Chapter 25

The Mammoth Steppe Hypothesis: The Middle Wisconsin (Oxygen Isotope Stage 3) Peopling of North America

Steven R. Holen and Kathleen Holen

Abstract
In this chapter we introduce the Mammoth Steppe Hypothesis suggesting an Oxygen Isotope Stage 3 (OIS3), human movement into the Americas sometime between 40,000 and 30,000 years ago. OIS3 was characterized by a relatively mild climate that created a vast contiguous grassland, which was capable of supporting abundant fauna. Humans had adapted to this Mammoth Steppe biome during the latter part of OIS3 as demonstrated by material cultural evidence from the Yana Rhino Horn site and other northern Siberian sites. Ecological data from the Mammoth Steppe support the assertion that humans could have followed the Mammoth Steppe into the Americas during OIS3. We suggest that human populations from northern Siberia were able to disperse across Beringia and down the eastern edge of the Rocky Mountains when an interior corridor was open prior to 22,000 \(^{14}\)C yr BP. Support for the hypothesis is based on evidence from multiple North American mid-continent archaeological sites dating to OIS3 and the Last Glacial Maximum (LGM). Evidence from 14 sites, 5 of which contain stone artifacts, is summarized. The dispersal of small pre-LGM populations left a sparse archaeological record in North America that warrants ongoing investigation through systematic research in geological deposits greater than ca. 20,000 \(^{14}\)C yr BP.

KEYWORDS: Early humans in the Americas, Mammoth Steppe, Middle Wisconsin, Taphonomy

Introduction
The ecological model of a Mammoth Steppe was developed by R. Dale Guthrie (1968, 1982, 1984a, 1984b, 1991, 2001; Guthrie and van Kolfschoten 1999) over many years of paleontological research in Alaska. Guthrie described an extensive, cool grassland (Figure 25.1) with a diverse floral and faunal biota that extended from central Europe to Alaska and the Yukon during Oxygen Isotope Stage 3 (OIS3), ca. 65,000–27,000 cal yr BP. The Mammoth Steppe concept defined by Guthrie, as presented here, is a simplified version of a changing OIS3 climate and biotic community in northern Siberia and Beringia (see Hoffecker and Elias 2007 for a more complete discussion of OIS3 environments).

The Mammoth Steppe Hypothesis proposes that Upper Paleolithic groups had developed technological innovations including efficient shelter, tailored clothing, new heat sources, and a lithic and bone/ivory tool kit that allowed them to adapt to the Mammoth Steppe in northern Siberia and Beringia during OIS3. A small number of hunter-gatherer groups from Siberia moved across the steppe environment, through Beringia, and then south following an American steppe biome east of the Rocky Mountains, into the central part of North America. These small populations were subsequently cut off from groups in Siberia and Beringia when Canada was glaciated from coast to coast during the LGM. Hunter-gatherer groups, although small in number, left an
archaeological record in the American mid-continent during the latter part of OIS3 and the LGM, and later developed the Clovis techno-complex at about 11,500 $^{14}$C yr BP.

The idea of OIS3 peopling of North America is not new. Muller-Beck (1966, 1967) envisioned an expanding population of Upper Paleolithic hunters adapted to the vast open plains, armed with a bifacial projectile-point technology derived from the Kostenki area of the Russian plain. These populations reached the "Asiatic coast of the Pacific" during the "Aurignac oscillations" approximately 35,000–27,000 years ago. Muller-Beck (1966:1207) stated that "the first invasion of man in the New World for which a reliable archaeological reconstruction seems possible—there could have been earlier invasions—took place about 28,000 to 26,000 years ago." After this time “the invaders were isolated by the ice advances of the Wisconsin maximum in the southern part of North America and separated from the continuing technological evolution of the Old World” (ibid:1208–09, Figure1). In this contribution, Muller-Beck’s ideas are revisited and a Mammoth Steppe Hypothesis, based on R. Dale Guthrie’s ecological model, is developed and tested.

To test the Mammoth Steppe Hypothesis we take into consideration archaeological, paleoecological, and genetic information from Siberia, Beringia, and the North American mid-continent to determine if evidence exists that supports the hypothesis that humans entered North America via the Mammoth Steppe during OIS3. In this contribution, Muller-Beck’s ideas are revisited and a Mammoth Steppe Hypothesis, based on R. Dale Guthrie’s ecological model, is developed and tested.

The Middle Wisconsin (OIS3) Mammoth Steppe

During OIS3, a warm interstadial, the guild of large mammalian fauna was species-rich from central Europe to northeastern Asia and Alaska, more diverse in the southern parts of the biome than in the north, and was larger during OIS3 than in either OIS2 or OIS4 (Guthrie and van Kolfschoten 1999). Major mammalian herbivorous species of the Mammoth Steppe included: bison, woolly mammoth, woolly rhinoceros, caribou, horse, and saiga antelope that are all predominantly grazers. Lion, wolf, and hyenas were major carnivore species preying on the herbivores.

In North America during OIS3, a vast grassland that we term the American Steppe, extended from the Mammoth Steppe of Alaska and the Yukon into the present Great Plains of North America and as far south as central Mexico (Johnson 2005). An inhabitable corridor from Beringia to the American mid-continent was open throughout the later part of OIS3 until the LGM. Based on dated faunas from Alberta (Burns 1996) and on cosmogenic $^{36}$Cl dating of glacial erratics in Alberta (Jackson et al. 1997) the corridor closed about 22,000 $^{14}$C yr BP when the Cordilleran and Laurentide glacial systems coalesced.

