# MAMMOTH TRUMPET

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# The Clovis/Folsom Transition: New Evidence from Jake Bluff

ALTHOUGH WE'VE BEEN STUDYING the lingering traces of the First Americans for nearly a century now, we still don't entirely understand their lifeways, who they were, or how their cultures evolved over time. Oh, it's easy to look at the mass of data and make certain assumptions, based on the preponderance of evidence. But no matter how logical these conjectures may seem, we can't stamp them with the imprimatur of Truth until we've connected all the dots and polished away the rough edges through debate and testing—insofar as any scientist will allow that Truth with a capital T is even possible.

Refining the data to this level of confidence can be extraordinarily difficult. But thanks to almost two decades of work at Jake Bluff (34HP60), a bison kill site located on the Beaver River in northwestern Oklahoma, several of our most cherished assumptions about the First Americans may be on the verge of becoming Truth—while another may be on its way to the scrap heap, once and for all.

## A momentous discovery

Jake Bluff is that rarity of rarities, an intact Paleoamerican site with both Clovis and Folsom components (**MT 21-2**, "Probing the Past: Leland Bement and the Paleoindians of Oklahoma"). Painstaking excavations and paleoenvironmental reconstructions by the research teams of Leland C. Bement


The West Arroyo processing pile, exposed in 2001.

ALL ILLUSTRATIONS AND PHOTOS: LELAND C. BEMENT

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of the Oklahoma Archaeological Survey and Brian J. Carter of Oklahoma State University have demonstrated that the two cultural horizons at Jake Bluff are distinct, diagnostic, and well preserved—and that the Clovis occupants definitely killed and slaughtered a bison herd there, using a method eerily similar to that used by later Folsom hunters.

The researchers initially discovered Jake Bluff while working at an extraordinary locality close by: Cooper (34HP45), the site of three distinct Folsom bison kills. During the second field season at Cooper in 1994, Bement directed a pedestrian survey of the nearby floodplain margin. Just 400 m west of Cooper, the crew found ancient bison bone eroding out of a bluff on the toe-slope of a low hill. The locality was small but intriguing, so they kept an eye on it. Four years later, they excavated a 1.5-by-0.5-m unit there and found more bones lying on a bedrock bench, embedded in a loamy red matrix similar to the bone-bearing stratum at Cooper. Associated with the bone was a single chert flake. Coring nearby revealed a stratigraphic profile at least 3 m deep, yielding more bone in the process, so they officially recorded the site and monitored it thereafter. Eventually, two more flakes and a flake knife came to light, confirming human association with the bison remains.

**Carter recording the stratigraphy at Jake Bluff, 2004.**

Systematic investigations began in 2001 and continued through 2007, supported by grants from the National Geographic Society, the University of Oklahoma, the Oklahoma Department of Wildlife Conservation, and private donations, particularly from Courson Oil and Gas. In addition, notes Dr. Bement, "Several OU field schools, Oklahoma Anthropological Society Spring Digs, and the work of volunteers made these investigations important as teaching as well as learning endeavors."

The excavations revealed a locale where hunters herded bison into a narrow arroyo, killed them, and butchered them in place. The paleo-arroyo is V-shaped in cross section and at least 20 m long. It was eroded by natural processes about 1½ m below the sandstone bedrock

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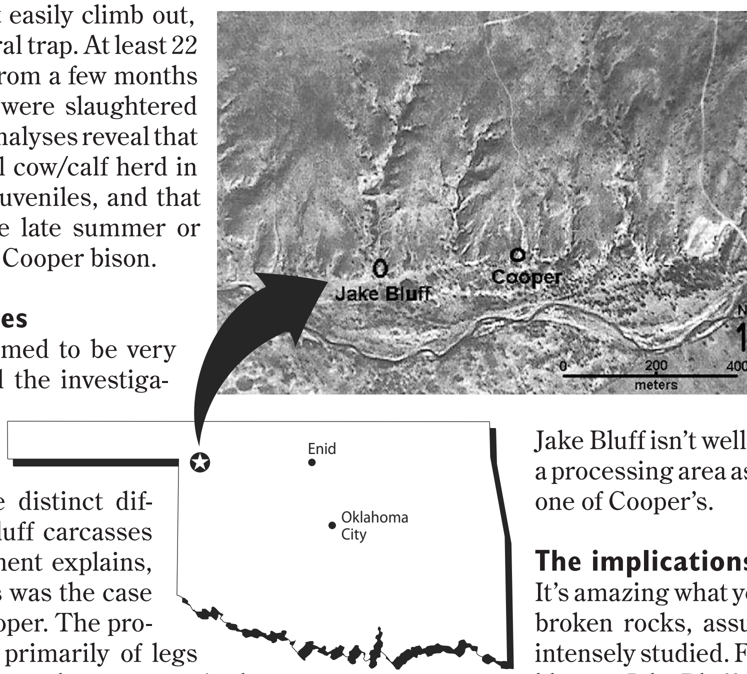
*–Michael R. Waters, Director*

at its deepest point, and measured no more than 2 m wide at the base—snug, easy to cordon off, and just deep enough that a large animal couldn't easily climb out, making it an ideal natural trap. At least 22 bison, ranging in age from a few months to about 10 years old, were slaughtered there. Bone and tooth analyses reveal that they comprised a small cow/calf herd in the company of a few juveniles, and that they were killed in the late summer or early fall—just like the Cooper bison.




## Unexpected surprises

At first, Jake Bluff seemed to be very much like Cooper, and the investigators proceeded on the assumption that it too was a Folsom site. But they soon noted some distinct differences. "The Jake Bluff carcasses were dismantled," Bement explains, "rather than filleted, as was the case in the three kills at Cooper. The processing pile consisted primarily of legs that had been severed from the carcasses in the arroyo . . . [then] handed to someone on the west gully edge for further meat stripping." The hunters did process some of the meat in the arroyo bottom, and to a lesser extent on the eastern bench of the gully. Interestingly, the bone bed also contained bear remains, specifically, a rib and scapula from a black bear, *Ursus americanus*. Although there are no obvious cutmarks on the ursine bones, they were scattered among the bison remains, strongly suggesting that the bison hunters also killed and butchered the bear. The clincher came when one of the Clovis points eventually recovered from the bone bed tested positive for bear proteins.

The first Jake Bluff Clovis point was discovered in 2002. The Clovis assemblage itself came as a complete surprise: Here was a bison kill of a type credited to Folsom, yet the lithic artifacts (4 Clovis points, a drill, 23 flakes, a flake knife, 12 possible hammerstones, and one possible anvil stone) proved that a Clovis group had slaughtered these animals. This changed the whole complexion of the site, and altered our assumptions about local Paleoamerican sites in general. At the very least, as Dr. Carter puts it, "If you find a bison kill site, you can no longer assume a purely Folsom occupation."

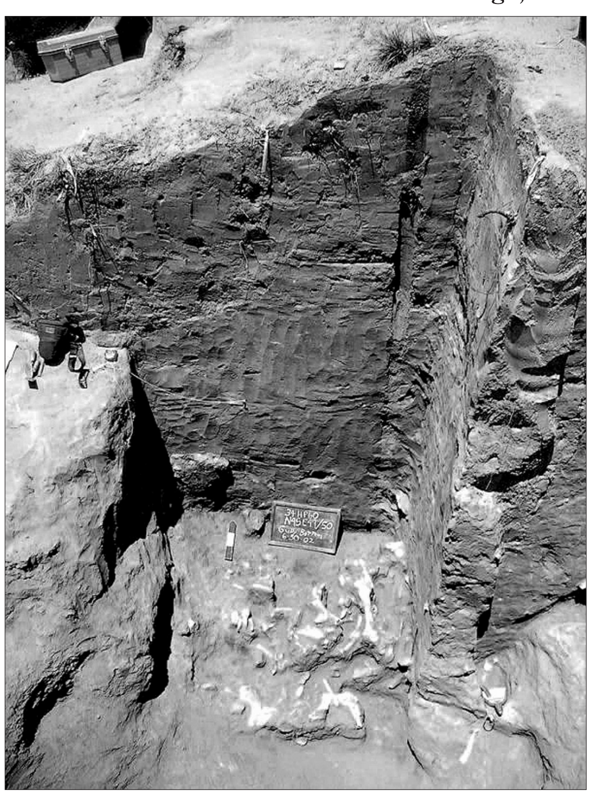
And then there's the Folsom component. A distinct stratum above the Clovis deposit yielded a Folsom point, a flake, a hammerstone spall, and a number of caliche pebbles, all mixed with what Carter calls a "debris lag" of bison bone fragments. There's no Folsom bone bed as such, nor any discernible features. Because of the dearth of artifacts and poorer preservation than the Clovis occupation enjoyed, the nature of the Folsom occupation at Jake Bluff isn't well understood, though it may represent a processing area associated with a nearby kill—perhaps one of Cooper's.

## The implications

It's amazing what you can conclude from a few bones and broken rocks, assuming they're well documented and intensely studied. For example, most of the Clovis assemblage at Jake Bluff was made of Alibates dolomite, which comes from a quarry 200 km away in Texas. This suggests two things. First, that the people who hunted here were culturally aligned with Clovis people elsewhere in the Texas panhandle, the Oklahoma panhandle, and southwestern Kansas who used the same lithic material. Second, that they probably had a very wide range, since they no doubt acquired the material at the source. Combined with the season of the kill, these factors provide, as Bement and Carter pointed out in a 2010 *American Antiquity* article, "both a bearing and season of movement for this Clovis hunting group."

