A Dendrochronological Analysis of the Petrus Hoffman House, Tivoli, Dutchess County, New York.

Dr. Edward R. Cook
William J. Callahan, Jr.
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Introduction

This is the final report on a dendrochronological analysis of the Petrus Hoffman House The house stands at 5020 Route 9G, Tivoli, Dutchess County, NY, (42°03'06"N 73°53'41"W).

In an effort to establish a more empirically precise chronology of the structure's history, the owners Donna Brown and Elliott Bristol requested that dendrochronologists William Callahan and Dr. Edward Cook perform a tree-ring analysis of selected representative structural timbers. Callahan and Cook visited the site on 12 April 2022, and collected samples for dendrochronological analysis. Of the 7 field samples taken, all 7 were deemed methodologically and conditionally of sufficient quality for submission for laboratory analysis. The submitted 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 completion of this analysis the 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 Petrus Hoffman House were processed in the 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; cut samples were similarly surfaced . The rings widths were measured under a microscope to a precision of ±0.001 mm. The cross-dating of the obtained measurements utilized a revised and modernized 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), now disused. 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 itself. 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, one or more internally cross-dated series are compiled from the individual site samples, and these are compared in turn 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.

During the Petrus Hoffman House study, species specific, regional composite master chronologies from living trees and historical structures from Central New York state and other near-lying regions were referenced primarily. All dating results were verified finally by subsequent comparison with other independent dating masters from surrounding regions. In each case, the datings as reported here were confirmed as correct.

Results and Conclusions

To achieve these datings required attention during analysis to the previously recorded structural context of the samples (see **Table 1**, column 3). 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 individual sample cross-dates with the mean of all 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 absolute cutting year. Absence of the bark edge (interchangeably called the wane) on a sample indicates that the outermost extant ring is not the year of cutting, but some identifiable year preceding the cutting. In the absence or loss of wane, field observations of wood anatomical factors often permit close approximation of the number of missing rings, and thus reasoned estimation of the cutting date. In particular the presence of sapwood, a physiologically active wood found immediately within the bark on the outer portion of the trunk, is an indication that the original wane was near.

The results of the dendrochronological dating of the timbers collected from the Petrus Hoffman House are summarized in **Table 1** and **Figure 1**. A total of 7 samples from 7 timbers were analyzed in the laboratory; all 7 were oak (*Quercus* sp.) and all dated strongly. Of these 7 dated samples, 4 had field identified bark/wane indicating the precise cutting year.

One of the cellar timbers (PHHTNY07) was judged to have wane when initially examined but unfortunately lost to some degree during extraction due to surface degradation, while leaving some sapwood rings. This presence is an indication that the original yet now absent bark-edge once had been near, commonly within 15 ± 5 years. Such surface loss (generally extending for less than an inch, or the equivalent 15 ± 5 years) is not unusual when timbers have been exposed to damp conditions for decades or even centuries, but importantly it is not evidence that these timbers have lost their structural bearing integrity. In this case the depth of loss was estimated post-sampling to be no more than circa 3/4 of an inch from the wane edge, in other words falling within the estimated, usual depth of sapwood.

It was common practice during this historical period that timbers intended for major structural usage were cut during forest growth dormancy, i.e. were harvested during the period between the cessation of wood growth of one calendar year and prior to the start of growth in the next. Timbering when done manually and in an era when transport was primarily horse drawn was simpler during a season when forest undergrowth was greatly suppressed and ground surfaces easier to navigate, especially if snow covered. This was true for both commercial and private timbering, both large scale and small.

Completed ring growth for the year 1751 indicates that these particular trees were harvested during growth dormancy of 1751/52, i.e that the trees were cut after 1751 growth ended and before 1752 growth started, i.e. approximately between November 1751 and February 1752. Completed ring growth for the year 1752 indicates that these trees were harvested during growth dormancy of 1752/53, i.e that the trees were cut after 1752 growth ended and before 1753 growth started, i.e. approximately between November 1752 and February 1753. See **Table 1,** column 6. None of the samples exhibited cutting dates later than indicated above.

