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TREE-RING INVESTIGATION OF HOLOCENE FLOOD-DEPOSITED WOOD FROM THE ONEIDA LAKE WATERSHED, NEW YORK STATE

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ABSTRACT

Glacial deposition and fluvial/lacustrine sedimentation interact over terrains in central New York State to preserve a history of geological and hydrological events as well as hydroclimatic transitions. The lower reach of Fish Creek draining the eastern watershed of Oneida Lake, NY, is an area with prominent wood remains. This study explores a collection of 52 logs encased in organic-rich deposits exposed by bank erosion at three locations along Fish Creek near Sylvan Beach, NY, with respect to radiocarbon ages, species, and the crossdating potential of tree rings. Radiocarbon ages and successful tree-ring crossdating document what we interpret as seven major hydrologic episodes *ca.* 10 ka (*i.e. ca.* 10,000 cal yr BP), 7.4 ka, 6.8 ka, 6.4 ka, 5.5 ka, 3.1 ka and 2.2 ka cal BP, during which channel aggradation and tree burial may have been associated with abruptly increased flood frequency and/or high water tables. This pilot study establishes four floating tree-ring records: [1] early Holocene hemlock (*Tsuga*), mid-Holocene [2] walnut (*Juglans* sp.) and [3] sycamore (*Platanus*), and [4] late Holocene elm (*Ulmus* sp.), with sample sizes of 8–14 series of 55–135 years length. Despite the complexity of distribution of radiocarbon ages at each site, the wealth of well-preserved wood demonstrates great promise for understanding the paleoflood history of the Oneida watershed by documenting the magnitude, location, and timing of floods. Further additional systematic sampling can add and strengthen tree-ring dating and tree-ring based flood records, confirm results, and contribute to the Holocene hydrological history of the region.

Keywords: paleoflood, paleohydrology, riparian forest, U.S. Northeast, Fish Creek, dendrochronology.

INTRODUCTION

Significant increases in flood discharge and frequency in recent decades across the densely populated U.S. Northeast (Baldigo 1999; Knox 2000; Collins 2009; Smith *et al.* 2011) can be put into long-term context with hydrological proxies resolving Holocene flood history at local and regional scales (Changnon and Kunkel 1995). Instrumental records of runoff recorded since 1890 provide some historical measure of flood events and offer insights into linkages of large-scale climate modes with continental rainfall and streamflow in the eastern U.S. (Enfield *et al.* 2001). For pre-instrumental events, with proper dating control, lacustrine sediments provide the primary proxy record for frequency and magnitude of large Holocene runoff events (Kochel 1988; Brown *et al.* 2000; Ward *et al.* 2007), but uneven availability of such records in space and time supports the need for as many flood proxies as possible. Additionally, correspondence between pollen climatic proxies and discrete radiocarbon-dated chronologies of extreme runoff and paleoflood events is often weak (Brown *et al.* 2000). Consequently, new proxies with higher spatial and temporal resolution are needed to improve the dating control and correspondence of coarsely resolved proxies and to advance our understanding of paleohydroclimate of this region.

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The U.S. Northeast landscape underwent profound changes in climate, hydrology and vegetation over the last 20,000 years, shaping the environment and imprinting on plant growth and preservation. Forests previously occupying belts and isolated refugia south of the Laurentide ice sheet were gradually able to expand into newly exposed terrain as the glacier retreated (Williams *et al.* 2001; Shuman *et al.* 2002; Panyushkina and Leavitt 2012). In addition to abrupt climate fluctuations during deglaciation up to the beginning of the Holocene, such as the Younger Dryas event *ca.* 12,900 to 11,600 cal BP (henceforth "cal BP" denotes cal yr BP, *i.e.*, calibrated radiocarbon ages in years before AD 1950), significant changes of hydroclimates occurred throughout the North Atlantic sector during cold events dating back at *ca.*11.5 ka cal BP (the Preboreal Oscillation), 10.2 ka cal BP, 9.3 ka cal BP, 8.2 ka cal BP, 5.9 ka cal BP, 4.2 ka cal BP, 2.8 ka cal BP, 1.4 ka cal BP and 0.4 ka cal BP (the Little Ice Age) (Mayewski *et al.* 2004; Wang *et al.* 2013).

Pollen has been the key plant fossil for unraveling North American climate evolution and vegetation changes of the past 20,000 years (*e.g.* Shane and Anderson 1993; Grimm 2001; Jackson *et al.* 2006), supplemented by other measurements (*e.g.* charcoal, ostracodes, isotope composition) from sediment cores (*e.g.* Yu 2000; Curry and Filippelli 2010; Moos and Cumming 2012). Nevertheless, the best potential for annually-resolved insight into environmental variability lies with tree rings, and fortunately wood in the Great Lakes area has been widely preserved in glacial, lacustrine, alluvial and bog deposits (*e.g.* Kaiser 1994; Griggs and Kromer 2008; Panyushkina and Leavitt 2010). The Great Lakes Tree-Ring Network (http://greatlakes.ltrr.arizona.edu/) has been developing annually-resolved floating tree-ring records suitable for interpretation of environmental/hydrological changes (*e.g.* Panyushkina *et al.* 2008).

