PINYONS, PACKRATS, AND VEGETATION HISTORY AT CITY OF ROCKS

National Parks, Monuments and Reserves have been established to conserve natural and cultural resources, but this lofty goal presents a daunting challenge in a changing world. Changes brought on by climate, land use, invasive species and catastrophic fires could add or subtract both flora and fauna in protected areas. If it occurs at the magnitude and pace predicted by climate models, regional warming could trigger migrations to higher latitudes and elevations across the western United States. To predict the future, we need to understand the mechanisms, pathways, rates and impacts of past migrations, including how they might have changed fuel loads and fire regimes.

There is growing evidence that, during the last 4000 years and as recently as the last millennium, warmer winters and extended periods of drought triggered northward migrations by some of the signature species in woodlands of the northern Great Basin and the central Rockies, including ponderosa pine (*Pinus ponderosa*), Utah juniper (*Juniperus osteosperma*), Colorado pinyon pine (*Pinus edulis*) and one-needle pinyon pine (*Pinus monophylla*).

Most of the evidence for these recent migrations came from ancient deposits made by packrats (*Neotoma* spp.) and preserved for thousands of years in rock crevices and shelters in the western U.S. Packrats, also called woodrats are North American rodents with some fascinating habits. They gather twigs, seeds, and other plant parts from about a 30 yard radius, accumulate them in a large pile, and then tunnel through the pile to create their living quarters or midden. Packrats get all of their water from plant tissue, so their urine tends to be highly concentrated and viscous with salts. In arid areas, and specifically in rock crevices and shelters, the urine crystallizes as it evaporates, embedded in a hard, crystalline matrix called amberat. Over time, the midden can become hard as a rock.

So long as it doesn't get wet (the crystallized urine is soluble in water), middens are preserved in rock crevices for thousands, if not tens of thousands of years. Since 1960, when this method was discovered, paleoecologists (scientists who reconstruct environments of the past) collect and analyze packrat middens to reconstruct vegetation change and plant migrations in western North America throughout what is called radiocarbon time, or the last 50,000 years. The middens are full of organic remains that can be aged (plus or minus a few decades) through radiocarbon dating, identified using a variety of microscopes, and analyzed both chemically and genetically. Packrat middens are one of the most versatile fossil deposits in the world, and have contributed a great deal of what we know about vegetation change during past 50,000 years in the American West.

Here at City of Rocks National Reserve (CIRO), scientists from the U.S. Geological Survey, the Agricultural Research Service (ARS), the University of Arizona, and Boise State University have collected and studied fossil packrat middens preserved in crevices that abound in our granite outcrops. Some of the middens came from large walk-in rock

shelters (**Fig. 1**), others from small crevices reachable by scampering a short distance up a cliff. In some cases, midden sampling required ropes and technical gear (**Fig. 2**).

Analysis of plant remains (**Fig. 3**) and pollen (**Fig. 4**) from middens tell a fascinating story about the local pinyon-juniper woodlands. Utah juniper, which is near its northern limits at CIRO, apparently arrived only 3300 years ago. A long-standing question at CIRO is the age and origin of its single-needle pinyon population, the northernmost, isolated outpost of *Pinus monophylla* in the Great Basin (**Fig. 5**). The midden record shows that single-needle pinyon colonized at least two sites ~2800 years ago, but did not spread across the reserve until after 700 years ago. Comparison of photographs taken 100 years ago and today invariably show more pinyon trees, suggesting that the infilling of this woodland is still ongoing.

Paleoecologists believe that the dramatic expansion in the last 700 years was linked to widespread ecological disturbances (fires and tree dieoffs) caused by intense and prolonged droughts, which killed other species and cleared the way for pinyon expansion. Examination of charcoal in the cutbanks of arroyos (gulleys) at CIRO reveals episodes of intensive wildfires, most recently between 1000 and 500 years ago. Pinyon expansion may have happened in the wake of these most recent fires.

Figure 1. fossil packrat midden in rock shelter at City of Rocks National Reserve. The dark weathered midden in the center of the photo was radiocarbon dated at more than 40,000 years old.

Figure 4. Using technical climbers to collect “hanging” midden in City of Rocks. This midden was radiocarbon dated at 5200 years old.

