The Prehistoric Development of Intensive Green-Cone Piñon Processing in Eastern California

Jelmer W. Eerkens
University of California
Davis, California

Jerome King
Eric Wohlgemuth
Far Western Anthropological Research Group
Davis, California

The upland piñon zone has long been an important source of data for archaeological theory-building in the Western Great Basin. Recent excavations in the piñon zone on Sherwin Summit, eastern California, the traditional homeland of the Owens Valley Paiute, have shed much light on the role of rock rings and charcoal stains in green-cone piñon processing and storage. Radiocarbon dating points to a late prehistoric intensification of green-cone processing in the area (ca. 500–100 b.p., uncalibrated), which we suggest is the result of scheduling conflicts during late summer and fall. Green-cone procurement allowed local residents to harvest piñon earlier in the season, freeing time to harvest irrigated and wetland seeds, to participate in annual festivals, and to hunt.

Introduction

Archaeologists working in the Western Great Basin of North America have long been interested in the upland piñon-juniper zone, which contains a distinctive array of plants and animals exploited by American Indians throughout the prehistoric period. The ethnographic record in this region clearly stresses the dietary importance of piñon nuts and the social and ceremonial role of piñon harvesting to Paiute and Shoshone people (Kelly 1964; Steward 1938; Stewart 1942). Archaeologists have also been interested in the piñon-juniper zone because of the distinctive character of archaeological sites, which include unusual items such as piñon-harvesting poles, hunting blinds, and, occasionally, still-standing house structures, in addition to more common artifacts such as projectile points, millingstones, and debitage (Bettinger 1975, 1989; Delacorte 1990; Hildebrandt and Ruby in press; Reynolds 1996; Rhode 1987; Thomas 1971; Thomas and Bettinger 1976).

Rock rings are a common component of sites in the piñon zone. These circular features vary from one to five meters in diameter and follow the distribution of the modern piñon zone. Although they are assumed to be related to piñon processing, the exact role, function, and temporal affinities of these features are not well known. Archaeologists have proposed several functions, including foundations for house structures, cleared areas used for sleeping or other activities, piñon processing areas, and piñon storage facilities (Bettinger 1975, 1989; Reynolds 1996). Some (Bettinger 1975, 1989) have suggested that internal size can be used to differentiate rock rings that served as storage facilities from those that served as house foundations. With rare exceptions (Steward 1933: 242), the ethnographic record is silent on the function and formation of rock rings.

Our investigations on Sherwin Summit in eastern California (FIG. 1) revealed the presence of several "burn features." These features are circular to ovoid in plan, between 2 and 4 m in diameter, and have a shallow deposit of darkened charcoal-rich earth visible against a background of lighter-colored soil. Perhaps owing to their ephemeral nature, these features have rarely been reported or excavated (Thomas 1971: 47), yet examination of the ethnographic record suggests that they should be common. Our analyses of rock rings and burn features suggests that both were used in green-cone piñon processing.