Though trees were sometimes cut a year or two in advance, either in preparation for a planned construction and/or for sale, initial usage of these materials likely took place not long after harvesting, for in situ inspection of the timbers indicated that most if not all were worked very soon after cutting, in keeping with historical woodworking practices and traditional carpentry techniques.

The evidence of these datings in aggregate, as indicated by the datings of the outermost extant rings and the assumed range of sapwood to the wane surface, suggests one, or perhaps two, construction phases for the building sections represented by the tested materials: either a single phase (using two years' harvest) with its beginning in 1753 as indicated by the composite date of all the cellar timbers, or alternately two nearly simultaneous construction phases as indicated by separate timber harvests of 1751/52 and 1752/53. Given that it is unlikely that one fully completed construction would be almost immediately followed by a second, it is reasonable to assume that although the building in fact may have begun in 1752 the effort was not completed until after the later felling date of 1752/53, i.e. that final construction took place in 1753, perhaps extending into 1754, or even into 1755.

It should be remembered when considering these results that, although not suggested by any of the timbers analyzed in this project, other construction phases prior to or subsequent to the dates identified by this investigation cannot be either supported or discounted. Re-use of the timbers in and for other later construction phases, although not evidenced directly in these materials, cannot be excluded absolutely and must be considered when 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 dates given are demonstrative of the history of the existing building unit.

Table 1. Dendrochronological dating results for samples from the Petrus Hoffman House, Tivoli, Dutchess County, New York. All correlations are Spearman rank correlations of each series against the mean of all of the others of the same species. For WANEY, +BE means the bark edge ring 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. If –BE, +SP refers to the strong likelihood that sapwood rings are present; if so, the outermost date will be close to the cutting date. 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
PHHTNY 01	White Oak	Cellar, N side, 1st joist from N wall	+BE comp	94	1659-1752	0.314
PHHTNY 02	White Oak	Cellar, N side, 2nd joist from N wall	-BE, SP?	110	1626 1735	0.647
PHHTNY 03	White Oak	Cellar, N side, 3rd joist from N wall	-BE, SP?	214	1504-1717 [a] (1626 1717)	0.516
PHHTNY 04	White Oak	Cellar, N side, 4th joist from N wall	+BE comp	85	1668 1752	0.511
PHHTNY 05	White Oak	Cellar, S side, 5th joist from N wall	+BE comp	100	1652 1751	0.597
PHHTNY 06	White Oak	Cellar, S side, 6th joist from N wall	+BE comp	68	1684 1751	0.589
PHHTNY 07	White Oak	Cellar, S side, 7th joist from N wall	-BE, SP+	118	1626 1743	0.707

a Severely suppressed growth prior to about 1620, only the overlap with the other samples back to 1626 can be correlated.

Table 1. Dendrochronological dating results for samples taken from the Petrus Hoffman House located in Tivoli, Dutchess County, New York. For interpreted felling dates of the trees used for construction, +BE means that the bark edge was present and believed 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 outer date may be close to the cutting date. All correlations are Spearman rank correlations of each series

