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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.

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COVER: The second tallest eastern white pine found in the Great Smokey Mountains (Caldwell Fork, Cataloochee Valley, North Carolina). Sadly, this eastern white pine, at 11.1 ft CBH and 184.4 ft tall, is surrounded by eastern hemlocks killed by the hemlock woolly adelgid. Photo courtesy of Will Blozan.

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TABLE OF CONTENTS

Looking for Inspiration in All the Wrong(?) Places
ANNOUNCEMENTS AND SOCIETY ACTIONS
4th Annual Field Technology Conference for Data Collection and Mapping in Forestry
Not-Quite-New Publication of Interest
FEATURE ARTICLES
Crown Volume Estimates
Edward Forrest Frank, Eastern Native Tree Society
Southwestern Old Growth Forests Conference in Durango: Part I – Preliminary Trips and Field Events
FIELD REPORTS
Comparing Tape Drop Height to that Obtained With a Nikon 440
FOUNDER'S CORNER
Science, Passion, and Getting Personal
INSTRUCTIONS FOR CONTRIBUTORS

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LOOKING FOR INSPIRATION IN ALL THE WRONG(?) PLACES

Having just spent two fantastic weeks crossing much of the western United States, including visits to Sequoia and Redwood national parks, you may guess what inspired this column...Three hundred foot tall redwoods or thirty foot diameter sequoias, right? Well, as impressive as those specimens are, I think I may have gotten as much inspiration from the shortest, scraggliest, most timber-poor trees out there—the gnarly, ancient pinyon and junipers that so dominate much of the southwestern United States. These trees are some tough hombres—many of them have survived for centuries, enduring epic droughts, bugs, fires, winds, and even severe weather events (rain, snow, hail, etc.). They have always played a critical role in the natural and human systems that have dominated this region.

Yet, these forests are imperiled by many factors today, from climate change to invasive species to human activities. These ecosystem cornerstones are more than just green flourishes to the dusty, rocky landscapes of the region – they are inspiring survivors that have much to teach us about natural and human history, the interconnectedness of ecosystems and socioeconomics, and to anthropomorphize, the values of patience and persistence in the face of adversity. I certainly do not begrudge those who find the redwoods, sequoias, and other giant trees as inspiring reasons for the need to conserve our natural treasures; I sincerely hope they choose to also take the time to draw inspiration from the "little" things in life that are all around us.



Don C. Bragg Editor-in-Chief

Groves of tough, ancient pinyon pine currently abound across much of the red rock deserts of the southwestern United States, such as this example from Navajo National Monument in Arizona. Photograph by Don C. Bragg.

ANNOUNCEMENTS AND SOCIETY ACTIONS

4th Annual Field Technology Conference for Data Collection and Mapping in Forestry and Natural Resources

November 19-20, 2014 Holiday Inn Portland Airport Hotel Portland, Oregon

Sponsors: Laser Technology, Inc.

Various talks will be given on topic such as LiDAR, UAVs (drones), laser hypsometers, GPS, and other technologies. Please check their website for details: http://www.westernforestry.org/Events/conference/field-technology-2014/



Not-Quite-New Publication of Interest

For those not aware, Native Tree Society webmaster/ BBS guru Edward Forrest Frank also produces an online magazine that encapsulates the primary discussion threads and posts made to the Native Tree Society's BBS (http://www.ents-bbs.org/index.php). Sign up for the FREE bulletin board, and take advantage of this great resource!

According to the magazine, "[eNTS]...is published monthly and contains material that is compiled from posts made to the NTS BBS...[and] features notable trip reports, site descriptions and essays posted to the BBS by NTS members. The purpose of the magazine is to have an easily readable and distributable magazine of posts available for download for those interested in the Native Tree Society and in the work that is being conducted by its members.

This magazine serves as a companion to the more formal science-oriented Bulletin of the Eastern Native Tree Society and will help the group reach potential new members. To submit materials for inclusion in the next issue, post to the BBS. Members are welcome to suggest specific articles that you might want to see included in future issues of the magazine, or point out materials that were left from a particular month's compilation that should have been included."

The current issue of eNTS contains over 260 pages and loads of spectacular pictures. This issue (cover picture provided to the left) can be found at:

www.ents-bbs.org/viewtopic.php?f=274&t=6564 Back issues are also available!

CROWN VOLUME ESTIMATES

Edward Forest Frank

Eastern Native Tree Society

INTRODUCTION

This paper presents a simplified method for estimating the crown volumes of trees using a limited number of measurements. Looking at a tree standing in a field a profile of the crown can be seen. Different trees have different general crown profiles and crown shapes. The overall shape of the crown will tend to range from roughly conical, to spherical, to cylindrical. It is a reasonable assumption that trees with these differing crown shapes, even if of similar overall crown thickness and spread would have different volumes, and that these volumes would progressively vary as the overall crown shape varied from one form to another.

The volume of the crown can be determined using three values: 1) crown spread, 2) crown thickness, and 3) crown shape. The thickness of the crown and the average crown spread will be measured and the general crown shape of the tree will determined by visual comparison with a chart. The crown shape will be used to derive a Crown Form (CF) value for different tree shapes and will be the third parameter of the crown volume calculation formula.

Crown spread can be measured in several different ways. Commonly a diameter of the crown is measured along its widest point and a second measurement is taken at right angles to the first measuring the width of the crown in this second axis. The two are averaged to determine the average crown spread. Alternatively a series of spokes are measured from the outer extension of the branches to the center of the tree. These are averaged and multiplied by two to calculate an average crown spread. In reality this is actually the average of the maximum spread in each axis or spoke measured and should be thought of as the average maximum crown spread.

Crown thickness is simply the difference in height from the base of the crown, ignoring stray branches and epicormic sprouts, and the top of the crown or top of the tree. This parameter is measured using standard height measurement techniques. Crown spread and height measurements use the standard ENTS methodology presented by Blozan (2004).

Crown shape is the third parameter. The crown of a tree is a three dimensional object that may be thought of as this visual profile rotated about the trunk of the tree.

One method of determining the volumes of the crown of a tree is by climbing the tree and doing detailed mapping of each portion of the crown and adding these mapped volumes together. This is a very time consuming process and may not be practical in many situations. In the methodology presented here the profile of a tree is compared visually to a set of standards and a best match is selected. Each different profile has an associated CF value that can then be used determine crown volume.



Figure 1. Crown profile rotation.

DISCUSSION

A solid form can be modeled as a series of disks stacked one atop another of varying diameters, each diameter equal to the average crown diameter at that height. The more disks, the closer this disk stack will approximate the volume of the crown. This is one of the basic principles of calculus. Different diameters of the crown can be measured at different heights, calculating the volume of each of these disks, and totaling them together. The limbs are not exactly the same length in each direction on a tree, but an average length can be used for calculating the volume each individual disk.

Consider that there must be a single cylinder of the same height as the crown thickness that has the same volume as the irregularly shaped crown. The problem then becomes one of determining the diameter of this cylinder so that its volume equals that of the crown of the tree. The volume (V_{disk}) of each of the individual disks can be calculated by using the formula for the volume of a cylinder:

$$V_{disk} = \pi h r^2 = \pi h (d^2/4)$$
^[1]

where *h* is cylinder height, *r* is the cylinder's radius (*r* also equals half the cylinder's diameter, so $r^2 = (d/2)^2 = d^2/4$). By rearranging the numbers you can derive a formula for the radius needed for the single cylinder solution. The height and π drop out and the result is the needed radius is equal to the

square root of the average of the squared radius (r^2) for each of the disks.

$$r_{cylinder} = [\text{AVERAGE} (r_1^2 + r_2^2 + \dots + r_x^2]^{0.5}$$
[2]

The key to understanding this is that the absolute length of each radius is important, but also how they change in length relative to each other at different heights is just as important. This progression of relative lengths may be thought of as the form of the crown. For any given Crown Form, the length of this single cylinder radius and single cylinder diameter will be proportional to the measured average maximum crown spread of the tree.



