Oxford Tree-Ring Laboratory
Report 2017/18

Britton-Rapp Barn (Holland Township Barn Survey #13), 235 Riegelsville Road, Holland Township, Hunterdon County, New Jersey

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Summary:

Britton-Rapp Barn (Holland Township Barn Survey #13), 235 Riegelsville Road, Holland Township, Hunterdon County, New Jersey (40.571453, -75.152068)

Primary Barn	*Felling dates:* **Summer 1827, Winter 1830/1, Summer 1831, Winter 1831/2, Summer 1832**

Site Master 1663-1831 (Eastern hemlock) BRNJx1 (t = 9.73 PA011; 9.14 PA004; CT002 7.45).

The Britton/Rapp Barn is a seven-bay, ground-level, swing beam barn with a two-bay haw mow, two wagon entry bays, a bay for stabling horses, and a bay for stabling cows/ small livestock.

Dendrochronological analysis has shown that the barn was built from timbers felled over a short period of time from the summer of 1827 through to the summer of 1832.

Date sampled:	November 10, 2017
Owner:	Marc Phillips
Commissioners:	Larry LaFevre and Carla Cielo, Holland Township Historic Preservation Commission
Funder:	Holland Township Committee
Street address:	235 Riegelsville Road, Milford, NJ 08848
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.

