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"APPROXIMATE" WIGGLE-MATCH DATING APPLIED TO EARLY AMERICAN MUSEUM OBJECTS

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ABSTRACT. Wiggle-match dating of tree-ring sequences is particularly promising for achieving high-resolution dating across periods with reversals and plateaus in the calibration curve, such as the entire post-Columbian period of North American history. Here we describe a modified procedure for wiggle-match dating that facilitates precise dating of wooden museum objects while minimizing damage due to destructive sampling. We present two case studies, a dugout canoe and wooden trough, both expected to date to the 18th–19th century. (1) Tree rings were counted and sampled for dating from exposed, rough cross-sections in the wood, with no or minimal surface preparation, to preserve these fragile objects; (2) dating focused on the innermost and outermost portions of the sequences; and (3) due to the crude counting and sampling procedures, the wiggle-match was approximated using a simple ordered Sequence, with gaps defined as Intervals. In both cases, the outermost rings were dated with precision of 30 years or better, demonstrating the potential of wiggle-match dating for post-European Contact canoes and other similar objects.

KEYWORDS: Bayesian modeling, boats, calibration, historic period.

INTRODUCTION

Wiggle-match dating is a powerful technique that facilitates accurate and precise dating by "matching" a floating time series of tree-ring ^{14}C measurements to the "wiggles" of the atmospheric radiocarbon (^{14}C) calibration curve (Pearson 1986). The potential of this technique has long been recognized (Ferguson et al. 1966; Clark and Renfrew 1972; Kruse et al. 1980; Pearson 1986; Manning and Weninger 1992), and its application has only grown in popularity as standardized statistical approaches (e.g., Bronk Ramsey et al. 2001; Christen and Litton 1995; Galimberti et al. 2004) and specialized calibration software packages such as OxCal (Bronk Ramsey 2009) have made it accessible to a wider user-base.

While dendrochronology remains the method of choice for dating tree-ring series, wiggle-matching dating can often be used in cases where dendrochronological dating is not possible because, for example, a well-established master chronology is lacking (e.g., Nakamura et al. 2007) or, in some cases, when the tree-ring sequence is relatively short (e.g., Marshall et al. 2019; but see Bayliss et al. 2017, 2020). The technique also has been employed to anchor floating dendrochronological sequences (Kessler et al. 2022); as independent verification of tentative dendrochronological dates (Arnold et al. 2022); and to resolve dating ambiguities resulting from reversals and plateaus in the radiocarbon calibration curve (Manning et al. 2020). The latter application is particularly relevant to American archaeology because the radiocarbon record of the entire post-Columbian ("historic") period in the Americas is characterized by "wiggles," reversals, and plateaus in the calibration curve, rendering practically useless the broad and/or multi-modal calibrated dates obtained from single ^{14}C measurements.

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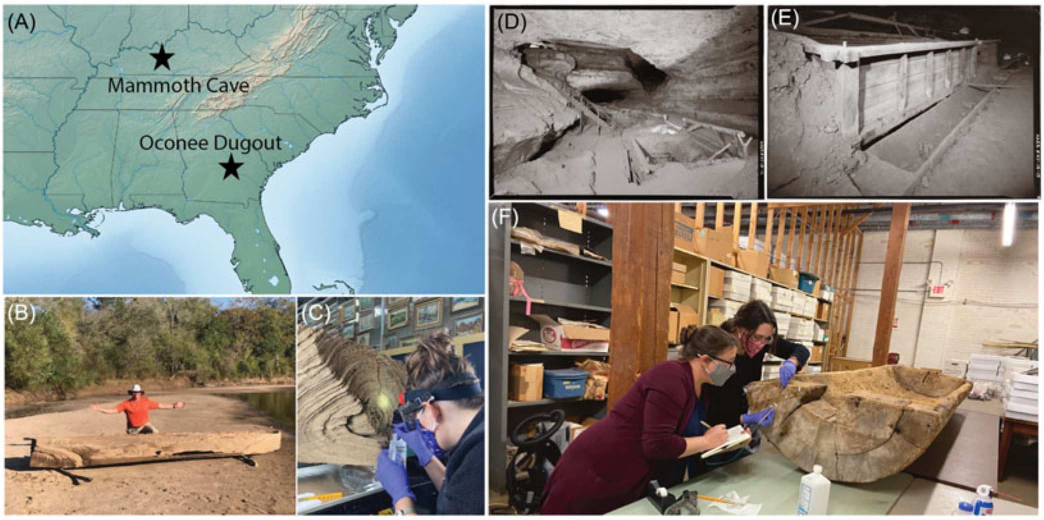

Figure 1 (A) map of study area; (B) discovery of the Oconee Dugout (photo courtesy of Georgia Department of Natural Resources); (C) K. Napora collecting samples from the Oconee Dugout; (D, E) Mammoth Cave saltpeter mine ruins as of 1986 (photos by Jet Lowe, courtesy of Historic American Engineering Record); (F) C. Hadden and K. Napora collecting samples from the Webb Museum Trough.

