

**Oxford Tree-Ring Laboratory
Report 2016/13**

**The Tree-Ring Dating of the
Hammerstone Barn (Holland Township Barn Survey #1),
Bloomsbury, New Jersey**

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Summary:

Hammerstone Barn/Hamilton Tract Lot #28 Tenant Barn (Holland Township Barn Survey #1),
133 Hawks Schoolhouse Road, Holland Township, Hunterdon County, New Jersey (40.629952,
-75.108040)

Primary Barn

Felling dates: **Spring 1803, Winter 1803/4**

Swing beam (1/1) 1803 (C); Tie beams (1/2) 1755; *Ex-situ* joists (2/2) 1802 (¼C), 1783; *Ex-situ* beams (2/2)
1724, 1714.

Site Master 1607-1803 HSNJx1 ($t = 11.08$ HOLL2; 9.97 APNJx1; 9.13 WYDNJx1).

The Hammerstone Barn is a ground-level, three-bay, swing beam barn in Holland Township, New Jersey. It features a heavy timber frame with full-width cambered tie beams in all four bents.

Dendrochronological analysis has shown that the original structure was built from timbers felled in the spring of 1803 and the winter of 1803/4, suggesting that the building was constructed in the winter of 1803/4 or shortly thereafter.

Date sampled:	December 6, 2016
Owner:	Michael Hammerstone
Commissioners:	Larry LaFevre and Carla Cielo, Holland Township Historic Preservation Commission
Funder:	Holland Township Committee
Street address:	133 Hawks Schoolhouse Road, Bloomsbury, NJ 08804
Summary published:	www.dendrochronology.com

How Dendrochronology Works

Dendrochronology has over the past few decades become one of the leading and most accurate scientific dating methods. While not always successful, when it does work, it is precise, often to the season of the year. Tree-ring dating to this degree of precision is well known for its use in dating historic buildings and archaeological timbers. However, more ancillary objects such as doors, furniture, panel paintings, and wooden boards in medieval book-bindings can sometimes be successfully dated.

The science of dendrochronology is based on a combination of biology and statistics. In temperate zones, a tree puts on a new layer of growth underneath the bark every year, with the effect being that the tree grows wider and taller as it ages. Each annual ring is composed of the growth which takes place during the spring and summer and continues until about November, when the leaves are shed and the tree becomes dormant for the winter period. For the two principal American oaks, the white and red (*Quercus alba* and *Q. rubra*), as well as for the black ash (*Fraxinus nigra*) and many other species, the annual ring is composed of two distinct parts: the spring growth or early wood, and the summer growth, or late wood. Early wood is composed of large vessels formed during the period of shoot growth which takes place between March and May, before the establishment of any significant leaf growth. This is produced by using most of the energy and raw materials laid down the previous year. Then, there is an abrupt change at the time of leaf expansion around May or June when hormonal activity dictates a change in the quality of the xylem, and the summer growth, or late wood, is formed. Here the wood becomes increasingly fibrous and contains much smaller vessels. Trees with this type of growth pattern are known as ring-porous, and are distinguished by the contrast between the open, light-colored early wood vessels and the dense, darker-colored late wood.

Other species of tree, such as tulip poplar (*Liriodendron tulipifera* L.), are known as diffuse-porous. Unlike the ring-porous trees, the spring vessels consist of very small spring vessels that become even smaller as the tree advances into the summer growth. The annual growth rings are often very difficult to distinguish under even a powerful microscope, and one often needs to study the medullary rays, which thicken at the ring boundaries.

Dendrochronology utilizes the variation in the width of the annual rings as influenced by climatic conditions common to a large area, as opposed to other more local factors such as woodland competition and insect attack. It is these climate-induced variations in ring widths that allow calendar dates to be ascribed to an undated timber when compared to a firmly-dated sequence. If a tree section is complete to the bark edge, then when dated a precise date of felling can be determined. The felling date will be precise to the season of the year, depending on the degree of formation of the outermost ring. Therefore, a tree with bark that has the spring vessels formed but no summer growth can be said to be felled in the spring, although it is not possible to say in which particular month the tree was felled.

Another important dimension to dendrochronological studies is the presence of sapwood and bark. This is the band of growth rings immediately beneath the bark and comprises the living growth rings which transport the sap from the roots to the leaves. This sapwood band is distinguished from the heartwood by the prominent features of color change and the blocking of the spring vessels with tyloses, the waste products of the tree's growth. The heartwood is generally darker in color, and the spring vessels are usually blocked with tyloses. The heartwood is dead tissue, whereas the sapwood is living, although the only really living, growing, cells are in the cambium, immediately beneath the bark. In the American white oak (*Quercus alba*), the difference in color is not generally matched by the change in the spring vessels, which are often filled by tyloses to within a year or two of the terminal ring. Conversely, the spring vessels in the American red oak (*Q. rubra*) are almost all free of tyloses, right to the pith. Generally the sapwood retains stored food and is therefore attractive to insect and fungal attack once the tree is felled and therefore is often removed during conversion.



Figure 1. A cross-section of an oak timber with sapwood rings on the left-hand side (above). The boxes illustrate conversion methods resulting in **A**) a precise felling date and **B**) a *terminus post quem* or felled after date. Also pictured is a core showing complete sapwood (below).

Methodology: The Dating Process

All samples were from what appeared to be primary first-use timbers. Timbers that looked most suitable for dendrochronological purposes—those with complete sapwood or reasonably long ring sequences—were selected. *In-situ* timbers were sampled through coring, using a 16 mm hollow auger, while samples from *ex-situ* timbers were taken with an electric saw.

The dry samples were sanded on a finisher, or bench-mounted belt sander, using 60 to 1200 grit abrasive paper, and were cleaned with compressed air to allow the ring boundaries to be clearly distinguished. They were then measured under a x10/x30 microscope using a travelling stage electronically displaying displacement to a precision of 0.01mm. Thus each ring or year is represented by its measurement which is arranged as a series of ring-width indices within a data set, with the earliest ring being placed at the beginning of the series, and the latest or outermost ring concluding the data set.