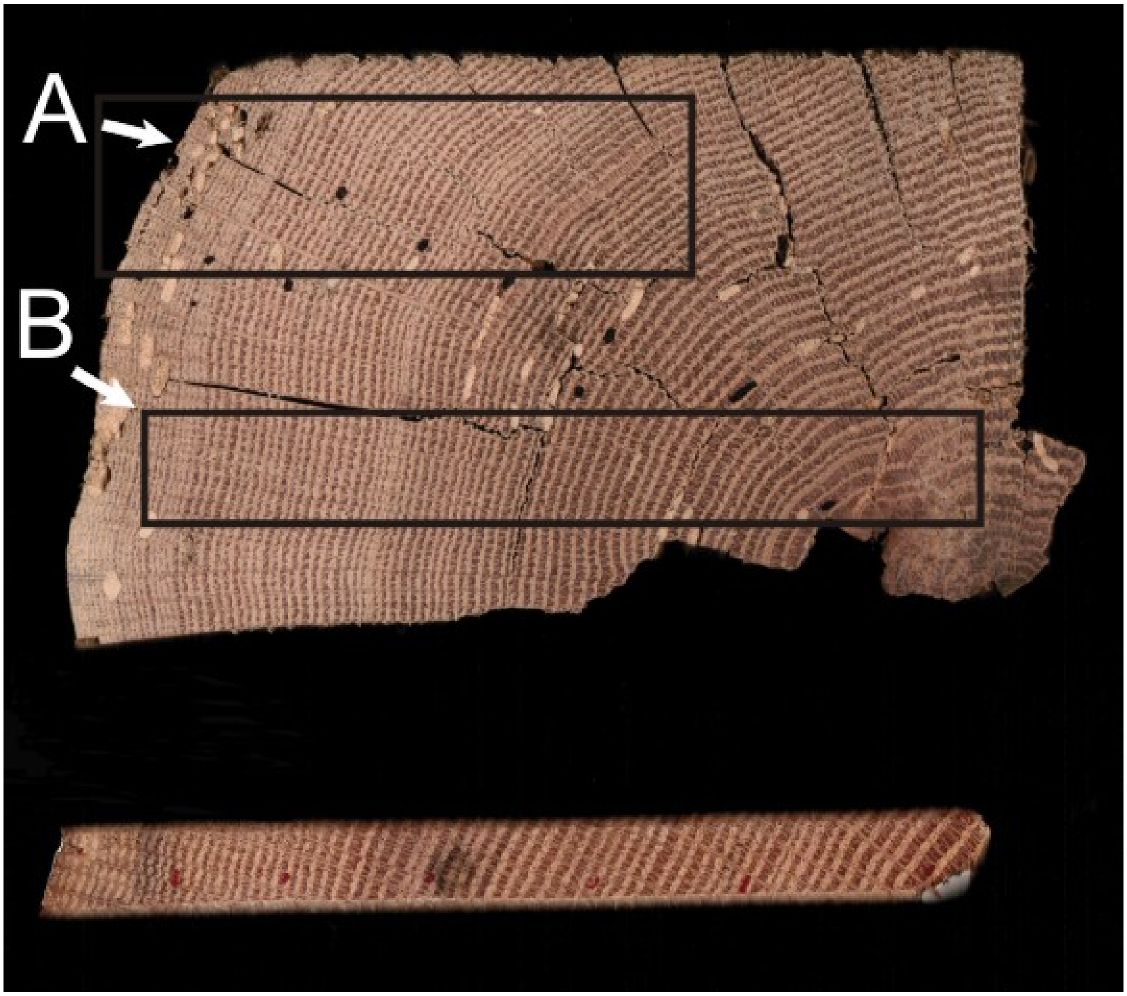

Figure 1. A cross-section of an oak timber with sapwood rings on the left-hand side (above). The boxes illustrate conversion methods resulting in **A)** a precise felling date and **B)** a *terminus post quem* or felled after date. Also pictured is a core showing complete sapwood (below).

Methodology: The Dating Process

All samples were taken 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.

The dry samples were sanded on a linisher, 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 Britton/Rapp Barn was undertaken in an attempt to date the primary construction phase of the building. A total of nine timbers were sampled, all from the primary phase of the building. Eight of the timbers were constructed from Eastern hemlock and one was made of white oak.

Each sample was given the code **brnj** (for Britton/Rapp Barn, Milford, New Jersey) and numbered 1 to 9 (table 1). The position of each sample was noted at the time of sampling (figure 2).

Summary of Dating

Bark edge survived on eight of the nine timbers deemed suitable for analysis. The outer wood on some of the timbers was extremely friable and therefore difficult to keep intact during coring. As a result, multiple samples were taken from six of these timbers in order to maximize the chances of retaining a complete core. The multiple samples were combined to form the five new individual sample sequences **brnj1, brnj4, brnj5, brnj6,** and **brnj9**, which were used in all subsequent analysis (table 2a).

All of the individual timber sequences were compared with each other. Three of the timbers from the primary building roof—**brnj4**, **brnj5**, and **brnj7**—were found to match together with a *t*-value of over 10.00, indicating that they were converted from the same tree, and were therefore combined into the same-tree mean **brnj457**, which was used in the rest of the analysis.

The same-tree mean and five of the individual timbers (**brnj1**, **brnj3**, **brnj457**, **brnj6**, **brnj8b**, and **brnj9**) were found to match each other, allowing them to be combined into the 169-year site master **BRNJx1** (table 2b).

The site master and the remaining unmatched samples were compared with more than nine hundred master chronologies from the East Coast of the United States. **BRNJx1** was found to date spanning the years 1663 to 1831 (table 3).

Interpretation

The tree-ring analysis has resulted in the successful dating of the Britton/Rapp Barn (figure 3). The eight timbers that formed the dated site master **BRNJx1** were all from the primary phase of the building. All of the eight timbers retained complete sapwood, which provided felling dates of the summer of 1827, the winter of 1830/1, the summer of 1831, the winter of 1831/2, and the summer of 1832, suggesting that the barn was constructed in the summer of 1832 or shortly thereafter.

Acknowledgements

Thanks are given to Larry LaFevre and Carla Cielo for organizing the Holland Township Barn Survey project and to the owners of each barn for allowing access to their building.

