Agate Fossil Beds

Agate Fossil Beds National Monument
Nebraska

National Park Service
U.S. Department of the Interior

DENNIS HENRY

About 19–20 million years ago drought struck the plains of western Nebraska. Deprived of food, hundreds of animals died around a few shallow waterholes. Over time their skeletons were buried under the silt, fine sand, and volcanic ash carried by the wind and reworked by streams. A large fossilized waterhole with hundreds of skeletons is preserved today in the Niobrara River valley at Agate Fossil Beds National Monument. The early 1900s discovery of this deposit and others nearby was important to the developing science of paleontology. Study of these fossils—continuing today—has helped answer questions about the past. But what were the conditions that created this drought and brought these animals together so long ago?

Millions of years before the drought, sediments from eroding mountain ranges to the west were laid down to form the bed of a shallow sea in the Age of Dinosaurs. About the time that dinosaurs went extinct, the Rocky Mountains were developing into the ranges we now know, the sea receded, and tropical lowlands occupied what is now the Great Plains.

As time passed, North America's climate became cooler and drier, and volcanic activity in the western United States produced enormous amounts of volcanic ash that was blown eastward. Ash-mantled plains were home to great herds of plant-eating mammals and their predators. As in today's savannas of east Africa, the rich volcanic soils supported grasses that, together with small trees and bushes along shallow streams, were ready food for grass- and leaf-eaters. Many animals that thrived here depended on the moderate climate for their survival, and their numbers expanded to the capacity of the food available.

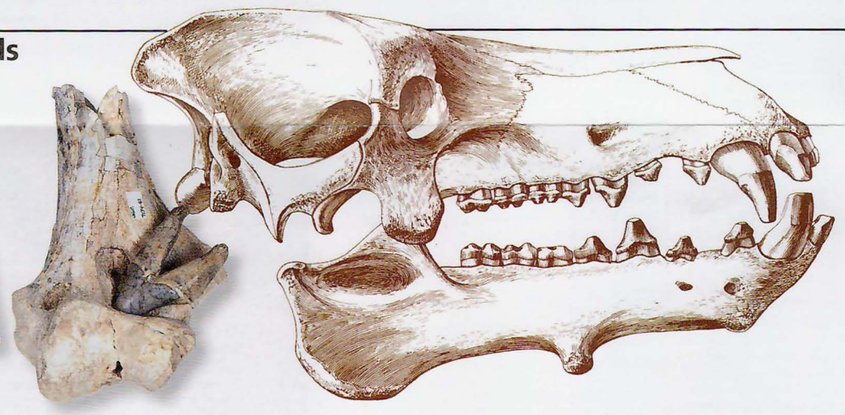
In time the climate grew more arid. The Rocky Mountains kept rising and blocked the flow of moisture-laden air from the west. With less rain came plants that could survive with less water. Droughts were common. Streams dried up and grasses withered. Water-dependent animals, drawn to waterholes in the streambeds, congregated there between times of feeding on the dwindling plants. Large animals like the rhinoceros and the chalicothere *Moropus*, a distant relative of the horse, finally could not travel far enough to find fresh forage, so they died in the shallow water of the few remaining ponds.

Hundreds and thousands of some species died, littering the area in and around waterholes with their remains. In time the rains returned, the streams filled, and the process of burial began. Silt, sand, and ash covered the remains, burying them under several feet of wind- and stream-transported sediment.

Fossils at Agate Fossil Beds

Fossil photographs are not in relative scale.

JOURNAL AND FOSSIL: UNIVERSITY OF NEBRASKA STATE MUSEUM



DENVER MUSEUM OF NATURAL HISTORY

Left to right: E.H. Barbour's 1892 field book shows his *Daemonelix* sketches and his notes on the *Moropus* bone he mistook for a sloth claw. A fossil *Dinohyus* tooth neatly fits the ancient bite mark on a *Moropus* bone.

