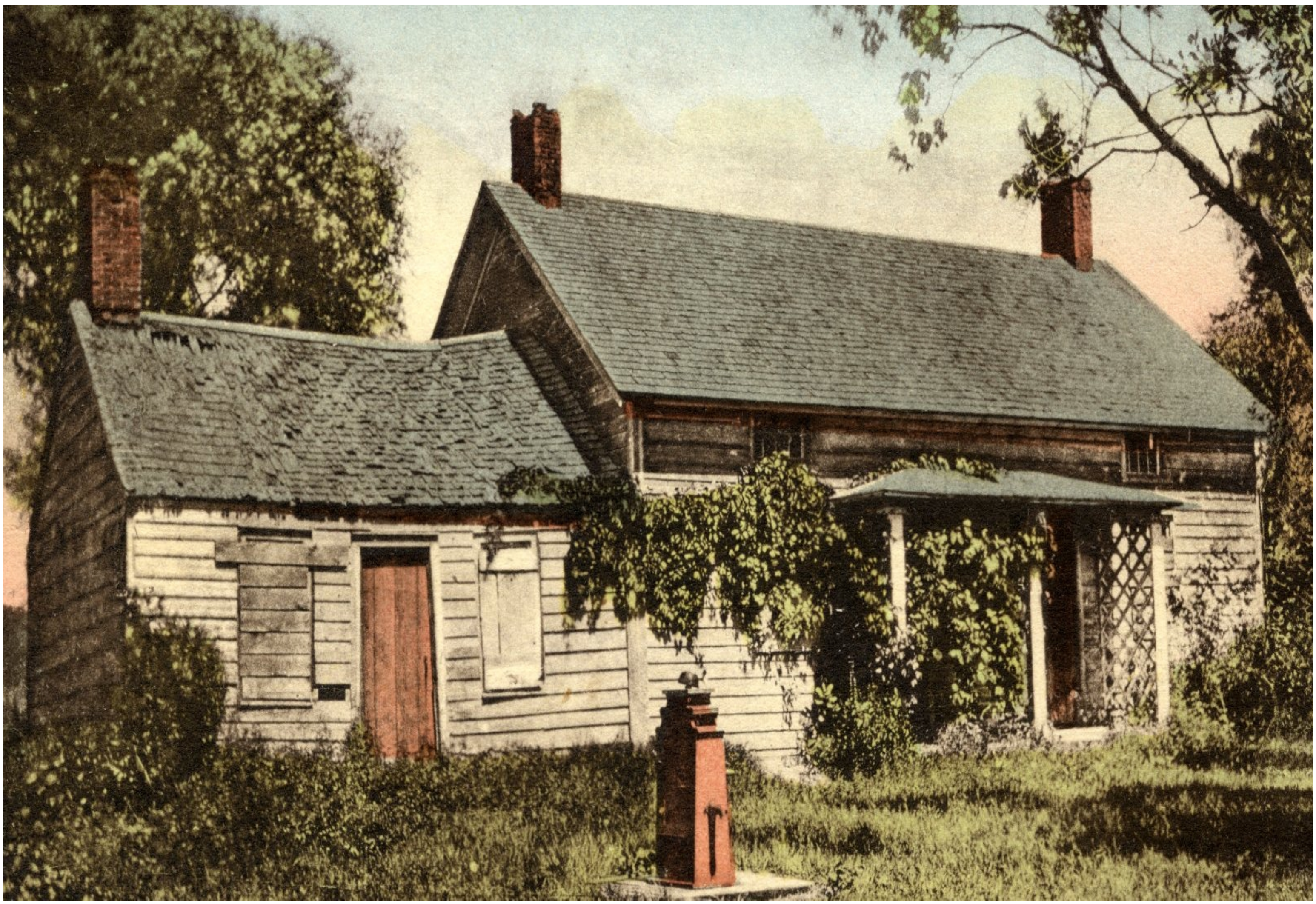
A Dendrochronological Analysis at "Tory Hill Farm", Hillsdale, Columbia County, New York.



