Re-evaluation of mastodon material from Oregon and Washington, USA, Alberta, Canada, and Hidalgo and Jalisco, Mexico (#94276)

First submission

Guidance from your Editor

Please submit by **16 Jan 2024** for the benefit of the authors (and your token reward) .

Structure and Criteria
Please read the 'Structure and Criteria' page for general guidance.

Raw data check
Review the raw data.

Image check
Check that figures and images have not been inappropriately manipulated.

If this article is published your review will be made public. You can choose whether to sign your review. If uploading a PDF please remove any identifiable information (if you want to remain anonymous).

Files

Download and review all files from the materials page.

8 Figure file(s)
4 Table file(s)
1 Raw data file(s)
1 Other file(s)

Structure and Criteria

Structure your review

The review form is divided into 5 sections. Please consider these when composing your review:

1. **BASIC REPORTING**
2. **EXPERIMENTAL DESIGN**
3. **VALIDITY OF THE FINDINGS**
4. General comments
5. Confidential notes to the editor

You can also annotate this PDF and upload it as part of your review

When ready submit online.

Editorial Criteria

Use these criteria points to structure your review. The full detailed editorial criteria is on your guidance page.

BASIC REPORTING

- Clear, unambiguous, professional English language used throughout.
- Intro & background to show context. Literature well referenced & relevant.
- Structure conforms to PeerJ standards, discipline norm, or improved for clarity.
- Figures are relevant, high quality, well labelled & described.
- Raw data supplied (see PeerJ policy).

EXPERIMENTAL DESIGN

- Original primary research within Scope of the journal.
- Research question well defined, relevant & meaningful. It is stated how the research fills an identified knowledge gap.
- Rigorous investigation performed to a high technical & ethical standard.
- Methods described with sufficient detail & information to replicate.

VALIDITY OF THE FINDINGS

- Impact and novelty not assessed. *Meaningful* replication encouraged where rationale & benefit to literature is clearly stated.
- All underlying data have been provided; they are robust, statistically sound, & controlled.
- Conclusions are well stated, linked to original research question & limited to supporting results.

Standout reviewing tips

The best reviewers use these techniques

Tip	*Example*
Support criticisms with evidence from the text or from other sources	*Smith et al (J of Methodology, 2005, V3, pp 123) have shown that the analysis you use in Lines 241-250 is not the most appropriate for this situation. Please explain why you used this method.*
Give specific suggestions on how to improve the manuscript	*Your introduction needs more detail. I suggest that you improve the description at lines 57- 86 to provide more justification for your study (specifically, you should expand upon the knowledge gap being filled).*
Comment on language and grammar issues	*The English language should be improved to ensure that an international audience can clearly understand your text. Some examples where the language could be improved include lines 23, 77, 121, 128 – the current phrasing makes comprehension difficult. I suggest you have a colleague who is proficient in English and familiar with the subject matter review your manuscript, or contact a professional editing service.*
Organize by importance of the issues, and number your points	*1. Your most important issue* *2. The next most important item* *3. …* *4. The least important points*
Please provide constructive criticism, and avoid personal opinions	*I thank you for providing the raw data, however your supplemental files need more descriptive metadata identifiers to be useful to future readers. Although your results are compelling, the data analysis should be improved in the following ways: AA, BB, CC*
Comment on strengths (as well as weaknesses) of the manuscript	*I commend the authors for their extensive data set, compiled over many years of detailed fieldwork. In addition, the manuscript is clearly written in professional, unambiguous language. If there is a weakness, it is in the statistical analysis (as I have noted above) which should be improved upon before Acceptance.*

Re-evaluation of mastodon material from Oregon and Washington, USA, Alberta, Canada, and Hidalgo and Jalisco, Mexico

Alton C Dooley Jr. [1], **Chris Widga** [2], **Brittney E Stoneburg** [Corresp., 1], **Chris N Jass** [3], **Victor M Bravo-Cuevas** [4], **Andrew R Boehm** [5], **Eric Scott** [6], **Andrew T McDonald** [1], **Mark Volmut** [7]

[1] Western Science Center, Hemet, CA, United States

[2] College of Earth and Mineral Sciences, Pennsylvania State University, University Park, Pennsylvania, United States

[3] Royal Alberta Museum, Edmonton, Alberta, Canada

[4] Museo de Paleontología, Universidad Autónoma Hidalgo, Pachuca, Hidalgo, Mexico

[5] Museum of Natural and Cultural History, University of Oregon, Eugene, Oregon, United States

[6] Cogstone Resource Management, Riverside, California, United States

[7] Faunal Archaeology Consultant, Olympia, Washington, United States

Corresponding Author: Brittney E Stoneburg
Email address: bstoneburg@westerncentermuseum.org

The presence of at least two contemporaneous Pleistocene mastodon taxa in North America (*Mammut americanum* and *M. pacificus*) invites re-examination of specimens at the geographic margins of each species, in order to determine range boundaries, overlaps, and fluctuations. Third molars from Oregon in the United States, as well as from Hidalgo and Jalisco in Mexico, were found to be morphologically consistent with *M. pacificus*. Washington in the United States and Alberta in Canada were each found to have some specimens that were consistent with *M. pacificus*, but others that were identified as *M. americanum*. The Alberta specimen referred to *M. pacificus* is the same tooth found to have a Pliocene divergence time from *M. americanum* based on mitochondrial genome data from a previous study, suggesting a deep divergence time between the two taxa.

The apparent presence of both mastodon taxa in close geographic proximity has interesting paleobiogeographic implications. It is not yet clear if both taxa were present simultaneously in a given location; if not, it suggests fluctuating ranges that may reflect shifting climates and/or biomes over time. Alternatively, if both taxa were simultaneously present in the same place, is may suggest a high degree of niche partitioning in mammutids. Additional accurately dated specimens will be required to resolve this question.

Re-evaluation of mastodon material from Oregon and Washington, USA, Alberta, Canada, and Hidalgo and Jalisco, Mexico

Alton C. Dooley[1], Jr., Chris Widga[2], Brittney E. Stoneburg1, Christopher N. Jass[3], Victor M. Bravo-Cuevos[4], Andrew R. Boehm[5], Eric Scott[6], Andrew T. McDonald[1], Mark Volmut[7]

[1] Western Science Center, Hemet, CA, USA

[2] Penn State University, State College, PA, USA

[3] Royal Alberta Museum, Edmonton, Alberta, Canada

[4] Museo de Paleontología, Área Académica de Biología, Universidad Autónoma del Estado de Hidalgo, Ciudad del Conocimiento, Carretera Pachuca-Tulancingo Km 4.5, CP. 42184 Pachuca, Hidalgo, Mexico

[5]Museum of Natural and Cultural History University of Oregon, Eugene, CA, USA

[6]Cogstone Resource Management, Riverside, CA, USA

[7]Faunal Archaeology Consultant, Olympia, WA, USA

Corresponding Author:

Brittney Elizabeth Stoneburg[1]

2345 Searl Parkway, Hemet CA 92543, USA

Email address: bstoneburg@westerncentermuseum.org

Abstract (English)

The presence of at least two contemporaneous Pleistocene mastodon taxa in North America (*Mammut americanum* and *M. pacificus*) invites re-examination of specimens at the geographic margins of each species, in order to determine range boundaries, overlaps, and fluctuations. Third molars from Oregon in the United States, as well as from Hidalgo and Jalisco in Mexico, were found to be morphologically consistent with *M. pacificus*. Washington in the United States and Alberta in Canada were each found to have some specimens that were consistent with *M. pacificus*, but others that were identified as *M. americanum*. The Alberta specimen referred to *M. pacificus* is the same tooth found to have a Pliocen[redacted]ivergence time from *M. americanum* based on mitochondrial genome data from a previous study, suggesting a deep divergence time between the two taxa.

The apparent presence of both mastodon taxa in close geographic proximity has interesting paleobiogeographic implications. It is not yet clear if both taxa were present simultaneously in a given location; if not, it suggests fluctuating ranges that may reflect shifting climates and/or biomes over time. Alternatively, if both taxa were simultaneously present in the same place, is may suggest a high degree of niche partitioning in mammutids. Additional accurately dated specimens will be required to resolve this question.

Abstract (Spanish)

La presencia de al menos dos especies de mastodontes en el Pleistoceno de Norteamérica (Mammut americanum y M. pacificus), conduce a revaluar ejemplares reportados en los límites geográficos de cada especie. Esto con la finalidad de conocer su área geográfica, cambios y

sobrelapamiento en distribución. En este estudio, se reconoció que terceros molares procedentes de Oregón, Estados Unidos, así como de Hidalgo y Jalisco, México, tienen una morfología consistente con la de M. pacificus. Por su parte, en Washington, Estados Unidos y Alberta, Canadá, se encontraron algunos ejemplares pertenecientes a M. pacificus y otros a M. americanum. En particular, el ejemplar de M. pacificus de Alberta, es el mismo que indica un tiempo de divergencia de M. americanum en el Plioceno, esto con base en datos de genoma mitocondrial derivado de un estudio previo, lo cual sugiere una separación temprana entre estos taxones.

El reconocimiento de ambas especies de mastodontes en cercana proximidad geográfica tiene interesantes implicaciones biogeográficas. Por el momento, si ambas especies estuvieron presentes simultáneamente en una misma localidad es incierto. En el caso de que hallan tenido fluctuaciones en su rango de distribución podría asociarse a modificaciones climáticas y/o de los ecosistemas al paso del tiempo, mientras que si hubiesen coexistido se podría asociar a un alto grado de repartición de recursos en mamútidos. La disponibilidad de ejemplares fechados aportará evidencia a esta interrogante

Abstract (French)

La présence d'au moins deux taxons contemporains de mastodontes durant le Pléistocène en Amérique du Nord (*Mammut americanum* et *M. pacificus*) invite un réexamen des spécimens en marge géographique de chaque espèce, afin de déterminer les limites d’aires de répartition, les chevauchements possibles et fluctuations des aires. Les troisièmes molaires des spécimens de

l'Orégon aux États-Unis, ainsi que de l'Hidalgo et de Jalisco au Mexique, s'avèrent morphologiquement cohérentes avec *M. pacificus*. Certaines de l'état de Washington aux États-Unis et de l'Alberta au Canada sont compatibles avec *M. pacificus*, alors que d'autres ont été identifiés comme *M. americanum*. Le spécimen de l'Alberta référé comme *M. pacificus* avait précédemment fait l'objet d'une étude de son génome mitochondrial. Les résultats de cette analyse avaient démontré un temps de divergence dans le Pliocène avec *M. americanum*, s'avérant donc profond entre les deux taxons.

