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132ND ANNUAL ACADEMY MEETING[1]

Presidential Plenary Address by Darrin L. Rubino[2]

"Dendroarchaeology: Using Building Timbers and Tree Rings to Explore the Past"

The following text is a summary of the plenary presentation delivered by Darrin L. Rubino at the 132nd annual meeting of the Indiana Academy of Science. Citations have been added.

INTRODUCTION

Trees deposit a layer of wood, a tree ring, around their circumference each year in temperate regions. Dendrochronology, tree-ring science, focuses on assigning these annual increments of growth to the precise calendar year in which they were formed and on interpreting the short- and long-term growth patterns found in woody plants. Dendrochronological techniques can be used to investigate a wide variety of phenomena. For example, tree-ring science has been used to investigate past climatic conditions, forest fire history, insect outbreaks, and forest stand dynamics. This plenary address focuses on the subfield of dendrochronology known as dendroarchaeology. Dendroarchaeological investigations utilize tree-ring principles to date the construction of historically erected buildings. Dating is accomplished by sampling the timbers found in a building and assigning calendar dates to their tree rings.

Dendroarchaeology, and fundamentally all tree-ring science, relies on the identification of unique growth patterns in trees over time. Tree-ring width varies annually based on resources available to a tree. Ring width, consequently, is an aggregate response to the various biotic and abiotic factors experienced by a tree in a given year (Cook 1987). In years of favorable growth conditions, larger than average rings will be formed, and, likewise, smaller than average rings will be formed under stressful annual growing conditions (e.g., drought). Since temperature and precipitation have a large influence on growth, climatic conditions impart a common growth pattern or signal on tree growth over a large geographic region. Once unique growth patterns have been identified in samples of known age (living trees, for example), one can look for these patterns in samples of unknown age.

The goals of this long-term and on-going project are to date and document the construction of historically erected structures in Indiana and to tap the tree-ring data found within their timbers. With European settlement of the state, much of Indiana's forests were lost. A.W. Butler (1896) commented on the loss of the archetypical old-growth or virgin forests of the state in his presidential address to the Indiana Academy of Science in 1895. In his address titled "Indiana: A Century of Changes in the Aspects of Nature," Butler comments on the loss of "tall trees" and "heavy timber" especially in the southern portion of the state. With the loss of nearly all of the old trees, studying past forest growth using tree rings is greatly hampered. However, dendroarchaeology offers a unique opportunity to simultaneously utilize the cultural and natural heritage of the state to study the past. The numerous eighteenth century buildings that dot the Hoosier landscape are made of local timber, the trees that original settlers and explorers found when they arrived in the region. By studying these buildings and the tree-ring patterns found in their timbers much information about the dynamics, composition, and architecture of the pre-European settlement forest can be studied. For the past 15 years I have worked with numerous colleagues and students to explore the cultural legacy left by early Hoosiers.

CONDUCTING DENDROARCHAEOLOGICAL STUDIES

Determining the construction date of a historical building is a multistep process. First samples need to be extracted from the buildings' timbers. This can be accomplished by harvesting salvaged logs made available during renovation or repair.

[1] J.W. Marriott, Indianapolis, IN, 25 March 2017.
[2] Professor of Biology, Hanover College, Biology Department, 517 Ball Drive, Hanover, IN 47243; 812-866-7247 (phone); rubino@hanover.edu.

Most commonly, samples are obtained by coring timbers with a boring bit chucked into a power drill (Figs. 1 & 2). Coring permits sample acquisition without negatively affecting the structural integrity of a building.

To date a building's construction it is necessary to determine the year in which a tree died and was subsequently used as a building timber. Death dates can be determined by dating the last year a tree formed a ring—a ring adjacent to the bark or a ring taken from the waney surface of a timber. Wane can be identified by noting a uniform, rounded outer surface of a timber that is free of any tool marks (e.g., those created by hatchet, ax, adze, chisel, or saw). If wane is present but bark is not, the outermost ring of the timber represents the last ring formed by a tree, and the bark most likely sloughed off or was removed. When numerous timbers from a structure have similar or comparable death (cutting) dates, identifying the construction date of a building is possible. Sampling, therefore, is routinely focused on bark- and wane-bearing timbers.