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Introduction

This is the final report on the dendrochronological analysis of two structures at the "Tory Hill Farm", 77 Old Town Road, Hillsdale, Columbia County, New York 01259 (42°11'10"N 73°30'58"W). The houses and grounds are owned by David & Frances Eberhart, who wish to chronicle the historical evolution of the property.

In an effort to establish a more precise history of the buildings, architectural historian Neil Larson of Larson Fisher Associates, Woodstock NY, requested that dendrochronologists William Callahan and Dr. Edward Cook perform a tree-ring analysis of selected representative structural timbers from these two structures on the farm. The primary subject of the project was the "Bristol House" structure (so-called after a historical resident, while also known interchangeably as the "tenant house"), while a secondary subject of the project was the farm's "main residential house". Throughout this report the two structures will be specified by the terms "Bristol House" and "main house"

Callahan visited the site and collected samples for the dendrochronological analysis of the timbers on 3 & 4 December 2019. Of the 16 field samples taken, 14 were deemed methodologically and conditionally of sufficient quality for submission for laboratory analysis. Two samples were discarded on site after extraction due to deficient physical quality and/or insufficient number of rings. Nine of the submitted samples were of oak (Quercus sp.), six from the Bristol House and three from the main house, and five were of pine (Pinus sp.), all from the Bristol House.

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 Tory Hill Farm 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), 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 Tory Hill Farm study, species specific, regional composite master chronologies from living trees and historical structures from the Hudson Valley and 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

The results of the dendrochronological dating of the Tory Farm timbers are summarized in **Table 1** and **Figures 1 & 2**. A total of 14 samples were analyzed in the laboratory, with 11 of the samples providing firm dendrochronological dates. All of the 11 dated samples were collected from the Bristol House. None of the samples from the main house dated; unfortunately the 3 samples collected from the main house contained too few rings either individually or in aggregate to provide statistically viable dates.

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(s), 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 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 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.

Of the 6 oak samples from the Bristol House that cross-dated well between themselves and also dated well against the local oak historical dating master (see **Table 1**, column 6), one (BHCCNY01) had field verified bark edge at the time of sampling. Of the 5 pine samples that cross-dated well between themselves and also dated well against the local pine historical dating master (see **Table 1**, column 6), one (BHCCNY10) had field verified bark edge at the time of sampling. Evidence of sapwood remained on some or all of the non-wane oak samples, strengthening a reasoned evaluation of the cutting date for the structural unit as a whole.

For both the oak and pine samples, 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 winter dormancy following the end of the growth season, i.e. cutting took place during approximately November to February when no wood growth occurs (see **Table 1**). The outermost extant ring on any of the analyzed oak samples is 1759; the oaks employed in the construction of the cellar were harvested during dormancy between 1759/1760. The outermost extant ring on any of the analyzed pine samples is from 1759; the pines employed in the construction of the tested pines from the first floor and the attic likewise were harvested during dormancy between 1759/1760. 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 chronological congruency in the collective set of datings of the selected cellar oak and attic pine timbers from the building indicates that a significant construction phase for the Bristol House at Tory Farm took place no earlier than the laying down of the cellar oak timbers, and arguably was completed during that calendar year of 1760. Moreover, that the cutting dates of the pine timbers are coincident with the cellar oak materials indicates that the construction was a deliberate and planned undertaking, and suggests that the work was likely completed within a relatively brief period. Of course, it must be remembered that timber harvesting may have occurred somewhat in advance of a planned construction, and that final construction activities may possibly have continued for some few years after. Nevertheless, it is reasonable to speculate that general construction probably took place during the early and middle part of calendar year 1760 (eg. after sowing and before the harvest), perhaps -but not necessarily- continuing into calendar year 1761.

Although not suggested by any of the timbers analyzed in this project, other construction phases prior or subsequent to the dates identified by this investigation cannot be empirically supported or discounted. Furthermore, re-use of individual older timbers in any construction phases, although not evidenced directly in the sampled 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 are demonstrative of the history of the existing Bristol House structure.