Figure 2. Different idealized crown shapes with the same Crown Form value.

Each of these shapes above represent idealized tree crowns and in each of these shapes the spread varies proportionally the same way at different heights within the crown. Therefore they have the same overall Crown Form. All that varies among the shapes is the overall diameter of the crown. The ratio of the simple cylinder diameter to average crown would be the same in each example.

Evaluation of Idealized Crown Forms

The next step is to calculate the volumes of a variety of crowns of different forms. Calculus can be used to calculate the volume of any shape rotated about an axis; however there is no series of equations that define various crown shapes. Therefore a graphical solution was employed. The National Audubon Society Field Guide to Trees (Little 1980, p. 10), lists seven tree shapes: 1) pyramidal, 2) conical, 3) columnar, 4) broad, 5) rounded, 6) spreading, and 7) vase-shaped. This is a reasonable classification of general tree forms, however, there were only a limited number of specific tree form examples presented in the text. *Peterson Field Guides Eastern Trees* (Petrides and Wehr 1998) has a chapter on tree silhouettes by Roger Troy Peterson. In it are illustrations of 48 different tree silhouettes. These illustrations of idealized tree forms were used as a basis to make crown volume calculations. For purposes of this type of analysis it does not matter if the idealized form shown for tuliptrees was actually representative of all tuliptrees or not. What is important is that there was a wide variety of tree profiles representing the overall continuum of actual tree shapes presented that could be measured. Photocopies of these drawing were annotated. First the crown of the tree was outlined and a centerline was drawn vertically through the illustration marking the center point of the tree.



Figure 3. Illustration of the spread measurement process.

The tree was divided into ten equal height vertical segments, and the center point of each of these segments was determined with a variable template. The width of the crown in the illustration was measured at 5%, 15%, 25%, 35%, 45%, 55%, 65%, 75%, 85%, and 95% of the height of the crown. These values represent the average of the diameter of each of the disks making up volume of the crown. Then using these values, and a variation of the formula presented above the diameter of a single cylinder of equal volume to the crown of the tree was calculated. Of the 48 illustrations, 44 were used in the measurement process. Those not used included one multi-trunk example, and three examples of smaller trees/shrubs that were too asymmetrical to provide useful comparisons. I included a drawing of a clump of pussy willows for comparisons.

Standard Geometric Forms

Similar calculations can be made for several standard geometrical forms that are similar to tree canopy shapes:

Volume of a cylinder = πhr^2

The ratio of avg. crown spread/diameter of cylinder = 1 Volume of a Sphere = $4/3\pi r^3$

- The ratio of average radius of a sphere/diameter of cylinder = 0.8165
- Volume of a cone = $1/3\pi r^2$
- The ratio of average radius of a cone/diameter of cylinder = 0.577

Ratio of Average Crown Diameter to Average Maximum Crown Spread

The results generally are what would be expected. Those trees with a more conical shape are at the bottom end of the range, while those trees with some almost cylindrical segments are in the higher range. The results are presented on the table below. The tree species listed are those used by Peterson to denote the respective silhouettes. The example with the lowest ratio was the illustration of the white spruce illustration with a 0.679. This is still substantially higher than that of a simple cylinder. The example with the highest ratio was eastern sycamore illustration with a ratio of 0.897. The numerical average of the entire set was a ratio of 0.800. It is surprising that the variation between the maximum and minimum ratio is so small. The range of the entire measured set fell between -12.1% and +9.7% of the average value for the set in spite of the dramatic variations of overall shape.

Some general observations can be made. Those trees having a pyramidal to conical shape fell in the range of 0.679 to 0.729. The next category could be described as spade shaped with a rounded base section and a triangular shaped point. These fell in the ratio range from 0.753 to 0.785. The next group had a range of shapes from more elongated spades, to round, to oval and the ratio ranged from 0.804 to 0.836. The final group were spreading, generally broad crowned trees that tended to have vertical segments of their crown represented by longer limbs all of similar length, essentially vertical sides in sections. These ratios ranged from 0.847 to 0.897. There were only three examples of vase-shaped or upswept trees. Two of them respectively had ratios of 0.762 and 0.772. This seems an appropriate range for this form. The other, an elm, had a ratio of 0.835, but while this tree had upswept limbs, the crown could better be described as round in shape. The Audubon *Guide* listed a category of columnar but this referred to the fact that the limbs of these trees were short relative to the tree height. In terms of form they generally were better categorized as pyramidal to spade shaped with ratios between 0.685 and 0.781. It is important when applying these criteria to analyze branch length pattern rather than branch length itself.

The names assigned by the *Petersons' Guide* have been used in the tabulations and graphs of the results for illustrative purposes. This does not imply that the form of all trees of a particular species will have the same overall profile and will have the same Crown Form.

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Species	Ratio	Species	Ratio
Cone	0.577	Honey Locust	0.816
White Spruce	0.679	Sphere	0.817
Northern Red Cedar	0.685	White Oak	0.817
Red Spruce	0.704	White Oak	0.817
Balsam Fir	0.715	Tuliptree	0.824
Hemlock	0.718	Bur Oak	0.826
Eastern Red Cedar	0.722	Pitch Pine	0.829
Norway Spruce	0.729	American Elm	0.830
Sassafras	0.753	Loblolly Pine	0.835
Bald Cypress	0.762	American Elm	0.835
Lombardy Poplar	0.765	Red Maple	0.835
Sugar Maple	0.766	Black Cherry	0.836
Eastern Cottom wood	0.772	Pignut Hickory	0.848
Black Willow	0.776	Dogwood	0.849
Sweetgum	0.776	Weeping Willow	0.849
Sugar Maple	0.777	White Pine	0.850
Quaking Aspen	0.777	Shagbark Hickory	0.850
Black Spruce	0.782	Osage-orange	0.854
Tamarack	0.785	Beech	0.868
Butternut	0.785	Catalpa	0.882
Pussy Willow clump	0.804	Black Locust	0.889
White Ash	0.810	Eastern Sycamore	0.897
Red Pine	0.812	Average	0.800
Pin Oak	0.815		

Figure 4. Summary table of the ratio of the diameter of the equivalent cylinder volume to the average maximum crown spread for the illustration of the species.

Normalized Crown Shapes

For each diameter of each crown profile measured, a normalized crown diameter/limb length was calculated to determine the limb length pattern and the overall shape of the tree. The measured diameters were divided by the average diameter to normalize these values. The average diameter used to normalize the values is the diameter of the cylinder calculated to be equivalent in volume to that of the crown of that particular shape. Six distinct form groups emerged from the data.

CROWN FORM FACTOR

Each different crown shape will have an associated crown shape ratio of the measured maximum average crown spread to radius of the equivalent cylinder diameter. This value cannot be used directly but first must be converted to a unique Crown Form factor value. The formula for an equivalent cylinder may be expressed as follows:

Volume equivalent cylinder = $\pi hr^2 = \pi$ (thickness of crown)[(crown shape ratio)(average maximum crown spread)]²/4,

where average maximum crown spread = $2 \times average$ maximum radius. The constants can be rearranged to derive a Crown Form (*CF*) factor:

- $CF = [\pi(\text{crown shape ratio})^2]/4$
- The overall volume equation can then be rewritten as:
 - Crown volume = CF x (crown thickness) x (average maximum crown spread)²



Figure 5. Examples of various tree crown forms based on field-measured trees.

Thus the complex problem of estimating crown volume is reduced to two easily measured parameters—average maximum crown spread and crown thickness, and one value that can be determined using visual matching of shapes from a table of standard shapes. The figures below provide graphic examples of different crown shapes. The user can compare the forms illustrated with those of the tree being examined to find the best match. It is important that the pattern of change in branch length be examined rather than the actual length of the branches when making this determination of which forms best match. Extraneous branches and sprigs that make up a small portion of the volume of the crown and that extend beyond the general mass of the crown itself should be ignored, as should hollows within the mass of the crown. Each tree crown profile on the chart is accompanied by a CF value for that particular shape. The result of this process is the generation of a series of crown profile shapes and associated CF values that can be used in the field to determine the CF value of a particular tree.



