Ice Age Mammals of the San Pedro River Valley
Southeastern Arizona

Arizona Geological Survey
Down-to-Earth Series 6
About the Arizona Geological Survey...

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To provide unbiased geologic information to the public to enhance understanding of the geologic framework and processes in Arizona and support prudent management and use of land, water, mineral, and energy resources.

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To map and describe bedrock and surficial geologic units and geologic processes and materials, including those that can be hazardous to residents or limiting to the use of land, water, mineral, and energy resources in Arizona.

To provide administrative and staff support for the Arizona Oil and Gas Conservation Commission, which has responsibility to protect public health and safety relative to oil and gas drilling and production.

History

The AZGS and its predecessors have provided information and assistance to Arizonans since 1889. The Office of the Territorial Geologist was established in 1881, but was not funded until 1889. To keep pace with the times, its enabling legislation and duties were updated and the agency was renamed in 1915 (Arizona Bureau of Mines), 1977 (Arizona Bureau of Geology and Mineral Technology), and in 1988 (Arizona Geological Survey). In 1991 the Oil and Gas Conservation Commission, which regulates the drilling and production of oil, gas, helium, and geothermal resources, was attached administratively to the AZGS.

For more information

Additional information about the geology of Arizona, the Arizona Geological Survey, the Oil and Gas Conservation Commission, or publications that are available for purchase, please contact us at the following address:

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What did the San Pedro River valley look like 11,000 years ago? It wasn't the same then as it is today. One difference is that the river had not eroded quite so deeply into its valley as it now has. The climate was cooler and wetter and more water was probably flowing in the river. Fossils prove that plant and animal communities were not the same either. Remains of a number of large animals that are now extinct have been unearthed at several sites along the San Pedro, as well as at other places in Arizona and the Southwest. Points from spears of ancestral humans have been found in association with the fossil remains of some of the animals.

Geologists know that if they understand how geologic and climatic processes operate today, they can find evidence of those processes in the rock and fossil record. With sufficient evidence, they can reconstruct past environmental conditions. Furthermore, if we understand what happened in the past, we can make informed speculations about what might happen in the future. For example, scientific studies confirm that during the past million-and-a-half years, commonly referred to as the Ice Age, at least four major episodes of glaciation occurred in Canada and the adjoining United States. Global cooling caused the formation of large masses of ice, which covered about a third of the earth's surface. Ice sheets spread southward from Canada into the midwestern U.S. Many mountainous areas in the western U.S. were also glaciated. Each glacial epoch was followed by global warming, which caused the ice to melt, glaciers to recede, and sea level to rise. Civilization began just after the last glaciation. Another cycle of global cooling will eventually begin, triggering yet another glacial advance in the northern hemisphere and causing humans and other life to relocate.

Many scientists believe that global warming is now taking place. If so, is the warming being caused by natural processes similar to those that took place during the Ice Age? Are human activities partly or largely responsible? Scientists are actively collecting data and developing hypotheses.

This book highlights some of the large, now-extinct animals that were living in southeastern Arizona while glacial ice was receding from the Midwest. In the final chapter, the authors offer alternative explanations that have been proposed for their extinction.

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The Late Pleistocene
San Pedro Valley

Introduction

As recently as 11,000 years ago the broad plains of the San Pedro River Valley (Figure 1) teemed with herds of horse, camel, mastodon, mammoth, and long-horned bison. They, along with tapir and ground sloth, were preyed upon by dire wolf, jaguar, cougar, bear, and man. Most of these large Ice Age (Pleistocene) mammals, collectively called megafauna by scientists, are extinct. The Clovis people (Paleo-Indians), big-game hunters who followed the herds, are also gone—replaced by a succession of cultures that were dependent on small game, the gathering of seeds and nuts, and, later, agriculture. Today, just a few feet below the ground in the San Pedro Valley, the fossil remains of these large animals, together with associated plant pollen and Paleo-Indian artifacts, provide one of the most complete records of Pleistocene mammals, vegetation change, and early man in North America.