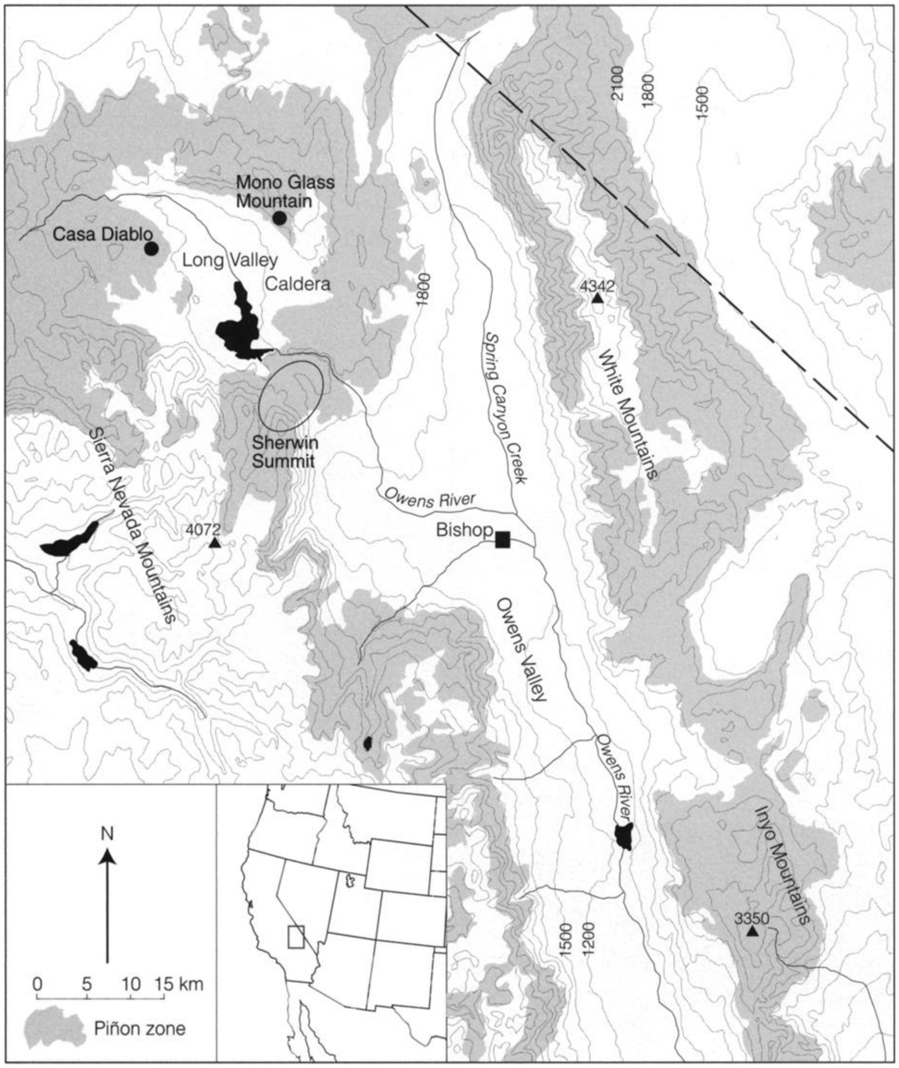


Figure 1. Map of Sherwin Summit project area near the California–Nevada line. Contour interval is 300 m.

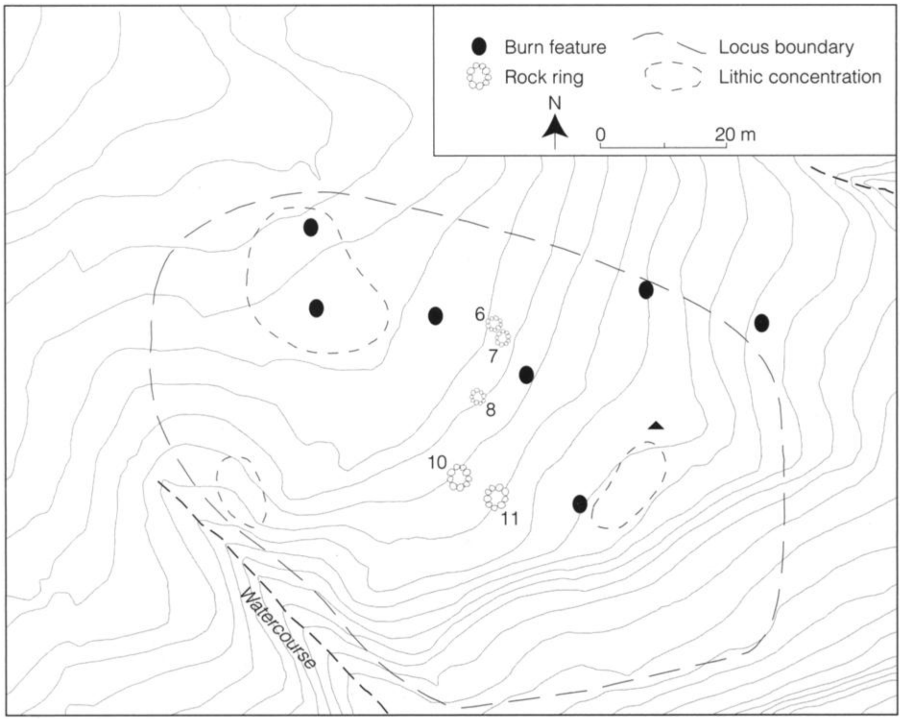
Rock Rings and Burn Features

Sherwin Summit represents a transitional zone between Owens Valley, characterized by open sagebrush scrub at 1400 m in elevation, and the Long Valley Caldera, composed of a more forested and rugged terrain including Jeffrey Pine (*Pinus jeffreyi*) woodland at 2300 m in elevation (FIG. 1). Between these extremes (1800–2100 m) lies the piñon woodland. This environmental zone includes a dense distribution of piñon pine (*Pinus monophylla*), with an understory composed of big sagebrush (*Artemisia tridentata*), rabbitbrush (*Chrysothamnus nauseosus*), desert peach (*Prunus andersonii*), ephedra (*Ephedra nevadensis*), and various small shrubs, grasses, and herbs. Piñon nuts and large game were two subsistence resources that served to draw people to this area. The proximity of two obsidian sources, Mono Glass Mountain and Casa Diablo, also attracted nearby inhabitants to the piñon zone.