A large amount of wood has been previously observed in fluvial sediments along Fish Creek in the Oneida Lake watershed in north-central New York (Cleary 2002). This paper describes the first dendrochronological sampling of ancient wood from this location in a pilot study to determine its (1) taxa and age, (2) characteristics and suitability for crossdating and tree-ring analysis, and (3) potential value for the Holocene hydrological studies and our initial interpretations.

SITE SETTING

Oneida Lake is located *ca.* 25 km northeast of Syracuse, New York. The lake is oriented east to west, *ca.* 30 km (20 mi) long, *ca.* 8 km (5 mi) wide, and an average depth of *ca.* 7 m (22 ft). The lake is a remnant of Glacial Lake Iroquois, which existed in the Late Pleistocene when the flow of the St. Lawrence River from the Great Lakes to the Atlantic Ocean was dammed by the Laurentide Ice Sheet (Bloomfield 1978). Fish Creek drains from the Tug Hill Plateau (main source of rainfall for surface runoff in the area) north-northeast of Oneida Lake. The Fish Creek watershed is one of seven primary sub-watersheds of Oneida Lake. Fish Creek meanders across an extensive alluvial plain that includes the lower Wood Creek watershed whose drainage delivers water westward toward Fish Creek from further east. Within the plain are at least four sets of meanders, each characterized by distinctive channel widths and meander radii. These likely reflect long-term changes in water discharge and/or hydroclimate during the Holocene (Cleary 2002). Exposed along the cut banks of the modern channel are various sequences representing (1) point bar lateral accretion, and (2) floodplain and oxbow lake vertical accretion. Within these latter two facies, buried large-diameter logs are found in abundance (Figure 1). The majority of these are clearly transported, and no *in situ* buried trees have yet been discovered, although peat layers rich in wood may indicate some sequences of floodplain paleosoils (Cleary 2002).

The alluvial plain succession of Fish and Wood Creeks cuts though a prograded beach ridge and dune landscape of eastern Oneida Lake, which yields ages of *ca.* 12,800 cal BP, indicating contemporaneous development of both landscapes as the shoreline of Oneida Lake built westward (Hiscott 2000; Fadem 2001). The shoreline and fluvial facies themselves rest upon an older glacial landscape of sculpted (west to east) ridges (ground

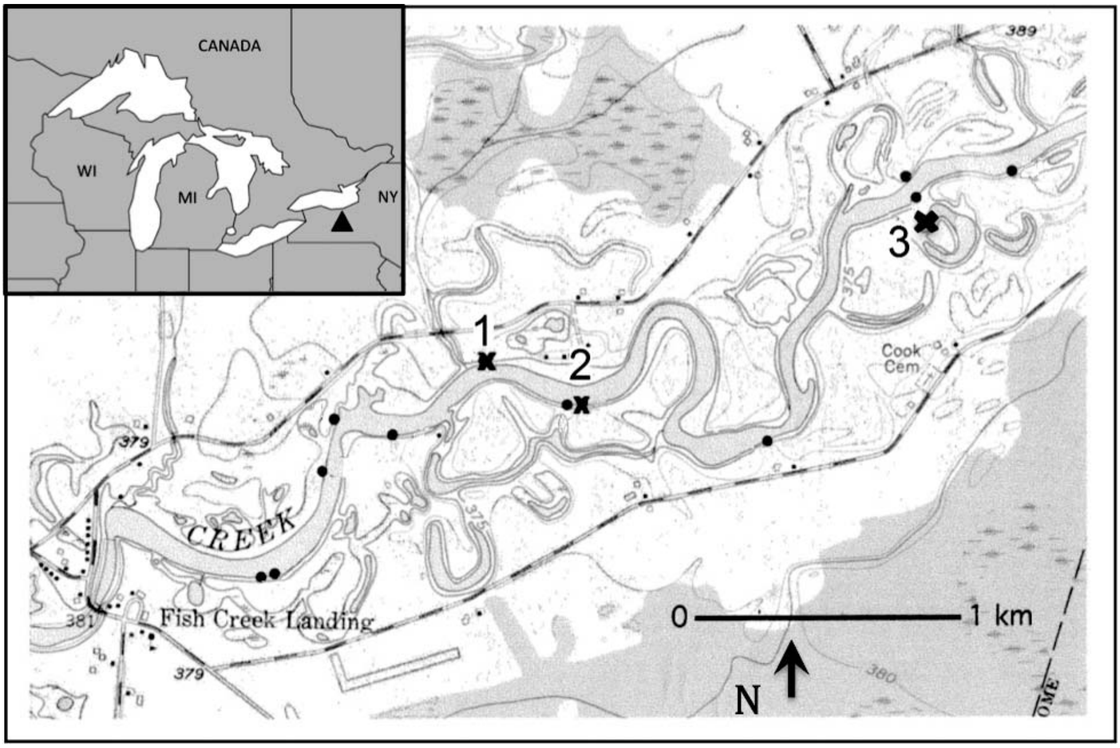

Figure 1. Map showing exposures of buried wood (•) documented by Cleary (2002) and sites sampled for this study (**X**) on the banks of the low reach of Fish Creek near Sylvan Beach, Oneida County, New York State. See triangle on the left insert map indicating the location of the studied area in the Great Lakes watershed.

moraine), ice marginal banks, and older shorelines of Glacial Lake Iroquois, the latter of which yield ages of *ca*. 14,600 cal BP (Hiscott 2000; Fadem 2001).

