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Cover Photograph: Photo of the excavation of the Northborough Mastodon in Maynard's Meadow in 1885 with inset line drawing of one of the mastodon's molars (photograph used with permission of the Worcester Telegram; line drawing from Rice 1885).

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"Man and the Mastodon": Revisiting the Northborough Mastodon

Robert S. Feranec[1*], Martin Christiansen[2], David "Bud" Driver[3], and Stuart J. Fiedel[4]

Abstract - The Northborough Mastodon (*Mammut americanum*), discovered in central Massachusetts in 1884, has never been dated. We have obtained a high precision AMS radiocarbon age on collagen from a tusk: 11,350 ± 30 rcbp (UCIAMS 225612), ca. 13,200 cal BP. We review the circumstances of the discovery and discuss the implications of the new date and isotopic data with regard to mastodon ecology, their colonization of New England, their coexistence with humans, and their extinction at the end of the Pleistocene.

Introduction

Compared to New York and the southern Great Lakes region to the west, New England appears depauperate in Pleistocene-aged megafauna, such as *Mammut americanum* Blumenbach (American Mastodon). The identification of additional specimens from New England and description of their depositional contexts can enhance our understanding of mastodon ecology and extinction during the latest Pleistocene, both at local and regional scales. Of greatest interest are those sites that may demonstrate the contemporaneity of humans and proboscideans and may provide evidence of human predation. The relative roles of human hunters versus climate change in the megafaunal extinctions in North America at the end of the Pleistocene have been the focus of research and debate for decades (e.g., Barnosky et al. 2004, Emery-Wetherell et al. 2017, Haynes 2009, MacPhee 1999, Martin and Klein 1984, Martin and Wright, Jr. 1967).

Teeth and skull fragments of the Northborough Mastodon (*Mammut americanum*) were discovered and excavated in a meadow in central Massachusetts in 1884. A year later, a human skull and mandible were found in the same meadow, just 18 feet (5.5 m) away from the mastodon. Here, we review the circumstances of the discovery, present the first, high precision AMS radiocarbon date for the mastodon as well as isotopic data, and discuss the implications of these new data with regard to mastodons' ecology, their colonization of New England, their contemporaneity with Paleoindians, and their extinction at the end of the Pleistocene.

The Strange History of the Northborough Mastodon and the Human Skull

Discovery of the Mastodon

The Northborough Mastodon (*Mammut americanum*) was discovered on November 17, 1884, by workmen digging a 70-foot-long drainage trench in a wet meadow on the farm of William U. Maynard. His place was located in Northborough, Massachusetts, on the line dividing the town from Shrewsbury to the west (Fig. 1). The meadow was located just east of the town line and "a few rods" north of the highway. The workmen encountered several teeth (Fig. 2), bone fragments and parts of tusks, "the outer layer of ivory being well pre-

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served" (Rice 1885:3). The fossils lay at the base of a peat layer, seven or eight feet (~2.3 m) below the surface, just above bedrock. Maynard took the fossils to Dr. F. W. Brigham of Shrewsbury, who brought them to nearby Worcester where he showed them to members of that city's Natural History Society and Society of Antiquity. The next day, Brigham and five members of the Society of Antiquity visited the findspot. Despite rumors that the bones might be those of a recently deceased circus elephant, these local savants believed they were mastodon bones. To confirm this, Mr. Thomas A. Dickinson of the Society took two teeth, bones, and ivory to Harvard University, where Professors Alexander Agassiz and J. A. Allen of the Museum of Comparative Zoology identified them as mastodon. Judging from the tooth size and wear, Allen estimated that the animal was "probably about two-thirds grown" (Allen 1884 *in* Raymenton 1885a:6, Rice 1885)

Dickinson also showed the teeth to Dr. Frederic W. Putnam of the Peabody Museum of American Archaeology and Ethnology. Putnam expressed the hope that some evidence of human activity might be discovered if the rest of the animal were exposed.

Dr. William H. Raymenton, a 32-year-old physician who was the President of the Worcester Natural History Society, began negotiating with Maynard for the rights to

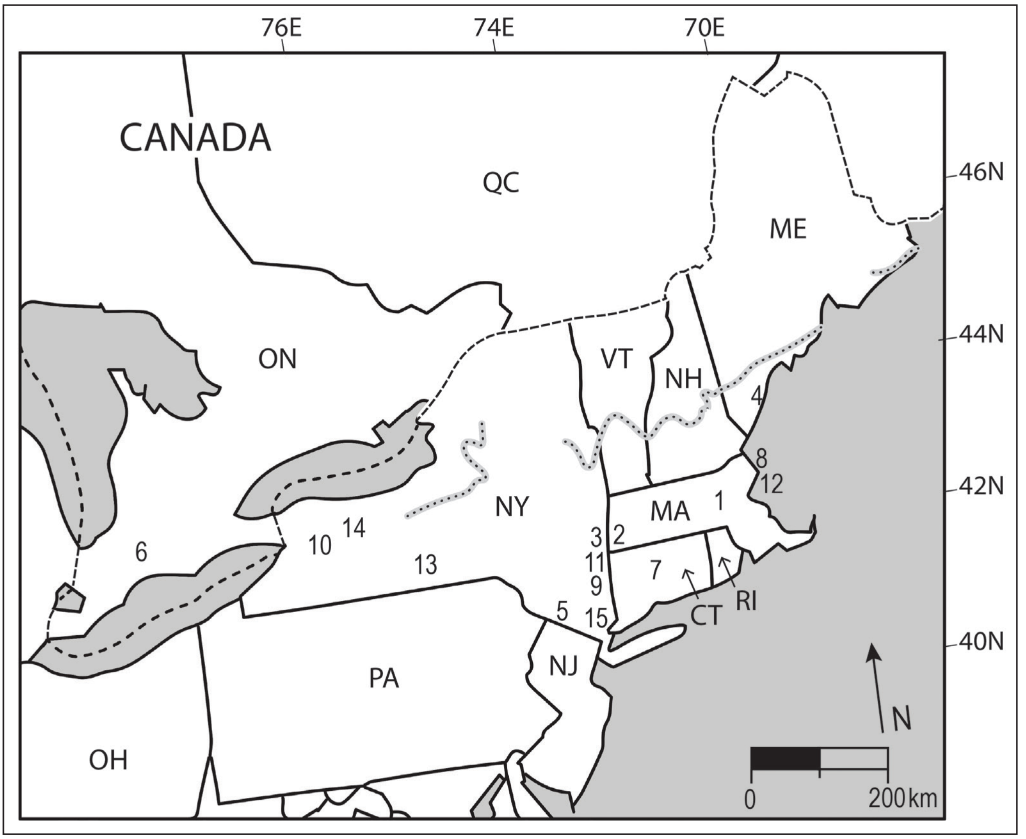

Figure 1. Map of locations of mammoths and mastodons mentioned in this study. Numbering as follows: 1, Northborough Mastodon; 2, Ivory Pond Mastodon; 3, Claverack Mastodon; 4, Scarborough Mammoth; 5, Tunkamoose Mastodon; 6, Delaware Mastodon; 7, Farmington Mastodon and New Britain YWCA Mastodon; 8, Merrimack River Mastodons (two individuals) and Mammoth; 9, Poughkeepsie Mastodon; 10, North Java Mastodon; 11, Hyde Park Mastodon; 12, Grimes Mastodon and Berry Mammoth; 13, Chemung Mastodon; 14, Hiscock Mastodons; 15, Kitchawan Mammoth. Gray-highlighted dots represent the ice-front positions of the Laurentide Ice Sheet about 14,600 cal BP (Ridge 2019).

excavate and curate the rest of the skeleton in his meadow. Raymenton offered $100, but Maynard demanded $500. Eventually Maynard lowered the price to only $50 for both the bones and teeth already recovered and the right to dig for more. Maynard also contracted on March 5, 1885 to undertake the excavation himself for an additional $35 (Hartwell 1979, Raymenton 1885a).

