Periodic Report

to the
Massachusetts
Department of Conservation
and Recreation

Submitted by

Friends of Mohawk Trail State Forest

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General Introduction

This report is presented to the Chief Forester for Massachusetts, James DiMaio; the Region 5 Supervisor, Robert Mellace; and the management forester within Region 5, Thomas Byron. **Friends of Mohawk Trail State Forest (FMTSF)** will also present copies of this report to the **Eastern Native Tree Society (ENTS)**, Harvard Forest for inclusion in their archives, the Massachusetts Audubon Society, Board members of the **FMTSF**, and Dr. Lee Frelich, Director for the Center of Hardwood Ecology of the University of Minnesota. **ENTS**, Mass Audubon, Dr. David Orwig of Harvard Forest, and Dr. Lee Frelich have been important contributors to the research described in this report.

On February 5, 2004, "**Report on Forest Research at Mohawk Trail State Forest**" was submitted to the then Department of Environmental Management (DEM) through William Rivers. The report covered research done by **FMTSF** to that date and explained the mission of **FMTSF**. Up to the present submission, the 2003 report and its two updates have served as the principal statements of record of **FMTSF's** work, originally in the old growth, and later in mature second-growth forest sites on State lands, with the bulk of the work being done in the following properties:

1. **Mohawk Trail State Forest (MTSF),**
2. **Monroe State Forest (MSF),**
3. **Savoy Mountain State Forest (SMSF),**
4. **Mount Greylock State Reservation (MGSR),**
5. **Mount Everett State Reservation (MESR),**
6. **Wachusett Mountain State Reservation (WMSF),**
7. **Mount Washington State Forest (MWSF)**
8. **Mount Tom State Reservation (MTSR)**.
9. **Bashbish Falls State Park (BFSP)**
10. **Other properties with old growth remnants**

Beginning with this reporting cycle, we are instituting a new approach to submitting updates. Our new approach will break up the **FMTSF** subject matter into ten standard reporting areas. The following subject areas have been identified:

1. Old-growth inventory and mapping,
2. Forest reserves,
3. Rucker indexing analysis and exemplary forest documentation,
4. White pine volume modeling, individual profiles, and lists,
5. White pine stand tagging, inventorying, and growth analysis
6. Activities and history of **FMTSF** and **ENTS,**
7. Dendromorphometry
8. Natural baseline forest identification and mapping,
9. Recreational trails and guides
10. Native American use of **MTSF**
11. Miscellaneous

Instead of submitting updates on the above topics in a single, all encompassing report, we have decided to present separate updates by subsets of the topics. This approach will allow us to be timely in our submissions. Areas that are under continuous study such as Rucker indexing analysis and white pine growth analysis and profiling will be updated more frequently, two to three times per year. Other areas may receive only annual updates. This update includes material on seven of the above eleven topics.

In presenting the many tables within the text, as opposed to including them as appendices, we chose this path because the data drive not only conclusions, but reinforce the importance of our approach, i.e. to collect statistics that are out of the mainstream of forestry data collection models and the common plot-based research designs of ecology. Conclusions are usually driven by measures of central tendency and individual trees and impressive site statistics and distributions that look data from a top down approach are often drowned in the averaging of the other approaches. No criticism is intended of the widely approved CFI methodology for the purposes that systems was designed to fulfill, but it not an exaggeration to say that the CFI system cannot provide the view of the forests of **MTSF** and **MSF** that is accomplished by our experimental designs. A simple test of this hypothesis is to take the current CFI data and see what kinds of conclusions can be drawn that are parallel to those derived from our analysis. Were we to rely of CFI data, the anonymity of Mohawk's superlative forests would continue.

As the final comment of this general introduction, in preparing and presenting this report, we apologize for grammatical and spelling errors that may have slipped through. In past submission, we caught them after it was too late. However, the staff of **FMTSF** is 100% volunteer. None of the researchers or drafters of this report are paid to do any of this work. We have been as thorough as we could be and ask your indulgence for what may have been missed.

SECTION 1: Old Growth Inventory and Mapping

Introduction

The **FMTSF's** DCR-sanctioned mission of old-growth forest identification, mapping, documentation, and research has been active primarily through the concentrated efforts of UMASS Amherst doctoral candidate and member of the **FMTSF** board, Anthony D'Amato. Tony's extensive research has tightened the boundaries of what can be legitimately considered pre-settlement forest. Less demanding definitions of old growth that require old growth characteristics to be present, but do not exclude some active anthropogenic impacts encompass another 2,000 to 2,500 acres. **FMTSF** will eventually delineate the boundaries of both classes of old growth. However, for the present, we concentrate on the most important class.

Pre-settlement Old-growth

The following table lists our best determination of the surviving pre-settlement old growth forest acreage on DCR lands. **FMTSF** will continue to refine the boundaries, but there is little chance that significant acreage will be added to what is reflected in the table. Strips of forest on the escarpment of Mount Tom, a small acreage of old trees on Mount Holyoke, and similar spots in Irving State Forest and on Mount Toby may be exceptions. The age structures of the trees at these places are sufficient to qualify them as second-generation old growth. The settlement dates of the areas and the probable encroachment into the old growth areas and the heavy use of the surrounding areas makes risky the classification of the sites as pre-settlement old growth.

Location/Site Name	State Forest	Size (ha)
Cold River: Rte. 2 to Black Brook	MTSF	38.4
Cold River: Rte. 2 to Black Brook Picnic Area	MTSF	14.2
Lower Gulf Brook	MTSF	6.1
Manning Brook	MTSF	6.1
Black Brook	MTSF	10.1
Tannery Falls	MTSF	3.6
Todd and Clark Mountains	MTSF	80.9
Trout Brook West	MTSF	6.1
Hawks Mountain	MTSF	2.0
Thumper Mountain	MTSF	0.8
Middle Cold River to Rte. 2	MTSF-SMSF	18.2
Upper Cold River	MTSF-SMSF	32.4
Upper Gulf Brook	MTSF-SMSF	8.1
Bear Swamp	MSF	12.1
Dunbar Brook	MSF	8.1
Parsonage Brook	MSF	1.6
Spruce Mountain	MSF	1.6
Smith Brook-Deerfield River	MSF	1.6
Hunt Hill	MSF	2.8
Windsor Jambs	WSF	1.2
The Hopper	MGSR	46.5
Stony Ledge	MGSR	4.0
Mount Williams	MGSR	10.1
Roaring Brook	MGSR	10.1
Bash Bish Falls	MWSF	15.4
Mount Race	MWSF	2.0
Sages Ravine-Bear Rock Falls	MWSF	4.9
Alander Mountain	MWSF	2.0
Mount Everett-Glen Brook	MESR	14.2
Mount Everett-Guilder Pond	MESR	1.6
Burgoyne Pass	BSF	1.2
Ice Gulch	EMSF	3.6
Wachusett Mt.	MWSR	80.9
	Total	**452.8**
	Acres	**1118.4**

Old growth age data

Tree cores obtained at the DCR old growth sites listed above have revealed remarkable ages for eastern hemlocks, red spruce, yellow birch, black birch, and northern red oak. Cores taken by Tad Zebryk and Bob Leverett in the 1988-1991 period, by Dr. Peter Dunwiddie and Bob Leverett in the 1991-1993, and currently by Tony D'Amato erase any doubt about the pre-settlement status of the old growth at the listed sites. However, it has been the cores taken by Tony D'Amato that have provided the most information about cohort development, successional patterns, maximum species ages, and where we draw the line in separating the pre-settlement old growth from lesser classifications. One black birch core taken by Tony D'Amato on the Todd-Clark ridge was aged to 332 years, making it the second oldest known for the species. A second core yielded 326 years. This makes **MTSF** the location of the second and third oldest known members of the species. In the early 1990s a 12-centimeter core taken by Tad Zebryk represented 183 years of age. Another 17 inches of core were too rotten and could not be dated.

The 488-year old hemlock at the Cold River A site is the oldest hemlock dated in Massachusetts and the second oldest dated in New England. The core confirms that the Cold River old growth matches the age characteristics of the best that New England has to offer.

It is with distinct pride that we are able to report such superlatives for the Massachusetts old growth. The following table summarizes the maximum ages that Tony D'Amato has substantiated.

Site	**State Forest**	**Max Age (Species)**
Black Brook	MTSF	303 (*Tsuga canadensis*) 323 (*Betula lenta*)
Cold River A	MTSF	488 (*T. canadensis*) 228 (*Fagus grandifolia*) 326 (*B. lenta*)
Cold River B	MTSF	333 (*Tsuga canadensis*) 238 (*B. lenta*)
Cold River C	MTSF	306 (*Tsuga canadensis*) 271 (*F. grandifolia*) 231 (*Acer saccharum*)
Cold River D	MTSF	441 (*T. canadensis*) 332 (*Picea rubens*) 261 (*B. lenta*)
Manning Brook	MTSF	315 (*Tsuga canadensis*) 231 (*F. grandifolia*) 221 (*Acer saccharum*)
Wheeler Brook	MTSF	307 (*T. canadensis*) 224 (*Acer rubrum*) 284 (*B. lenta*)
Todd-Clark Mt.	MTSF	377 (*T. canadensis*) 262 (*Quercus rubra*) 332 (*B. lenta*)
Dunbar Brook	MSF	404 (*T. canadensis*) 197 (*F. grandifolia*) 234 (*B. alleghaniensis*)
Hopper A	MGSR	264 (*T. canadensis*) 414 (*P. rubens*) 240 (*B. alleghaniensis*)
Hopper B	MGSR	295 (*T. canadensis*) 329 (*P. rubens*) 317 (*B. alleghaniensis*)
Money Brook	MGSR	302 (*Tsuga canadensis*) 190 (*F. grandifolia*) 242 (*Acer saccharum*)
Deer Hill	MGSR	261 (*T. canadensis*) 282 (*P. rubens*) 216 (*B. alleghaniensis*) 236 (*B. lenta*)
Grinder Brook	MWSF	333 (*T. canadensis*) 218 (*B. lenta*)
Bash Bish Falls	MWSF	277 (*T. canadensis*) 269 (*Pinus strobus*) 215 (*A. saccharum*) 211 (*B. lenta*)
Mt. Everett	MESR	325 (*T. canadensis*) 220 (*B. lenta*)

SECTION 3: Forest Reserves

Introduction

The existing DCR plan to identify forest reserves in Massachusetts on both large and small spatial scales is now focused on the northern Berkshires to identify small reserves in **MTSF, SMSF, MSF**, and elsewhere. A meeting at Pittsfield, MA on Feb 8th led to the delineation of forest reserve boundaries. For **MTSF** and **MSF** this amounted to identifying obvious inclusions and exclusions. In implementing the reserve concept, priority is given to factors such as existence of old growth, inaccessibility to logging, rare species, existence of 1830s forest cover, pre-existing natural areas, lack of fragmentation, etc.. There is general agreement that significant portions of **MTSF, MSF, SMSF**, and **MGSR** should be in reserves. The following list identifies the recommended reserves and exclusions specifically for **MTSF**. The adjoining reserves in **SMSF** are not shown in this report, but will be included in the next update.

MTSF Acreage:

Original boundaries to Black Brook:	5733 acres
Krudiak acquisition:	393 acres
Burke acquisition:	325 acres (approximate)

Total acreage: 6,451 acres

(Note: The original boundaries of MTSF extend westward beyond Black Brook. In recent maps of MTSF, this area shows up as Savoy Mountain State Forest.)

Exclusions from MTSF Reserve:

1883 acres – southern extension of **MTSF**
603 acres – central region
53 acres – northern extension of Krudiak acquisition

Total exclusions: 2539 acres

Recommended Reserve area: 3912 acres

We have included 3 topographical maps that conclude this section on reserves. The maps show exclusions instead of inclusions. The maps are organized from north to south. The first map excludes recommended reserve exclusion from the disjunct Krudiak property. The second map included recommended exclusions from the main section of **MTSF** north or Route #2, and the third part includes recommended exclusions from that part of **MTSF** that lies south of Route #2. Areas not encircled in red are proposed reserves. Specifically included in the reserves are the exemplary white pine stands.

Before presenting the maps, the Todd-Clark ridge of **MTSF** merits special discussion. The historic Mohawk Trail runs atop this ridge and for most of its length, its crest is narrow and its sides are steep. The following table lists slope percentages of the ridge complex.

Slope data for Todd-Clark Ridge

Location on Todd-Clark Ridge	Direction	Linear Dist - Mtrs	Upper Elev Mtrs	Lower Elev Mtrs	Diff Mtrs	Slope	
Todd Mtn - Summit to Upper meadow	E	566	519	204	315	55.7%	
Todd Mtn - Summit to Deerfield River	NE	710	519	192	327	46.1%	
Todd Mtn - Summit to Cold River	SW	613	519	236	283	46.2%	
Clark Mtn - Summit to Deerfield River	NE	1037	586	192	394	38.0%	
Clark Mtn - Summit to Cold River	SE	613	586	258	328	53.5%	
Todd-Clark Saddle	N	497	450	192	258	51.9%	
Todd-Clark Saddle	S	355	450	240	210	59.1%	
Western Clark	SE	382	534	264	270	70.6%	
Western Clark	S	515	540	276	264	51.3%	
Northern Clark	NE	806	480	192	288	35.7%	
Sums and averages		**6093**	**5183**	**2246**	**2937**	**48.2%**	**<--- Avg**

And analysis of the slope of the Cold River Gorge from near the entrance to where the Cold River and Route #2 depart was accomplished with 18 transects. The following table gives the results. The transects start at summit point above the gorge and run down to the water except for two transects on the south facing side of the gorge near the eastern entrance. This is where the wide river terraces are found.

Slope analysis of Cold River Gorge

Drainage	Horizontal-F	Vertical Hi-M	Vertical lo-M	Vertical Diff-M	Ratio
Cold River-NF	1139	510	300	210	0.604896
Black Brook	1639	570	270	300	0.60052
Cold River-NF	1618	570	276	294	0.596148
Cold River-NF	1885	558	264	294	0.511707
Cold River-NF	3740	570	228	342	0.300013
Cold River-NF	2009	488	210	278	0.453994
Cold River-NF	2656	522	192	330	0.407634
Cold River-NF	1586	390	180	210	0.434411
Cold River-SF	1259	552	384	168	0.437793
Cold River-SF	1853	540	288	252	0.44618
Cold River-SF	1982	586	240	346	0.57274
Cold River-SF	1474	498	234	264	0.587613
Cold River-SF	1139	450	240	210	0.604896
Cold River-SF	1936	519	228	291	0.493143
Cold River-SF	831	294	216	78	0.307949
Cold River-SF	1927	516	336	180	0.306461
Trout Brook-EF	1746	486	276	210	0.394603
Trout Brook-WF	2092	565	294	271	0.425004
Sum	**32511**	**9184**	**4656**	**4528**	**45.69%**
Avg	**1806.17**	**510.22**	**258.67**	**251.56**	

The forests of the Todd-Clark ridge have been the subject of much research and meet the criteria for reserve status. Approximately 200 acres of pre-settlement old growth cover the Todd-Clark ridge out of the 560 acres identified by D'Amato and Orwig within the boundaries of **MTSF**. In addition to the old growth, we find some of our most outstanding second growth forests in the Commonwealth. These areas of second growth generally date from the early to late 1800s and boast many tall tree champions for Massachusetts and some for all New England. The Todd-Clark complex (includes the ridge of Thumper Mountain) has 12 champion trees of height. If **MTSF** is the forest icon for the entire state for tree height, then the Todd-Clark ridge is the most outstanding single feature. Of the 1730+ acres of **MTSF** that lie north of Route #2, excepting for the 393-acre Krudiak acquisition, 1400 acres have been identified as a candidate for the forest reserves.

SECTION 4: Update on Rucker Indexing Analysis and Exemplary Forest Documentation

Introduction

As is explained in the original 2003 report, **FMTSF** and **ENTS** make extensive use of Rucker Indexing Analysis (RIA) to identify and compare exceptional trees and exceptional forest sites. In this kind of analysis, the dimension of total tree height has been our primary focus, but other dimensions, such as circumference or diameter, height to diameter ratio, and total trunk volume, can be used as well. The principles are the same.

An outgrowth of RIA has been a better comprehension of the conditions that produce exemplary forest sites from the standpoint of individual and collective tree growth for individual and assemblages of species. Here the concept of exemplary growth is not restricted to the local area, but is being examined across the eastern forest type. The methodology of RIA has been adopted by at least one research scientist in the U.S.D.A. Forest Service.

RIA started as the computation of a single index per forest site based on tree heights. RIA has since been extended to provide incorporate multiple (or iterated) indices that is providing us with a continuing data stream. From the stream we are gleaning a slightly different view of growth than is ordinarily obtained from forestry. At the least, RIA yields, by far, our best statistical descriptions of absolute tree growth performance for the sites we study. Consequently, it would be hard to overstate the importance of Rucker indexing in helping us to understand individual species performance at the sites we study. Most relevant to this report, RIA is allowing us to assess how Mohawk ranks as a tree growing environment as compared to other sites in the same and different geographical areas. This assessment has given us an appreciation of Mohawk that did not previously exist. But how has this newly found knowledge flowed from RIA? It is worthwhile exploring the origins of RIA, its initial components, subsequent enhancements, and its future direction.

Basic Concept

As originally conceived, Rucker indexing was designed to compare tree heights among forest sites for the ten tallest species at each site. The ten tallest at one site did not have to match the ten tallest at other sites. The purpose of the comparison was to identify exceptional growing sites, individually outstanding trees, and to ultimately determine the maximum heights to which eastern species can grow at individual sites, regionally, and across their full ranges. For sites being subjected to RIA, we made concentrated searches for the tallest members of each of the ten tallest species of trees. The ten heights were averaged. The resulting average for the ten heights was called the site's Rucker index. The same concept was then extended to circumferences. To distinguish between height-based indices and circumference-based indices, we coined the terms RHI and RCI, i.e. Rucker height index and Rucker circumference index. Obviously, the RHI is nothing more than the average height of the tallest member of the ten tallest species and similarly for the largest circumferences. In this initial form of the index, a particular species is represented in the average only once. For example, two white pines cannot be included in a calculation of a site's RHI.

In this basic form of Rucker indexing, a site rich in species that have the genetic propensity to achieve significant heights, such as white pine, tuliptree, white ash, and pignut hickory can be expected to yield a high index. These sites are distinguished from those that have a single tall species.

The challenge for us has been to determine what kind of useful historical and scientific/ecological information can be derived from this form of Rucker indexing that can be derived from conventional forestry methods. What new truths can be discovered? The rewards have been surprising. They were not initially obvious to any of us. When originally proposed, the concept of the Rucker index, which at that point was totally height based, was viewed by some of the **ENTS** members as more of a sporting than a scientific tool, rather like comparing batting averages. But the index has gradually attracted attention from the serious scientists in **ENTS**. They recognize that the developing database of site data has definite scientific applications. For instance, Dr. Don Bragg at the Southeastern Experiment Station of the U.S.F.S is beginning to employ RHI in his work. Prominent forest ecologists in **ENTS** like Dr. Lee Frelich see the concept as useful for studying site-based factors that produce maximum tree growth.

But isn't the kind of tree height data described above widely available at least as a byproduct of data routinely compiled in forestry programs and projects and captured by the champion tree programs? The answer is a simple no. Historical data from all sources for species height maximums are notoriously inaccurate. Data published in books on species maximums are all over the board. A large gap exists in our understanding of species maximums except in a very general way. RIA fills the gap. It has been a zeroing in on the absolute maximum height growth potential for eastern species over their full geographical ranges and determining where within those ranges maximums tend to occur.

Early Applications of RIA

In applying RIA, at the outset, **ENTS** tree measuring experts concentrated on several well-known places recognized to grow very tall trees. Among the sites were Cook Forest State Park (PA), the Great Smoky Mountains NP (TN/NC), Hartwick Pines SP (MI), and Congaree NP (SC). There was a lot of anecdotal information about tree height at these sites and a few formal studies. One study led the National Park Service to conclude that the Congaree Swamp forest is the tallest or equal to the tallest hardwood woodland in the northern temperate zone. This distinction actually goes to the Great Smoky Mountains NP, but Congaree does rank very high. What could not be produced from these early sources was a coherent, ranked list that would permit meaningful comparisons to be made. Joyce Kilmer Memorial Forest was thought to be by some writers the most exemplary example of a virgin forest. Tree heights were thought by local members of the U.S. Forest Service to top 170 feet based on input from big tree hunters involved with the state and national champion tree program. But all these sources were sketchy and often cited data collected for a single tree.