Recent investigations in a 200 acre area in the Sherwin Summit piñon zone revealed a high density of archaeological sites, including numerous lithic scatters, burn features, and 23 rock rings. Nine rock ring features, eight burn features, and several nearby lithic scatters were excavated. Spatial analysis of rock rings and lithic scatters, functional analysis of rock ring attributes, and analyses of macrobotanical remains were undertaken to give greater context and meaning to the rock rings and burn features.

Spatial Analysis

On Sherwin Summit, rock rings are often found at the same "site" as dense lithic scatters representing short-lived



A

B

Figure 2. A) Plan of CA-MNO-2433/H, Locus A showing distribution of rock rings, burn features, and lithic scatters; B) Photograph of typical rock ring from Sherwin Summit.

flintknapping events. Figure 2 is a plan of one site (CA-MNO-2433/H, Locus A), showing the spatial arrangement of rock rings, burn features, and flintknapping areas. Because they are sometimes found at the same site, rock rings have occasionally been dated by association with nearby lithic scatters, themselves dated by projectile points and obsidian hydration measurements (Reynolds 1996). Since most lithic scatters date to the Newberry period (Gilreath and Hildebrandt 1997; Hildebrandt and McGuire 2002), that is, between 3500 and 1500 b.p. (radiocarbon years), the implication has sometimes been that rock rings also date to this period.

The notion that these two archaeological phenomena (rock rings and lithic scatters) are correlated can be questioned on two counts. First, a test of spatial association between 23 rock rings and 20 lithic scatters on Sherwin Summit was conducted, using the test outlined by Pielou (1961, 1969; also see Hodder and Orton 1976). Results demonstrate that, although there is a weak tendency for the two to co-occur, this relationship is not statistically significant ($S = 0.27$, $\chi^2 = 3.05$, $p = 0.08$). Thus, the activities leading to the formation of rock rings are not strongly correlated to those leading to the formation of lithic scatters, putting into question temporal and functional relationships between the two. Second, as discussed below, radiocarbon dates on charcoal within several rock rings suggest a much later date.

Rock Ring Attribute Analysis

Our second analysis was a comparison of rock rings in Sherwin Summit and other nearby piñon uplands with rock rings in lowland locations. A total of 229 recorded rock rings from the Inyo-Mono region was included. These comprise 23 rings from Sherwin Summit, 108 rings from other upland localities, and 98 rings from lowland or valley-bottom settings. The data were compiled from numerous cultural resource management reports. Figure 3 presents two typical rock rings from Sherwin Summit.

The following attributes were included in the study: the types of artifacts within four meters of the ring; whether the ring was constructed on or within 10 cm of bedrock; whether the ring had any opening or entrance (and if so, the cardinal direction); and whether the ring contained a hearth or charcoal stain. We also included the internal diameter of rock rings (i.e., the cleared area within the enclosing rocks), since this is where any activities would have taken place.

The internal diameter for lowland and upland rock rings is shown in Figure 4. A bimodal distribution for lowland rings is evident, the first mode comprising rings under 1.5 m D., and the second mode composed of those over 3 m. Excavation suggests that the smaller rings are often hearths or pit-hearths and the larger rings are often the remains of residential structures (Basgall and Giambastiani 1995; Bettinger 1989; Gilreath and Hildebrandt 1997). On the other hand, the upland rings display a more unimodal distribution of medium-sized rings.

There is little difference in average internal diameter between upland and lowland settings. A t-test comparison of means is not significant at the 0.05 level (TABLE 1). If smaller rings under 1.5 m D. are excluded from the lowland

