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EASTERN NATIVE TREE SOCIETY

Bulletin of the Eastern Native Tree Society

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Mission Statement:

The Eastern Native Tree Society (ENTS) is a cyberspace interest group devoted to the celebration of trees of eastern North America through art, poetry, music, mythology, science, medicine, and woodcrafts. ENTS is also intended as an archive for information on specific trees and stands of trees, and ENTS will store data on accurately measured trees for historical documentation, scientific research, and to resolve big tree disputes.

ENTS Officers:

Editorial Board, *Bulletin of the Eastern Native Tree Society*:

ENTS Membership and Website Submissions:

Membership is free when you sign up for our discussion group, ENTSTrees, at: http://groups.google.com/group/entstrees?hl=en. Submissions to the ENTS website in terms of information, art, etc., should be made to Edward Frank at: ed_frank@hotmail.com

The *Bulletin of the Eastern Native Tree Society* is provided as a free download in Adobe™ PDF format (optimized for version 5 or newer) through the ENTS website. The Eastern Native Tree Society and the *Bulletin of the Eastern Native Tree Society* editorial staff are solely responsible for its content.

COVER: An old loblolly pine towers above a mixture of bottomland hardwoods in the Lost Forty Natural Area in Calhoun County, Arkansas. Photo by Don C. Bragg.

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PREPARING THE NEXT GENERATION

This issue may seem somewhat on the abbreviated side, for which I have a good reason. He's squirming in my arms right now—our one-month-old son Stephen. Though his thoughts are currently limited to his next bottle or diaper change, I hope someday they include concern for all things natural—especially trees (my forester bias comes shining through). I am almost finished with a very sobering book—*Last Child in the Woods*, by Richard Louv. This book associates a large number of social ills with the increasing distance from the natural world of our children. Whether or not you agree with his thesis, the reality is that fewer and fewer young people get the same natural experiences we do, and this will inevitably mean that less of them will have the same fascination with big, old trees, or delicate understory herbs, or quiet sunsets on a still northern lake.

We plan to fight these trends, to ensure that our children have every opportunity possible to connect to the natural world, and to teach them our appreciation for the wild things and places that can still be found. In our modern world, this task gets harder and harder, and we must fight the allure of our increasingly electronic universe.

While I do not expect Stephen or my other children to follow my path into forestry and ecology, I sincerely hope that the path to the woods does not become the one less traveled.

Don C. Bragg
Editor-in-Chief

Editor-in-Chief Don Bragg holds his sleeping daughter Elizabeth on a 2006 northern Wisconsin canoe trip. Li'l Beth was not bored with the trip—rather, she was under the weather. Photo by Hope Bragg.

ANNOUNCEMENTS AND SOCIETY ACTIONS

ENTS Online Discussion Group Has Moved to Google

After some years using Topica as the host for the ENTS online discussion group, a decision was made recently to migrate to Google. Some Ents had reported problems in getting posted messages, or posting to the list, so the change was made. Robert Leverett, ENTS founder, is currently overseeing the migration, which should be complete by the time you read this. Preliminary indications by those of us who have already migrated are positive—few problems have arisen to date. Google Groups promises to offer ENTS more functionality with fewer quirks and bugs, and should serve us well to the future.

If you haven't yet migrated, or are interested in joining ENTS, please register yourself with Google and sign-up for the list at:
http://groups.google.com/group/entstrees?hl=en

Long-Time Old-Growth Advocate Dr. Robert Zahner Passes Away

An icon of old-growth forest identification and preservation, Dr. Robert Zahner, recently passed away. Robert Leverett, the founder of ENTS, plans to eulogize Dr. Zahner's contributions by describing the immense contribution that Bob made to old-growth awareness.

Vandals Torch the Insides of the Webster Springs Sycamore

The Webster Springs Sycamore, a huge old hollow American sycamore growing near Webster Springs, West Virginia, was recently violated by vandals, who set the insides of the venerable old tree on fire. News reports stated how the tree seems to have survived this assault, but there is no indication if the fire weakened its structure or accelerated its decline. It is not unusual for vandals to injure these old hollow trees with fires—the MacArthur white pine in northern Wisconsin was struck in a similar manner, and this led to its demise.

Announcing the 5th Holyoke Community College Forest Summit

Plan to attend the Holyoke Community College (HCC) Forest Summit 5 Lecture Series (http://www.hcc.edu/forest/), hosted by Holyoke Community College and the Eastern Native Tree Society. This year's free public program will be held at the HCC Leslie Phillips Forum on October 19, 2007, from 1:00 p.m. until 9:30 p.m. The list of speakers is still being finalized, and will probably include Dr. Lee Frelich (University of Minnesota), Dr. Thomas Diggins (Youngstown State University), Professor Gary Beluzo (HCC), John Davis, Will Blozan, Robert O'Connor, Ehrhard Frost, and ENTS founder Robert Leverett. Topics on the agenda include discussions of forest health, the status and future of Eastern forests, forestry and red maple, climate change, and tuliptrees. This year's featured speaker is Dr. David Stahle, Director of the Tree Ring Laboratory of the University of Arkansas in Fayetteville, Arkansas, and he will be speaking on the cypress trees of Central America. For more information on the HCC Forest Summit, contact Gary Beluzo at gbeluzo@hcc.mass.edu.

The next day (Saturday), the annual fall ENTS Rendezvous at the Mohawk Trail State Forest (MTSF) will begin at 9:30a.m. with a dedication to Native Americans who have visited and contributed to Mohawk Trail State Forest. Will Blozan will then climb and model the Saheda Pine in MTSF from 10:30 a.m. to 1:30 p.m. At 2:00 p.m., weather (and Bob Leverett's toe) cooperating, we will take a hike up to the original Indian Trail on the Todd-Clark Ridge. This will be a rigorous, mostly off-trail jaunt, with a total altitude gain of about 1,100 ft. After the interpretive hike, we'll gather at the Charlemont Inn for a dinner buffet and concert. Note that the cost to attend the buffet and concert will be $23 per person. For more information on the ENTS Rendezvous, contact Bob Leverett at dbhguru@comcast.net.

The concert is a continuation of the immensely successful evenings of music, poetry, and prose, hosted by the talented Monica Jakuc Leverett. Monica and tenor Peter Shea will "cook up" some more songs, and Monica will also find a solo piano piece or two to play. Charlotte Dewey, co-owner of the Charlemont Inn, will sing some cabaret songs at the end. To volunteer your talents or simply to enjoy this evening, please contact Monica Jakuc Leverett at mjakuc@email.smith.edu.

Joining ENTS: A Beginner's Guide

Edward Frank

Eastern Native Tree Society

Why isn't the Eastern Native Tree Society (ENTS) discussion group where it used to be? Why the change? Unfortunately, too many people were having problems sending and receiving posts—a condition that became progressively worse. An executive decision was made to switch to a new list, which became active on September 24, 2007. Don't worry, though—membership in the Eastern Native Tree Society is still free and remarkably easy. Simply join the discussion list for the group and begin participating in the discussions. That's it! Joining the list will give you access to other people in your area interested in trees and access to some of the foremost experts in the world on trees and measuring trees.

To participate, please observe the following steps and courtesies:

1) The ENTS discussion list is hosted by Google Groups and is called "ENTS Trees." To join the ENTS Discussion List go to the website: http://groups.google.com/group/entstrees?hl=en and follow the instructions give. Note that you may first need to create a Google account, which is also free and easy—the instructions for creating a username and password are self-explanatory.

2) Depending on the set-up, you may need to respond to a message from Google confirming your registration and subscription.

3) Most of the significant posts from the Topica list have been archived over the years as part of the official ENTS website: http://www.nativetreesociety.org

4) If you want to receive individual posts or digests of posts, follow these steps. First, after you join the discussion list, it will send you an e-mail. Then, after you receive this e-mail, you must reply using the instructions given in the message. If you do not receive this e-mail, it is possible your e-mail provider is blocking mail from googlegroups.com. If so, you can either work with your provider to fix this, or subscribe to one of the many free web-based e-mail providers.

5) You may choose one of three ways to receive the discussions: a) copies of each e-mail posted to the list sent individually to your e-mail address, b) a daily digest sent to your e-mail address, or c) participation via the web only. In the first option, every e-mail posted to the discussion list is mailed individually to your listed e-mail address, and any attachments to the e-mails are also forwarded. In digest form, the messages for each day are compiled and sent as an individual post to your e-mail address. Be sure to add entstrees@googlegroups.com to your safe list for any spam filters protecting your e-mail account. You may also opt to not have any messages sent to you and view the messages from the list website only. These options may be chosen from the "Edit My Membership" page of the list.

6) E-mails may be sent by members using any e-mail program or by posting directly from the discussion list. However, to post a message **YOU MUST BE A MEMBER OF THE LIST**. When using an external e-mail program, the message must be sent from the e-mail address in your e-mail profile. Members may create pages or upload files to the ENTS list to share with the group. Go to the list's home page and follow the directions. Because of space limitations, large posts may be archived to the website and deleted from the list after a reasonable period of time.

