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Sandal Types and Archaic Prehistory on the Colorado Plateau

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Perishable artifacts provide an alternative to projectile points for examining spatial patterns in Archaic material culture between northern and southern portions of the Colorado Plateau of the North American Southwest. This is so because they possess a potential great variety of specific construction and design attributes and can be directly dated to establish independent chronologies of development. The analysis and dating of a collection of warp-faced plain weave sandals from Chevelon Canyon, Arizona demonstrates the potential utility of perishable artifacts to our understanding of prehistory. The collection provides an important first sample of early Archaic footwear for the southern Colorado Plateau. AMS dating reveals that the oldest Chevelon Canyon sandal (8300 ± 60 B.P.) is 1,500 years earlier than the oldest directly dated sandal of this style on the northern Colorado Plateau. Most of the Chevelon Canyon sandals date from 7500 to 6000 cal. B.C., contemporaneous with open-twined sandals on the northern Colorado Plateau. This study provides another contrast in forager material culture between southern and northern portions of the plateau during the early Archaic, prior to ca. 5700 cal. B.C. After this time, the plain weave sandal style was adopted on the northern Colorado Plateau but not because of population replacement.

Los artefactos perecederos proveen una alternativa a las puntas de projectil para examinar patrones espaciales en cultura material arcaica entre las porciones norte y sur de la Meseta de Colorado en el Suroeste norteamericano. Los artefactos perecederos potencialmente poseen una gran variedad de atributos de construcción y diseño y pueden ser fechados directamente para establecer cronologías independientes. El análisis y fechamiento de una colección de sandalias tejidas encontradas en el Cañón Chevelon, Arizona, demuestran la utilidad de estos artefactos para entender la prehistoria. La colección provee una muestra importante de calzado arcaico en el sur de la Meseta de Colorado. Fechados de AMS revelan que la sandalia más antigua en esta colección (8300 ± 60 a.p.) es 1500 años más temprana que aquélla de estilo similar datada en el norte de la Meseta de Colorado. La mayoría de las sandalias del Cañón Chevelon datan entre 7500 y 6000 cal. a.C. y son contemporáneas con sandalias de cordado abierto norteñas. Este estudio provee otro contraste en la cultura material de recolectores arcaicos entre estas regiones, antes de 5700 cal. a.C. Después de esta fecha, la sandalia de tejido liso de los llanos es adoptada en el norte de la Meseta de Colorado, pero no por reemplazo de población.

The archaeological study of prehistoric hunter-gatherers is largely based upon the analysis of stone artifacts. Some regions of the world are blessed, however, with better-than-average preservation of organic remains, and these provide an alternative means to investigate past cultures. Perishable artifacts like basketry and sandals, along with rock art and portable art such as figurines, allow archaeologists to examine issues of social interaction, band affiliation, and information exchange that are difficult to approach with the usual material remains of stone and bone. Perishable artifacts also can be directly dated to create histories of artifact development that are independent of each other and not tied to projectile point chronologies or derived phases. One principal aim of this paper is to demonstrate the potential contribution of perishables to our understanding of Archaic prehistory through the careful study and dating of sandals from the Colorado Plateau of the North American Southwest.

Perishable artifacts of various types, basketry and other forms of weaving in particular, possess a great number of specific and unique technological and stylistic attributes that can inform about social groups and boundaries (Adovasio 1986; Adovasio and Pedler 1994; Croes 1977, 1989; Weltfish 1932). Perishable artifacts can passively monitor or reflect ethnic or other social groups because of learned patterns of production—the basic motor habits of artifact fabrication that are usually transmitted from generation

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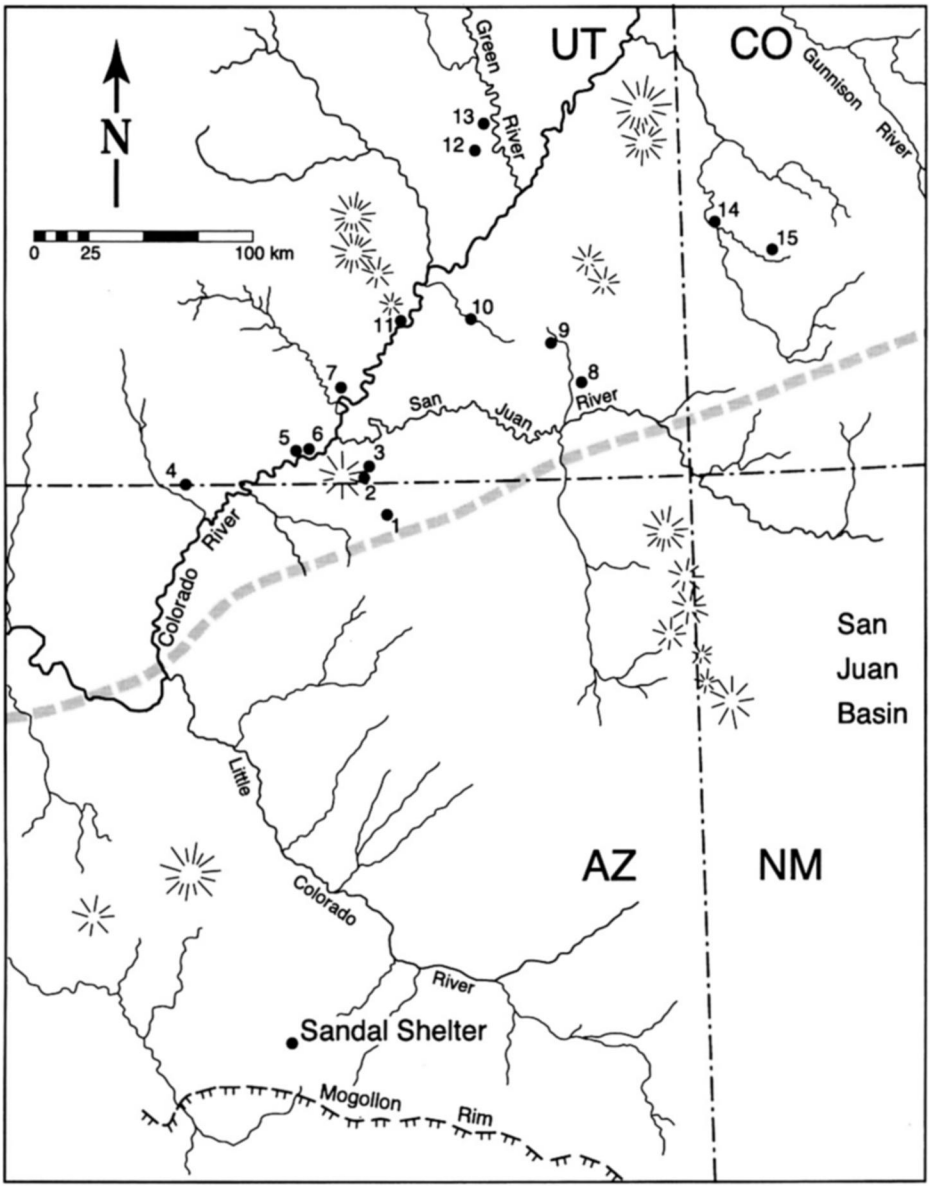