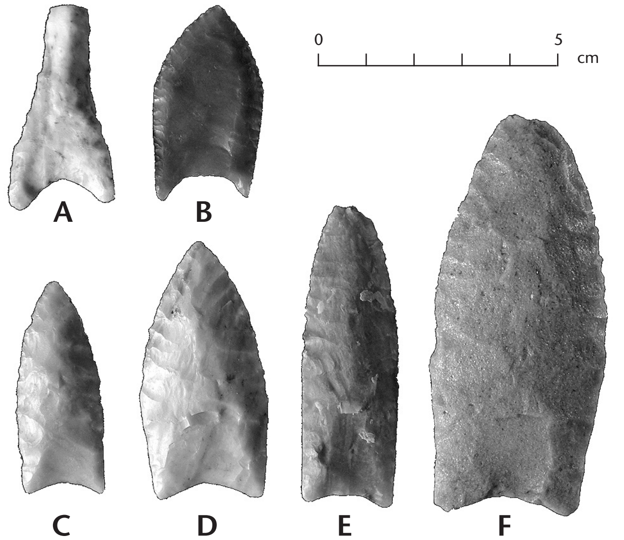
Indeed, the single season of kill observed at both Jake Bluff and Cooper is key, Bement argues, to understanding the development of the local arroyo-trap bison hunting technique. "All arroyo-trap kills in this area occurred during the late summer/early fall season," he points out. "Either the bison were migrating through at this time, or people were scheduling aggregations for this season—or both. The three kills at Cooper and the kill at Jake Bluff are of cow/calf herds. It's also important that there were arroyos open that were useful for this technique. All these attributes contribute to defining an arroyo-trap bison kill complex."

Furthermore, this discovery helps clarify our understanding of Clovis subsistence strategies in at least two ways. Given the



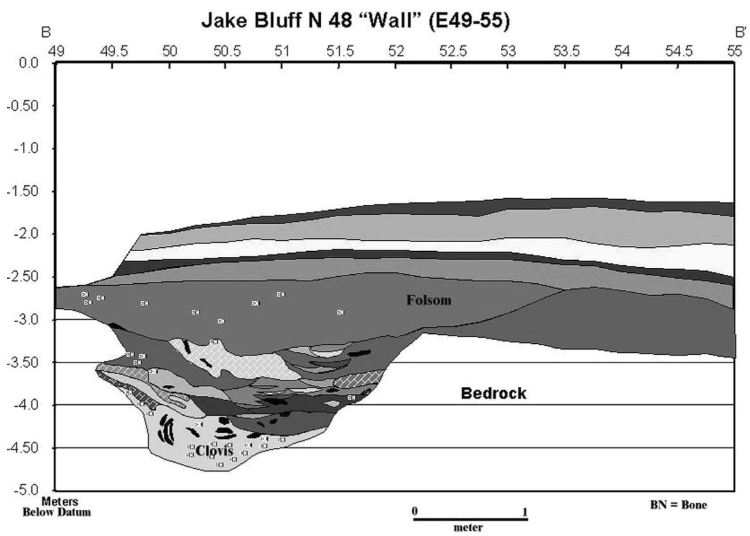
**North wall profile at Jake Bluff, showing the core hole in the arroyo-bottom bone bed, 2002.**

highly visible mammoth kills they left behind, most researchers assumed for decades that mammoths were, in fact, the primary focus of Clovis subsistence. But that model has taken a beating over the past 25 years, as contrary evidence from sites like Gault, Aubrey, and Murray Springs has steadily mounted. The consensus is gradually tipping toward a more varied diet for Clovis, with mammoth kills simply representing the most obvious traces of their presence. Jake Bluff helps tilt the balance. In addition, even if the Clovis people *were* mammoth-hunting specialists at first, logic dictates that other game must have become their primary prey as the proboscideans died off at the end of the Pleistocene. Jake Bluff adds another brick to this evidential edifice as well.




**The complete projectile point assemblage from Jake Bluff. A, Clovis point reworked into a drill; B, Folsom point; C–F, Clovis points.**

And then there's the age and character of the Clovis occupation at Jake Bluff. Most researchers assume Clovis evolved into Folsom, at least on the Plains, though there's never been any incontrovertible proof of the link. But the local Folsom occupation isn't much younger than the Clovis remains at Jake Bluff, and again, the hunting technique the Clovis occupants used is quite characteristic of Folsom. While this doesn't clinch the Clovis-into-Folsom argument, the evidence is suggestive—and no other site comes closer to providing the requisite "smoking gun."




**Stratigraphy of the Jake Bluff site, showing Clovis and Folsom occupations.**

The four accepted radiocarbon dates from the Clovis bone bed at Jake Bluff yield an average calibrated age of 12,838 CALYBP, dating the kill comfortably after the latest known Clovis mammoth kill, the Domebo site in Oklahoma (12,873–12,917 CALYBP)—and near the youngest limit of the recently recalculated age range for Clovis (**MT 22-3, 4**, "Clovis Dethroned: a New Perspective on the First Americans"). So far, this is the earliest known example of an arroyo-trap bison kill. Evidently, the Jake Bluff Clovis group was pioneering a new hunting method; and it's interesting that the toolkit they used to kill and process the bison is functionally identical to toolkits used at Domebo and other Clovis mammoth kills. Could it be that they hadn't yet adjusted their lithic technology to smaller game? Might the subsequent toolkit employed by the local Folsom hunters (who also utilized the arroyo-trap technique, repeatedly and with great success) *represent* that adaptation?


**A Jake Bluff Clovis point, in situ.**

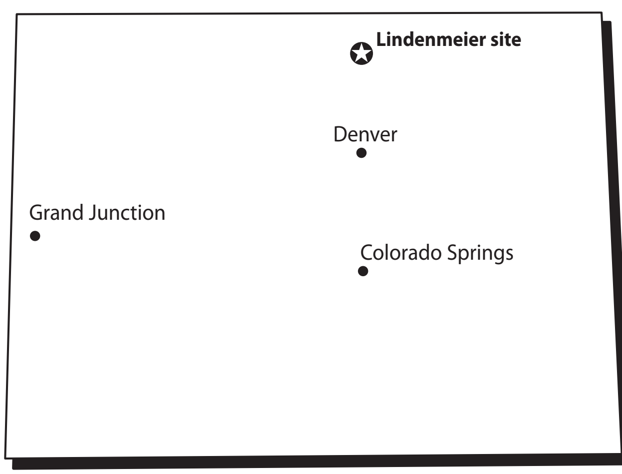
It's impossible to say with certainty that the Jake Bluff findings demonstrate cultural continuity between Clovis and Folsom; the similarities may simply arise from rational use of the same landscape by two different peoples. "I believe the arroyo bison trap technique is a logical and, given modern bison behavior, an obvious development," says Bement. "Arroyo traps, dune traps, jumps, etc., are found wherever bison and the appropriate landforms are found, regardless of age."

Still, it's tempting to think the two occupations are connected. While Jake Bluff's Folsom material remains undated, the dates for the oldest kill at Cooper suggest a Folsom presence in the immediate area as early as 12,758 CALYBP—just 28 calibrated years after the oldest possible Clovis occupation at Jake Bluff (12,786 CALYBP). On the other hand, the gap between the *median* ages for the two components is 242 calibrated years, so Bement believes a separation of about 200 years is more likely. This leaves ample

*continued on page 15*


**CSU Field School at the Lindenmeier site, summer 2011. Folsom paleosols are exposed in the arroyo system in midground, and Folsom Hill is visible in left background.**

CHALLENGES EXCITE archaeology professor Jason LaBelle of Colorado State University. Armed with a small mountain of data, he has launched a wide-ranging archaeological survey to develop a new "regional Paleoindian understanding of northern Colorado/southern Wyoming." Much of Dr. LaBelle's information was gleaned from the famed Lindenmeier site, where, in the summer of 2006, he and a team of graduate students began a walking survey of Lindenmeier and surrounding land. Their mission was to locate other possible Folsom sites in the area along with sources for the raw materials used by ancient inhabitants. "We revisit Lindenmeier and resurvey portions of the site once or twice a year," LaBelle says. "Surface collection is important since artifacts appear regularly due to erosion, and we've recently built a 'Hot Spot' map to indicate surfaces that are actively eroding." Since that initial 2006 work, CSU has now recorded nearly 300 newly discovered archaeological sites in the vicinity of Lindenmeier.




### Where Folsom studies began

Among archaeologists, Lindenmeier is the standard of reference for studies of the Folsom culture. Today public access is limited to designated areas of the site, but scientists now have ample opportunity to explore further into the Folsom culture. It was more than 70 years ago that the Smithsonian Institution and the Colorado Museum of Natural History (now Denver Museum of Nature & Science) (**MT 21-1,** "The Denver Museum of Nature & Science: A History of Early-Paleoindian Research") launched aggressive excavations. Teams of horses pulling slip scoops removed overburden and exposed the Folsom floor, which yielded many distinctive fluted points in association with remains of *Bison antiquus*, an extinct species of long-horned bison (**MT 26-3,** "Pre-Clovis Butchers of *Bison antiquus*"). One exceptional specimen, a bison vertebra with a Folsom point embedded in its neural canal, is indisputable proof of the association of Folsom hunters with this giant species. In 1936, exact specimen locations were recorded for the first time. Smithsonian archaeologist Frank H. H. Roberts kept meticulous records even by today's standards, listing artifacts and associated floral and faunal materials, keeping field notebooks and catalogs, and drawing stratigraphic profiles, distribution plots, and specimens.

The Smithsonian team learned that the Lindenmeier Valley supported a different plant community 11,000 years ago, and that pine and spruce trees grew much closer to the site in the terminal Pleistocene than they do today. Moreover, Roberts's photographs have proved invaluable in gauging how the topography has changed since the 1930s.

Lindenmeier was a self-sufficient occupation, a unique member of a suite of functionally related, interdependent locations. From Roberts's documentation of the area in 1935, LaBelle knew that other Folsom sites were likely scattered about nearby. Roberts's records also note a mammoth tusk discovered a mere 1.2 km from Lindenmeier as well as evidence of more-recent occupations above the Folsom level.