References

Baillie, M G L and Pilcher, J R 1973 A Simple Cross-Dating Program for Tree-Ring Research, *Tree-Ring Bulletin* **33**: 7-14

Chattaway, M M 1949 The Development of Tyloses and Secretion of Gum in Heartwood Formation, *Australian Journal of Scientific Research, Series B, Biological Sciences* **2**: 227-240

Contributors of the International Tree-Ring Data Bank, IGBP PAGES/World Data Center for Paleoclimatology, NOAA/NCDC Paleoclimatology Program, Boulder, Colorado, USA

Desch, H E 1948 The Cedars, *Wood* **13 (2)**: 40-3

Fritts, H C 1976 *Tree Rings and Climate*, London, Academic Press

Gerry, E 1914 Tyloses: Their Occurrence and Practical Significance in Some American Wood, *Journal of Agricultural Research* **1**: 335-469

Kato, H and Kishima, T 1965 Some Morphological Observations of Tyloses, *Wood Research* **36**: 55-60

Miles, D H 1997 The Interpretation, Presentation, and Use of Tree-Ring Dates, *Vernacular Architecture* **28**: 40-56

Munro, M A R 1984 An Improved Algorithm for Crossdating Tree-Ring Series, *Tree-Ring Bulletin* **44**: 17-27

Table 1: Summary of tree-ring dating

BRITTON/RAPP BARN, MILFORD, 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 range
brnj1a1	c	TSCA	Swing beam bent 4	-	h/w only	37	1.93	0.47	0.149	
brnj1a2	c	TSCA	ditto	1736-1830	C	95	1.59	0.46	0.192	
brnj1b	c	TSCA	ditto	1742-1830	C	89	1.31	0.41	0.189	
* **brnj1**	m		Mean **brnj1a2** + **brnj1b**	1736-1830	C	95	1.46	0.42	0.181	Winter 1830/1
brnj2	c	QUAL	Brace swing beam bent 4 south	-	C	201	0.52	0.16	0.180	
* **brnj3**	c	TSCA	Brace on 2nd vertical nailer bent 3	1698-1826	½C	129	0.75	0.16	0.147	Summer 1827
brnj4a	c	TSCA	Post north truss 4	1701-1830	C	130	0.90	0.53	0.191	
brnj4b	c	TSCA	ditto	1701-1830	C	130	0.93	0.57	0.192	
brnj4	m		Mean **brnj4a** + **brnj4b**	1701-1830	C	130	0.92	0.55	0.183	Winter 1830/1
brnj5a	c	TSCA	Center post between upper two ties bent 6	1729-1830	h/w only	102	0.90	0.40	0.144	
brnj5b	c	TSCA	ditto	-	h/w only	86	0.83	0.37	0.155	
brnj5c	c	TSCA	ditto	1747-1831	C	85	0.72	0.36	0.196	
brnj5	m		Mean **brnj5a** + **brnj5c**	1729-1831	C	103	0.86	0.40	0.155	Winter 1831/2
brnj6a1	c	TSCA	Purlin post south bent 6	-	h/w only	40	0.62	0.12	0.136	
brnj6a2	c	TSCA	ditto	-	h/w only	32	0.60	0.11	0.163	
brnj6a3	c	TSCA	ditto	1722-1824	h/w only	103	0.49	0.16	0.169	
brnj6b	c	TSCA	ditto	1722-1830	½C	109	0.48	0.16	0.166	
* **brnj6**	m		Mean **brnj6a3** + **brnj6b**	1722-1830	½C	109	0.48	0.16	0.162	Summer 1831
brnj7	c	TSCA	Post north bent 4	1706-1812	h/w only	107	0.89	0.49	0.188	
brnj8a	c	TSCA	Upper tie swing beam bent 4	-	C	176	0.62	0.36	0.174	
* **brnj8b**	c	TSCA	ditto	1663-1831	½C	169	0.93	0.28	0.190	Summer 1832
brnj9a	c	TSCA	Tie lower bent 7	1746-1824	h/w only	79	0.71	0.14	0.137	
brnj9b	c	TSCA	ditto	1753-1831	C	79	0.75	0.17	0.144	
* **brnj9**	m		Mean **brnj9a** + **brnj9b**	1746-1831	C	86	0.73	0.16	0.137	Winter 1831/2
* **brnj457**	m		Mean **brnj4** + **brnj5** + **brnj7**	1701-1831		131	0.92	0.50	0.160	
*** = BRNJx1 Site Master**				**1663-1831**		**169**	**0.93**	**0.25**	**0.142**	