7) When posting messages, be sure to include a subject line in the message. When changing the topic of a thread it is appreciated if the subject line is changed to reflect the change in subject. Messages without subject lines may be filtered by some firewall or anti-spam programs and will not be received by all subscribers.

8) When posting messages, address the message to ENTS or to an individual. Messages that do not include a salutation may be filtered by some firewall or anti-spam programs and will not be received by all subscribers. Use something like "Hello," "ENTS—", "Bob—", or whatever.

9) When you reply to a message or a message thread, you end up putting multiple copies of every message in the thread back on the list, doubling and quadrupling the volume of messages the rest of us have to wade through. If you are replying to a message, please delete everything except the relevant lines from the original message. Everyone will already have received a copy of the complete message. By using the default setting which attaches the original message to the reply, you will bombard everyone with multiple instances of the same message.

10) "Shouting"—the practice of sending e-mails con-

taining large blocks of capitalized, bold face, or large font text within the body of the message—is strongly discouraged. Using these formats makes the text more difficult to read and is considered rude. The discussion list is not moderated and politeness is expected of all participants.

11) If you are not receiving posts from the discussion list, the most likely explanation is that anti-spam software is blocking it. First check your e-mail account and see if the posts from entstrees@googlegroups.com are being put in a junk or bulk mail folder. If they are, most programs have the option to allow you to tell the program that you want to receive these messages. If you have a separate spam filter program, be sure to add entstrees@googlegroups.com to your "safe" list. Another potential problem is software blocks used by your Internet service provider. You can call and check on this if you believe it is a problem, but likely they will not be able to correct it for just your account.

Following these rules and courtesies will make the ENTS list a much more productive and pleasant experience for everyone.

Switching to the new ENTS discussion group is nowhere near as thorny as this water locust. Photo by Don C. Bragg.

A NEW LOOK AT TREE TRUNK MODELING: OLD FORMULAE AND NEW

Robert T. Leverett

Eastern Native Tree Society

INTRODUCTION

A key component of the ENTS mission is the mathematical exploration of tree architecture with the concomitant development of formulae that can be readily applied in the field. Our contributions currently lie principally in the realm of field techniques as opposed to computer modeling. In this mission, our principal goal is to quantify elements of tree form for individual trees, species, and groups of species in ways that capture the essence of what the eye sees. Not unexpectedly, we have been concentrating on species that are well-represented in big tree lore, are of primary interest to big tree aficionados, and send the hearts of timber professionals to palpitating.

One species in particular that has received a lot of ENTS attention is *Pinus strobus*, the eastern white pine. Our focus on this charismatic species is due to its great stature, important role in the economy of colonial America, importance to Native Americans, and the pure elegance of its shape as a mature tree. The stateliness of old-growth eastern white pines provides a continuous stream of inspiring images to many an Ent. A walk through the Cathedral Grove of Cook Forest State Park is unforgettable.

Within big tree lore, accounts of huge eastern white pines are legendary. However, the dimensions often cited for the eastern white pines of the past are highly improbable. For example, specimens in New Hampshire reportedly grew to 260 ft in height, and presettlement pines have been cited in literature as having achieved diameters of 10 ft. Based on what we see today, there is no evidence to support such astounding heights and girths. Still, modern-day eastern white pine loses nothing in stature when compared to other eastern species.

Exaggerations notwithstanding, *Pinus strobus* is our tallest, and in the belief of some, our most voluminous of evergreen eastern conifers. However, it is unclear how the volume conclusion has been reached. Because ENTS cannot accept the big tree stories of the past as conclusive, we look to contemporary maximums to settle the issue. There are serious contenders for the title of most voluminous eastern evergreen conifer in *Pinus taeda*, the loblolly pine, and *Tsuga canadensis*, the eastern hemlock. To our knowledge, there are no other eastern evergreen conifer contenders (*Taxodium distichum*, the baldcypress, is a deciduous conifer). At this stage, the evidence points to the eastern hemlock as number one, the loblolly as number two, and the eastern white pine as number three.

To arrive at conclusions such as the above, we continuously seek the biggest, tallest, and oldest among competing species as a way to not only settle which is the most voluminous, which is the tallest, etc., but also to debunk the big tree myths as best we can. With respect to the debunking mission, regrettably, there is no way to turn the calendar back and view with a critical eye and measure the presettlement giants that excited the early chroniclers, but we can closely examine each species today and make exacting comparisons among the best of the survivors.

The best way to make the comparisons is to collect data on maximum tree size across the full range of each species and see what the numbers tell. The importance of covering the entire range of a species cannot be stressed enough, and covering the full ranges of the species is what we have attempted for many years. As a consequence, we now have an impressive database of maximum tree heights and girths for the tallest and largest members of many eastern species. We know our numbers are accurate, and we do not mix in numbers from unreliable sources. With respect to eastern white pines, we have visited many important and/or famous pine-dominated sites, such as:

Maine:
- Ordway Pines (Norway municipal property)
- Bowdoin College Pines (Bowdoin College)

New Hampshire:
- Pine Park in Hanover (Dartmouth College)
- Claremont Pines (private)
- Tamworth Pines (state property)
- College Pines at Durham (UNH)
- Dartmouth College campus (Dartmouth College)

Vermont:
- Fisher Scott Memorial Pines (state property)
- Cambridge Pines (state property)

Massachusetts:
- Mohawk Trail State Forest (state property)
- Ice Glen (Laurel Hill Associates)
- Bryant Homestead Pines (Trustees of Reservations)
- Monroe State Forest (state property)
- Quabbin Reservoir (state property)
- Carlisle Pines (state property)

Connecticut:
- Cathedral Pines (TNC)
- Gold Pines (state property)
- Bally Hack (TNC)

New York:
- Elders Grove (Paul Smith's College)
- Cathedral Pines (state property)
- Pine Orchard (state property)

Michigan:
- Hartwick Pines (state property)
- Porcupine Mountains (state property)

Wisconsin
- Nicolet National Forest (federal property)
- Menominee Reservation (Indian reserve)

Pennsylvania:
- Cook Forest State Park (state property)
- Heart's Content (federal property)
- Anders Run (state property)
- Delaware Water Gap (state property)

North Carolina
- Great Smoky Mountains National Park
- Linville Gorge (federal property)
- Cullasaja Gorge (federal property)
- Joyce Kilmer Memorial Forest (federal property)

South Carolina:
- Ellicot Rock Wilderness Area
- Walhala Fish Hatchery (federal property)

Georgia:
- Chattahoochee National Forest (federal property)

Besides the above locations, isolated eastern white pines on scores of sites have been modeled and measured. Perhaps equally important to those measured have been those we have passed over as insufficiently distinguished, though highly touted by others. People see big trees with different eyes. We are often led to sites with undistinguished trees, but the experiences give us insights to what impresses people. We have also deflated the exaggerated statistics as presented in the state and national champion tree programs.

If we can be forgiven for giving kudos to ourselves, we are also aware of the deficiencies in the kinds of statistics that are commonly collected by big tree hunters and forest professionals, as well as ourselves, to capture the essence of great size. I speak of the three common measures used to gauge "tree bigness": height, girth, and average crown spread. These measures are usually put together in the well known, if not "infamous" champion tree formula:

$$P = H + \frac{S}{4} + C \qquad [1]$$

where H = full tree height in feet, S = average crown spread in feet, C = circumference at breast height in inches, and P = champion tree points.

This formula is widely recognized as a compromised expression of size, but is nonetheless generally accepted in big tree circles—in fact, accepted without much thought given to the compromises. For ENTS, the compromises in equation [1] fall far short. The formula is not an accurate method of comparing large specimens of trees of the same species, let alone of different species. The formula is too heavily weighted toward girth at breast-high level. Trees of great height and modest girth are pitted against trees of great girth and modest height. By the current method of evaluating tree size, the latter is almost always the winner because girth counts for more than height. In fact, in the current champion tree formula, one inch of girth counts the same as twelve inches of height, since girth is measured in inches and height in feet. What if a tree has a large butt swell, but then narrows down quickly, such as the baldcypress shown below? Is the current champion tree formula sensitive to such a radical change in trunk shape? The answer is "no," and that, for ENTS, is a fatal flaw.

The current co-national champion baldcypress from Mississippi, with its extremely swollen base and rapid taper. Photo by Don C. Bragg.

ENTS wants ways of making more exacting comparisons, but to develop usable field techniques, we must start simple. Species with simple architectures such as many eastern conifers provide that simple start. More specifically, the eastern white pine and eastern hemlock are our points of departure. For these conifers, if we are going to compare size, we need to concentrate on trunk shape. When trees grow in close proximity to one another, they are mostly trunk—limb volume counts for little. For example, most eastern white pines contain over 90% of their volume in their trunks. So if we are going to choose among competing specimens of eastern white pine and eastern hemlock as to which are the largest, measuring trunk volume is unavoidable. Measurement of trunk volume falls within the traditional purview of forestry, so it is logical to begin with forestry methods for measuring trunk volume. We have no need to reinvent the wheel.