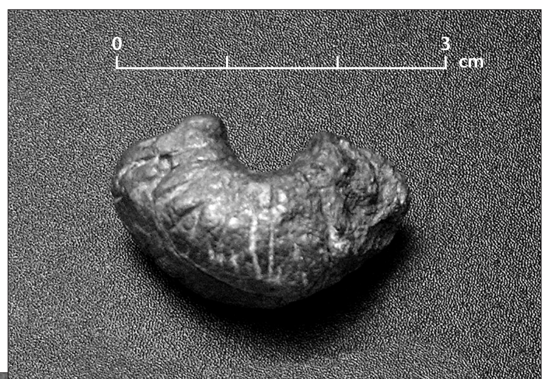
## A large-scale survey

Now a National Historic Landmark, the Lindenmeier Valley lies on land recently protected under the Laramie Foothills Mountains to Plains Project, which encompasses 29 square miles of prairie and foothills in northern Colorado, protecting an area much larger than the original half square mile for investigation by archaeologists. The city of Ft. Collins, Larimer County, and the Nature Conservancy and other groups joined in partnership with private landowners to ensure preservation of this archaeological gold mine, which LaBelle has christened "the New York City of Folsom sites." In 2009, the city of Ft. Collins opened to the public the Soapstone Prairie Natural Area, which contains the Lindenmeier site. "Part of the reason we work at Lindenmeier," LaBelle says, "has to do with the management and education aspects. Although there are no active trails that lead hikers to areas of artifact erosion, I've given many public tours of the site. One of our main purposes there is public education and stewardship."

**LaBelle and CSU students Travis Hill, Lauren Denton, and Greg Sustad at the Lindenmeier public interpretation pavilion.**

JASON LABELLE, 2010

The Folsom complex spans a period of 800 radiocarbon years, mute testimony to the enduring success of the Folsom culture. Interestingly, Folsom people weren't the only ones who used the site. Nearly every area of excavation yielded evidence of short-term late-Paleoindian occupations. Alberta, Eden, and Scottsbluff points were discovered along with Archaic-era hearths. A Goshen point found at Lindenmeier opens the intriguing possibility of an occupation even earlier than Folsom.




**Ocher bead and stone drill from Pit 13, Colorado Museum of Natural History Excavations, Lindenmeier Site, 2007.**

JASON LABELLE, DENVER MUSEUM OF NATURE & SCIENCE COLLECTIONS

LaBelle used the information from his survey to create 3-dimensional computer-generated maps of the newly discovered sites alongside the original excavations. The rich assemblage of artifacts found in the larger area supports his long-held belief that humans have inhabited the Laramie Foothills for over 13,000 years. Its average date of 10,660 ± 60 RCYBP puts Lindenmeier high on the list of the oldest well-documented sites in the Western Hemisphere.

LaBelle's work pinpointed many other nearby areas with multicomponent lithic scatters, some of them located far enough from the main site to put them outside the typical daily foraging range of inhabitants. Other large Folsom sites in Larimer County make it likely that Lindenmeier was repeatedly used as a base camp. The layout of other camp and kill sites shows what archaeologists might expect to find if Folsom groups used Lindenmeier as a central base camp from which task groups spread across the area.

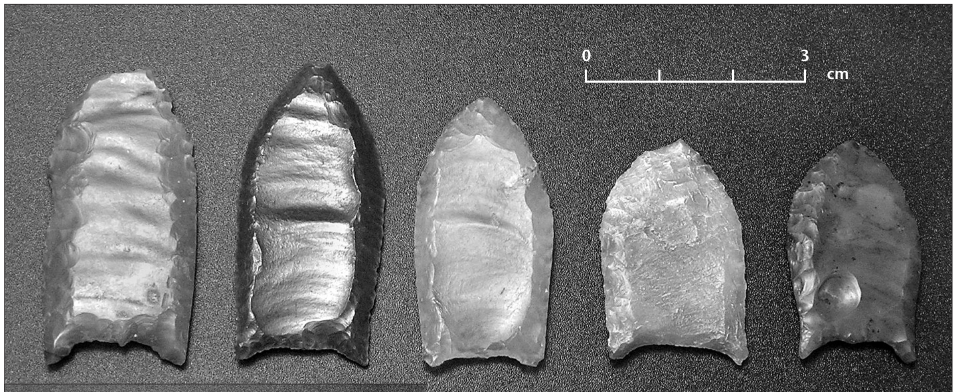
## Reassessing Folsom mobility

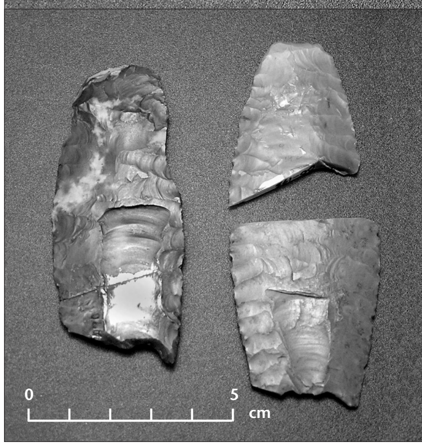
LaBelle's analysis on a macro-regional scale of data collected from 619 Folsom sites suggests that Folsom groups weren't constantly moving across vast territories as previously thought. Instead, LaBelle believes groups either occupied or frequently revisited locations—he calls them "hubs"—selected for ready access to such resources as lithic raw materials, water, small game, and edible plants. Small task groups likely forayed some distance to hunt bison, camping at the kill site and returning to the hub when butchering was completed.

LaBelle wants to see archaeology break free of the earlier assumption that Folsom groups were highly mobile by using *all* available data to construct models of subsistence and land use during the late Pleistocene. In earlier studies, almost half the diagnostic artifacts analyzed came from only 3% of Folsom sites—all of them large, well-excavated and -reported sites. Often ignored were artifacts from the other 97% of Folsom occupations, thereby giving an incomplete and possibly misleading picture of Folsom behavior. In place of this limited approach, LaBelle and his team use an analytical method with three different scales, or fields of view:

- **Site** Detailed analysis of assemblages from 27 well-published Folsom sites.
- **Foraging radius** Surveying the resources within the area surrounding Folsom sites exploited by hunter-gatherers.
- **Macro-regional** Studying 619 sites in 5 states to investigate large-scale Folsom land use.

This incremental method has the virtue of being sensitive to differing spatial components in the archaeological record. Artifacts within a site are related, sites are related to each other within a landscape, and landscapes are related to each other within regions. Patterns found in the data for each of these three scales help LaBelle draw inferences about Folsom mobility.




BOTH: JASON LABELLE

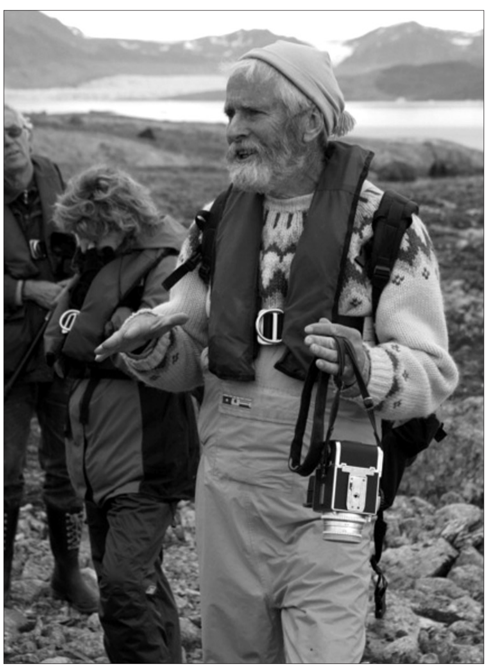
**Folsom points (*above*) and preforms (*left*) from Colorado Museum of Natural History Pit 13 Excavation, Lindenmeier site. Collections housed at the Denver Museum of Nature & Science.**

## Hunter-gatherer adaptations

At the end of the Younger Dryas, a late-Pleistocene cooling event, LaBelle believes conditions in northern Colorado changed quickly. Temperatures rose, tree lines moved uphill, and modern climatic conditions took hold. Human groups adapted by subtly changing their subsistence and settlement patterns, and the populations of Paleoindian communities increased in size. "Daughter" groups split off and expanded into new areas, perhaps forming new cultural identities over time.

The earliest cultural groups of northern Colorado left distinctive footprints, which help archaeologists determine the effects of climate change. Although little evidence has been found to chronicle the lives of pre-Clovis people, we know that Clovis sites consistently reflect a pattern of short-term, low-intensity habitation and minimal investment in modifying the site. The Folsom record, illustrated by the long-term, high-intensity occupation of Lindenmeier, is quite different.

An interesting land-use practice common to the largest Folsom occupations and exemplified by Lindenmeier was situating campsites with "viewsheds." This served two purposes: Inhabitants could spy game at great distances; and foraging groups returning from the hunt could see their destination from far away. Smoke trailing into the sky from its elevated location advertised the presence of Lindenmeier. "It is no coincidence that Lindenmeier is located halfway between the northern and southern limits of Folsom habitation as well as halfway between the eastern and western boundaries," LaBelle says. "Being the center of the Folsom world, sites like Lindenmeier could have served as lighthouses, places to facilitate interaction and communications over vast empty territories."



