

# Fossil Footprints and Ice Age Ecosystems of White Sands National Park

## Plain Language Summary

This fact sheet summarizes the discovery, documentation, and publication of scientific results related to ancient human footprints at White Sands National Park that showed humans were present in North America during the Last Glacial Maximum.

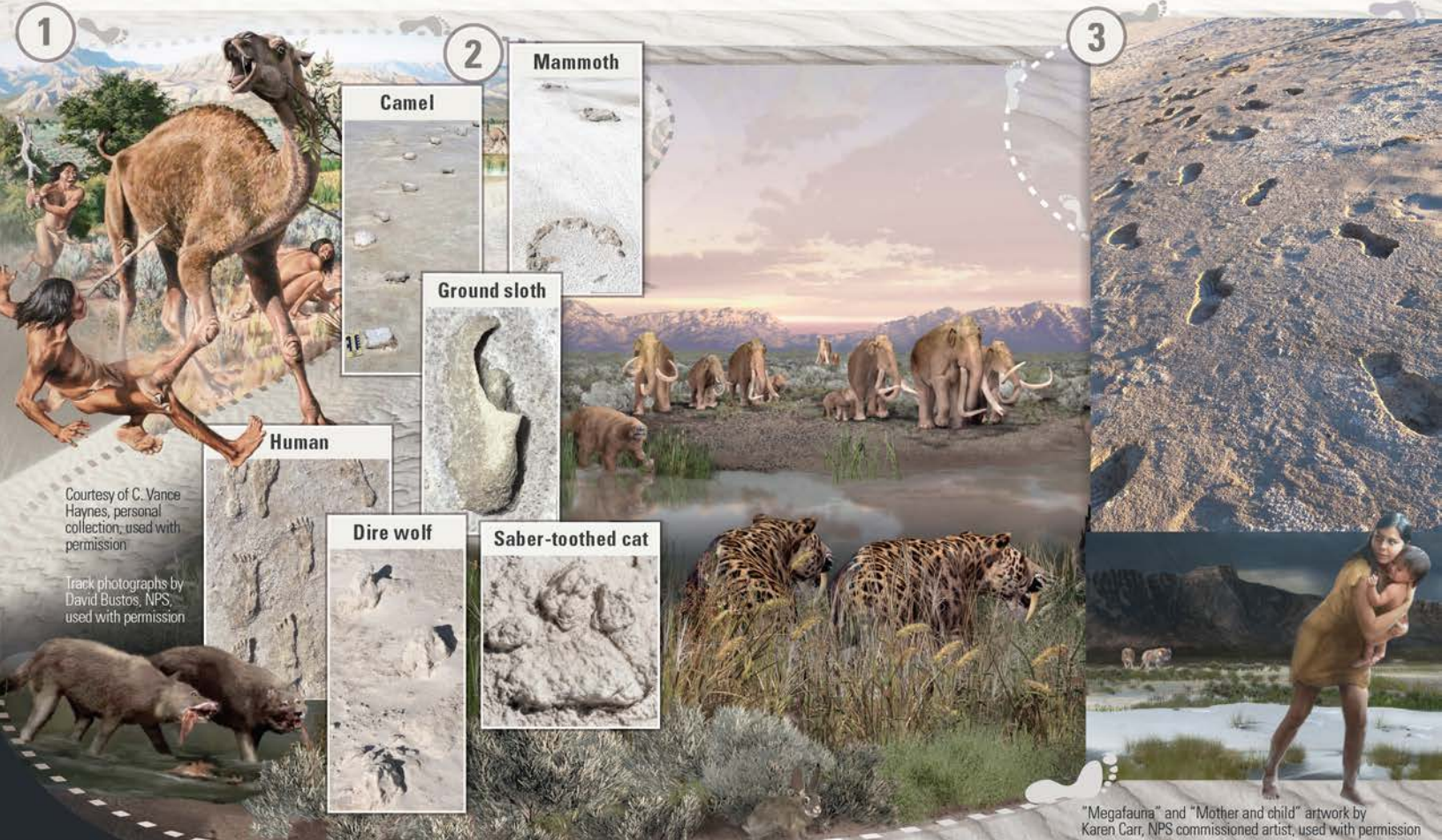
In September 2021, National Park Service (NPS) staff, U.S. Geological Survey (USGS) scientists, and an international team of researchers revealed evidence in the form of human footprints at White Sands National Park, New Mexico, that showed people were present in North America between 23,000 and 21,000 years ago. This time was during the Last Glacial Maximum, when large ice sheets covered much of the continent. The results stunned the scientific community and sparked a global debate. The story of how the discoveries were made, how they upended traditional thought, and how they “rewrote the book” on the earliest phases of North American prehistory is a classic example of the process of science.

