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ORIGINAL ARTICLE

Dendrochronological evaluation of ship timber from Charlestown Navy Yard (Boston, MA)

Pearce Paul Creasman*, Christopher Baisan, Christopher Guiterman

Laboratory of Tree-Ring Research, University of Arizona, 1215 E. Lowell Street, Tucson, AZ 85721-0058, USA

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ABSTRACT

More than 200 ships were built, and thousands serviced, at Charlestown Navy Yard (Boston, MA) in its 174 years of service for the U.S. Navy (1800–1974 C.E.). Recent redevelopment of portions of the former yard revealed an historic timber pond where hundreds of unfinished naval-quality ship timbers were intentionally sunk and remained buried until ca. 2008. Many of these timbers were offered to the Henry B. du Pont Preservation Shipyard (Mystic Seaport, CT) for their restoration of *Charles W. Morgan*. Courtesy of Mystic Seaport, 38 specimens from the Charlestown yard (mostly *Quercus* sp.; including live [evergreen] oak and white oak) were selected for dendrochronological analysis. Most of the white oak specimens could be sourced with confidence to Ohio. Dates clustered in the late 1860s, suggesting late-Civil War or Reconstruction Era activities. This paper discusses the dates, origin, and other findings derived from this collection.

Introduction

As items of material culture, ship and boat timbers are individual artifacts that can reveal chronological, environmental, and behavioral information when analyzed (i.e., Dean, 1996; Čufar, 2007; Creasman, 2013, 2014; Manning et al., 2014). Dendrochronology, although long applied to ships and boats with success (e.g., Farrell and Baillie, 1976), in recent years has been employed more regularly and for a greater breadth of interpretations (Loewen, 2000; Creasman, 2010a). Many scholars have expounded on the benefits of applying dendrochronological analyses to ship timbers in general (e.g., Crumlin-Pedersen, 2002; Indruszewski et al., 2006; Loewen, 2007), which include the two most common applications: dating and provenancing the wood (e.g., Daly, 2007; Bridge, 2012; Domínguez-Delmás et al., 2013; Haneca and Daly, 2014; Nayling and Susperregi, 2013). Still, historic vessels and timbers from the New World are often overlooked for dendrochronological analyses, as proportionately more tends to be known about them from written records. Dendrochronology nonetheless offers definite advantages for increasing the understanding of historic timber structures, the people who harvested the timbers, and the environments in which they lived (e.g., Stahle and Wolfman, 1985; Creasman, 2010b).

To demonstrate the benefits of dendrochronological investigation of wood recovered from historic contexts, the present article relays the results of such analyses performed upon a collection of unfinished ship timbers recovered from an historic timber pond of unknown date and source. Specifically sought were answers pertaining to: (1) dating; (2) felling date (were the timbers harvested in the same year?); (3) provenance; and (4) relationship to local histories (at the locations of felling and recovery).

Materials and methods

The Charleston yard

Shuttered in 1974, Charlestown Navy Yard (Boston, MA) served the U.S. Navy for 174 years (1800–1974). An essential component of Boston Harbor, the yard, formally known as the Boston Navy Yard (until 1945) and the Boston Naval Shipyard (1945–1974), produced hundreds of wooden and iron warships, and repaired or serviced perhaps more than 10,000 vessels during its working life; this includes approximately 6000 vessels during World War I alone (Bither, 1999). In 1974, 30 acres of the former yard were converted into Boston National Historical Park, with the remaining 100 acres offered for redevelopment (Bither, 1999). Recent redevelopment of portions of the former yard revealed an historic timber pond (Fig. 1) where hundreds of unfinished, naval-quality ship timbers were intentionally sunk for preservation while awaiting use, were subsequently buried, and remained so until ca. 2008. Many

* Corresponding author. Tel.: +1 520 621 2414; fax: +1 520 621 8229.
E-mail address: pcreasman@ltrr.arizona.edu (P.P. Creasman).

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Fig. 1. Photograph of the timbers at Charlestown Navy Yard (Courtesy C. Taylor).

of these roughly shaped historic timbers were then provided to the Henry B. duPont Preservation Shipyard, Mystic Seaport (CT), to serve as a raw timber supply for restoration of the American-built whaler *Charles W. Morgan*. Built in 1841, the ship underwent a major restoration program from 2008 to 2013 to return it to service, including replacement of structural timbers. With renovations underway, Chris Taylor of the Henry B. duPont Preservation Shipyard contacted the Laboratory of Tree-Ring Research (LTRR) at the University of Arizona in mid-2010 to inform researchers there that a large volume of wood potentially fit for dendrochronological analysis could be made available for study.

