A Dendrochronological Analysis of the "Voorhees Family Barn", Branchburg, Somerset County, New Jersey.

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Introduction

This is the final report on the dendrochronological analysis of a timber structure known as the "Voorhees barn" which stood originally at 858 Old York Road, Branchburg, Somerset County, New Jersey 08876 (40°33'34"N - 74°43'43"W). This historic Dutch timber frame barn was conveyed from Christine Sena to The Friends of the Jacobus Vanderveer House (with assistance from Restoration Technologies of New Jersey LLC, Branchburg Historic Commission, Somerset County, NJ) with the intent that reconstruction and restoration of the building would take place on grounds of the Jacobus Vanderveer House at 3055 River Road, Bedminster, NJ.

In an effort to establish the precise age of the building, Mr. Adam Wengryn of Restoration Technologies of New Jersey LLC, representing the Vanderveer association and HMR Architects of Princeton NJ, requested that dendrochronologists William Callahan and Dr. Edward Cook perform a tree-ring analysis of selected representative structural timbers. Together with Mr. Wengryn, site supervisor Ridge Hartpence and crew, Callahan visited the site and collected samples for the dendrochronological analysis of the timbers on 12 August 2016.

Of the 14 field samples taken, 11 were deemed of sufficient quality for submission for laboratory analysis. All collected samples were of oak (Quercus sp.). Every effort was made on site to locate bark or waney edges on the sampled timbers in order to ascertain the absolute cutting date, or dates, of the trees used in the construction. After this analysis, the core samples and their associated measurement series will be permanently archived at the Tree Ring Research Laboratory, Lamont-Doherty Earth Observatory, Columbia University, under the sample reference numbers listed in Table 1, column 1.

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 Voorhees barn were processed in the Tree-Ring Laboratory by Dr. Edward Cook following well-established dendrochronological methods. The core samples were carefully glued onto grooved mounts and were 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 greatly 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, internally cross-dated series are compiled and are compared with independently established tree-ring master chronologies compiled from living trees and dated historical tree-ring material. All of the regional "master chronologies" are based on completely independent tree-ring samples.

In the Voorhees barn study, species specific, regional composite master chronologies from living trees and historical structures from New Jersey and eastern and central Pennsylvania, and other near-lying regions were referenced primarily. All dating results were verified finally by subsequent comparison with other independent dating masters from surrounding areas. In each case, the datings as reported here were confirmed as correct.

Results and Conclusions

The results of the dendrochronological dating of the Voorhees barn timbers are summarized in **Tables 1** and **Figures 1**. A total of 11 oak samples were analyzed in the laboratory, with 9 of the samples providing firm dendrochronological dates. The 2 additional field samples collected but not successfully dated were of insufficient wood-anatomical quality to satisfy rigorous analysis, and although thoroughly assessed in the laboratory were discarded in advance of final dating and statistical processing. In addition, 3 cores were collected but rejected in the field before submission to the laboratory.

To achieve these datings required attention during analysis to the previously recorded structural context of the samples (see **Table 1**). The contextual association of samples from within the structure, the redundancy of the indicated relative cross-datings, and the eventual existence of 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 in the range that is expected for correctly cross-dated timbers from buildings in the eastern United States.

The outermost ring on a waney, bark-edged sample identifies the cutting year. Absence of the wane on a sample indicates that the outermost extant ring is not the year of cutting, but some year, identifiable, preceding the cutting. Of the 9 oak samples that cross-dated well between themselves, and also dated well against the local historical dating master (see **Table 1**, column 6), three had field verified bark edge at the time of sampling. (see **Table 1,** column 4).

Analysis of the degree of development of the outermost wane rings indicates that cutting of the bark-edged timbers occurred during the regional period of dormancy following the end of the growth season, i.e. cutting took place during approximately November to February (see **Table 1**). Initial usage of the materials took place not long after harvesting, for *in situ* inspection of the timbers indicated that most if not all were worked soon after cutting, in keeping with historical woodworking and carpentry techniques. The degree of congruency in the achieved oak datings of the selected timbers from the building indicates a significant construction phase for the

Voorhees barn took place at the very end of 1831 or most likely during 1832. Of course, final construction activities may possibly have continued into as late as 1833 or beyond.

