New Estimates of Massachusetts Old-growth Forests: Useful Data for Regional Conservation and Forest Reserve Planning

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Abstract - Old-growth forests are currently identified as core components of regional conservation and forest-reserve planning efforts by agencies and organizations across the northeastern United States. Despite the importance of these ecosystems from an ecological and conservation standpoint, major questions remain concerning their actual extent, location, and configuration in many states. Here we report a substantially revised estimate for individual tracts and the total area of old-growth forests in Massachusetts based on analysis of historical documents and extensive field research and mapping. We estimate that the total area of old-growth in the state is 453 ha, in 33 stands that range from 1.2 to 80.9 ha in size. Over 80% of these forests occur in the Berkshire Hills and Taconic Mountains in the extreme western part of the state. These forests are structurally unique and contain some of the oldest documented *Tsuga canadensis* (hemlock) and *Picea rubens* (red spruce) in New England, as well as the second-oldest documented *Betula lenta* (black birch) in the country. Due to their relatively small size and isolated character, these areas are susceptible to human and natural disturbance and require protection, including substantial buffer areas. Old-growth stands will enhance the value and function of designated forest reserves and will gradually become surrounded by forests of increasingly similar structure and ecosystem characteristics.

Introduction

The few remaining old-growth forests in New England have long been conservation priorities due to their unusual ecosystem characteristics and value for scientific study (Dunwiddie et al. 1996). Traditionally, many of these areas were protected as small isolated tracts (Cogbill 1985, Peterken 1996); however, recent efforts at broad-scale conservation planning in the northeastern United States have initiated interest in incorporating old-growth forests as core components of large forest reserves and networks of reserves (Jenkins et al. 2004, TNC 2004). For example, recent statewide conservation plans in Massachusetts, a state with scattered old-growth stands, have used the amount of old-growth forest as a primary criterion for prioritizing candidate reserves (EOEA 2005, Foster et al. 2005). While other criteria, such as rare species habitat and the extent of existing protected land, also inform this decision process, old-growth forests play a central role in

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this and other broad-scale forest-conservation efforts in the Northeast (Jenkins et al. 2004, Rusterholz 1996).

Despite the emphasis on old-growth forests in forest-conservation planning in Massachusetts, the data employed in these efforts is of variable and changing quality. Information on the number, location, and extent of old-growth stands has changed greatly over time. Early studies concluded that there were no old-growth forests (Egler 1940), whereas recent estimates have ranged from 260 (Dunwiddie and Leverett 1996) to 1200 ha (R.T. Leverett and G.A. Beluzo, Holyoke Community College, Holyoke, MA, unpubl. data). The wide range of these estimates is due to the limited number of rigorous field-based studies (Dunwiddie 1993, Dunwiddie and Leverett 1996, Hosier 1969) and variation in the definition of old-growth conditions (R.T. Leverett and G.A. Beluzo, unpubl. data). Clearly, the importance of old-growth forests in guiding the large forest-reserve planning process in Massachusetts and other northeastern states warrants the development of accurate maps and data for all remaining stands.

This note summarizes recent efforts to extend prior studies of old-growth forests in Massachusetts (Dunwiddie 1993, Dunwiddie and Leverett 1996) by developing a comprehensive assessment of remaining old-growth stands based upon extensive analysis of historical documents, exhaustive field research (including detailed tree aging at all sites), and the consistent application of stringent definitions. This research is part of a larger study examining the disturbance dynamics, structural and compositional attributes, and ecosystem properties of the eighteen largest old-growth forest stands in western Massachusetts (A.W. D'Amato and D.A. Orwig, unpubl. data).

Methods

A series of hand-drawn maps depicting confirmed (Dunwiddie 1993) and potential old-growth areas based primarily on visual characteristics of trees (Leverett 1996a,b) were used to guide reconnaissance efforts aimed at determining the extent of old-growth on the landscape in western Massachusetts. Field reconnaissance of the potential old-growth areas was conducted in the summers of 2003 and 2004. In addition, extensive historical and dendroecological analyses were used at Wachusett Mt. in central Massachusetts (Princeton) to estimate the extent of old-growth at this location (Cogbill 1995, Orwig 2004, Orwig et al. 2001).