La présence apparente des deux taxons de mastodontes en proximité géographique a des implications paléobiogéographiques intéressantes. Il n'est pas encore clair si les deux taxons étaient présents simultanément en un endroit donné; si cela n'était pas le cas, cela suggère des fluctuations des aires de répartition qui pourraient refléter des changements du climat et / ou des biomes au fil du temps. Alternativement, si les deux taxons étaient simultanément présents au même endroit, cela pourrait suggérer un haut degré de partitionnement des niches chez les mammutidés. Des spécimens supplémentaires datés avec précision seront nécessaires pour résoudre cette question.

Introduction

Mastodons (*Mammut*) are a nearly ubiquitous part of the Late Pleistocene fauna of North America and have been scientifically studied for more than 200 years. With such a lengthy period of study, it is perhaps surprising that recent research has revealed surprising new information about mastodons, including unexpected regional concentrations of specimens (e.g., Springer et al. 2009, 2010; Fisher et al. 2014), information about life histories and extinctions

(Fisher 2008, 2009; Miller et al. 2022; Smith and Fisher 2011; Widga et al. 2017, 2021), genetic information documenting complex biogeographic patterns (Karpinski et al. 2020), and previously unrecognized taxa (Dooley et al. 2019).

The discovery of the Pacific mastodon (*Mammut pacificus*) on the west coast of North America (Dooley et al. 2019) and the high level of endemism indicated in genetic data (Karpinski et al. 2020) both suggest that much remains to be learned about the diversity and relationships of different regional populations of mastodons. Indeed, the discovery of a Pacific mastodon specimen in Montana (McDonald et al. 2020), hundreds of kilometers east of any other records of this taxon, confirmed the potential for valuable data to be derived from locations not traditionally considered as "mastodon country".

Here we report several newly recognized occurrences of *Mammut pacificus* in Canada, the United States, and Mexico, based on specimens previously referred to *M. americanum*. Most of these represent considerable range extensions for *M. pacificus*, and indicate a more complex biogeographic history of Pleistocene mastodons.

Materials & Methods

When describing *M. pacificus*, Dooley et al. (2019) took a conservative approach in referring specimens to *M. pacificus*. They only referred specimens for which there was compelling morphological and biogeographic data to *M. pacificus*, while all other specimens were considered *M. americanum* (i. e., essentially, the null hypothesis was that a specimen was *M. americanum*). As a result, they considered material from the Pacific Northwest and from Mexico

to be *M. americanum,* as at the time there was little biogeographic or morphological support for referral of these specimens to *M. pacificus*. Additional studies on mammutids since 2019, including McDonald et al. (2020) and Karpinski et al. (2020) invite reassessment of material from these regions.

Calculations for length/width ratio of mastodon third molars follows Dooley et al (2019); measurements of limb elements follow Hodgson et al (2008).

Institutional Abbreviations

F-, Tualatin Public Library, Tualatin, Oregon, USA; **DMNH**, Denver Museum of Natural History, Denver, Colorado, USA; **LACM**, Natural History Museum of Los Angeles County, Los Angeles, California, USA; **RAM**, Royal Alberta Museum, Edmonton, Alberta, Canada; **LSUMG**, Louisiana State University Museum of Natural Science, Baton Rouge, Louisiana, USA; **NMC**, Canadian Museum of Nature, Ottawa, Ontario, Canada; **SBMNH**, Santa Barbara Museum of Natural History, Santa Barbara, California, USA; **SDSNH**, San Diego Natural History Museum, San Diego, California, USA; **UAHMP**, Museo de Paleontología, Universidad Autónoma del Estado de Hidalgo, México; **UCMP**, University of California, Berkeley Museum of Paleontology, Berkeley, California, USA; **USNM**, United States National Museum of Natural History, Washington DC, USA; **UWBM**, University of Washington Burke Museum Seattle, Washington, USA; **WSC**, Western Science Center, Hemet, California, USA.

Results

Oregon

Dooley et al. (2019) considered all Pleistocene mammutid material from Oregon as *Mammut americanum*. All of the teeth they examined were either non-diagnostic for distinguishing between *M. americanum* and *M. pacificus* (e.g., M2), or came from tooth positions with very small sample sizes (e.g., premolars). Even so, Oregon specimens of tooth positions with small sample sizes, such as P3, still had L:W ratios that were more similar to *M. pacificus* than to *M. americanum*. Dooley et al. (2019) noted that these remains were biogeographically and anatomically anomalous if assigned to *M. americanum*, and hypothesized that they may in fact represent *M. pacificus*.

One specimen not examined by Dooley et al. (2019) was the Tualatin mastodon (F-30282), recovered in 1962 and currently on display in the Tualatin Public Library. Nearly the entire left side of the animal is preserved, including the left tusk and a portion of the maxilla with the preserved M2 and M3 (Figure 1). Based on photos of the excavation and rudimentary notes, the remains were situated approximately 3.5-5 feet (1.067-1.52 m) below the surface in a marsh. The Tualatin mastodon dates to the Late Pleistocene (Gilmour et al. 2015, Table 1), post-dating the Missoula floods and human colonization of the area (Davis et al. 2019; O'Connor et al. 2020). The M3 has a L:W ratio of 2.07, which is outside the range of M3s of *M. americanum* in our dataset (1.59-1.95), but well within the range of *M. pacificus* (1.69-2.33) (Table 2, Figure 2). Additionally, the left femur is complete and has a maximum length of 807 mm and mid-shaft width of 130 mm, placing it within the range of smaller *M. pacificus* specimens (Dooley et al. 2019: Figure 25). These measurements indicate that the Tualatin mastodon is *M. pacificus*, suggesting that other Oregon material previously reported as *M. americanum* may be *M. pacificus* as well.

Another noteworthy Oregon specimen is USNM 4911, an isolated left M2 described as *Mammut oregonense* by Hay (1926). Dooley et al. (2019) showed that M2 does not differ in any consistent way between *M. pacificus* and *M. americanum*, even in L:W ratio. As *M. oregonense* is only represented by an M2 and no other specimens have ever been referred to this taxon, we concur with assessment of Dooley et al. (2019) that *M. oregonense* should be considered a *nomen dubium*, and its use restricted to the holotype.

Washington

Dooley et al. (2019) assigned three specimens from Washington to *M. americanum*, two mandibles that included m3s and an isolated M3, all from different localities. The isolated right M3 (UWBM 83312) from Jefferson County is a tetralophodont tooth missing large areas of enamel (Figure 3F). There is little to no wear on lophs 4 and 5, but damage on the first three lophs make it impossible to assess the wear in these areas. The L:W ratio is 1.82, closer to the average of *M. americanum* (1.76) that to *M. pacificus* (1.98), but within the known range of values for both taxa (Figure 2).

UWBM 88099 is a mandible from Lewis County that includes the left m2 and m3, and the right m3 (Figure 3C-E). The anterior tip of the mandible is damaged, as are both ascending mandibular rami, which are missing the condyles. While the anterior tip of the mandible is imperfectly preserved, there is no indication of alveoli for mandibular tusks. The L:W ratio of the left m3 is 1.94. This value is slightly lower than any known specimen of *M. pacificus* (the

lowest known value is 1.95, average 2.26), and close to the mean value for *M. americanum* (1.89) (Figure 4).

UBMW 14491 is a complete mandible from Clallam County that includes both left and right m1, m2, and m3 (Figure 3G-I). The m1s show heavy wear, the m2s are in moderate wear, and the m3s are not yet fully erupted and show only slight wear on the first lophids. This is most equivalent to Laws (1966) Group XVII or XVIII, indicating and age of 28-30 ±2 African elephant equivalent years. There are no alveoli for mandibular tusks. The right m3 has a L:W ratio of 2.11. This is well within the known range for *M. pacificus*, but is greater than all but one *M. americanum* in our database (N=134) (Figure 4).

Given the newly recognized presence of *M. pacificus* in Oregon, it appears that Dooley et al. (2019) were overly conservative in their assignment of all Washington specimens to *M. americanum*. While the referral of UBMW 88099 to *M. americanum* is justified, we refer UWBM 14491 to *M. pacificus*, while UWBM 83[illegible]2 should be considered *Mammut* sp.

The Manis mastodon was not included in Dooley et al. (2019). This specimen was discovered during excavation of a holding pond near Sequim, Clallam County, Washington in 1977, and became well known because of a reported bone projectile point embedded on one of the ribs (Gustafson et al. 1979; Waters et al. 2011), although subsequent studies have determined that the putative projectile point was actually forced into the rib by the machinery used to excavate the specimen (Haynes and Huckell 2016). Carbon dates from bone collagen yielded an age of approximately 13,800 ybp (Waters et al. 2011). The Manis mastodon has never been fully

206 described or figured, but Gustafson et al. (1979) mention tusk segments up to 2 m in length,
207 suggesting that the individual may have been a male. Field sketches reproduced in Gustafson et
208 al. (1979) indicate the presence of numerous ribs, and at least portions of a forelimb including
209 the scapula, humerus, and ulna. They also figure a heavily worn m2, and mention numerous skull
210 fragments.
211
212 A number of elements from the Manis mastodon are on exhibit at the Sequim Museum and Arts
213 in Sequim, including a complete right dentary with an *in situ* m3 (Figure 3A, B). The mandibular
214 symphysis does not have alveoli for mandibular tusks. The m3 is pentaloph, with wear on all five
215 lophids and heavy wear on the first two. This level of wear is consistent with Laws Group XXII
216 or XXIII, yielding an age of 39-43 ± 2 AEY. The L:W ratio of this tooth is 2.09, within the
217 normal range for *M. pacificus* and much narrower than typical *M. americanum* m3s (only two *M.*
218 *americanum* specimens out of 134 in our dataset are narrower) (Figure 4). Based on the narrow
219 m3 and the absence of mandibular tusks, we assign the Manis specimen to *M. pacificus*.
220
221 **Hidalgo**
222 Multiple elements of a single mastodon are known from Rancholabrean deposits at Ventoquipa,
223 Hidalgo, Mexico (UAHMP-311; Bravo-Cuevas et al. 2015) (Figure 5). Dooley et al. (2019)
224 included this specimen as *M. americanum* in their database, even though the L:W ratio of the M3
225 of UAHMP-311 is 1.93, close to the mean for *M. pacificus* (1.98) and close to the maximum
226 value known for *M. americanum* (1.95) (Table 2, Figure 2). Measurements of the m3 of this
227 specimen are now available; it a L:W ratio of 2.29. This is higher than any specimen of *M.*
228 *americanum* in our database (maximum=2.23, n=134), and is greater than the mean for *M.*

pacificus (2.25) (Table 3, Figure 4). As both M3 and m3 of UAHMP-311 fall within the known range of *M. pacificus*, and m3 falls outside the known range of *M. americanum*, we refer this specimen to *M. pacificus*.