Although not evidenced by the timbers analyzed in this project, other specific construction phases for the barn prior or subsequent to the dates identified by this investigation cannot be empirically supported or discounted. The re-use of individual older timbers in any construction phases, as evidenced directly in the materials, (note XDBBNJ08 and XDBBNJ11) must be considered whenever purporting the site's construction history. However, given the uniformity of the dating of the tested timbers, selected as structurally representative after deliberate inspection, it is very likely that the indicated dates, i.e. 1831/32, are highly demonstrative of the history of the existing building, in its present configuration.

Table 1. Dendrochronological dating results for oak samples from the "Voorhees Family Dutch Barn", Branchburg, Somerset County, New Jersey. For WANEY, +BE means the bark edge ring was interpreted as 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. If –BE, +SP refers to the likelihood that sapwood rings are present; if so, the outermost date will be close to the cutting date. 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. “Inc” means that the outermost ring was not fully formed, meaning that the tree was felled during the spring/summer growing season of the indicated calendar year.

ID	SPECIES	DESCRIPTION	WANEY	RINGS	DATING	CORREL
XDBBNJ01	Oak	Corner post, southwest corner, center bay (tag: BY)	+BE Comp	39	1792 1830	0.44
XDBBNJ02	Oak	Post, 2nd from south wall, west side of center bay (tag: BY)	-BE, +SP	70	1754 1823	0.65
XDBBNJ03	Oak	Lower tie, 2nd from south wall, center bay (tag: BY/BX)	+BE?, +SP	56	1766 1821	0.43
XDBBNJ04	Oak	Post, 2nd from south wall, east side center bay (tag: BX)	-BE, +SP?	64	1760 1823	0.48
XDBBNJ05	Oak	Post, 3rd from south wall, east side center bay (tag: CX)	+BE Comp	68	1764 1831	0.62
XDBBNJ06	Oak	Post, 2nd from southeast corner, east bay outer wall (tag: BW)	-BE?, +SP	56	1765 1820	0.77
XDBBNJ07	Oak	Post, 3rd from south wall, west side center bay (shattered along medullary rays, discarded)	---	---	No Date	-.--
XDBBNJ08	Oak	Post, 2nd from south wall, west bay outer wall (tag: BZ) – reused?	-BE, +SP	79	1656 1734	0.48
XDBBNJ09	Oak	Lower tie, 3rd from south wall, center bay (tag: CY/CX)	+BE?	39	No Date	-.--
XDBBNJ10	Oak	Lower tie, 4th from south wall, center bay, north wall (tag: DY/DX)	+BE Comp	69	1763 1831	0.56
XDBBNJ11A	Oak	Post x-section (tag CZ) radius #1	-BE, +SP	169	1581 1749	0.66
XDBBNJ11B	Oak	Post x-section (tag CZ) radius #2	-BE, +SP	172	1582 1753	0.62

The "r-factor” is the Spearman rank correlation coefficient, a measure of relative statistical 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 exponentially increasing, stronger statistical certitude.

The t-statistics (t=7.9) associated with the correlation between the Voorhees Family barn oak series and the regional oak master chronology (r=0.45) is statistically very significant (p<<0.001) for a 251-year overlap. For that reason, there can be no doubt that the dates presented here for the sampled oak elements of the barn are robustly valid, and that the statistical chance of the cross-dates being incorrect is exponentially far less than 1 in 1000.