On Sunday, November 23, 1884, while Maynard and his family were in church, looters from nearby towns swarmed into the meadow and dug up several teeth. Fortunately, the naturalists were able to recover those finds. As of December 1884, the mastodon consisted of nine teeth (four of them undeveloped molars), numerous skull fragments, and portions of the tusks. Rice (1885:8) reported that the roots had eroded away but the crowns of the teeth were intact; five of them were "of extraordinary beauty, being covered with enamel resembling agate or turquois." An unpublished handwritten account by Raymenton in Putnam's files at the Peabody generally agrees with Rice's narrative, but also provides some additional and alternative details. With respect to the teeth in particular, Raymenton (1885a) observed that the five enamel-covered teeth did have roots attached, and that one of the largest measured 2 5/8 by 4 1/8 inches (6.7 cm by 10.5 cm) across the crown and weighed 19 ½ ounces (550 g).

A drawing published by Rice (1885) shows a trilophodont tooth with roots that was later identified by Hay (1923:47) as an "upper penultimate" molar. Judging from the drawing alone, this tooth could be a fourth deciduous premolar, first molar, or second molar. If the mastodon was "about two-thirds grown" this would most likely be a first or second molar, and the four developing teeth would probably be unerupted third molars.

Raymenton noted that, in addition to the teeth, fragments of the face were recovered; these ranged "from two to six inches square, sufficient to fill a ten-quart pan" (Raymenton 1885a:3).

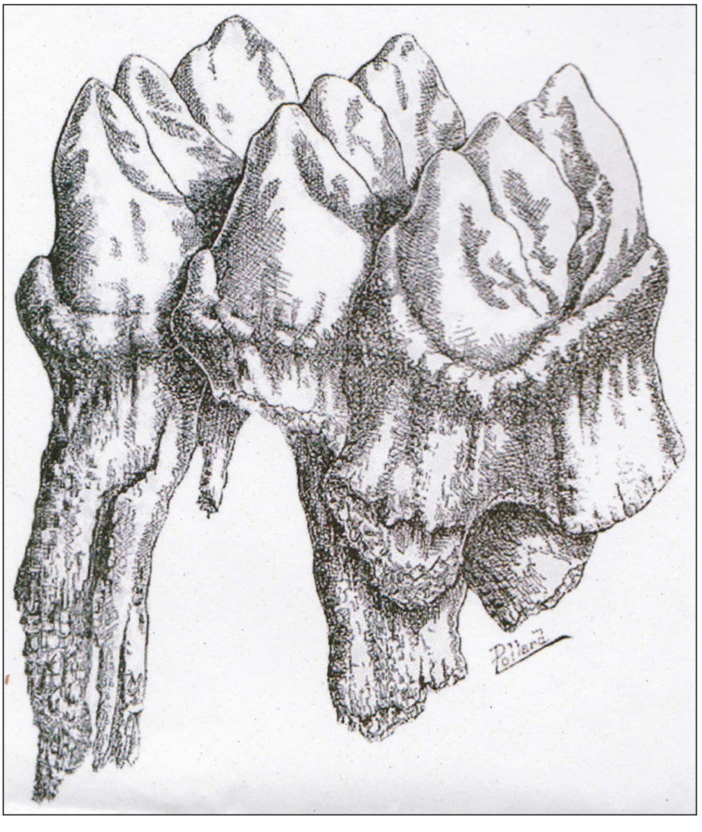

Figure 2. Sketch of one of the Northborough Mastodon teeth (from Rice 1885).

Soon after exposure to the air, most of the interior of the tusk disintegrated, "the interior portion resembling flour and filling a six-quart pan even full. The outer shell, thin, tough, elastic and of a dark chocolate color with a fine polish, shriveled and curled in drying."

Discovery of the Human Skull and Mandible

On October 12, 1885, workmen supervised by Raymenton began digging to search for more of the skeleton in Maynard's meadow (Fig. 3). At first, no additional mastodon bones turned up. However, on Tuesday, October 13, Walter Hall, one of the workmen supervised by Raymenton, while slicing through the peat, exposed a "yellowish brown, oval body having the appearance of bone" about five feet below the surface (Raymenton 1885a:12). Raymenton immediately recognized this as a human cranium. Besides Dr. Raymenton and Walter Hall, three other men witnessed the discovery: the doctor's brother, Louis W. Raymenton, Charles Kennedy, and a Mr. Nichols. Raymenton (1885a:12–13) "called the particular attention of the spectators to the appearance of the skull in place and the firm and undisturbed character of the peat surrounding it…it lay embedded in the peat as though cast in a mold." His brother jumped into the trench and carefully removed the skull. The skull faced southwest; its base rested on a large flat stone, from which it was separated by two inches (5 cm) of blue clay. Removing the surrounding peat by hand, Raymenton discovered the detached mandible lying, teeth downward, about 8 inches (20.3 cm) southwest of the skull. The human remains were located about six feet southwest of the spot where Maynard recalled finding the mastodon teeth, and they lay in the same relative stratigraphic position. The peat was eight feet thick above the mastodon, but owing to the slope of the basin, it was only five to six feet thick over the human skull. "The peat was saturated with water and the skull had the appearance of being thoroughly water-soaked. The orbits of the eyes, sockets of the teeth and interior of the skull were filled with fine

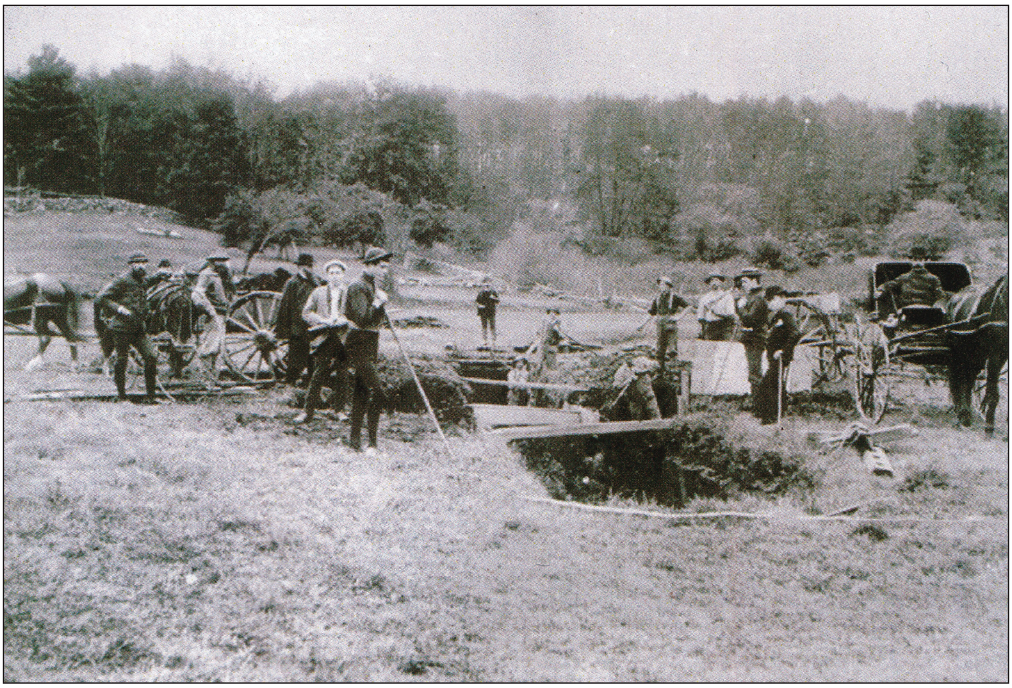

Figure 3. Workmen digging in Maynard's meadow in October 1885 (*Worcester Telegram* photograph used with permission).

peat" (Raymenton 1885a). In his letters to Putnam, Raymenton emphasized that the skull was surrounded by delicate fibers in the peat and that "The horizontal lamination of the peat was everywhere distinctly preserved around the skull" and also was evident in the matrix around the mandible (Raymenton 1885a).

