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A LATE PLEISTOCENE/HOLOCENE BIOTIC COMMUNITY FROM MARMOT END ALCOVE, ESCALANTE RIVER BASIN, COLORADO PLATEAU, USA

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ABSTRACT.—Skeletal remains of the extinct mountain goat *Oreamnos harringtoni* and *Marmota* (marmot), an extralimital species, were recovered from Marmot End Alcove along with remains of montane plants that included *Pseudotsuga menziesii* (Douglas-fir), *Picea* (spruce), *Pinus flexilis* (limber pine), and *Juniperus communis* (common juniper). The alcove is located in Harris Wash, a semiarid tributary in an unstudied portion of the Escalante River Basin on the Colorado Plateau in southern Utah. A *Marmota* incisor tooth and montane plant needles returned late Pleistocene AMS dates ranging from 12,300 yr BP to 15,600 yr BP.

Key words: Marmota, *Escalante River Basin, Colorado Plateau, Pleistocene, Harris Wash,* Oreamnos harringtoni, Pseudotsuga menziesii, Picea, Pinus flexilis, Juniperus communis.

Marmot End Alcove is a small sandstone alcove located in Harris Wash, a tributary of the Escalante River situated in the heart of the Colorado Plateau. The site falls within the boundaries of the Glen Canyon National Recreation Area (GLCA; Fig. 1). Harris Wash drains an area of over 700 km^2, from its inception at an elevation of 2800 m on the Kaiparowits Plateau to its union with the Escalante River at 1400 m (Patton and Boison 1986). From its confluence with the Escalante River to 16 km upstream, Harris Wash is a perennial stream with steep-sided canyon walls. This stretch of the wash contains numerous alcoves that provide a unique, dry environment for the preservation of late Pleistocene remains.

Today, climate in the Harris Wash region is semiarid with seasonal rains and a mean annual temperature of 10–12 °C. The landscape is dominated by an open pinyon-juniper woodland that includes desert scrub and sagebrush, while riparian vegetation with hanging gardens can be found along the stream bed (Withers and Mead 1993).

The elevation of the stream-level alluvial fill near the alcove is approximately 1460 m, with the top of the canyon walls around 1525 m and the floor of the alcove approximately 25 m above stream level. The alcove entrance is 5.5 m high and 16.2 m wide. The floor of the alcove slopes up to the rear, a distance of 13.5 m, to a small area of level sediment. The total area of the alcove floor, 220 m^2, is covered with very loose sedimentary fill containing bone, plant material, and several large and small pieces of packrat midden. The packrat midden material appears to be falling from a ledge that runs along the ceiling of the alcove, but some of the material may be coming from below the floor fill.

The floor-fill deposits are fairly homogeneous in color and are typically sand-size with occasional rock slabs mixed in from episodes of roof fall. The majority of the sediments were probably deposited by in situ erosion of sandstone surfaces within the alcove, with some secondary deposition occurring from windblown sand. It is unlikely that stream elevation was once much higher than presently observed or that sediments were deposited into the alcove by the stream. Harris Wash has undergone several episodes of aggradation and degradation, but the highest alluvial terrace observed by Patton and Boison (1986) is not much higher than 10 m, which falls short of the alcove floor elevation by 15 m. The oldest date obtained by Patton and Boison (1986) for any alluvial terraces in the canyon is 8160 yr BP. This may suggest that older deposits were removed by erosion before the end of the late Pleistocene. However, while hiking to the site, I noticed no evidence of alluvial terrace remnants that would suggest valley fills higher than the ones observed by Patton and Boison (1986).