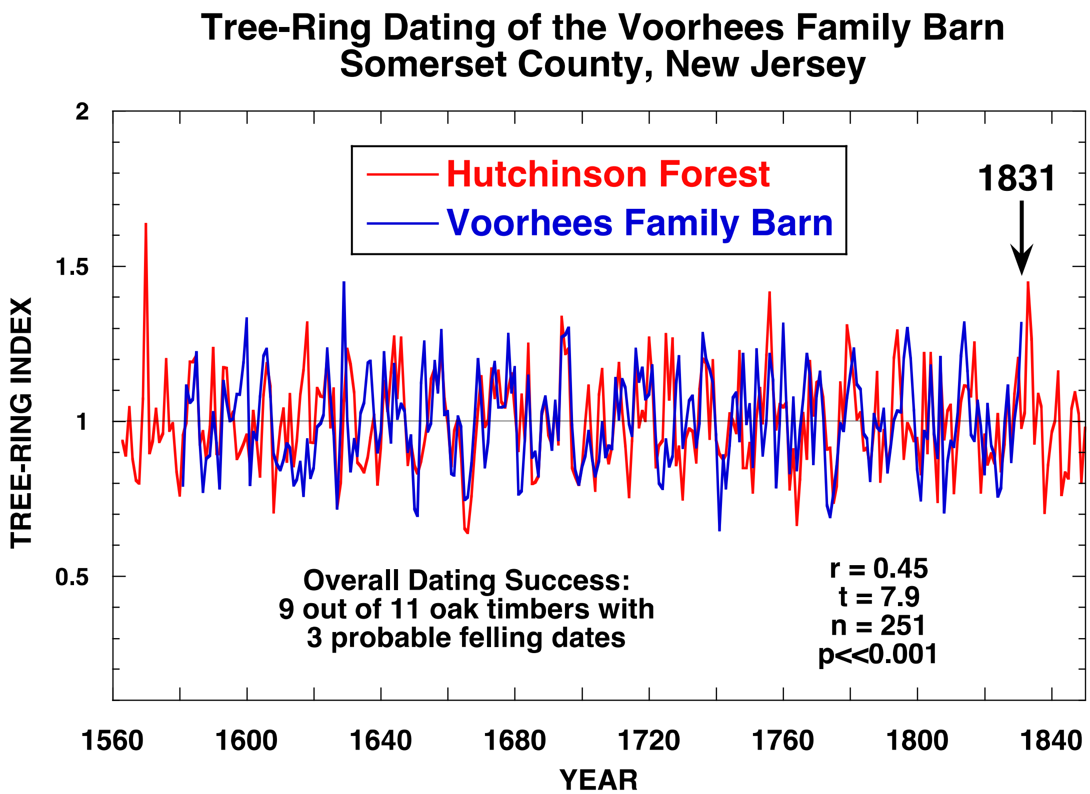
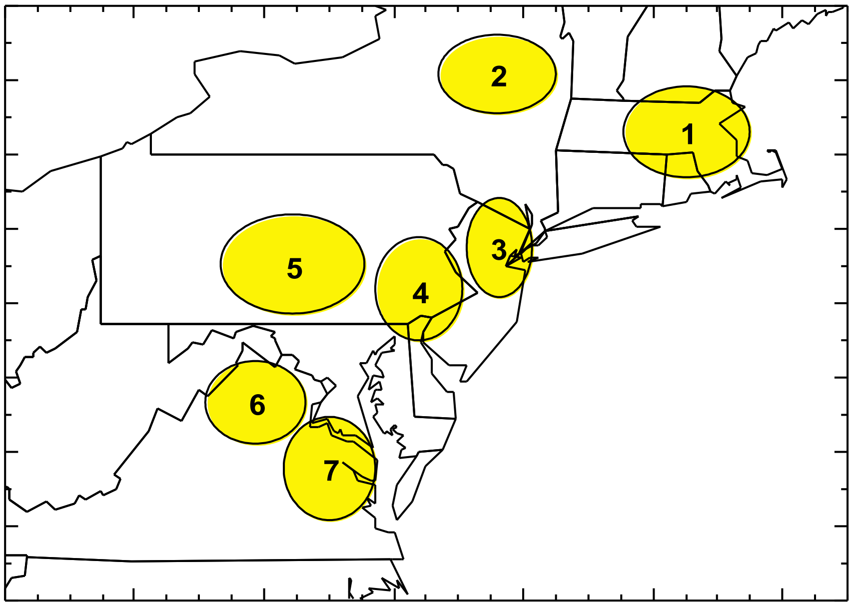