Faunal and floral diversity was the hallmark of this vast grassland. On the American Steppe, mammalian species diversity was high owing to a long growing season that supported a diversity of floral resources. Columbian mammoth, camel, bison, horse, and llama were the major herbivorous species, while lion, sabertooth cat, dire wolf, and giant short-faced bear were the primary carnivores.

Mammalian species in North America, including Columbian mammoth, mastodon, camel, and giant short-faced bear, extended their range north into Alaska and the Yukon during OIS3. Guthrie (2001) postulated the presence of a moderately moist, mesic, ecological barrier between present-day Alaska and Siberia in central Beringia that kept certain species from crossing in either direction. The North American species listed above did not move into the area of western Beringia now known as eastern Siberia, and woolly rhinoceros and hyenas did not reach Alaska.

Guthrie and van Kolfschoten (1999) suggested the Mammoth Steppe grassland contained a large variation in species composition between regions that was preserved by climatic variability and short climatic episodes quite dissimilar to the Last Glacial Maximum or the Holocene. Overall the steppe biome was continuous from Europe to Siberia and Beringia, and into North America and Mexico, with some spatial varia-
tions in faunal and floral composition, but, most importantly, there was general homogeneity of the biome over this large area (Madsen 2004).

Research History

Researchers have occasionally discussed, and a few have advocated a human dispersal into North America during OIS3 (Bonnichsen 1978, 1979; Morlan 2003; Stanford et al. 2005). Others have supported the possibility (Butzer 1991; Madsen 2004) or have at least considered it (Goebel et al. 2003; Goebel et al. 2008; Pitblado 2011). However, the idea has never been widely accepted (Meltzer 2009).

Evidentiary arguments against a human presence in the Americas during the OIS3 have focused on the purported inability of OIS3 human populations in Asia to adapt to and populate a far northern steppe environment, and also on critique of bone-modification patterns found in the Yukon that were put forward as evidence of human technology (Bever 2001; Dixon 1999; Goebel 1999; Guthrie 1984c, 1991; Hoffecker 2002; Hoffecker and Elias 2003, 2007; Adams et al. 2001).

Guthrie (1984c, 1991) provided detailed arguments against a human entry into North America during OIS3, suggesting it was technologically impossible for human hunters to have lived north of 60°N latitude owing to lack of necessities that included tailored clothing, wood, suitable housing, and an advanced lithic technology to produce efficient stone projectile points. Guthrie (1991:275–76) concluded, “Interstadial people 35,000 years ago still faced a limit at 60N. Yet the warm and wet interstadial probably allowed people to move farther north in Eurasia than they had ever been, an expansion that was slowly driven southward during the last glacial.” Guthrie (1991:273–77) suggested that human technology was the key to adapting to the Mammoth Steppe north of 60°N latitude and included as requirements for this adaptation “well-insulated housing, tailored clothing, efficient heat sources, and a suite of tools that reduce danger, frustration, and expended energy.”

In Eastern Europe, Early Upper Paleolithic (EUP) societies were developing technological innovations including new blade and bifacial lithic tools, efficient structures, new fuel sources, and sophisticated osseous tools (Hoffecker 1985; Hoffecker and Elias 2003; Bradley et al. 1995). The earliest record of these new technologies is present at Kostenki on the Russian Plain and appears to date 45,000–42,000 cal B.P. Lithic technological advances include prismatic blade cores, bladelets, endscrapers, burins, and small bifaces (Hoffecker 2009; Anikovich et al. 2007). Non-stone technology included bone awls and points, antler mattocks, and carved ivory art. There is circumstantial evidence for the rotary drill and traps for small animals. Animals also provided resources for fuel and for manufacturing tools and shelters. Canids may have been domesticated (Germonpré et al. 2009; Ovodov et al. 2011) and assisted in hunting, acted as companions, provided protection, and served as an emergency food source.

Another site, Mezmaiskaya Cave in the Caucasus, provides the earliest conclusive evidence for the invention of bone needles, indicating sewn clothing. Two bone-needle fragments were found in layer 1C dating to 38,000–37,000 cal B.P. (Golovanova et al. 2010). Earlier invention of the eyed needle is possible because they are also reported from layers 9 and 11 of Denisova Cave in southern Siberia (Derevianko and Shunkov 2004). Radiocarbon dates of greater than 37,235 14C yr BP (SOAN-2504) from layer 11 (Vasil’ev et al. 2002) indicate that eyed needles appeared in central and eastern Europe and Siberia much earlier than traditionally thought (Kuzmin 2008).

These new technologies allowed EUP people to move into southern Siberia by 46,000 cal BP (Goebel 2004; Graf 2009). EUP people also moved northward to the Arctic Circle in western Siberia between 40,000 and 30,000 BP. Pavlov and Indrelid (1999) and Pavlov et al. (2004) discuss four sites in the western foothills of the Ural Mountains (Figure 25.2). These sites, Talisky, Garchi, Bryzovaya and Mamontovaya Kurya, range between 58°N and 66°N latitude. Mamontovaya Kurya at the Arctic Circle dates to more than 40,000 cal B.P. and contains artifacts similar to the earliest Upper Paleolithic horizon at Kostenki 12 (Hoffecker 2009).
In 2004, Pitulko et al. (2004) reported the Yana Rhino Horn site (RHS) on the Yana River at 71°N latitude, the first pre-LGM site in western Beringia (Figure 25.2). The site is buried deep in a permafrost terrace fill and is securely dated at ca. 27,000 14C yr BP by 10 radiocarbon ages that fit well with the stratigraphic position deep in stratified second terrace fill. Numerous stone tools, four bone tools, and faunal material from several extinct and extra-local species including mammoth, horse, bison, musk ox, lion, and hare were discovered. Stone tools include choppers, bifaces, unifacial scrapers, chisel-like tools, and retouched flakes. Three beveled osseous rods are present; two are made of mammoth ivory and one is of rhinoceros horn.

