

# A New AMS Radiocarbon Date for the Ivory Pond Mastodon

Stuart Fiedel, Robert Feranec, Thomas  
Marino, and David “Bud” Driver



# EASTERN PALEONTOLOGIST

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## A New AMS Radiocarbon Date for the Ivory Pond Mastodon

Stuart Fiedel<sup>1\*</sup>, Robert Feranec<sup>2</sup>, Thomas Marino<sup>3</sup>, and David “Bud” Driver<sup>4</sup>

**Abstract** - The Ivory Pond Mastodon (*Mammut americanum*) was found in South Egremont, Massachusetts, in 1982. A recent AMS radiocarbon assay on bone collagen yielded an age of 11,885 ± 30 rcbp (UCIAMS 193953), which currently calibrates to 13,580–13,770 cal BP. This date is statistically similar to a much more imprecise date (GX9024-G; 11,440 ± 655 rcbp; 11,500–15,290 cal BP) previously obtained from the specimen. This age is similar to those of other American Mastodon specimens; collectively, these dates imply prior expansion of boreal forest (mastodon habitat) into the region ca. 14,600 cal BP. The location of this specimen east of the Hudson River implies that Late Glacial proglacial lakes that occupied the Hudson River Valley in the past were not a hindrance to megafaunal colonization of New England. The chronology and depositional contexts of this and other mastodon specimens in the region necessitate that human predation be considered as a possible cause of the extinction of this and other megafaunal species in the northeast US.

### Introduction

*Mammut americanum* (American Mastodon, hereafter, mastodon) is a quintessential species of the Pleistocene epoch; its remains occur in particular abundance in eastern New York. Markedly fewer specimens have been discovered east of the Hudson River in New England. Data regarding the American Mastodon’s distribution and relative abundance are important for understanding ancient habitats, dispersal, and colonization, and the patterns and causes of extinction. Here, we review the discovery and some of the initial findings about the Ivory Pond Mastodon (found in 1982 in South Egremont, MA; Fig. 1). Interestingly, the first published record of a North American fossil vertebrate is Cotton Mather’s description of a mastodon tooth found in Claverack, NY, less than 32 km (20 mi) west of Ivory Pond (Mather 1714). Although early investigations were undertaken on the Ivory Pond specimen, these produced minimal published literature. We present here a review of the context, a new AMS radiocarbon date for the mastodon, and a discussion

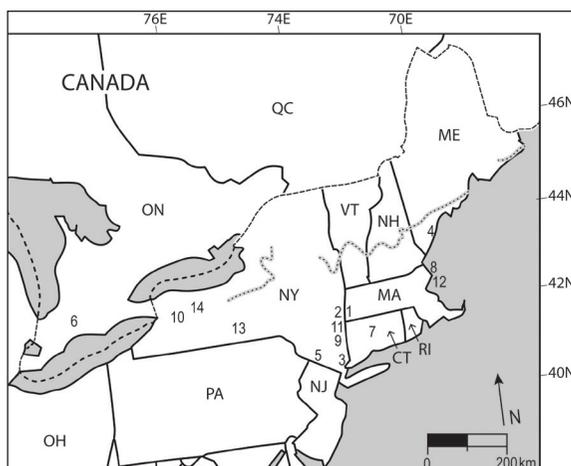


Figure 1. Map of locations of mammoths and mastodons mentioned in this study. Numbering as follows: 1, Ivory Pond Mastodon; 2, Claverack Mastodon; 3, Kitchawan Mammoth; 4, Scarborough Mammoth; 5, Tunkamoose Mastodon; 6, Delaware Mastodon; 7, Farmington Mastodon and New Britain YWCA Mastodon; 8, Merrimack 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. Gray-highlighted dots represent the ice-front positions of the Laurentide Ice Sheet about 14,600 cal BP (Ridge, 2019).

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of its implications regarding mastodon ecology, colonization of New England, and the extinction of this and other megafaunal species at the end of the Pleistocene.

## Background

### Discovery and initial examination of the Ivory Pond Mastodon

The Ivory Pond Mastodon was accidentally discovered by Thomas Marino in June 1982, during mechanical excavation to create a pond in a muck-filled glacial kettle-hole on his property in South Egremont, MA. Marino troweled and sifted through the backdirt pile of muck and marl, thus recovering bones, teeth, and ivory, as well as cones of *Picea glauca* (Moench) Voss (White Spruce) and seeds of *Najas flexilis* (Willd.) Rostk. & Schmidt (Nodding Waternymph). The mastodon remains included parts of the left and right humeri, left tibia, teeth, and tusks. Marino treated most of this material with preservatives (polyethylene glycol, polyvinyl acetate, and Carnuba wax) but set aside some unpreserved bone and cones for possible radiocarbon dating. Marino first received assistance from James Parrish and curatorial staff from the Berkshire Museum (Pittsfield, MA). Although he contacted other institutions to undertake further investigations at the site, the only enthusiastic response came from Roger Moeller, then at the American Indian Archaeological Institute (since renamed as Institute for American Indian Studies, Washington, CT) (Moeller 1984, Parrish et al. 1983). Moeller was particularly excited by the possibility of butchery by Paleoindians, which seemed to be indicated by ostensible cut marks on a distal humerus fragment, and launched a research effort. Screening of the spoil pile also yielded a fist-sized cobble and a chert flake, which, though only very loosely associated with the bones, might conceivably have been used as butchering tools. However, the cutmarks subsequently were identified by Pat Shipman (then at Johns Hopkins University, Baltimore, MD) as vascular grooves, not cutmarks. There was no evidence of either machine- or water-induced striations. Moeller (1984) surmised that the bones, derived from massive skeletal elements, must already have been broken at the edge of the bog prior to their submergence; he speculated that predators (probably non-human) had been responsible. It is important to note that an unknown portion of the skeleton may remain unexcavated in the muck, so the representation of skeletal elements cannot be used for comparative taphonomic analysis.