Figure 6. CF forms for a number of species. Note that the American elm in the *Pederson's Guide* has an upswept branch form but the crown itself is more rounded in form.

Additional Comments

There are a couple of special cases that need consideration. The first is the case of a domed shaped canopy, such as found in a number of open grown live oak trees. A CF factor and form matching chart has not been included for this particular shape, although they could be calculated. Trees of this form can be modeled as the top section of a hemisphere. A tree crown fits this shape model if: a) it has a domed shaped top surface, b) the base of the crown is flat or at ground level on a flat surface, and 3) the width of the crown spread is greater than or equal to twice the vertical thickness of the crown. Because of the shape variations this form can be easily numerically evaluated. Robert Leverett developed an Excel spreadsheet that automatically calculates the volume of this section given the crown height and average maximum crown spread and submitted it to the ENTS discussion list on February 24, 2009.

The second special case is where the crown of the tree is exceptionally asymmetrical. In most cases averaging the length of the maximum and minimum axis of the crown will produce an acceptable result. In extreme cases each horizontal axis can be entered separately into this formula:

Crown volume = *CF* x (crown thickness) x (maximum axis) x (minimum axis)

This formula includes the hidden assumption that the shape of the crown is similar in shape as bisected by both axis. In cases of trees with unusually shaped crowns, if a photograph of the crown can be taken from a distance to mitigate distortion the methodology described above for calculating idealized crown volumes can be applied to these trees to derive the CF. With measurements of average maximum crown spread and crown thickness and this individualized CF the volume of this individual crown can be calculated.

Some trees simply have a crown shape that is too irregular to use this methodology to determine crown volume. These trees, if a crown volume value is required, will need to be evaluated in sections and the volume of the individual sections added together to determine crown volume.

LITERATURE CITED

- Blozan, W. 2004. Tree measuring guidelines of the Eastern Native Tree Society, revised 2008. ENT website http://www.nativetreesociety.org/measure/Tree_Meas uring_Guidelines-revised1.pdf Last accessed 10 December 2010.
- Leverett, R. 2009. Crown Volume Problem #11, February 24, 2010. ENTS Website http://www.nativetreesociety.org /measure/problems/Problem_11.htm Last accessed 10 December 2010.
- Little, E.L. 1980. National Audubon Society field guide to trees, eastern region, North America. Alfred A. Knoft, Inc., New York, NY. 716 p.
- Petrides, G.A. and J. Wehr. 1988. Peterson Field Guides: A field guide to eastern trees, eastern United States and Canada, including the Midwest. Houghton Mifflin Company, New York, NY. 428 p.

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Fall colors from oaks, hickories, and maples just outside of Wisconsin Dells. Photograph by Don C. Bragg.



SOUTHWESTERN OLD GROWTH FORESTS CONFERENCE IN DURANGO: PART I – PRELIMINARY TRIPS AND FIELD EVENTS

Robert T. Leverett

Co-founder and Executive Director The Native Tree Society

INTRODUCTION

In the summer of 2008, my wife Monica and I traveled to Durango, Colorado. We were visiting friends, hunting for old growth forests and big trees in the surrounding San Juan Mountains, and enjoying the exceptional beauty of the southern Rockies. The San Juans are often described as the scenic pinnacle of Colorado's display of mountain majesty. Twelve peaks thrust their summits above the coveted 14,000-ft threshold. Three (Eolus, Windom, and Sunlight) lie north of Durango, between 36 and 38 miles as the crow flies. Along the main travel corridors, like U.S. 550, these peak-bagger destinations are largely hidden from view in the vastness of the Weminuche Wilderness. But from a spectacular scenery standpoint, it doesn't matter. Travelers on the Durango to Silverton Scenic Railway are treated to a line of respectable "thirteeners." Two, Pigeon Peak at 13,978 ft and Turret at 13,836 ft, are especially dramatic.



The high peaks are the region's main draw, but beneath their snowcapped summits, the San Juans hold an ecological feature unknown to most- the exceptional stature of the trees within their conifer-dominated forests.

On our initial visit, I contacted the San Juan National Forest, making the acquaintance of Laura Stransky, an old-growth forest inventory specialist. She gave me a list of locations to explore. I also searched trail guides for hints on where to look for old growth. For example, *Hiking Trails of Southwestern Colorado* (Pixler and Peel 2006) has phrases like "enter big timber", which gave us clues on where to explore.

As I frequently reported on the NTS BBS, the tree discoveries came immediately. Was it a case of beginner's luck? Would I need to develop a more sophisticated search strategy if the discoveries were to continue?

Elevations in southwestern Colorado range from 6,000 to 14,000 ft. Below 7,500 ft, increasingly dry conditions dictate the composition and size of the vegetation, creating the juniper and pinyon pine zone – ancient trees, but barely trees in terms of form and size. In the upper elevations, the tundra takes over between 11,000 and 11,500 ft as the last colonies of subalpine fir and Englemann spruce drop out. Straggler trees assume the krummholz form, snaking their way along the ground, barely knee high, their forms sculpted by high winds, frigid temperatures, and heavy snow loads. In more benign locations, generally between 7,500 and 11,000 ft, timber harvesting is important in the San Juan National Forest. Large accessible tracts are managed with rotation periods that keep the forest from going beyond economic maturity, and there have been ravaging fires throughout the region in years past. So despite our early successes, these factors would seem to work against continuing discoveries of big and/or old trees. What actually happened is another story.

From 2008-2013, Lee Frelich, Don Bertolette, Rand Brown, Larry Tucei, Steve Colburn, Mark Rouw, Joan Maloof, John Davis, Bob and Monica Leverett, Laura Stransky and Laurie Swisher participated in and witnessed old growth and tall tree discoveries. Our searches were concentrated in:

- (1) the Hermosa Creek drainage
- (2) the Hermosa Cliffs
- (3) below Wolf Creek Pass
- (4) Engineer Mountain and Coal Bank Pass
- (5) the Piedra River
- (6) the HDs
- (7) the Bear Creek area of the Delores River
- (8) the Vallecito Reservoir
- (9) the beginning of the Colorado Trail
- (10) the high ridges surrounding Durango

Ponderosas, Douglas-firs, and Colorado blue spruces were measured to over 150 ft in height, and quaking aspens and narrowleaf cottonwoods to over 100. Ponderosas were measured to over 16 ft in girth, and Douglas-firs to over 12. And if that wasn't enough, a giant Rio Grande cottonwood stretched our tape to 26.6 ft. We explored the zone of Englemann spruce between 10,000 and 11,500 ft, and found many trees between 100 and 120 ft with a few topping 130 ft, and several exceeding 13 ft in circumference. This was a real eye-opener. It began to look like this elevation zone might support the culmination of forest stature at high elevation within the Rocky Mountain biome. Our special champion was a 141-ft tall Englemann spruce growing at 10,560 ft just below the summit of Coal Bank Pass.

At elevations ranging from 7,000 to 9,000 ft, a different forest presents itself. The old ponderosa pines command attention. And nowhere did we find more of them than in the watershed of Hermosa Creek as it cuts a gorge through the La Platas on its way to joining the Animas River north of Durango.

From a distance, the visual impact of the ponderosas is defined by the cinnamon-orange bark of long, straight trunks. The effect would be different were their bark darker, but the color sets the standard for what western pines should look like.

Here is a typical view from along the Hermosa Creek Trail:



The impact of the pines on the senses grows as one gets closer. The large bark plates of the older trees provides the visual experience, and their heady vanilla fragrance in the sun provides the olfactory counterpart. One feels that a special privilege has been bestowed as one strolls among these forest elders.

The ponderosas dominate over large areas and grow in a variety of habitats from dry to moderately moist. In the protected places along Hermosa Creek, I began confirming heights to over 150 ft, including the Schrater Pine at 160.3 ft, which was measured by Steve Colburn of Laser Technology, Inc., and myself. The tree made it into the *Durango Herald* and signaled the start of a wider local awareness of the superlative nature of the Hermosa Creek forests. Below is an image of an old-growth specimen with Monica in it for scale. The pine is likely over 300 years old (coring suggests 300-350 years to be typical age maximums for the species in the San Juans).



