	10.7	14.4
5	Yellow birch	728.4	5.9	7.2	1,752.1	8.5	6.4
6	American beech	613.1	7.0	6.1	1,168.1	11.0	4.3
7	Red spruce	499.9	8.6	4.9	1,366.7	10.6	5.0
8	White ash	489.8	9.1	4.8	1,456.2	13.1	5.4
9	Paper birch	424.5	8.6	4.2	824.8	11.8	3.0
10	Balsam fir	388.5	8.8	3.8	724.8	10.4	2.7
	Other softwoods	221.0	14.7	2.2	529.6	18.1	1.9
	Other hardwoods	1,141.8	6.1	11.3	3,166.0	9.0	11.7
	<b>All Species</b>	<b>10,111.3</b>	<b>1.8</b>	<b>100.0</b>	<b>27,174.9</b>	<b>2.8</b>	<b>100.0</b>



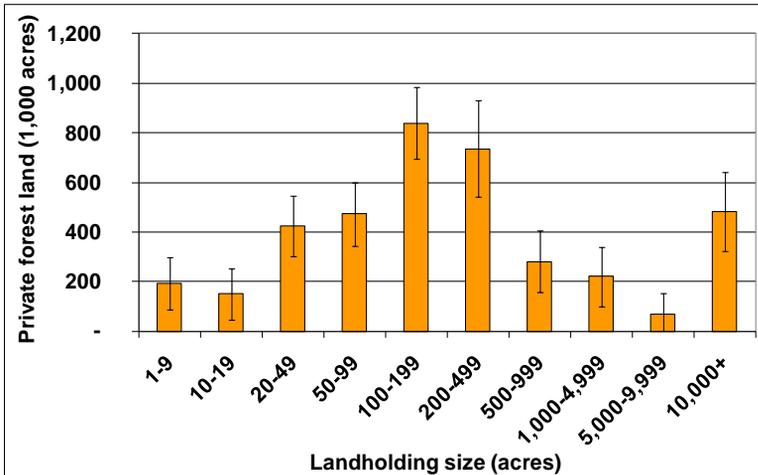
**Forest Land Ownership**

- Private
- Public

0 25  
Miles

**Map Legend**

- Private forest land – 80.1 percent of all forest land
- Public forest land – 19.9 percent of all forest land
- Nonforest



Data sources: USDA Forest Service, Conservation Biology Institute Protected Areas Database, National Land Cover Database 2001. Geographic base data provided by the National Atlas of the USA.

**Figure 4. – Area of forest land by major owner group (2008) and size of private family forest landholding (2006).**

## Continuous Improvement Process for Volume, Biomass, and Carbon Estimation

Implementation of the annual inventory requires ongoing evaluation of existing methods and implementation of improved system components as they become available. Recently, significant changes were made to the methods for estimating tree-level volume and biomass (dry weight) for Northeastern states, and the calculation of change components (net growth, removals, and mortality) was modified for national consistency. These changes have focused on improving the ability to report consistent estimates across time and space--a primary objective for FIA.

### Tree-level Volume Estimation

As the remeasurement phase of the annual inventory was implemented, "noise" (random variation in the data) began to outweigh the signal (detectable change in volumetric variables); thus limiting the ability to track real change over time. Sources of noise include: measurement variability, field protocol changes, field crew cohort changes, definition changes, processing algorithm changes, and model error. This noise impacts estimates of volume, biomass, carbon, and associated change component estimates.

Volume estimation is critically important because individual tree volume estimates form the basis for biomass and carbon estimates. In the past, estimates of individual tree gross volumes (cubic foot and board foot) were estimated using equations based on field-measured diameters and lengths (bole and saw log). Net volume of the tree was computed by subtracting field-measured cull (Scott 1981, Scott 1979). Over time, it was found that noise in the measurements of tree lengths and cull outweighed the true signal. To ameliorate this, a taper model was used to estimate length (Westfall 2009). In addition, a model was developed for determining the percent of total tree volume represented by cull. The modeled length and cull estimates are used in conjunction with Scott's volume equations, thus providing a consistent estimation procedure across the Northeast. In general, the new volume estimates will be higher because previous estimates were based on length measurements that included reductions based on merchantability, e.g., prior to 2007, the measurement of the top of the bole may have been below the 4-inch top due to form deficiencies that prevents use for pulpwood. In 2007, the merchantability limits were removed from the field protocols. In conjunction with the removal of merchantability limits, changes in cull measurements were implemented, such that net tree volume would continue to represent only the merchantable portion of the tree. The modeled lengths and culls are aligned with these new measurement protocols.

### Component Ratio Method (CRM) for Biomass/Carbon Estimation

Biomass and carbon have become increasingly important to FIA clients as demand for bioenergy has increased and carbon sequestration has emerged as a vital component of climate change analyses. As such, a method for harmonizing volume, biomass, and carbon estimates was needed. Prior to implementation of the CRM method, volume and biomass were estimated using separate sets of equations. The CRM method is comprised of the following steps (Heath and others 2009):

- Conversion of sound-wood volume in the merchantable bole to biomass using species-level specific gravities (dry mass per unit of green volume)
- Calculation of bark biomass using a set of percent bark and bark specific gravities
- Calculation of biomass in tops and limbs as a proportion of merchantable bole biomass based on component proportions using equations from Jenkins and others (2003)
- Calculation of stump biomass using equations from Raile (1982)
- Summation of biomass components to obtain total aboveground biomass

Estimates of carbon are derived through simple conversion of the biomass variables.