Next, samples must be sanded, using progressively finer grits of sandpaper, so that the tree-ring structure in a sample can be observed under a microscope. Individual rings of a sample are then assigned years, not calendar dates, since the year of formation of rings is not known in dendroarchaeological investigations. The innermost (oldest) ring in each sample is assigned "year 1", the next "year 2", and so on until each of the rings in the sample is assigned a year. The tree rings in these samples are considered floating in time since years, not dates, were assigned to the individual tree rings.

Assigning actual calendar dates to the floating series is accomplished by crossdating (Stokes & Smiley 1968). Crossdating has proven to be a highly reliable method for dating wood of unknown age. Crossdating is a method of pattern matching that utilizes regional chronologies (series of accurately dated tree rings from living trees or other historically erected buildings; Fig. 3). The samples of unknown age are crossdated with the dated chronologies using skeleton plots. Skeleton plots are graphical representations of the widths of individual tree rings in a sample. These plots allow for the identification and matching of unique growth patterns in the timbers of unknown age and verified chronologies. Crossdating also is performed using ring-width measurements. The tree-ring widths in the samples of unknown age are measured and correlated with the ring widths in dated chronologies. When skeleton plots and measured ring-width analyses suggest similar dates of ring formation, a sample is considered to be dated (see Rubino & Baas' 2014 article in *The Proceedings* for a more complete description of field and laboratory methodologies used in the region).

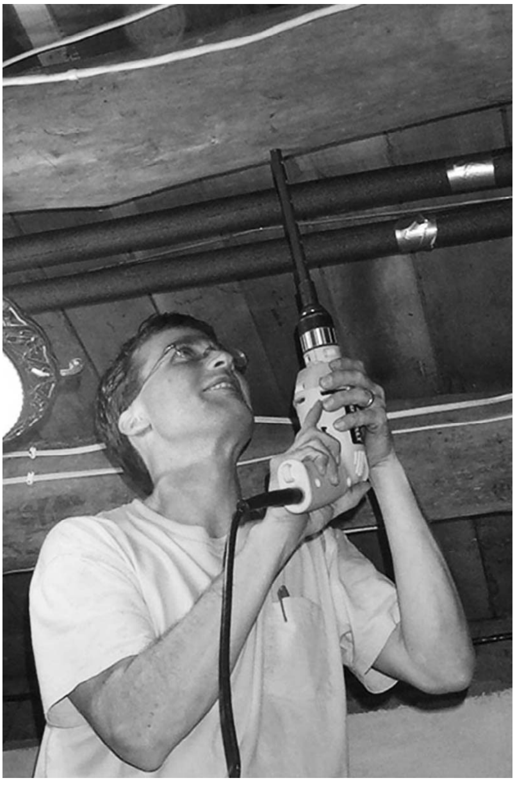
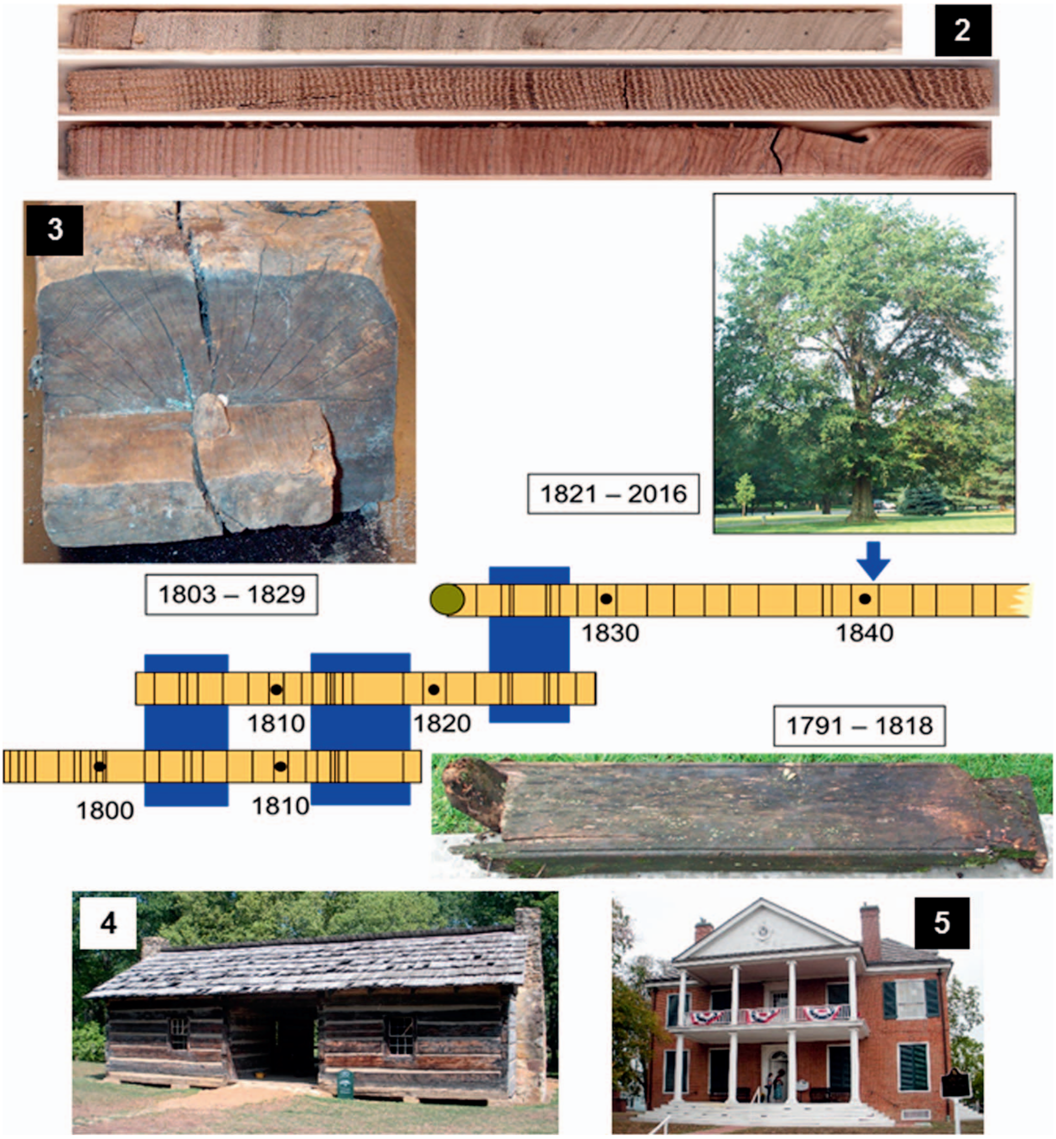