In October 2010, Creasman and Baisan, traveled to Mystic to evaluate the dendroarchaeological potential of the *Charles W. Morgan*. For 5 days the team collected specimens from the various stocks of timber available at Mystic Seaport, including those removed from the *Morgan*. While the primary goal of the trip was to evaluate the *Morgan*'s timbers (Creasman, 2012), a second opportunity (and subject of this article) presented itself. Thirty-eight specimens from the Charlestown Navy Yard cache at Mystic Seaport (mostly *Quercus* spp.; including live oak and white oak) were selected for dendrochronological analysis.

Unfortunately, very little data regarding the origin and nature of the Charlestown cache was transferred to Mystic Seaport with the timbers. As a result, we cannot be certain what part of the navy yard the timbers came from, nor do we know how many timbers in total were exhumed or virtually anything else regarding their original placement other than that they were reportedly laid out in an organized manner and weighed down with granite blocks to keep them submerged (Taylor, personal communication, October 2010). However, cross-referencing historic maps and images of the yard with photographs from the modern construction seems to allow for the identification of the timbers' approximate location (Fig. 2). While we have not been able to uncover maps of specific timbers stored within the ponds or grounds at the Charlestown Navy Yard, the U.S. Navy kept such records in certain instances, so we are hopeful that some can be located in the future. For example, maps and charts recording the location and dimensions of live oaks for shipbuilding stored at Portsmouth Navy Yard, New Hampshire (Navy Yard, Portsmouth, New Hampshire, 1931), as well as live oak timbers reserved specifically for U.S.S. *Constitution* and stored at Pensacola Naval Air Base, Florida (Boston Naval Shipyard, 1971a,b) can be found.

Sampling and data analysis

As the cache of unfinished timbers from Charlestown was not the priority for this research trip, we selected only the largest and best-quality materials readily available from the storage pile at Mystic Seaport. Specimens with waney edge present or other evidence of the outermost rings were prioritized. Thirty-eight complete sections were collected via chainsaw, given field labels (NEA 100–135; three timbers were sampled at both ends [ca. 7–12 m apart; specimens range from 20 cm^2 to 60 cm^2] and assigned "a" and "b" designations; NEA 124a was collected for its tool marks only and is not included in the specimens analyzed), and shipped to Tucson for analysis.

Once in Tucson, the specimens, some of which were still damp, were cured in an open-air environment before preparation. Once dried, sections were mounted on backing boards and sanded with a belt sander and successively finer paper to ANSI 400-grit (20.6–23.6 μm) (Orvis and Grissino-Mayer, 2002), yielding a high polish and sufficient clarity to observe all rings. Specimens were then measured by standard procedures (Cook and Kairiukstis, 1990; Schweingruber, 1988) and re-checked for visual confirmation of calendar dating suggested by the program COFECHA (Holmes, 1983; Grissino-Mayer, 2001). Decades and centuries were marked on each specimen, per Stokes and Smiley (1968). Quality of the final dated measurements and chronology was checked in COFECHA.

Results

Specimens collected were: 23 from long, straight white oak timbers and 6 from curved (i.e., knee) white oak timbers (*Quercus* sp.; white swamp oak [probably *Quercus bicolor*], not *Quercus alba* as might be expected); 5 from robust (ca. 1 m diameter) live oaks (*Quercus virginiana*) that are not viable due to erratic growth rings, despite their dendrochronological potential (Bartens et al., 2012); and 2 from curved hemlock (*Tsuga* sp.), which were analyzed but did not crossdate. Species were preliminarily identified in the field and later independently confirmed by Michael C. Wiemann of the Center for Wood Anatomy Research, Forest Products Laboratory, U.S. Department of Agriculture (personal communication, 13 May 2013). Further discussion of the anatomical aspects lies beyond the scope of the present paper, which focuses on the results derived from analysis of the 29 white oak sections.

