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The Last Entire Earth

by Paul S. Martin

In his explorations around Concord, Massachusetts, Henry David Thoreau, whose eye for prehistoric artifacts was unexcelled, never found a fossil mastodon. Unlike the mires of Orange County and other parts of New York State, New England harbors few, if any, fossil Proboscidea (elephants).

Nevertheless, Thoreau thought about them, perhaps stimulated by reading *Voyage of the Beagle* where Darwin mentions the extinct megafauna of South America. During a Philadelphia visit (21 November 1854) Thoreau saw the huge molars of a mastodon from Missouri, housed in the Academy of Natural Sciences. For whatever reason, Thoreau kept an eye out "looking" for images of the extinct beasts. Few naturalists since have bothered.

The stump fences of the Corner Road west of Walden Pond reminded him of fossil remains of mastodons (Journal, 19 July 1851). A pair of boulders in the woods, great slumbering masses of rock, invoked an image of mastodons (3 November 1857). When thaw came, tracks of dogs in thin snow on ice expanded to a foot in diameter, he wrote on 23 January 1860, "with all the toes distinct, looking like the track of a mammoth or a megatherium" (giant ground sloth).

Extinction was still a new idea in Thoreau's day. Not long before, Thomas Jefferson entertained the romantic view that proboscideans might be found alive in the Wild West. The dream vaporized when Lewis and Clark and other explorers with instructions to keep a look out failed to find any. Cuvier, the French paleontologist, used the absence of living Proboscidea in America as evidence of extinction of the American mastodon and of extinction as a fact of life. Part of Jefferson's denial was based on his belief in a great chain of being in which all species depended on each other. Take one away and the whole of creation would collapse. Soon dinosaurs were discovered, fossils much larger and considerably older than those of the ice age megafauna. The great chain of being was a myth. Extinction had become irrefutable.

Thoreau's musings appeal to me. In the shadows along the trail I keep an eye out for the ghosts, the beasts of the ice age. What is the purpose of the thorns on the mesquites in my backyard in Tucson? Why do they and honey locusts have sugary pods so attractive to livestock? Whose foot is devil's claw intended to intercept. Such musings add magic to a walk and may help to liberate us from tunnel vision, the hubris of the present, the misleading notion that nature is self-evident.

Archie F. Carr, the magnificent Florida naturalist, caught the drift when he decided that cattle and even earth movers are understudies for the extinct megafauna. Heavy equipment he was watching dig a ditch attracted snowy egrets that flew up in the wake of the drag line to snatch grubs uncovered by the bucket. Adjacent fields held buff backs (cattle egrets) following cattle, another proxy for the ice age way of life that persists in Africa. "There is a growing emptiness around us, and we fill it in with noise, and never know anything is gone. But the buff back remembers times, with great game thundering through all the High Masai. And back at home you come upon a raging dredger with a wisp of snowy heron there, dodging the cast and drop of the bucket as if only mammoth tusks were swinging— and what can it be but a sign of lost days and lost hours that the genes of the bird remember?" (Ulendo, *Travels of a Naturalist in and out of Africa*, 1964).

To get the true picture, it helps to know more about our prehistoric "game park." It has a remarkable African flavor. The extinct fauna from ice age North America consists mostly of large herbivores. The casualty list of flagship species, large impressive beasts best known by paleontologists, includes mammoths and gomphotheres, the mastodon, horses, camels, ground sloths, giant peccaries, shrub and musk oxen, several bison species, four-horned antelope, giant beaver, tapir, glyptodonts, a giant armadillo, and capybara. Carnivores and omnivores also lost include a giant bear, the dire wolf, two types of machairodont (saber-tooth) "cats," a lion akin to the African lion and a cheetah. The

illustration is of Smilodon, *the New World sabertooth*

disappearance of a grand total of at least 30 genera and 50 species of large creatures up to the size of the imperial mammoth in North America, with even more losses of megafauna in South America, is one of the great mysteries in the deep history of our hemisphere.

Geological evidence indicated that the mammoths and the other animals vanished toward the end of the Quaternary [near the end of the Pleistocene epoch, 10,000-12,000 years ago—Sci. Ed.], long before the Europeans arrived. The last ice age saw many comings and goings of polar ice sheets. Out of all the ferment—a rise and fall of sea level, changes in carbon dioxide gas content and dustiness of the atmosphere, changes in sea surface temperature and in seasonality of the climate accompanied by prehistoric human and other animal invasions—it may not seem surprising that so many extinctions took place. In the 1950s, when I began to look into some of this, there were casual speculations on what caused the end of the golden age of mammals, whatever that meant. But the matter lay dormant for the most part, as it had for many years. No one knew just when or how fast the animals disappeared. Without fixing these extinctions in time, speculations on cause or consequences were fruitless.