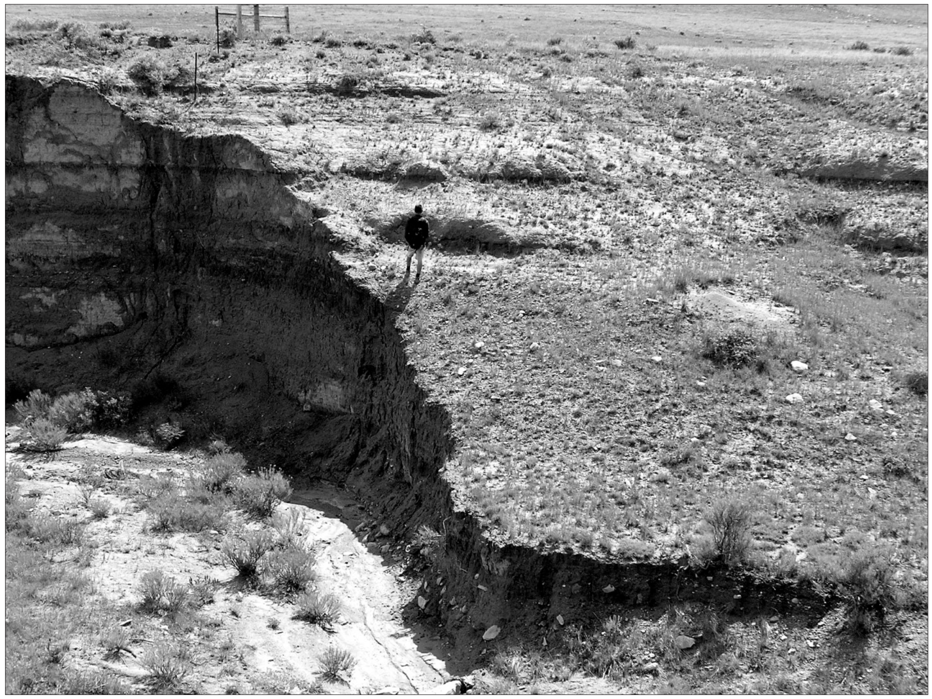
AUDREY BENEDICT

**Dr. James (Jim) Benedict, 1938–2011. Photo taken in late 2000s.**

## Abundant evidence of change

The archaeology of the Central Plains and Rocky Mountains is replete with evidence of changes in Paleoindian subsistence and behavior during the late Pleistocene made necessary by dramatic climate change. During the Younger Dryas, Folsom groups appear to have settled in. They engaged in mapping the natural and cultural landscape and gradually acquired a sense of place. It was a period of increasing cultural complexity. Some groups even seem to have used seasonal residences.

A few of the Folsom sites in Colorado and Wyoming contain traces of Folsom houses, the beginnings of formal physical



Students surveying buried paleosols downstream from the Lindenmeier site, 2009.

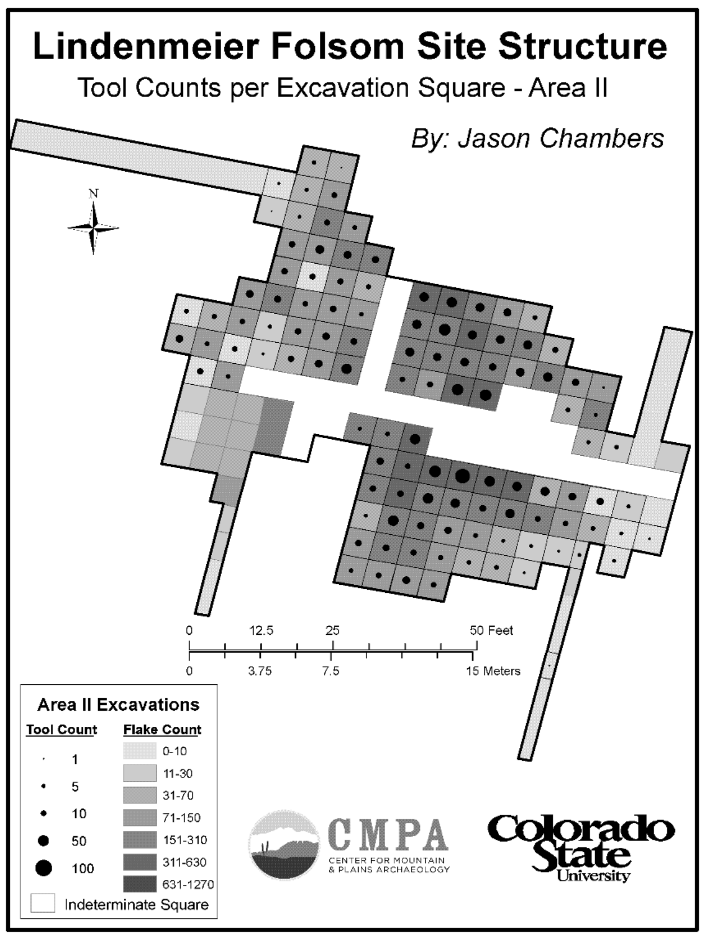
JASON LABELLE

architecture (**MT 21-3,** “Folsom on a Mountain Top”). Concentrations of burnt daub show the impressions of poles used to support a roof, which may indicate an adaptation to the colder climate of the Younger Dryas. Although Lindenmeier has yet to yield evidence of Paleoindian structures, the presence of decorative bone and beads in various states of manufacture suggests these nonessential activities most likely occurred during winter, when Folsom inhabitants sought shelter from the cold and had time to engage in activities other than food gathering. “The sheer magnitude of the site and the amount of debris there suggest a cold-weather site,” LaBelle says, “and an accumulation of hundreds upon hundreds of endscrapers points to major clothing manufacturing, normally a cold season occupation.”

Upon close examination, some artifacts discovered at Lindenmeier show traces of red ocher, a hematite pigment that lodged in the crevices of chipped-stone tools. Endscrapers and other scrapers used to prepare hides show the highest incidence of imbedded ocher, suggesting an association between the pigment and hide preservation. “It’s possible that the ocher was sprinkled on the hides to stain them and worked in with tools, but it may also have been used as a preservative,” LaBelle explains.

## The Center for Mountain and Plains Archaeology

As the director of Colorado State’s new Center for Mountain and Plains Archaeology, Dr. LaBelle oversees a $1 million endowment to the Department of Anthropology, which has enabled him to move research facilities and thousands of artifacts from off-




The Lindenmeier site in a nutshell! This superb rendering was created from a database compiled by CSU graduate student Jason Chambers, using distribution maps generated from the 1934–40 Smithsonian Institution excavations by Frank H. H. Roberts, Jr. To construct this database, Chambers scanned 17 different individual artifact distribution maps, geo-referenced them into common coordinate space, and digitized the results. The derived dataset, which embraces all 413 squares excavated by Roberts, includes 5,480 individual items representing 22 distinct artifact types. Both piece-plotted and general excavation-square counts are included, resulting in a robust geo-relational database that documents the spatial relationships of archaeological materials recovered during the Smithsonian Institution excavations. As part of his thesis project, Chambers also analyzed spatial patterning to determine the overall distribution of bone and lithic items at the site and reveal spatial relationships among several functionally related artifact types. “This project,” says Chambers, “represents a collections-based approach that incorporates existing data and modern mapping software unavailable to previous generations of researchers to maximize the information available for this important Paleoindian site, and demonstrates the commitment of the Center for Mountain and Plains Archaeology (CMPA) to advancing regional Paleoindian research.”

campus areas to the Clark Building on the Main Campus, making them more accessible to students and faculty. The gift, which establishes the James and Audrey Benedict Mountain Archaeology Fund, is the largest ever received by the department. The Center will expand the university's collaborations with other universities and with federal, state, and local resource agencies. It is home to the Archaeological Repository, which retains more then 18,000 catalog items consisting of prehistoric and historic artifacts from the cultures of peoples living in the Northern Colorado region over the past 12,000 years or more.

| | |
|---|---|
| **5,478** | catalog numbers for chipped stone |
| **46,380** | waste flakes and chips |
| **18** | pieces of raw material in varying stages of core development |
| **31** | tools commonly known as choppers or pounders |
| **27** | sandstone artifacts |
| **4** | pieces of used limestone |
| **69** | bone artifacts |
| **1** | piece of used magnetite |
| **68** | pieces of worked hematite and ocher |
| **10,000–20,000** | animal bones |

**These conservative estimates of discoveries at Lindenmeier during the 1930s reveal the vast quantities of specimens at the site.**

Jim Benedict, an internationally known geoarchaeologist who died in 2011, developed a rotary model that has enlarged our understanding of Paleoindian land use and how it changed across space and altitude. Deeply committed to research, stewardship, and public education, Dr. Benedict conducted extensive research on the natural history of the alpine country. The Benedicts have been long-time friends and supporters of the Department of Anthropology at CSU, and their generous gift will advance geological and archaeological research in the Rocky Mountains. The Center for Mountain and Plains Archaeology is pledged to carry on his legacy, and the fund will help train a new generation of Colorado State anthropology students.

"In the summer of 2013, I plan to return to Lindenmeier with students to excavate an unexplored area on the east side of the site near the bison pit," LaBelle says. Meanwhile he continues to expand his database of evidence of human presence in northern Colorado and southern Wyoming in the Pleistocene. These activities could easily consume a lifetime, but Jason LaBelle isn't one to retreat from a challenge.

*–Martha Deeringer*

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**Students surveying the vicinity of the bison pit, eastern side of Lindenmeier site, 2009.**

## Suggested Readings

Andrews, B. N., J. M. LaBelle, and J. D. Seebach 2008 Spatial Variability in the Folsom Archaeological Record: A Multi-Scalar Approach. *American Antiquity* 73.3:464–90.

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LaBelle, J. M., and Cody Newton 2010 Red Ocher: Endscrapers, and the Folsom Occupation of the Lindenmeier Site, Colorado. *Current Research in the Pleistocene* 27:112–15.

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# Mass Extinction of Megamammals

## A Prehistoric Who-Done-It

ARTIST GEORGE "RINALDINO" TEICHMANN. ©YUKON GOVERNMENT

**IF AGATHA CHRISTIE** were a scientist, this is the kind of mystery she would set one of her masterful detectives to solving: What killed off megafauna in the Late Quaternary? Beginning 50,000 years ago, entire species of megamammals in Eurasia and North America began disappearing from the face of the Earth. Over the years scientists searching for the cause of this mass extinction—36 percent of Eurasian and 72 percent of North American species—have theorized many possible causes. Today two prime suspects have emerged, climate and man.

The gradually warming climate over the millennia was assumed the likely cause until Paul S. Martin introduced his controversial Blitzkrieg hypothesis, which places the blame squarely on the shoulders of deadly efficient human hunters (**MT 22-1**, "The Timing of Megafaunal Extinctions in North America: Earlier Than You Think"; **MT 25-4**, "The Paleoindian Menu: Subsistence and Diet"). Some scientists believe humans may have been indirectly responsible for the demise of these genera by introducing hyperdisease: Early man's contact with these animals, they submit, may have ignited a pandemic in the megamammal population (**MT 18-4,** "Tuberculosis Found in Mastodon Makes the Case for Hyperdisease in Megafauna"; **MT 14-1,** "Explaining Pleistocene Extinctions: Mammalogist Testing New Theory Linked to First Contact with Humans"). The sheer number of articles about extinctions we've published in previous issues of *Mammoth Trumpet* is a measure of the intensity with which the scientific community has pursued this mystery.

