TREE-RING RESEARCH, *Vol. 70(1), 2014, pp. 41–48*
DOI: http://dx.doi.org/10.3959/1536-1098-70.1.41

RESEARCH REPORT

DENDROCHRONOLOGICAL DATING OF TWO TULIP POPLARS ON THE WEST LAWN OF MONTICELLO

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ABSTRACT

Two tulip poplars (*Liriodendron tulipifera* L.) growing at Monticello, the home of Thomas Jefferson, were recently removed because of potential damage to the house; however, their ages were uncertain. Jefferson's writings express his interest in tulip poplars and suggest that he may have planted at least one, but his documents are not conclusive. After the Thomas Jefferson Foundation purchased the property in A.D. 1923, expert opinions on the ages of these trees were divided. This study investigated the ages of both trees (referred to as northwest and southwest). Even though the southwest tree's bole was hollow and decay was present in the northwest tree, usable cross-sections were obtained. The southwest tree's cross-section was from an upper branch, whereas upper and lower cross-sections were extracted from the bole of the northwest tree. Ring widths were crossdated and statistically verified using an oak chronology from Monticello. The innermost rings of the southwest tree dated to A.D. 1852 and those of the upper and lower sections of the northwest tree dated to 1822 and 1808, respectively. These dendrochronological analyses in combination with historical photographs support the conclusion that the northwest tree and likely the southwest tree were Jefferson era, but the evidence for the southwest tree is less certain.

Keywords: Monticello, Thomas Jefferson, *Liriodendron tulipifera*, garden history, Southeastern US, agricultural plantation.

INTRODUCTION

Monticello, located in the Virginia piedmont, was the plantation home of Thomas Jefferson, who in his own words sought to be remembered as the ''Author of the Declaration of American Independence, Of the Statute of Virginia for Religious Freedom, And Father of the University of Virginia'' (Jefferson 2008: 44). Monticello is now classified as a National Historic Landmark as well as a UNESCO World Heritage Site. In 1768, Jefferson cleared and leveled the site for Monticello and began construction in 1769. Jefferson moved into the house in 1770, but continued to build and remodel other parts of the house through 1809 (Nichols and Bear 1967). He lived there until his death in 1826. While Jefferson lived at Monticello, he took an active interest in planning the grounds surrounding Monticello, notably with the plantings of gardens in 1807 as he neared the end of his second term as President (Betts and Perkins 1971). Using tree-ring dating, the objective of this study is to determine whether two large tulip poplar trees recently removed from the west lawn of Monticello date to the Jefferson era. These tulip poplars are referred to as southwest and northwest (Figure 1) following Jefferson's designations for the four shrub circles placed around the main house (Jefferson 2008).

Jefferson's own writings attest to his interest in native trees – tulip poplars particularly. In an 1805 letter to Madame de Tessé, Jefferson exclaims that only the white oak (*Quercus alba* L.) ''disputes for pre-eminence with the Liriodendron,'' calling the white oak the Jupiter and the tulip poplar ''the Juno of our groves'' (Jefferson 2008: 305–306). As he planned changes to his west

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Figure 1. Southwest tulip poplar (with cables) in foreground and northwest tulip poplar in background. Photograph was taken the day before the removal of the southwest tree (June 24, 2008). Northwest tree was removed in June 2011. [Credit: Thomas Jefferson Foundation, Inc. at Monticello].

lawn gardens, on April 16, 1807, Jefferson states that he planted "1. Laurodendron in margin of S. W. [shrub circle] from the nursery" (Jefferson 2008: 334). This entry has led to a historical interpretation that the southwest tree is likely a Jefferson-era tree, but no direct link has shown that either tree dates to that time. Other contemporary references to the natural establishment of tulip poplars in the soil at Monticello exist in a 1793 letter from Thomas Mann Randolph, Jr., lamenting the rapid ability of tulip poplars to establish in Monticello's plantation fields and an 1827 letter from Cornelia J. Randolph who mentions the weeding of young poplars from the yard at Monticello; however, her letter may refer instead to *Populus* (L.) species that were planted at Monticello (Jefferson 2009). Tulip poplar seedlings are still common today in fields adjacent to Monticello at Montalto where an annual mowing is used to prevent the re-establishment of forests in historically open areas.

