



Revisiting Paleoindian exploitation of extinct North American mammals



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ARTICLE INFO

Article history:

Available online 17 February 2015

Keywords:

Clovis
Extinct mammals
Pleistocene extinctions
Pleistocene overkill
North America

ABSTRACT

In 2002, we assessed all sites known to us that had been suggested to provide evidence for the association of Clovis-era archaeological material with the remains of extinct Pleistocene mammals in North America. We concluded that, of the 76 sites we assessed, 14 provided compelling evidence for human involvement in the death and/or dismemberment of such mammals. Of these sites, 12 involved mammoth (*Mammuthus*), the remaining two mastodon (*Mammut*). Here, we update that assessment. We examine Clovis-era, and earlier, sites reported since 2002, as well as sites examined previously but for which additional information has become available. Our assessment leads us to exclude Hebior (Wisconsin) from the list of accepted sites, and to add El Fin del Mundo (Sonora) and Wally's Beach (Alberta). There are now 15 sites on our list, providing what we find to be compelling evidence for human involvement in the death and/or dismemberment of five genera of now-extinct late Pleistocene mammals: *Equus*, *Camelops*, *Cuvieronius*, *Mammut*, and *Mammuthus*. As in 2002, however, we note this is a small fraction of the 37 genera that disappeared at the end of the Pleistocene, and for this and other reasons we remain highly skeptical that human overkill was responsible for their extinction.

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1. Introduction

Over a decade ago, we provided a detailed assessment of all sites known to us that had been suggested to provide evidence for the association of Clovis-era archaeological material with the remains of extinct Pleistocene mammals in North America (Grayson and Meltzer, 2002). We did this for two reasons. First, and most importantly, we wished to continue our assessment of the possible causes of the extinction of those mammals and especially the claim that human predation – Pleistocene overkill – might have been involved (e.g., Grayson, 1977, 1984, 1989, 1991, 2001; Meltzer, 1986, 1993a, 1993b, 1995; for more recent assessments on our part, see Grayson, 2007, 2015; Meltzer, 2009, 2015; Meltzer et al., 2014). Second, and closely related to our primary goal, we wanted to increase the depth of our understanding of the role of large mammals in human subsistence during the North American late Pleistocene and, in particular, during Clovis times (ca. 11,500–10,800 ¹⁴C BP).

We began our previous assessment with a list of 76 sites gathered from a wide variety of sources, including FAUNMAP Working

Group (1994). We then eliminated all of the sites on that list that were insufficiently described or documented. For instance, we eliminated sites for which the stratigraphic context had not been described with sufficient detail to allow the relationship between archaeological materials and the remains of extinct mammals to be assessed. We also eliminated sites: 1) that the initial investigator(s) considered to provide only tenuous evidence for interactions between people and extinct mammals; 2) that provided only bone or ivory tools fabricated from the remains of extinct mammals; 3) for which the claims of interaction were based on poorly-controlled protein residue analysis; and, 4) that were clearly paleontological.

This process left us with 29 sites that merited more detailed analysis. We examined each of these sites in great detail. We assessed whether the evidence for the association between artifacts and extinct mammal remains supported not just the contemporaneity of the two, but was also sufficient to document that people were involved in the demise of the animal involved. Such evidence included intimate associations between artifacts and skeletal remains, as well as evidence for human utilization of those remains, such as artifacts that might have been used to process those remains, anthropogenically modified bones, and so on (Grayson and Meltzer, 2002:327).

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In those cases for which the evidence of human exploitation rested on modified bones in the absence of artifacts, we sought to preclude natural causes for those modifications. Since a wide range of non-human processes can modify bone in ways that mimic human activity, we accepted only those specimens that displayed compelling evidence of human modification (e.g. burning, or bone showing cut marks at critical points of muscle attachment) and for which the possibility of natural modification could be rejected (Grayson and Meltzer, 2002).

In case it be thought that our criteria for exploitation were unduly rigid and thus improperly limited the sites we would find acceptable, we noted that:

the kind of evidence we seek to demonstrate human exploitation of extinct mammals is precisely the same kind of evidence we seek (and find) in post-Clovis-age modern faunas killed and butchered by humans. We might not see impact-fractured points in all cases (Hofman, 2001, p. 98), or clear evidence of butchering (Haynes, 1991, p. 303), but signs of human activity should certainly be present nonetheless. To imply otherwise – that human exploitation of these animals would leave no traces at all – requires special pleading that the Clovis archaeological record is unique or otherwise different from later periods or other areas, and draws us into an unacceptable netherworld in which negative evidence becomes positive (Grayson and Meltzer, 2002:344).

This process led us to conclude that 14 sites provided strong evidence suggesting that people caused the death of the animals involved (Table 1). Twelve of those sites involved mammoth; two, mastodon. Given that this process led us to eliminate over 80% of the sites we had begun with, we expected that our conclusions might be highly controversial. This, however, turned out not to be the case. While there are those who disagreed with the conclusions we reached concerning the possible impact of Clovis-era hunting on the late Pleistocene fauna of North America (e.g., Surovell and Waguespack, 2008; Surovell and Grund, 2012), we are aware of no significant disagreement over the relatively small number of sites that we concluded provided secure evidence of Clovis-era hunting of now-extinct late Pleistocene mammals, even among staunch advocates of overkill (see discussion in Meltzer, 2015).

During the past decade or so, however, new sites have been forwarded as providing evidence for Clovis-era, or earlier, human hunting or scavenging of extinct mammals. In addition, some sites that we discussed in 2002 have been the focus of additional work. As a result, we are revisiting this topic, examining all of these sites

of which we are aware (see Fig. 1 for selected site locations). We are taking the same approach now that we took then, employing the same criteria used in 2002. Before beginning that analysis, however, we must address several more general issues.

First, at the time Grayson and Meltzer (2002) appeared, the North American late Pleistocene mammal fauna included 35 genera of now-extinct mammals (Grayson and Meltzer, 2002:316). Today, with the secure addition of the gomphothere *Cuvieronius* (Sanchez et al., 2014) and the notoungulate *Mixotoxodon* (Lundelius et al., 2013), that list includes 37 such genera. We provide that updated list in Table 2. Table 3 provides the current last appearance dates for those genera, documenting that 17 of the 37 can be shown to have lasted beyond 12,000 ¹⁴C years BP.

Second, we recognize that we were remiss in not previously providing a formal definition of “North America” in our earlier paper. Here, we follow Morgan (2008; see also Grayson, 2015), and define North America as the North American continent north of the Tropic of Cancer.

Finally, we recognize that we were cavalier in our treatment of the meaning of secure associations between such things as Clovis points and the remains of extinct mammals. We referred to the sites listed in Table 1 as having provided secure “kill/butchery” associations (Grayson and Meltzer, 2002:344), but we also routinely referred to these sites as having provided evidence for human predation on the animals involved. We, in short, took these sites to be kill sites.

We should have been more cautious. In most instances, all we were able to establish was that human traces were compellingly associated with the remains of extinct animals. We were not able to establish, nor did we make any realistic attempt to establish, the cause of death of those animals. Humans could have been responsible for the *death and dismemberment* of the animal (the hunting, killing and butchering of the animal); for the *death* of the animal, but not its dismemberment (as, for example, may have occurred with an unsuccessful kill); or only the *dismemberment* of the animal (i.e. a case of scavenging). Identifying these separate possibilities is not straightforward. In some instances—Pleasant Lake, for instance—it is fully possible that those animals were scavenged, not hunted, by the people who utilized their remains. In the context in which we are working, with generally isolated and often partial skeletons, it can be difficult, if not impossible, to distinguish the results of the use of fresh carcasses that became available to hunters as a result of hunting from those that became available by scavenging (see, for instance, the discussion of El Fin del Mundo, below).

Modern hunters and gatherers often do not concern themselves with whether the meat they obtain comes from a hunted or scavenged animal. As O’Connell and Hawkes (1988:117) have observed, the Hadza of east Africa are carefully alert for scavenging possibilities and, having found such a possibility, “move quickly to the spot and, on arrival, attempt to drive off any predators that are present and to appropriate the kill”. Because they are so good at this, up to 25% of the carcasses they acquire may be obtained this way (O’Connell and Hawkes, 1988; O’Connell et al., 1992).

If modern hunters obtain significant amounts of their meat diet by scavenging, there is no reason to think that late Pleistocene North American hunters did not do the same thing. In the discussion that follows, we have made no attempt to distinguish between these two possibilities, and are not likely to have been successful had we tried. Instead, what we have looked for is secure evidence that people were responsible for the subsistence-related death and/or dismemberment of a now-extinct mammal.

In what follows, we do not consider sites that have been reported in only a very preliminary way, and that may or may not prove to be worthy of detailed consideration once further work has

Table 1

Archaeological sites with evidence suggesting human predation on now-extinct Pleistocene genera: the Grayson and Meltzer (2002) list.

Site	Genus
Kimmswick	<i>Mammot</i>
Pleasant Lake	<i>Mammot</i>
Blackwater Locality 1	<i>Mammuthus</i>
Colby	<i>Mammuthus</i>
Dent	<i>Mammuthus</i>
Domebo	<i>Mammuthus</i>
Escapule	<i>Mammuthus</i>
Hebior	<i>Mammuthus</i>
Lange-Ferguson	<i>Mammuthus</i>
Lehner	<i>Mammuthus</i>
Lubbock Lake	<i>Mammuthus</i>
Miami	<i>Mammuthus</i>
Murray Springs	<i>Mammuthus</i>
Naco	<i>Mammuthus</i>