As indicated above, the principle behind tree-ring dating is a simple one: the seasonal variations in climate-induced growth as reflected in the varying width of a series of measured annual rings is compared with other, previously dated ring sequences to allow precise dates to be ascribed to each ring. When an undated sample or site sequence is compared against a dated sequence, known as a reference chronology, an indication of how good the match is must be determined. Although it is almost impossible to define a visual

match, computer comparisons can be accurately quantified. While it may not be the best statistical indicator, Student's (a pseudonym for W S Gosset) t -value has been widely used among dendrochronologists. The cross-correlation algorithms most commonly used and published are derived from Baillie and Pilcher's CROS program (Baillie and Pilcher 1973).

Generally, t -values over 3.5 should be considered significant, although in reality it is common to find demonstrably spurious t -values of 4 and 5 because more than one matching position is indicated. For this reason, dendrochronologists prefer to see some t -value ranges of 5, 6, or higher, and for these to be well replicated from different, independent chronologies with local and regional chronologies well represented. Users of dates also need to assess their validity critically. They should not have great faith in a date supported by a handful of t -values of 3s with one or two 4s, nor should they be entirely satisfied with a single high match of 5 or 6. Examples of spurious t -values in excess of 7 have been noted, so it is essential that matches with reference chronologies be well replicated, and that this is confirmed with visual matches between the two graphs. Matches with t -values of 10 or more between individual sequences usually signify having originated from the same parent tree.

In reality, the probability of a particular date being valid is itself a statistical measure depending on the t -values. Consideration must also be given to the length of the sequence being dated as well as those of the reference chronologies. A sample with 30 or 40 years growth is likely to match with high t -values at varying positions, whereas a sample with 100 consecutive rings is much more likely to match significantly at only one unique position. Samples with ring counts as low as 50 may occasionally be dated, but only if the matches are very strong, clear, and well replicated, with no other significant matching positions. This is essential for intra-site matching when dealing with such short sequences. Consideration should also be given to evaluating the reference chronology against which the samples have been matched: those with well-replicated components that are geographically near to the sampling site are given more weight than an individual site or sample from far away.

It is general practice to cross-match samples from within the same phase to each other first, combining them into a site master, before comparing with the reference chronologies. This has the advantage of averaging out the "noise" of individual trees and is much more likely to obtain higher t -values and stronger visual matches. After measurement, the ring-width series for each sample is plotted as a graph of width against year on log-linear graph paper. The graphs of each of the samples in the phase under study are then compared visually at the positions indicated by the computer matching and, if found satisfactory and consistent, are averaged to form a mean curve for the site or phase. This mean curve and any unmatched individual sequences are compared against dated reference chronologies to obtain an absolute calendar date for each sequence. Sometimes, especially in urban situations, timbers may have come from different sources and fail to match each other, thus making the compilation of a site master difficult. In this situation samples must then be compared individually with the reference chronologies.

Therefore, when cross-matching samples with each other, or against reference chronologies, a combination of both visual matching and a process of qualified statistical comparison by computer is used. For this study, the ring-width series were compared on an IBM compatible computer for statistical cross-matching using a variant of the Belfast CROS program (Baillie and Pilcher 1973).

Ascribing and Interpreting Felling Dates

Once a tree-ring sequence has been firmly dated in time, a felling date, or date range, is ascribed where possible. For samples that have sapwood complete to the underside of, or including, bark, this process is relatively straight forward. Depending on the completeness of the final ring, i.e. if it has only the early wood formed, or the latewood, a *precise felling date and season* can be given. Where the sapwood is partially missing, or if only a heartwood/sapwood transition boundary survives, then the question of when the tree was felled becomes considerably more complicated. In the European oaks, sapwood tends to be of a

relatively constant width and/or number of rings, and it is possible to estimate the approximate number of sapwood rings that are missing from any given timber.

Unfortunately, it has not been possible to apply an accurate sapwood estimate to either the white or red oaks at this time. Primarily, it would appear that there is a complete absence of literature on sapwood estimates for oak anywhere in the country (Grissino-Mayer, *pers comm*). The matter is further complicated in that the sapwood in white oak (*Quercus alba*) occurs in two bands, with only the outer ring or two being free of tyloses in the spring vessels (Gerry 1914; Kato and Kishima 1965). Out of some 50 or so samples, only a handful had more than 3 rings of sapwood without tyloses. The actual sapwood band is differentiated sometimes by a lighter color, although this is often indiscernible (Desch 1948). In archaeological timbers, the lighter colored sapwood does not collapse as it does in the European oak (*Q. rober*), but only the last ring or two without tyloses shrink tangentially. In these circumstances the only way of being able to identify the heartwood/sapwood boundary is by recording how far into the timber wood boring beetle larvae penetrate, as the heartwood is not usually susceptible to attack unless the timber is in poor or damp conditions. Despite all of these drawbacks, some effort has been made in recording sapwood ring counts on white oak, although the effort is acknowledged to be somewhat subjective.

As for red oaks (*Quercus rubra*) it will probably not be possible to determine a sapwood estimate as these are what are known as “sapwood trees” (Chattaway 1952). Whereas the white oak suffers from an excess of tyloses, these are virtually non-existent in the red oak, even to the pith. Furthermore, there is no obvious color change throughout the section of the tree, and wood-boring insects will often penetrate right through to the center of the timber. Therefore, in sampling red oaks, it is vital to retain the final ring beneath the bark, or to make a careful note of the approximate number of rings lost in sampling, if any meaningful interpretation of felling dates is to be made. Similarly, no study has been made in estimating the number of sapwood rings in tulip-poplar, black ash, or any of the pines.

Therefore, if the bark edge does not survive on any of the timbers sampled, only a *terminus post quem* or *felled after* date can be given. The earliest possible felling date would be the year after the last measured ring date, adjusted for any unmeasured rings or rings lost during the process of coring.

Some caution must be used in interpreting solitary precise felling dates. Many instances have been noted where timbers used in the same structural phase have been felled one, two, or more years apart. Whenever possible, a group of precise felling dates should be used as a more reliable indication of the construction period. It must be emphasized that dendrochronology can only date when a tree has been felled, not when the timber was used to construct the structure under study. However, it is common practice to build timber-framed structures with green or unseasoned timber and therefore construction usually took place within twelve to eighteen months of felling (Miles 1997).