Figure 1. General location of Sandal Shelter along Chevelon Creek and other sites yielding Archaic age sandals on the Colorado Plateau. Table 1 provides the site names, general locations, sandals types recovered, and reference(s) for the numbered sites. Also shown is an approximate boundary between northern and southern portions of the Colorado Plateau defined by Archaic projectile point types.

to generation (see Sackett 1982, 1985; cf. Wiessner 1989). Patterns that arise from enculturation (technological traditions) provide the raw material for ethnic and other forms of social differentiation and clearly serve to track the history of cultural transmission. Perishable artifacts also can possess many malleable features (decoration) that might actively express identity in the sense argued by Wobst (1977) and subsequently elaborated upon by Wiessner (1983, 1989), with her notion of emblematic style. In particular, decorated clothing and other perishable artifacts of display are likely to convey information about social identities.

Sandals woven of plant fibers are the focus of this paper. Many aspects of sandal construction likely relate to the passive representation of group identity

in that they reflect traditionally learned production methods and have low social visibility. These include the preparation of warps and wefts, the materials used for both, and the weaving techniques by which the weft engages the warp.[1] Sandals also may have had an active role in expressing social identity using designs or other decorative elements or by the imprints left by the footwear (Hays-Gilpin 1998:122). For people accustomed to tracking animals and "reading" the subtleties of the environment, sandals could have provided distinctive tracks that easily may have served as social group identifiers. Different weaving techniques make different imprints; thus in this sense production methods also can actively impart social information.

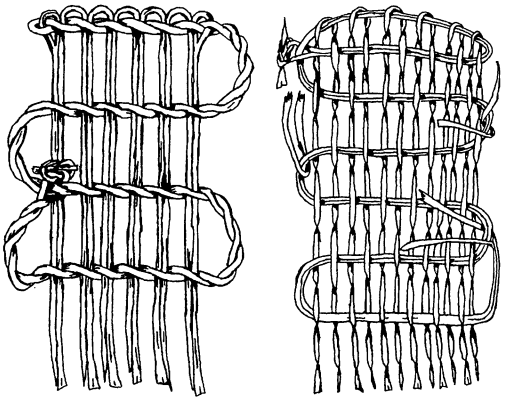

Figure 2. Construction methods for Archaic open-twined sandals (left) and warp-faced plain weave sandals (right) from the northern Colorado Plateau.

Background

Spatial variability in the material record produced by Archaic foragers of the North American Southwest may be expected to be broadly gradational. This is so because of evident low population density and anticipated high residential mobility coupled with socially fluid populations. Given the assumption of common social interaction across large areas and lack of territoriality (boundary defense), cultural differentiation should not be marked. Yet, in 1976 Alan Schroedl perceived clear differences in Archaic material culture between northern and southern portions of the Colorado Plateau (Schroedl 1976:82). Despite its being a distinct physiographic province, he believed that the plateau was not a unified region in terms of Archaic prehistory. Over 20 years of additional research has added to the impression that the Archaic archaeological record for the northern and southern portions of the plateau contrasts in several basic aspects (see reviews in Huckell 1996; Matson 1991). Geographical placement of a dividing line for this north and south distinction is somewhat arbitrary, but the line shown in Figure 1 best accords with current knowledge. Projectile points provide a principal basis for making a north-south distinction. The point sequence on the northern Colorado Plateau as described by Holmer (1978, 1986) is markedly different from the point sequence for the southern Colorado Plateau as represented by the Oshara Tradition of the San Juan Basin (Irwin-Williams 1973, 1979). On the northern Colorado Plateau, long-stemmed points (resembling Jay or Bajada) are poorly represented and there is an early preference for side- or corner-notched points beginning by about 6600 cal. B.C. On the southern Colorado Plateau, stemmed points persist throughout much of the Archaic sequence from at least 8000 cal. B.C. until about 2500 cal. B.C. and notched points are not common occurrences until after 2500 cal. B.C.

Sandals are one of the most distinctive artifact types of Archaic foragers on the northern Colorado Plateau and might provide another cultural contrast with the southern portion of the plateau. In the north they appear with the first traces of Archaic occupancy in the region and have been directly dated to almost 8000 cal. B.C. Two general styles of Archaic sandals are recognized on the northern Colorado Plateau: open-twined and plain weave (Figure 2). Both styles are made with whole yucca leaves and their warp is identical, consisting of folded leaves. Weft treatment is the distinguishing characteristic: open Z-twining vs. simple over-one under-one plain weaving.

The earliest foragers within the rugged canyonlands of the Colorado River and its tributaries wore the simple open-twined sandal type. First reported by J. Richard Ambler from excavations at Sand Dune and Dust Devil caves (Lindsay et al. 1968; also Ambler 1996), this sandal type is now known from 13 sites within a large region of southeastern Utah and far northeastern Arizona (see Figure 1, Table 1). Open-twined sandals were in fashion for a few thousand years from roughly 8000 to 5400 cal. B.C. (Figure 3, Table 2). After about 5800 cal. B.C., a new sandal type best described as warp-faced plain weave[2] began to replace the open-twined style. Several hundred years of overlap in the use of both sandal types is evident in the direct radiocarbon dates

Table 1. List of Archaic Sites on the Northern Colorado Plateau that have Open-Twined or Plain Weave Sandals.