In this paper we demonstrate the use of wiggle-match radiocarbon dating on two museum objects of significance to 18th–19th century United States history: a cypress dugout logboat exhibiting a unique combination of European and Native American design elements; and a tulip poplar wood trough believed to be utilized in the production of saltpeter by an enslaved workforce (Figure 1). Direct and precise dates were important for verifying the objects' biographies and for developing museum signage and interpretive materials. The goal was to use scientific dating methods to enhance interpretation while minimizing the risk of damage to the objects.

Both objects are essentially hollowed-out logs, with intact long (>200 rings) tree-ring sequences. Dendrochronological dating of cores or lateral slices (cookies) was not possible due to their delicate condition, and the objects are too large and fragile for approaches such as micro-CT and x-ray tomography (e.g., Bossema et al. 2021). Owing to their expected "historical" (post-1492 AD) ages, single ^{14}C dates would be insufficient for resolving the ages of these objects to within even a single century. Wiggle-matching has been shown to produce accurate dates for even short (~30 ring) sequences for the post-1510 AD period (Marshall et al. 2019), although the precision can vary widely (McDonald and Manning 2023). However, our analyses were restricted to existing rough-hewn, irregular cross-sectional exposures in the wood, and minimal surface preparation was permitted. This, in addition to wood degradation in the case of the trough, introduced additional uncertainty in tree-ring counts, precluding the use of the OxCal D_Sequence or V_Sequence routines (Bronk Ramsey et al. 2001; Bronk Ramsey et al. 2001), which are commonly used in wiggle-match dating.

In the case studies presented here, objects were radiocarbon dated with 30-year precision (95% highest posterior density HPD range), from just 7 samples, leaving little visible evidence of the analyses. This was achieved by (1) collecting micro-samples from exposed cross-sections of the wood for radiocarbon dating; (2) including the innermost and outermost rings, spanning over

200 years, to reduce the likelihood of sequences fitting multiple positions of the curve; (3) and modeling the dates in OxCal as ordered Sequences, with gaps defined as Intervals, to approximate a wiggle-match. This variation of wiggle-match dating is applied in situations where a less restrictive model structure is necessary, such as trees that do not routinely form annual growth rings (e.g., Pearson et al. 2023), or as in our case, where ring counts are known only approximately.

To our knowledge, this is the first study to successfully apply wiggle-match dating to a dugout canoe. Few examples of small, post-Columbian American watercraft have been precisely dated, both because of the paucity of geographically and species-specific dendrochronological master series in North America and "the unstable nature of dating sequences for younger objects" (Porter 2009). Museum staff are generally reluctant to approve destructive sampling unless the benefits outweigh the risks (Freedman et al. 2018). This study demonstrates that approximate wiggle-matching is an effective, fast, and minimally destructive technique for dating early American logboats, and has the potential to refine and enhance studies of watercraft manufacturing techniques in the post-Columbian Americas. This approach can be applied to other objects of similar form or structure with relatively long sequences of rings exposed, as demonstrated by the case study of the Webb Museum Trough.

MATERIALS

Oconee Dugout

Dugout canoes were essential to Native American lifeways prior to the colonization of the Americas by Europeans. The simplest dugouts are constructed from a single log with the sapwood removed, which is then hollowed out with tools, often aided by the controlled use of fire. Lateral stability can be improved by a variety of techniques such as widening the watercraft, lashing two dugouts together, or adding outriggers or stabilizers (Meide 1995:25). European colonizers adopted many Native American techniques for constructing small watercraft, often combining elements of Indigenous and European traditions (Briggs 2020; Fleetwood 1995:31–44).

The so-called "Oconee Dugout" was discovered in 2019 in the Oconee River, Georgia, USA (Figure 1a) by a group of recreational paddlers (Figure 1b). The dugout measures 4.8 m long, 0.6 m wide, and 0.4 m in height and was carved from a single bald cypress (*Taxodium distichum*) trunk. Bald cypress are large, slow-growing trees native to the eastern United States, and a common building material for small tidewater watercraft, such as canoes and periaguas, throughout its range (Fleetwood 1995:44). A notable feature of the Oconee Dugout is its "wineglass transom"—the flat, vertical surface at the aft of the watercraft that resembles a wineglass in profile—a feature not found on Native American watercraft but common among vessels of Euro-American construction (Briggs 2020). The transom exposed a nearly complete cross-section of the cypress tree trunk, which consisted of 354 annual rings (Figure 1c). The sapwood had been removed in the construction of the canoe, as is common with dugout canoes. Georgia Southern University Museum (GSUM) wished to date this unique vessel as precisely as possible.