A *Dinohyus* skull illustrated O.A. Peterson's 1906 article on vertebrate fauna of western Nebraska. A fossil slab of *Menoceras* bones. Harold Cook at his Colorado Museum of Natural History office.

What Animals Roamed Here? All animals whose fossil remains were found at Agate Fossil Beds are now extinct, but some are represented today by a few relatives and, rarely, by descendants. *Palaeocastor* had powerful clawed forelimbs for digging and long, curved teeth like modern beavers. Herds of *Stenomylus*, gazelle-camels about two feet tall, grazed grasslands beside the three-toed, pony-sized rhinoceroses, *Menoceras*. The most common mammal in the bonebed, *Menoceras* may have roamed these plains in large herds. Only a few oreodonts, about the size of a sheep, have been found here, and they are most common in the carnivore dens nearby, where they were the prey of beardogs. Fossil remains of the ancestors of the modern horse, *Parahippus*, also have been found in the waterhole but are rare. Horses became extinct in North America millions of years after the die-off event at Agate, not to return until brought back by the Spaniards.

Moropus was quite fantastic. Related to both the horse and rhinoceros, it was large, had back legs shorter than the front, and had great claw-like hooves. It probably browsed leaves of bushes and small trees. Another large animal, *Dinohyus*, was a giant entelodont related more closely to cows and pigs than to carnivores. Tracks of this huge scavenger—its skull alone was three feet long and its teeth enormous—have been found in the waterhole mud. It broke bones with its teeth (bite marks show on chalicothere limb bones). Discoveries in the 1980s included fossil remains of beardogs and other carnivores and their dens—one of the few paleontological sites of this type in the world.

Discovery of the Fossils Most of the land that is now Agate Fossil Beds National Monument was once part of the Agate Springs Ranch owned by James and Kate Cook. They bought the ranch from her parents in 1887, a few years after they had found "a beautifully petrified piece of the shaft of some creatures leg bone." Erwin H. Barbour of the University of Nebraska, in 1892, was the first scientist to examine the strange Devil's Corkscrews at Agate, later recognized as the fossilized burrows of *Palaeocastor*. In August 1904, O.A. Peterson of the Carnegie Museum in Pittsburgh discovered the great bonebed with the help of Harold J. Cook *(above)*, son of James and Kate Cook. Scientists from Yale University, the American Museum of Natural History in New York City, and other institutions also worked at these fossil beds, mostly between 1904 and 1923. The competition to find the best bones, while mostly cordial, sometimes grew spirited. The work of these bone hunters formed many outstanding collections in museums around the world.

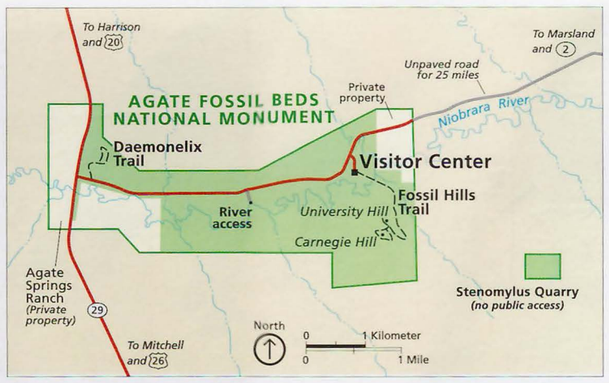
Exploring Agate Fossil Beds

Like an island, the park preserves the fossil beds in a sea of ranchland dotted with windmills and cattle. Shortgrass prairie and marshland along the Niobrara River harbor wildlife. Spring sees wildflowers color the hills, and always the windswept prairie basks beneath a vast sky.

Visitor Center Both a museum and information center, the visitor center offers fossils and artifacts, brochures and books, activity schedules, and a video. A picnic area is nearby. School groups can call about educational programs. The visitor center is open every day except Thanksgiving, December 25, and January 1.