Details of Dendrochronological Analysis

The results of the dendrochronological analysis for the buildings under study are presented in a number of detailed tables. The most useful of these is the summary **Table 1**. This gives most of the salient results of the dendrochronological process, and includes details for each sample, such as its species, location, and felling date, if successfully tree-ring dated. This last column is of particular interest to the end user, as it gives the actual year and season when the tree was felled, if bark or bark edge is present. If bark edge is not present, it gives a *terminus post quem* or date after which the timber was felled. Often these *terminus post quem* dates begin far earlier than any associated precise felling dates. This is simply because far more rings have been lost in the initial conversion of the timber. If the sapwood was complete on the timber but some was lost during coring, an estimated date range can sometimes be given.

It will also be noticed that often the precise felling dates will vary within several years of each other. Unless there is supporting archaeological evidence suggesting different phases, all this would indicate is either

stockpiling of timber, or of trees that had been felled or died at varying times but were not cut up until the commencement of the particular building operations in question. When presented with varying precise felling dates, one should always take the latest date for the structure under study, and it is likely that construction will have been completed for ordinary vernacular buildings within twelve or eighteen months from this latest felling date (Miles 1997).

Table 2 gives an indication of the statistical reliability of the match between one sequence and another. This shows the t -value over the number of years overlap for each combination of samples in a matrix table. It should be born in mind that t -values with less than 80 rings overlap may not truly reflect the same degree of matching and that spurious matches may produce similar values.

First, multiple radii have been cross-matched with each other and combined to form same-timber means. These are then compared with other samples from the site and any which are found to have originated from the same parent tree are again similarly combined. Finally, all samples, including all same timber and same tree means, are combined to form one or more site masters. Again, the cross-matching is shown as a matrix table of t -values over the number of years overlaps. Reference should always be made to **Table 1** to clearly identify which components have been combined.

Table 3 shows the degree of cross-matching between the site master(s) and a selection of reference chronologies. This shows the state or region from which the reference chronology originated, the common chronology name, the publication reference, and the years covered by the reference chronology. The number of overlapping years between the reference chronology and the site master is also shown together with the resulting t -value. It should be noted that well replicated regional reference chronologies, which are shown in **bold**, will often produce better matches than individual site masters or indeed individual sample sequences.

Figures include a bar diagram that shows the chronological relationship between two or more dated samples from a phase of building and any plans showing sample locations, if available.

Publication of all dated sites for English buildings occurs annually in *Vernacular Architecture*, but regrettably there is at the present time no vehicle available for the publication of dated American buildings. However, a similar entry is shown on the summary page of the report, which could be used in any future publication of American dates. This does not give as much technical data for the samples dated, but does give the t -value matches against the relevant chronologies, provides a short descriptive paragraph for each building or phase dated, and gives a useful short summary of samples dated. These summaries are also listed on the web-site maintained by the Laboratory, which can be accessed at www.dendrochronology.com. The Oxford Tree-Ring Laboratory retains copyright of this report, but the commissioner of the report has the right to use the report for his or her own use so long as the authorship is quoted. Primary data and the resulting site master(s) used in the analysis are available from the Laboratory on request by the commissioner and bona fide researchers. The samples form part of the Laboratory archives, unless an alternative archive, such as the Colonial Williamsburg Foundation in association with the Oxford Tree-Ring Laboratory, has been specified in advance.

Sampling

A dendrochronological study of the Hammerstone Barn was undertaken in an attempt to date the primary construction phase of the building. Seven timbers in total were sampled: six of white oak and one of Eastern hemlock. Three of the samples were taken from the standing structure (from a swing beam and two tie beams) while four were taken from timbers removed during a recent renovation.

Each sample was given the code **HSNJ** (for Hammerstone Barn, New Jersey) and numbered 1 to 7 (see table 1). The position of each sample was noted at the time of sampling (see figure 2).

Summary of Dating

Bark edge survived on three of the timbers deemed suitable for analysis (**hsnj1**, **hsnj3**, and **hsnj4**).

All of the timber sequences were compared with each other. Six of the timbers (**hsnj1**, **hsnj2**, **hsnj4**, **hsnj5**, **hsnj6**, and **hsnj7**) were found to match each other, allowing them to be combined into the 197-year site master **HSNJx1** (see table 2).

The site master and the remaining unmatched sample were compared with more than eight hundred master chronologies from the East Coast of the United States. **HSNJx1** was found to date spanning the years 1607 to 1803 (see table 3).

Interpretation

The tree-ring analysis has resulted in the successful dating of the Hammerstone Barn. The six timbers that formed the dated site master **HSNJx1** were all from the primary phase of the building; two of the samples retained complete sapwood that provided felling dates of the spring of 1803 and the winter of 1803/4 (see figure 3). These felling dates suggest that the building was constructed in the winter of 1803/4 or shortly thereafter.

Acknowledgements

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Table 1: Summary of tree-ring dating

HAMMERSTONE BARN, BLOOMSBURY, NEW JERSEY

Sample number & type	Species	Timber and position	Dates AD spanning	Last Ring	No of rings	Mean width mm	Std devn mm	Mean sens mm	Felling seasons and dates/date ranges	
* hsnj1	c	QUAL	Swing beam from swing beam bent	1611-1803	C	193	0.88	0.15	0.146	Winter 1803/4
* hsnj2	c	QUAL	Tie beam from swing beam bent	1677-1755	h/w only	79	1.03	0.42	0.158	
hsnj3	c	QUAL	Upper tie beam west wall	-	C	88	1.13	0.24	0.109	Spring 1803
* hsnj4	s	QUAL	<i>Ex-situ</i> joist	1680-1802	¼C	123	0.90	0.33	0.154	
* hsnj5	s	QUAL	<i>Ex-situ</i> beam	1608-1724	h/w only	117	0.96	0.42	0.177	
* hsnj6	s	QUAL	<i>Ex-situ</i> beam	1607-1714	h/w only	108	0.98	0.39	0.178	
* hsnj7	s	TSCA	<i>Ex-situ</i> joist	1685-1783	h/w only	99	1.34	0.43	0.143	
* = HSNJx1 Site Master				1607-1803		197	0.98	0.26	0.121	

Key: *, †, § = sample included in site-master; c = core; mc = micro-core; s = slice/section; g = graticule; p = photograph; ¼C, ½C, C = bark edge present, partial or complete ring; ¼C = spring (last partial ring not measured), ½C = summer/autumn (last partial ring not measured), or C = winter felling (ring measured); h/w only = heartwood only; nm = number of unmeasured rings; std devn = standard deviation; mean sens = mean sensitivity; QUAL = *Quercus alba* (white oak), TSCA = *Tsuga canadensis* (L.) (Eastern hemlock)

Explanation of terms used in Table 1

The summary table gives most of the salient results of the dendrochronological process. For ease in quickly referring to various types of information, these have all been presented in Table 1. The information includes the following categories:

Sample number: Generally, each site is given a two or three letter identifying prefix code, after which each timber is given an individual number. If a timber is sampled twice, or if two timbers were noted at time of sampling as having clearly originated from the same tree, then they are given suffixes 'a', 'b', etc. Where a core sample has broken, with no clear overlap between segments, these are differentiated by a further suffix '1', '2', etc.

