



Distribution of Upper Paleolithic human fossil footprints from White Sands National Park

David Bustos, U.S. National Park Service

Daniel Odess, University of Alaska Fairbanks

Matthew Bennett, Bournemouth University

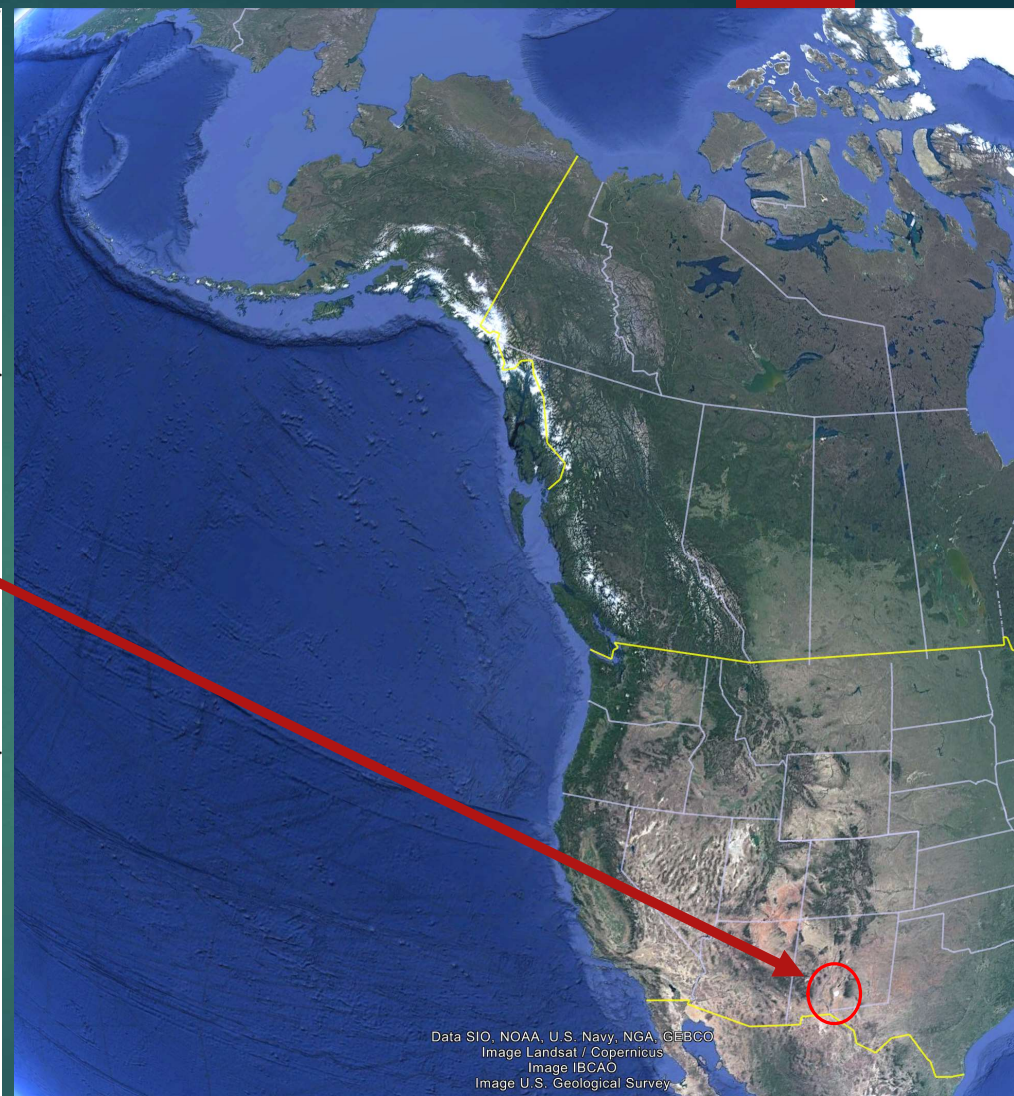
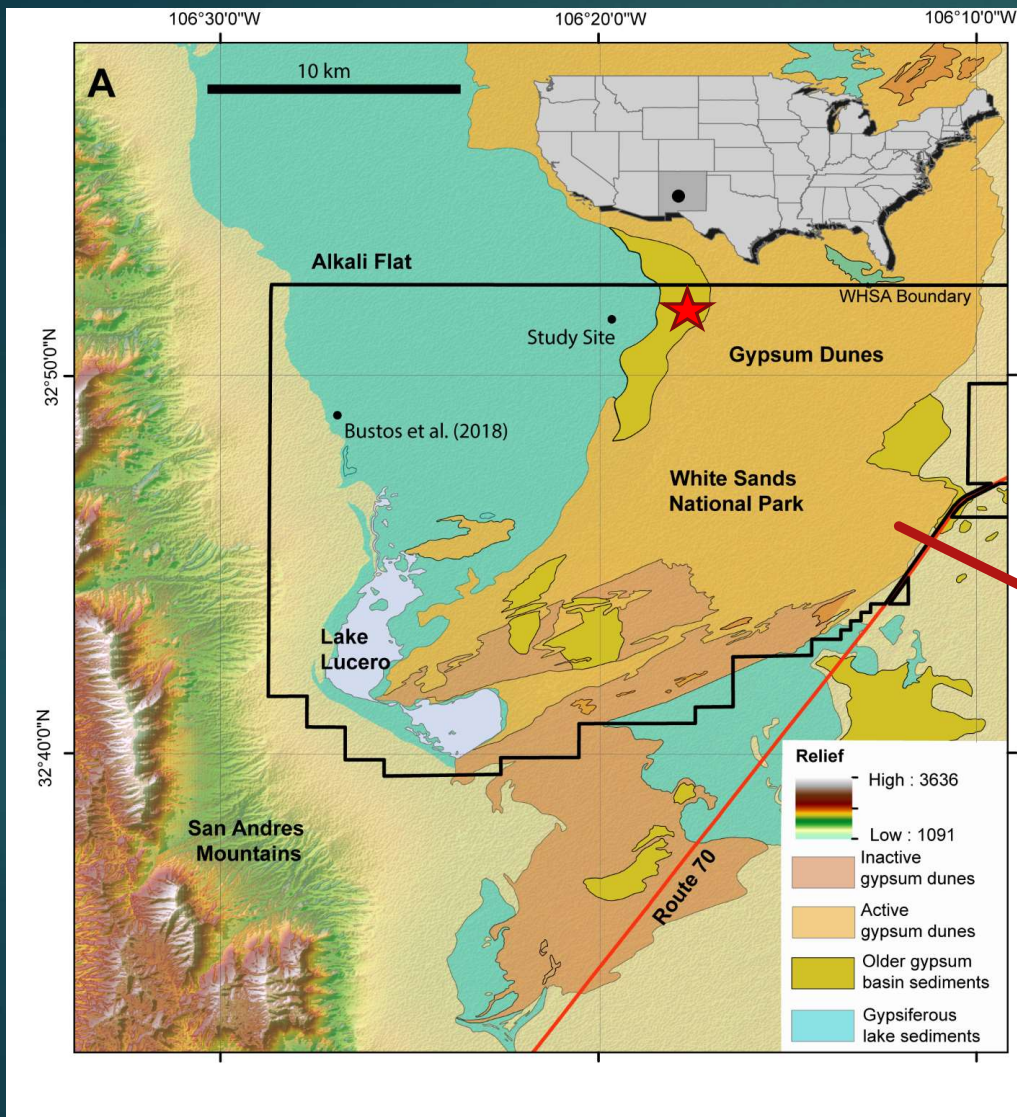
Sally Reynolds, Bournemouth University

Jeffrey Pigati, U.S. Geological Survey

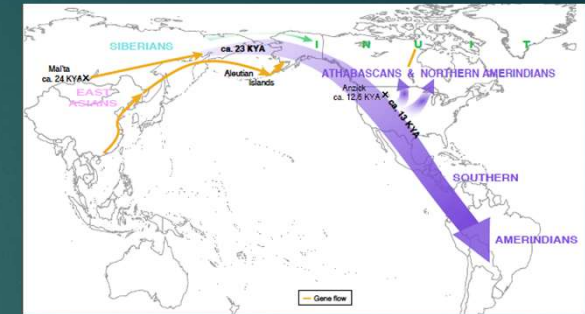
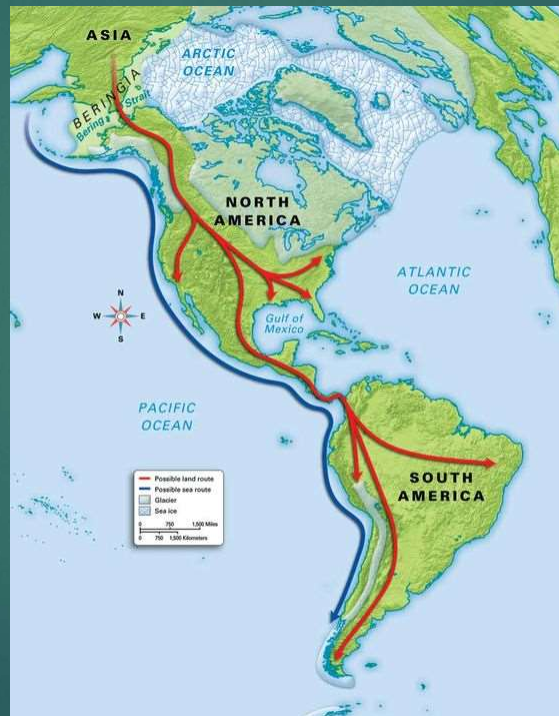
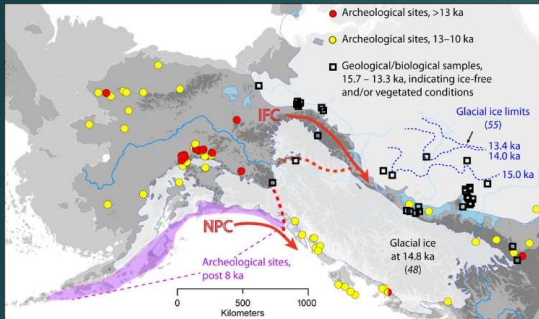
Kathleen Springer, U.S. Geological Survey

Tommy Urban, Cornell University

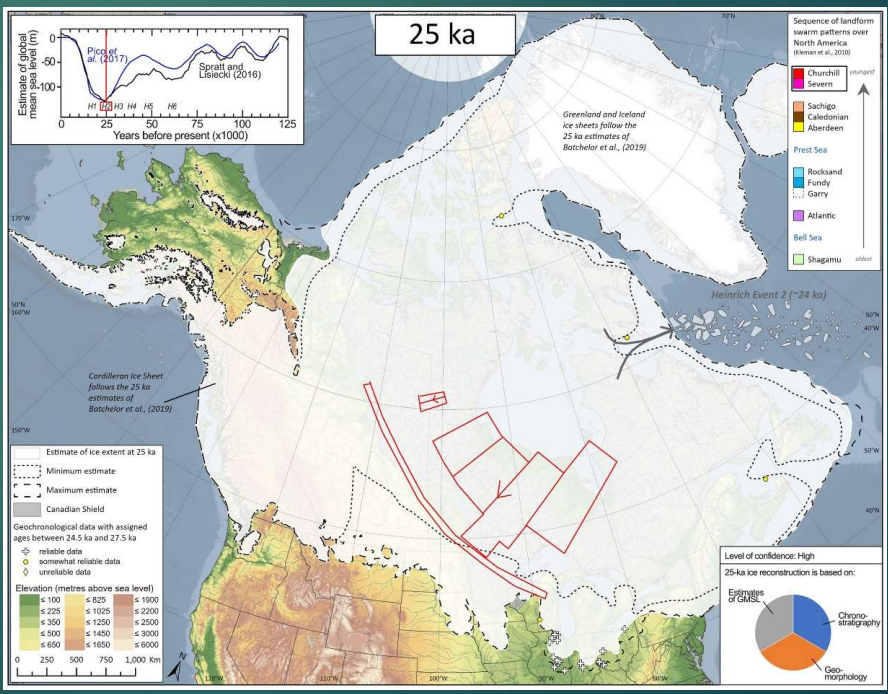
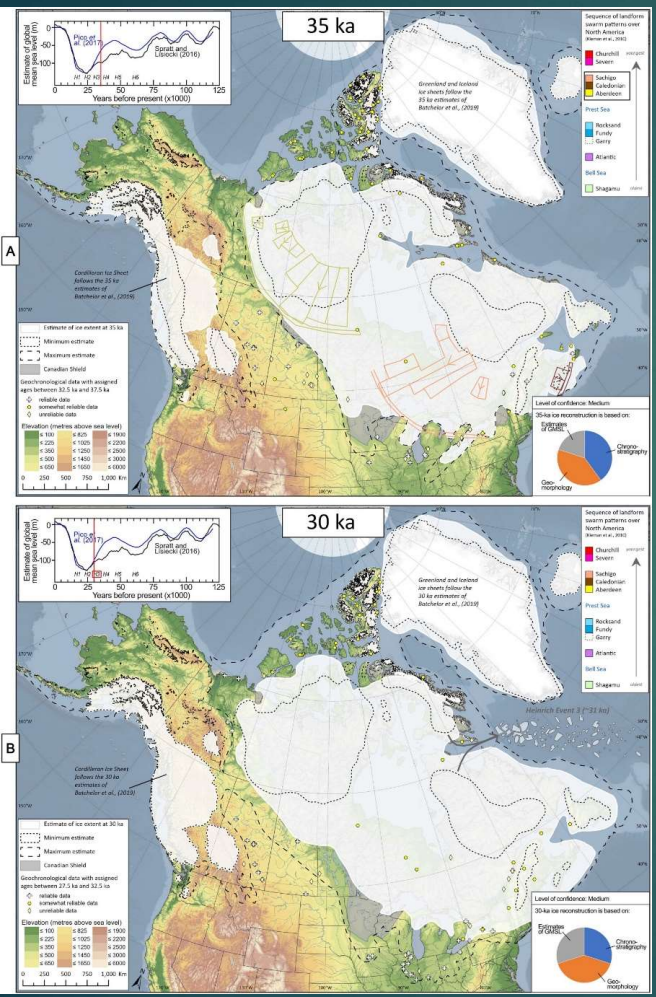
Vance Holliday, University of Arizona