Interpretive Trails Two trails lead to important fossil discovery areas. The 2.7-mile Fossil Hills Trail (an hour-plus hike) leads from the visitor center to University and Carnegie hills, where most of the fossil digging took place in the early 1900s. The one-mile Daemonelix—Devil's Corkscrew—Trail is near the River Road-Neb. 29 junction. It leads to the fossilized corkscrew burrows of the small beaver *Palaeocastor*.

Nearby Services The park offers no camping, but public and private campgrounds lie within 25 to 50 miles of the visitor center. Restaurants, lodging, gasoline, and groceries are available in Mitchell (37 miles) and Harrison (25 miles).



Safety and Regulations Natural areas can pose dangers, but by using common sense you can prevent most accidents. • Rattlesnakes live here, but you are unlikely to encounter one. Please stay on the trails and out of high grass. • Do not remove any fossils, animals, rocks, artifacts, or plants. They are all protected by federal law. Leave things as you find them for others to enjoy too. • Private land exists within the park boundary. Respect owners' rights and do not trespass. • Keep pets on a leash and on the trails. They are not allowed in the visitor center. • Open fires are prohibited. • Lightning kills; *seek shelter before a thunderstorm hits.* • No overnight camping or overnight parking is permitted.

More information
Agate Fossil Beds
National Monument
301 River Road
Harrison, NE 69346-2734
308-668-2211
www.nps.gov/agfo

The Cook Collection of Indian Artifacts

James H. Cook was a frontiersman, hunter, and scout before he settled on the Niobrara River. Cook first met Chief Red Cloud in 1874 when Yale University Professor Othniel C. Marsh came to western Nebraska looking for fossils.

The Oglala Lakota (Sioux) were suspicious of Marsh, because most white men they knew were gold seekers. But "Captain" Cook helped convince Red Cloud and the other Oglala that Marsh was what he said he was, a bone hunter.

Over the years Cook often helped the Oglala and Cheyenne, and a steadfast friendship grew up between the Cook family and the Indians, who brought them many gifts and told them stories about individual items. The family's collection now belongs to the park.

Pictographs painted on hides—one of a buffalo hunt and one of Custer's Last Stand—saddles, bows, shirts (including one of Red Cloud's that he gave to the Cooks, *right*), moccasins, bags, war clubs, pipes, and guns make this collection an outstanding representation of Plains Indian culture. You can see many of these artifacts on display in the visitor center.

His interest in fossils led the Cooks' son Harold to become a paleontologist, publishing many papers and taking part in important scientific research.

Preserved and available to researchers here at the park are the Cook collection, other natural history specimens, the paleontological library of Harold Cook, and family correspondence, books, and papers that span four generations.

Agate Fossil Beds is one of over 390 parks in the National Park System. To learn more about parks and National Park Service programs in America's communities visit www.nps.gov.

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The Age of Mammals

Life in the Cenozoic Era—the Last 65 Million Years

From simple beginnings great numbers and varieties of life forms have evolved and populated the Earth. For 140 million years before the Cenozoic Era, dinosaurs held dominion over the land. Mammals also existed, but they were small and not abundant. As the dinosaurs perished the mammals took center stage. Even as mammals increased in numbers and diversity, so did birds, reptiles, fish, insects, trees, grasses, and other life forms. The fossil record gives us a fascinating glimpse into the Cenozoic Era. Without fossils we would have little way of knowing that ancient animals and plants were different from today's. With fossils we discover that an extraordinary procession of organisms lived in North America and around the world. Species changed as the epochs of the Cenozoic Era passed. Those that could tolerate the changes in the environment survived. Other species migrated or became extinct. The fossil record tells these stories, but the study of fossil remains, paleontology, also raises many questions: What types of environments did these plants and animals live in? How did they adapt to climatic changes? How did different groups of plants and animals interrelate? How have they changed through time?