This book, written by scientists from the Bureau of Land Management, Arizona-Sonora Desert Museum, and National Park Service, describes the San Pedro Valley as it appeared during the waning stages of the last great continental glaciation in North America. It is a fascinating story of climatic change, species adaptation and migration, predator-prey ecology, human occupation, and, for some species, extinction. Special emphasis is given to extinct species, such as the saguaro, have spread into southern Arizona during only the last 10,000 years. Other species, including many small mammals, that currently inhabit the area were present during the Pleistocene. Bridging the millennia, this fossil record illustrates the environmental changes that have occurred since humans first entered the San Pedro Valley.

The Pleistocene Environment

The San Pedro Valley is a linear block of crustal rocks that has dropped down due to vertical movement along faults that form its margins. This basin and the adjacent mountains, including the Mule, Dragoon, Whetstone, Rincon, and Galiuro ranges, are characteristic landforms of the Basin and Range Province. Material worn from the surrounding mountains filled the basin and entombed the remains of many of the plants and animals that inhabited the valley. Erosion has been removing the basin fill and exposing the fossilized remains that enable scientists to reconstruct the Pleistocene environment of the San Pedro Valley.

The Pleistocene Epoch extended from about 1.7 million to 10,000 years ago. During that time glaciers advanced and retreated across the northern part of this continent at least four times. Although Arizona was beyond the reach of the ice masses, the cooler glacial and warmer interglacial intervals exerted great influences on the climate, vegetation, and animal life of the San Pedro Valley. This publication describes the environmental conditions and the life forms that existed in the valley near the end of the last major glacial interval.

Dramatic changes took place as the plant and animal communities adjusted to the shifting...
THE LATE PLEISTOCENE SAN PEDRO VALLEY

Figure 1. San Pedro River Valley and adjacent areas. The boundary of the San Pedro Riparian National Conservation Area is shown in green. Ice Age mammal remains have been found at the Murray Springs, Lehner, and Naco sites, shown in red and referred to in the report.
THE LATE PLEISTOCENE SAN PEDRO VALLEY

climatic patterns. During the full glacial peak, around 18,000 years ago, winters were cooler with about 60 percent more precipitation than current levels. Summers were also cool, perhaps 7 to 8 degrees centigrade (12.6 to 14.4 degrees Fahrenheit) colder than today, but much drier. Winter jet stream flows may have been stronger, resulting in a dominant pattern of frontal precipitation and the lack of well developed summer monsoon seasons.

During the cooler, wetter glacial interval, plant species from adjacent mountains extended their ranges into the valley. Ponderosa pine forest dominated lower mountain slopes. Pinon-juniper woodlands covered the higher valley surfaces, giving way to an open juniper savannah on the valley floor. Cottonwoods and willows formed an almost continuous ribbon of trees along the course of the Rio San Pedro. Typical Chihuahuan desert plant species were generally absent.

The San Pedro Valley holds ample geological evidence of streams, ponds, and swampy areas called cienegas. An amazing variety of animal species lived along these wet areas. Huge animals like the Shasta ground sloth and the elephant-like mammoth fed on vegetation. Large predators such as the Pleistocene jaguar (Panthera onca) and the dire wolf (Canis dirus) fed on the herbivores.

As the continental ice masses began to retreat, major climatic changes again took place in the valley. Winters became warmer and drier while summer precipitation greatly increased and summer temperatures began to approach current levels. Plant communities that had moved into the valley from higher elevations or more northerly habitats during the full glacial period were forced to retreat or perish. Oak, pine, and juniper retreated to the lower slopes of the adjacent mountains. Desert grasslands came to dominate the valley floor.

Wetter summers did not compensate for the loss in winter precipitation and as a result, cienegas and ponds began to dry up. Perennial streams became intermittent and animals concentrated along the remaining water sources—leaving fossilized bones, teeth, and tracks as testimony of their passage.