From the early period of RIA, a seemingly unlikely northeastern site joined the well-known tall tree locations as an outstanding performer. The site is **MTSF** in western Massachusetts. A second unlikely site later joined the list, Zoar Valley, NY. RIA now shows all the above listed sites to be exceptional in terms of the heights of their trees either absolutely or for their respective geographical areas. However, data coming specifically from **MTSF,** Cook Forest State Park, and the Great Smoky Mountains NP have provided the strongest incentives for **ENTS** members to expand the searches, locate the best tree-growing sites, and apply RIA and of the big three, **MTSF** has been especially prominent. For a time, **MTSF** boasted the highest Rucker index in the Northeast. But **ENTS** has expanded its tall tree search. We have discovered tall trees growing at many locations heretofore unknown. After RHIs had been computed for about three dozen tall tree sites from New Hampshire to Georgia, it became increasingly evident to us that there are many tall tree hot spots left for **ENTS** to find and that collectively we can draw accurate maps reflecting tree growth potential. Sites in protected ravines and gorges of our wilder parks might be expected to hold secrets, but it was evident that forests on old estates and in city parks also held treasures. But surprisingly, even though the list of impressive tall tree sites is growing steadily, the early sites continue to hold high rankings, at least regionally. In the Northeast, **MTSF** and Cook Forest have stayed very high in the rankings. Only Zoar Valley ranks higher. But beyond the simple rankings of the sites came the inevitable questions.

A question that arose early for those in **ENTS** who were studying growth patterns in **MTSF** was whether or not its high index was: (1) an anomaly that depended on a few statistical outlier trees, (2) reflected a lack of wider searches, (3) had to do with forest practices, (4) reflected the result of favorable environmental growing conditions in combination with a long growth history, (5) another explanation, or (6) some combination of the above. To determine if Mohawk's high index was dependent on a few statistical outliers and consequently not ecologically significant, the Rucker index concept was extended to include a multiple iterations process. Iterations represented the first extension of RIA beyond the initial RHI and lifted RIA out of the arena of sport. For the scientists who had been skeptical about the purpose to which indexing was put came on board as advocates for the process.

In applying the **iteration process**, the RHI is first computed as described above. Then the ten trees making up the index are removed from the data set and the whole process is repeated as though the original trees were not present. The RHI computed on the remaining trees at the site is called a second order RHI. The iteration process can be repeated multiple times and the distribution of species and heights analyzed to see how a few species or just a few exceptionally tall trees influence the index. Iteration is an extended process of elimination and it is important to understand that there is no requirement that the same species be involved in successive iterations. This was an early misunderstanding by some users of the process. For example, they thought that if the sugar maple was a member of the first iteration, then sugar maple was supposed to remain in succeeding iterations. That is not the case.

From applying the iteration process using **MTSF** as the test case, we were able to confirm the value of the iteration process. Iteration clearly distinguishes the sites that are **deep in a single versus multiple species of tall trees**. Sites that depend on one or two species and/or a few statistical outliers stand out clearly from those deep in many species with increasing iterations. The sites that have a few statistical outliers show rapidly falling indices with successive iterations.

From our early analysis, it was clear that **MTSF** maintained a high Rucker index beyond the initial one and it appeared that Mohawk would hold a relatively high Rucker index for many iterations. This increasingly identified Mohawk as exceptional compared to adjacent sites as we noted that potentially competing sites exhausted their tall trees in two or three iterations. As a consequence, the latter sites tend to be of lesser interest to us than those that maintain a high index through multiple iterations. The latter are the truly exceptional sites.

There is another factor to be considered in comparing a site's index value to that of another. It is also clear that increases to a RHI will result from extending a site's boundaries. This is obvious, but it also points to a valuable kind of analysis that investigates how tall trees tend to be clustered. Site boundary analysis is needed when comparing sites of very different sizes since the basic indexing concept does not incorporate a tall tree density factor. This will change in the future as RIA evolves to examine clustering in greater detail.

We should emphasize that what can be done for height in terms of indexing can be also be done for diameter, crown spread, or even a complicated calculation such as trunk volume. Indexing can also be extended to include fewer or more than ten trees. Finally, the indexing scheme can be extended to average the 10 tallest or largest trees irrespective of the species. In this type of indexing, the same species can be represented multiple times and reveal the dominating role of a species like white pine.

By including various types of Rucker indexing schemes, sites can be ever more finely compared and absolute height and circumference/diameter limits for a species can be analyzed locally and range wide. The practical value of RIA is that it presents us with a powerful set of tools for identifying exceptional growing sites and revealing data about individual species that cannot be obtained by other methods of data collection such as the state's CFI plots.

From the current state of Rucker indexing, there are many directions that our analysis can take. **ENTS** regularly employs relative and absolute scales for comparing species. For instance, we do not expect to see height or girth measurements for ***Liriodendron tulipifera***, the tuliptree, in New England match those farther south, and in particular, those in the mountains of North Carolina, Tennessee, South Carolina, and Georgia. We are more apt to compare tuliptree growth in New York State to that in southern New England than in North Carolina, when our objective is to analyze site variables at a local level.

A byproduct of Rucker index analysis is that **ENTS** has sharpened its criteria for what makes an exemplary site. We can speak of an exemplary white pine site, an exemplary hardwood site, etc. Sites exhibiting trees that reach absolute or regional maximums for any of four dimensions are usually considered to be exemplary, but the more superlatives that a site has, the more that site is considered truly exemplary or exceptional.

Although circumference, crown spread, height to diameter ratio and other derivations are subject to Rucker indexing, and are now being used, for this report, we will concentrate on tree height, since we have the most data on the RHI.

As a side point, it is with height that the **ENTS** database is particularly useful since the height dimension has been badly mis-measured throughout the history of forest data collection. Of all the sources of information on tree dimensions, to include those put out by the U.S. Forest Service, the **ENTS** database provides by far the best determinations of maximum species heights.

Application of Rucker Indexing to MTSF with Comparisons to Other Sites

RIA has proving invaluable to **ENTS** in identifying exceptional eastern forest sites that have escaped notice as important tall tree sites. One of the late site additions is Savage Gulf State Park in Tennessee. Another is McConnell Mill State Park in Pennsylvania. However, no site has benefited as much as **MTSF**. Mohawk has been recognized for its old growth by a few and for its recreational possibilities by many. But up to 1990, **MTSF** was unknown as an important site for exceptionally tall trees. However, RIA has changed that and as a consequence of intense analysis by **ENTS**, **MTSF** has emerged as an extraordinary site. But just how extraordinary is it? Answering that question requires a number of comparisons be made to other sites, local, regional, and eastern-wide. We will begin by examining **MTSF** from an eastern-wide perspective. The table below lists Rucker height indices for 107 sites spread across the eastern United States. In making these comparisons, we point out that there is no standard acreage for a site. For example, a small property in Table #1 is Monica's Woods, which cover approximately 35 acres. By contrast, the largest site is the GSMNP at approximately 520,000 acres. The Park taken as a whole reflects many eastern maxima. Obviously, sites with such disparate sizes cannot be logically compared. However, in an apples-to-apples comparison, the best areas in the Smoky Mountains comparable in size to **MTSF** have Rucker indices that lie between 155 to 159.

In the table below, the 17 Massachusetts sites are color coded red. Massachusetts accounts for 15.8% of the sites in the list. As more sites are added, the proportion of Massachusetts sites will drop and as more southern sites are added; those in the Northeast will drop further in the rankings. Consequently, to keep proper perspective on the regional role of **MTSF**, we will zero in on the Northeast, then New England, and finally just Massachusetts.

MTSF's Position in the Eastern United States

Rucker Height Indices for 107 Eastern Sites			
Site	Rucker Index	State	Region
GSMNP	163.6	North Carolina-Tennessee	Southeast
Savage Gulf Wilderness	152.1	Tennessee	Southeast
Congaree National Park	151.0	South Carolina	Southeast
Central Brevard Zone	150.6	South Carolina	Southeast
Tamassee Knob, Brevard Fault Zone	146.1	South Carolina	Southeast
Wadakoe Mtn	144.2	South Carolina	Southeast
NE Aspect Cove, Tamassee Knob, BFZ	142.7	South Carolina	Southeast
Alexander Creek, Brevard Fault Zone	140.1	South Carolina	Southeast
Indian Creek	138.7	North Carolina	Southeast
Station Cove, Brevard Fault Zone	138.4	South Carolina	Southeast
Robin Shelby SP	138.1	Tennessee	Southeast
Panther Creek	137.8	Georgia	Southeast
Zoar Valley	137.3	New York	Northeast
Bankhead National Forest	137.2	Alabama	Southeast
Cook Forest State Park	136.2	Pennsylvania	Northeast
Mohawk Trail State Forest	136.0	Massachusetts	Northeast
Cliff Creek	135.8	Georgia	Southeast
Kelly Creek Roadless Area	135.4	Georgia	Southeast
Red Mountain	134.5	Alabama	Southeast
Camp Creek	133.6	Georgia	Southeast

Ocmulgee Flats	133.3	Georgia	Southeast
Joyce Kilmer Wilderness	133.1	North Carolina	Southeast
Brasher Woods, Red Mountain	132.9	Alabama	Southeast
Jewel Branch, Wadakoe Mountain	132.9	South Carolina	Southeast
Fairmount Park	132.3	Pennsylvania	Northeast
Cohutta Wildlife Mgt Area	132.2	Georgia	Southeast
Opossum Creek	132.2	South Carolina	Southeast
Camp Branch	132.2	Georgia	Southeast
Cohutta Wilderness Area	132.0	Georgia	Southeast
Belt Woods	131.0	Maryland	Central Atlantic
Rock Creek Park	130.3	Washington D.C.	Central Atlantic
Chase Creek Woods	130.2	Maryland	Central Atlantic
Rock Creek	129.9	Georgia	Southeast
Turkey Creek	129.4	South Carolina	Southeast
Wintergreen Gorge	128.5	Pennsylvania	Northeast
Long Cane Creek	128.3	South Carolina	Southeast
Stockbridge (town)	128.0	Massachusetts	Northeast
Fitzhugh's Woods, Red Mountain	127.7	Alabama	Southeast
Vanderbilt Estate	126.9	New York	Northeast
Ricketts Glen State Park	126.3	Pennsylvania	Northeast
Ice Glen (in Stockbridge township)	126.2	Massachusetts	Northeast
Otter Creek	125.1	South Carolina	Southeast
North Prong Sumac Creek	124.9	Georgia	Southeast
Davidson Creek	124.8	Georgia	Southeast
Mountain Bridge Wilderness	124.3	South Carolina	Southeast
Monroe State Forest	123.7	Massachusetts	Northeast
Hocking Hills State Park	123.7	Ohio	Midwest
Big Oak Tree State Park	123.3	Missouri	Central
Widen Stand	122.5	West Virginia	Central Atlantic
Anders Run N.A.	122.3	Pennsylvania	Northeast
Tyler Arboretum	123.1	Pennsylvania	Northeast
Western NC Nature Center	122.1	North Carolina	Southeast
Carter's Grove	122.0	Virginia	Southeast
Walnut Creek Gorge	121.7	Pennsylvania	Northeast
Alum Bridge	119.9	West Virginia	Central Atlantic
Northampton (town)	119.3	Massachusetts	Northeast
Corcoran Woods	119.2	Maryland	Central Atlantic
Green Lake	118.0	New York	Northeast
Clear Creek State Park	117.5	Pennsylvania	Northeast

Easthampton (town)	116.6	Massachusetts	Northeast
Claremont-Private	116.5	New Hampshire	Northeast
Mill Creek park	115.9	Ohio	Midwest
Coho Property (Erie Bluffs)	115.7	Pennsylvania	Northeast
Lower Huron Metro Park, Detroit	115.7	Michigan	Midwest
Mount Tom State Reservation	115.2	Massachusetts	Northeast
Sisters of St. Francis	115.2	Pennsylvania	Northeast
Hemlocks N.A.	114.8	Pennsylvania	Northeast
Kyle Wood	114.8	Ohio	Midwest
Kaaterskill Falls	114.5	New York	Northeast
Heart's Content N.A.	113.8	Pennsylvania	Northeast
Starza Woods, Atlanta	113.8	Georgia	Southeast
Lake Erie Community Park	113.6	Pennsylvania	Northeast
Bullard Woods	112.9	Massachusetts	Northeast
Laurel Hill in Stockbridge	112.5	Massachusetts	Northeast
Bartholomew Cobble	112.5	Massachusetts	Northeast
Poland Woods	112.4	Ohio	Midwest
Monica’s Woods (Florence, MA)	112.1	Massachusetts	Northeast
Carl Sandburg Home	111.8	North Carolina	Southeast
Conway (town)	111.7	Massachusetts	Northeast
Arcadia Wildlife Sanctuary	111.5	Massachusetts	Northeast
Alan Seeger N.A.	111.1	Pennsylvania	Northeast
Calloway Gardens	110.7	North Carolina	Southeast
Wawa Preserve	110.0	Pennsylvania	Northeast
Scott Community Park	109.6	Pennsylvania	Northeast
Montgomery Estate	109.5	New York	Northeast
Tionesta Scenic and Research N.A.	109.4	Pennsylvania	Northeast
Stanley Park, Westfield, MA	109.1	Massachusetts	Northeast
Hatfield Floodplain	107.4	Massachusetts	Northeast
Bryant Woods	106.9	Massachusetts	Northeast
The Pocket, Pigeon Mountain	106.6	Georgia	Southeast
Look Park	106.6	Massachusetts	Northeast
Latodami Nature Center	106.5	Pennsylvania	Northeast
Allegheny River Islands Wilderness	105.0	Pennsylvania	Northeast
Detweiler Run N.A.	104.7	Pennsylvania	Northeast
Laurel Run Rd-Centre County	104.6	Pennsylvania	Northeast
Parker Dam State Park	104.1	Pennsylvania	Northeast
Skinner State Park	101.7	Massachusetts	Northeast
Hemmenway State Park	101.0	New Hampshire	Northeast

Glenwood Park	98.1	Pennsylvania	Northeast
Shingletown Gap	97.5	Pennsylvania	Northeast
Arkansas-Pinnacle Mountain	98.8	Arkansas	Eastern
University of Arkansas, Monticello	96.8	Arkansas	Central
Yates Park, Lawrence Park	96.0	New York	Northeast
Bear Meadows N.A.	93.7	Pennsylvania	Northeast
Scholarie Valley	91.8	New York	Northeast
Reynoldsville suburbs	88.8	Pennsylvania	Northeast
Gouverneur Site, Lawrence County	66.1	New York	Northeast

Notes:

(1) The dominance of Pennsylvania sites in the Northeast in the above table results from a concentrated effort by **ENTS** members to cover the Keystone state in-depth. Pennsylvania has a historical role as the repository of significantly big and/or tall trees. But even with the above coverage, we have a long way to go to cover the entire state. Pennsylvania will continue to be the highest performer of all states in the Northeast. The southeastern region of Pennsylvania still has significant sites and with additional searching, the Rucker index of Fairmount Park will likely approach 135.

(2) There may be a few other sites in other Northeastern states with a Rucker index at 130 or over. New York will likely yield another one or two. With increased searching, **MTSF**'s claim to 3rd place in the Northeast may slip slightly. However, given the small size of **MTSF** and its latitude, excepting Zoar Valley, NY, Mohawk's position in the hierarchy of northeastern sites will remain remarkable and dominant at its latitude. In addition, so long as the white pine and white ash maintain their current level of dominance, the Rucker index of **MTSF** will likely stay at 136 or slightly more. **MTSF** will likely remain the northernmost eastern site with a Rucker index over 130.

(3) For the eastern U.S., Mohawk's current position of 16th will slip substantially as more exemplary sites are added in the central Atlantic and in the South. Both hardwoods and conifers reach impressive sizes, especially heights, in the southern parts of their ranges when allowed to grow on good sites for 100 years or more. Older trees of a dozen species common to north and south achieve significantly greater diameters in the southern parts of their range. Consequently, tall tree statistics often favor the southern parts of the ranges of target species. The best example of this dominance is ***Tsuga canadensis. Tsuga*** reaches heights of 160+ feet in the southern Appalachians. It rarely reaches 120 feet in latitudes of 43 degrees north.

We will now look just as the Northeast. There are 25 sites for which **ENTS** has RHIs computed. The format of the Northeastern table will be changed to include site acreages and identification of the tallest tree at each site.

MTSF's Position in the Northeastern United States

TOP 25 INDICES IN NORTHEAST	State	Approximate Acreage Involved in Index	Rucker Index	Number Species	Tallest Single Tree	Species
Zoar Valley	NY	1200	137.2	10	156.0	TT
Cook Forest	PA	3000	136.2	10	182.3	WP
Mohawk Trail State Forest	MA	2500	136.0	10	167.3	WP
Fairmount Park	PA	1000	132.3	10	158.6	TT
Wintergreen Gorge	PA	120	128.5	10	145.4	TT
Vanderbilt Estate	NY	100	126.9	10	155.1	TT
Ricketts Glen SP	PA	1500	126.3	10	152.9	TT
Ice Glen	MA	50	126.2	10	154.3	WP
Monroe State Forest	MA	500	123.7	10	160.2	WP
Anders Run	PA	250	122.3	10	167.1	WP
Walnut Creek Gorge	PA	200	121.7	10	135.5	TT
Green Lake State Park	NY	250	118.0	10	144.7	TT
Coho (Erie Bluffs SP)	PA	??	117.6	10	140.3	TT
Claremont	NH	120	116.5	10	166.1	WP
Mount Tom	MA	300	115.8	10	140.2	WP
Sisters of Saint Francis	PA	??	115.2	10	137.5	TT
Hemlocks Natural Area	PA	150	114.8	10	138.0	TT
Hearts Content	PA	120	113.8	10	162.0	WP
Lake Erie Community Park	PA	??	113.6	10	140.4	TT
Bullard Woods	MA	25	113.1	10	133.0	WP
Laurel Hill	MA	25	112.5	10	138.1	WP
Bartholomew Cobble	MA	125	112.5	10	130.9	WP
Kaaterskill Falls	NY	70	111.5	10	140.3	WA
Arcadia Wildlife Sanctuary	MA	600	111.5	10	126.1	WP
Alan Seegar	PA	??	111.1	10	137.7	TT

The above table shows us the importance of three species to the tall tree listings for the Northeast. Of the 25 sites listed above, the tallest species is white pine on 12 of the sites, tuliptree on 12 sites, and white ash on one site. The ubiquity of white pines and tuliptrees in tall tree lists should come as no surprise to the readers of this report familiar with those species. The stature of the white pine and the tuliptree is substantiated by historical data, that although may suffer in absolute accuracy, is reliable as a general ranking for comparison purposes. **MTSF** has white pine, but no tuliptrees, so the white ash becomes the second dominant species.

The role of the white pine and tuliptree raises interesting questions on how species common to Mohawk are represented in the other top northeastern sites. The table below presents a comparison of the 10 top species in **MTSF** to see how they are represented at the other sites.

The species featured are white pine, white ash, hemlock, bitternut hickory, black cherry, American basswood, sugar maple, northern red oak, red maple, and American beech. These are the species that give **MTSF** its RHI of **136.0**. Boldface numbers represent rankings of 1, 2, or 3 for the represented sites. Red is #1, Green is #2, and Blue is #3.