Jalisco

A left M3 (LACM 1854) (Figure 6) was recovered in 1955 from Lago de Chapala, near San Luis Soyatlan, Jalisco, Mexico. A rich fauna from this site includes remains from both *Mammuthus* and *Cuvieronius* (Lucas 2008), but LACM 1854 is the only mammutid element identified thus far. The age of the Lago de Chapala specimens has been problematic, potentially ranging from Rancholabrean to Blancan, but the material from San Luis Soyatlan appears to be Rancholabrean (Lucas, 2008; Rufolo, 1998).

LACM 1854 is a tetralophodont left M3. Large portions of the tooth, including the entire root area, are encrusted with what appears to be a carbonate or other evaporitic mineral. While there is some damage to the pretrite side of the first loph, the other lophs are undamaged. The lophs are simple, lacking the additional conelets that commonly fill the troughs between lophs in gomphotheriids. There is light to moderate wear on the pretrite side of the first three lophs, with the fourth loph showing only very slight wear. There is a distinct cingulum on the anterior margin, but this does not appear to extend to other portions of the tooth.

The length:width ratio of this tooth is 2.07, well within the known range of *M. pacificus* (1.69 - 2.33; mean = 1.98) (Table 2, Figure 2). No *M. americanum* M3 in our database has such a high

L:W value (maximum = 1.95; mean = 1.77) justifying the referral of LACM 1854 to *M. pacificus*.

Alberta

A limited number of mammutid remains are known from Alberta, and were reviewed by Jass and Barrón-Ortiz (2017). Nearly all of those records represent isolated specimens recovered from gravel pits in the Edmonton area. The most complete specimen is a partial mandible, RAM P94.16.1 (Figure 7) from the Apex Galloway Pit, located near Edmonton. The m3 in this specimen has a L:W ratio of 1.78, well outside the known range of *M. pacificus* and within the known range of *M. americanum*. Moreover, RAM P94.16.1 has well-developed alveoli for lower tusks, which are unknown in *M. pacificus* but occur in about 30% of *M. americanum* mandibles (Green 2006), regardless of age or sex.

A second specimen, RAM P97.7.1 (Figure 7), also comes from an Edmonton-area gravel pit (Pit 46). Although damaged, this specimen is identified as a partial left M3 based on the right angle formed by the loph axis and the long axis of the tooth (note: this specimen was reported as an m3 in Jass and Barrón-Ortiz (2017)). The tooth includes five lophs, but the first two lophs are damaged, making direct measurement of the maximum tooth width impossible, as in M3 the widest part of the tooth is always at either the first or second loph.

In order to estimate the likely maximum width of RAM P97.7.1, we calculated individual loph widths as a percentage of maximum loph width for 34 *Mammut* M3s, including 17 specimens

each of *M. pacificus* and *M. americanum* (Table 4). This enabled us to calculate a range of likely values of the maximum width of a tooth for a given width of the third loph.

RAM P97.7.1 is 183.69 mm long, while the third loph has a width of 81.27 mm. Using the values of of *Mammut* specimens Table 4 as a guide yields a L:W ratio for the specimen of 1.95-2.26 (average = 2.12). RAM P.97.7.1 has a L ratio that plots completely within the normal range for *M. pacificus*, and essentially outside the range for *M. americanum* (the narrowest M3 of *M. americanum* in our dataset has an L:W ratio of 1.95). Based on these data, we confidently assign RAM P97.7.1 to *M. pacificus*.

Discussion

The presence of *M. pacificus* in Oregon and Washington is consistent with earlier reports of this taxon from northern California, Idaho, and Montana (Dooley et al. 2019; McDonald et al. 2020) (Figure 7). These records highlight a broad distribution of *M. pacificus* across the Pacific Northwest and northern Rocky Mountain region of the western United States. At least some of those records (e.g., Montana) pre-date the late Pleistocene and may provide an opportunity to explore further paleobiological questions (e.g., do early records in Montana reflect greater capacity to occupy an array of environmental niches or are they a reflection of earlier Pleistocene environmental perturbations?).

The presence of *M. pacificus* in Jalisco and Hidalgo is a significant and surprising range extension for this taxon. The Mexican record represents the southernmost occurrences of Rancholabrean *M. pacificus*, inhabiting areas that now are part of west-central and central

Mexico. Given that Texas and New Mexico specimens are assignable with some confidence to *M. americanum* (Dooley et al. 2019), it seems that the range boundaries near the southern margins of the distribution for these two species lay somewhere in northern Mexico during the Late Pleistocene.

Pedersick et al. (2022) reported the presence of mitochondrial genome material consistent with *M. americanum* from American Falls, Idaho, a site that has produced specimens referred to *M. pacificus* based on morphology (Dooley et al. 2019). Here we add Washington and Alberta to Idaho as states/provinces that have produced specimens of both *M. americanum* and *M. pacificus*, although it is unclear if these taxa were present contemporaneously in each location. While the *M. pacificus* specimens from Clallam County, Washington were post-LGM (the Manis site is dated to 13,800 ybp (Waters et al. 2011)), the single *M. americanum* specimen from Jefferson County, Washington has not been dated. Nearly all mastodon specimens from Alberta, and much of the record of megafauna of Alberta, were recovered as part of industrial gravel extraction (Jass and Barrón-Ortiz 2017). Precise contextual data are not available for most specimens, inhibiting our ability to temporally relate individual specimens from the region that lack C-14 data or exceed the capabilities of radiocarbon dating. Direct dates on the Alberta specimens discussed here are either infinite (P97.7.1; >41,100 ^{14}C yr BP; Metcalfe et al. 2016) or close to infinite and in need of re-evaluation (P94.16.1; 40,700±3000 ^{14}C yr BP; Jass and Barrón-Ortiz 2017). Although our ability to relate the specimens in time is somewhat challenged, that does not diminish the significance of the observation of both taxa in the same geographic region.

The eastern Montana *M. pacificus* specimen reported by McDonald et al. (2020) lies far to the east of the Washington and Alberta occurrences of *M. americanum*, suggesting that the ranges of these taxa may have overlapped significantly in the northern Great Plains or that the range boundaries may have fluctuated over time. Although limited temporal control leaves that question presently unresolved, we note that the record of both *M. americanum* and *M. pacificus* in Alberta and Washington points to further complexity in movement of taxa through the interior of northern North America during the Pleistocene. South-to-north dispersals through Alberta may have been influenced by population sources from both sides of the Rocky Mountains.

These data are of particular interest when considered in the context of mitochondrial genome data *for Mammut* described by Karpinski et al. (2020). They found a high level of endemism in *Mammut* populations in all regions they studied except in Alberta, where there were specimens with phylogenetic affinities to Missouri, Alaska, and Mexico. The single specimen with genetic affinities to Mexican specimens was RAM P.97.7.1, and is the same tooth that we have morphologically identified as *M. pacificus*. This suggests that the "Clade M" of Karpinski et al. (2020), which included RAM P97.7.1 and the Mexican specimens, may represent *M. pacificus*, while their clades Y, G, L, N, and A, taken together, represent *M. americanum*. According to Karpinski et al. (2020), Clade M diverged from the other clades at 3.03 Ma, indicating that *M. pacificus* and *M. americanum* likely diverged from each other sometime in the Pliocene. Examination of Early Pleistocene and Pliocene mammutids along with better age constraints on known specimens should help illuminate the nature of the divergence of these taxa as well as the biogeographic changes that have taken place in North America during the Neogene.

Acknowledgements

The authors would like to thank the Tualatin Pubic Library, the Sequim Museum and Arts, the Natural History Museum of Los Angeles County, Royal Alberta Museum, Museo de Paleontología, Universidad Autónoma del Estado de Hidalgo, and the Burke Museum of Natural History and Culture for access to specimens in their care.

References

Bravo-Cuevas V.M., Morales-García N.M., and Cabral-Perdomo M.A. 2015. Description of mastodons (*Mammut americanum*) from the late Pleistocene of southeastern Hidalgo, central Mexico. *Boletín de la Sociedad Geológica Mexicana* 67(2): 337-347. DOI 10.18268/bsgm2015v67n2a14

Davis L.G., Madsen D.B., Becerra-Valdivia L., Higham T., Sisson D.A., Skinner S.M., Stueber D., Nyers A.J., Keen-Zebert A., Neudort C., Cheyney M., Izuho Ml, Iizuka Fl, Burns S.R., Epps C.W., Willis S.C. & Buvit I. 2019. Late Upper Paleolithic occupation at Cooper's Ferry, Idaho, USA,~ 16,000 years ago. *Science*, 365(6456), 891-897.

Dooley A.C. Jr., Scott E., Green J., Springer K.B., Dooley B.S., Smith G.J. 2019. *Mammut pacificus* sp. nov., a newly recognized species of mastodon from the Pleistocene of western North America. *PeerJ* 7: e6614 DOI 10.7717/peerj.6614.