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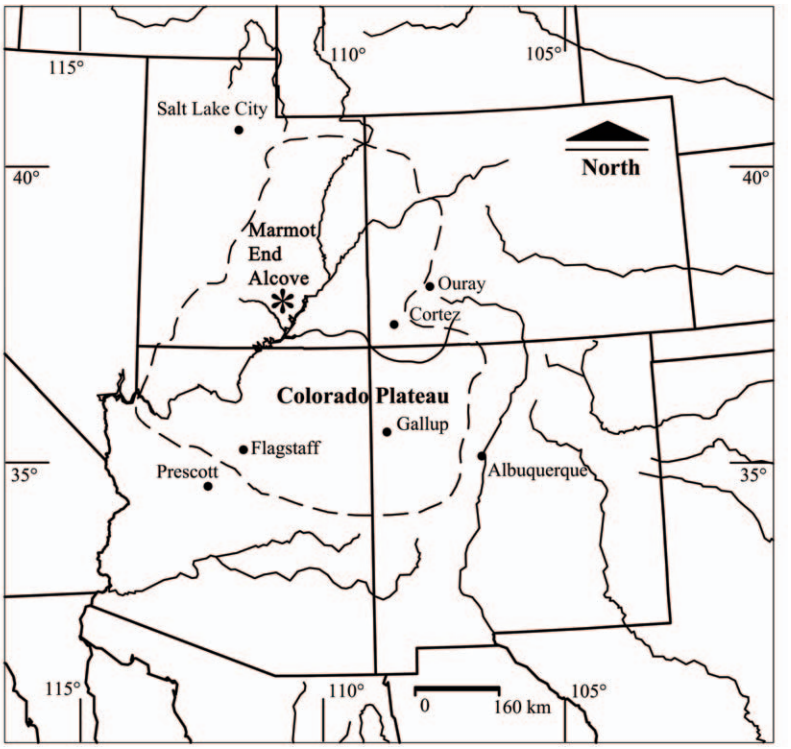

Fig. 1. Map of the Colorado Plateau illustrating the general location of Marmot End Alcove (*).

Stratigraphy within the sedimentary floor fill was not evident in either a hole almost 30 cm deep near the north wall of the alcove or a test unit excavated to rock level. The lack of stratigraphy appears to be caused by several factors, such as constant reworking of the fill by wind action, human and animal foot traffic, rodent activity, and shallow depth of the deposits (<1 m). The reworking of the floor fill is possibly one reason why the recovered fauna is highly fragmentary, with new and old fossil remains intermixed. Without distinctive stratigraphic layering, chronological control for the collected materials is not possible. Radiocarbon dates were taken directly from a small sample of plant and skeletal remains (Table 1).

With permission from the National Park Service, all visible skeletal material at Marmot End Alcove was collected, along with floor sediment from a test unit and 3 masses of unattached packrat midden material from the floor. All collected material was brought back to the Laboratory of Quaternary Paleontology, Northern Arizona University, for cataloging, storage, and analysis.

The majority of fossil skeletal materials recovered from the alcove are mammal, with some material representative of lizards, snakes, birds, fish, and snails. For a more extensive treatment and discussion of the fauna and flora from the site, see Kropf (2005).

Many of the animal and plant taxa recovered from Marmot End Alcove still occur in the vicinity today; however, several do not, including *Marmota, Oreamnos harringtoni* (extinct Harrington's Mountain Goat), and plant material from *Pseudotsuga menziesii, Picea, Pinus flexilis,* and *Juniperus communis*. Modern *Marmota* populations on the Colorado Plateau are typically found only at elevations above 2000 m, with the closest known *Marmota* population to Harris Wash occurring on the Aquarius Plateau approximately 50 km to the west (Frase and Hoffmann 1980).

Marmota skeletal material included most of a skull and right tibia, and fragments of a femur and 2 frontal bones. The skull (Fig. 2) and the fully preserved frontal bones indicate the skeletal presence of at least 3 individuals. The majority of the skull is intact, but it is missing a

TABLE 1. Radiocarbon dates performed by the University of Arizona AMS laboratory for specimens from Marmot End Alcove, Harris Wash, Utah.