For most of the 20th century, archaeologists thought that Clovis people were the first to arrive in the Americas, roughly 13,000 years ago. A few older sites, called pre-Clovis sites, have withstood intense scrutiny and collectively push back the timing of when people

arrived in the Americas to 15,000 or maybe even 16,000 years ago. Some scientists have made claims for older sites, but they remain controversial to the archaeological community.

White Sands National Park staff have been discovering and documenting megafaunal tracks and trackways and human footprints for nearly two decades. The Pleistocene animals that co-occurred with humans included dire wolves, saber-toothed cats, giant ground sloths, camels, and mammoths.

Thousands of megafaunal tracks, trackways, and human footprints are present in the park, and many can be followed for long distances, including the longest fossil back and forth human trackway in the world, which is more than 1.5 kilometers long. There is also evidence of humans interacting with giant ground sloths and following in the footsteps of these now-extinct animals.



Courtesy of C. Vance Haynes, personal collection, used with permission

Track photographs by David Bustos, NPS, used with permission

"Megafauna" and "Mother and child" artwork by Karen Carr, NPS commissioned artist, used with permission



White Sands National Park is located in the Tularosa Basin of south-central New Mexico. Pleistocene Lake Otero occupied this basin, like many other pluvial (Ice Age) lakes in basins throughout the Southwestern United States. White Sands National Park is home to the largest gypsum sand dune field in the world, created from the sediments of Lake Otero that were scoured by wind erosion in a process called deflation, leaving behind the vast Alkali Flat. Some lake deposits and lake margin sediments are still exposed along the edges of the flat.

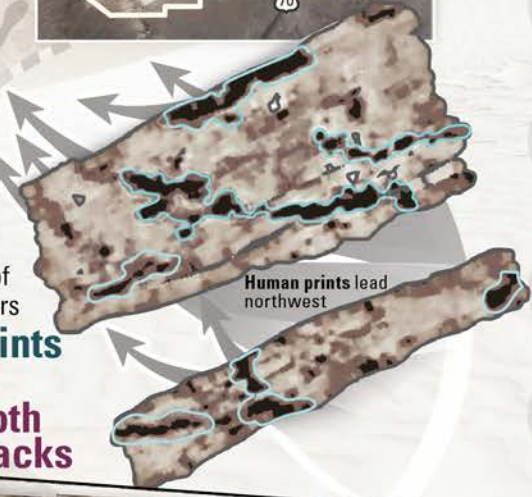
Ground penetrating radar was used at White Sands Locality 2 (hereafter Locality 2), a research site along the east edge of Alkali Flat, to confirm that human footprints were present in the subsurface.

A trench was dug at Locality 2 to expose the sediments and footprint track horizons (TH) in the third dimension. Ancient human footprints are present at multiple sedimentary levels, including TH1, TH2, TH3, and TH4.

The team excavated 61 footprints from 8 distinct stratigraphic horizons at Locality 2, but thousands of unstudied tracks are present in White Sands National Park.