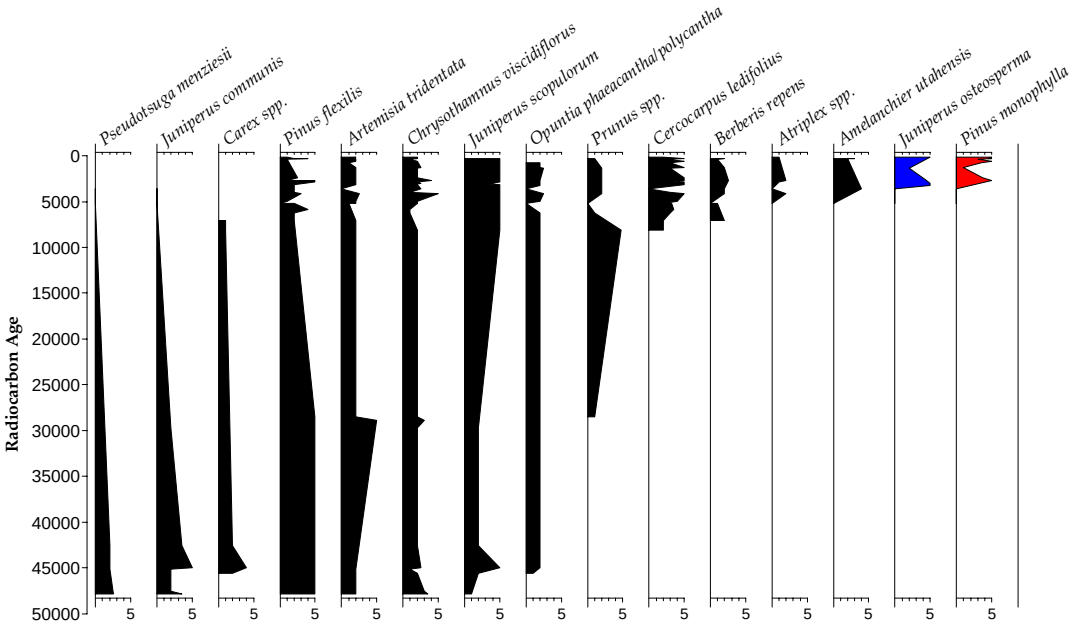

Figure 3. Plant macrofossil diagram showing changes in plant species abundance through last 50,000 years at City of Rocks National reserve. Note recent arrivals of Utah juniper (*Juniperus osteosperma*) in blue bar and single-needle pinyon (*Pinus monophylla*) in red bar on the right.

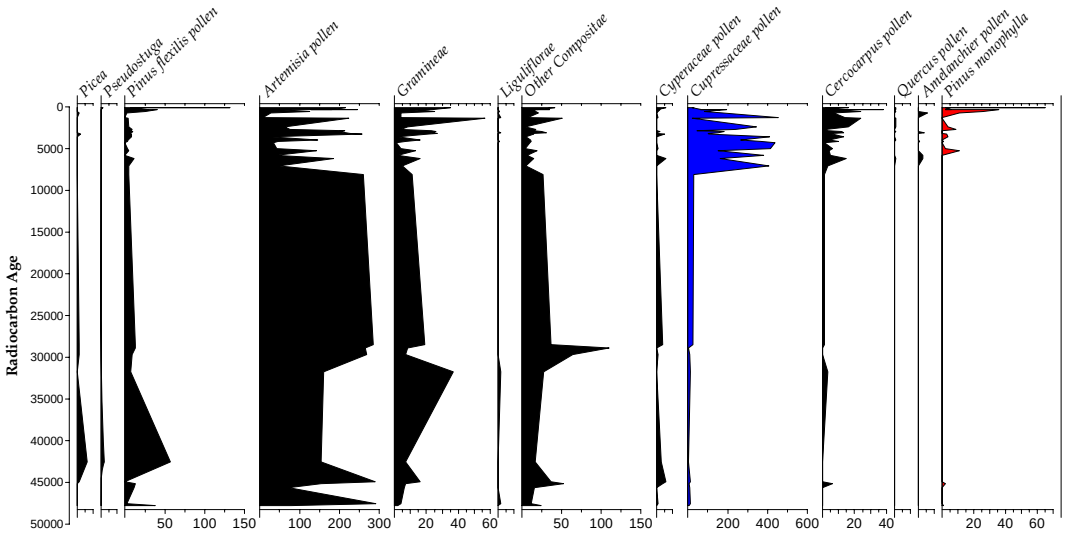

Fig. 4. Figure 3. Pollen diagram showing changes in plant taxon abundance through last 50,000 years at City of Rocks National reserve. Note recent increase in Cuppressaceae (includes Utah juniper) in blue bar and arrival of pinyon (*Pinus monophylla*) in red bar on the right.

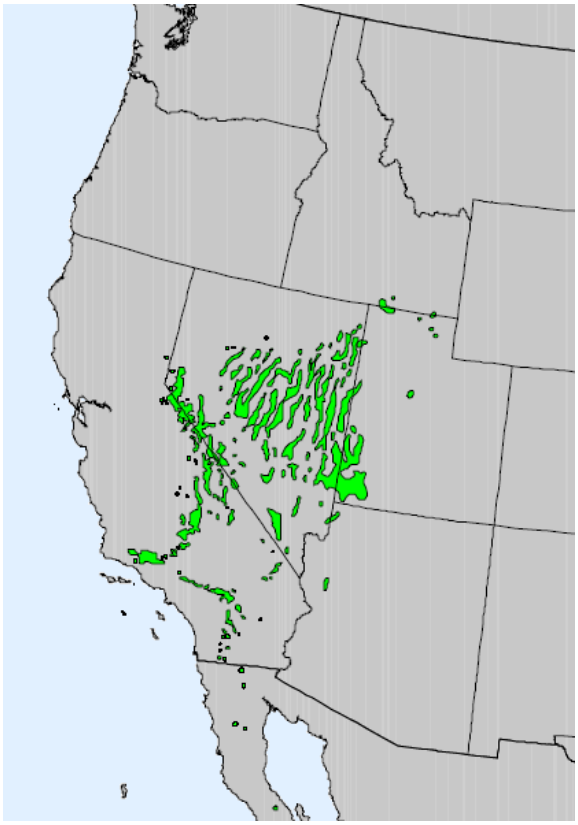

Figure 5. Distribution map for single-needle pinyon (*Pinus monophylla*). Northernmost point in south-central Idaho is City of Rocks National Reserve