Big Trees, Old Trees and Growth-Factor Tables

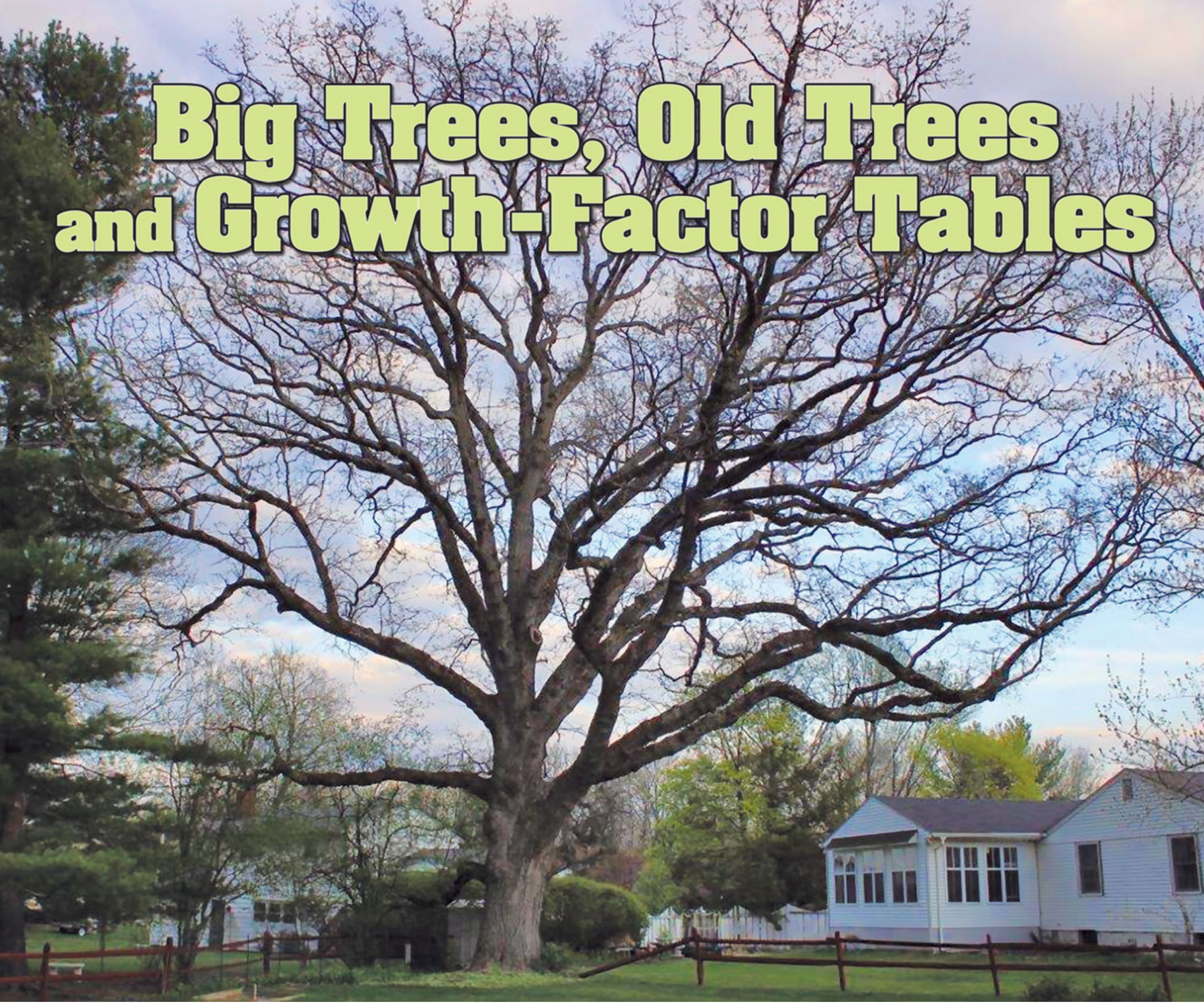

Figure 1. What land-ownership changes has this mature oak witnessed at the agricultural-urban interface? John Mungo, whose property this tree is on in Goshen, New York, measured its circumference at breast height to be 15 feet 2 inches. Thomas J. Martin, owner of Tommy Trees, Inc., a TCIA member company based in Chester, N.Y., has provided some care for the tree and speculates that it could be as much as 300 years old. This and the cover photo courtesy of John Mungo.

By Kevin T. Smith, Ph.D.