Figure 1.—Obtaining a core from a floor joist using a boring bit and drill. Note the waney surface of the log. If the outer ring of this timber can be dated, its death date can be verified.

APPLICATION OF DENDROARCHAEOLOGY

To date, my collaborators and I have been able to sample scores of buildings from the region. We have successfully crossdated churches, smokehouses, forts, barns, houses, factory buildings, and mills. When scant historical evidence is available, tree rings offer an excellent method to determine the age of buildings. We have used tree-ring analysis to verify the construction of many buildings throughout the state. Tree rings also



Figures 2–5.—Dendroarchaeological methodology and findings. (2) Cores obtained from timbers used in the construction of a historically erected building. From top to bottom: tulip poplar, white oak, American beech; the wane or bark edge is to the left. (3) Dating timbers of unknown age (a beam [upper left)] and floor joist [lower right]) is performed by crossdating their tree-ring growth patterns with chronologies consisting of dated tree rings. Blue areas represent unique growth patterns or signatures that make pattern matching and crossdating possible. Note: the sample lengths used in this demonstration illustration are much shorter than those that are needed to perform an actual analysis. Modified from Rubino (2014). (4) The Grayson dogtrot house (Posey County, IN). This building was reportedly built in 1775. Tree-ring analysis suggests a construction date of 1853. Photo courtesy of C. Baas. (5) Grouseland, the home of William Henry Harrison when he served as the Territorial Governor of the Indiana Territory in the early 1800s. Photo courtesy of C. Baas.

have been useful in providing construction dates when dubious historical information was available. For example, the Grayson House, a dogtrot house in Posey County, has been attributed a construction date of 1775 (Fig. 4). This date seemed suspect in light of regional settlement patterns. Through tree-ring analysis we were able to determine that the structure was built sometime