Researchers from the New York State Museum (Albany, NY), directed by Robert Funk, and the University of Massachusetts (Amherst, MA), directed by Dena Dincauze, took 2 pollen cores from the vicinity of the bog. Sediment samples were taken at 5.08-cm (2-in) increments for pollen analysis (Lewis 1984:Table 1). The pollen indicated that the deglaciated landscape had first supported a sedge tundra or park-tundra, followed by a boreal forest of spruce, *Pinus banksiana* Lamb. (jack pine), *Betula* (birch), and probably *Populus* spp. (aspen), with *Abies* sp. (fir) and *Larix laricina* (Du Roi) K. Koch. (tamarack) increasing over time. Spruce was dominant at the top of this lower sequence (perhaps indicative of Younger Dryas onset at 12,800 cal BP?) followed by a hiatus, after which late-Holocene *Castanea* sp. (chestnut) pollen was unusually prevalent (Lewis 1984). The location of the cores was estimated as about 45.7 m (50 yards) from the mastodon bones, and the latter (found at an unspecified depth) could not be linked definitively to any section of the pollen sequence.

### Old and new radiocarbon dates

During the early investigations, 2 untreated samples (i.e., white spruce cones, bone) were submitted to Geochron Laboratories (Cambridge, MA) for radiocarbon dating. These

samples were treated at the lab using techniques that were standard at the time. As per the 1983 report, the spruce sample was cleaned of exogenous dirt, split into smaller pieces, and treated with hot HCl to remove carbonates, and hot NaOH to remove humic acids. The sample was then combusted and analyzed. The results (Table 2) were reported in January 1983. White spruce cones were dated to  $11,630 \pm 470$  rcbp (GX-9259). This date was not corrected for  $^{13}\text{C}$  fractionation. The Mastodon bone was decalcified, washed, boiled in slightly acidic water, and then filtered. The filtrate was evaporated and the collagen was recovered as bone gelatin. This small sample of gelatin was dated to  $11,440 \pm 655$  rcbp (GX-9024-G) and the date was corrected for  $^{13}\text{C}$ ; the  $\delta^{13}\text{C}$  was reported as  $-20.6\text{‰}$ .

### Methods

Since the time of this initial dating, AMS technology has come into wide use in archaeology and Quaternary environmental research. Direct counting of carbon atoms permits much more precise dating of samples than the old radiometric method. Given the very imprecise nature of the previous date for the animal (ranging from 10,785 to 12,095 rcbp at 1 sigma), and its unique status as the only known Terminal Pleistocene proboscidean in western Massachusetts, we thought it would be important to obtain a more precise AMS date. Following discussions with Fiedel and Driver, Marino provided a sample of untreated bone stored in his collection from the site, and Feranec submitted it to the W.M. Keck Carbon Cycle Accelerator Mass Spectrometry Laboratory at University of California at Irvine (UCI; Irvine, CA). The remaining portion of this sample is curated in the vertebrate paleontology collection of the NY State Museum as NYSM VP-16555.

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

Table 1. Pollen zones near Ivory Pond (Lewis 1984). Original data are in inches.

Depth (cm)	% NAP	Arboreal data	Interpretation (Lewis 1984)
Near surface	-	Chestnut decline	20 <sup>th</sup> -century blight
61	-	Chestnut (24%)	Ca. 3000 rcbp
63.5–86	[hiatus]	-	-
88	-	Spruce, fir, tamarack	Ca. 10,000 rcbp; boreal forest, fir and tamarack increasing
101	-	-	Abrupt change from mineral to organic sediments (typical for late spruce pollen zone)
109	33	Spruce dominant	-
124	76	Pine dominant	Tundra or park–tundra

Table 2. Radiocarbon data for the Ivory Pond Mastodon reported in 1983.

Radiocarbon Lab #	Specimen	Fraction Modern <sup>A</sup>	$^{14}\text{C}$ Age (BP)	2- $\sigma$ cal age range (cal BP) <sup>B</sup>
GX-9259	White Spruce cones	NA	$11,630 \pm 470$	12,650–15,040
GX-9024-G	Ivory Pond Mastodon	NA	$11,440 \pm 655$	11,500–15,290

<sup>A</sup>Not provided in initial report.

