

New Record of Terminal Pleistocene Elk/Wapiti (*Cervus canadensis*) from Ohio, USA

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ABSTRACT. The earliest appearance of elk/wapiti (*Cervus canadensis*) in eastern North America is not thoroughly documented due to the small number of directly dated remains. Until recently, no absolute dates on elk bone older than 10,000 ¹⁴C yr BP (11,621 to 11,306 calibrated years (cal yr) BP) were known from this region. The partial skeleton of the Tope Elk was discovered in 2017 during commercial excavation of peat deposits from a small bog in southeastern Medina County, Ohio, United States. Subsequent examination of the remains revealed the individual to be a robust male approximately 8.5 years old at death. The large size of this individual is compared with late Holocene specimens and suggests diminution of elk since the late Pleistocene. Two accelerator mass spectrometry (AMS) radiocarbon assays on bone collagen samples taken from the scapula and metacarpal of this individual returned ages of 10,270 ± 30 ¹⁴C yr BP (Beta-477478) (12,154 to 11,835 cal yr BP) and 10,260 ± 30 ¹⁴C yr BP (Beta-521748) (12,144 to 11,830 cal yr BP), respectively. These results place *Cervus canadensis* in the terminal Pleistocene of the eastern woodlands and near the establishment of the mixed deciduous forest biome over much of the region. This early temporal placement also situates this early elk as closely following the last representatives of now-extinct megafauna such as the American mastodon (*Mammuth americanum*) and contemporary with the Late Paleoindian inhabitants of the region.

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INTRODUCTION

The earliest presence of elk/wapiti (*Cervus canadensis*) in the eastern woodlands of North America is not thoroughly documented. In fact, there are virtually no records of directly dated elk specimens in North America, south of Beringia, that are more than 10,000 radiocarbon years in age (O’Gara and Dundas 2002: p. 77; Burns 2010: p. 39). Most specimens that exceed this date threshold were aged using indirect methods involving biostratigraphic contexts or direct dating of associated geological or archaeological deposits (Table 1). The recent discovery of a partial elk skeleton in northeast Ohio (a.k.a. the Tope Elk) provides new evidence for the presence of this species in at least the lower Great Lakes region by the terminal Pleistocene, referred to herein as the period between 12,000 to 10,000 ¹⁴C yr BP (ca. 13,800 to 11,500 calibrated years (cal yr) BP). This paper describes the Tope Elk remains and direct radiocarbon dating, and then discusses the importance of this find to understand the timing of

the dispersal of elk into eastern North America and its environmental context in the eastern woodlands.

BACKGROUND

The Tope Elk was discovered during the commercial excavation of peat from a 7.2 ha (17.8 acre), unnamed bog located 4.2 km (2.6 miles) southwest of downtown Wadsworth, Ohio, lat 41°00'28.1"N, long 81°46'25.4"W (41°0.468'N, 81°46.423'W), 293 m AMSL (Fig. 1). The bones were reportedly recovered between 2.5 to 3.0 m (8.2 to 9.8 ft) below the surface of the bog, and were lying on a clay marl substrate. In September 2017, Stephens reported the discovery to Redmond. The remains were initially thought to be stag-moose (*Cervalces scotti*), but further examination revealed them to be elk (*Cervus canadensis*). The Tope family loaned the recovered parts of the skeleton to the Cleveland Museum of Natural History (CMNH) for study and preliminary documentation by Redmond. Later, title to the collection was permanently transferred to CMNH under Accession Number 2017-13.

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Two early Holocene elk skeletons from Ohio were previously reported: the Cranberry Prairie Elk from Mercer County (Murphy et al. 1985) and the Lattimer Elk from Champaign County (Hansen 1996) (Fig. 1). The site of the Lattimer Elk skeleton has yielded more remains in subsequent years. Ten more finds have been made, consisting of one or more bones, which have been deposited into the Natural History collection of the Ohio History Connection (OHC) in Columbus, Ohio, United States. None of these later donations have been radiocarbon dated.