MATERIALS AND METHODS

With help of the Hamilton College Dept. of Geosciences pontoon research vessel we traversed a stretch of Fish Creek *ca*. 7–9 km upstream from its mouth at Sylvan Beach, NY, on the eastern flank of Oneida Lake. Along this stretch we sampled three locations with abundant wood, designated as Sites #1 (*ca*. 43.228127N, 75.686264W), #2 (*ca*. 43.226688, 75.682230W) and #3 (*ca*. 43.233036, 75.668626W) (Figure 1). The sites fall within an elevation range of *ca*. 113–114 m a.s.l. (370–375 feet a.s.l.), *ca*. 1–2 m above the average recent elevations of Oneida Lake. Fifteen, 25 and 12 samples were obtained from the three sites, respectively, at positions both just above and just below the water level (Figure 2). Logs at Site 1 were mainly situated in a peaty muck layered with yellowish brown sand. At Sites 2 and 3, the logs were found buried in a yellowish brown sandy silt of the modern riverbank. Cross-sections were cut from the logs with a handsaw in the field. In most cases, the cross-sections were complete, with pith, the outermost rings and even bark preserved for many. Samples were tightly covered in plastic wrap and shipped to the University of Arizona for analysis.

Wood taxonomy of 17 specimens from Sites 1 and 2 was determined at the Center for Wood Anatomy Research, USDA Forest Products Lab, Madison (WI). Thin-sections prepared along the grain from the radial and tangential surfaces were analyzed under high magnification of a reflecting light microscope to identify diagnostic anatomical features. Taxonomy at the species level could not be determined with certainty for any of the samples because of the condition of the wood, but genus identification was made for most. Genus

Figure 2. Buried logs at Sites 1, 2 and 3 inundated by past floodwaters. The logs likely were transported downstream and deposited as congested assemblages in ancient channels along Fish Creek.

assignment of the other wood samples was made through visual comparison with wood structure/microanatomy attributes of the 17 identified wood specimens.

Tree-ring widths were measured on slightly wet wood that was surfaced by freshly cutting with a razor blade. The tree-ring series were crossdated visually by plotting the tree-ring width measurements and matching the patterns. First, crossdating was performed among tree-ring series from the same tree genus within a site. Second, the floating tree-ring records from the same genus were overlapped between sites where possible (Figure 3). Accuracy of the crossdated data was checked with the COFECHA program (Holmes 1983). Dates of the outermost rings from the crossdated series were tabulated and employed to develop a mortality record of trees buried in the Fish Creek sediments.

For radiocarbon dating, the outer 10 rings of specimens from Sites 1, 2 and 3 were subsampled and processed to isolate the alpha-cellulose component using the sodium chlorite delignification method (Leavitt and Danzer 1993) followed by sodium hydroxide removal of hemicelluloses (Sternberg 1989). The α-cellulose samples were submitted to the NSF-Arizona Accelerator Mass Spectrometry (AMS) Laboratory at the University of Arizona for radiocarbon dating. The ^{14}C dates were calibrated and plotted with OxCal 4.2 software (https://c14.arch.ox.ac.uk/) that utilizes the IntCal13 calibration curve (Reimer *et al.* 2013).

RESULTS AND DISCUSSION

Anatomy and tree genus identification of wood specimens from Fish Creek indicate a collective suite of hemlock (*Tsuga*), sycamore (*Platanus*), elm (*Ulmus*), walnut (*Juglans sp.*), beech (*Fagus grandifolia*) and maple (*Acer*). The buried wood collected at the sites largely comprised hemlock and elm (28% and 30% of total collected specimens, respectively), and fewer sycamore (20%) and walnut (18%). Beech and maple representation was much less (4% and 2%, respectively). Spatial distribution of tree genera among the three sampled locations is not uniform. All identified tree genera appear at Site 1 and the adjacent Site 2 (except for beech). Site 3, located about one kilometer eastward from the other two sites, has only elm and hemlock (Table 1, Figure 1).