Recently Eline D. Lorenzen and Eske Willerslev of the University of Copenhagen, in cooperation with a host of other scientists from all over the globe, brought the formidable tool of genetics to bear on unraveling the conundrum. "The extinction debate," Dr. Lorenzen explains, "has for many decades been over-polarized between climate vs. humans." After their exhaustive investigation of six extinct megaherbivores, Drs. Lorenzen and Willerslev and company arrived at a conclusion that neither wholly satisfies nor disappoints climate-change and human-hunter advocates. The agent of extinction, the scientists conclude, wasn't exclusively climate or humans. Sometimes both played a part. Moreover, they find that the cause of extinction varies with the species.

Willerslev and Lorenzen.

### Data, data, data

As any sleuth would do, Lorenzen and Willerslev's group begin by uncovering the facts. To narrow the search they selected six herbivores from the Ice Age that coexisted in the same geographical areas and thus were subject to the same challenges of infringing humans and changing climate and habitat: bison, musk ox, reindeer, wild horse, woolly mammoth, and woolly rhinoceros. Some of these species are extant today, others have completely disappeared. The musk ox uniquely went extinct in some localities, but survived in others. Like detectives reconstructing the scene of the crime, the scientists followed the history of these animal populations, peering into the DNA of extinct species like *Bison priscus* and sometimes into that of living descendants like *Bison bison*.

The data consisted of "846 radiocarbon-dated mitochondrial DNA (mtDNA) control region sequences, 1,439 directly dated megafaunal remains and 6,291 radiocarbon determinations associated with Upper Paleolithic human occupations in Eurasia." Besides fossil megafauna remains, species distribution models and paleoclimatic data were examined to assess the influence of climate on these species. The team tracked the estimated range size across the millennia at milestone dates of 42, 30, 21, and 6 kYBP. If climate had a significant impact on the size of a species population, there would be a positive correlation between the scope of its geographic range and the size of the population. The woolly mammoth and rhino were both extinct by 6 kYBP and therefore lacked data. For the other four species, however, the results were congruent, implying that climate change indeed affected both geographic range and population size.

Nevertheless, affecting the size of a population and driving a species to extinction are two different things. There was still that other suspect to take into account—man. To gauge the possible effect of humans on the population size of a megafauna species, Lorenzen and Willerslev's group took three factors into consideration. The first was the geographical range overlap between each species and humans at the four dates mentioned above. In other words, Were humans at the scene of the crime? Human presence was determined from the Eurasian Paleolithic archaeological record. In the North American record, humans are indisputably present only in the final interval (though this doesn't give First Americans an alibi; we know they appeared by at least 16 kYBP). The second factor was the count of megafaunal remains found in European (48–18 kYBP) and Siberian (41–12 kYBP) archaeological sites—call it Paleolithic primafacie evidence. For the last category, the scientists factored the incidence of remains found in these sites together with the frequency at which sites appear across the landscape and throughout the millennia.

"What we did," says Lorenzen, simplifying for a moment, "was combine all the available data, sit back and see what patterns emerged in favor of one or the other models."

Elementary, my dear Watson?

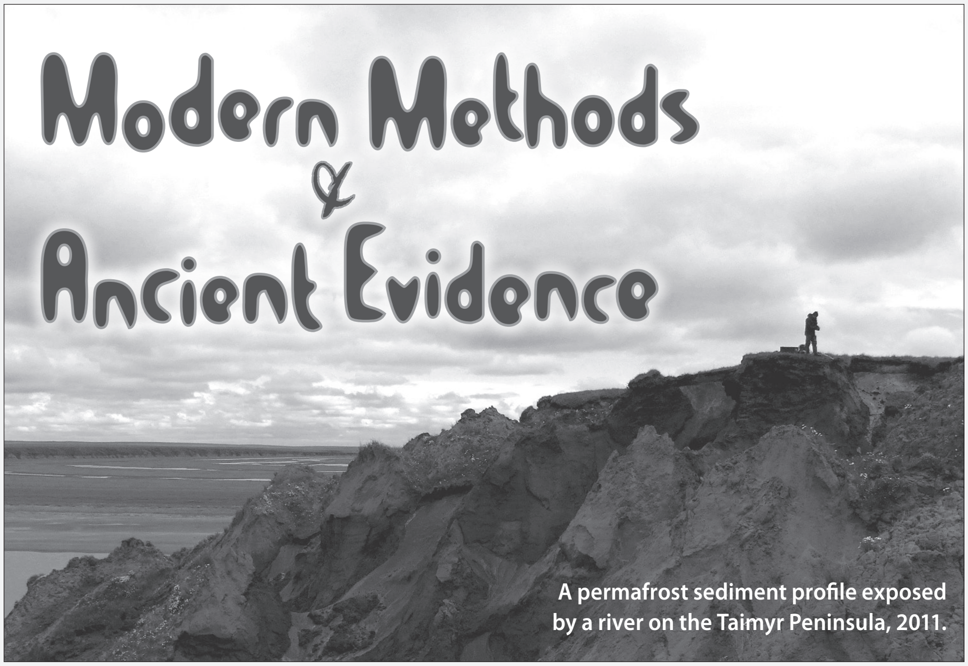

**Potential ranges of megafauna species at intervals in the Pleistocene and early Holocene, modeled using the megafauna fossil record and paleoclimate data for temperature and precipitation. The extent of the ice sheet wasn't included as a co-variable. Range measurements are restricted to regions for which fossils were found, rather than the entire potentially suitable Holarctic area.**

## The moving finger points

Actually, "complicated" and "dynamic" are the words Lorenzen uses to describe the pattern that emerged. Though all six species were subjected to the same stressors, the effects were unique to each species.

The most successful by far were reindeer. How they achieved such a remarkable degree of survival is another mystery altogether, for their geographic range coincided with Paleolithic humans over the long term and there are abundant

# Modern Methods & Ancient Evidence



A permafrost sediment profile exposed by a river on the Taimyr Peninsula, 2011.

**THOUGH WE CAN'T IDENTIFY** precisely what dealt the death blow to the mammoth, there's no shortage of theories. Besides an increasingly less friendly climate, and overkill and hyperdisease introduced by man, there's extraterrestrial impact—champions and naysayers of the Clovis Comet have appeared in *Mammoth Trumpet* for several years. Archaeologists are divided into different camps on these theories. What's missing from all their theories, however, is one critical piece of information: When did the mammoth finally succumb to extinction?

Hasn't this been researched to death? Some might ask, What's the use of beating a dead horse? This is actually a useful metaphor because this ancient enigma involves American ancient horses, too. The last mammoth and horse populations disappeared from the Americas about 15,000–13,000 CALYBP. We know this from macrofossils and fossil pollen. And although we've become adept at prying loose their secrets, perhaps we should consider how much of the big picture they can actually divulge. At question isn't their usefulness, only their limitations. After all, pollen can travel thousands of kilometers from its origin before being deposited, which renders suspect its usefulness in inferring local paleoenvironments. As for macrofossils, an animal can only deposit a single skeleton, which is terribly vulnerable to destruction by other animals, the elements, and time. Moreover, finding macrofossils is largely a hit-and-miss proposition, relying on chance in lieu of the daunting task of combing the landscape. The dearth of macrofossils makes it difficult to widen the lens of our research to help us establish the span of megafauna existence.

Generally it's presumed that the youngest macrofossil on record loosely represents the time of extinction for a species. This is known as the latest appearance date, or LAD. The likelihood of actually uncovering the remains of the very last surviving member is, of course, slim to none. As a population dwindles, so does the probability of discovering fossil evidence of them. Therefore the actual time of extinction must be younger than the fossil evidence, though how much younger is anybody's guess. Scientists cope with this insoluble problem by assuming the species lingered on for an unspecified length of time, referred to as the "ghost range."

### Dirt, DNA, and time

Scientists, of course, aren't much for guessing. Eske Willerslev and other scientists, aware that a vertebrate's mtDNA from skin cells, hair, and waste can linger for many years in sediments, reasoned that the place with the right conditions for preserving this "sedimentary" ancient DNA, or *seda*DNA, is the Arctic. It's not a bad place to look if the DNA you want is that of ancient, extinct mammals.

reindeer remains in both European and Siberian Paleolithic sites. Between 21 kYBP and 6 kYBP their habitat shrank by 84%, which would lead us to conclude that this species must be staring into the abyss. Yet today they are neither extinct nor endangered. How did they survive? If we ever discover their secret, perhaps to insure our own future we should consider breeding like reindeer instead of rabbits.

The musk ox wasn't entirely so lucky. Though herds of these animals exist today, entire subpopulations fell into extinction. Considering humans as the possible guilty party, the geographic overlap of this species and humans is comparatively small. Remains of this species are found in only 1% of European Paleolithic archaeological sites and only 6% of Siberian Paleolithic sites. These facts apparently exonerate humans, but climate doesn't escape scot free. During the period when reindeer suffered a loss of 84% of its habitat, musk ox losses were nearly as severe, 60% of its habitat. By 19 kYBP musk ox had divided into geographically isolated subpopulations. Gene flow was therefore restricted, resulting in genetically homogeneous subpopulations, a situation that doesn't bode well for survival because it renders the population less resilient and unable to adapt to a changing environment. The ultimate telling fact is the inability of musk ox to withstand temperatures above 50°F (10°C). The final verdict names climate change as the sole guilty party in the near extinction of the musk ox.