Webb Museum Trough

In the late 18th century, sediments rich in calcium nitrate (saltpeter), a major component of gunpower, were discovered in Mammoth Cave, Kentucky, USA (Figure 1a). Small-scale mining may have begun as early as the late 1790s (Crothers et al. 2013: 105). Demand for domestically produced saltpeter, driven by the Embargo Act of 1807 and the War of 1812 against the United Kingdom, led to a massive expansion of the mining operation at Mammoth Cave, which came to include an extensive underground system of wooden vats, troughs, and pipes for lixiviating the cave sediments and transporting the leachwater to the surface. The end of the war in 1815 led to the collapse of the domestic saltpeter market, and the end of the Mammoth Cave mining operation (Hill and DePaepe 1979; George and O'Dell 1992). However, by the 1840s Mammoth Cave had been developed as a tourist attraction (Thomas et al. 1970). Portions of the ruins remain in situ within the cave (Figure 1d and Figure 1e), now part of Mammoth Cave National Park (MCNP), although many of the saltpeter vats, troughs, and pipes have been removed, relocated/repurposed, or destroyed over the years (Crothers et al. 2013:103).

In 2004, a wooden trough (Figure 1f) with a vague oral history of association with the Mammoth Cave saltpeter operation was brought to the Webb Museum of Anthropology at the University of Kentucky. The trough had been donated to a park in Louisville, Kentucky, by a private individual. Details regarding when, why, or how the trough was obtained by the individual are unknown. The Webb Museum Trough measures 3.4 m long by 0.9 m wide and 0.4 m in height, and was made from one half of a hollowed tulip poplar (*Liriodendron tulipifera*) trunk, matching the material, shape, and approximate size of the in-situ troughs at Mammoth Cave. The ends of the trough present nearly complete cross sections of the poplar tree trunk, which contained 227 annual rings. MCNP and the Webb Museum sought to verify its provenance through a variety of techniques, including radiocarbon dating.

METHODS

Sampling

For the Oconee Dugout, rings were visibly discernible and countable in the transom without any surface preparation. However, the surface of the cross-section was eroded, irregular, rough, and brittle, hampering attempts at dendrochronological dating. The rings nearer the pith were easier to discern than the outer portion of the radius. Small (~5 mg) single-year samples of the brittle wood were collected using scalpel and forceps (Figure 1c). Rings 0 (the innermost annual ring present), 290, 300, 310, 320, 340, and 354 (the outermost ring) were analyzed at the Center for Applied Isotope Studies for wiggle-match dating. We included Ring 0 in order to fit the floating sequence against a longer stretch of the calibration curve, which is more likely to include significant variations in ^{14}C (Bayliss et al. 2014).

In the case of the Webb Trough, the annual rings were difficult to discern without surface preparation. One full radius (~4 cm in width) and a second partial radius (~6 cm in width) were gently sanded using a manual hand sander with fine grit. A total of 227 annual rings were counted across these overlapping radii, although degradation of the wood introduced some uncertainty in ring count in the middle portion of the trough. The waney edge (i.e., outermost growth) was present in the Webb Museum Trough, unlike the Oconee Dugout. We applied the same general sampling strategy as with the Oconee Dugout: small (~5 mg) samples were radiocarbon dated from Ring 0 (innermost ring), 180, 190, 200, 210, 220, and 227 (outermost ring).

Additional samples and sample remnants are archived at the CAIS for future study.

Table 1 Radiocarbon and stable isotope results for Oconee Dugout and Webb Museum Trough.

Approximate ring #	UGAMS	$\delta^{13}C$ (‰)	^{14}C age (years BP)	±
Oconee Dugout				
0	52042	–24.9	620	23
290	52193	–28.8	80	20
300	52194	–22.5	140	20
310	52195	–24.2	160	24
320	52196	–24.5	150	20
340	52197	–23.8	170	21
354	52043	–23.4	220	20
Webb Museum Trough				
0	57336	–26.6	296	22
180	57337	–28.6	201	24
190	57338	–26.7	137	23
200	57339	–24.3	191	22
210	57340	–25.0	151	21
220	57341	–23.9	225	23
227	57342	–24.8	215	42

AMS Pretreatment and Measurement

Wood samples were pretreated following a standard acid/alkali/acid (AAA) protocol as follows. The samples were treated with 1N HCl at 80ºC, followed by a 0.1M NaOH treatment at room temperature, followed by a second HCl treatment at 80ºC. Samples were rinsed with ultra-pure (MilliQ©) water to neutral between each step, and dried at 105ºC.