The Yana RHS was occupied during a warm interval near the end of OIS3. Based on evidence from Yana RHS and the Ural Mountains foothills in northeast Siberia it is evident that humans were in far northern Siberia during the latter part of OIS3. Hoffecker and Elias (2003:38–39) asserted that “modern humans were unable to occupy areas of northeast Asia above 60° north before 24,000 cal. BP because of a persistent warm climate adapted body morphology”; however, discovery of the Yana RHS and Mamontovaya Kurya site demonstrated that humans were adapted to areas north of 60°N during OIS3. These discoveries immediately changed the discussion about early peopling of the Americas.

Hoffecker and Elias (2007) suggested that Yana RHS represents a northward movement of hunter-gatherers during the warm months with a retreat to southern Siberia during the cold winter months, and Hoffecker (2009) also suggested the Mamontovaya Kurya site may represent only seasonal occupation of northern Siberia. This hypothesis of seasonal use of northern Siberia suggests a highly mobile adaptation. Graf (2009, 2010) hypothesized a low-mobility residential adaptation by populations in southern Siberia during the Middle Upper Paleolithic, late in OIS3, which seems to contradict the seasonal long-distance movements into northern Siberia. It would be important to determine seasonality of the Yana RHS and Mamontovaya Kurya sites to determine if the occupations occurred only in the summer months.

Climate change associated with the LGM is suggested to have forced Siberian populations southward (Graf 2009), but Kuzmin and Keates (2005); Kuzmin (2008); and Vasil’ev et al. (2002) take the position that humans were able to live in northern parts of Siberia during the cold LGM, which suggests that humans would have been able to live in northern Siberia year-round during the latter part of the relatively warm OIS3.

In the late 1970s, evidence for an OIS3 human population in eastern Beringia at the Old Crow locality in the Yukon (Figure 25.3) was presented (Bonnichsen 1978, 1979; Harington 1975; Irving 1985; Morlan 1978, 1980, 1984, 1986) based on impacted and flaked mammoth limb bone and cutmarks on bison bone. The evidence was most recently summarized by Morlan (2003).

Impact-fractured and flaked proboscidean long bones dating between 40,000 and 25,000 14C yr BP appear to indicate a long human occupation in Beringia. Morlan (2003:127) stated, “These findings support the hypothesis that a new agency and process entered the taphonomic histories of proboscidean bone in the Old Crow Basin around 40,000 yrs ago,” and later, “The arrival of Homo sapiens, practicing processes such as marrow extraction and percussion flaking on proboscidean bones, as well as butchering bison carcasses, could be the new agency in these taphonomic histories”.

Additional evidence of early humans in Beringia from Bluefish Caves (Figure 25.3) is in the form of a flaked mammoth limb-bone segment dated to 23,910–23,200 14C yr BP and a whittled and polished caribou tibia dated to 24,280 14C yr BP found just below a mammoth bone flake (Morlan 2003; Cinq-Mars and Morlan 1999). Other bones from Bluefish Cave dating from 24,000 to 12,000 14C yr BP exhibit cutmarks (Cinq-Mars 1990; Morlan 2003; Cinq-Mars and Morlan

![Figure 25.3 OIS3 and LGM sites in mid-continent North America and the Yukon.](image)
Evidence from Old Crow and Bluefish Cave suggests a human presence in Beringia by 42,000–40,000 \(^{14}\)C yr BP. Morlan (2003) correctly pointed out that critics of the hypothesis that humans were present in Beringia during OIS3 have not disproved the evidence from cutmarks on bison bones or from impacted and flaked proboscidean limb bone. Cutmarks on bone are taphonomic evidence of human agency and can be identified with accuracy (Domínguez-Rodrigo et al. 2009). The Bluefish Cave cutmarks should be reexamined with modern methods.

Taphonomic evidence from the Yukon and Beringia has been critiqued because the bones were found in secondary contexts and because alternative causes, such as ice-flow activity, may have caused the fracture patterns based on an experiment by Thorson and Guthrie (1984). However, the experiment was flawed primarily because large ungulate limb bones, not proboscidean limb bones, were used. The suggestion that natural causes are responsible for the fracture patterns found at Old Crow and Blue Fish sites does not take into consideration the unique thickness and strength of proboscidean limb bone (Morlan 1984). Experimental work replicating Pleistocene percussion technology has demonstrated that breaking fresh elephant limb bone requires the force of multiple hammerstone blows (K. Holen and S. Holen 2010, S. Holen and K. Holen 2006, 2009, 2011; Stanford 1987; Stanford et al. 1981). In addition, these elephant-bone experiments created breakage patterns like these found on mammoth bone from Clovis-age archaeological sites.

Archaeological evidence from northern Siberia and Beringia demonstrates that humans were adapted to the steppe biome and inhabited these regions during OIS3. Ecological evidence shows that neither climate nor environmental barriers blocked the path to the Americas. Once adapted to a steppe biome human migration into the North American mid-continent was possible, but what evidence of early human presence exists there?