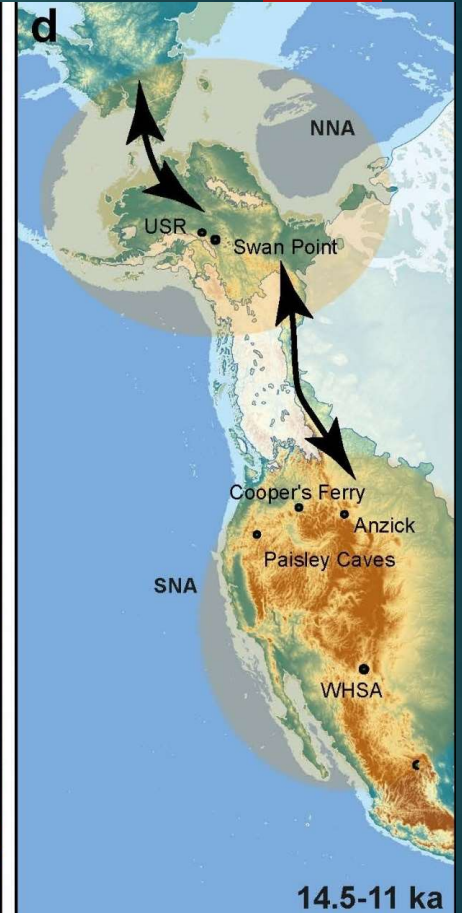
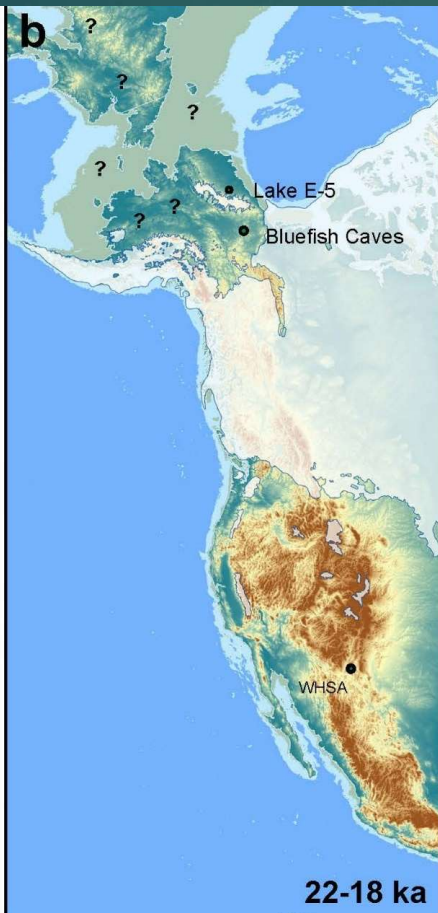


Connections through Space and Time

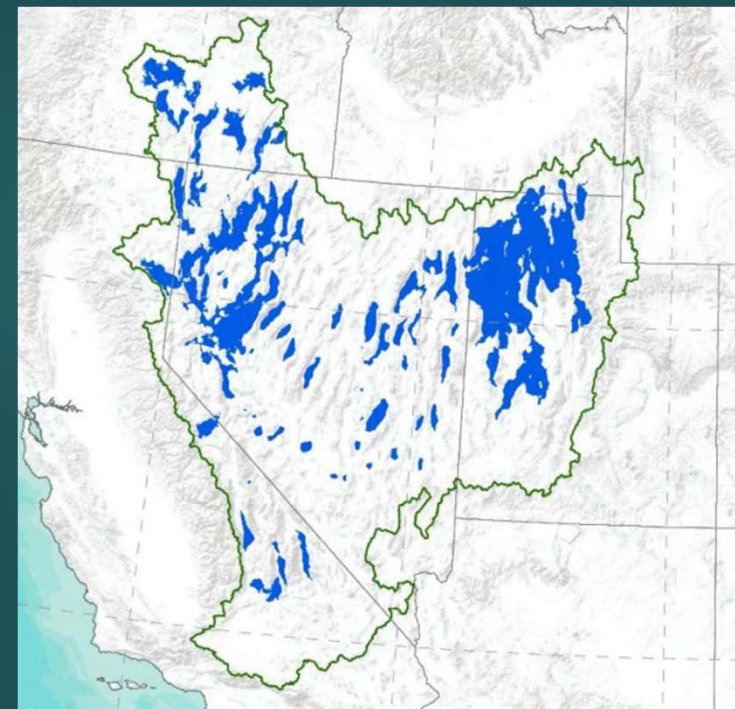


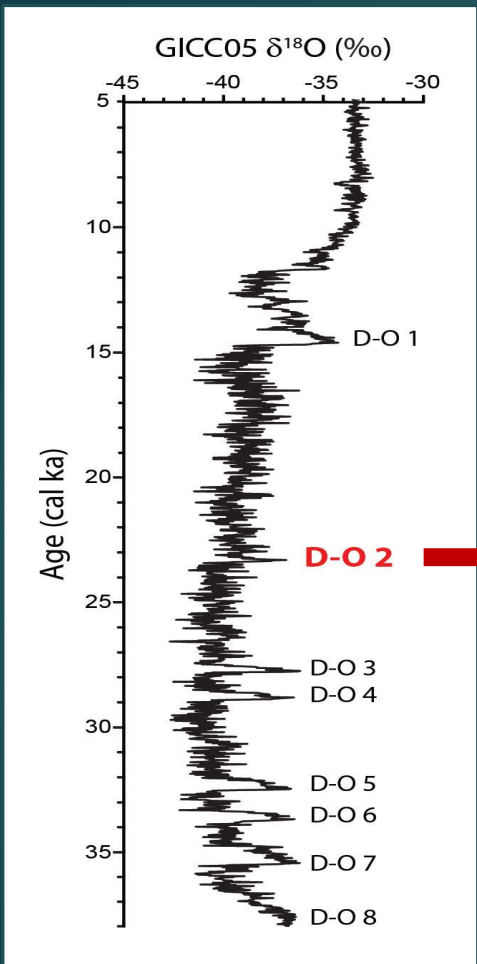
The Position of Ice Before the Last Glacial Maximum (Dalton et al. 2022 ESR)





Rich Pluvial Lake Systems and Modern Dry Wastelands



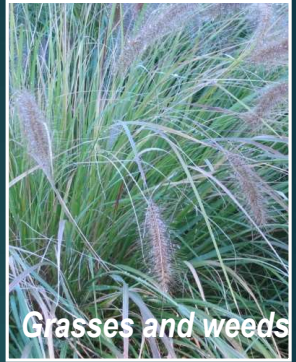




Pine



Oak



Grasses and weeds



Sagebrush



Fir



Spruce

Help of our tribal partners

A Chameleon Landscape

PLAYA Trail

Most of us decide what to wear and what to do depending on the weather. The playsa—the barren dry lakebed ahead of you—also changes depending on the weather. It might be brown. It might be white. It might be filled with water or it could be growing crystals.

What is the playsa wearing today? Walk this trail and discover the importance of a changing playsa to the creation of habitat for plants and animals.

Walk back in time to the end of this trail to see what you may have seen 10,000 years ago.

Una tierra camaleónica

La respuesta de nosotros decidimos qué hacer y qué ponernos dependiendo del clima. La playsa, el árido lecho de lago que ve más adelante, también cambia su aspecto dependiendo del clima. Podría ser café o blanco. Quizás esté llena de agua o con cristales creciendo en su interior.

¿Qué lleva puesta la playsa hoy? Recorra este sendero y descubra la importancia que tiene una playsa cambiante en la creación del hábitat para la flora y la fauna.

Retróvase en el tiempo hasta el final de este sendero para ver lo que había hace 10,000 años en este lugar.

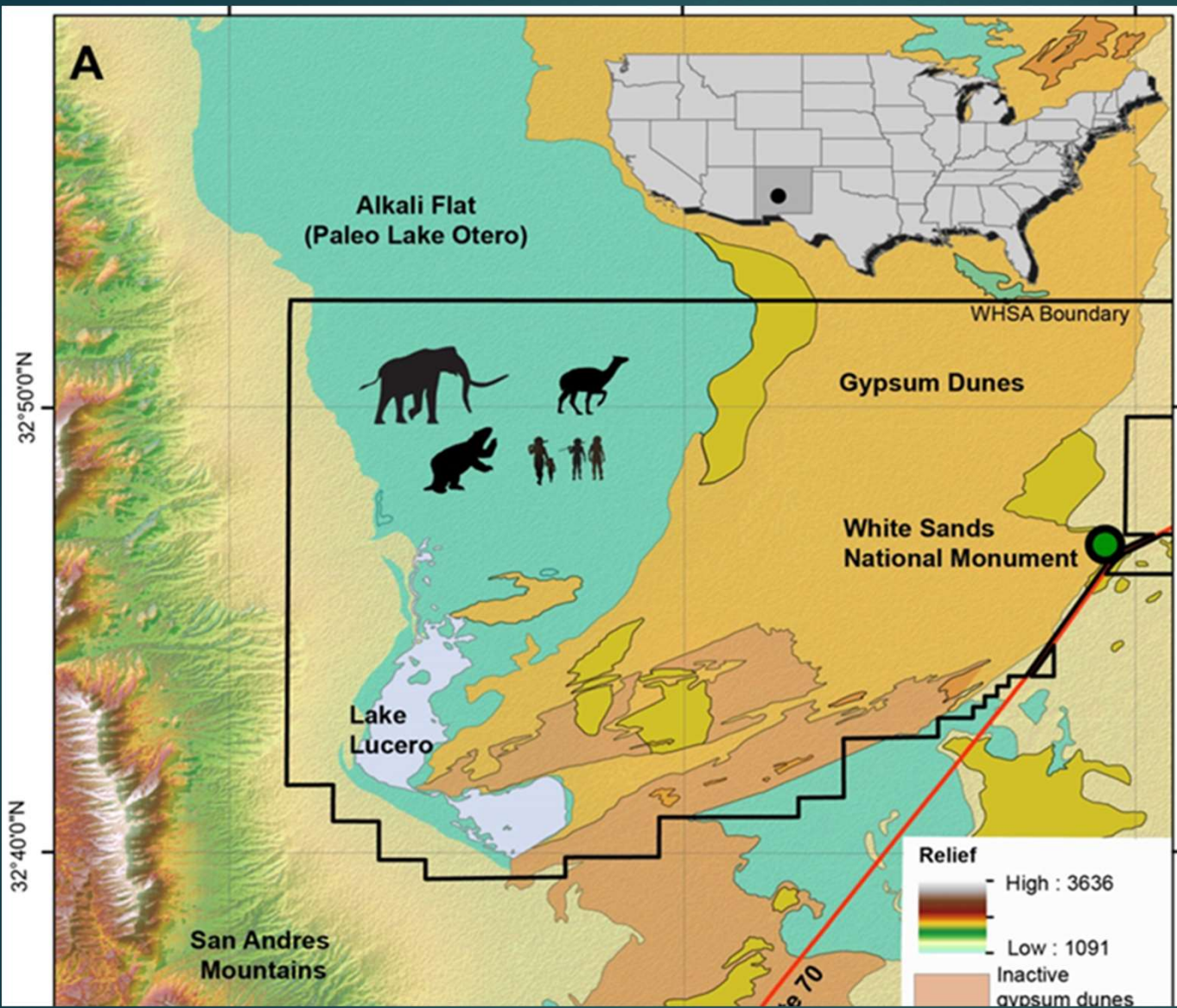


- Involving Tribal Youth in resource management
- Working with Tribes on new interpretation.
- Assistance with research and monitoring