EXISTING METHODS TO DETERMINE TRUNK VOLUME

Forestry texts are explicit in how trunk shapes are classified and volumes are measured. The science is well established. However, it should be pointed out that the objective of forestry calculations is to compute log volumes in ways that express commercial value. Noncommercial parts of the trunk, such as the bark and the upper portions that include many limbs, are not included. Nonetheless, we may be able to put the log-oriented measures to good use.

Forestry texts usually see the trunk of a single-stemmed conifer as a combination of up to three shapes. At the base of a conifer such as a eastern white pine, the trunk form is often concave, quickly narrowing down from the root flare and then straightening out. The concave form near the base is called neiloid, which is usually held for only a few feet. For a substantial length of the trunk above the neiloid section, the trunk slows its taper in such a way as to be paraboloid in shape. The paraboloid section is most prominent in old trees. The top section of the trunk is usually best approximated by a cone, but can be paraboloid. Young eastern white pines on level ground can form almost perfect cones, but older trees and trees on sloping ground or in wet areas depart from the cone.

Forestry methods of log modeling often treat a log as a paraboloid (convex sides). The following formula is used to compute log volume using this model:

$$V = (L)\left(\frac{A_1 + A_2}{2}\right) \quad [2]$$

where A_1 = area at base, A_2 = area at top, V = volume of log, and L = length of log.

The second factor is used to approximate the cross-sectional area at the middle of the log. In forestry parlance, the above formula is called the Smalian method. If the cross-sectional area at the middle of the log is known, then the formula simplifies to $V = LA$, where A = cross-sectional area at the middle. This second formula is known as the Huber method. Another formula, called Newton's rule, is often used to compute the volume of a log:

$$V = \left(\frac{A_1 + 4A_3 + A_2}{6}\right)L \quad [3]$$

where A_3 = area at middle. The requirement of this formula is that the log be symmetrical in shape, but can be a neiloid, cone, or paraboloid. However, in practice, few logs stay symmetrical for very many feet. For large numbers of logs, individual shape variations don't matter. The volume effects of the variations average out, so Newton's rule is sufficiently accurate.

In the case of ENTS, we are not looking at just the commercial part of the trunk, but the entire trunk. Therefore, variations in trunk form are the rule and have led ENTS to model trunks of important trees from ground to crown by measuring circumference at intervals of a few feet and treating the sections as frustums of cones. The formula for a frustum of a cone follows:

$$V = \frac{L}{3}\left(A_1 + A_2 + \sqrt{A_1 A_2}\right) \quad [4]$$

Equation [4] works if the frustum form is cylindrical. For if that is the case, then A_1 = A_2 and the following algebraic simplification does the rest:

$$V = \frac{L}{3}\left(A_1 + A_1 + \sqrt{A_1 A_1}\right) \quad [5]$$

$$V = \frac{L}{3}\left(2A_1 + \sqrt{A_1^2}\right) \quad [6]$$

$$V = \frac{L}{3}\left(2A_1 + A_1\right) \quad [7]$$

$$V = \frac{L}{3}\left(3A_1\right) \quad [8]$$

$$V = LA_1 \quad [9]$$

Derivations of the above frustum formula in terms of circumference or diameter are used at times. The formula using diameter is:

$$V = \frac{L\pi}{12}(D^2 + d^2 + Dd) \quad [10]$$

where D and d replace A_1 and A_2 in the prior frustum formula. If circumference is used, the formula becomes:

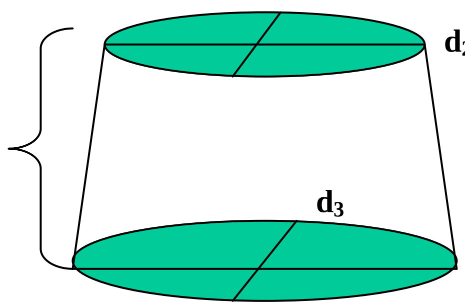
$$V = \frac{L}{12\pi}(C^2 + c^2 + Cc) \quad [11]$$

Early tree climbs by Will Blozan with repeated applications of the frustum formula provided the first volume determinations of the giant eastern hemlocks of Great Smoky Mountains National Park. The Yonaguska and Tsali trees were modeled this way and provided ENTS with our first good understanding of the immense volumes of the Great Smoky Mountains eastern hemlocks.

However, this method has two drawbacks. It is labor intensive and doesn't handle the area where a single trunk splits into two trunks. The area around the split departs significantly from circularity and a simple frustum does not assure proper handling of form ambiguities.

A technique devised by Will Blozan called frame mapping with the mathematics supplied principally by the author handles the anomalies of trunk form around the points of fusion. The frame mapping method will not be described here, but works very well. Again, it is labor intensive and requires climbing the tree and setting up a rectangular frame around the fusion.

One way to tackle the problem of shape ambiguities is to introduce alternative models that allow for the kinds of trunk forms that we commonly see. For example, the cross-sectional form of many tree trunks is elliptical instead of circular. The following diagram illustrates a model that allows for the bases of a frustum to be ellipses instead of circles.



In this diagram, d_2, d_3, and d_4 are major and minor axes of the ellipse. The challenge is to get accurate measurements of the major and minor axes. Calipers are one way, but the capability to get indirect measurements using ground-based instruments is always desirable. Until recently, laborious use of a transit was the primary way to get measurements of the trunk. But, we now have laser and optically-based instruments that allow us to take precise measurements of objects at a distance for a relatively modest investment.

For measurements of tree diameter from a distance, the Macroscope 25™ by RF Inter-Science provides a simple and relatively inexpensive way to get accurate measurements at fairly long distances. A reticle scaled in either inches or millimeters can be used with a simple formula to compute diameter, or more appropriately, cross-sectional width:

$$D = \frac{LM}{F} \qquad [12]$$

Equation [12] assumes L is the linear distance to mid-point of trunk where diameter is to be measured, M equals the millimeter reading on reticle that matches trunk width in reticle at distance L, F is the factor used with instrument, and D is the diameter at chosen point. With the Macroscope mounted on a tripod, accuracies of under an inch (and usually under a half inch, if the distance is known accurately) are attainable at distances of 100 to 150 ft.

A more expensive instrument is LaserTech's RD1000™ dendrometer/relascope. It allows direct reading of diameters and gives good results at distance between 60 and 150 ft. In using the instrument, the distance to the center of the trunk is fed to the RD1000. The instrument then calls for shooting the base of the tree. Thereafter, the tree can be scanned to chosen heights above the base and diameters at those heights read directly from an LED. Extremely small or large targets or very close or distant targets do not work well—or work at all. But, within the ranges where the RD1000 works well, it is extremely easy to use and makes tree modeling deceptively simple. However, the RD1000 does not accumulate the numbers and calculate volume. That calculation must be done manually or with an Excel spreadsheet set up for the purpose.

Before the author confirmed the limitations of the RD1000, it appeared to be the ideal instrument to use with the frustum of a cone formula. By taking a sufficient number of readings up the trunk, plugging the readings into a computer program, we thought that we could get a very good approximation of trunk volume without climbing a tree. The job has not proven that easy, but the RD 1000 is still useful and can give good diameter approximations for trees that cannot be reached, such as on the other side of a stream, and where time does not permit using the more labor intensive Macroscope 25.

NEW TECHNIQUES AND FORMULAE

The modeling methods described above are routinely used, but we also want to develop methods to approximate trunk volume that require a minimum of equipment, time, and calculations. For example, can species such as the eastern white pine be modeled to an acceptable degree of accuracy by taking a few measurements near the ground, calculating total tree height, and then applying a simple formula? The answer to that question is not yet in, but promising developments are in the works.

I have long recognized that for young to mature eastern white pines, applying the cross-sectional area at trunk flare with full tree height in the cone formula almost always overstates the fully modeled volume. Similarly, using the cross-sectional area at breast height with full tree height in the cone formula usually understates the volume. So, we have upper and lower bounds for actual volume. It must be emphasized that these bounds do not always work for old-growth forms. Old-growth pines can develop a columnar form, and if they have only a modest root flare, the actual trunk volume can exceed the volume as estimated by the upper bound formula. With workable upper and lower bounds, it becomes a question of how tight the boundaries are and how often they are violated. The following table provides a clue to the answers.

Table 1 profiles 44 trees: 42 eastern white pines, one eastern hemlock, and a single tuliptree. The average of the upper- and lower-bound volumes as compared to the modeled volume shows that the average divided by the modeled volumes is 0.98 with a standard deviation of 0.10. The volumes of 34 trees fall within the hypothetical upper- and lower-bound calculations. Ultimately, the question becomes, "Can we improve on the results?" We believe the answer is "Yes."

Table 1. Measured versus modeled volumes of select individuals using the new formulation. RC = root collar; vol. = volume; avg. = average; n/a = not available; HM = eastern hemlock; WP = eastern white pine; TT = tuliptree.