With the advent of a new and powerful method of dating, matters began to change. The touchstone was carbon-fourteen, a slowly decaying radioactive isotope with a half life of 5700 years produced by cosmic ray bombardment of nitrogen. Measurements of the amount of carbon-fourteen remaining in organic matter after death of an organism provided direct dates on the last 40,000 years. Wood from trees dated by dendrochronology is used to calibrate the method. Now geologists could determine when the extinct animals were last around. What would the pattern look like? Would the disappearances be independent of each other, as many expected? What forced the change?

The start was shaky. Into the 1960s and even later, paleontologists sought data on all sorts of fossils; most proved to be poor carbon sources and ill-suited for accurate measurements. Contamination was a serious problem. Bone is cancellous, spongy, and easily penetrated by ground water. Ground water may contain dissolved organic carbon, a vexing source of contamination. Initial measurements of fossil bone from buried sites yielded variable results. If taken literally, the dates (some good, some bad; it was impossible to know) indicated that extinctions had dragged out over at least 10,000 years. At the time no one objected to that. Although many of the extinct beasts, mainly large herbivores plus their associated predators and commensals, suggested potential human prey, there were few good associations between bones of the large extinct animals and human artifacts. With only a few possible kill sites, it seemed unlikely that human activity drove many of the extinctions, especially since they seemed to drag on for thousands of years. This was enough to dissuade most archaeologists that prehistoric people had anything to do with it.

In Arizona and adjacent states, those of us interested in good radiocarbon dates on extinct animals had a golden opportunity. We had carbon-rich fossils in dry caves. We did not have to worry about secondary contamination which complicates the dating of bone or ivory from open sites. From suitable desert caves, we could obtain not only collagen-rich bones but even perishable tissues such as hair, hide, horn sheaths or claws, and the dry excrement of extinct animals—ideal material for reliable dates. The dung, the keratin, and the dry tissues were preserved only because they had never been exposed to water or even to damp air and so escaped being consumed by dermestid beetles and other reducers. There was little, if any, danger of contamination of the carbon-fourteen content of the animal manures we would date. At lec-