Several criteria were applied in the field to help identify old-growth forests: 1) the absence of any evidence of past land-use (e.g., cut stumps, stone walls or structures, numerous multiple-stemmed trees); 2) the presence of at least 5 old trees (> 225 years old; indicating establishment prior to European settlement in these locations [Field and Dewey 1829] and exceeding 50% of the maximum longevity for species commonly encountered [Dunwiddie and Leverett 1996]) per hectare in the forest overstory as determined through the collection of increment core samples (see below); and 3) the existence of forest structural characteristics that are often indicative of old-growth condition, such as pit and mounds, large snags, gnarled tree crowns, and the accumulation of large volumes of coarse woody debris (Leverett 1996b).

The age of overstory trees in potential old-growth areas was determined by taking increment cores at 0.3 m in height from at least 10 trees per hectare. Cores were mounted, sanded, and aged under a dissecting microscope. In addition, periods of increased radial growth were qualitatively assessed during age determination to identify patterns of dramatic, sustained growth releases that may indicate past selective logging (Orwig and Abrams 1999). To complement field evidence, extensive historical research was also undertaken to ensure the absence of past land-use at areas designated as containing old-growth forests. Historical maps and documents were utilized to note the location of settlements, sawmills, and other areas of intensive land-use (e.g., tanneries) in relation to the potential old-growth areas (e.g., Beers 1876, Hall et al. 2002, MGS 1940, Nason 1847).

Once an area was confirmed as containing old-growth based on field and historical evidence, a series of three to five 400-m^2 plots were established along transects through the central portion of each stand. Locations of all plots were recorded using a GPS. In addition, boundaries of old-growth stands were determined in the field by extensive visual and dendroecological evidence as mentioned above, delineated onto 7.5-minute USGS quadrangles, and transferred into shape files using GIS (ArcView 3.2). When available, old-growth boundaries were also confirmed with historical evidence. Species and diameter at breast height (dbh) was recorded for all living and dead trees (stems ≥ 1.37 m tall and ≥ 10 cm dbh) within these plots. In addition, increment cores were taken from all trees within these plots and from additional trees outside of the plots for age determination and reconstruction of dendroecological dynamics. Plots were permanently marked to enable long-term investigations of the disturbance dynamics in these areas, comparisons with adjacent managed second-growth forests, and changes associated with pests and pathogens in the region (e.g., *Adelges tsugae* Annand (hemlock woolly adelgid) and beech bark disease (caused by the fungi *Nectria* spp., preceded by the beech scale *Cryptococcus fagisuga* Lind.).

Results and Discussion

Based on our collected field data and historical research, we estimate the total area of old-growth forest remaining on public land in Massachusetts to be 452.8 ha (Table 1). As reported in previous studies (Dunwiddie and Leverett 1996), much of this area is located within the Berkshire Hills and

Taconic Mountains of western Massachusetts; however, a sizable amount (80.9 ha) of old-growth forest also exists on Wachusett Mt. in the north-central portion of the state (Fig. 1, Table 1). Our estimate is greater than the prior published estimate of old-growth forest area in Massachusetts (260 ha; Dunwiddie and Leverett 1996) due largely to the expansion of boundaries for previously recognized old-growth areas on Wachusett Mt., Todd Mt., Clark Mt., Mt. Greylock, and along the Cold River (combined expansion of

Table 1. Characteristics of old-growth forests on public land in Massachusetts. MT = Mohawk Trail State Forest, SM = Savoy Mountain State Forest, M = Monroe State Forest, W = Windsor State Forest, MG = Mount Greylock State Reservation, MW = Mount Washington State Forest, ME = Mount Everett State Reservation, B = Beartown State Forest, EM = East Mountain State Forest, WM = Wachusett Mountain State Reservation.