Tree name	Species	Sine height (ft)	Circumference at: RC (ft)	Circumference at: 4.5 ft (ft)	Cone volume at: RC (ft³)	Cone volume at: 4.5 ft (ft³)	Avg. cone vol. at RC & 4.5 ft (ft³)	Modeled volume (ft³)	Average divided by modeled
Hemlock #2	HM	104.1	n/a	n/a	246.2	195.6	220.9	237.3	0.93
Graves Pine	WP	130.3	n/a	n/a	658.2	457.1	557.7	508.0	1.10
Graves Pine #2	WP	117.4	n/a	n/a	441.0	336.8	388.9	380.0	1.02
Jake Swamp	WP	169.1	n/a	n/a	656.9	485.2	571.0	570.0	1.00
Grandfather	WP	145.0	n/a	n/a	1021.9	753.9	887.9	967.0	0.92
Thoreau	WP	160.2	n/a	n/a	844.8	706.3	775.6	812.0	0.96
Tecumseh	WP	161.8	n/a	n/a	649.3	587.5	618.4	679.0	0.91
Saheda	WP	165.3	n/a	n/a	696.1	569.8	633.0	618.0	1.02
Joseph Brant	WP	156.0	n/a	n/a	657.0	528.4	592.7	604.0	0.98
Ed Perle	WP	126.0	n/a	n/a	530.6	347.7	439.2	520.0	0.84
Ice Glen	WP	154.4	14.8	12.9	892.9	679.5	786.2	954.0	0.82
Spencer Pine	WP	121.3	13.8	12.6	614.8	508.1	561.5	710.0	0.79
QB#1	WP	141.1	9.1	8.2	310.7	249.7	280.2	256.0	1.09
QB#2	WP	138.4	9.1	8.2	304.7	244.9	274.8	256.0	1.07
Bullard	WP	133.0	17.3	13.8	1053.3	674.1	863.7	761.0	1.13
Whitman	WP	146.5	13.5	11.6	709.2	525.1	617.1	761.0	0.81
Decontie	WP	160.2	11.3	10.1	543.6	429.5	486.5	453.0	1.07
Norton	WP	163.9	11.8	9.6	600.7	397.0	498.9	453.0	1.10
Clutter	WP	152.4	11.9	10.3	571.1	432.3	501.7	447.0	1.12
Arvol	WP	150.2	12.6	9.0	634.4	325.0	479.7	459.0	1.05
Log Cabin#1	WP	114.0	7.8	7.0	184.1	150.0	167.0	176.0	0.95
Log Cabin#3	WP	123.0	5.0	4.7	80.7	72.5	76.6	78.0	0.98
BB#2	WP	125.7	7.6	7.2	194.9	172.8	183.8	200.0	0.92
Sacajawea	WP	155.4	10.6	9.9	463.4	403.7	433.6	439.0	0.99
Dave Chief	WP	150.3	9.7	9.1	374.1	327.1	350.6	386.0	0.91
Childs#1	WP	107.2	10.0	8.8	284.4	220.2	252.3	263.0	0.96
Childs#2	WP	107.0	11.8	10.2	395.2	292.4	343.8	416.0	0.83
Mt Tom #2	WP	126.8	9.4	8.7	293.8	254.1	274.0	309.0	0.89
Log Cabin #2	WP	110.8	7.0	6.5	145.8	123.9	134.8	118.0	1.14
Childs#3	WP	120.0	12.3	9.5	481.6	287.3	384.4	350.0	1.10
Childs#4	WP	120.8	11.3	9.7	409.2	301.5	355.3	371.3	0.96
Jani Pine	WP	150.3	12.5	10.8	621.7	461.6	541.7	502.0	1.08
Longfellow	WP	183.2	12.1	11.0	707.8	590.3	649.1	569.0	1.14
Belchertown B.	WP	136.0	13.7	12.6	676.3	572.1	624.2	590.4	1.06
Fearn#2	WP	121.5	8.5	8.0	231.9	205.2	218.6	228.0	0.96
Big Boy	WP	147.4	11.6	10.6	525.9	439.6	482.7	492.0	0.98
Childs#5	WP	110.5	11.1	9.7	361.1	275.8	318.5	368.8	0.86
Mountain Mama	WP	174.9	14.9	12.5	1030.0	724.9	877.4	930.0	0.94
Seneca	WP	173.2	16.7	12.5	1281.3	717.9	999.6	921.0	1.09
Cook Pine	WP	161.5	13.8	12.2	811.1	639.8	725.5	788.0	0.92
Fearn Driveway	WP	105.4	9.7	8.5	263.1	202.0	232.5	276.0	0.84
Monica's TT	TT	123.0	8.0	6.6	206.2	142.1	174.2	180.2	0.97
								Average ratio =	**0.98**
								Standard deviation =	**0.10**

However, it should be noted that trees with major root flare or pronounced taper skew the formula. Extreme root flare produces noticeable overestimates of volume. Conversely, a rapid trunk taper leads to an estimated volume that is too low. This can be addressed if we create multipliers for the averaged volume—one for flare and one for taper. If, by visual inspection, we see a large flare, we could use a flare multiplier of 0.90, otherwise 1.00. If we saw a very slow taper, we could use a taper multiplier of 1.11. Their product to two decimal places is 1.00. The averaging formula can be simplified to use the conventional measurements that we take, i.e. circumference and tree height.

The new model used in Table 1 is calculated as follows:

$$V = F_1 F_2 H\left(\frac{C_1^{\ 2} + C_2^{\ 2}}{75.4}\right) \qquad [13]$$

where C_1 = circumference at root flare, C_2 = circumference at 4.5 ft, H = full tree height, F_1 = flare factor, F_2 = taper factor, and V = volume. Any objection to equation [13] rests primarily with the subjective nature of F_1 and F_2. However, at this point we are experimenting with a method for estimating trunk volume. The method does not replace more complete modeling. But using subjectively assigned factors works acceptably well for us, so we incorporate them in a formula until we can develop a better method.

We can legitimately broaden the range of the 0.90 and 1.11 factors by examining what range is needed to bring extreme forms into compliance. The range of 0.80 to 1.25 seems reasonable for reasons that will not be discussed here. By using separate factors for flare and taper and multiplying them together to create a composite factor, the ratio of the adjusted average to the modeled volume approaches 1.00 with a standard deviation reduced to 0.075.

NEW EQUIPMENT FOR MODELING

RD1000 Upgrade

Equipment for measuring bole volume includes trunk height indicators and diameter measurers. As previously mentioned, the RD1000, relascope-dendrometer is a very convenient (but at $1500, costly) instrument that allows the measurer to scale a trunk, measuring diameter at chosen points of known height up/down the trunk. Early models of the instrument have questionable accuracy, but a recent company upgrade appears to bring the accuracy within advertised ranges, especially for trunks between 60 and 120 ft distant. The instrument is very easy and convenient to use and can be mounted on a tripod for greater precision. However, even in hand-held mode, surprisingly consistent readings can be attained with the RD1000. Thus, where a high degree of accuracy is not required, the RD1000 fits many needs.

Macroscope 25/45

For a higher degree of accuracy, either the Macroscope 25 or 45 fits the need. These instruments must be used with a tripod to enable it to read the reticle with precision. The Macroscopes combine the features of a microscope and telescope. When used in telescope mode, reading a scale for an object at a known distance yields its cross-sectional width via:

$$D = \frac{LM}{F} \qquad [14]$$

where F = 75 for the Macroscope 25, with its reticle scaled to 5 mm. For the Macroscope 45, the reticle is 3 mm and the F value has been determined to be 41.667. Oddly, it is not provided with the minimal instructions that accompany the instrument. The reticle of the 45 is slightly easier to read than that of the 25. Currently, the Macroscope 25 can be purchased for about $140 and the Macroscope 45 costs around $180.

TruPulse 360

The newest instrument useful in trunk and limb modeling is LaserTech's TruPulse™ 360. The TruPulse 360 is expensive (around $1,600), but adds a highly useful feature to those offered by the TruPulse 200 laser rangefinder. The 360 provides azimuth readings and a routine to calculate measurements associated with two points in space. It does this through a built-in state of the art compass. The compass is rated as accurate to within ± one degree. The measurer does not have to be in any particular orientation relative to the two points. Instrument returns include horizontal, vertical, and slope distance between the two points. Also returned is the angle of inclination between the points, and the azimuth of the second point relative to the first. This is a quantum leap in capability. The central question to answer is how accurate are the horizontal angle measurements? Early tests indicate an acceptable degree of accuracy. Slope distance between objects in space will frequently be within ± 1.0 ft, although magnetic interference can cause problems. The user must be careful where the instrument is used, as my initial tests were rendered useless because of magnetic interference.

