TREE-RING DATING OF HISTORIC BUILDINGS IN WILLSBORO, NORTHEASTERN NEW YORK, AND DEVELOPMENT OF REGIONAL CHRONOLOGIES FOR DENDROARCHAEOLOGY

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ABSTRACT

Historical timbers have been sampled from buildings at 13 sites in Willsboro, New York, on the west shore of Lake Champlain. Ring-width series from 139 timbers have been successfully crossdated and used to develop tree-ring chronologies for ash (*Fraxinus* spp.), oak (*Quercus* spp.), pine (*Pinus* spp.), eastern hemlock (*Tsuga canadensis* (L.) Carr.), and spruce (*Picea* spp.), which collectively span A.D. 1555 to 1878. Tree cutting dates suggest that Windyview Manor was likely built in or soon after 1799, and a barn and farmhouse at the 1812 Homestead were built in or soon after 1812 and 1813, respectively. These dates are all consistent with documentary records for these sites. Aggregate data for the town suggest a shift in wood use for building during the 19th Century, with ash and oak commonly used for large frame timbers from the 1790s to 1820s, and hemlock and spruce dominating from the 1830s to 1860s. Chronologies developed in this project are among the first from historical timbers for northern New York and will facilitate further dendroarchaeological work in the region.

Keywords: tree rings, dendroarchaeology, New York, Adirondacks, Lake Champlain.

INTRODUCTION

Over recent decades there has been a slow increase of dendroarchaeological work in eastern North America (Stahle 1979; Robichaud and Laroque 2008; Grissino-Meyer 2009; Querrec *et al.* 2009). This region has a rich settlement history and such studies are important for dating structures and inferring wood-use behaviors of indigenous peoples, European colonizers, and American settlers. Old buildings are also a repository of tree-ring samples from the original pre-clearance forests and so enable extension of living tree-ring chronologies for dendroclimatic reconstructions (*e.g.* Pederson *et al.* 2013).

In New York State, dendroarchaeological work can be challenging for several reasons. Forest clearance in the 18th and 19th Centuries exceeded 80% in some areas (Glitzenstein *et al.* 1990; Smith *et al.* 1993; McMartin 1994), and so there are relatively few living tree-ring chronolo-

gies long enough or located close enough for crossdating with samples from old buildings. The species diversity and varied ecological niches of trees in New York (Edinger *et al.* 2002) also means that historical buildings may contain wood from a range of species and from growth settings dissimilar to the available master chronologies. Nonetheless, the potential for dendroarchaeological work in New York is demonstrated by a number of successful building and site studies, mostly in the Hudson Valley in the southeast part of the state (Harvey 2012; see also reports at <http://hvva.net/dendro.html>).

In this paper we present the initial results from dendroarchaeological work in Willsboro in northeastern New York (Figure 1). Since 2008 we have sampled historical structures at 13 sites in this town with the goal of dating buildings and better understanding the local settlement history. Here we detail development of seven tree-ring chronologies for Willsboro and present results from structures at two of the oldest sites studied thus far, the 1812 Homestead and Windyview Manor.

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Figure 1. Hillshade map of study area. Black dots are sample sites in and around Willsboro.

SETTING

Willsboro is located on the west shore of Lake Champlain (Figure 1). Pleistocene-age glacial, glacialacustrine, and glacialmarine sediments over early Paleozoic sedimentary rocks fringe the lakeshore, while the Adirondack upland to the west is formed of Precambrian igneous and metamorphic rocks (Buddington and Whitcomb 1941). Mountain peaks immediately west of Willsboro reach up to 501 m above sea level whereas the Willsboro lowlands range in elevation from about 120 m down to the surface of Lake Champlain at 30 m. The Boquet River (Figure 1) is about 64 km long and drains from the High Peaks area of the Adirondacks. Climate is characterized by warm summers and cold snowy winters with Burlington, 22 km to the northeast in Vermont on the east shore of Lake Champlain, recording monthly average temperatures of -8°C in January, 21°C in July, and total annual precipitation of 914 mm (1981–2010 NCDC normals).