Type shows whether the sample was from a core 'c', or a section or slice from a timber's'. Sometimes photographs are used 'p', or timbers measured *in situ* with a graticule 'g'.

Species gives the four-letter species code used by the International Tree-Ring Data Bank, at NOAA. These are identified in the key at the bottom of the table.

Timber and position column details each timber sampled along with a location reference. This will usually refer to a bay or truss number, or relate to compass points or to a reference drawing.

Dates AD spanning gives the first and last measured ring dates of the sequence (if dated),

H/S bdry is the date of the heartwood/sapwood transition or boundary (if identifiable).

Sapwood complement gives the number of sapwood rings, if identifiable. The tree starts growing in the spring during which time the earlywood is produced, also known also as spring growth. This consists of between one and three decreasing spring vessels and is noted as *Spring* felling and is indicated by a ¼ C after the number of sapwood ring count. Sometimes this can be more accurately pin-pointed to very early spring when just a few spring vessels are visible. After the spring growing season, the latewood or summer growth commences, and is differentiated from the preceding spring growth by the dense band of tissue. This summer growth continues until just before the leaves drop, in about October. Trees felled during this period are noted as *summer* felled (½ C), but it is difficult to be too precise, as the width of the latewood can be variable, and it can be difficult to distinguish whether a tree stopped growing in autumn or *winter*. When the summer

growth band is clearly complete, then the tree would have been felled during the dormant winter period, as shown by a single C. Sometimes a sample will clearly have complete sapwood, but due either to slight abrasion at the point of coring, or extremely narrow growth rings, it is impossible to determine the season of felling.

Number of rings: The total number of measured rings included in the samples analysed.

Mean ring width: This, simply put, is the sum total of all the individual ring widths, divided by the number of rings, giving an average ring width for the series.

Mean sensitivity: A statistic measuring the mean percentage, or relative, change from each measured yearly ring value to the next; that is, the average relative difference from one ring width to the next, calculated by dividing the absolute value of the differences between each pair of measurements by the average of the paired measurements, then averaging the quotients for all pairs in the tree-ring series (Fritts 1976). Sensitivity is a dendrochronological term referring to the presence of ring-width variability in the radial direction within a tree which indicates the growth response of a particular tree is "sensitive" to variations in climate, as opposed to complacency.

Standard deviation: The mean scatter of a population of numbers from the population mean. The square root of the variance, which is itself the square of the mean scatter of a statistical population of numbers from the population mean. (Fritts 1976).

Felling seasons and dates/date ranges is probably the most important column of the summary table. Here the actual felling dates and seasons are given for each dated sample (if complete sapwood is present). Sometimes it will be noticed that often the precise felling dates will vary within several years of each other. Unless there is supporting archaeological evidence suggesting different phases, all this would indicate is either stockpiling of timber, or of trees which have been felled or died at varying times but not cut up until the commencement of the particular building operations in question. When presented with varying precise felling dates, one should always take the *latest* date for the structure under study, and it is likely that construction will have been completed for ordinary vernacular buildings within twelve or eighteen months from this latest felling date (Miles 1997).

Table 2: Matrix of *t*-values and overlaps for site master

Components of site master **HSNJx1**

<i>Sample:</i> <i>Last ring date</i> <i>AD:</i>	hsnj2 1677-1755	hsnj4 1680-1802	hsnj5 1608-1724	hsnj6 1607-1714	hsnj7 1685-1783
hsnj1 1611-1803	$\frac{2.36}{79}$	$\frac{3.71}{123}$	$\frac{2.57}{114}$	$\frac{4.29}{104}$	$\frac{0.00}{99}$
	hsnj2	$\frac{3.34}{76}$	$\frac{3.65}{48}$	$\frac{2.31}{38}$	$\frac{2.67}{71}$
		hsnj4	$\frac{2.16}{45}$	$\frac{0.99}{35}$	$\frac{1.42}{99}$
			hsnj5	$\frac{5.63}{107}$	$\frac{1.30}{40}$
				hsnj6	$\frac{2.79}{30}$

Table 3: Dating of site master **HMNJx1** (1607-1803) against reference chronologies

	<i>State or region:</i>	<i>Chronology name:</i>	<i>Short publication reference:</i>	<i>File name:</i>	<i>Spanning:</i>	<i>Overlap:</i>	<i>t-value:</i>
	New Jersey	Holland Township Master Chronology	Worthington and Seiter 2013	HOLL2	1550-1824	197	11.08
¥	New Jersey	Apgar Barn, Milford	Worthington and Seiter 2014/19	APGNJx1	1619-1808	185	9.97
¥	New Jersey	Wydner Barn, Milford	Worthington and Seiter 2013/19	WYDNJx1	1623-1820	181	9.13
¥	New Jersey	Richard Cain Barn, Milford	Worthington and Seiter 2013/17	RCNJx1	1550-1793	187	8.86
¥	New Jersey	Silva Barn, Milford	Worthington and Seiter 2013/18	SVNJx1	1692-1802	111	8.35
	New Jersey	James Salter Barn, Milford	Worthington and Seiter 2015/11	JSNJx1	1709-1793	85	8.09
	New York	Abraham Hasbrouck House, New Paltz	Cook, Krusic, and Callahan 2002	npzny	1449-1806	197	7.57
	New Jersey	Mid-Hudson Valley Region Historical	Pederson et al. 2013	NY041	1449-1799	193	7.18
	Pennsylvania	Alan Seeger Natural Area, Jackson	Columbia unpublished	ALLENS	1516-1983	197	6.92

