In cooperation with Northern Arizona University

Prehistoric Packrats Piled Up Clues to Climate Change

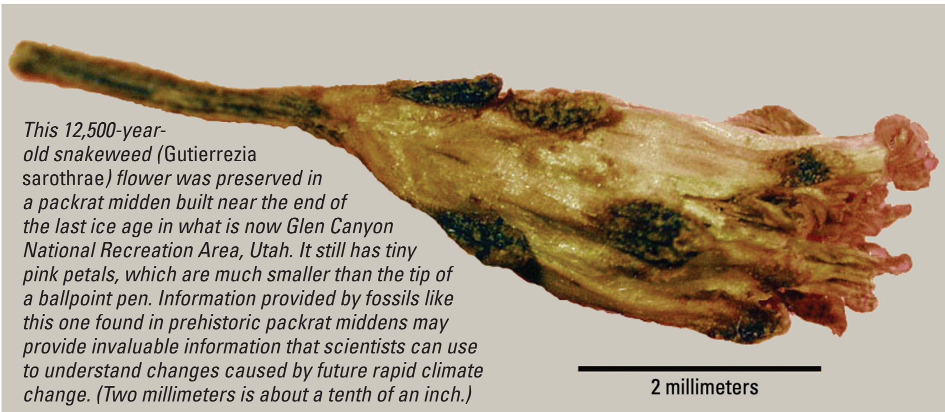
Scientists from the U.S. Geological Survey and Northern Arizona University studying climate change in the Southwestern United States are getting a helping hand—or would that be paw?—from prehistoric packrats. By hoarding parts of animals and plants, including seeds and leaves, in garbage piles or "middens," these bushy-tailed rodents preserved crucial ecological and environmental information about the past. From these middens, scientists are able to reconstruct plant communities and natural systems from as long ago as 50,000 years. The contents of middens allow scientists to understand how ecosystems responded to rapid, large-scale climate changes of the past. The insights gained from midden research could offer clues to future changes driven by rapid climate shifts .

U.S. Geological Survey scientists are studying the contents of ancient packrat garbage piles or "middens" in the Southwestern United States that are as much as 50,000 years old to help understand how ecosystems respond to large-scale, rapid climate change. In this photograph, a scientist is using a special sampling pole to collect a 12,500-year-old midden deposit tucked into a canyon alcove.

Just as modern North American packrats—small, bushy-tailed rodents, also known as woodrats—like to hoard things, their prehistoric ancestors also collected objects from their surroundings, including parts of plants and animals, in garbage piles or dunghills. From these "middens," U.S. Geological Survey (USGS) and Northern Arizona University scientists are reconstructing ancient plant communities and natural systems of the Southwestern United States from as long ago as 50,000 years.

How does a garbage pile survive tens of thousands of years? The secret is packrat urine in combination with a desert climate and the protection of the midden from the elements. To conserve water in an arid environment, the packrat produces very viscous, concentrated urine and often urinates on its garbage pile, which is usually near its nest. The urine then dries and crystallizes, acting as a glue to hold the midden together. The midden becomes a solid barrier protecting the nest from predators.

*The packrat (*Neotoma albigula*), is a small rodent that collects just about anything—seeds, twigs, fruits, the bones of small animals, lizard scales, and insects—in fossilized middens preserved by the dry climates of the Southwest. (Photograph courtesy of www.saguaro-juniper.com.)*



*This 12,500-year-old snakeweed (*Gutierrezia sarothrae*) flower was preserved in a packrat midden built near the end of the last ice age in what is now Glen Canyon National Recreation Area, Utah. It still has tiny pink petals, which are much smaller than the tip of a ballpoint pen. Information provided by fossils like this one found in prehistoric packrat middens may provide invaluable information that scientists can use to understand changes caused by future rapid climate change. (Two millimeters is about a tenth of an inch.)*

Over time, the plant and animal parts encased within this crystallized urine become mummified and invulnerable to decay. As long as the midden is protected from water, say under a rock ledge or in a dry cave, it remains intact.

Middens contain mostly twigs, leaves, rocks, and packrat fecal pellets, but they also contain seeds, fruits, the bones of small animals, pollen, lizard scales, and insects. Packrats collect just about anything; however, they can only carry their haul a short distance, about 65–160 feet (20–50 m). As a result, middens allow scientists to reconstruct past environments at very specific times and places.

To unravel the exact nature of the materials contained in an ancient midden, scientists wash small sections of the midden in water and extract the plant and animal fossils from the matrix of crystallized urine. The fossilized bits are then identified by comparing them to reference collections of plants, pollen, bones, and other materials. The comparative collection at the USGS-Northern Arizona University Macrobotanical Laboratory contains more than 2,500 identified specimens of seeds, leaves, fruits, flowers, and twigs. Some specimens can be viewed at the online Macrobotanical Digital Library at http://sbsc.wr.usgs.gov/cprs/research/projects/global_change/MacroDigitalLibrary.asp.

As the result of midden research, USGS scientists have been able to reconstruct the vegetation of Grand Canyon as it existed during the last ice age. During this period, plants escaped the colder climates by growing at lower elevations than they do today or by growing in warmer, more southerly latitudes. As the ice age ended 11,600 years ago, climates rapidly warmed, increasing by more than 7.2°F (4°C) in less than 200 years. This rate of warming is similar to the 0.9°F (0.5°C) increase that has been measured globally over the past 25 years. Even at the lowest rates of warming predicted by climate models, the total increase over the next 200 years would equal the 7.2°F (4°C) increase that occurred after the last ice age.

Following the last ice age, Grand Canyon plant species—many of the same species found today—responded at different rates to the warming climate. Species adapted for rapid dispersal, like those with small windborne seeds, quickly became established at higher elevations and farther north, escaping the increasing heat. Plant species whose seeds are dispersed by animals also quickly migrated vertically to more suitable local habitat; however, reaching the new northern limits of their habitat ranges, some of which were more than a 1,000 miles away, took 4,000 to 8,000 years. Other species, including those that reproduce by shoots or spreading roots, migrated even more slowly. Because individual species migrated at different rates, local ice-age plant communities were replaced by new communities with different species compositions.

Similar changes appear to be beginning today, as some older, established tree populations are dying, while rapidly dispersing weeds and grasses with windblown seeds are becoming more abundant. Trees and shrubs could expand into nearby higher elevation habitats within only a few hundred years, as they did in the past; however, northward migrations across long distances will be very slow. National parks and other natural areas may preserve rare species, if higher or wetter habitats in these places are close enough to be rapidly invaded by plant species responding to warming. Species populations that are already restricted to the highest elevations or wettest areas have nowhere to go and may not survive.

Thanks to the hoarding behavior of prehistoric packrats, USGS and other scientists are gaining a better understanding of how ecosystems responded to rapid, large-scale climate changes of the past. This invaluable information may help scientists answer crucial questions about future ecological and other changes that may be caused by rapid climate shifts.

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Online Resources:

http://sbsc.wr.usgs.gov/cprs/research/projects/global_change/cprsmain.asp
http://www.nau.edu/~qsp/macrobotanical_lab.html

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