The musk ox doesn't appear to be the only victim to succumb to changing climate. The woolly rhinoceros is now completely extinct, and the principal cause appears to be climate change. In the period 34–19 kYBP its population in Eurasia was on the rise, even though this period saw the appearance of man into its range. When the woolly rhinoceros became extinct in the Late Quaternary, around 14 kYBP, the species had spread across

This *seda*DNA has several points to its credit. The first is that an animal is likely to leave such traces wherever it travels, not merely its skeleton where it dies. (Think how much your dog sheds!) Now expand this concept to mammoth proportions. In non-frozen deposits scientists must allow the possibility that DNA migrated from its original place of deposition to another, but studies have indicated that migration isn't a problem in frozen sediments. Moreover, we can be certain on finding *seda*DNA that the animal was actually present in that locality. It doesn't drift long distances as pollen can because exposure to oxygen-free radicals, UV irradiation, and water causes it to quickly decompose. The catch is that *seda*DNA won't be found sitting on the surface. You have to dig for it.

**At the core of the matter**

For his study Dr. Willerslev chose a site in interior Alaska near Stevens Village located on a floodplain topped by sediment deposited in the late Pleistocene/early Holocene. Once Willerslev's team had systematically documented the layers of soil and verified that water had caused no leaching, 15 permafrost core samples were extracted. "The frozen soil is drilled directly from the permafrost," says Kenneth Andersen, a Ph.D. student at the Centre for GeoGenetics, University of Copenhagen, who is currently working with *seda*DNA. The cores, he explains, are "kept frozen until back in the lab, then opened and the undisturbed internal part used for extraction. It is actually the laboratory work that takes up most time."

Guarding against contamination all the while, the cores were brought back to the lab. The mtDNA found in the sediment was cross checked using a statistical approach for taxon and a BLAST check, which uses GenBank. This, Lorenzen explains, is an online database of "all published DNA sequences in the world." BLAST FX is a program that searches the database and identifies species whose DNA is present in the sample.

The permafrost cores revealed the presence of bison, horse, moose, snowshoe hare, and woolly mammoth. The mammoth DNA samples appear to represent two or possibly more individuals from the same clade (a group evolved from a common ancestor). In this case the detected clade and subclades have been documented as late surviving groups of the species.

The age of an identified species was inferred from its depth in the core sample. The results were surprising. DNA from both the horse and mammoth resided in a single layer dating to about 7600–10,500 CALYBP. Surprising indeed, considering that for this region the LAD (based on the fossil record) for the horse is 14,180–14,960 CALYBP, and for the mammoth 13,100–13710 CALYBP. According to *seda*DNA results, however, these two megamammals survived many millennia later than shown by the fossil record.

**Future possibilities for ancient DNA**

Discovering that species of megafauna survived so far inland well into the Holocene flies in the face of accumulated wisdom about Ice Age extinctions. Although Willerslev and his colleagues are pleased with the results, they don't advocate relying exclusively on *seda*DNA analysis. Instead, they regard it as a valuable tool for use in conjunction with macrofossils. For paleontologists, the sticking point is that *seda*DNA cannot be directly dated with the same assurance as, say, bone collagen from a skeleton. A lawyer would call *seda*DNA circumstantial evidence, not prima facie evidence. Nonetheless it certainly lets us step back and see the big picture. Andersen believes *seda*DNA could help scientists gauge the correlation between genetic changes and ecologic changes through time. "In the future," he explains, "this may allow us to bridge community ecology and evolutionary biology."

And what about its potential in anthropology? Could *seda*DNA be used to detect the presence of early humans in Arctic America? It hasn't been attempted yet, but according to Andersen the potential exists. Lorenzen is quick to caution that the greatest obstacle would be our own human contamination.

*–K. Hill*

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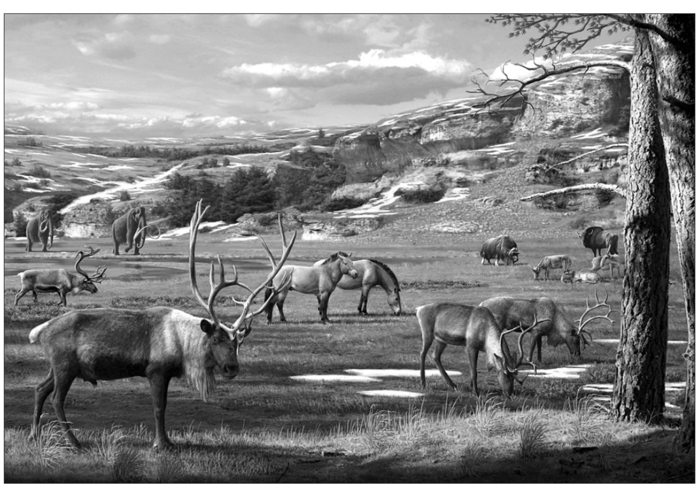


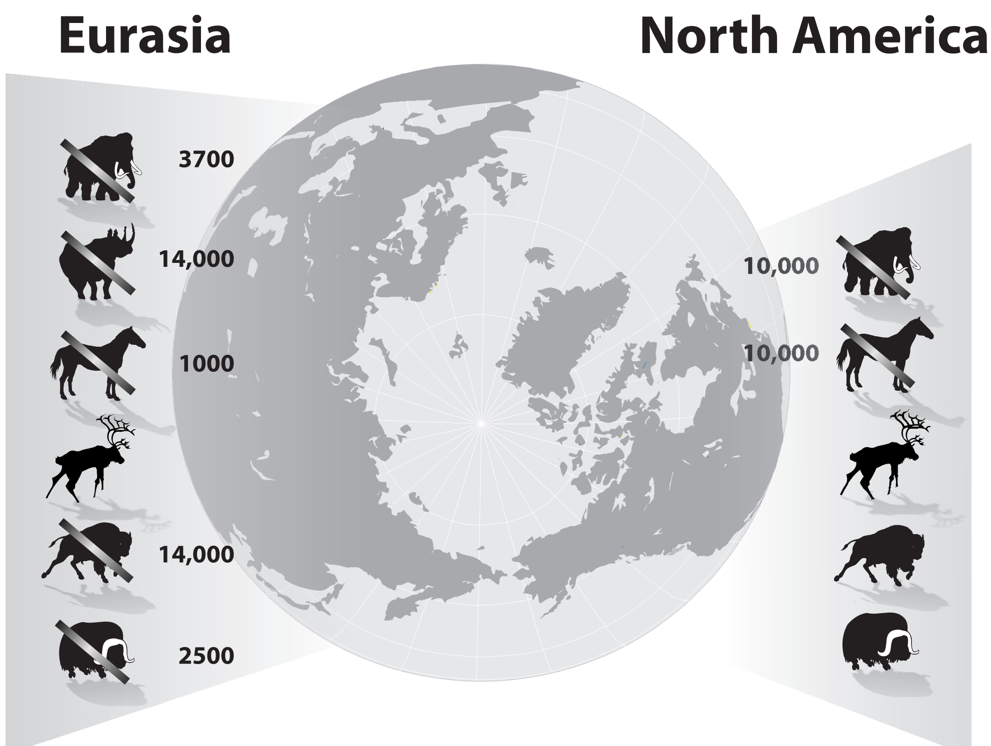


Pleistocene landscape, including mammoth, horse, reindeer, bison, and musk ox.

Eurasia and showed no signs of a lack of genetic diversity. Perhaps the populations were too widely spread to insure survival, however, because isolation-by-distance had set in before extinction. Woolly rhino remains are present in only 11% of Siberian archaeological assemblages. In Europe, humans and woolly rhinos coexisted for only two millennia before the latest appearance date of the species. Although humans can't be absolutely absolved in the extinction of the woolly rhinoceros, their part was minimal at most. Changing climate alone stands convicted.

## Here comes man the hunter—watch out!

Man's record in megafaunal extinction is far from spotless. Although correlation of range and population size demonstrates that changing climate did play a part in the demise of the ancient horse (*Equus ferus*), these animals showed little genetic isolation-by-distance. Neither did they exhibit a decline in genetic diversity, the trait that lends robustness to a species, until after the Last Glacial Maximum (LGM). At this time the range of human and horse widely overlapped, making human encroachment suspect. There's no doubt that this species was a substantial part of human subsistence during the Paleolithic, for their remnants are found in 58% of European sites and 66% of Siberian. The final verdict labels humans and climate as partners in crime in the demise of the ancient horse, and also of the ancient steppe bison, *Bison priscus*, a supersized version of today's *Bison bison* (**MT 24-4,** "Bison Carcass Dates the Ice-free Corridor"). Evidence points to the waning of the ancient species' genetic diversity as early as 35 kYBP. Combine that with the simultaneous diminution of its range and population density and you have a strong case against climate as the culprit. *B. priscus* was also an apparent favorite with Paleolithic humans, judging by its widespread appearance in their archaeological assemblages: It was found in 77% of all Siberian sites. The decline of this species also picked up speed about 16 kYBP, when the first humans are known to appear in North America. At first blush this evidence seems only circumstantial, but it's certainly grounds for suspicion. The cops would warn both man and climate not to leave town.




**Extinction dates for megamammal species in Eurasia and North America.**

## A special case, the woolly mammoth

Of all the megafauna, the woolly mammoth has captured our imagination like no other. For decades archaeologists focused on its importance to human subsistence. Some scholars have rebelled against the stereotypical image of Clovis the Mammoth Hunter and insist instead on Clovis the Hunter-Gatherer, and today the debate has become an academic tug of war. Nonetheless we revere this splendid beast as the icon of the Ice Age. Were our forebears the cause of its extinction? The evidence is contradictory. The species experienced population growth in the period 34–19 kYBP. During the last 10,000 years of this period the rapid expansion of the foraging range of humans resulted in a significant overlap throughout the Paleolithic with territory occupied by mammoths. This long-term period of coexistence, which witnessed a *rise* in the mammoth population, seems to negate both the blitzkrieg and hyperdisease theories. On the other hand, mammoth remains are found in 40% of European and 35% of Siberian Paleolithic assemblages, and its incidence in Siberian sites actually shows a decrease after the LGM. And of course we have abundant evidence that this species was exploited by Clovis hunters in the New World. As for indicting climate for decline of the mammoth, it's true that their population withdrew to the north during its last millennium. And yet the species shows no sign of declining genetic diversity. In the face of all this contradictory evidence, the inescapable fact remains that the Late Quaternary saw the last of the woolly mammoth. Who-dun-it? The jury is still out.