## Continuous Improvement Process for Volume, Biomass, and Carbon Estimation

### Change Component Estimation

Change components are perhaps the most important volumetric variables reported by FIA because they are indicative of sustainability (net growth-to-removals ratio) and forest health (mortality). To summarize, gross growth is equal to ingrowth (volume of trees reaching the 5.0-inch minimum diameter threshold for merchantable volume) plus accretion (growth of surviving trees that were above the threshold at previous measurement). Net growth is equal to gross growth minus mortality (volume of trees meeting the threshold at previous measurement that died). Removals are equal to the volume of trees meeting the threshold at the previous measurement that were harvested or on forest land that changed to nonforest land. Net change in inventory is equal to net growth minus removals.

The National Inventory Management System (NIMS) is the compilation system for all FIA estimates. Implementation of NIMS has included some adjustments to regional change-component algorithms to achieve national consistency. A new method, termed the “midpoint method,” has introduced some fundamental changes in methods (Westfall et al. 2009). Essentially, the new approach uses models to “grow” trees to the midpoint of the inventory cycle (2.5 years for a 5-year cycle). Although the overall net change component is equivalent under the previous and new theory evaluations, estimates for individual components will be different. For ingrowth, the midpoint method produces a smaller estimate because volumes are calculated at the 5.0-inch threshold instead of using the actual diameter measurement, which may be larger. The estimate for accretion is higher because growth on ingrowth, mortality, and removal trees are included. As such, the removals and mortality estimates will also be higher than before.

### Literature Cited in Continuous Improvement Section

- Heath, L.S.; Hansen, M.H.; Smith, J.E.; Smith, W.B.; Miles, P.D. 2009. Investigation into calculating tree biomass and carbon in the FIADB using a biomass expansion factor approach. In: McWilliams, W.; Moisen, G.; Czaplewski, R., comps. 2008 Forest Inventory and Analysis symposium; 2008 October 21-23; Park City, UT. Proc. RMRS-P-56CD. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. CD.
- Jenkins, J.; Chojnacky, D.C.; Heath, L.S.; Birdsey, R.A. 2003. National scale biomass estimators for United States tree species. *Forest Science*. 49(1): 12-35.
- Raile, G.K. 1982. Estimating stump volume. Res. Pap. NC-224. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Research Station. 4 p.
- Scott, C.T. 1979. Northeastern forest survey board-foot volume equations. Res. Note NE-271. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 2 p.
- Scott, C.T. 1981. Northeastern forest survey revised cubic-foot volume equations. Res. Note NE-304. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 2 p.
- Westfall, J.A. In press. Taper models for tree species in the Northeastern U.S. *Forest Science*.
- Westfall, J.A.; Frieswyk, T.; Griffith, D.M. 2009. Implementing the measurement interval midpoint method for change estimation. In: McRoberts, R.E.; Reams, G.A.; Van Deusen, P.C.; McWilliams W., eds. Proceedings of the eighth annual Forest Inventory and Analysis symposium; 2006 October 16-19; Monterey, CA. Gen. Tech. Rep. WO-79. U.S. Department of Agriculture, Forest Service: 221-236.



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### FIA Program Information

Bechtold, W.A.; Patterson, P.L. 2005. The enhanced forest inventory and analysis program: national sampling design and estimation procedures. Gen. Tech. Rep. SRS-80. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 85 p.

Smith, W.B. 2002. Forest inventory and analysis: a national inventory and monitoring program. Environmental Pollution. 116: 233-242.

USDA Forest Service. 2005. Forest inventory and analysis national core field guide, Vol. 1, field data collection procedures for phase 2 plots, Ver. 3.0. Available at <http://www.fia.fs.fed.us/library/field-guides-methods-proc/> (verified Aug. 1, 2008).

### Additional Vermont Inventory Information

Frieswyk, T.S.; Malley, A.M. 1985. Forest statistics for Vermont, 1973 and 1983. Resour. Bull. NE-87. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 102 p.

Frieswyk, T.; Widmann, R. 2000. Forest statistics for Vermont, 1983 and 1997. Resour. Bull. NE-145. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 130 p.

Kingsley, N.P. 1977. The forest resources of Vermont. Resour. Bull. NE-46. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 58 p.

Kingsley, N.P.; Barnard, J.E. 1968. The timber resources of Vermont. Resour. Bull. NE-12. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 117 p.

McGuire, J.R.; Wray, R.D. 1952. Forest statistics for Vermont. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 47 p.

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Estimates, tabular data, and maps from this report may be generated at: [fiatools.fs.fed.us](http://fiatools.fs.fed.us)

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