Fossils are studied in the context in which they were found and as one element in a community of organisms. Every fossil can serve as a key to unlock knowledge, so the National Park Service is especially concerned with the protection of these keys as the questions unfold. The Cenozoic Era continues today—see the right side of the chart below—and scientists estimate that as many as 30 million species of animals and plants now inhabit the Earth. This is a mere fraction of all life forms that have ever existed. Scientists now think that about 100 species will become extinct every day, a rate accelerated by human actions. Pollution of the air and water; destruction of forests, grasslands, and other ecosystems; and other adverse changes to Earth's environment challenge life's very ability to survive. "Looking back on the long panorama of Cenozoic life," Finnish scientist Björn Kurten has said, "I think we ought to sense the richness and beauty of life that is possible on this Earth of ours." It is no longer enough to plan for the next generation or two, Kurten suggests. We should plan "for the geological time that is ahead. . . . It may stretch as far into the future as time behind us extends into the past."

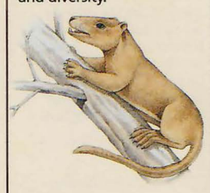
These national parks (NP) and national monuments (NM) feature fossils from the Cenozoic Era: **Agate Fossil Beds NM**, 301 River Road, Harrison NE 69346-2734; **Badlands NP**, P.O. Box 6, Interior, SD 57750-9700; **Florissant Fossil Beds NM**, P.O. Box 185, Florissant, CO 80816-0185; **Fossil Butte NM**, P.O. Box 592, Kemmerer, WY 83101-0592; **Hagerman Fossil Beds NM**, P.O. Box 570, Hagerman, ID 83332-0570; and **John Day Fossil Beds NM**, HCR 82 Box 126, Kimberly, OR 97848-9701.

Paleocene
Began 65 million years ago

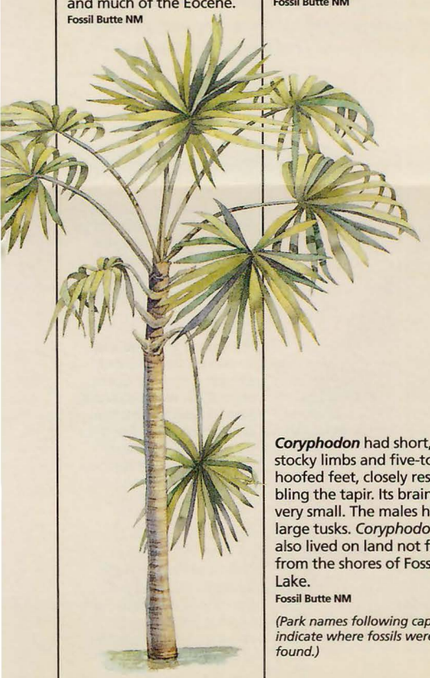
The Paleocene Epoch began after dinosaurs became extinct. Mammals that had lived in their shadows for millions of years eventually evolved into a vast number of different forms to fill these newly vacated environmental niches. Many forms of these early mammals would soon become extinct. Others would survive to evolve into other forms.

The variety of other animals and plants also increased, and species became more specialized. Although dinosaurs were gone, birds continued to flourish, and reptiles lived on as turtles, crocodiles, lizards, and snakes.

As the Paleocene began, most mammals were tiny, like this rodent-like **multituberculate**. With time mammals grew in size, number, and diversity.

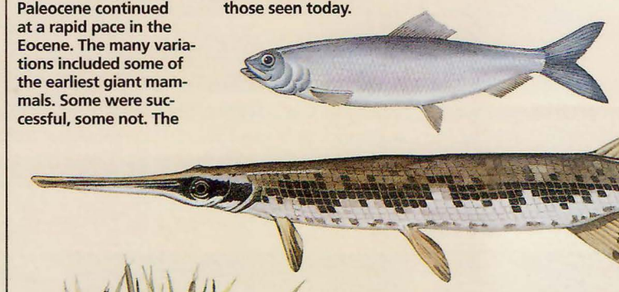


Palm trees and **crocodilians** thrived in the subtropical forests of the Paleocene and much of the Eocene.
Fossil Butte NM