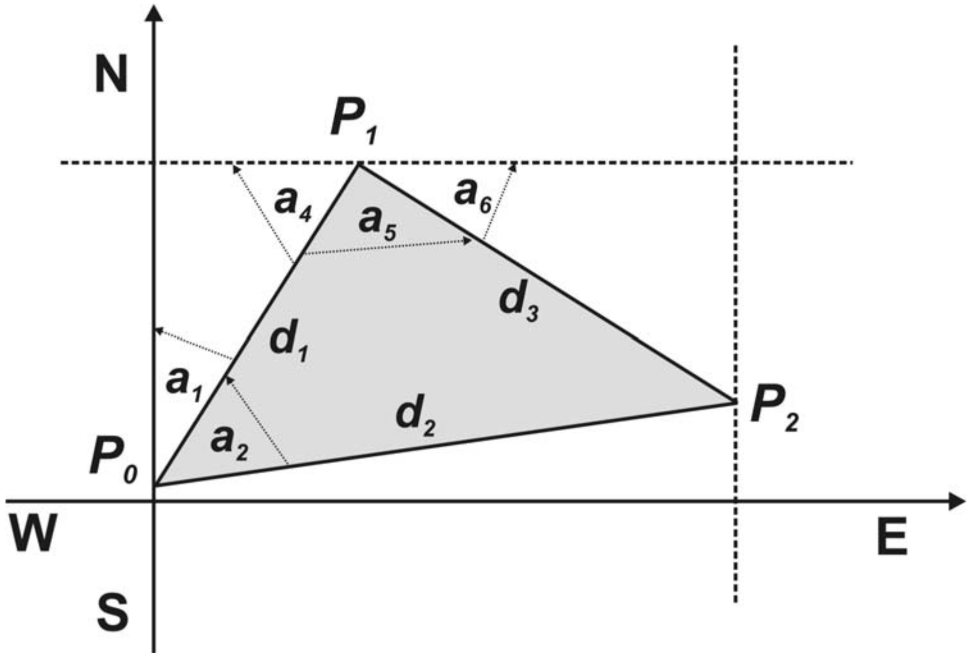
The relative azimuth reading of the TruPulse 360 is especially useful for three-dimensional mapping of the trunk-limb structure of a tree. But how accurate is the relative azimuth capability? The following formula has been worked out to test this feature, and assumes both points are in the first quadrant and the first point has the lower azimuth reading:

$$A = 180 + a_1 - \cos^{-1}\left[\frac{\left(d_1 - d_2\cos(a_2 - a_1)\right)}{\sqrt{d_1^2 + d_2^2 - 2d_1 d_2\cos(a_2 - a_1)}}\right] \qquad [15]$$

where a_1 = azimuth reading to first point, d_1 = horizontal distance to first point, a_2 = azimuth reading to second point d_2 = horizontal line distance to second point, and A = azimuth reading of second point relative to the first. To use [15] as a test for the horizontal angle measurer of the TruPulse 360, obtain independent azimuth readings for a_1 and a_2. A separate high precision compass can be used. The laser rangefinder of the TruPulse 360 in HD mode can be used to get d_1 and d_2. Substitute the values in the above formula to get the relative azimuth of point#1 looking toward point#2 (see the appendix for the derivation of this equation).

SUMMARY

The methods of trunk modeling outlined in this article are constantly being refined. For instance, it is clear to me that formulae such as equation [13] that incorporate purely subjective factors can be neither a satisfactory solution nor a final answer. However, formulae with a subjective component such as the above can give useful approximations, and perhaps more importantly, focus our attention on the physical characteristics that govern trunk volume on a species-by-species basis.



APPENDIX

Derivation of the equation [15] follows—consult the diagram above for a better understanding of the variables a_4, a_5, and a_6. Other variables are defined as:

- a_1 = azimuth reading to first point,
- a_2 = azimuth reading to second point,
- A=azimuth reading of second point relative to the first,
- d_1=horizontal distance to first point,
- d_2=horizontal line distance to second point,
- d_3=distance between d_1 and d_2 in horizontal plane.

According to basic mathematics, $a_4 = 90 - a_1$, $a_6 = 180 - a_4 - a_5$,

and $d_3 = \sqrt{d_1^{\,2} + d_2^{\,2} - 2d_1 d_2 \cos(a_2 - a_1)}$.

Likewise, $a_5 = \cos^{-1}\left(\frac{d_1^{\,2} + d_3^{\,2} - d_2^{\,2}}{2d_1 d^{\,2}}\right)$.

With simple substitution,

$$a_6 = 180 - 90 + a_1 - \cos^{-1}\left(\frac{d_1^{\,2} + d_3^{\,2} - d_2^{\,2}}{2d_1 d_3}\right)$$

and with more substitutions,

$$a_6 = 90 + a_1 - \cos^{-1}\left(\frac{d_1^{\,2} + d_1^{\,2} + d_2^{\,2} - 2d_1 d_2 \cos(a_2 - a_1) - d_2^{\,2}}{2d_1 d_3}\right)$$

This equation can then be simplified further:

$$a_6 = 90 + a_1 - \cos^{-1}\left(\frac{2d_1^{\,2} - 2d_1 d_2 \cos(a_2 - a_1)}{2d_1 d_3}\right)$$

$$a_6 = 90 + a_1 - \cos^{-1}\left(\frac{2d_1 (d_1 - d_2 \cos(a_2 - a_1))}{2d_1 d_3}\right)$$

$$a_6 = 90 + a_1 - \cos^{-1}\left(\frac{d_1 - d_2 \cos(a_2 - a_1)}{d_3}\right).$$

Now, substituting for d_3,

$$a_6 = 90 + a_1 - \cos^{-1}\left(\frac{d_1 - d_2 \cos(a_2 - a_1)}{\sqrt{d_1^{\,2} + d_2^{\,2} - 2d_1 d_2 \cos(a_2 - a_1)}}\right)$$

Since $A_6 = 90 + a_6$, it follows that:

$$A_6 = 180 + a_1 - \cos^{-1}\left(\frac{d_1 - d_2 \cos(a_2 - a_1)}{\sqrt{d_1^{\,2} + d_2^{\,2} - 2d_1 d_2 \cos(a_2 - a_1)}}\right)$$

This is the basic form of equation [15].

RUCKER INDEXING ANALYSIS—SOME CONCLUSIONS

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INTRODUCTION

We will now leave MTSF as a case study and examine some other results of RIA. Beyond the pictures of individual site performance that have emerged from RIA, what else do RIA data show? What conclusions can we draw about species' maximum growth capabilities? A picture is gradually emerging of how species dimensions change latitudinally.

LATITUDINAL EFFECTS

Table 1 compares 25 species in two latitude bands: 41 to 44 and 34 to 37 degrees north for maximum species height performance. For species that are well represented north to south, the average of 15.6 ft height difference in favor of the South tells only part of the story. The tuliptree exemplifies this point. Although they have been documented, tuliptrees above 150 ft are extremely rare at the latitudes of 42 degrees and farther north. By contrast, there are thousands of tuliptrees in the southern Appalachians over 150 ft. However, the tuliptree seems to experience some kind physical height limit at around 175 ft—very few tuliptrees exceed this height range, although many fall in the range of 160 to 175 ft.

Future ENTS applications of RIA will focus more attention on the performance of species north to south to search for patterns that can be correlated to key environmental variables. In this context, RIA includes the full range of outputs, not just indices. How do data from the intermediate latitudes fit into the north-south trend? Table 2 shows the previous data, with an intermediate column included for Pennsylvania. The last column identifies Pennsylvania trees that fall between the north-south values.

Table 1. Maximum tree height variation, north to south, between 36° and 42° latitude.

Species	Maximum height (ft) south of 36° lat.	Location	Maximum height (ft) north of 42° lat.	Location	Actual difference in height (ft)	Percent difference
American beech	143.2	Savage Gulf, TN	130.5	MTSF, MA	12.7	8.9%
American elm	137.6	Savage Gulf, TN	120.8	MTSF, MA	16.8	12.2%
American sycamore	162.2	GSMNP	153.0	Zoar Valley, NY	9.2	5.7%
Bigtooth aspen	91.6	White Oak, NC	126.0	MTSF, MA	-34.4	-27.3%
Bitternut hickory	156.3	GSMNP	136.4	Zoar Valley, NY	19.9	12.7%
Black birch	118.8	GSMNP	116.2	MTSF, MA	2.6	2.2%
Black cherry	140.9	GSMNP	132.0	Lilly Dale, NY	8.9	6.3%
Black locust	162.2	GSMNP	126.6	Schenectady, NY	35.6	21.9%
Eastern cottonwood	153.6	Meeman-Shelby SP, TN	134.4	Zoar Valley, NY	19.2	12.5%
Eastern hemlock	171.5	GSMNP	138.4	Ice Glen, MA	33.1	19.3%
Eastern hophornbeam	81.9	GSMNP	78.2	MTSF, MA	3.7	4.5%
Northern red oak	153.0	White River, SC	140.3	Zoar Valley, NY	12.7	8.3%
Pignut hickory	168.2	Lee Branch, SC	120.8	Ice Glen, MA	47.4	28.2%
Red maple	142.6	GSMNP	128.0	MTSF, MA	14.6	10.2%
Red spruce	154.7	GSMNP	133.8	Mt. Greylock, MA	20.9	13.5%
Scarlet oak	138.9	Tanglewood Park, NC	107.1	Monica's Woods, MA	25.1	19.0%
Shagbark hickory	154.4	Savage Gulf, TN	135.5	Ice Glen, MA	18.9	12.2%
Silver maple	118.9	Meeman-Shelby SP, TN	118.2	Hatfield, MA	0.7	0.6%
Striped maple	76.7	GSMNP	64.8	MTSF, MA	11.9	15.5%
Sugar maple	144.2	GSMNP	134.4	MTSF, MA	9.8	6.8%
Tuliptree	178.2	GSMNP	156.0	Zoar Valley, NY	22.2	12.5%
White ash	167.3	GSMNP	151.4	MTSF, MA	15.9	9.5%
White oak	147.1	GSMNP	115.3	Bullard Woods, MA	31.8	21.6%
Eastern white pine	187.0	GSMNP	168.5	MTSF, MA	18.5	9.9%
Yellow birch	116.7	GSMNP	105.6	MTSF, MA	11.1	9.5%
Average	**142.6**		**127.0**		**15.6**	**10.3%**

Table 2. Maximum tree height variations from north to south, with a Pennsylvania ENTS (PA ENTS) record in the middle column.