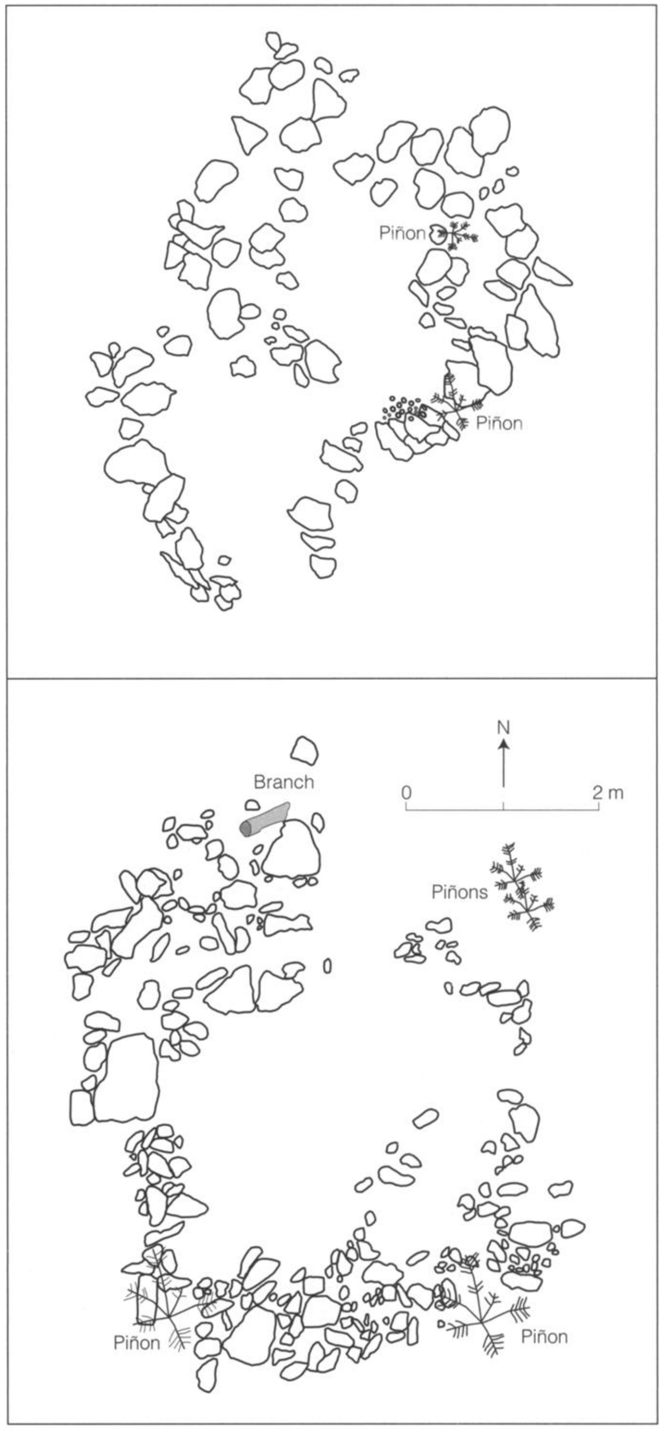


Figure 3. Plan view of two typical rock rings from Sherwin Summit.

sample, the difference in size is less significant. While rock rings are not greatly different in size between upland and lowland settings, Table 1 does point to other significant differences. For example, lowland rings usually contain breaks in the circular arrangement of rocks, which are of-

Table 1: Comparison of lowland and upland ring attributes for all rock rings.

Elevation Zone	*Average internal diameter (m)*	*Entry-way present (%)*	*Multiple classes of artifacts (%)*	*Hearth or stain visible (%)*	*Bedrock within 10 cm (%)*
Lowland	2.53	75	48	25	4
Upland	2.73	48	24	6	37
Test for Difference (p)	0.21	0.005	0.0007	0.0002	0.002

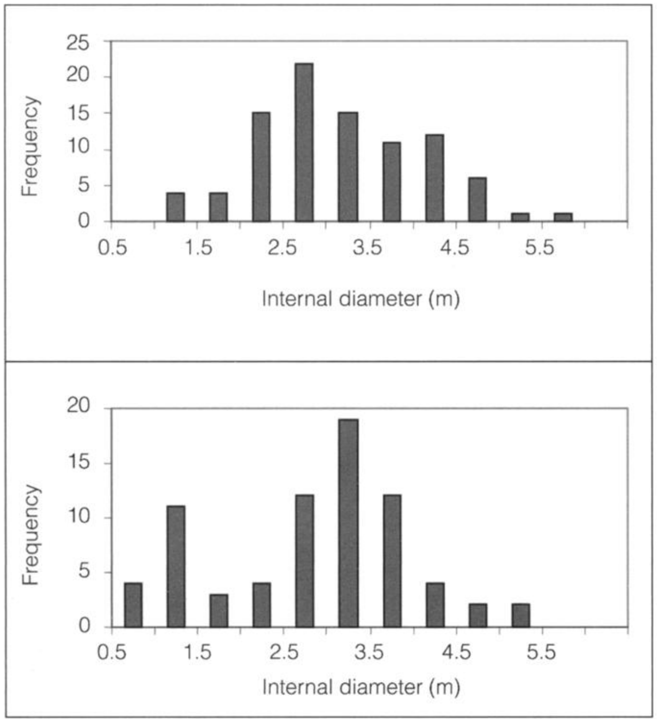


Figure 4. Histograms of rock ring internal diameter from uplands (top) and lowlands (bottom).