Fisher D.C. 2008. Taphonomy and paleobiology of the Hyde Park mastodon.. *In* W. D. Allmon and P. L. Nester (eds.). Mastodon paleobiology, taphonomy, and paleoenvironment in the late

364 Pleistocene of New York State: studies on the Hyde Park, Chemung, and North Java sites.
365 *Palaeontographica Americana* 61: 197-290.
366
367 Fisher D.C. 2009. Paleobiology and extinction of proboscideans in the Great Lakes region of
368 North America. *In* G. Haynes (ed.). American Megafaunal Extinctions at the End of the
369 Pleistocene. Springer Science+Business Media, New York, pp. 55-75.
370
371 Fisher D.C., Rountrey, A.N., Smith, K.M., and Fox, D.L. 2010. Stable isotope time series and
372 dentin increments elucidate Pleistocene proboscidean paleobiology. *Geophysical Research*
373 *Abstracts*, Vol. 12, European Geosciences Union 2010.
374
375 Fisher D.C., Cherney M.D., Newton, C., Rountrey, A.N., Calamari, Z.T., Stucky, R.K., Lucking,
376 C., Petrie, L. 2014. Taxonomic overview and tusk growth analyses of Ziegler Reservoir
377 proboscideans. *Quaternary Research* 82:518-532. DOI 10.1016/j.yqres.2014.07.010
378
379 Gilmour D.M., Butler V.L., O'Connor J.E., Davis E.B., Culleton B.J., Kennett D.J., Hodgins G.
380 2015. Chronology and ecology of late Pleistocene megafauna in the northern Willamette Valley,
381 Oregon. *Quaternary Research*, 83(1), 127-136.
382
383 Green J.L. 2006. Chronological variation and sexual dimorphism in *Mammut americanum*
384 (American mastodon) from the Pleistocene of Florida. *Bulletin of the Florida Museum of Natural*
385 *History* 46(2):29-59.
386

387 Gustafson C.E., Gilbow D.W., Daugherty R.D. 1977. The Manis Mastodon Site: early man on
388 the Olympic Peninsula. *Canadian Journal of Archaeology* 3:157-164.
389
390 Haynes C.V. Jr., Huckell B.B. 2016. The Manis Mastodon: An alternative interpretation.
391 *PaleoAmerica* 2(3):189-191. https://doi.org/10.1080/20555563.2016.1210945
392
393 Hodgson J.A., Allmon W.D., Nester P.L., Sherpa J.M., Chimney J.J. 2008. Comparative
394 osteology of late Pleistocene mammoth and mastodon remains from the Watkins Glen Site,
395 Chemung County, New York. *In* Allmon W.D., Nester P.L., (eds.). Mastodon Paleobiology,
396 Taphonomy, and Paleoenvironment in the Late Pleistocene of New York State: Studies on the
397 Hyde Park, Chemung, and North Java Sites. Ithaca: *Paleontographica Americana*. 61:301-367
398
399 Jass C., Barron-Ortiz C. 2017. A review of Quaternary proboscideans from Alberta, Canada.
400 *Quaternary International* 443:88-104. 10.1016/j.quaint.2016.10.028.
401
402 Karpinski E., Hackenberger D., Zazula G., Widga C., Duggan A.T., Golding G.B., Kuch M.,
403 Klunk J., Jass C.N., Groves P., Drukenmiller P., Schubert B.W., Arroyo-Cabrales J., Simpson
404 W.F., Hoganson J.W., Fisher D.C., Ho S.Y.W., MacPhee R.D.E., Poinar H.N. 2020. American
405 mastodon mitochondrial genomes suggest multiple dispersal events in response to Pleistocene
406 climate oscillations. *Nature Communications* 11: 4048 https://doi.org/10.1038/s41467-020-
407 17893-z
408

Lucas S. 2008. Late Cenozoic fossil mammals from the Chapala rift basin, Jalisco, Mexico. *In* Lucas S.G., Morgan G.S., Spielmann J.A., Prothero D.R. (eds.). Neogene Mammals. *New Mexico Museum of Natural History and Science Bulletin* 44: 39-49.

McDonald A.T., Atwater A.L., Dooley Jr. A.C., Hohman C.J.H.. 2020. The easternmost occurrence of *Mammut pacificus* (Proboscidea: Mammutidae), based on a partial skull from eastern Montana, USA. *PeerJ* 8: e10030 https://doi.org/10.7717/peerj.10030

Metcalfe J.Z., Longstaffe F.J., Jass C.N., Zazula G.D., Keddie G., 2016. Taxonomy, location of origin, and health status of proboscideans from western Canada investigated using stable isotope analysis. *Journal of Quaternary Sciences* 31: 126-142.

Miller J., Fisher D., Crowley B., Konomi B. 2022. Male mastodon landscape use changed with maturation (late Pleistocene, North America). *PNAS 119, 25.* https://doi.org/10.1073/pnas.2118329119

O'Connor J.E., Baker V.R., Waitt R.B., Smith L.N., Cannon C.M., George D.L., Denlinger R.P.. 2020. The Missoula and Bonneville floods—A review of ice-age megafloods in the Columbia River basin. *Earth-Science Reviews*, 208, 103181.

Peek B.R., Karpinski E., Widga C., Boehm A., Kuch M., Murchie T.J., Thompson M.E., Poinar H.N. 2022. Molecular and morphological assessments of mastodons of the American

Falls Reservoir, Idaho: American? Pacific? Both? Abstract. *Society of Vertebrate Paleontology 82nd Annual Meeting Program Guide*, 266.

Rufolo S.J. 1998. Taxonomy and the significance of the fossil mammals of Lake Chapala, Jalisco, Mexico. MS thesis, Brigham Young University, Provo.

Smith K., Fisher D. 2011. Sexual dimorphism of structures showing indeterminate growth: tusks of American mastodons (*Mammut americanum*). *Paleobiology* 2011;; 37 (2): 175–194. doi: https://doi.org/10.1666/09033.1

Springer K.B., Scott E., Sagebiel J.C., Murray L.K.. 2009. The Diamond Valley Lake local fauna: late Pleistocene vertebrates from inland southern California. In L.B Albright III (ed.). Papers on Geology, Vertebrate Paleontology and Biostratigraphy in Honor of Michael O. Woodburne. *Museum of Northern Arizona Bulletin* 65, 217-235.

Springer K.B., Scott E., Sagebiel J.C., Murray L.K. 2010. Late Pleistocene large mammal faunal dynamics from inland southern California: The Diamond Valley Lake local fauna. *Quaternary International* 217: 256-265. DOI 10.1016/j.quaint.2009.10.041

Waters M.R., Stafford T.W. Jr., McDonald H.G., Gustafson C., Rasmussen M., Cappellini E., Olsen J.V., Szklarczyk D., Jensen L.J., Gilbert M.T.P., Willerslev E. 2011. Pre-Clovis mastodon hunting 13,800 years ago at the Manis Site, Washington. *Science* 334:351-353.

454 Widga C., Lengyel S.N., Saunders J., Hodgins G., Walker J.D., Wanamaker J.D. 2017. Late
455 Pleistocene proboscidean population dynamics in the North American Midcontinent. *Boreas*
456 46(4):772-782. DOI 10.1111/bor.12235
457
458 Widga C., Hodgins G., Kolis K., Lengyel S., Saunders J., Walker J.D., Wanamaker A.D. 2021.
459 Life histories and niche dynamics in late Quaternary proboscideans from midwestern North
460 America. *Quaternary Research 100:224-239.* https://doi.org/10.1017/qua.2020.85

Figure 1

Mammut pacificus F-30282 (Tualatin mastodon) left M3, occlusal view

Scale = 5 cm

Figure 2

Length/width ratios of *Mammut* M3s, segregated by state/province.

Symbols in red are *M. pacificus*; all other colors are *M. americanum*.

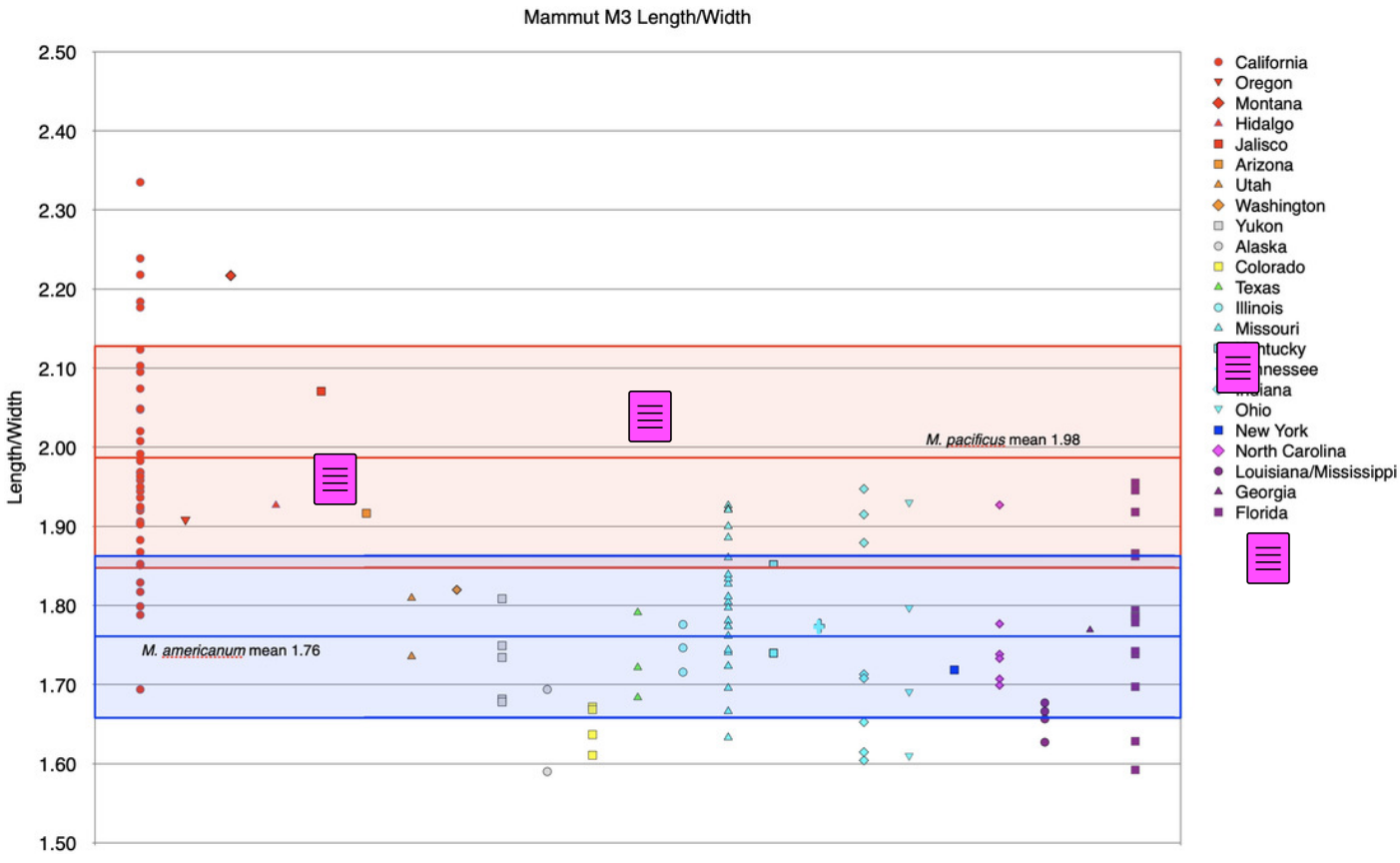

Figure 3

Mammut specimens from Washington, USA.

A, B: *Mammut pacificus* (Manis mastodon) right m3, occlusal view (A), right dentary, medial view (B). C-E: *Mammut americanum* mandible UWBM 88099, dorsal (C), left lateral (D), and right lateral (E). F, Mamm sp. right M3 UWBM 83312, occlusal view. G-H: Mammut cificus mandible UBMW 14491, dorsal (G), left lateral (H), and right lateral (I). All scales = 5 cm.