Site name	Location # on Figure 1	Location	Archaic Sandal Type		Site Reference(s)
			Plain Weave	Open-Twined	
Atlatl Rock Cave	1	Rainbow Plateau, NE Ariz.		X	Geib et al. 1999
Bechan Cave	7	Southern Waterpocket Fold, SE Utah		X	Agenbroad et al. 1989
Benchmark Cave	6	Lower Glen Canyon, SE Utah	X	X[a]	Geib 1996; Lipe 1960; Sharrock 1964
Bernheimer Alcove	10	Moqui Canyon, SE Utah		X	Sharrock et al. 1963:Fig. 77b[b]
Boomerang Alcove	8	Butler Wash, SE Utah		X	Smiley and Robbins 1997
Broken Arrow Cave	4	East Clark Bench, SE Utah	X	X	Talbot et al. 1999
Cottonwood Cave	15	Southern Uncompahgre Plateau, SW Colo.	X[c]		Hurst 1948:Plate IV
Cowboy Cave	12	Upper Barrier Canyon, SE Utah	X	X	Jennings 1980; Schroedl and Coulam 1994
Dolores Cave	14	Middle Dolores River, SW Colo.		?[d]	Hurst 1947:11-13
Dust Devil Cave	3	Rainbow Plateau, SE Utah	X	X	Ambler 1996; Lindsay et al. 1968
Good Hope Alcove	11	Southern Henry Mts., SE Utah		X	Geib 1989
The Hermitage	5	Lower Glen Canyon, SE Utah			Geib 1996; Lipe 1960
Lizard Alcove	5	Lower Glen Canyon, SE Utah	X		Lipe 1960
Old Man Cave	9	Comb Wash, SE Utah	X	X	Geib and Davidson 1994
Rock Bar Alcove	13	The Spur, SE Utah		X	Geib 1994
Sand Dune Cave	2	Rainbow Plateau, SE Utah		X	Lindsay et al. 1968
Walters Cave	12	Upper Barrier Canyon, SE Utah	X	X	Jennings 1980; Schroedl and Coulam 1994

[a]Small sandal fragment (FS 95.26) from 1962 excavations not identified in the 1964 report but observed in the site collections at the Utah Museum of Natural History.
[b]Sandal fragments misidentified as a yucca mat; one (FS 68.31) shown in Figure 77b of report, the other (FS 68.32) not illustrated.
[c]Sandal type identified from photograph, new laboratory analysis needed to verify this assignment.
[d]Fragments of this sandal type evidently recovered but new laboratory analysis needed to verify this assignment.

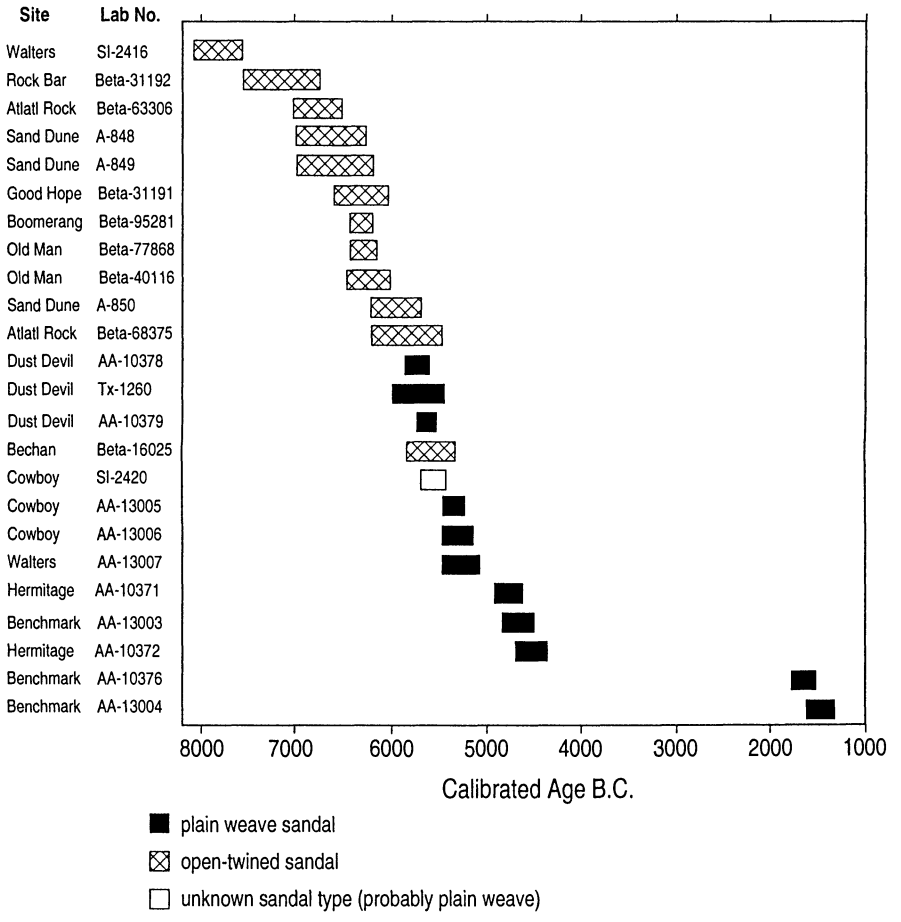

Figure 3. Graph of all directly dated Archaic sandals from the northern Colorado Plateau; see Tables 1 and 2 for list of dates, sites, and references.

(Geib 1996). A few rare sandals from the region exhibit aspects of both construction techniques, with a first weft pass of twining, shifting to plain weave. These examples provide good evidence that the two sandal styles represent a continuum, with the plain weave style developing out of the preceding open-twined style. The latest dates for warp-faced plain weave sandals on the northern Colorado Plateau are late Archaic, at roughly 1450 cal. B.C.

Whether this chronology of Archaic sandal types holds true for the southern Colorado Plateau remains unknown because Archaic sandal types from this region are virtually unknown. It was, therefore, with some surprise that late in 1997 I saw at the Museum of Northern Arizona a shelf of well-preserved warp-faced plain weave sandals from a site situated close to the southern edge of the Colorado Plateau. Thus began a study of these artifacts, the results of which are presented here. Analysis and radiocarbon dating of these sandals greatly adds to the growing data base on Archaic footwear.

Sandal Shelter

The sandals described here come from a small rockshelter (NA25,946) located in Chevelon Canyon (Figure 1), about halfway up the canyon from its confluence with the Little Colorado River in Arizona.[3] The shelter (Figure 4) is at the contact of the resistant Kaibab Limestone, which forms the ceiling, and the underlying Coconino Sandstone, which is semi-friable and has eroded from under the limestone. Because the shelter is on the outside of a bend, it is probable that when the canyon was younger the stream helped cut away the sandstone; presently the water flows in a channel about 5 m below the floor of the shelter. The shelter has a main central cham-

Table 2. All Prior Direct Dates on Archaic Sandals of the Northern Colorado Plateau.