ten interpreted as entranceways. Figure 5 shows a strong predisposition for an eastern orientation of entryways in lowland rings, as eighty-six percent of them open towards the SE, NE, or east. Ethnographic data from the Great Basin suggest that houses frequently orient their doorways towards the east (Liljeblad and Fowler 1986; Steward 1933, 1938), supporting their general interpretation as house foundations. Such a pattern was not obtained for upland rings, where entryways are more randomly distributed across the cardinal directions (FIG. 5). If anything there is a slight bias towards a western orientation.

Lowland rock rings are more likely to be associated with multiple classes of artifacts and interior hearths (or charcoal staining), and less likely to be on or just above bedrock. All these differences are significant. Multiple classes of artifacts and central hearths should be associated with domestic structures, and houses are usually built on a softer substrate rather than bedrock. In other words, lowland rings appear to be dwellings, while upland rock rings are not. This suggests that lowland and upland rings represent different types of activities.

Excavation and Flotation Analysis

In order to gain greater insight into their function, nine rock rings and eight burn features were selected for test excavation. Units (1 × 1 m or 1 × 2 m in size) were excavated in the interior of each feature, with all sediment screened through 1/8″ wire mesh. Flotation samples were removed from all features, with botanical remains over 1 mm in size identified under a microscope. To determine if rock rings and burn features contain higher densities of artifacts or plant remains than the cultural and natural background, flotation samples were also processed from units outside of the rock rings and from off-site locations.

Excavations in all nine rock rings failed to turn up significant numbers of artifacts. Typically a maximum of four or fewer flakes was recovered within a rock ring, significantly lower than the amounts recovered in surrounding units. Bedrock was often discovered within 5 cm of the ground surface, suggesting that most rings had been constructed on exposed rock. Burn features, however, occur in areas with much deeper sediments, up to 40–50 cm of deposit, and have more artifacts.

The overwhelming majority of the botanical remains recovered from the flotation work consisted of burned and unburned piñon nutshell and cone scales. Both off-site samples contained only unburned piñon remains. Of the four samples from units outside of the rock rings three contained moderate levels of unburned remains and only one had moderate levels of burned remains. Thus, in these samples unburned remains are common and burned remains are rare. None of these six samples represent the remains of piñon processing. By contrast, five of the eight (63%) burn features we tested have high densities of burned and only moderate to low densities of unburned piñon nutshell and cone scales. The remaining three are nearly devoid of macrobotanical remains. Radiocarbon samples were taken from three of the high-density features and all date to the last 250 radiocarbon years. Ethnographic accounts of green-cone piñon processing in the western Great Basin