What were we finding in terms of overall tree size for the big ponderosas and Douglas-firs? Since 2008, we've found several huge ponderosas with girths exceeding 12 ft. A prestigious category of 12-ft girth x 140-ft height was created. These and other such categories mean little other than to distinguish the exceptional from the ordinary and to create a system of comparative analysis. Larry Tucei measured a huge pine on the Hermosa Creek Trail during our joint venture in 2013. We later named the tree in his honor. It is 13.6 ft in girth and 146.5 ft in height. The massive tree holds close to 900 ft³ of trunk volume. I later learned that in a prior year, Mark Rouw measured a ponderosa with a girth of 14.8 ft and height of 144 ft. In all likelihood, the pine exceeds 1,000 ft³ in trunk volume. We were getting a handle on size limits for the ponderosas.

A third species also made its presence felt—the blue spruce, Colorado's state tree. Its pointed spires and attractive foliage adorn many mountain slopes at elevations between 8,000 and 9,500 ft. But in moist, protected ravines, spruces can grow down to elevations of 7,500 ft. In those highly protected places, we began finding the species surpassing 140 ft, and occasionally topping 150 ft. I had not anticipated heights in this range.

The following image is near a campground on the west fork of the San Juan River at the base of Wolf Creek Pass:



These and the other discoveries pointed to a forested area with exceptional attributes within the Rocky Mountain biome. Others have noted that the San Juans have rich sites, but what does that mean on a comparative scale? It became increasingly clear we needed a team of high-powered tree measurers to visit the area and do some concentrated measuring in new places. It was also time to focus attention on the Southwest's old growth forest treasures in terms of their ecology, threats, and what their rings tell us about the climate of the past. Last year, several Durango friends agreed, and pitched in to help: Dr. Florence Mason, a consultant, and Dr. Jay Harrison, Director of the Center of Southwest Studies at Fort Lewis College.

In the fall of 2013, we began planning for an August 2014 conference to be held at Fort Lewis College. We would offer indoor presentations and outdoor field events. We were able to line up a good team of co-sponsors for the event:

- 1. Western Native Tree Society
- 2. Friends of Mohawk Trail State Forest (funding agent)
- 3. Fort Lewis College Center of Southwest Studies
- 4. The Mountain Studies Institute
- 5. The Tree-Ring Laboratory, University of Arkansas
- 6. Great Old Broads for Wilderness
- 7. Tree Climbers International, Laser
- 8. Laser Technology Inc.
- 9. American Forests
- 10. Seventy-Seven Outfit

On August 4 and 5 were devoted to the following indoor presentations:

- 1. Remarks on Area History and Lands, by Alden Naranjo Southern Ute elder
- 2. The Road Ahead: Climate Trends and Implications for Forests in Southwest Colorado by Marcie Bidwell, Mountain Studies Institute
- 3. Current Trends and Future Prospects for Old

Trees and Ancient Forests in the Southwest, and Globally, by Craig D. Allen, PhD, USGS, Bandelier, New Mexico

- 4. Effects of Wildfire in Old Growth Ponderosa Pine Stands on the San Juan National Forest by Laurie Swisher, Forester, U.S. Forest Service
- 5. The Big, the Bigger, and the Biggest: How We Measure Trees for Championship Status by Robert T. Leverett
- 6. Advanced Techniques for the Quantification of Giant Trees: Examples from Around the Globe by Dr. Robert Van Pelt, Research Forest Ecologist, Humboldt State University
- 7. Introduction to American Forests, by Lea Sloan, Vice President for Communications
- 8. Dating the Ancient Douglas-firs of Mesa Verde and What the Trees Teach Us by Dr. David Stahle, Director, Tree-Ring Laboratory, University of Arkansas
- 9. The Effects of Climate Change on Species in the Upper Midwest by Dr. Lee Frelich, Director, Center for Forest Ecology, University of Minnesota
- What We Have Learned About the Use of Natural Resources by the Ancestral Puebloans by Dr. Mark Varien, Crow Creek Archeological Center, Cortez, Colorado
- 11. Paleoforesty: Using Ancient Wood from Old Growth Forests to Reconstruct the Timber Procurement for Chacoan Great Houses by Chris Guiterman, PhD Student, Laboratory of Tree-Ring Research, University of Arizona
- 12. Lessons from a By-gone Era: What Past (and Present) Southern Pine Silviculture Can Tell Forest Managers in the Southwest About the Future by Dr. Don Bragg, Research Forester, U.S. Forest Service
- 13. Indian Melody and Pawnee Preludes by Composer Dr. Curt Cacioppo, Professor, Haverford College, and Pianist Monica Jakuc Leverett

The indoor part of the conference concluded with an evening of poetry and music for the trees, organized by Monica Jakuc Leverett. It presented winners of a poetry contest for Four Corners poets, and included music by Curt Cacioppo and Katherine Freiberger as well as other composers who featured nature in their compositions. In addition to pianists Monica and Curt, performers included oboist Jane Owen, sopranos Ruth Wilson Francisco and Brooke Snyder, and pianist Marilyn Garst.

We videotaped the lectures and hope to eventually have them available to NTS members. In a future article I will present the highlights of the lectures. I do not exaggerate when I say that conference attendees were mesmerized, and are still talking about the quality of the presentations. The indoor presentations demonstrated the accomplishments of science in understanding the ecology of our oldest southwestern forests, including their role in ancestral Puebloan culture.

The outdoor achievements to follow were of equal measure. Each deserves its own special treatment. So, I am breaking the coverage up into two Parts. The remainder of Part I covers the tree discovery events. The outdoor team included NTS President Will Blozan, Larry Tucei (Live Oak Larry), Matt Markworth, Mark Rouw (Iowa Big Tree Guy), Chris Morris, Dr. Bob Van Pelt, Steve Colburn (Director of North American Sales for Laser Technology Inc.), and myself. For our first outing, we also picked up a couple of scientists: Dr. Rob Blair, a geologist, and Dr. Tom Norton, a physicist, both retired from Fort Lewis College. Dr. Rob Blair is on the Board of Directors of Mountain Studies Institute.

August 2nd

Big tree hunting activities began formally with a trip to Coal Bank Pass and Engineer Mountain for a high altitude tall tree search. The team of Will Blozan, Bob Van Pelt, Matt Markworth, the two retired Fort Lewis College professors, and myself started at Coal Bank Pass to further the documentation of the Englemann spruce forest that had been previously explored by Don Bertolette, Rand Brown, Larry Tucei, and myself. The spruces appear to reach a climax state in the vicinity of Coal Bank Pass where specimens commonly surpass 120 ft in height and a few reach between 12 and 13 ft in circumference.



One objective was to test the old record of a 141-ft Englemann spruce growing at 10,560 ft. The tree exceeds all others in the vicinity. Bob Van Pelt used his Impulse 200 Laser to lock in the numbers while Will Blozan and Matt Markworth searched elsewhere. Will and Mark proved to be the racehorses among the group in terms of covering ground. Our best search strategy was to turn them loose to cover ground, and try to catch up when we heard an excited yell.

We eventually reached the current high altitude champion Englemann (above 11,000 ft). Larry Tucei and I had measured it the year before at 134 ft. Will re-measured it from far upslope so that there was no question about hitting the absolute top. The updated measurement is 134.7 ft at 11,060 ft. A nearby spruce, dead now, measured 135 ft.

I doubted that these numbers would be topped. But going a short distance off trail, Will locked in on an Englemann spruce that we confirmed with my TruPulse 200X at 137.5 ft. It grows at an elevation of 11,164 ft, setting the bar a bit higher for maximum tree height at 11,000 ft or more. Will Blozan measured a subalpine fir in the vicinity to 118.5 ft. Several other Englemanns measured by Will and/or Matt at 11,000 ft or slightly above topped 130 ft. Will is convinced there are many in that drainage. I do not question his eye.

