Dendrochronological Analysis of the Updike Farm barn, Princeton Township, Mercer County, New Jersey

By

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Introduction

This is the final report on the dendrochronological analysis of the structure known as the Updike Farm barn, located at 354 Quaker Road, Princeton, Princeton Township, Mercer County, NJ. The Updike Farm barn is owned and administered by the Historical Society of Princeton, Bainbridge House, 158 Nassau Street, Princeton, NJ 08542. The farmstead site consists of six acres of land, farmhouse, barn, coops, and assorted outbuildings.

In an effort to confirm the construction history of this barn, Penny Watson of Watson & Henry Associates, 12 N. Pearl Street, Bridgeton, NJ 08302 (856 451 1779), acting on behalf of the Historical Society, requested that dendrochronologists William Callahan and Dr. Edward Cook perform a tree-ring analysis of its structural timbers. Together with Ms. Watson and Mr. Michael Henry, Callahan visited the house on 15 May, 2007, and collected wood core samples for the dendrochronological analysis of the timbers. Of the 9 samples acquired and analyzed, all 9 were of hemlock (Tsuga sp., see Table 1). Every effort was made on site to locate bark or waney edges on the sampled timbers in order to ascertain an absolute cutting date, or dates, of the trees used in the construction.

Dendrochronological Analysis

Dendrochronology is the science of analyzing and dating annual growth rings in trees. Its first significant application was in the dating of ancient Indian pueblos of the southwestern United States (Douglass 1921, 1929). Andrew E. Douglass is considered the "father" of dendrochronology, and his numerous early publications concentrated on the application of tree-ring data to archaeological dating. Douglass established the connection between annual ring width variability and annual climate variability which allows for the precise dating of wood material (Douglass 1909, 1920, 1928; Stokes and Smiley 1968; Fritts 1976; Cook and Kariukstis 1990). The dendrochronological methods first developed by Douglass have evolved and been employed throughout North America, Europe, and much of the temperate forest zones of the globe (Edwards 1982; Holmes 1983; Stahle and Wolfman 1985; Cook and Callahan 1992, Krusic and Cook 2001). In Europe, where the dendrochronological dating of buildings and artifacts has long been a routine professional support activity, the success of tree-ring dating in historical contexts is noteworthy (Baillie 1982; Eckstein 1978; Bartholin 1979; Eckstein 1984).

The wood samples collected from the Updike Farm barn were processed in the Tree-Ring Laboratory by Dr. Edward Cook following well-established dendrochronological methods. The samples were carefully glued onto grooved mounts and sanded to a high polish to reveal the annual tree rings clearly. The rings widths were measured under a microscope to a precision of ±0.001 mm. The cross-dating of the obtained measurements utilized the COFECHA computer program (Holmes 1983), which employs a sliding correlation to identify probable cross-dates between tree-ring series. In all cases, the robust non-parametric Spearman rank correlation coefficient was used for determining cross-dating. Experience has shown that for trees growing in the northeastern United States, this method of cross-dating is superior to the traditional skeleton plot technique (Stokes and Smiley 1968). It is also very similar to the highly successful CROS program employed by, for instance, Irish dendrochronologists to cross-date European tree-ring series (Baillie 1982).

COFECHA is used to first establish internal, or relative, cross-dating amongst the individual timbers from the site. This step is critically important because it locks in the relative positions of the timbers to each other, and indicates whether or not the dates of those specimens with outer bark rings are consistent. Subsequently, the internally cross-dated series are each compared with independently established tree-ring master chronologies compiled from living trees and dated historical tree-ring material. All of the “master chronologies” are based on completely independent tree-ring samples.

In the Updike Farm barn study, species specific, regional composite master dating chronologies from living trees and historical structures in the Middle Atlantic region were referenced primarily. All dating results were verified finally by comparison with independent dating masters from surrounding areas in New York, New Jersey, Massachusetts and central Pennsylvania. In each case, the datings as reported here were verified as correct.

Results and Conclusions

The results of the dendrochronological dating of the Updike Farm barn timbers are summarized in **Table 1** and **Figure 1**. A total of 9 hemlock samples were analyzed in the laboratory, with all 9 samples providing firm dendrochronological dates. To achieve these datings required attention during analysis to the recorded structural context of the samples (see **Table 1**). The contextual association of samples from within the barn, the redundancy of the indicated relative cross-datings, and the eventual existence of sapwood and bark/waney edges demonstrating cutting year, provides the essential constraints necessary for establishing cross-dating, both within a site and with absolute chronological masters.

The strength of the cross-dating of the samples is indicated by the Spearman rank correlations in the seventh column (“CORREL”) of **Table 1**. These statistical correlations, produced by the COFECHA program, indicate how well each sample cross-dates with the mean of the others in the group. The individual correlations vary slightly in statistical strength, but all are within the range that is expected for correctly cross-dated timbers from buildings in the eastern United States.