Glimpses of the Past



Ice Age Fossil Prints from White Sands



Artwork by Karen Carr

Bear



Dog/wolf



Large Cat



Sloth



Camelid



Mammoth



Human

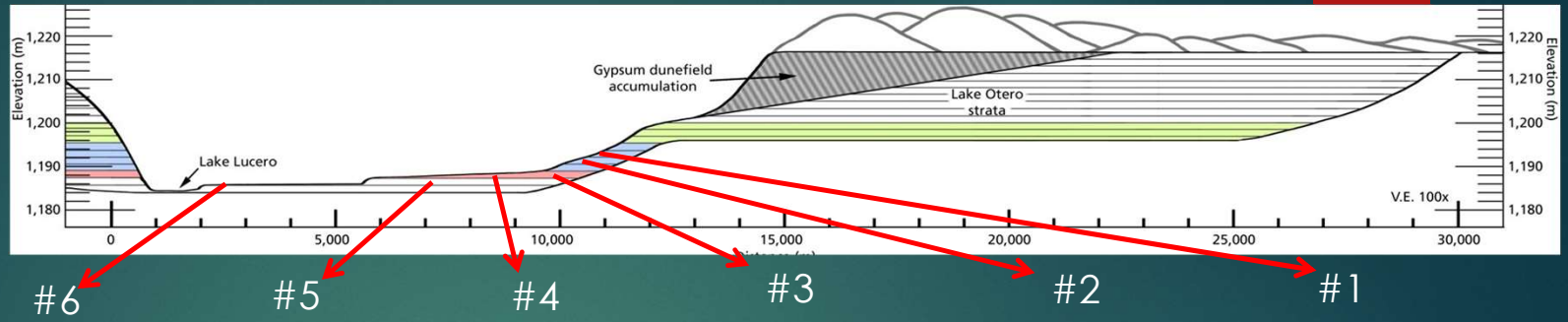


Child and Adult prints from the last ice age



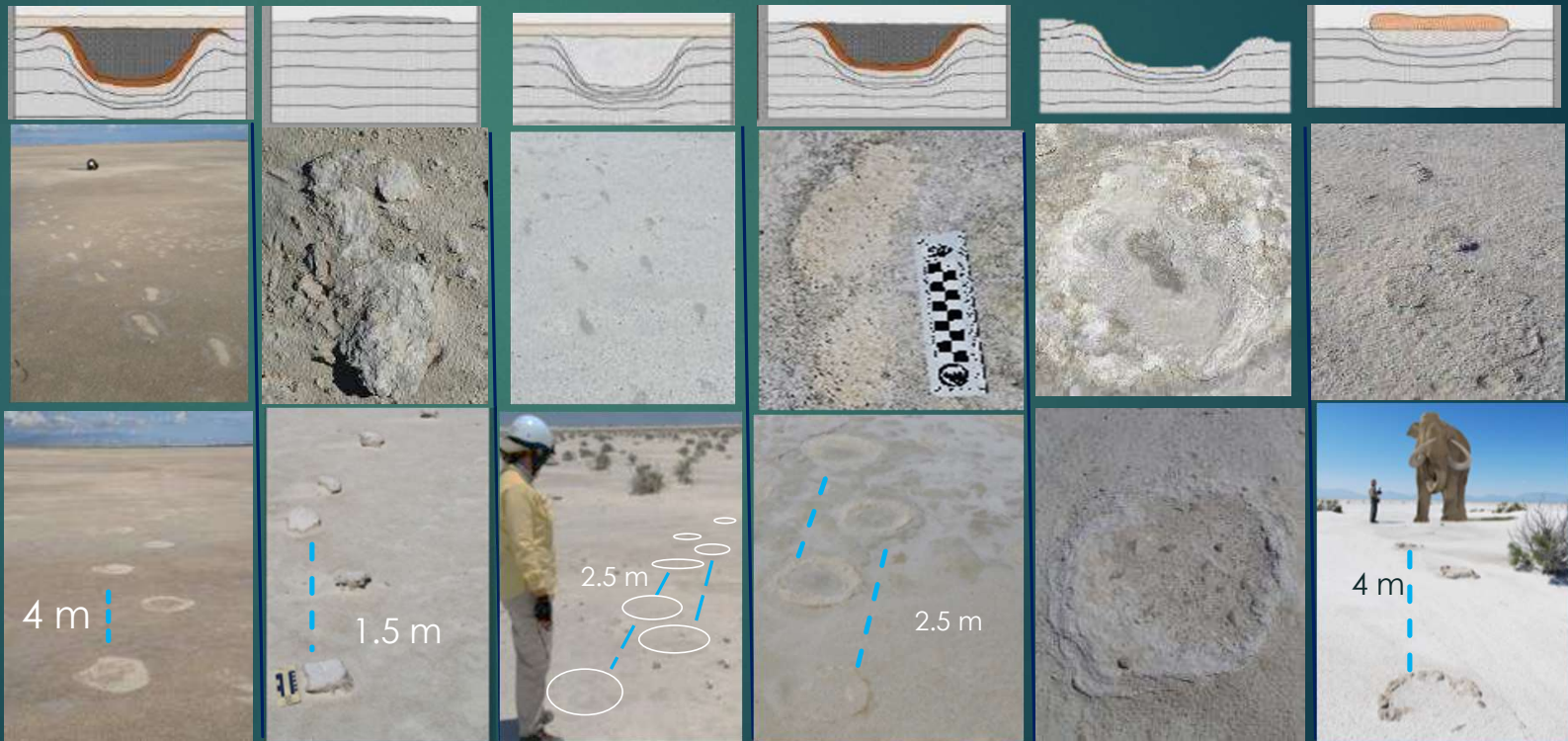
Six Print Types:

1. Clay, positive relief
2. Exposed, negative relief
3. Fine gray sand, no cap
4. Pale Fine Sand with cap
5. Dolomite, positive relief
6. Gary Coarse Sand with cap



Human Prints

Megafauna Prints



“Soil Moisture Visibly Dependent Prints” Always Present, but not always seen



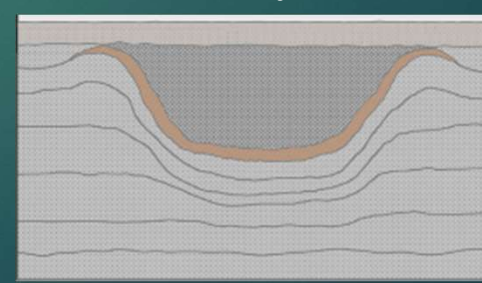
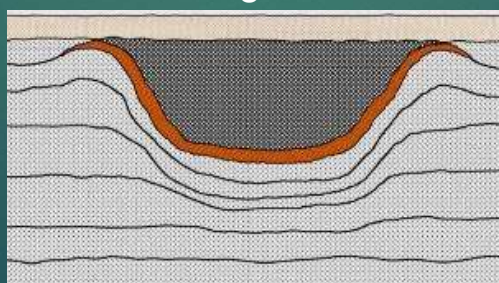
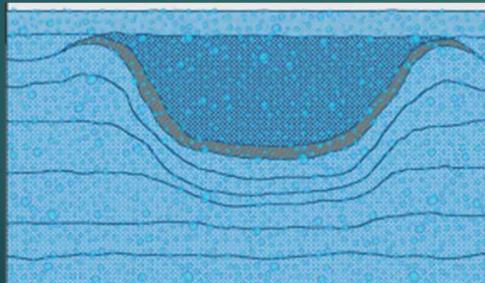
Too wet

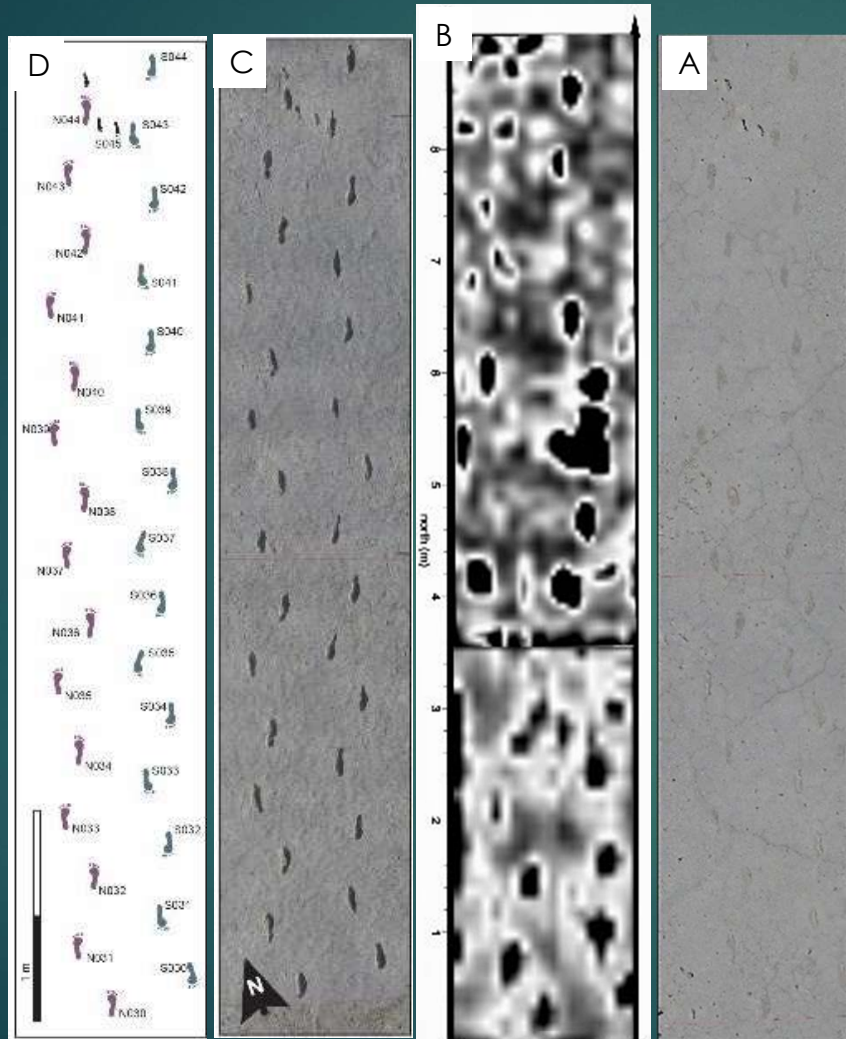


Just right



Too dry

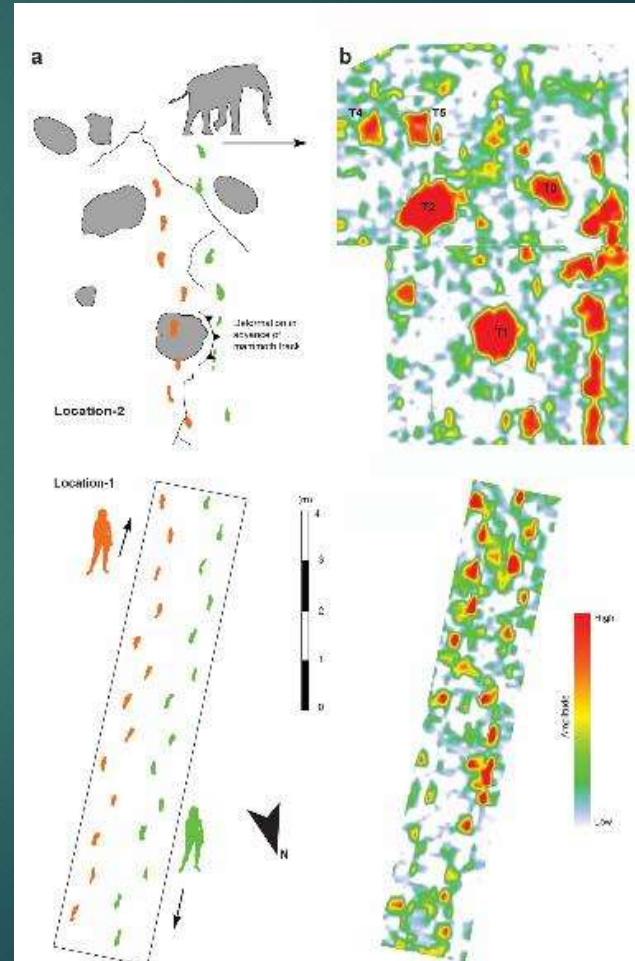
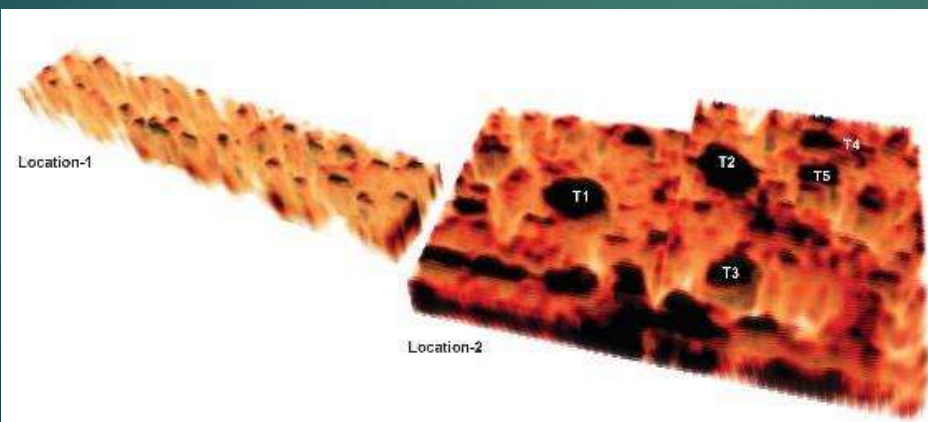




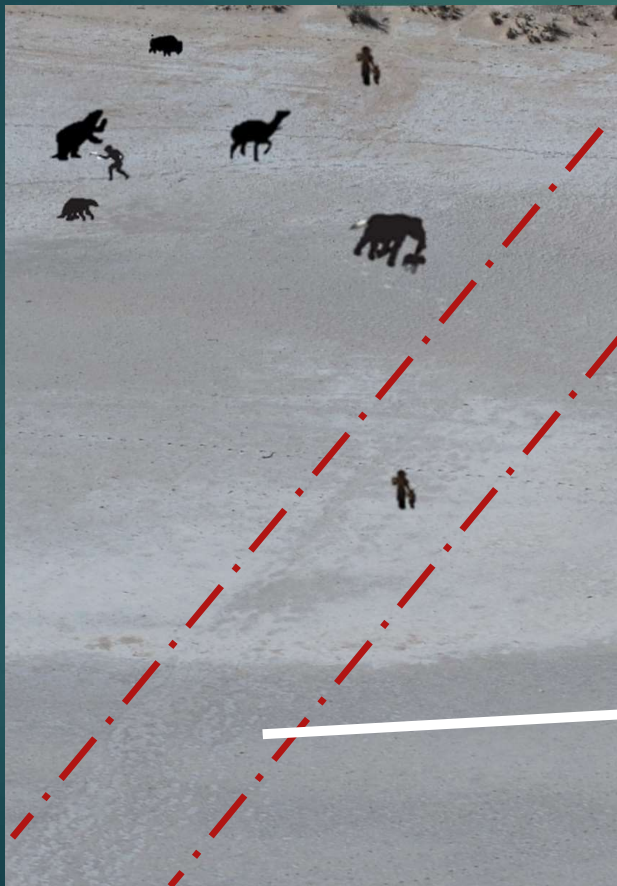
Urban, Thomas M., et al. "3-D radar imaging unlocks the untapped behavioral and biomechanical archive of Pleistocene ghost tracks." *Scientific reports* 9.1 (2019): 1-10.