Radiocarbon age	Laboratory Number	Sandal Type[a]	Site Name/Number	Artifact Identification	Reference(s)
8875 ± 125	SI-2416	OT[b]	Walters Cave	FS 370	Jennings 1980
8280 ± 160	Beta31192	OT	Rock Bar Alcove	—	Geib 1994
7900 ± 60	Beta-63306	OT	Atlatl Rock Cave	PN 2.2	Geib et al. 1999
7740 ± 20[c]	A-848	OT	Sand Dune Cave	—	Lindsay et al. 1968
7700 ± 20	A-849	OT	Sand Dune Cave	—	Lindsay et al. 1968
7590 ± 60	Beta-95281	OT	Boomerang Shelter	ECPR 96014	Smiley and Robbins 1997
7560 ± 130	Beta-31191	OT	Good Hope Alcove	—	Geib 1989
7490 ± 60	Beta-77868	OT	Old Man Cave	PN 153.1	Geib and Davidson 2000
7440 ± 100	Beta-40116	OT	Old Man Cave	ECPR 84.6	Geib and Davidson 1994
7150 ± 130	A-850	OT	Sand Dune Cave	—	Lindsay et al. 1968
7010 ± 200	Beta-68375	OT	Atlatl Rock Cave	PN 11.1	Geib et al. 1999
6890 ± 60	AA-10378	PW	Dust Devil Cave	F 10.2	Geib 1996
6840 ± 130	Tx-1260	PW	Dust Devil Cave	Str. IV, Sq. F9	Ambler 1996
6785 ± 60	AA-10379	PW	Dust Devil Cave	F 8.6	Geib 1996
6750 ± 120	Beta-16025	OT	Bechan Cave	—	Agenbroad et al. 1989
6675 ± 75	SI-2420	?[d]	Cowboy Cave	FS 485	Jennings 1980
6390 ± 65	AA-13005	PW	Cowboy Cave	FS 1692.1	Geib 1996
6385 ± 85	AA-13006	PW	Cowboy Cave	FS 1790	Geib 1996
6350 ± 85	AA-13007	PW	Walters Cave	FS 576.1	Geib 1996
5890 ± 55	AA-10371	PW	Hermitage Site	FS 19.1	Geib 1996
5810 ± 70	AA-13003	PW	Benchmark Cave	FS 77.5	Geib 1996
5665 ± 60	AA-10372	PW	Hermitage Site	FS 24	Geib 1996
3680 ± 60	Beta-77869	PW	Old Man Cave	PN 524.2	Geib and Davidson 2000
3355 ± 50	AA-10376	PW	Benchmark Cave	FS 35.1	Geib 1996
3210 ± 55	AA-13004	PW	Benchmark Cave	FS 142.11	Geib 1996

[a]OT = open-twined; PW = warp-faced plain weave
[b]Identification of this sandal as open-twined was based upon examination of field photographs showing the artifact *in situ*; the sandal was not described prior to dating (see Geib 1996, note 2).
[c]Grass lining of sandal was dated but not corrected for isotopic fractionation; because the grass was probably *Sporobolus* sp. with a delta value between –11 and –13, 200 years have been added to the reported value of 7540 ± 120.
[d]Sandal fragment was not identified prior to destruction for dating; likely to be plain weave (Schroedl and Coulam 1994:14) because this was the common sandal type for the upper portion of Unit III in the cave.

ber, flanked by several smaller grottos and crannies strung out along the geologic contact. Humans clearly used the main central shelter and probably a few of the smaller grottos. All of the sheltered area along the contact is occupied by packrats, whose middens fill the nooks and crannies. A large packrat midden about 20 m east of the main shelter contained nearly all of the sandals, with just a few coming from the deposits of the main shelter proper.

The main shelter is somewhat funnel-shaped in plan, measuring about 24 m wide by 14 m deep from the overhang or roughly 12 m deep from the dripline. The long part of the funnel, a narrow chamber that pinches out at its far end, is too narrow and dark for human use. It opens on an area about 10 m wide by 6 m deep from the dripline that provides the best-protected living space at the site. Here there are cultural deposits of an unknown depth, but probably less than 1 m. The entire surface of this area and part of the narrow chamber is dotted with looter holes and churned backdirt piles. Despite the amount of recent disturbance, intact deposits may remain, especially under a large block that fell from the ceiling sometime in the distant past. Remains scattered on the disturbed sediment of the shelter or placed upon roof spall blocks include several Archaic-style cobble manos, debitage and cores, burned bone, charcoal, a few human feces, and small organic remains. One of the individuals who dug at the site reported that relatively little of interest came from this portion of the shelter: a few sandal fragments, odd bits of string, and the like.

Of great interest was the packrat midden east of the main shelter that yielded numerous whole and nearly whole sandals. This is not the first find of sandals or other moderately large cultural items from

Figure 4. View of Sandal Shelter in Chevelon Canyon looking downstream and generally north; shelter is formed at the contact of the Kaibab Limestone and the underlying Coconino Sandstone.

within packrat middens, but the recovery of over a dozen sandals from a single large midden is unique to my knowledge. It seems likely that the sandals had been left in or near the main shelter, where the rodents collected them for additions to their nests. This was perhaps fortunate, for otherwise the footwear might not have preserved.

The Sample

The 19 sandals reported here (Table 3) are from the shelter described above (MNA Accession Number 3761). Six of the 19 are whole, 7 are nearly whole (listed as partial in Table 3), and 6 are large fragments. There is every indication that all of the large fragments are separate artifacts, so 19 is the minimum number of specimens. There are probably over 10 pairs of sandals represented based on differences in size and fabric density. The partial sandals are sufficiently intact to allow accurate measurement of total length and width and reliable analysis of warp and weft. The sandal fragments have full width, but their length remains unknown; warp and weft treatments are evident including an accurate warp count, but the number of weft passes remains unknown. In addition to the 19 sandals reported here, there are 3 small fragments in the collections from this shelter that appear to be from similar warp-faced plain weave sandals. These pieces are so small that they do not contribute meaningfully to the sample. It is possible that these 3 bits are from some of the reported sandals. A layer of packrat midden covers one face of several sandals, totally obscuring the fabric. The obverse sides of these sandals are free of midden accumulation so construction details are observable. In a few cases, the visible side is the worn sole, and this limited certain measurements or observations.