Of the 9 hemlock samples that cross-dated well between themselves, and also dated well against the local hemlock historical dating masters (see **Table 1**, column 6), 6 had verifiable or likely bark edge at the time of sampling. Microscopically in the laboratory, 3 were determined to have complete growth rings in their cutting years, and 3 were determined to have begun earlywood growth.

From the datings that were achieved, there emerged compelling evidence of a significant, distinct construction period. The hemlock samples UPDFNJ02, 03, 04, 05, 06 indicate a construction phase for this section of the Updike barn sometime during or shortly after the growth season 1891 (that is, calender years 1891, 1892 or 1893: timbers cut during dormancy 1890 and 1891, or during early growth season 1891; - in those cases that trees were cut during dormancy after the end of the growth season, it is meant late in the autumn or immediately before the beginning of the next growth season of the following spring, i.e. approximately November through February, the “winter months”).

Other dated samples provide redundant support for this construction phase. Hemlock samples UPDFNJ01 & 09 (dated after 1888 and 1874, respectively) lacked bark edge at sampling, but their datings lie within the range expected if some few rings were lost to working or to erosion over time. The dating of sample UPDFNJ01 (after 1774) appears anomalous; this dating may represent a re-used timber, or, more likely, its function as a door post may have required heavy working to adjust its dimension to its use, with a subsequent loss of rings.

The comparative strengths of the cross-correlations between the sampled materials and the geographically diffuse standard chronologies very strongly suggests provenience of the timbers at some distance to the site, almost certainly in the northwestern region of Pennsylvania. The Spearman rank correlation r=0.74 between the Updike barn and the Tionesta Hemlock Master is extraordinary, so strongly significant statistically that the hemlock logs used to construct the Updike Farm barn must have their provenience in that region of Pennsylvania. It is known that the Allegheny Plateau (the location of the Tionesta hemlock forests) contained some of the last great old growth forests in Pennsylvania in the late 1800s, and was actively being logged at that time.

Close *in situ* inspection of the dated timbers indicated that all of the first-use materials initially were utilized relatively soon after cutting, in keeping with historical woodworking and carpentry techniques. Finally, the possibility of other construction phases not documented by this dendrochronological sampling cannot and should not be excluded on the basis of available evidence.

Table 1. Dendrochronological dating results for all samples taken from the Updike Farm barn located in Princeton, New Jersey. For WANEY, +BE means the bark edge was present and thought to be recovered at the time of sampling; -BE means that the bark edge was not recovered or was completely missing on the timber; +BE(?) indicates that by field observation of the presence of bark edge seemed likely but inconclusive; if appropriate, SP refers to sapwood being present and recovered (+), or not (-). All correlations are Spearman rank correlations of each series against the mean of all of the others of the same species. If the outermost recovered +BE ring is completely formed, it is indicated as "comp", meaning that the tree was felled in the dormant season following that last year of growth. An indicated, incomplete ("incomp") outermost ring indicates that the tree was felled in the spring of that growth year.

ID	SPECIES	DESCRIPTION	WANEY	RINGS	DATING	CORREL
UPDFNJ01	Hemlock	E1-E2, lower beam, -BE, but bark present at start	-BE	294	1595 1888	0.57
UPDFNJ02	Hemlock	E1-E2, north diagonal brace	+BE	181	1710 1890 comp.	0.76
UPDFNJ03	Hemlock	F1.5, post	+BE	226	1666 1891 comp.	0.73
UPDFNJ04	Hemlock	E-F1, center horizontal plate	+BE	212	1680 1891 incomp.	0.65
UPDFNJ05	Hemlock	A1-A2, center horizontal plate	+BE	310	1581 1891 incomp.	0.64
UPDFNJ06	Hemlock	C1-C2, lower beam	+BE	224	1667 1891 incomp.	0.62
UPDFNJ07	Hemlock	H7, post	+BE(?)	213	1675 1887 comp.?	0.49
UPDFNJ08	Hemlock	H3, post	-BE	207	1568 1774	0.49
UPDFNJ09	Hemlock	H3, lower beam	-BE	225	1650 1874	0.75