Elk from later in the Holocene are represented by 2 incomplete skeletons found in Silver Lake (Fig. 1), Logan County, Ohio, in 1960 (Goslin 1961). A third elk skeleton, housed with the original 2 at the OHC, may be a specimen that was recovered from the lake at a later date. The Silver Lake Elk were not radiocarbon dated, but Hansen (1996) concludes they may only be a few hundred years old based on their stratigraphic position near the top of the lake sediments (following Ogden 1966). The skeletons were found in shallow water after they were noticed by youth from a lakeside camp (Goslin 1961), rather than recovered from the well-studied and dated sediment from Silver Lake as documented by Gill et al. (2012). Elk were common in later

pre-European contact Ohio as demonstrated by the plethora of remains preserved in archaeological faunal assemblages curated in museums throughout Ohio. The species was extirpated from Ohio in 1837 (Kirtland 1838).

METHODS

The bones of the Tope Elk were initially inventoried and photographed by Redmond at CMNH. Individual elements were examined for evidence of excavation damage, pathology, trauma, and ancient human modifications (e.g., butchering marks). In October 2017, a 2.28 g sample of cortical bone from the left scapula of the specimen was submitted to Beta Analytic® Inc., Miami, Florida, for accelerator mass spectrometry (AMS) radiocarbon dating of collagen. All calibrated radiocarbon dates are reported at the 2σ (95%) confidence level and were calculated using CALIB software version 7.0.4 (Stuiver and Reimer 1993) and the IntCal13.14c calibration curve. Student's *t* statistical comparisons of radiocarbon dates were also calculated using CALIB 7.0.4 software.

In October 2018, the elk bones were loaned to Dyer for formal inventory and analysis in the Natural History section of the OHC in Columbus. The identification of the skeleton was confirmed



FIGURE 1. Locations of Tope Elk and other Ohio elk specimens discussed in the text

by comparison to known elk specimens and observation of the maxillary canine alveolus. The bones were then identified to element and the following information noted: side present, portion, age, taphonomy, and measurements. The age of the individual was estimated by examining multiple criteria including epiphyseal fusion, tooth wear, and alveolar bone resorption. The sex of the elk was confirmed by the presence of an antler tine, and the antler also helped to estimate the season of death as a winterkill. The specimens were then returned to CMNH in March 2019 for permanent curation. A second bone sample, consisting of a 1.0 g fragment of the left metacarpal, was submitted to Beta Analytic in March 2019 for AMS dating.

RESULTS

A complete inventory and morphometrics of the Tope Elk remains are listed in Table 2 and Table 3, respectively. A total of 21 skeletal elements were recovered from the bog site and preservation is good. No ancient cultural modifications, such as stone tool cut marks or other signs of human butchering, are evident on the skeleton. Also, no rodent or carnivore tooth marks were found, indicating that the skeleton was not exposed on the surface for a long period before burial or submersion in water. Minor breakage is present on several of the bones, including the innominate, scapula, sacrum, sixth cervical vertebra, and third thoracic vertebra. None of this breakage follows the pattern of typical fragmentation of long