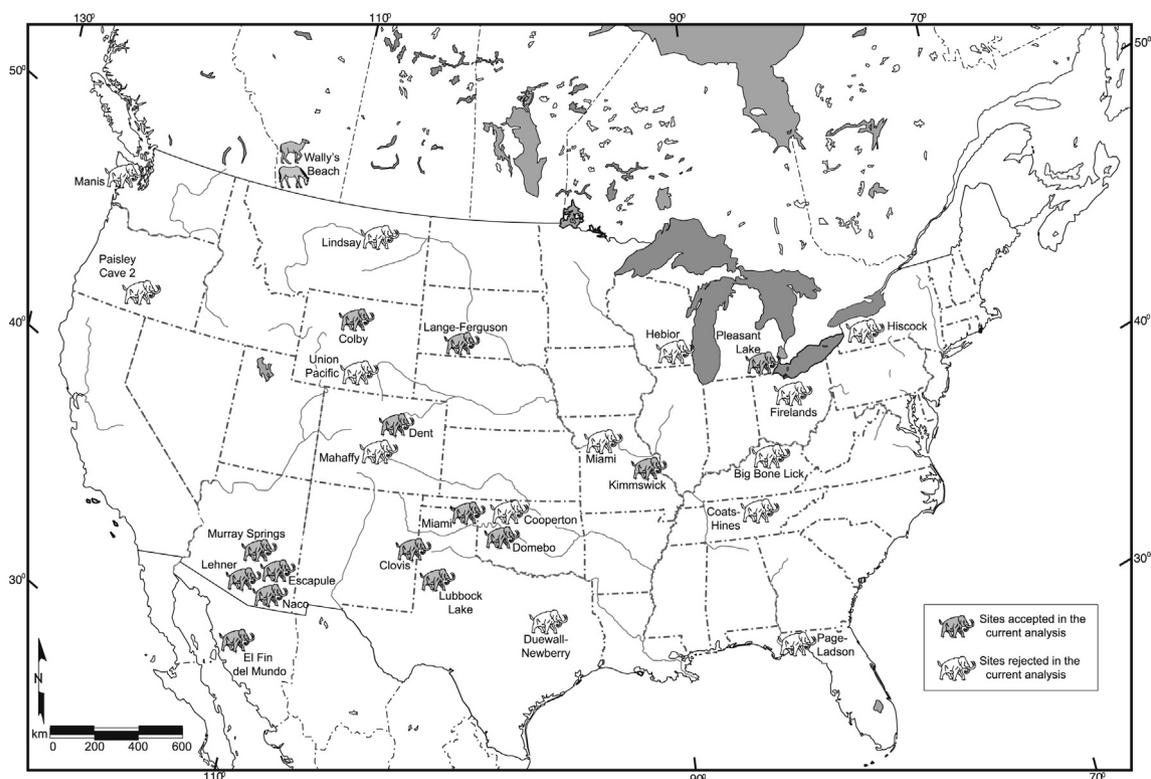


Fig. 1. The location of selected sites mentioned in the text.

been conducted and more detailed descriptions provided. Andrew Farm, Illinois, provides an excellent example. This site provided the remains of a mastodon (*Mammot*) dated to $10,775 \pm 35$ ^{14}C BP. Although no stone tools have been found associated with it, “possible cutmarks” on the spinous process of a thoracic vertebra have been reported (Kuehn et al., 2010:111). Clearly, much more work will be needed at this location before it can be properly evaluated, and we do not examine this site, or others like it, here.

2. The sites

2.1. Possible bone quarries

Many sites have been reported to contain mammoth bones broken by human agency. These are often interpreted as bone quarries on the presumption that those skeletal remains are from animals that died of natural causes before people came upon their bones and exploited them for raw material, as at the Broken Mammoth site, Alaska (Yesner, 2001). Even though these sites are generally not claimed to provide evidence of human predation on, or scavenging of, mammoth, they do warrant brief mention. For the sake of completeness, we include several purported pre-Clovis age bone quarries, though as will be seen we are skeptical these provide secure evidence of a human presence at that time.

2.1.1. Pre-Clovis bone quarry sites?: the Holen locations

Steven R. Holen and his colleagues have described a series of sites from the Great Plains that date to between about 12,400 and 39,000 years ago and that they suggest provide, or may provide, evidence for human interaction with Columbian mammoth (*Mammuthus columbi*; see Table 4). That evidence includes large bone flakes that appear to have been struck from mammoth long bones; mammoth bone suggested to have been spirally fractured

while fresh; and, negative flake scars on the fractured limb bones themselves. These sites all contain the remains of a single mammoth, but none contain stone artifacts and only one (Lovewell II, Kansas) contains what might be bone tools (Holen, 2007; Holen and Holen, 2011, 2014). Holen (2014) suggests that these sites represent the ancestors of the later Clovis peoples of this region.

Holen and his colleagues generally do not contend that all of these are kill or scavenging sites. Instead, they maintain that, with one possible exception, they represent the results of people quarrying mammoth carcasses for raw material for bone tool manufacture. The exception is the Lovewell II mammoth (ca. 18,000 ^{14}C BP), which Holen (2006:62) suggests may have been killed by people. If this is correct, then Lovewell II joins such sites as Murray Springs, Lehner, and Naco in documenting human predation on mammoths, albeit at a much earlier date.

The illustrations that Holen and his colleagues have provided of the fractured bone from these sites leave little doubt that they were broken by impact. However, G. Haynes (2000) has shown that the kinds of bone breakage that Holen and his colleagues see as strong evidence for human involvement can, in fact, be produced in other ways. This does not mean that such sites as Lovewell II were not produced as a result of human behavior. It does, however, mean that the kinds of bone breakage found on these sites is not diagnostic of a human role in the accumulation of these sites. In addition, there are no butchering marks on the Lovewell II mammoth, the only one of the sites listed in Table 4 that Holen has suggested may represent a mammoth kill. As a result, we have not included this site on our list.

Holen and his colleagues also suggest that Missouri’s Miami mastodon site and Oklahoma’s Cooperton mammoth site also represent human utilization of extinct proboscideans during pre-Clovis times. We treat each of these sites in turn.

Table 2

The extinct late Pleistocene mammals of North America. Genera marked with an asterisk live on elsewhere.

Order and family	Genus	Common name
Cingulata		
Pampatheriidae	<i>Pampatherium</i>	Southern Pampathere
	<i>Holmesina</i>	Northern Pampathere
Glyptodontidae	<i>Glyptotherium</i>	Simpson's Glyptodont
Pilosa		
Megalonychidae	<i>Megalonyx</i>	Jefferson's Ground Sloth
Megatheriidae	<i>Eremotherium</i>	Laurillard's Ground Sloth
	<i>Nothrotheriops</i>	Shasta Ground Sloth
Mylodontidae	<i>Paramylodon</i>	Harlan's Ground Sloth
Carnivora		
Mustelidae	<i>Brachyprotoma</i>	Short-faced Skunk
Canidae	<i>Cuon*</i>	Dhole
Ursidae	<i>Tremarctos*</i>	Florida Cave Bear
	<i>Arctodus</i>	Giant Bear
Felidae	<i>Smilodon</i>	Sabertooth
	<i>Homotherium</i>	Scimitar Cat
	<i>Miracinonyx</i>	American Cheetah
Rodentia		
Castoridae	<i>Castoroides</i>	Giant Beaver
Caviidae	<i>Hydrochoerus*</i>	Holmes's Capybara
	<i>Neohoerus</i>	Pinckney's Capybara
Lagomorpha		
Leporidae	<i>Aztlanolagus</i>	Aztlán Rabbit
Perissodactyla		
Equidae	<i>Equus*</i>	Horses
Tapiridae	<i>Tapirus*</i>	Tapirs
Artiodactyla		
Tayassuidae	<i>Mylohyus</i>	Long-nosed Peccary
	<i>Platygonus</i>	Flat-headed Peccary
Camelidae	<i>Camelops</i>	Yesterday's Camel
	<i>Hemiauchenia</i>	Large-headed Llama
	<i>Palaeolama</i>	Stout-legged Llama
	<i>Navahoceros</i>	Mountain Deer
Cervidae	<i>Cervalces</i>	Stag-Moose
Antilocapridae	<i>Capromeryx</i>	Diminutive Pronghorn
	<i>Tetrameryx</i>	Shuler's Pronghorn
	<i>Stockoceros</i>	Pronghorns
Bovidae	<i>Saiga*</i>	Saiga
	<i>Euceratherium</i>	Shrub Ox
	<i>Bootherium</i>	Helmeted Muskox
Notoungulata		
Toxodontidae	<i>Mixotoxodon</i>	Toxodont
Proboscidea		
Gomphotheriidae	<i>Cuvieronius</i>	Cuvier's Gomphothere
Mammutidae	<i>Mammut</i>	American Mastodon
Elephantidae	<i>Mammuthus</i>	Mammoths

Table 3

Trustworthy last appearance radiocarbon dates for North American late Pleistocene extinct mammal genera. Dates that fall between 12,000 and 10,000 ¹⁴C BP are in bold; see Grayson (2015) for details. Genera marked with an asterisk live on elsewhere.

Genus	Common name	LAD	Reference
<i>Megalonyx</i>	Jefferson's Ground Sloth	11,450 ± 90	Faith and Surovell, 2009
<i>Eremotherium</i>	Laurillard's Ground Sloth	38,860 ± 1300	Faith and Surovell, 2009
<i>Nothrotheriops</i>	Shasta Ground Sloth	10,500 ± 180	Thompson et al., 1980
<i>Paramylodon</i>	Harlan's Ground Sloth	20,450 ± 460	Faith and Surovell, 2009
<i>Arctodus</i>	Giant Bear	10,870 ± 75	Faith and Surovell, 2009
<i>Smilodon</i>	Sabertooth	11,130 ± 275	Faith and Surovell, 2009
<i>Homotherium</i>	Scimitar Cat	22,250 ± 130	Widga et al., 2012
<i>Miracinonyx</i>	American Cheetah	19,765 ± 80	Williams, 2009
<i>Castoroides</i>	Giant Beaver	10,150 ± 50	Feranec and Kozłowski, 2010
<i>Equus*</i>	Horses	10,370 ± 350	Faith and Surovell, 2009
<i>Tapirus*</i>	Tapirs	10,940 ± 90	Faith and Surovell, 2009
<i>Mylohyus</i>	Long-nosed Peccary	11,860 ± 40	Faith and Surovell, 2009
<i>Platygonus</i>	Flat-headed Peccary	10,750 ± 50	Feranec and Kozłowski, 2010
<i>Camelops</i>	Yesterday's Camel	10,370 ± 350	Faith and Surovell, 2009
<i>Hemiauchenia</i>	Large-headed Llama	36,320 ± 320	Hockett and Dillingham, 2004
<i>Palaeolama</i>	Stout-legged Llama	10,890 ± 130	Faith and Surovell, 2009
<i>Navahoceros</i>	Mountain Deer	37,750 ± 440	Hockett and Dillingham, 2004
<i>Cervalces</i>	Stag-Moose	10,800 ± 45	Feranec and Kozłowski, 2010
<i>Saiga*</i>	Saiga	12,220 ± 130	Guthrie et al., 2001
<i>Euceratherium</i>	Shrub Ox	11,630 ± 150	Faith and Surovell, 2009
<i>Bootherium</i>	Helmeted Muskox	10,980 ± 80	Faith and Surovell, 2009
<i>Cuvieronius</i>	Cuvier's Gomphothere	11,550 ± 60	Sanchez et al., 2014
<i>Mammut</i>	American Mastodon	10,032 ± 40	Woodman and Athfield, 2009
<i>Mammuthus</i>	Mammoths	10,340 ± 40	Faith and Surovell, 2009

Lacking any evidence that the Cooperton mammoth represents an animal killed or scavenged by people, there is no reason for us to discuss it further. We do, however, note that this is an intriguing site, combining fractured mammoth bone with the very tools that might have done the fracturing, all published in some detail. The radiocarbon dates run on bone apatite are of little value, since such dates are no longer considered reliable (Stafford et al., 1991). It would be very much worthwhile to obtain a new series of ages on this material.