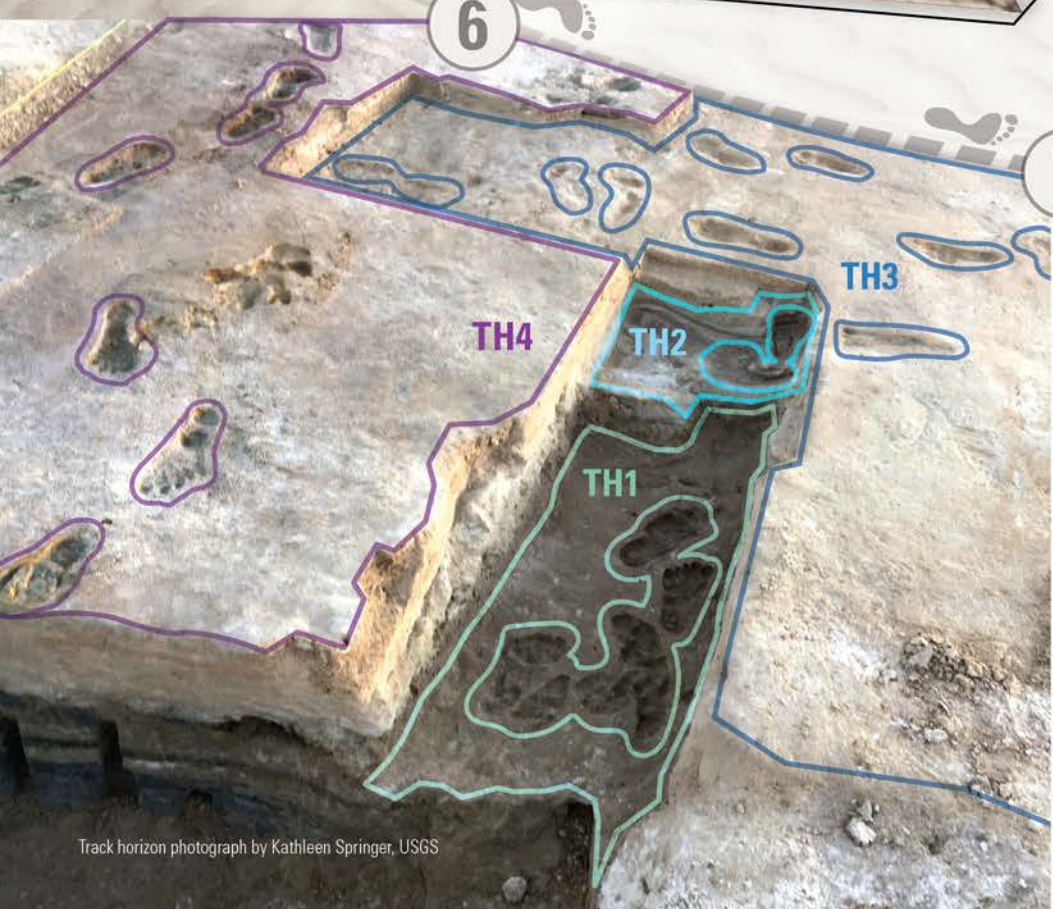
Demographic analyses show the age group most represented by the footprints were teenagers and children between 9 and 14 years old. One hypothesis is the division of labor, where adults are involved in skilled tasks and “fetching and carrying” tasks are delegated to teenagers. Children accompanied the teenagers, thus leaving a higher number of footprints that are preferentially recorded in the fossil record.

**Locality 2**  
**Ground penetrating radar**  
 revealed at depths of 0.15 to 0.20 meters **Human footprints** alongside **Mammoth tracks**



Human prints lead northwest

Modified from Thomas Urban, Cornell University, unpub. data, 2019



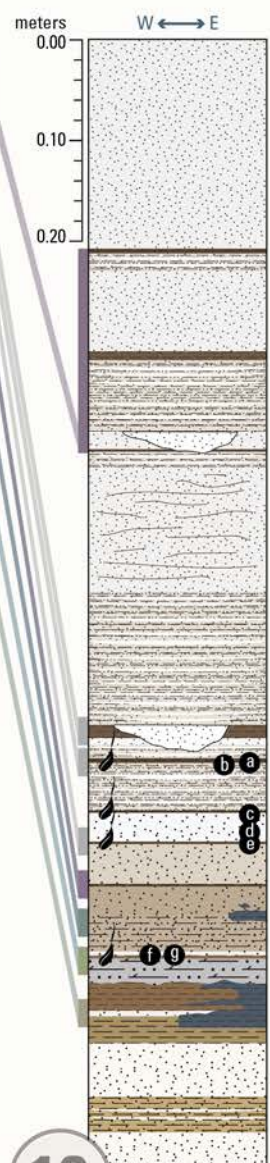
Track horizon photograph by Kathleen Springer, USGS