### Definitions of human-induced modifications

<table>
<thead>
<tr>
<th>Modification</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impact notches</td>
<td>Semicircular or arcuate indentations on the fracture edge of a long bone produced by percussion.</td>
</tr>
<tr>
<td>Spiral fractures</td>
<td>Tensile failures along a helical path produced by breaking at oblique angles to the longitudinal axis of the bone.</td>
</tr>
<tr>
<td>Bone flakes</td>
<td>Debitage produced by bone percussion that have features characteristic of lithic flakes produced by human agency.</td>
</tr>
<tr>
<td>Flake scars</td>
<td>Patterned indentations on bone surfaces indicating flakes have been removed.</td>
</tr>
<tr>
<td>Patterned distributions of bone</td>
<td>Human-induced arrangements of skeletal elements.</td>
</tr>
<tr>
<td>Preferential breakage</td>
<td>The intentional breaking of thick cortical limb bones while leaving lighter bones unbroken.</td>
</tr>
<tr>
<td>Modified bone tools</td>
<td>Skeletal elements with evidence of modification or use wear.</td>
</tr>
<tr>
<td>Chipped-stone tools</td>
<td>Manufactured lithic artifacts exhibiting multiple flake scars.</td>
</tr>
<tr>
<td>Anvils or hammerstones</td>
<td>Cobbles associated with bone assemblages interpreted as percussors or anvils.</td>
</tr>
<tr>
<td>Lithic flakes</td>
<td>Utilized or waste flakes.</td>
</tr>
</tbody>
</table>

### Evidence for Last Glacial Maximum (LGM) and Middle Wisconsin (OIS3) Humans in the North American Mid-Continent

Evidence of human technology from LGM (20,000–14,000 \(^{14}\)C yr BP) and OIS3 (40,000–20,000 \(^{14}\)C yr BP) North American sites in the Great Plains and Midwest (Figure 25.3) is summarized below and in Tables 25.1 and 25.2. We are not advocating the archaeological legitimacy of all the sites presented. Some sites have more data than others, and some sites are in a preliminary stage of research, for example, the Schulz Mammoth, New Mammoth site and Villa Grove Mammoth site. In the discussion below, we are documenting what others have reported and what we have learned during our field and collections research. In the conclusion of this section, we will offer our thoughts on the status of these sites. We also discuss DNA research that may support the Mammoth Steppe Hypothesis.

### Last Glacial Maximum (LGM) Sites (20,000–14,000 \(^{14}\)C yr BP)

Five of the seven sites discussed below, La Sena, Hamburger, Prettyman, Jensen, and Shaffert are situated in LGM Peorian loess. The radiocarbon ages of these sites (Table 25.1) are consistent within this well-dated geological deposit. La Sena and Hamburger were found deep in cutbanks along a reservoir, and a backhoe was required to remove overburden before excavation. Prettyman was found on a reservoir beach, while Shaffert was discovered in a modern gully cut. The Jensen site was found in the bottom of a borrow pit. Two sites, Cooperton and Lovewell Mammoth II, were excavated from fine-grained alluvium. Low-energy loess and fine-grained alluvial deposits eliminate geological factors in the breakage of thick cortical mammoth limb bones, thus making taphonomic interpretations of bone breakage less complicated. Table 25.1 lists the sites, radiocarbon ages and geological context, and taphonomic indicators of human technology.

#### La Sena Mammoth Site, Nebraska

The La Sena Mammoth site, consisting of the partial skeletal remains of a single adult male mammoth was excavated by the senior author at Medicine Creek Reservoir in southwest Nebraska (Holen 2006; Holen and May 2002; S. Holen and K. Holen 2011). Evidence for human association with the mammoth skeleton is in the form of broad arcuate impact notches on thick cortical bone, both longitudinal and side-struck bone flakes, and preferential breakage of the limb bones. The lightest...
bones, ribs and vertebrae, are either complete or far less fragmented than the thick cortical limb bones that were broken at mid-shaft by an object 5 cm in diameter at the point of impact. Holen (2006) eliminated carnivores and trampling by other large mammals as causes, thus strengthening the argument that human agency was responsible. A radio carbon age on mammoth bone (18,440 ± 90 14C yr BP AA6972) and stratigraphically consistent radio carbon ages on sediments above and below the mammoth horizon indicate the site dates to the LGM.

Hamburger Mammoth, Shaffert Mammoth, Prettyman Mammoth and Jensen Mammoth Sites, Nebraska These four single-adult mammoth sites are situated in south-central Nebraska and were excavated from Peorian loess. Hamburger (Holen and May 2007; S. Holen and K. Holen 2011) and Shaffert (Holen and May 2002; S. Holen and K. Holen 2011) are in the Medicine Creek drainage near the La Sena site. Prettyman is at Harlan County Lake (Holen et al. 1998) and Jensen (S. Holen and K. Holen 2011; May and Holen 2005) is in the Platte River valley. These sites all exhibit preferential breakage of thick limb bones and impact notches on thick limb bones. Evidence of bone flaking is present at the Jensen site (see Table 25.1).

Table 25.1 Evidence for human technology at LGM sites in mid-continent North America (14C 20,000–14,000 yr BP).