Terrestrial ecosystems around Willsboro are predominantly classified as Laurentian-Acadian

Pine-Hemlock-Hardwood and Northern Pine (Oak) forests (Sayre *et al.* 2009). The earliest land surveys of the area between the mouth of the Boquet River and Split Rock Mountain (Figure 1) were done in A.D. 1765–1766 and suggest that the pre-clearance forest of the Willsboro lowland was dominated by pine, with 46 of the 101 trees identified in the lotting surveys being pine and one area being described as a pinery (Watson 1863). Other witness tree taxa named between three and eight times in these lotting surveys were ash, beech, birch, cedar, elm, hemlock, hickory, maple, oak, and poplar. Modern maps indicate that there are about 50 different species of medium to large trees native to the Willsboro area (Little 1971, 1980), which potentially could have been used as building timbers.

Lake Champlain and its fringing lowlands have historically formed the primary travel route between the Hudson and Saint Lawrence valleys, but the Willsboro area remained largely unsettled during most of the pre-Columbian and Colonial eras (Palmer 1983). Permanent settlement began after the French and Indian War with arrival in 1765 of a small group of pioneers led by William Gilliland, an Irish immigrant and war veteran who had purchased grants for lands along the lakeshore (Watson 1863). Homesteading and forest clearance initially focused on the area around the mouth of the Boquet River and south to Split Rock Mountain (Figure 1). However, the growing settlement was abandoned in the American Revolutionary War, during which the pioneer homesteads were looted and razed by armies, raiding parties, and war refugees (Watson 1863).

Re-settlement began in 1784 and the community center grew at the falls of the Boquet River (Figure 1), an area where Gilliland had previously built grist and saw mills and which was formerly known as Milltown. Population, land clearance, and farming increased throughout the 19th Century and expanded to Willsboro Point and into lower areas of the adjacent upland (Tefft 1997). The 1812 Homestead is located on the edge of the upland along the original main road leading north to Plattsburgh and Canada, and includes a farmhouse (Figure 2A), a barn (Figure 2B), and a small wood shop. Windyview Manor is south of

Figure 2. 1812 Homestead farmhouse (A), barn exterior (B) and barn interior (C).

the Boquet falls on Middle Road, a local road to farms on the lowland, and is comprised of a main house (Figure 3A) and an attached annex.

METHODS

Sample Collection and Preparation

Our general sampling strategy for each building in Willsboro was to core original frame timbers that were likely to have at least 50 rings and, whenever possible, also had bark or a wane edge. In the open interiors of barns (Figure 2C) we were usually able to core all the major vertical

Figure 3. Windyview Manor main house exterior (A), square-cut beams in ceiling of main house cellar (B) and round beam with bark in ceiling of annex cellar (C).

timbers (posts) and many of the major horizontal timbers (beams, girts, plates, and sills). Haylofts provided access to upper areas of most barns and additional samples were sometimes taken from smaller timbers (joists, studs, purlins, and rafters). Sampling was more limited in other structures (houses, annexes, additions, a cabin, and a church) because of frame timbers being hidden by external siding, and internal paneling, plastering, and flooring. Basements and attics were often the only places where frame timbers could be accessed. Our samples for 2008 to 2011 averaged 15 timbers per barn (minimum three, maximum 26) and six

timbers (minimum one, maximum 15) in other structures.

Sampling was done using a 5.15-mm-diameter increment borer. Cores were collected through bark, a waney edge, or the corner of square-cut timbers whenever possible, and most timbers were cored one or two times depending on timber exposure, wood quality, and safety considerations. Core holes were digitally photographed and notes made on the likely preservation of outer rings, both at the core position and elsewhere along the timber.

In the lab the samples were air-dried, glued into holders, and sanded with increasingly fine sand papers (up to 1500 grit for some samples) to reveal wood cells and structures on the cross-sectional surface. Tree taxa were identified to the genus level based on microscopic examination of the prepared cross-sectional surface using keys in Brown *et al.* (1949) and Hoadley (1990), and by comparison with reference samples collected from living trees around the Willsboro area. Photographs of bark were also used to aid identification of some samples with reference to Little (1980).