A distinct crossdated tree-ring sequence spanning from 1508 to 1868 was assembled, with waney edge present on at least 5 of 18 datable oak specimens (Table 1). The period of 1509–1866 was used for maximum sample depth. Non-cutting dates are clustered around the 1830s (see Table 1), near cutting dates in the 1850s (1847 [NEA 101], 1850 [NEA 109], 1851 [NEA 104], 1852 [NEA 117], 1863 [NEA 106]), with cutting dates at 1865 (NEA 100, NEA 115), 1867 (NEA 108) 1868 (NEA 107, NEA 127).

Specimen NEA 127 is the only curved oak that dated, whereas the other timbers that dated were from straight oaks. As such, NEA 127 is included in these analyses with a note of caution. In this case, the timber appears to be from the base of a tree (as noted by small root shoots) that grew on a hillside (Fig. 3). The conditions that cause trees to grow straight and large, like most of the specimens we collected, are often different from those that result in robust curved timbers, so it would not be surprising if curved and straight timbers have different origins and were collected at different times.

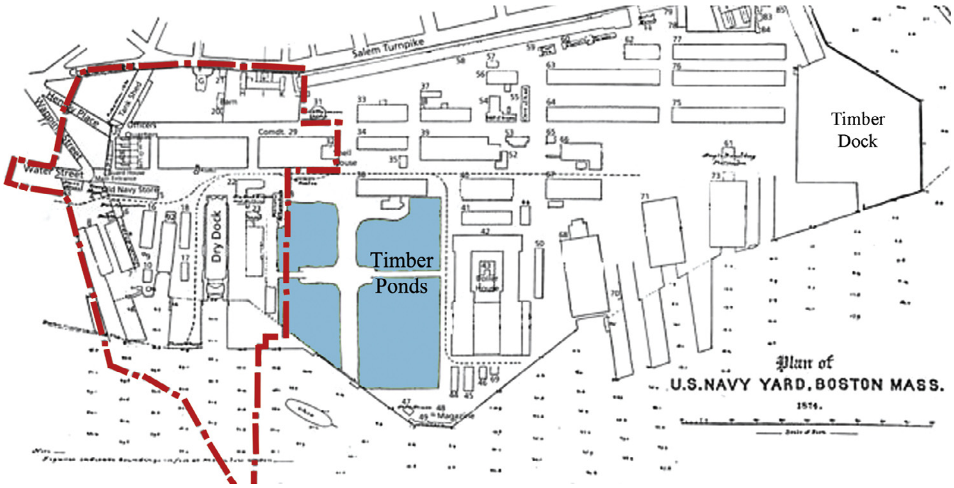

Fig. 2. Map of Charlestown Navy Yard (1874) with timber ponds. Most likely source is the northeastern pond; current park boundary noted at left. After Preble, 1875; Stevens et al., 2005

However, our curved timber sample set was too small for a separate analysis to test this hypothesis.

The Charlestown Navy Yard timber chronology (NEA) was compared to 30 reference chronologies that (1) were located in an area where white oak is a dominant species in local forest composition and (2) date early enough in time to allow for substantial overlap (>150 years) (Table 2). While white oak is found throughout the eastern United States and southern Canada (Little, 1971), optimal growing conditions for the species are restricted to the central Mississippi River Valley, the state of Ohio, and the western slope of the Appalachian Mountains (Burns and Honkala, 1990). Provenancing was carried out through correlations of the NEA chronology with each of the 30 reference chronologies such that the maximum overlap of years was achieved. Prior to calculating the correlations, autocorrelation was removed from the NEA chronology and all reference chronologies via AR modeling to produce white noise series. Correlations were converted to *t*-values for hypothesis testing, where the null hypothesis was that there is no match (with $\alpha = 0.01$) between the NEA chronology and each reference chronology. The *t*-values were mapped to highlight the spatial pattern of timber origin.

Table 1
Tree-ring dates for the Charlestown Navy Yard cache white oaks (*Quercus* sp.), with date codes (p indicates pith; r indicates outermost ring intact and thus a cutting date; v indicates near cutting date; vv indicates a non-cutting date [per Bannister, 1962; see also Grissino-Mayer et al., 2013, 484]). The innermost rings of many specimens, especially those extending into the 16th century, were extremely compact and difficult to discern.