The seed for this article was a question from John Mungo, a Goshen, New York, resident with a large oak on his property. He wanted to know some of its history and asked how to determine the age without injuring the tree. We hope this article at least partially answers that question.

The potential for a tree to reach a great size and to live a long life frequently captures the public's imagination. Sometimes the desire to know the age of an impressively large tree is simple curiosity. For others, the date-of-tree establishment can make a big difference for management, particularly for trees at historic sites or those mentioned in property deeds, literature or historical documents (Figure 1). If we know with certainty that a tree is 150 years old, we can be sure that the shade of that tree didn't inspire a poet or revolutionary from 200 years ago. We know that trees tend to increase in size as they age. Can age be determined for mature landscape trees by simply measuring tree circumference or diameter?

Tree age and size

Some organizations produce tables of "growth factors" of various tree species to provide age estimates from size measurements. The process usually involves passing a tape measure around the trunk at 4.5 feet above groundline to determine the stem circumference. The circumference can be divided by pi (π, approximately 3.14) to yield the diameter at breast height (DBH). Specialized diameter tape measures have the circumference-to-diameter conversion already made in the scale markings. Depending on the particular table, either the diameter or circumference is multiplied by the listed growth factor to give tree age, usually accompanied by a caution that the age given is an approximation.

Based on local experience, a forester or an arborist may know that a 2-foot DBH red maple is usually about 75 years of age, while an eastern cottonwood of the same size at the same location might be less than half that age simply due to inherent differences between species. The amount of confidence to have in such estimates is hard to assess, as they are rarely checked against actual observations. Even when valid, this sort of experience is not readily transferred to other locations or growing conditions.

Anatomy of growth

Trees increase in diameter through cell division of the vascular cambium (VC). The VC forms a continuous layer beneath the bark and to the outside of the pith or existing wood of roots, stems and branches. Cells in the VC divide to produce phloem ("inner bark") and xylem. Xylem produced by the VC matures into the wood that provides structural support, transportation conduits and storage repositories for living trees.

The wood of many tree species in the temperate zone appears in cross-section as tree rings, a series of visibly distinct annual layers or increments of wood. Ring boundaries in many conifer species appear as the contrast of relatively thick-walled and dark "latewood," formed late in the growing season, with the thin-walled and lighter-colored early wood, formed in the succeeding year. Ring-porous hardwoods such as oak have ring boundaries marked by the large-diameter pores or vessels formed to the outside of the fine-grained latewood of the previous growing season. The ring boundaries of diffuse-porous hardwoods such as birch and maple are especially difficult to see without good smoothing of the cross-section with sandpaper or a carpenter's plane.

Tree-ring anatomy including ring width varies in response to the innate genetic program, tree age and size, environmental conditions such as temperature, soil moisture and soil fertility, and disturbance factors such as defoliation, disease or mechanical injury.

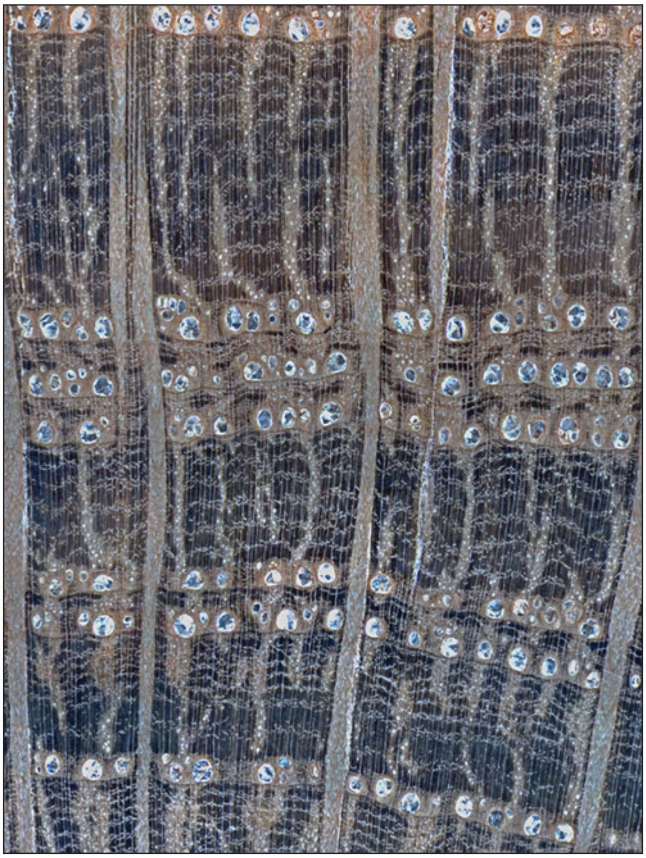

Figure 3. Microscopic view of variation in the width of six complete annual rings of white oak in southern Missouri (bark side to the top). Is average ring width a useful concept here? All graphics courtesy of the author.