Table 1
Indirectly dated late Pleistocene elk remains from eastern North America

Site name	Analysis unit	Age range [†]	Dating method	Reference
Baker Bluff Cave, TN	5–6 ft. level	11,640–10,560 ¹⁴ C yr BP (14,076–13,013 cal yr BP)	¹⁴ C dated strata	Guilday et al. 1978: p. 53-54
Big Bone Lick, KY	Zone B	11,000 yr BP–modern	Biostratigraphy	Schultz et al. 1963: p. 1168; Williams et al. 2018
Clark's Cave, VA	Entrance 2	20,000–11,000 yr BP	Biostratigraphy	Guilday et al. 1977
Duncker Muscox, IN	Assemblage	15,000–11,000 yr BP	Biostratigraphy	Lyon 1931
Hiscock, NY	Unit B	9,340±100 ¹⁴ C yr BP (10,788–10,248 cal yr BP)	¹⁴ C date on wood	Laub et al. 1988: p. 73
Hollidaysburg Fissure, PA	Assemblage	11,000 yr BP	Amino acid racimization	Fonda and Czebieniak 1986
Hosterman's Pit, PA	Assemblage	9,240±1,000 ¹⁴ C yr BP (12,981–8,199 cal yr BP)	¹⁴ C dated strata	Guilday 1967
Meadowcroft Rockshelter, PA	Stratum IIA	14,255–10,850 ¹⁴ C yr BP (22,025–13,063 cal yr BP)	Six ¹⁴ C dates on cultural features	Adovasio et al. 1978
Paw Paw Cove, MD	Overlying paleosol	17,820±170 ¹⁴ C yr BP (22,005–21,040 cal yr BP)	¹⁴ C dated stratum	Eshelman et al. 2018
Raddatz Rockshelter, WI	Level 13–15	11,602±300 ¹⁴ C yr BP (14,121–12,801 cal yr BP)	¹⁴ C dates on cultural strata	Cleland 1966
Wormhole Cave, WV	Assemblage	51,650±4,110 ¹⁴ C yr BP*	¹⁴ C date on <i>Neotoma floridana</i>	Semken et al. 2010

[†] All calibrated radiocarbon dates are reported at the 2σ confidence level and were calculated using CALIB software version 7.0.4 (Stuiver and Reimer 1993).

* Calibration not possible.

bones resulting from human butchering as described by Gustafson and Wegener (2004). Much of this damage is recent, possibly associated with discovery or excavation of the specimen. Some of the breakage is older, however, as indicated by staining of the fracture surface. The straight edges and the lack of spiral fractures indicate that the older fractures occurred when the bone was dry rather than fresh (Johnson 1985). None of the long bones in this partial skeleton exhibited any type of breakage.

The recovered bones of the Tope Elk are derived from diverse parts of both the axial and appendicular regions of the skeleton (Table 2). They include elements from both the right and left sides of the animal, but only in the maxilla are both right and left sides present. Most of the vertebrae are missing from the collection as well as nearly all the leg bones—except for the left metacarpal, right femur, and 3 phalanges. This assemblage appears to be an almost random selection of skeletal elements, which may indicate that the skeleton was highly disarticulated prior to, or during, deposition. Alternatively, this may be due to the use of a backhoe for excavation, during which additional bones were missed.

Age, Sex, and Size Estimates

The Tope Elk is a male based on the presence of an antler fragment. Antlers are usually found exclusively on males in the members of the family Cervidae (excluding *Rangifer*, where females have antlers, albeit smaller). The remains are determined to be those of a prime-age adult—clearly older than 4 years and approximately 8.5 years old—based on the following 6 reasons:

1) The antler fragment from the sample is a large tine rather than part of a main beam, and measures 459 mm (18.1 in) long. The tines tend to be more flattened in cross section, in contrast to the more rounded main beam. It is difficult to age an elk from the antlers (Murie 1951). Also, Willis et al. (2009) state that elk 3.5 years and older cannot be accurately aged from the antlers. The tine from the Tope Elk is, however, significantly larger than the tines from the Lattimer Elk, the latter being a 3 to 3.5-year-old male as determined by the tooth eruption sequence of the mandible following Quimby and Gaab (1952) and Jensen (1999). Thus, the Tope Elk must be at least 4 years old, and most likely much closer to the higher end of the range (8.5+ years), as defined by the tooth wear analysis (below).

2) Pronounced muscle attachment sites (entheses) are seen on many of the skeletal elements—indicating a robust, prime-aged individual. Such entheses were especially noted on the femur, innominate, metacarpal, scapula, vertebrae, and ribs. The entheses were much more pronounced than on the Lattimer Elk or on the Silver Lake Elk specimens, the latter of which are the same chronological age as the Tope Elk.