Species	Maximum height (ft) south of 36° lat.	PA ENTS champion height (ft)	Maximum height (ft) north of 42° lat.
American beech	143.2	127.5	130.5
American elm	137.6	--	120.8
American sycamore	162.2	144.0	153.0
Bigtooth aspen	91.6	110.8	126.0
Bitternut hickory	156.3	134.2	136.4
Black birch	118.8	113.5	116.2
Black cherry	140.9	137.3	132.0
Black locust	162.2	116.5	126.6
Eastern cottonwood	153.6	126.1	134.4
Eastern hemlock	169.8	146.5	138.4
Eastern hophornbeam	81.9	71.8	78.2
Northern red oak	153.0	135.2	140.3
Pignut hickory	168.2	126.7	120.8
Red maple	142.6	136.0	128.0
Red spruce	154.7	94.6	133.8
Scarlet oak	138.9	117.9	107.1
Shagbark hickory	154.4	126.1	135.5
Silver maple	118.9	123.3	118.2
Striped maple	76.7	41.4	64.8
Sugar maple	144.2	126.1	134.4
Tuliptree	178.2	158.6	156.0
White ash	167.3	139.7	151.4
White oak	147.1	127.3	115.3
Eastern white pine	207.0	183.1	168.5
Yellow birch	116.7	104.9	105.6
Average	**143.4**	**--**	**126.9**

Where data exist for all three regions, heights of 8 of the 24 species (or 33%) for Pennsylvania listed fall between the north-south extremes. This is an unexpectedly low percentage, but it is likely that we have under-sampled species such as American beech, American sycamore, northern red oak, sugar maple, shagbark hickory, bitternut hickory, white ash, and striped maple. Except for their performance in the Great Smoky Mountains National Park (GSMNP), yellow birch, black birch, bigtooth aspen, and red spruce may reach maximums north of Pennsylvania.

As a final table, it is interesting to examine the performance of the species that represents the tallest member at each eastern site in the ENTS database. Eastern white pine and tuliptree are generally regarded in literature and confirmed by ENTS as the two tallest eastern species. How do they and other species perform across the sites for which data have been collected and RHI values have been computed? Table 18 below shows the distribution of tallest members of each of 120 eastern sites.

The tuliptree is the most-often-seen tallest tree at the sites for which ENTS has data and where tuliptree is present. However, there are large geographical regions of the eastern forest type that are poorly represented in the ENTS database.

Table 3. Height performance of the tallest trees at 120 eastern sites currently documented by ENTS.

Species	Number of times the tallest	Percent of total
Tuliptree	57	47.5
Eastern white pine	32	26.7
Eastern hemlock	6	5.0
American sycamore	4	3.3
Pignut hickory	4	3.3
Eastern cottonwood	4	3.3
White ash	3	2.5
Loblolly pine	2	1.7
Cherrybark oak	2	1.7
Baldcypress	1	0.8
Sugar maple	1	0.8
Mockernut hickory	1	0.8
Willow oak	1	0.8
White oak	1	0.8
Scarlet oak	1	0.8
Total number of sites:	**120**	**100.0**

Tall tree contenders that extend outside the normal range of the tuliptree include loblolly pine, sweetgum, cherrybark oak, Shumard oak, cottonwood, and sycamore. As more Deep South sites are added, it is expected that the dominance of the tuliptree will drop. Similarly, we expect that as more northern sites are added, eastern white pine will increase in dominance. However, in the relative rankings that include only sites with RHI values over 125 ft, the tuliptree will probably remain dominant.

Eastern white pine almost certainly holds height dominance among eastern species, historically and currently. This conclusion is in agreement with the research of forest historians, memories of timber professionals, and ENTS measurements. However, some authors place the tuliptree in the number one position, without offering convincing evidence to support their conclusion. Nothing in the ENTS database suggests that any other species will challenge the eastern white pine for the greatest heights. At present, tuliptree ranks second, and is unlikely to be displaced. Perhaps more surprising is the number three ranking (Table 3) of eastern hemlock, one of the least-recognized tall tree species in the eastern forest biome.

RIA MISCELLANEOUS INFORMATION

There are many interesting bits of information that can be derived from ENTS' use of RIA. In some cases, the conclusions are obvious. In other instances, interesting facts must be teased out of the data. The following list represents a small sample of conclusions supported by the analysis that we have done to date, and represents as a convenient source of big tree-tall tree trivia provided by ENTS for those interested in tree statistics.

1. The champion tall tree area of the eastern US is the Great Smoky Mountains National Park in North Carolina and Tennessee. The GSMNP RI exceeds its closest competitor by a full 11.5 points
2. The champion tall tree site in the northeastern US is currently Zoar Valley, New York with an RHI value of 137.3 ft.
3. Although there is much searching by ENTS left to be done, there appear to be a very limited number of eastern sites with RHI values above 150 ft. As a consequence, in the view of ENTS, the 150 ft RHI value sites create a class of super sites. The four we have documented so far in the East are in South Carolina (2), North Carolina (1), and Tennessee (1). With the exception of Congaree Swamp National Park, the others are found in mountainous areas. This may highlight the role of ravine environments in supplying sufficient water and soil and providing a higher degree of protection. There are likely no sites in the Northeast anywhere close to a RHI value of 150 ft, and there may be none that reach 140 ft.
4. Southern sites above 140 ft are more numerous than we once thought, but are still rare. To date, 11 have been confirmed (using sub-sites in the Smokies). There are undoubtedly more in the southern Appalachians, Cumberlands, and perhaps one or two in the central Alleghenies.
5. There are unquestionably many sites with RHI values above 130 ft in the South, but a very limited number above 130 ft in the Northeast.
6. Corresponding to the super sites in the South with RHI values of 150 ft or more, the super sites in the Northeast are the ones with RHI values of 130 ft or higher, a 20-point differential.
7. North of latitude 42 degrees, sites with a RHI above 120 ft are rare and there may be none above latitude 43 degrees.
8. Based on our existing dataset that includes 124 sites for which we have computed RHI values, there is a 15- to 20-ft decreasing maximum height gradient going from south to north for species well-represented in both.
9. Sites with high RHI values can be surprisingly small in area. The presence of one or two very tall species often signals the existence of others. Rich sites in the middle and southerly latitudes can grow tall trees of a dozen or more species in an area of 25 ac or less. In the GSMNP, the clustering of very tall species allows relatively small areas to be representative of much larger areas. A species count within a 25-ac area in some of the Smoky Mountain coves can have 50 to 60 species, or approximately half of the Park's total of native species of trees.
10. Of the most northerly tall tree sites with a RHI over 130 ft, perhaps the most unusual is Zoar Valley in western New York. At 42.4 degrees latitude, Zoar Valley achieves its number one RHI position in the Northeast (137.3 ft) with all hardwoods for the ten species, riverine site. Zoar Valley is the ecological anomaly of northeastern sites and suggests that the bottoms of the steep-sided western New York gorges are some of our most ecologically interesting places.
11. Eastern white pines have been measured by ENTS to heights of 150 ft or more in 12 states, heights to 160 ft or more in ten states, and 170 ft or more in five states, and 180 ft or more in three different states. One tree in the GSMNP was confirmed in 1995 by ENTS to 207 ft. Anecdotal claims of great trees of the past sometimes list eastern white pines as tall as 260 ft, but these cannot be substantiated. Our belief is that 220 ft represents the tallest that this species has achieved.
12. Beyond the eastern white pine, tuliptree, eastern hemlock, loblolly pine, pignut hickory, white ash, American sycamore, and cherrybark oak are proving to be our tallest eastern species, with many specimens of some of these species likely exceeding 160 ft.
13. The eastern hardwood species that has the widest geographical range supporting heights of 160 ft or more is the tuliptree, but the latitude band for the 160-ft individuals is narrower than that of eastern white pine (less than 9 degrees of latitude, versus 12 to 13 degrees for eastern white pine).
14. Our data suggests that eastern white pine and tuliptree can both surpass 150 ft at relatively young ages—cores indicate trees as young as 80 to 100 years can be in the 150-ft height range.
15. The eastern hemlock, generally considered to be a northerly species, reaches its greatest dimensions in the southern Appalachians. Heights to 171.5 ft have been accurately recorded and trunk volumes of just under 1,600 ft^3 have been confirmed. Several dozen eastern hemlocks in the GSMNP have volumes of 1,000 ft^3 and many others exceed 800. As such, the eastern hemlocks of the southern Appalachians are the largest evergreen eastern conifer currently measured in terms of volume, even more so than eastern white pine and loblolly pine. However, the largest conifer (in terms of volume) in the eastern US is the baldcypress, which is deciduous.
16. From the collective pool of our observations, it increasingly obvious that the tallest trees of most species are seldom the oldest or largest. Our present dataset suggests that most species achieve their maximum heights between 100 and 200 years. However, there may be exceptions.
17. The heights of tall, broad-crowned trees are frequently mismeasured by amateur big tree hunters and forest professionals alike. Tuliptrees, American sycamore, eastern cottonwood, black walnut, pecan, white oak, and baldcypress are but a few examples of species that have been over-measured. However, forest-grown specimens of these species that are not measured (except by ENTS personnel) often match or exceed the heights quoted for the mis-measured open-grown