2.1.3. Pre-Clovis bone quarries?: Miami mastodon, MO

The Miami, Missouri mastodon was hastily excavated in 1973 after large mammal bones were exposed by construction. Luminescence dates now firmly establish the formation of the site between 30,000 and 40,000 years ago (Table 4). The only description of the excavation to have appeared in print reported the discovery of at least six artifacts with the mastodon itself: two flakes, a "flaked pebble", a "scraper", a "scraper or knife", a "pretty little pebble" thought to have been introduced to the site by people (Hamilton, 1993:82), and two large pieces of limestone which Hamilton (1993) asserted had to have been carried here by the creators of the site. Hamilton (1993) also claimed that at least some of the mastodon bones had been broken by people, and that one of the tusks had been cut.

Hamilton (1993) presented no evidence for these assertions, and provided no details on the excavations themselves, "except to say that it was the middle of July, insufferably hot, and that it was only too evident that we were holding up the work of the contractor" (Hamilton, 1993:81). The supposed artifacts have never been

2.1.2. Pre-Clovis bone quarries?: Cooperton, OK

Cooperton provided the remains of a single mammoth in relatively fine-grained sediments. The bones of that animal showed multiple signs of having been fractured while still fresh—"a remarkable bone-cracking record" as paleontologist M. G. Mehl (1966:29) put it. Unlike the Great Plains sites we described earlier, Cooperton also provided a series of cobbles found immediately adjacent to the bones themselves. The smallest of these were interpreted by Anderson (1962, 1975) as a hammerstone, while the largest—some 24 cm in diameter and weighing 8.6 kg—was interpreted as an anvil. Three radiocarbon dates were obtained from the bones and teeth of this mammoth, all on bone apatite. As Table 4 shows, these dates ranged from 17,600 to 20,200 ¹⁴C BP.

Anderson (1962, 1975) carefully noted that there is no evidence that this animal was hunted, scavenged, or butchered by people. He entertained the possibility that people had come across the remains of a decomposing mammoth and fractured the bone to access any marrow that might be worth accessing, but found it far more likely that this site represents a bone quarry.

Table 4
Claimed pre-Clovis bone quarrying sites.

Site	¹⁴ C bone date	Luminescence dates	References
Cooperton, OK	17,575 ± 550 ^a 19,100 ± 800 ^a 20,400 ± 450 ^a		Anderson, 1962, 1975; Holen and Holen, 2014
Hamburger, NB	16,480 ± 60 ^c		Holen and May, 2007; Holen and Holen, 2011, 2014
Jensen, NB	13,880 ± 90 ^b		May and Holen, 2005; Holen and Holen, 2011, 2014
Kanorado, KN	12,375 ± 35 ^c		Holen and Holen, 2011
La Sena, NB	18,000 ± 190 ^c 12,090 ± 95 ^c 18,440 ± 145 ^c		Holen and May, 2002; Holen, 2006; Holen and Holen, 2011, 2014
Lovewell I, KN	20,430 ± 300 ^c		Holen, 1996, 2006, 2007; Holen and Holen, 2011, 2014
Lovewell II, KN	16,110 ± 280 ^c 18,250 ± 90 ^c 19,530 ± 80 ^c 19,570 ± 60 ^c		
Miami Mastodon, MO	7840 ± 40 ^d 35,900 ± 900 ^e 35,733 ± 251 ^e	34,000 ± 6100 ^e 37,100 ± 4700 ^f 41,700 ± 6100 ^g	Dunnell and Hamilton, 1995; Feathers, 2000
New Nebraska, NB	33,590 ± 450 ^b 33,220 ± 420 ^c 33,170 ± 370 ^c		Holen and Holen, 2014
Prettyman, NB	Undated		Holen et al., 1996; Holen and Holen, 2014
Schulz Mammoth, SD	37,567 ± 591 ^b 39,350 ± 770 ^b		Fosha et al., 2012; Holen and Holen, 2014
Shaffert, NB	15,600 ± 60 ^c		Holen and May, 2002; Holen and Holen, 2011, 2014
Villa Grove, CO	33,405 ± 340 ^b		Holen, 2013; Holen and Holen, 2014

^a Conventional bone apatite date.

^b On mammoth tooth, presumably AMS.

^c AMS on bone.

^d Dated material might not be bone collagen; date rejected as too young (Feathers, 2000).

^e Average of 8 IRSL dates on associated sediment (Feathers, 2000).

^f OSL date on associated sediment (Feathers, 2000).

^g OSL date on sediment 4 cm beneath mammoth bone (Dunnell and Hamilton, 1995).

described and, since they were lost to a fire in 1977, never will be. The large pieces of limestone might not have been artifacts at all, since, as Dunnell and Hamilton (1995) noted, they might have formed naturally in the calcareous loess said to have surrounded the mammoth bones. The bones have never been analyzed in detail but this is not surprising since they are said to have been in very poor condition. A crude plan map of the site exists but has not been published (Feathers, 2000). Although Carl Chapman, who led the excavations, considered the Miami mastodon to provide a “definite” association between people and mastodon (Chapman, 1975:54), and Holen and Holen (2014) agree with this conclusion, there is no evidence to support that claim. Accordingly, we agree fully with O’Brien and Wood (1998:53), who concluded that “the discovery still has too many unanswered questions to qualify as a candidate for human–mastodon association.” Given the loss of the artifacts and the poor condition of the bone from the site, it is unlikely that these questions will ever be answered.

2.1.4. Clovis-era bone quarry?: Hiscock, NY

Located in spring-disturbed deposits in western New York state, the late Pleistocene fauna of the Hiscock site is dominated by the disarticulated and often fragmented and worn remains of at least ten mastodons, along with specimens of California condor (*Gymnogyps californianus*; Steadman and Miller, 1987), giant beaver (*Castoroides ohioensis*), long-nosed peccary (*Mylohyus* sp.) stag-moose (*Cervalces scotti*), and caribou (*Rangifer tarandus*; see Laub, 2003a, 2003c, 2007, 2008). The late Pleistocene deposits at Hiscock have also yielded an abundance of conifer twigs that appear to represent the contents of the gastrointestinal tracts, and perhaps fecal material, of the mastodons that were recovered here (Laub, 2002, 2003b, 2006; Laub et al., 1994). Nine fluted bifaces are known from the site, none of which can be directly associated with the remains of the extinct mammals, perhaps a function of the

reworked nature of the deposits (Laub, 1990, 2002, 2006, 2011; Laub et al., 1988; also Ellis et al., 2003). In addition to the lithic artifacts, at least 18 “expedient” bone tools have been described from Hiscock (Laub, 1995, 2000, 2002, 2006; Laub and Haynes, 1998; Laub et al., 1996; Tomenchuk, 2003; Tomenchuk and Laub, 1995), though G. Haynes (2003) appropriately advises a more cautious approach to at least some of these objects. A large series of radiocarbon dates suggests that the late Pleistocene unit at this site was primarily deposited between 11,200 and 10,200 ¹⁴C BP (Laub, 2003b).

G. Haynes (2003) suggests that people may have come to Hiscock to hunt weakened, or scavenge dead, mastodon, but there is no evidence that this was the case. Instead, Laub and his colleagues argue that human interactions with the Hiscock mastodons took place after the death of those animals, when people used their remains as a source of raw material for bone and ivory tools (Laub, 2002; Laub and Spiess, 2003). In support of this conclusion, Krasinski’s (2010) examination of a small part of the Hiscock mastodon collection provided no indications of human involvement in the accumulation of this material. As a result, we do not consider the site further here.

2.2. Residue-based (CIEP) arguments

A number of investigators have used cross-over immunoelectrophoresis (CIEP) to detect positive reactions on stone tools to antisera of the relatives of now-extinct Pleistocene mammals, and in particular to those of elephant, camel, and horse. Although we are intrigued by these results, and are impressed by the detailed nature of some of the analyses in this general realm (e.g., Seeman et al., 2008), we remain extremely cautious about them (Grayson and Meltzer, 2002) and are unwilling to accept them at face value in the absence of other supporting evidence of predation.

There are two reasons for this. First, in some cases CIEP has been applied to stone tools of apparent or likely late Pleistocene age that were retrieved from surficial settings, removing the possibility of analyzing the reactivity of the sediments in which they were originally embedded (e.g., Kooyman et al., 2001; Puseman, 2004; Yost, 2013). In such contexts it is impossible to assess the degree to which any protein on the analyzed tool(s) might represent contaminants transferred from the sediments that once contained them.

Second, we are concerned about the possibility of false positive reactions, including the fact that proteins found in rodent urine can apparently induce false positives to proteins from distantly-related mammals (Barnard et al., 2007; Yost, 2011). Most disturbing, however, is the experimental evidence showing that CIEP can produce results that are inconsistent and incorrect (Leach, 1998; Vance, 2011). It is difficult to have any confidence in a technique that reports the presence of bovine protein on experimentally-produced stone tools that were actually used to process yucca (*Yucca baccata*) or rabbits (*Sylvilagus* sp.), as documented by Vance (2011). If commercial laboratories analyzing modern tools cannot return valid and reliable results, there would seem to be little reason to trust the results returned by such labs on stone tools that are 10,000 years old or older, including those at the Mahaffy Cache, Colorado (Bamforth, 2014; Yohe and Bamforth, 2013) and Paisley Cave 2 (Jenkins et al., 2014; Yost, 2011). Unless methods independent of CIEP analysis itself are available to verify the validity of a CIEP-identified residue, we are unwilling to accept the results of these analyses.

2.3. Updating sites previously considered by Grayson and Meltzer (2002)

2.3.1. Dent, CO

In 2002, we accepted Dent as providing evidence for Clovis era mammoth hunting or scavenging (Grayson and Meltzer, 2002:337). However, we also found it to be one of the least compelling sites on our list. There were two reasons for this latter conclusion. First, because the Dent materials were not in primary depositional context, the nature of the association between mammoth bones and artifacts (and, in particular, two Clovis points) could not be properly evaluated. Second, the claim that the bones bore butchering marks had not been substantiated (Brunswig and Fisher, 1993). Since that time, Brunswig and his colleagues have provided an impressive amount of evidence documenting the case for human involvement at the site. The stratigraphy has been clarified in detail (Brunswig, 2007; C. V. Haynes et al., 1998), the mammoths have been the subject of exacting studies (Fisher and Fox, 2007; Hoppe, 2004; Saunders, 2007), and a wealth of processing marks have been described in detail by two different investigators (Krasinski, 2010; Saunders, 1999). While Dent retains the status we gave it in 2002, it now does so from a position of greater strength.