This rather conservative pretreatment strategy was chosen over cellulose extraction for several reasons. Cellulose extraction requires much larger samples of starting material than AAA to yield 1 mg of graphite—30 mg for cellulose compared to approximately 5 mg for AAA (Southon and Magana 2010). Although the AAA method is ineffective in removing lignin (Hoper et al. 1997), previous research has shown that AAA pretreatment often performs as well as cellulose extraction, even for wood samples near the limit of ^{14}C dating (Southon and Magana 2010). This is true for bald cypress wood specifically (Napora et al. 2019). Considering the expected young sample ages and small sample sizes, the AAA protocol was the better fit for the goals of the dating project.

The dried, pretreated samples were combusted at 900°C in evacuated and sealed quartz tubes in the presence of CuO to produce CO_2. The CO_2 samples were cryogenically purified from the other reaction products and catalytically converted to graphite using the method of Vogel et al. 1984. Graphite $^{14}C/^{13}C$ ratios were measured using the CAIS 0.5 MeV AMS. Sample ratios were compared to the ratio measured from the Oxalic Acid I standard (NBS SRM 4990). The quoted uncalibrated dates are presented in Table 1 and are given in radiocarbon years before 1950 (years BP), calculated using the ^{14}C half-life of 5568 years. The error is quoted as one standard deviation and reflects both statistical and experimental errors. The dates have been corrected for isotope fractionation using the $\delta^{13}C$ value measured by IRMS.

Modeling

Wiggle-match dating in OxCal generally is implemented using D_Sequence, a variant of the Combine function, where the gaps between rings are known exactly in calendar years (Bronk Ramsey et al. 2001; Bronk Ramsey 2009). The posterior is calculated numerically, without using Markov chain Monte-Carlo (MCMC) methods (Bronk Ramsey et al. 2001).

In our case studies, the gaps are known only approximately, precluding the use of the D_Sequence. This increases the number of variables and the complexity of the model. OxCal can certainly accommodate this additional uncertainty; however, the mathematical approach is quite different, and implementation requires MCMC methods. One option is to use the V_Sequence function with Gaps, which requires uncertainty to be Normally distributed. The caveat is that the V_Sequence can perform poorly if uncertainty terms are too low or not Normally distributed, or if there are a large number of elements in the model. For these reasons, the V_Sequence was too restrictive for our needs. The OxCal user manual describes the use of Sequence, with gaps described using the Interval function, as an alternative to the V_Sequence.

The use of Sequences to approximate a wiggle-match date has been described previously (Friedrich et al. 2014; Dury et al. 2021; Pearson et al. 2023). We modeled the tree-ring dates as an ordered Sequence, with gaps between radiocarbon-dated rings described using the Interval function, as follows:

```
Plot()
{
Sequence(“Oconee Dugout”)
{
Boundary();
R_Date(“Ring0”,620,23);
Interval(N(290,30));
R_Date(“Ring290”, 80, 20);
Interval(N(10,2));
R_Date(“Ring300”, 140, 20);
Interval(N(10,2));
R_Date(“Ring310”, 160, 24);
Interval(N(10,2));
R_Date(“Ring320”, 150, 20);
Interval(N(20,2));
R_Date(“Ring340”, 170, 21);
Interval(N(14,5));
R_Date(“Ring354”,222,20);
```

```
Interval("Sapwood", P(49));
Boundary();
};
};
```

In the case of the Oconee Dugout, we assumed errors on gaps were Normally distributed, with σ ranging from as low as 2 to as high as 30, reflecting the dendroarchaeologist's confidence in ring counts. The largest σ is associated with a large gap—the jump from Ring 0 to Ring 290. σ values of 2–5 years were more typical for gaps of 10–15 years.

One advantage of this approach is that the Interval function can accommodate non-Normal distributions. Seven sub-fossil bald cypress trees of comparable size and ontogenetic age recovered from an anoxic buried context in southeastern Georgia, USA, contained between 29 and 92 sapwood rings (Napora 2021). The sapwood ring counts approximate a Poisson distribution with a mean of 49 sapwood rings. This information can be used to account for the missing outer rings of the Oconee Dugout. A Poisson Interval with mean 49 was specified to approximate the missing number of sapwood rings.