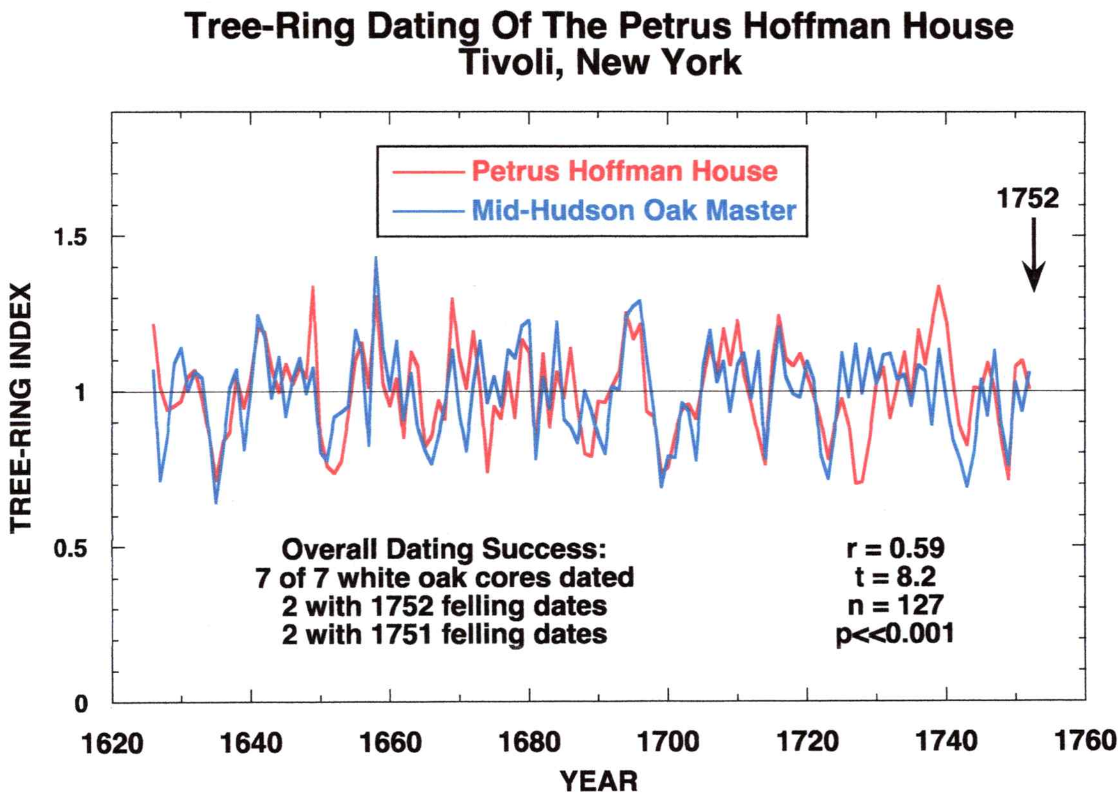
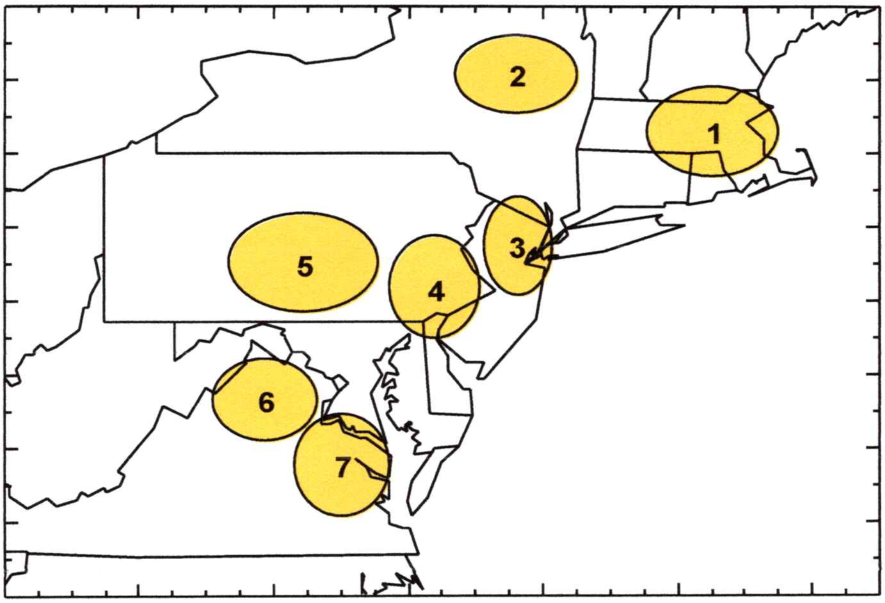


Figure 1. Comparison of the cross-dated, compiled site chronology for the Petrus Hoffman House in Tivoli, NY (red plot) against a regional historical dating master from mid-to-northern Hudson Valley (blue plot). The indicated cross-dating is statistically very strong (t>>3.5) and the 1751/52 waney edge rings were completely formed, thus indicating that the timbers used to construct the Petrus Hoffman House were felled sometime between the end of the 1751/52 growth seasons and before the start of the 1752/53 growth seasons (see **Table 1**).