Regionally, the pre-settlement forest on the Oneida watershed was transitional between boreal and broadleaf deciduous, with mixed stands of hardwoods (yellow birch, sugar maple and American beech), Appalachian oak, pine, and occasionally eastern hemlock (Küchler 1964), so the collective suite of sampled trees does not match this potential modern-forest species composition. Major land-cover changes since AD 1650 (European settlement period) have significantly modified the vegetation in the Great Lakes area, drastically reducing the coverage of the old growth conifer forest on river watersheds and riparian corridors (Steyaert and Knox 2008). Heavy logging prior to 1929 (USDA 1994), and insect outbreaks, pathogens, and urban development over the late 20th Century have removed or replaced original natural vegetation (Cole *et al.* 1998). This could also explain the genus differences between the ancient and the Modern-era riparian forests. Additionally, the suite we collected may be biased taxonomically by field sampling

Table 1. Distribution of tree-ring specimens among sites (Sites 1, 2 and 3) collected at the lower reach of Fish Creek. The total number of samples (51) is less by one because #216 disintegrated during inadvertent rapid drying prior to tree species being identified.

Tree Species	Number of Trees			Radii Range (cm)	Total Length of Series		
	Site 1	Site 2	Site 3		Site 1	Site 2	Site 3
Hemlock	1	6	7	3–19	129	104	124
Elm	5	5	5	5–15	92	96	98
Walnut	4	5	0	5–25	50	47	–
Sycamore	3	7	0	3–21	55	100	–
Maple	1	1	0	8–9	61	75	–
Beech	1	0	0	10	103	–	–

of large embedded logs expected to have many rings, which were readily accessible for cutting from the boat or the shore.

Crossdating of specimens within genus per site was successful but not straightforward in some cases because there are some specimens with fewer than 50 rings (years) (Table 2). From a statistical point-of-view, the low ring number (24 in one case), especially for walnut specimens, could confound the crossdating, but we found the tree-ring variance had distinct patterns that visually matched well. Furthermore, the short time series have similar growth rates and a few very distinctive pointer years, which further favor the trees most likely being contemporaneous. Forty-five out of 52 specimens were crossdated. One hemlock specimen (#208, 116 rings) and one elm specimen (#105, 93 rings) could not be matched with the groups. One walnut sample had only 12 rings (#213), and specimen # 216 (53 rings) disintegrated during inadvertent rapid drying. One beech (#108, 103 rings) and two maple (#109, 61 rings and #219, 75 rings) specimens were not included in the pilot dating because of low sample replication even though the maple tree-ring series overlapped. Overlapping tree-ring series from the same genus between sites resulted in four floating tree-ring records of hemlock, walnut, sycamore and elm spanning 55 to 135 years (Table 3). These crossdating results support contemporaneity among trees of a genus buried together within and between sites along the Fish Creek riverbanks near Sylvan Beach.

Four ^{14}C dates measured on outer rings of the studied specimens (Table 4) provide ages of the crossdated assemblages at *ca*. 10,000 cal BP (hemlock), 7400 cal BP (walnut), 5500 cal BP (sycamore) and 3100 cal BP (elm). Radiocarbon dating on wood specimens from earlier studies (Fadem 2001; Cleary 2002), which had not been crossdated and were collected at other locations of along Fish Creek near Sylvan beach, reveals three additional episodes of wood deposition occurring *ca*. 6400 cal BP, 6800 cal BP and 2200 cal BP (Table 4, Figure 4A). Cumulative distribution of all calibrated ^{14}C ages (Figure 3B) dates the earliest deposition of hemlock soon after the 10.2 ka cal BP cold event abrupt climate excursion (Mayewski *et al.* 2004). Next, a cluster of four radiocarbon ages emerged during the Mid-Holocene between 7.4 ka and 5.5 ka cal BP. The final two events in the wood record occurred at *ca.* 3.1 ka and 2.2 ka cal BP in the Late Holocene. Overall, the dating establishes seven major discrete wood deposition episodes during the Holocene and documents gaps in wood deposition during *ca*. 2000-year intervals before and after the Mid-Holocene and in the most recent 2200 years.

The age of ^{14}C-dated trees and their range of radial growth rates may provide some clues about geomorphological evolution of the Fish Creek valley. Even though all identified groups of trees include young and/or near-maturity trees, their growth rates vary widely as regulated by a combination of edaphic and climatic factors. The group of 10 ka cal BP hemlock trees with a 139-year span had much slower growth than trees from other intervals. The 120- to 130-year-old hemlocks formed 20- to 30-cm diameter stems (Table 1, 3). The trees growing during the mid-Holocene intervals have more than twice the growth rate of the hemlock.

Table 2. Tree-ring crossdating results for the Fish Creek specimens. The first digit of the 3-digit specimen ID number corresponds to the site number. Bold sample ID indicates radiocarbon-dated specimen. Length (years) and correlation coefficient of tree-ring series (R) shorter than 45 years are designated with italic font. Span is fit into floating chronologies.