Across their wide range in eastern North America from New York to Florida, tulip poplars grow best in deep, moist loam soils within coves or lower slopes and are common on the Ultisol soils of the Virginia piedmont (Burns and Honkala 1990). Although originally considered an early successional species, tulip poplars can attain ages of more than 500 years and may be a component of late successional forests as well (Skeen *et al.* 1980; Pederson 2012).

MATERIALS AND METHODS

The growth of trees in the Virginia piedmont can be explained largely as a function of precipitation and available solar radiation passing through a forest canopy to a tree (Kozlowski 1949; Druckenbrod *et al.* 2005). Thus, a component of the annual growth of these trees is a common climate signal, typically spring or summer precipitation (*e.g.* Druckenbrod *et al.* 2003). The samples from these two trees are compared to a well-replicated oak chronology extending back to A.D. 1728 at Monticello with many of the trees growing nearby on the western slopes of Monticello.

The southwest tree was felled in 2008 and the northwest tree in 2011. Five radii of tree-ring widths from three cross-sections were analyzed in this study. Two radii from an upper cross-section of the southwest tree, one radius from an upper cross-section on the northwest tree, and two radii from a lower cross-section of the northwest tree at *ca.* 1 m (stump height). The diameter of the northwest tree at stump height was *ca.* 1.3 m (inside bark), noticeably smaller than the diameter of the southwest tree. Crossdating using skeleton plots (Stokes and Smiley 1968) and ring-width measurements was conducted using a dissecting stereo microscope. Ring widths were measured using a Velmex TA System to a 1-micron precision (as described in Speer 2010) and the J2X measurement program. COFECHA was used to verify the visual crossdating of the ring-width data by generating correlations for each sample in 50-year moving windows (Holmes 1983). Samples with poor statistical correlation in COFECHA were compared with

skeleton plots to confirm the most accurate possible dating. Ring-width measurements from each tulip poplar were converted into separate standard chronologies using the program ARSTAN (Cook and Krusic 2011). Cores were detrended using either a negative exponential or linear regression fit (with a positive or negative slope) and a 20-year cubic spline. These chronologies enabled a final correlation of each tree's average tree-ring indices with a master oak (*Quercus* L.) chronology ($n = 134$ trees) from forests surrounding Monticello dating back to A.D. 1728 using the Spearman rank correlation, a nonparametric measure of similarity between the two chronologies through time.

RESULTS

For each of the five ring-width series (Figure 2), COFECHA generated positive correlations across all 50-year sample windows; however, the southwest tree had lower correlations than the northwest tree (Table 1). The earliest ring of the upper section of the northwest tree crossdated to 1822, but the lower radii crossdated to 1808. The upper branch of the southwest tree crossdated to 1852; however, some of the moving window correlations for these series were low, below a commonly accepted threshold of 0.32 for individual series. Similarly, an averaged growth chronology of ring-width series from the northwest tree correlated significantly with the local oak chronology (Figure 3A) with a correlation of 0.455 ($p < 0.0001$). The averaged growth chronology from the southwest tree again exhibited a lower, but still highly significant, correlation (Figure 3B) of 0.277 ($p < 0.001$).

As an additional verification, the northwest tree chronology was compared with an independently dated chronology of tulip poplars from an old stand near Buena Vista, Virginia, collected by Dr. Neil Pederson (unpublished data). The correlation between these two chronologies was 0.295 ($p < 0.0001$), even with a large distance between these sites extending into the Blue Ridge Mountains physiographic province.

DISCUSSION

These results clearly evidence that the northwest tree and likely the southwest tree began growing well before Jefferson's death in 1826. Although the southwest tree did not crossdate as strongly as the northwest tree, the dendrochronological dating of both trees is extremely unlikely to have resulted from chance. Several factors could explain the variation in magnitude of these correlations with the local oak chronology across series and through time. First, the oak species present at Monticello are generally more drought tolerant during the growing season and may not respond to interannual climate variation in the same manner as tulip poplars. Second, these oaks grew in a closed-canopy forest environment, whereas the two tulip poplars were likely in open canopy conditions and maintained as part of the formal gardens for at least their latter years. Finally, perhaps most importantly the southwest poplar's correlations are particularly low during the early to mid 1900s. This tree was topped around 1900 and heavily pruned during the 1920s (Thomas Jefferson Foundation, Inc. 2008). These actions may have induced other interannual growth trends in this tree obscuring the climate forcing on its growth through the mid-twentieth century.