Crossdating

Crossdating began with pairs of cores of the same genus, often from the same timber, under a binocular microscope. Each core was visually matched to the other based on annual ring widths and earlywood and latewood appearance, and the tenth, fiftieth, and hundredth rings marked with respectively one, two or three dots (Stokes and Smiley 1968). This marking began with an assumed starting year on one of the cores being crossdated. Annual ring widths were measured digitally to the nearest 0.001 mm using a Velmex linear encoder system and PJK software (P. Krusic, unpublished), and on-screen line graphs showing the ring width patterns over decades (Baillie 1982) were used to assist the on-core crossdating. This process progressed through the paired cores until all problem sections (*e.g.* false rings, missing rings, condensed growth, ring offsets along rays, gaps caused by breaks, woodworm, and decay) were resolved and the samples were visually crossdated relative to each other throughout.

The COFECHA program (Holmes 1983) was used to statistically check crossdates. To enhance the time-series characteristics important to crossdating, each measured ring width series was standardized using a spline with a 50% frequency response of 32 years, persistence removed by autoregressive modeling, and each series log-transformed (Grissino-Mayer 2001). Series were then tested against the COFECHA master chronology in 50-year segments offset by 25 years. Segments that did not correlate at or above the 99% one-tailed confidence level (CL), or which correlated better with a systematic offset of one to a few years in successive 50-year segments, were re-examined visually to identify and resolve the crossdating problem. Samples were accepted as correctly crossdated if all or most of the successive 50-year segments correlated at or above the 99% CL and if the crossdate was visually convincing.

Chronology development proceeded with crossdating of paired samples to other samples of the same genus from timbers in the same building, and then with samples of the same genus from elsewhere in Willsboro. COFECHA was used to suggest crossdate positions, crossdates were confirmed by visual inspection with line graphs and on the cores, and crossdating problems resolved as the chronologies grew. Our goal was to develop chronologies that had a strong common signal and this led to multiple chronologies being developed for some genera that subdivided into distinct populations based on their crossdating characteristics. The resulting floating chronologies (*i.e.* internally crossdated but not calendar-dated by linkage to living trees) were checked with COFECHA to ensure that all component series correlated with the COFECHA master at or above the 99% CL for the full series lengths, and that all or most 50-year segments also correlated at or above the 99% CL.

Final Chronologies and Outer Ring Dates

The Willsboro floating chronologies were calendar-dated by crossdating with each other and with master chronologies from northern, eastern, and central New York. COFECHA was used to identify crossdate positions based on offset

50-year segments, and crossdates were confirmed visually with line graphs and statistically with correlations based on the full periods of overlap. Dates of the component ring-width series were then updated to reflect the final chronology calendar dates.

The outermost rings of all calendar crossdated samples were re-examined carefully to confirm the last year of growth. Only complete annual rings had been measured and so any earlywood or latewood of a partial growth ring beyond the last measured ring was noted. Core hole photographs, field notes, and the core samples were also reviewed to check for the presence of bark or a waney edge. First and last year dates were determined for each timber based on all available cores and with partial growth years included. Distorted or badly damaged rings had also been avoided during measurement, but are included in the first and last year dates in cases where they could be counted with confidence. Using a modified form of a scheme proposed by Baillie (1982), the quality of the outermost ring dates of all crossdated timbers were rated as follows:

- A_e or A_l Precise date. Bark or a waney edge present and last ring date is the actual last year of growth. Subscript indicates that the last ring ends with earlywood (e) or latewood (l).
- B Close date. Quality of outer rings and consilience with other samples suggests that date is within a few years of when the tree died.
- C Minimum date. No clear indication that the last ring date is close to the actual death date of the tree, so date simply constrains the year of tree death to be sometime after the last year of recorded growth.
- D Suspect. Outer rings known to be lost, removed, badly decayed, or damaged.

RESULTS

Willsboro Chronologies

A total of 139 timbers have been successfully crossdated and assigned calendar dates (Table 1).

Table 1. Sampled taxa and crossdating success.