Chronologies in **bold** denote regional masters

¥ = Component of **HOLL2**

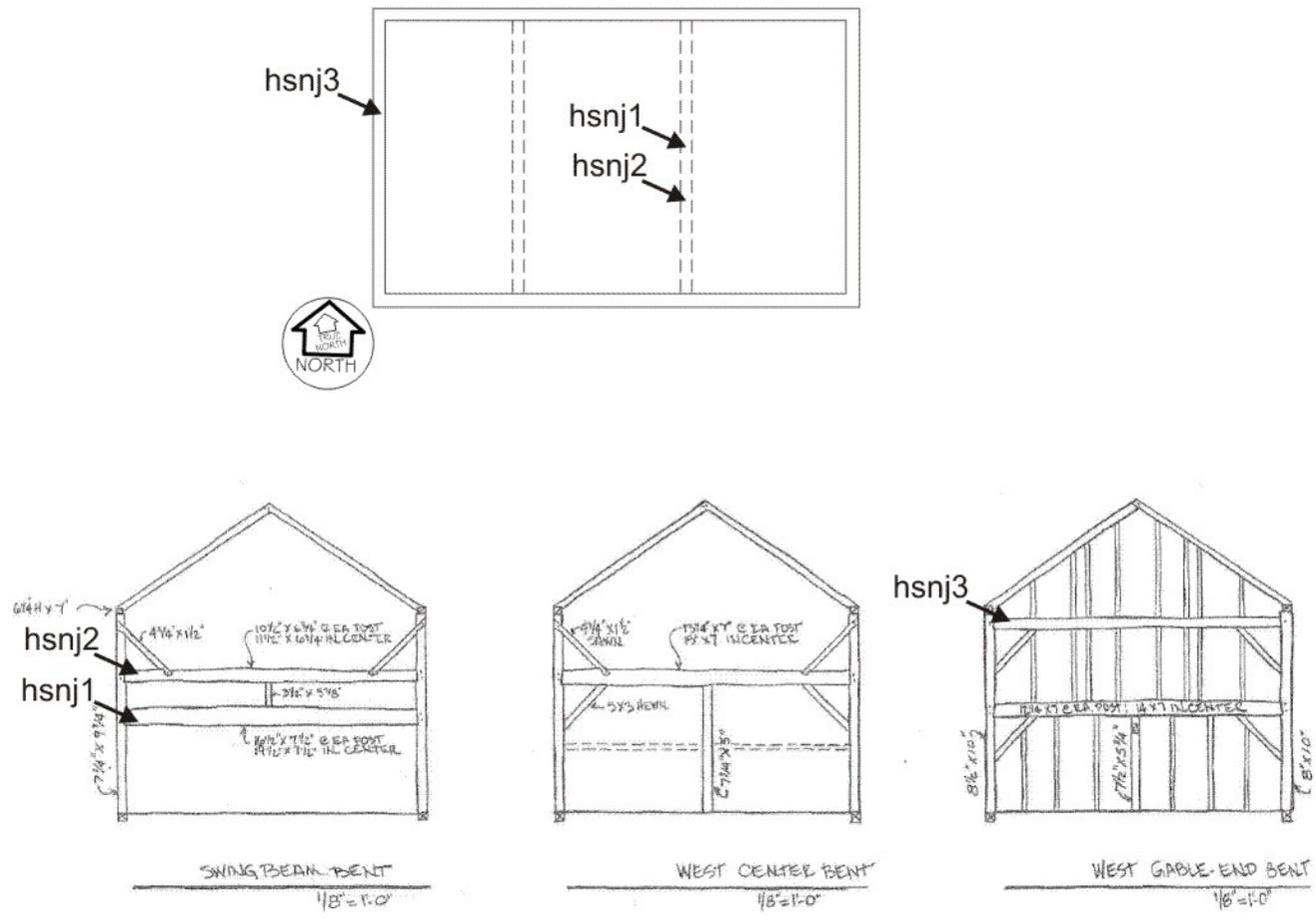


Figure 2. Sketch drawing of the Hammerstone Barn showing sample locations

Hammerstone Barn, Bloomsbury, New Jersey

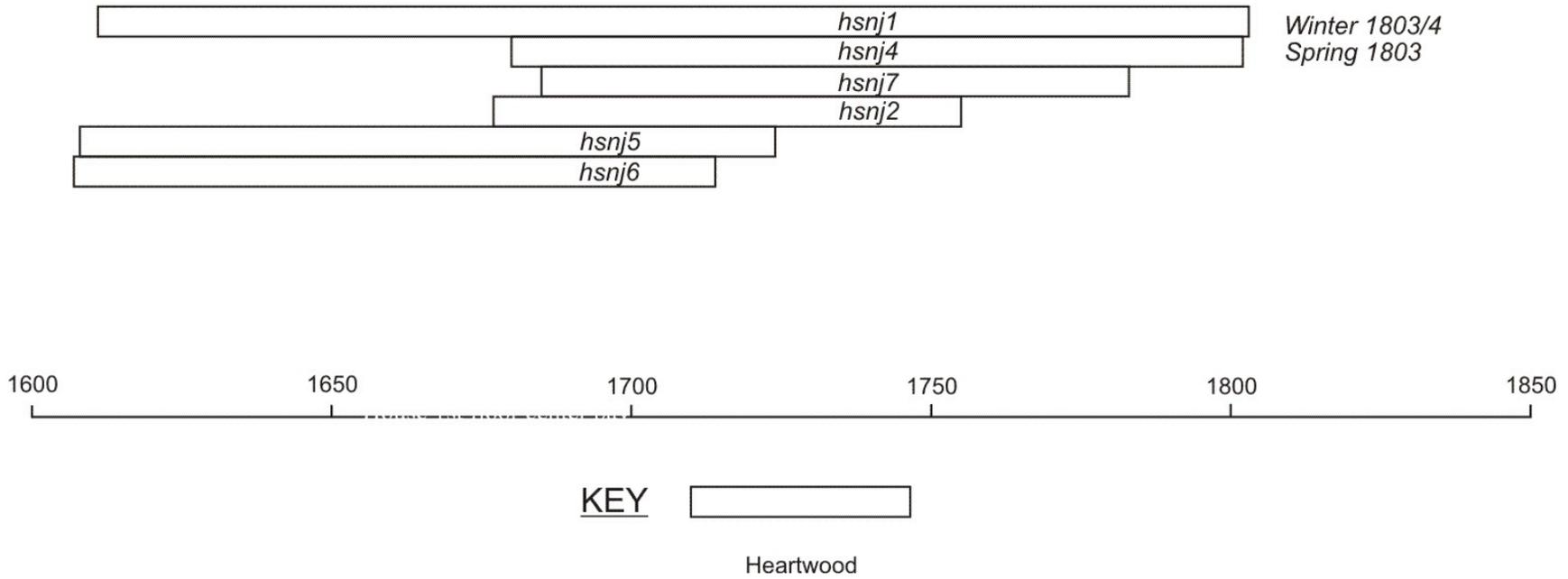


Figure 3. Bar diagram showing dated timbers in chronological order

Appendix A

Re-analysis of samples taken in 2012 at the Hammerstone Barn

Background to sampling

A previous dendrochronological study of the Hammerstone Barn was undertaken in 2012 by Richard Veit of Monmouth University, who took the cores, and Alice Gerard of Columbia University, who carried out the dendrochronological analysis of the samples (Veit and Gerard 2012). Since 2012, eleven other barns have been sampled and dated by the Oxford Tree-Ring Laboratory as part of the larger Holland Township Barn Survey. Eleven new site chronologies and two new area master chronologies (**HOLL2** and **HOLL2016**) were produced from this new data, all from within a ten-mile radius of the Hammerstone Barn. Accordingly, it was decided to cross-check the 2012 analysis with this wealth of new data. The measured data from 2012 was made available by Alice Gerard for re-analysis.

Summary of 2012 Study Data

Three *in-situ* floor joists were sampled during the 2012 study of Hammerstone Barn, all of which have subsequently been removed during restoration but are still stored on the property. All three were determined to retain complete sapwood. Of the three, two were assigned final dates. The first sample (referred to in the original report as sample #1 and in the measured data as **ham01a**) contained 164 rings and gave a final date of 1787. The second sample (referred to in the original report as sample #2 and in the measured data as **ham02**) contained 140 rings but was left undated because of conflicting results. The third sample (referred to in the original report as sample #3 and in the measured data as **ham03**) contained 74 rings and gave a final date of 1785.

New Analysis of 2012 Data

As an initial step, the 2012 measured data was added to the existing Table 1 in preparation for further analysis (see Appendix Table 1). Upon checking the data, **ham03** was found to contain 137 rings rather than the 74 stated in the 2012 report. Alice Gerard was unable to shed light on this discrepancy due to a loss of computer files.

The 2012 samples were then compared against each other. Samples **ham01a** and **ham03** were found to match each other with a *t-value* of 11.17 and an overlap of 135 rings (see Appendix Table 2). As *t-values* of above 10 suggest that the timbers came from the same tree, these two samples were combined to form the new same-tree master **ham0103**, which was used in the rest of the analysis. **Ham0103** and **ham02** were then compared with each other but were not found to cross-match.

The new same-tree master **ham0103** and the individual timber **ham02** were compared with more than eight hundred master chronologies from the East Coast of the United States. Both were found to date, **ham0103** to 1787 (see Appendix Table 3a) and **ham02** to 1803 (see Appendix Table 3b). The successful cross-matching provided the individual samples from 2012 with last-ring dates of 1787 for **ham01a**, 1803 for **ham02**, and 1758 for **ham03** (see Appendix Figure 1).