Construction

Construction of all sandals follows the same basic pattern as illustrated in Figure 5; representative examples of the sandals are shown in Figure 6, depicting the range of variation in fabric density from open to compact. Both the warp and weft are of whole yucca leaves, untreated in any way except for occasional trimming of tip and butt ends. The leaves for the warp are folded in half and laid over a leaf or two forming the weft at the toe (Figure 6a). The warp usually consists of paired leaves folded in half and laid over the toe weft, with each half forming a separate two-element warp. On several sandals (four definitely

Table 3. Summary of Characteristics for 19 Warp-Faced, Plain Weave Sandals from Sandal Shelter.

Sandal Number	Condition[a]	Length (cm)	Width (cm)	Warp Count[b]	Element Count	Fabric Density	Warp# Width	Weft Count	Element Count	Weft Spacing (cm)
A10848	whole	20.4	9.2	9	2	open	.98	7	1	1.6
A10853	whole	17.3	7.2	7	2	open	.97	6	1	1.6
A10855	partial	22.1	9.1	9	2	open	.99	6	1	2.5
A10856	fragment	—	10.3	19	2	compact	1.84	—	2	2.0
A10857	partial	18.7	7.8	15	2	compact	1.92	5	2	3.3
A10858	partial	22.8	8.8	13	2	open±	1.48	8	1	1.5
A10859	fragment	—	9.1	9	1	open	.99	—	2	2.3
A10860	fragment	—	8.4	7	2	open	.83	—	1	1.9
A10861	whole	22.8	9.8	11	2	open	1.12	7	1	1.8
A10863	fragment	—	9.4	7	1	open	.74	—	1	1.8
A10864	whole	20	9.2	35	1?	compact	3.80	5	1	3.1
A10865	fragment	—	10.3	21	2	compact	2.04	—	2	1.9
A10866	partial	14.6	7.0	7	2	open	1.00	6	1	1.3
A10867	partial	21.4	9.2	7	1	open	.76	6+	1	1.7
A10868	fragment	—	8.6	7	1	open	.81	—	1	1.9
A10869	whole	23.3	9.7	13	2	open±	1.34	7+	1	2.1
A10871	whole	19.3	9.5	17	2	compact±	1.79	5+	2/1	2.2
A10872	partial	20.9	8.9	9	1/2[c]	open	1.01	8	1	1.7
A13724	partial	21.7	10.6	42	1	compact	3.96	7?	2	3.0

[a]Partial sandals are nearly whole, allowing accurate measurement of length and width and reliable analysis of warp and weft; fragments have full width preserved but not length.
[b]Warp count includes the weft-turned-to-warp, a feature that was evident on 15 sandals; one sandal (A13724) lacked this feature and on three sandal fragments this feature could not be identified or inferred.
[c]This sandal has a warp of both single and paired leaves, evidently because the tips of long leaves were folded at the heel and brought forward.

and one possibly) single leaves folded in half form single-element warps. One side of the toe weft is woven back and forth across the warp in a widely spaced, simple, over-one under-one fashion. The other side of the toe weft, however, is folded down to form an outer warp and is secured by the second and subsequent weft passes (Figure 5c). This weft-turned-to-warp occurs on all but one of the 16 sandals for which this trait was evident or inferable;[4] three sandal fragments lack the toe or any other basis for inferring this construction detail. The weft-turned-to-warp is not reported for Archaic plain weave sandals of the northern Colorado Plateau.

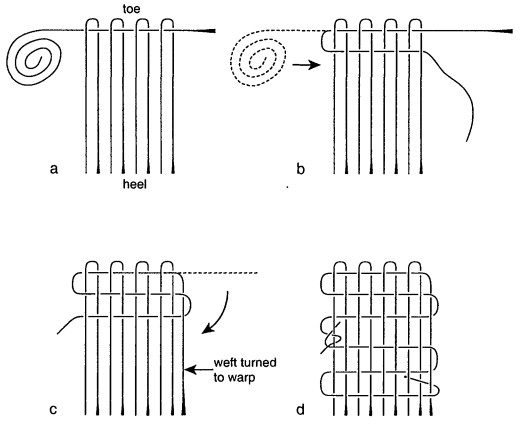

Figure 5. Construction method for the warp-faced, plain weave sandals of Sandal Shelter. There are slight differences between sandals mainly from warp density—warp counts above 15 result in a compact weave, counts below 10 result in an open weave, and those between 10 and 15 are intermediate. These differences seem largely the result of whether narrow- or wide-leafed species of yucca were used in construction.

The weft consists of a single leaf in all but five cases. The exceptions include four sandals with a weft of two leaves and one example with two leaves for the upper half, then a single leaf to finish. Weft passes vary from 5 to 8. The blanks in the weft column of Table 3 are fragmentary sandals where the total number of weft passes is unknown. Weft spacing in these fragmentary examples is the same as for the whole specimens (ca. 1.3 to 3.3 cm); thus weft number is likely no different. In several cases an extra leaf is woven across the heel, evidently as reinforcement; this is indicated in Table 3 by the + in the weft column. In all observable cases, a second leaf (or pair of leaves) is added to finish the weft after the

Figure 6. Representative examples of the plain weave sandals from Sandal Shelter showing differences in fabric density: a) open, b) compact. Specimens from left to right for a) are A10861, A10848, and A10869, and for b) A10871, A10865, and A10857. Specimens shown here that were radiocarbon dated are A10865, A10869, and A10871. Toes are to the top, heels at bottom; the middle sandal of compact weave is cut in half with the toe portion missing. Scale bar is 5 cm.

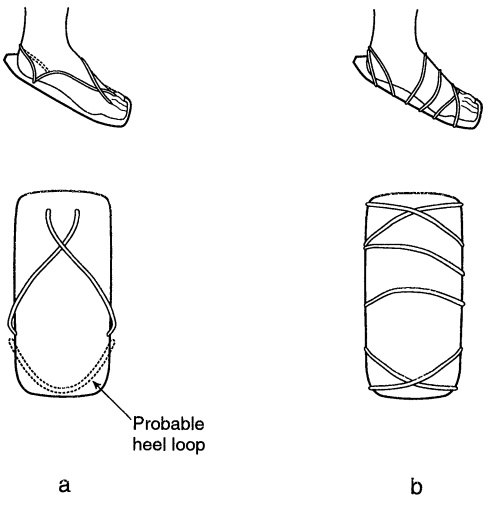

Figure 7. Method for securing the warp-faced plain weave sandals to the feet: a) tie method for sandals from Chevelon Canyon, b) tie method for sandals from the northern Colorado Plateau.

toe leaf (or leaves) expires on the third to fifth pass. In a few cases, the new weft element is simply laid in, but more usually, both the expired and new weft elements are wrapped around an outside warp (see Figure 5d).