<table>
<thead>
<tr>
<th>Site</th>
<th>Date, 14C yr BP</th>
<th>Impact notches</th>
<th>Spiral fracture</th>
<th>Bone flakes, flake scars</th>
<th>Patterned distribution of bones</th>
<th>Preferential breaking</th>
<th>Tools—modified bone</th>
<th>Tools—chipped stone</th>
<th>Anvil, hammerstone</th>
<th>Lithic flakes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hamburger</td>
<td>17,575–20,000</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>La Sena</td>
<td>18,440±90</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
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</tr>
<tr>
<td>Hamburger</td>
<td>16480±60</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shaffert</td>
<td>15,600±60</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
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</tr>
<tr>
<td>Prettyman</td>
<td>17,880±260</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Jensen</td>
<td>14,830±220</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Lovewell II</td>
<td>19,530±80</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td></td>
<td>19,570±60</td>
<td>X</td>
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<td>X</td>
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</tbody>
</table>

Table 25.2 Evidence for human technology at OIS3 sites in mid-continent North America (14C 40,000–20,000 yr BP).

<table>
<thead>
<tr>
<th>Site</th>
<th>Date, 14C yr BP</th>
<th>Date, non-14C method</th>
<th>Impact notches</th>
<th>Spiral fracture</th>
<th>Bone flakes, flake scars</th>
<th>Patterned distribution of bones</th>
<th>Preferential breaking</th>
<th>Tools—modified bone</th>
<th>Tools—chipped stone</th>
<th>Anvil, hammerstone</th>
<th>Lithic flakes</th>
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<tbody>
<tr>
<td>Burnham</td>
<td>36,000–35,000</td>
<td>34,000±1600 (IRSL)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Miami</td>
<td></td>
<td>40,000–35,000 (stratigraphic)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Frye</td>
<td>20,430±300</td>
<td>33,405±340</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Lovewell I</td>
<td>37,567±590</td>
<td>39,350±770</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
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</tr>
<tr>
<td>Villa Grove</td>
<td>33,540±400</td>
<td>33,590±450</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Schultz</td>
<td>33,540±400</td>
<td>33,350±240</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>New Nebraska</td>
<td>33,540±400</td>
<td>33,170±370</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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Cooperton Mammoth Site, Oklahoma The Cooperton Mammoth in southwestern Oklahoma was excavated in 1961 by Adrian Anderson (Anderson 1962, 1975; Northcutt 2007). The single adult mammoth skeleton is situated in fine-grained silt/sand alluvium. Our research indicates that the limb bones were broken at mid-shaft by impacts that formed notches. One flake scar is present. Limb bones were preferentially broken, while the left scapula and right side of the pelvis and many thoracic vertebral spines are intact. One 8.6-
kg granite cobbles with an area of battering on the upper surface (Figure 25.4) is associated with fractured limb-bone segments. Because numerous small bone fragments were found around the large cobble it was interpreted by Anderson as an anvil. Three fist-sized cobbles were also associated with the skeleton, one of which exhibits two flake scars. Anderson (1975) interpreted the cobbles to be hammers and an anvil used to break the fresh limb bone for marrow extraction or bone tool production. That there are no naturally occurring cobbles in the fine-grained alluvium indicates humans must have brought the cobbles to the site location to break mammoth bones. The site was dated to between 20,400 and 17,575 14C yr BP based on three bone-apatite radiocarbon dates (GX1212, 1215, 1216) (Anderson 1975). Radiocarbon ages run on bone apatite are generally unreliable, but they may provide an approximate age of the site.

**Lovewell Mammoth II Site, Kansas**  The Lovewell Mammoth II site was discovered at Lovewell Reservoir in northern Kansas in 1991 when the reservoir level was low. At first, investigators thought this was the same mammoth (Lovewell Mammoth I) that was excavated in 1969. Later excavations indicated that this was a second mammoth located about 80 m from the 1969 excavation. The Lovewell Mammoth II site is situated within a shallow U-shaped swale. Impact notches on the mid-shaft of thick cortical limb bones, numerous bone flakes, a bifacially flaked fist-sized “chopper” (Figure 25.5A), and a small highly polished tip of a bone tool (Figure 25.5B) indicate that humans were involved in breaking some of the bones (Holen 2006, 2007; S. Holen and K. Holen 2011). The two most recent radiocarbon ages from the site, 19,530 ± 80 14C yr BP (UCIAMS-11211) from the bone biface and 19,570 ± 60 14C yr BP (UCIAMS-53543) from the highly polished bone tool, are consistent with the geological context.

**Middle Wisconsin (OIS3) Sites, (40,000–20,000 14C yr BP)** The seven sites described here have all been dated to the latter half of OIS3 by radiocarbon (14C), thermoluminescence (TL) and infra-red stimulated luminescence (IRSL) dating, or
stratigraphic correlation (Table 25.2). The dates used here are somewhat arbitrary because the OIS3 transition to the LGM in the Great Plains and Midwestern United States is usually dated to ca. 20,000 \(^{14}\)C yr BP, while in more northern areas the transition took place earlier, ca. 25,000 \(^{14}\)C yr BP. We use the 20,000 \(^{14}\)C yr BP age because the sites discussed here are in the Midwest or Great Plains. Three of the sites discussed, Schulz, Villa Grove, and New Mammoth, have been tested in the last two years by the authors, and the information presented is preliminary and published for the first time. Four of the seven sites contain stone artifacts.

Two of the sites discussed below, Miami and Frye, were found in OIS3 loess; three other sites, Burnham, Lovewell Mammoth I, and New Mammoth, were excavated from fine-grained alluvial or lacustrine deposits. Loess and fine-grained alluvial/lacustrine deposits represent low-energy deposition that eliminates geological explanations for the associated stone artifacts at three of the sites, Burnham, Miami, and Frye, and for the bone-breakage patterns at the Lovewell Mammoth I and New Mammoth sites. The Schulz Mammoth and Villa Grove Mammoth were excavated from higher-energy geological situations that will be described below.