Eocene
Began 55 million years ago

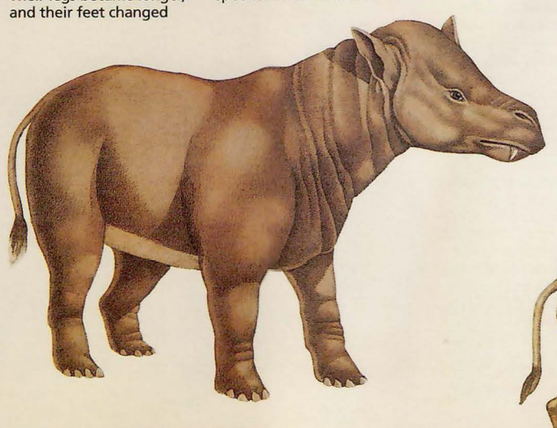
In the Eocene Epoch mammals emerged as the dominant land animals. They also took to the air and the sea. The increasing diversity of mammals begun in the Paleocene continued at a rapid pace in the Eocene. The many variations included some of the earliest giant mammals. Some were successful, some not. The fossil record reveals many mammals quite unlike anything seen today. Increasingly, however, there were forest plants, freshwater fish, and insects much like those seen today.



The variety of flowering plants exploded just before, during, and after the Eocene. They would populate the land with all sorts of new species of trees, shrubs, and smaller plants. **Cattails** grew in the shallows of Eocene freshwater lake edges.
Fossil Butte NM

Ancient tapirs such as ***Heptodon*** browsed near the shores of Fossil Lake in what is now western Wyoming. Unlike modern tapirs, *Heptodon* had a very small snout.
Fossil Butte NM

Living in Eocene forests, the first **horse-like** animals were barely bigger than today's domestic cat. Throughout the Cenozoic Era their size increased. Their legs became longer, and their feet changed from many-toed to single-hoofed for faster running. Their teeth evolved from being adapted for browsing to being adapted for grazing. Just a few of the species in the evolutionary history of horses are shown here in silhouette across this chart. Fossil horses occur at many sites in the National Park System.

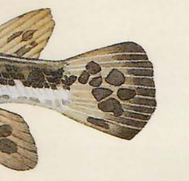


Coryphodon had short, stocky limbs and five-toed, hoofed feet, closely resembling the tapir. Its brain was very small. The males had large tusks. *Coryphodon* also lived on land not far from the shores of Fossil Lake.
Fossil Butte NM

(Park names following captions indicate where fossils were found.)

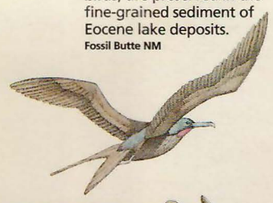
Bats, the only type of mammal ever to develop the power of active flight, took to the air more than 50 million years ago.
Fossil Butte NM

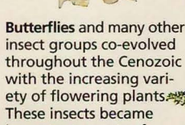
Many freshwater fish lived in North American lakes during the Eocene Epoch. **Gars** *(bottom)*, **herring** *(middle)*, and **sunfish** *(top)* are similar in appearance to those Eocene fish.
Fossil Butte NM



Groves of giant **redwood** trees once grew throughout western North America. Changes in climate were responsible for these trees' shrinking range.
Florissant Fossil Beds NM

Delicate bones of shorebirds, including **frigate birds**, are preserved in the fine-grained sediment of Eocene lake deposits.
Fossil Butte NM





Butterflies and many other insect groups co-evolved throughout the Cenozoic with the increasing variety of flowering plants. These insects became important agents of pollination.
Florissant Fossil Beds NM

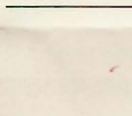
Tsetse flies occur today in tropical Africa and as fossils in the Florissant formation.
Florissant Fossil Beds NM