Independent verification of the age of these two trees was also considered through a comparison of photographs, paintings, maps, and letters depicting the conditions of the west lawn of Monticello from 1793 to the present. To assist in approximating the size of these two trees through time, Beck (1962) provides a site index curve for tulip poplars by age in different soil fertilities. The curve shows the range in tree heights for forest-grown, dominant or co-dominant tulip poplars through time based on sites in the Virginia and North Carolina piedmont. Extrapolating from the range of soils on this site index curve, a typical tulip poplar would have grown taller than the top of Monticello (*ca.* 13.5 m) by 36 years of age, even on the lowest quality site. Most tulip poplars would be taller than 13 m by twenty years of age. The tulip poplars at Monticello were growing in largely open conditions, which could reduce the rate of height growth relative to trees in a forest. These two tulip poplars may also be growing on a site that wouldn't naturally feature this species in a forest. Even though tulip poplars readily establish

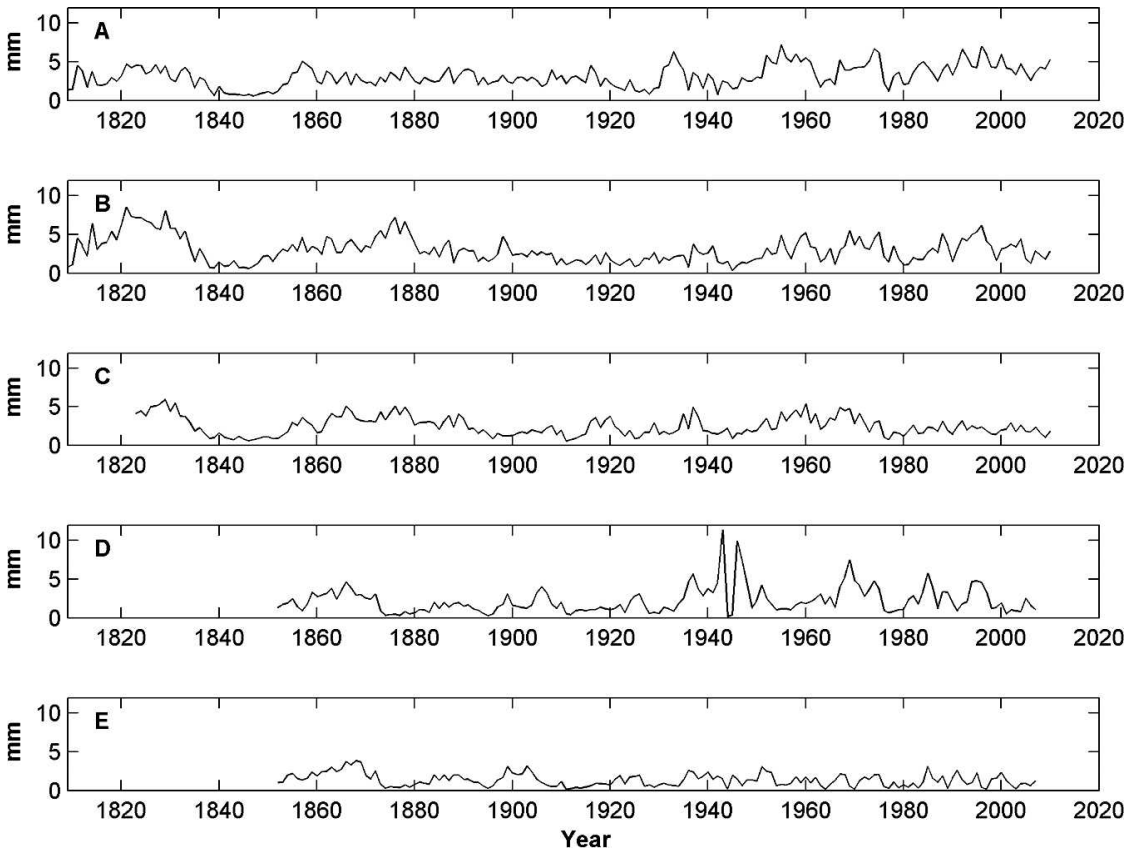

Figure 2. Crossdated ring-width measurements from northwest and southwest tulip poplars sampled in this study. A and B are lower radii and C is an upper radius from the northwest tree, and D and E are upper radii from the southwest tree.

in the soils as seedlings at Monticello, their distribution is limited to largely the north and east slopes of the site. Oaks and other species dominate the forests on the south and west slopes of the site. The soils on the top of the site would not have as much soil moisture as those on the north and east slopes and could result in a slower rate of growth for these poplars.