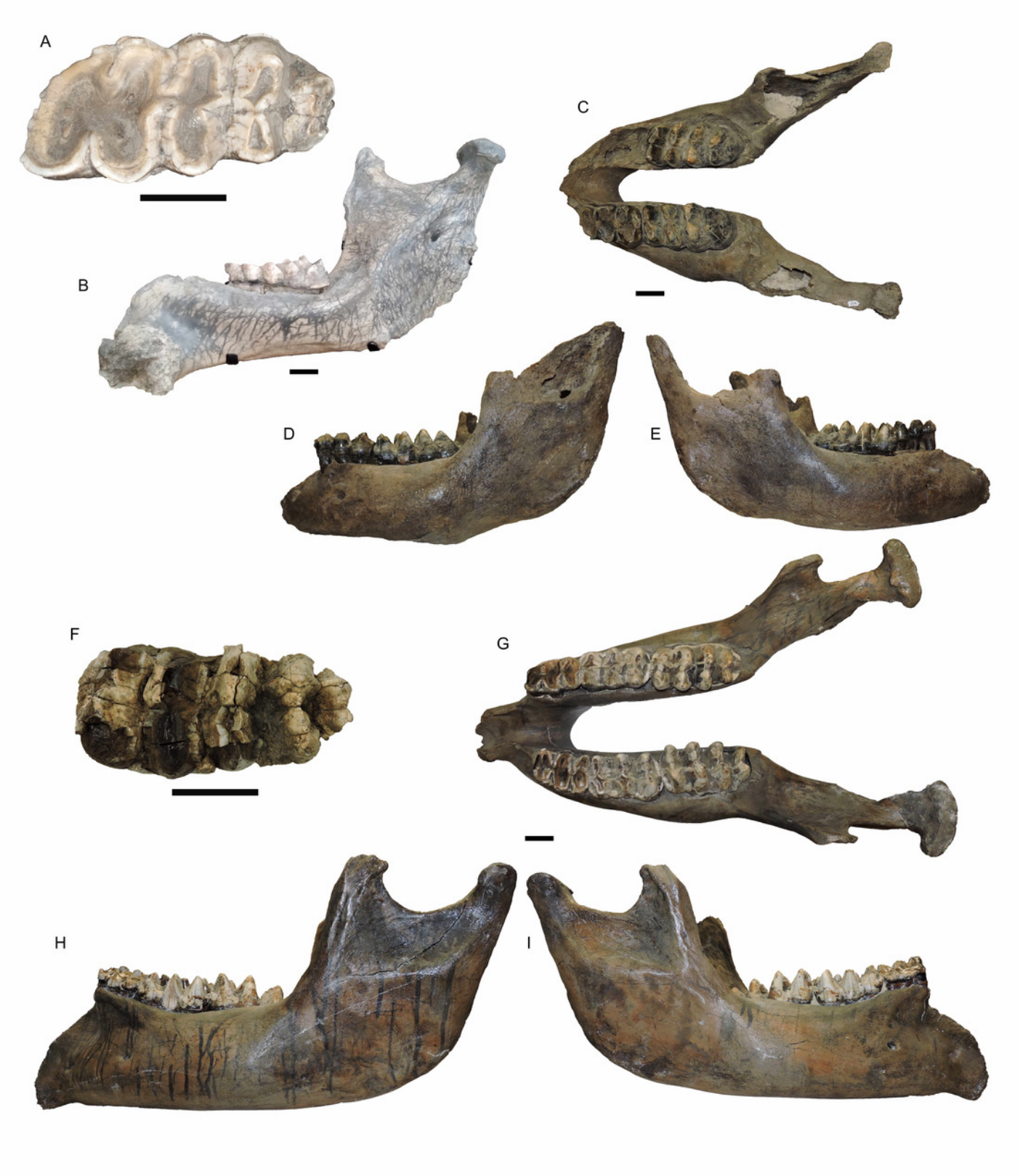
A
B
C
D
E
F
G
H
I

Figure 4

Length/width ratios of *Mammut* m3s, segregated by state/province.

Symbols in red are *M. pacificus*; all other colors are *M. americanum*.