The farm's main residential house proved disappointing, the oak samples being of insufficient methodological quality because they had too few growth rings to support any statistically viable correlation with either the regional master chronologies or with the constituent timbers from within the site. Although the minimum number of rings required for reliable cross-dating is dependent on multiple circumstances, to satisfy methodological parameters in general a sample should contain at least 60+ growth rings, and preferably more. Often samples with so few rings produce random aberrant correlations, and thus dating(s) that are empirically unsupportable. Unlike at the Bristol House, the timbers in the main house were from very fast growing oaks, indicative of unhindered growth in an open landscape rather than in tight forested conditions, and, in spite of being chosen for larger dimensions suitable to their function within the structure, when harvested were not older than ≈50 years. Given their growth patterns, a reasonable inference is that these timbers developed from saplings that grew after the old forests were harvested and the local lands cleared for agriculture. The timbers thus suggest a construction phase for the main house multiple decades after the construction of the earlier structure, but nevertheless can provide no proof for that supposition.

Table 1. Dendrochronological dating results for oak and pine samples from the "Tory Hill Farm", Hillsdale, Columbia 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.

PRIMARY SAMPLING, TAKEN FROM THE BRISTOL HOUSE/TENANT HOUSE						
ID	**SPECIES**	**DESCRIPTION**	**WANEY**	**RINGS**	**DATING**	**CORREL**
BHCCNY01	Oak	Cellar joist, 1st from east wall	+BE comp	127	1633-1759	0.361
BHCCNY 02	Oak	Cellar joist, 2nd from east wall	-BE, -SP?	98	1651-1748	0.383
BHCCNY 03	Oak	Cellar joist, 3rd from east wall	-BE, -SP?	95	1650-1744	0.525
BHCCNY 04	Oak	Cellar joist, 4th from east wall	-BE, +SP	89	1662-1750	0.515
BHCCNY 05	Oak	Cellar joist, 5th from east wall	-BE, -SP?	192	1549-1740	0.540
BHCCNY 06	Oak	Cellar joist, 6th from east wall	-BE, -SP?	88	1657-1744	0.469
BHCCNY07	Pine	1st floor joist, 3rd from west wall	-BE	112	1611-1722	0.429
BHCCNY 08	Pine	1st floor joist, over west wall, south side of fireplace	-BE	78	1651-1728	0.619
BHCCNY 09	Pine	1st floor joist, 1st from wall, chamfering surface	-BE	70	1651-1720	0.521
BHCCNY 10	Pine	2nd floor rafter, 1st at west wall, north side	+BE comp	66	1694-1759	0.305
BHCCNY 11	Pine	2nd floor rafter, 3rd from east wall, south side	-BE	52	1702-1753	0.301
SECONDARY SAMPLING, TAKEN FROM THE MAIN HOUSE						
ID	**SPECIES**	**DESCRIPTION**	**WANEY**	**RINGS**	**DATING**	**CORREL**
BHCCNY 21	Oak	Cellar, east/west beam, southeast side, center section	-BE, +SP	54	undated, too few rings	-.---
BHCCNY 22	Oak	Cellar, north/south summer beam, center section	-BE, +SP	37	undated, too few rings	-.---
BHCCNY 23	Oak	Cellar, east/west beam, northeast side, center section	-BE, +SP	33	undated, too few rings	-.---

Table 1. Dendrochronological dating results for oak and pine samples taken from two structures at the Tory Hill Farm located in Hillsdale, Columbia 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 strong 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

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.