Group	Sample ID	Length	Span	*r* with Master
Hemlock 10,000 cal BP	#106	129	6–135	0.42
	#305	115	1–115	0.48
	#214	104	14–117	0.37
	#309	77	39–115	0.52
	#210	75	34–108	0.42
	#308	73	51–123	0.58
	#302	72	50–121	0.51
	#310	54	69–122	0.44
	#303	49	75–123	0.45
	#218	*44*	33–76	0.57
	#221	*43*	70–112	0.41
	#220	*37*	78–114	0.44
	#304	*27*	63–89	*0.40*
Walnut 7400 cal BP	**#103**	50	1–50	0.55
	#201	47	9–55	0.46
	#217	45	1–45	0.53
	#206	*42*	5–46	*0.50*
	#100	*39*	17–55	*0.33*
	#215	*32*	16–47	*0.53*
	#101	*28*	15–42	*0.75*
	#111	*27*	16–42	*0.59*
Sycamore 5500 cal BP	#200	100	32–100	0.39
	#203	95	34–86	0.54
	#211	69	5–99	0.50
	#202	64	48–71	0.51
	#102	55	42–93	0.49
	#212	53	36–99	0.57
	#205	52	22–76	0.47
	#114	45	1–100	0.39
	#104	*42*	29–74	*0.34*
	#222	*24*	56–97	*0.64*
Elm 3100 cal BP	#301	98	1–98	0.58
	#204	97	1–97	0.60
	#107	92	8–100	0.50
	#113	59	43–101	0.49
	#112	55	25–79	0.36
	#207	55	24–78	0.38
	#311	53	37–90	*0.55*
	#300	51	44–94	0.63
	#223	46	26–71	0.53
	#306	46	47–92	0.40
	#209	*44*	51–94	*0.52*
	#307	*42*	49–90	*0.60*
	#110	*37*	43–79	*0.32*
	#224	*32*	44–75	*0.46*

Sycamores formed *ca.* 20-cm diameter trunks in 90 years of growth. Diameter of *ca.* 55-year-old walnut trees was nearly 0.5 m (Table 1, 3). American walnut is sensitive to soil conditions and grows best on deep, well-drained and moist alluvial soils like those of the Appalachian Piedmont (Williams 1990). It is likely that the large walnut logs dated *ca.* 7.4 ka cal BP came from a well-established part of floodplain formed during a prolonged period of stability and soil development. Alternatively, low growth rate of hemlock may indicate growth on shallow muck soils corresponding to a shorter period of stability, *ca.* 10 ka cal BP.

The pattern of studied tree mortalities in dated episodes seems to provide further insight into paleoflooding history of the area. The position of buried logs and the crossdating results support the hypothesis that most trees were not falling randomly but rather entrained and deposited by profound hydrologic events. The relatively young age of studied trees and lack of pith rot (that commonly develops when aging trees naturally die) may indicate a sudden fall, and rapid transport and burial of trees in the fluvial sediments. Buried wood from the fluvial deposits can document high-magnitude flood disturbances that remove flood-plain trees and transport floating wood downstream in channels (Johnson *et al.* 2000). Additionally, high water adversely affects the vegetative and reproductive growth of trees, alters plant anatomy, and induces plant mortality (Kozlowski 1997). Comparison of tree-ring growth patterns (Figure 3) and distribution of tree mortality dates (Figure 5) suggests that prolonged wet conditions may be contributing to decadal deteriorating growth conditions for some species just prior to the *coup de grâce* flood(s) that removes the trees. The slow growth rates and reduced variance over the final decade or so of several of the records may reflect effects of water-table rise and oxygen-deficiency on the tree roots across the Fish Creek alluvial plain (Figure 3), possibly indicating pluvial periods with substantial increase in rainfall in the phases when the extreme flooding occurred. A large range of termination dates for individual trees within cross-site records (Figure 5) suggests subsequent occurrence of large floods and river aggradation during which the trees were likely toppled or uprooted and buried.

Table 3. Group statistics of averaged tree-ring width series from the Fish Creek wood collection.

Chronology	Length	# Trees	Site	Mean, mm	Mean Sensitivity	Interserial Correlation
10,000 cal BP						
Hemlock	135	13	1, 2, 3	1.04	0.28	0.43
7400 cal BP						
Walnut	55	8	1, 2	2.15	0.31	0.48
5500 cal BP						
Sycamore	100	10	1, 2	1.31	0.29	0.48
3100 cal BP						
Elm	101	14	1, 2, 3	1.32	0.30	0.48

Modern Fish Creek runoff is strongly influenced by the seasonal distribution of precipitation, with maximum river discharge in spring from melted snow and prominent rainstorms (Matonse and Frei 2013). The increase in the number of extreme floods across the U.S. Northeast in the last decade is attributed to the highest frequency of extreme warm-season precipitation events in the last 100 years (Collins 2009; Matonse and Frei 2013), particularly associated with high-precipitation events promoted by tropical cyclones and organized extratropical systems (Smith *et al.* 2011; Dai 2013). The dated episodes of wood deposition may result from a similar increase in frequency of such extreme summer precipitation events in the area. Overall, all ^{14}C dates derived from the tree rings may be associated with periods of significant changes in the fluvial process and hydrological regime of the Fish Creek catchment. If our accumulations of wood from discrete periods represent flooding events, as is generally the inference in a number of such studies (*e.g.* Jílek *et al.* 1995; Kukulak *et al.* 2002), our results suggest that the fluvial stability of the Creek has been interrupted by frequent flooding events followed by an intensification of channel aggradation processes dated *ca.* 10 ka cal BP, 7.4 ka cal BP, 6.8 ka cal BP, 6.4 ka cal BP, 5.5 ka cal BP, 3.1 ka cal BP and 2.2 ka cal BP. High flood recurrence is highly sensitive to climate change, and increased flood frequency occurs abruptly at various timescales from decadal to millennial (Baker *et al.* 1992; Knox 2000). These dated episodes may indicate increased frequency and/or magnitude of floods, which could be coupled with generally higher variability of rainfall.