It was absolutely clear that at the altitude of two miles or more, there are countless Englemann spruces in the region that surpass 120 ft in height. However, one must go off trail to find these elusive trees, hidden in steep drainages that retain deep snow packs, and thus have sources of moisture well into summer.

My main objective in selecting Coal Bank Pass and environs as our first group destination was to get Bob Van Pelt's interpretation of the Englemann spruce growing on the slopes of Engineer Mountain, and in general at elevations above 10.000 ft. I had measured trees northward to Montana, on both eastern and western slopes of the Rockies, and I had a sense that the San Juans might represent a culmination of tallness at high altitude-perhaps within the entire Rocky Mountain biome. I was reluctant to extend the zone geographically to the West Coast, but within the Rockies, by the time one reaches northern Wyoming, the alpine zone has dropped to 10,000 ft or less. Thereafter, it only gets lower with increasing latitude. Where could I match what I was seeing in the San Juans? Northern New Mexico is a candidate, but my limited forays into the New Mexico Sangre de Cristos had not produced trees of comparable stature.

As we searched and measured trees on August 2nd, Bob was putting what he saw into a geographical context, and by day's end, he was willing to entertain the thought that the San Juan Mountains indeed could lay claim to being home to the tallest forest within the western hemisphere north of Mexico.

Bob has explored the Sierras, Cascades, and Great Basin ranges, as well as the Rockies. He has an encyclopedic knowledge of species and where they do their best. There is nobody better qualified to make such a proclamation than he. Bob later repeated his belief during the indoor sessions. As far as I'm concerned, it is up to others to prove us wrong. They will have to do it with numbers obtained from comparably accurate measurements. Maybe the Utah Uintas can give the San Juans some competition. I don't know.

Turning from the skill of tree measuring to science, what are the environmental, geological, climatic factors, etc. leading to the remarkable performance of the San Juan forests? I posed these questions to Rob Blair of Mountain Studies Institute, and hopefully, a partnership will develop in which the Native Tree Society, through its western arm, can supply data to the institute in the search for answers to these and other questions. Eventually the use of LIDAR will provide reliable, region-wide data on tree dimensions, but in the interim, we have a role to play.

August 3rd

The tree adventures of August 3 belonged to NTS members Matt Markworth from Ohio and Chris Morris from Nevada. According to Matt's account, Chris has an eagle eye, and spotted an extremely tall-looking ponderosa pine on the Hermosa Creek Trail. At 162.3 ft tall and 8.6 ft in girth, it sets a new height record for subspecies *scopulorum*. Matt named the tree the Rouw Ponderosa Pine in honor of Iowa Big Tree Guy Mark Rouw who had spotted the pine the previous year, but didn't have the time to take precise measurements. The previous height record belongs to the Dr. Faye Schrater Pine at 160.3 ft.

August 6th

This day started a period destined to make tree discovery history for the San Juans. Outfitter extraordinaire Sandy Young took Will Blozan, Larry Tucei, Chris Morris, and Matt Markworth on horseback with Mark Rouw, Laurie Swisher, and Nikki Jones trekking on foot. In Stony Gulch, the team measured a Colorado blue spruce to a height of 164 ft, tallest known at that point, as measured with laser, clinometer, and the sine method. The team also confirmed a white fir to the eye-popping dimensions of 157.5 ft in height and 10.5 ft in girth. Our previous height record had been for a fir measuring 146 ft at the base of Wolf Creek pass, discovered by Mark Rouw years before. In 2013, Mark and I measured a couple of white firs to the mid-130s along the Hermosa Creek Trail. The 146-footer appeared to me to be something of a statistical outlier at the time.

The team continued on toward Dutch Creek for a rendezvous with the 17-ft girth, 161-ft tall Douglas-fir that Sandy Young had visited for years. This huge Douglas-fir is now the state champion. In the image below Will Blozan, at about 6 ft 2 inches in height, stands next to the fir.



Trunk volume is another measure of tree size. This fir likely has at least 1,500 ft³ of volume, if not more. A simple calculation using a form factor of 0.4 would give the tree 1,480 ft³. However, the taper is slow enough that a factor if 0.42 or more is justified for volume estimating purposes. The factor 0.42 would yield 1,555 ft³.

To do justice to all concerned, Mark Rouw visited the Douglasfir the year before, taken there by outfitter Sandy Young. Evidently, Sandy had visited the tree for years. Below is another view of the tree.



Although the Outfitter Fir was not a new find for the team, exciting discoveries awaited along the path to the tree. One find was especially significant.

Will Blozan spotted a double-topped blue spruce in the distance. His eye told him that if the base was low on the slope, the team had a real find. The base was. After the team thoroughly measured the big spruce, Will reported, via text message, its measurements of 165.5 ft with a girth of 12.4 ft, and an average crown spread of 32.5 ft. It was a new height champion for the species and maybe a contender for national champion. Its dimensions earn the tree 324 points on the American Forests champion tree list and does put it into competition with the official national champion, a tree in Utah, which earns 332 points. Trees with point totals within 5% of each other can be treated as co-champions. However, the accuracy of the height measurement for the Utah tree is unknown. The heights of most trees in the champion tree lists have been certified by the use of tape and clinometer measurements. For trees with tops that are easily visible and vertically positioned over their bases, tape and clinometer measurements usually suffice. However, as we know so well in NTS, tape and clinometer measurements are often in error and in the direction of being over rather than under.

American Forests has decided to handle the situation at this time by considering the two trees to be co-champions. In the future, certification requirements will be tightened. Ample photographs will be required to reveal the shape of the trunk at DBH point. The Sine Method will be required for new certifications. And in time, a group of highly skilled measurers called the National Cadre will be used to certify all nominations. The era of mis-measured trees making it into the National Register is about to end. Below is a close-up of the cochampion-to-be. In the photograph from left to right are: Will Blozan (standing), Matt Markworth (squatting), Chris Morris, Larry Tucei, and Mark Rouw.



During the trek to the Outfitter Fir, and the discovery of the cochampion Colorado blue, the team would also confirm other towering blue spruces: 164, 164, and 157 ft. It was clear that these drainages harbor blue spruces that may fairly commonly reach heights of 150 ft. Ample protection and sufficient water provided in the drainages seems to be the habitat that the tall blues exploit.

While the main team went well upstream, Bob Van Pelt, Steve Colburn and his wife Bea, and I, followed the main Hermosa Creek Trail looking for important trees along the streambeds that feed the Hermosa Creek, staying on the uphill side. In one ravine, we measured a large ponderosa that just makes 148 ft in height with a girth of 12.8. I believe it is a pine discovered a few years before by Rand Brown. Its trunk is a solid column and it sports a big crown. It is hidden from view from the main trail, as are many other worthy specimens, reminding us of how few of these big trees we have actually documented.

A ponderosa of the dimensions and shape as shown below (with Bob Van Pelt) is likely to have a trunk volume of between 800 and 900 ft³. I expect that there is a scattering of San Juan ponderosas that reach $1,000 \text{ ft}^3$ of trunk volume. I am not of the opinion that we would find them much larger.



On our way up the trail, we stopped and re-measured a southwestern white pine at 127.5 ft. This is the tallest we have measured to date.

August 8th

The team of Matt Markworth, Larry Tucei, Mark Rouw, and Chris Morris continued piling up the records. Their exploration of Clear Creek, a tributary of Hermosa Creek, produced an Englemann spruce measuring 152.5 ft in height and 9.6 ft in girth. It was a team effort. The tree grows at slightly over 8,900 ft elevation. It is the only Englemann in Colorado that we've measured exceeding 150 ft in height. I thought I had spotted one previously on Goulding Creek, but it turned out to be a Colorado blue.

August 9

The 9th began a period of discovery by Matt Markworth that continues to dazzle us. It is a testament to what grows in wild places that are otherwise difficult to access. Matt returned to Clear Creek, eventually confirming a quaking aspen there to 115 ft. That broke the previous record of 113 ft and illustrated the aspen's capacity to reach 100 ft in good growing conditions. Popular descriptions of the species quote a maximum height of anywhere from 50 to 80 ft. We knew better, having topped 100 ft for the species on several occasions.