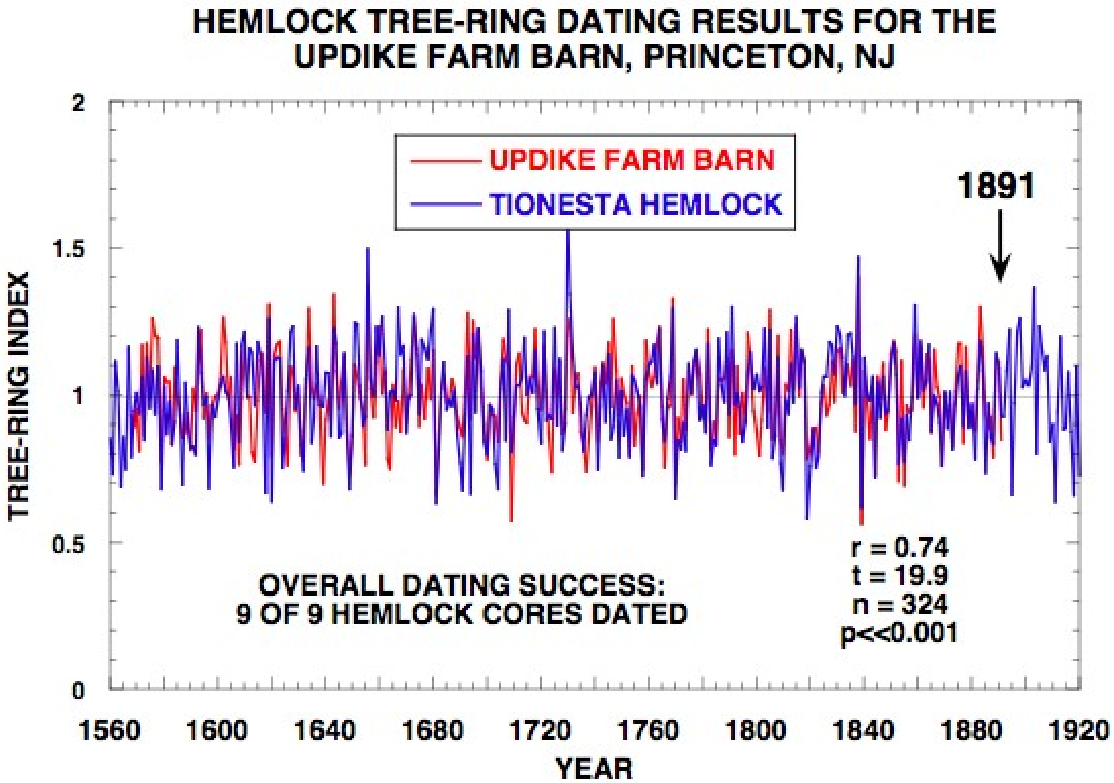

Figure 1. Comparison of the cross-dated historical Hemlock master from the Updike Farm barn with a living tree Hemlock dating master from the Tionesta Natural Area on the Allegheny Plateau of northwestern Pennsylvania. The Spearman rank correlation between the Updike barn master and the Tionesta Hemlock master (r=0.74) is very highly significant (p<<0.001) with a t-statistic of 19.9, the strongest correlation among 10 referenced hemlock masters, all of which dated the Updike barn to the same year, 1891; the next highest correlation is r=0.56 for a hemlock master from East Branch Swamp in north-central Pennsylvania.

The t-statistics (t=19.9 for the Tionesta hemlock series) associated with the correlations between the individual series and the regional master chronology (r=0.74 for the Tionesta hemlock) are statistically highly significant (p<<0.001) for their 324-year overlap. For that reason, the dates presented here for these sampled sections of the Updike Farm barn are very strongly valid, and the statistical chance of the cross-dates being incorrect is much, much less than 1 in 1000.

The "r-factor" is the Spearman rank correlation coefficient, a measure of relative agreement between two groups of measurements or data. It can range from +1 (perfect direct agreement) to -1 (perfect opposite agreement). The "t-value" is Student's distribution test for determining the unique probability distribution for "r", i.e. the likelihood of its value occurring by chance alone. As a rule, a t=3.5 has a probability of about 1 in 1000, or 0.001, of being invalid. Higher "t" values indicate increasingly stronger statistical certitude.

Selected References

Baillie, M.G.L. 1982. *Tree-Ring Dating and Archaeology*. Croom Helm, London and Canberra. 274 pp.

Baillie, M.G.L. 1995. *A Slice Through Time: Dendrochronology and Precision Dating.*B.T. Batsford, Ltd., London

Bartholin, T.S. 1979. ”Provtagning för dendrokronologisk datering och vedanatomisk analys.” *Handbook i archeologiskt fältarbete, häfte 2.* 1-15 Riksantikvarieämbetets dokumentationsbyrå, Stockholm.

Cook, E.R. and Callahan, W.J. 1987. *Dendrochronological Dating of Fort Loudon in South-Central Pennsylvania*. Limited professional distribution.

Cook, E.R. and Callahan, W.J. 1992. *The Development of a Standard Tree-Ring Chronology for Dating Historical Structures in the Greater Philadelphia Region.* Limited professional distribution.

Cook, E.R. and L. Kariukstis, eds. 1990. *Methods of Dendrochronology: Applications in the Environmental Sciences*. Kulwer, The Netherlands.