2.3.2. DUEWALL-NEWBERRY, TX

Duewall-Newberry provided the remains of a single *M. columbi* from a level surface within fine-grained alluvium along the Brazos River, eastern Texas. No bone or stone tools were found, but three of the six mammoth long bones that were recovered displayed spiral fractures and scars that appeared to have been produced by dynamic impact. In addition, the original reports on the site suggested the possible presence of cut marks on the animal's ribs. Although the vertebrate remains were scattered across the site, some were clustered around the mammoth's skull, suggesting purposeful bone stacking. The site has not been dated, but stratigraphic evidence suggests that it was formed between 12,000 and 10,000 ¹⁴C BP (Carlson and Steele, 1992; Carlson et al., 1984; Steele and Carlson,

1989a, 1989b). Carlson and Steele concluded that the animal had either been killed or had died on its own, and that its bones were then processed for marrow or for raw material for tool manufacture (Carlson and Steele, 1992; Steele and Carlson, 1989a, 1989b).

Although we did not accept Duewall-Newberry in our previous assessment of Clovis-era hunting (Grayson and Meltzer (2002:329–330), we found it to be the most intriguing of all the sites argued to be archaeological on the basis of bone fragmentation in the absence of artifacts. In that assessment, we were concerned by the lack of artifacts from the site, including those that might have been used to break mammoth long bones. We agreed with G. Haynes's (1991) observation that Steele and Carlson (1989a) had not shown that people were necessarily the cause of the bone fragmentation that makes this site so intriguing. More recently, Krasinski (2010) has revisited the Duewall-Newberry bone assemblage and has argued that some of those bones bear the marks of human processing, including cutmarks. However, G. Haynes and Hutson (2014) are more circumspect. They observe that the bone breakage might have been due to trampling, and that some skeletal elements "may have been cut by stone tools" (G. Haynes and Huston, 2014:297). They conclude that this site "may be another example of dried/defleshed bone breakage by people" (G. Haynes and Huston, 2014:303), a conclusion very similar to that reached by Carlson and Steele. We agree with this conclusion. Duewall-Newberry may represent a bone quarry but there is no evidence that the mammoth represented here was either killed or scavenged by people and, as a result, we do not include it on our list.

2.3.3. FENKSE, HEBIOR, MUD LAKE, AND SCHAEFER, WI

We treat Fenske, Hebior, Mud Lake, and Schaefer together because they are all located within about 15 km of one another in far southeastern Wisconsin, all come from similar depositional settings (the edge of small ponds), each provided the remains of a single proboscidean argued to have been butchered, and all tend to have been analyzed as a unit (e.g., Joyce, 2014). Radiocarbon dates for these sites are provided in Table 5.

Fenske was discovered in 1919 during the construction of a culvert and was initially thought to have provided the femur and humerus of an adult woolly mammoth (*Mammuthus primigenius*). Subsequent work suggested that the humerus had come from elsewhere (Joyce, 2005), though Joyce has recently again referred to a humerus from this site (2014:469). Since attempts to discover more of the skeleton *in situ* failed (Overstreet and Kolb, 2003), the femur appears to be all that is reliably available from Fenske. Initial AMS radiocarbon dates from the humerus suggested that the site dates to about 13,400 ¹⁴C BP. These dates must now be replaced with those more recently made available from the femur, which provide an average age of 11,230 ± 30 ¹⁴C BP (Table 5). Overstreet (1998) and Overstreet and Kolb (2003) identified this femur as having come from a mammoth; J. J. Saunders, as from a mastodon (in Joyce, 2005, 2014). Johnson (2007) noted the lack of a secure identification but treated it as a mammoth. Given Saunders' expertise with mastodon (e.g., Saunders, 1977, 1996), we strongly suspect that this is what it is, an identification accepted by Joyce (2014) as well.

Mud Lake was discovered in 1936, again as the result of construction. The initial find consisted of 21 specimens from a nearly complete subadult woolly mammoth forelimb resting on or slightly into lacustrine clay (Joyce, 2014). Subsequent work at the site in 1997 and 2005 failed to locate additional specimens from this individual (Joyce, 2014; Overstreet, 1998; Overstreet and Kolb, 2003). Four dates taken directly from mammoth bone yielded an average age of 13,460 ± 25 ¹⁴C BP (Table 5). Five wood specimens, of unspecified relationship to the mammoth, range in age from 12,250 to 12,830 ¹⁴C BP (Joyce, 2014).

Table 5

Radiocarbon dates available for Fenske, Hebior, Mud Lake, and Schaefer. Assessments of statistical contemporaneity and the averaging of ages are based on Hietala (1989); averages not calculated for Schaefer because the dates are not statistically contemporaneous.

Site	Conventional ¹⁴ C	AMS bone collagen	
Fenske		11,220 ± 50 11,230 ± 50 11,240 ± 50 (average = 11,230 ± 30)	Johnson (2007); Joyce (2014)
Hebior		12,480 ± 60 12,520 ± 50 12,590 ± 50 (average = 12,540 ± 30)	Overstreet (1998); Overstreet and Kolb (2003); Joyce (2014)
Mud Lake		13,440 ± 50 13,460 ± 50 13,490 ± 40 13,530 ± 50 (average = 13,460 ± 25)	Overstreet (1998); Overstreet and Kolb (2003); Joyce (2014)
Schaefer	10,960 ± 100 (mammoth bone) 11,980 ± 70 (wood) 12,030 ± 70 (wood) 12,220 ± 80 (spruce) 12,270 ± 80 (spruce) 12,280 ± 80 (spruce) 12,300 ± 70 (spruce) 12,350 ± 70 (wood) 12,370 ± 70 (wood) 12,420 ± 70 (spruce) 12,480 ± 130 (spruce) 12,500 ± 80 (wood) 12,560 ± 70 (wood) 12,610 ± 80 (spruce) 12,700 ± 70 (wood) 12,790 ± 70 (wood) 12,875 ± 40 (spruce) 12,940 ± 70 (wood)	12,290 ± 60 12,310 ± 60 12,320 ± 50 12,365 ± 35 12,390 ± 40 12,400 ± 35 12,440 ± 40 12,460 ± 45 12,485 ± 45 12,490 ± 40 12,490 ± 50 12,525 ± 45 12,540 ± 45 12,550 ± 45 12,570 ± 45	Dallman et al. (1996); Overstreet (1996, 1998); Overstreet and Kolb (2003); Joyce and Blazina-Joyce (2002); Joyce (2005, 2006, 2014)

Schaefer was discovered in 1964 and was professionally excavated in 1992–1993. This work resulted in the recovery of a significant part (*ca.* 75%) of a skeleton identified as having come from either a woolly or a Jefferson's mammoth (*Mammuthus jeffersoni*; Joyce, 2006, 2014). Two artifacts—a chert flake and a fragment of a chert biface—were found immediately beneath the innominate of this animal, and the mammoth bones themselves were felt to have been suspiciously clustered (Overstreet, 1996, 1998; Overstreet and Kolb, 2003). The site has been extensively dated, with 18 conventional radiocarbon ages (17 on wood, one on bone), and 15 AMS ages taken on mammoth bone. The mammoth bone AMS ages place the site at around 12,450 ¹⁴C BP (Table 5).

Hebior was the most recent of these sites to have been discovered, as a result of construction work in 1994. As with Schaefer, this site was professionally excavated, again providing the remains of a nearly complete woolly mammoth skeleton felt to have been artificially clustered. Four artifacts were discovered scattered among the bones of this specimen—two chert bifaces, a chert flake, and a dolomite chopper (Overstreet, 1996, 1998; Overstreet and Kolb, 2003). An average of three AMS dates on mammoth bone suggests the animal died around 12,540 ± 30 ¹⁴C BP (Table 5).

Grayson and Meltzer (2002:331–332) rejected Fenske and Mud Lake out-of-hand. Although the mammoth specimens from these sites were said to bear butchering marks (Overstreet, 1996, 1998; Overstreet and Kolb, 2003), insufficient evidence had been published to support this assertion.

We also rejected Schaefer (Grayson and Meltzer, 2002:331–332). Not only had insufficient evidence been provided to convince us that this animal had been butchered, but inspection of the plan map for the site did not suggest that the bones had been clustered in a way that required human intervention. In addition, we were concerned about the nature of the association between the artifacts and the mammoth bones. Spruce wood said to be “in

intimate association with the Schaefer bonepile” (Overstreet, 1998:42) dated to 12,220 ± 80 and 12,260 ± 130 ¹⁴C BP (Table 5) was also “inferred to represent deposits from wood rafting” (Overstreet, 1998:42), a concern repeated by Overstreet and Kolb (2003:98). Given that the wood in these deposits might have been transported from elsewhere, we suggested that the artifacts associated with the mammoth might not be in primary depositional context.

We reached a very different conclusion about Hebior (Grayson and Meltzer, 2002:337). We were not convinced by the argument that the animals had been butchered since no detailed analysis of that butchery had appeared. However, we were convinced by the apparently tight association between the artifacts and the mammoth remains that had been found here. While hoping for a more detailed discussion of this material than was available at the time, we accepted Hebior as providing evidence for human interaction with a mammoth that did not turn out well for the latter.

In short, of these four sites, we previously rejected Fenske, Mud Lake, and Schaefer, and accepted Hebior. Significant additional work has been published on these four sites since Grayson and Meltzer (2002) appeared. Unfortunately, this work has made the archaeological status of these sites even less compelling and we now reject all of them.

Joyce (2006) provided a broad-ranging and detailed assessment of the depositional context of Schaefer. Unfortunately, he did not address the issues raised by Overstreet (1998) and Overstreet and Kolb (2003) concerning the possibility that the spruce wood “intimately associated” with the mammoth had been floated in. More recently, however, Joyce (2014:471) has observed that significant amounts of non-cultural wood “had drifted into the Schaefer backwater and was recovered from below, within, and above the bones”. Given this situation, we cannot be confident that

the two artifacts from this Schaefer are in primary depositional context and we continue to reject this site.