**Burnham Site, Oklahoma** This site was excavated from the mid-1980s to the early 1990s by Don Wyckoff of the University of Oklahoma and an interdisciplinary team from several institutions (Wyckoff et al. 2003). A bison skull and other bison post-cranial elements were found in OIS3 pond sediments. Associated with the bison bone are two lithic tools, 40 flakes and flake fragments, 11 pieces of shatter, and one chert cobble, all thought to be cultural in origin. One lithic tool is a utilized flake with retouch caused by use; the second is a biface fragment. The lithic cobble with two flake removals was found next to the bison skull and appears to be too large to have been moved by fluvial action. Twelve flakes exhibit a ventral lip platform most commonly characteristic of soft hammer percussion or pressure flaking (Figure 25.6G). One non-local lithic flake was identified as Edwards chert from the central Texas source area, ca. 400 km from the site (Figure 25.6C). Lithic flakes and tools interpreted as cultural were concentrated in eight excavated units with the bison bones. The pond deposits and associated bison bone are radiocarbon dated to ca. 36,000–35,000 \(^{14}\)C yr BP (Wyckoff et al. 2003).

**Miami Mastodon, Missouri** The Miami Mastodon site was excavated by Carl Chapman of the University of Missouri in 1973 in a new road cut about 4 m deep in middle-Wisconsin loess (Chapman 1975; Hamilton 1993; Dunnell and Hamilton 1995; O’Brien et al. 1998). Excavation of the site produced evidence of one mastodon skeleton associated with three or four stone tools and some limestone slabs. One of the stone tools (Figure 25.7) had wear on one surface (Chapman 1975) and was reported to have been found among the long bones according to Hamilton, who also reported a pile of ribs separate from the main concentration of bones (O’Brien et al. 1998). The age of the site is thought to be ca. 41,700–35,000 years old based on radiocarbon and thermoluminescence dating (Dunnell and Hamilton 1995). The most recent dating for the site is the weighted average of eight IRSL ages, 34,000 ± 1600 yr BP (Early et al. 2003). There is no lithic material higher in the landscape that could have been redeposited down slope into the loess. The only logical explanation for lithic tools and limestone slabs associated with the mastodon in loess is that humans were present processing the carcass. Unfortunately the collection was destroyed by a fire at the University of Missouri Archaeological Collections Facility in 1977 and is no longer available for study.
Frye Site, Illinois  The Frye site consists of one percussion flaked lithic artifact found 5.5 m deep in the freshly exposed face of a loess road cut by Leonard Frye, a soil scientist from the Illinois Geological Survey (Munson and Frye 1965). The piece was identified as an artifact by Patrick Munson, an archaeologist at the University of Illinois. The estimated age of the middle Wisconsin Roxanna loess in which the artifact was found is 40,000–35,000 years old based on its position in a well-known regional stratigraphic sequence.

Lovewell Mammoth I Site, Kansas  The Lovewell Mammoth I site was excavated in 1969 by Kansas State Historical Society archaeologists at Lovewell Reservoir (Holen 2006, 2007; S. Holen and K. Holen 2011). Evidence of possible human association reported by the initial excavators included spirally fractured limb bone, stacked bone, and the skull and tusks orientated with the tusks pointing toward the axial skeleton, 180 degrees from the anatomical position. Unfortunately, after a consulting geologist reported that the site was more than 100,000 years old the archaeologists abandoned the excavation and did not collect the skeleton. More recent work at the site indicates that the mammoth is situated in OIS3 alluvium, and a radiocarbon age on a mammoth rib places the site at 20,430 ± 300 14C yr BP (CAMS-112739). By the time the site was rediscovered in 1991 almost all the mammoth bones except one in situ rib had eroded and were scattered by reservoir wave action.

Villa Grove Site, Colorado  The Villa Grove Mammoth site was discovered in an alluvial fan gravel pit in the San Luis Valley in southern Colorado (Holen 2012). Mammoth limb bone was found in a gully fill containing small gravel and sand within an organic-rich channel fill. All the mammoth bone had been moved downstream in the gully fill and therefore was not in primary context. The site was overlain by 12 m of LGM sand and gravel that was removed by gravel mining. Evidence for human association with the mammoth is in the form of flaked mammoth limb bone. Both longitudinal and side-struck flakes are present (Figure 25.8). Limb-bone fragments were broken while still fresh. Downstream deposition in the gully fill apparently is not the cause of the flaked limb bone because lighter bone like ribs and vertebrae were complete or more complete than the limb bones. One radiocarbon date from mammoth molar dentine places the site at 33,405 ± 340 14C yr BP (NZA-51383).

Figure 25.7  Lithic artifact from the Miami mastodon site (after Hamilton 1993).

Figure 25.8  Flakes produced from mammoth limb bone at the Villa Grove mammoth site. A, longitudinal flake; arrows point to flake scars. B, side-struck flake, arrows point to impact notch and bulb of percussion.
Schulz Mammoth Site, South Dakota  The Schulz mammoth site consists of a single adult mammoth that was discovered during a sewer-line excavation in the backyard of a home in western South Dakota in 2012 (Fosha et al. 2012). The mammoth skeletal material is situated in an alluvial fan deposit that alternates between high-energy flood deposits and fine-grained alluvial deposition. Some faunal elements and the associated lithic flake are in primary context in fine-grained alluvium, and other elements are in coarser deposits that have been moved a short distance in a flood. Preliminary evidence for a human presence at the site comes from the discovery one high-quality tertiary chert flake associated with the mammoth (Figure 25.9). There are a few fragments of spirally fractured limb bone; the bone, however, is in poor condition. Two radiocarbon ages of 37,567 ± 591 14C yr BP (NZA 51828) and 39,350 ± 770 14C yr BP (Aeon 1351) were obtained from mammoth molar dentine. Additional test excavations in 2013 were unable to confirm the archaeological nature of this site, and we now think the associated flake is probably a geofact.