3) The Tope Elk exhibits complete epiphyseal fusion, also indicative of a full-grown adult. Elements that show complete fusion, with obliterated epiphyseal lines, are the distal femur, distal metacarpal, distal scapula, proximal second phalanx, and bodies of the vertebrae. There is a paucity of literature on epiphyseal fusion rates in elk; however, Lyman (1991) examined 6 elk skeletons and devised a chart relating age with epiphyseal fusion in long bones and phalanges. The Tope Elk must be at least 46 months old, based on the fully fused distal femur and distal metacarpal.

4) Though estimating the age (aging) of elk by tooth eruption and wear criteria is less accurate than other techniques, such as examination of the annuli of the cementum of incisor root tips (Hamlin et al. 2000), the eruption-wear criteria must be considered for the Tope Elk since no incisors are present. Several researchers have aged elk based on the eruption-wear criteria for cheek teeth (Murie 1951; Swanson 1951; Quimby and Gaab 1952; Jensen 1999). However, these studies use the mandibular dentition for aging rather than the upper dentition, due to the applicability of the former to field work with hunted animals (i.e., the incisors are readily visible and the lower dentition can be seen with a simple dissection). The mandibles are not present in the Tope Elk skeleton, but this specimen is much older than the 3 to 3.5-year-old Lattimer Elk, and according to Jensen (1999), elk 4.5 years and older are less reliable to age by tooth wear. Jensen (1999) also states that for the lower first molar the dentine nearly surrounds the infundibulum by 8.5 years of age, and in older individuals the infundibulum will be completely worn away. If extrapolated to the upper dentition, the first molar in the Tope Elk shows the infundibulum still present and not completely surrounded by dentine (Fig. 2). This would give an estimated age of approximately 8.5 years, and clearly more than 4 years. One of the

Table 2
Inventory of Tope Elk skeletal remains

Element	Side	Portion	Age	Taphonomy	Comments
Maxilla & premaxilla	L	Complete	Adult		With tooth row: PM2-4 and M1-3; canine missing. Abscess on mesiobuccal root of M3. Alveolar resorption along PM & M tooth row. Large muscle scar on maxilla.
Maxilla	R	Partial	Adult		With PM2-4. Canine alveolus not present. Darker stain but same individual as L. maxilla.
First molar	R	Complete	Adult		Re-fits with R. maxilla above. Bone surrounding roots.
Antler tine	?	Complete	Adult		Large tine, broken off of main beam.
6th cervical vertebra	N/A	Complete	Adult	Missing ventral branch of transverse process, right side, and some damage to cortex of centrum, anterior surface. All old breakage.	Large muscle scars on dorsal spine. Darker stain, same as seen on R. maxilla.
2nd thoracic vertebra	N/A	Complete	Adult		Pronounced muscle attachments, on dorsal spine, zygapophyses, etc.
3rd thoracic vertebra	N/A	Complete	Adult	Some breakage to L. transverse process (recent).	Pronounced muscle attachments, on dorsal spine, zygapophyses, etc.
4th thoracic vertebra	N/A	Complete	Adult		Pronounced muscle attachments, on dorsal spine, zygapophyses, etc.
Sacrum – S1-S4	N/A	Complete	Adult	Minor breakage to anterior edges of wings of S1 (older and recent) and to crest of S1 (recent).	
Scapula	L	Distal	Adult	Breakage is old, but scapular spine damage is recent.	Missing scapular spine, 1 fragment present (below), and missing supra- and infraspinous fossa.
Scapular spine	L	Fragment	Adult		Re-fits to distal scapula above.
Metacarpal	L	Complete	Adult		Epiphyses fully fused. Pronounced muscle attachment sites.
2nd (middle) phalanx	?	Complete	Adult		Proximal epiphysis fully fused.
3rd (distal) phalanx	?	Complete	Adult		
3rd (distal) phalanx	?	Complete	Adult		
Innominate	R	Complete	Adult	Breakage appears recent.	Missing posterior portion of the symphyseal branch of the pubis and symphyseal branch of ischium. Some breakage to anterior end of iliac crest.