As Joyce (2014) has discussed, the taphonomic work that has recently been conducted on the proboscidean remains from Fenske, Hebior, Mud Lake, and Schaefer is key to understanding the history of those remains. That work, however, is deeply problematic. Johnson (2005, 2006, and especially 2007; see also Joyce, 2014) provided a detailed taphonomic assessment of the proboscidean remains from all four of these sites. She found those remains to bear the unmistakable imprint of human butchering, showing both cut and pry marks. She found 19 such marks on the Fenske femur, 135 marks on ten Mud Lake specimens, 16 marks on nine Hebior specimens, and 30 marks on ten Schaefer specimens. She concluded that the Fenske and Mud Lake proboscideans had been scavenged after they had died, that the Schaefer mammoth had most likely been hunted, and that the Hebior individual had either been hunted or, if not, had been scavenged soon after death.

The analysis provided by Johnson (2007) was thorough and insightful. She noted, and we fully agree, that a lack of cut marks on the remains of elephant-sized animals does not mean that they had succumbed in the absence of human intervention, that the presence of projectile points with the remains of such animals does not necessarily mean that they had been hunted, and that a “lithics-only standard” (Johnson, 2007:79) for assessing human involvement with archaeological proboscideans will inappropriately limit our understanding of the past. Carlson and Steele (1992) had made similar comments in association with DUEWALL-NEWBERRY, and we agree strongly with them all.

Nevertheless, we are deeply concerned by the stark inconsistencies that have arisen among different taphonomists who have examined these materials, and by what these inconsistencies suggest about the reliability and validity of the taphonomic art. Krasinski (2010; see also G. Haynes and Krasinski, 2010) reanalyzed one of the Mud Lake specimens, an ulna, as part of a detailed investigation designed to bring new taphonomic approaches to late Pleistocene bone-bearing sites in North America. Her reanalysis of the Mud Lake ulna found 21 marks of various sorts, none of which were cultural. On the very same specimen, Johnson (2007) found 44 anthropogenic cut and pry marks—17 of the former and 27 of the latter.

These two sets of results are completely incompatible at the same time as they are convincing when each is read in the absence of knowledge of the other. It is perhaps at least in part because of Krasinski's results that G. Haynes and Hutson (2014) reject all of Johnson's taphonomic conclusions concerning Fenske, Hebior, Mud Lake, and Schaefer.

This situation is unsettling, especially given that Haynes and Johnson are experienced taphonomists with broad and deep knowledge of proboscideans, and Krasinski was trained by Haynes. If highly knowledgeable analysts can come to such different conclusions about the same sites—and, in the case of Mud Lake, about the same specimen—then we can only conclude that the processes that modified the bones from these four sites remain unknown. In the absence of reliable and compelling evidence, we join G. Haynes and Hutson (2014) in rejecting the taphonomic evidence for a human role in modifying the proboscidean remains from those sites. Clearly, problems of reproducibility, so common in the biomedical world (Gardner, 2014), continue to plague taphonomic research.

The argument for Hebior involved both putative butchering marks (which we now reject) and associated artifacts. Grayson and Meltzer (2002:337) accepted both this site and Dent, but also noted that these were the least compelling ones on our list and that further supporting information was needed for both. In the case of Hebior, we noted the “apparently” tight association between mammoth remains and artifacts that had been reported from this

location (Grayson and Meltzer, 2002:337). At the same time, we looked forward to a more detailed and compelling analysis of this material than was available at the time. Unlike the situation with Dent, for which a wealth of new information is now available, no such discussion has appeared for Hebior. Because, as Joyce (2014:478) has noted, “Hebior awaits a more complete analysis and report”, and because we have become unconvinced by the taphonomic analysis available for this site, we now exclude Hebior from our list of accepted associations.

2.3.4. Lindsay, MT

In our previous assessment of Clovis-era hunting (Grayson and Meltzer, 2002), we dismissed Lindsay because we found it to be inadequately documented. Recent work conducted on the material from this site requires that we return to it here.

Lindsay yielded a single male adult Columbian mammoth embedded in fine-grained sediments. Although the site has not provided stone or bone tools, eight non-descript quartzite blocks, weighing a total of 4.5 kg, are said to have been found immediately beneath the mammoth remains (Davis and Wilson, 1985; Hill, 2006; Hill and Davis, 1998, 2014).

Sixteen radiocarbon dates obtained from the mammoth itself range widely in time. Hill and Davis (2014) note that the dates with the two lowest standard deviations fall at $12,220 \pm 35$ and $12,300 \pm 35$ ^{14}C BP. The initial description of the site suggested the presence of bone stacking and the possible presence of cut marks (Davis and Wilson, 1985), but later discussions of the site by the primary investigators have focused on the stratigraphic setting and chronology of the mammoth itself (Hill, 2006; Hill and Davis, 1998, 2014). Krasinski (2010) has identified 13 cutmarks on this mammoth, making this site of potential archaeological significance. However, no detailed description of the site has been published, there is no description of the full set of excavated mammoth remains, and no description of the precise relationship between the quartzite blocks and those remains. As Frison observed long ago, Lindsay is “provocative, but it lacks absolute proof of human association” (Frison, 1978:86). Lacking any additional information to make this a more compelling case, Frison's conclusion remains true today. We continue to exclude it from our list, even though we recognize that it might contain strong evidence of mammoth butchery.

2.3.5. Manis mastodon, WA

Discovered as the result of construction activities, the Manis site provided a nearly complete mastodon skeleton from the base of a kettle pond located on the northern edge of Washington State's Olympic Peninsula (Gustafson, 1985; Gustafson and Manis, 1984; Gustafson et al., 1979; Waters et al., 2011). One specimen from that mastodon put Manis on the archaeological map: the proximal end of a right rib with the tip of what appeared to be a bone object protruding from it (for illustrations, see Gustafson et al., 1979; Waters et al., 2011; Grayson, 2015). Assuming that the protruding object represented the tip of a bone projectile point, the site was soon interpreted as a mastodon kill site (Gustafson, 1985; Gustafson and Manis, 1984).

Grayson and Meltzer (2002) rejected the Manis mastodon site as providing secure evidence for human interaction with a mastodon. We did this because no complete report on the results of the excavation had ever appeared (and still has not), because there were no undoubted artifacts associated with the skeleton, because there was no compelling evidence that the bones bore cut marks or were broken in ways that could only be accounted for by human action, and because it had not been shown that the bony object protruding from the rib represents a projectile tip. Even Gustafson

et al. (1979:157) referred to this object as a “supposed projectile point”.

More recently, Waters et al. (2011) documented that the Manis mastodon dates to $11,960 \pm 14$ ^{14}C BP. They also used high resolution X-ray computed tomography (CT) scanning to show that the supposed projectile point protruding from the rib is, in fact, a pointed object made of dense bone. Finally, they analyzed the DNA from the pointed object and showed that it was mastodon bone. They concluded that this object represents a bone projectile point, one that must have been between 27 and 32 cm long to have penetrated this far through mammoth skin and muscle. They also concluded that “the Manis site provides further evidence of a human presence in the New World some 800 years before Clovis ... and shows that people were hunting with mastodon bone weapons made from earlier kills” (Waters et al., 2011:352). By “further evidence”, they meant in addition to such sites as Hebior and Schaefer, which we reject in this paper (see also Grayson and Meltzer, 2002).

We do not agree with these conclusions. The original X-rays, taken in 1983 (Grayson, 2015), made it clear that the object was pointed; Waters et al. (2011) used far more modern and effective technology to verify this fact. However, our concern in 2002 was not the shape of the object, but whether it was actually the point of a weapon fashioned from bone. Waters et al. (2011) do not address this issue, evidently assuming that any pointed piece of bone embedded in a mastodon rib must be there because people caused it to be there. This is decidedly not the case.

During the bouts of male–male aggression known as the “musth”, male elephants can do dramatic damage to one another. Fisher (2008:280) provides a description of one such battle between two male African elephants (*Loxodonta africana*), taken from the work of zoologist R. W. Carroll. During this battle, one of the combatants had a tusk snapped midlength, but triumphed in the end:

... that one tusk thrust home and caught his opponent in the throat, going deep. With a tremendous heave One Tusk raised his head, lifted the impaled bull off his front feet, and ripped a great hole in his neck. As he caught his balance his guard dropped, and again the one tusk went home, this time through the trunk and deep into the head. Both elephants went down to their knees. The one tusker immediately arose, tossed his head, and again thrust his tusk deep into the head of his opponent. With this blow the stricken bull went over on his side, feet flaying the air. One Tusk quickly stepped around and repeatedly drove his tusk into the fallen bull's back, all the while trumpeting and screaming.

Fisher has shown that male mastodons did the same thing, documenting late Pleistocene sites from New York and elsewhere that contain mastodon skeletons showing bone breakage that could only have come from musth battles. That damage includes broken tusks, circular tusk wounds, shattered skull bones, splintered ribs, and fractured vertebra (Fisher, 2008, 2009). If we use modern elephants as our guide (Poole, 1994), the Manis mastodon, which was about 45 years old when it died (Gustafson, 1985; Gustafson et al., 1979), was not too old to be in musth. This raises the very real possibility that the intrusive object comes from the Manis mastodon's own skeleton, driven there by the anger of its opponent (Grayson, 2015). Until this issue is resolved, we will not know the meaning of the pointed object embedded in the Manis mastodon rib so ably described by Waters et al. (2011).

In theory, there are ways in which this could be tested without removing the bone that surrounds that object. Ancient mtDNA was recovered from both the mastodon rib and the supposed projectile point, and though both proved to be mastodon it could not be

determined if the two DNA sequences were from the same individual mastodon, though over the region targeted the sequences were identical (M.T.P. Gilbert, personal communication, 2011). Unfortunately, poor DNA preservation, lack of sufficient background material (only one mastodon mtDNA genome had been sequenced at the time the work was done), and insufficient sample material for analysis made it impossible to determine if these were one or two separate individuals (E. Willerslev, personal communication, 2011). Additional sample material would resolve this question.

Alternatively, the Manis skeleton could be examined to determine if there a missing piece that might match the object in the rib—if, of course, that piece had been recovered at all. Since the Manis mastodon has never been described in detail, there is currently no way of knowing whether or not this might be the case. Until then we reject the Manis site as providing secure evidence of human interaction with a mastodon.

2.3.6. Murray Springs, AZ

Grayson and Meltzer (2002) accepted Murray Springs as providing evidence of an association between artifacts and mammoth but did so hesitantly since no detailed report had appeared that described the work that had been done at this site. All this changed with the appearance of the monograph by C. V. Haynes and Huckell (2007). That monograph made it clear that Murray Springs does, indeed, provide evidence that Clovis people hunted and killed at least one, and perhaps two, mammoth at this spot, along with at least 11 bison. Although Hemmings (2007) suggested that at least one horse was killed here as well, Huckell and Haynes (2007) observe that the evidence for this is not compelling, and we concur. As with Dent, the evidence for human involvement with the death of a mammoth (but not horse) has strengthened since 2002, and this site remains on our list.