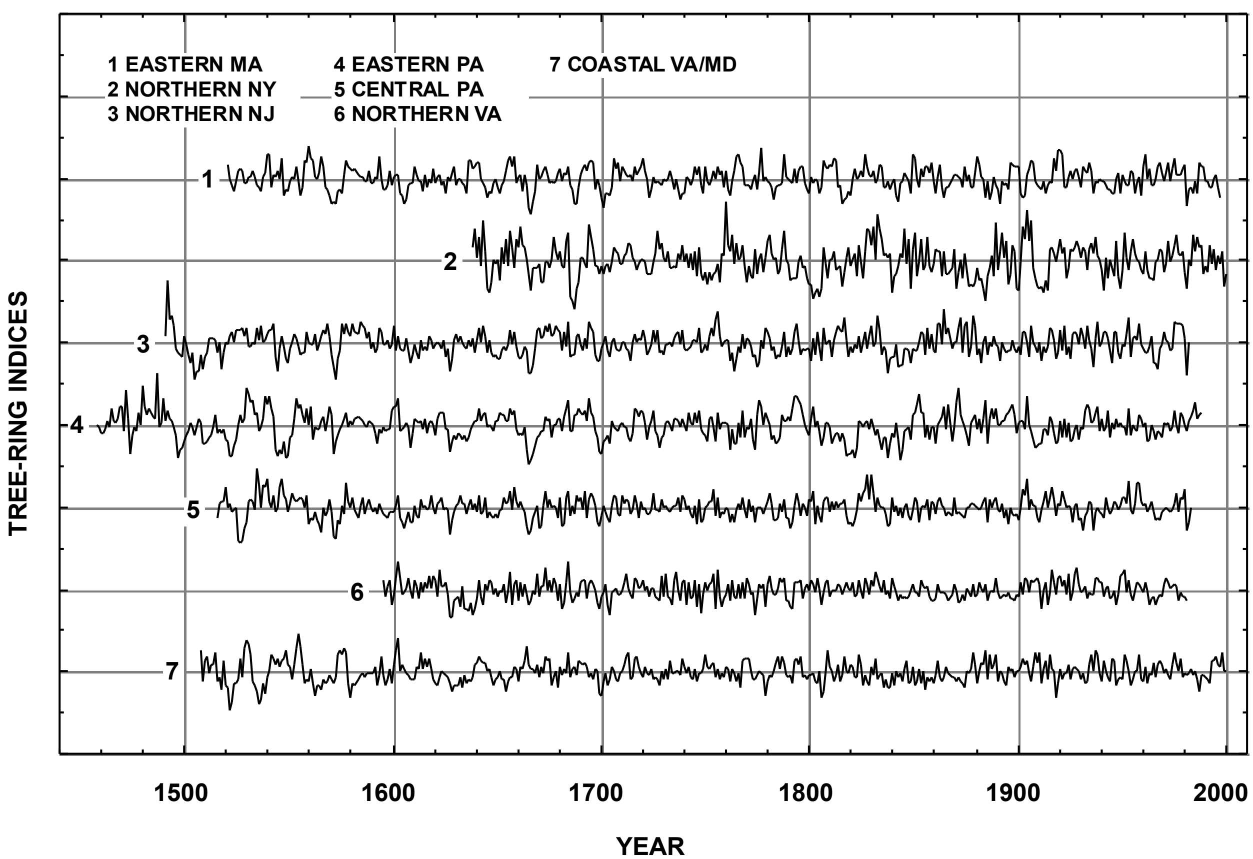