Fabric density varies from open to compact, but this has no relation to weft spacing because both open and compact weaves have the same number of weft passes. The compact weaves simply have a greater number of warps per sandal width, with roughly one warp per cm for the open woven sandals but about 2 warps per cm for the compact woven sandals. Visually, the distinction is made by whether or not the weft is visible—totally obscured with the compact weave, creating a truly warp-faced sandal, but varyingly apparent with the open weave, including examples where the weft and warp are essentially balanced.

Differences in fabric density are at least partially related to yucca species. The compact plain weaves are made with a narrow-leaf variety (leaves measure ca. 6 to 7 mm in width on average), whereas the open plain weaves are often made with a wider-leaf variety (leaves measure 11 to 14 mm in width on average). The yucca species represented in the collection are unknown because it is difficult to make such identifications based just on leaves. The species common to Chevelon Canyon today are the wide-leafed *Y. baccata,* and the narrow-leafed *Y. angustissima.*

Tie System

Nearly all sandals exhibit some evidence of the ties for foot attachment. As with the rest of sandal construction, the ties consist of whole, unmodified yucca leaves. The basic pattern for all sandals is shown in Figure 7a. This "criss-cross" tie-system (Deegan 1993:62) is a version of toe-heel attachment that is common to the Southwest during the Basketmaker and Puebloan periods. A yucca leaf was inserted through 2 or 3 warps at the toe so that one side passes between the first (big) and second toes and the other side between the third and fourth toes. The leaves then cross over the arch of the foot back toward the heel, where they are inserted through the edge warps at the ball of the foot and secured. Athough there is little direct evidence, it seems likely that yucca leaves continued around the back of the heel, otherwise the sandals could easily slip off. This could have been accomplished with the same leaves that formed the criss-cross over the arch if they were long enough. If too short and tied at the warps, an additional leaf could have been used by tying it to either the warps or the criss-cross elements. This tie method contrasts with the tie method for plain weave sandals on the northern Colorado Plateau shown in Figure 7b.

Dating

To cover the range of variation in fabric density within the warp-faced plain weave sandals documented above, I selected small portions from six of them for radiocarbon dating. These samples are from three of the sandals with open weave and three with compact weave. It is possible that weave density is simply related to yucca species differences. Nevertheless, there might also be an underlying temporal pattern, either because species preference varied with time or because of shifts in species availability due to climatic change. The samples consisted of portions of yucca leaves from the fabric of each of the six sandals. Selection was partly based on which sandals had portions that could be removed without noticeable loss to the fabric and were free of packrat urine. To remove any unobserved urine contamination prior to submission to the dating laboratory, each leaf specimen was soaked in distilled water for about two hours, then gently scraped and brushed and rinsed in additional distilled water.[5]

The NSF-Arizona AMS Facility pretreated and analyzed all six samples and corrected the ages for

Table 4. Radiocarbon Determinations for Plain Weave Sandals from Chevelon Canyon.

Sample no.	Sandal No.	PN	^{14}C Age	$^{13}C/^{12}C$ Ratio	Calibrated 1 Sigma Range	Calibrated 2 Sigma Range
AA-29093	A10855	593.1	7425 ± 65	–13.01‰	6360–6175 B.C.	6390–6055 B.C.
AA-29094	A10864	604.2	8300 ± 60	–11.48‰	7470–7260 B.C.	7490–7060 B.C.
AA-29095	A10865	612.1	5575 ± 50	–13.63‰	4460–4350 B.C.	4505–4335 B.C.
AA-29096a	A10866	615.3	7540 ± 55	–13.64‰	6420–6255 B.C.	6455–6215 B.C.
AA-29096b	A10866	615.3	7565 ± 65	(–13.64‰)	6450–6265 B.C.	6470–6215 B.C.
AA-29097	A10869	548.1	7445 ± 65	–12.59‰	6370–6180 B.C.	6415–6065 B.C.
AA-29098	A10871	572.1	7290 ± 60	–13.59‰	6175–6015 B.C.	6210–5985 B.C.

Note: Calibrations based on CALIB 3.0.3A, 20-year data set, method A (Stuiver and Reimer 1993).

^{13}C fractionation using individually measured delta values. Because yucca has a CAM photosynthetic pathway, the $^{13}C/^{12}C$ ratio can vary significantly both within and among species. Indeed, the values obtained from this study significantly differ from those of yucca used in Archaic sandals on the northern Colorado Plateau (e.g., Geib 1996:Table 1). Table 4 presents the dating results. Note that the laboratory obtained two independent assays on one of the sandals (A10866), with the results just 25 years apart—7540 and 7565 radiocarbon years B.P.

Contrary to my anticipation that the ages of the Chevelon sandals would mirror the results obtained in prior dating of plain weave sandals from the northern Colorado Plateau (Geib 1996), most of the dates are surprisingly early. I expected that the dates would fall in the middle to late Archaic range, between 5700 and 1450 cal. B.C.; however, only one of them is in this range and the rest are older. The youngest sandal is 5575±50 B.P., which is within the expected date range based on prior direct dates. The oldest sandal has an age of 8300±60 B.P. with the rest varying between 7600 and 7200 B.P. The dates reveal no temporal difference between compact and open weaves.

Discussion

Figure 8 illustrates how the dating results from Sandal Shelter (presumptively representing the southern Colorado Plateau) compare with those previously obtained from several sites of the northern Colorado Plateau. The warp-faced plain weave sandals from Chevelon Canyon are largely contemporaneous with open-twined sandals on the northern Colorado Plateau and predate the use of this sandal style there by ca. 1,500 radiocarbon years. Indeed, just a single open-twined sandal, one from Walters Cave, is older than the oldest Chevelon Canyon sandal (see Table 2). Most directly dated open-twined sandals occur within a 7000 to 5800 cal. B.C. temporal range, contemporaneous with most of the Chevelon plain weave sandals. Based on this analysis, it is apparent that not only do point types differ between northern and southern portions of the Colorado Plateau but sandal types also differ prior to 5800 cal. B.C.