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; TSCA = Tsuga canadensis (L.) Carr. (Eastern hemlock); QUAL = *Quercus alba* (white oak); LITU = *Liriodendron tulipifera L.* (tulip poplar); PISP = *Pinus L.* (Southern yellow pine); QUPR = *Quercus prinus* (chestnut oak)

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 proceeding 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 2a: Matrix of *t*-values and overlaps for same-timber means and same-tree mean

Components of timber mean **brnj1**

Sample:	**brnj1b**
Last ring date AD:	1742-1830
brnj1a2 1736-1830	<u>15.55</u> 89

Components of timber mean **brnj4**

Sample:	**brnj4b**
Last ring date AD:	1701-1830
brnj4a 1701-1830	<u>23.29</u> 130

Components of timber mean **brnj5**

Sample:	**brnj5c**
Last ring date AD:	1747-1831
brnj5a 1729-1830	<u>11.15</u> 84

Components of timber mean **brnj6**

Sample:	**brnj6b**
Last ring date AD:	1722-1830
brnj6a3 1722-1824	<u>20.56</u> 103

Components of timber mean **brnj9**

Sample:	**brnj9b**
Last ring date AD:	1753-1831
brnj9a 1746-1824	<u>9.71</u> 72

Components of same-tree mean **brnj457**

Sample:	**brnj5**	**brnj7**
Last ring date AD:	1729-1831	1706-1812
brnj4 1701-1830	<u>10.36</u> 102	<u>12.90</u> 107
	brnj5	<u>10.09</u> 84

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

Components of site master **BRNJx1**

Sample: Last ring date AD:	**brnj3** 1698-1826	**brnj457** 1701-1831	**brnj6** 1722-1830	**brnj8b** 1663-1831	**brnj9** 1746-1831
brnj1 1736-1830	4.63 91	4.27 95	5.87 95	5.33 95	4.84 85
	brnj3	7.88 126	4.91 105	6.91 129	4.53 81
		brnj457	8.30 109	6.22 131	4.66 86
			brnj6	8.11 109	8.34 85
				brnj8b	6.10 86

Table 3: Dating of site master **BRNJx1** (1663-1831) against reference chronologies

Tree species:	*State or region:*	*Chronology name:*	*Short publication reference:*	*File name:*	*Spanning:*	*Overlap:*	t-*value:*
TSCA	Pennsylvania	Salt Springs State Park	World Data Bank (Cook, E.R)	PA011	1619-1981	169	9.73
TSCA	Pennsylvania	East Branch Swamp	World Data Bank (Cook, E.R)	PA004	1540-1981	169	9.14
TSCA	Connecticut	North Forty Tract	World Data Bank (Cook, E.R)	CT002	1650-1985	169	7.45
TSCA	Pennsylvania	Tionesta Natural Area	World Data Bank (Cook, E.R)	PA013	1425-1978	169	7.21
TSCA	Pennsylvania	Rickett's Glen State Park	World Data Bank (Cook, E.R)	PA010	1637-1981	169	7.20
TSCA	Vermont	West Brattleboro Apartments Historical	World Data Bank (Baisan, C.H.)	VT010	1570-1869	169	6.70
TSCA	New York	Mohonk Lake Talus Slope	World Data Bank (Cook, E.R)	NY006	1626-1984	169	6.41
TSCA	Pennsylvania	Alan Seeger Natural Area	World Data Bank (Cook, E.R)	PA001	1609-1981	169	6.09
TSCA	Connecticut	Bigelow Pond	World Data Bank (Cook, E.R)	CT001	1659-1985	169	5.88
TSCA	New York	Spruce Glen	World Data Bank (Cook, E.R)	NY012	1511-1984	169	5.53