Figure 1. Comparison of the dated master series from the "Voorhees Family" barn (red plot) versus an independent oak dating master (blue plot). Nine out of eleven sampled oak timbers dated, with three having confirmed felling dates. The Voorhees barn master has a highly significant (p<<0.001) Spearman rank correlation with the oak dating master. See Table 1 for more details on the dating.

MODERN/HISTORICAL OAK CHRONOLOGIES
REGIONAL LOCATIONS OF SAMPLES



MODERN/HISTORICAL OAK TREE-RING CHRONLOGIES



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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 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 research 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
Allen House, Shrewsbury, NJ
Belle Ilse, Lancaster County, VA
Bowne House, Queens, NY
Carpenter’s Hall, Philadelphia, PA
Charpentier House, Philadelphia PA
Christ’s Church, Philadelphia, PA
Clifton, Northumberland County, VA
Conklin House, Huntington, NY
Customs House, Boston, MA
Daniel Boone Homestead, Birdsboro, PA
Daniel Pieter Winne House, Bethlehem, NY
Ditchley, Northumberland County, VA
Ephrata Cloisters, Lancaster County, PA
Fallsington Log House, Bucks County, PA
Ferris House, Old Greenwich, Fieldfield County, CT
Fawcett House, Alexandria, VA
Gadsby's Tavern, Alexandria, VA
Garrett House, Sugartown PA
Gilmore Cabin, Montpelier, Montpelier Station, VA
Gracie Mansion (Mayor’s Residence), New York, NY
Grove Mount, Richmond County, VA
Hanover Tavern, Hanover Courthouse, VA
Harriton House, Bryn Mawr, PA
Hills Farm, Accomack County, VA
Hollingsworth House, Elk Landing, MD
Indian Banks, Richmond County, VA
Indian King Tavern, Haddonfield NJ
Independence Hall, Philadelphia, PA
John Bowne House, Forest Hills, NY
Kirnan, Westmoreland County, VA
Linden Farm, Richmond County, VA
Log Cabin, Fort Loudon, PA
Lower Swedish Log Cabin, Delaware County, PA
Lummis House, Ipswich MA
Marmion, King George County, VA
Martin Cabin, New Holland PA
Menokin, Richmond County, VA
Merchant’s Hope Church, Prince George County, VA
Millbach House, Lebanon County, PA
Monaskon, Lancaster County, VA
Morris Jumel House, Jamaica, NY
Frederick Muhlenberg House, Trappe, PA
Nottingham DeWitt House, NY
Old Barn, Madison VA
Old Caln Meeting House, Thorndale, PA
Old Swede’s Church, Philadelphia, PA
Panel Paintings, National Gallery, Washington, DC
Pennock House & Barn, London Grove, PA
Penny Watson House, Greenwich, NJ
Podrum Farm, Limekiln, PA
Powell House, Philadelphia, PA
Pyne House, Cape May, NJ
Radcliff van Ostrade, Albany, NY
Reese's Corner House, Rock Hall, MD
Rippon Lodge, Prince William County, VA
Rochester House, Westmoreland County, VA
Rockett¨s, Doswell VA
Rural Plains, Hanover County, VA
Sabine Hall, Richmond County, VA
Shirley, Charles City County, VA
Sisk Cabin, Culpeper VA
Skiles Cabin, Sewickely PA
Spangler Hall, Bentonville, VA
Springwater Farm, Stockton, NJ
St. Peter’s Church, Philadelphia, PA
Strawbridge Shrine, Westminster, MD
Sweeney-Miller House, Kingston, NY
Thomas & John Marshall House, Markham, VA
Thomas Grist Mill, Exton, PA
Thomas Thomas House, Newtown Square, PA
Ticonderoga Pavilion, Ticonderoga, NY
Tuckahoe, Goochland County, VA
Tullar House, Egremont MA
Updike Barn, Princeton, NJ
Varnum’s HQ, Valley Forge, PA
Verville, Lancaster County, VA
West Camp House, Saugerties, NY
Westover, Charles City County, VA
White Plains House, King George, VA
Wilton, Westmoreland County, VA
Yew Hill, Fauquier County, VA