Documenting and Locating with GPR



Great assemblage of human footprints (in area and number): New class of behavior data for archaeological sites

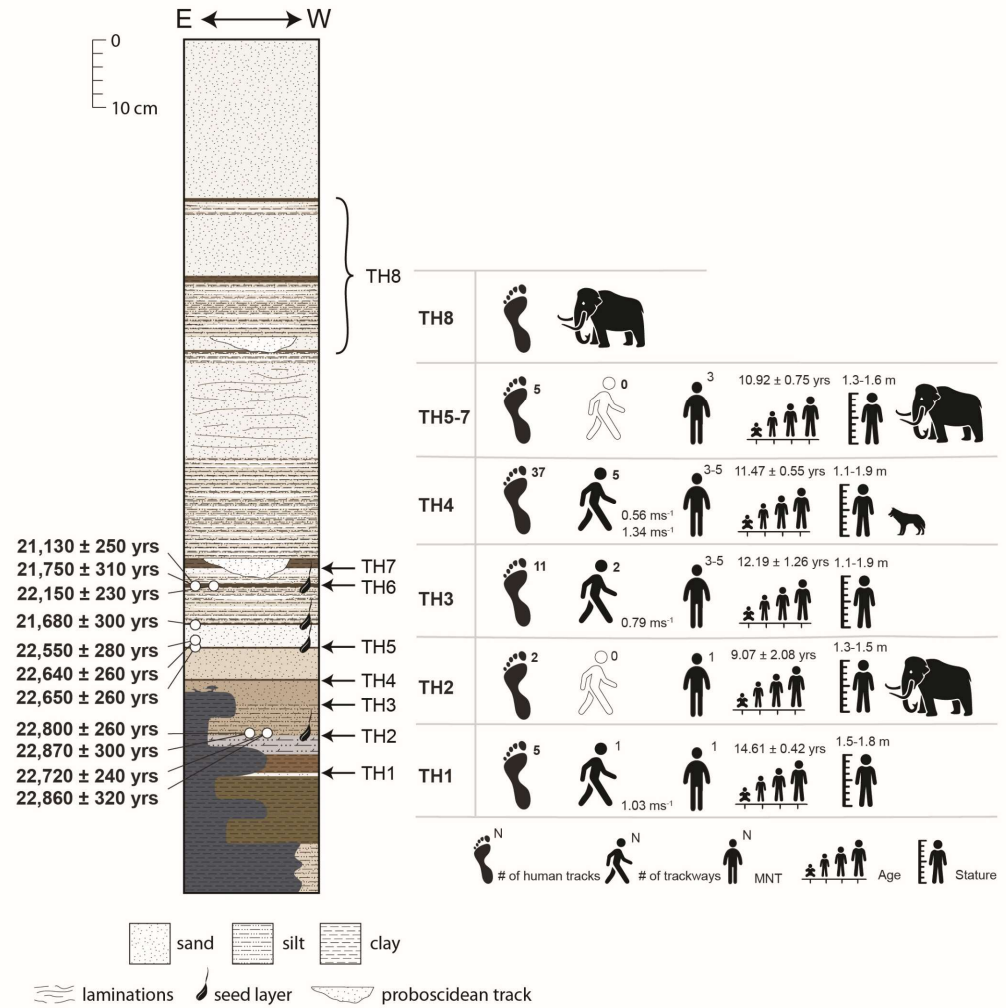
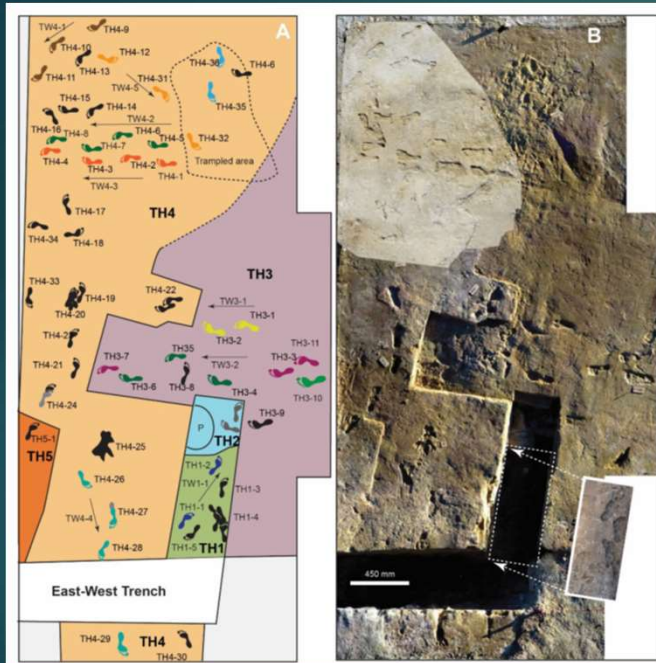




Tracks extend over great distances

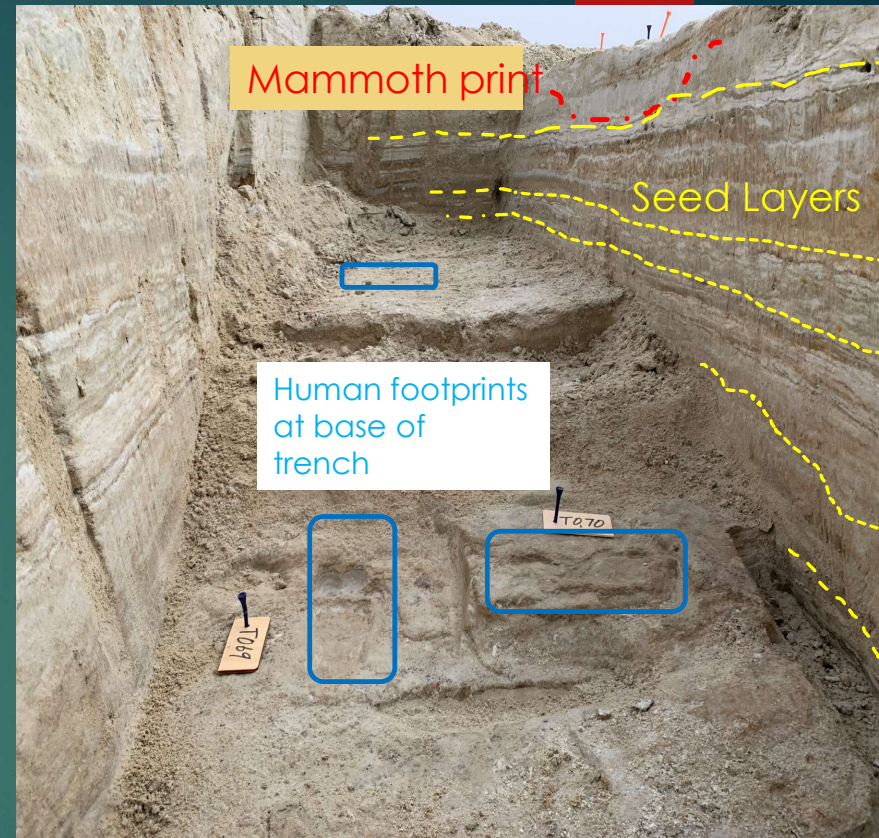


Layers Range From 21,000 to 23,000 BP



Bennett, M. R., Bustos, D., Pigati, J. S., Springer, K. B., Urban, T. M., Holliday, V. T., ... & Odess, D. (2021). Evidence of humans in North America during the last glacial maximum. *Science*, 373(6562), 1528-1531.

Over 11 stratified layers of organics and fossil prints (6. shown below)



Defining the age of the prints

Fossilized Footprints Video - B roll - White Sands National Park (U.S. National Park Service) (nps.gov)



Nice prints, but where are the lithics ???

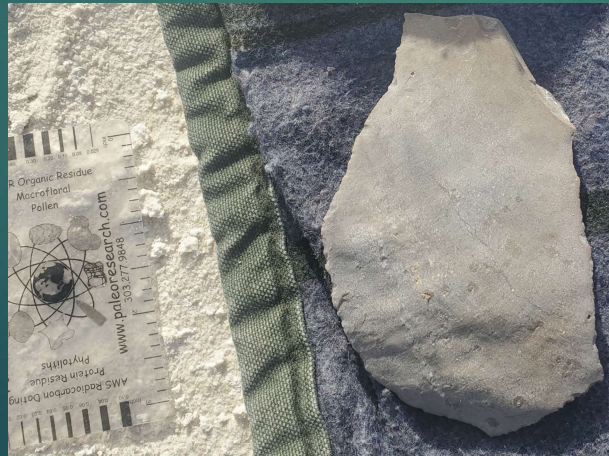
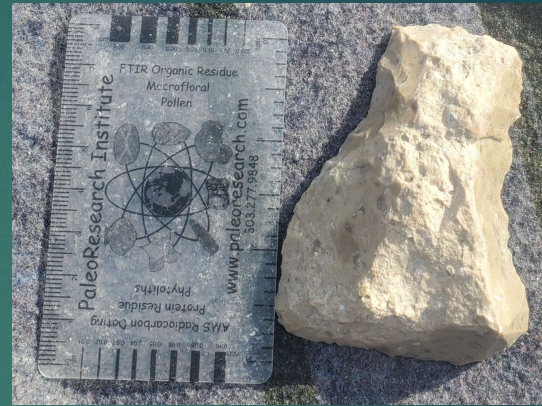
- ▶ Lithics found on same surface as prints
- ▶ Age unknown, could be the same age or younger
- ▶ Many large lithics, retouched edges, do not fit known typologies well
- ▶ No local stones present on salt flats
- ▶ Increased number of sites with lithics found on surface with trackways across 324 km (80,000 acres)



Large Tools Found Near Fossil Prints



Very large bifacial, uniface, and blades with retouched edges



New Ice Age Trail Exhibit

White Sands National Monument


FOOTPRINTS TELL stories

The Harlan's ground sloth is an ancient relative of modern tree sloths, armadillos, and anteaters, although it would have towered over its modern relatives. This massive animal stood as fast as a tortoise and weighed over a ton!

These giant herbivores lived in grasslands where permanent water sources were common at White Sands. Their abundant tracks are sometimes so well preserved that scientists can observe fine details of animal toes, claws, foot shapes, and the texture of fur.

El pesado terrestre de Harlan es un antiguo pariente de los modernos armadillos, armadillos y osos hormigueros modernos, aunque habría superado a sus parientes modernos. Este enorme animal podía ser tan lento como una tortuga y pesaba más de una tonelada.

Estos herbívoros gigantes vivían en praderas cuando las fuentes de agua permanente eran comunes en White Sands. Sus abundantes huellas a veces están tan bien preservadas que los científicos pueden observar fino detalle de los dedos de los pies, garras, formas de las patas y la textura del pelaje de los animales.



White Sands National Monument

ALL COMES TO AN end

One of the best-known Ice Age mammals, the saber-toothed cat was renowned for having oversized canine teeth that reached up to eight inches long and extended outside their mouths. Standing three feet tall at the shoulder and weighing up to 750 pounds, these heavy cats with short legs were built for ambushing prey rather than chasing them. Saber-toothed cats lived coast-to-coast from southern Canada to Peru.

As the Ice Age drew to a close, the large grass and wetlands began to disappear; prey species went extinct and the saber-toothed cat disappeared. Around this same time, Lake Otero began to dry and the world's largest gypsum dunesfield began to form.

Uno de los mamíferos de la edad de hielo más conocidos, el gato de dientes de sable es famoso por tener dientes caninos de gran tamaño que alcanzaban hasta veinte centímetros de largo y se extendían fuera de la boca. Con un metro de alto hasta el hombro y un peso de hasta 750 kilos, estos gatos pesados con patas cortas fueron construidos para emboscar a sus presas en lugar de perseguirlas. Los gatos caninos de sable vivían de costa a costa desde el sur de Canadá hasta Perú.

A medida que la edad de hielo llegaba a su fin, los grandes campos de hierba y los humedales comenzaron a desaparecer. Alrededor de esta misma época, el gran lago Otero comenzó a secarse y se formó el campo de dunas de yeso más grande del mundo.

Paratylocheilus harrisi
Saber-toothed cat
Height: 3.00 (98.43) in
Weight: 750 (1680) lbs (340 kg)
Range: 15,000 (4,760) years ago
Status: Extinct (found only as fossils)



White Sands National Monument

One print AT A TIME

The prints at White Sands are unique in the world both for the variety as well as the length of the tracks, including the longest prehistoric human track ever documented. There are examples of humans stepping on animal prints, and animals stepping on human footprints.

These people were skilled hunters who followed and hunted massive animals. The tracks record people running, walking, kneeling, interacting with each other, tending to children, and following animals. Some tracks reveal children tugging along behind adults and stepping in and out of mammoth tracks as they played.


Una huella A LA VEZ

Las impresiones en White Sands son únicas en el mundo tanto por la variedad como por la longitud de las huellas, incluidas las huellas humanas prehistóricas más largas documentadas. Hay ejemplos de humanos pisando huellas de animales y animales pisando huellas humanas.

Estas personas eran hábiles cazadores que seguían y cazaban animales enormes. Las huellas registran a las personas corriendo, caminando, arrodillándose, interactuando entre sí, atendiendo a los niños y siguiendo a los animales. Algunas huellas revelan que los niños van de un lado al otro arrastrando y corriendo y saliendo de las huellas gigantes de mamotes y jabalíes.

From the prints, it appears that adults were carrying children. The tracks also reveal people typically stood up or knee around and knelt in the opposite direction when they encounter any sign of people. It also appears people hunted ground sloths.

Por las impresiones, parece que los prehistóricos eran capaces de cargar a los niños. Las huellas también indican que las personas con frecuencia se arrodillaban o se inclinaban en la dirección opuesta cuando se encontraban con algún signo de personas. También parece que los gente cazaba mamotes y jabalíes.



White Sands National Monument

ICE AGE Trail

Take a walk back into deep time. Here at White Sands National Park, ancient people and giant animals left behind footprints in the sand that tell a complex story of interaction and behavior.