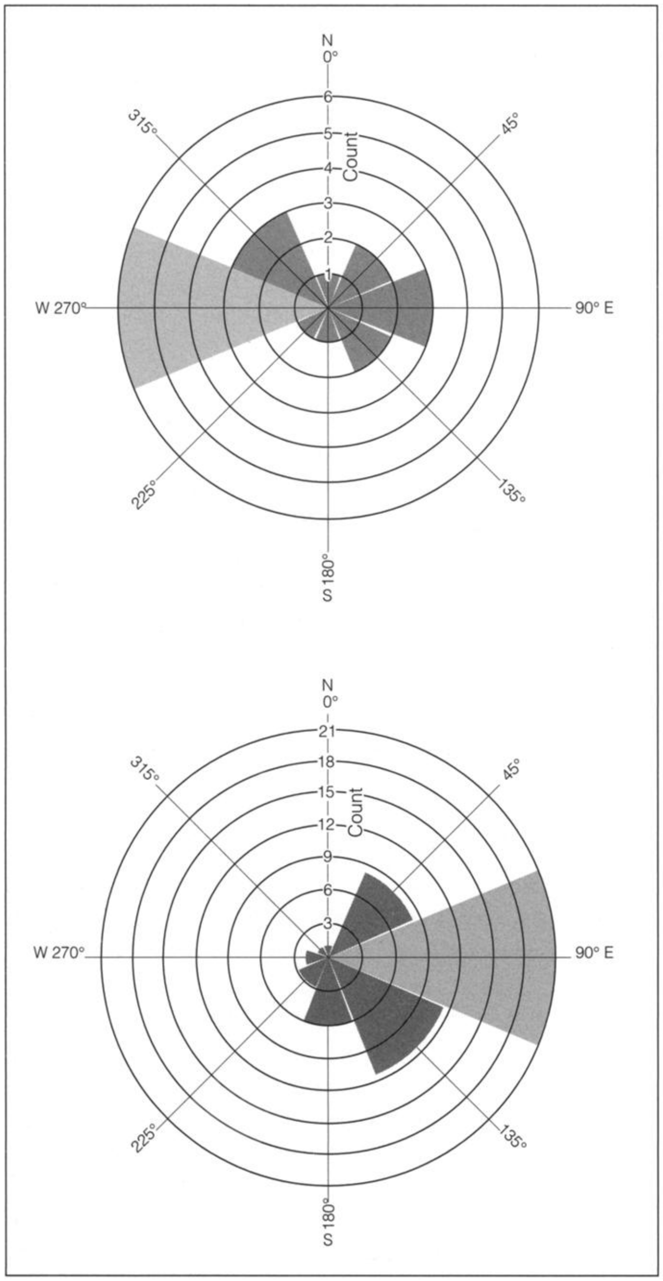


Figure 5. Circular histograms of entryway orientation for rock rings from uplands (top) and lowlands (bottom). The lighter tints are for due west and due east orientations, resectively.

(Dutcher 1893; Irwin 1980: 6–8; Steward 1933: 241–242; Zigmond 1981) consistently mention the use of open fires to force open the scales on premature (i.e., green) cones (Madsen 1986). Burn features have not been described archaeologically, perhaps owing to their ephemeral nature. Based on the flotation studies, we suggest that a significant number of these patches of burned earth are the remains of green-cone processing.

Two of nine (22%) flotation samples from rock rings contain high densities of burned remains suggesting piñon processing. Radiocarbon dates on these two samples fall within the last 150 radiocarbon years. Additionally, one of nine (11%) samples contains high levels of unburned but only moderate levels of burned remains, and six are devoid (or nearly so) of any botanical remains. Thus, only a minor fraction of rock rings appear to represent the remains of piñon processing. Neither do they represent dwellings, which typically contain more diverse and dense macrobotanical remains (Basgall and Giambastiani 1995; Basgall and McGuire 1988; Bettinger 1989).

Finally, our investigations at a rockshelter (CA-MNO-3490) below the piñon zone but above the valley floor, produced large numbers of burned nutshell fragments, but only one burned cone scale. This implies that nuts procured during green-cone processing in the piñon zone were transported in the nutshell (but outside the cone) to lower elevations for additional processing. Thus, our investigations suggest at least two steps in the gathering and processing of piñon remains: collection and initial processing within the piñon zone to remove the cones and occasionally shells, followed by transportation to lower elevations where they were further shelled.

Function of Rock Rings and Burn Features

Having established that the Sherwin Summit rock rings are unlikely to represent houses, what do they represent? Possibilities include sleeping circles, territorial markers, piñon processing features, and piñon caches. The first two options are unlikely: that rock rings are often found on bedrock argues against the former and the ubiquity of rock rings across the landscape argues against the latter. Use as piñon processing features is also unlikely, because ethnographic accounts do not describe the use of rock rings for this activity, and only two of the nine rock rings excavated on Sherwin Summit contain large numbers of burned piñon remains. Although we do not believe the initial construction of a rock ring was associated with processing activities, it is possible that an existing ring was later used as a convenient place to burn green-cones, or alternatively, that a rock ring was constructed on top of an existing burn feature.

The most parsimonious explanation is that rock rings represent the remains of piñon caches (Bettinger 1976, 1989; Hildebrandt and Ruby in press; McGuire and Garfinkel 1976; Reynolds 1996). Caches were probably constructed by piling green-cones in one location, covering them with pine boughs and needles, and placing rocks along the edges of the boughs to hold them in place. The resulting pile of cones and enclosing ring of rocks were arranged in a circle to maximize the internal volume. Upon opening the cache, the boughs were removed, but there was no reason to disturb the circular arrangement of rocks (Bettinger 1976).