Representation of key species in northeastern sites

Site	WP	WA	HM	BNH	BTA	ABW	SM	NRO	RM	AB	Rucker
Zoar Valley	134.0	**140.5**		**136.4**	**126.4**	**128.7**	**127.0**	**140.3**		**130.1**	**137.2**
Cook Forest	**182.0**	129.8	**145.7**	106.2	**140.0**			122.8	**126.0**	**124.4**	**136.2**
MTSF	**167.3**	**151.5**	131.0	131.0	**126.0**	**126.9**	**133.8**	**133.5**	**128.0**	**130.5**	**136.0**
Fairmount Park		135.7	112.5	**134.2**				**135.2**		118.0	**132.3**
Winter Green State Park		129.8	128.0		121.3	121.7	123.4		**136.7**		**128.5**
Ricketts Glen SP	144.6	**139.7**	**136.7**			**123.2**	115.8	106.8	110.6	116.8	**126.3**
Ice Glen	154.3	**140.0**	**138.2**	108.3	120.5		109.9	110.9	116.5		**126.2**
Vanderbilt	134.0		111.3	122.0			**125.0**			115.1	**126.9**
Monroe SF	160.2	134.2	124.3		117.1		118.5	120.5	110.0	116.3	**123.7**
Anders Run	**167.1**	118.4	125.4		121.8	120.7			116.0		**122.3**
Walnut Creek Gorge		124.2	112.3	115.0			122.9			119.3	**121.7**
Green Lakes SP		113.0	116.0	**135.6**	104.9		120.1	115.9	105.8	104.9	**118.0**
Claremont	166.1	125.8	125.7			98.3	103.8	102.6	112.3	104.9	**116.5**
Mt. Tom SR	140.3	120.1	125.1	107.8			105.5	108.8	106.7	100.4	**115.2**
Hearts Content	162.0		127.8		106.4			98.6	119.0	109.8	**113.8**
Average	**155.6**	**131.0**	**125.7**	**121.5**	**120.4**	**119.7**	**118.7**	**117.8**	**117.0**	**115.8**	**125.3**

Notes:

1. **MTSF** places 1st, 2nd, or 3rd in 8 of the 10 species.
2. Zoar Valley has placements for 7 species.
3. Cook Forest has placements for 5 species.
4. Species that boost the RHI at some of the other sites that are not represented in Mohawk include tuliptree and sycamore.

Championship status of 25 species in MTSF in the Northeast

Our next examination will be of the championship status of 25 species that are native to **MTSF**. The championship status of the 25 species is shown in the next table categorized as **MTSF**, Massachusetts, New England, and Northeast. The last column gives a subjective evaluation of how likely the particular championship classification is to hold up as further searching and measuring is done across the Northeast.

Species	*Location*	*Height*	*Circumference*	*DOM-Last*	*Champion Status*	*Probability*
WP	Trees of Peace	167.3	10.4	2/27/2005	New England	H
WA	Trout Brook	151.5	6.2	11/20/2004	Northeast	H
SM	Trout Brook	133.8	5	4/16/2005	Northeast	M
NRO	Todd Mtn	133.5	9.3	11/25/2004	New England	M
HM	Black Brook	131	10.7	9/21/2003	MTSF	H
AB	Clark Ridge-North	130.5	8.4	4/9/2006	Northeast	M
BNH	Clark Ridge-Indian Flats	131	4.3	4/24/2006	New England	M
BTA	Clark-Shunpike	126	3.5	10/24/2002	Northeast	H
RM	Clark Ridge-Elders Grove	128	6.2	4/24/2006	New England	M
ABW	Clark Ridge-North	126.9	5.9	4/24/2006	New England	M
BC	Trout Brook	125.3	5.5	4/9/2005	New England	M
AE	Clark Ridge-North	120.8	6.6	5/10/2005	New England	M
RP	Red Pine Grove	116.3	5	3/4/2004	MTSF	H
BB	Clark Ridge-North	116.2	3.6	10/14/2002	Northeast	M
RS	Cold River East	114.7	7.3	5/1/1999	MTSF	M
SBH	Encampment	111.8	3.9	5/22/2004	MTSF	H
WB	Clark Ridge-North	110.5	5.2	10/14/2002	Northeast	H
BO	Clark Ridge-Ash Flats	110.5	4.8	8/18/2002	Massachusetts	L
YB	Trout Brook	105.6	4.8	5-1--2005	Northeast	M
WO	Encampment	101.8	8.2	10/26/2003	MTSF	H
GA	Indian Springs	98.2	8.4	4/9/2005	MTSF	H
CW	MTSF-HQ	95	7	8/11/2003	MTSF	H
BLCT	Todd Mtn	84.9	5.5	2/22/2004	MTSF	H
HH	Cold River East	78.2	3.3	10/23/2003	Northeast	M
STM	Encampment	60.5	1.8	7/16/2004	Northeast	L

We will now return to an eastern-wide comparison. For the above distribution of championship heights, we might ask how does **MTSF** compare with sites in other geographical areas? Although, the southern United States excels when it comes to large, tall trees, Mohawk's record continues to be impressive, particularly with respect to white pine, white ash, sugar maple, northern red oak, bigtooth aspen, and yellow, black, and white birch. Although American elm is listed below as a regional champion, it has been greatly under-sampled because of its scarcity. Similarly, bitternut hickory has been under-sampled relative to its known potential. Extended searching in southern Connecticut will likely reduce the Mohawk's share of the New England champions by two to four species. But, irrespective of future height confirmations, Mohawk's number of height champions is likely to remain well beyond any other single public or private property in New England in terms of the number of height champions. Barring disturbance, **MTSF** will continue to dominate the New England sites.

Comparison of 23 species for maximum height across regions

The next comparison shows how the individual performers in **MTSF** compare statewide, in New England, the Northeast, and the East.

	Maximum Height	Maximum Height	Maximum Height	Maximum Height	Maximum Height	MTSF % of Maximum	MTSF % of Maximum
Species	In MTSF	In Mass	In New England	In Northeast	In East	In Northeast	In East
White pine	167.3	167.3	167.3	182.5	187	91.67%	89.47%
White ash	151.5	151.5	151.5	151.5	167.1	100.00%	90.66%
Sugar maple	133.8	133.8	133.8	133.8	151	100.00%	88.61%
N. red oak	133.5	133.5	133.5	143.1	153	93.29%	87.25%
Hemlock	131	138.2	138.2	145.7	168.9	89.91%	77.56%
American beech	130.5	130.5	130.5	130.5	136.6	100.00%	95.53%
Bitternut hickory	131	131	131	136.4	156.3	96.04%	83.81%
Big tooth aspen	126	126	126	126	126	100.00%	100.00%
Red maple	128	128	128	136.6	142.3	93.70%	89.95%
American basswood	126.9	126.9	126.9	128.7	128.7	98.60%	98.60%
Black cherry	125.3	125.3	125.3	140	146.7	89.50%	85.41%
American elm	120.8	120.8	120.8	120.8	136.5	100.00%	88.50%
Red pine	116.3	121.3	121.3	121.3	143.6	95.88%	80.99%
Black birch	116.2	116.2	116.2	116.2	118.8	100.00%	97.81%
Red spruce	114.7	129.5	129.5	129.5	154.7	88.57%	74.14%
Shagbark hickory	111.8	134.4	134.4	134.4	152	83.18%	73.55%
White birch	110.5	110.5	110.5	110.5	110.5	100.00%	100.00%
Black oak	110.5	110.5	110.5	116.7	143.8	94.69%	76.84%
Yellow birch	105.6	105.6	105.6	105.6	116.3	100.00%	90.80%
White oak	101.8	115.3	115.3	126.8	147.2	80.28%	69.16%
Green ash	98.2	113.7	113.7	132	153.4	74.39%	64.02%
Cottonwood	95	129	129	134.4	154.4	70.68%	61.53%
Hop Hornbeam	78.2	78.2	78.2	78.2	78.8	100.00%	99.24%
Totals and Averages		21	20	9	2	93.06%	85.37%

Notes:

1. Black birch stays remarkably close in its height maximums north to south. A maximum height of 110 to 120 feet for both north and south represents an extremely tight maximum height range for any species. Yellow birch has a similarly tight maximum height range

north to south. White birch gains height as it moves from south to north up to latitude 42-43 degrees. Then it loses height.

2. Species like eastern cottonwood are often improperly measured by tree hunters because of the broad crowns that are open in the center. Cottonwoods typically are quoted as having heights of 25 to as much as 50 feet above actual maximums. Eastern cottonwoods in the 200-foot height measurement have been reported. The tallest cottonwood measured by **ENTS** is 154.4 feet.

3. The bigtooth aspen is a much better performer in the North than the South. The same can be said of white birch. Interesting, other species associated with northern forests such as hemlock reach their greatest sizes in the southern and central Appalachians. By latitude 43.5 – 44.0 degrees north, 100 feet is more of a common hemlock maximum. However, many sites in the southern Appalachians have hemlocks in the 140-foot height class and over. Sites in the North Carolina, South Carolina, Tennessee, and the Georgia Appalachians all have hemlocks in the 160-foot height class.

4. Relative to its potential, bitternut hickory has been significantly under-sampled across its range. In fact, all species of hickories have been under-sampled by **ENTS**.

5. Black cherry is a particularly interesting species in that it exhibits an increasing height gradient from east to west at latitudes of 40 –43 degrees north. The species also gets taller in the southern Appalachians. We have found no explanation for the east-west height gradient.

6. The above comparisons show that **MTSF** has at least one very tall member of a dozen species.

Iterated index analysis

The next avenue of investigation is to examine how deep Mohawk is in tall trees for the species that commonly enter the RHI. As was first illustrated in the 2003 report, the Rucker index can be computed iteratively. As explained previously, in an iterated index, the ten selected trees are removed and the process is applied again from the remaining unselected trees. This process can be done repeatedly so long as the sample of tree species and trees per species is large enough to support the chosen number of species selected for iteration. The following table lists the RHI and RCI for 20 iterations.

Summary of Iterated Rucker Index

Rucker Height Index Summary Height Iteration	Height	Circ	Rucker Circumference Index Summary Circumference Iteration	Circ	Height
1	136.0	7.0	1	12.4	105.6
2	134.0	7.0	2	10.6	99.9
3	132.4	6.8	3	10.2	105.7
4	130.6	7.2	4	9.7	117.0
5	129.3	6.8	5	9.1	118.9
6	128.3	6.6	6	8.9	114.1
7	127.7	6.8	7	8.7	114.0
8	126.6	6.9	8	8.6	119.2
9	126.0	6.6	9	8.4	118.4
10	125.4	6.7	10	8.0	122.8
11	124.7	6.3	11	7.9	119.2
12	124.2	6.3	12	7.7	121.3
13	122.9	6.4	13	7.4	112.2
14	122.5	6.7	14	7.6	114.3
15	121.7	6.7	15	7.5	112.1
16	121.3	6.8	16	7.4	117.4
17	120.6	6.1	17	7.3	116.7
18	120.4	6.1	18	7.2	118.2
19	119.7	6.6	19	7.1	113.8
20	119.2	6.0	20	7.0	117.0
Average	**125.7**	**6.6**		**8.4**	**114.9**

Notes:

1. The iterated RHI stays above 120 for 18 iterations and the index averages 125.7 for the first 20 iterations.
2. The diameter of trees that produce these significant heights average 25.1 inches. The interpretation is that **MTSF**'s population of tall trees is relatively young. As the trees get

older their crowns are usually pared back by ice, wind, insect damage, etc. For height performance, **MTSF** may be nearing its zenith.

3. The circumference index for **MTSF** is far less impressive. However, its low performance reflects a lack of concentration of circumference to this point in time. More time will be spent in 2006 cataloging the largest girth trees in **MTSF**.
4. One pattern that stands out in our analysis is that the largest trees are seldom the tallest. When taking all the species represented, the largest trees are often older trees that have had their crowns pared back over the years. However, that conclusion does not hold for the large white pines that have not reached sufficient age to see crown loss, but are nonetheless large trees. The white pine is the largest species in **MTSF.**
5. Presently, we have documented 54 pines that reach 10 or more feet in circumference. Not all the 10-footers have been documented. There are not likely to be more than 5 or 6. So it is safe to conclude that **MTSF** presently has 60 white pines with circumference of 10 feet or more. Within the Trees of Peace, the 127 tagged pines have an average diameter of 27.2 inches. By contrast the 18 white pines of the older Elders Grove trees have an average diameter of 35.4 inches

Relative Abundances of Species in iterated index

Another way to examine the distribution of tall tree species is to look at the roles of individual species in the RHI iterations. Surprises for us included American basswood, bigtooth aspen, and black cherry. Basswood is lightly distributed throughout **MTSF,** yet it competes well for canopy dominance. Bigtooth aspens can be isolated individuals or in clonal groups, but are still thinly distributed in Mohawk. Black cherry is widely distributed in **MTSF**, but nowhere is it abundant.

Species	# times represented	Percentage
White pine	20	100.0%
White ash	20	100.0%
Sugar maple	20	100.0%
N. red oak	20	100.0%
Hemlock	20	100.0%
Black cherry	19	95.0%
A. basswood	14	70.0%
Red maple	15	75.0%
Bigtooth aspen	13	65.0%
Bitternut hickory	12	60.0%
American beech	6	30.0%
Black birch	7	35.5%
Red spruce	2	10.0%
Red pine	3	15.0%
White birch	2	10.0%
Shagbark hickory	1	5.0%
Black oak	1	5.0%
American elm	1	5.0%

Companion distributions for circumference and **ENTS** points are not shown since much of the data reflects our search for the tallest members of each species. Excepting for white pine data, circumference data basically hitchhike on the height data. In the height data, the white pine, hemlock, northern red oak, sugar maple, and white ash show up in all circumference iterations. Were we to concentrate on circumference, the dominance of the above listed species would continue to be the case, because all they all reach large size and are abundantly distributed. By contrast, yellow birch shows up in 11 of the 20 iterations of our data, which as pointed out is driven by our search for height. Had we concentrated of circumference, yellow birch would have been represented in all 20 iterations. The five species in the table and yellow birch are the ones in **MTSF** that frequently grow to diameters of 3 feet or more. Of the six species, the white pine has the greatest numbers of 3-foot diameter trees. Sugar maple is probably second and hemlock third. Defining the order of the remaining three requires more data gathering.

Where do we go from here with iteration? One approach is to develop indices using specific species. For example, an index that concentrates on white pine, white ash, sugar maple, etc. separately. Another approach is to continue the present iteration process. At present, there are sufficient trees in the **FMTSF/ENTS** database to complete 41 full iterations of the RHI using 10 species per iteration. This represents 410 trees. As more hardwoods are measured in the shorter species classes, the iterations possibilities will grow to 50 or more. However, there is probably nothing to gain by extending iterations beyond 50. We now know basically how each species performs. We know that white pine and white ash are superb performers and sugar maple and northern red oak are good performers. The table below summarizes what we know about the performance of the species that achieve heights of 120 feet or more.

Clark-Todd ridge

MTSF's current 136.0 RHI is based on trees located in the high growth areas of the following areas.

1. Trout Brook – south of Route #2 – 95 acres
2. Clark Ridge-Indian Flats – 5 acres
3. Clark Ridge – Ash Flats – 6 acres
4. Todd Mountain-eastern side bowl – 20 acres
5. Todd-Clark ridge- north side – 105 acres
6. Trees of Peace – Cherokee-Choctaw pines – 15 acres

The total acreage of the theses highest performance areas only amounts to 246 acres. If the high growth region is extended to include the areas that contribute to the high iterated index, the total area expands to around 600 acres, but that is still less than 10% of **MTSF**'s total area. The Todd-Clark ridge areas of high growth amount to about 150 acres. The region that represents the most remarkable area of high growth is the north side of the Todd-Clark ridge. This 105-acre area has a RHI index of 133.2 and represents the most concentrated collection of tall trees in Mohawk.

Focusing on the highest performers

Another approach to analyzing **MTSF**'s performance is to focus on tall trees that meet a height threshold. In this case, we focus on trees that reach 120 feet or more in height. What is the height distribution of the species that reach this threshold for the data we currently have in the **ENTS** database for **MTSF**?

Distribution of heights over 120 feet for native species in MTSF currently in ENTS database

Distribution of Heights for native species					
Species	>=160	>=150	>=140	>=130	>=120
WP	4	78	227	301	349
WA		2	25	68	124
SM				6	35
NRO				4	11
AB				2	5
HM				1	14
RM					3
BC					3
ABW					6
BTA					6
BNH					5
AE					1
Totals	4	80	252	382	562

Other outcomes derived from Rucker Indexing

One of the benefits of RIA has been a much better understanding of how the Berkshire forests perform relative to forests elsewhere in Massachusetts. The conclusion is that the Berkshire-Taconic forests perform best when considering tree height for northern hardwoods and conifers. White pine, white ash, sugar maple, red maple, hemlock, red spruce, bitternut hickory, black cherry, and northern red oak are outstanding performers. Flood plain species like cottonwood are marginal performers. But to put the Berkshire-Taconic into perspective, we need to examine where the tallest members of many species grow, not just the ones listed above.

Our analysis has given rise to a new kind of champion tree list. We will now look at the tall trees of **MTSF**'s and compare them to the rest of the State. The following table lists 50 species of trees. **MTSF**'s placement in the list is highlighted in green.

List of Maximum Tree Heights for MA

	Species	Location	Height	Circ	ENTS Pts	H/D Ratio	DOM
1	White Pine	MA-Charlemont-MTSF-Trees of Peace	167.3	10.4	1740.3	50.5	8/7/2005
2	White Ash	MA-Charlemont-MTSF-Trout Brook	151.5	6.2	939.3	76.8	11/20/2004
3	Hemlock	MA-Stockbridge-Ice Glen-Ice Glen	138.1	10.2	1408.6	42.5	10/30/2004
4	Sycamore	MA-Easthampton-Town-Town	136.5	13.2	1801.5	32.5	2/20/2005
5	Shagbark Hickory	MA-Stockbridge-Ice Glen-Ice Glen	134.4	5.1	685.6	82.8	10/3/2004
6	Sugar Maple	MA-Charlemont-MTSF-Trout Brook	133.8	5.0	668.8	84.0	4/16/2005
7	Red Spruce	MA-Williamstown-Mt Greylock State Reservation-Hopper	133.5	6.7	894.6	62.6	6/19/2005
8	Northern Red Oak	MA-Charlemont-MTSF-Todd Mtn	133.5	9.3	1241.2	45.1	11/25/2004
9	Tuliptree	MA-Northampton-Mill River-Hampshire Gazette	133.1	13.4	1783.1	31.2	1/1/2005
10	Bitternut Hickory	MA-Savoy-MTSF-Clark Ridge-Indian Flats	131.8	4.3	560.0	97.4	4/24/2006
11	American Beech	MA-Charlemont-MTSF-Clark Ridge-North	130.5	8.4	1096.2	48.8	4/9/2006
12	Eastern Cottonwood	MA-Ashley Falls-Bartholomew's Cobble-Bartholomew's Cobble	129.0	18.8	2425.6	21.6	1/16/2005
13	Red Maple	MA-Charlemont-MTSF-Clark Ridge-Elders	128.0	6.6	845.0	60.9	4/15/2006
14	Norway Spruce	MA-Charlemont-MTSF-Trout Brook	127.1	4.2	534.0	95.1	10/9/2004
15	American Basswood	MA-Charlemont-MTSF-Clark Ridge-North	126.9	5.5	698.0	72.5	4/26/2006
16	Big Tooth Aspen	MA-Charlemont-MTSF-Clark Ridge-Shunpike Area	126.0	3.5	447.0	113.1	4/27/2006
17	Black Cherry	MA-Charlemont-MTSF-Trout Brook	125.3	5.5	689.0	71.6	4/9/2005
18	Red Pine	MA-Holyoke-Mt Tom State Reservation-Mt Tom State Reservation	121.3	5.4	656.8	70.3	11/1/2003
19	American Elm	MA-Charlemont-MTSF-Clark Ridge-Shunpike Area	120.8	6.6	762.9	57.5	5/10/2005
20	Pignut Hickory	MA-Stockbridge-Ice Glen-Ice Glen	120.8	6.4	773.0	59.3	3/30/2002
21	Black Locust	MA-Northampton-Mill River-Hampshire Gazette	118.7	6.3	747.6	59.2	11/23/2003
22	Silver Maple	MA-Hatfield-Town-Town	118.2	11.2	1323.6	33.1	3/27/2005
23	Slippery Elm	MA-Greenfield-Town-Town	118.0	6.8	802.4	54.5	2/24/2002
24	Black Birch	MA-Charlemont-MTSF-Clark Ridge-North	116.2	3.6	412.4	102.8	10/14/2002
25	White Oak	MA-Stockbridge-Bullard Woods-Bullard Woods	115.3	6.9	795.9	52.5	3/14/2004
26	Green Ash	MA-Easthampton-Town-Town	113.7	10.0	1137.0	35.7	2/20/2005
27	Butternut	MA-Northampton-Mill River-Hampshire Gazette	111.7	6.0	664.5	59.0	7/21/2002
28	White Birch	MA-Charlemont-MTSF-Clark Ridge-North	110.5	5.2	574.4	66.7	10/14/2002
29	Black Oak	MA-Savoy-MTSF-Clark Ridge-Ash Flats	110.5	4.8	530.2	72.3	8/18/2002
30	Pin Oak	MA-Northampton-Town-Town	107.9	1877.3	0.0	12/11/2005	
31	Scarlet Oak	MA-Florence-Town-Monica	107.4	7.3	784.0	46.2	10/15/2005
32	Yellow Birch	MA-Charlemont-MTSF-Clark Ridge-Shunpike Area	105.6	4.8	506.9	69.1	5/10/2005
33	Swamp White Oak	MA-Northampton-Mill River-Hampshire Gazette	104.2	9.9	1031.9	33.1	1/1/2005
34	White Spruce	MA-Charlemont-MTSF-HQ	102.9	6.9	709.7	46.8	7/6/2001
35	Asiatic Elm	MA-Northampton-Smith College-Smith College	102.5	14.8	1516.3	21.7	2/24/2002
36	European Beech	MA-Northampton-Mill River-Hampshire Gazette	101.2	10.6	1072.7	30.0	8/10/2002
37	Norway Maple	MA-Manchester by-the-Sea-Town-Andrew Carnegie	99.5	10.0	995.1	31.3	6/13/2005
38	Chestnut Oak	MA-Shelburne-Private-Private	98.7	6.2	612.2	50.0	9/29/2002
39	Dawn Redwoods	MA-Northampton-Smith College-Smith College	95.8	15.1	1447.3	19.9	2/16/2002
40	Pitch Pine	MA-Holyoke-Mt Tom State Reservation-Mt Tom	92.0	5.0	460.1	57.8	4/14/2002

		State Reservation					
41	Black Willow	MA-Whately-Town-Town	88.7	19.1	1694.9	14.6	7/17/2003
42	Mockernut Hickory	MA-Holyoke-Mt Tom State Reservation-Mt Tom State Reservation	87.3	4.1	358.1	66.9	10/25/2004
43	Bur Oak	MA-Northampton-Smith College-Smith College	87.2	11.2	976.5	24.5	2/16/2002
44	Quaking Aspen	MA-Williamstown-Mt Greylock State Reservation-Hopper	85.4	8.7	742.9	30.8	11/8/2000
45	Catalpa	MA-Holyoke-Town-Town	85.0	7.7	654.7	34.7	3/2/2002
46	Ginkgo	MA-Northampton-Smith College-Smith College	84.0	15.1	1268.2	17.5	2/16/2002
47	Hackberry	MA-Hatfield-Town-Town	83.7	10.2	854.0	25.8	2/16/2002
48	Black Gum	MA-Holyoke-Mt Tom State Reservation-Mt Tom State Reservation	81.0	7.2	580.9	35.5	4/2/1999
49	**Hop Hornbeam**	**MA-Savoy-MTSF-Cold River East**	**78.2**	**3.3**	**258.0**	**74.4**	**10/23/2003**
50	American Chestnut	MA-Mount Washington-Mount Everett State Reservation-Mount Everett State Reservation	66.3	1.5	99.5	138.9	5/27/2002

MTSF=Mohawk Trail State Forest **No Species: 50**

Notes:

1. Mohawk presently claims title to 18 of the 50 species being tracked. This represents 36% of the total is at the saturation point for Mohawk. Mohawk is not likely to claim more champions in the future.