Table 2 (continued)
Inventory of Tope Elk skeletal remains

Element	Side	Portion	Age	Taphonomy	Comments
Femur	R	Complete	Adult		Epiphyses fully fused. Pronounced muscle attachment sites.
Rib, ca. 7th	L	Complete	Adult		Pronounced muscle attachment sites.
Rib, ca. 11th	R	Complete	Adult		Pronounced muscle attachment sites.
Rib, ca. 12th	L	Complete	Adult		Pronounced muscle attachment sites.
Rib	?	Fragment	Adult		Fragment of posterior rib, medial surface.

Silver Lake Elk skeletons (specimen number 3) has wear on the upper dentition (similar to that of the Tope Elk), and the mandibles are present with this specimen. These mandibles exhibit a worn first molar with the infundibulum nearly surrounded by dentine and can be aged to the approximately 8.5-year category. Though wild elk can live over 20 years (Senseman 2002), Wisdom and Cook (2000) found that male elk in wild, non-hunted populations typically live less than 10 years. Thus, the Tope Elk was a full adult probably nearing the end of a typical lifespan for a male elk.

5) Alveolar bone resorption is seen in the Tope Elk along the lateral surface of the premolars and molars of the left maxilla and along the premolars in the right maxillary fragment. This is normal alveolar bone loss with aging, and is the same degree of resorption seen in the right maxilla of one of the similar-aged Silver Lake Elk (Goslin 1961). This would also suggest an age near the 8.5-year category. Also noted is considerable bone loss along the mesiobuccal root of the third molar in the left maxilla. Most of the root is exposed due to bone resorption along the buccal surface of the root, and pitting is seen along the length of the root. Porosity of the bone surrounding the mesiobuccal root, and pitting on the root, is suggestive of an abscess (Ortner and Putschar 1981).

6) No substantial signs of osteoarthritis were observed in the bones of the Tope Elk skeleton. Osteoarthritis does occur in large mammals in the wild, and has previously been reported in cervids, such as elk (Lyman 2010) and moose (*Alces alces*) (Peterson 1988), and also in wild horses (Wilson

2012). Lyman (2010) describes 2 pathologies in a partial skeleton of a large elk from the Marmes Rockshelter in Washington State. The individual had a form of spinal arthritis, diffuse idiopathic skeletal hyperostosis (DISH), in 2 cervical vertebrae and a pathology similar to osteoarthritis, spondylosis deformans, in 2 thoracic vertebrae. Lyman (2010) did not attempt to age the individual, probably because no cranial elements were found with the skeleton; however, he did deem it as a skeletally mature individual.

In the Tope Elk, the presence of pronounced muscle attachment sites and fully fused epiphyses, along with the lack of signs of idiopathic arthritis, help substantiate that the Tope Elk is a mature adult but not yet of advanced age.

The conclusion that the Tope Elk is a large, robust male was tested by comparing measurements of the Tope Elk to 2 of the Silver Lake Elk (specimens number 2 and number 3) (Table 3). These 2 Silver Lake skeletons were selected because of their completeness and that they—based on mandibular wear—are in the same 8.5-year age range as the Tope Elk. Silver Lake Specimen Number 2 is believed to be a male, but it's uncertain if one of the large antler pairs found in storage with the Silver Lake skeletons does, indeed, belong with this specimen. Silver Lake Specimen Number 3 is a male, based on antler pedicles on the frontal bones.