Because the sites are only *ca.* 1–2 m above the elevation of Oneida Lake and the terminus of Fish Creek at Oneida Lake may effectively also function as a delta, the hydrology of sampling sites may have also been affected by lake level. Studies of sediment sequences in neighboring lakes

Table 4. ^{14}C dating of wood buried along Fish Creek near Sylvan Beach, NY. Fadem (2001) and Cleary (2002) are sources of ^{14}C dates measured on bulk wood marked with asterisks.

Lab ID	Site	Tree Species	^{14}C Age, yr BP	Cal Age Range, 2 Sigma Cal yr BP	Material
FCIP-103	1	Walnut	6513 ± 48	7320–7500	10 outer rings
*GX-28622	1	n/a	6000 ± 40	6740–6940	bulk wood
*GX-28623	1	n/a	5510 ± 50	6260–6400	bulk wood
FCIP-107	1	Elm	2910 ± 40	2950–3200	10 outer rings
*GX-28624	1	n/a	2280 ± 40	2160–2260	bulk wood
*GX-28624	2	n/a	4900 ± 43	5590–5730	10 outer rings
FCIP-202	2	Sycamore	4826 ± 45	5470–5560	10 outer rings
*GX-28621	2	n/a	2970 ± 40	3000–3260	bulk wood
FCIP-308	3	Hemlock	8964 ± 55	9910–10,100	10 outer rings