2. As the search continues for exceptional trees, on the basis of probability alone, Mohawk is likely to lose its championship claim for a few of the species included below. Regardless, **MTSF** will certainly retain the title to more regional and state height champions than any other state or federal property in New England well into the foreseeable future.

3. Mohawk's competitors elsewhere in the Northeast will likely be restricted to a handful of properties. At present, Zoar Valley, NY, Cook Forest, PA, and Fairmount Park, PA are strong candidates to equal Mohawk.

In our final topic on RIA, we introduce the concept of the RHI that allows repeats of a species. Under this concept, the RHI is just a simple average of the 10 tallest trees at a site. If iteration is allowed, the 10 tallest are moved and the process is repeated. The one difference is the same species can enter iteration multiple times. In **MTSF**'s case all 10 of the tallest trees are white pines. The following table gives 20 iterations of the RHI under the repeatable species concept. This accounts for **MTSF**'s 200 tallest trees. The iterated RHI without repetition is repeated beside the repeated version.

Iterated RHI with and without species repetition			
Height	Circumference	Height	Circumference
161.0	9.9	136.0	7.0
154.2	8.7	134.0	7.0
152.1	10.1	132.4	6.8
151.7	8.4	130.6	7.2
151.1	8.1	129.3	6.8
150.8	8.0	128.3	6.6
150.5	8.6	127.7	6.8
150.2	8.2	126.6	6.9
148.9	6.4	126.0	6.6
148.1	9.0	125.4	6.7
147.4	8.1	124.7	6.3
146.2	8.1	124.2	6.3
145.7	8.4	122.9	6.4
144.9	8.3	122.5	6.7
144.5	7.5	121.7	6.7
144.2	7.9	121.3	6.8
143.8	8.5	120.6	6.1
143.2	7.9	120.4	6.1
142.7	6.9	119.7	6.6
142.2	7.9	119.2	6.0
148.2	8.2	125.7	6.6

The influence of the white pine and white ash are seen in this comparison. In fact, the tallest 347 trees in the **ENTS** database for **MTSF** are all white pines and white ashes and there are more white pines to measure that are above the 133.8-foot sugar maple. The total number of white pines and white ashes that exceed in height all other species is probably between 500 and 600 trees.

SECTION 5. White Pine Volume Modeling, Individual Profiles, and White pine Tree Dimensions Index (TDI) lists

Introduction

This section is an update on selected topics pertaining to the modeling of white pines. The objects of the modeling project are:

1. Historical documentation of **MTSF** and **MSF** significant white pines where significance is reflected in the dimensions of height, circumference, or trunk volume,

2. Data input to the white pine growth analysis project.

The prior update to DCR presented several areas of white pine research in which **FMTSF** and **ENTS** are engaged**.** The report had considerable detail on volume modeling, the methodology and results. The tagging and location methodology was also explained.

This update concentrates on modeling methodology and introduces **ENTS** tree comparison using the Tree Dimensions Index (TDI) concept.

RD 1000 Dendrometer versus Macroscope 25

Our prior report update listed a number of white pines we modeled using the RD 1000 Dendrometer. A specific objective is to model all white pines with trunk volumes of 500 cubic feet or more and to be accurate to within +/-5%. To increase our accuracy, we have added a new instrument, the Macroscope 25. It is a combination telescope and microscope with a reticule that can be read to 1/50th of a millimeter. Its accuracy level is extremely high and it is now being used to assist us in our trunk modeling. The Dendrometer is much faster to use and will continue to be used, but when refinements are needed, the Macroscope will be called in to service.

In a series of tests, where the target could be measured with a tape measure and was at a distance of 25 to 30 feet, the absolute difference between the taped width and the width as determined by the RD 1000 averaged between 4% and 5% of actual. Taking the average with algebraic sign intact, the average difference is 3%. The error can be considerable at distances of 100 feet and more. The largest errors occur for large targets at long distances. The direction of error tends to be in the overage category.

The following table gives a comparison of the results of a test between the Macroscope and Dendrometer.

Mac Diam inches	Dendro Diam inches	Mac-RD Diff in inches	Abs in	Pct Mac
23.27	22.60	1.11	1.11	5%
23.21	22.30	1.20	1.20	5%
29.89	31.60	-1.71	1.71	6%
18.11	17.40	0.71	0.71	4%
23.13	22.00	1.13	1.13	5%
20.51	21.50	-0.99	0.99	5%
17.10	18.40	-1.30	1.30	8%
17.30	17.80	-0.50	0.50	3%
8.78	9.60	-0.82	0.82	9%
23.28	23.70	-0.42	0.42	2%
24.93	25.90	-0.97	0.97	4%
33.64	35.30	-1.66	1.66	5%
				5%

	Target			
Distance to target in ft	diam-inches (act)	diam-inches	Differences	Pct
226	18.00	18.11	-0.11	-0.61%
63	11.00	11.09	-0.09	-0.80%
78	18.00	18.10	0.10	0.53%
167	7.10	6.99	0.11	1.51%
68	20.50	20.65	-0.15	-0.75%

Partial Trunk Modeling:

If accuracy to within 5% of water displacement volume is desired for the white pines being modeled, then trunk volume modeling becomes a labor-intensive activity. Approximations are useful to qualify trees as worthy of more intense modeling. Two areas of our research have been undertaken to allow us to obtain early volume approximations. White pine forms appear to the eye to be fairly conical when young. However, asymmetry becomes increasingly apparent with age. Large limbs create trunk bulges. Foresters have historically used the paraboloid form to model the shape of the lower trunk. When extended to the full height of the tree, this model does not work, nor does reapplying the strict conical form. So, an area of investigation for us has become the determination of departure from the conical form with increasing tree age. The following table shows the results of modeling of 21 white pines in which we compare the theoretical, conical diameter at the midpoint of tree height with actual diameter as determined with the Macroscope 25. Little can be concluded from this early modeling except to note that many white pines probably approximate cones at their midpoints.

Comparison of actual diameter at mid-height to conical diameter							
Total trunk length-ft	Length of proportion of trunk	Monocular diam at proportion- ft	D-tape base diam-ft	Conical diam at proportion-ft	Diff - ft	Pct variation from cone	Tree Name
167.3	83.7	1.9	3.6	1.8	0.1	7.66%	Jake Swamp
164.8	82.4	2.3	4.3	2.1	0.1	5.92%	Saheda
161.7	80.9	1.9	4.3	2.1	-0.2	-9.52%	Tecumseh
157.9	79.0	1.7	3.7	1.9	-0.1	-7.20%	Frank Decontie
152.0	76.0	2.1	4.2	2.1	0.0	-0.86%	Jani
151.6	75.8	1.9	3.8	1.9	0.0	2.40%	Mirror
151.1	75.8	1.8	3.1	1.6	0.3	17.14%	Lynn Rogers
150.7	75.4	1.8	3.5	1.8	0.0	1.83%	Dave Chief
139.0	69.5	1.8	3.5	1.7	0.1	3.45%	Graveyard Gretta
131.3	65.6	1.8	3.9	2.0	-0.1	-5.29%	Mt Tom
131.1	65.5	1.4	2.8	1.4	0.0	-2.67%	Monica's Pine
130.7	65.1	2.2	4.3	2.1	0.1	4.92%	Mt Tom-Spencer Pine
129.8	64.9	2.2	4.1	2.1	0.1	6.92%	Graves Pine
128.4	64.2	1.7	3.4	1.7	0.0	-0.32%	Mt Tom near champ
125.9	56.2	1.6	3.4	1.7	-0.1	-6.94%	Mt Tom
124.5	62.3	1.6	3.1	1.5	0.1	4.40%	Erhard's Pine
124.5	62.3	1.5	3.1	1.5	0.0	-0.33%	Broadbrook #1
121.4	60.7	1.7	3.0	1.5	0.2	10.24%	Group site Pine
112.5	56.3	1.1	2.6	1.3	-0.2	-12.98%	Broadbrook #2
110.6	55.3	1.1	2.5	1.3	-0.1	-10.32%	Monica's Pine Stand
55.8	27.9	0.9	1.9	0.9	0.0	-2.14%	Broadbrook #3
Avg deviation in ft					0.01		

Summary comments on white pine modeling:

The work done to date by **FMTSF** and **ENTS** shows that the largest white pines in **MTSF** are in the volume range of 400 to 700 cubic feet, with the exception of Big Bertha, now standing dead, which approaches 1000 cubic feet. Massachusetts has many white pine stands with pines in the 150 to 300 cubic-foot volume range. Young stands with pines in the 100-foot height class typically have volumes of 150 to 200 cubic feet. The largest white pines in Massachusetts are represented in two distinct populations. The first and most conspicuous is a population of scattered multi-stemmed pines with CBH's of 14 to 16 feet and heights of 115 to 130 feet. The members of this population have total trunk volumes of 900 to 1000 cubic feet. The statewide population may be under 10 trees.

The second population consists of forest-grown pines at sites like **MTSF**, **MSF**, Bryant Homestead, Ice Glen, Bullard Woods, Quabbin Reservoir, and Mount Tom State Reservation. There are presently 3 pines in the 900 to 1000 cubic foot class. However, there is a substantial population over 500 cubic feet. What size pine will typically make the 500 Club? The following table shows combinations that make 500 cubic feet based on a conical form with the circumference being taken just above the root collar. We believe that this determination usually over-states total trunk volume. Large old-growth pines can bulk up in the lower trunk to an almost cylindrical form for a dozen feet or more and produce overall volumes that slightly exceed the conical form just described. However, in general, root collar cross sectional area and full tree height produces a slight over-calculation of trunk volume. The limits of the table reflect the range of the size for the species in Massachusetts taking into account the genetics of white pine. For example, except in very poor growing conditions, it would not be likely to find a white pine 8.5 feet in circumference just above the root collar that was less than 90 feet in height and so far **FMTSF-ENTS** has not measured a single-trunked white pine 170 feet tall or 16 feet in circumference. As can be seen, there is very little chance that a white pine with a base circumference less than 11 feet will have a volume of 500 cubic feet.

		Circumference above root collar in feet															
		8.5	**9**	**9.5**	**10**	**10.5**	**11**	**11.5**	**12**	**12.5**	**13**	**13.5**	**14**	**14.5**	**15**	**15.5**	**16**
H	**90**	172	193	215	239	263	289	316	344	373	403	435	468	502	537	574	611
e	**100**	192	215	239	265	292	321	351	382	414	448	483	520	558	597	637	679
i	**110**	211	236	263	292	322	353	386	420	456	493	532	572	613	657	701	747
g	**120**	230	258	287	318	351	385	421	458	497	538	580	624	669	716	765	815
h	**130**	249	279	311	345	380	417	456	497	539	583	628	676	725	776	828	883
t	**140**	268	301	335	371	409	449	491	535	580	628	677	728	781	836	892	951
	150	287	322	359	398	439	481	526	573	622	672	725	780	837	895	956	1019
	160	307	344	383	424	468	514	561	611	663	717	773	832	892	955	1020	1086

The current list of 500-cube white pines in **MTSF** and **MSF** are shown in the table below which is organized by stand.

500 Cubic-foot white pines				
Property	**Grove**	**Tree**	**Height**	**Circumference**
MSF		Grandfather Thoreau	145.2 160.2	14.0 12.9
MTSF	Trees of Peace	Jake Swamp Mirror Clutter Unnamed	167.3 152.6 152.4 140.4	10.4 10.9 10.4 11.3
MTSF	Cherokee-Choctaw	Jani	152.0	10.7
MTSF	Algonquin	William Commanda Bear Tree	155.0 152.4	10.3 10.8
MTSF	Encampment	Ed Frank Unnamed	150.5 140.4	10.8 10.9
MTSF	Elders	Tecumseh Saheda Benchmark	161.8 164.8 150.1	11.7 11.4 11.0
MTSF	Shunpike	Brant	157.3	10.9
MTSF	Indian Springs	Indian Springs Pine	140.5	11.5
MTSF	Trout Brook	Big Bertha King Trout Hiawatha Totem	148.0 147.0 141.7 137.5	14.6 11.7 12.1 11.8

Updates on significant white pines in MTSF and MSF

Introduction

The white pine can be fairly considered to be the flagship tree species of all New England, due in no small measure to its role in supplying the British Navy with ship masts. It is the state tree of Maine. Historical references to the stature of the white pine by Henry David Thoreau form the basis for the **FMTSF-ENTS** focus on the 150-foot height threshold. No other New England species reaches this height threshold except the white ash and possibly the tuliptree in southern Connecticut. Only two white ash trees are known to exceed 150 feet in New England and so far no tuliptrees have been confirmed to 150 feet in New England. By contrast, 158 white pines have been confirmed to 150 feet in New England. In terms of a flagship species for New England, the only competition to the white pine would come from the sugar maple.

As has been frequently pointed out in our reports, **MTSF** and **MSF** have 79 of the 87 white pines in Massachusetts that have reached a height of 150 feet or more and **MTSF** has many pines over 140 feet in height with the potential to make 150. However, there is a second category of significant white pines and that is the category of the both tall and large-girthed trees. It is this latter category that is truly inspiring to visitors and **FMTSF** carefully monitors a group of large and tall pines for scientific, ecological, historical, and aesthetic purposes. Updates on these trees will be a routine part of our reports. The following is the first update devoted to an exclusive club of great white pines on DCR properties.

Big Bertha-MTSF

Big Bertha is now a standing dead snag. It is slowly breaking up. When alive, it was the largest pine in **MTSF** and one of the largest pines in New England. Big Bertha's maximum circumference and height were 14.6 feet and 148.0 feet. Its total trunk volume approached 1,000 cubic feet.

Tecumseh Pine-MTSF:

The Tecumseh pine is the largest white pine in the Elder stand and probably the largest living white pine in **MTSF**. It was re-measured by John Eichholz and Bob Leverett in April 2006. Its current height is 161.8 feet and its CBH is 11.7 feet. Computing Tecumseh's trunk volume has been a challenge. A re-modeling of Tecumseh on May 20th using the Macroscope 25 yielded 671 cubic feet of trunk volume. This is lower than the RD 1000. With limbs added in, Tecumseh 's volume will exceed 700 cubic feet.

Saheda-MTSF:

Saheda is one of two huge pines growing in the Elders grove on the north side of the Todd-Clark ridge in **MTSF**. Saheda is one of our most attractive pines. In April John Eichholz and Bob Leverett re-measured Saheda. The tree's height is now placed at 164.8 feet, making it the second tallest tree in Massachusetts and the 4th tallest in New England. However, Saheda has a substantial circumference. It is 11.44 feet at breast height. Volume determinations have been problematic for the big pine, but its trunk volume is almost certainly between 625 and 675 cubic feet.

Grandfather Pine-MSF:

The Grandfather pine in Monroe State Forest is the largest volume pine that is living that we know of on DCR properties and one of the 5 largest white pines we have measured in Massachusetts. What makes the Grandfather tree so impressive is that it is single-trunked. The height of the Grandfather pine stands presently at 145.1 feet. It is growing slowly, perhaps 4 to 5 inches per season.

The Grandfather pine was first modeling in 2005 with the RD 1000 Dendrometer. Of the several modeling results, the minimum determination of trunk volume is 930 cubic feet. In March of 2006, using the Macroscope, a volume of 985 cubic feet was obtained. The difference between the RD 1000 modeling and the Macroscope 25 modeling of 5.5% is close to the average difference between the two instruments as explained above in the series of tests.

When limb volume is included, the volume of the Grandfather tree easily exceeds 1000 cubic feet. The Grandfather pine is also the only single-stemmed white pine that reaches 14 feet in circumference. The tree was dated about 5 years ago and was approximately 170 years old at the time. Allowing for 5 years to the base, the tree is 180 years old.

Jake Swamp Pine-MTSF:

The Jake Swamp tree has been modeled with both RD 1000 and Macroscope 25. At this point, the best determination we can make of its trunk volume is 562 cubic feet. We are fairly confident that its cubic footage is between 550 and 575 cubic feet. Total trunk and limb volume is between 580 and 600 cubic feet.

The Jake tree is almost perfectly conical in shape taken from the top of the root collar to its tip. At the beginning of the 2006 growing season, Jake was 167.3 feet tall, placing it as the tallest accurately measured tree in New England. It is growing in height at the rate of 9 to 12 inches per season and is expected to surpass 168 feet by the end of the 2006 growing season. We do not know Jake's age, but believe it to be between 140 and 150 years.

Mirror Tree-MTSF:

The Mirror tree is an extremely attractive pine with a large, full crown growing along the road from the group campsite to the lower meadow – the old colonial Mohawk Trail. An April 2006 re-measurement of the Mirror tree places its height at 152.6 feet and its circumference at 10.9 feet. The Mirror tree's trunk volume is very close to 500 cubic feet. This tree has a very full crown and will be monitored closely for growth increases.

Jani Tree-MTSF:

The Jani tree had been modeled to 501 cubic feet using the RD 1000 and Macroscope 25. This large tree's CBH is 10.7 feet and its height is 152.0 feet. It is a symmetrical tree. It is named in honor of Jani Leverett, late wife of Bob Leverett. Jani was the President of **FMTSF**. It is this tree that is shown on the photograph at the Jani Shrine.

Trout Brook Pine- MTSF

In March 2006, John Eichholz modeled a large white pine in Trout Brook to 632 cubic feet. The pine stands 147 feet in height and has a CBH of 11.7 feet. The tree is partially open-grown and probably not over 130 years of age.