The same basic model structure was applied for the Webb Museum Trough, adjusting the prior probabilities on the Interval distributions to reflect our confidence in the ring counts. Since the sapwood and waney edge were present in the Webb Museum Trough, the model did not include an Interval representing the sapwood.

RESULTS AND DISCUSSION

Uncalibrated radiocarbon dates are presented in Table 1. Calibrated results, both unmodeled and modeled, are presented in Table 2 and Table 3. Model runs converged quickly and differences between runs were negligible. Throughout this discussion we use the convention of referring to modeled parameters in italics, and always refer to the 95% highest posterior density (HPD) unless otherwise noted.

In both cases, the unmodeled calibrated date for the outermost extant rings (Oconee Dugout Ring 354 and Webb Trough Ring 227) have multiple intercepts, with plausible calendar ages spanning the 17th–20th centuries (Table 2 and Table 3; Figure 2). These results exemplify why radiocarbon dates are generally considered to have limited utility by archaeologists studying the "historical" (post-Columbian or post-European Contact) period of the Americas. In comparison, the modeled date for the outermost ring is narrowed down to a <30-year range of *1766–1796* for the Oconee Dugout (Table 2 and Figure 3); and *1778–1804* for the Webb Trough (Table 3 and Figure 4).

A notable feature of both series of dates is the near-perfect reversal of ^{14}C measurements in the outer rings, with younger rings having progressively older radiocarbon dates (Table 1). These sequences of dates maps onto an inversion in the calibration curve (Figure 3 and Figure 4)—one of the best periods for wiggle-match dating in the post-1500 period (McDonald and Manning 2023: Figure 7). While the result is not as precise as cases of wiggle-match dating where gaps are known exactly, or in dendrochronologically dated wood, both of which have the potential to yield single-year dates, the precision achieved here is adequate for the research

Table 2 Unmodeled and modeled calibrated results for the Oconee Dugout. The end Boundary of 1810–1851 represents the best estimate of the felling date of the tree (95% HPD). Amodel = 92.8; Aoverall = 97.9.

	Unmodeled (BC/AD)			Modeled (BC/AD)			
Name	from	to	%	from	to	%	A
Sequence							
Boundary				1086	1404	95.4	
R_Date Ring0	1300	1398	95.4	1355	1405	95.4	92.9
Interval N(290,30)	230	350	95.4	308	362	95.4	61.2
R_Date Ring290	1694	1725	27.9	1705	1727	95.4	115
	1811	1917	67.5				
Interval N(10,2)	6	14	95.4	7	14	95.4	99.8
R_Date Ring300	1673	1778	34.5	1715	1738	95.4	109.9
	1797	1825	10.5				
	1830	1895	32				
	1903	1944	18.5				
Interval N(10,2)	6	14	95.4	6	14	95.4	99.8
R_Date Ring310	1665	1700	16.2	1726	1749	95.4	124.2
	1721	1785	34.2				
	1793	1816	9.8				
	1833	1889	14.6				
	1908	...	20.6				
Interval N(10,2)	6	14	95.4	6	14	95.4	99.2
R_Date Ring320	1668	1705	15.5	1734	1759	95.4	90.7
	1720	1781	27.7				
	1796	1818	9.9				
	1832	1891	21.9				
	1907	...	20.5				
Interval N(20,2)	16	24	95.4	16	24	95.4	100.2
R_Date Ring340	1663	1695	17.9	1754	1780	95.4	116.1
	1725	1786	42.6				
	1792	1813	9.9				
	1838	1878	4.1				
	1916	...	20.9				
Interval N(14,5)	4	24	95.4	6	25	95.4	100
R_Date Ring354	1643	1680	44.3	1766	1796	95.4	99.4
	1740	1753	4.1				
	1762	1800	45.2				
	1940	...	1.8				
Interval P(49)	35	63	95.4	35	63	95.4	99.7
Boundary				1810	1851	95.4	99.7

question and a vast improvement over a single radiocarbon determination of the outermost ring.

Because an unknown number of exterior sapwood rings were removed during the construction of the Oconee Dugout, the wiggle-matched date for Ring 354 could be interpreted as the *terminus post quem* for the felling of the tree and the construction of the canoe. To refine the

Table 3 Unmodeled and modeled calibrated results for the Webb Museum Trough. The modeled date for Ring 227 (the waney edge) of 1778–1804 represents the best estimate of the felling date of the tree (95% HPD). Amodel = 94.5; Aoverall = 92.4.