Matt measured a huge broken blue spruce at 13.1 ft in girth. Matt also discovered a "sweet spot" that supported a Colorado blue measuring 155.5 ft tall, 12.9 ft in girth, and an average crown spread of 33.5 ft.

August 11

Matt's exploits were far from over. He returned to Jones Creek, dropping down the steep drainage toward Hermosa Creek, avoiding the plunging rock ledges, and eventually confirmed a white fir to a mindboggling 162.4-ft height with a respectable 9.8-ft girth. This was a new height record for the species in Colorado. Matt also confirmed another tall Colorado blue to 158 ft. It was now abundantly clear that the Hermosa Creek Gorge had tightly held on to its secrets, but was finally willing to divulge them.

August 13

Matt reported measuring a Colorado blue on the opposite side of the creek to 162 ft and 9.1 ft in girth. It became the fourth 160-footer measured on by a member of the team.

August 14

August 14th was a day for Matt like no other. It is best to hear what he found through his own words. I quote him below:

Well, Hermosa called me back and my motivation level seemed higher than ever. I set out in the rain down the second cattle guard and hiked/slid my way down. I wanted to see what this section of Hermosa Creek could produce, knowing that it would have been more accessible to logging in the past. After walking quite a ways upstream, I came to the conclusion that it probably had been logged and I came back up, still south of the campground, through two cliff faces. I've never been so appreciative of having vegetation (mostly Gambel oak) for footholds and handholds. It was time to revisit the strategy of checking out the lower reaches of the side creeks that drain into Hermosa Creek.

I'm glad I came back to Hermosa. Her beauty and awesome tree growing potential were on full display on this day. Sunshine prevailed in the afternoon and I would measure the tallest tree that I ever have. Navigating another drop off, I descended down a steep slope into the recesses.



A double-topped Colorado blue spruce [pictured above] revealed itself. Memories of Will's find a week before flashed through my mind. If the tree extended to the very bottom, like Will's did, then what a tree it would be! Continuing down the creek and approaching the trunk, with the top no longer visible, I shot the laser to the highest point that I could see and got over 170 ft. This would be Colorado's tallest known tree of any species and the tallest known blue spruce across its range. I wrapped the tape at breast height for a good target for the TruPulse 200. Climbing the south-facing slope provided a perfect view all the way to the bottom and all the way to the top. The height came in at 178.8 ft. I sat and admired the tree, got a few more shots to the tape and to the top to confirm the height and gave Bob a call. "Bob," I said. "Are you sitting down?"

Matt was later to name the Colorado blue the Protect Hermosa Tree, a fitting name for such an important tree, and one firmly establishing the dominance of the species in Colorado. Is the Protect Hermosa Tree a statistical outlier? My current belief is that it is, but only a lot more searching will let us answer that question decisively. We are now confident that the Hermosa Creek drainage harbors many 150-ft Colorado blues. Elsewhere, we have measured them on Clear Creek, Goulding Creek, and near the Piedra River. At the base of Wolf Creek Pass, we have measured them to the mid-140s, and on Bear Creek feeding the Dolores River on the western slopes of the La Platas. We have no data on tall Colorado blues elsewhere, although I have measured a few in the Sangre de Cristos to slightly over 130 ft. Visitors to the San Juans commonly see Colorado blues that are not especially old since the road corridors are, or were, logging routes. Finding the exceptional trees is more commonly a bushwhacking exercise. In Matt's case, finding the 178.8-footer was extreme bushwhacking. The previous image shows most of the tree.

August 15

Matt's big/tall tree exploits were to have one more chapter. He returned to the region harboring the super tall Colorado blue. Following a slightly different path, he spotted a Douglas-fir, unfortunately mostly dead. Its statistics turned out to be: height = 169 ft, girth = 10.3 ft, and average crown spread, a narrow 22.5 ft. Matt had done it again. He had just measured the tallest know Douglas-fir in Colorado. He can lay legitimate claims to having measured the tallest Colorado blue spruce and white fir in Colorado and participated in the measurement of the tallest ponderosa pine, Englemann spruce, narrowleaf cottonwood, and quaking aspen in the Centennial State. The contributions of Will Blozan, Larry Tucei, Mark Rouw, and Chris Morris are not to be understated in the team effort.

Tal	ble 1. San	Juan N	Iountains	(Colorad	o) l	Rucker	Index
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Species	Location	Height (ft)	
Colorado blue spruce	Silver Creek	178.8	
Douglas-fir	Silver Creek	169.0	
White fir	Hermosa Creek	162.4	
Ponderosa pine	Dutch Creek	162.3	
Engelmann spruce	Clear Creek	152.5	
Southwest white pine	Jones Creek	127.5	
Subalpine fir	Engineer Mountain	118.5	
Narrowleaf cottonwood	Hermosa Creek	117.0	
Quaking aspen	Hermosa Creek	115.0	
Rio Grande cottonwood	Durango	112.3	

Rucker Height Index

The tall tree discoveries of the team, and especially Matt Markworth, gave us enough species to compute a Rucker Height Index for the Durango region. Table 1 tells the story of the remarkable achievements of the team.

SUMMARY

Beyond the enumeration of big tree/tall tree discoveries, what are we to take away from the Durango experience? First, there are vast unexplored tracts in the San Juans that likely harbor a few trees comparable to those we measured. The San Juans cover an area exceeding 12,000 square miles by a rough outlining in Google Earth. We have barely penetrated the region. So, there is plenty of opportunity remaining. The big/tall trees occur mainly in the protected stream corridors. Developing a search strategy will not be difficult. Carrying it out will.

Our August Durango experiences reveals the gulf between what we know in the Native Tree Society and what was more generally known about individual species maximum growth attainment, especially maximum height. Measuring isolated trees for big tree contests is fun and we in NTS are an important part of that, but more significantly, we can determine, better than any other present day organization, the maximum dimensions achieved by those species that interest us, and how each species behaves across its full geographical range. It is, admittedly, niche science that we do, but it is real. Here is an example.

The Colorado blue spruce is described in many sources including the prestigious *Silvics of North America*. This source says:

It is a slow-growing, long-lived tree of medium size that, because of its symmetry and color, is planted extensively as an ornamental. Because blue spruce is relatively scarce and the wood is brittle and often full of knots, it is not an important timber tree.

No maximums are cited for the blue spruce, although Silvics does so for many other species.

Virginia Tech's distinguished Department for Forest Resources and Environmental Conservation says: "A medium to large tree with pyramidal form reaching up to 80 feet tall. Branches appear layered, especially with age." Wikipedia says: "In the wild, *Picea pungens* grows to about 23 m (75 ft), but when planted in parks and gardens it seldom exceeds 15 m (49 ft) tall by 5 m (16 ft) wide." Iowa State Forestry Extension says: "Height: 30 to 60 feet under average landscape conditions (90 to 135 feet in the wild)". The Arbor Day Foundation says:

A magnificent sight of silver blue-green spruce. Rated one of the most popular evergreens. It grows well while young and matures at 50-75'; 10'-20' spread in the landscape, up to 135' and 35' spread in the wild. (zones 2-7)

And, lastly, Colorado State University's website for tree descriptions says: "Height: 70 to 115 feet."

The NTS team measured many Colorado blues exceeding 150

ft in height, and Matt Markworth's amazing 178.8-footer puts the species in a different category. Is this just southwestern Colorado? To some extent, probably, but I expect that throughout much of Colorado, where the growing conditions are favorable, the Colorado blue will reach heights of between 130 and 140 ft. But outside the San Juans, are there sweet spots supporting 150-footers, and on occasion spruces topping 160 ft? This remains to be determined.

Regardless, the species emerges, courtesy of our discoveries, to be a much statelier tree than most descriptions of it. There are hints by some authors that they do not think the species is meant to be a yard tree, indicating that it grows best in the wild state. Perhaps there is a lesson here that we need to think about.