## The verdict

In the extinction of some megafauna species, such as the woolly rhinoceros and some populations of the musk ox, it appears that climate worked alone. In these six cases at least, it doesn't appear that man was solely responsible for their extinctions. He is implicated, however, together with climate in the disappearance of the ancient horse and the steppe bison. For the woolly mammoth the case remains open. Will we ever know the cause? Though the mammoth enjoys the most thorough fossil records of any Ice Age megamammal—specimens kept in cold storage in Siberian ice caves are available to today's scientists (**MT 24-4** and **25-1,** "Decoding the Woolly Mammoth")—everyone interprets the information differently. Lorenzen looks at the problem in proper Nancy Drew fashion and believes we must develop better methods for ferreting out information. Perhaps, she opines, *seda*DNA, DNA recovered from frozen sediments by new technology, will prove to be a useful tool.

The purpose of sleuthing out the reasons for these extinctions isn't simply to cast blame. Discovering what led to the loss of these megamammals might help us protect animals living today. We know that climate change affects species and can even imperil their very existence. After examining massive climate shifts of the past, we can conclude positively that the continents that experienced the greatest change in climate also lost the most species. Though the reasons for extinction vary with the species, it holds true for every species in the study that habitat geographical range is inexorably linked with population size. This axiom holds true then, now, and in the future. Lorenzen and Willerslev leave us with the parting thought that by "incorporating the lessons from the past into rational, data driven strategies for the future" we might be better prepared to protect species that are endangered by climate change—and ourselves.

–*K. Hill*

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## Suggested Readings

Lorenzen, E. D., et al. 2011 Species-specific Responses of Late Quaternary Megafauna to Climate and Humans. *Nature* 479:359–64.

Haile, J., et al. 2009 Ancient DNA Reveals Late Survival of Mammoth and Horse in Interior Alaska. *Proceedings of the National Academy of Science,* USA. 106:22352–57.

## The Clovis/Folsom Transition

*continued from page 4*

time for unrelated cultures to arise and adopt similar hunting techniques, so we still can't be sure if Folsom evolved from Clovis. But Jake Bluff does prove that Clovis definitely predates Folsom—that is, they couldn't have been contemporaneous, which is itself suggestive.

### The future for Jake Bluff

Bement and Carter currently have no plans for further work at Jake Bluff. "I want to leave the remaining portions of the arroyo kill intact for future archaeologists," says Bement. "Hopefully, new techniques in excavation and analysis will improve the information to be gained from this site." He does intend to continue working along this stretch of the Beaver River, however, since "it's still producing copious information on Paleoindian hunting adaptations. It also contains sediments conducive to paleoenvironmental reconstructions that will aid in understanding the broader context of early Paleoindian decisions."

Carter agrees with Bement's assessment of the importance of the region. "In the future, that whole area will be known as a complex rather than individual sites, since they're all linked by age and context. Undoubtedly, there are other sites there that are similar and will yield similar materials.

"I don't know if we'll get to do the work or if someone 50 years from now will do it, but that area will continue to be of significant interest for that period."

–*Floyd Largent*

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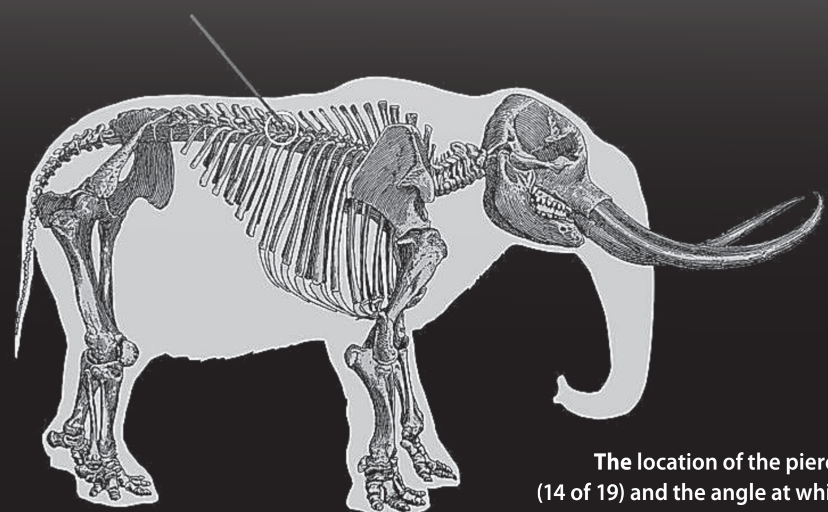
**Bement *(left)* and C. Vance Haynes at Jake Bluff, 2004.**

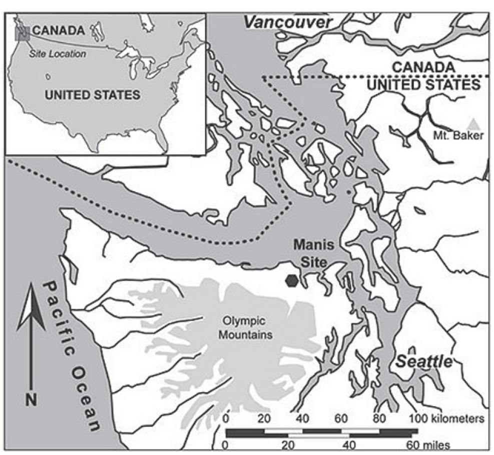
# Reconsidering the Manis Mastodon



The location of the pierced rib (14 of 19) and the angle at which the intrusive object entered the body.

MICHAEL R. WATERS

On a cool day near the end of the last Ice Age, a mastodon fell onto its left side and died. After being buried by natural processes, its remains lay entombed for nearly 14,000 years before suddenly coming to light 35 years ago—whereupon it became the centerpiece of an archaeological conundrum. A few facts about the case are undisputed. We know, for instance, that the animal expired in the shallows of a glacial pond near what would become, in the fullness of time, the town of Sequim, Washington. We know, too, that it was elderly when it died, and almost certainly male. The locality would eventually pass into the hands of a family named Manis, and the circumstances of the mastodon's rediscovery in 1977 are well documented.




MICHAEL R. WATERS

But those who have reviewed the evidence agree on very little else, especially the cause of death of the Manis mastodon. The principal investigator, Carl Gustafson, became convinced early on that human hunters had killed and butchered the animal. However, the Manis site dates to at least 800 years before Clovis—which, at the time of its discovery, most archaeologists agreed was the earliest human culture in the Americas. Many critics rejected it as a kill site for that reason alone. Others challenged the accuracy and interpretation of the data, or dismissed the site as a misdated anomaly.

Late last year, however, Manis reemerged as a pre-Clovis contender when a team led by CSFA Director Michael Waters set the record straight on several points. In the 21 October 2011 issue of *Science*, Dr. Waters, Dr. Gustafson, and nine coauthors demonstrated conclusively that the old mastodon really did die almost 14,000 years ago—with what appears to be a bone projectile point broken off in a rib.

## Making history

Like so many scientific discoveries, the Manis find was serendipitous. In August 1977 the landowner, Emanuel "Manny" Manis, was digging a pond with a backhoe when he uncovered two huge tusks. Several phone calls later, an archaeological salvage team from Washington State University, led by Gustafson, arrived to oversee salvage excavations. Although the team initially treated Manis as a paleontological site, that changed on the very first day when Gustafson reached into the backdirt and pulled out a chunk of rib with a lump protruding from one end. When he washed off the bone, he realized that the lump was a piece of foreign osseous material. "I thought it was probably antler, at first," he recalls.

But how had a bit of antler become lodged in a mastodon's rib? It didn't take long for Gustafson to decide that he might be looking at the tip of a prehistoric spearpoint. He immediately called a halt to the backhoe excavations, and began a laborious, multi-year excavation of the site, in which the primary digging tools were streams of water. This was necessary because most of the mastodon bone was very fragile—soft enough to score with a thumbnail. Metal tools would have been too dangerous to use, and even implements made of a softer material like wood might have left tool marks on the bones.

Gustafson excavated the site every field season from 1977 to 1985, with one summer off—without official funding and often with little help. Ultimately he accumulated a large dataset that included several lines of evidence pointing toward human involvement in the mastodon's death. In addition to the pierced rib, some of the bones are spirally fractured, others show cutmarks, a few tusk fragments exhibit polish and scratching, and one long bone bears several flake scars. In addition, the mastodon's right side was disarticulated from its left side, suggesting that someone had butchered it in situ.

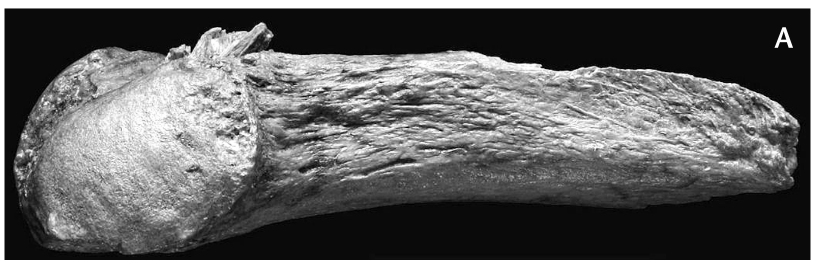
## Arguments against

Initially, Gustafson's conclusions that humans had killed and processed the Manis mastodon were not widely accepted by the archaeological community for several reasons. First of all, only a few limited publications were available on Manis (as is still true). "It's extremely unfortunate that the Manis site materials have never been fully described and reported," says R. Lee Lyman, a former student of Gustafson's who now chairs the Department of Anthropology at the University of Missouri, Columbia. Unlike most Manis critics, Dr. Lyman has actually handled and examined some of the Manis skeletal material.