Figures 6–7.—Tulip poplar tree-ring samples. (6) Sample TRC01A (1561–1803). This tulip poplar sample was obtained from the attic of the Territorial Capitol (Vincennes) during renovation. Since dating the ring adjacent to the bark was possible for this sample, we were able to determine when the tree was cut and used in construction (1803). Numbers on the sample indicate individual decades of growth. (7) Sample KEL69A, a wall stud obtained from the Kellems House. The tree rings in the sample date from 1564 to 1836. The growth in this sample is extremely compact, and mean ring width is a mere 0.56 mm (± 0.24 SD).

after the initiation of the 1852 growing season (Rubino & Baas 2014). In situations such as this, tree rings enhance our cultural interpretation of unique structures found throughout the state.

Several of the buildings we have had the pleasure to date are important pieces of the cultural and historic fabric of our state. For instance, we were able to confirm the construction date of Grouseland, the Home of William Henry Harrison when he served as the Territorial Governor of the Indiana Territory (Fig. 5). Samples taken from the basement warming kitchen had a bark date of 1802. Dating also was performed on the Territorial Capitol (Vincennes); we found two samples with bark dates of 1803 (Fig. 6). We were able to verify construction dates of several buildings from New Harmony including Community House No. 2 (1822) and Thrall's Opera House (1823).

IMPORTANCE OF DENDROARCHAEOLOGY

Most of our dendroarchaeological investigations, however, have focused on the dating of vernacular structures that belonged to every-day Hoosiers. Their buildings, which have survived for well over a century, have provided us with thousands of samples that have enabled us to create long, well-replicated regional chronologies. With these chronologies we can date other buildings, gain a better understanding of how regions were settled, determine how buildings were constructed based on cultural differences, and understand the composition and growth of historic regional forests.

One such building is the Kellems House located in Canaan, Indiana (Jefferson County). During the renovation of this building we were able to extract fascia boards, floor boards, wall studs, and