Based on our analyses, we suggest the following steps in harvesting piñon nuts. During middle to late summer, groups of people entered the piñon zone in places where cones were plentiful. Piñon is known to produce large quantities of cones in certain years, and the location of particularly rich stands can be predicted up to one year ahead of time (Lanner 1981, 1999; Thomas 1972; Welsh et al. 1987). Ethnographically, mass-processing of green-cones involved placing them within a large pile (or nest) of brush, which was set ablaze. Heat from the fire dried out the cones, forcing the scales open and exposing the nuts. Nuts were extracted and the cones discarded. The refuse of such activities resulted in the accumulation of large amounts of charcoal, charred cones, and unsuitable or immature nuts, which constitute up to 2/3 of the nuts in a cone (Lanner 1981, 1999). Some of the extracted nuts may have been consumed in the piñon zone, but a large fraction of unshelled nuts were transported to the valley bottom.

The sheer volume of cones and nuts harvested within a productive grove was more than could be processed in a single logistical trip. A single tree can produce over 500 cones in a year, yielding over 10,000 edible seeds, and the output of a productive grove has been measured at over 2500 cones (or 50,000 seeds) per acre (Janetski 1999). Moving the residential base to the piñon zone during fall and winter was one option to handle this bounty, but scheduling in the late prehistoric period may have made this option unattractive. Rather than leave the remaining crop unutilized, it would have been a simple matter to store these cones in caches for later collection.

We estimate that a rock ring 3 m in diameter could hold about 40,000 nuts (roughly 16 kg of nut meat), or between one and three large (i.e., burden) baskets. Based on information from the United States Department of Agriculture for *Pinus edulis* this would provide roughly 100,000 kilocalories, or enough to feed a family of five (two adults and three children) for two weeks. A rock ring full of green-cones, then, could hold the produce of four to five productive trees in any given year. This figure explains the high density of rock rings, which are often found in pairs, in the Sherwin Summit area (one every 35,000 sq m). By contrast, a rock ring could hold some 750,000 nuts (i.e., with cone removed), or nearly two million kilocalories. At least 80 to 100 productive trees would be required to fill such a cache, representing a large spatial area. It seems unlikely that individuals would carry the produce of so many trees to a single location for storage, especially since they were left unguarded (there are no obvious residential base camps in Sherwin Summit). The amount of work involved in accumulating nearly a million nuts is large and worth guarding. Moreover, cones provide a natural and convenient protective casing for nuts. Given these findings, it is likely that rock rings were used to store green-cones rather than nuts from brown cones.

In sum, green-cones were probably not carried for long distances and were cached close to where they were collected. The high density of rock rings is probably a result of spatial variability in the productivity of piñon trees and the ease with which these features could be constructed. On Sherwin Summit a ring could be constructed in a matter of minutes, though preparation of a pine bough covering could have taken longer. Had the construction of rock rings been more labor intensive, we might expect to see fewer of them. Given that tree productivity varies from year to year, thousands of rock rings could be constructed over the course of two or three centuries.

As Bettinger (1999) has argued, much of the effort expended on green-cones goes not into storage but into subsequent processing for consumption. In this respect, the loss of a few piñon caches to rodents or people would not have been detrimental as little had been invested in gathering and storing the contents. The value of any single cache was not very high and it is likely that many were never revisited. We suggest that in lean years, when other resources had been meager, individuals would return to the piñon zone to access cached green-cones.

Dating of Intensive Green-Cone Piñon Processing

Based on associations with projectile points and obsidian hydration dates, Bettinger (1975, 1976, 1989) and Bettinger and Baumhoff (1983) suggested that green-cone piñon processing activities began approximately 1500 years ago, while Reynolds (1996) suggested that people were engaged in these activities at least 2000 years earlier. Our five radiocarbon dates on green-cone processing refuse from Sherwin Summit sites are all later than 240 ± 70 b.p. (uncalibrated). Combined with four assays on piñon processing refuse from the nearby Sherwin Grade site (430 ± 150, 455 ± 140, 490 ± 70, and 1155 ± 160 b.p.; Garfinkel and Cook 1979, 1981), these dates imply that intensive green-cone processing is a late prehistoric to historic period phenomenon in this area. If green-cone processing and storage was important to the residents of Owens Valley before 500 b.p., it is not reflected in our data.

Figure 6 presents a histogram of all radiocarbon dates from piñon-zone sites in the Inyo-Mono region (n = 38).