2.3.7. Union Pacific Mammoth, WY

We previously dismissed the Union Pacific Mammoth as non-archaeological, given that we – and others – deemed the cultural association to be tenuous (Frison, 1978:29; Grayson and Meltzer, 2002:323; C. V. Haynes, 1970). As Frison noted, the “question remains as to whether [Union Pacific] is a Clovis site because of the lack of Clovis projectile points and the questionable context of some other artifactual material recovered” (Frison, 1978:29; also C. V. Haynes et al., 2013:99). However, Frison also observed that “bones other than mammoth were recovered and some of these as well as the mammoth bones demonstrate evidence of possible butchering by humans” (Frison, 1978:85). Since none of those remains were available to him for observation and analysis, he did not accept the site as a Clovis kill.

C. V. Haynes was involved in the original work at the site, and he and colleagues have recently provided previously unpublished information on site stratigraphy and on the apparent association between the artifacts and mammoth remains, along with a newly obtained radiocarbon age (C. V. Haynes et al., 2013). Interpretations of skeletal provenience and possible artifact associations were complicated by the fact that the discovery of the mammoth remains was made in 1960 while deepening a local spring with a dragline, and most of the skeleton (and one of the bifaces) was removed from under water. As a result, the precise stratigraphic position of this material was not visible (C. V. Haynes et al., 2013:104, 106). In 1961 pumps were brought in to lower the water level to examine the deposits, but as Haynes et al. (2013) note, the precise stratigraphic position of the mammoth bones remains uncertain. They place the original context of this skeletal material on the Stratum B/A contact (G. Agogino, the original investigator, had put the remains in lower Stratum A), and note that at least

some of the remains were removed or redeposited to post-Clovis upper strata C₁ and C₂ (C. V. Haynes et al., 2013).

No further information on the provenience of the artifacts was available, though Haynes et al. (2013) noted that “artifacts typical of Clovis, though non-diagnostic, have been found on the surface” (Haynes et al., 2013:108–109). They were able, however, to obtain an AMS radiocarbon age for the site of $11,560 \pm 60$ ¹⁴C BP on tusk, to supplement the original conventional age $11,280 \pm 350$ ¹⁴C BP obtained on ivory in the 1960s (Haynes et al., 2013:109). Haynes et al. (2013:110) “believe it is likely that Paleoindians interacted with the [mammoth] skeleton”, though they are uncertain whether that interaction involved killing a live animal or scavenging a dead one.

Although the additional information on site stratigraphy and the new radiocarbon age provided by C. V. Haynes and his colleagues are both important and welcome, the critical matter of the provenience of the mammoth and its association with any possible artifacts remains ambiguous. The majority of the artifacts recovered at the site have no provenience. Of the 29 specimens for which the original field notes provided some locational information, almost half (13) were found in the post-Clovis age upper strata C₁ and C₂ with fewer (10) on the B/A contact where the mammoth originally lay, suggesting the possibility that a “later band of people interacted with the mammoth skeleton” (C. V. Haynes et al., 2013:107–108). In effect, the record for Union Pacific remains insufficient to determine the nature of the association of humans and mammoth at this locality. Accordingly, we consider a Clovis cultural association at this site to be tenuous.

2.3.8. Wally's Beach, AB

Located in southeastern Alberta, Wally's Beach has provided a rich late Pleistocene faunal record, from the skeletal remains of *Equus*, *Camelops*, and *Bootherium* to the remarkably well-preserved tracks of camel, horse, mammoth, and other large mammals (McNeil et al., 2004, 2005, 2007).

We previously rejected the argument that protein residue reported from Clovis points found in a lag deposit on the surface of this site documented that these points had come into contact with horse and bovid tissue (Grayson and Meltzer, 2002). As discussed earlier in this paper, we continue to reject claims based on this evidence.

However, subsequent reports have provided detailed information on the carefully excavated remains of seven horses (*Equus conversidens*) and one camel (*Camelops hesternus*), associated with small numbers of artifacts, from Wally's Beach. We discuss this new information here.

Of the seven horses, Kooyman et al. (2006) find the best evidence for human involvement to have been provided by horse B. Eight non-diagnostic lithic artifacts were found in and near the remains of this animal, including a large cobble directly associated with the animal's vertebral column. Of the remaining artifacts, one, a utilized flake, was found partly beneath a thoracic vertebra, suggesting it was unlikely to have worked its way down the sedimentary column to this position. Finally, the hyoid of horse “B” display what certainly appear to be cut marks. There is no need to review the evidence suggesting that the other six Wally's Beach horses were either killed or scavenged by people since, with Kooyman et al. (2006), we find horse B to provide the strongest evidence of this, and accept it as such. Kooyman et al. (2006) argue that this horse, along with the six others, was likely killed by people.

Although we accept this association, we are nonetheless puzzled by several matters. The horse B hyoid might have been cut in the process of removing the animal's tongue, and it is certainly possible for this to have occurred in such a way as to cut this bone and no others (e.g., Wheat, 1972:105). However, in spite of the

presence of the large cobbles and flakes, no other bones of this animal show signs of cut marks, possible anthropogenic fractures, or impact marks. We also note that the surfaces of the horse B skeletal elements “are in excellent condition and show no evidence of abrasion” (Kooyman et al., 2006:103). On the other hand, some of the associated lithics “show abrasion on one or both surfaces to varying degrees” (Kooyman et al., 2006:105). One surface of the utilized flake found partly beneath a horse B thoracic vertebra, for instance, “shows clear evidence of the pebble-textured, pitting type of abrasion typical of wind-blown sand” (Kooyman et al., 2006:105). Kooyman et al. (2006) report finding use wear on top of the abraded surfaces, and suggest that this sequence results from the use of tools cached at the site. Still, we are puzzled how wind could have abraded the surfaces of stone tools yet left bone surfaces unscathed and the tracks of horse, camel, mammoth, and other large mammals intact (McNeil et al., 2004, 2005, 2007), all in an area in which wind speeds today can reach 160 km/h (Kooyman et al., 2001). Different taphonomic histories of artifacts and bones seem suggested by this.

Kooyman et al. (2006:104–105) consider this possibility, but argue that there has been “no opportunity for deflation of recent archaeological material from higher in the deposits.” However, given that ca. 1.5–2 m of overlying sediment were removed by wind erosion prior to the discovery of the site (McNeil et al., 2005; Kooyman et al., 2006), we cannot entirely preclude the possibility that just such a process did occur. Even if this did happen, however, it would remain difficult to account for deflation placing a large cobble directly atop the vertebral column of horse B.

The archaeological and geological situation with the Wally's Beach camel is quite similar (Kooyman et al., 2012). The careful excavation of this individual yielded two sets of articulated vertebrae with associated rib fragments directly dated to $11,070 \pm 80$ ¹⁴C BP. Evidence for human use of these elements comes from a single cut mark on the second cervical vertebra on one of the two sets of articulated vertebrae, and breakage patterns on the second set. The latter set includes two rib fragments said to have been fractured when fresh, and four proximal ribs still in articulation with thoracic vertebrae, at least two of which had been snapped not far from the articular surfaces (Kooyman et al., 2012). As Kooyman and his colleagues (2012) note, this is a common method of removing material from this part of the skeleton. Three non-diagnostic lithic artifacts are closely associated with the camel material, one of which, described as a stone core or chopper, was partially beneath a cervical vertebra. As with the utilized flake associated with horse B, such a position suggests that this artifact was unlikely to have worked its way down-column to the location in which it was ultimately found.

It is possible that the lithics associated with this camel are not in primary depositional context. Kooyman and his colleagues carefully note that while the archaeological and paleontological materials are found in windblown sand and silt, “the lithic pieces are much larger and therefore could not have been brought in by the natural processes that resulted in the burial of the site, nor by any water transportation mechanism” (Kooyman et al., 2012:120). They note as well that since the local topography is flat, “there has been no opportunity for any lithic pieces to roll downslope from another context, creating a false association” (Kooyman et al., 2012:120). In fact, mechanisms are known that can produce just such associations in precisely this kind of context (Baumgardner and Shaffer, 2015; Norris et al., 2014).

However, even if such an extremely unlikely event occurred, we would still be left with the cut mark evidence and with the snapped ribs. We find the evidence presented by Wally's Beach for human utilization of camel even more compelling than the evidence presented by horse B, and accept them both. That this evidence is

compelling, where other cases for camel and horse exploitation were not (Grayson and Meltzer, 2002:343), is due to the occurrence at Wally's Beach of multiple lines of evidence for human involvement, and which occur on more than single isolated specimens.

Kooyman and his colleagues (2006, 2012) argue that these animals were hunted by Clovis-age peoples. We do not reject this possibility, but, as we have discussed earlier, see no way to distinguish between hunting and scavenging in the absence of any implements that might have been used to dispatch the animals involved. Perhaps future work in this area will clarify this matter, given that Clovis points are known from surficial contexts here (Kooyman et al., 2001, 2006, 2012).

2.4. Newly considered sites

2.4.1. Big Bone Lick, KY

One of the most famous of North American Pleistocene paleontological sites, Big Bone Lick has been the focus of often uncontrolled collections of paleontological remains since at least the 1700s and probably earlier (Schultz et al., 1963; Tankersley, 1985, 1992; Tankersley et al., 2009; Thomson, 2008). Over the years, it has also provided a small series of fluted points, none from known buried contexts (Tankersley, 1985, 1987, 1992; Tankersley et al., 2009). Tankersley's tightly controlled excavations at the site provided, among other things, two lithic artifacts in close proximity to mastodon bone. As he and his colleagues note, however, such artifacts "are rare and appear to lie in a secondary context among a palimpsest of mastodon bone" (Tankersley et al., 2009:566). These researchers also provided the first trustworthy radiocarbon ages for Big Bone Lick mastodon specimens, ages that fall at $11,020 \pm 30$, $11,700 \pm 35$, and $12,210 \pm 35$ ^{14}C BP. The youngest of these came from a phalanx that bears what Tankersley and his coworkers describe as a "possible cut mark", at the same time concluding that Big Bone Lick does not provide secure evidence that people either hunted or scavenged mastodon at this location.