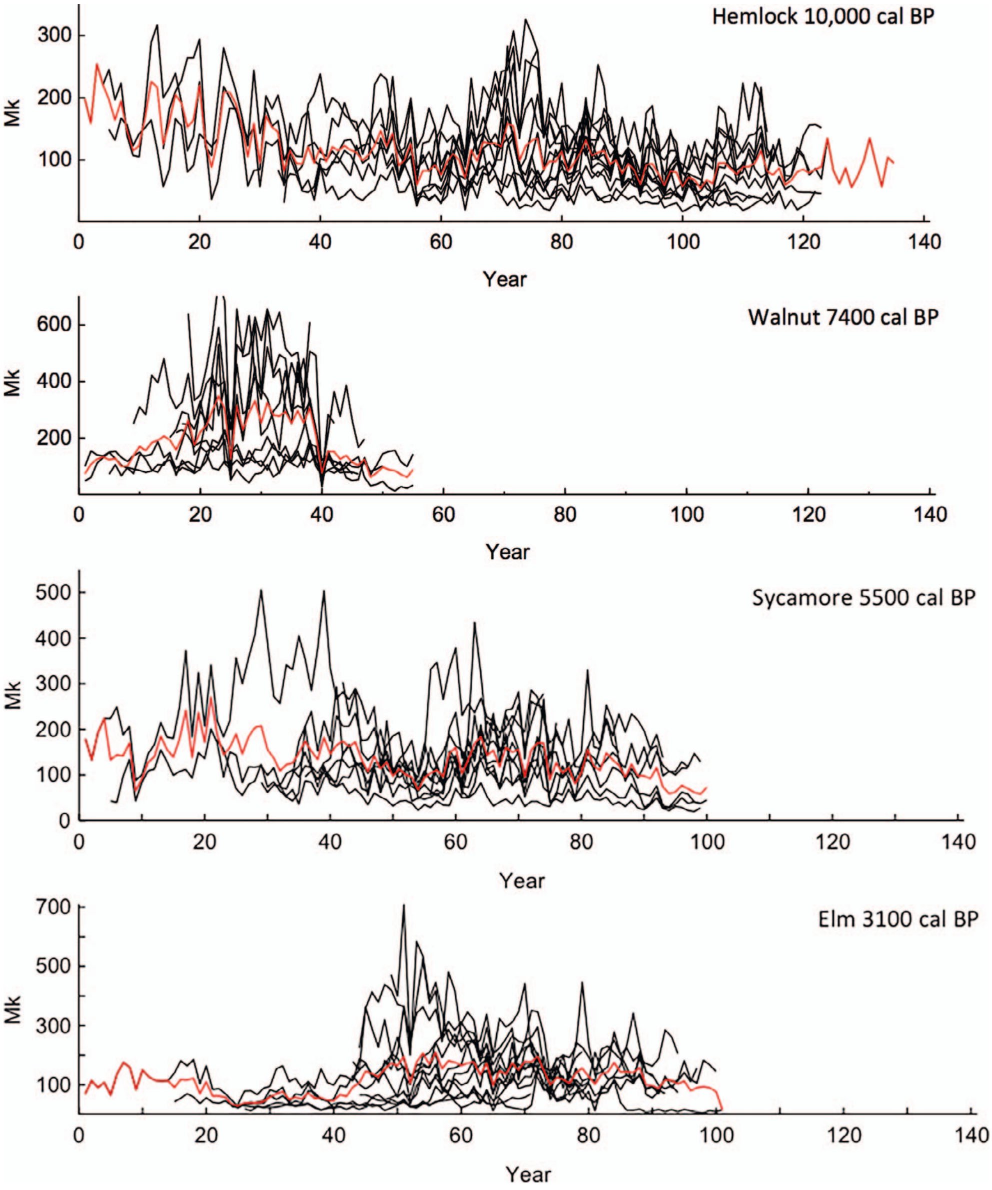

Figure 3. Curves of tree-ring width measurements (raw data) showing the crossdating positions of trees. Red line is the mean, and y-axis units of "Mk" are microns.

suggests higher lake levels between ca. 6000 and 9000 cal BP despite warming of the mid-Holocene climate optimum (Mullins 1998; Mullins and Halfman 2001). Although we did not consider this in the analysis, more careful future sampling may also help in understanding variations in Oneida Lake levels.

CONCLUSIONS

In the Holocene, the riparian landscape of the Fish Creek floodplain transformed from cold-mesic conifer forest dominated by hemlock in the early Holocene to a broad-leaf deciduous forest of the warm and more humid mid-Holocene, which