Douglass, A.E. 1909. Weather cycles in the growth of big trees. *Monthly Weather Review* 37(5): 225-237

Douglass, A.E. 1920. Evidence of climate effects in the annual rings of trees. *Ecology* 1(1):24-32

Douglass, A.E. 1928. Climate and trees. *Nature Magazine* 12:51-53

Douglass, A.E. 1921. Dating our prehistoric ruins: how growth rings in trees aid in the establishing the relative ages of the ruined pueblos of the southwest. *Natural History* 21(1):27-30

Douglass, A.E. 1929. The secret of the southwest solved by talkative tree-rings. *National Geographic Magazine* 56(6):736-770.

Eckstein, D. 1978. Dendrochronological dating of the medieval settlement of Haithabu (Hedeby). In: *Dendrochronology in Europe*, (J. Fletcher, ed.) British Archaeological Reports International Series 51: 267-274

Eckstein, D. 1984. *Dendrochronological Dating (Handbooks for Archaeologists, 2).* Strasbourg, European Science Foundation.

Eckstein, D. and Bauch, J. 1969. “Beitrag zur Rationisilerung eines dendrokronologischen Verfahrens und zur Analyse seiner Aussagesicherheit.” *Forstwissenschaftliches Centralblatt* 88, 230-250.

Edwards, M.R. 1982. Dating historic buildings in lower Maryland through dendrochronology. In: *Perspectives in Vernacular Architecture*. Vernacular Architecture Forum.

Fritts, H.C. 1976. *Tree Rings and Climate.* Academic Press, New York. 567 pp.

Holmes, R.L. 1983. Computer assisted quality control in tree-ring dating and measurement. *Tree-Ring Bulletin* 43:69-78

Krusic, P.J. and E.R. Cook. 2001. *The Development of Standard Tree-Ring Chronologies for Dating Historic Structures in Eastern Massachuesetts: Completion Report*. Great Bay Tree-Ring Laboratory, May 2001, unpublished report.

Stahle, D.W. and D. Wolfman. 1985. The potential for archaeological tree-ring dating in eastern North America. *Advances in Archaeological Method and Theory* 8: 279-302.

Stokes, M.A. and T.L. Smiley. 1968. *An Introduction to Tree-Ring Dating*. University of Chicago Press, Chicago 110 pp.

Edward Cook was born in Trenton, New Jersey, in 1948. He received his PhD. from the Tucson Tree-Ring Laboratory of the University of Arizona in 1985, and has worked as a dendrochronologist since 1973. Currently director of the Tree-Ring Laboratory and Senior Scholar at the Lamont-Doherty Earth Observatory of Columbia University, he has comprehensive expertise in designing and programming statistical systems for tree-ring studies, and is the author of many works dealing with the various scientific applications of the dendrochronological method.

William Callahan was born in West Chester, Pennsylvania, in 1952. After completing his military service he moved to Europe, receiving his MA from the University of Stockholm in 1979. He began working as a dendrochronologist in Sweden in 1980 at the Wood Anatomy Laboratory at the University of Lund, and returned to the United States in 1998. A former associate of Dr. Edward Cook at the Tree-Ring Laboratory of Lamont-Doherty, he has extensive experience in using dendrochronology in dating archaeological artifacts and historic sites and structures.

Some regional historical dendrochronological projects completed by the authors:

Abraham Hasbrouck House, New Paltz, NY
Carpenter's Hall, Philadelphia, PA
Christ's Church, Philadelphia, PA
Conklin House, Huntington, NY
Customs House, Boston, MA
Daniel Pieter Winne House, Bethlehem, NY
Ephrata Cloisters, Lancaster County, PA
Fawcett House, Alexandria, VA
Frederick Muhlenberg House, Trappe PA
Gadsby's Tavern, Alexandria, VA
Gilmore Cabin, Montpelier, Montpelier Station, VA
Gracie Mansion (Mayor's Residence), New York, NY
Hanover Tavern, Hanover Courthouse, VA
Harriton House, Bryn Mawr, PA
Hollingsworth House, Elk Landing, MD
Independence Hall, Philadelphia, PA
John Bowne House, Forest Hills, NY
Log Cabin, Fort Loudon, PA
Lower Swedish Log Cabin, Delaware County, PA
Morris Jumel House, Jamaica, NY
Old Swede's Church, Philadelphia, PA
Panel Paintings, National Gallery, Washington, DC
Pennock House & Barn, London Grove, PA
Powell House, Philadelphia, PA
Spangler Hall, Bentonville, VA
St. Peter's Church, Philadelphia, PA
Strawbridge Shrine, Westminster, MD
Thomas & John Marshall House, Markham, VA
Varnum's HQ, Valley Forge, PA
William Garrett House, Sugartown, PA
Yew Hill, Fauquier County, Virginia