Ham0103 and **ham02** were then compared with the samples taken during the 2016 study. They were found to match with the six dated samples from the 2016 study (**hsnj1**, **hsnj2**, **hsnj4**, **hsnj5**, **hsnj6**, and **hsnj7**). The matching 2012 and 2016 samples were combined to form the new 197-year site master **HAMMx1** (see Appendix Table 2). This new master chronology was compared with the East Coast master chronologies and was found to date spanning the years 1607 to 1803 (see Appendix Table 3c).

As can be seen in Appendix Table 3c, the site master **HAMMx1** matched the East Coast master chronologies with extremely high *t*-values, helping to confirm the successful new dating for the 2012 samples.

Interpretation

The new analysis of the 2012 data has successfully dated all three samples. It has confirmed the 1787 date for **ham01a** that was found by the 2012 study, dated the previously undated sample **ham02** to 1803, and adjusted the date of sample **ham03** from 1785 to 1758.

Sample number	2012 date	2016 date
ham01a	1787	1787
ham02	n/a	1803
ham03	1785	1758

The 2016 dendrochronological study of Hammerstone Barn provided precise felling dates of the spring of 1803 for an *ex-situ* floor joist and the winter of 1803/4 for an *in-situ* swing beam. The swing beam was an integral part of the primary construction phase of the barn. The joist was removed from its original position at some point between the 2012 analysis and the 2016 sampling; while *in situ*, it had been a part of the barn's main floor, which was interpreted as being original and therefore also part of the primary construction phase of the barn. Both samples retained complete sapwood. The felling dates provided by the sapwood suggest that the Hammerstone Barn was constructed during the winter of 1803/4 or shortly thereafter. The newly found date for **ham02** accords with this construction date.

According to the 2012 dendrochronological study, all three floor joists sampled in 2012 retained complete sapwood. The original timbers were not provided for re-analysis, making it impossible to confirm this assessment. One possibility is that not all of the 2012 samples retained complete sapwood, making the dates provided by these samples felled-after dates. Several of the timbers assessed in the 2016 study did not retain sapwood and provided felled-after dates in keeping with the dates for **ham01a** and **ham03**.

Another possibility is that the 2012 samples did retain sapwood but were taken from timbers that were re-used from earlier structures, possibly a log cabin that was demolished prior to the construction of the Hammerstone Barn. The joists used in the Hammerstone Barn employed a very simple tree-to-timber conversion process—stripping off the bark and sapwood from both sides of a tree with an adze to make two parallel flat surfaces, on one of which the flooring rests. This is the exact same process used to construct the timbers for the walls of log cabins, with the addition of a dove-tail joint at the end of each timber to form the corner joints, which are slotted in to each other to make a strong, four-walled structure.