<sup>B</sup>Calibration performed with Calib 7.1 online using the IntCal13 calibration curve (Reimer et al. 2013, Stuiver et al. 2018).

website ([https://www.ess.uci.edu/group/ams/files/bone\\_protocol.pdf](https://www.ess.uci.edu/group/ams/files/bone_protocol.pdf)). 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 °C in weak acid, and the gelatin is ultrafiltered using a Centriprep YM-30 (MilliporeSigma, Burlington, MA; 30,000 molecular weight cutoff) to remove small, contaminating molecules. The purified gelatin extract is then freeze dried in a vacuum centrifuge.

Calibrated dates presented in this study were obtained using Calib 7.1 online, based on the IntCal13 calibration curve (Reimer et al. 2013, Stuiver et al. 2018). Stable isotope data were obtained on aliquots of the ultrafiltered bone collagen and measured on a Fisons NA1500NC elemental analyzer (IsoMass Scientific, Inc., Calgary, AB, Canada)/Finnigan Delta Plus isotope ratio mass spectrometer (Select Science, Waltham, MA).  $\Delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  values have a precision of <0.1‰ and <0.2‰, respectively.

### Results and Discussion

UCI provided a new AMS date (Table 3) and carbon and nitrogen isotope measurements for the collagen of the Ivory Pond Mastodon (Table 4). The new date,  $11,885 \pm 30$  rcbp, is obviously much more precise than the radiocarbon date from 1982; with a sigma of only 30 y, this date appears to be the most precise yet reported for any Mastodon. But, is this date more accurate than the previous conventional age? To ensure accuracy, radiocarbon dates should be assessed against some independent chronometer.

One way to assess chronological accuracy would be to examine dates on other materials, such as plant macrofossils, from the same site. However, the fact that the new AMS date falls within the very broad range of the 1983 date for the spruce cones (470 y at  $1\sigma$ ) is not particularly helpful, as there is no way to ascertain if the animal ingested the cones, or even if they were contemporaneous. The calibrated age range for the spruce cones (12,650–15,040 cal BP) shows that they could have been deposited about 1000 y either before or after the Ivory Pond Mastodon.

At a regional scale, comparison of the dates for the Ivory Pond Mastodon site to other mastodon localities reveals some similarities but also some differences (Table 5). At Hyde Park, NY, 1 spruce bole was dated to  $12,548 \pm 38$  rcbp (14,570–15,120 cal BP), several others from the same context were dated to about 12,400 rcbp (14,150–14,820 cal BP),

Table 3. Radiocarbon data for the Ivory Pond Mastodon reported in 2018.

Radiocarbon lab #	Specimen	Fraction Modern	$^{14}\text{C}$ Age (BP)	$2\text{-}\sigma$ cal age range (cal BP) <sup>A</sup>
UCIAMS 193953	Ivory Pond Mastodon	$0.2278 \pm 0.0008$	$11,885 \pm 30$	13,580–13,770

<sup>A</sup>Calibration performed with Calib 7.1 online using the IntCal13 calibration curve (Reimer et al. 2013, Stuiver et al. 2018).

Table 4. Stable isotope values for bone collagen of the Ivory Pond Mastodon.

Sample Number	$^{13}\text{C}$ (‰)	$^{15}\text{N}$	%C	%N	C/N <sup>A</sup>
UCIAMS 193953	-20.8	2.9	41.9	15.0	3.25
GX-9024-G	-20.6	NA <sup>B</sup>	NA <sup>B</sup>	NA <sup>B</sup>	NA <sup>B</sup>

<sup>A</sup>Atomic C/N ratio.

<sup>B</sup>Not provided in initial report.

and the most recent was dated to  $12,230 \pm 80$  rcbp (13,830–14,560 cal BP). Like the Ivory Pond specimen, the bone date for the Hyde Park Mastodon, loosely associated with the dated spruce logs (and cones), is much later than and significantly different from the spruce samples:  $11,480 \pm 50$  rcbp (13,210–13,440 cal BP) (Griggs and Kromer 2008). At the North Java, NY site, there appear to be 2 temporally distinct populations of dated spruce: 10 older trees date to between 11,900 rcbp and 12,250 rcbp (13,560–14,500 cal BP), while 2 more recent samples date to about 11,300 rcbp (13,070–13,290 cal BP). The North Java Mastodon has an intermediate date of  $11,630 \pm 60$  rcbp (13,330–13,570 cal BP; Griggs and Kromer 2008). Two pine cones derived from the same zone as the mastodon remains at the Hiscock site, in western New York, dated to about 11,135 and 11,200 rcbp; slightly older than most of the dated bones (ca. 10,500–11,100 rcbp) but younger than 1 of them ( $11,390 \pm 80$  rcbp; McAndrews 2003). Compared to those specimens just mentioned, the wood and mastodon bone dates are unusually synchronous at the Chemung, NY site. This finding is less surprising upon further examination, as the spruce and tamarack twigs, a sample of which dated to  $10,758 \pm 25$  rcbp (12,660–12,740 cal BP), are interpreted as mastodon digesta. This date is not statistically different from

Table 5. Radiocarbon dates on bone and associated materials from selected proboscidean sites in the Northeast. CMam = Chemung Mammoth, HM = Hiscock Mastodon, HPM = Hyde Park Mastodon, NJM = North Java Mastodon, SM = Scarborough Mammoth, TM = Tunkamoose Mastodon.