TSCA = Tsuga canadensis (L.) Carr., Eastern hemlock

Chronologies in **bold** denote regional masters

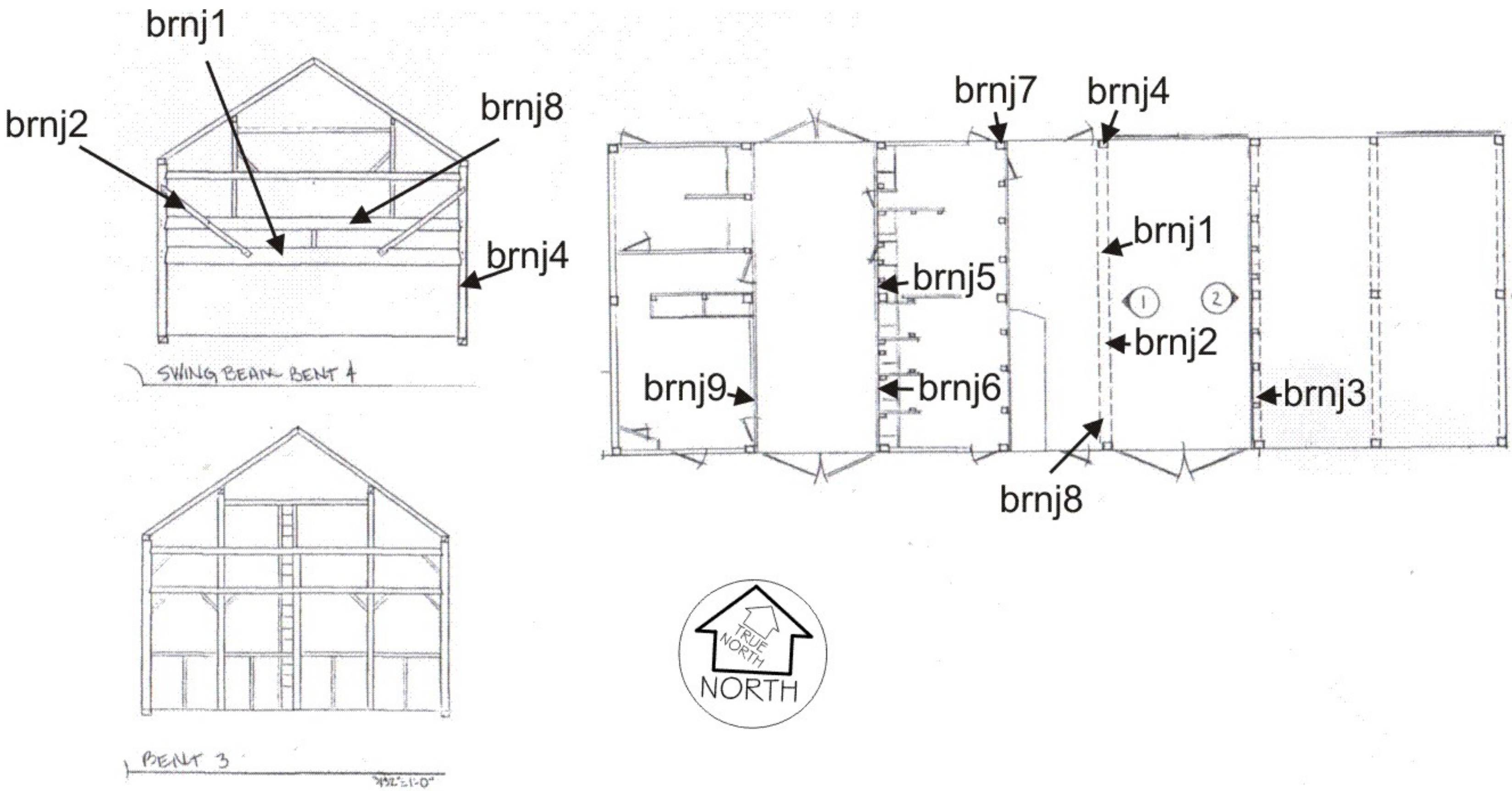

Figure 2. Sketch drawing of the Britton/Rapp barn showing sample locations (after drawing by Carla Cielo).