The Oxford Tree-Ring Laboratory has on at least two occasions sampled buildings where older log cabin timbers have been re-used as floor joists in later buildings. At the Roulette Barn, part of the Antietam National Battlefield in Maryland, the primary construction phase of the barn was found to date to the winter of 1854/5 or shortly thereafter (Worthington and Seiter 2013/4). However, some of the floor joists were found to date to the winter of 1793/4, 61 years earlier than the primary construction date. During sampling, it was noted that these floor joists had been notched out for use as corner joints in a log cabin, and were clearly re-used from this earlier structure in order to build the later Roulette Barn. A similar progression of construction was seen in the Fugate House in Monkton, Maryland (Worthington and

Seiter 2014/12). No suitable timbers survived from the primary phase of construction, but the floor joists were dated to the winter of 1763/4. Here, again, the floor joists were seen to contain the same corner joint notching indicative of earlier use in a now-demolished log cabin. The best way to confirm this hypothesis for the Hammerstone Barn would be to work out if any of the floor joists from the 2012 study retain the notches for log cabin corner joints.

Discussion of methodology

The methodology that the Oxford Tree-Ring Laboratory uses is based on dendrochronology guidelines originally developed by English Heritage (now known as Historic England), the British government's statutory adviser on all aspects of the historic environment and its heritage assets (Hillam 1998). These guidelines state that robust and well-replicated site chronologies should be made for each building. In order to achieve this level of replication, Oxford Tree-Ring Laboratory aims to take at least 6 to 10 samples per building in areas that have numerous pre-existing chronologies available and 10 to 15 samples in areas where less data is available. The laboratory then compares these well-replicated chronologies for each building with more than eight hundred chronologies from both individual sites and regional master chronologies across the East Coast of America. As only three samples were taken from the Hammerstone Barn in 2012, it is possible that an insufficient number of samples were taken to allow a well-replicated site chronology to be made, particularly for an area that has few local dated master chronologies. Additionally, the samples were cross-matched to only three master regional chronologies, an extremely low number, increasing the possibility of assigning incorrect dates to the samples.

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Appendix Table 1: Summary of tree-ring dating

HAMMERSTONE BARN, BLOOMSBURY, NEW JERSEY

Sample number & type	Species	Timber and position	Dates AD spanning	Last Ring	No of rings	Mean width mm	Std devn mm	Mean sens mm	Felling seasons and dates/date ranges	
Data from 2016 Study										
* hsnj1	c	QUAL	Swing beam from swing beam bent	1611-1803	C	193	0.88	0.15	0.146	Winter 1803/4
* hsnj2	c	QUAL	Tie beam from swing beam bent	1677-1755	h/w only	79	1.03	0.42	0.158	
hsnj3	c	QUAL	Upper tie beam west wall	-	C	88	1.13	0.24	0.109	Spring 1803
* hsnj4	s	QUAL	<i>Ex-situ</i> joist	1680-1802	¼C	123	0.90	0.33	0.154	
* hsnj5	s	QUAL	<i>Ex-situ</i> beam	1608-1724	h/w only	117	0.96	0.42	0.177	
* hsnj6	s	QUAL	<i>Ex-situ</i> beam	1607-1714	h/w only	108	0.98	0.39	0.178	
* hsnj7	s	TSCA	<i>Ex-situ</i> joist	1685-1783	h/w only	99	1.34	0.43	0.143	
Re-analysis of Data from 2012 Study										
* ham01a	?	QUAL	<i>Ex-situ</i> joist	1624-1787		164	0.57	0.23	0.248	
* ham02	?	QUAL	<i>Ex-situ</i> joist	1664-1803		140	1.01	0.43	0.154	
* ham03	?	QUAL	<i>Ex-situ</i> joist	1622-1758		137	0.56	0.22	0.242	
* ham0103	m	QUAL	Mean of ham01 + ham03	1622-1787		166	0.58	0.23	0.224	
* = HAMMx1 Site Master				1607-1803		197	0.93	0.26	0.119	

Key: *, †, § = sample included in site-master; c = core; mc = micro-core; s = slice/section; g = graticule; p = photograph; ¼C, ½C, C = bark edge present, partial or complete ring; ¼C = spring (last partial ring not measured), ½C = summer/autumn (last partial ring not measured), or C = winter felling (ring measured); h/w only = heartwood only; nm = number of unmeasured rings; std devn = standard deviation; mean sens = mean sensitivity; QUAL = *Quercus alba* (white oak), TSCA = *Tsuga canadensis* (L.) (Eastern hemlock)

Appendix Table 2: Matrix of *t*-values and overlaps for same-timber mean and site master

Components of same-timber mean **ham0103**

Sample: **ham03**
Last ring date AD: 1622-1758

ham01a 11.17
 1624-1787 135

Components of site master **HAMMx1**

Sample: **ham02** **hsnj1** **hsnj2** **hsnj4** **hsnj5** **hsnj6** **hsnj7**
Last ring date AD: 1664-1803 1611-1803 1677-1755 1680-1802 1608-1724 1607-1714 1685-1783

ham0103 1622-1787	<u>2.81</u> 124	<u>4.38</u> 166	<u>4.04</u> 79	<u>3.22</u> 108	<u>4.51</u> 103	<u>3.47</u> 93	<u>1.06</u> 99
	ham02	<u>1.16</u> 140	<u>2.54</u> 79	<u>1.56</u> 123	<u>1.79</u> 61	<u>2.47</u> 51	<u>3.73</u> 99
		hsnj1	<u>2.36</u> 79	<u>3.71</u> 123	<u>2.57</u> 114	<u>4.29</u> 104	<u>0.00</u> 99
			hsnj2	<u>3.34</u> 76	<u>3.65</u> 48	<u>2.31</u> 38	<u>2.67</u> 71
				hsnj4	<u>2.16</u> 45	<u>0.99</u> 35	<u>1.42</u> 99
					hsnj5	<u>5.63</u> 107	<u>1.30</u> 40
						hsnj6	<u>2.79</u> 30

Appendix Table 3a: Dating of same-tree mean **HAM0103** (1622-1787) against reference chronologies