A large lake, Lake Otero, once covered this land and an extinct lake sediment and flowing streams covered the animal and human tracks, preserving them for thousands of years. The unexpected giant wall of gypsum you see in dunes here that once washed where you are standing.

Regresa al tiempo profundo. Aquí en White Sands, la gente antigua y los animales gigantes dejaron huellas en el barro que cuentan una historia compleja de interacción y comportamiento. Un gran lago, el lago Otero, cubrió esta tierra con sedimentos y corrientes cubrieron las huellas de animales y humanos, preservándolas durante miles de años. Una sorpresiva pared gigante de yeso que se inundó donde estás parado.

TAKE WATER PHONE

Follow the trail markers. Don't take shortcuts. Stay on marked surfaces. No horse riding.

YOU Are Here! Usted está aquí!

1.0 MILE 1600 METERS



EXPERIENCE YOUR AMERICA

Human print in mammoth print



Tracks show interactions occurred



Footprints preserve terminal Pleistocene hunt? Human-sloth interactions in North America.

Bustos, D., Jakeway, J., Urban, T. M., Holliday, V. T., Fenerty, B., Raichlen, D. A., ... & Santucci, V. L. (2018).

Science advances, 4(4), eaar7621.

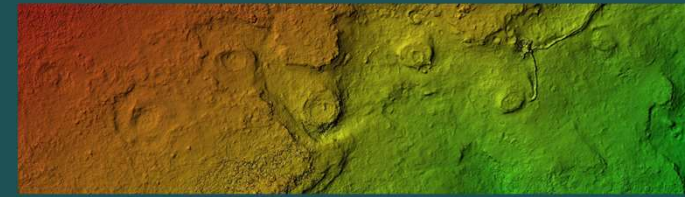
Ground sloth and children prints



Erosion Exposes Tracks

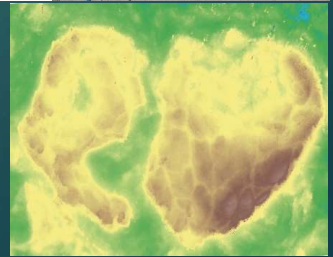


Loss of Mammoth Trackway
2018



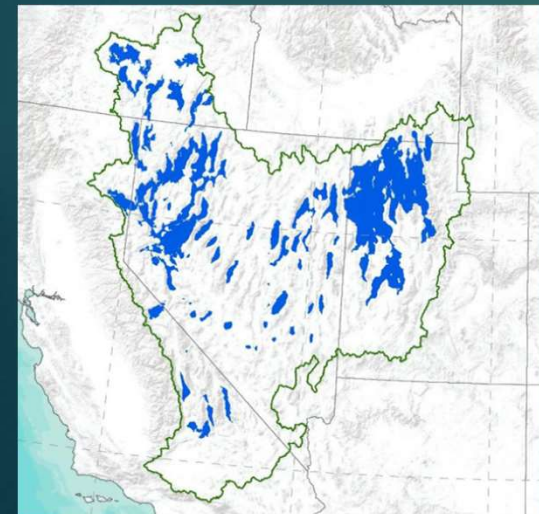
2020

Racing to capture the stories

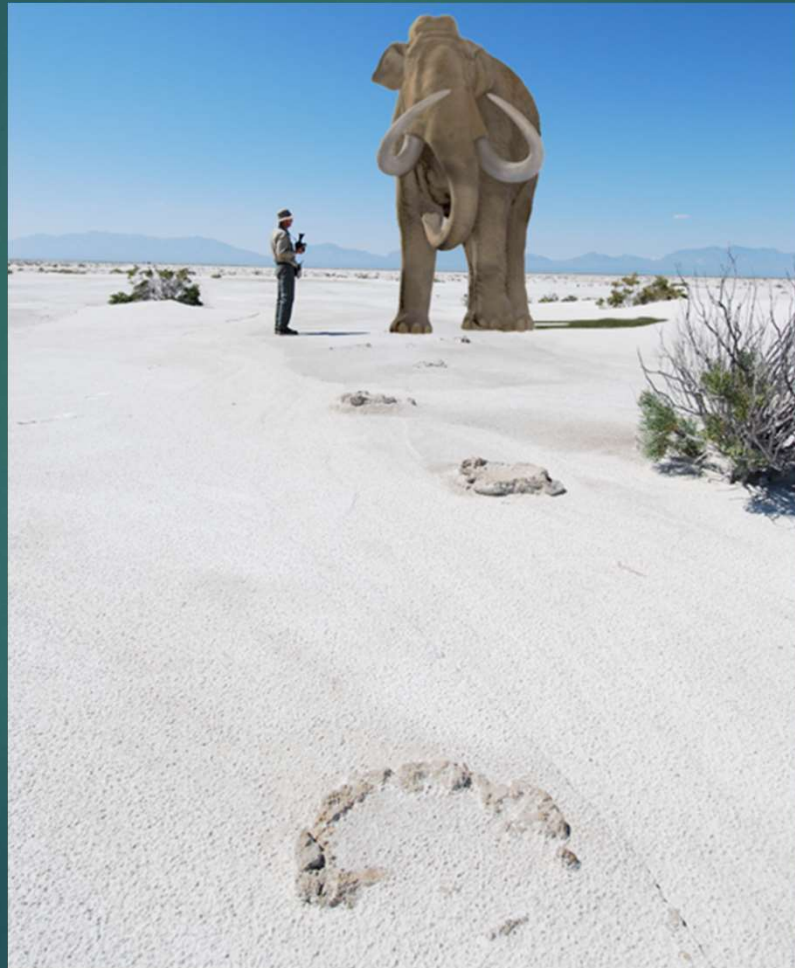


One of many

- ▶ Large pluvial lakes common throughout the Americas
- ▶ Support for large migrations
- ▶ Rapid erosion is a common theme
- ▶ White Sands can server as an analog for other playas where late Pleistocene trace fossil are present and being lost



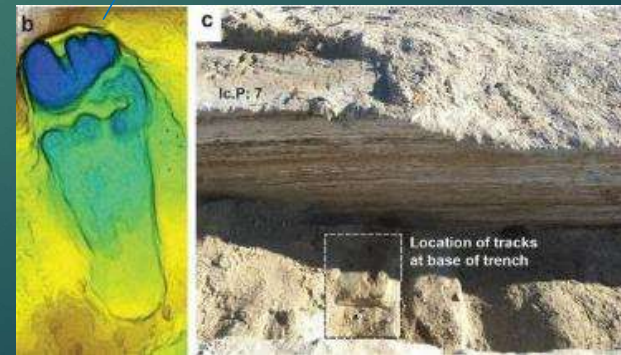
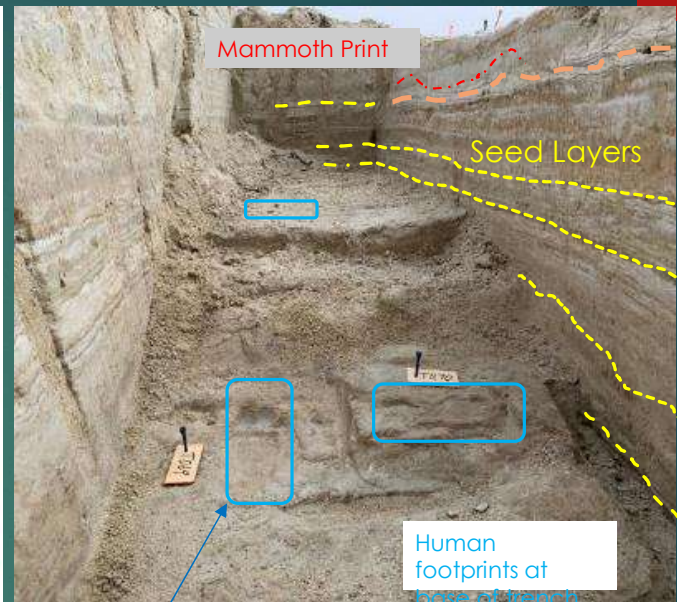
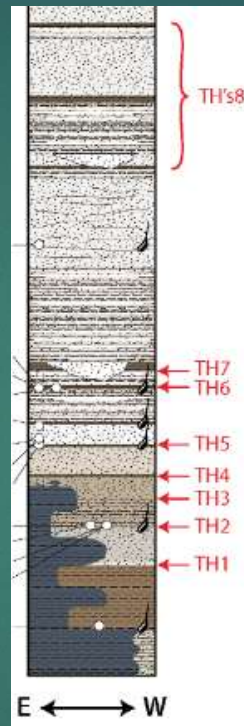
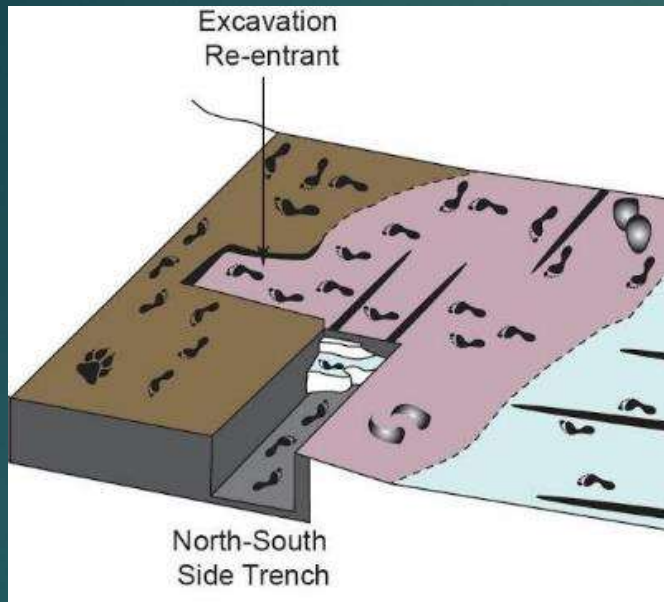
Thank you!







Defining the age of the prints



New Trackways found on Westside



Mammoth Prints

Giant Ground
Sloth Prints

Human Prints

EXPERIENCE YOUR AMERICA

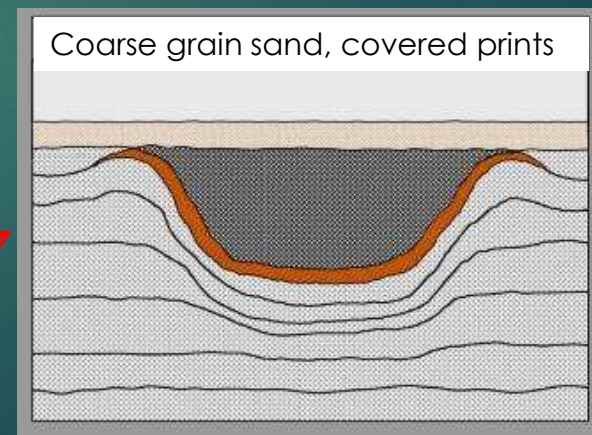
Soft-sediment deformation

Bennett, M. R., Bustos, D., Belvedere, M., Martinez, P., Reynolds, S. C., & Urban, T. (2019). Soft-sediment deformation below mammoth tracks at White Sands National Monument (New Mexico) with implications for biomechanical inferences from tracks. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 527, 25-38.

Proboscidean Prints
(*Mammuthus columbi*)



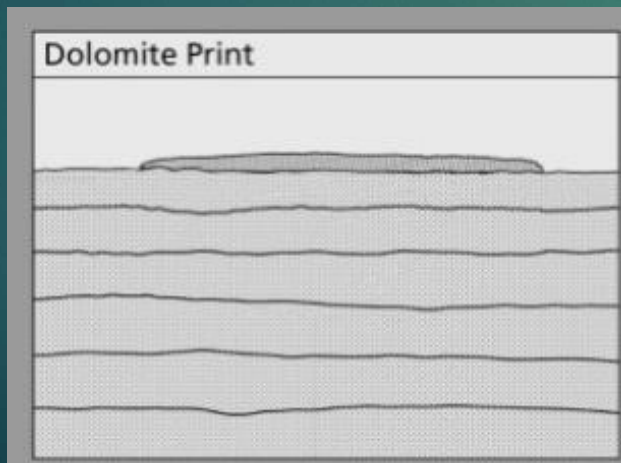
Cross section of mammoth print



Camelops conidens

Lucas, S. G., Allen, B. D., Morgan, G. S., Myers, R. G., Love, D. W., & Bustos, D., (2007). Mammoth footprints from the upper Pleistocene of the Tularosa Basin, Doña Ana County, New Mexico. *Cenozoic Vertebrate Tracks and Traces*, 42, 149-154.

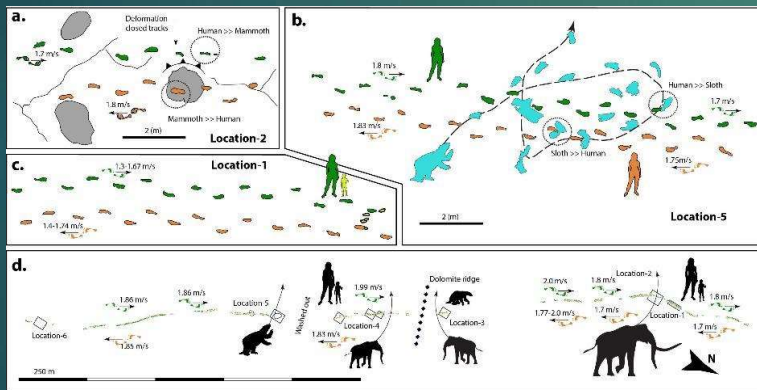
Two mile dolomite camel trackway



Longest known record human fossil trackway, over 1.5 kilometers

Bennett, Matthew R., et al. "Walking in mud: Remarkable Pleistocene human trackways from White Sands National Park (New Mexico)." *Quaternary Science Reviews* 249 (2020): 106610.