University of Arizona sample number	GLCA catalog number	Date ^{14}C yr B.P.	Material dated
AA61376	GLCA 22308	Inadequate bone collagen	*Oreamnos harringtoni* metacarpal bone
AA61377	GLCA 22252	12,880 ± 110	*Marmota* cf. *flaviventris* – incisor tooth from skull
AA61377	GLCA 22252	12,940 ± 130	*Marmota* cf. *flaviventris* – incisor tooth from skull
AA61379	GLCA 22329	12,302 ± 70	*Pinus flexilis* needles from packrat mass
AA61380	GLCA 22323	15,615 ± 87	*Picea* sp. needles from floor sediment

portion of the premaxillary, all teeth except 3, and most of the zygomatic arch. Skull length is 77 mm and width is 54 mm. Tooth row length is 20.7 mm. Palatal width at P^3 is 15.8 mm, and palatal width at M^3 is 9.6 mm. The material displayed characteristics typically found in the genus *Marmota* and not in similar size genera (i.e., *Erethizon* [porcupine], *Castor* [beaver], and *Myocastor* [nutria]): the distinctive flat shape of the skull, the brachyodont rooted teeth, the occlusal patterns to LM^1 and LM^3, the outline of the postorbital processes, and the large, squarish rostrum.

There are currently 6 North American species of *Marmota. Marmota flaviventris* is the most common and most widely distributed *Marmota* species in the western half of North America. In Montana and Washington, the range of *M. flaviventris* overlaps with the range of a second, closely related species, *Marmota caligata* (the hoary marmot), whose range extends to Alaska (Frase and Hoffmann 1980, Whitaker 1996). Studies by some researchers (Heaton 1985, Polly 2003, Schubert 2003) suggest species can be separated based on body size, size differences between P^4 and M^1, and molar shape; however, P^4 is not available and body size is difficult to determine with the few fossil specimens available for analysis. I failed to find any significant differences in the molar shapes to suggest alignment with either *M. caligata* or *M. flaviventris.* The southern extent of *M. caligata* during the late Pleistocene is unknown, and its presence on the Colorado Plateau has not been previously reported. Until the late Pleistocene distribution of *M. caligata* is better understood and morphological differences are more clearly distinguished between species, I am tentatively assigning all the specimens to *M.* cf. *flaviventris* based on modern geographic distribution.

Oreamnos harringtoni skeletal material included a well-preserved adult right metacarpal and more fragmentary material: 2 right first phalanges, a left ulna, a left radius, a right innominate, and a right metacarpal. The complete right metacarpal measurements are total length 91 mm, proximal width 30.8 mm, proximal depth 19.1 mm, distal width 32.7 mm, and distal depth 19.3 mm. *Oreamnos harringtoni* is an extinct species of mountain goat closely related to the living mountain goat, *Oreamnos americanus.* The remains of *O. harringtoni* have been found in more than a dozen localities throughout the Southwest, with the greatest concentration of remains coming from the Grand Canyon (Mead et al. 1987, Mead and Lawler 1994).

Table 2 lists the plant material identified from a packrat midden mass consisting of 14 genera, 8 of which were identified to species level. No identifiable skeletal material was recovered from the midden mass. Table 3 lists the plant material identified from the sedimentary floor unit, consisting of 32 genera, 8 of which were identified to species level. This variety of plants represents the diverse topography near Marmot End Alcove, which consists of dry slickrock terraces, sand dunes, a perennial stream, and microenvironments created by the varying slopes and orientations of the canyon walls.

Pseudotsuga menziesii, Picea, Pinus flexilis, and *Juniperus communis* do not occur in Harris Wash, in protected microenvironments, or above the canyon walls. Much of the region today, from stream level to an elevation of 2300 m, is dominated by a pinyon-juniper woodland (Withers and Mead 1993). Many of the elevationally depressed montane species mentioned above occur today only in the higher elevations of the Aquarius Plateau and the Henry Mountains, located 50 km to the north and northwest, respectively (Dixon 1935, Spaulding and Van Devender 1977, Welsh et al. 1978, Betancourt 1984, Withers and Mead 1993). *Picea* populations typically occur at elevations ranging from 3660 to 2438 m, although some *Picea*