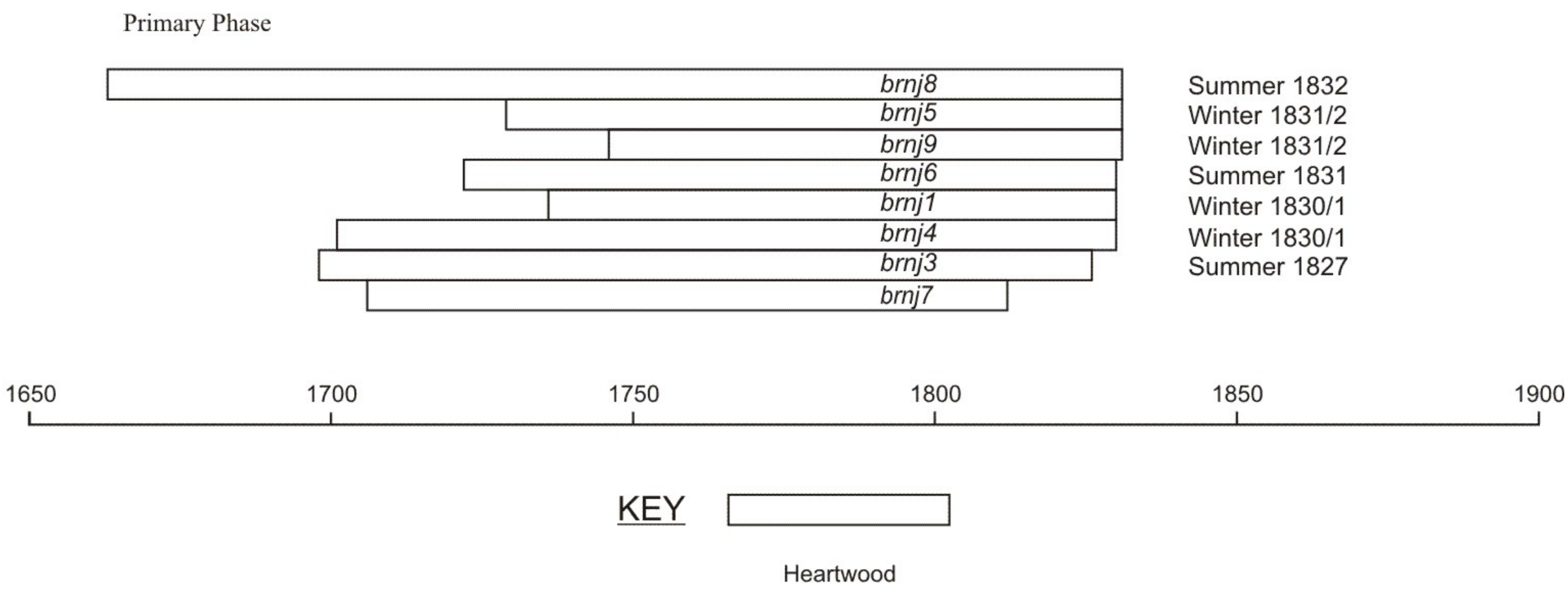

Figure 3. Bar diagram showing dated timbers in chronological order.