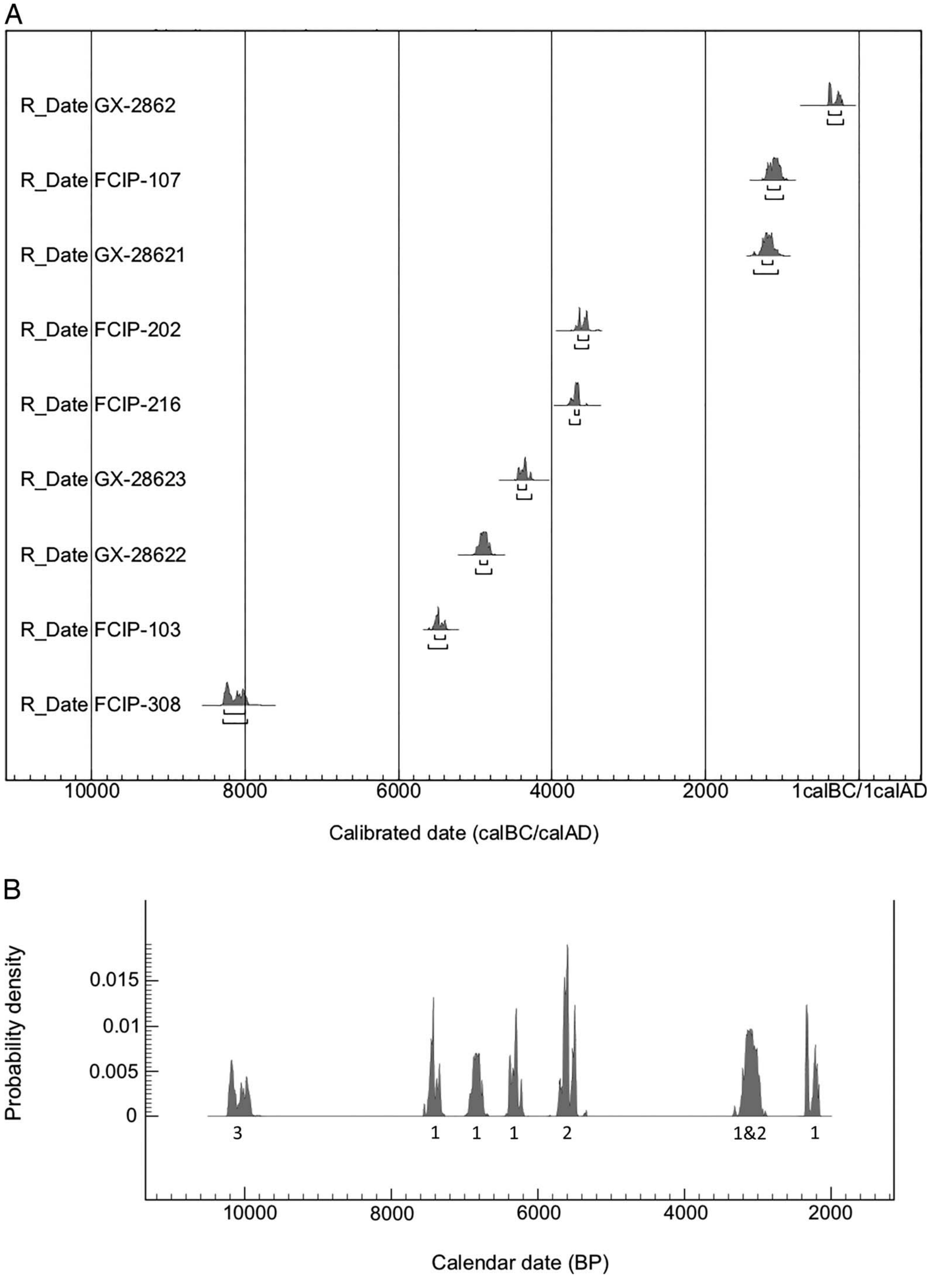

Figure 4. Radiocarbon dating summary of the Fish Creek wood. (A) Individual calibrated radiocarbon dates (data from Table 4). Probability distribution is shown in shaded area. The bars under the probability distribution denote 68.2% and 95.4% ranges. (B) Cumulative probability density function (PDF) plot of calibrated ^{14}C ages of Fish Creek wood. The numbers immediately below each PDF refer to the contributing site(s).

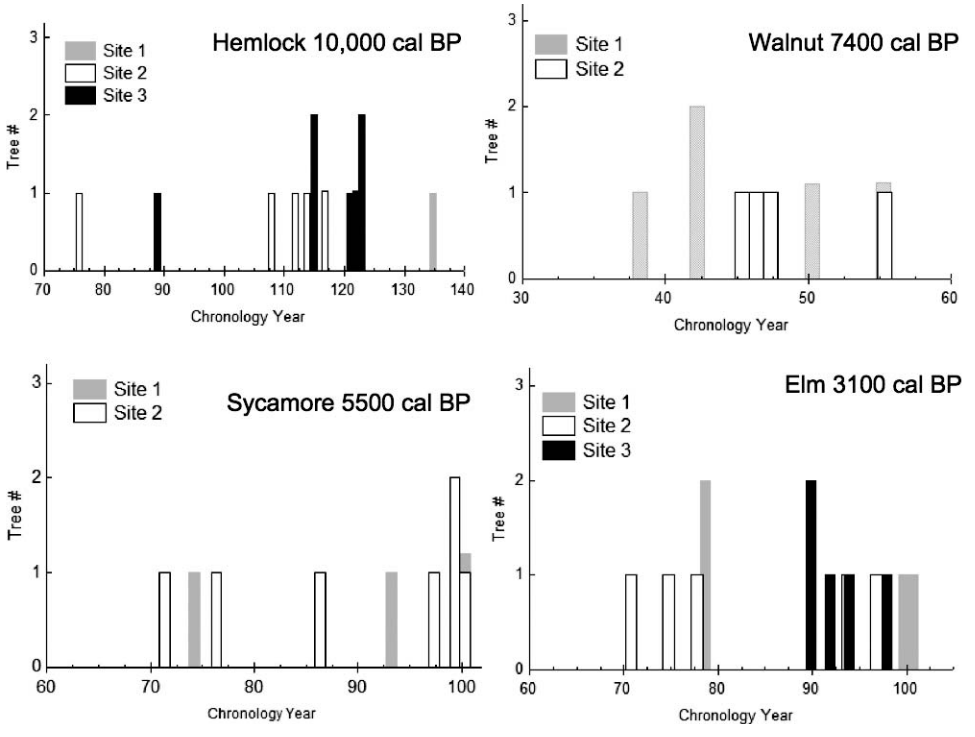

Figure 5. Tree mortality records of studied intervals and sites based on crossdating results of the outermost preserved rings often with bark.

included walnut (7.4 ka cal BP) and sycamore (5.5 ka cal BP), and later hardy elms (3.1 ka cal BP). The fluvial disturbance of the riparian forest has resulted in major deposition of wood in levees along meandering creek channels in the lower reach of the Fish Creek. The promising results of this pilot study of buried wood in Fish Creek riverbanks show that wood is abundant and can be crossdated, and that the preserved wood and tree rings are suitable for (1) developing records of paleofloods and fluvial geomorphic activity in the lower reach of Fish Creek, and (2) providing details of the Holocene history of U.S. Northeast hydrology and its response to climate change.

The crossdating of various tree species from multiple locations and a high number of contemporaneous trees suggests that wood buried by the floods is a good diagnostic tool for understanding temporal and spatial patterns of large paleofloods in the area. Thus far, based on the tree rings alone, the Holocene history of Fish Creek encompasses seven major episodes of increased flood frequency dating back to *ca.* 10 ka cal BP, 7.4 ka cal BP, 6.8 ka cal BP, 6.4 ka cal BP, 5.5 ka cal BP, 3.1 ka cal BP and 2.2 ka cal BP driven by increased precipitation over the Tug Hill Plateau and/or at the larger scale of the U.S. Northeast.

Amplified concern about recent extreme floods across New York State motivates interest in long well-dated paleoflood records from this area. The good crossdating potential of tree rings from the fluvial deposits provide a framework for linking tree-ring flood evidence to a fluvial sediment chronology of Fish Creek, which would be a rich, well-dated archive of flooding history at various temporal and spatial scales. To fully exploit this paleoenvironmental archive, however, a large-scale wood sampling campaign with a more sophisticated sampling protocol will be needed to verify and expand on our results.

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