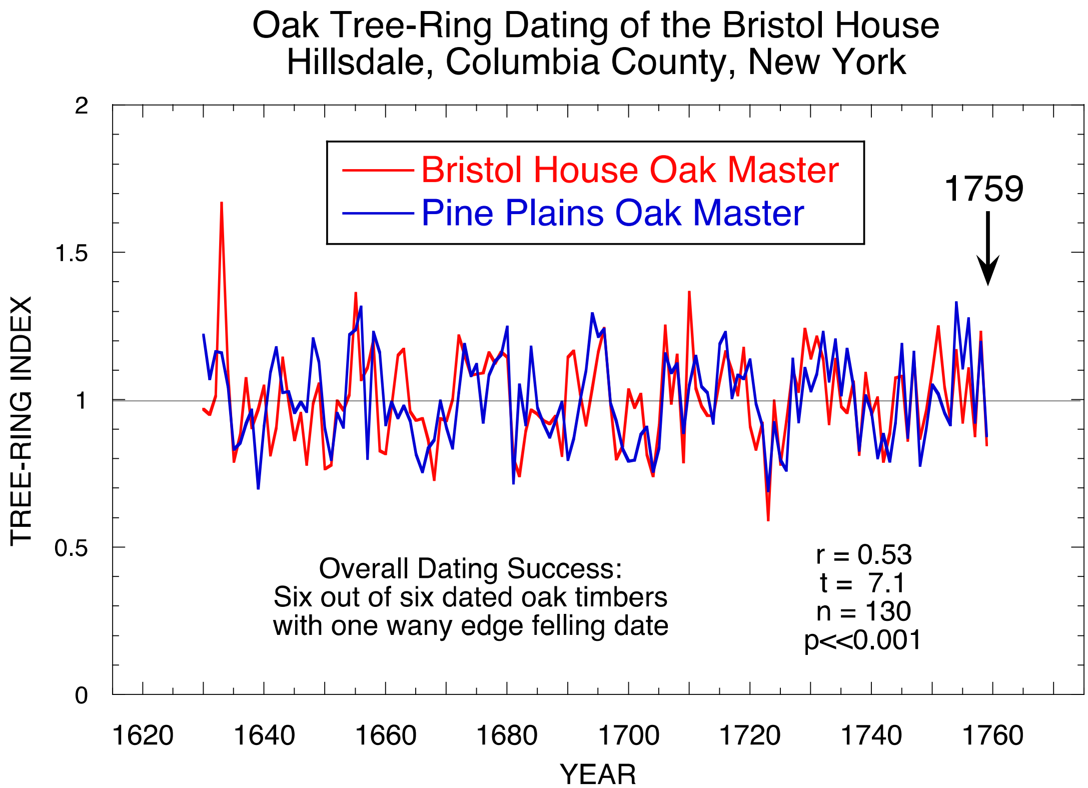


Figure 1. Comparison of the cross-dated, site compiled oak chronology for the Bristol House against a historical oak master chronology from Central New York state. Six of the nine sampled oak timbers dated, with one of the six providing a felling date of 1759 with the outermost annual ring complete, indicating that the tree was felled during the growth-dormant period of 1759-60 (i.e. autumn/winter months). The Spearman rank correlation between the series (r=0.53) is highly significant (p<0.001) with an overlap of 130 years and a t-statistic of 7.1.