Specimen	Inner ring date	Outer ring date
NEA 100	1666p	1865r
NEA 101a	1623p	1847v
NEA 101b	1532p	1847v
NEA 104	1549p	1851v
NEA 105	1615p	1832vv
NEA 106	1699p	1863v
NEA 107	1692p	1868r
NEA 108	1588p	1867r
NEA 109	1607p	1850v
NEA 110	1594p	1825vv
NEA 111a	1535p	1838vv
NEA 111b	1609p	1830vv
NEA 112	1596p	1830vv
NEA 113	1663p	1841vv
NEA 114	1508p	1837vv
NEA 115	1631p	1865r
NEA 117	1600p	1852v
NEA 127	1707p	1868r

The NEA chronology showed the best matches with tree-ring chronologies from Ohio (Fig. 4). Although statistically significant correlations were found with 21 of the 30 chronologies, all *t*-values above 5.0 clustered in the area of Ohio and southern Michigan (Table 3). The highest *t*-value (7.438) was associated with the chestnut oak (*Quercus prinus*) chronology from Stebbins Gulch at the Holden Arboretum near Cleveland, Ohio, in the northeastern part of the state and near the shore of Lake Erie. The next two best matches ($t > 6.5$) are with chronologies from southern Ohio. These results clearly demonstrate that timbers being used for ship-building at the Charlestown Naval Yard in Boston, MA during the 19th century were sourced from the U.S. Midwest, likely Ohio. Transporting these timbers by ship would have required traveling over 3000 km via the northern route through the Great Lakes and St Lawrence River to the North Atlantic Ocean and on to Boston, MA, or alternatively over 5000 km via the southern route down the Ohio and Mississippi Rivers, through the Gulf of Mexico, and northward along the US eastern seaboard in the Atlantic Ocean.

With a source for ship-building timbers in Ohio and harvesting taking place in the mid-19th century, it is essential to consider the

Fig. 3. Specimen NEA 127 (authors).

Table 2
Regional oak chronologies used to provenance the Charlestown Navy Yard cache.

Chronology	Species	State	First year	Last year	Latitude	Longitude	References
Buffalo Park Boundary	*Quercus stellata*	Arkansas	1620	1993	36.07	−93.18	[1]
Ferne Clyffe State Park	*Quercus alba*	Illinois	1655	1981	37.53	−88.98	[2]
Giant City State Park	*Q. alba*	Illinois	1652	1981	37.6	−89.2	[2]
Davis Purdue, Glen Helen	*Q. alba*	Indiana, Ohio	1662	1985	39.9	−84.4	[3]
Mammoth Cave	*Q. alba*	Kentucky	1649	1985	37.18	−86.1	[3]
Wachussett Mountain	*Quercus rubra*	Massachusetts	1673	1997	42.48	−71.89	[4]
Wachussett Mtn + Hist.	*Quercus* species	Massachusetts	1362	1997	42.48	−71.89	[4]
Cranbrook Institute	*Q. alba*	Michigan	1581	1983	42.67	−83.42	[3]
Current River NA	*Q. alba*	Missouri	1588	1992	37.25	−91.27	[5]
Democrat Ridge update	*Q. stellata*	Missouri	1620	1992	37.67	−92	[6]
Linville Gorge	*Q. alba*	North Carolina	1617	1977	35.88	−81.93	[3]
Hutchenson Forest	*Q. alba*	New Jersey	1620	1982	40.5	−74.57	[3]
Hudson Valley Mod. + Hist.	*Q. alba*	New York	1449	2002	41.65	−74	[8]
Middleburgh + Albany Hist.	*Quercus* species	New York	1507	2002	42.74	−74.34	[8]
Andrew Johnson Woods	*Q. alba*	Ohio	1626	1985	40.88	−81.75	[3]
NE Ohio Mod. + Hist.	*Q. alba*	Ohio	1550	2005	41.4	−81.4	[7]
Stebbins Gulch, Holden Arb.	*Q. prinus*	Ohio	1612	1983	41.55	−81.27	[3]
SW Ohio Hist.	*Quercus* species	Ohio	1539	1913	39.1	−84.52	[7]
SE Ohio Hist.	*Quercus* species	Ohio	1599	1863	39.1	−81.89	[7]
W Penn Hist.	*Quercus* species	Pennsylvania	1661	1825	40.4	−79.98	[4]
E Penn Mod. + Hist.	*Q.* species	Pennsylvania	1458	2003	40.2	−75.05	[4]
Otter Creek NA update	*Q. prinus*	Pennsylvania	1578	2003	39.88	−76.4	[3]
Alan Seegar	*Q. alba*	Pennsylvania	1516	1983	40.69	−77.76	[4]
Norris Dam SP	*Q. alba*	Tennessee	1633	1980	36.22	−84.08	[2]
Piney Creek Pocket Wilderness	*Q. alba*	Tennessee	1651	1982	35.7	−84.88	[2]
Blue Ridge Parkway	*Q. prinus*	Virginia	1587	1982	37.55	−79.45	[3]
Mountain Lake	*Q. alba*	Virginia	1552	1983	37.38	−80.5	[3]
Patty's oaks, Blue Ridge Parkway	*Q. alba*	Virginia	1569	1982	37.92	−79.8	[3]
Pinnacle Point, Hawksbill Gap	*Q. alba*	Virginia	1612	1981	38.5	−78.35	[3]
S Vermont Mod. + Hist.	*Quercus* species	Vermont	1569	1985	42.85	−72.83	[9]