Raymenton showed the skull to members of the Society of Antiquity at a special meeting convened that evening. Although he recounted how he had removed the skull from the peat with his own hands, "Some doubts were expressed as to the character and age of the skull, and the probability of a hoax was discussed" (Worcester Society of Antiquity 1886:102). Franklin Rice suggested that they write to Dr. Putnam and invite him to visit the site and examine the skull. Accordingly, Raymenton and Dickinson contacted Putnam. Putnam replied on October 15, 1885, saying that he could not come immediately owing to the death of his father-in-law, but he would come to Worcester the following Monday.

On Wednesday, October 14, the diggers continued the search for additional human bones or artifacts. Digging about 12 feet north of the spot where Maynard remembered finding the mastodon teeth, a workman encountered a bone fragment, 8 x 4 inches and ¼-inch thick. By probing nearby the workmen found a piece of tusk. They then dug a 4x10-foot trench that exposed a partial tusk, lying at a depth of 7 feet in the peat, 2 inches above a flat rock in the blue clay. The tusk was very soft and broke into pieces upon being removed, although some exterior surface pieces remained firm. In addition to the tusk, some facial bone fragments and three "milk teeth" were recovered. This brought the total number of mastodon teeth to 12.

Meanwhile, Raymenton cleaned the peat from the human skull, saving a sample in a cigar box. By Thursday, October 15, 1885, as the skull dried, its appearance changed. "It had lost something of the yellowish color and the appearance of being water-soaked, was more brown, hard and dry. The outer portion of the bone had begun to scale off in places, the sutures to open a little and the teeth had become somewhat loose in their sockets" (Raymenton 1885a:18).

Putnam arrived in Worcester on Saturday, October 17, visited the site, and examined the human and mastodon bones. That evening, he presented a talk to the Worcester Natural History Society on mammoths and mastodons. He also talked about the human skull. Based on a cursory examination, "he was not prepared to say whether it was the skull of an Indian or a white man. At a glance it appeared to be a cross between the two. He was inclined to think it was the skull of a woman" (Raymenton 1885a:19).

Putnam quickly dashed off a letter report to *Science*, which was published on October 30 under the title, "Man and the Mastodon." He noted that Raymenton's account of the discovery and location of the bones was confirmed by "the evidence of several witnesses" (Putnam 1885:375). Putnam described the context as a "peat bog" (Putnam 1885). The lowest peat immediately covering the skulls had a very fine texture and incorporated a few wood fragments. The overlying peat became increasingly coarse toward the surface; it contained several large logs, and what appeared to be a partially burned stump, about two feet above the human skull. Putnam deduced that both the mastodon and human remains had been moved by water before the peat formed over them. He observed that the human skull was "as deep, if not deeper brown, than the bones of the mastodon. Its comparatively perfect preservation when compared with the mastodon skull is, however, remarkable; but this could easily be accounted for by the longer exposure of the mastodon bones on the surface of a gravel deposit before being washed into the basin" (Putnam 1885:376).

Putnam contacted Willard D. Johnson of the USGS, who examined and mapped the findspot on December 11. Johnson dismissed Putnam's theory that the bones had been transported by a stream. He found that the meadow had long been a landlocked pond in a depressed basin, fed by an underground spring. The water that filled the bottom of the trench was probably still coming from the spring. A channel cut into the pond during the 18th century had drained water southward into Hop Brook (*Worcester Evening Gazette*, December 24, 1885).

Raymenton carefully excavated two stratigraphic sections and packed each in a glass-fronted box. One box was shipped to the Peabody. The other box was taken to the Natural History Society's museum in Worcester; its ultimate fate is unknown.

Putnam sent a sample of the "blue sandy peat" that lay under the mastodon to Professor James Goldsworthy at the University of Michigan. Goldsworthy isolated the tiny diatoms from this matrix, recognizing 15 genera; the most common were *Stauroneis, Cymbella*, *Gomphonema*, and *Tetracyclus*. Putnam reported the results in a letter to Raymenton, from which an excerpt was published in the *Worcester Spy* on May 5, 1887. These diatoms belonged to freshwater genera, consistent with Johnson's inference of a pond in the basin at the time of the animal's death.

Putnam handed the human skull to his assistant, Cornelia Studley, for a comparative analysis "to determine its race characters" (Putnam 1886:493). While she studied the skull, Putnam made some tantalizing comments to the press, including: "the skull has the appearance of being a cross between an Indian and a white man…This is the most remarkable and interesting skull I have ever studied…The skull refuses to be accurately classified. It is unlike anything in the Peabody Museum, and its points of difference are such as tend to confuse rather than explain" (Hartwell 1979:18). After several months, based on Studley's research Putnam concluded that, "It proves to be that of an Indian, with some interesting peculiarities, but it cannot have been long in the peat. It was found by members of the Worcester Society of Natural History while excavating for mastodon remains found under the same layer of peat, but it is evident that it has no association with the mastodon" (Putnam 1886:493).

While preparing this report, we confirmed that the human skull and mandible are still stored today at the Peabody Museum. Fiedel examined these remains. As Putnam noted, the skull is brown, much darker than the mastodon bones. It exhibits some post-depositional damage, such as broken zygomatic arches and nasal bones. The maxilla retains four teeth; the mandible holds three molars. Neither the upper nor lower dentition includes the incisors; therefore, the most diagnostic dental attribute that would indicate Native American affiliation is missing. The forehead seems to be rather sloping. Both the orbits and the nasal cavity appear extraordinarily large. Based on a prominent mental eminence and modest supraorbital ridges, the individual appears to be a male; the third molars had erupted and they display some wear, but the cranial sutures had not fused, so this was an adult, but not an elderly man. The skull measures about 165 mm long and 129 mm wide, for a cephalic index of .78.

Several years prior to the discovery of the Northborough skull, Lucien Carr (1880) had reported his analysis of 67 skulls of New England Indians (including 40 from Massachusetts) in the collection of the Peabody Museum at Harvard. Carr separated the skulls into male and female sub-groups for his analysis, but Hrdlicka (1916) later remarked that Carr's sex assignments had been unreliable. Carr reported the average length of 29 female skulls as 175 mm; the average width was 132 mm, and the average cephalic index was .752. The minimum length was 165 mm and the minimum width was 122 mm. For 38 male skulls, Carr reported an average length of 180 mm, an average width of 138 mm, and an average cephalic index of .767. The minimum length of the male skulls was 168 mm, and the minimum width was 129 mm. In this respect, the Northborough skull falls close to the average of this sample. Carr's assessment of the population's diversity is particularly pertinent to our inquiry: "The crania differ among themselves in every possible way….and in their distinguishing features, are … hopelessly mixed" (Carr 1880:9).