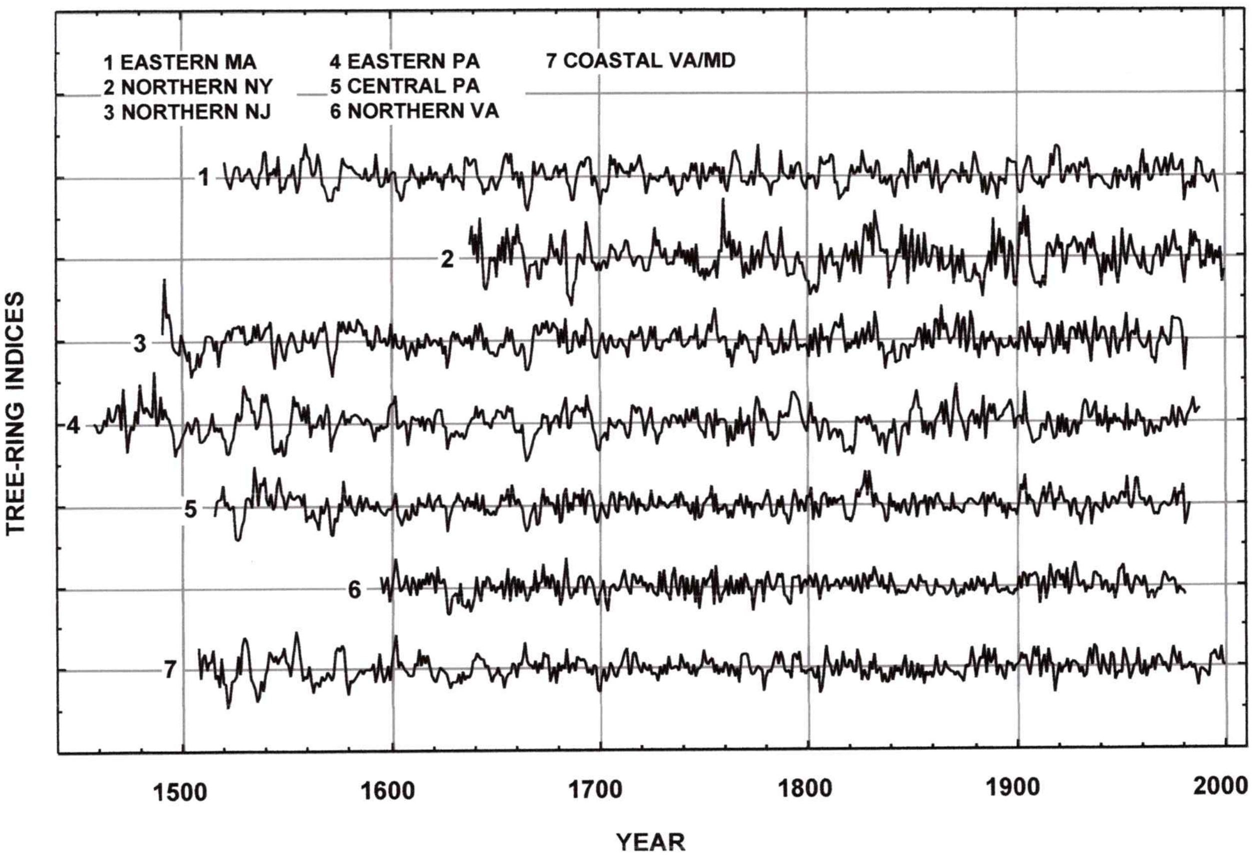
The Spearman rank correlation between the series (t=8.2) associated with the correlation between the Petrus Hoffman House compiled series and the regional master chronology (r=0.59) is statistically very significant (p<<0.001) for a 127-year overlap. For that reason, there can be no doubt that the dates presented here for the sampled oak elements of the structure are robustly valid, and that the statistical chance of the cross-dates being incorrect is exponentially far less than 1 in 1000.

The "r-factor" is the Spearman rank correlation coefficient, a measure of the 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.

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 Isle, 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, Fairfield 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 Parsonage, Kinderhook NY
Old Swede's Church, Philadelphia, PA
OTB House, West Nyack, NY
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
Stiles 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