Frank Decontie Tree-MTSF

The Frank Tree named for an Algonquin elder and advisor to **FMTSF** has been repeatedly measured. Its current height is listed as 160.1 feet. However, this value has not been sustained from repeated measurements. The tree is probably between 158 and 159 feet. The margin of error on difficult trees such as the Decontie tree is around 1.5 feet. The 160.1 gives the Frank tree the benefit of the doubt.

Joseph Brant Pine-MTSF

The Joseph Brant pine is the northern-most of the MTSF tall trees. It has been repeatedly measured with heights varying from 157 to 160 feet. Crown visibility of this tree is poor. In addition it is on a very steep slope so that establishing the midpoint of the slope is prone to error. The latest measurement of this tree places its height at 157.3 feet and its circumference is listed as 11.2 feet. Measurements of between 10.9 and 11.2 feet can be obtained by slight adjustments of the basal midpoint. The 11.2 gives the tree the benefit of the doubt.

Tree Dimensions Index (TDI)

The white pines being measured and monitored in **MTSF** and **MSF** are between the ages of 100 and 180 years in age. Most are between 120 and 140 years of age. The Mohawk and Monroe pines exhibit superb growth. They are often compared to trees that are between 150 and 300 years old, which is not always clear from the context. Most of the Mohawk pines have full, healthy crowns that show the potential for much more growth. So comparisons being made are often not in an apples-to-apples context if age is ignored. Nonetheless, it is useful to compare the Mohawk and Monroe pines to other eastern pines through a system that ranks each pine in terms of how its height and circumference compare to the maximums for all members of species that are included within the comparison. To do this we have established a system of 200 points. One hundred points can be earned by a tree for height and 100 points for circumference. A particular tree's score is determined by dividing its height by the maximum height in the data set and the quotient multiplied by 100. A similar process is applied to the circumference. The two scores are added together to get the tree's full score.

The following table computes the scores of 259 eastern white pines. Massachusetts trees are coded in blue. Note that Big Bertha (standing dead) ranks 9th on the list. The next update will expand this list by between 200 to 300 trees that will be drawn mostly from the southern Appalachians. There will be a number of pines larger than Big Bertha, but they will generally be older trees by anywhere from 50 to 200 years.

Tree Dimensions Index (TDI) List

	ENTS big tree ranking of white pines	Max Hgt	Max Cir	Max possible pts=200			
	For eastern United States using the TDI system	207.0	17.8				
	Tree	hgt	cir	hgt pts	cir pts	tot pts	State
1	Champion-Porkies-MI (Down)	154.0	17.4	74%	98%	172.1%	MI
2	MacArthur Pine-WI (down)	148.0	17.8	71%	100%	171.5%	WI
3	Champion-Porkies-MI (Down)	146.0	16.9	71%	95%	165.5%	MI
4	Unnamed-Paul Smith-Elders Grove-NY	157.5	15.2	76%	85%	161.5%	NY
5	Boogerman Pine-GSMNP-NC	187.0	11.5	90%	65%	154.9%	NC
6	Coon Branch Natural Area-SC	146.5	14.9	71%	84%	154.5%	SC
7	Seneca Pine-Cook Forest SP-PA	173.2	12.5	84%	70%	153.9%	PA
8	Cornplanter Pine-Anders Run, Cornplanter SF-PA	167.1	13.0	81%	73%	153.8%	PA
9	Big Bertha-MTSF-MA (Standing Dead)	148.0	14.6	71%	82%	153.5%	MA
10	Unnamed-Paul Smith-Elders Grove-NY	156.2	13.8	75%	78%	153.0%	NY
11	Laurel Creek-GA	181.4	11.5	88%	65%	152.2%	GA
12	Tamworth Pine-Hemminway SP-NH	150.0	14.2	72%	80%	152.2%	NH
13	Menominee Pine-WI	163.4	13.0	79%	73%	152.0%	WI
14	Stanley Park Pine-Westfield-MA	131.5	15.7	64%	88%	151.7%	MA
15	Longfellow Pine-Cook Forest SP-PA	182.5	11.3	88%	63%	151.6%	PA
16	Unnamed-Paul Smith-Elders Grove-NY	158.3	13.1	76%	74%	150.1%	NY
17	Henry David Thoreau Pine-MSF-MA	160.2	12.9	77%	72%	149.9%	MA
18	Grandmother Tree-Pack Forest-NY	150.3	13.7	73%	77%	149.6%	NY
19	Grandfather Pine-MSF-MA	145.3	14.0	70%	79%	148.8%	MA
20	Hearts Content	160.0	12.7	77%	71%	148.6%	PA
21	Cook Pine-Cook Forest SP-PA	161.7	12.4	78%	70%	147.8%	PA
22	Conway Graveyard Pine-Conway-MA	140.6	14.2	68%	80%	147.7%	MA
23	Ice Glen Pine-Ice Glen-Stockbridge-MA	154.3	12.9	75%	72%	147.0%	MA
24	Featherduster Pine-Cook Forest-PA	174.0	11.2	84%	63%	147.0%	PA
25	Unnamed-Cranberry Lake-NY	139.0	14.2	67%	80%	146.9%	NY
26	Yo Mama-Conway-MA	122.3	15.6	59%	88%	146.7%	MA
27	Conway Graveyard Pine #2-Conway-MA	122.3	15.6	59%	88%	146.7%	MA
28	Unnamed-Cook Forest-PA	159.4	12.4	77%	70%	146.7%	PA
29	Childs Memorial Park Pine-Northampton-MA	121.1	15.5	59%	87%	145.6%	MA
30	Hearts Content	153.5	12.7	74%	71%	145.5%	PA
31	Hearts Content	154.2	12.5	74%	70%	144.7%	PA
32	Unnamed-Cook Forest-PA	163.8	11.6	79%	65%	144.3%	PA
33	Conway Graveyard Pine-Conway-MA	121.9	15.2	59%	85%	144.3%	MA
34	Bradford Pine-Bradford-NH	125.0	14.9	60%	84%	144.1%	NH
35	Tecumseh Pine-MTSF-MA	161.8	11.7	78%	66%	143.9%	MA
36	Unnamed-Cook Forest-PA	159.0	11.9	77%	67%	143.7%	PA
37	Saheda Pine-MTSF-MA	164.8	11.4	80%	64%	143.7%	MA
38	Reed Creek-GA	153.6	12.3	74%	69%	143.3%	GA
39	Cliff Creek-GA	185.6	9.5	90%	53%	143.0%	GA
40	Monarch-Hartwick Pines-MI (Dead)	153.0	12.3	74%	69%	143.0%	MI

41	Hearts Content	155.0	12.1	75%	68%	142.9%	PA
42	Bullard Woods Whopper-Stockbridge-MA	133.3	13.9	64%	78%	142.5%	MA
43	Consauga Creek-GA	152.6	12.2	74%	69%	142.3%	GA
44	Cliff Creek-GA	149.9	12.4	72%	70%	142.1%	GA
45	Anders Run	142.3	13.0	69%	73%	141.8%	PA
46	Mill Creek-GA	151.3	12.2	73%	69%	141.6%	GA
47	Unnamed-Cook Forest-PA	161.2	11.3	78%	63%	141.4%	PA
48	Unnamed-Cook Forest-PA	135.5	13.5	65%	76%	141.3%	PA
49	Unnamed-Cook Forest-PA	157.0	11.6	76%	65%	141.0%	PA
50	Mill Creek-GA	154.2	11.8	74%	66%	140.8%	GA
51	Cedar Creek Woods-NC	148.0	12.3	71%	69%	140.6%	NC
52	Anders Run	159.6	11.3	77%	63%	140.6%	PA
53	Unnamed-Cook Forest-PA	152.6	11.9	74%	67%	140.6%	PA
54	Anders Run	151.2	12.0	73%	67%	140.5%	PA
55	John Marshall Pine-Bryant Woods-MA	141.1	12.8	68%	72%	140.1%	MA
56	Anders Run	150.4	12.0	73%	67%	140.1%	PA
57	Jani Pine-Cook Forest-PA	171.3	10.2	83%	57%	140.1%	PA
58	Unnamed-Cook Forest-PA	151.4	11.9	73%	67%	140.0%	PA
59	Unnamed-Cook Forest-PA	151.3	11.9	73%	67%	139.9%	PA
60	Unnamed-Cook Forest-PA	153.5	11.7	74%	66%	139.9%	PA
61	Lillydale Pine-Lillydale-NY	143.9	12.5	70%	70%	139.7%	NY
62	Anders Run	148.4	12.1	72%	68%	139.7%	PA
63	Unnamed-Paul Smith-Elders Grove-NY	151.2	11.8	73%	66%	139.3%	NY
64	Unnamed-Paul Smith-Elders Grove-NY	152.2	11.7	74%	66%	139.3%	NY
65	Unnamed-Cook Forest-PA	139.4	12.8	67%	72%	139.3%	PA
66	Jake Swamp Pine-MTSF-MA	167.3	10.4	81%	58%	139.2%	MA
67	Unnamed-Cook Forest-PA	165.9	10.5	80%	59%	139.1%	PA
68	Unnamed-Paul Smith-Elders Grove-NY	136.8	13.0	66%	73%	139.1%	NY
69	Unnamed-Cook Forest-PA	150.5	11.8	73%	66%	139.0%	PA
70	Brant Pine-MTSF-MA	157.3	11.2	76%	63%	138.9%	MA
71	Unnamed-Paul Smith-Elders Grove-NY	149.1	11.9	72%	67%	138.9%	NY
72	Unnamed-Cook Forest-PA	138.5	12.8	67%	72%	138.8%	PA
73	Burl King-Cook Forest-PA	158.5	11.1	77%	62%	138.8%	PA
74	Hiawatha-MTSF-MA	141.8	12.5	69%	70%	138.7%	MA
75	Unnamed-Cook Forest-PA	150.7	11.7	73%	66%	138.5%	PA
76	Unnamed-Cook Forest-PA	156.4	11.2	76%	63%	138.5%	PA
77	Holcomb Creek-GA	152.6	11.5	74%	65%	138.3%	GA
78	Chatooga River-SC	163.0	10.6	79%	60%	138.3%	SC
79	Bryant Giant-Bryant Homestead-Cummington-MA	142.0	12.4	69%	70%	138.3%	MA
80	Cornelia North Pine-Claremont-NH	166.1	10.3	80%	58%	138.1%	NH
81	Unnamed-Cook Forest-PA	162.6	10.6	79%	60%	138.1%	PA
82	Unnamed-Cook Forest-PA	157.8	11.0	76%	62%	138.0%	PA
83	Unnamed-Paul Smith-Elders Grove-NY	148.2	11.8	72%	66%	137.9%	NY
84	Helton Creek-GA	163.1	10.5	79%	59%	137.8%	GA
85	Unnamed-Paul Smith-Elders Grove-NY	142.0	12.3	69%	69%	137.7%	NY
86	Unnamed-Porcupine Mts-MI	144.1	12.1	70%	68%	137.6%	MI
87	Unnamed-Cook Forest-PA	161.3	10.6	78%	60%	137.5%	PA
88	Unnamed-Cook Forest-PA	163.1	10.4	79%	58%	137.2%	PA

89	Anders Run	156.1	11.0	75%	62%	137.2%	PA
90	Paul Bunyon Pine -College Park-Durham-NH	130.5	13.2	63%	74%	137.2%	NH
91	Cliff Creek-GA	170.0	9.8	82%	55%	137.2%	GA
92	Unnamed-Cook Forest-PA	149.0	11.6	72%	65%	137.1%	PA
93	Unnamed-Cook Forest-PA	165.2	10.2	80%	57%	137.1%	PA
94	Trout Brook King-MTSF-MA	147.4	11.7	71%	66%	136.9%	MA
95	Menominee Pine-WI	167.0	10.0	81%	56%	136.9%	WI
96	Unnamed-Cook Forest-PA	144.9	11.9	70%	67%	136.9%	PA
97	Ice Glen Pine-Ice Glen-Stockbridge-MA	142.2	12.1	69%	68%	136.7%	MA
98	Unnamed-Cook Forest-PA	152.5	11.2	74%	63%	136.6%	PA
99	Belchertown Bully-MA	136.1	12.6	66%	71%	136.5%	MA
100	Walt Whitman Pine-Bryant Woods-MA	146.5	11.7	71%	66%	136.5%	MA
101	Unnamed-Cook Forest-PA	162.3	10.3	78%	58%	136.3%	PA
102	Robert Frost Pine-Bryant Woods-MA	154.1	11.0	74%	62%	136.2%	MA
103	Cliff Creek-GA	169.1	9.7	82%	54%	136.2%	GA
104	Unnamed-Cook Forest-PA	155.0	10.9	75%	61%	136.1%	PA
105	Unnamed-Cook Forest-PA	161.7	10.3	78%	58%	136.0%	PA
106	Unnamed-Cook Forest-PA	146.2	11.6	71%	65%	135.8%	PA
107	Unnamed-Cook Forest-PA	139.1	12.2	67%	69%	135.7%	PA
108	Unnamed-Cook Forest-PA	146.0	11.6	71%	65%	135.7%	PA
109	Hearts Content	135.5	12.5	65%	70%	135.7%	PA
110	Holcomb Creek-GA	154.1	10.9	74%	61%	135.7%	GA
111	Unnamed-Cook Forest-PA	158.7	10.5	77%	59%	135.7%	PA
112	Unnamed-Cook Forest-PA	151.7	11.1	73%	62%	135.6%	PA
113	Hearts Content	154.0	10.9	74%	61%	135.6%	PA
114	Unnamed-Cook Forest-PA	150.4	11.2	73%	63%	135.6%	PA
115	Unnamed-Pack Forest-NY	142.2	11.9	69%	67%	135.5%	NY
116	Emily Dickenson Tree-Bryant Woods-MA	154.8	10.8	75%	61%	135.5%	MA
117	Hearts Content	145.2	11.6	70%	65%	135.3%	PA
118	Unnamed-Cathedral Pines-NY	132.1	12.7	64%	71%	135.2%	NY
119	Unnamed-Cook Forest-PA	150.7	11.1	73%	62%	135.2%	PA
120	Hearts Content	141.2	11.9	68%	67%	135.1%	PA
121	Unnamed-Cook Forest-PA	156.2	10.6	75%	60%	135.0%	PA
122	Little Mountain Town Creek-GA	142.2	11.8	69%	66%	135.0%	GA
123	Mirror Tree-MTSF-MA	152.6	10.9	74%	61%	135.0%	MA
124	Unnamed-Cook Forest-PA	147.9	11.3	71%	63%	134.9%	PA
125	Unnamed-Cook Forest-PA	147.8	11.3	71%	63%	134.9%	PA
126	Camp Creek-GA	165.2	9.8	80%	55%	134.9%	GA
127	Unnamed-Cook Forest-PA	151.0	11.0	73%	62%	134.7%	PA
128	Frank Decontie-MTSF-MA	160.1	10.2	77%	57%	134.6%	MA
129	Trout Brook Bully-MTSF-MA	130.6	12.7	63%	71%	134.4%	MA
130	Benchmark Tree-MTSF-MA	150.2	11.0	73%	62%	134.4%	MA
131	Unnamed-Pine Park-NH	151.0	10.9	73%	61%	134.2%	NH
132	Cliff Creek-GA	185.8	7.9	90%	44%	134.1%	GA
133	Unnamed-Cathedral Pines-NY	140.3	11.8	68%	66%	134.1%	NY
134	Unnamed-Cook Forest-PA	167.9	9.4	81%	53%	133.9%	PA
135	Hearts Content	155.1	10.5	75%	59%	133.9%	PA
136	Hearts Content	162.0	9.9	78%	56%	133.9%	PA

137	Unnamed-Cook Forest-PA	149.2	11.0	72%	62%	133.9%	PA
138	Unnamed-Cook Forest-PA	144.2	11.4	70%	64%	133.7%	PA
139	Unnamed-Pack Forest-NY	146.5	11.2	71%	63%	133.7%	NY
140	Unnamed-Cook Forest-PA	155.7	10.4	75%	58%	133.6%	PA
141	Unnamed-Cook Forest-PA	147.5	11.1	71%	62%	133.6%	PA
142	Camp Branch-SC	156.8	10.3	76%	58%	133.6%	SC
143	Holcomb Creek-GA	162.6	9.8	79%	55%	133.6%	GA
144	Cathedral Pine-Adirondack Park-NY	152.1	10.7	73%	60%	133.6%	NY
145	Jani Pine-MTSF-MA	152.0	10.7	73%	60%	133.5%	MA
146	Unnamed-Cook Forest-PA	165.9	9.5	80%	53%	133.5%	PA
147	Unnamed-Cook Forest-PA	166.9	9.4	81%	53%	133.4%	PA
148	Unnamed-Cook Forest-PA	162.1	9.8	78%	55%	133.4%	PA
149	Unnamed-Cook Forest-PA	164.4	9.6	79%	54%	133.4%	PA
150	Ed Frank Tree-MTSF-MA	150.4	10.8	73%	61%	133.3%	MA
151	Joe Norton Tree-MTSF-MA	164.2	9.6	79%	54%	133.3%	MA
152	Mahican Pine-Cornwall-CT	138.5	11.8	67%	66%	133.2%	CT
153	Jay Healey #1-MA	133.8	12.2	65%	69%	133.2%	MA
154	Unnamed-Bryant Woods-MA	143.1	11.4	69%	64%	133.2%	MA
155	Clutter Tree-MTSF-MA	152.4	10.6	74%	60%	133.2%	MA
156	Unnamed-Cook Forest-PA	151.1	10.7	73%	60%	133.1%	PA
157	Cliff Creek-GA	176.6	8.5	85%	48%	133.1%	GA
158	Unnamed-Cook Forest-PA	155.6	10.3	75%	58%	133.0%	PA
159	Unnamed-Cook Forest-PA	134.6	12.1	65%	68%	133.0%	PA
160	Unnamed-Cook Forest-PA	143.8	11.3	69%	63%	133.0%	PA
161	Unnamed-Cook Forest-PA	150.7	10.7	73%	60%	132.9%	PA
162	Unnamed-Paul Smith-Elders Grove-NY	140.0	11.6	68%	65%	132.8%	NY
163	Hearts Content	133.0	12.2	64%	69%	132.8%	PA
164	Bradford Pine-Bradford-NH	138.8	11.7	67%	66%	132.8%	NH
165	Unnamed-Trout Brook-MTSF-MA	137.6	11.8	66%	66%	132.8%	MA
166	Bryant Pine-Bryant Woods-MA	156.1	10.2	75%	57%	132.7%	MA
167	Smith Creek-SC	143.3	11.3	69%	63%	132.7%	SC
168	Hearts Content	153.7	10.4	74%	58%	132.7%	PA
169	Cliff Creek-GA	159.4	9.9	77%	56%	132.6%	GA
170	Unnamed-Cook Forest-PA	145.4	11.1	70%	62%	132.6%	PA
171	Unnamed-Cook Forest-PA	149.8	10.7	72%	60%	132.5%	PA
172	Unnamed-Cook Forest-PA	135.8	11.9	66%	67%	132.5%	PA
173	Cooper Creek-GA	154.3	10.3	75%	58%	132.4%	GA
174	Unnamed-Paul Smith-Elders Grove-NY	132.2	12.2	64%	69%	132.4%	NY
175	Unnamed-Indian Springs-MTSF-MA	140.3	11.5	68%	65%	132.4%	MA
176	Anders Run	146.1	11.0	71%	62%	132.4%	PA
177	Hearts Content	156.5	10.1	76%	57%	132.3%	PA
178	Unnamed-Cook Forest-PA	148.3	10.8	72%	61%	132.3%	PA
179	Helton Creek-GA	151.7	10.5	73%	59%	132.3%	GA
180	Unnamed-Cook Forest-PA	147.0	10.9	71%	61%	132.3%	PA
181	Unnamed-Cook Forest-PA	124.9	12.8	60%	72%	132.2%	PA
182	Unnamed-Dartmouth-NH	137.3	11.7	66%	66%	132.1%	NH
183	Bear Tree-MTSF-MA	152.4	10.4	74%	58%	132.1%	MA
184	Unnamed-Cook Forest-PA	142.9	11.2	69%	63%	132.0%	PA