References: [1] Stahle, D.W. & Therell, M.D., ITRDB[1]; [2] Duvick, D.N., ITRDB; [3] Cook, E.R., ITRDB; [4] Cook, E.R. & Krusic, P.J., *unpublished data*; [5] Guyette, R., ITRDB; [6] Stahle, D.M., et al., ITRDB; [7] Wiesenberg, N., *unpublished data*; [8] Pederson et al., 2013, ITRDB; [9] Baisan, C.H., *unpublished data*.
Notes: [1]International Tree-Ring Data Bank, accessed at http://www.ncdc.noaa.gov/data-access/paleoclimatology-data/datasets/tree-ring.

Table 3
Dendroprovenance of the Charlestown Navy Yard cache with regional oak chronologies.

Chronology	Overlap (years)	Correlation	*t*-value	*p*-value
Stebbins Gulch, Holden Arb.	255	0.424	7.438	<0.001
SW Ohio Hist.	328	0.351	6.763	<0.001
SE Ohio Hist.	264	0.379	6.629	<0.001
Cranbrook Institute	286	0.345	6.186	<0.001
Andrew Johnson Woods	241	0.343	5.650	<0.001
Davis Purdue, Glen Helen	205	0.355	5.417	<0.001
NE Ohio Mod. + Hist.	317	0.253	4.649	<0.001
Mammoth Cave	218	0.265	4.043	<0.001
Patty's oaks, Blue Ridge Parkway	298	0.227	4.017	<0.001
Alan Seegar	351	0.208	3.982	<0.001
Wachussett Mountain	194	0.259	3.721	<0.001
W Penn Hist.	164	0.275	3.641	<0.001
Middleburgh + Albany Hist.	358	0.184	3.523	<0.001
Current River NA	279	0.204	3.473	<0.001
S Vermont Mod. + Hist.	298	0.193	3.383	<0.001
Giant City State Park	215	0.22	3.293	0.00116
Norris Dam SP	234	0.196	3.049	0.00256
Hudson Valley Mod. + Hist.	358	0.155	2.958	0.00330
Wachussett Mtn + Hist.	358	0.149	2.834	0.00486
Mountain Lake	315	0.149	2.658	0.00826
Buffalo Park Boundary	247	0.164	2.599	0.00990
Ferne Clyffe State Park	212	0.169	2.483	0.01381
E Penn Mod. + Hist.	358	0.130	2.469	0.01402
Piney Creek Pocket Wilderness	216	0.161	2.387	0.01788
Blue Ridge Parkway	280	0.138	2.327	0.02070
Pinnacle Point, Hawksbill Gap	255	0.135	2.168	0.03108
Democrat Ridge update	247	0.125	1.971	0.04987
Hutchenson Forest	247	0.088	1.378	0.16935
Otter Creek NA update	289	0.042	0.717	0.47422
Linville Gorge	250	−0.017	−0.264	0.79205