Two documentary records from the early to mid-20th Century provide conflicting interpretations of the ages of these two trees. A map of the garden restoration undertaken by the Garden Club of Virginia between 1939–1941 (Betts and Perkins 1971; p. 50–51) labels both of these tulip poplars as original to Jefferson's time (Figure 4), but earlier in the 1920s an arborist and architect both concluded that these trees post-dated Jefferson (Thomas Jefferson Foundation, Inc. 2008).

An analysis of photographs of the west lawn of Monticello during the 20th and late 19th Centuries consistently shows these two tulip poplars in their present locations. Notably in the early 20th Century, an oblique aerial of the west lawn in the winter of 1927–1928 shows both trees at that time (Figure 5). At the turn of the 20th Century, these trees remain visible in a Holsinger Studio Collection photograph of the east front of the house taken between 1889 and 1912 (Figure 6). The two trees are clearly taller than the house in this image, and the diameter of the northwest tree remains noticeable smaller than the southwest tree even at this early date. This east front perspective is similar to one of the oldest images of the house taken by William Roads in 1867 (held by the Albert and Shirley Small Special Collections Library, University of Virginia). The southwest

Table 1. 50-year moving window correlations for each ring-width series compared against the other four ring-width series from the northwest and southwest tulip poplars growing on the west lawn at Monticello.

Tree	Series	Time Span	1800–1849	1825–1874	1850–1899	1875–1924	1900–1949	1925–1974	1950–1999	1975–2010
Northwest	A	1809–2010	0.69	0.48	0.42	0.46	0.31	0.38	0.58	0.58
Northwest	B	1809–2010	0.72	0.53	0.42	0.55	0.40	0.45	0.63	0.62
Northwest	C	1823–2010	0.59	0.62	0.46	0.59	0.55	0.46	0.74	0.67
Southwest	A	1852–2007			0.27	0.37	0.32	0.24	0.47	0.40
Southwest	B	1852–2007			0.26	0.37	0.28	0.20	0.25	0.32

tree and the faint outline of the northwest tree are also apparent in this image. Again, both trees are taller than the house in this image.

Using the lower cross-section of the northwest tree, one can estimate the size of this tree through time. By the end of 1826, the year of Jefferson's death, the diameter of the tree (as averaged from the two measured radii) inside the bark would have been *ca.* 14.7 cm. By the end of 1867, the year of the Roads photograph, the diameter inside the bark would have been 36.7 cm. An estimation of the tree's height in 1867 is also possible with an allometric equation. A parabolic equation ($H = 137 + b_2 \times D + b_3 \times D^2$) from Ker and Smith (1955) for forest grown trees (see Druckenbrod *et al.* 2005) requires the tree's