Site	Material sampled	<sup>14</sup> C Age (BP)	Cal BP (IntCal 13)	Lab #
Kitchawan Mammoth	Bone	12,950 ± 100	15,070–16,330	OS-97775
Scarborough Mammoth	Tusk	12,720 ± 250	13,960–14,200 <sup>B</sup>	AA-8215A
SM	Tooth	12,200 ± 55	<sup>B</sup>	OS-5636
SM	Bone	12,160 ± 50	<sup>B</sup>	CAMS-54733
Tunkamoose Mastodon	Tusk	12,300 ± 45	14,060–14,540 <sup>B</sup>	OS-78282
TM	Tusk	12,350 ± 65	<sup>B</sup>	OS-78281
Delaware Mastodon	Bone	12,360 ± 120	13,930–15,010	AA-84998
Farmington Mastodon	Tusk	12,430 ± 40	14,200–14,900	Beta-[NA]
Merrimack River Mastodon	Tooth	12,300 ± 130	13,860–14,940	OS-487
Poughkeepsie Mastodon	Bone	12,060 ± 40	13,770–14,060	UCIAMS-169202
North Java Mastodon	Bone	11,630 ± 60	13,310–13,670	Beta-176928
NJM	Spruce bole	12,254±60	13,970–14,500	Hd-22780
NJM	Tamarack bole	12,064±44	13,770–14,060	Hd-22596
NJM	Spruce bole	12,092±32	13,800–14,090	Hd-22585
NJM	Spruce bole	12,049±27	13,770–14,020	Hd-24121
NJM	Tamarack bole	11,966±25	13,730–13,970	Hd-24123
NJM	Spruce bole	12,056±29	13,770–14,030	Hd-24122
NJM	Spruce bole	11,970±80	13,580–14,030	Beta-168586
NJM	Spruce bole	11,969±30	13,730–13,970	Hd-25622
NJM	Spruce bole	11,902±51	13,560–13,930	Hd-23065

Table 5 (Continued).

Site	Material sampled	<sup>14</sup> C Age (BP)	Cal BP (IntCal 13)	Lab #
NJM	Spruce bole	11,969±19	13,730–13,970	Hd–24119
NJM	Spruce bole	12,046±74	13,740–14,100	Hd–22597
NJM	Spruce bole	12,030±45	13,750–14,030	Hd–22782
NJM	Spruce bole	11,328±61	13,080–13,290	Hd–22598
NJM	Spruce bole	11,296±44	13,070–13,250	Hd–22586
Hyde Park Mastodon	Bone	11,480 ± 50	13,210–13,440	Beta–141061
HPM	Spruce bole	12,548 ± 38	14,570–15,120	Hd–22395
HPM	Spruce bole	12,416 ± 31	14,210–14,790	Hd–22583
HPM	Spruce bole	12,416 ± 33	14,200–14,800	Hd–22687
HPM	Spruce bole	12,396 ± 53	14,150–14,820	Hd–22595
HPM	Spruce bole	12,230 ± 80	13,830–14,560	Beta–168585
Merrimack River Mastodon	Bone	11,570 ± 60	13,480–13,310	Beta–371886
New Britain YWCA Mastodon	Bone (bioapatite)	11,160 ± 130	12,894–13,100	UGAMS–17668
Merrimack River Mammoth	Tooth root	11,202 ± 88	12,830–13,250	AA106431b
Grimes Mastodon	Tooth	11,070 ± 130	12,690–13,170	AA–1506
Berry Mammoth	Tooth	10,930 ± 315	12,110–13,430	AA–1505
Chemung Mastodon	Bone	10,840 ± 60	12,590–12,890	Beta–176930
Chemung Mammoth	Bone	10,890 ± 50	12,680–12,840	Beta–176929
CMam	Spruce/tamarack twigs	10,758 ± 25	12,660–12,740	Hd–26603
CMam	Spruce root	12,269 ± 66	13,990–14,610	Hd–20780
CMam	Spruce root	12,365 ± 75	14,090–14,840	Hd–20795
Hiscock Mastodons	bone	11,390 ± 80	13,110–13,410	AA–6977
HM	tusk	11,100 ± 80 <sup>A</sup>	-	CAMS–30528
HM	tusk	11,070 ± 70 <sup>A</sup>	12,760–13,030 <sup>B</sup>	CAMS–30529
HM	tusk	10,930 ± 70 <sup>A</sup>	-	GX–22038
HM	bone	10,810 ± 50	12,600–12,850	CAMS–62560
HM	bone	10,790 ± 70	12,550–12,850	CAMS–27143
HM	bone	10,630 ± 80	12,400–12,700	CAMS–17407
HM	bone	10,515 ± 120	12,050–12,650	Beta–24412
HM	Jack pine cone	11,135 ± 100	12,750–13,170	Beta–28829
HM	Jack pine cone	11,200 ± 100	12,820–13,260	Beta–28830
HM	conifer	10,240 ± 120	11,400–12,420	NZA–1107
HM	twigs	11,250 ± 140	12,800–13,380	Beta–16736
HM	Fir or juniper	10,705 ± 80	12,440–12,740	AA–6968