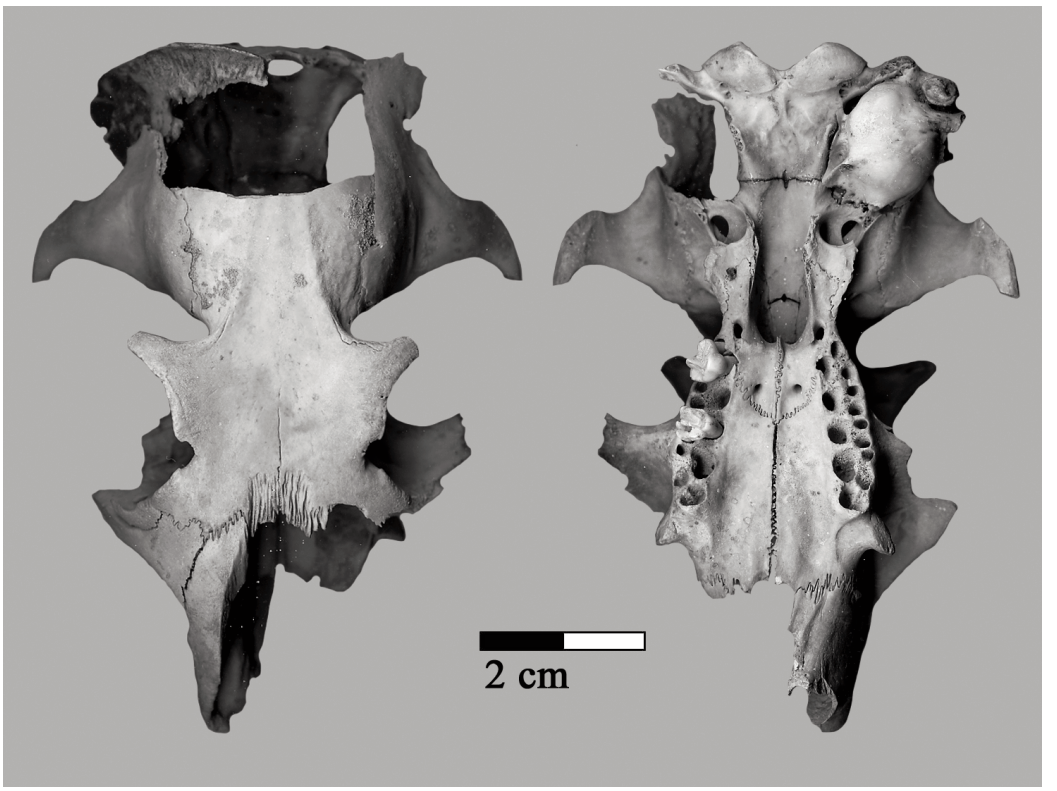

Fig. 2. Dorsal and ventral view of fossil *Marmota* skull GLCA 22252.

populations in the Henry Mountains occur at elevations as low as 2140 m (Spaulding and Van Devender 1977). *Pseudotsuga menziesii* trees typically occur in mixed-conifer forests at elevations ranging from 3048 to 2438 m; however, some relict populations of *P. menziesii* occur in canyons at elevations as low as 1830 m (Spaulding and Van Devender 1977, Betancourt 1984). *Pinus flexilis* typically occurs near the uppermost tree zone with *Picea* populations, but it is apparently not a common tree in the higher elevations of southern Utah today and is absent from some of the smaller nearby mountain ranges (Welsh et al. 1978, Betancourt 1984).

Several localities in or near the Escalante River Basin contain sites where paleoenvironmental research has focused on pre-Quaternary deposits and their plant remains. *Picea* and *Pseudotsuga menziesii* macrobotanical remains were recovered by Withers and Mead (1993) from alcove deposits in Forty Mile Canyon. The canyon is located 40 km south of Harris Wash at an elevation of 1200 m. *Picea* twigs were found below a layer dating to 11,690 yr BP, while *Pseudotsuga menziesii* needles were dated directly to 12,130 yr BP. At an elevation of 1710 m in Cowboy Cave in southern Utah, *Picea* and *Pseudotsuga* needles were found mixed within a dung layer dating to 11,810 yr BP (Spaulding and Van Devender 1977). Plant macrofossils from packrat middens in 2 southeastern caves, Fishmouth Cave and Allen Canyon Cave (elevations of 1585 m and 2195 m, respectively) were analyzed and radiocarbon dated by Betancourt (1984). *Pseudotsuga menziesii, Picea, Pinus flexilis,* and *Juniperus communis* were common at both sites before 9380 yr BP. The results suggest that during the early Holocene, the montane species of the late Pleistocene were displaced by 700 to 800 m in elevation, as suggested by Cole (1990) and Betancourt (1984). Marmot End Alcove, at 1485 m, appears to have experienced a similar shift in elevation of plant communities during the early Holocene.