	Unmodeled (BC/AD)			Modeled (BC/AD)			
Name	from	to	%	from	to	%	A
Sequence							
Boundary				1443	1651	95.4	
R_Date Ring0	1509	1594	68.6	1525	1598	46.1	90
	1618	1654	26.9	1615	1655	49.4	
Interval N(180,36)	108	252	95.4	90	133	49.6	72.5
				148	220	45.9	
R_Date Ring180	1650	1688	26.1	1733	1757	95.4	96.3
	1731	1807	57.4				
	1925	. . .	12				
Interval N(10,2)	6	14	95.4	6	14	95.4	101
R_Date Ring190	1675	1766	31.9	1742	1765	95.4	72.7
	1798	1943	63.5				
Interval N(10,2)	6	14	95.4	6	14	95.4	101.8
R_Date Ring200	1658	1688	21.8	1749	1775	95.4	119.7
	1730	1808	58.4				
	1924	. . .	15.3				
Interval N(10,2)	6	14	95.4	6	14	95.4	101.5
R_Date Ring210	1668	1703	15.4	1759	1785	95.4	68.5
	1721	1782	28.6				
	1796	1817	9.9				
	1832	1891	20.9				
	1907	. . .	20.7				
Interval N(10,2)	6	14	95.4	6	14	95.4	101.9
R_Date Ring220	1641	1682	45.9	1769	1795	95.4	124.4
	1738	1754	5.1				
	1761	1802	42				
	1938	. . .	2.5				
Interval N(7,2)	3	11	95.4	3	11	95.4	100.3
R_Date Ring227	1527	1554	2.5	1778	1804	95.4	151.3
	1632	1699	30.1				
	1722	1814	45.8				
	1835	1885	4.6				
	1910	. . .	12.5				
Boundary				1776	1926	95.4	

estimate for the felling date, in our model we assumed that the number of sapwood rings followed a Poisson distribution based on comparison with a collection of subfossil trees from the same region. Accounting for the missing sapwood rings in this manner, the *Boundary* date of *1810–1851* represents the best estimate for the felling date of the tree.

In the case of the Webb Trough, the waney edge of the wood was present, meaning there was no need to account for missing sapwood. The modeled date for the outermost ring of the trough (Ring 227) of *1778–1804* (Table 3 and Figure 4) is our best estimate of the felling year of the