Carr's brief report included drawings of one male and one female skull, both from Massachusetts. In profile outline, the female skull is quite similar to the Northborough skull. However, in frontal view, the orbits and nasal cavities of both the male and female are markedly smaller than those of the Northborough skull. A broader comparison with published illustrations of Native American skulls shows similarities in shape, particularly to some individuals from southern California (Hrdlicka 1907: Plates 18, 20). The facial features can be nearly matched by some skulls from the Chilean coast, dated to ca. AD 500–1000 (Marsteller et al. 2011). On the other hand, the Northborough skull is surprisingly similar to crania from Australia and Egypt. It also resembles the generic African last common ancestor of *Homo sapiens* as virtually reconstructed by Mounier and Lahr (2019: fig. 3 in that publication). As demonstrated by re-analyses of presumptive Paleoindian crania in relation to ancient DNA from the same specimens, skull measurements alone cannot reliably affiliate ancient individuals to any ancestral population (Manriquez et al. 2011, Perez et al. 2009, Raghavan et al. 2015). We note the similarities in geographically distant crania because such an assignment would support the skull having been fraudulently planted—not from a population that lived near and at the time of the mastodon. The human skull might have been deposited near the mastodon remains by sheer coincidence at some time during the Holocene. The untrained excavators' failure to perceive any trace of an indigenous burial pit in this matrix is understandable. A hypothetical pit might have stopped when the diggers encountered the hard-packed, stony clay. In that case, the position of the human skull at the same interface where the mastodon lay would not be an indication of their true contemporaneity. Analogies are provided by the Early and Middle Archaic burials in peat from Windover (Doran 2002) and several other sites in Florida as well as late Holocene burials in Missouri (Bass and McMillan 1973, McMillan 2019), although we have no archaeological evidence of this practice in the Northeast. Radiocarbon dating would be necessary to determine the age of the Northborough skull, and DNA sampling would be required to ascertain its specific cultural affiliation.

While the human skull went to Harvard in 1885 and has stayed there since, the mastodon remained in Worcester, MA. The Worcester Natural History Society became the Worcester Science Museum in 1960, the New England Science Center in 1986, and the Worcester EcoTarium in 1998. The EcoTarium now curates most of the surviving teeth, bone and tusk fragments from the mastodon. Hartwell (1979) reported that only two teeth were still in the museum, and that one of these was the tooth shown in Rice's 1885 report. However, that tooth does not seem to be in the EcoTarium collection today. Seven tusk fragments are in the collection of the Northborough Historical Society (K. Pierce, pers. comm. 2020). Some of the material at the EcoTarium is on display, and the rest is in storage. The bone fragments, generally buff to light tan in color, appear to be mainly pieces of maxilla and mandible. The ivory fragments seem to have suffered from exfoliation and warping after they were excavated, resulting in thin, curved pieces. This warping is concordant with Raymenton's (1885a) description of the tusks; however, the dark brown color he mentioned is not evident today. The difference in coloration may be due to a complex history of taphonomic conditions present at the Northborough Mastodon site (Hill et al. 2014, Hill et al. 2015, Widga 2014). A few small areas of short, shallow scratches on the outermost ivory surfaces are of uncertain origin (Fig. 4); they appear, at first glance, potentially anthropogenic, but ostensibly similar scratches on modern African elephant tusks are produced by natural processes

(G. Haynes, pers. comm. 2020). Hartwell (1979), based on newspaper accounts, reported the finding of a "bone tube," 3 inches in diameter, which seemed to be a postcranial element; however, he did not suggest that this was an artifact. We saw nothing matching this description in the EcoTarium collection.

^{14}C Dating Methods

We thought it would be important to obtain an AMS radiocarbon date for the Northborough Mastodon, the only known specimen from central Massachusetts. Following discussions with Fiedel and Driver, Martin Christiansen, Collections Management Specialist at the EcoTarium, agreed to provide two samples. Feranec extracted the samples from a tusk fragment and a bone and submitted them to the W.M. Keck Carbon Cycle Accelerator Mass Spectrometry Laboratory at University of California Irvine (UCI), Irvine, CA, USA.

The bone proved to contain insufficient collagen for an assay, but dentin from the tusk yielded adequate collagen (Table 1). The sample was processed at UCI using standard techniques for bone collagen. Details of sample preparation are available in Beaumont et al. (2010), and on the laboratory's website (https://sites.uci.edu/keckams/files/2016/12/bone_protocol.pdf accessed 20 January 2021). UCI's procedure is a modified Longin (1971) collagen extraction followed by ultrafiltration (Brown et al., 1988). The bone is first mechanically cleaned and then decalcified with relatively strong acid. A weak base treatment may be applied if the presence of contaminating humics is suspected. The resulting crude collagen extract is then hydrolyzed to gelatin at 60^{o} C in weak acid, and the gelatin is ultrafiltered using a Centriprep YM-30 (30,000 molecular weight cutoff) to remove small contaminating molecules. The calibrated date presented in this study was obtained using Calib 8.2 online, based on the IntCal20 calibration curve (Reimer et al., 2020, Stuiver et al., 2018).

Stable isotope data were obtained on aliquots of the ultrafiltered bone collagen and measured on a Fisons NA1500NC elemental analyzer/Finnigan Delta Plus isotope ratio mass spectrometer (Table 2). The $\delta^{13}C_{VPDB}$ and $\delta^{15}N_{AIR}$ values have a precision of <0.1‰ and <0.2‰, respectively.

Figure 4. Tusk fragment from the Northborough Mastodon showing small scratches.

Results and Discussion

The date for the Northborough Mastodon is 11,350±30 rcbp; with a sigma of only 30 years, this is one of the most precise dates yet reported for any mastodon (Table 3). At 2 sigma, the date calibrates in the range of 13,170-13,300 cal BP.

A persistent concern for this and other studies focused on AMS dating of Ice Age faunal remains is the relative credibility of radiocarbon dates on collagen derived from different pre-treatment methods (Deviese et al. 2018, Fiedel et al. 2013, Fulop et al. 2013, Higham 2011, Kuzmin et al. 2018, Marom et al. 2012, McCullagh et al., 2010, Nalawade-Chavan et al. 2014, Waters et al. 2015). Widga et al. (2017) recently reported a large suite of new AMS dates for Late Glacial mastodons and mammoths from the northern Midwest. These samples were processed at the University of Arizona AMS laboratory using the standard acid-base-acid (ABA) technique to yield purified collagen for dating. Nine samples that might produce terminal ages for proboscideans were subjected to additional analyses. The ABA-extracted gelatin was ultra-filtered (UF) and the UF fraction also was dated. In all cases, the UF fraction radiocarbon age was the same as the ABA fraction radiocarbon age at two sigma. Six of the nine paired ABA and UF measurements overlapped at one sigma. Widga et al. (2017)

Table 1. Radiocarbon data for the Northborough Mastodon (*Mammut americanum*).

Radiocarbon Lab #	Specimen	Fraction Modern	^{14}C Age (BP)	2-σ cal age range (cal BP)[A]
UCIAMS 225612	Northborough Mastodon (*Mammut americanum*)	0.2434 ± 0.0009	11,350 ± 30	13,170-13,300

[A]Calibration performed with Calib 8.2 online using the IntCal20 calibration curve (Reimer et al. 2020; Stuiver et al. 2018).

Table 2. Stable isotope values for bone collagen of the Northborough Mastodon (*Mammut americanum*).

Sample Number	$\delta^{13}C$ (‰)	$\delta^{15}N$	%C	%N	C/N[A]
UCIAMS 225612	-20.2 ± 0.1	5.0 ± 0.2	43.7	15.4	3.3

[A]Atomic C/N ratio.