We are currently laying the groundwork for a tree-measuring workshop next summer in Durango sponsored by American Forests, the Native Tree Society, and hopefully others, to train members of the National Cadre. We will probably be working with the Mountain Studies Institute to undertake an intensive documentation of the species listed in the Rucker table. It will be our contribution to science: highly accurate measurements that give us a reliable profile of what southwestern Colorado tree species can achieve, dimension wise.

I will conclude Part I with a photograph from an overlook below Wolf Creek Pass that provides a bird's-eye view of the rich habitat that supports some of the outstanding trees of the San Juans.

LITERATURE CITED

Peel, J. and P. Pixler. 2004. Hiking trails of southwestern Colorado. 4th ed. Pruett Publishing Company, Boulder, CO. 338 p.

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The Wolf Creek Pass area in southwestern Colorado. All photographs in this article are courtesy of Robert T. Leverett.



COMPARING TAPE DROP HEIGHT TO THAT OBTAINED WITH A NIKON 440

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Editor's Note: This paper is an adaptation of a post to the Native Tree Society BBS by the author.

Tape drop is considered the definitive measure of a tree's exact height, but climbing a tree to measure its height is usually not feasible. A recent publication (Bragg et al. 2011) reported on measuring 42 trees using the NTS sine method with a TruPulse 200 hypsometer and compared the height to that obtained by tape drop. Many of these trees were in the 150 ft range and they found a height discrepancy for those specimens ranged from -1.9% to +1.4%, with a standard deviation of 0.64%. In other words, 68% of the time (definition of one standard deviation) one could expect that the sine-based measurement would be within 0.64% of the tape drop measurement. On a tree 150 ft tall, that equates to less than one foot. Or, as the Bragg et al. (2011, p. 6) put it:

Hence, with the accurate laser rangefinders and electronic clinometers available today, instrument error when measuring total tree heights with the sine method can be expected to be consistently less than 1 percent for experienced users.

I was curious to know how accurate my Nikon 440 laser range finder and Suunto clinometer are when compared to a tape drop. To my knowledge there hasn't been a careful experiment done to answer that question for the Nikon 440. The manufacturer-stated accuracy of the TruPulse 200 is ± 0.1 yds and for the Nikon it is ± 0.5 yd. It is widely accepted that the accuracy of the Nikon 440 can be improved through instrument calibration. Even so, I embarked on this study with the expectation that the Nikon 440 might only be accurate to within 3% of tape drop accuracy. I'm happy to say that I had underestimated the Nikon's capabilities.

METHODS

I measured the total height of four loblolly pines (*Pinus taeda*) ranging in height from 126 to 141 ft tall. The pines were situated on three sites near Chapel Hill, North Carolina, that I located using LiDAR data obtained from Doug Newcomb, Cartographer at the Raleigh, North Carolina field office of the US Fish and Wildlife Service. The first two pines are located in a stately grove of Loblolly pines along Morgan Creek near the North Carolina Botanical Gardens. I used satellite imagery from Google and Bing to narrow the list of sites to those on publicly accessible land that were most likely to contain tall pine trees. Loblolly pines are common in the Piedmont of North Carolina and are ideal for this experiment because they have tall, straight boles and conical tops with easily identified height maxima.

I measured the trees from the ground first using the NTS sine method. Each tree was measured from at least three locations on different sides of the tree, often on two different days. I had previously calibrated my Nikon 440 to determine the needed correction factor. I recalibrated it in February 2014 with nearly the same results. I should point out that I have found it impractical in a woods setting to always step back or step forward to LRF "click over" in order to take a measurement – usually there is only a small window through which to point the laser and often taking a step back or forward puts underbrush clutter in the way of a clear view to the tallest point of the tree. For this reason when I calibrate my LRF, I average the reading of four measurements for each reference point – two readings walking backward to click over and two readings walking forward to click over.

Here are the details of my calibration protocol: I calibrate the LRF by measuring the distance to the side of a brick shed at the end of a long, level parking lot. I stake the end of a 300-ft tape measure at the base of the shed and extended it past 80 yds (240 ft). I record the actual distance (tape measure reading) at 10-yd intervals between 20 and 80 yds as measured on the LRF. For example, I step backward until the LRF says 20 yds and then record the actual distance from the tape measure. Then I step forward until the LRF reads 20 yds and record the actual distance at that point. I repeat both measurements once more and then average all four measurements for the 20 yd distance. Then I repeat that process for the 30, 40, 50, 60, 70 and 80 yd reference points. At each point the standard deviation of the four averaged measurements was between 0.4 and 0.5 ft, indicating that most any measurement returned by the LRF can be trusted within an accuracy of 6 inches or less. Comparing the LRF reading at each 10 yd reference point to the average of the four measurements from the tape measure allows me to determine a correction factor for each range distance:

subtract 0.8 ft for measurements between 0 and 19.9 yds subtract 0.9 ft for measurements between 20 and 29.9 yds subtract 1.0 ft for measurements between 30 and 39.9 yds subtract 1.1 ft for measurements between 40 and 59.9 yds subtract 1.2 ft for measurements between 60 and 79.9 yds subtract 1.25 ft for measurements over 80 yds

I then used a spreadsheet program on my iPad to calculate the total height (*HT*, in ft) in the field based on the equation:

$$HT = [((LRF_{top} \times 3) + CF) \times \sin(A)] + [((LFR_{base} \times 3) + CF) \times \sin(B)]$$

Table 1. Comparison of tape drops and Nikon 440 and clinometer height estimates following the sine method for four loblolly pines from North Carolina.

	т	o ton	Та	hass	Unight	Diver	gence
Specimen (other information)	(yds)	(angle)	(yds)	(angle)	(ft)	from ta (%)	in.)
Loblolly #1 (approximate GPS coordinates	s: -79.03,	35.89; LiDAR s	uggested heig	ght = 123 ft; CE	3H = 7.1 ft)		
tape drop on 2/10/14					127.75		
LRF reading 1 on 2/4/14	58.5	43.50	44.0	2.75	126.26	-1.17	-18
LRF reading 2 on 2/8/14	61.0	42.00	47.0	2.00	126.53	-0.95	-15
LRF reading 3 on 2/8/14	57.0	46.00	40.5	3.00	128.45	0.55	8
average of LRF measures					127.08	-0.52	-8
standard deviation of LRF measures					1.19		
Loblolly #2 (GPS coordinates: -79.03, 35.89); LiDAR	suggested heig	ght = 140 ft; C	2BH = 7.4 ft)			
tape drop on 3/31/14					141.25		
LRF reading 1 on 2/4/14	58.0	52.00	37.0	1.50	139.05	-1.56	-26
LRF reading 2 on 2/8/14	55.5	55.25	32.5	2.00	139.19	-1.46	-25
LRF reading 3 on 2/8/14	64.0	44.75	45.0	3.00	141.33	0.06	1
LRF reading 4 on 2/8/14	71.5	41.25	54.5	0.75	142.76	1.07	18
average of LRF measures					140.58	-0.47	-8
standard deviation of LRF measures					1.79		
Loblolly #3 (GPS coordinates: -79.06, 35.90); LiDAR	suggested heig	ght = 139 ft; C	2BH = 7.1 ft)			
tape drop on 2/20/14					139.66		
LRF reading 1 on 2/18/14	57.0	50.75	36.5	4.50	140.00	0.24	4
LRF reading 2 on 2/18/14	60.5	55.00	36.5	-4.00	140.12	0.33	6
LRF reading 3 on 2/18/14	50.5	58.00	26.0	8.75	139.19	-0.34	-6
average of LRF measures					139.77	0.08	1
standard deviation of LRF measures					0.51		
Loblolly #4 (GPS coordinates: -78.97, 35.94	4; LiDAR	suggested heig	ght = 125 ft; C	CBH = 11.4 ft)			
tape drop on 3/28/14					126.75		
LRF reading 1 on $3/4/14$	50.5	52.25	33.0	5.00	127.38	0.50	8
LRF reading 2 on $3/4/14$	49.5	52.75	32.0	4.50	124.78	-1.55	-24
LRF reading 3 on $3/4/14$	52.0	50.00	35.0	4.00	125.84	-0.72	-11
LRF reading 4 on $3/28/14$	55.0	47.25	40.0	2.00	124.43	-1.83	-28
average of LRF measures					125.61	-0.90	-14
standard deviation of LRF measures					1.33		

where *LRF* is the distance reading from the Nikon 440 in yards to the top or base, *CF* is a correction factor determined from the calibration process, and *A* and *B* are top and base angles, respectively. I did not calibrate my Suunto clinometer since extensive conversations between Karl Heinz, Bob Leverett and others on the NTS bulletin board indicated that clinometer error is essentially negated when combining crown and base angle measures.