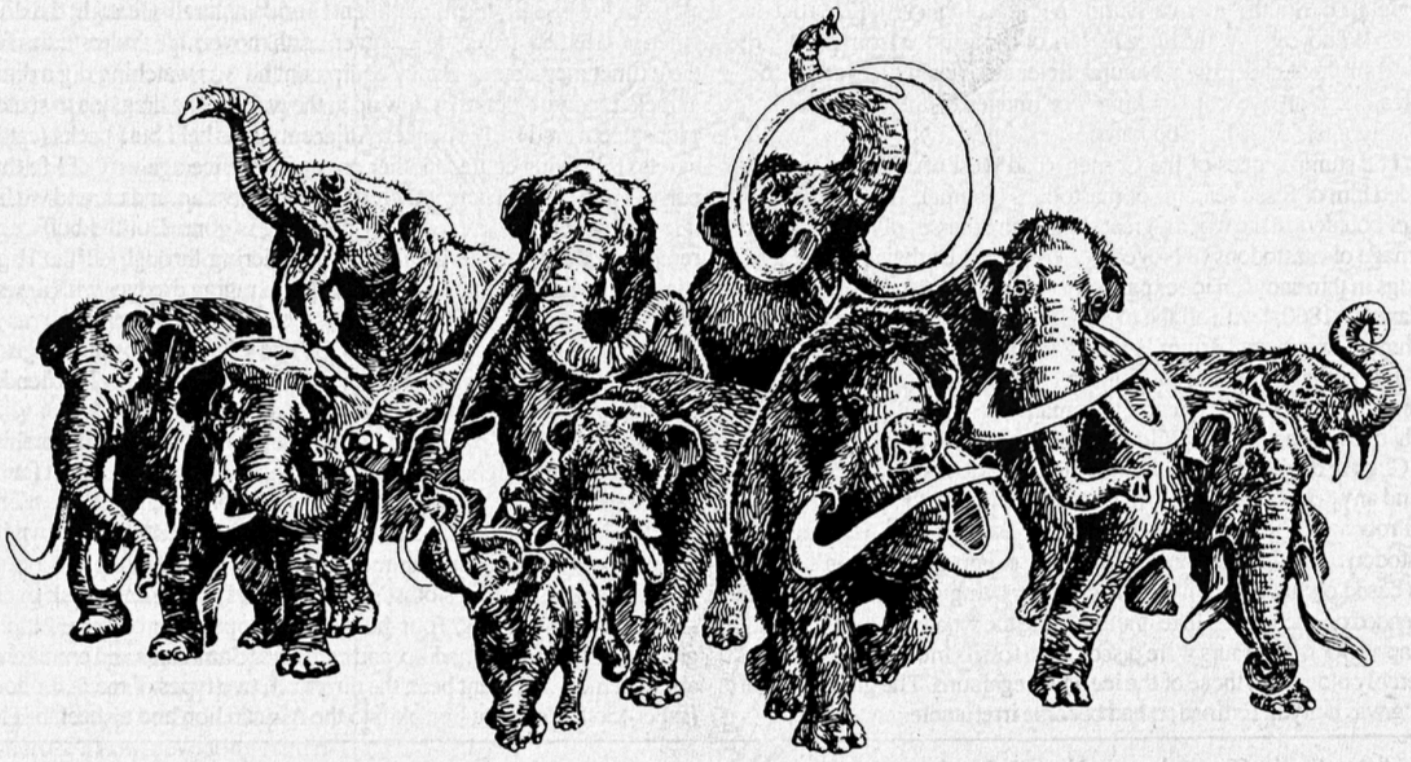


illustration by Peter Murray, based on a painting by Barbara J. Hoopes in Zoobooks, *©1980*

tures I began to brag to audiences that in Arizona we "knew our shit" and thanks to it we could determine with confidence when the extinct beasts were last around.

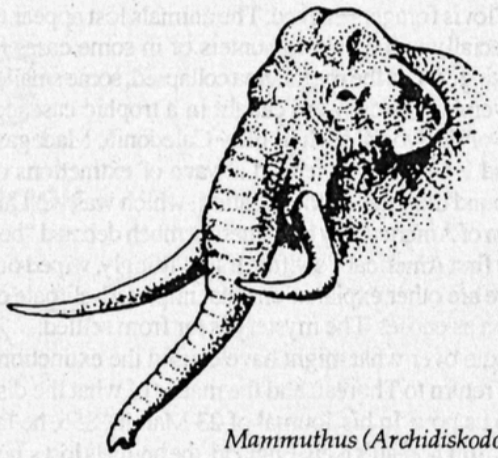
Given the youthful appearance of these organic treasures from the desert caves, one might imagine that the animals involved, Shasta ground sloths, Harrington's extinct goats, Colombian elephants, and native species of horses, might be no older than the prehistoric pueblo farmers or foragers who inhabited dry caves in the Southwest until only 500 to 700 years ago. At times potsherds could be found in close proximity to remains of the extinct megafauna. Perhaps Thomas Jefferson was off by only a thousand years in thinking that New World ground sloths were still living. No one could refute the idea given the fresh looking body parts and fecal remains in desert caves that we were about to date in the radiocarbon laboratory. How long did Shasta ground sloths live in the arid Southwest?

A team of Arizona students and faculty visited the sloth caves and probed museum collections for extinct animal remains, deliberately selecting the youngest when possible. Everything was old, the ground sloth dung, the horn sheaths and fecal pellets of extinct goats, extinct horse hooves, and even dung of mammoth from one unusual cave in Utah. Some specimens radiocarbon dated at 30,000 years or older. The youngest samples we could obtain were also ancient, between 12,000 and 10,000 radiocarbon years old. From carefully dated archaeological sites studied by geologist Vance Haynes, we knew that mammoths lived in the Southwest no later than 11,000 years ago. The disappearance, as we determined by radiocarbon dates from separate caves, of ground sloths, extinct goats, and horses along with the mammoths did not look gradual, as many paleontologists once imagined. It looked like the extinctions happened fairly quickly and all at once. Lewis and Clark had arrived 10,000 years too late to encounter a mammoth or a ground sloth.