Table 3. Radiocarbon dates on bone from selected proboscidean sites in the Northeast USA.

Site	Material Sampled	^{14}C Age (BP)	Cal BP (IntCal 20)	Lab #	Reference[A]
Northborough Mastodon	Tusk	11,350 ± 30	13,170–13,300	UCIAMS-225612	This Study
Ivory Pond Mastodon	Bone	11,885 ± 30	13,610–13,800	UCIAMS-193953	(1)
Scarborough Mammoth	Tusk	12,720 ± 250	14010–14,300[B]	AA-8215A	(2)
Scarborough Mammoth	Tooth root	12,200 ± 55	14010–14,300[B]	OS-5636	(2)
Scarborough Mammoth	Bone	12,160 ± 50	14010–14,300[B]	CAMS-54733	(2)

Table 3. Continued.

Site	Material Sampled	^{14}C Age (BP)	Cal BP (IntCal 20)	Lab #	Reference[A]
Tunkamoose Mastodon	Tusk	12,300 ± 45	14,100–14,810[C]	OS-78282	(3)
Tunkamoose Mastodon	Tusk	12,350 ± 65	14,100–14,810[C]	OS-78281	(3)
Delaware Mastodon	Bone	12,360 ± 120	14,060–14,970	AA-84998	(4)
Farmington Mastodon	Tusk	12,430 ± 40	14,290–14,900	Beta-[NA]	(5)
Merrimack R. Mastodon	Tooth	12,300 ± 130	13,880–14,960	OS-487	(6)
Poughkeepsie Mastodon	Bone	12,060 ± 40	13,810–14,050	UCIAMS-169202	(7)
North Java Mastodon	Bone	11,630 ± 60	13,350–13,600	Beta-176928	(8)
Hyde Park Mastodon	Bone	11,480 ± 50	13,240–13,460	Beta-141061	(9)
Merrimack R. Mastodon	Bone	11,570 ± 60	13,310–13,580	Beta-371886	(6)
New Britain YWCA Mastodon	Bone (bioapatite)	11,160 ± 130	12,780–13,300	UGAMS-17668	(10)
Merrimack River Mammoth	Tooth root	11,202 ± 88	12,910–13,300	AA106431b	(6)
Grimes Mastodon	Tooth	11,070 ± 130	12,750–13,180	AA-1506	(11)
Berry Mammoth	Tooth	10,930 ± 315	11,950–13,460	AA-1505	(11)
Chemung Mastodon	Bone	10,840 ± 60	12,720–12,890	Beta-176930	(8)
Chemung Mammoth	Bone	10,890 ± 50	12,740–12,900	Beta-176929	(8)
Hiscock Mastodon	Bone	11,390 ± 80	13,120–13,440	AA-6977	(12)
Hiscock Mastodon	Tusk	11,100 ± 80[*]	12,840–13,080[D]	CAMS-30528	(13)
Hiscock Mastodon	Tusk	11,070 ± 70[*]	12,840–13,080[D]	CAMS-30529	(13)
Hiscock Mastodon	Tusk	10,930 ± 70[*]	12,840–13,080[D]	GX-22038	(13)
Hiscock Mastodon	Bone	10,810 ± 50	12,720–12,830	CAMS-62560	(13)
Hiscock Mastodon	Bone	10,790 ± 70	12,670–12,890	CAMS-27143	(13)
Hiscock Mastodon	Bone	10,630 ± 80	12,480–12,740	CAMS-17407	(13)
Hiscock Mastodon	Bone	10,515 ± 120	12,000–12,730	Beta-24412	(13)
Kitchawan Mammoth	Bone	12,950 ±100	15,200–15,780	OS-97775	(3)

[*]Split sample from the same specimen.
[A] (1) Fiedel et al. 2019; (2) Hoyle et al. 2004; (3) Feranec and Kozlowski 2016; (4) Metcalfe 2011; (5) Boulanger and Jones 2015; (6) Claesson et al 2017; (7) Feranec and Kozlowski 2018; (8) Griggs and Kromer 2008; (9) Robinson and Burney 2008; (10) Boulanger et al. 2015; (11) Oldale 1987; (12) Laub et al. 1996; (13) Laub 2003.
[B]Calibrated date from the pooled mean of three dated specimens of Scarborough Mammoth.
[C]Calibrated date from the pooled mean of two dated specimens of Tunkamoose Mastodon.
[D]Calibrated date from the pooled mean of three dates from the same Hiscock Mastodon specimen.

recommend that critical dates (e.g., terminal dates for Ice Age megafauna) be subjected to replicate dating in different labs using various techniques to better certify an age for the specimen or event.

We infer that our new, high precision AMS date for the Northborough Mastodon, and the calibrated age based upon it, are probably accurate, although we cannot entirely preclude the possibility that some contaminants survived ultrafiltration of the sample. In that case, the true age might be somewhat older (or less likely, younger) than the reported age of the tusk (Herrando-Pérez 2021).

Carbon and Nitrogen Isotopes

The $\delta^{13}C$ of the Northborough Mastodon was determined as -20.2 ± 0.1‰ (Table 2). This value is slightly higher than those reported for a bone collagen sample of the Ivory Pond Mastodon from western Massachusetts (-20.8‰ and -20.6‰) (Fiedel et al. 2019). It falls within the established range for dentin from teeth and tusks of Late Glacial mastodons in Ontario and western New York; the mean for those is -20.3 ± 0.6‰ (Metcalfe 2011: Table 6.2). Widga et al. (2020) report $\delta^{13}C$ values for Late Glacial mastodons in the northern Midwest ranging between about -19.5‰ and -22.5‰; many samples cluster in a tighter interval of about -20.5 to -21.5‰. The average for the Older Dryas-age mastodons is -20.5 ± 0.7‰; Bølling-age samples average -20.4 ± 0.5‰; and Allerød-age mastodons average -21.1 ± 0.6‰.

Metcalfe (2011) observed no differences between the $\delta^{13}C$ values of tusk dentin and those of molar tooth dentin or bone, although the $\delta^{13}C$ values she obtained for mastodon bone collagen were slightly lower than those of molar tooth dentin. One reason for this discrepancy may be that most of the bones she sampled came from the Hiscock site in western New York, while most of the teeth came from Ontario. Metcalfe (2011) noted that the small inter-regional difference might be ascribed to a variety of metabolic, vegetational, or climatic factors, different timing of formation, or tissue-dependent isotopic fractionation.

The $\delta^{15}N$ of the Northborough Mastodon is 5.0 ± 0.2‰. This value is unexpectedly high, compared with samples from both New England and farther west, but not as high as would be expected for mammoths in this region (Fig. 5). A mastodon mandible dredged up from the paleodelta of the Merrimack River off the coast of New Hampshire, dated to 11,570 ± 60 rcbp (13,280–13,540 cal BP) has a $\delta^{13}C$ value of -19.4‰ and a $\delta^{15}N$ value of 3.0‰ (Claesson et al. 2017). The $\delta^{15}N$ value of the Ivory Pond Mastodon from western Massachusetts is 2.9‰ (Fiedel et al. 2019). Ontario and western New York mastodons average 2.3 ± 0.3‰ (Metcalfe 2011, Metcalfe et al. 2013). The Northborough Mastodon's value is just beyond the range reported for mastodons from Michigan, Ohio, Indiana, and southern New York (3.9 ± 1.0‰) (Koch 1991). Metcalfe (2011) observed that dentin from the roots and crowns of mastodons' molar teeth had significantly higher $\delta^{15}N$ values than tusk dentin or bones. She speculated that the teeth, formed early in the animal's life, might retain a signal from nursing, while continuously-growing or remodeling tusk, bone, and cementum would reflect the adult diet.