RESULTS

Angle, distance and resulting sine-based height calculations are listed in Table 1 along with the CBH, date of measurement, and rough GPS coordinates of each tree. Within a few weeks of the ground based measurements I climbed each tree and measured the trees by tape drop. It is best to have a ground helper when performing a tape drop, but I couldn't convince anyone to come out to the woods with me for a few hours at a time in February/March. The person on the ground is helpful because they can position the tape at the correct point at the base of the tree and provide tension while the climber reads off the measurement. A ground person with the right perspective can also let the climber know when a telescoping measuring pole is at the same height as the tallest twig of the tree.

Since I was performing the tape drops myself, I carried a 200 ft construction tape measure into the canopy and lowered the end directly to the ground using a brightly colored, 1 pound throw bag as weight. In each case it was easy to tell when the bag hit the ground both by visual confirmation and because the tension on the tape relaxed. In each tree I could climb safely to within 10 ft of the highest point. When I reached that point I used a metal tape measure to record the remaining distance to the top of the tree. Then I added the numbers from the upward measurement to the tape drop measurement to obtain the total height. Although I did not have a ground helper, I have no reason to believe that my tape drop measurements are off by more than 2 inches. Tape drop measurements, dates, and comparison to sine-based ground measurements are listed in Table 1.

CONCLUSIONS

1). The average divergence was 0.49%, but that value is misleading because some LRF values are high (positive divergence values) and some are low (negative divergence values) so the average looks artificially low. For that reason it is more informative to look at the absolute value of the percent divergences. The average of the absolute values of all the divergences was 0.88% with standard deviation = 0.57%. The range of the divergences was -1.83% to +1.59%. These numbers are almost exactly what Bragg et al. (2011) reported for the TruPulse.

2). I have heard some NTS members state that when taking multiple sine based measurements on the same tree they will throw out all but the highest measurement assuming that in that attempt they found the true highest point in a nested crown and in the others they were not measuring the highest sprig in the crown. Interestingly, I noticed that in two out of four trees in this small study, the highest LRF measurement I recorded was actually the most accurate measurement (lowest percent divergence from tape drop). This observation lends some credibility to the practice of throwing out all but the highest sine-based height value. However, even though the tallest measurement was the most accurate in half the cases, it was also an overestimate of the true height in 4 out 4 cases.

3). In three out of four cases (Loblolly #4 being the only exception), averaging the LRF measures from different sides of the tree resulted in a height value that was closer to the tape drop measure. That leads me to conclude that when possible it is better to average multiple measurements from different locations around the tree.

Overall, I'm happy to learn that the Nikon 440/Suunto clinometer pairing is very good at estimating the height of woods grown trees up to 140 ft tall. I think it is safe to reaffirm that the Nikon 440 is an excellent low-cost alternative to the TruPulse brand hypsometers and that percent divergence from tape drop measurements is comparable between the two instruments.

LITERATURE CITED

Bragg, D.C., L.E. Frelich, R.T. Leverett, W. Blozan, and D.J. Luthringer. 2011. The sine method: an alternative height measurement technique. USDA Forest Service Res. Note SRS-22. 11 p.

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View from the top of loblolly pine #2. Photograph courtesy of Patrick Brandt.



SCIENCE, PASSION, AND GETTING PERSONAL

Edward Forrest Frank

Eastern Native Tree Society

Why do scientists pursue science with so much vigor and enthusiasm? It is because of the passion we have for our subjects. Even what would appear to be the most boring subject of a lecture can be invigorated when the speaker is passionate about the subject. When the listener sees the speaker's eyes light up with that passion, it enables the listener to share in that experience with the speaker. I have watched the Charlie Rose Show and listened to his guests and have been enthralled by some of the guests speaking on the most mundane subjects because of their passion for their subjects.

I think research scientists and artists share much in common. Both groups delight in the product of their efforts without concern for how practical it might be. In one the search is often for knowledge for its own sake, the simple delight in "knowing." There is the story of Harlow Shapely who in the early 1900s figured out the size of the Milky Way and discovered that the sun was located in a non-descript corner of the galaxy. It was late at night when he finished his calculations. He sought out the only other person in the building, a cleaning lady, and explained his discovery to her, saying they were the only two people on Earth that understood it. It is this excitement about pure knowledge, even if there is not an immediate practical application that drives scientists, like the creation of art that drives artists.

As a scientist we are told to remain dispassionate about our subjects so as to not introduce bias into our results. We are not assembly workers on a production line. There is no science without passion. What we can do is to use protocols to limit bias in our analysis, but I don't think there can be science without passion. The passion is to find what is true rather than to find a desired answer. In 2004, Robert Leverett wrote about the Eastern Native Tree Society in an essay called "Looking Back":

What keeps ENTS from being exclusively research-oriented is the value judgments we make. We get up close and personal with the trees and forest sites. In doing this, we may appear to violate the impersonal requirement of objective science. But we can keep different objectives separated in our approaches. We just want the range of future researchers to be able to go beyond an either or dichotomy: superficial public site descriptions at the one extreme and heavy scientific data at the other. We want future generations to know not only about the ecology of Cook Forest State Park's Forest Cathedral, but also about the Longfellow pine and Seneca pines. We want people to know which trees were climbed, when, and the results. Individuals matter to us, and if they don't to others, they should. (http://www.nativetreesociety.org/threads/looking_back.htm)

This comment came back to me as I was looking on the web for material about Jane Goodall, the famous primate specialist who did groundbreaking work with chimpanzees. She is giving a talk at a university here in Pennsylvania in a couple weeks and I am planning to attend. I came across this video interview, it lasts only a couple of minutes and discussed criticisms she received when she named her chimpanzee subjects and interacted with them. It talks about passion, and getting personal, and where she thinks science has gone wrong. Dr. Goodall says in the video (https://www.youtube.com/watch?v=0Qu7Wn1mRYA) "I was told you have to give them numbers because you have to be objective as a scientist and you mustn't empathize with your subject. And I feel this is where science has gone wrong. To have this coldness, this lack of empathy, has enabled some scientists to do unethical behavior." In a different interview, Goodall also says empathy can bring a better understanding of animal – and human – behavior, adding, "I think only when our clever brain and our human heart work together in harmony can we achieve our full potential." (http://www.huffingtonpost.com/2014/09/04/jane-goodall-video-science-gone-wrong_n_5765260.html)

I believe individuals, whether a scientist or simply an enthusiast, should go forth and be passionate about your subject. Allow yourself to become personal about individuals. Allow yourself to feel and explore the range of logic and emotion inherent in your subject and work. Allow yourself the joy of discovery and simply knowing. Dispassionate comes into play when you are analyzing your data, when you are analyzing your sampling protocols, when you are forming your conclusions. And even though they might be redlined in a professional publication, include in your analysis non-quantifiable observations that help in the understanding of the subjects and processes you are observing.

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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:

Don C. Bragg Editor-in-Chief, Bulletin of the ENTS USDA Forest Service-SRS P.O. Box 3516 UAM Monticello, AR 71656

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, but does imply the consent to do so.

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, leftjustified, 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 twoauthor 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. 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.



A winding gravel road leads to the Aldo Leopold Center near Baraboo, Wisconsin. Photograph by Don C. Bragg.