We were running out of species suitable for critical dating and had no dates on carnivores. Luckily, fresh chronological support came from an unexpected quarter. Geochemists had refined their techniques on quality radiocarbon dating of bone from open sites, finding ways to remove organic contaminants. Petroleum residues from the Rancho La Brea tar pits ensured good preservation of the fossils they contained. Bitumen is a sealant against moisture. Once the oily sealants were removed, California geochemists Les Marcus and Ranier Berger obtained some 50 new radiocarbon dates on the extinct fauna from Rancho La Brea, most on the fossil bones of the saber tooth, *Smilodon*. As scavengers or predators capable of an explosive rush at vulnerable prey, the big cats would be closely linked to the abundance of the large herbivores. A gradual decline in the latter might result in saber tooth extinction even before the large herbivores were all gone.

No such change could be seen in the saber tooth radiocarbon dates obtained by the California geochemists. The youngest dates were slightly younger than 12,000 years old and matched the terminal dates we had assembled on mammoths, Grand Canyon ground sloths, and extinct goats. At least one large carnivore, the saber tooth, exited from the American range around the same time as the large herbivores.

Then radiocarbon dating was further improved. A new technique of carbon-fourteen measurement by accelerator mass spectrometry (AMS) meant only very small samples were needed. A University of Florida graduate student, Steve Emslie, used the Arizona accelerator to date not only bits of fossil condor bones from Grand Canyon caves but also condor eggshell fragments and even a chip of the keratinous



Mammuthus (Archidiskodon) meridionalis

condor beak found in place on a fossil condor skull from a remote unexplored Grand Canyon cave. Such fossils would have been too small to measure previously.

Once again freshness of the fossils suggested late survival. Did the prehistoric Anasazi people in northern Arizona a thousand years ago watch condors soaring over the Grand Canyon to feed nestlings in the great caves of the Redwall and Muav limestone? While some ornithologists imagined such a possibility, none of Emslie's 17 dates on condor remains supported it. The samples were all much too old: 10,000 radiocarbon years old or older. One fossil deposit in a cave in the Redwall could be reached only by ropes. It revealed food scraps brought to nestling condors. Identification of the scraps revealed that the condors feasted upon extinct goats, bison, camel, horse, and mammoth. When these animals disappeared from the Coconino and Kaibab Plateaus, the condors disappeared too. Evidently the surviving megafauna, mule deer and mountain sheep, were insufficient to maintain breeding California condors. The remnant herbivores pale beside the past natives of the region, Shasta ground sloths, mammoth, camels, extinct bison, extinct horses, and extinct goats. Had it survived, such a fauna might well distract Park visitors from the scenery. I hope this illustrates what I mean by the hubris of the present. To behold the Grand Canyon without thoughts of its ancient condors, sloths, and goats is to be half blind.

So the best dating evidence as far as it goes suggests that the extinctions came, for many at least, about 11,000 years ago. That date also marks the appearance of the first widespread archaeological sites, reflecting a New World invasion by Clovis foragers, with big game hunting skills detached from the Eurasian Paleolithic. My friend Jim Mosimann, a biometrician with the National Institutes of Health, had helped me model an imagined invasion, a "blitzkrieg," based on the assumption that the Clovis colonizers rapidly swept the continent, eliminating all of the more vulnerable species. Given a healthy, largely disease-free New World, and easy hunting, we reasoned that the first Americans would increase at two to four percent per year, as many people have historically under favorable circumstances. Within what is now the United States, the extinctions would run their course in about 200 years, the hunters laying waste to a biomass not much less than the weight of domestic livestock currently on the land.

The blitzkrieg model dances along the edge of a narrow time slice. There is no reliable evidence of extinct mammoth, ground sloth, saber tooth or other disappeared species in archaeological sites younger than 10,000 years, and none shows that any of the Late Pleistocene species

disappeared before Clovis foragers arrived. The animals lost appear to have been those especially vulnerable to hunters or in some cases to side effects of the hunting. When the magafauna collapsed, some smaller species, such as scavenging birds, were caught in a trophic cascade. Islands in other parts of the world, such as New Caledonia, Madagascar, New Zealand and Hawaii, experienced a wave of extinctions of their native fauna around the time of colonization, which was well after Clovis colonization of America. My best guess, a much debated "bed time"story, is that the first Americans swiftly, if unwittingly, wiped out our megafauna. There are other explanations that implicate climate or disease or competition as causes. The mystery is far from settled.