<sup>A</sup>Split sample.<sup>B</sup>Calibrated range from pooled mean of multiple dates from a particular specimen.

a bone date of  $10,840 \pm 60$  rcbp ( $12,660$ – $12,830$  cal BP) for the Chemung Mastodon (Griggs and Kromer 2008). Dates on digesta and the individual would be expected to be the same.

Another 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. Pleistocene-age samples treated recently either by ultra-filtration, XAD resin, or separation of the hydroxyproline fraction have yielded ages that are hundreds or thousands of years older than previous gelatin-based ages for the same specimens (e.g., Higham 2011, Marom et al. 2012, McCullagh et al. 2010, Nalawade-Chavan et al. 2014, Waters et al. 2015). An extreme position is that all collagen-based dates produced by any other methods are likely to be inaccurate, probably too young because of incomplete removal of exogenous humic acids (e.g., Higham 2011, Waters et al. 2015). Other specialists contend that the new methods are not a panacea; e.g., the filters may introduce old carbon, as happened at the Oxford AMS laboratory before 2004 (Bronk Ramsey et al. 2004, Fülöp et al. 2013). In a test of pretreatment protocols, Fiedel et al. (2013) compared the dates produced by 4 laboratories (including UCI) for bones of the Miesenheim Elk (moose), for which the overlying Laacher See tephra ( $11,060$  rcbp or ca.  $13,000$  cal BP) provided a *terminus ante quem*. Only Oxford's hydroxyproline date of  $11,100$  rcbp was in the expected range; the other dates, averaging about  $10,700$  rcbp, were clearly too young, although the suspected contaminant could not be determined. In a follow-up experiment involving 5 laboratories, most of the conventionally prepared bone samples yielded expected ages (averaging  $11,092 \pm 19$  rcbp), but 2 paired ultra-filtration-derived dates from the University of Arizona AMS laboratory appeared to be about 130 radiocarbon-y too old (Kuzmin et al. 2018). Similarly, 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 2 sigma. Six of the 9 paired ABA and UF measurements overlapped at 1 sigma. Widga et al. (2017) recommended 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.

Our conclusion from these findings is that the new Ivory Pond AMS date, in the context of the initially obtained dates from the mastodon bone and white spruce, is probably accurate but, we acknowledge that this current calibrated age might well be several centuries younger (or less likely, older) than the true age of the bones. In the future, with improved pretreatment techniques, analytical methodologies, and calibrations, the Ivory Pond Mastodon's age may be further refined.

### Regional context and implications

Although the Mastodon might be somewhat older than the new date indicates, a likely *terminus post quem* is provided by regional environmental data. Mastodons appear to have expanded into New York and New England in tandem with the boreal forest. The expansion of boreal forest into southeastern New York apparently was underway by  $12,548 \pm 38$  rcbp, as indicated by the oldest of the dated spruce boles from Hyde Park. Interestingly, this date calibrates from  $14,570$  cal BP to  $15,120$ . Much of the calibrated age range for this date

precedes the abrupt Bølling-Allerød warming seen in Greenland ice cores at 14,650 cal BP. This interpretation would be problematic, as the warmer Bølling climate was the evident precondition for the northward forest expansion. Several other dates for spruce boles from the same context are about 12,400 rcbp; they currently calibrate to as recent as 14,200–14,400 cal BP, but again, they could be as old as ca. 14,800 cal BP. Similar dates have been obtained for the oldest spruce remains at the Chemung (or Gilbert, or Watkins Glen) and North Java sites in western New York (Griggs and Kromer 2008). It would appear then that the boreal forest biome had spread to the latitude of, at least, Hyde Park, NY, just after the initiation of Bølling warming.

The oldest dated mastodon specimen in New York is the Tunkamoose Mastodon from Orange County, NY, with 2 dates:  $12,300 \pm 45$  and  $12,350 \pm 65$  rcbp (Feranec and Kozłowski 2012, 2016). A calibrated date on the pooled mean of the Tunkamoose Mastodon ( $12,316 \pm 37$  rcbp) is 14,080–14,560 cal BP. A mastodon of the same age was found in Delaware, in southern ON, Canada; dentin from this specimen has been dated to  $12,360 \pm 120$  rcbp (Metcalf 2011). These dates calibrate to about 14,450 cal BP, but could instead be centuries older, ca. 14,700 cal BP, due to rapid radiocarbon excursions (Adolphi et al. 2017). In either case, these dates for mastodon imply that their colonization of previously glaciated areas of New York and northward closely coincided with the onset of Bølling warming and northward boreal forest expansion.