Ring counting and dendrochronology

The simple counting of rings provides an estimate of the number of years of growth contained in the cross-section of the sample. In fast-growing trees that are dormant during winter cold, the age estimate from ring counting may be reasonably accurate. In trees that are slow growing, stressed by pests or disease or with growing seasons interrupted by pronounced drought, age estimates from ring counts become unreliable (Figure 2).

Determining the correct calendar year of formation for an individual tree-ring is the task for the art and science of dendrochronology. By assigning a date to each ring through to the tree pith, an accurate and precise age for a tree may be determined. Dendrochronology is far more than "counting the rings"!

First, samples from multiple trees need to be collected for comparison, most often from increment cores or from stumps following tree removal. Increment cores are narrow cylinders of wood cut from the bark toward the tree center using a specialized borer. Coring injures trees. Vigorous, healthy trees do tolerate borer injury. But bore holes do provide opportunities for new infections and may release previously compartmentalized decay fungi.

In increment cores or other samples, inner rings may be missing due to decay. This can result in an age estimate of "no younger than" based on the innermost ring still present. Common patterns of wide and narrow rings need to be identified and aligned in a process called crossdating. Crossdating across samples from living and dead trees and wood 1in service

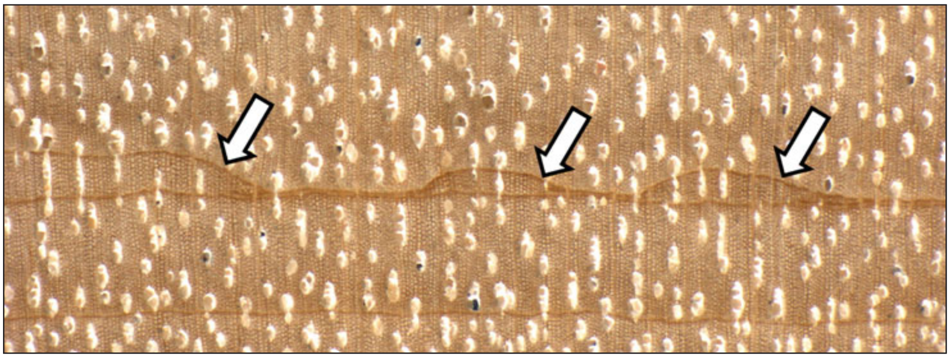

Figure 2. Microscopic view of tree ring "wedging" (arrows) in mountain birch following attack by winter moth in northern Finland. Not only are the ring boundaries faint, but rings are locally absent.

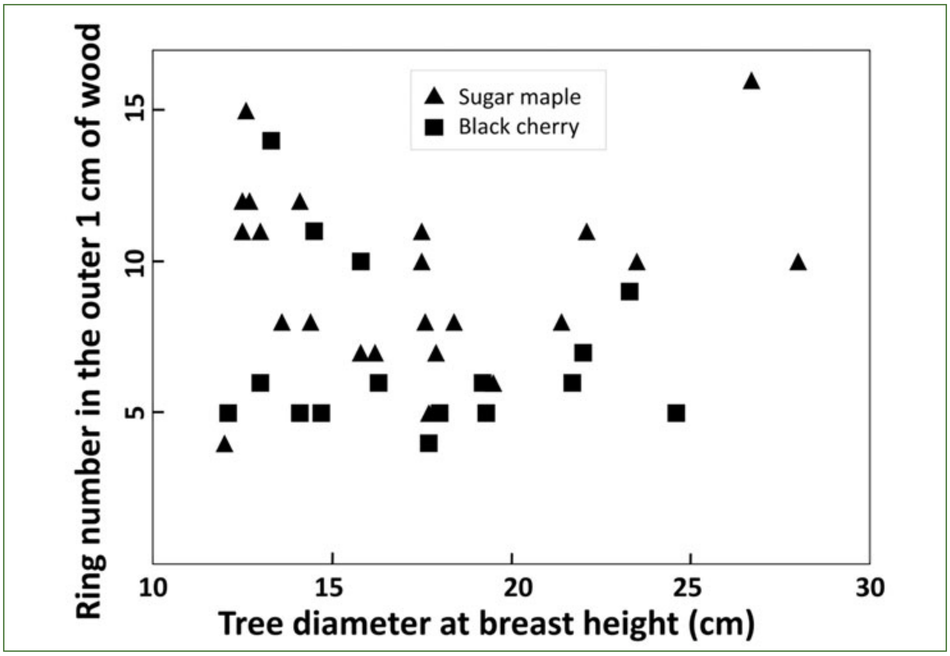

Figure 4. Relation of the number of recent rings to diameter of young sugar maple and black cherry in western North Carolina.