New Nebraska Mammoth Site  The New Nebraska mammoth site is situated on a reservoir beach below a 10-m cutbank of OIS3 alluvial fan and LGM loess (Holen 2012). Evidence for a human presence at the site consists of mammoth (Figure 25.10) and bison limb bone with impact notches on the mid-shaft. A distal bison humerus exhibiting a marrow-extraction impact notch was still articulated with a spirally fractured proximal radio-ulna when excavated from in situ deposits. Before the site was dated, an expert on bison butchering identified this articulation as a bison-bone butchering unit produced by humans. A large mid-section of spirally fractured mammoth femur with a broad arcuate impact notch from the surface of the site is also suggestive of human association.

Radiocarbon ages from different laboratories on the impact-fractured butchered bison bone, 33,590 ± 450 14C yr BP (NZA-22968) and 33,220 ± 420 14C yr BP (UCIAMS-61658), and a radiocarbon age from the impact-fractured mammoth femur, 33,170 ± 370 14C yr BP (UCIAMS-61663), are consistent with another date on excavated unmodified horse bone of 33,540 ± 400 14C yr BP (NZA-36316). Radiocarbon ages fit the well-known geological sequence in the western central Great Plains. Preliminary test excavations indicate several buried soils in the alluvial fan that contain fractured bone.

DNA Research  A detailed overview of DNA evidence related to human dispersal into the Americas is beyond the scope of this chapter; recent studies, however, have shown to be promising, albeit controversial, adjuncts to archaeological data. Tamm et al. (2007) describe the Beringian Standstill hypothesis, which suggests that humans entered Beringia about 30,000 years ago and in that location their founder lineages differentiated from their Asian relatives. These populations moved south into the Americas about 15,000 years later. A study by O’Rourke and Raff (2010) postulates a migration along
the north coast of Beringia before the LGM, and then movement down the east coast of North America. They offer the alternative early-migration route as a hypothesis subject to rigorous testing by geneticists and archaeologists working in tandem. However, Dulik et al. (2012) and Regueiro et al. (2013) suggest the migration into North America may have taken place after 15,000 years ago. DNA research cannot at present provide a conclusive date of the initial human entry into the Americas.

Discussion

Of the seven LGM sites, the site with the best evidence for human association is the Cooperton mammoth, where stone tools consisting of a large cobbles and several smaller cobbles were found associated with impact-fractured mammoth limb bone. Small bone fragments situated around the large cobbles and battering on the upper surface of the cobbles indicate that geological processes can be eliminated as the cause of the site. The mammoth and associated cobbles were excavated from a primary context in fine-grained alluvium. There are no cobbles found naturally in this matrix, which indicates the cobble is a manuports used to break the mammoth limb bone.

The other six LGM sites consist of single-mammoth death sites, five situated in loess and one in fine-grained alluvium. These sites all exhibit breakage of mammoth limb bone while it was still fresh, with impact notches on thick cortical limb bone. Geological context in low-energy deposits indicates that geological processes can be eliminated as the cause of the site. The mammoth and associated cobbles were excavated from a primary context in fine-grained alluvium. The only logical explanation for stone tools and limestone blocks to be associated with the carcass is that humans were processing the carcass at ca. 34,000 years ago.

Further evidence of OIS3 humans in the American mid-continent comes from fractured mammoth bone at the Villa Grove mammoth site, where both longitudinal and side-struck bone flakes produced on mammoth limb bone are present, while lighter bones like ribs and vertebrae are unbroken or broken to a lesser degree. Impact fractures on both mammoth and bison limb bone are present at the New Nebraska mammoth site. Both these sites are ca. 33,000 14C yr BP.

Impact notches and bone flaking at several of the sites discussed here duplicate the mammoth-bone technology at a Clovis site, Lange/Ferguson (Hannus 1989, 1990). The Lange/Ferguson site dates to ca. 11,000 14C yr BP and is associated with bone and stone tools, including Clovis fluted projectile points. The Clovis-age Owl Cave site (Miller 1989) has evidence of human association including impacted and flaked mammoth limb bones and associated fluted points that are more similar to Folsom points than Clovis points.

Mammoth limb-bone-reduction technology is also present in Upper Paleolithic sites in Siberia and central Europe (Goebel 1999; Morlan 2003) and represents a standard part of the preliminary reduction sequence used to produce highly patterned bone and ivory tools like foreshafts, projectile points, and shaft wrenches. These tool types are shared by Upper Paleolithic cultures and the Clovis culture at the terminal Pleistocene in North America. The presence of mammoth ivory and rhinoceros horn foreshafts at Yana RHS in Siberia places this technology far north on the Mammoth Steppe at 27,000 14C yr BP (30,000 cal yr BP) (Pitulko et al. 2004).

The tip of a bone tool, dated to 19,570 ± 60 14C yr BP, discovered at the Lovewell II mammoth site suggests that this technology was present during the LGM on the central Great Plains of North America. The artifact may be the tip of a projectile point, with the distal end broken by impact or leverage; then the broken surface was highly polished. One lateral segment of a mammoth limb-bone diaphysis dated 19,530 ± 80 14C yr BP exhibits flakes that were removed from both faces producing a biface with a sinuous edge. This artifact appears to be an expedient tool.