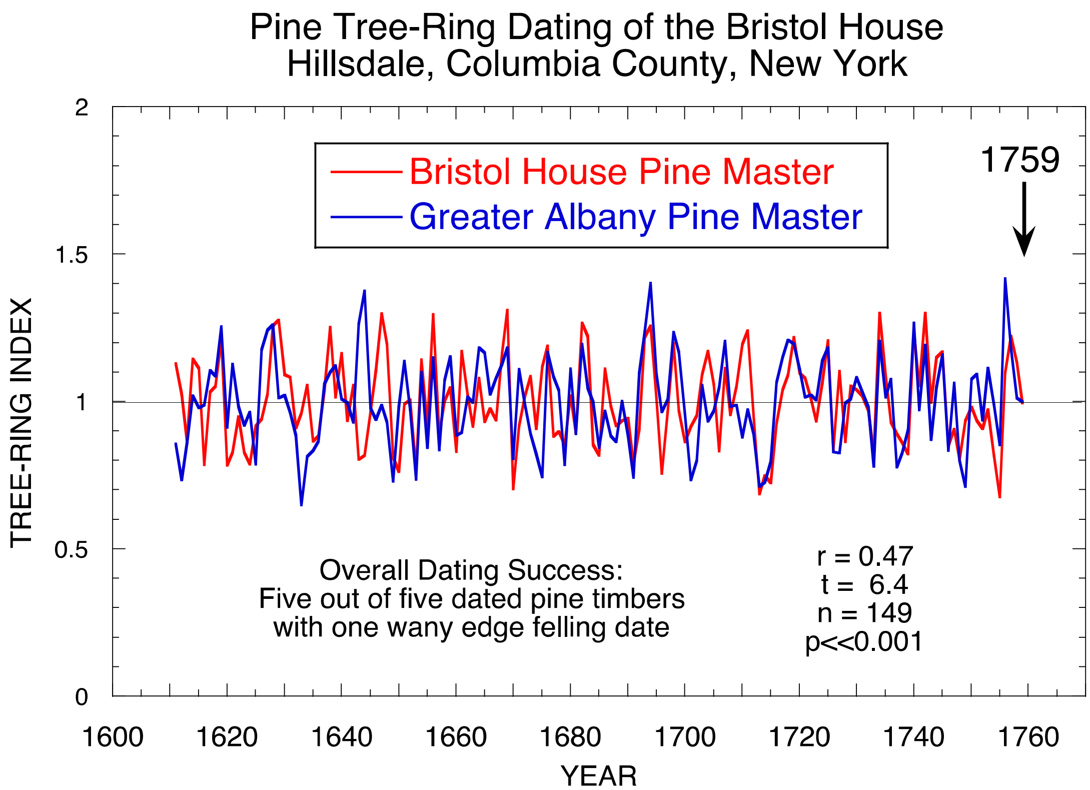
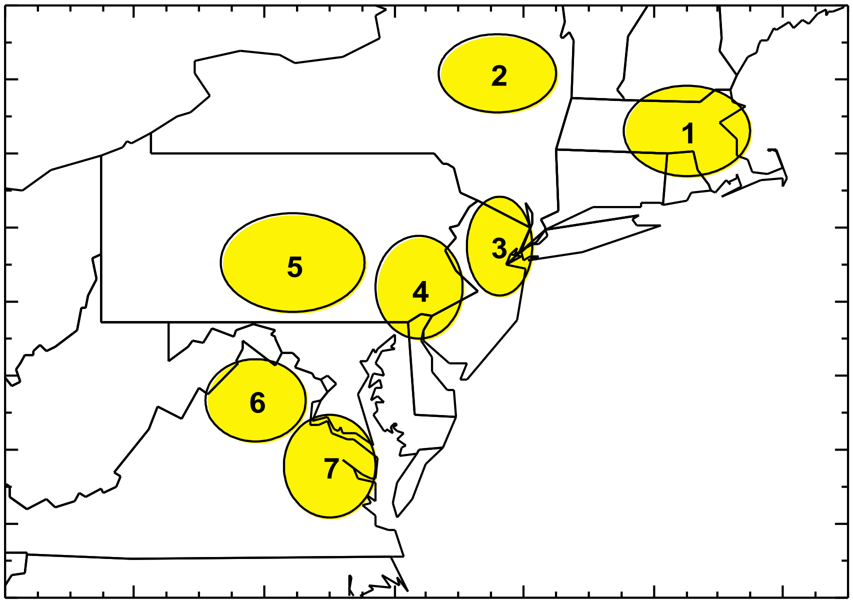