Oligocene
Began 34 million years ago

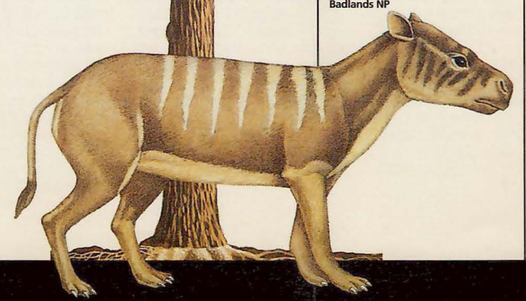
The Oligocene Epoch was a time of transition between the earlier and later Cenozoic Era. The once warm and moist climate became cooler and drier. Subtropical forests gave way to more temperate forests.

Late in the Oligocene, savannas—grasslands broken by scattered woodlands—appeared. These changes caused mammals, insects, and other animals to keep trending toward specialization. Some adapted to the diminishing forests by becoming grazers. Early types of mammals continued to die out as more modern groups—**dogs, cats, horses, pigs, camels, and rodents—rose to new prominence.**

Ekgmowechashala marked the end of the original primate lineage in North America. A small lemur-like primate, it may have used large skin folds to glide from tree to tree. Its name means "little cat man" in Lakota, which the discoverer understood to be their name for monkey.
John Day Fossil Beds NM

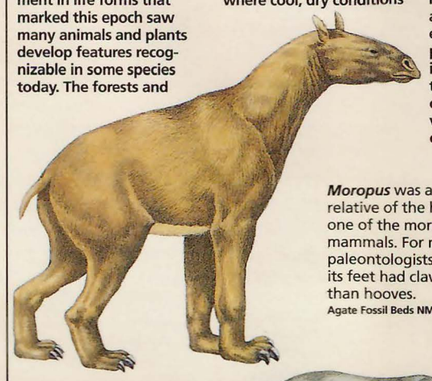


Oreodonts, a group of sheep-like animals, were successful in the Eocene and Oligocene. By the end of the Miocene they had completely died out.
Badlands NP



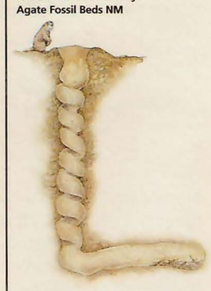
Miocene
Began 23 million years ago

The abundance of mammals peaked in the Miocene Epoch. The refinement in life forms that marked this epoch saw many animals and plants develop features recognizable in some species today. The forests and savannas persisted in some parts of North America. Treeless plains expanded where cool, dry conditions prevailed. Many mammals adapted for prairie life by becoming grazers, runners, or burrowers. Large and small carnivores evolved to prey on these plains-dwellers. Great intercontinental migrations took place throughout the Miocene, with various animals entering or leaving North America.



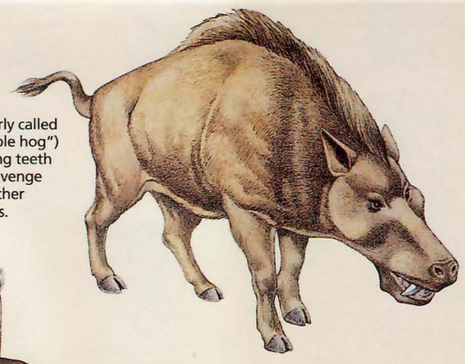
Moropus was a distant relative of the horse and one of the more puzzling mammals. For many years paleontologists thought its feet had claws rather than hooves.
Agate Fossil Beds NM

Lacking other defenses, some larger rodents, such as the dry-land beaver ***Palaeocastor***, lived in colonies beneath the High Plains of North America. Their burrows remain as trace fossils today.
Agate Fossil Beds NM



Rhinos were varied and abundant during most of the Cenozoic Era. Around the world they ranged in size from the three-foot-tall North American species ***Menoceras*** (shown here) to a giant Asian species, the largest land mammal yet found in the fossil record.
Agate Fossil Beds NM