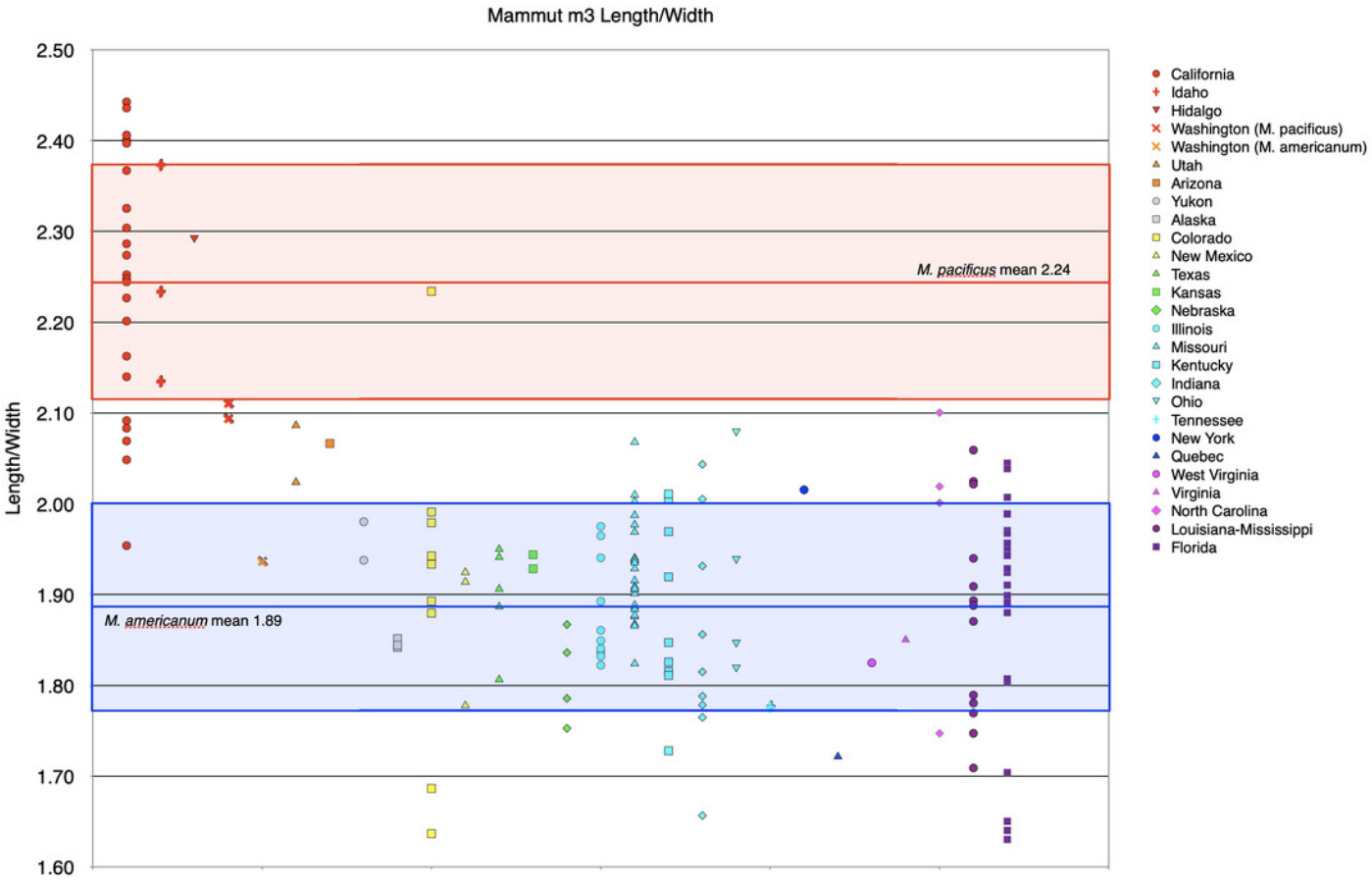

Figure 5

Mammut pacificus UAHMP-311 right M3 (A) and right m3 (B), occlusal view

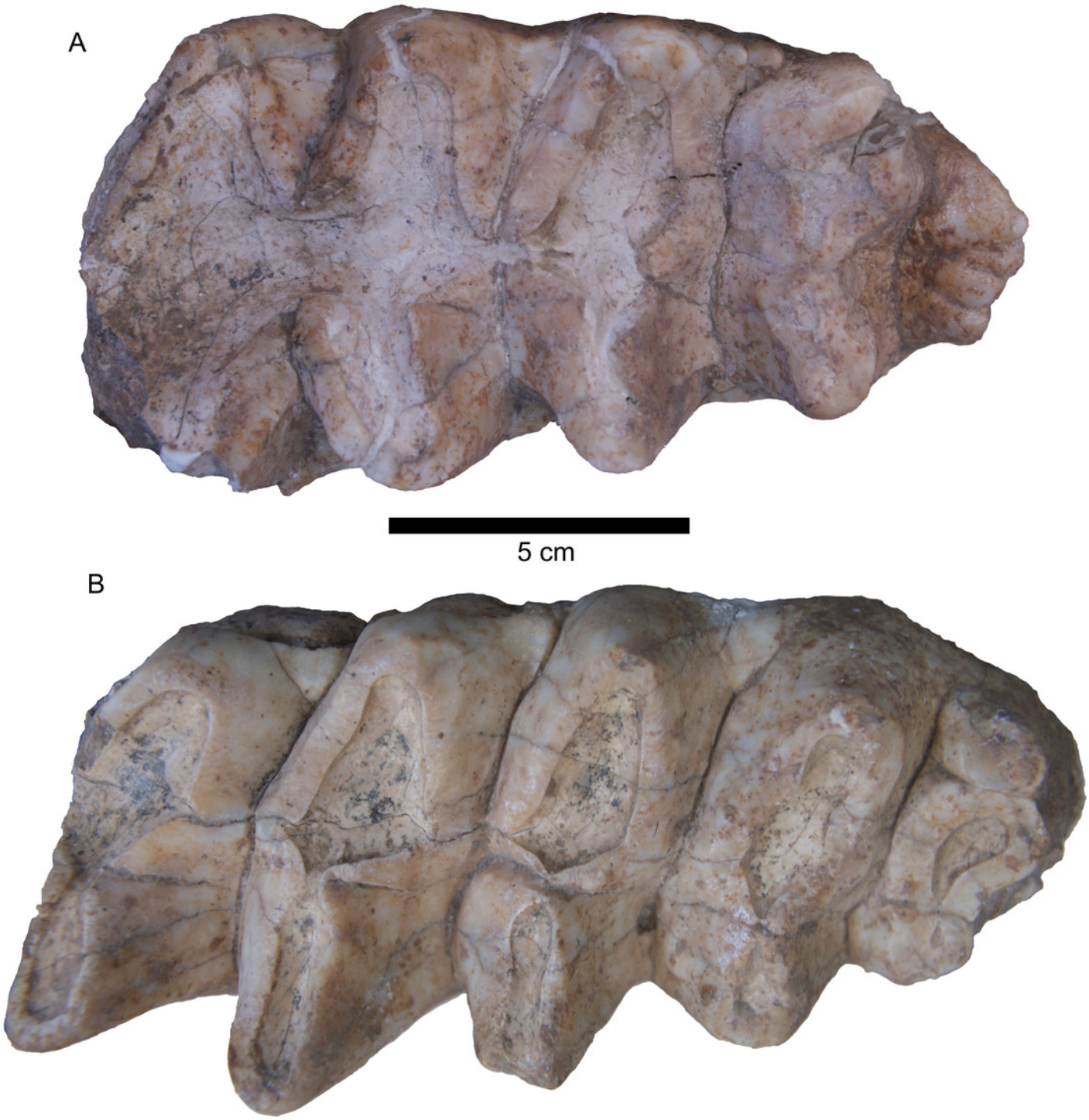

Figure 6

Mammut pacificus LACM 1854 left M3

Mammut pacificus LACM 1854 left M3, in occlusal (A), labial (B) and lingual (C) views.

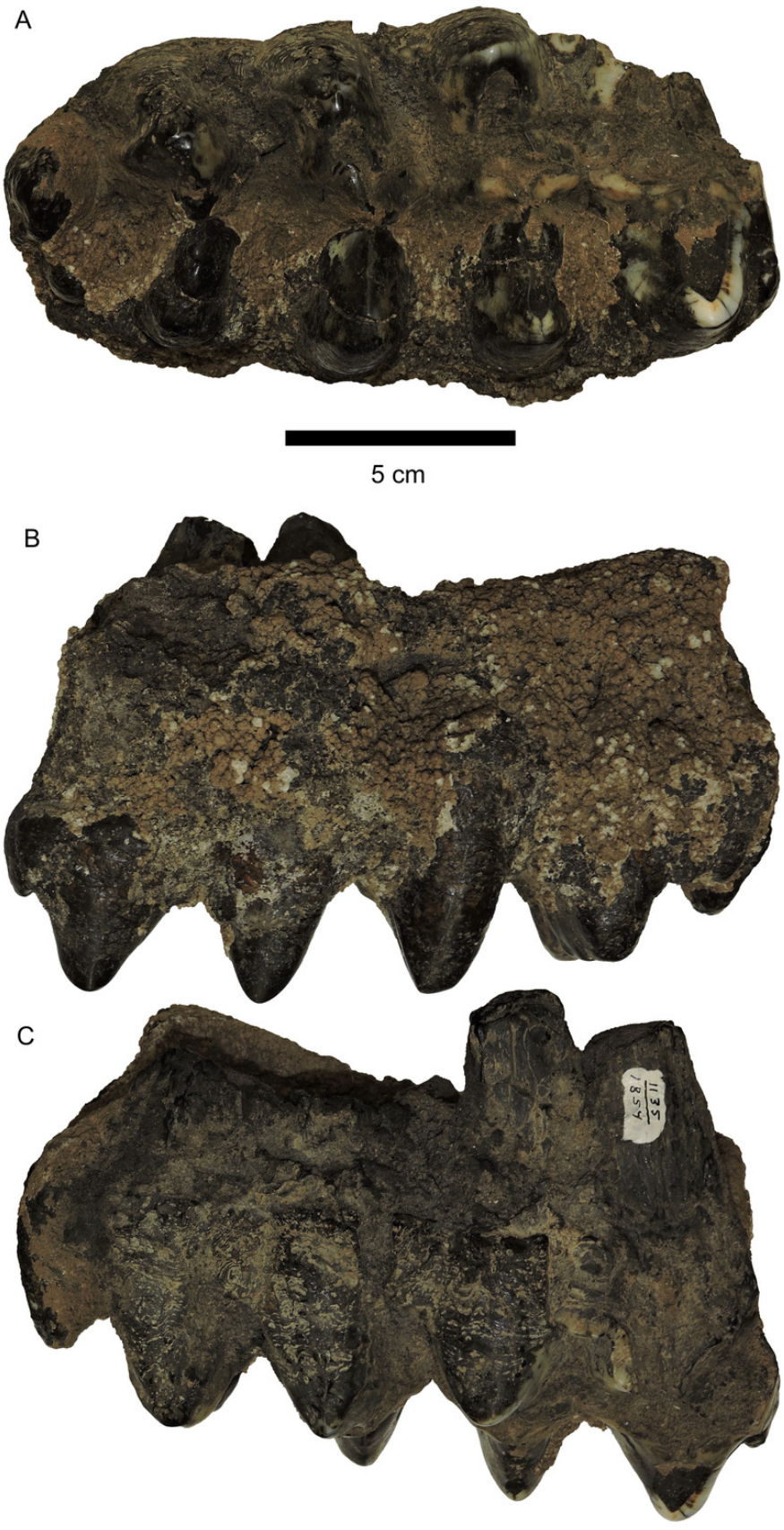
A
5 cm
B
C

Figure 7

Mammut specimens from Alberta. A-C, *Mammut americanum* mandible RAM P94.16.1 in dorsal (A), anterior (B), and right lateral (C) views.

Note the large chin tusk alveolar in (B). D- E, *Mammut pacificus* left M3 RAM P97.7.1 M3 in occlusal (D) and labial (E) views.

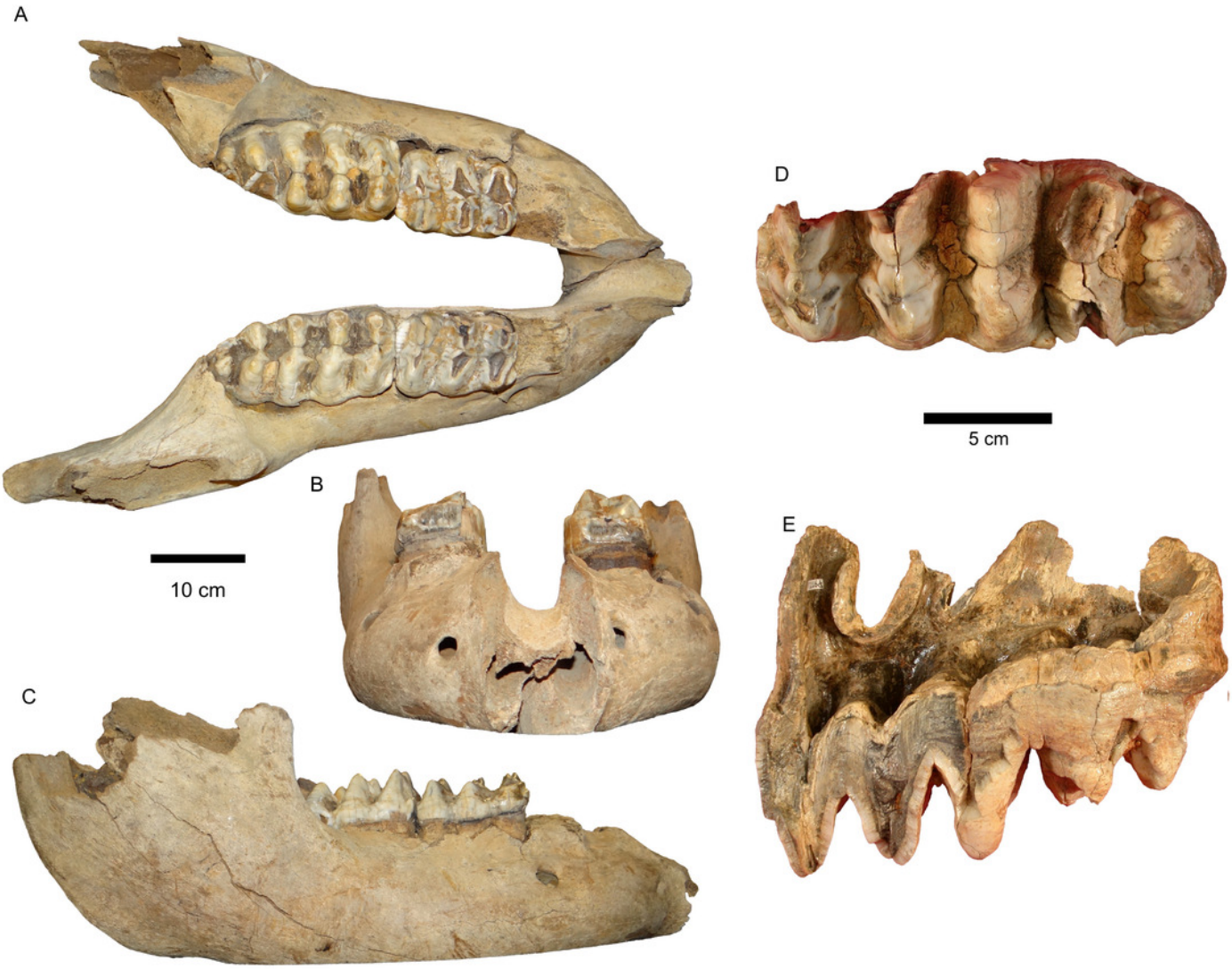

Figure 8

Late Pleistocene distribution map of *Mammut pacificus* and *Mammut americanum*

based on specimens examined in this paper, Karpinski et al. 2020, McDonald et al. 2021, and Dooley et al. 2019. Note that these distributions are approximate and most likely fluctuated with time.