Twenty-five measurements were taken on Silver Lake Specimen Number 2, and when compared to the Tope Elk, 88% of the measurements were larger for the Tope Elk (Table 3). For Silver Lake Specimen Number 3, 29 measurements were taken



FIGURE 2. Upper left tooth row of the Tope Elk, with premolars 2 through 4 and molars 1 through 3. Anterior on the left.

and 86.2% of the measurements were larger for the Tope Elk. This clearly demonstrates that the Tope Elk is larger and more robust than similar-aged elk skeletons. All measurements follow von den Driesch (1976). Muscle scars (entheses) were visually compared between the Tope Elk and the Silver Lake Elk Specimen Number 3, a similar-aged male, to assess robustness. Entheses were evaluated for 12 of the bones that were measured in Table 3, and in each case the entheses were more pronounced in the Tope Elk.

Some species of late Pleistocene mammals tended to be larger than their more recent counterparts (Guthrie 1984). Lyman (2010) notes that terminal Pleistocene elk in eastern Washington State grew to a very large size, greater than their modern counterparts, probably as a result of the high quality forage available at the time. Diminution in size has also been documented for *Bison* in the Great Plains of North America during the late Quaternary (Hill et al. 2008), and also in areas peripheral to the center of their natural range (Lyman 2004). The greater size of the Tope Elk compared to the more modern Silver Lake Elk holds to this pattern of diminution since the late Pleistocene.

Seasonality

Barnosky (1985) studied another large cervid species, the extinct late Pleistocene Irish elk (*Megaloceros giganteus*) at Ballybetagh bog in Ireland. He concluded that within male groups, which were segregated from females during the winter, winterkill was the chief cause of death of individuals. He found that male Irish elk visited

the bog more often than females during winters, and unfit individuals died and decomposed near the edge of the water. In general, male cervids are more likely to die during the winter than females because males eat less during the fall rut (Clutton-Brock et al. 1982). Thus, the Tope Elk, a mature male as evidenced by the presence of a tine from a large antler, most likely died in the fall or winter when elk have fully grown antlers. Though a large individual, the Tope Elk could have been in declining health due to conditions not indicated on the skeleton and could not survive the winter.

Accelerator Mass Spectrometry (AMS) Radiocarbon Dating

The fragment of scapula from the Tope Elk returned an AMS radiocarbon age of $10,270 \pm 30$ ^{14}C yr BP (Beta-477478) with a 2-sigma calibrated (Reimer et al. 2013) date range of 12,154 to 11,835 cal yr BP (C/N: 3.2; %C: 42.25; %N: 15.23; $\delta^{13}\text{C}$: -21.1‰; $\delta^{15}\text{N}$: 4.1‰). The second radiocarbon assay on metacarpal bone resulted in a nearly identical age of $10,260 \pm 30$ ^{14}C yr BP (Beta-521748) and a 2-sigma calibrated date range of 12,144 to 11,830 cal yr BP (C/N: 3.3; %C: 41.72; %N: 14.93; $\delta^{13}\text{C}$: -21.0‰; $\delta^{15}\text{N}$: 4.0‰). The 2 radiocarbon determinations for the Tope Elk remains are significantly older (Student's $t = 139.65$, $\chi^2 = 3.84$ [0.05], $df = 1$) than the Cranberry Prairie Elk, the next most ancient specimen in this group. These results place the Tope Elk in the terminal Pleistocene epoch, thereby predating all other directly dated specimens of *Cervus canadensis* in the region as discussed below.