Leaving the debate over what might have caused the extinctions to its partisans, let us return to Thoreau and the matter of what the disappearances mean to us now. In his Journal of 23 March 1856, he lamented historic losses. In Thoreau's New England, the animals lost since settlement in the 1600s included the cougar or panther, lynx, wolverine, wolf, bear, moose, deer, beaver and turkey. Seeking to discover the nature of life through nature herself, Thoreau reflected on the extinctions. "I cannot but feel as if I lived in a tamed and, as it were, emasculated country...I should not like to think that some demigod had come before me and picked out some of the best of the stars." The demigods (European settlers) had indeed driven cougar, lynx, wolverine, wolf, et al. from the woods of Concord. And earlier demigods, perhaps the first Americans, had destroyed the mastodons, mammoth, ground sloths, giant bison, and the other large mammals. The continent indeed had known better days, with a suite of large mammals on par with what can now be seen only in an African game park. Thoreau's words reach deeper than he knew: "I listen to a concert in which so many parts are missing... I seek acquaintance with nature—to know her moods and manners. Primitive nature is the most interesting to me. I take infinite pains to know all the phenomena of the spring, for instance, thinking that I have here the entire poem, and then, to my chagrin, I hear that it is but an imperfect copy that I possess and have read, that my ancestors have torn out many of the first leaves and grandest passages."Thoreau was not thinking of mastodons or giant ground sloths but he might as well have been. " I wish to know an entire heaven and an entire earth, "he said. The last entire earth went with the mammoths, 10,000 years ago.

This, then, is our birthright, a continent whose wilderness once echoed to the thunder of many mighty beasts, a fauna that eclipsed all that remains, including the wild animals of Yellowstone and Denali. Those who ignore the giant ground sloths, native horses, and saber tooth cats in their vision of outdoor America sell the place short, it seems to me. This land is the mastodon's land. While "Home on the Range" commemorates buffalo, deer, and antelope, it misses the mammoth, glyptodonts, and camels. There was a wild America considerably wilder than any brought to us on TV. Our late Pleistocene legacy means we can imagine more, not fewer, *kinds* of large animals on public lands, on the western range and in our national parks. The mesquites, the honey locusts and Archie Carr's snowy egrets, to name a few, remember how it was. The rest of us are learning. ❦

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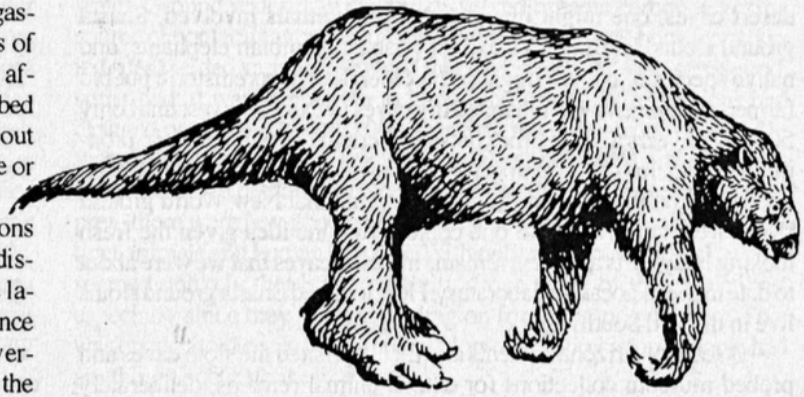

Nothrotheriops, *the Shasta Ground Sloth, hailed for its dung deposits in caves of arid North America.*

Editor's Comment: Professor Martin's article has even more to tell us about our presence in North America than is immediately evident. If his overkill hypothesis—for which convincing evidence is mounting—is at least partly true, some important lessons can be drawn from it:

1) We must be exceedingly cautious in developing and employing new tools and technologies. If early human hunters on this continent exterminated scores of species with nothing more than Clovis points and fire, modern humanity's arsenal is entirely too deadly.

2) Introducing exotic species is inherently dangerous. The native megafauna of North America was susceptible to the depredations of *Homo sapiens* in part because this bipedal hunter was an invader with which the natives had not co-evolved. The one continent still blessed with a wide array of large mammals, Africa, is also the continent on which the other mammals have had the longest time to adapt to (and with) hominids.

3) Environmental ethicists might do well to shift some of their emphasis from developing new normative systems to addressing real-life questions. For example, should we reintroduce the condor to the Grand Canyon, or the lion to its former range in North America, given that these species are now absent here primarily or secondarily due to human overkill?

4) We should be reintroducing, not exterminating, large native mammals in North America. This will necessitate restoring vast wild areas throughout the continent.

—John Davis