The location of the Ivory Pond Mastodon is geographically interesting in that it highlights the dispersal abilities of these ancient proboscideans. Evidently, neither glacial lakes Albany and Vermont, nor the paleo-river in the now-submerged Hudson Shelf Valley, posed an impassable obstacle for Late Glacial proboscideans. Perhaps they crossed the lakes in the winter when they were frozen. In any case, proboscideans were living east of the present Hudson River even before the Bølling warming began.

First came the mammoths. The Kitchawan, NY, Mammoth has been dated to  $12,950 \pm 100$  rcbp (15,170–15,800 cal BP) (Feranec and Kozłowski 2018). At that date, the recently deglaciated region would have been a nearly treeless tundra (as indicated by the lowest pollen zone at Ivory Pond). The Scarborough Mammoth, found on the coast of Maine, yielded 3 radiocarbon dates:  $12,160 \pm 50$ ,  $12,200 \pm 55$ , and  $12,720 \pm 250$  rcbp (Hoyle et al. 2004). These dates are not statistically different and have a pooled mean of  $12,190 \pm 37$  rcbp (13,960–14,200 cal BP).

It appears that the first mastodons arrived very soon after the conifers colonized New England. A specimen found in Farmington, CT, in 1913, has been dated recently to  $12,430 \pm 40$  rcbp (14,210–14,870 cal BP) (Boulanger and Jones 2015). A mastodon tooth recovered 3 miles (~5 km) offshore the Merrimack River in the Gulf of Maine was dated to  $12,300 \pm 130$  rcbp (13,860–14,940 cal BP; OS-487) (Claesson et al. 2017).

Once established east of the Hudson Valley, both mastodons and mammoths persisted until the onset of the Younger Dryas. A mastodon found in 1854 near Poughkeepsie, NY, has been dated recently to  $12,060 \pm 40$  rcbp (13,770–14,050 cal BP) (Feranec and Kozłowski 2018). The Hyde Park Mastodon was dated to  $11,480 \pm 60$  rcbp (13,210–13,440 cal BP). The New Britain YWCA Mastodon has been dated to  $11,160 \pm 130$  rcbp (12,750–13,260 cal BP; Boulanger 2014). A mammoth molar dredged up from the paleodelta of the Merrimack River in 2013 has been dated to  $11,202 \pm 88$  rcbp (12,830–13,250 cal BP). A mastodon mandible found about 8 km to the south of the mammoth tooth was dated to  $11,570 \pm 60$  rcbp (13,280–13,540 cal BP;  $\delta^{13}\text{C}$ : -19.4 ‰,  $\delta^{15}\text{N}$ : 3.0 ‰) (Claesson et al. 2017). Among the many other proboscidean teeth previously found offshore are the Berry Mammoth tooth ( $10,930 \pm 315$  rcbp, 12,000–13,450 cal BP, AA-1505) and the Grimes Mastodon tooth

(11,070 ± 130 rcbp, 12,710–13,140 cal BP, AA-1506); both were dredged up from ca. 50 m below the present ocean surface in Massachusetts Bay off Salem (Oldale 1987).

### Mastodon diets

The recently acquired  $\delta^{13}\text{C}$  of the Ivory Pond sample (-20.8‰) agrees closely with the value of -20.6‰ reported for the 1983 sample (Table 4). It also falls precisely within the established range for bones of Late Glacial mastodons in Ontario and western New York; the mean is -20.9 ‰ with a standard deviation of 0.6 (Metcalf 2011:Table 6.2). These values imply consumption of  $\text{C}_3$  plants with a  $\delta^{13}\text{C}$  value of about -26‰, which are expected for a boreal forest environment.

The  $\delta^{15}\text{N}$  of the Ivory Pond sample is 2.9‰. This value is slightly higher than was normal for the bone collagen of the Ontario and western New York mastodons ( $2.3 \pm 0.3\text{‰}$ ) (Metcalf 2011:11, Metcalf et al. 2013), but it is a little lower than the typical values reported for Michigan, Ohio, Indiana, and southern New York ( $3.9 \pm 1.0\text{‰}$ ) (Koch 1991). These low values, contrasting with the high values seen in mammoths, have been attributed to occupation of a recently deglaciated landscape with young soils, consumption of nitrogen-fixing plant taxa (e.g., alder or lichens), or consumption of spruce (Metcalf et al. 2013).

These very low  $\delta^{15}\text{N}$  values also may reflect the mastodons' occupation of open spruce forests (Metcalf 2011:177; Metcalf et al. 2013). The nitrogen content of the forest floor is much higher around spruce trees than other tree species (Vesterdal et al. 2008). The plants growing in that soil would have low  $\delta^{15}\text{N}$  values (Amundson et al. 2003). In modern Alaska, spruce needles have significantly lower  $\delta^{15}\text{N}$  values than the shrubs and grass leaves growing underneath the trees (mean  $\delta^{15}\text{N} = -7.7$  [spruce],  $-4.3$  [shrub], and  $0.9\text{‰}$  [grass]) (Schulze et al. 1994). The approximately contemporaneous spruce cones, as well as the pollen core, show that the Ivory Pond animal was living among spruce trees, although it has not been demonstrated that it was consuming their twigs or needles. It is noteworthy that White Spruce cones have been recovered previously from the vicinity of several other mastodons (Dreimanis 1968:Table 3).