Location/site name	State forest	Size (ha)	Latitude (N)	Longitude (W)	Elevation (m)	Aspect
Cold River: Route 2 to Black Brook	MT	38.4	42°38'7"	72°58'48"	350–420	NW–NE
Cold River: Route 2 to Black Brook Picnic Area	MT	14.2	42°37'48"	72°58'	320–450	N–NW
Lower Gulf Brook	MT	6.1	42°37'53"	72°59'52"	380–415	NW
Manning Brook	MT	6.1	42°38'23"	72°59'20"	375–420	NE
Black Brook	MT	10.1	42°37'45"	72°58'12"	360–500	N–NW
Tannery Falls	MT	3.6	42°37'39"	73°0'12"	390–420	NW
Todd and Clark Mountains	MT	80.9	42°38'50"	72°56'45"	330–460	Varied
Trout Brook West	MT	6.1	42°37'57"	72°56'19"	410–450	E
Hawks Mountain	MT	2.0	42°37'45"	72°55'34"	360–410	NW
Thumper Mountain	MT	0.8	42°38'23"	72°56'6"	250–270	NE
Middle Cold River to Route 2	MT-SM	18.2	42°38'3"	72°59'29"	360–415	N
Upper Cold River	MT-SM	32.4	42°39'7"	73°1'	390–450	Varied
Upper Gulf Brook	MT-SM	8.1	42°37'59"	73°0'43"	380–415	NE
Bear Swamp	M	12.1	42°41'50"	72°57'31"	360–480	E
Dunbar Brook	M	8.1	42°42'14"	72°58'8"	390–490	NE
Parsonage Brook	M	1.6	42°42'44"	72°58'46"	470–510	NW
Spruce Mountain	M	1.6	42°42'52"	72°59'56"	600–670	SE
Smith Brook-Deerfield River	M	1.6	42°41'58"	72°58'56"	360–450	NE
Hunt Hill	M	2.8	42°41'25"	72°58'53"	520–600	SE
Windsor Jambs	W	1.2	42°31'20"	72°59'35"	430–475	SW
The Hopper	MG	46.5	42°39'2"	73°9'58"	540–720	Varied
Stony Ledge	MG	4.0	42°38'54"	73°11'34"	675–720	NE
Mount Williams	MG	10.1	42°40'32"	73°9'59"	510–600	NW–NE
Roaring Brook	MG	10.1	42°37'44"	73°12'5"	550–630	N–NW
Bash Bish Falls	MW	15.4	42°6'47"	73°29'43"	415–485	N–NE
Mount Race	MW	2.0	42°4'39"	73°25'47"	645–710	Varied
Sages Ravine-Bear Rock Falls	MW	4.9	42°3'18"	73°26'4"	350–420	N
Alander Mountain	MW	2.0	42°5'7"	73°28'48"	585–610	SW
Mount Everett-Glen Brook	ME	14.2	42°6'37"	73°25'32"	490–560	NE
Mount Everett-Guilder Pond	ME	1.6	42°6'36"	73°26'22"	610–630	SW
Burgoyne Pass	B	1.2	42°16'3"	73°17'8"	390–470	S–SW
Ice Gulch	EM	3.6	42°9'30"	73°19'18"	405–440	SE–SW
Wachusett Mountain	MW	80.9	42°29'	71°53'	425–520	Varied
Total		452.8				

areas previously reported by Dunwiddie and Leverett [1996] equaled 181.4 ha). In all cases, the old-growth areas for which boundaries were expanded had not been rigorously sampled in prior investigations (e.g., no quantitative vegetation sampling and/or minimal tree aging [Dunwiddie and Leverett 1996]). In addition to the expansion of boundaries, another factor that contributed to the difference in our estimates from those published by Dunwiddie and Leverett (1996) is the inclusion of several previously unreported areas (e.g., Tannery Falls and Stony Ledge [Table 1]). It is important to note that although our estimates of total area of old-growth forest are higher than previously reported, these estimates are substantially lower than those used in recent forest-reserve planning exercises for western Massachusetts (see below).

Most of the old-growth areas in Massachusetts are small (< 10 ha) and are located in rugged topography (see Dunwiddie and Leverett 1996 for a detailed description of site characteristics), which presumably protected these areas from extensive land-use. Other factors such as Native American hostility (Hosier 1969) and an unfavorable climate for agriculture (Egler 1940) also help explain the persistence of old-growth on these landscapes, particularly in the regions of the state containing the largest areas of old-growth (i.e., Mohawk Trail and Savoy Mountain State Forests [Table 1]). Beyond these physiographic and historical factors, the composition of these old-growth forests may also partially explain their presence on the landscape in Massachusetts. In particular, the majority of these forests are dominated by *Tsuga canadensis* (Table 2), a historically low-value timber species (Howard et al. 2000) that likely limited the

Figure 1. Location of old-growth forests on public land in Massachusetts.

Table 2. Basal area (B, m^2/ha) and density (D, stems/ha) of overstory tree (≥ 10 cm dbh) species in the eighteen largest old-growth areas in western Massachusetts. BASH = Bash Bish Falls, BB = Black Brook, CRA1 = Cold River A1, CRA2 = Cold River A2, CRB = Cold River B, CRC = Cold River C, CRD = Cold River D, DH = Deer Hill, DB = Dunbar Brook, GR = Grinder Brook, HA = Hopper A, HB = Hopper B, MB = Manning Brook, ME = Mt. Everett, MO = Money Brook, TB = Tower Brook, TC = Todd-Clark Mountains, and WB = Wheeler Brook.