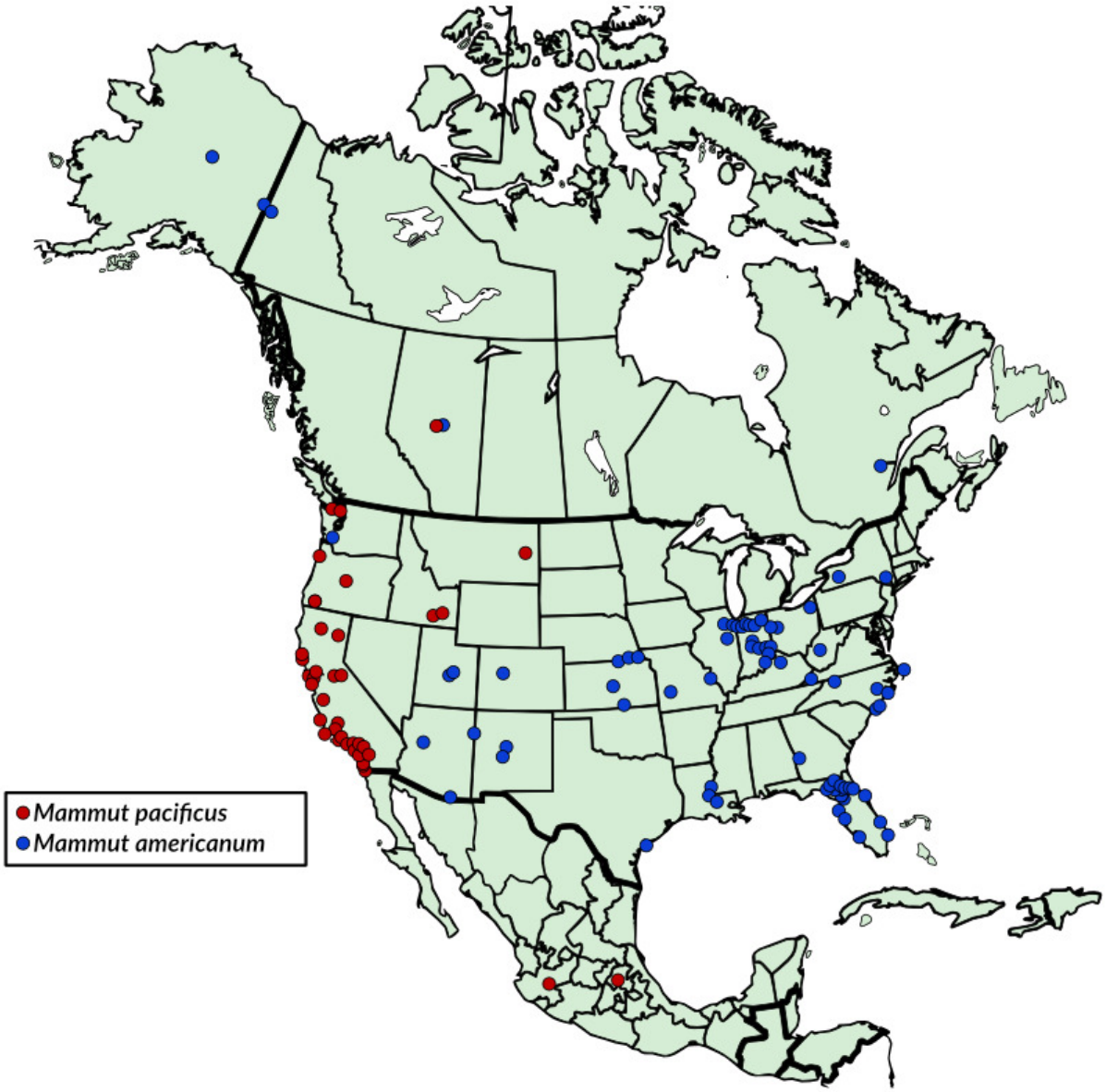
Mammut pacificus
Mammut americanum

Table 1(on next page)

Results of radiocarbon analysis, reproduced from Gilmour et al.

1 Results of radiocarbon analysis, reproduced from Gilmour et al.

Specimen	Lab No.	C:N	Conventional age (14C yr BP)	Error (± 14C yr)	2 SD calibrated age range (cal yr BP)
F-30282	UCIAMS78127X	3.18	11480	35	13,425-13,255
	AA87428 U		11570	120	13,706-13,143
	AA87428 S		11490	110	13,545-13,114

2

Table 2(on next page)

Ma mut M oph Width

1 Aggregate M3 data

State/Province	n	Mean maximum length	Median maximum length	SD	Max	Min	Mean maximum width	Median maximum width	SD	Max	Min	Mean L/W	Median L/W	SD	Max	Min
California	39	168.76	168.00	####	##	#####	85.39	85.20	6.00	#####	####	1.98	1.96	0.14	2.33	1.69
Montana	1	174.70	174.70		##	#####	78.80	78.80		78.80	####	2.22	2.22		2.22	2.22
Oregon	1	149.89	149.89		#####	#####	78.61	78.61		78.61	####	1.91	1.91		1.91	1.91
Hidalgo	1	158.00	158.00		#####	#####	82.00	82.00		82.00	####	1.93	1.93		1.93	1.93
Ja	1	168.97	168.97		#####	#####	81.60	81.60		81.60	####	2.07	2.07		2.07	2.07
A	2	157.00	157.00	####	#####	149.7	95.58	95.58	2.02	97.0	94.2	1.64	1.64	0.07	1.69	1.59
Arizona	1	188.2	188.20		#####	188.2	98.2	98.20		98.2	98.2	1.92	1.92		1.92	1.92
Colorado	4	163.50	163.50	0.58	#####	#####	99.30	99.25	1.70	#####	####	1.65	1.65	0.03	1.67	1.61
Florida	15	177.35	177.30	####	#####	#####	99.07	100.60	7.51	#####	####	1.79	1.79	0.11	1.95	1.59
Ge	1	184.00	184.00		#####	#####	104.00	104.00		#####	####	1.77	1.77		1.77	1.77
Ill	3	181.81	175.94	####	#####	#####	104	102.00	6.42	#####	####	1.75	1.75	0.03	1.78	1.72
In	8	175.32	180.50	####	#####	#####	99	99.75	7.16	#####	####	1.75	1.71	0.14	1.95	1.60
Kentucky	2	164.73	164.73	5.58	#####	#####	91.89	91.89	7.16	96.95	####	1.80	1.80	0.08	1.85	1.74
Louisiana	4	176.02	174.00	####	#####	#####	106.18	104.36	9.73	#####	####	1.66	1.66	0.02	1.68	1.63
Missouri	23	181.99	181.70	####	#####	#####	101.02	101.70	7.92	#####	####	1.80	1.80	0.08	1.93	1.63
Nebraska	4	180.50	184.13	####	#####	#####	100.08	100.93	####	#####	####	1.80	1.87	0.15	1.88	1.57
New York	1	172.20	172.20		#####	#####	100.20	100.20		#####	####	1.72	1.72		1.72	1.72
North Carolina	6	166.82	165.16	####	#####	#####	94.58	93.80	6.30	#####	####	1.76	1.74	0.08	1.93	1.70
Ohio	4	180.03	181.75	####	#####	#####	102.30	104.85	8.97	#####	####	1.76	1.74	0.14	1.93	1.61
Texas	3	171.68	167.00	####	#####	#####	99.30	97.00	9.66	#####	####	1.73	1.72	0.05	1.79	1.68
Tennessee	1	174.48	174.48		#####	#####	98.42	98.42		98.42	####	1.77	1.77		1.77	1.77
Utah	2	151.50	151.50	0.71	#####	#####	85.50	85.50	2.12	87.00	####	1.77	1.77	0.05	1.81	1.74
Washington	1	161.63	161.63		#####	#####	88.82	88.82		88.82	####	1.82	1.82		1.82	1.82
Yukon	5	153.04	154.98	5.27	#####	#####	88.44	88.56	0.80	89.52	####	1.73	1.73	0.05	1.81	1.68
M. americanum	89	176.03	174.59	####	#####	#####	98.84	99.04	8.01	#####	####	1.76	1.77	0.10	1.95	1.57
M. pacificus	43	168.20	167.75	####	#####	#####	84.99	84.28	5.97	#####	####	1.98	1.95	0.14	2.33	1.69

2

Table 3(on next page)

Aggregat M3 data

1 Aggregate m3 data

State/Provi ountry	n	Mean maximum length	Median maximum length	SD	Max	Min	Mean maximum width	Median maximum width	SD	Max	Min	Mean L/W	M n	SD	Max	Min	
California	23	185.84	187.00	####	#####	#####	82.86	82.90	6.28	94.03	####	2.25	2.25	0.14	2.44	1.95	
Idaho	3	185.93	192.90	####	#####	#####	82.70	192.90	6.81	90.10	####	2.25	2.23	0.12	2.37	2.13	
Hidalgo	1	180	180.00		#####	180	78.55	78.55		78.6	78.6	2.29	2.29		2.29	2.29	
Washington (*M. pacificus*)	2	174.30	174.30	####	#####	#####	82.96	82.96	6.99	87.90	####	2.10	2.10	0.01	2.11	2.09	
Washington (*M. americanum*)	1	165.68	165.68		#####	#####	85.58	85.58		85.58	####	1.94	1.94		1.94	1.94	
Alaska	3	167.56	169.79	####	#####	145.9	90.76	92.07	####	101.0	79.2	1.85	1.84	0.01	1.85	1.84	
Ariz	1	171.1	171.10		#####	171.1	82.8	82.80		82.8	82.8	2.07	2.07		2.07	2.07	
Colo	9	182.44	174.80	####	#####	#####	95.97	95.70	6.09	#####	####	1.91	1.93	0.17	2.23	1.64	
Florida	23	181.59	183.00	####	#####	#####	96.12	95.90	5.45	#####	####	1.89	1.93	0.13	2.04	1.63	
Illinois	10	192.87	187.65	####	#####	#####	102.52	101.50	9.51	#####	####	1.88	1.85	0.06	1.98	1.82	
Indiana	9	185.02	188.50	####	#####	#####	100.13	99.00	5.02	#####	####	1.85	1.81	0.12	2.04	1.66	
Kansas	2	195.00	195.00	####	#####	#####	100.74	100.74	6.41	#####	####	1.94	1.94	0.01	1.94	1.93	
Kentucky	9	185.35	182.50	####	#####	#####	98.62	97.10	7.72	#####	####	1.88	1.85	0.10	2.01	1.73	
Louisiana-Mississippi	14	189.12	188.30	####	#####	#####	103.58	102.46	7.86	#####	####	1.83	1.88	0.22	2.06	1.17	
Missouri	24	189.65	188.65	####	#####	#####	98.46	98.85	5.93	#####	####	1.93	1.91	0.06	2.07	1.82	
Nebraska	4	181.18	181.05	3.63	#####	#####	100.10	100.20	1.27	#####	####	1.81	1.81	0.05	1.87	1.75	
New Mexico	3	166.33	168.00	####	#####	#####	89.00	93.00	8.26	94.50	####	1.87	1.91	0.08	1.92	1.78	
New York	1	196.70	196.70		#####	#####	97.60	97.60		97.60	####	2.02	2.02		2.02	2.02	
North Carolina	4	180.45	188.90	####	#####	#####	91.63	92.15	3.00	94.40	####	1.97	2.01	0.15	2.10	1.75	
Ohio	4	191.30	191.20	####	#####	#####	99.40	101.85	8.72	#####	####	1.92	1.89	0.12	2.08	1.82	
Quebec	1	136.00	136.00		#####	#####	79.00	79.00		79.00	####	1.72	1.72		1.72	1.72	
Tennessee	1	160.90	160.90		#####	#####	90.60	90.60		90.60	####	1.78	1.78		1.78	1.78	
Texas	5	188.80	195.00	####	#####	#####	99.40	100.00	5.08	#####	####	1.90	1.91	0.06	1.95	1.81	
Utah	2	169.50	169.50	0.71	#####	#####	82.50	82.50	2.12	84.00	####	2.06	2.06	0.04	2.09	2.02	
Virginia	1	165.60	165.60		#####	#####	89.50	89.50		89.50	####	1.85	1.85		1.85	1.85	
West Virginia	1	177.00	177.00		#####	#####	97.00	97.00		97.00	####	1.82	1.82		1.82	1.82	
Yukon	2	160.40	160.40	3.75	#####	#####	81.88	81.88	0.66	82.34	####	1.96	1.96	0.03	1.98	1.94	
M. americanum	134	183.48	184.00	####	#####	#####	96.74	96.90	7.25	#####	####	1.89	1.91	0.12	2.23	1.17	2.000
M. pacificus	29	184.85	186.36	####	#####	#####	82.70	82.41	6.06	94.03	####	2.24	2.25	0.13	2.44	1.95	1.000