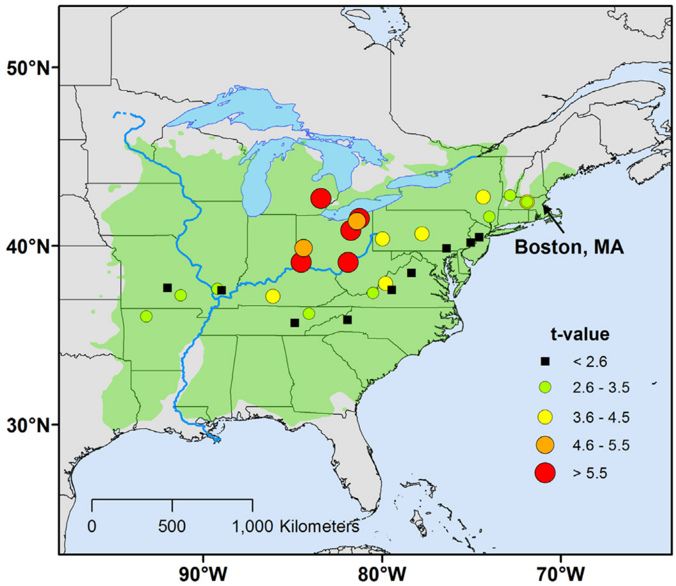

Fig. 4. Map of *t*-values for comparison of the Boston ship timbers against 30 reference chronologies. Squares represent non-significant correlations ($t < 2.5$), and circles are sized and colored proportional to the respective *t*-value. Information of each reference chronology is provided in Table 2. The green shaded area represents the range of white oak (Little, 1971).

Fig. 5. Log mark stamped or hammered into a beam end, reading "5U 340" (authors).

possible relationship of these timbers with the American Civil War (1861–1865) and Reconstruction Era (1865–1877).

Discussion

Chronological and historical context

All of the Charlestown Navy Yard timbers we sampled at Mystic Seaport had log marks (functionally equivalent to livestock brands), inventory data, or serial numbers stamped or carved into their ends and surfaces (Figs. 5 and 6). Characters on beam ends (e.g., Fig. 5) were stamped or otherwise impressed by means of a heavy log hammer (see Stairs (1999) for more detail), while the surface/carpenter marks (e.g., serial numbers, Fig. 6) were made with a race knife, as evidenced by the arced nature of many characters with a dimple in the middle of the arc (visible in Fig. 6). Log marks became extremely common by 1860 (Stairs, 1999). More than 20,000 marks were registered in Minnesota alone and vast records exist for that state, Wisconsin, Michigan, and several in New England (e.g., Work Projects Administration, 1941; Bachmann, 1945; Wood, 1935). It was reported that more than 1600 different marks were used in the Mississippi River in a single season (Bryant, 1923). Unfortunately, there appears to be no such resource for Ohio, where the timbers under consideration here most likely originated. Nonetheless, that the log marks do not bear any single unifying symbol (which would be expected of a merchant or businessman to make their timber identifiable), but rather an organized series of alpha-numeric marks (e.g., 5T, 5U, 5V, 5W) over a two- or three-digit number in which many of the top-tier alphanumerics are repeatedly found, suggests large-scale organization as seen in military and other government enterprises. Similarly, more than 80% of the timbers we observed were lightly charred on their outermost layer: this was a common method thought to prevent marine boring creatures, such as shipworms. Considering these facts and the context of the timbers' recovery from a government shipyard, we believe these timbers were harvested specifically as naval timbers for government operations.

While the state of Ohio saw virtually no military action on its soil during the Civil War, along with Indiana it constituted a major hub for timber production for the second half of the 19th century; although the trade focused on black walnut, oak was among the hardwood species brought from the region to the east to meet the needs of not only shipbuilders but also other manufacturers (Whitney, 1994, 145). Consequently, Ohio, the third most populated state in the Union, played a significant role in supplying resources for the war effort. Cincinnati served as the seat of the Department of the Ohio (which included all federal troops from this state, Indiana, Illinois, and later also Pennsylvania and western Virginia), initially under Major General George B. McClellan (Naval War Records Office, 1908). Cincinnati had Ohio's largest shipyard,

Fig. 6. Serial number ("S N° 1230″) carved into a large live oak (*Q. virginiana*) with a race knife (authors).

but it was not well equipped to build wooden ships (Roberts, 2002), making it an unlikely candidate to receive these timbers. In support of the Union plan to control the Mississippi and Ohio Rivers, troops and supplies gathered at and from the Cincinnati area were regularly sent downriver, especially to Mound City, Illinois (near the confluence of the Ohio and Mississippi Rivers), where the Union had a variety of facilities, including a shipyard, hospital, and prison. Emphasis is thus focused on the nearby Mound City shipyard because the NEA timbers were discovered at a shipyard, have distinctly maritime characteristics (described below), and are therefore presumed to be of similar origin.