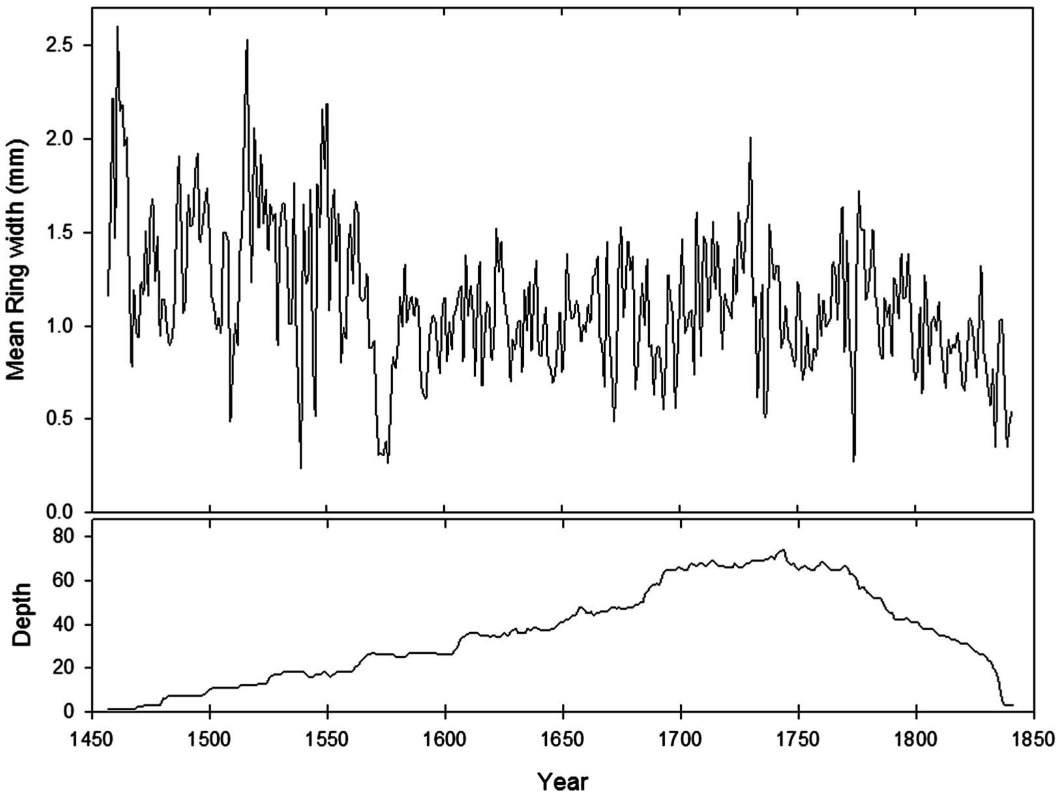


Figure 8.—Mean tree-ring chronology of tulip poplar timbers obtained from the Kellems House. This chronology was prepared by combining all tulip poplar timbers into one aggregate sample. Depth is the sample depth or number of tree rings dated and measured for a particular year.

joists and to date the construction of the building to 1836. Dating this structure was notable for several reasons. First, we were able to obtain several hundred timbers, data for creating a robust regional chronology. Secondly, we sampled several different timber types including white oak, beech, ash, and tulip poplar. Most regional dendroarchaeological work focuses on white oaks. Sampling this structure enabled us to create new species chronologies—a necessity when trying to understand past forest growth and dynamics since analyses of different species help to paint a more complete picture of how trees and forests grow in the past. We completed an ash chronology (135 samples; 11,321 rings) that spanned from 1654 to 1836. Most notably, we obtained and accurately crossdated 153 tulip poplar timbers. From these samples we developed a chronology spanning from 1457 to 1836; the final chronology consisted of 14,596 tree rings. Creation of this chronology has proven pivotal in dating many regional structures that contain tulip poplar timbers. Additionally, we were able to gain a better appreciation of how tulip poplar, our state tree, grew in old-growth forest conditions (Figs. 7 & 8).

Dendroarchaeological investigations also may give insight into cultural practices of early Hoosier settlers. For example, tree-ring analysis of numerous barns throughout the region elucidated how particular agricultural systems developed in the state. In 1843 Samuel Hewitt invented a hay press, a unique device designed to create compressed hay bales (2 × 3 × 4 foot; 0.6 × 0.9 × 1.2 m) that weighed 400 pounds (180 kg). By compressing hay, growers and shippers were afforded ease in handling, storing, and shipping hay to markets on the East Coast. The timber-built hay press was incorporated into a three story barn and compressed hay by dropping a large wooden block into a hay-filled box. Our dendroarchaeological analysis has documented 19 of these unique barns (it is thought that hundreds dotted the mid-Ohio River Valley in the mid- to late-1800s). Timbers

Figure 9.—Floor joists from a hay press barn located in Braytown, Indiana (Switzerland County). Note the author straddling a floor joist that is constructed from an entire tree bole.

used in the construction of these barns are often oversized to sustain the strains associated with the pressing process. Thus, large, entire trees are often used as floor joists (Fig. 9). From these large timbers one may generate remarkably long tree-ring series. For example, a white elm floor joist from a hay press barn in Braytown, Indiana (Switzerland County) yielded the oldest tree-ring sample we have collected to date, 1436–1863 (Fig. 10).

IN CONCLUSION

Through dendroarchaeological analysis of historically erected buildings in the region, we may better understand short and long-term growth patterns of the dense forests that once characterized Indiana. It is my hope that we continue, into the distant future, to sample buildings throughout the state and region. By adding new buildings from different areas and by analyzing new timber species, a clearer picture of the history of our forests and the settlement of