185	Unnamed-Cook Forest-PA	152.2	10.4	74%	58%	132.0%	PA
186	Unnamed-Cook Forest-PA	151.0	10.5	73%	59%	131.9%	PA
187	Coon Branch Natural Area-SC	144.0	11.1	70%	62%	131.9%	SC
188	Unnamed-Paul Smith-Elders Grove-NY	137.0	11.7	66%	66%	131.9%	NY
189	Unnamed-Hartwick Pines-MI	142.8	11.2	69%	63%	131.9%	MI
190	Unnamed-Cook Forest-PA	148.6	10.7	72%	60%	131.9%	PA
191	Jay Healey #2-MA	129.9	12.3	63%	69%	131.9%	MA
192	Unnamed-Cook Forest-PA	142.6	11.2	69%	63%	131.8%	PA
193	Unnamed-Cook Forest-PA	157.7	9.9	76%	56%	131.8%	PA
194	Hearts Content	141.4	11.3	68%	63%	131.8%	PA
195	Unnamed-Claremont-NH	158.8	9.8	77%	55%	131.8%	NH
196	Ellicott Rock-NC	161.0	9.6	78%	54%	131.7%	NC
197	Unnamed-Cook Forest-PA	152.7	10.3	74%	58%	131.6%	PA
198	Unnamed-Cook Forest-PA	153.6	10.2	74%	57%	131.5%	PA
199	Unnamed-Stanley Park-MA	104.7	14.4	51%	81%	131.5%	MA
200	Unnamed-Cook Forest-PA	166.3	9.1	80%	51%	131.5%	PA
201	Bryant Pine-Bryant Woods-MA	140.7	11.3	68%	63%	131.5%	MA
202	Unnamed-Paul Smith-Elders Grove-NY	150.0	10.5	72%	59%	131.5%	NY
203	Unnamed-Elders-MTSF-MA	147.4	10.7	71%	60%	131.3%	MA
204	Anders Run	143.0	11.0	69%	62%	130.9%	PA
205	Sacajawea-Elders-MTSF-MA	155.4	9.9	75%	56%	130.7%	MA
206	Hearts Content	152.9	10.1	74%	57%	130.6%	PA
207	Crazy Horse-Elders-MTSF-MA	152.1	10.1	73%	57%	130.2%	MA
208	Unnamed-Hartwick Pines-MI	150.8	10.2	73%	57%	130.2%	MI
209	Petersham Pine-MA	130.8	11.9	63%	67%	130.0%	MA
210	Bruce Spencer Pine-Quabbin Reservoir-MA	121.3	12.7	59%	71%	129.9%	MA
211	Oneida Pine-MTSF-MA	155.0	9.8	75%	55%	129.9%	MA
212	Loona's Pine-MTSF-MA	152.6	10.0	74%	56%	129.9%	MA
213	Unnamed-Claremont-NH	161.8	9.2	78%	52%	129.8%	NH
214	Unnamed-Encampment-MTSF-MA	151.9	10.0	73%	56%	129.6%	MA
215	Unnamed-Paul Smith-Elders Grove-NY	146.0	10.5	71%	59%	129.5%	NY
216	Unnamed-Lisa Bozzuto#2-MTSF-MA	150.4	10.1	73%	57%	129.4%	MA
217	Unnamed-Claremont-NH	162.0	9.1	78%	51%	129.4%	NH
218	Jess Riddle-MTSF-MA	151.5	10.0	73%	56%	129.4%	MA
219	Fisher-Scott-Pine-VT	128.0	12.0	62%	67%	129.3%	VT
220	Unnamed-Cold River East-MTSF-MA	141.9	10.8	69%	61%	129.2%	MA
221	Unnamed-Hartwick Pines-MI	147.7	10.3	71%	58%	129.2%	MI
222	Unnamed-Bryant Woods-MA	145.2	10.5	70%	59%	129.1%	MA
223	Unnamed-Ice Glen-MA	147.4	10.3	71%	58%	129.1%	MA
224	Unnamed-Porcupine Mts-MI	116.0	13.0	56%	73%	129.1%	MI
225	Unnamed-Encampment-MTSF-MA	140.4	10.9	68%	61%	129.1%	MA
226	Unnamed-Bryant Woods-MA	140.3	10.9	68%	61%	129.0%	MA
227	Unnamed-Bryant Woods-MA	148.0	10.2	71%	57%	128.8%	MA
228	Unamed-Huntington-MA	137.2	11.1	66%	62%	128.6%	MA
229	Charlie Spencer-Mt Tom-MA	130.2	11.7	63%	66%	128.6%	MA
230	Unnamed-Paul Smith-Elders Grove-NY	142.6	10.6	69%	60%	128.4%	NY
231	Unnamed-Cook Forest-PA	162.1	8.9	78%	50%	128.3%	PA
232	Unnamed-Bryant Woods-MA	132.9	11.4	64%	64%	128.2%	MA

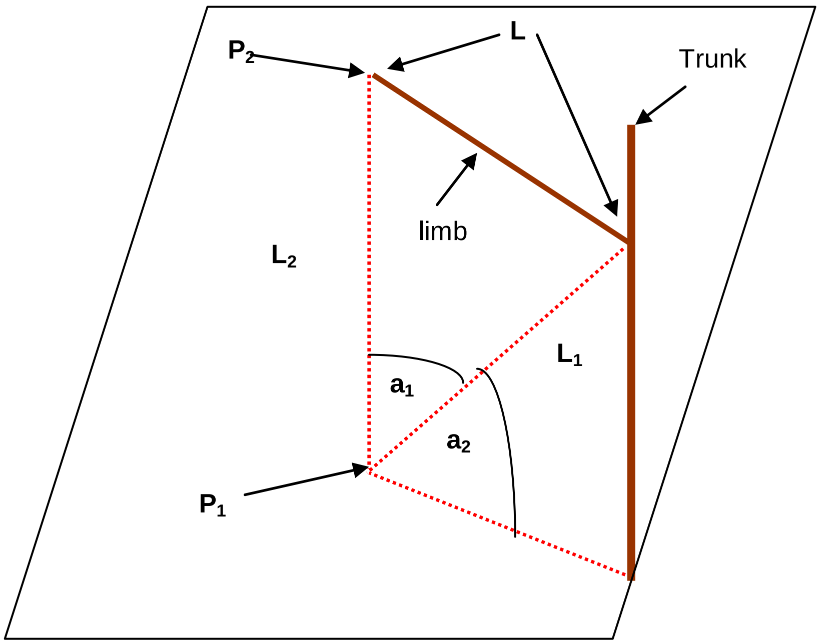
233	Unnamed-Paul Smith-Elders Grove-NY	150.3	9.9	73%	56%	128.2%	NY
234	Unnamed-Trout Brook-MTSF-MA	142.1	10.6	69%	60%	128.2%	MA
235	Hull Pine-Ashfield-MA	128.1	11.8	62%	66%	128.2%	MA
236	Unnamed-Clark Ridge North-MTSF-MA	143.2	10.5	69%	59%	128.2%	MA
237	Unnamed-Trees of peace-MTSF-MA	151.0	9.8	73%	55%	128.0%	MA
238	Unnamed-Cook Forest-PA	166.1	8.5	80%	48%	128.0%	PA
239	Unnamed-Ice Glen-MA	140.0	10.7	68%	60%	127.7%	MA
240	Colby Rucker-Encampment-MTSF-MA	153.8	9.5	74%	53%	127.7%	MA
241	Unnamed-Paul Smith-Elders Grove-NY	136.3	11.0	66%	62%	127.6%	NY
242	Graveyard Greta-Conway-MA	129.2	11.6	62%	65%	127.6%	MA
243	Unnamed-Bryant Woods-MA	150.5	9.7	73%	54%	127.2%	MA
244	Unnamed-Bryant Woods-MA	141.0	10.5	68%	59%	127.1%	MA
245	Unnamed-Bryant Woods-MA	141.9	10.4	69%	58%	127.0%	MA
246	Unnamed-Trout Brook-MTSF-MA	141.7	10.4	68%	58%	126.9%	MA
247	Fisher-Scott-Pine-VT	142.2	10.3	69%	58%	126.6%	VT
248	Unnamed-Bryant Woods-MA	141.8	10.3	69%	58%	126.4%	MA
249	Unnamed-Porcupine Mtns-M	95.0	14.3	46%	80%	126.2%	MI
250	Unnamed-Trout Brook-MTSF-MA	141.9	10.2	69%	57%	125.9%	MA
251	Unnamed-Todd Mtn-MA	137.1	10.6	66%	60%	125.8%	MA
252	Unnamed-Bryant Woods-MA	141.5	10.2	68%	57%	125.7%	MA
253	Clark Ridge-North-MTSF-MA	141.1	10.2	68%	57%	125.5%	MA
254	Unnamed-Dunbar Brook-MSF-MA	138.7	10.4	67%	58%	125.4%	MA
255	Unnamed-Pocumtuck Pines-MTSF-MA	143.2	10.0	69%	56%	125.4%	MA
256	Unnamed-Trees of peace-MTSF-MA	130.4	11.1	63%	62%	125.4%	MA
257	Algonquin Tree-MTSF-MA	158.1	8.7	76%	49%	125.3%	MA
258	Unnamed-Trout Brook-MTSF-MA	154.5	9.0	75%	51%	125.2%	MA
259	Unnamed-Ice Glen-MA	140.5	10.2	68%	57%	125.2%	MA

Rules for inclusion:	State	State	State	State	State	
1. Minimum height 90 feet	PA	MA	GA	NY	NH	
2. Minimum diameter 2.5 feet (7.9 ft in circumference)	99	82	20	25	10	
3. Minimum total points 125						
	State	State	State	State	State	State
	MI	NC	WI	CT	SC	VT
	9	3	3	1	5	2

Techniques for measuring limb length

Beyond the simple system used by American Forests to maintain the National Register of Big Trees and the equivalent state programs, tree measuring quickly becomes a complex, mathematically intense process. Measurement methods that work well in the field are continuously being developed by **ENTS**. The following diagram shows a workable method for measuring limb length from a distance that we have adopted.

Limb Length Measurement



NOTES:

1. Limb to be measured is represented by length L
2. Find P_1 by standing under $P_{2,}$ using clinometer and moving and sighting up until a 90 degree angle is found. for the point P_2. P_1 is underfoot.
3. L_1, L_2, a_1, and a_2 are measured as follows:
   L_1 and L_2 by laser
   a_2 is measured by clinometer
   $a_1 = 90 - a_2$
4. L is computed by the law of cosines
   $L = SQRT(L_1^2+L_2^2 - L_1L_2Cos(a_1))$.

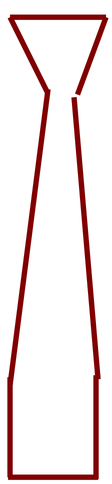
Area and volume considerations

ENTS measurement techniques achieve unprecedented field accuracy for linear measurements. The challenge of achieving a high degree of accuracy for tree height and one-directional crown spread has been overcome. However, two-dimensional determinations such as cross sectional area and three-dimensional determinations such as trunk volume present many challenges that require the use of a tool kit of techniques. One troublesome measurement is the cross sectional area of a trunk or limb. Conventional forestry methods treat the cross sectional shape of a trunk or limb as circular. However, departures from circularity are of the rule instead of exception. The cross sectional shape is often elliptical. A formula that allows us to compensate for an elliptical cross sectional area includes:

1. $A = \Pi(b)(a)$ where a and b are the semi-major axes of the ellipse and A is the area.
2. $P = \Pi[3(a+b)-\{(a+3b)(3a+b)\}^{1/2}]$ where a and b are the semi-major axes of the ellipse and P is the perimeter.

One simple check for ellipticality is to measure a and b with the Dendrometer or Macroscope, compute P using the formula in 2 above and then, using a tape measure, determine the actual perimeter. It the semi-minor and semi-major axes produce a perimeter that agrees with the taped perimeter, the assumption of ellipticality is met.

Areas of a main trunk that split into separate trunks or limbs are especially troublesome to model. The following table contains data from the modeling of a 25-foot section of the trunk of a northern red oak in Monica's woods. The modeling goes to point of main trunk branching. The diagram shows the general shape of the trunk.



Main Trunk					
	Len	**Diam**	**Area**	**Vol**	**Error**
	0.00	2.59	5.28		
	2.50	2.11	3.50	10.90	
	3.78	1.56	1.91	3.41	
	5.28	1.71	2.30	3.15	
	10.05	1.60	2.01	10.25	
	12.70	1.69	2.25	5.63	
	17.58	1.84	2.67	11.98	
	25.20	1.84	2.67	20.31	
				65.64	**0%**
1 frustum				98.22	50%
1st frustum				13.05	
2nd frustum				48.74	
				61.79	-6%
Actual middle rule				56.66	-14%
Engineer's rule				104.49	59%
Avg middle rule				100.08	52%

The above calculations show the challenges of calculating volume of a trunk that narrows and then widens at the point of separation into trunk limbs. Treating the whole form as a single frustum over-calculates the volume by 50%. Treating the shape as two frustums, one from the base to the narrowest width and the second from the narrowest width to the top produce an under-calculation of the volume by 6%. Treating the form as a frustum with an average width equal to that of the mid-point of the frustum leads to an under-calculation of the volume by 14%. Using forestry log rules leads to either a 59% over-calculation or a 52% over-calculation. These are highly revealing calculations.

The following table shows another modeling of a trunk through the first major trunk split.

Silver Maple										
Dist-ft	**Deg**	**Len**	**mm**	**diam-ft**	**mm**	**diam-ft**	**Area-ft^2**	**Area-ft^2**	**Tot Area**	
63.0	-4.5	0.0	3.6	3.0			7.2	0.0	7.2	
63.0	-1.5	3.3	3.2	2.7			5.7	0.0	5.7	
66.0	9.0	12.2	2.8	2.5			4.8	0.0	4.8	**<=bottom**
66.0	11.0	2.3	2.9	2.6			5.1	0.0	5.1	**<=top**
66.0	14.0	3.5	1.8	1.5	2.4	2.1	1.9	3.5	5.4	**separate**

The total area column is revealing of a common pattern. The trunk narrows down to a point just below the start of trunk/limb separation. At the top of the fused area, the area maybe slightly smaller or larger than the combined areas of the separate trunks/limbs. In the above model, the combined area of the separate trunks is slightly larger than the spot just below separation.

It would be counterproductive to adopt a process that assumes the shape of a regular geometric solid over a long log length in order to keep calculations simple. There is no alternative to breaking the trunk into short sections and modeling each section separately from multiple directions. The process is labor intensive, but until we find shortcuts, there is no alternative.

SECTION 5: White Pine Stand Tagging, Inventorying, and Growth Analysis

Introduction

One of the primary projects of **FMTSF** is a long-term study of the growth of the white pines of **MTSF** with comparisons to growth rates of pines elsewhere**.** This study follows logically from the status of Mohawk's pines as the tallest known trees in New England.

To facilitate this project, we have grouped areas growing white pines into the following named sites:

1. HQ Hill
2. Tuscarora
3. Pocumtuck
4. Cherokee-Choctaw
5. Trees of Peace
6. Indian Springs
7. Encampment
8. Algonquin
9. Elders
10. Shunpike

Pines are presently being tagged in these areas and position coordinates of each tagged pine determined. The prior update presented the methodology for locating each tagged tree and doing various kinds of spatial-dimensional analysis. To date we can report the following information.

MTSF		**Diameter class in ft**							
Stand	**Tot No. tagged trees**	**1-1.499**	**1.5 - 1.99**	**2.0 - 2.499**	**2.5 - 2.99**	**3.0-3.499**	**3.5 - 3.99**	**Avg Diam in ft**	**Avg Diam in inches**
Trees of Peace	127	9	33	46	31	8	0	**2.3**	**27.0**
Elders	18	0	0	3	7	5	3	**2.9**	**35.0**
Pocumtuck	278	60	95	101	21	1	0	**1.9**	**22.8**
Cherokee-Choctaw	71	4	17	32	17	1	0	**2.3**	**27.0**
Totals/averages	**494**	**73**	**145**	**182**	**76**	**15**	**3**	**2.1**	**24.9**

What is surprising in the above inventory is the relatively small average diameter of the pines. The average diameter of 24.9 inches equates to an average circumference of 6.5 feet. This is not exceptional. However, when tree height is factored in, the Mohawk pines can be seen as extraordinary. The average height of 84 of the 494 tagged pines is a remarkable **145.4 feet**. The 84 tagged trees include only 34 of the seventy-eight 150-foot tall pines in **MTSF**. When the average age of the pines is factored in, which is between 110 and 120 years of age, the growth potential of the Mohawk pines can be seen as impressive. White pines are long-lived with individuals that have been recorded to over 500 years. The average longevity of the species is between 250 and 300 years. Assuming an absolute average of the tagged Mohawk pines at 120 years and assuming an average longevity of 275 years, the Mohawk pines are 44% of average maximum age and about 33% of the expected upper maximum for the entire region.

Central research questions for us are:

1. **How much growing do the pines have left?**
2. **At what rates will the growth occur?**
3. **What is the current rate of growth in terms of,**
    a. **Height,**
    b. **Diameter,**
    c. **Trunk volume**

Answers to the above questions form the basis of much of our research. Information that we currently have suggests that height growth of the Mohawk pines is averaging 8 to 14 inches per year for the pines in the 120+ age range. In addition, the dominant trees, which are usually those with room to grow, show plenty of crown area.

There are several areas of young white pines forming thick stands in the age range of 40 - 60 years that will be studied for volume in 2006 and compared to the 100+ year old stand-based trees. Our current calculation of average volume for the 50-year old stock is 90 to 120 cubic feet. The average volume for 120-year old trees is probably in the range of 300 to 325 cubic feet. This represents approximately triple the volume of 50-year old stock. If our analysis is correct, the Mohawk pines continue to be powerful growing machines at ages of 120 years. We believe that high growth continues for another 40 to 60 years, with many pines reaching trunk volumes of 450 to 500 cubic feet at the upper age range. Averages will likely be 375 to 400 cubic feet.

SECTION 6: Activities and History of FMTSF

Introduction

FMTSF has a distinguished record of fostering public awareness of and appreciation for the old growth forest remnants in the eastern United States in general and Massachusetts in particular. The local mission of Friends is well known within DCR. However, the broader mission of Friends is less well understood. The following paragraphs provide some of the history of Friends that we hope will explain the strong connections that Friends enjoys within the scientific and forestry communities. These connections allow us to bring the highest level of expertise to bear on identification, mapping, and research in the old growth on DCR lands and in the related forest research as described in the above sections. The information presented below is far from complete. Additional information on the activities and history of Friends will be included in future report updates.

1. Ancient Eastern Forest Conference Series

During the period from 1992 to 1999, the importance of the Massachusetts old growth confirmations to the scientific community was leveraged by its visibility in an important series of eastern old growth forest conferences. From an idea originally proposed in May 1992 by Ted Watt of the Massachusetts Audubon Arcadia Wildlife sanctuary, **FMTSF** began organizing a series of eastern wide old growth forest conferences that were conceived to bring naturalists, scientists, foresters, forest historians, environmentalists, and governmental resource specialists together to share information on eastern old growth forests. The series was conceived to function at several levels to include:

(1). definitions and characteristics of old growth,

(2) ecological, scientific, historical, and aesthetic values of old growth,

(3). threats to survival, and

(4) management and restoration.

However, Massachusetts did not prove to be a viable location for the first conference. Through the grassroots environmental organization Virginian for Wilderness under the leadership of X-NASA geologist Dr. Robert Meuller, Washington D.C. was initially selected as the best place to hold the first conference, but renting conference space proved too expensive. The Western North Carolina Alliance, another important grassroots organization, stepped up to the plate and working with **FMTSF** created an impressive coalition of academic, environmental, and governmental organizations. The result was the 1st conference in what became known as the **Ancient Eastern Forest Conference Series**. The conference was held at the University if North Carolina in Asheville in August 1993. The attendance was approximately 350 and included a good balance of scientists, naturalists, foresters, forest historians, resource professionals, and forest activists. The agenda included science, management and restoration, and values and placed the spotlight clearly on gaps in our understanding of old growth ecosystems.

The first old growth conference was a recognized success and it provided **FMTSF** with a blueprint for future conferences. The blueprint called for an academic sponsor supported by governmental, environmental, and other academic cosponsors. Using this model, the 2nd conference was held at Williams College, MA. Primary cosponsors included the Massachusetts Audubon Society, DEM, the U.S.F.S, and **FMTSF**. The role of DEM as a conference cosponsor was a significant event. It attested to an internal recognition that the department needed to understand more about the old growth remnants on its properties. A field trip was organized by Leverett into the Hopper on Greylock. Principal presenters at the second conference included Dr. Lee Frelich of the University of Minnesota and Dr. David Foster of Harvard Forest, both of whom have become central players in the Massachusetts old growth story. A number of DEM representatives attended the conference and placed the organization clearly on record as desiring to protect remaining old growth sites on DEM lands.