Widga et al. (2020) set a $\delta^{15}N$ value of 5‰ as the dividing line between the majority of Late Glacial mastodons in the Great Lakes region and a distinctive population, with values below 5‰, that lived in the lower Great Lakes (39–43° latitude) during the Bølling-Allerød. The division corresponds roughly to 41° N latitude (Widga et al. 2020: fig. 8). Although no factor has been pinpointed as the explanation for these low $\delta^{15}N$ values, Widga et al. (2020) list various potential causes, such as changes in the age at weaning, expansion of available ecological niches, *in situ* changes in an extant niche, or a mix of these factors. Metcalfe et al. (2013) suggest that the generally low values in mastodons, in contrast to mammoths, reflect their occupation of a recently deglaciated landscape with young soils and their consumption of either nitrogen-fixing plants (e.g., alder or lichens), or of spruce. These low values might indicate the mastodons' occupation of open spruce forests (Metcalfe 2011, Metcalfe et al. 2013). Southern New England was covered by a spruce-jack pine forest throughout the Bølling-Allerød (Oswald et al. 2018). Spruce needles have very low $\delta^{15}N$ values (Schulze et al. 1994), and it is widely assumed that mastodons browsed often on spruce twigs, needles and bark (e.g., Dreimanis 1968: Table 2; Griggs and Kromer 2008, McAndrews 2003, Teale and Miller 2012, Yansa and Adams 2012; but for evidence of a more diverse diet, see Birks et al. 2018, Lepper et al. 1991, and Newsom and Mihlbachler 2006). In any case, the mastodons that lived south of the Great Lakes during the Bølling-Allerød were feeding in a "disharmonious" woodland dominated by black ash (Saunders et al. 2010), not an open spruce forest. At that time, the mastodon population appears to have been extraordinarily dense (Widga et al. 2017). Widga et al. (2020) speculate that the anomalous low $\delta^{15}N$ values of that southern population might be attributable to the mastodons' consumption of isotopically light plant shoots, which could have resulted from the plants' increasing uptake of volatilized ammonia (NH_4) from organic sources, including the animals' own urea excreted while they crowded around water sources. However, the hypothesized megafaunal crowds should also have created fecal concentrations around ponds. This is not indicated by the very low percentages of dung-dependent fungi in Midwestern pond sediments during this period (Gill et al. 2009).

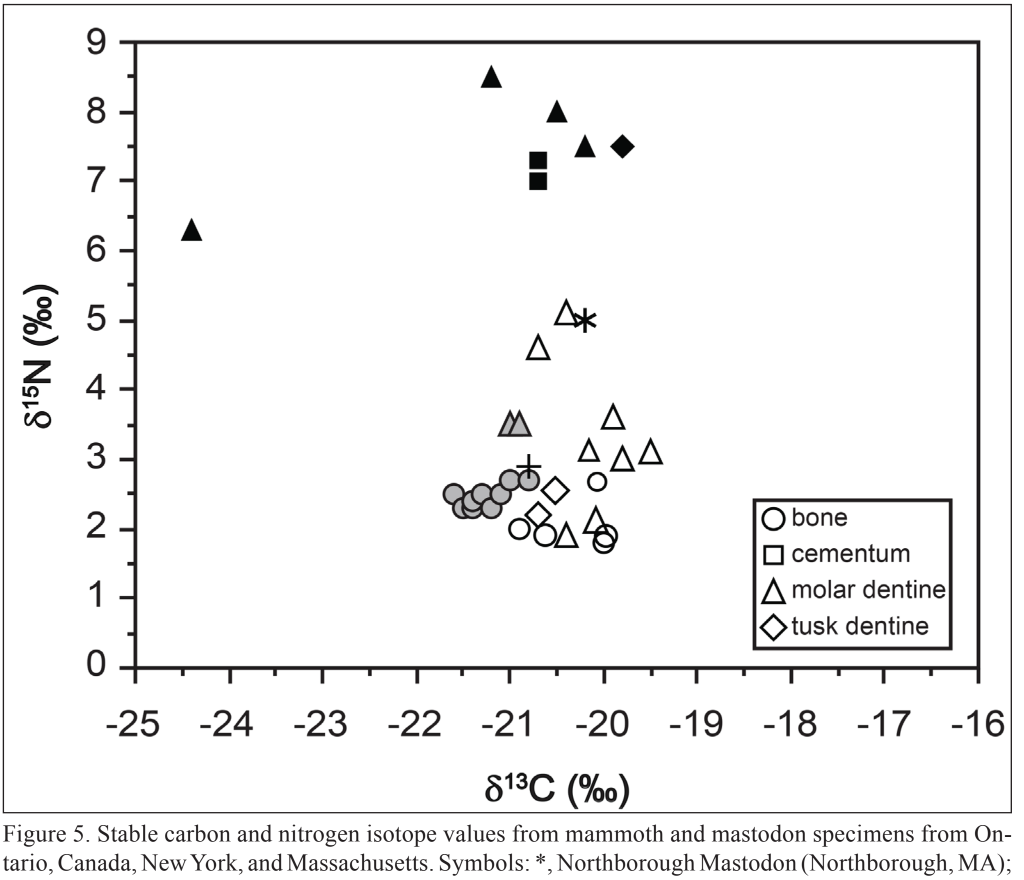

Figure 5. Stable carbon and nitrogen isotope values from mammoth and mastodon specimens from Ontario, Canada, New York, and Massachusetts. Symbols: *, Northborough Mastodon (Northborough, MA); +, Ivory Pond Mastodon (South Egremont, MA); Black symbols, Ontario mammoths; Open symbols, Ontario mastodons; Gray symbols, New York mastodons. Figure modified from Metcalfe et al. (2013).

Implications of the Depositional Context

With rare exceptions, mastodons in the Northeast have been found in ponds or bogs. Putnam described the meadow where the Northborough Mastodon was found as a "peat bog". Raymenton noted that the 5-acre meadow "was many years ago overflowed and used for raising cranberries and it is only within a few years, by means of ditching, draining and carting on of earth that a surface has been formed capable of sustaining the weight of heavy teams" (Raymenton 1885a:1). This modification explains the presence of the horse-drawn carriages and carts visible in the period photograph of the 1885 excavations (Figure 3). Below this artificial surface, the meadow was still very wet. "It is full of springs and water stands, in the various ditches that have been cut, the year round" (Raymenton 1885a:1). When digging began in 1885, Maynard's ditch contained some 15,000 gallons of water to within a foot of the top (Raymenton 1885a). The water had to be pumped out while it continued seeping into the ditch from the sides and from springs.

The findspot lies today in a wetland on a 2-acre patch of soil classified as a Whitman fine sandy loam. The typical pedon for this soil type includes only an inch of peat at the top. Perhaps the peat or muck, valued in the 19th century as fertilizer, had all been stripped off before the first soil surveys were conducted in the 1960s. There were still some thick peat deposits in Worcester County in the early 20th century, but far from the mastodon findspot; Soper and Osborn (1922) noted the presence of 7-foot-thick peat near Quaboag Pond, more than 40 km southwest of Northborough. We did not re-examine the field for this report. The stratigraphic descriptions by Rice, Putnam, and Raymenton are all consistent: thick, water-saturated, laminated peat overlying blue clay with stones, and in some places, directly on bedrock.