We know of changes in the fauna of the San Pedro Valley from that evidence. Browsers, like the mastodon, were being replaced by grazers. Mammoth, bison, camel, and horse fed on the grassland and probably did a little browsing as well. Deer, pronghorn, and other species found in Arizona today roamed the valley in the late Pleistocene.

Megafauna shared the valley with a host of smaller but no less significant animals. Bats, gophers, mice, rabbits, and squirrels formed a large part of the animal community. Birds and reptiles, including lizards, snakes, and turtles, were other important members. Many animals that we know as current residents--the badger, ringtail cat, and jackrabbit--were present during Pleistocene times. All of these animals coexisted in the valley until approximately 11,000 years ago, when many of the large terrestrial mammals became extinct.

The end of the Pleistocene Epoch in the San Pedro Valley is marked by the disappearance of the many of the large animals and the appearance of small aquatic plants evidenced in a dark black layer known as the Clanton Ranch Member. This organic-rich sediment is believed to have been caused by thick algal mats. These plants "bloomed" in shallow ponds created by a rise in the water table during a warm, moist interval about 10,700 years ago. This deposit overlies the Murray Springs Formation, on which fossil animal remains were found in association with Paleo-Indian artifacts. Fossil animal tracks of mammoth and evidence of the men who hunted them were also found.
Large Extinct Animals

Fossilized remains of more than 170 genera and species of Late Pleistocene and Recent vertebrates have been identified from the San Pedro Valley. Of the mammals, only nine genera have disappeared completely from the valley. It is likely, however, that additional evidence of extinct species will be found in the San Pedro Valley.

What follows are the descriptions of the larger extinct mammals, the megafauna of the San Pedro Valley. These creatures flourished in the late Pleistocene but vanished from the valley approximately 11,000 years ago. Their absence forever altered the balance of nature. It is likely that additional evidence of these and other extinct species will be found in the San Pedro Valley.
**Bison**

Commonly called buffalo, bison of the Pleistocene San Pedro Valley were abundant and existed as a number of different species distinguished generally by body size and horn spread. *Bison latifrons*, shown below, was the giant among these forms, with a horn spread of over ten feet. Most other bison generally resembled the modern bison and likely were gregarious creatures freely roaming the grasslands in herds. Bison succeeded in surviving whatever calamity that befell most other larger Ice Age mammals, and continued on in much of their original range in North America until historic times when they were hunted to near extinction for their hides.

The predominance of bison fossils at the Murray Springs site suggests that bison were the big-game of choice for the Paleo-Indians of late-Pleistocene Arizona. Bison bones are frequently confused with those of modern cattle and are therefore not reported to researchers.
Camel

Herds of camel may have been a common sight during the Late Pleistocene of the San Pedro Valley. Two types of camel have been identified from the valley. *Camelops*, lower right, was the large form—about eight feet tall at the shoulder. Reminiscent of the familiar desert dromedary camel of North Africa, it was one of the most widespread of the Ice Age megafauna, ranging over much of Arizona and North America. The camel first evolved in North America and eventually migrated across the Bering land bridge to populate the Old World. It subsequently evolved into the two-humped Bactrian form of Asia and the single-humped Dromedary. *Hemiauchenia*, a relatively small llama-like camel (lower left), also found suitable habitats in the San Pedro Valley. Like its larger cousins, the llamas eventually made their way into distant places. Large populations became established in South America, where they became important domestic animals in more recent times. There is only circumstantial evidence that camels were hunted and eaten by Paleo-Indians of the San Pedro Valley.
Large Extinct Animals

Dire Wolf

This large Pleistocene canid was one of the most effective predators of the San Pedro Valley. *Canis dirus*, the dire wolf, weighed more than today’s grey wolf, had a broader head, larger teeth, massive bone-crushing jaws, and stocky limbs—ideal physical adaptations for a life of hunting and scavenging. This Ice Age wolf ranged widely over North and South America. It became extinct at the close of the Pleistocene epoch, outcompeted by more adaptable, modern wolf species.