In conjunction with this 2nd old growth conference at Williams College, a symposium on old growth definitions was held at Harvard Forest. The symposium was cosponsored by **FMTSF**, Harvard Forest, and DEM. The fact that DEM was a formal cosponsor of the symposium stems from the foresight of then Commissioner Peter Webber. Webber recognized that DEM had probably lost old growth to DEM timber management without his foresters being aware. He wanted DEM personnel to become fully aware of the thinking in the scientific community on old growth. He was also aware that private citizens were making old growth discoveries on DEM lands and he wanted to support the private effort.

A total of about 45 scientists and foresters attended the symposium and what became clear from the symposium was that all eastern old growth ecosystems did not fit into a simple, inclusive definitional framework. Old growth in the northern forest types had different structural characteristics from those in the South. The symposium was highly valuable and from it emerged several important scientific papers including one by Drs. Malcolm Hunter and Alan White of the University of Maine, but a simple acceptable definition for the old growth on DEM lands did not emerge.

The 3rd old growth conference was held in October 1995 at the University of Arkansas at Fayetteville. **FMTSF** was represented by Bob and Jani Leverett and Chief Jake Swamp. Drs. Charles Cogbill and David Foster were among the presenters. As with prior conferences, **FMTSF** was one of the organizers. The 4th old growth conference was held at Clarion University of PA in June 1997. DCNR of Pennsylvania, DEM's equivalent, was a co-sponsor.

There was no conference in 1998, but a second old growth definitions symposium was held at Harvard Forest in November 1998. DEM was a cosponsor. The three co-sponsors were Harvard Forest, DEM, and **FMTSF**. The event was organized differently from the 1994 symposium. Lectures were sequential as opposed to concurrent as was the case in 1994. Representation from Canada. There were a number of DEM management foresters present. While it is not clear if the information presented by ecologists on the nature of old growth changed the perceptions of DEM field personnel, it was abundantly clear that upper level DEM management left with a firm conviction that the old growth areas were to receive the highest level of administrative protection under their watch.

Meanwhile, the conference series moved on. The University of Minnesota at Duluth was the location of the 5th conference during June 1999. While the science presented at the 5th conference was extremely strong, attendance had dipped to around 140 and with the conclusion of the 5th conference, the series was suspended for several years to allow scientists engaged in old growth studies to complete their research and have fresh material to present. The series was continued in 2005 with the 6th conference cosponsored by a number of academic, government, and environmental organizations. The University of New Hampshire was the principal academic planner. The location was Lake Winnipesaukee. The theme of the 6th conference was management and partnership themes between private and public interests.

To date, the 6 full conferences and two definitional symposia held at Harvard Forest. In 2000, a special conference was held at Sweetbrier College in Virginia to education landowners on the nature and value of old growth. The primary sponsor of the event was the 500 Year Forest Foundation of Lynchburg, VA. Cosponsors included **FMTSF** and **ENTS**. Both organizations continued with their outreach, but with respect to **FMTSF**, the conference provided another opportunity to tell the story of the Massachusetts old growth.

The 7th in the Ancient eastern Forest Conference Series was held in Little Rock Arkansas in March 2006. It concentrated on the forests of that region and the rediscovery of the Ivory-billed woodpecker. The conference was attended by approximately 120 people.

Plans are being laid for the series to be held in the Adirondack region of New York in 2008.

2. Wild Earth Old Growth Inventory

As important as the old growth conferences were to the visibility of Massachusetts old growth, other related activities also figured in prominently. During the early 1990s, **FMTSF** participated in an eastern wide old growth inventory spearheaded by the "Wild Earth" publication. The eastern effort was an outgrowth of interest in old growth forests spawned by conflicts in the West, especially the Pacific Northwest. Dr. Mary Byrd Davis became the focal point for collecting and reporting data. She contacted potential sources of information in all eastern states. The individual Natural Heritage programs were prime sources. It was through Natural Heritage that Bob Leverett and Davis linked up. **FMTSF** was the organizational arm through which Leverett worked. **FMTSF** assisted Davis with information on New England and wrote the forward to the study report "Old Growth in the East – an Inventory". The report was released in 1993 and received fairly wide distribution. The primary value of the report was that it became an important vehicle to report surviving areas old growth forest under one cover and insured that the old growth of **MTSF** and **MSF** was reported for the record along with well known places like Hearts Content in western Pennsylvania.

3. "Eastern Old Growth Forests – Prospects for Rediscovery and Recovery"

In addition to the old growth conferences and the eastern wide old growth inventory, Leverett and Davis organized a team of 34 scientists, naturalists, and forest historians and produced the Island Press book "Eastern Old Growth Forests – Prospects for Rediscovery and Recovery". The book was published in 1996. One chapter was devoted to the Northeast. It was co-authored by Dr. Peter Dunwiddie, Dr. David Foster, Dr. Don Leopold and Bob Leverett. Leverett also wrote the introduction to the book, which still stands as the best source of information on eastern old growth for the general public. The book would not have been possible were it not for the success of the Ancient Eastern Forest Conference Series in stimulating interest in eastern old growth and bringing wider attention to the topic. **FMTSF** was the organizational vehicle that funded travel for the above project.

4. Other Releases of Information about Massachusetts Old Growth

During the period from 1988 to the present, the efforts of **FMTSF** have found frequent outlets to include NPR, WFCR, Channel 5 in Boston, and WQED public television in Pittsburgh(no longer active). Newspapers included large ones like the Boston Globe, New York Times, New York Post; USA Today carried stories about eastern old growth that reported on discoveries in **MTSF** and elsewhere in Massachusetts. The content of these stories is not particularly important. However, collectively, they record the level of interest and activity in eastern old growth forest that was occurring during the period of 1988 to the present. In so far as the Massachusetts old growth is concerned, it has been of special interest. The existence of old growth in the Pacific Northwest is hardly news. However, pockets of old-growth forest that have survived against all odds in the crowded Northeast, and especially Massachusetts, have proven to be of broad, enduring public interest.

FMTSF Participation in GSMNP battle to save key hemlocks

FMTSF will be the fiscal agent of **ENTS** in a planned project to save some of the Greay Smoky Mountains National Park's finest hemlocks. **ENTS** will partner with Park employees. In the formal justification for releasing the funds, the Park submission stated the following:

"The primary partner for this project is The Eastern Native Tree Society (**ENTS). ENTS** is non-profit organization devoted locating, measuring and researching exceptional forests and individual trees of eastern North America. For the past 12 years**, ENTS** members have documented unique hemlock forests and have found trees that exceed the known size limits for the species. **ENTS** researchers are the foremost experts in locating, identifying, and documenting old growth hemlock forests. **ENTS** members will be the primary researchers in surveying, identifying, measuring, and documenting exceptionally large eastern hemlocks in the park. This information will assist park management in targeting important resources at risk and prioritizing areas that require immediate systemic treatment."

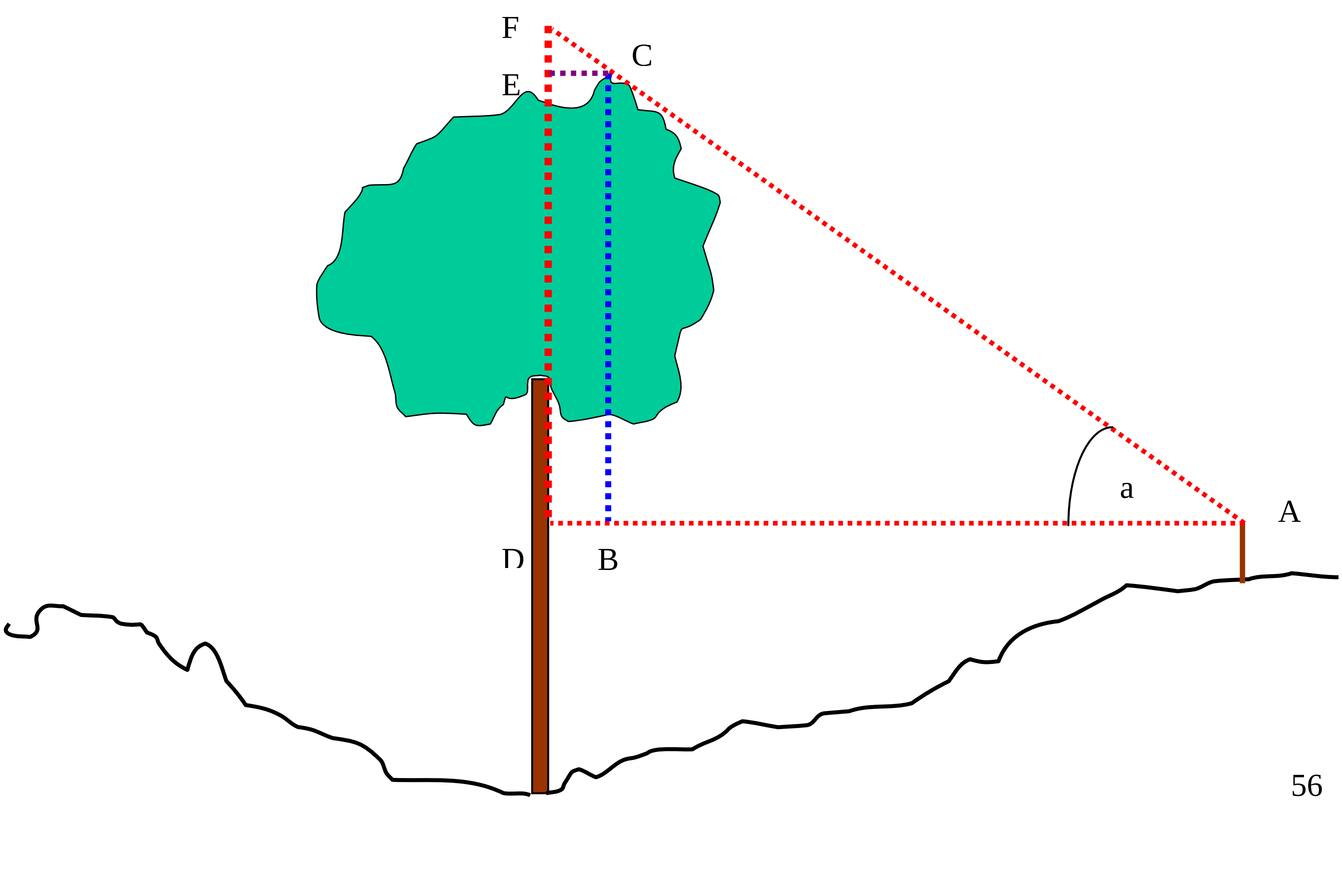
The degree of acceptance of **ENTS** and its fiscal sponsor, **FMTSF**, as the foremost experts in the accurate measuring of eastern trees is an outside affirmation of the expertise that **FMTSF** brings to the studies outlined in this report. **ENTS** has elevated the science of tree measuring from its commercial roots that concentrates on usable trunk volume and from its casual sporting roots as reflected in champion the tree listings. This is giving science a chance to undertake more serious studies of the growth limits of eastern species.

SECTION 7: Dendromorphometry

FMTSF uses the **ENTS** engineered methods for dendromorphometry (the science of measuring trees). Of special concern to us is the height technique because tree height it is the basis of the RHI. We have described the height measurement process in prior reports. However, it merits repeating here because the errors introduced by the common percent slope height measuring technique used in forestry renders invalid many, if not most, comparisons made of tree height that mix techniques. The percent slope method typically employs a tape measure and clinometer, or a laser rangefinder in place of the tape measure. The following diagram illustrates the common problem encountered with the percent slope technique. In the diagram, the measurer is at A. The point on the tree that appears to be the top is at C. However, C is not directly over the base of the tree. The measurer constructs the triangle ADF without being aware that the points C and F do not coincide. The distance AD is measured with a tape measurer or laser rangefinder. The slope represented by the angle a to the point in the crown, thought to be the top, is measured with a clinometer. The slope percent converted to a decimal is multiplied by the distance AD to get the tree's height above eye level. The height should be DC, but is computed as DF, resulting in the error EF. A comparable error for the part of the tree below eye level is seldom made because the base is in vertical alignment with the trunk. If the crown of the tree is wide, the distance EC can be 15 to 30 feet, which can lead to a substantial height error. In a computer simulation involving 1800 trees, the average height error using the percent slope method instead of the **ENTS** approved sine top-sine bottom method was 8.4 feet.

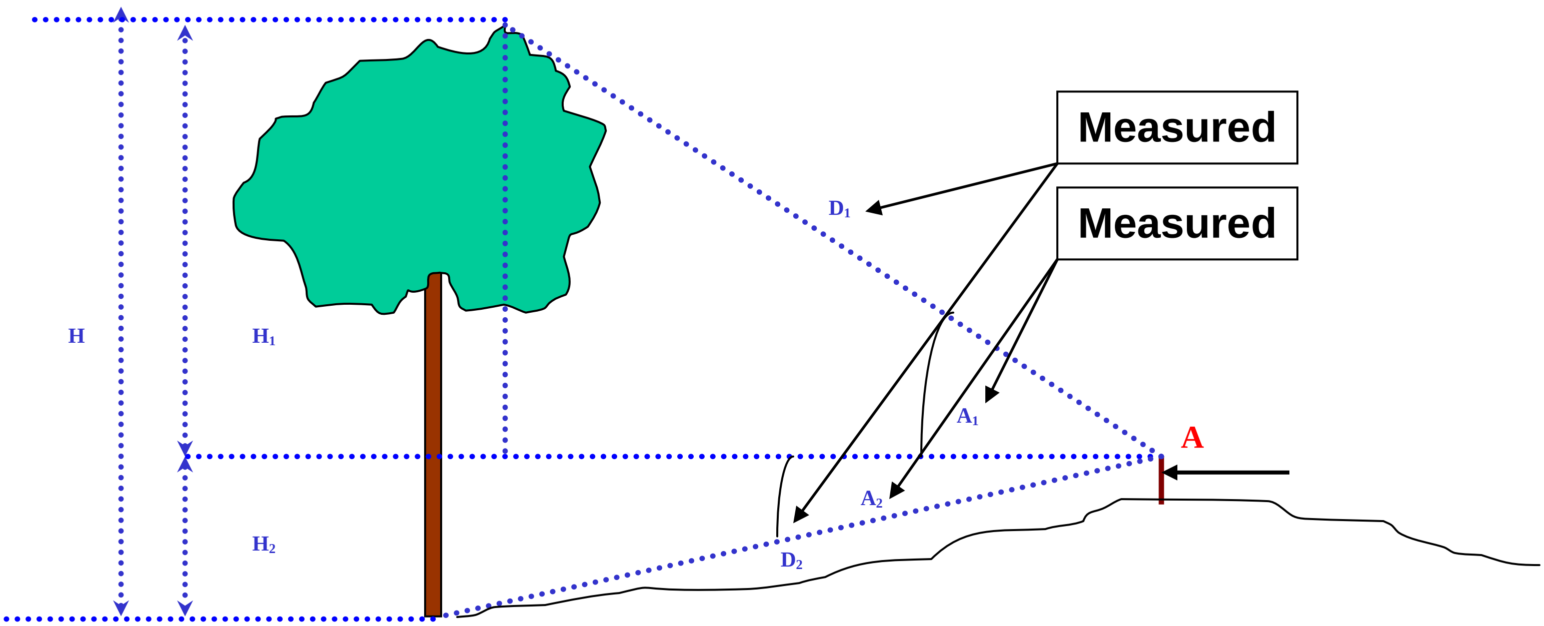
With the use of laser rangefinders, clinometers, and trigonometry, there is no need to make this kind of measurement error as the diagram on the following page will show. The same tree profile is used to permit a clearer comparison between techniques.

Tangent-based tree measuring



Sine-based tree measuring

We have described the **ENTS** methods of measuring tree height and the reasons we use it. We repeat a description of the method here. The following diagram and accompanying explanation shows the sine-sine method employed by **ENTS**.



Calculated height of tree using sine-based method.

The height of the tree in the diagram is denoted by **H** and is composed of the components $\mathbf{H_1}$ and $\mathbf{H_2}$. $\mathbf{H_1}$ is height above eye level and $\mathbf{H_2}$ is height below. The eye is maintained in a fixed position. $\mathbf{H_1}$ and $\mathbf{H_2}$ are calculated by the following formulas.

$$H_1 = \sin(A_1)\, D_1$$

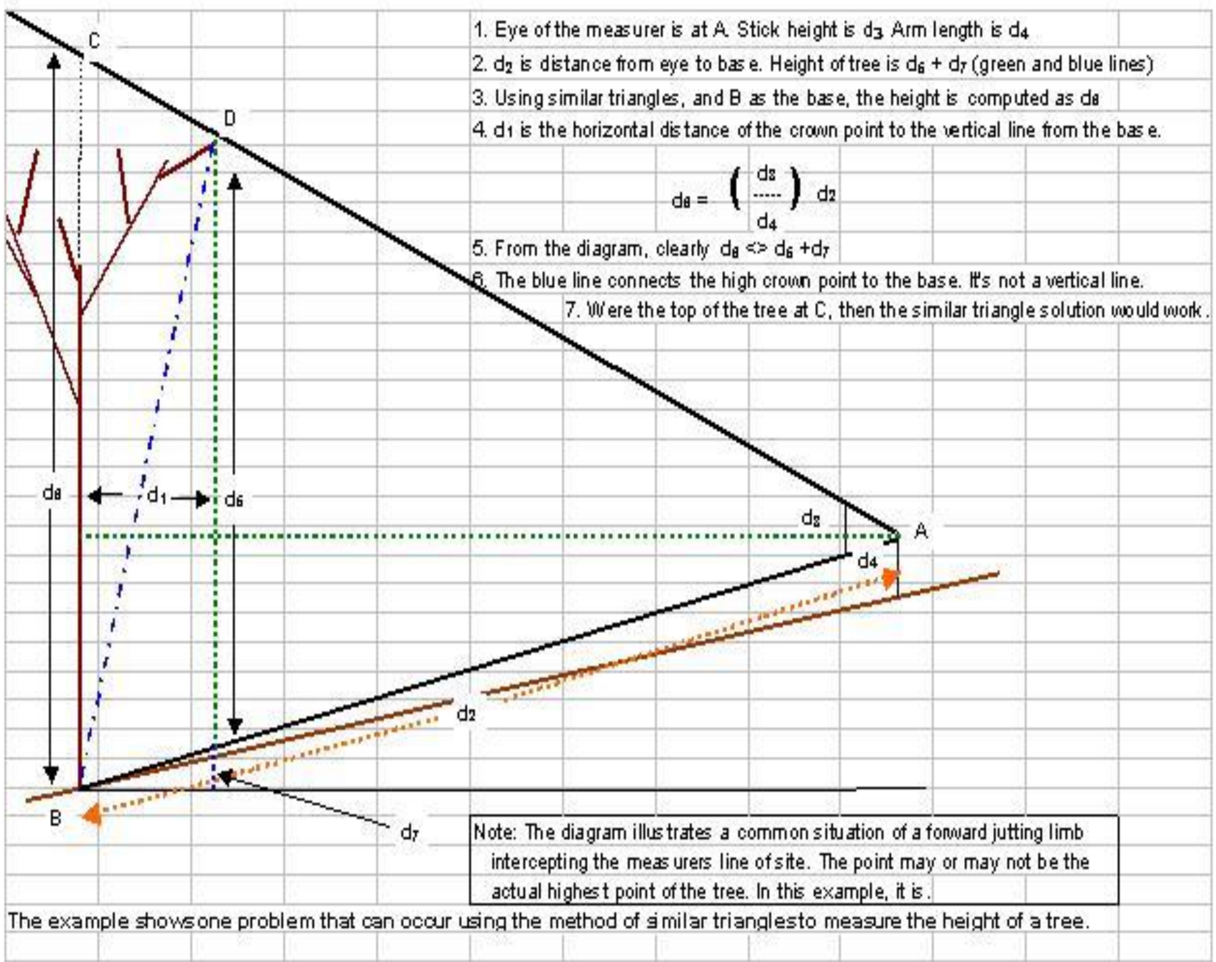
$$H_2 = \sin(A_2) D_2$$

$$H = H_1 + H_2$$

The idea here is to establish two right triangles to measure the height of the tree. One triangle measures the height above eye level. The other, below. For the top triangle, the measurer shoots the hypotenuse distance $\mathbf{D_1}$ from the eye to the high point of the crown using a laser rangefinder and measures the associated angle $\mathbf{A_1}$ with a clinometer. The calculation $\mathbf{H_1}$ is the height of the point above eye level regardless of where the point is located in relation to the base of the tree. The measurer creates a comparable triangle using the distance $\mathbf{D_2}$ from eye to base to compute $\mathbf{H_2}$, height of eye level above the base of the tree. The eye has to stay in a fixed location. The sum of $\mathbf{H_1}$ and $\mathbf{H_2}$ is the height of the tree. The sine method avoids the assumption made by the tangent method of that the top of the tree is directly over the base.