**The Manis site on the first day of the excavations, August 1977.**

CARL GUSTAFSON

Some critics didn't care for the fact that the only potential artifact directly associated with the remains is "a piece of foreign bone stuck in a rib," as Gustafson puts it; the lack of lithic artifacts was, to them, a strike against human involvement. Third, the pierced rib was found in a backhoe trench, which made its provenience suspect. Fourth, at 12,000 RCYBP, the radiocarbon date Gustafson obtained for the site just seemed too old. And it wasn't a direct date in any case: bone dating was notoriously inaccurate back then, so Gustafson dated tiny seeds laboriously collected from the surrounding sediment.





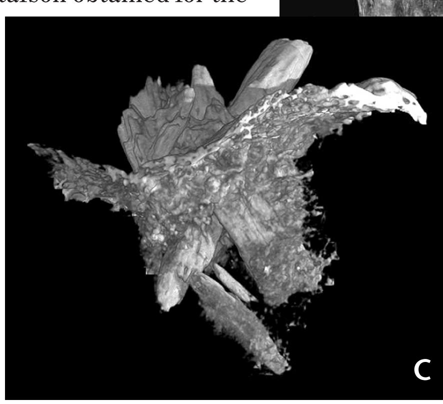
**A, the pierced mastodon rib from the Manis site, with the foreign bone visible at upper left. B, another view of the pierced rib from Manis, with the foreign bone visible at center. C, three-dimensional reconstruction of the pierced rib from Manis, with the foreign bone object entering the rib at upper right. Note the shattered tip on the lower left.**

Gustafson notes that most people who have examined the evidence and discussed it with him have gone away convinced that Manis does, in fact, represent an early mastodon kill site. Lyman is a notable exception. Although he considers Manis significant, he remains unconvinced that humans killed the mastodon. He was intrigued when he first looked at the material in the early 1980s, and admits that "the modifications to the tusk fragments . . . were quite unusual and, given my taphonomic naïveté at the time, inexplicable." However, by 1990, Lyman had concluded that we simply don't know enough about the taphonomy to decisively interpret the Manis site data. He still has serious reservations about the possibility of a human presence at Manis, and regrets that the full dataset remains unavailable to the scientific community at large.

## That fateful rib

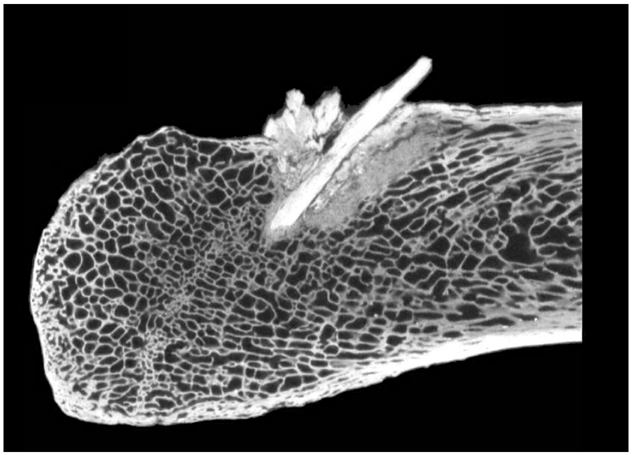
Arguably, the most significant Manis discovery is the pierced rib, with its anomalous fragment of foreign material jammed nearly an inch deep into one end. Close examination of the specimen suggests that the intruder entered the rib at the proximal end near its intersection with the animal's spine, after passing through 25–30 cm of hide and muscle. It then shattered, leaving the tip behind. No material corresponding with the remainder of the intrusive object has ever been found.

Gustafson's initial hypothesis was that the damage took place a few months before the mastodon's death. "It looked for all the world like healing had occurred," he says. "There seemed to be excess bone development, and spicules of excess bone on the surface." A low-resolution Computed Tomography (CT) scan seemed to support that conclusion. But the recent *Science* study included a very high resolution CT scan that indicates quite the opposite. Those who have examined the scan, including a bone pathology expert, have concluded that no healing occurred at all. In other words, the mastodon died immediately after the event that left the foreign material embedded in its rib—whatever that event might have been.




ALL: MICHAEL R. WATERS

If indeed the foreign material is the tip of a projectile point hurled or thrust by a prehistoric hunter, as Gustafson and other Manis proponents contend, then the hunting party would most likely have recovered the rest of the point (and any other weapons used to dispatch the mastodon) before the animal was butchered. Many archaeologists, however, have been reticent about accepting this hypothesis. Some have suggested that, given the softness of the skeletal material, Mr. Manis's backhoe excavations might have driven a bone splinter into the rib. Others argue that natural processes might have resulted in the bone intrusion. "When I had the opportunity to handle the Manis materials, [Dr. Gustafson] thought two mastodons were represented," Lyman recalls, "so I thought that perhaps one had trampled the other . . . and maybe even driven the bone splinter into the rib, though the latter seemed unlikely to me."



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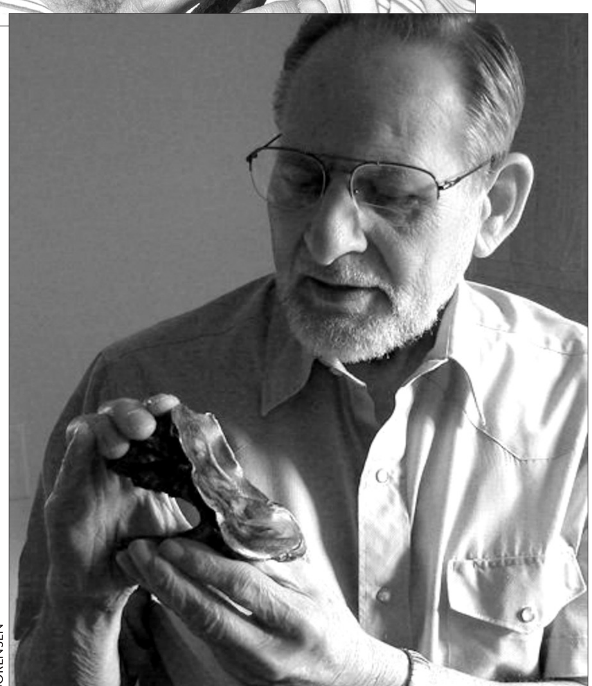
A high-resolution CT scan of the pierced rib, clearly showing the foreign object and the damage it caused.

CARL GUSTAFSON

◀ Gustafson at the Manis site, with the pierced mastodon rib.

▼ Gustafson with a mastodon tooth from the Manis site.



ERIC SORENSEN

Other critics besides Lyman have proposed their own hypotheses to explain the intrusive bone in the mastodon's rib, none of which he considers likely scenarios. One idea is that an elk gored the mastodon, and the tip of the attacker's horn broke off in the rib. There's also the possibility that the mastodon accidentally rolled or fell onto a bone splinter, either pushing the piece into its rib or breaking it off in its flesh, whereupon the bone worked its way into the rib over time. Some critics have even proposed that a bone fragment from the mastodon's own skeleton may have somehow migrated into the rib.

## Marshaling the evidence

Gustafson doesn't buy any of those explanations. Neither does Waters. Indeed, genetic sequencing has invalidated the elk hypothesis, proving conclusively that the intrusive material isn't antler of any kind, but mastodon bone. Still, so little of the mastodon genome has been reconstructed that it's impossible to state conclusively that the rib and the pointed bone jammed into it are from two *different* mastodons. Even if they are, some argue, the Manis mastodon may in fact have accidentally driven an existing bone splinter into its body.

"Perhaps if we knew how much force it took to penetrate the hide, muscle, and then bone of the mastodon, it would help us decipher the origin of the intrusive object," suggests Lyman. He recommends further experimentation, perhaps with dead zoo elephants or other proxies, to determine the force necessary to achieve the level of penetration observed.

Waters considers the accident scenarios unlikely, especially since he *does* have a good idea of the amount of force necessary to drive the foreign object so deep into the animal. "It had to have been a high-velocity impact to go through 25 to 30 centimeters of muscle and tissue to reach the bone," he asserts. Waters believes that a human hunter was trying to pierce through to a vital organ with a spear. "A natural mechanism whereby the foreign object would enter the rib seems, in my opinion, far-fetched," Waters states. "A lot of people make pronouncements like that—but I'd like to know if they'd ever seen a case in nature where this happened? Can they come up with one?"

Furthermore, the new study confirms the initial radiocarbon age for the Manis site. Bone dating is much more accurate now than it was in the 1970s, and a suite of four radiocarbon ages on purified bone collagen have fixed the mastodon's death at 11,960 ± 17 RCYBP—about 13,800 calendar years ago.

While Waters understands the reasoning behind alternative explanations for the observed data, he believes the theorists are grasping at straws in an attempt to explain away the origins of the intrusive bone—especially in light of what the science is telling us now. "Having lived this, I believe it's definitely a mastodon bone point, and dates to 13,800 CALYBP," he says. "If someone wants to present an alternative explanation, I'd also like them to produce evidence of how that process would work. Show me a bone splinter that migrated into bone."

CARL GUSTAFSON

Second molar of the Manis mastodon *(foreground)* compared with the same molar in the jaw of a mastodon aged about 45 years at time of death. Note the extreme wear on the Manis tooth.

Still, not everyone is convinced—some, like Lyman, because most of the data simply aren't available for independent review. Lyman suggests that all the Manis material—including provenience, context, and association data for every object—be restudied, and a thorough new report published. "Once such a report has been written and studied by the profession, there's a much better chance of a verdict being reached about whether or not human action was involved at the site. . . . To me, it's still a tantalizing but unresolved enigma."

CARL GUSTAFSON

Gustafson *(left)* and Richard Daugherty washing through the bone-bearing deposit and collecting bone fragments.

## Future plans

At the moment, Waters doesn't anticipate doing much more work with the Manis remains, beyond basic conservation. He and his colleagues have extracted some fascinating information from the bones, but as he explains, "We've done all we can with the technology we now have available."

Gustafson, energized by the new data, will keep working on the faunal remains from the site. "We're continuing to reanalyze the material we think is artifactual, working toward getting a paper out on it," he says. "So the Manis site hasn't died, like the mastodon. It's 35 years later, but it's not forgotten."

*– Floyd Largent*

MICHAEL R. WATERS

Gustafson (*right*) and Waters.

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