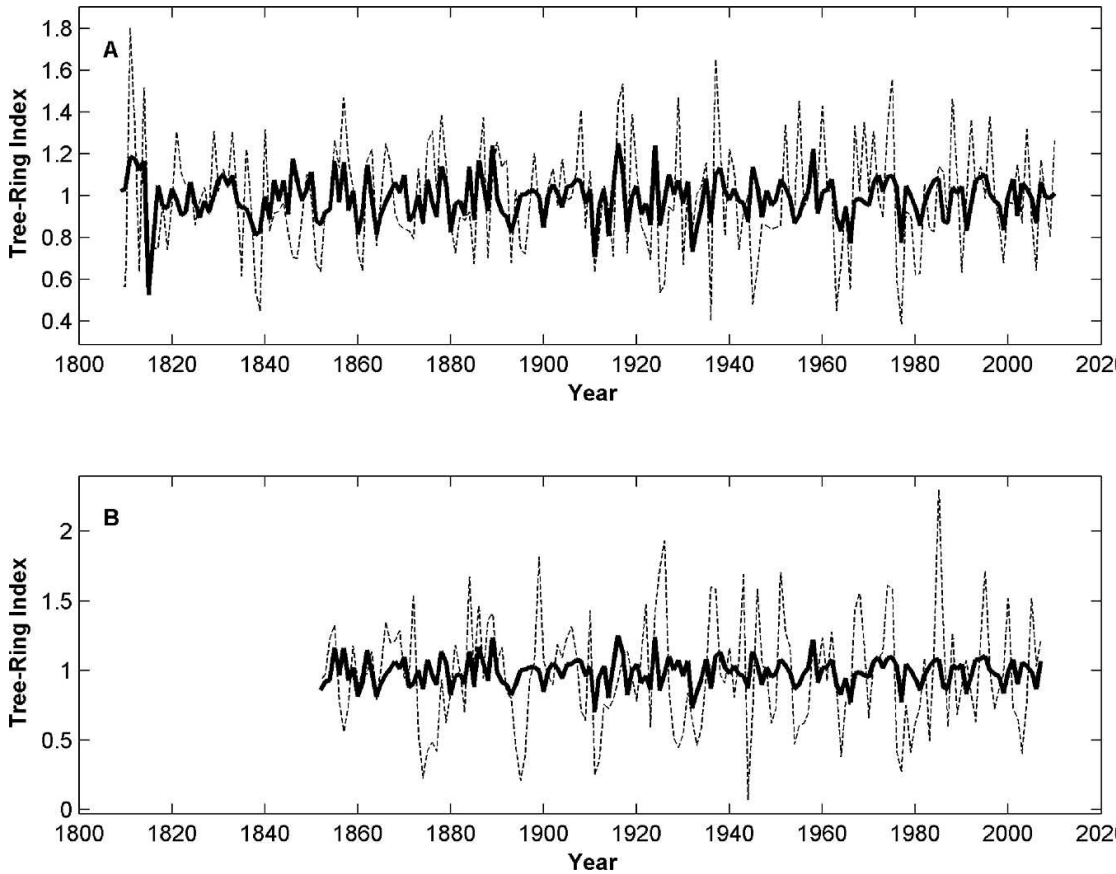

Figure 3. Comparison of the northwest tree (A) and southwest tree (B) chronologies (dashed lines) with a local Monticello oak chronology (bold line).