Daphoenodon was carnivorous. It differed from the earliest true dogs of the Oligocene Epoch. Its so-called "beardog" family eventually went extinct.
Agate Fossil Beds NM



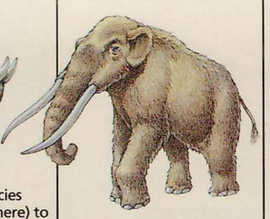
Daeodon (formerly called ***Dinohyus***, "terrible hog") had bone-crushing teeth enabling it to scavenge the remains of other grassland animals.
Agate Fossil Beds NM

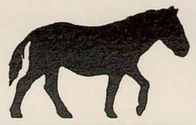
The tiny gazelle-camel ***Stenomylus*** probably grazed in herds for protection from predators.
Agate Fossil Beds NM

Pliocene
Began 5 million years ago

Most life forms of the Pliocene Epoch would have been recognizable to us today. Many individual species were different, but distinguishing characteristics of various animal and plant groups were present. Evidence of wet meadows and of dry, open grassland environments has been found in the Pliocene. Toward the end of this epoch grasslands spread across much of North America, brought on by an ever cooler, ever drier climate. Horses and other hoofed mammals and the powerful, intelligent predators that preyed on them continued to prosper.

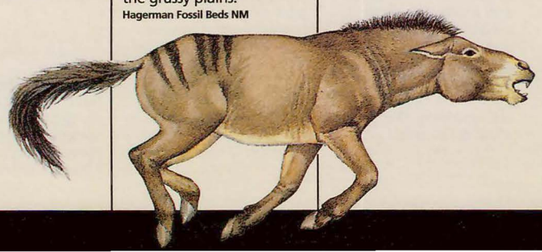
Mammut was a type of mastodon that migrated to North America in the Pliocene. In the early Pleistocene another elephant group called mammoths joined the mastodons. By the late Pleistocene mastodons and mammoths both became extinct, possibly because of climatic changes or hunting by early people.
Hagerman Fossil Beds NM





Willow, alder, birch, and elm grew on the ancient river plains of the Pliocene. These same plants grow along streams and rivers today.
Hagerman Fossil Beds NM

Horses such as this early zebra-like version of the modern horse were superbly adapted to life on the grassy plains.
Hagerman Fossil Beds NM

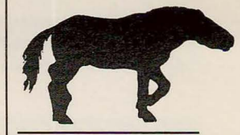


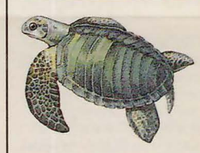
Pleistocene
Began 2 million years ago

The Pleistocene Epoch began with widespread migrations of mammals and ended with massive extinctions. It was also a time when glaciers repeatedly covered much of North America.

Known evidence of humans living in North America dates to about 12,000 years ago. In this relatively brief period we have had a profound effect on the plants and other animals here. Do we have a responsibility to try to limit our effects on other species, or are humans simply a natural agent of extinction?

Endangered species today include the **loon** *(top)*, **timber wolf** *(middle)*, and **Kemp's ridley sea turtle** *(bottom)*. The National Park Service is among the many public agencies and private organizations entrusted with helping to protect endangered plants and animals and to preserve the diversity of life throughout North America.





TREE ILLUSTRATION NPS/JOHN DAWSON. ALL OTHER FULL-COLOR ILLUSTRATIONS NPS/KAREN BARNES. SOME DEPICTIONS OF MAMMAL SPECIES FOLLOW FOSSIL RECONSTRUCTIONS AS REPRESENTED IN R.J.G. SAVAGE AND M.R. LONG'S *MAMMAL EVOLUTION: AN ILLUSTRATED GUIDE*, NEW YORK: FACTS ON FILE PUBLICATIONS, 1986. THE DRAWINGS ARE NOT TO SCALE.