Genus	No. Timbers Sampled	No. Timbers Crossdated	Success Rate (%) ¹
Ash (<i>Fraxinus</i> spp.)	27	17	71
Oak (<i>Quercus</i> spp.)	27	25	100
Birch (<i>Betula</i> spp.)	9	0	-
Maple (<i>Acer</i> spp.)	3	0	-
Elm (<i>Ulmus</i> spp.)	3	0	-
Cherry (<i>Prunus</i> sp.)	2	0	-
Hickory (<i>Carya</i> spp.)	1	0	-
Pine (<i>Pinus</i> spp.)	73	34	87
Hemlock (<i>Tsuga</i> sp.)	43	40	100
Spruce (<i>Picea</i> spp.)	24	23	100
Cedar (<i>Thuja</i> sp.)	1	0	-
Totals	213	139	-

¹After exclusion of short (< 60 rings) and broken samples.

These samples have been used to develop tree-ring chronologies for ash (*Fraxinus* spp.), oak (*Quercus* spp.), pine (*Pinus* spp.), eastern hemlock (*Tsuga canadensis* (L.) Carr.), and spruce (*Picea* spp.) (Table 2, Figure 4). An additional six tree genera have been found during sampling (Table 1) but in too few numbers to enable chronology development.

All seven of the Willsboro chronologies correlate well ($p < 0.001$) with master chronologies from New York (Table 2, Figure 4). One of these masters is a composite chronology of historical oak timbers from central and northern New York (CNQUSP), while the others are living tree chronologies from 40 km to the west of Willsboro in the Adirondack Mountains (WNPIST, WPPIST, RBTSCA, and RBPCRUC) and 145 to 165 km to the south-southeast of Willsboro in the northern Hudson Valley (PMQUAL and GEQUMT). All of these chronology crossdates are between trees of the same genus, except WHFR1-to-GEQUMT that is between ash and chestnut oak (*Quercus montana* Willd.).

Most of the Willsboro chronologies also correlate well with each other (Table 3). The groupings of WHFR1-WHQU1-WHP11 and WHP11-WHTS1-WHPC1 in particular show consistently strong ($p < 0.001$) inter-relationships, suggesting common responses to climate in their growth signals. The weaker correlations involve

Table 2. Willsboro tree-ring chronologies.

Willsboro Chronology	Genus	Interval	No. of Timbers	No. of Series	Mean Correlation ¹	Mean Sensitivity ¹	Linked Chronology ²	Correlation ³
WHFR1	Ash	1654–1822	17	23	0.428	0.185	GEQUMT	0.339 (157)
WHQU1	Oak	1555–1811	6	12	0.573	0.207	PMQUAL	0.370 (123)
WHQU2	Oak	1557–1798	19	40	0.477	0.175	CNQUSP	0.434 (190)
WHPI1	Pine	1619–1848	29	45	0.551	0.230	WNPIST	0.430 (217)
WHPI2	Pine	1655–1851	5	7	0.528	0.312	WPPIST	0.345 (156)
WHTS1	Hemlock	1704–1877	40	47	0.565	0.221	RBTSCA	0.608 (174)
WHPC1	Spruce	1635–1848	23	32	0.517	0.205	RBPCRU	0.553 (214)

¹Statistics for COFECHA master chronology.
²Master chronology to which each Willsboro chronology correlates most strongly. GEQUMT: Goose Egg Ridge chestnut oak, Pederson *et al.* 2013, ITRDB NY017; PMQUAL, Prospect Mountain white oak, Pederson *et al.* 2013, ITRDB NY035; CNQUSP: central New York historical oak, C. B. Griggs, unpublished data; WNPIST: Wilmington Notch Roaring Brook eastern white pine, E.R. Cook, ITRDB NY013; WPPIST: Winch Pond Adirondack Mountains eastern white pine, E.R. Cook, ITRDB NY014; RBTSCA: Roaring Brook Keene Valley eastern hemlock, E.R. Cook, ITRDB NY009; RBPCRU, Roaring Brook Keene Valley red spruce, E.R. Cook, ITRDB NY010.
³Correlation with master chronology, number of overlap years in parentheses. All significant at $p < 0.001$.

one or both of WHQU2 and WHPI2, which may reflect the trees comprising these two chronologies coming from settings where the factors limiting growth were somewhat different to trees in the other chronologies.