The dire wolf is a rare fossil in San Pedro Valley sediment, but its possible association with early man poses the question: Which was the predator and which was the prey when their paths crossed in the pinon-juniper forest 11,000 years ago?
Ground Sloth

Large, bulky, and unable to climb trees like their living South American relatives, the Pleistocene sloths of the Southwest were committed to a ground living existence. Big and glacially slow in their endless search for forage, these great herbivores used their long muscular tongue to strip trees of their leaves or dig tasty roots from the hard soil using forefeet equipped with huge, sharp claws.

Some of the giant sloths of the Ice Age often exceeded the weight of an elephant while others, like Nothrotheriops shastensis, pictured below, were considerably smaller, not much larger than a 400 pound, 6-foot-long, black bear. This Shasta ground sloth occupied the San Pedro Valley’s forested uplands and may occasionally have ventured into lower riparian habitats.

Sloth dung excavated from dry, remote caves in the Grand Canyon of northern Arizona gives us remarkable insight into the diet of these animals. Being an opportunistic browser, the Shasta ground sloth is known to have dined on many plants, including globe mallow, Indian tea, mesquite, salt bush, and yucca. No convincing evidence yet exists which shows that sloths were eaten by Paleo-Indians in Arizona. Perhaps these creatures were just too bizarre or smelled too bad to Paleo-Indians who were skilled at hunting other giants of the late Ice Age.
Horse

First evolving in North America more than 40 million years ago, primitive horses (*Equus spp.*) gradually progressed from tiny three-toed browsers to the large and swift single-toed plains-living grazers of the Pleistocene. All of the Ice Age horses, asses, and burros that were adapted to a variety of habitats—from grassy plains to mountain forests—became extinct in the New World at the close of the Pleistocene. When reintroduced by the early Spanish settlers, they once again prospered and spread over much of their original territory. This fact alone suggests that the great Pleistocene extinction of North America's megafauna was not entirely caused by postglacial climatic changes.
Lion

During the late Pleistocene, large cats were permanent members of the valley’s animal community. A lion, *Panthera leo atrox*, shown below, apparently lived as lions do today, as family-dominated prides hunting in packs on grasslands or savannahs. Some species of late Pleistocene lions weighed about 500 pounds, a third or more larger than modern lions of Africa. *P. atrox* has been extinct in Arizona for 10,000 years.

Sightings of jaguars continue to be reported in southern Arizona, likely representing temporary extensions beyond their modern normal range in sub-tropical Mexico.
Many of us think first of the great woolly mammoth (*Mammuthus primigenius*) when asked to describe life during the Ice Age. Actually, this hairy giant of the frozen northern world rarely, if ever, made its way into the warm San Pedro Valley and deferred its place in the environment to the less hairy, but equally imposing, Columbian mammoth (*Mammuthus columbi*), shown below. About the size of a large modern elephant, the Columbian species was a grazing animal, dining primarily on enormous quantities of coarse grass. Fossil remains of these ancient elephants, especially their large surfaced grinding teeth, are common in the Ice Age sediment of the San Pedro Valley. The high frequency of fossil elephant finds suggests that these animals existed in large numbers, probably living in herds much like elephants do in East Africa today. Archeological evidence excavated at several sites, such as Lehner ranch, Naco, and Murray Springs, has led to scientific speculation that selective Paleo-Indian hunting of young mammoth may have contributed to the extinction of this species.
**Mastodon**

The mastodon, another large animal with a trunk, was only remotely related to the mammoth. In the late Pleistocene San Pedro Valley only one species is known to have existed, the American Mastodon (*Mammut americanum*). Smaller than the Columbian Mammoth and having comparatively shorter legs, a flatter head, and large multi-cusped teeth, a living mastodon would have looked quite different than a mammoth. The American Mastodon was primarily a browser, living in more forested habitats than the mammoths. The mastodon utilized its trunk and tusk to gather coarse browse—twigs, leaves, and roots of plants found along waterways or in upland pine forests.