Mound City would have been in great need of timber through 1865, since "[w]ar-related activities at Mound City were almost strictly limited to the supply and repair of the Union Naval Vessels" (Matthews, n.d.). Notably, the ironclads ships USS *Cairo*, USS *Cincinnati*, and USS *Mound City* were built at the Mound City Marine Railway and Shipyard during the war (Bearss, 1980; Gibbons, 1989). Substantial volumes of wood were needed to construct the ironclads, to convert steamers into armored vessels, and to service the hundreds of ships repaired or stationed at Mound City during the war, including the U.S. Navy's Mississippi River Squadron of 162 ships that were stationed there from 1863 (Joiner, 2007; Lamszuz, n.d.). Naval activities in the region continued to intensify in the area through 1865, only beginning to subside in 1866 (Naval War Records Office, 1917). In these capacities, Mound City certainly required copious amounts of timber. Perhaps not coincidentally, the robust timbers from the Charlestown Navy Yard would have been sufficient for construction in watercraft such as ironclads. At >20 m in length and 1 m square, the largest of the cache we investigated would have been suitable to serve as structural timbers in a vessel similar to the *Cairo* (53 m length × 15.5 m beam; Delgado, 1997).

Since there is a documented intensive exchange between Ohio and operations at Mound City around the time the timbers were cut, it is not unreasonable to suggest that the Charlestown Navy Yard cache we sampled may have been related to these operations. After the war ended and naval activities were significantly reduced and consolidated, especially on the western front, such valuable resources (in this case, large old-growth timber) could possibly have been transferred to a centralized repository, such as the Charlestown Navy Yard. However, as the Union's lease of the Mound City shipyard did not expire until 1874 (Lamszuz, n.d.), near the end of Reconstruction, precisely when such an event could have occurred cannot be determined.

It is, of course, possible that these timbers never passed through Mound City and were sent directly to Boston, or that they found their way to Charlestown Navy Yard via a northern Great Lakes/canal-based network or some other circuitous route. Yet, it seems unlikely that they were ordered directly for the Charlestown yard, since it only built six ships during Reconstruction (1865–1877), with none between 1868 and 1874 (Carlson, 2005). However the timbers made it to Boston, it is likely that they did so by the 1880s or 1890s, when the expansive timber ponds at the Charlestown Navy Yard began to be filled in to provide more ground for administrative and recreational areas. (Most of the ponds were filled by 1898, with the last sliver being reclaimed as land in 1934 to accommodate a baseball field [Bither, 1999; Stevens et al., 2005].) With the onset of metal shipbuilding and growth of manufacturing, timber was no longer the priority it once was in a naval yard.

Behavioral and environmental context

The dendrochronological analyses, while unable to tell the complete story of these timbers, have revealed more about the local environment and human interaction with it. NEA 127, noted above, provides a prime example: acquisition of curved timbers and straight timbers (used for different purposes in a vessel) from different locations. An earlier example can be found in the 1660s.

Fig. 7. NEA 104 (date: 1549p–1851v; pith at right), with the 1661/2 event indicated (authors).