1812 Homestead

Intact samples were collected from seven large beams exposed in the cellar ceiling of the 1812 Homestead farmhouse (Figure 2A). All were ash and three were too broken or short to crossdate (Table 4). The remaining four cellar beam samples had outer ring dates of 1739, 1778, 1790, and 1811, but the poor quality of the outermost wood and lack of bark in the samples means that these are not true felling dates of the original trees. Much better quality samples were obtained from two pine beams exposed in the farmhouse attic. Both had latewood for 1812, no earlywood for 1813, and intact bark, indicating that they were cut at the end of or after the 1812 growing-season and before the 1813 growing-season. The two attic beams were identified as red pine (*Pinus resinosa* Ait.) on the basis of bark on the timbers, wood hardness, and the abrupt onset and strong color of the latewood.

Nineteen posts and beams were sampled in the adjacent barn (Figure 2B and 2C). Eleven of the ash, oak, and pine timbers had latewood for

1811, no earlywood for 1812, and bark or a waney edge (Table 4). All but one of the last ring dates of the other samples range from 1769 to 1809 and, when considered with the 11 samples with precise outer ring dates, these data are consistent with the trees being felled at the end of or after the 1811 growing-season and before the 1812 growing-season. The one exception is a pine timber that has a last ring date of 1828, but this was clearly an internal frame (Figure 2C) added to the barn after it was built. Furrowed bark on four of the ash timbers suggests that they were white ash (*Fraxinus americana* L.) or green ash (*F. pennsylvanica* Marsh.), while numerous small latewood pores and scaly bark on two of the oak posts suggests that they were white oak (*Quercus alba* L.). Local abundance and large size make eastern white pine (*Pinus strobus* L.) or red pine the most likely species for the pine posts and beams.

A total of 12 timbers were sampled from the 1812 Homestead wood shop, a separate small structure close to the farmhouse and barn. Nine of these were identified as pine (probably eastern white pine) and three as birch (*Betula* spp.). However, none of the samples had more than 40 rings and so none could be crossdated. Annual rings of these samples show fast and even growth, suggesting that these trees grew in an unstressed environment such as an open canopy setting with plentiful water.

Figure 4. Tree-ring chronologies for Willsboro (black) and regional master chronologies (grey) with which they are crossdated. All chronologies have been detrended with flexible splines and prewhitened to remove persistence. See Table 2 for explanation of labels. All plots have same vertical scale.

Table 3. Correlation (upper right) and overlap years (lower left) of Willsboro chronologies.

	WHFR1	WHQU1	WHQU2	WHPI1	WHPI2	WHTS1	WHPC1
WHFR1		0.480***	0.316***	0.322***	0.172*	0.199*	0.146*
WHQU1	156		0.229***	0.539***	0.129	0.278**	0.287***
WHQU2	143	240		0.182**	0.134	0.149	0.193**
WHPI1	167	191	178		0.014	0.443***	0.434***
WHPI2	166	155	142	192		0.106	0.021
WHTS1	117	106	93	143	146		0.602***
WHPC1	167	175	162	212	192	143	

Significance level of correlations: *p < 0.05, **p < 0.01, ***p < 0.001.

Table 4. Sample results for 1812 Homestead.