EXPERIENCE YOUR AMERICA



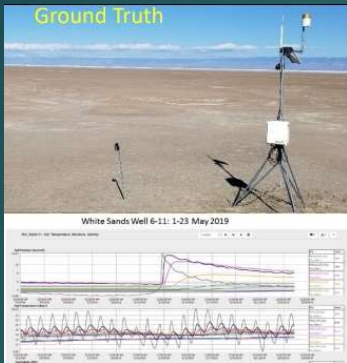
Tracks suggest interactions occurred



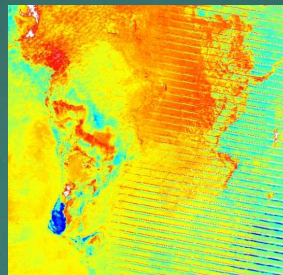
Footprints preserve terminal Pleistocene hunt? Human-sloth interactions in North America.

Bustos, D., Jakeway, J., Urban, T. M., Holliday, V. T.,
Fenerty, B., Raichlen, D. A., ... & Santucci, V. L.
(2018).

Science advances, 4(4), eaar7621.



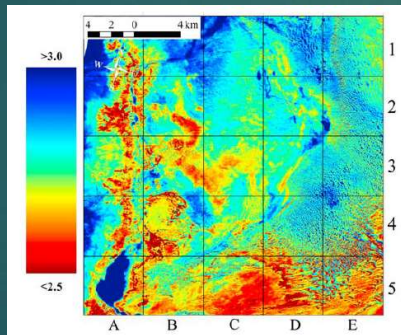
Reflection band math



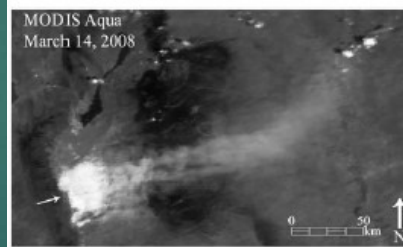
Testable hypothesis are generated, parameters can be based on future climate models, and management is informed by science



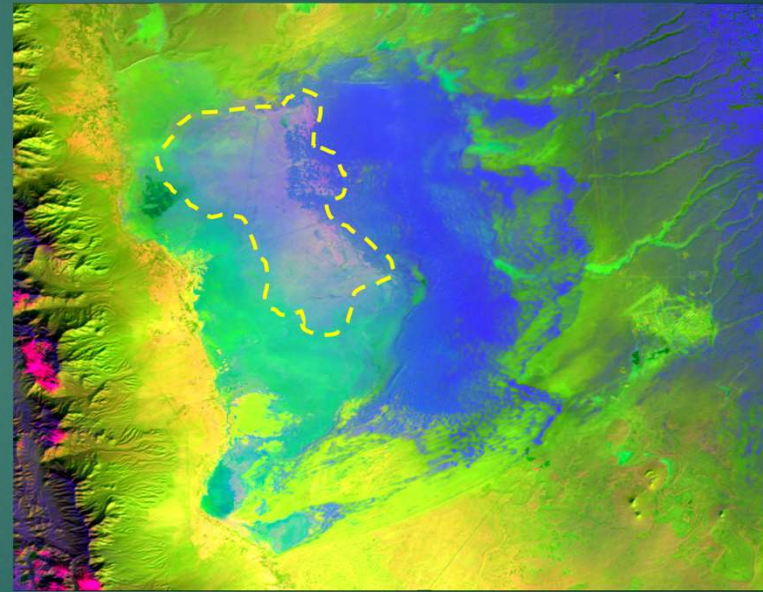
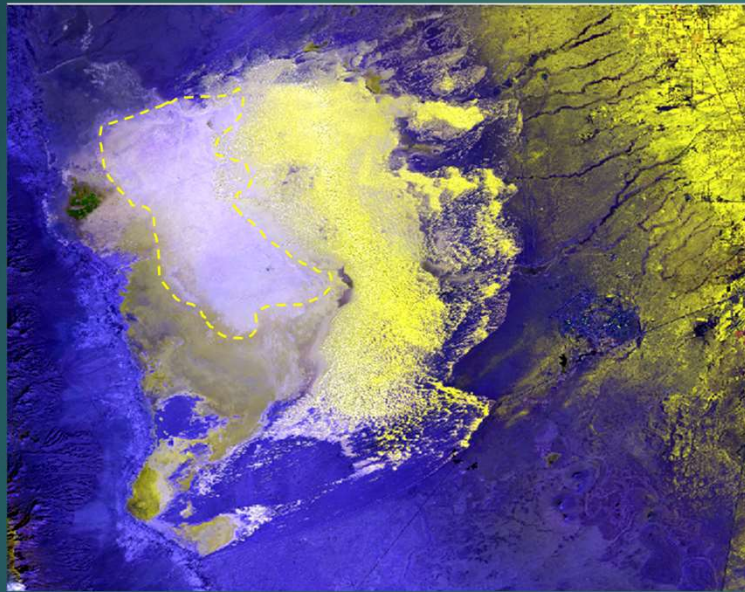
Thermal model



Trend Analysis and Predictive Model



Use of Satellite Imagery to Monitor Landscape Soil Moisture and Temperature Changes





San Andres
Mountains

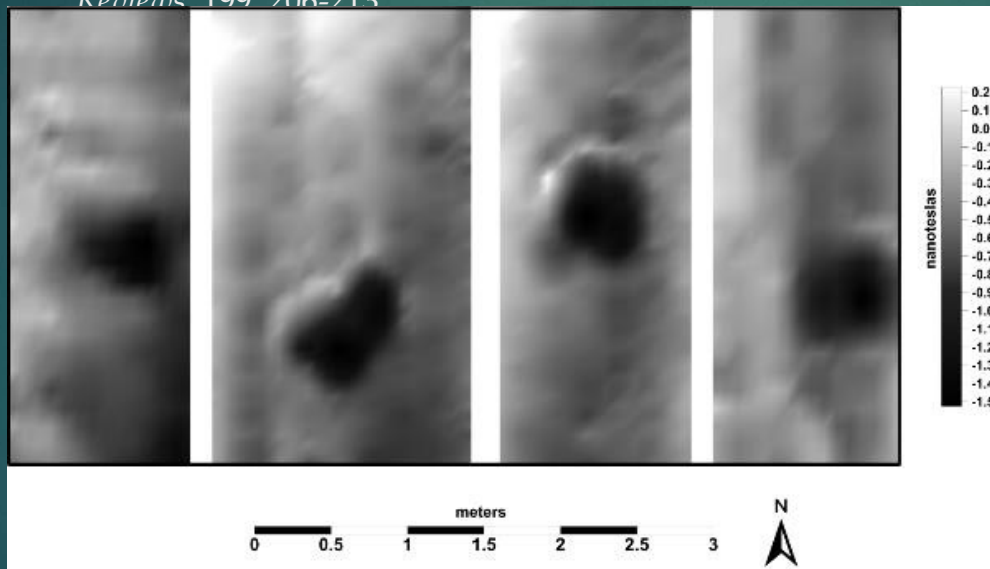
Sacramento Mountains



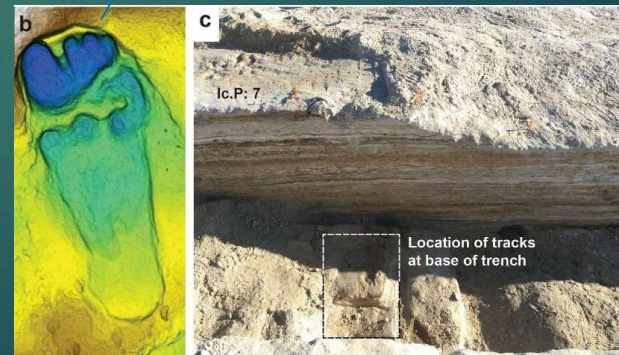
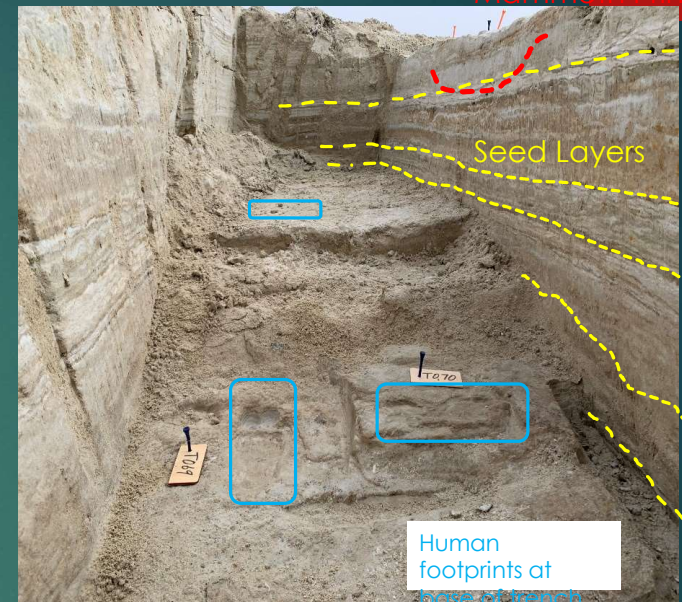
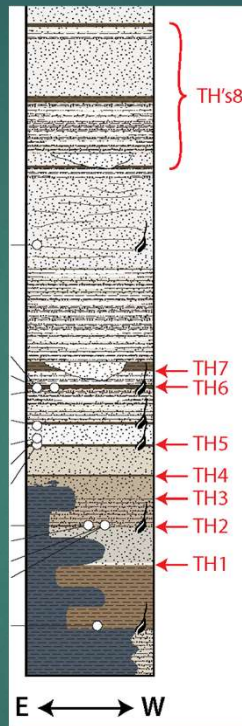
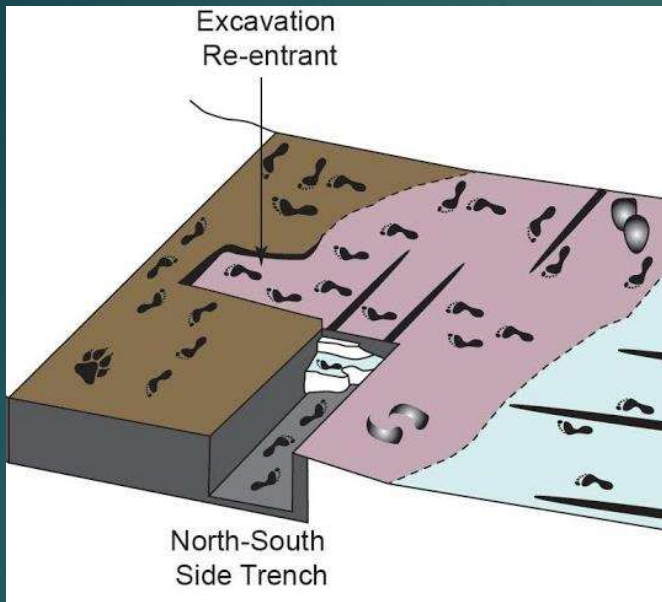
Inventory & Monitoring

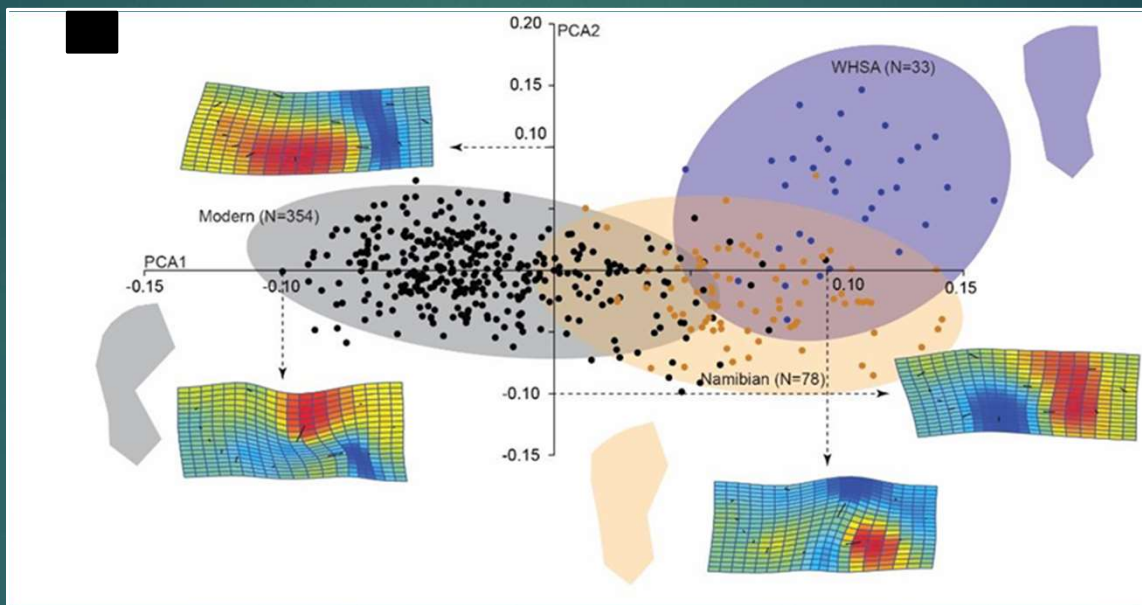
Use of magnetometry for detecting and documenting multi-species Pleistocene megafauna tracks.