(part of some built thing such as a building, bridge, wharf piling, etc.) enables the construction of tree-ring chronologies longer than the lifespan of an individual tree. Crossdating also helps to identify the presence of false or missing rings.

Variability in ring width

Can growth-factor tables be a reasonable alternative to rigorous dendrochronology or simple ring counting? Growth-factor tables assume a consistent linear or straight-line relationship of diameter increment to years of growth. The tables assume that small year-to-year variation will average out both within an individual tree and among groups of trees. A close look at tree-ring patterns, even along a single radius of a single tree, shows great variability (Figure 3). High-frequency year-to-year variation in ring width can be due to episodes of drought, flooding, defoliation, delayed spring warming and other environmental factors. In larger trees with full crowns, declining ring width may simply be an expression that stem growth is geometric rather than linear.

Adding one inch of a diameter to a 1-foot DBH stem adds about 20 square inches of wood at breast height. Adding that same inch to a 2-foot DBH stem adds about 38 square inches of wood. When a tree reaches the full extent of its mature crown and has reached a plateau of maximum wood production, the width of the annual rings will likely decrease as the annual addition to cross-sectional area remains about the same.

Among groups of trees of the same species and within the same geographic area, there can be a wide range of growth rates that are not necessarily related to the size of the individual tree. In a recent study in western North Carolina, 16 forest-grown black cherry ranged in diameter from 12 to 25 cm and had five to 14 rings in the outermost centimeter of wood. In the same area, 23 sugar maple ranged in diameter from 12 to 18 cm and had 6 to 16 rings in the outermost cm (Figure 4). The results show both a great range of ring width and no obvious relationship of ring width to tree diameter for these relatively young, vigorous trees. The point here is that ring width is highly variable and that a simple average growth rate, even adjusted for tree size, isn't very accurate, even for trees growing under apparently similar conditions.

Is the largest tree the oldest tree?

A mistaken notion that perhaps reaches the status of a tree myth is that the largest tree is also the oldest tree for a given species and location. Although the biology is not fully understood, there is increasing evidence that between and within species, slower-growing trees live longer than fast-growing trees. Comparing the lists of largest versus the oldest trees illustrates the divergence of great size from age.

The champion tree program identifies the largest tree of a species and is conducted by national and state organizations. Champion criteria include tree height and crown spread as well as stem circumference. In contrast, the OldList database identifies the oldest trees, usually determined by dendrochronology. For the example of red oak (*Quercus rubra*) in Massachusetts, the Eastern OldList database cites an age of 326 years (determined in 2006). The diameter was not given, but the accompanying photo on OldList shows the tree to be no more than 3 feet in diameter. The Massachusetts state list gives the diameter of the state champion as a full 5 feet. Rarely do the champions of size and age coincide.

The desire to know tree age from a simple measurement of size is understandable. Variation in ring width makes that a difficult proposition, at least to some degree of accuracy. The best contribution of the growth-factor tables may be to help connect people to the remarkable trees in the landscape. Although unlikely to be adequate for the arborist or other technical specialist, the tables may help to satisfy public imagination and curiosity.

For more information, please see:

American Forests Champion Trees. http://www.americanforests.org/explore-forests/americas-biggest-trees/champion-trees-national-register/.

Grissino-Mayer, H.D. The Science of Tree Rings Webpage. Http://web.utk.edu/~grissino/.

OldList Tree Age Database. http://www.rmtrr.org/oldlist.htm/.

Smith, K.T. 2011. Tree rings and the local environment. Arborist News 20(3): 12-15. https://www.nrs.fs.fed.us/pubs/38087.

Smith, K.T. 2008. An organismal view of dendrochronology. Dendrochronologia 26: 185-193. https://www.nrs.fs.fed.us/pubs/9076.

Speer, J.H. 2010. Fundamentals of Tree-Ring Research. University of Arizona Press, 333 p.

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