Paleo-Indian mastodon kill sites are rare. Did the forest-living habits of the mastodon make them more difficult or dangerous to hunt? Was mastodon meat unpalatable due to diet that may have included pungent Juniper berries? Were the mastodons less common, or were they actively hunted but the kill sites simply not preserved in the archaeological record? Further exploration in the San Pedro Valley may answer some of these intriguing questions.
The shrub ox, *Euceratherium*, may have been a common grazer of the Pleistocene San Pedro Valley, but, because of its foothills habitat, fossils of this bovid are relatively rare. We do know that the shrub ox was one of the first ox-like mammals to have migrated into North America. From its fossil remains we can calculate that a male shrub ox weighed about 1600 pounds and had massive, curved horns. Unlike the musk ox, a bovid of the Pleistocene which survives today and is supremely adapted to cold Arctic conditions, the shrub ox likely developed far less body hair in response to living in the warmer habitats of Ice Age Arizona.
Tapir

Swine-like in appearance and weighing over 200 pounds, the long nosed tapirs (*Tapirus spp.*) of the Late Pleistocene were primitive relatives of the horse and rhinoceros. Shy and solitary, these creatures browsed deep mountain forests and riparian habitats.

Bones of tapir in the San Pedro Valley are rare in Ice Age sediment. It is likely that these animals existed in significant numbers, however, and were the prey of big cats. At the Lehner mammoth kill site near Hereford, a single lower jaw of a tapir was recovered.
Anthropoid Primates in the San Pedro Valley

No one is certain exactly when the late Pleistocene hominids, *Homo sapiens*, first appeared in North America. Modest-sized, bipedal predators, they followed herds of big-game animals migrating from Asia across the Bering land bridge and eventually made their way into every habitat on the North American continent.

Being intelligent and able to organize into sophisticated, technology-based hunting bands, these adaptive hunters relied more on learned skill than instinct. A well known and controversial theory suggests that these new predators’ rapid overuse of dwindling animal resources may have planted the seeds of the great Pleistocene extinction.

The San Pedro Valley is unique for its extraordinary archeological record of kill sites, especially sites in which the bones of mammoth and the hunting tools of man are conspicuously associated. Archeological evidence recovered from six sites in the San Pedro Valley, where Ice Age hunters killed and butchered mammoth and bison, indicates that people belonging to the Clovis culture were roaming southeastern Arizona at least 11,000 years ago.

The Clovis culture is identified by the presence of lance-like, fluted projectile points, first found in a kill site near Clovis, New Mexico. Other discoveries have shown that the Clovis people ranged through most of the United States. Clovis sites have also been found in Mexico. Archaeologists have not yet discovered the origin of this culture, but, because Clovis points have not been found elsewhere, it is believed to be of New World origin.

Although very little skeletal evidence of the Clovis people has been found, enough has been recovered to conclude that they were fully evolved humans (*Homo sapiens*). Stone artifacts of these people are found in the Pleistocene sediment of the San Pedro Valley, but no Ice Age human skeletal remains have been identified in the area.

Lifestyle

Six Clovis sites have been documented in the San Pedro Valley. All appear to be locations where hunters killed Pleistocene megafauna. Because the hunters may have camped at only one of these sites, Murray Springs, archaeologists have minimal information about the domestic and social life of the Clovis people.

Because the earliest discovered Clovis sites so often contained numerous mammoth bones, it was at one time a popular assumption that the Clovis people lived on a diet consisting mainly of mammoth meat. Later discoveries produced evidence that Clovis hunters also killed and butchered bison, horse, and other species of smaller game.

Popular literature and illustrations often depict Clovis hunters using stone-tipped spears to attack full-grown mammoth. Archaeological evidence indicates, however, that they more often concentrated their efforts on calves and young adults, sometimes ambushing them near or at watering places. At the Lehner Mammoth Site bones of nine mammoths, all juveniles, were recovered. They were apparently trapped and killed in the stream bed where archaeologists uncovered their bones thousands of years later. The mammoth killed at the Naco Site was also a young adult.