After 5800 cal. B.C. the plain weave sandal style was adopted on the northern Colorado Plateau. The earliest directly dated plain weave sandals from the northern Colorado Plateau are from Dust Devil Cave at ca. 5800–5600 cal. B.C. Further north (165 km) at Cowboy and Walters caves, the earliest dates on this sandal type are less than 5400 cal. B.C.[6] Additional direct dating of sandals ultimately may disclose a different pattern, but the evidence currently in hand reveals a northward spread of the plain weave sandal style at the end of the early Archaic. This is clearly not the result of population replacement, because the plain weave sandals on the northern Colorado Plateau retain subtle but important distinctions

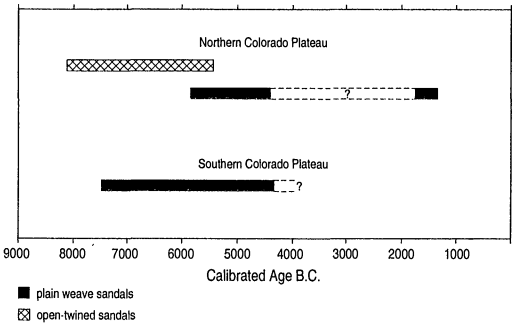

Figure 8. Distribution of radiocarbon dates for Archaic sandals on the northern and southern portions of the Colorado Plateau. All northern Colorado Plateau sandal dates are listed in Table 1.

from those of Chevelon Canyon. First, the tie method for plain weave sandals on the northern Colorado Plateau remained what it was for the earlier open-twined sandals—a series of criss-cross leaves tied to the warp that lash the artifact to the foot (see Figure 7b; Ambler 1996:47; Hewitt 1980:58, Figures 26 and 28; Lindsay et al. 1968:Figure 95). Second, one side of the toe weft does not become an outer warp along one edge of the sandal, but is always treated as a weft element (Ambler 1996:46–47, Figure 14; Hewitt 1980:58, Figures 26 and 27; Lindsay et al. 1968:Figure 95). Third, the occurrence of sandals at several northern Colorado Plateau sites that combine aspects of both open-twined and plain weave techniques implies an in situ developmental sequence (Geib 1996). None of these aspects would be evident if population replacement occurred. The change in sandal construction on the northern Colorado Plateau occurred by melding the new style with the old, so that certain aspects such as the tie system were unaltered.

This change may have resulted from sustained contact and interaction among foragers on southern and northern portions of the Colorado Plateau. Because of evident warming and drying at the end of the early Holocene (see review in Huckell 1996), foraging ranges may have expanded, as survival required even larger areas to gather and hunt within. This also could have created a need for greater social connectivity across vastly greater distances. Bands not only would have required information on resources in terrain outside the limits of their traditional seasonal rounds but they would have required access to new areas during times of shortage. The change in sandal style on the northern Colorado Plateau might signal an active expression of participation in this expanded network of forager bands. This could be seen as a relaxation of the means for "social boundary defense" (Cashdan 1983), where the use of space and its attendant resources is predicated upon being part of a social group. Sandals might have been one way of negotiating access into a redefined and expanded social group. The distributions of lithic raw materials such as obsidian, rock art styles, and projectile point types might be used to test this idea.

With regard to the above speculation, it is worth mentioning that I have found no clear technological or functional advantage of the plain weave sandal over the open-twined sandal. Having made and worn both types, I can offer the following observations. Construction of both types requires the same materials and is similarly easy, with both taking 10 minutes or less per sandal. Both work fine as footwear, but in my experience the earlier open-twined style has better traction on slickrock, which abounds on the northern Colorado Plateau. The plain weave style is perhaps more comfortable, but this is too subjective for evaluation.

Sandal Shelter is about 3 km downstream from O'Haco Shelter (NA11,910), a similar rockshelter that was about 85 percent excavated in the early 1970s (Briuer 1977).[7] The lowest cultural deposit at this site (Stratum V) has charcoal radiocarbon dates of 8100 and 8680 B.P. (Briuer 1977:Table 4.5). Given the likely burning of old wood, these dates probably indicate use of O'Haco Shelter by the same foragers who left the warp-faced plain weave sandals at Sandal Shelter. No similar sandals were recovered from O'Haco and few remains were recovered from the early Archaic Stratum V, although it was limited in horizontal extent (only one excavation unit), with just a small volume of matrix sampled. Briuer (1977:100–101) speculated that traces of the Archaic occupation may have been removed by later occupants—something that is true for many places on the Colorado Plateau. Sandal Shelter may shed additional light on this early interval, but even if early Archaic deposits are not preserved, the site has provided an invaluable record of the footwear used by early foragers.

Conclusions

The Chevelon Canyon sandals are some of the earliest footwear in the Americas and have no known close counterparts in adjoining regions such as the Great Basin, the southern Basin-and-Range into Mexico, or the southern Plains. The sandals of comparable age in adjacent regions are twined—the open-twined type of the northern Colorado Plateau and the Fort Rock type from the Columbia Plateau (Andrews et al. 1986). Plain weave sandals similar to those from Sandal Shelter were used on the northern Colorado Plateau roughly 1,500 years after their initial use in Chevelon Canyon on the southern Colorado Plateau. Adoption of the plain weave style on the northern Colorado Plateau evidently resulted from the diffusion of ideas and not a population migration because the plain weave sandals in the two areas, though structurally similar, have important differ-

ences. Most tellingly, the plain weave style on the northern Colorado Plateau appears to have developed out of the antecedent open-twined style. No such developmental trend is yet apparent on the southern Colorado Plateau; if there was one, it would have been prior to ca. 7500 cal. B.C., perhaps before the age of open-twined sandals on the northern Colorado Plateau.

The Chevelon Canyon sandals form part of a long tradition of sandal use on the Colorado Plateau present shortly after 8000 cal. B.C. When and where the making of footwear by weaving together plants originated remains unknown (independent invention in several places seems likely). The earliest directly dated sandals anywhere in the Americas are the open Z-twined Fort Rock style sandals made of shredded bark and directly dated between about 8600 and 7200 cal. B.C. (Connolly and Cannon 1999). Recovered from several dry caves of central and southwest Oregon, Fort Rock sandals may be antecedent to the similar twined examples of the Colorado Plateau. Nonetheless there are currently no known antecedent forms for the plain weave sandals of Chevelon Canyon.