Krasinski (2010) examined the collection of Big Bone Lick mastodon bones collected at the behest of Thomas Jefferson in 1807 and housed at the Academy of Natural Sciences of Philadelphia. She found the 62 specimens that she analyzed to bear 271 marks, of which five were interpreted to be cut marks. Although we admire Krasinski's work, we do not accept her results as providing compelling evidence for human interactions with mastodon at this site. We are concerned by her careful observation that "angular gravels remained in some of the elements" (Krasinski, 2010:370). Such gravels, combined with the observation by Tankersley and his colleagues that the fossil-bearing sediments they excavated are not in primary depositional context, present the very real possibility that the five (of 271) marks observed by Krasinski are cut-mark mimics, produced by the movement of bone against small clasts in the Big Bone Lick deposits. This possibility is heightened by the fact that Krasinski found 29 of the specimens she examined to exhibit "probable trampling marks" (Krasinski, 2010:370). Trampling opens the possibility of bone being forced against angular stone, producing marks analogous to the famous "pit wear" at Rancho La Brea (Frischia et al., 2008; see also Domingo-Rodríguez et al., 2010). Given this situation, we agree with Tankersley and his colleagues, and reject Big Bone Lick as having provided strong evidence for human interaction with mastodons.

2.4.2. Coats-Hines, TN

Coats-Hines is an extremely intriguing site. Work extending across three decades has revealed the presence of three mastodons spaced more than forty meters apart. These include the partial skeletons of an adult female (Mastodon A, recovered in 1977) an adult male (Mastodon B, recovered in 1994), and a scatter of highly

fragmented and poorly preserved remains that, based on their size, also appear to be mastodon (Mastodon C, recovered in 2008 and 2010). Mastodon B is reported to have been "in direct association" with 34 lithic artifacts (Deter-Wolf et al., 2011:147), while artifacts were also recovered in the vicinity of Mastodon C, though none *in situ* (Deter-Wolf et al., 2011). Water screening of matrix samples taken from around mastodons A and B yielded additional debitage, and, from the sample associated with Mastodon B, possible bone and antler tools (Deter-Wolf et al., 2011). Although radiocarbon ages from the mastodon bones themselves are not available, a date of $10,260 \pm 240$ ^{14}C BP has been obtained from just above mastodon B, and of $12,030 \pm 40$ ^{14}C BP from immediately beneath the ribs of this animal. A third radiocarbon date, of $12,050 \pm 60$ ^{14}C BP, is available for the "top of the artifact-bearing deposit" (Deter-Wolf et al., 2011:152; see also Breitburg and Broster, 1995; Breitburg et al., 1996). Breitburg and Broster (1995) noted possible cut marks on the humerus and thoracic vertebra of Mastodon B. More recent work, however, identifies cut marks only on the spinous process of a thoracic vertebra, a specimen said to have been recovered in "direct contact with several lithic artifacts" (Deter-Wolf et al., 2011:147).

We consider Coats-Hines to have great potential as a possible mastodon butchering site, but agree with G. Haynes and Hutson (2014:295–296) that a much more detailed assessment of the cut marks, and we add of the artifacts and the relationships of the artifacts to the mastodons, is needed before the site can be accepted as such. Accordingly, we have not included it on our list. Finally, although immaterial to any conclusion concerning the anthropogenic nature of the site, we would also like to see more compelling evidence that the ca. 12,000 ^{14}C BP dates pertain to the mastodons at the site; direct dates on those remains would be most helpful.

2.4.3. El Fin del Mundo, SON

Located in western Sonora, Mexico, El Fin del Mundo (Sanchez et al., 2014) provided the remains of two juvenile gomphotheres associated with lithic flakes and four Clovis projectile points. Charcoal flecks from the bone bed date returned ages of $11,550 \pm 60$ ^{14}C BP and $11,880 \pm 200$ ^{14}C BP. Since the older date was obtained from humates, Sanchez et al. (2014) consider the younger date to provide the best approximation of the age of the bone bed. Unfortunately, the gomphothere bones were not sufficiently well-preserved to allow them to be dated directly, or for their surfaces to be analyzed for indications that they had been altered by human hands. A camp site or camp sites located in the uplands a few hundred meters from the bone bed provided an additional 13 Clovis points or point fragments. While the bone bed has been extensively excavated by Sanchez and her colleagues, much work remains to be done at the camp site(s).

The El Fin del Mundo gomphotheres have been identified as *Cuvieronius* sp. Given current understanding of gomphothere systematics, they are most likely *Cuvieronius hyodon* (Lucas, 2008a, 2008b; Lucas and Alvarado, 2010; Mothé et al., 2013). No matter what species they belong to, this site not only provides a very early date for Clovis, but it also provides the first evidence that gomphotheres survived this late in the North American Pleistocene (Grayson, 2015).

Sanchez et al. (2014) find it unlikely that people would have encountered two young, dead gomphotheres at the same spot on the landscape and then scavenged them in such a way as to leave Clovis points associated with their remains. These animals, they conclude, were killed by Clovis hunters. However, and as one of us has pointed out (Meltzer, 2014), these arguments do not preclude the possibility that the animals were scavenged, since their cause of death is unknown and the "points" could have been used as knives in this setting. Although we disagree between ourselves as to

whether these animals are more likely to have been hunted or scavenged, we do not disagree in regard to the strength of the association between Clovis artifacts and gomphotheres at El Fin del Mundo.

Sanchez et al. (2014) document multiple concentrations of Clovis points and tools in nearby uplands, and, based on similarities in stone tool morphology, technology, and raw materials, argue that the upland sites were contemporary with the gomphothere location. We very much look forward to the results of future work at these upland sites. Not only would lithic refits between the two areas confirm their contemporaneity, but the presence of gomphothere remains in a subsistence-related context in the uplands would provide even stronger confirmation that Clovis-era peoples included gomphotheres in their diet.

In short, we find the tight association of artifacts with the remains of gomphotheres at El Fin del Mundo to provide compelling evidence that people living at El Fin del Mundo were either hunting or scavenging gomphotheres and we have included this site on our list.

2.4.4. Firelands, OH

The Firelands, Ohio, *Megalonyx* was removed from a bog sometime prior to 1915, with the remains ultimately ending up in the collections of the Firelands Historical Society Museum, in Norwalk, Ohio. Redmond et al. (2012) analyzed that material and obtained an AMS radiocarbon date of $11,740 \pm 35$ ^{14}C BP from the left femur of the animal. Of the ten specimens available for analysis, only the femur bore what might represent cutmarks. Although those marks were analyzed in impressive detail, the investigators were only able to conclude that these were “likely” to be butchering marks (Redmond et al., 2012:94). Given the unknown history of this specimen, and given the tentative conclusion reached by the authors, we do not accept the anthropogenic nature of these marks.

2.4.5. Page-Ladson, FL

Located in a sinkhole in northern Florida's Aucilla River, Page-Ladson is an underwater paleontological and archaeological site that yielded a remarkable abundance of late Pleistocene vertebrates. Stratigraphic unit 3 from this site yielded a substantial assemblage of mastodon remains, the remains of a domestic dog (*Canis familiaris*), and eight non-diagnostic lithic artifacts. It also provided four specimens of extinct Pleistocene mammals said to bear diagnostic signs of human manipulation. Seven AMS dates for this unit, averaging $12,425 \pm 30$ ^{14}C BP, were obtained from seeds, wood, and a specimen of the extinct large-headed llama, *Palaeolama mirifica*. Webb and Dunbar (2006) observe that since the Floridan Aquifer provided the water for this sinkhole, carbon reservoir effects might mean that the actual ages of the dated material are younger than this. Unfortunately, the domestic dog material has not been dated directly (Dunbar, 2006; Kendrick, 2006; Webb and Dunbar, 2006; Webb and Simons, 2006).

Since the lithic artifacts from stratigraphic unit 3 are not closely associated with the remains of extinct Pleistocene mammals, we focus our discussion on the four specimens of mammals said to have been modified by people.

Of these four specimens, two—an *Equus* phalanx and a *Tapirus* humerus—are said to bear “fresh cut marks” (Webb and Simons, 2006:235) but no further descriptions or illustrations of these specimens have been provided and so cannot be considered here.

The remaining specimens are both from mastodon: a thoracic vertebra and a tusk. Webb and Simons (2006) interpret the thoracic vertebra as having been broken while fresh and claim that it bears both “obvious impact fractures” and “fine longitudinal cuts” (Webb and Simons, 2006:236). These marks are not otherwise described or illustrated and so cannot be taken to provide compelling

evidence for human interaction with mastodon. Dunbar (2006) agrees that this vertebra was broken while fresh, but does not claim that it has also been cut.

G. Haynes (2000) has discussed the many ways in which the bones of large proboscideans may be fractured without requiring human intervention, including trampling by other large mammals. Given that Webb and Simons (2006) observe that trampling seems to have occurred at this site, we cannot accept the Page-Ladson broken thoracic vertebra as evidence that people were involved in the demise, or processing, of the mastodon from which it came.

The tusk has been the focus of a wide array of important analyses by Hoppe et al. (1999), Hoppe and Koch (2006, 2007), and Fisher and Fox (2006), but its importance to us here is that it shows a series of six near-parallel grooves near the alveolar border, the morphology of which is consistent with having been made by a stone tool. Webb (2006) suggests that these marks represent an attempt to remove the tusk for further use as raw material for tool manufacture. We do not question that the grooves on this specimen are the result of human manipulation. Quarrying raw material for tool manufacture, however, does not establish that the mastodon that bore this tusk met its demise as a result of human activity or was scavenged for food after having died in other ways. As a result, we have not included Page-Ladson on our list of such sites.

3. Conclusions

In 2002, our analysis of Clovis-era sites led us to conclude that 14 sites provided compelling evidence of human involvement in the subsistence-oriented death and/or dismemberment of mammoth (12 sites) and mastodon (2 sites; see Table 1). For reasons discussed above, we now eliminate Hebior from that list while adding El Fin del Mundo (the gomphothere *Cuvieronius*) and Wally's Beach (*Camelops*, *Equus*). Table 6 provides the modifications we have made to our 2002 list; Table 7 provides the final results. To the extent that this list of 15 sites, and our interpretation of it, is correct, it suggests that people were responsible for the subsistence-oriented death and/or dismemberment of now-extinct late Pleistocene mammals drawn from five genera: *Camelops* (one site), *Equus* (one site), *Cuvieronius* (one site), *Mammuthus* (two sites), and *Mammuthus* (11 sites).

It thus remains the case that there are strikingly few archaeological sites that document human predation on, or scavenging of, these now extinct animals. We anticipate that proponents of overkill will agree on this point, as they have in the past (Surovell and Waguespack, 2008), and perhaps will dismiss this scarcity of

Table 6
Archaeological sites with evidence suggesting human predation on now-extinct Pleistocene genera: the Grayson and Meltzer (2002) list with current modifications.