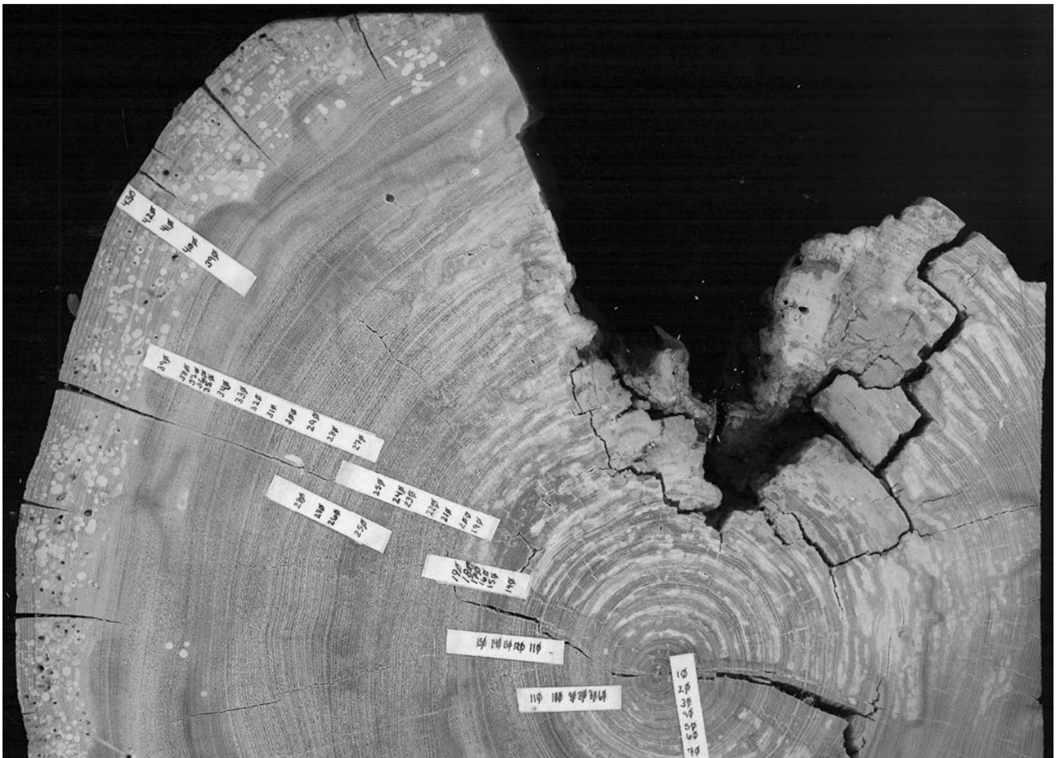


Figure 10.—Sample BRB02A, a floor joist obtained from a hay press barn in Braytown, Indiana. This white elm sample spans from 1436 to 1863 and represents the oldest crossdated sample we have collected to date.

Indiana will be possible. Ultimately, chronologies prepared from historically constructed buildings can be joined with chronologies prepared from living trees to provide a record of growth that extends, without interruption, from the present to several centuries in the past; we currently have a tulip poplar chronology spanning from 1457 to 2016. Future sampling will likely enable us to create similar chronologies for red and white oaks, beech, elm, and ash. This additional sampling will help us to understand growth of some of the most common and important species that flourished in pre-European settlement forests.

In closing, the timbers of historically erected buildings have given us a unique opportunity to look into the past. Future research can put the chronologies prepared from these building timbers to work. Research can focus on a wide variety of topics such as historic climate patterns and forest disturbance regimes. Additional work in the region will help contribute to our knowledge of how the vast forests that once covered Indiana functioned. Thank you.

ACKNOWLEDGMENTS

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Dr. Darrin Rubino is a Professor of Biology at Hanover College. He joined the Hanover Faculty in 2002. He is a graduate of Thiel College (1995) and earned his Masters from Clarion University of Pennsylvania (1997) and Ph.D. from Ohio University (2002). He has been a member of the Indiana Academy of Science since 2002. In addition to serving as the President of the Academy, Darrin served as Chair and Vice Chair of the Academy's Botany Section on several occasions. He became a Fellow of the Academy in 2013. Darrin is a forest ecologist and studies wood decay, vascular plant community composition, non-native plants, and woody debris (dead and down trees). His main research interest is dendrochronology, the study of tree-rings. He uses patterns of tree rings to understand the influence of historic human impacts and natural processes on forest structure, function, and composition. Currently, Darrin mainly uses tree rings to date the construction and modification of historic buildings (mainly in the mid-Ohio River Valley). He and his students and colleagues have dated scores of buildings in the region. Additionally, he and his students have created accurately dated series of tree-rings from living and recently dead trees from forests throughout the regions. By combining the tree-ring studies from buildings and forests, he has been able to create tree-ring series stretching from the present to the mid-fifteenth century. In 2007 and 2012 Darrin was awarded the Arthur and Ilene Baynham Award for Outstanding Teaching at Hanover College, and he won the College's Daryl R. Karns Award for Scholarly and Creative Activity in 2014.