Sandals were the common footwear for Puebloan populations of the Colorado Plateau up through the thirteenth century, and a developmental sequence of sandal types from the preceramic farmers, known as Basketmakers, into the Puebloan Period is well established (Hays-Gilpin et al. 1998; Matson 1991). What remains to be demonstrated is how the Archaic sandals of the Colorado Plateau relate to those of the Basketmakers. Because there are no certain antecedent forms for the Basketmaker sandals, these artifacts might provide evidence for farmer migration to the plateau as argued by Matson (1991). Yet it may be possible to demonstrate that Basketmaker weft-faced plain weave sandals are derived from Archaic warp-faced plain weave sandals. Shifting from warp-faced to weft-faced plain weaving is not a significant alteration of technique, although there are other changes in technological features that also had to have occurred. Perhaps key in such a developmental continuum are the whole yucca leaf weft-faced plain weave sandals recovered from Basketmaker II sites in low frequencies (Kidder and Guernsey's [1919] Type Ia). Detailed study and dating of sandals from late Archaic and Basketmaker II contexts might eventually disclose the intermediate technological features that demonstrate a developmental continuum.

Archaic prehistory is commonly discussed in terms of phases or temporal intervals (early, middle, late, and so on) tied to changes in projectile point styles. The direct dating of sandals has allowed the creation of an Archaic sandal chronology revealing patterns of change and stability in an aspect of culture totally independent from the patterns of point types. On the northern Colorado Plateau, plain weave sandals provide evidence for cultural continuity from the end of the early Archaic through the late Archaic, during a period of multiple changes in favored projectile point styles. This should serve to remind us that there were likely variable and independent rates and reasons for change in different aspects of culture. As such, phases derived from changes in projectile point styles may not correlate with changes in other aspects of culture and lifeways and may obscure patterns of interest. This is not a call to replace phases defined by point types with phases defined by sandals, because both could equally misinform. My point is that we can probably learn more by independently analyzing each aspect of culture or other variable of interest such as subsistence against the dimension of time furnished by chronometric dates. Fortunately, in the case of perishable artifacts such as sandals, and with the advent of AMS dating, unencumbered by phases we can separately track their historical development, change, and spread. The ability to directly date artifacts also eliminates difficulties with stratigraphic control during excavation and problems with prehistoric movement of remains within deposits.

As the number of well-dated sandals from the Colorado Plateau and beyond increases, the patterns indicated here might well change, requiring revision of these interpretations. Nonetheless, I hope this paper has achieved the immediate goal of illustrating the potential utility of perishable artifacts for our understanding of the Archaic Period. Perishable artifacts such as sandals provide a different and informative alternative to projectile points for examining social identities and relationships and for differentiating migration from diffusion in the more distant past. The sample of sandals described here has long-term relevance by providing detailed technological data about early Archaic footwear from the southern Colorado Plateau.

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Notes

1. Following standard terminology for describing sandal construction, warps run parallel to foot length and wefts are perpendicular. Wefts are the active element of weaving but, because sandals are generally made without the use of a loom, there is a tendency during actual construction for warps to play something of an active role as well. This is especially true for the simple plain weave sandals described here.

2. Various names exist in the literature for sandals of this type. The first published description was by Lipe (1960:202–204) who labeled them simply as "woven." He reversed warps and wefts, as is clear in the accompanying photo (Figure 62b), but once this is realized, his description makes sense. Ambler (in Lindsay et al. 1968:94,118–119) recognized the problem with Lipe's description and clarified the details of construction. He labeled the sandals as warp-faced, with two varieties—fine and coarse—based on whether the warps were closely packed so that the weft was not visible (fine) or more widely spaced allowing the weft to show (coarse). Hewitt (1980:58–61) subsequently labeled identical sandals from Cowboy and Walters caves as plain-weave. Ambler (1996:446–47) has acknowledged that Hewitt's term plain weave is appropriate for what he had called coarse warp-faced sandals, noting that warp-faced plain weave is the technically correct label. This is the name used here for all of the Archaic plain weave sandals of the Colorado Plateau, including Ambler's (1996) fine warp-faced sandals, which are also made by simple over-one under-one weaving. This term also helps to differentiate Archaic sandals from later Basketmaker II sandals that are also plain weave but weft-faced. Technically the least ambiguous label for the Archaic plain weave sandals would be 1 x 1 warp-faced plain weave (see Deegan 1993).

3. I was able to visit the site with two of the individuals that recovered the sandals, at which time I prepared a sketch map and MNA site form. During this visit, the individuals made it clear that most of the sandals came from a large packrat midden off to one edge of the main shelter, but that a few sandals came from deposits within the main shelter. By finding another plain weave sandal still embedded within a chunk of rat midden at the site, I was able to verify the excavators' account. They also showed me a small grotto 10m or more above the shelter from which they recovered a large storage basket (wicker granary) associated with pottery (the basket is housed at MNA). Within this container there was at least one Puebloan style plaited sandal, which is not part of this study.

4. This feature could be inferred for several of the sandal fragments because one outer warp differs in element number from the other warps.

5. I have no doubt that the ^{14}C determinations are unaffected by packrat urine, first because the samples were visibly clean and second because of the distilled water rinse prior to submission to the laboratory. If there was contamination then the sandals are even older than indicated (the packrat urine being younger); thus, my argument would remain unchanged.

6. There is an unidentified sandal from Cowboy Cave with an age of 6675 ±75 radiocarbon years B.P. (see Table 2); if it was a plain weave type as Schroedl and Coulam (1994:14) suspect, then the northward spread of this sandal style occurred more rapidly.

7. Briuer (1977) made an important point in his report about controlling for noncultural sources (packrats, and the like) for the biological remains recovered from sheltered sites. Nevertheless, because his noncultural control sites (packrat middens) were located less than 40 m from the cultural sites (1977:29), they likely contain considerable admixture of cultural debris. Packrats gather everything for inclusion in their nests and if the rats live near an archaeological site they will collect from it, as the results from Sandal Shelter demonstrate. The materials found in a packrat midden 40 m or less from an archaeological site will contain many bones, plant remains, etc. that humans collected and that the rodents subsequently relocated to their nests. Realistic controls for a study such as Briuer's will require packrat middens that are well away from the influence of human activity.

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