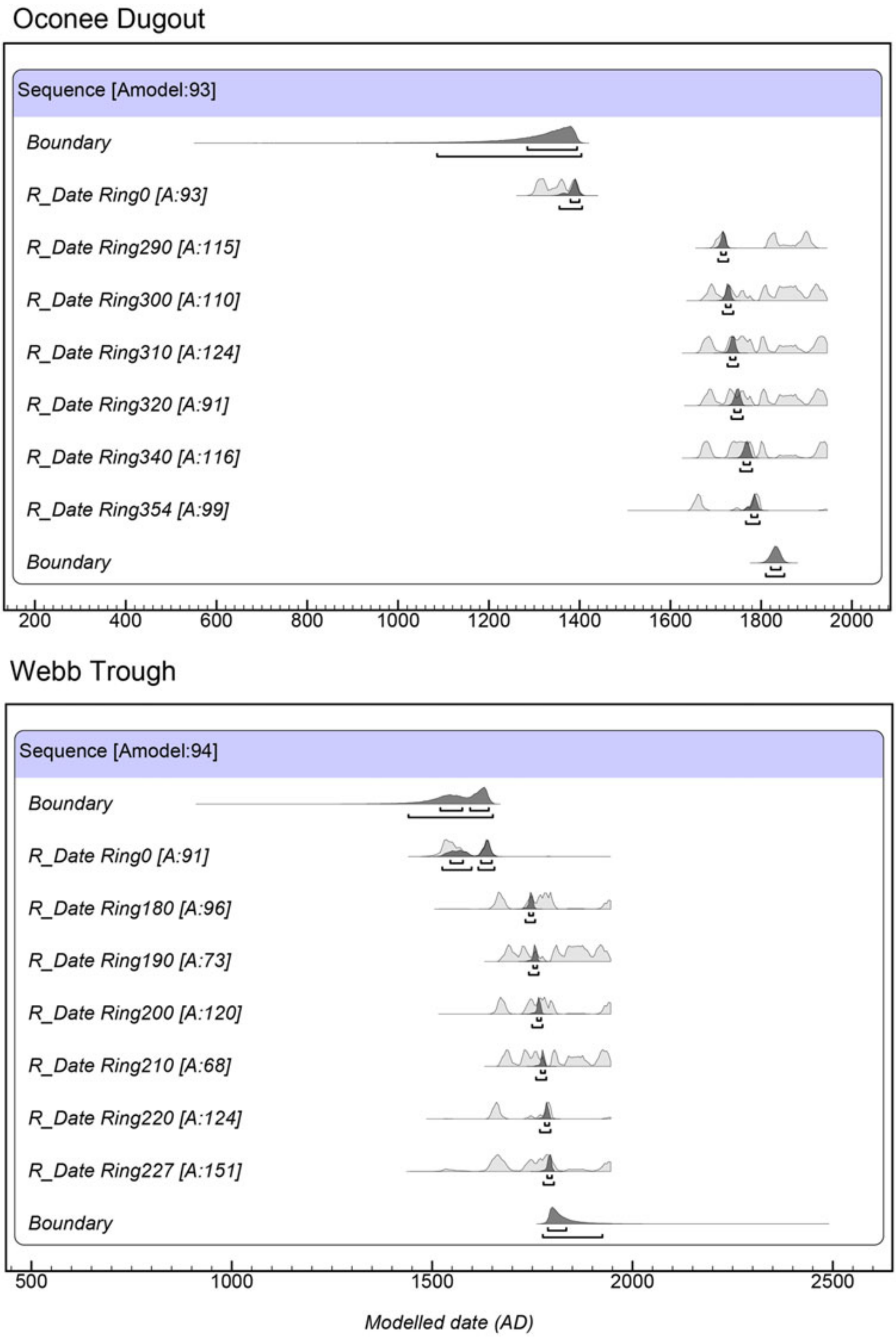

Figure 2 Unmodeled (light gray distributions) and modeled (dark gray distributions) calibrated dates for the Oconee Dugout (top) and the Webb trough (bottom). Brackets indicate 68% and 95% HPD ranges.

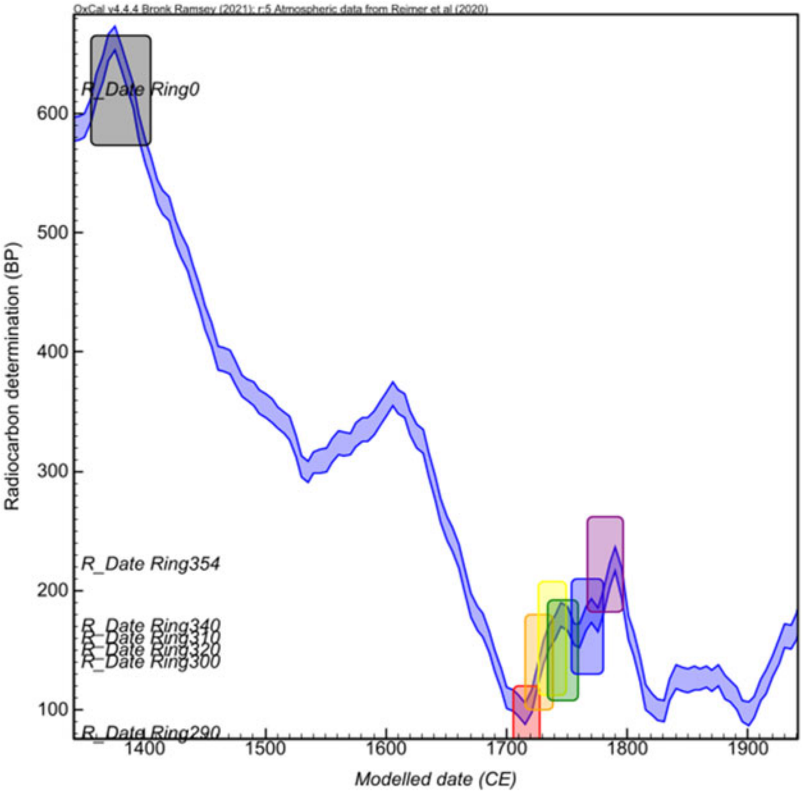

Figure 3 Wiggle-matched dates for Oconee Dugout plotted on the IntCal20 calibration curve. Boxes represent 95.4% highest posterior density ranges. Colors used to enhance visibility.

tree. This felling date is consistent with the initial period of the mining operation at Mammoth Cave, prior to the "Niter Boom" brought on by the War of 1812. We interpret this as cooroborating the trough's oral provenance within the Mammoth Cave saltpeter mine.