Footprints photograph from Dan Odess, NPS, used with permission

Children and mammoths artwork author commissioned artist, used

Number of human tracks	Number of trackways	Walking speed in meters per second	Minimum number of track makers	Age in years Standard deviation	Stature in meters	Fauna	Stratigraphic section
*	*		*	*	*		<b>TH8</b> *Data collection ongoing
5	0		3	10.92 ±0.75	1.3–1.6		<b>TH7</b> <b>TH6</b> <b>TH5</b>
37	5	1.34 and 0.56	3–5	11.47 ±0.55	1.1–1.9		<b>TH4</b>
11	2	0.79	3–5	12.19 ±1.26	1.1–1.9		<b>TH3</b>
2	0		1	9.07 ±2.08	1.3–1.5		<b>TH2</b>
5	1	1.03	1	14.61 ±0.42	1.5–1.8		<b>TH1</b>



### Stratigraphic column EXPLANATION



- Sample age, in years with standard deviation
- a** 21,130±250 and 21,750±310
  - b** 22,150±230
  - c** 21,680±300
  - d** 22,550±280 and 22,640±260
  - e** 22,650±260
  - f** 22,800±260 and 22,870±300
  - g** 22,720±240 and 22,860±320

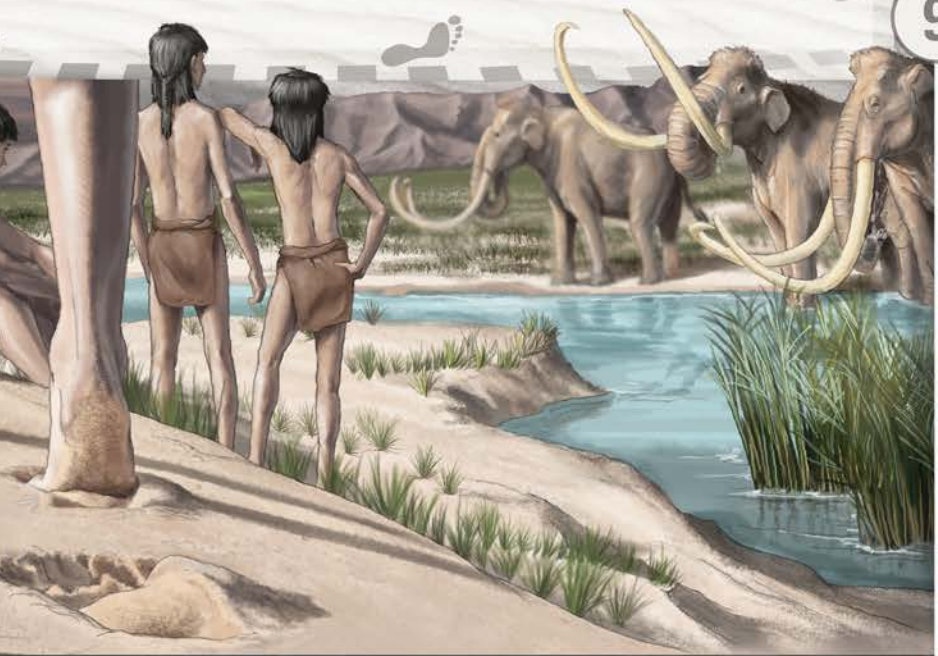
Stratigraphic section and track-maker information modified from Bennett and others (2021)

Within the sedimentary sequence at Locality 2, there are several thin seed layers of *Ruppia cirrhosa* (spiral ditchgrass) found in clay-rich sediments above and below several trackways. Seeds chosen for radiocarbon dating were often still attached to their stems and within well-defined layers, which ensures they have not moved since the plants were alive.