It is widely assumed that the preferred diet of mastodons consisted of 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). They may have been able to digest spruce twigs, with their toxic terpenes and resins, by ingesting silts and clays, which could act as laxatives and detoxifiers (McAndrews 2003). However, some presumed mastodon gut contents or feces indicate a very different diet including sedges, grasses, weeds, pond plants, mosses, and twigs and leaves of deciduous trees including *Ulmus* (elm), *Quercus* (oak), and *Fraxinus* (ash) (e.g., the Burning Tree, OH, specimen excavated by Lepper et al. [1991] and re-analyzed recently by Birks et al. [2018]). Yansa and Adams (2012) dismissed this mastodon as a late-surviving ( $11,390 \pm 80$  rcbp, 13,397–13,085 cal BP), stressed individual forced to broaden its diet due to loss of its favored habitat. However, given the extensive range of this species, they seem to have had very flexible diets. At the Page–Ladson site in Florida, mastodon dung yielded remnants of more than 27 plant genera, including very numerous *Taxodium* (cypress) twigs and cones, nuts, fleshy fruits, gourds, and wetland herbs (Newsom and Muhlbachler 2006). Both mammoths and mastodons in northern Illinois occupied Late Glacial woodlands that were dominated by *Fraxinus nigra* Marsh. (black ash), not spruce (Saunders et al. 2010). For the northern mastodons, low-quality spruce twigs might have been a near-starvation food, consumed mainly in winter. As Dreimanis (1968:267) succinctly observed, “Even if mastodons lived

in spruce forests, the spruce branches were not necessarily their main food. They may have preferred other plants growing in spruce forests”.

### **Implications of the depositional context**

With rare exceptions, mastodons in the Northeast, including the Ivory Pond animal, have been found in ponds. It is obvious that these settings were unusually propitious for bone preservation by alkaline marl. However, it is not so obvious how the giant carcasses ended up in these ponds. Mastodons, like their modern elephant cousins, were long-lived and probably very intelligent animals (Haynes 1991); they did not blunder into muck-filled ponds through sheer stupidity. Fisher (2009:63) recognized mastodon trackways along lake and pond margins at the Brennan and Heisler sites; these “suggest that mastodon behavior was characterized by an appropriate avoidance of the soft, yielding substrates encountered within the pond itself”.

Fisher (2009) identified 24 out of a sample of 34 Late Glacial mastodons as males. Based on their tusk growth, he inferred that most of these males were young adults that died in autumn, probably due to predation. A minority died in the mid- to late spring; Fisher interpreted these as animals that died as a result of musth (rutting) battles. In contrast, Haynes (1991:105) speculated that male rutting battles would have occurred in early winter.

Proboscideans require a lot of water. Thirst alone might have impelled mastodons to frequent pond edges, but in that case, we would expect them to have ventured into the muck, or onto thin ice, either in summer or winter, not autumn and spring when water should have been more available. Haynes (1991:281) suggested that some damage observed in mammoth tusks may have been caused by the animals’ fighting for access to late-winter water sources.

The closest living analogue to the mastodon, at least with respect to habitat and diet, although not social behavior, may be the *Alces alces* L. (moose) (an Early Holocene immigrant into northeastern North America [Hundertmark et al. 2002]). Haynes (1991:103) observed that “In northern ranges, where predation accounts for the greatest proportion of carcasses, many moose die in low-lying areas because moose spend a great deal of time feeding there. Many also die on iced-over lakes, ponds, and sloughs, where they are chased by wolves or are ambushed while feeding”. On Isle Royale, where most moose died due to *Canis lupus* L. (gray wolf) predation, “Calves were found primarily near shorelines, where the most effective means of escape from wolves was to enter the water”. Before the gray wolves became established on the island, “Moose carcasses and skeletons apparently were not uncommon sights, especially near salt licks, bogs, and lakes, the results of deaths caused by winterkill, disease, or accident” (Haynes 1991:104).

Using data from Isle Royale as an analogue, Fox-Dobbs et al. (2007) interpreted carbon and nitrogen isotope data from the La Brea tar pits as indicating that dire wolves may have obtained as much as 21% of their meat by hunting or scavenging mastodons. Saber-toothed cats (particularly *Homotherium*) evidently could hunt immature proboscideans and drag them back to their dens, as indicated by the undated remains from Friesenhahn Cave, TX (Evans 1961). *Homotherium* were ranging close to the ice front in Minnesota ca. 26,000 cal BP (Widga et al. 2012), and they were still prowling about the southern end of the ice-free corridor in Alberta ca. 12,700 cal BP (10,740 ± 40 rcbp) (Ewald et al. 2017). However, neither dire wolves nor saber-toothed cats have yet been found in the Northeast. In fact, the ostensible absence of any tooth marks of large carnivores on the bones of Late Glacial proboscideans in the Midwest led Widga et al. (2017) to hypothesize that those predators were already extinct or regionally extirpated.