Marshall et al. (2019) have shown that short wiggle-match sequences produce accurate dates for the post-1500 AD period. However, McDonald and Manning (2023) demonstrated that the dating precision that can be achieved from short sequences varies widely over this interval, even with increased sampling resolution and improved precision on ^{14}C measurements. In our case studies, long (>200 ring) sequences were available. Rather than increasing sampling resolution or measurement precision, we opted to improve accuracy and precision by sampling from the innermost and outermost sections of the sequence, in order to fit the floating sequence against a longer and more varied region of the calibration curve (Bayliss et al. 2014), thereby reducing the chance of a wiggle-*mis*match. We were fortunate that our case studies included the 18th-century inversion in the calibration curve. However, we completed simulation experiments (following McDonald and Manning 2023) that suggest that this sampling strategy significantly improves the dating precision, without sacrificing accuracy, for more problematic periods as well.

The posterior probabilities for the *Interval* parameters represent updated estimates of ring counts based on all other model parameters. For the Oconee Dugout, we specified a prior probability of 290 ± 30 years for the jump from Ring 0 to Ring 290; the posterior probability of

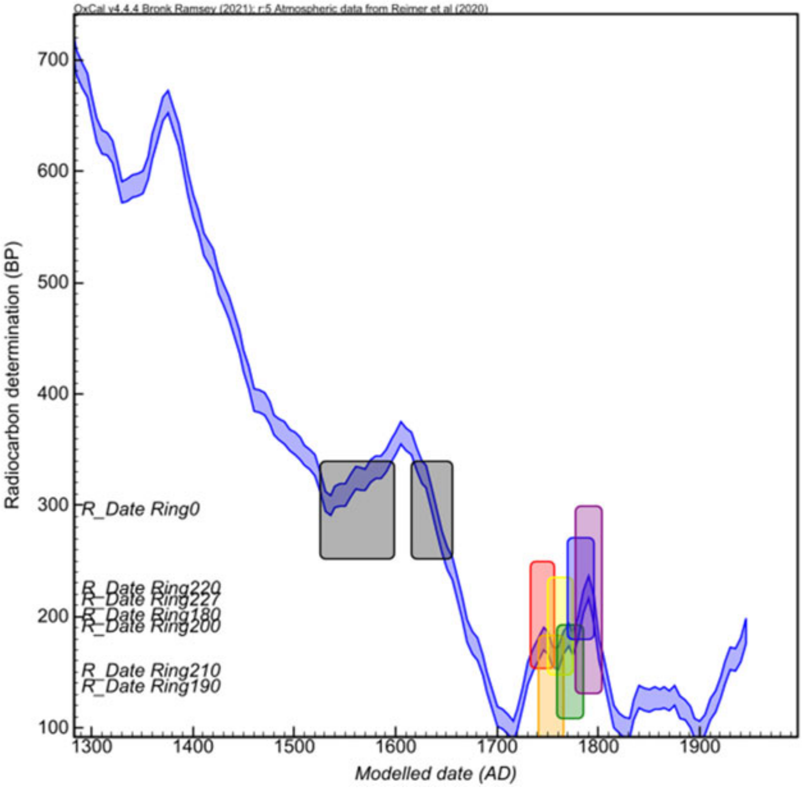

Figure 4 Wiggle-matched dates for Webb Museum Trough plotted on the IntCal20 calibration curve. Boxes represent 95.4% highest posterior density ranges. Colors used to enhance visibility. (Please see online version for color figures.)

330 ± 13 suggests that several rings were missed (Table 2). In contrast, ring counts were overestimated for the Webb Trough (Table 3). These results both highlight the problem of precisely counting tree-rings from unprepared, rough-hewn wood, and demonstrate that the model structure is flexible enough to accommodate approximate ring counts.

CONCLUSIONS

We presented two case studies demonstrating that high-precision wiggle-match dating can be achieved for 18th–19th century North American museum objects, a notoriously problematic period for the radiocarbon method, with minimal damage to the objects. Working in collaboration with museum staff, we developed a minimally destructive sampling strategy that balanced their desired research outcomes with the long-term preservation and stability of the study objects. Though conventional wiggle-match dating and dendrochronology have the potential to provide higher-precision dates, our approach is a more flexible strategy that can be utilized when the preferred methods are not an option. The combination of sampling and modeling methods we described have great potential for better resolving the ages of post-European Contact, Colonial, and Plantation-era watercraft of the Americas (e.g., Porter 2009; Singleton and Landers 2021; Bonomo and Soledad Ramos 2023). However, they also can be adapted for other wooden objects that possess an exposed cross-section of wood, such as structural beams and posts, utilitarian objects such as feed troughs, or stump furniture. It is our hope that the present study will encourage others to think more broadly about the applications of wiggle-match dating in archaeology and museum studies, particularly in case that are less-than ideal for either conventional wiggle-match dating or dendrochronology.

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DECLARATION OF COMPETING INTERESTS

The authors declare that they have no competing interests.

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