Sample Number	Description	Genus	First Year	Last Year	Outer Ring ¹	Willsboro Chronology	Correlation of Series with Willsboro Chronology ²	
1812 Homestead farmhouse:								
W01A	Cellar beam	Ash						
W01B	Cellar beam	Ash						
W01C	Cellar beam	Ash	1675	1739	D	WHFR1	0.533 (63)	
W01D	Cellar beam	Ash	1660	1778	D	WHFR1	0.327 (95)	
W01E	Cellar beam	Ash						
W01F	Cellar beam	Ash	1684	1811	B	WHFR1	0.455 (118)	0.310 (62)
W01G	Cellar beam	Ash	1673	1790	C	WHFR1	0.644 (114)	0.486 (66)
W01H	Cellar beam	Ash						
W01I	Attic beam	Pine	1751	1812	A _I	WHPI1	0.529 (61)	
W01J	Attic beam	Pine	1712	1812	A _I	WHPI1	0.580 (100)	
1812 Homestead barn:								
W20A	Post (center)	Ash	1710	1811	A _I	WHFR1	0.520 (101)	0.549 (93)
W20B	Internal frame	Pine	1751	1828	C	WHPI1	0.694 (76)	
W20C	Post (door)	Oak	1607	1808	B	WHQU1	0.656 (186)	0.651 (191)
W20D	Post (corner)	Pine						
W20E	Post (wall)	Ash	1689	1811	A _I	WHFR1	0.460 (114)	0.580 (122)
W20F	Post (door)	Oak	1620	1811	A _I	WHQU1	0.699 (191)	0.683 (174)
W20G	Post (door)	Oak	1631	1811	A _I	WHQU1	0.545 (139)	0.726 (179)
W20H	Post (corner)	Pine	1625	1803	C	WHPI1	0.627 (177)	
W20I	Post (wall)	Pine	1644	1809	B	WHPI1	0.504 (164)	0.581 (100)
W20J	Post (corner)	Pine	1636	1769	C	WHPI1	0.660 (132)	0.573 (100)
W20K	Post (door)	Oak	1622	1811	A _I	WHQU1	0.615 (188)	
W20L	Post (center)	Ash	1697	1811	A _I	WHFR1	0.507 (114)	
W20M	Beam (wall)	Pine	1646	1811	A _I	WHPI1	0.646 (151)	0.695 (72)
W20N	Beam (center)	Pine	1734	1811	A _I	WHPI1	0.359 (54)	0.407 (64)
W20O	Beam (wall)	Maple?						
W20P	Beam (wall)	Ash	1653	1811	A _I	WHFR1	0.316 (158)	
W20Q	Beam (wall)	Maple?						
W20R	Beam (wall)	Ash	1721	1811	A _I	WHFR1	0.578 (90)	
W20S	Beam (wall)	Ash	1653	1811	A _I	WHFR1	0.407 (158)	

¹See Methods for definition of codes.

²Overlap years in parentheses. All significant at or above the 99% confidence level in one-tailed t-test.

Table 5. Sample results for Windyview.

Sample Number	Description	Genus	First Year	Last Year	Outer Ring ¹	Willsboro Chronology	Correlation of Series with Willsboro Chronology ²	
Windyview Manor main house:								
W06A	Cellar beam	Oak						
W06B	Cellar beam	Pine						
W06C	Cellar beam	Oak	1605	1798	A ₁	WHQU2	0.483 (152)	0.498 (181)
W06D	Cellar beam	Oak	1648	1798	A ₁	WHQU2	0.445 (150)	0.552 (134)
W06E	Cellar beam	Oak	1659	1789	C	WHQU2	0.691 (115)	0.604 (127)
W06F	Cellar beam	Oak	1672	1798	A ₁	WHQU2	0.514 (122)	0.378 (113)
W06I	Cellar beam	Oak	1595	1794	B	WHQU2	0.599 (198)	0.533 (55)
W06J	Cellar beam	Oak	1587	1795	B	WHQU2	0.474 (207)	0.426 (38)
W06K	Cellar beam	Oak	1599	1794	B	WHQU2	0.453 (128)	0.360 (156)
W06L	Cellar beam	Oak	1646	1796	B	WHQU2	0.461 (149)	0.404 (122)
W06M	Cellar beam	Oak	1567	1739	C	WHQU2	0.333 (164)	0.456 (152)
W06N	Cellar beam	Oak	1556	1772	C	WHQU2	0.293 (214)	0.369 (172)
W06O	Cellar beam	Oak	1679	1798	A ₁	WHQU2	0.515 (119)	0.618 (118)
Windyview Manor annex – south side:								
W06H	Cellar beam	Oak	1717	1788	C	WHQU2	0.536 (63)	0.573 (64)
W06P	Cellar beam	Oak	1718	1789	C	WHQU2	0.553 (70)	
W06Q	Cellar beam	Oak	1703	1797	B	WHQU2	0.515 (78)	0.532 (83)
W06R	Cellar beam	Oak	1704	1791	B	WHQU2	0.429 (84)	0.451 (79)
W06U	Cellar beam	Oak	1589	1775	C	WHQU2	0.412 (155)	0.310 (173)
W06Z	Cellar beam	Oak	1690	1796	B	WHQU2	0.545 (95)	0.442 (95)
Windyview Manor annex – north side:								
W06G	Cellar beam	Hemlock	1729	1847	B	WHTS1	0.552 (117)	0.627 (101)
W06S	Cellar beam	Pine						
W06T	Cellar beam	Pine	1703	1852	A _e	WHPI2	0.461 (148)	0.531 (66)
W06V	Cellar beam	Pine	1683	1852	A _e	WHPI2	0.623 (168)	
W06W	Cellar beam	Pine	1654	1852	A ₁	WHPI2	0.530 (197)	
W06X	Cellar beam	Pine	1659	1852	A _e	WHPI2	0.463 (192)	
W06Y	Cellar beam	Pine	1673	1852	A _e	WHPI2	0.498 (178)	0.668 (83)