Similar Triangle Methodology

We will conclude the tree height measuring techniques with a look at a popular method included in tree measuring guidelines for the National Register of Big Trees and state programs. It is the method of similar triangles. This method suffers from the same problem as does the % slope or tangent method. Comment #7 identifies the condition under which the method works.



SECTION 8: Summary of exemplary trees and forest features in MTSF and MSF

Below is a summary of the unique and exemplary trees and forest features of **MTSF** and **MSF**. The list includes what we consider to be the most exceptional features and facts about Mohawk's and Monroe's large/tall trees.

MTSF:

1. **Rucker index**. The Rucker Height Index (RHI) is the arithmetic mean of the ten tallest trees representing the ten tallest tree species in a given area. The value is in units of feet. For multiple iterations the tallest tree is removed from each species for successive iterations. For example, **MTSF**'s Rucker index of **136.0** is the highest in New England and the 3rd highest in the Northeast. The **MTSF** Rucker index supports 4 iterations over 130, 11 iterations over 125, and 18 over 120. Through 20 iteration, Mohawk's index averages 125.7. In this iterated distribution, **MTSF** is presently number one in the Northeast. When species repetition is allowed, the RHI for **MTSF** for the 10 tallest trees independent of species is 161.0. This ranks second in the Northeast behind Cook Forest, PA. Through 20 iterations, Mohawk's index averages 148.2. This extremely high index is altogether dependent on white pine and white ash. It is unclear why **MTSF's** RHI is as high as it is. Bedrock geology seems to favor Mohawk. Rainfall is adequate and altitude is not a constraint. However, the same could be said for other areas in central and western Massachusetts. Rather than unique growing conditions, Mohawk's high Rucker index probably is a result of poor timber practices over much of Massachusetts. The widespread elimination of the larger, older, and more commercially valuable trees elsewhere, especially on private lands keeps the forest abnormally young, even-aged, and high-graded. Leaving large commercially valuable trees like northern red oak and white pine to grow for 100 years or more is the exception instead of the rule. As mentioned, on private lands, there is the common practice of high-grading and this practice obscures the growth potential and maximum sizes achievable for each species. So, at least as a working hypothesis, **MTSF** may provide us with our best baseline for natural growth on good sites for the Berkshire-Taconic region. Section 3 of this report provides an in-depth discussion of the Rucker Index Analysis (RIA) and the results we have obtained for the process.

2. **Greatest population of 150-foot tall trees in New England**. **MTSF**'s white pines are the property's most impressive forest feature and Mohawk's pines replace the Cathedral Pines of Cornwall, CT, as New England's flagship stand. **FMTSF** has now confirmed 78 white pines and two white ash trees over 150 feet in height in **MTSF;** 4 and possibly 5 of the white pines exceed 160 feet. Two other pines will likely reach 160 within 2 to 3 years and between 12 and 15 within 5 years. Elsewhere in Massachusetts, we have documented an additional ten 150s. There is a likelihood of between 3 and 6 that we have not found. But the total number of 150s in Massachusetts is almost certainly under 100. Mohawk has by far the largest population of 150-footers in Massachusetts and exceeds its nearest rival in New England by 15 to 20 trees. For a period of time, a private property at

Claremont, NH was thought to have a larger population of 150s. However, subsequent visits to that property have allowed us to establish the boundaries of the population. Current estimates are between 60 and 65 pines in the 150 class on the Claremont property. Elsewhere in New Hampshire, we have documented (4) 150-footers. Beyond the two properties, 150s are lightly scattered over the remainder of New England. To put the Mohawk 150-footers into further perspective, we turn to the entire Northeast. **MTSF** has the second highest number of 150-footers in the Northeast, defined as New England, New York, Pennsylvania, and New Jersey. We have not documented any 150s in Vermont, Connecticut, or Rhode Island.

3. **Single tallest tree in New England**. The Jake Swamp white pine now stands at **167.3** feet tall. Its latest measurements were conducted with 5 separate sets of equipment and 4 experienced measurers. The Claremont tall tree in New Hampshire is listed as 166.1 feet, but our measurement of it in December 2004 did not confirm the 166 figure. Until additional measurements can be taken of the Claremont tree, the Jake Swamp tree is the tallest. The Jake Swamp tree continues to grow at a rate of 10 to 13 inches per year. This season's growth is expected to send the Jake tree over 168 feet. Barring damage, the Jake Swamp tree should reach 170 feet by 2009. The potential for crown damage lessens the probability that Jake will get much beyond 170 feet. The great pines in Cook Forest, Hearts Content, Ander's Run in PA show us that.

4. **Most species state height champions of any property in the Northeast**. The 17 statewide height champions, as reflected in one of the tables in Section II, is a remarkable achievement for a property as small as **MTSF**. That a small state forest in Massachusetts could have so many champions begs for an explanation. Given the large forested acreage that Massachusetts now boasts, one might believe that the distribution of champions would be much wider, at least wider than what it has proven to be. The full explanation must await more analysis. However, as has been previously explained, high-grading and over-cutting of mature trees in Massachusetts forests is the most likely explanation. The temptation of landowners to cut mature trees, especially large white pines and northern red oaks is overwhelming. That leaves the mature populations of these species on public and conservation lands to demonstrate what we can expect, or should be able to expect, from growth rates, maturity, and longevity of these species. Additionally, landowners may think pines are mature at a younger age because they overtop other species and appear mature in comparison when the pines are still growing at fairly high rates. Trees like the Jake tree are still adding volume at the rate of between 3 and 3.5 cubic feet per season. The determination of what the white pine growth rates are for different age classes is a high priority research project of **FMTSF**.

5. **Most significant population of tall white ash trees in the Northeast**. In 2004, **FMTSF/ENTS** identified a pocket of "super-growth" white ash trees in the upper Trout Brook watershed. The Trout Brook pocket joined three super ash groves on the Todd-Clark Ridge. A new individual height champion in Trout Brook was measured at 151.5 feet. This was well beyond what we had anticipated ever finding. The tree is located at 42.625 degrees latitude north and at the time of measurement, was the northern most hardwood that we have measured to 150 feet in height. The height of this tree was

reconfirmed by mathematician John Eichholz on April 4, 2005. We considered the white ash to be an extreme statistical outlier. However, a second white ash was confirmed to the height if 150.1 feet in Ash Flats in April 2006. It is located at latitude 42.636 degrees north. So far, 25 white ash trees in **MTSF** have been measured to heights of 140 feet or more. No other hardwood has been measured to 140 feet in Massachusetts, including the tuliptree (***Liriodendron tulipifera***). Only three other ash trees in the Northeast are known to reach 140 feet. One tree is in Ice Glen and is 140.1 feet tall. A second tree is in Zoar Valley, NY and is 140.5 feet and the third is in Kaaterskill Falls, NY and is 140.3 feet tall. A fourth will likely be confirmed in Ricketts Glen, PA and as we expand our search for tall white ash trees, we will unquestionably confirm more scattered across New York and Pennsylvania, perhaps with a few places to rival Mohawk, but that has not happened yet. And without a sustained long-term search effort by **ENTS**, it will be hard for any site to match Mohawk's white ash height dominance. As with Mohawk's overall Rucker index and abundance of height champions, the reasons for the dominance of white ash in **MTSF** remain unknown to us. Other species such as bigtooth aspen and the three species of birches that we list as Northeastern champions are also remarkable, but are not singled out for special consideration like the white ash because these latter species have been greatly under-sampled in potentially competing forests.

6. **Largest number of species reaching significant height thresholds on any property in New England**. As has been pointed out, **MTSF** is not the province of just a few species of trees that reach significant height thresholds. Twenty-two species, 20 native and 2 non-native, surpass 100 feet. Thirteen species, 12 native and one non-native, surpass 120 feet, seven native species surpass 130 feet, two native species surpass 150 feet, and one surpasses 160 feet. No other New England property approaches these thresholds. Ice Glen in Stockbridge, MA is Mohawk's nearest New England competitor. Ice Glen boasts one species over 150, 2 over 140, 4 over 130, 6 over 120, and 14 over 100.

7. **Second greatest population of 160-foot tall trees in New England.** The Claremont, NH private property previously mentioned has 7 white pines that reach 160 feet in height. **MTSF** has 4, with the possibility of a 5th. Within the next 3 years, an additional 2 white pines in Mohawk will likely reach 160 feet. The Claremont pines may add one or possibly two, but the Mohawk trees are growing faster than the Claremont trees, and barring significant disturbance, Mohawk will surpass the Claremont property in all comparison categories within 4 to 5 years.

8. **Oldest dated hemlocks in Massachusetts.** Beyond height data, we mention that a hemlock in the Cold River A site has been dated by Anthony D'Amato to 488 years as a solid core. A reasonable projection to the base of the tree is 15 to 20 years. So the tree is almost certainly over 500 years of age. Several years ago, a hemlock in **MSF** was dated by Hampshire College to 474 years in age. A third hemlock was dated to 430 years of age by Gary Beluzo in Little River Gorge, also several years ago. Bob Leverett dated a hemlock in Cold River Gorge to 425 years of age in 1990. Tony D'Amato dated a second hemlock in **MTSF** to 441 years of age. It is clear that a scattering of hemlocks in the 400 to 500-year age range continue to survive in the **MTSF** old growth. Unless treated in the next few years, their deaths due to the hemlock woolly adelgid are probably imminent. If

we wish to protect this heritage and to gain data from these old hemlocks, we should be planning to do root injections. Treatment could at least be done for small patches and to protect the oldest trees.

9. **Second and third oldest dated black birches known.** The second and third oldest black birches dated anywhere grow in MTSF. The ages are 332 and 326 years respectively. Tony D'Amato has confirmed many black birch trees in MTSF at over 200 years of age. The work done by Tad Zebryk, Bob Leverett, Peter Dunwiddie, and Tony D'Amato has changed our perspective on the longevity of this species. When considering the long period of time that this species has been part of the timber base, it is revealingf that its ecological history has remained so poorly understood.

10. **Largest confirmed acreage of old growth.** **MTSF** has the largest confirmed acreage of pre-settlement old growth forest of any of our state forests. With Mohawk, we have identified 4 distinct 4 classes of forest:

    a. Pre-settlement forests: the current acreage of these forests in Mohawk has been set at 560. As his PhD dissertation, Anthony D'Amato of UMASS Amherst and part of **FMTSF** continues to collect stand and age data from the old growth stands on DCR lands. Tony now has far more data than anyone heretofore has collected, including the 1993 study by Dr. Peter Dunwiddie and Bob Leverett and its 1996 update. To date, the Commonwealth has 1188 acres of pre-settlement forest. Thus, MTSF has 50% of the entire Commonwealth's pre-settlement OG.

    b. Forests high in old growth characteristics: The current acreage of this class in Mohawk is somewhere between 700 and 800 acres. This includes the pre-settlement acreage,

    c. Mature forests: a good determination of this acreage remains to be done, it is is likely around 4000 acres. This is independent of the old growth,

    d. Young forests: by default this is about 1400 acres.

MSF:

1. **Largest volume single-stemmed white pine in Massachusetts:** The Grandfather white pine has a combined trunk and limb volume exceeding 1,000 cubic feet. The only serious competitor of the Grandfather tree is the huge Ice Glen pine, which is very close to the Grandfather pine. The Grandfather pine has a total height of 145.1 feet and a circumference at breast height of 14.0 feet.
2. The 3rd highest RHI in New England: **MTSF** boasts a RHI of 123.7. It is the only Massachusetts site other than MTSF to have a 160-foot tall tree, the Henry David Thoreau pine (160.2 feet tall, 12.9 feet CBH).

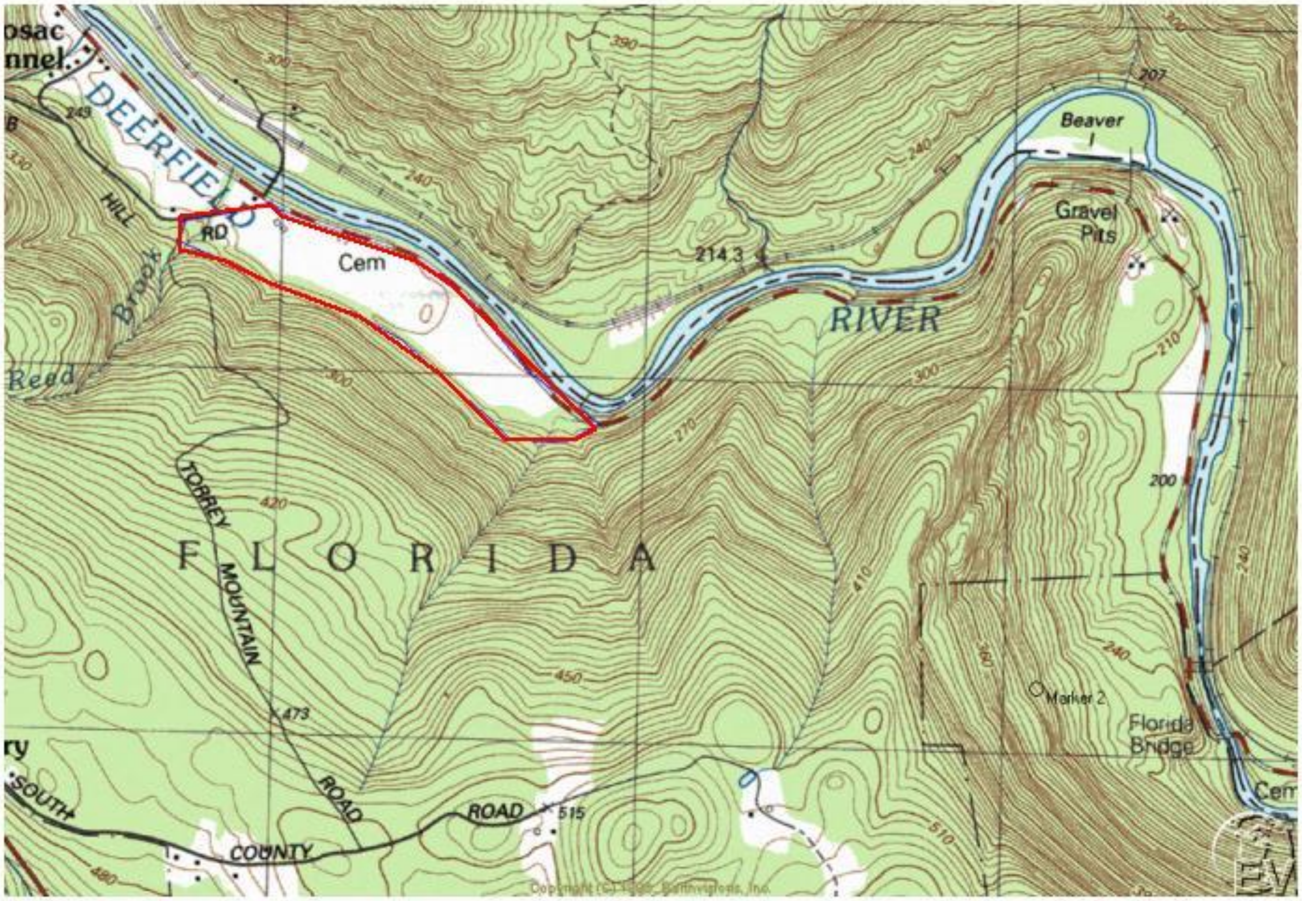
Appendix I

Maps

Of

Recommended

Reserves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RD
HILL
Brook
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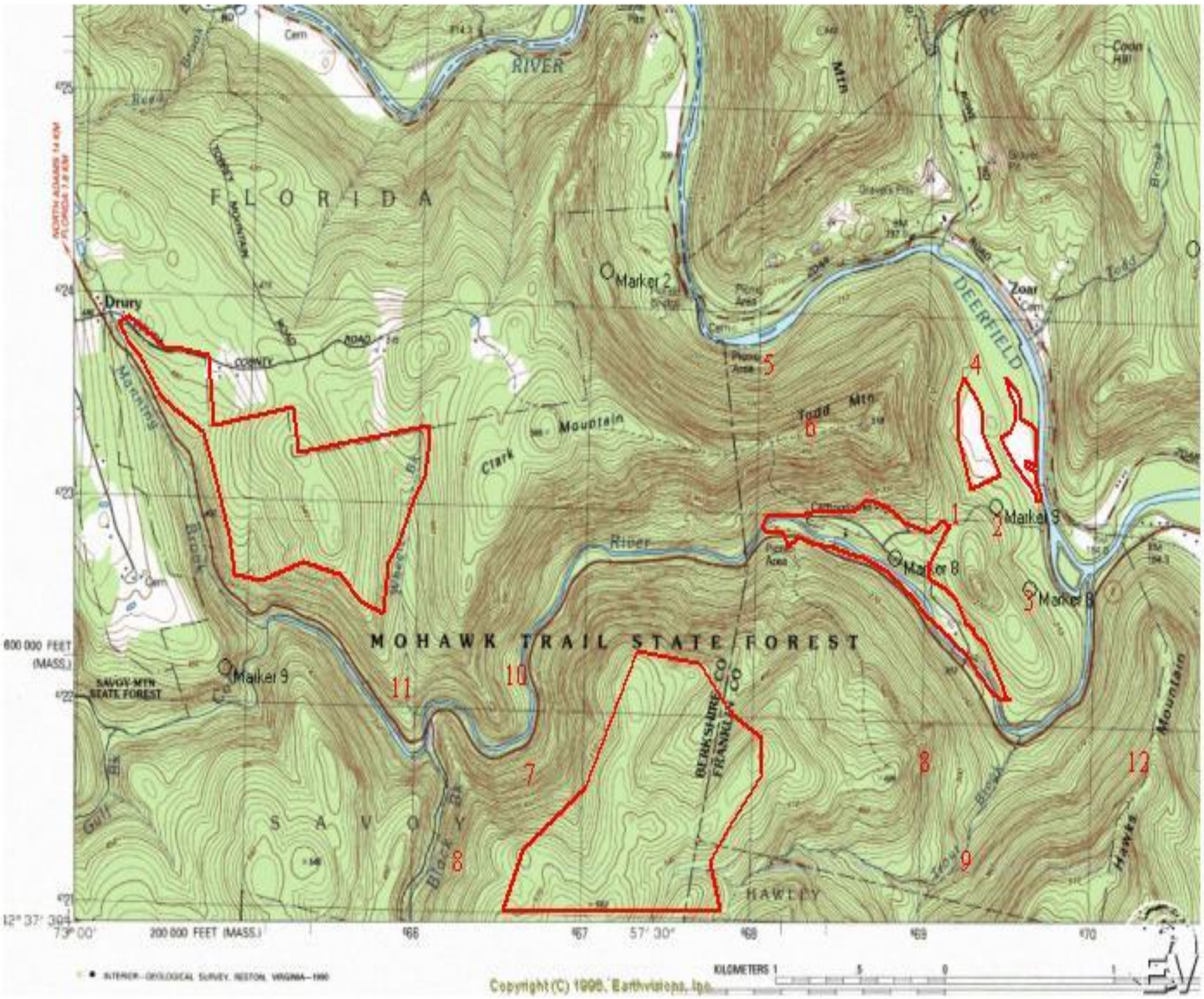
Gravel
Pits
FLORIDA
TORREY MOUNTAIN ROAD
SOUTH COUNTY ROAD
Marker 2
Florida
Bridge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F L O R I D A
Drury
Marker 2
Clark Mountain
Todd Mtn
DEERFIELD
Zoar
Marker 9
Marker 8
River
M O H A W K T R A I L S T A T E F O R E S T
SAVOY-MTN STATE FOREST
S A V O Y
HAWLEY
BERKSHIRE CO
FRANKLIN CO
Hawks Mountain
1
2
3
4
5
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Exclusion#5: 1883 acres