Urban, T.M., Bustos, D., Jakeway, J., Manning, S.W. & Bennett M.R. 2018. *Quaternary Science Reviews* 199: 206-213

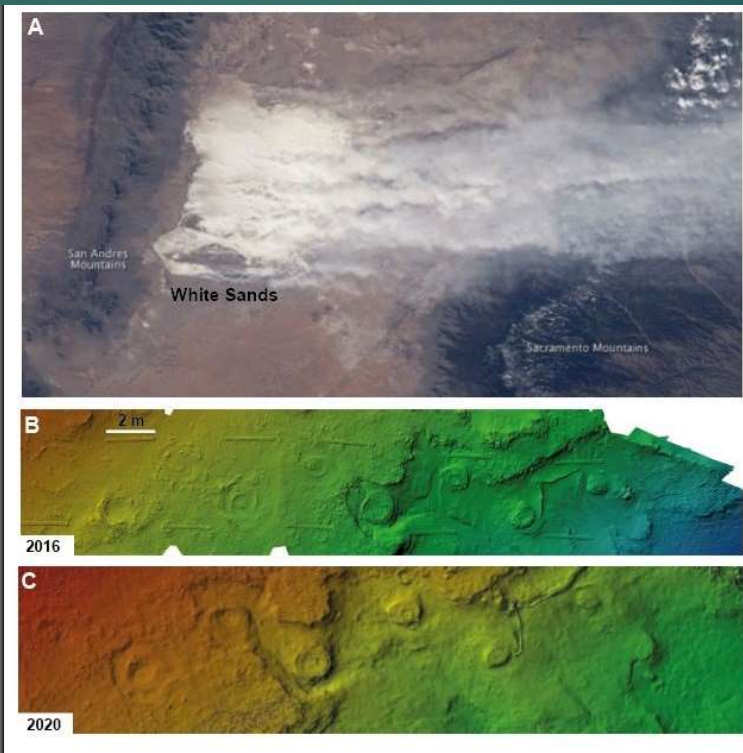


Defining the age of the prints

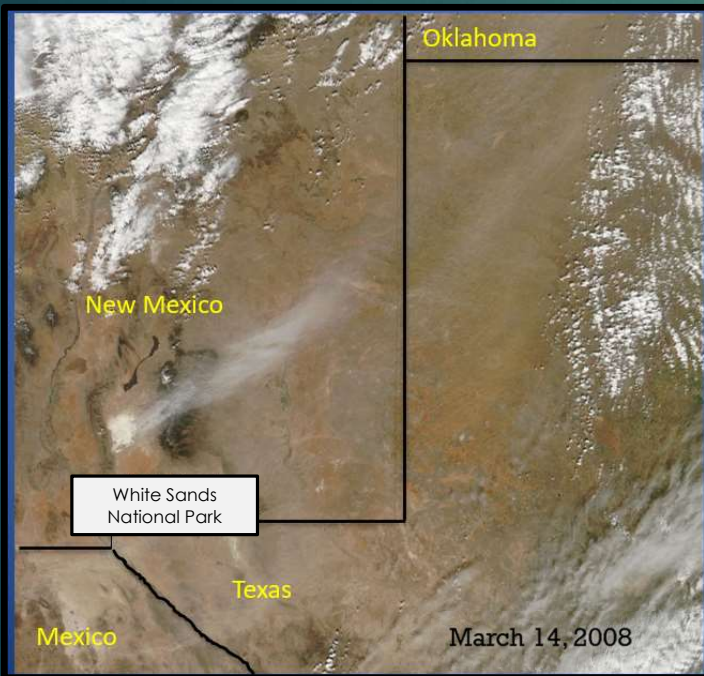




Bennett et al., 2022,
Science



WATER PROVIDES GYPSYM DUNE STABILITY

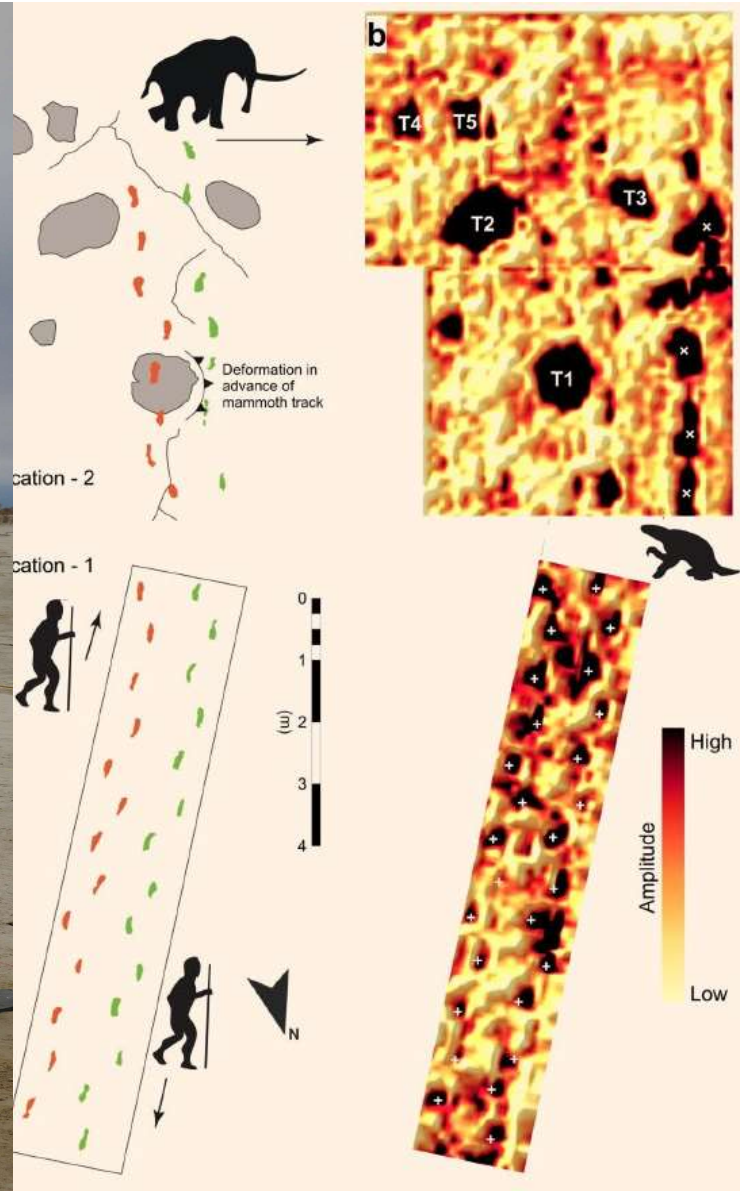


02/26/2009

03/16/2010

05/26/2011

Mammoth Trackway





Ruppia cirrhosa

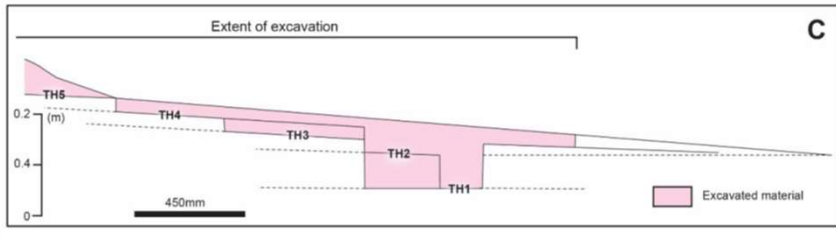
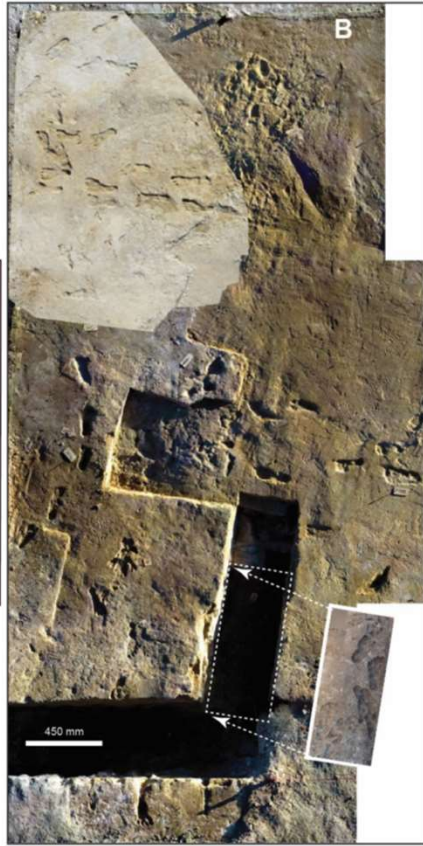
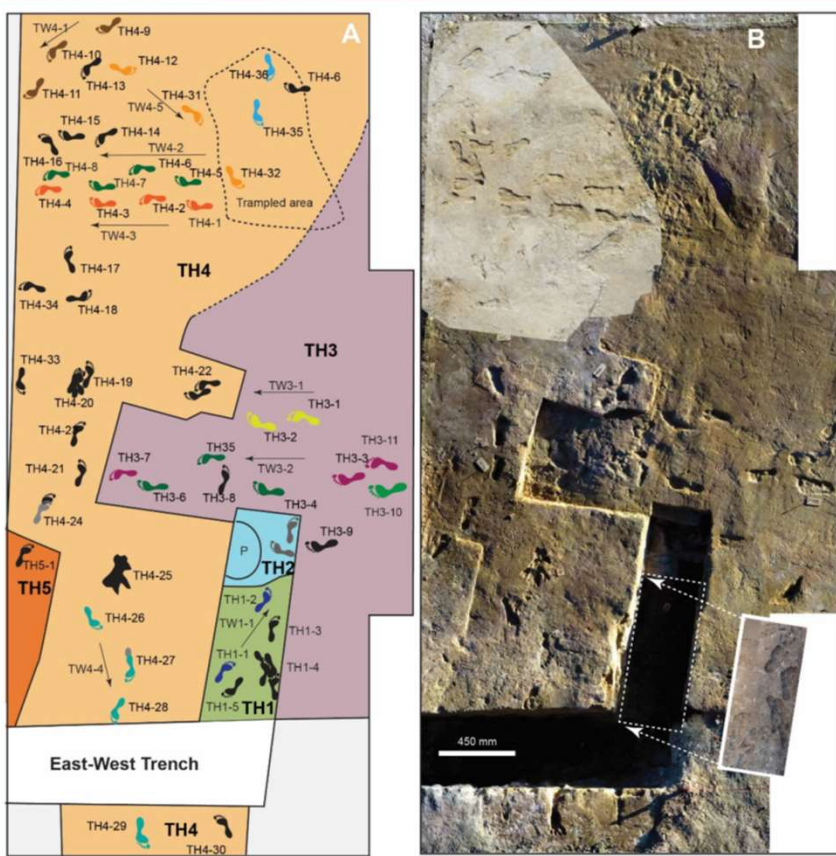


2 mm

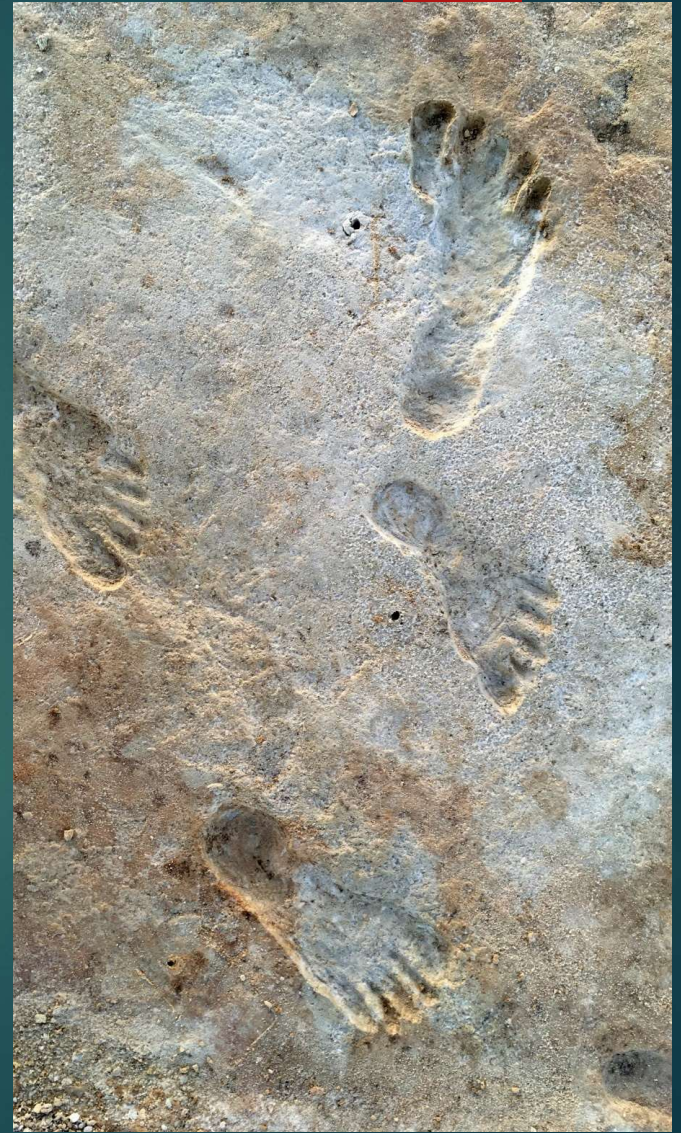
Microscope: Olympus SZX12- MDU
Camera :Olympus Q-Color 5