¹See Methods for definition of codes.²Overlap years in parentheses. All significant at or above the 99% confidence level in one-tailed t-test.

Windyview Manor

Thirteen beams exposed in the cellar ceiling of the main house (Figure 3A) at Windyview Manor were sampled. One of these was a pine that did not crossdate, whereas the other 12 were large (20–30 cm wide), mostly square-cut beams of oak (Figure 3B). Four of these had latewood for 1798 and then bark, while outer rings of the other eight beams were less well preserved and had outer ring dates ranging from 1739 to 1796 (Table 5). These data are consistent with the trees being felled at the end of or after the 1798 growing-season and before the 1799 growing-season. All of the oak samples had small and numerous latewood pores

indicative of the white oak group (*Quercus* Sect. *Leucobalanus*), and the four beams with bark were identified as probably swamp white oak (*Q. bicolor* Willd.).

Six beams in the cellar ceiling of the adjacent annex were also identified as being of the white oak group and, based on bark found on five (Figure 3C), were also probably swamp white oak. However, outer rings beneath the bark had decayed and last year dates ranged from 1775 to 1797 (Table 5). These six beams were all in the southern half of the annex and appear to be all or part of a structure that was built using wood cut at the same time as the timbers used for the main house.

Figure 5. Timber usage in the 1790s–1820s and 1830s–1860s in Willsboro. Data are for the five most commonly sampled genera ($n = 174$).

Seven beams were sampled from the cellar ceiling of the northern half of the annex, and these were respectively identified as an eastern hemlock and six pine. The hemlock had a last ring date of 1847 but no bark, and one pine did not crossdate (Table 5). Four of the other pine ended with earlywood for 1852 beneath bark or a wane edge, whereas the last had a little latewood for 1852 and then bark. These results suggest that the pine were felled during the growing season of 1852, and that the northern half of the annex was built using trees cut more recently than the trees in the southern half. Based on the bark and the abrupt onset of latewood, the five crossdated pine beams were all probably red pine.

DISCUSSION AND CONCLUSIONS

Building Dates and Wood Use

Winter and early spring were the usual times for cutting large trees in the Willsboro region in the 18th and 19th Centuries because the logs could be moved relatively easily on sleds over the snow-covered landscape (Watson 1863; Keller 1980). This documented practice is consistent with our tree-ring results with almost all of the precise last year dates at the 1812 Homestead farmhouse and barn and Windyview Manor indicating tree death between two growing seasons. The Windyview annex pines are the exception, but the smaller size of these particular timbers would have made overland transportation feasible in the late spring or summer.

Documentary records show that there were no buildings at the 1812 Homestead site when it was surveyed for New York State in 1811, and

that a Joseph Moor(e) obtained a license to operate an inn or tavern at the site in 1813 (Tefft 1997). The tree-ring results support this history. Our dates show that the trees for the barn were likely cut in the winter of 1811–1812, allowing the barn to be built in 1812. The trees for the farmhouse, which served as the inn or tavern, were likely cut in the winter of 1812–1813 allowing the structure to be built and opened in 1813. The wood shop was probably added to the property at some later date.