Typically, mastodons have been found in ponds or bogs where a marl layer lies below the peat. Generally, the acidity of peat causes destruction of bones lying within it. Underlying alkaline marl or shell deposits counteract the peat's acidity and foster bone preservation. Groundwater percolating into the bog from surrounding alkaline bedrock can have a similar effect. However, none of the stratigraphic descriptions mention any marl, and the regional bedrock is not limestone that might counteract groundwater acidity. In northern Europe as well as in sites around the Great Lakes in the United States, bones of early Holocene age are often very well-preserved in peat (Boethius et al. 2020, Hill et al. 2014, Hill et al. 2015, Widga 2014). Anoxic conditions, not pH, appear to the most important factor that accounts for this. Drainage ditches can introduce oxygen, which creates more acidic groundwater that accelerates bone decay (Boethius et al. 2020). It is interesting to note that, when the mastodon was discovered in Northborough, savants across the Atlantic were debating the precise stratigraphic position of skeletons of the "Irish Elk", *Megaloceros*, in Ireland and the Isle of Man. In the early 19th century, almost all of these had been found in the marl underlying peat. However, in *Nature* in 1882, G. Kinahan reported his observation of an elk skull that lay almost entirely in peat. The bone and antler in the peat were soft, but hardened after they were removed (Kinahan 1882). Raymenton (1885a) reported a similar process after the Northborough bones were exposed.

It is a truism of paleontology that teeth generally survive longer than bone, but it is not obvious why pieces of the mandible or maxilla were preserved in this case, along with the teeth. The skulls of mastodons and other proboscideans have very thin cortical bone; Barbour (1932:247) noted that "the bone covering much of the crown has about the thinness and fragility of an egg shell. Accordingly, it is easily broken through". Thus, the presence of only small skull fragments associated with the Northborough animal's teeth can be attributed entirely to normal weathering and later breakage after burial. However, there is no unambiguous record of any postcranial bones having been discovered during the subsequent 1885 digging in Maynard's meadow (although the 8-inch-long fragment might have been a piece of long bone or rib). It is possible that only the mastodon's detached head was ever deposited here, but that raises the question of how and why it became separated from the carcass. The same question could be asked about the human skull and mandible (assuming that they were not fraudulently deposited). Fisher (2009) hypothesized that "head-alone" mastodon sites might represent the remnants of consumption by humans, during the winter, of fat-rich brains and nasal mucosa from heads that they had cached in ponds during the spring. The early-Clovis-contemporary date of the Northborough mastodon would be consistent with a human role in its deposition, even if the human skull has no real association with the proboscidean remains. However, we note that Fisher's model is, as yet, unsupported by association with lithic or osseous artifacts or recognition of unambiguous butchering marks at any of the "head-alone" sites. These sites might, instead, represent the normal behavior of some Pleistocene carnivores and scavengers, discarding the unwieldy heads.

Fisher (2009:71) inferred that the tusks of the Hyde Park, New York mastodon indicated both atypically late maturation (at 15 years of age) and annual musth battles from the age of 23 until his death at 36, "implying a dense local population of adult male adversaries". It is clearly risky to model the behavior of an extinct species as identical to that of surviving distant relatives. In modern African elephants, males' first musth typically occurs between the ages of 25 and 30, and the presence of older bull males suppresses this behavior in younger males (Slotow et al. 2000, Vidya and Sukumar 2005). First musth as early as age 23 might thus imply a rather sparse presence of older bulls. The Hyde Park animal has been dated to 11,480 ± 50 rcbp. If Fisher's interpretation is correct, the density of mastodons living east of the Hudson during the Bølling-Allerød must have been much greater than is suggested by the very small number of accidentally preserved skeletons in New England. Nevertheless, the history of the Northborough discovery implies that this sparse record, although perhaps misleading with respect to the original living population, may at least accurately represent the frequency of surviving fossils on the landscape. Nineteenth-century farmers stripped off massive amounts of muck and peat to "freshen" their fields with nitrogen, and when they unearthed megafaunal bones in the process, they knew they had something of both scientific and monetary value. Hence, Maynard demanded $500 to permit the Worcester antiquarians to search for more remains in his field. If dozens or hundreds of mastodon teeth were being unearthed by New England farmers in the 19th century, many of these finds should have made it into the newspapers; but in fact, the Northborough incident is one of only two cases in Massachusetts (the other was the accidental discovery of a tooth in Colerain, which was reported to geologist Edward Hitchcock in 1871 [Hitchcock 1872]).

Were Humans and Mastodons Contemporaneous in New England?

The purported association of a human skull with an extinct proboscidean at Northborough was not the first such claim, nor would it be the last. In 1842, Danish naturalist P.W. Lund had reported human remains mixed with those of extinct fauna in the Lagoa Santa caves in Brazil. In 1845, M.W. Dickeson reported his discovery of a mineralized human pelvis stratified below fossils of mastodon, ground sloths, horse and bison in Natchez, Mississippi. Dickeson excavated the bones from blue clay at the base of a bluff. The famous English geologist, Charles Lyell, observed this locality during his American trip in 1846. He suggested that all of the bones probably had been redeposited, which resulted in reversed stratigraphy. Although the dark color of the pelvis resembled that of the megafaunal bones, Lyell hypothesized that it had been blackened while it lay in the peat at the top of the bluff; he was informed that more recent Native American burials were of a similar appearance (Lyell 1863). Dickeson originally came from Philadelphia, and he donated the Natchez fossils to the Academy of Natural Sciences there. In 1895, Thomas Wilson of the Smithsonian obtained pieces of the pelvis and a giant sloth (*Paramylodon*) bone for a comparison of their chemical content. This was one of the first attempts to use fluorine for relative dating of bone; a similar test would provide conclusive evidence, decades later, of the recent age of Piltdown Man. Wilson concluded that the human pelvis was about as old as the sloth bone (Wilson 1895). Nearly a century later, John Cotter re-located the pelvis and the *Paramylodon* bone to which Wilson had compared it, and arranged for their radiocarbon dating by the University of Arizona. The pelvis dated to 5580 ± 80 rcbp; the sloth, to 17,840 ± 125 rcbp (Cotter 1991).

In 1866 a heavily mineralized *Homo sapiens* skull was found in a deep mine shaft in Calaveras, California. Its stratigraphic position implied that it must be of Pliocene age. However, stories soon emerged that the local miners had planted the skull as an amusing hoax. Nevertheless, the director of the California Geological Survey, J. D. Whitney, believed the find was genuine (Dexter 1986). Whitney was appointed as a professor at Harvard in 1865. In 1880, with funding from Harvard's Museum of Comparative Zoology, he published *The Auriferous Gravels of the Sierra Nevada of California*, in which he still argued for the authenticity of the controversial Calaveras skull. The skull remained at the Peabody Museum. In 1992, Taylor et al. reported radiocarbon dates for an associated metatarsal bone; these indicated an age of less than 1,000 years (Taylor et al. 1992).