After the growing season of 1661, a major release is evident (Fig. 7). A similar mid- to late-century tree recruitment event has been observed within Ohio and more broadly across the region (Pederson et al., in press). The post-1661/2 event can be found in 7 of the 14 datable specimens that span this period (NEA 104, 105, 108, 109, 110, 113, 115; but not in NEA 101a/b, 111a/b, 112, 114, and 117). When evident, the event is synchronous, found across trees that range in ages when the event occurred (as young as ca. 20 years and as old ca. 110 years). The growth surge in our specimens lasted for about 15 years, allowing what were probably sub-canopy oaks to fill the available space without significant competition during that period (Nowacki and Abrams, 1997). Most likely this is a response to a change in the local environment that resulted in an opened canopy. Since we do not know the exact growing location of each tree, or even the scale at which these timbers were harvested, we can only speculate as to the nature of the disturbance that is recorded by the tree rings on our specimens. The event could have been localized (i.e. a fire or windstorm), and only those trees that recorded it were in that place, or it could have been a widely distributed climate-driven event with spatially heterogeneous effects on the forest. Pederson et al. (in press) posit that episodic climatic shifts (a combination of droughts and pluvials) during the 1660–1680 period could have caused regionally widespread, yet locally spotty, overstory mortality that allowed for new recruitment and turnover in eastern deciduous forests. Should the Charlestown timbers have been harvested from a wider area, the nature of the release event(s) might have helped to produce the sort of timber quality that was desirable for ship building (i.e. mostly clear, straight boles; or curved timbers in rare cases). Therefore, the wood cutters could have targeted these trees over a larger landscape to fulfill their timber needs, and thus the ecological signals within the wood might be pointing to spatially distributed, yet highly synchronous, canopy disturbances within Ohio at the same time, and potentially for the same reasons, as was noted for much of the Central Hardwood Region (Pederson et al., in press). However, since the change in our specimens is so significant and abrupt, human impact must be considered, but what human agents of change were active in the Ohio River Valley during the 1660s?

In the 17th century (the Early Contact period), southwestern Ohio was nominally part of the French territory known as New France, sparsely populated by indigenous groups. The Beaver Wars – a series of brutal conflicts in which the Iroquois and other native groups, each side backed by rival European trading partners, vied for dominance over trade – saw the region become more active by the middle of the century. By 1656, the Iroquois Confederacy claimed most of what is now Ohio during its "Great War for

Survival" (Maslowski, 2011; Wallace, 1956). Since the Beaver Wars are known for their human toll and ferocity (Axelrod, 2011), the landscape might have suffered concurrently, perhaps from fires or other activities related to the conflict. The event could also have resulted from swidden farming in the newly occupied lands; this is known to have been practiced by the Iroquois, who were apparently capable of producing "dramatic changes in forest composition" (Clark and Royall, 1995, 1). Indeed, in 1661 two specimens (NEA 108 and NEA 114) have fire scars, which are otherwise rare in these timbers. Unfortunately, without greater historical records or more archeological or environmental data, the cause of the 1661/2 event cannot be identified with certainty. Whatever the cause(s) (i.e., human, climate, fire, insect, flood), conditions improved radically for a portion of the trees in the region for about 15 years, then returned to a more consistent pattern of growth for the subsequent 200.

Conclusions and future work

Given that the Charlestown Navy Yard cache was recovered from a timber pond, it is not surprising to find some level of variation among cutting dates and source. Indeed, variation should be expected since the timbers were extracted en masse in Boston, jumbling an unknown number of deposits that could have occurred over more than a century of use. The timber ponds would have been regularly used and reused, and it is inevitable that some timbers would have remained in the basin when most of their contemporaries were harvested. Similarly, as the timbers came from the Midwest, it is possible they were stockpiled there, which would likely cause variation in the dates and broad range of potential origins. Dendrochronological analyses, as presented here, cannot inform regarding *how* the timbers traveled from the Ohio area to Boston, only that they *did*. It is very likely that this occurred between 1868 and 1898, when most of the timber ponds at Charlestown Navy Yard were filled.

Numerous opportunities exist for future work with these specimens, including chronological, behavioral, and environmental analyses. For example, the ring for 1836 is very narrow in almost all of the specimens and in most proportionately smaller than that of 1816. A more thorough evaluation of the log marks and serial numbers is needed. Similarly, a potentially very interesting evaluation of this collection could be made by comparison to the timber remains of U.S.S. *Cairo*. While the *Cairo* was built in 1862, it is an (the only?) identifiable wooden ship built at Mound City that is presently accessible for study. It would be interesting to evaluate whether the provenance for the *Cairo*'s timbers is similar to that of the Charlestown Navy Yard cache. Furthermore, exploring the correlation between individual timber ring-width series and independently constructed chronologies would be a worthy and interesting endeavor. Clearly, much work remains to be done to fully understand and take advantage of this small collection of timbers, but the benefits are evident. Using tree-ring analyses more extensively can help to realize the full potential of traditionally underutilized data present in historical-era ship timbers.

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