For Windyview Manor, documentary records suggest that a Thomas Stafford bought the property in 1786, that the house was built *ca.* 1800, and then subsequently added to and modified during the 19th Century (D. Darrah and M. Bonfey, personal communication, 2008). The tree-ring results support this history as well and suggest that trees for the house were likely cut in the winter of 1798–1799, allowing the house to be built soon thereafter. The south side of the annex was likely built at the same time and, based on the decay of the timbers, may originally have been partially open or exposed to more water than the main house cellar. The north side of the annex was either added later or rebuilt using trees that were mostly cut in the spring or summer of 1852.

We have yet to date any buildings older than the 1790s in the town, which is consistent with local history that suggests the original pioneer settlement of William Gilliland was completely destroyed during the American Revolutionary War (Watson 1863). In our results so far we also note that the subsequent 18th and 19th Century redevelopment and growth of Willsboro was marked by an apparent change in wood use, with ash and oak being often found as primary framing timbers in buildings from the 1790s to 1820s but almost never thereafter (Figure 5). Gilliland had exported a “vast raft of oak timber” to Quebec in the 1780s (Watson 1863) and it is possible that this timber trade, plus preferential selection of ash and oak for building, had led to local depletion of large trees of these two genera by the early 19th Century.

Hemlock and spruce have only been found in buildings from the 1830s and after (Figure 5). This could be because these were the next-best locally available trees for use as large framing timbers

after depletion of the preferred hardwoods. It may also reflect these conifers becoming widely and cheaply available as large-scale logging spread in the Adirondacks, with spruce in particular being cut in vast amounts by the 1830s (McMartin 1994). The Boquet River (Figure 1) was one of the waterways along which logs from the Adirondack uplands were floated to saw mills and markets each spring (Keller 1980). In contrast, we have found pine in buildings of all ages (Figure 5), suggesting steady use of this genus for construction in Willsboro despite the reported regional scarcity of pine by the early 19th Century (McMartin 1994).

Development of Willsboro Chronologies

The results from the 1812 Homestead barn are particularly important because we obtained the same precise date of tree cutting for ash, oak, and pine timbers. Furthermore, our tree-ring dates are entirely consistent with histories of the 1812 Homestead and Windyview Manor based on documentary sources. This gives considerable confidence in the Willsboro chronologies, despite the likely mixing of multiple species (albeit of the same genus) in some chronologies and their crossdating over long distances to the living-tree master chronologies.

During chronology development we found that there were two distinct crossdating populations of both oak and pine among the Willsboro samples. Two of the samples in WHQU1 were identified as probably *Q. alba* whereas nine of the samples in WHQU2 were identified as probably *Q. bicolor*, and this suggests that the crossdating populations may reflect different species. However, these two species grow respectively in dry and wet habitats (Little 1980; Edinger *et al.* 2002) and so the factors limiting growth may be just as important as species type to the crossdating signals. For pine it is even more important to consider the factors limiting growth because *P. strobus*, which is the most widespread pine in New York (Little 1970), grows in environments ranging from wetlands to alvars to rich mesophytic woodlands (Edinger *et al.* 2002). For historical timbers the exact growth setting of the wood is

usually unknown and so our crossdating strategy, of identifying to the genus-level and then forming chronologies based on crossdating signals, was adaptive to considerations of both taxa and habitat. This strategy enabled us to combine similar species in chronologies and so maintain good sample depth, and also perhaps to crossdate timbers of less common members of genera that might otherwise be excluded in species-specific chronologies.

The seven chronologies developed from historical timbers in Willsboro will be useful for further dendroarchaeological work in the Champlain Valley and surrounding areas. In particular, the International Tree-Ring Data Bank currently has no historical oak chronologies for northeastern North America north of *ca.* 43°N, and no historical ash chronologies at all. These data may also prove useful to dendroclimatic studies in the region for extending and increasing sample depth in the early periods of living tree chronologies.

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