Table 3
Comparative metrics in mm (in) of Tope Elk and Silver Lake Elk remains

Element	Measurement	Tope Elk	Silver Lake Elk No. 2	Silver Lake Elk No. 3
Left premaxilla and maxilla	Greatest length	304 (11.9)	N/A	N/A
Left maxilla	Lateral length	134 (5.3)	N/A	N/A
Tooth row, upper left	Greatest length	144 (5.7)	N/A	132 (5.2)
Antler tine	Length	459 (18.1)	N/A	N/A
6th cervical vertebra	Greatest height	182 (7.1)	158 (6.2)	181 (7.1)
	Greatest width	122 (4.8)	118 (4.6)	124 (4.9)
2nd thoracic vertebra	Greatest height	224 (8.8)	194 (7.6)	210 (8.3)
	Greatest breadth of body, with rib facets	48 (1.9)	42 (1.7)	51 (2.0)
3rd thoracic vertebra	Greatest height	240 (9.4)	183 (7.2)	220 (8.7)
	Greatest breadth of body, with rib facets	45 (1.8)	42 (1.7)	48 (1.9)
4th thoracic vertebra	Greatest height	231 (9.1)	184 (7.2)	211 (8.3)
	Greatest breadth of body, with rib facets	48 (1.9)	45 (1.8)	45 (1.8)
Sacrum – S1-S4	Greatest length	202 (8.0)	N/A	N/A
	Greatest breadth of anterior articular surface	69 (2.7)	55 (2.2)	65 (2.6)
	Greatest height of anterior articular surface	28 (1.1)	25 (1.0)	27 (1.1)
Left scapula	Greatest length of glenoid	72 (2.8)	69 (2.7)	76 (3.0)
	Greatest breadth of glenoid	55 (2.2)	50 (2.0)	53 (2.1)
Left metacarpal	Greatest length	270 (10.6)	271 (10.7)	278 (11.0)
	Greatest breadth, proximal	50 (2.0)	46 (1.8)	50 (2.0)
	Greatest breadth, distal	53 (2.1)	47 (1.9)	49 (1.9)
	Least breadth of diaphysis	31 (1.2)	32 (1.3)	30 (1.2)

Table 3 (continued)
Comparative metrics in mm (in) of Tope Elk and Silver Lake Elk remains

Element	Measurement	Tope Elk	Silver Lake Elk No. 2	Silver Lake Elk No. 3
2nd (middle) phalanx	Greatest length	47 (1.9)	N/A	41 (1.6)
	Greatest breadth proximal	26 (1.0)	N/A	24 (0.9)
	Least breadth of diaphysis	20 (0.8)	N/A	18 (0.7)
3rd (distal) phalanx –specimen A	Greatest length	56 (2.2)	49 (1.9)	58 (2.3)
	Length of dorsal surface	54 (2.1)	45 (1.8)	52 (2.0)
3rd (distal) phalanx –specimen B	Greatest length	55 (2.2)	N/A	N/A
	Length of dorsal surface	54 (2.1)	N/A	N/A
Right innominate	Length of acetabulum, including lip	74 (2.9)	66 (2.6)	70 (2.8)
	Length of acetabulum on rim	52 (2.0)	54 (2.1)	52 (2.0)
Right femur	Greatest length	381 (15.0)	361 (14.2)	377 (14.8)
	Greatest breadth, proximal	118 (4.6)	105 (4.1)	112 (4.4)
	Greatest breadth, distal	91 (3.6)	89 (3.5)	88 (3.5)
	Least breadth of diaphysis	38 (1.5)	35 (1.4)	36 (1.4)
	Greatest width of femoral head	47 (1.9)	45 (1.8)	47 (1.9)

Table 4
Elk remains directly dated by radiocarbon

Site name	Lab. No.	¹⁴ C age	2σ calibrated age range	Reference
Mohawk Pool, NY	Beta-197896	8,340±70 yr BP	9,489–9,135 cal yr BP	Laub 2009: p. 39
Hiscock, NY	CAMS-27142	8,620±50 yr BP	9,698–9,521 cal yr BP	Laub 2003: p. 37
Lattimer Farm, OH	---	9,020±60 yr BP	10,272–9,920 cal yr BP	Hansen 1996: p. 5
Cranberry Prairie, OH	DIC-2555	9,370±70 yr BP	10,769–10,301 cal yr BP	Murphy et al. 1985: p. 113
Tope Elk, OH	Beta-521748	10,260±30 yr BP	12,144–11,830 cal yr BP	This article
Tope Elk, OH	Beta-477478	10,270±30 yr BP	12,154–11,835 cal yr BP	This article