Without top-down control by the big carnivores, proboscidean populations increased unchecked until they crashed ca. 12,500 cal BP, and the result was their extinction (Widga et al. 2017). Even if dire wolves and big cats were present in the Northeast, they may not have been able to bring down a full-grown proboscidean, although perhaps they might have harassed some animals to the point where they sought refuge in ponds.

If not carnivores, perhaps the mastodons were fleeing from humans. Fisher (2009) has interpreted nearly all mastodons in ponds as animals killed, butchered and then stored in cold water by human hunters. This explanation must be seriously considered given the peculiar representation of skeletal elements in ponds (e.g., sometimes only the head is present), as well as the current wide acceptance of several claims of pre-Clovis hunting of proboscideans. Evidence to support these claims include: the Manis Mastodon in Washington State at ca. 13,800 cal BP ( $11,960 \pm 17$  rcbp) (Waters et al. 2011); the lithic artifacts lying dispersed in mastodon dung at the Page Ladson site in Florida at ca. 14,300 cal BP (Halligan et al. 2016); and the Schaefer and Hebior mammoths, both with a few associated lithic artifacts and both dated to ca. 14,300 cal BP (Joyce 2006, 2013). While Fisher thought humans stored mastodon meat in cold ponds, Gramly (2017) added the possibilities of bone and ivory treatment for tool production, as well as some ritual behaviors. It is pertinent to note that Pitulko et al. (2015) described storage of mammoth skulls in stagnant, relatively warm, slow-moving creek water at the Yana RHS site in Siberia, ca. 32,000 cal BP, in order to remove tusks from alveoli. In Arctic Siberia, the ivory was a necessary substitute for wood, a circumstance that would not have prevailed in the boreal forest of Late Glacial New England. Although the lithic assemblage at Yana is not as impressive as the ivory and bone tools, there are stone tools; it is primarily the absence of associated chipped stone tools and debitage that undercuts Fisher's and Gramly's theories about the mastodon sites.

Regardless of the behaviors that may have resulted in the fortuitous preservation of mastodons in ponds across the Northeast, the small number of these accidentally preserved skeletons east of the Hudson creates a misleading impression of the original density of living proboscideans on the Late Glacial landscape. Fisher (2009:71) noted that the tusks of the Hyde Park 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". As stated above, the date for this animal is  $11,480 \pm 50$  rcbp. Widga et al. (2017) observed a peak occurrence of dated proboscideans in the northern Midwest between 14,000 cal BP and 12,800 cal BP. Similarly, Boulanger and Lyman (2014) observed an equivalent peak in the Northeast (including New England) between 13,600 cal BP and 12,700 cal BP. But, while Widga et al. (2017) interpreted this maximum as evidence of a booming predator-free population, Boulanger and Lyman (2014), regarded it instead as indicating the accelerating mortality rate of a declining regional population. Despite their contradictory interpretations of the Allerød maximum of proboscidean deaths, both studies converged in their denial that the abrupt extinction by ca. 12,500 cal BP could have anything to do with the well-documented arrival of fluted point-using humans around 13,000 cal BP (Lothrop et al. 2016). We will not wade into the debate about the causes of extinction here as this has been dealt with in detail elsewhere (e.g., Barnosky et al. 2004, Prescott et al. 2012, Stuart 2015). We only note that: (1) the new Ivory Pond date fits comfortably near the start of the 14,000 cal BP to 12,800 cal BP peak; and (2) this Allerød maximum of dated proboscideans contradicts the inference of the "functional extinction" of megaherbivores around 13,800 cal BP based upon the sharply reduced relative frequency of *Sporormiella* fungal spores (Feranec and Kozlowski 2016, 2018; Feranec et al. 2011; Fiedel 2018; Gill et al. 2009).

### Conclusions

The Ivory Pond Mastodon, from South Egremont, MA, has yielded a precise AMS radiocarbon date of  $11,885 \pm 30$  rcbp (13,580–13,770 cal BP). This date is similar to those of other mastodon specimens from New York and New England and corresponds to a period when boreal forest prevailed in the region. These dates collectively indicate that mastodons were thriving in the Northeast during the Allerød, and contradict the inference from coprophilic fungal-spore abundance that their population was approaching extinction ca. 13,800 cal BP. No convincing explanation has yet been advanced for the discovery of so many specimens of this period, including the Ivory Pond Mastodon, within small ponds. We suggest that attempted evasion of predators, possibly including humans, may have driven animals into the water. Human manipulation and/or storage of carcasses, though unproven in the absence of lithic artifacts, cannot be precluded.

### Acknowledgements

We thank the NY State Museum for funding the radiocarbon assay and other logistical support. We also would like to thank the anonymous reviewers of this report, and S.C. Wallace and J.-H. Lotze of *Eastern Paleontologist* for their work in arranging its publication.

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