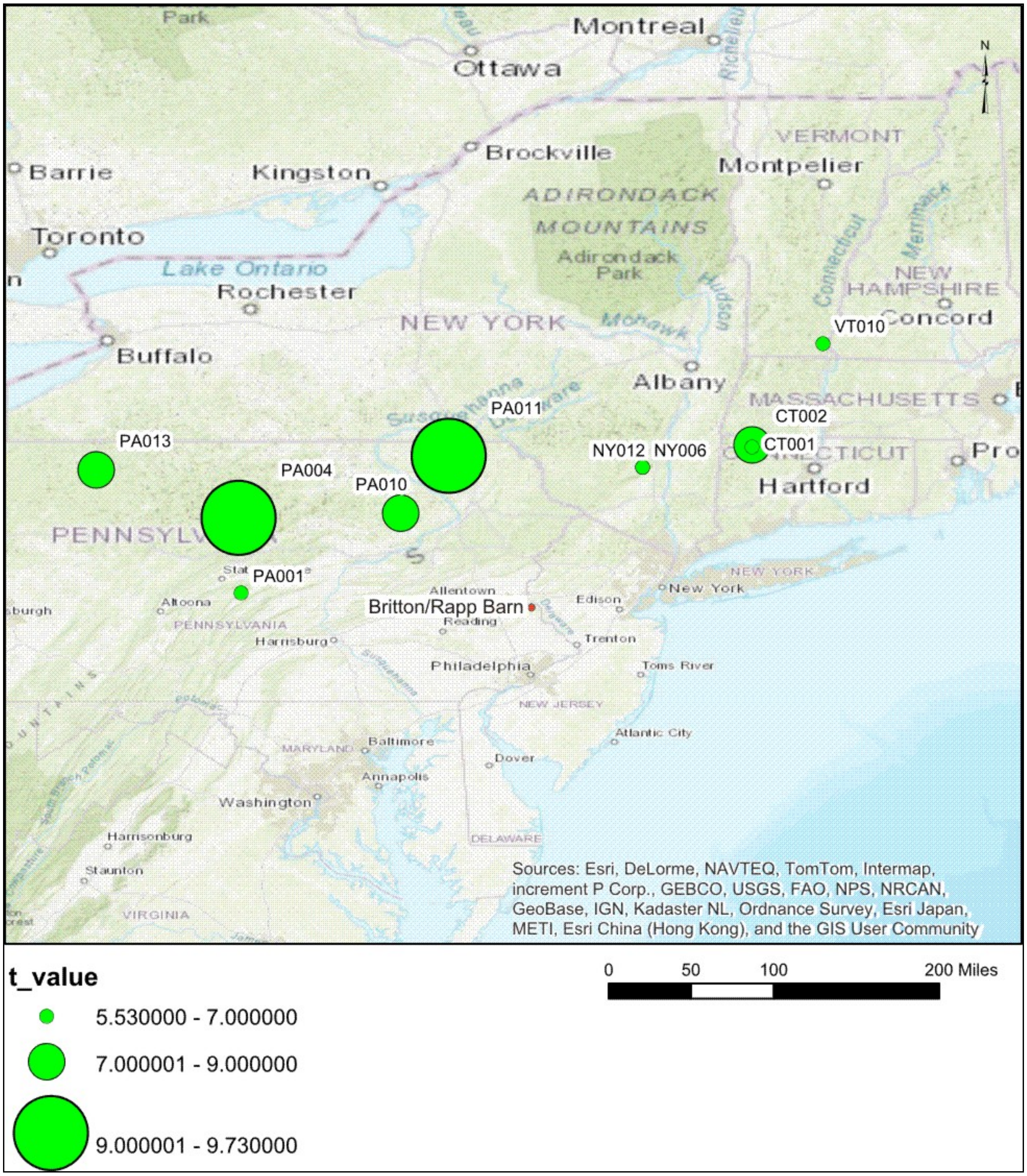

Figure 3. Map showing locations of matching reference chronologies and their *t*-values compared with the Britton/Rapp Barn master chronology, suggesting the timbers may have come from Eastern Pennsylvania.