	<i>State or region:</i>	<i>Chronology name:</i>	<i>Short publication reference:</i>	<i>File name:</i>	<i>Spanning:</i>	<i>Overlap:</i>	<i>t-value:</i>
¥	New Jersey	Hammerstone Barn, Bloomsbury	Worthington and Seiter 2016/13	HSNJx1	1607-1803	166	6.72
	New Jersey	Holland Township Master Chronology	Worthington 2016	HOLL2016	1550-1824	166	6.07
	New York	Tinker Log Cabin, Albany	Griggs pers. comm.	TINK	1632-1786	155	6.04
	New York	Mohonk	Columbia unpublished	NY_MOHONK	1449-1987	166	5.76
	Maryland	Maryland Master Chronology (Columbia University)	Columbia unpublished	MATHISTO	1540-1786	165	5.65
¥	New Jersey	Wydner Barn, Milford	Worthington and Seiter 2013/19	WYDNJx1	1623-1820	165	5.62
	New York	Abraham Hasbrouck House, New Paltz	Cook, Krusic, and Callahan 2002	npzny	1449-1806	166	5.48
	New York	Greater Albany Region Historical Oak	World Data Bank (Cook, Krusic, and Pederson)	NY040	1507-1838	166	5.20
¥	New Jersey	Apgar Barn, Milford	Worthington and Seiter 2014/19	APGNJx1	1619-1808	166	5.03

Chronologies in **bold** denote regional masters

¥ = Component of **HOLL2016**

Appendix Table 3b: Dating of individual timber **HAM02** (1664-1803) against reference chronologies

	<i>State or region:</i>	<i>Chronology name:</i>	<i>Short publication reference:</i>	<i>File name:</i>	<i>Spanning:</i>	<i>Overlap:</i>	<i>t-value:</i>
	New York	Palisades House	Columbia unpublished	HUTCH	1490-1982	140	6.36
	New Jersey	Holland Township Master Chronology	Worthington and Seiter 2016/13	HOLL2016	1550-1824	140	6.14
	New York	Dark Hollow Trail	Cook n.d.	NY002	1648-1977	140	5.92
	Maryland	Maryland Master Chronology (Columbia University)	Columbia unpublished	MATHISTO	1540-1786	123	5.71
	Maryland	Central Maryland Master Chronology	Worthington 2014	MARYLAND	1536-1892	140	5.57
	New York	Mid-Hudson Valley Region Historical	Pederson et al. 2013	NY041	1449-1799	136	5.52
	Pennsylvania	Alan Seeger Natural Area, Jackson	Columbia unpublished	ALLENS	1516-1983	140	5.50

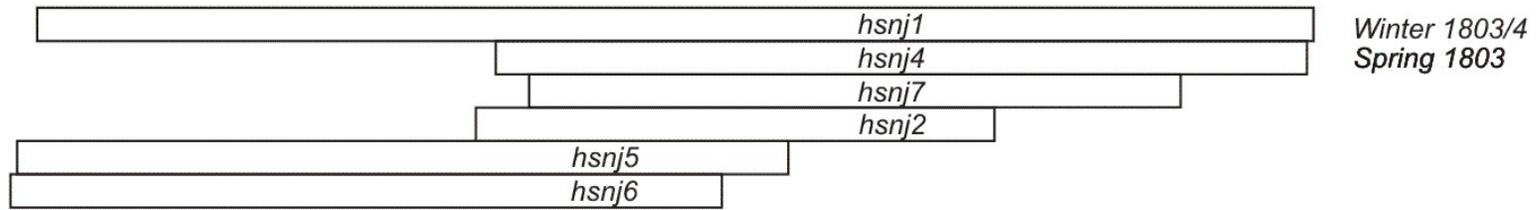
Appendix Table 3c: Dating of site master **HAMMx1** (1607-1803) against reference chronologies

	<i>State or region:</i>	<i>Chronology name:</i>	<i>Short publication reference:</i>	<i>File name:</i>	<i>Spanning:</i>	<i>Overlap:</i>	<i>t-value:</i>
	New Jersey	Holland Township Master Chronology	Worthington 2013	HOLL2	1550-1824	197	12.10
∪	New Jersey	Apgar Barn, Milford	Worthington and Seiter 2014/19	APGNJx1	1619-1808	185	10.65
∪	New Jersey	Wydner Barn, Milford	Worthington and Seiter 2013/19	WYDNJx1	1623-1820	181	10.14
∪	New Jersey	Richard Cain Barn, Milford	Worthington and Seiter 2013/17	RCNJx1	1550-1793	187	9.60
∪	New Jersey	Silva Barn, Milford	Worthington and Seiter 2013/18	SVNJx1	1692-1802	111	9.06
	New Jersey	William Vanderbelt Barn, Holland Township	Worthington and Seiter 2015/12	HOFFx1	1696-1811	108	9.03
	New York	Abraham Hasbrouck House, New Paltz	Cook, Krusic, and Callahan 2002	npzny	1449-1806	197	8.45
	Pennsylvania	Alan Seeger Natural Area, Jackson	Columbia unpublished	ALLENS	1516-1983	197	8.06
	New Jersey	James Salter Barn, Milford	Worthington and Seiter 2015/11	JSNJx1	1709-1793	85	7.95

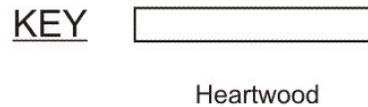
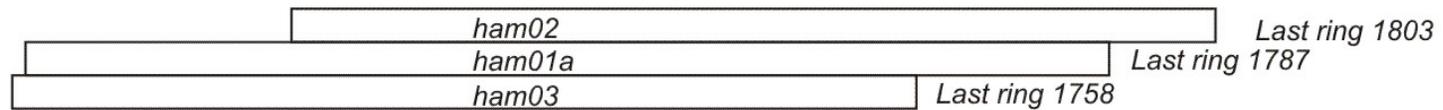
Chronologies in **bold** denote regional masters

∪ = Component of **HOLL2**

Hammerstone Barn, Bloomsbury, New Jersey 2016 samples



Hammerstone Barn, Bloomsbury, New Jersey 2012 samples



Appendix Figure 1. Bar diagram showing dated timbers in chronological order for both 2016 and 2012 dendrochronological studies