In summary, the discovery of late Pleistocene fossil remains at Marmot End Alcove has provided additional knowledge of the fauna and

TABLE 2. List of all plant material identified from a packrat midden mass taken from Marmot End Alcove, Harris Wash, Utah. Asterisks indicate extralimital species.

Plants	Common name	Plant material
Cercocarpus	mountain mahogany	leaves
Corispermum	American bugseed	seeds
Ephedra	Mormon tea	seeds
**Juniperus communis*	common juniper	leaves
Juniperus osteosperma	Utah juniper	twig fragments
Juniperus scopulorum	Rocky Mountain juniper	twig fragments
Lithospermum multiflorum	Gromwell/puccoon	seeds
Opuntia	pricklypear	seeds, spines and glochids
Achnatherum hymenoides	Indian ricegrass	seeds
**Picea*	spruce	needles
**Pinus flexilis*	limber pine	needles
**Pseudotsuga menziesii*	Douglas-fir	needles
Quercus	oak	acorn fragments
Rhus trilobata	skunkbush sumac	seeds
Rosa	wild rose	seeds
Yucca	yucca	seeds and leaf tips

TABLE 3. List of all plant material identified from the test unit sediments, Marmot End Alcove, Harris Wash, Utah. Asterisks indicate extralimital species.

Plants	Common name	Plant material
Acer negundo	boxelder	seeds
Agave	agave	seeds
Arabis	rockcress	leaves
Artemisia	sagebrush	leaves
Astragalus	milkvetch	seeds
Atriplex	saltbush	seed fragments
Berberis	barberry	seeds
Celtis	hackberry	seeds
Cercocarpus	mountain mahogany	leaves
Corispermum	American bugseed	seeds
Ephedra	Mormon tea	seed and twig fragments
Equisetum	horsetail	twig fragments
Festuca	fescue	seeds
Fraxinus anomala	singleleaf ash	seed and twig fragments
Hesperostipa	needle and thread	seeds
**Juniperus communis*	common juniper	leaves
Juniperus monosperma	oneseed juniper	twig fragments
Juniperus osteosperma	Utah juniper	twig fragments
Lithospermum multiflorum	Gromwell/puccoon	seeds
Mirabilis	four o'clock	seeds
Opuntia	pricklypear	seeds, spines and glochids
Achnatherum hymenoides	Indian ricegrass	seeds
**Picea*	spruce	needles
Pinus edulis	twoneedle pinyon	needles
**Pinus flexilis*	limber pine	needles
**Pseudotsuga menziesii*	Douglas-fir	needles
Quercus	oak	acorn fragments
Rhus trilobata	skunkbush sumac	seeds
Rosa	wild rose	seeds
Rosaceae	cliffrose / Apache plume	leaves
Sclerocactus/Echinocereus	hedgehog cactus	seeds
Shepherdia	buffaloberry	seeds
Sphaeralcea	globemallow	seeds
Sporobolus cryptandus	sand dropseed	panicle with seeds
Yucca	yucca	leaf tips
Zea mays	corn	seed kernels

flora of the Colorado Plateau from a new locality in an unstudied portion of the Escalante River Basin. The discovery of *Marmota* (marmot) remains introduces a new taxon previously unreported for the Escalante River Basin, and skeletal remains of *Oreamnos harringtoni* (extinct mountain goat; dung and skeletal remains have previously been identified from the region) provide supplementary evidence for its occurrence in the Escalante River Basin. In addition, the site demonstrates once again that a dramatic late Pleistocene climate shift caused a major reorganization of plant and animal communities on the Colorado Plateau, with the local extinction of mountain goats and marmots, the northward and upward migration of montane plant species, and the continued presence and arrival of southern plant species adapted to lower elevations.

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