specimens. This sets up a curious situation. The mismeasurements show up in champion tree listings and appear to validate maximum heights quoted for the referenced species by ENTS. However, the mis-measured trees distort our picture of where and in what conditions height thresholds are reached. An infamously mis-measured red maple in Michigan best illustrates the point. The tree, listed by American Forests at the wildly improbable 179 ft, proved to be right at 120. This represents a 59-ft error.

18. As demonstrated in Tables 1 and 2 of this paper, many species show definite north-south height trends. However, the maximums of black cherry, yellow and black birch, and eastern hophornbeam change little over a span of 10 degrees of latitude.
19. Of all species that we have tracked that are distributed over 10 degrees latitude or more, very few show better height performance toward the northern ends of their ranges as compared to the southern ends. However, there are exceptions. Bigtooth aspen, quaking aspen, white birch, black spruce, and black ash are examples of species that perform best in the northern half of their ranges. There is some question about bigtooth aspen, since it has been greatly undersampled.
20. Many of our tallest trees are early and mid-successional species that are also long-lived, such as eastern white pine, tuliptree, and white ash. However, exceptions to this trend include some hickories and eastern hemlock.

SUMMARY

Although a comparatively simple system, RIA in ENTS has no close counterparts in the research protocols of forestry or forest ecology for the specific purpose of identifying the maximum dimensions that eastern species are capable of achieving and where they reach those maximums. ENTS has not yet addressed the "whys" associated with maximum dimensions, a far weightier kind of scientific analysis. However, ENTS' work with RIA is pioneering. So, after patting ourselves on the back, what do we believe that we have accomplished through RIA?

By developing very accurate tree-dimension measuring techniques, focusing attention on forest site comparisons, and using a top-down tall tree search strategy, ENTS is gradually confirming maximum species dimensions within and across regions in preparation for identifying the conditions that explain the maximums. We see a bright future for RIA. We believe that we can provide natural sciences with more accurate baseline data to evaluate changes in our Eastern forests. As other dimension-based measurement methods emerge, which rely on pixel analysis from digital photographs, a generation of students will utilize approximating data. RIA may well stand as the only viable source of "ground-truthing" to evaluate the highly efficient digital measurement techniques.

In the future, the components of RIA that ENTS will focus on include:

1. Continuing the computation of basic site indices to arrive at overall measures of site performance;
2. Expanding our use of the iterated index to track the performance of each species;
3. Applying the concepts of dominance and persistence and computing Dominance-Persistence Indices (DPI) for the iterated index; and
4. Perfecting the process of companion species analysis for identification and ranking purposes.

Finally, we foresee that the primary and secondary products that ENTS will publish regularly as applications of RIA include the following:

1. Lists of species maximums locally, regionally, and range wide,
2. Lists of site indices, local, regional, and Eastern-wide.

A Giant Southern Pine From Historical Georgia

In a May 1925 letter to a trade journal, C.B. Harman wrote of a "swamp shortleaf pine" (probably a loblolly pine) that was 19 ft in circumference at 3 ft above the ground. This giant pine was still 3 ft in diameter at 75 ft above the ground, with a 40- to 50-ft long crown and a height of at least 125 ft. Harman estimated that this single tree would cut 16,000 board feet of timber (which seems to be an overestimate).

This big pine stood mixed with other pines and hardwoods in an area affected by overflow of a local creek, and was located in Wilkinson County, Georgia, about 4 miles north of Gordon and 20 miles south of Macon on the Central of Georgia Railway.

Source: Harman, C.B. 1925. Largest yellow pine tree in Georgia. The Timberman 26(7):142.

Contributed by Don C. Bragg

FOREST HEALTH—SCIENTIFIC CONCEPT OR POLITICAL GIMMICK?

Robert T. Leverett

Founder, Eastern Native Tree Society

Some time back, I mentioned that my topic for this year's presentation at the Forest Summit will be "Forest Health—Scientific Concept or Political Gimmick." I asked for comments and suggestions from members, yet so far nobody has taken the bait. I think I understand why, but I'll make the request again. Someone out there must have some thoughts on the subject that they are willing to share.

As I see it, forest health is a topic that drifts into the public arena as tied either to legitimate forest management efforts or attempts by the lumber industry and its extensions in government and academia to justify increased cutting of forest lands for good or not so good reasons.

As a concept, forest health is legitimately important to:

1. Lumbermen
2. Silviculturalists
3. Government foresters
4. Private foresters
5. Ecologists
6. Wildlife biologists
7. Naturalists-environmentalists

As a class, I define lumbermen as that group seeking to make money from cutting trees. Lumbermen often regard timber as a raw material or resource to be obtained at the lowest cost. Lumbermen include mill owners, timber cruisers, loggers, etc., and some foresters, but by no means all. Procurement foresters would be included in the lumbermen definition.

Lumbermen almost always see forest health in terms of individual tree health and a dominance of commercially valuable species. As a consequence, they will see a forest populated by noncommercial species as unhealthy. I think most foresters see forest health in a similar way, but an elite few are cognizant of processes that they believe need to play out (of course, these foresters belong to ENTS—everyone saw that coming, right?).

Silviculturalists are focused on growing timber for the future through employing scientific processes. Timber is usually the species that the silviculturalists consider most valuable. At its extreme and when controlled by timber companies, silviculture leads to tree plantations, but this is not an inevitable outcome of its implementation. Silviculture can be practiced toward meeting objectives other than maximizing the production of wood fiber in the shortest time period.

Ecologists tend to see forest health in terms of processes and balances, long- and short-term, such as an overall balance between the forces of regeneration and decay that leave the aggregate system functioning for long time periods. Individual species may change their percentages of composition, but looked at from afar, the whole system works.

At this point, I should mention that I recognize that the above seven groups are not necessarily mutually exclusive. They are presented mainly to stimulate further discussion. Definitions of forest health have overlapping ideas and concepts. Seen from a distance, the whole thing looks like a bowl of idea spaghetti. But on closer examination, we would notice distinct trends. As an example, when all the goobledegook is set aside, wildlife biologists may see health in simpler terms: ample habitat for species they think are important enough to be maintained across the landscape. If the habitat is there and has the "right" wildlife, they may see a forested ecosystem as healthy.

As a general rule, naturalists and environmentalists range far and wide—some have a good grasp of natural processes and accept the role of management in at least mitigating damage wrought by humans, but others can be incredibly naive. It is hard to pin this last group down on the subject of forest health. I say this freely, because I am, for the most part, a member of this group and know my brothers and sisters well.

Okay, I've gone and done it! I hope I'm not opening up Pandora's box, or at least a can of worms, but the topic is extremely important to discuss (my sneaky way of asking for ideas for my presentation).

Any takers?

INSTRUCTIONS FOR CONTRIBUTORS

SCOPE OF MATERIAL
The *Bulletin of the Eastern Native Tree Society* accepts solicited and unsolicited submissions of many different types, from quasi-technical field reports to poetry, from peer-reviewed scientific papers to digital photographs of trees and forests. This diverse set of offerings also necessitates that (1) contributors specifically identify what type of submission they are providing; (2) all submissions should follow the standards and guidelines for publication in the *Bulletin*; and (3) the submission must be new and original material or be accompanied by all appropriate permissions by the copyright holder. All authors also agree to bear the responsibility of securing any required permissions, and further certify that they have not engaged in any type of plagiarism or illegal activity regarding the material they are submitting.

SUBMITTING A MANUSCRIPT
As indicated earlier, manuscripts must either be new and original works, or be accompanied by specific written permission of the copyright holder. This includes any figures, tables, text, photographs, or other materials included within a given manuscript, even if most of the material is new and original.

Send all materials and related correspondence to:

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Depending on the nature of the submission, the material may be delegated to an associate editor for further consideration. The Editor-in-Chief reserves the right to accept or reject any material, regardless of the reason. Submission of material is no guarantee of publication.

All submissions must be made to the Editor-in-Chief in digital format. Manuscripts should be written in Word (*.doc), WordPerfect (*.wpd), rich-text format (*.rtf), or ASCII (*.txt) format.