2

3

4

5

Table 4(on next page)

Aggrega m3 data

1 Mammut M3 Loph Width

Specimen	Taxon	County	State/Province	1st loph width	2nd loph width	3rd loph width	4th loph width	5th loph width	1st loph width/widest loph width	2nd loph width/widest loph width	3rd loph width/widest loph width	4th loph width/widest loph width	5th loph width/widest loph width
Perris mastodon	*M. pacificus*	Riversid	CA	87	82.3	82.4	60.8	44	1.000	0.946	0.947	0.699	0.506
SBMNH specimen B	*M. pacificus*	Santa B	A	83.9	85.97	81.72	71.18	49.9	0.976	1.000	0.951	0.828	0.580
SBMNH specimen A	*M. pacificus*	Santa B	A	94.88	104.26	102.39	87.02		0.910	1.000	0.982	0.835	
SDSNH 116399	*M. pacificus*	San Diego	CA	84.46	80.79	77.31	65.35		1.000	0.957	0.915	0.774	
UCMP 1060	*M. pacificus*	Tuolumne	CA	78.13	75.79	72.87	55.12		1.000	0.970	0.933	0.705	
LACM-HC 87076	*M. pacificus*	Los Angeles	CA	73.08	72.54	67.97	53.3		1.000	0.993	0.930	0.729	
UCMP 1567	*M. pacificus*	Tuolumne	CA	78.54	80.04	74.95	57.64		0.981	1.000	0.936	0.720	
UCMP 212936	*M. pacificus*	Alameda	CA	94.64	95.5	91.05	81.69	60.93	0.991	1.000	0.953	0.855	0.638
UCMP 36684	*M. pacificus*	Alameda	CA	77.91	76.18	73.47	66.12	47.31	1.000	0.978	0.943	0.849	0.607
UCMP 41642	*M. pacificus*	Sonoma	CA	90	89.36	87.64	71.06		1.000	0.993	0.974	0.790	
UCMP 45265	*M. pacificus*	Contra Costa	CA	86.33	89.27	87.81	74.53	49.74	0.967	1.000	0.984	0.835	0.557
UCMP 70139	*M. pacificus*	Sonoma	CA	86.14	84.35	79.22	66.35		1.000	0.979	0.920	0.770	
WSC 10829	*M. pacificus*	Riverside	CA	85.2	81.8	80.3	65.9		1.000	0.960	0.942	0.773	
WSC 19730	*M. pacificus*	Riverside	CA	89.5	89.3	84.2	60.5		1.000	0.998	0.941	0.676	
WSC 22587.1	*M. pacificus*	Riverside	CA	86.8	84.4	80.9	72.4		1.000	0.972	0	0.834	
WSC 9964.7	*M. pacificus*	Riverside	CA	75.4	74	6	46.8		1.000	0.981	0	0.621	
WSC 18743	*M. pacificus*	Riverside	CA	79.97	84.1	7	55.69		0.951	1.000	0.872	0.662	
NMC 8060	*M. americanum*		AK	93.86	94.15	9	59.34		0.997	1.000	0.960	0.630	
DMNH 60675	*M. americanum*	Pitkin	CO	98.3	96.1	87.8	58.4		1.000	0.978	0.893	0.594	
DMNH 69327	*M. americanum*	Pitkin	CO	99.4	100.2	95.1	75.6		0.992	1.000	0.949	0.754	
DMNH 69331	*M. americanum*	Pitkin	CO	96.3	98.2	90.4	65.7		0.981	1.000	0.921	0.669	
DMNH 69943	*M. americanum*	Pitkin	CO	101.2	97.9	95.5	77.3		1.000	0.967	0.944	0.764	
LACM 130386	*M. americanum*	Bureau	IL	108.07	111.37	102.91	93.1		0.970	1.000	0.924	0.836	
LACM 154685	*M. americanum*	Allen	IN	83.35	87.85	87.78	62.81		0.949	1.000	0.999	0.715	
ANSP 13309	*M. americanum*	Boone	KY	96.95	92.68	90.2	68.37		1.000	0.956	0.930	0.705	
ANSP 13310	*M. americanum*	Boone	KY	86.83	83.1	82.32	65.99		1.000	0.957	0.948	0.760	
LSUMG V-17071	*M. americanum*	West Felician	LA	118	117.7	115	94.8		1.000	0.997	0.975	0.803	
USNM 437571	*M. americanum*	Dare	NC	96	93	89	78	56	1.000	0.969	0.927	0.813	0.583
UNSM1642	*M. americanum*	Dodge	NE	100.9	108.58	102.1	95.45	44.7	0.929	1.000	0.940	0.879	
UNSM2042-69	*M. americanum*	Nuckolls	NE	93.28	87.2	82.42	57.72		1.000	0.935	0.884	0.619	
UNSM1491	*M. americanum*	Cass	NE	109.24	110.98	107.5	95.02	56.41	0.984	1.000	0.969	0.856	
UNSM1369	*M. americanum*	Thurston	NE	86.15	87.46	81.88	70.56	36.15	0.985	1.000	0.936	0.807	
25BJS76	*M. americanum*	Hickory	MO	107.01	105.25	103.6	81.36		1.000	0.984	0.968	0.760	
NMC 8707	*M. americanum*		Yukon	86.91	87.29	83.05	56.73		0.996	1.000	0.951	0.650	
									M	1	1	203187	0.879075336	0.638010471
									M	0.910032611	0.934819897	395225	0.594099695	0.505747126
									Average	0.987034062	0.984391801	305478	0.752062571	0.578658526

2

Table Captions

Table 1. Results of radiocarbon analysis, reproduced from Gilmour et al. 2015: Table 1. Measurements are in mm.

Table 2. Aggregate M3 length and width measurements, segregated by state/province. Measurements in mm. Specimens from the first five states listed are assigned to *M. pacificus*; all other listed specimens are assigned to *M. americanum*. Measurements are in mm.

Table 3. Aggregate m3 length and width measurements, segregated by state/province. Measurements in mm. Specimens from the first three states listed are assigned to *M. pacificus*; all other listed specimens are assigned to *M. americanum*. Measurements are in mm.

Table 4. *Mammut* M3 loph percentages. Yellow fields indicate the widest loph on each tooth. Measurements are in mm.

Commented [MC1]: This does not apply to Table 1.

Commented [MC2]: This is duplicated at the end of the caption.

Commented [MC3]: This is duplicated at the end of the caption.

Commented [MC4]: Four? The fourth state (Washington) includes one row for a specimen identified as M. pacificus and one row for a specimen described as M. americanum.

Commented [MC5]: There are actually no "percentages" listed, so this table should be retitled or data adjusted.

Figure Captions

Figure 1. *Mammut pacificus* F-30282 (Tualatin mastodon), left M3, occlusal view. Scale = 5 cm.

Figure 2. Length/width ratios of *Mammut* M3s, segregated by state/province. Symbols in red are *M. pacificus*; all other colors are *M. americanum*.

Figure 3. *Mammut* specimens from Washington, USA. A, B: *Mammut pacificus* (Manis mastodon) right m3, occlusal view (A), right dentary, medial view (B). C-E: *Mammut americanum* mandible UWBM 88099, dorsal (C), left lateral (D), and right lateral (E). F,

Mammut sp. right M3 UWBM 83312, occlusal view. G-H: Mammut pacificus mandible UBMW 14491, dorsal (G), left lateral (H), and right lateral (I). All scales = 5 cm.

Figure 4. Length/width ratios of *Mammut* m3s, segregated by state/province. Symbols in red are *M. pacificus*; all other colors are *M. americanum*.

Figure 5. *Mammut pacificus* UAHMP-311 right M3 (A) and right m3 (B), occlusal view.

Figure 6. *Mammut pacificus* LACM 1854 left M3, in occlusal (A), labial (B) and lingual (C) views.

Figure 7. *Mammut* specimens from Alberta. A-C, *Mammut americanum* mandible RAM P94.16.1 in dorsal (A), anterior (B), and right lateral (C) views. Note the large chin tusk alveolar in (B). D- E, *Mammut pacificus* left M3 RAM P.97.7.1 M3 in occlusal (D) and labial (E) views.

Figure 8. Late Pleistocene distribution map of *Mammut pacificus* and *Mammut americanum* based on specimens examined in this paper, Karpinski et al. 2020, McDonald et al. 2021, and Dooley et al. 2019. Note that these distributions are approximate and most likely fluctuated with time.

Commented [MC6]: Italicize

Commented [MC7]: Italicize

Commented [MC8]: Alveolus or alveoli (pl.)

Commented [MC9]: Not included in specimen number in other instances

Commented [MC10]: The figure does not show reconstructed ranges, so this verbiage seems unnecessary. Plotted are merely localities of considered specimens. This data is not "approximate" and would not "fluctuate with time."

Commented [MC11]: Rather than the qualification at the end of this caption, I suggest being more specific in the first sentence:

Map of North America showing localities of specimens we identify as Mammut americanum and Mammut pacificus.