The stratigraphic section and ages before present for sediments exposed in the trench at Locality 2 are shown along with footprint evidence for each horizon (the number of human tracks and trackways, the minimum number of trackmakers, trackmaker age, stature, and fauna). Overall, **TH 2–6** date between 23,000 and 21,000 years ago, recording nearly 2,000 years of human activity at White Sands National Park during the Last Glacial Maximum.

The archaeological community’s response to the news from White Sands National Park has been predominantly positive, but a few scientists questioned the validity of the seed ages and therefore the ages of the footprints. Their main argument was that because *Ruppia cirrhosa* is an aquatic plant, there is the potential for uptake of old carbon from groundwater, which would cause the seed ages to be too old—a phenomenon known as a “hard-water effect.”

### 9 Horizon footprint evidence



### 10 *Ruppia cirrhosa* seeds



from Davide Bonadonna, with permission

*Ruppia cirrhosa* seeds used for radiocarbon dating. Photograph from David Bustos, NPS

Mat of ancient *Ruppia cirrhosa*. Photograph from Kathleen Springer, USGS

To address the controversy, the team obtained radiocarbon ages of terrestrial pollen recovered from the same stratigraphic intervals as the dated seeds and optically stimulated luminescence ages of quartz grains from within the footprint-bearing sediments. Conifer pollen (mainly *Pinus* [pine]) was targeted for radiocarbon dating because conifer trees are terrestrial plants, so this pollen is not subject to potential hard-water effects.

Extensive chemical processing was used in combination with a novel technique called flow cytometry to isolate about (~) 75,000 pollen grains per sample for dating. The results showed that the pollen ages and luminescence ages are statistically indistinguishable from the seed ages, which demonstrates that the original age estimates were accurate and robust (Pigati and others, 2023). The pollen assemblage from sediments containing the footprints includes pine, *Picea* (spruce), *Abies* (fir), *Quercus* (oak), *Artemisia* (sagebrush), and weeds. This assemblage is consistent with cooler and wetter conditions that prevailed in this region during the Last Glacial Maximum.

What caused the footprints to be created and preserved at White Sands National Park? The clues are in the sediments themselves. People were not walking around in Lake Otero; they were walking on a substrate that was a mosaic of wet and dry ground along the lake margin. At Locality 2, dark gypsum-rich clays at the base of the excavated trench represent the lake. The lake sediments are overlain by lighter colored gypsum sands and thin clay layers with seeds that formed in an alluvial and eolian environment, which is the part of the stratigraphic record where the footprints were found.

This change in the sedimentation represents a transition from a shallow lake to a lake margin environment, and it happened very abruptly with subtle shifts in the paleolake levels. The earliest ages of the footprint-bearing horizons are near the base of this transition and date to ~23,000 years ago; this date corresponds to a rapid warming event called Dansgaard-Oeschger (D-O) 2 that began ~23,300 years ago. Abrupt warming at this time drew the lake down, exposing a wide area along the lake margin where the humans and megafauna traveled. This climate signal is consistent with the geologic, hydrologic, stratigraphic, and chronologic evidence from White Sands National Park, which collectively demonstrates that humans were present in North America during the Last Glacial Maximum.

## Acknowledgments

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12  
Pollen grains  
isolated by flow  
cytometry



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## References Cited

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## For More Information

U.S. Geological Survey Geosciences and Environmental Change Science Center  
<https://www.usgs.gov/centers/geosciences-and-environmental-change-science-center>  
 A contribution of the “Integrated Hydrologic History of the American Southwest” project  
<https://www.usgs.gov/southwest-hydrologic-history>  
 National Park Service White Sands National Park  
<https://www.nps.gov/whsa/>

By Kathleen B. Springer, Jeffrey S. Pigati, David Bustos,  
 Thomas M. Urban, and Matthew R. Bennett

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 Background, pine tree, pine cone, and sediment layers photographs  
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