Images can be submitted in any common format like *.jpg, *.bmp, *.tif, *.gif, or *.eps, but not PowerPoint (*.ppt). Images must be of sufficient resolution to be clear and not pixilated if somewhat reduced or enlarged. Make sure pictures are at least 300 dots per inch (dpi) resolution. Pictures can be color, grayscale, or black and white. Photographs or original line drawings must be accompanied by a credit line, and if copyrighted, must also be accompanied by a letter with express written permission to use the image. Likewise, graphs or tables duplicated from published materials must also have expressly written copyright holder permission.

PAPER CONTRIBUTIONS (ALL TYPES)
All manuscripts must follow editorial conventions and styling when submitted. Given that the *Bulletin* is edited, assembled, and distributed by volunteers, the less work needed to get the final product delivered, the better the outcome. Therefore, papers egregiously differing from these formats may be returned for modification before they will be considered for publication.

Title Page
Each manuscript needs a separate title page with the title, author name(s), author affiliation(s), and corresponding author's postal address and e-mail address. Towards the bottom of the page, please include the type of submission (using the categories listed in the table of contents) and the date (including year).

Body of Manuscript
Use papers previously published in the *Bulletin of the Eastern Native Tree Society* as a guide to style formatting. The body of the manuscript will be on a new page. Do not use headers or footers for anything but the page number. Do not hyphenate text or use a multi-column format (this will be done in the final printing). Avoid using footnotes or endnotes in the text, and do not use text boxes. Rather, insert text-box material as a table.

All manuscript submissions should be double-spaced, left-justified, with one-inch margins, and with page and line numbers turned on. Page numbers should be centered on the bottom of each new page, and line numbers should be found in the left margin.

Paragraph Styles. Do not indent new paragraphs. Rather, insert a blank line and start the new paragraph. For feature articles (including peer-reviewed science papers), a brief abstract (100 to 200 words long) must be included at the top of the page. Section headings and subheadings can be used in any type of written submission, and do not have to follow any particular format, so long as they are relatively concise. The following example shows the standard design:

FIRST ORDER HEADING
Second Order Heading
Third Order Heading. The next sentence begins here, and any other levels should be folded into this format.

Science papers are an exception to this format, and must include sections entitled "Introduction," "Methods and Materials," "Results and Discussion," "Conclusions," "Literature Cited," and appendices (if needed) labeled alphabetically. See the ENTS website for a sample layout of a science paper.

Trip reports, descriptions of special big trees or forests, poetry, musings, or other non-technical materials can follow less rigid styling, but will be made by the production editor (if and when accepted for publication) to conform to conventions.

Table and figure formats. Tables can be difficult to insert into journals, so use either the table feature in your word processor, or use tab settings to align columns, but DO NOT use spaces. Each column should have a clear heading, and provide adequate spacing to clearly display information. Do not use extensive formatting within tables, as they will be modified to meet *Bulletin* standards and styles. All tables, figures, and appendices must be referenced in the text.

Numerical and measurement conventions. You can use either English (e.g., inches, feet, yards, acres, pounds) or metric units (e.g., centimeters, meters, kilometers, hectares, kilograms), so long as they are consistently applied throughout the paper. Dates should be provided in month day, year format (June 1, 2006). Abbreviations for units can and should be used under most circumstances.

For any report on sites, heights must be measured using the methodology developed by ENTS (typically the sine method). Tangent heights can be referenced, especially in terms of historical reports of big trees, but these cannot represent new information. Diameters or circumference should be measured at breast height (4.5 ft above the ground), unless some bole distortion (e.g., a burl, branch, fork, or buttress) interferes with measurement. If this is the case, conventional approaches should be used to ensure diameter is measured at a representative location.

Taxonomic conventions. Since common names are not necessarily universal, the use of scientific names is strongly encouraged, and may be required by the editor in some circumstances. For species with multiple common names, use the most specific and conventional reference. For instance, call *Acer saccharum* "sugar maple," not "hard maple" or "rock maple," unless a specific reason can be given (e.g., its use in historical context).

For science papers, scientific names MUST be provided at the first text reference, or a list of scientific names corresponding to the common names consistently used in the text can be provided in a table or appendix. For example, red pine (*Pinus resinosa*) is also known as Norway pine. Naming authorities can also be included, but are not required. Be consistent!

Abbreviations. Use standard abbreviations (with no periods) for units of measure throughout the manuscript. If there are questions about which abbreviation is most appropriate, the editor will determine the best one to use. Here are examples of standardized abbreviations:

inch = in	feet = ft
yard = yd	acre = ac
pound = lb	percent = %
centimeter = cm	meter = m
kilometer = km	hectare = ha
kilogram = kg	day = d

Commonly recognized federal agencies like the USDA (United States Department of Agriculture) can be abbreviated without definition, but spell out state names unless used in mailing address form. Otherwise, spell out the noun first, then provide an abbreviation in parentheses. For example: The Levi Wilcoxon Demonstration Forest (LWDF) is an old-growth remnant in Ashley County, Arkansas.

Citation formats. Literature cited in the text must meet the following conventions: do not use footnotes or endnotes. When paraphrasing or referencing other works, use the standard name date protocol in parentheses. For example, if you cite this issue's Founder's Corner, it would be: "…and the ENTS founder welcomed new members (Leverett 2006)." If used specifically in a sentence, the style would be: "Leverett (2006) welcomed new members…" Finally, if there is a direct quotation, insert the page number into the citation: (Leverett 2006, p. 15) or Leverett (2006, p. 16-17). Longer quotations (those more than three lines long) should be set aside as a separate, double-indented paragraph. Papers by unknown authors should be cited as Anonymous (1950), unless attributable to a group (e.g., ENTS (2006)).

For citations with multiple authors, give both authors' names for two-author citations, and for citations with more than two, use "et al." after the first author's name. An example of a two-author citation would be "Kershner and Leverett (2004)," and an example of a three- (or more) author citation would be "Bragg et al. (2004)." Multiple citations of the same author and year should use letters to distinguish the exact citation: Leverett 2005a, Leverett 2005b, Leverett 2005c, Bragg et al. 2004a, Bragg et al. 2004b, etc.

Personal communication should be identified in the text, and dated as specifically as possible (not in the Literature Cited section). For example, "…the Great Smoky Mountains contain most of the tallest hardwoods in the United States (W. Blozan, personal communication, March 24, 2006)." Examples of personal communications can include statements directly quoted or paraphrased, e-mail content, or unpublished writings not generally available. Personal communications are not included in the Literature Cited section, but websites and unpublished but accessible manuscripts can be.

Literature Cited. The references used in your work must be included in a section titled "Literature Cited." All citations should be alphabetically organized by author and then sorted by date. The following examples illustrate the most common forms of citation expected in the *Bulletin*:

Journal:

Anonymous. 1950. Crossett names giant pine to honor L.L. Morris. Forest Echoes 10(5):2-5.

Bragg, D.C., M.G. Shelton, and B. Zeide. 2003. Impacts and management implications of ice storms on forests in the southern United States. Forest Ecology and Management 186:99-123.

Bragg, D.C. 2004a. Composition, structure, and dynamics of a pine-hardwood old-growth remnant in southern Arkansas. Journal of the Torrey Botanical Society 131:320-336.

Proceedings:

Leverett, R. 1996. Definitions and history. Pages 3-17 *in* Eastern old-growth forests: prospects for rediscovery and recovery, M.B. Davis, editor. Island Press, Washington, DC.

Book:

Kershner, B. and R.T. Leverett. 2004. The Sierra Club guide to the ancient forests of the Northeast. University of California Press, Berkeley, CA. 276 p.

Website:

Blozan, W. 2002. Clingman's Dome, May 14, 2002. ENTS website http://www.uark.edu/misc/ents/fieldtrips/gsmnp/clingmans_dome.htm. Accessed June 13, 2006.

Use the hanging indent feature of your word processor (with a 0.5-in indent). Do not abbreviate any journal titles, book names, or publishers. Use standard abbreviations for states, countries, or federal agencies (e.g., USDA, USDI).

ACCEPTED SUBMISSIONS

Those who have had their submission accepted for publication with the *Bulletin of the Eastern Native Tree Society* will be mailed separate instructions to finalize the publication of their work. For those that have submitted papers, revisions must be addressed to the satisfaction of the editor. The editor reserves the right to accept or reject any paper for any reason deemed appropriate.

Accepted materials will also need to be accompanied by an author contract granting first serial publication rights to the *Bulletin of the Eastern Native Tree Society* and the Eastern Native Tree Society. In addition, if the submission contains copyrighted material, express written permission from the copyright holder must be provided to the editor before publication can proceed. Any delays in receiving these materials (especially the author contract) will delay publication. Failure to resubmit accepted materials with any and all appropriate accompanying permissions and/or forms in a timely fashion may result in the submission being rejected.

Sky Lake Wildlife Management Area in west-central Mississippi still contains a large quantity of ancient baldcypress that once dominated much of the Mississippi River alluvial plain. Photo by Don C. Bragg.