Bison meat appears to have been popular among the Clovis people. At Murray Springs
bones of eleven young bison were found along with bones of one mammoth. Both the mammoth and the bison were likely ambushed when they came to water.

Being so large and cumbersome to transport, a mammoth carcass was butchered where it fell. The presence of hearths at kill sites, such as Murray Springs and the Lehner Site, suggests that the hunters also ate some of the meat on the spot, perhaps roasting it as they proceeded with the butchering. Cut marks on bone surfaces, and broken cutting tools indicate that the meat was stripped from the carcass and transported to a nearby camp, where more of it could have been eaten or dried for future consumption.

Because most of the tools recovered from Clovis sites seem to be associated with hunting and butchering big-game animals, an inference might be drawn that the Clovis people lived on a meat diet. Like historically documented hunter-gatherers, the Clovis people probably also consumed nuts, roots, berries, and seeds.

Virtually nothing was left behind that could be used by archaeologists to determine what kind of clothing the Clovis people wore. Most assume that clothing was made from animal skins. Dress probably varied according to the season, with more being worn during the colder months and less, perhaps none, during the warmer times of the year.

The type of living structures used by the Clovis people is unknown. Like some later hunter-gatherers, they may have built small, simple dwellings from poles covered with brush and animal hides. There is also evidence that Clovis people sometimes occupied shallow caves and rock shelters.

Clovis social structure is believed to have been organized around small, nomadic bands composed of several extended families. Numbering between twenty-five to thirty people, each band would have ranged over a territory covering up to several thousand square miles, scheduling its movements according to the availability of game and wild plant foods. Periodically, different bands would meet, perhaps to stage a hunt, process meat, and visit with relatives from other bands.
Scientists do not fully understand why ground sloth, horse, mammoth, mastodon, llama, camel, tapir, and some species of bison became extinct. Other species of the Pleistocene megafauna, such as grizzly and black bear, cougar, elk, pronghorn, and wolf, survived in the San Pedro Valley into historic times. Human predation, climatic, and vegetation changes, or a combination of these factors may have caused such selective extinctions.

Summer temperatures may have been cooler and winter rainfall higher during the Pleistocene in southeastern Arizona. Climatic changes that were underway 11,000 years ago resulted in a more defined hot, dry summer season and reduced winter moisture. Plant communities were reorganized and became more zonal as woodlands were replaced by desert shrubs. Those herbivores that could not easily adjust to the changing food supply, together with the carnivores that preyed upon them, were replaced by animals that were more adaptable, and, therefore, more competitive.

The Clovis people could also have played a role in megafaunal extinction. By surrounding and killing small groups of their preferred prey—female and young mammoth and bison—at watering places, small bands of hunters could have exterminated animal populations already stressed by habitat deterioration and disease. Although these species had survived earlier, and, perhaps, more drastic climatic fluctuations, they did not have to contend with human predators for whom they had no natural fear. Scientists continue to search for fossil evidence that will provide a better understanding of these extinctions.

Studies of faunal and floral remains are important, because the information they provide allows scientists to reconstruct and interpret processes of environmental change. Remains of extinct animals preserved in the sediment beneath the San Pedro Valley pose questions regarding our own vulnerability to such change.

It is not clear whether the Ice Age is over. We may merely be in an interglacial period during which glaciers are melting. Will climates eventually cool again, causing glaciers to advance, or will there be additional warming before cooling begins again?

The climatic fluctuations represented in the four major glacial and interglacial periods of the Ice Age were the result of natural processes. Human presence was insufficient to have had any effect. Today, however, continuing increases in human population and advances in technology may enable humans to alter the global environment. Such potential requires that we better understand climatic and environmental changes that occurred in the past. Geologists remind us that the present is the key to the past. Conversely, the past may be the key to the present and, perhaps, the future.
Suggested Readings


Antevs, Ernest, 1959, New geological age of the Lehner mammoth site: American Antiquity, v. 25, no. 1, p. 31-34.


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