It is also significant that the proboscidean sites discussed here represent single-carcass assemblages. Haynes’s (1991) overview of actualistic studies of elephant death sites in Africa does not record any location where fresh elephant limb bones are broken into small pieces while lighter bones like ribs are more intact, that is, evidence for the preferential
breakage patterns noted at the sites reported here. Indeed his research reports exactly the opposite. At single-elephant death sites, limb bones are rarely broken (Haynes 1988).

A recent experimental study of a small sample of elephant limb bones (Krasinski 2010) demonstrated that trampling did not result in impact notches like those noted at the sites discussed here. Although more actualistic and experimental research is needed to support this finding, trampling is not the likely cause of the breakage patterns and notches found at the single-proboscidean death sites we have discussed.

Proboscidean limb bones exceed the effective gape of even the largest bone-crunching carnivore jaws (Stuart and Larkin 2010), and the pattern of carnivore modification differs from that of human modification (Egeland 2007; Haynes 1984; K. Holen 2011; Morlan 1984; Egeland and Domínguez-Rodrigo 2008; K. Holen and S. Holen 2012; Marean and Bertino 1994; Pickering and Egeland 2006; Galan et al. 2009; Pickering et al. 2005). Carnivores attack proboscidean limb bones at the articular ends, while humans break them at mid-shaft with hammerstones.

Holen (2006) eliminated carnivores and trampling by other mammoths as causes of the observed limb-bone breakage at La Sena and Lovewell. Human technology utilized during the Clovis techno-complex, for example, at the Lange/Ferguson mammoth site, and at Upper Paleolithic sites in Europe and Asia (Morlan 2003) exhibit the same type of mammoth limb-bone reduction by impact and flaking. The purpose of this limb-bone reduction was, in some cases, to produce expedient butchering tools. Marrow extraction and bone-core manufacture for the later production of the well-known suite of highly stylized shaft wrenches, bone rods, and other patterned tools was also practiced. Thus the system of mammoth limb-bone reduction in all sites discussed here fits well within a broad pattern of late Paleolithic tool production in both Eurasia and North America.

Conclusion
Humans became adapted to the Mammoth Steppe in western Siberia around 40,000 cal BP, and the Mammoth Steppe Hypothesis proposes that these populations spread rapidly across Beringia and into the American Steppe of mid-continental North America. The timing of this adaptation to the Mammoth Steppe would have allowed several thousand years for humans to move into the American mid-continent before the route was blocked by ice. Archaeological evidence indicates that Upper Paleolithic populations had reached northwestern Siberia by at least 40,000 cal. yr BP and that they were in western Beringia by 30,000 cal. yr BP. These groups were well adapted to the OIS3 Mammoth Steppe that extended from central Europe to Beringia. Development of new technologies like bone needles that allowed production of sewn clothing, efficient shelters, use of bone as fuel, specialized bifacial and unifacial lithic technology, and a utilitarian bone and ivory technology allowed humans to survive and flourish in this vast treeless steppe. A relatively mild climate during the OIS3 and productive steppe biome supported a diverse faunal community. This faunal community formed the primary nutritional resource for humans living on the Mammoth Steppe.

Evidence from mid-continental North American LGM and OIS3 archaeological sites reviewed here suggests that Upper Paleolithic groups were in North America. These populations arrived before the route from Beringia was blocked by ice, arriving in North America during OIS3 prior to 22,000 $^{14}$C yr BP (Holen 2006, 2007; S. Holen and K. Holen 2011) and bringing with them adaptive and technological skills suited to the steppe environment. Five of the archaeological sites in the North American mid-continent described here contain stone artifacts, and other sites exhibit evidence of large prey-animal bones being processed by humans utilizing percussion technology.

Numerous similarities between Upper Paleolithic technology and Clovis technology have been documented (C. V. Haynes 1987). Both Clovis and Upper Paleolithic technology included bifacial projectile points, bone and ivory projectile points and foreshafts, and other specialized lithic and bone/ivory tools. Goebel et al. (2003) conclude it is possible that the Clovis technological complex developed in North America from a population that migrated from Siberia before the LGM more than 24,000 cal yr BP. Clovis culture probably developed from these Paleolithic people in the southern United States and/or Mexico and spread rapidly northward into Canada as the ice sheets retreated. When these groups reached Beringia they came into contact with populations from which they had been separated by a thousand kilometers of ice for more than 10,000 years.

Evidence presented in this study demonstrates that humans were adapted to the Mammoth Steppe during the latter part of OIS3. Archaeological evidence from LGM and OIS3 sites in the North American mid-continent presented here indicates that the Mammoth Steppe Hypothesis is supported. Therefore we acknowledge an American Paleolithic as defined by Yellowhorn (2003) and others who have used this term in the past.

This contribution does not pretend to document the only adaptation that led early humans to enter the Americas; indeed we acknowledge a probable migration along the west coast of North America (Dixon 2001; Erlandson 2004; Fladmark 1978, 1979; Gruhn 1994) that may have been quite early based on evidence from the 33,000 $^{14}$C yr BP component at Monte Verde (Dillehay and Collins 1988). Trans-Atlantic migration by Solutrean people from Europe during the LGM (Stanford and Bradley 2012) is also a possibility. We do not claim to have documented the earliest evidence of humans in the Americas; there could have been earlier migrations, some of which may have failed (Meltzer 1989).

Archaeologists do not know when humans first entered the Americas; that remains an open question. Only by conducting research with open minds and systematically investigating older geological deposits will the question be answered.

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