DISCUSSION

Only 5 directly dated elk specimens of late Pleistocene to early Holocene age are known for the eastern woodlands, and these come from the states of Ohio and New York (Table 4, above). The radiocarbon assays demonstrate that *Cervus canadensis* was resident in at least the southern Great Lakes area during the final millennium of the terminal Pleistocene (ca. 12,500 to 11,500 cal yr BP), a time frame that overlaps with the Younger Dryas event (ca. 12,900 to 11,700 cal yr BP) (Alley 2000; Carlson 2013) and the demise of the remaining North American megafauna (Faith and Surovell 2009).

The extinct stag-moose (*Cervalces scotti*) is another large cervid from the late Pleistocene of Ohio. All known Ohio dates for this species range from 15,705 to 11,345 cal yr BP (12,840 ± 100 to 10,230 ± 150 ¹⁴C yr BP) (Glotzhober and McDonald 2015: Table 2), indicating that the stag-moose largely predated elk in Ohio. *Cervalces* has typically been associated with spruce forests and its local extinction in Ohio, with subsequent increase in *Cervus*, can be correlated with the decline in *Picea* and increase in deciduous vegetation (McDonald 1989; Gill et al. 2012).

Recent calculations of “last appearance” dates for proboscideans such as the Overmyer Mastodon (*Mammuth americanum*) in Indiana (11,801 to 11,330 cal yr BP) (Woodman and Athfield 2009: Table 1) suggest that the *Cervus canadensis* may have co-existed for several centuries with this species. A more recent study of proboscidean ages (including re-dating of the Overmyer specimen), however, points to the likely extinction of mammoth and mastodon in the midcontinent by ca. 12,500 cal yr BP (Widga et al. 2017). Yet, another analysis proposes the demise of mastodon in New York State between 12,460 and 11,930 cal yr BP, and even later for mammoth at 12,240 to 10,190 cal yr BP (Feranec and Kozlowski 2016: Table 1). These various results strongly indicate that the Tope Elk existed within just a few centuries, if not as a contemporary, of the last vestiges of ice age megafauna.

The late Pleistocene environment in the Ohio region was a time of significant habitat change (Shane 1987; Shane and Anderson 1993). Recent pollen data from glacial lakes in northeast Ohio indicate the continued decline of spruce-fir (boreal)

forest on the Allegheny Plateau after ca. 12,000 cal yr BP and establishment of pine woodland during the latter half of the Younger Dryas (Swisher and Peck 2020). The correlation of this environmental shift away from spruce parkland with the timing of the Tope Elk make sense given the woodland habitat preferences of historic eastern elk (*Cervus canadensis canadensis*) (O’Gara and Dundas 2002).

Finally, the terminal Pleistocene witnessed the earliest human (Paleoindian) presence in the eastern woodlands (ca. 13,000 to 11,200 cal yr BP) (Waters and Stafford 2007; Ellis et al. 2011). The temporal position of the Tope Elk skeleton places the appearance of this species in Ohio several centuries after the arrival of the first Clovis colonizers of northern Ohio (ca. 13,000 to 12,700 cal yr BP) (Brose 1994: p. 65; Eren et al. 2018: p. 189) and during the Late Paleoindian period (12,048 to 11,192 cal yr BP) (Ellis et al. 2011). Even though the Tope Elk exhibits no evidence of direct human predation, its availability at such an early date would have made it a new, viable prey species for early hunters.

Conclusions

The analysis and dating of the Tope Elk show a greater antiquity for this species in eastern North America than previously documented. This is the first directly dated record of elk in the terminal Pleistocene of Ohio. The morphological characteristics of the remains reveal the presence of robust males of large proportions at this early time and provide evidence suggesting diminution of this species through the Holocene. This discovery also provides the first direct chronological evidence for the presence of elk in the region just a few centuries after the extinction of most late Pleistocene megafauna, but contemporary with Late Paleoindian foragers.

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