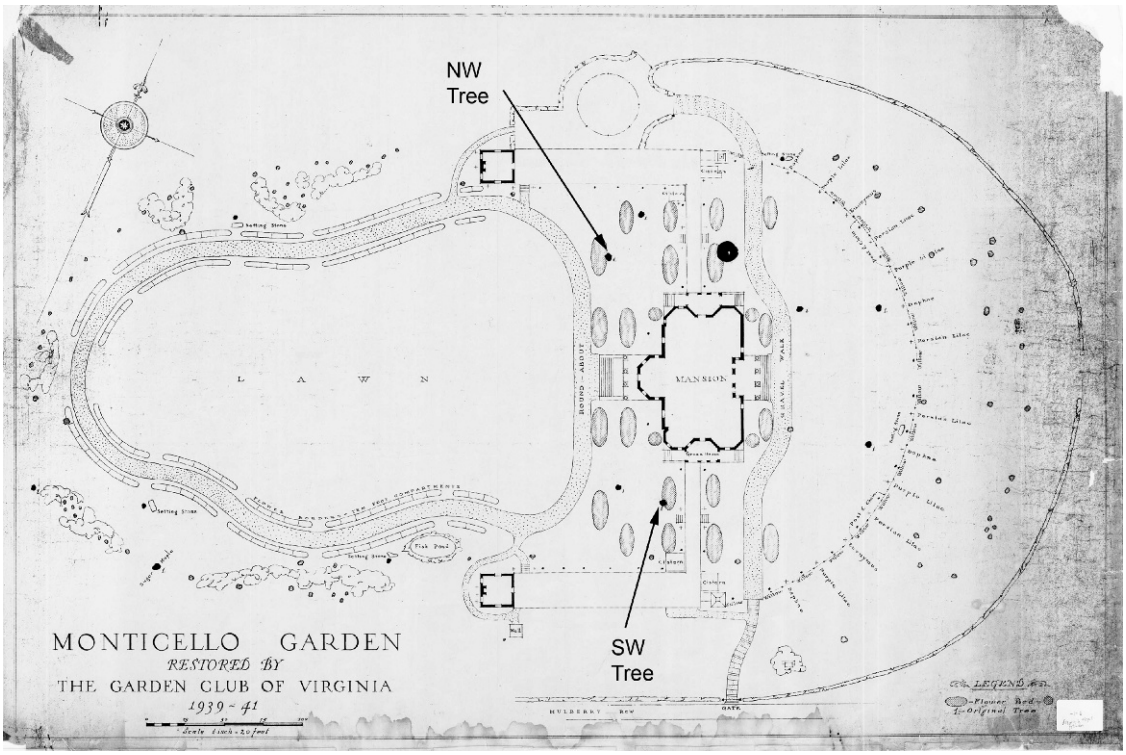

Figure 4. Plan of Monticello Garden restored by the Garden Club of Virginia between 1939 and 1941 labeling both the northwest and southwest trees as original to Jefferson. Flower beds and shrub circles are shown in gray, trees with black dots, and original trees are labeled ''1''. [Credit: Thomas Jefferson Foundation, Inc. at Monticello].

Figure 5. Oblique aerial photograph of the West Lawn at Monticello in 1927–1928 showing the northwest and southwest tulip poplars adjacent to the house. [Credit: Thomas Jefferson Foundation, Inc. at Monticello].

Figure 6. East front of Monticello showing the northwest and southwest tulip poplars adjacent to the house between 1889 and 1912. [Credit: Holsinger Studio Collection 1889–1939, Albert and Shirley Small Special Collections Library, University of Virginia, Charlottesville].

diameter including its bark (assuming 1 additional cm) as well as estimates of maximum height and diameter for tulip poplars. Because these parameters are imperfectly known, this height determination is approximate at best, but this equation suggests that the tree would have been *ca.* 19 m at the end of 1867. This result agrees with the interpretation of these early photographs in that even the northwest tree would have been noticeably taller than the house by the time of the Roads and Holsinger photographs. Thus, these photographs provide a consistent documentary record of what appears to be the northwest and southwest trees back to the late 1860s when both trees were still taller than the house.

Because the southwest tree was hollow at the base, we were limited to sampling a cross-section from an upper branch (with a cable wire attached). Comparing its size to the northwest tree and knowing that the branch position was at least as high as the house, it seems likely that the southwest tree is substantially older than the 1852 date determined from the upper cross-section. Potentially, the greater size of the southwest tree could have also resulted from a more productive soil beneath its position on the west lawn. Archaeological analyses of the west lawn suggest that prior to the construction of the house the site was leveled by transferring the A and a portion of the B soil horizons from the northern part of the west lawn (where the northwest tree was growing) to the southern portion (where the southwest tree was growing) (F. Neiman, Director of Archaeology, Monticello, personal communication), potentially improving the soil fertility for the southwest tulip poplar at the expense of the northwest tree.

The preponderance of the evidence suggests that the northwest tree and the southwest tree likely established during the time that Jefferson planned his formal gardens on the west lawn of Monticello. No documentary record exists to support the interpretation that Jefferson intentionally planted the northwest tree, as tulip poplars readily establish on mineral soil and documentary evidence suggests that their establishment was pervasive at Monticello. Regardless of the tree's origins, Jefferson was clearly fond of tulip poplars and appears to have incorporated this tree into his west lawn plan. Although dendrochronological dating cannot confirm that the southwest tree is the same as the one mentioned by Jefferson in his April 16, 1807, Garden Book entry, its size and presence in early photographs also suggest that it was also Jefferson era.

ACKNOWLEDGMENTS

We thank the Thomas Jefferson Foundation for the opportunity to crossdate these two tulip poplars. We are grateful for the assistance of Peggy Cornett, Peter Hatch, Gabriele Rausse, Robert Self, William Beiswanger, Jack Robertson, Leah Stearns, Fraser Neiman, and others from the Thomas Jefferson Foundation in providing these samples and early photographs. We are also grateful to Frederick Williamson for cutting the samples for the northwest tree and Neil Pederson for sharing a tulip poplar chronology. Ed Cook, Michael Mann, David Richardson, and the archaeology staff and field school students at Monticello all assisted in collecting samples for the master oak chronology. Nicole Chakowski was supported by a grant from Bristol-Myers Squibb to Rider University.

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Received 16 October 2012; accepted 15 September 2013.