Site	Genus	Current Status
Wally's Beach	<i>Equus</i>	New Addition
Wally's Beach	<i>Camelops</i> ,	New Addition
El Fin del Mundo	<i>Cuvieronius</i>	New Addition
Kimmswick	<i>Mammuthus</i>	Same
Pleasant Lake	<i>Mammuthus</i>	Same
Blackwater Loc 1	<i>Mammuthus</i>	Same
Colby	<i>Mammuthus</i>	Same
Dent	<i>Mammuthus</i>	Strengthened
Domebo	<i>Mammuthus</i>	Same
Escapule	<i>Mammuthus</i>	Same
Hebior	<i>Mammuthus</i>	Deleted
Lange-Ferguson	<i>Mammuthus</i>	Same
Lehner	<i>Mammuthus</i>	Same
Lubbock Lake	<i>Mammuthus</i>	Same
Miami	<i>Mammuthus</i>	Same
Murray Springs	<i>Mammuthus</i>	Strengthened
Naco	<i>Mammuthus</i>	Same

Table 7
Archaeological sites with evidence suggesting human predation on now-extinct Pleistocene genera: the current list.

Site	Genus
Wally's Beach	<i>Equus</i>
Wally's Beach	<i>Camelops</i>
El Fin del Mundo	<i>Cuvieronius</i>
Kimmswick	<i>Mammut</i>
Pleasant Lake	<i>Mammut</i>
Blackwater Loc 1	<i>Mammuthus</i>
Colby	<i>Mammuthus</i>
Dent	<i>Mammuthus</i>
Domebo	<i>Mammuthus</i>
Escapule	<i>Mammuthus</i>
Lange-Ferguson	<i>Mammuthus</i>
Lehner	<i>Mammuthus</i>
Lubbock Lake	<i>Mammuthus</i>
Miami	<i>Mammuthus</i>
Murray Springs	<i>Mammuthus</i>
Naco	<i>Mammuthus</i>

evidence of hunting as ‘irrelevant’ and a byproduct of poor preservation and other taphonomic biases, as they have also done in the past (e.g., Surovell and Grund, 2012). That is, it might be claimed that there are so few kill/scavenging sites of these extinct taxa simply because there are fewer sites preserved from this time period (e.g., Surovell and Grund, 2012).

One of us has recently addressed the problematic nature of this taphonomic rebuttal (Meltzer, 2015), admitting that while there are sampling and preservation biases with which we must contend

when dealing with sites of this age, those apply not only to the now-extinct taxa but also to the nine North American large mammals that survived the end of the Pleistocene and were also potential targets of human hunting (bison [*Bison bison*], caribou [*R. tarandus*], deer [*Odocoileus* spp.], elk [*Cervus elaphus*], moose [*Alces americanus*], pronghorn [*Antilocapra americana*], mountain goat [*Oreamnos americanus*], mountain sheep [*Ovis* spp.] and muskox [*Ovibos moschatus*]). Those survivors provide us with a measure of whether the 15 kill/scavenging sites of the 5 extinct genera on our current list represents a lot or a little relative to their abundance in the fossil record and to other hunted taxa.

In fact, those 5 extinct genera are relatively abundant in the Late Wisconsin age fossil record (the period dating from 35,000 to 10,000 years ago) when compared to the frequency of the 9 surviving taxa from that same period (n = 322 and n = 170, respectively [data from www.ucmp.berkeley.edu/faunmap]). And yet despite the relative scarcity of the surviving taxa in the fossil record from that period, fully 8 of these 9 genera occur in kill/scavenging sites (Meltzer, 2015). More striking, the survivors occur in a far greater number of kill/scavenging sites than do the extinct genera, indicating that the number of such sites is not merely proportional to fossil occurrences or its converse, taphonomic loss over time (cf. Surovell and Grund, 2012). The disparity in the number of kill/scavenging sites of extinct taxa (n = 15) versus surviving taxa (n = 111) is particularly evident in a plot of these sites to fossil occurrences (Fig. 2), which reveals that the surviving taxa occur at proportionately greater frequency in such sites than the extinct taxa (note the slopes of the respective curves). Thus, the absolute scarcity of kill/scavenging sites of extinct taxa is matched by their

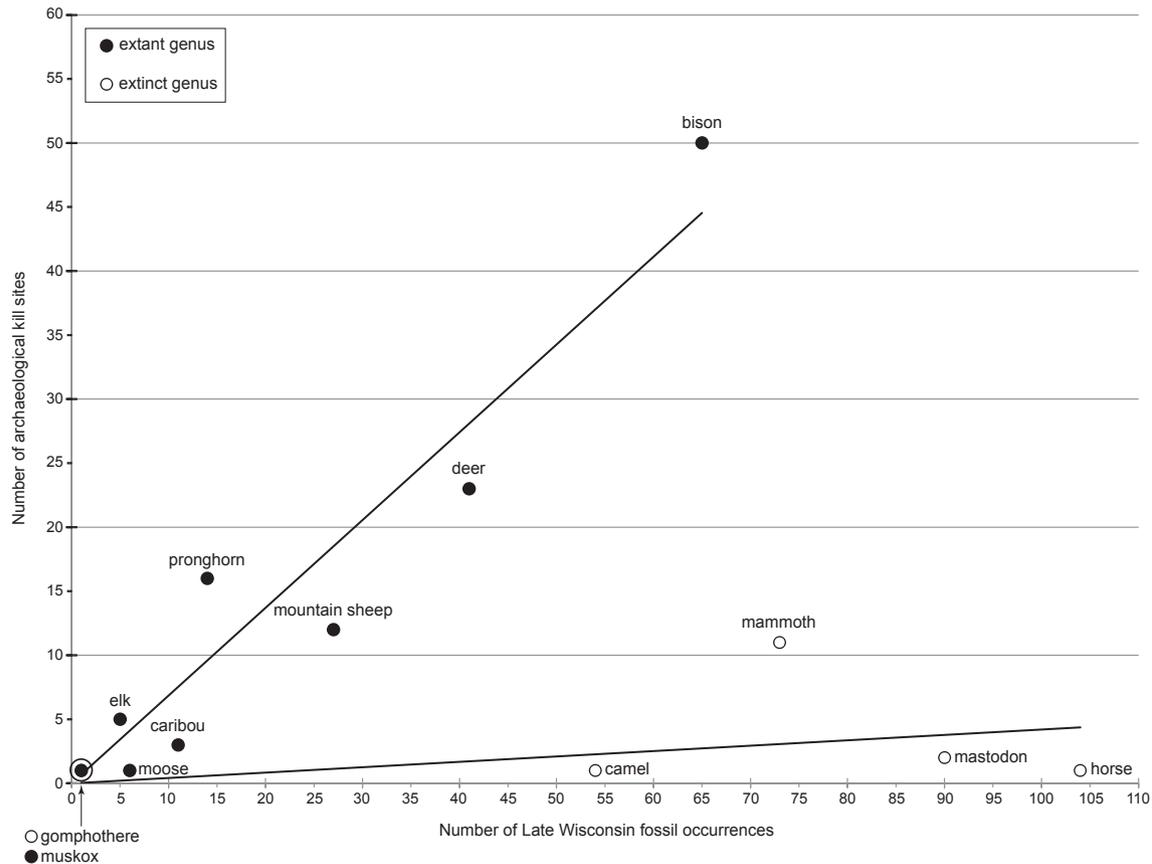


Fig. 2. A plot of the number of Late Wisconsin fossil occurrences against the number of archaeological kill sites for the 5 extinct and 8 surviving genera of large North American mammals. Note that gomphothere and muskox overlap on the plot (1 fossil occurrence at 1 archaeological kill site). The number of fossil occurrences for each genus is from the FAUNMAP electronic data base (www.ucmp.berkeley.edu/faunmap), and of archaeological occurrences from this paper and Meltzer (2015).

relative scarcity as well: this cannot be dismissed as a byproduct of taphonomic bias, given that the survivors are from sites of the same age. Indeed, to the degree that some of these sites reflect scavenging rather than predation, the number of true kill sites is reduced even further.

Of course, it must also be observed there are still 32 other extinct genera yet unaccounted for in any archaeological kill/scavenging sites, of which 25 are herbivores and thus presumably fair dietary game. On the other hand, and as noted above and shown in Table 3, it is not apparent that the majority of these survived late enough in the Pleistocene to have been available as targets for newly arrived Clovis (or perhaps even pre-Clovis) hunters.

Considering the matter of mammalian extinctions more broadly, we have argued elsewhere that those extinctions are not to be explained by treating now-extinct North American Pleistocene mammals (and some 20 genera of birds) as if they belonged to a single biological community on a continental scale, and as if explaining the extinction of one taxon would explain the extinction of all (Grayson, 2007, 2015; Meltzer, 2015). Nor are they to be explained by building models meant to be applied on that, or even larger, scales (e.g., Alroy, 2001; Prescott et al., 2012; see Brook and Bowman, 2002; Meltzer, 2015; Yule et al., 2014). Instead, they are to be explained by building individual species' histories that lead up to the times of extinctions themselves (Grayson, 2007, see e.g., Guthrie, 2003, 2006; Stuart and Lister, 2011, 2012; Stuart et al., 2004).

In recent decades, novel and powerful tools have become available to probe those histories. These include not only AMS dating, which has revolutionized our understanding of the various chronologies of extinction, but, even more recently and since our original paper appeared, the extraction and high-resolution sequencing of ancient DNA (e.g., Barnett et al., 2005; Campos et al., 2010; Enk et al., 2011; Moura et al., 2014; Orlando et al., 2009; Shapiro et al., 2004). The latter approach is especially important for helping us understand the crucial details of the population and demographic histories of now-extinct late Pleistocene animals, and for revealing when the extinctions of these individual taxa began rather than the less informative moment of when those processes came to an end (Meltzer, 2015).

Such DNA-based analyses are still in their infancy, but ultimately they can be combined with the construction of high-resolution chronologies, equally high-resolution paleoecological work to further our understanding of the changing environments in which now-extinct taxa lived, ecomorphological analyses of those taxa (Dompierre and Churcher, 1996; Green et al., 2005), the analysis of potential osteological and dental indicators of environmental stress (e.g. Fisher, 2001, 2008), and, of course, continued fine-scaled documentation of relevant archaeological sites. Together, these will ultimately help construct the individual species histories critical to understanding the extinctions of so many vertebrates in late Pleistocene North America.

Acknowledgments

This paper is in honor of our friend Richard G. Klein, whose work on African Quaternary extinctions has long been of pivotal importance to our understanding of African faunas both past and present, and serves, and will continue to serve, as the basis for advancing of our understanding of those faunas.

Many thanks to Mike Cannon, Tyler Faith, and Vance Holliday for extremely helpful comments on a draft of this paper. We also thank Linda Scott Cummings, Jennie Erikson, and Jenny Milligan (PaleoResearch Institute), Steve Hohen (Center for American Paleolithic Research) and Dennis Jenkins (University of Oregon), for crucial help provided along the way.

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