	Study area																	
	BASH		BB		CRA1		CRA2		CRB		CRC		CRD		DH		DB	
Species	B	D	B	D	B	D	B	D	B	D	B	D	B	D	B	D	B	D
Tsuga canadensis (L.) Carr.	34.6	431	37.6	468	31.5	119	27.5	275	31.0	375	-	-	34.5	450	33.5	267	-	-
Fagus grandifolia Ehrh.	-	-	1.0	42	5.5	131	5.8	119	-	-	5.4	63	0.1	5	1.8	8	7.0	88
Betula lenta L.	1.2	19	6.0	67	4.9	50	3.0	44	3.1	33	0.1	6	3.2	85	-	-	-	-
Betula alleghaniensis Britt.	-	-	-	-	0.9	19	0.7	25	2.1	33	5.3	44	-	-	-	-	6.1	13
Betula papyrifera Marsh.	0.5	6	-	-	-	-	0.4	6	0.6	8	-	-	0.8	20	-	-	-	-
Picea rubens Sarg.	-	-	0.3	8	-	-	-	-	-	-	-	-	9.3	90	6.2	50	-	-
Acer saccharum Marsh.	0.9	6	-	-	0.9	6	-	-	-	-	17.1	163	-	-	-	-	14.9	113
Acer rubrum L.	-	-	0.4	17	-	-	1.2	25	0.7	17	-	-	1.1	10	-	-	-	-
Acer pensylvanicum L.	-	-	-	-	0.4	31	0.3	13	0.5	33	-	-	-	-	-	-	0.5	31
Quercus rubra L.	-	-	2.0	25	-	-	0.8	6	0.6	17	-	-	-	-	-	-	-	-
Fraxinus americana L.	-	-	-	-	-	-	-	-	-	-	0.2	6	-	-	-	-	7.9	38
Ostrya virginiana (P. Mill.) K. Koch	0.4	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tilia americana L.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pinus strobus L.	10.7	50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	48.3	525	47.3	627	44.1	356	39.7	513	38.6	516	28.1	282	49	660	41.5	325	36.4	282

Table 2, continued.

	Study area																	
	GR		HA		HB		MB		ME		MO		TB		TC		WB	
Species	B	D	B	D	B	D	B	D	B	D	B	D	B	D	B	D	B	D
Tsuga canadensis (L.) Carr.	34.8	367	25.9	356	14.3	244	12.5	150	29.2	208	22.2	231	27.5	217	36.4	400	40.4	367
Fagus grandifolia Ehrh.	-	-	1.8	31	0.3	6	4.1	63	-	-	0.9	19	0.3	8	0.2	6	0.7	25
Betula lenta L.	2.0	33	0.4	6	-	-	1.6	38	2.9	42	1.7	13	-	-	2.8	44	4.1	58
Betula alleghaniensis Britt.	1.1	25	6.8	119	13.1	181	2.2	63	2.2	108	2.1	19	8.3	92	0.8	13	-	-
Betula papyrifera Marsh.	-	-	-	-	0.4	6	-	-	0.3	8	-	-	-	-	0.3	6	0.9	8
Picea rubens Sarg.	-	-	6.2	75	7.2	106	-	-	-	-	0.2	13	0.1	8	-	-	0.3	8
Acer saccharum Marsh.	-	-	-	-	-	-	11.6	88	-	-	17.5	125	9.4	108	-	-	-	-
Acer rubrum L.	-	-	-	-	-	-	-	-	0.6	8	-	-	-	-	3.9	63	2.1	42
Acer pensylvanicum L.	0.1	8	0.2	19	0.1	6	0.1	6	0.4	25	0.4	31	0.4	33	0.2	13	-	-
Quercus rubra L.	-	-	-	-	-	-	-	-	-	-	1.7	6	-	-	0.5	6	3.7	25
Fraxinus americana L.	-	-	-	-	-	-	0.1	6	-	-	3.8	6	0.6	8	-	-	-	-
Ostrya virginiana (P. Mill.) K. Koch	-	-	-	-	-	-	-	-	-	-	-	-	0.7	8	-	-	-	-
Tilia americana L.	-	-	-	-	-	-	-	-	-	-	-	-	1.6	17	-	-	-	-
Pinus strobus L.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	38	433	41.3	606	35.4	549	32.2	414	35.6	399	50.5	463	48.9	499	45.1	551	52.2	533

profitability of forest-harvesting activities in these areas. Moreover, the majority of hemlock stands examined in this study were located adjacent to forests that were logged in the past, suggesting that topography alone was not a deterrent for loggers. Due to the impending migration of the hemlock woolly adelgid into Massachusetts, there is a need to document these hemlock stands now, as they all could be substantially and irrevocably altered by this invasive pest (Orwig and Foster 1998).