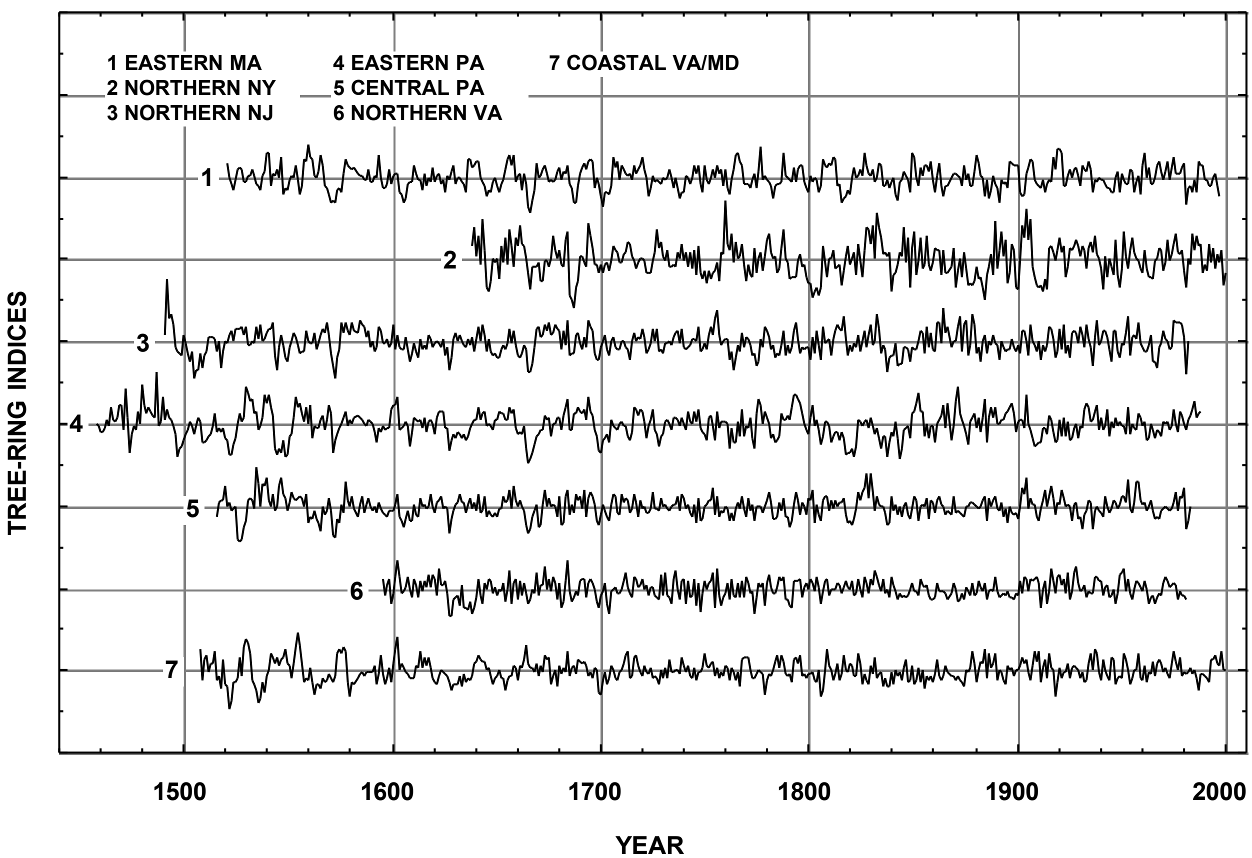
Figure 2. Comparison of the cross-dated, site compiled pine chronology for the Bristol House against a historical pine master chronology for the Central New York region. Five of the five sampled pine timbers dated, with one of the five providing a felling date of 1759 with the outermost annual ring complete, indicating that the tree was felled in the growth-dormant period of 1759-60 (i.e. autumn/winter months). The Spearman rank correlation between the series (r=0.47) is highly significant (p<<0.001) with an overlap of 149 years and a t-statistic of 6.4.

The t-statistics (t=7.1) associated with the correlation between the Bristol House oak series and the regional oak master chronology (r=0.53) is statistically very significant (p<<0.001) for a 130-year overlap. The t-statistics (t=6.4) associated with the correlation between the Bristol House pine series and a regional pine master chronology (r=0.47) is statistically very significant (p<<0.001) for a 149-year overlap. For that reason, there can be no doubt that the dates presented here for the sampled elements of that structure are robustly valid, and that the statistical chance of the cross-dates being incorrect is exponentially far less than 1 in 1000.

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