1.2x12@13%
Lens x mag @ % zoom range

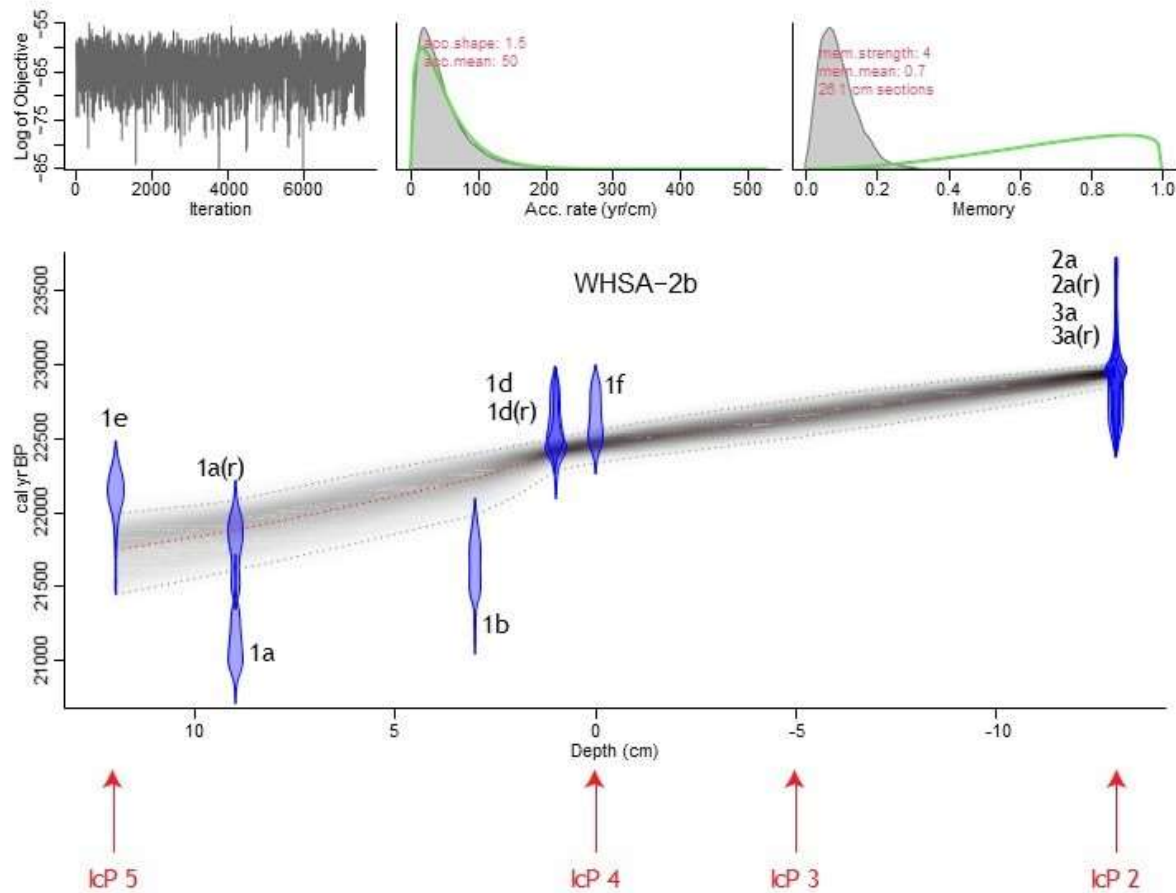




Overview of Work at Locality 2 Done in 2020

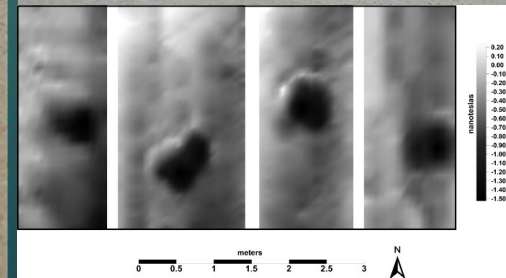
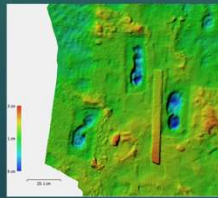
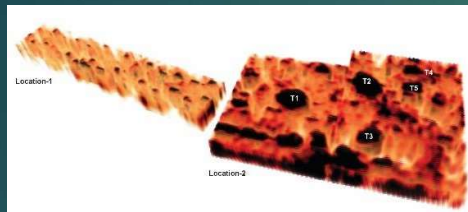


AMS Dates Constrain Ages of Track Horizons 2 to 5.



Older and Younger Horizons
remain undated.

Preserving Tracks

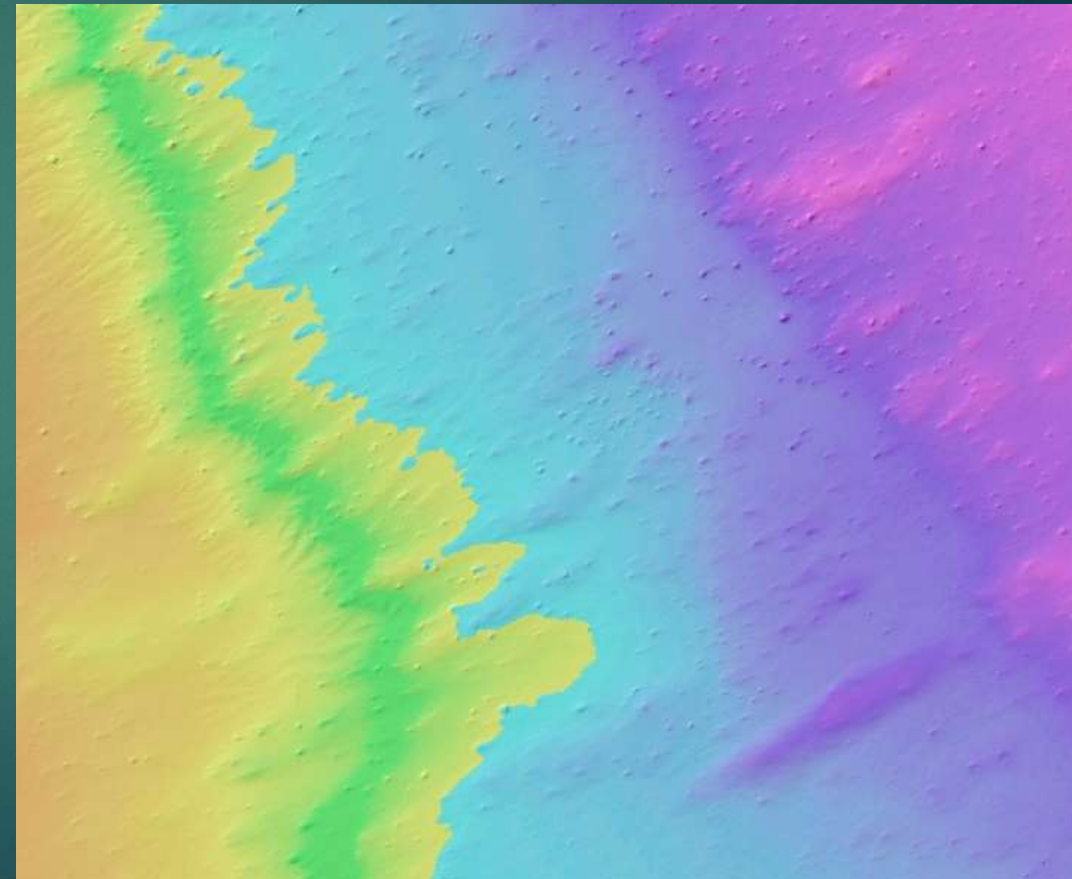


WHA CLIMATE PROJECTIONS (1950-1999 vs 2040)

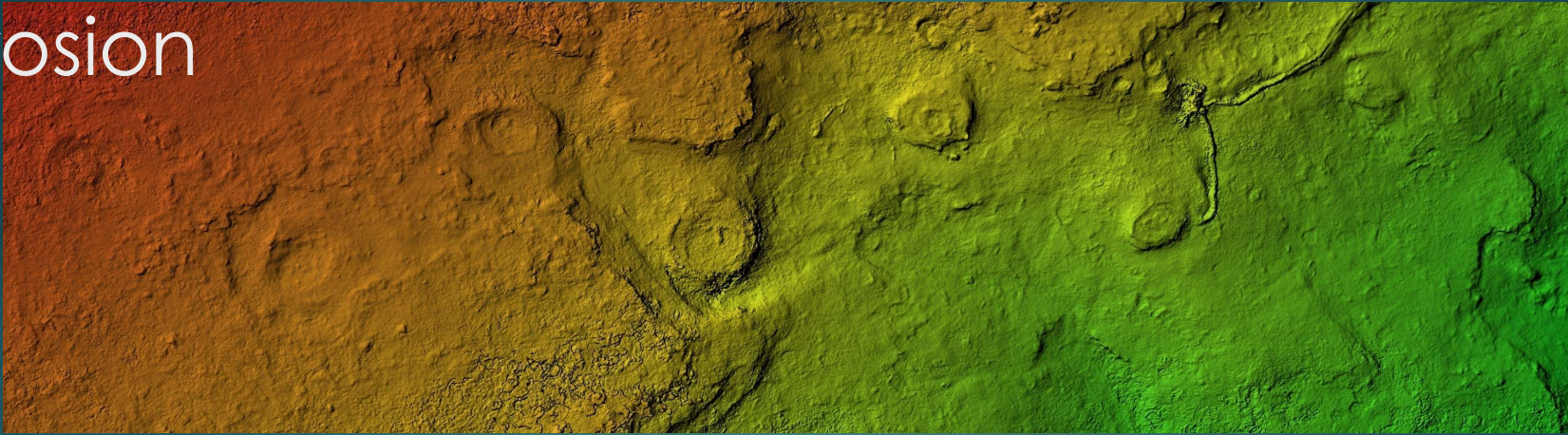
	Warm/Rain-No Δ	Hot Wet	Hot Dry
Warming	Common Across Scenarios <ul style="list-style-type: none"> Warming in all seasons Significant drop in days <32 °F 		
	Degree of warming <ul style="list-style-type: none"> ~ 1.5 °F 26 days >100 °F (+6 days) 	Degree of warming <ul style="list-style-type: none"> ~ 4.1 °F 36 days >100 °F (+16 days) 	Degree of warming <ul style="list-style-type: none"> ~ 4.1 °F 42 days >100 °F (+22 days)
Precipitation	Variable		
	<ul style="list-style-type: none"> No change 	<ul style="list-style-type: none"> 2" annual increase concentrated in Jul/Aug (\uparrow~66%) 	<ul style="list-style-type: none"> 1.5" annual decrease evenly distributed across June-Dec
Water Balance	Common Across Scenarios <ul style="list-style-type: none"> Increases in soil moisture deficit 		
	<ul style="list-style-type: none"> Annual soil moisture deficit increases 7% 	<ul style="list-style-type: none"> Annual soil moisture deficit increases 12% 	<ul style="list-style-type: none"> Annual soil moisture deficit increases 27%

Gregor Schuurman, NPS CCRP (2017)

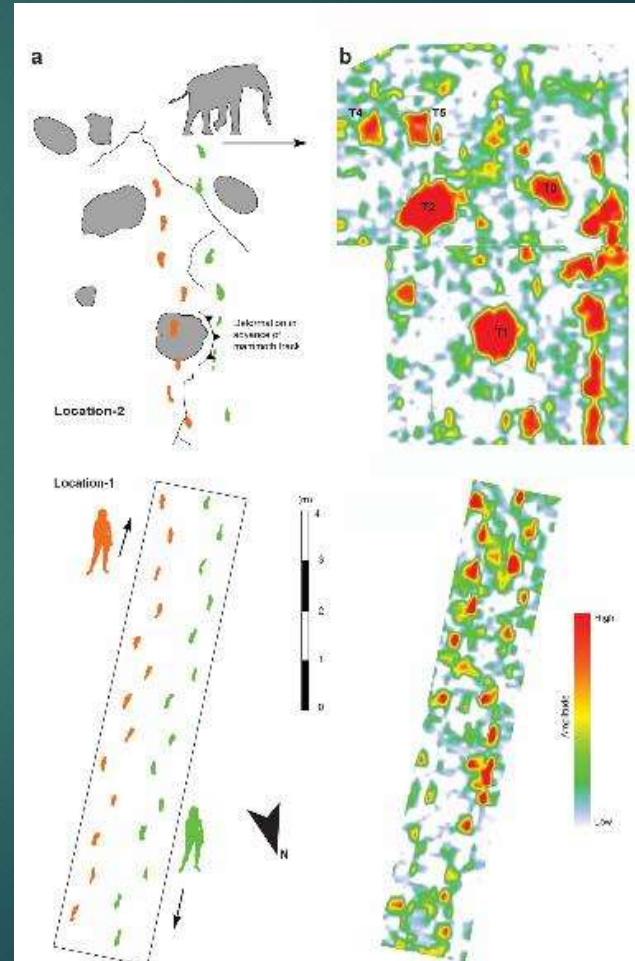
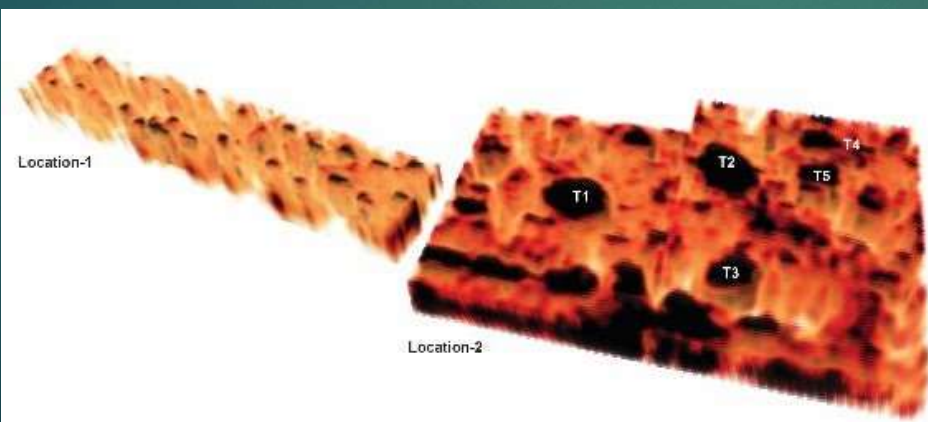
Use of Lidar, Aerial, Imagery, and photogrammetry to detect prints and monitor erosion



Use of Lidar, Aerial, Imagery, and photogrammetry to detect prints and monitor erosion



Documenting and Locating with GPR





02/26/2009



03/10/2010



05/26/2011

Eroding Tracks

Modern Day of the Past



Modern Day and Pleistocene Proboscidean

WHSA Fossil Print

Modern Day Elephant