Despite the relatively small size of these old-growth forests, they represent a rare and unique habitat type within a landscape dominated predominantly by 100–150 year old second-growth forests (A.W. D'Amato, unpubl. data). In addition, many of these parcels are located within the same state forest boundary and/or in different nearby state forests (e.g., MT and SM; Fig. 1, Table 1). These circumstances provide a wonderful opportunity for old-growth reserve efforts because many of the old-growth patches could be easily linked together in several large reserves on state-owned land that would protect and enhance the individual old-growth areas (Foster et al. 2005, Spies and Franklin 1996).

Our study of old-growth forests in Massachusetts differs from past efforts in the state by conducting extensive tree aging and analysis of historical documents for every site. Results highlight the fact that remaining old-growth forests in Massachusetts contain some of the oldest documented trees in New England (Table 3), including *T. canadensis* and *Picea rubens* 488 and 414 years old, respectively (cf. Brown 1996, Cogbill 1996, ITRDB 2006, Tyrrell et al. 1998). In addition, these areas contain some of the oldest known *Betula lenta* (332 years), *Betula alleghaniensis* (380 years), and *Quercus rubra* (325 years) trees in the country (Table 3; Burns and Honkala 1990; ITRDB 2006; Pederson et al., in press). Future comparisons of the structure, composition, and ecosystem properties of these old-growth areas with adjacent second-growth areas will increase our understanding of the importance of these areas as unique habitat types on the landscape.

Table 3. Maximum ages found for species commonly occurring in old-growth forests in Massachusetts.

Species	Age
Tsuga canadensis	488
Picea rubens	414
Betula lenta	332
Betula alleghaniensis[1]	370
Fagus grandifolia	271
Pinus strobus	269
Acer saccharum	242
Acer rubrum	224
Quercus rubra[1]	325

[1]Data from Orwig et al. (2001).

The estimates of the total area of old-growth forest remaining on public land in Massachusetts presented in this paper are much lower than estimates used in recent forest-reserve planning exercises for western Massachusetts (1200 ha; EOEA 2005; R.T. Leverett and G.A. Beluzo, unpubl. data). These higher estimates were generated primarily through the expansion of existing old-growth delineations onto portions of the landscape with similar topography, as well as through the inclusion of second-growth areas containing some trees with old-growth characteristics (e.g., large size; R.T. Leverett and G.A. Beluzo, unpubl. data). Based on our extensive field and archival research, we have confirmed that many of these areas have experienced extensive anthropogenic disturbance and therefore should not be included in delineations of old-growth forest stands on the landscape. While these second-growth forests will constitute important components of forest-reserve networks, the few remaining old-growth forest ecosystems should remain a higher conservation priority in these forest-reserve networks.

Conclusions

Old-growth forests are a rare ecosystem type on the landscape of Massachusetts. While our estimate of the total area of this forest type on the landscape is greater than prior studies, this still represents only 0.1 percent of the total forest area in Massachusetts. Therefore, the protection of these areas is critical as they represent one of the rarest habitat types in the state and region. As forest protection efforts and large-scale reserve planning in New England proceeds, it is crucial that these isolated old-growth areas are incorporated into larger reserve systems to ensure their protection and enhance the functioning of the established reserves. In order to ensure the protection of these unique systems as well as facilitate future old-growth research in Massachusetts, a rigorous, comprehensive estimate of the extent, location, and characteristics of old-growth forests remaining was paramount. By rigorously updating past estimates of old-growth area, we have developed a database that should be central to future legislative efforts aimed at old-growth protection, reserve planning, and comparisons between second-growth and old-growth forest ecosystems. While it is likely that other undocumented old-growth areas may exist within the landscape of Massachusetts, it is unlikely that the total area of old-growth in the state will exceed 500 ha.

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