Frederic W. Putnam, Whitney's Harvard colleague, was a staunch advocate of early human occupation of the Americas. Like Whitney, he thought the Calaveras skull was genuine, and he even made a trip to California in 1901 to visit the mine in an effort to verify the discovery. Putnam would surely have been predisposed to accept the association of the Northborough human skull with the mastodon. Why, then, after he excitedly reported the find in *Science* in October 1885, did he hand off the skull to his young assistant, Miss Studley, and then quietly refute its ostensible antiquity? A reasonable speculation would be that the suspicions of fraud voiced immediately upon the announcement of the find in Worcester were also soon communicated to Putnam, who prudently distanced himself from a possible fiasco in the making. Several items in the Peabody Museum file support this inference. In a letter to Putnam dated October 26, 1885, which accompanied photographs of the site, Raymenton seemed defensive about the rumors: "There were five persons looking on when the skull was unearthed, and I realized the importance of having them observe the condition of the earth about the skull and called their attention to the fact that to all appearances and as well as we could observe it was in the same condition as that where the bones of the mastodon were found. Would it be of any value to have their affidavits taken to that effect? So little attention was given by the scientists to the finding of the bones of the mastodon last fall that I did not suppose any special attention would be paid to the skull. Had I supposed you would have taken the interest you have I would have stopped work at once when the skull was found and waited till you could have seen it in place and taken it out in person". In a note added to the file in 1915, Peabody's secretary, Frances H. Mead, stated about the "Shrewsbury skull", "On further examination it was, 1887, pronounced to have been "planted" by a "scientific hand". In a January 7, 1916 note to "Mr. Willoughby" (presumably Charles C. Willoughby, director of the museum from 1915 to 1928), Ms. Mead quotes F. W. Putnam's son as saying that his father's scrapbook contained "no expressed opinion by the professor, but just statements picked up by reporters to the effect that the skull was doctored and made to look antique and then planted". Given the circumstances of the reported discovery, Mead's insinuations about "doctoring" by a "scientific hand" obviously were aimed at Dr. Raymenton. Raymenton, born in 1852, had earned his M.D. in 1873 from the Columbia University College of Physicians and Surgeons (Anonymous 1937). He was employed as a resident assistant physician on the staff of the Asylum for the Chronic Insane in Worcester (Anonymous 1881). In that position, he might have had access to the associated cemetery. He was active for many years in the Natural History Society, ran a natural history camp for boys, and evidently saw himself as a naturalist. By 1922, when was 70, he and his son were living in San Diego. In that year Raymenton was hired as Director of Gardens at the new zoo. In 1926 he became involved in a dispute about ownership of the zoo buildings. In 1928 the Balboa Park board moved to expel him from the building where he lived and worked, "carrying on experimental work with insects" (Amero n.d.). Raymenton died in San Diego in 1937.

An analogous discovery was reported in Florida, 40 years after the human skull was found in Northborough. In 1922 a landowner in the Melbourne area, C. P. Singleton, discovered fossils on his property and contacted the Smithsonian Institution. James Gidley, assistant curator at the Natural History Museum, asked his friend Frederic Loomis, a professor at Amherst College, to investigate the find. Digging at the site in December, 1923, Loomis found two *Mammuthus columbi* Falconer (Columbian Mammoth) skeletons and remains of other Pleistocene species. Within the rib cage of one of the mammoths, he uncovered a "rough flint implement shaped like an arrowhead" (Loomis 1924:503). Gidley joined Loomis in 1925 for further excavations at three loci (Gidley 1926). They found the crushed skull of a woman, along with some postcranial pieces, in the same stratigraphic context as the mammoths; Gidley suggested that her head "had been stepped on by a mastodon or mammoth" (Stewart 1946:1). Gidley and Loomis were convinced that these finds demonstrated the presence of humans alongside megafauna in Florida some 15 to 25,000 years ago. This assertion was sharply criticized, first by the aged W. H. Holmes who, 30 years before, had demolished F. W. Putnam's claims for early human occupation of the Americas, and then by Ales Hrdlicka. Ironically, in view of Hrdlicka's vituperative criticism of all such claims, his entry into a career in physical anthropology in the 1890s had been facilitated by Putnam's recommendation. Hrdlicka stormed into the December 28, 1925 meeting of the American Paleontological Society in New Haven, to dispute Gidley's paper assigning a Pleistocene age to the human remains from Melbourne (Stewart 1946, Meltzer 2015). Two decades later, T. Dale Stewart examined the skull, which was curated at the Smithsonian. He found that Hrdlicka had reconstructed the skull badly. It was actually long-headed, like other putatively early Native American skulls, and thus could be of Late Pleistocene antiquity, after all (Stewart 1946). Gidley and Loomis had kept working at the Melbourne site until 1930. The landowner, Singleton, also had continued collecting from the site. He donated his fossils to the Museum of Comparative Zoology at Harvard. One of Loomis's mammoths was restored and mounted and remains on display in the Beneski Museum of Natural History at Amherst College (It recently became the school's mascot!). The fate of the first mammoth Loomis found is unknown (Patterson 2019). To our knowledge, no attempt has been made to date either the Amherst mammoth or the human skull.

In a previous report on the re-dating of the Ivory Pond Mastodon (Fiedel et al. 2019) we discussed possible explanations for mastodons ending up dead and dismembered in Late Glacial ponds. As there is very limited contextual evidence relating to the Northborough find, it contributes little to resolution of this problem. We reiterate our previous conclusion that, given the demonstrated presence of humans south of the ice sheets by ca. 13,400 cal BP and their possible presence a millennium earlier (as suggested by artifacts associated with proboscideans' remains in Washington (Waters et al. 2011), Wisconsin (Joyce 2006, 2013) and Florida (Halligan et al. 2016)), human predation pressure cannot be precluded as a factor causing mastodons to seek refuge in wetlands. Dated to ca. 13,200 cal BP, the Northborough Mastodon died 200 years after humans butchered camels and horses at Wally's Beach in Alberta (Waters et al. 2015) and Clovis hunters killed a gomphothere in Sonora (Sanchez et al. 2014). The most precisely dated Clovis site in North America is Shawnee Minisink (10,940 ± 15 rcbp, ca. 12,800 cal BP) in northeastern Pennsylvania, about 380 km southwest of Northborough (Gingerich 2013). However, no Paleoindian site in New England has yet yielded credible radiocarbon dates earlier than 10,700 rcbp (ca. 12,750 cal BP), and very few surface-collected fluted points in the region are attributable to the "classic" Clovis style dated elsewhere to 13,400–12,800 cal BP.

Separate studies observe a peak occurrence of dated mammoths and mastodons in the northern Midwest and the Northeast (including New England) between 14,000 and 12,700 cal BP (Widga et al. 2017, Boulanger and Lyman 2014). These studies interpret this maximum very differently, either as evidence of a booming predator-free population (Widga et al 2017) or instead, as an indicator of the accelerating mortality rate of a declining regional population (Boulanger and Lyman 2014). Despite their contrasting interpretations of the Allerød-aged abundance of proboscidean specimens, Widga et al. (2017) and Boulanger and Lyman (2014) agree in discounting the possibility that the extinction of these species by ca. 12,500 cal BP was related to the arrival of fluted point-using humans around 13,000 cal BP (Lothrop et al. 2016). We note here that the new Northborough Mastodon date fits comfortably within the 14,000–12,700 cal BP peak identified by Boulanger and Lyman (2014) and Widga et al. (2017), but we suspect that human arrival was more causative in the extinction of these species than these authors would allow.

Conclusions

The Northborough Mastodon has yielded a precise AMS radiocarbon date of 11,350 ± 30 rcbp (13,170–13,300 cal BP at 2σ). This result, along with our recent assay for the Ivory Pond mastodon and similar dates for other specimens, indicates that mastodons were abundant in New England after expansion of boreal forest (prime mastodon habitat) into the region ca. 14,600 cal BP, and persisted until ca. 12,700 cal BP. This mastodon's N and C isotope values resemble those of Allerød-age mastodons from south of the Great Lakes and may indicate its adaptation to a similar niche. The association with a human skull, claimed at the time of discovery but later dismissed on suspicion of fraud, cannot now be demonstrated. Nevertheless, the age of the Northborough Mastodon is synchronous with early Clovis dates and, along with other skeletons of Allerød age, raises the possibility that human predation may have been involved in the extinction of this and other megafaunal species in the Northeast US.

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