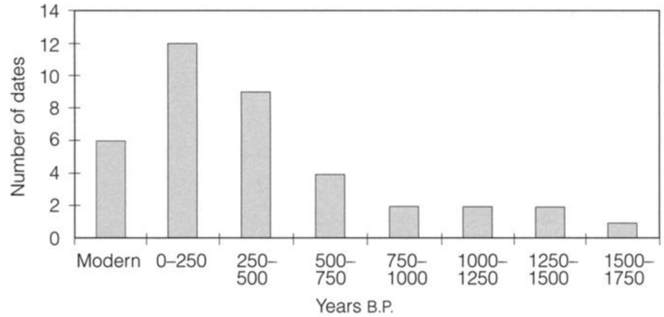


Figure 6. Histogram of radiocarbon dates from piñon-zone sites in the Inyo-Mono region.

The majority of these are from rock ring, burn, or hearth features, or from burned piñon fragments in middens (n = 30). The remaining eight are from undifferentiated charcoal from midden or unreported contexts. The oldest date, 1700 ± 60, may represent the inception of green-cone processing, but the vast majority (71%) are later than 500 b.p., indicating that the most intensive period of green-cone processing was late in time. This period (post 500 b.p.) is also a time when new technologies appear in Owens Valley, such as ceramics and portable schist millingstones, that were used to grind and boil small seeds. As we discuss below, the appearance of these technologies at the same time that green-cone processing increases in scale may not be fortuitous.

Late Prehistoric Piñon Processing and Scheduling Issues: A Model

What led to this late prehistoric focus on green-cone processing and caching? Green-cone harvesting and processing requires a significant increase in the amount of time and energy invested over brown-cone harvesting, where nuts are simply gathered ripe from the cone or off the ground. Bettinger and Baumhoff (1983) suggested that this change resulted from a need to increase efficiency in resource extraction. In particular, this strategy served to avoid competition with rodents by allowing humans to get to the nuts first. This shift is proposed to have occurred around 1500 years ago. We propose an alternative, though not necessarily contradictory, model that focuses more on landscape use and scheduling conflicts.

Normally, piñon trees drop their nuts in the fall (mid September to November). One of the advantages of green-cone processing is the opportunity to harvest nuts in summer (August to early September) before they ripen. Additionally, caching cones extends the availability of nuts into the winter, though the number of caches surviving rodent predation and human theft is likely to decrease with time. Thus, green-cone processing and caching extends the availability of pine nuts over a longer period of time, effectively late summer through winter.

Given that green-cone processing is more labor intensive, why did people want to change the seasonal availability of piñon, particularly after 500 years ago? Three potential scheduling conflicts may have encouraged people to spend autumn in the valley bottom, rather than in the uplands collecting brown-cone nuts. First, in Owens Valley autumn was the time in which seeds from irrigated fields were harvested (Steward 1930: 152; Lawton et al. 1976). Irrigation of seed plots is believed to have been a late prehistoric phenomenon (post 500 b.p.) and was an important part of the subsistence economy (Lawton et al. 1976). The need to protect fields that had been invested with considerable time and labor may have encouraged people to stay near home bases as harvesting season approached. Although irrigation seems to be limited to Owens Valley, and possibly neighboring valleys (Steward 1930), intensified use of seed-producing species that are only available in fall in the valley bottom, especially wetland seed resources such as rush, bulrush, and cattail, may have had a similar effect in other parts of the Great Basin.

Second, fall was the time when village festivals took place (Steward 1933: 238, 1938: 54). These gatherings took place in valley-bottom villages and were times to socialize, dance, gamble, meet potential spouses, and eat various foods, including piñon nuts. Village chiefs were in charge of these events and invited residents of nearby villages to attend. Individuals may have preferred to be in the valley to participate in these festivals, rather than stay in the hills to harvest piñon. Festivals may also have involved some degree of competitiveness, with one community trying to outdo the next (Hayden 1990, 1995). It is possible that festivals were originally scheduled in a small number of communities following the brown-cone piñon harvest. Giving away pine nuts, particularly in bountiful years, may have been a way for hard-working individuals to accrue social debt. As more communities attempted to engage in competitive feast-giving, they may have had to schedule their festivals at alternative times of the year, perhaps prior to the availability of fully ripe piñon nuts. Green-cone harvesting may have been a strategy pursued by some communities such that they could throw festivals earlier in the season and still give away pine nuts. Since all of the nuts could not be carried to the valley bottom at once, caching them in rock rings may have allowed feast-givers to return at a later date to collect the remaining crop. Alternatively, such caches could represent food stores needed after the fall festival season was over, particularly if other resources, such as irrigated seeds, had failed to provide enough to feed everyone through the winter.

Third, hunting activities may have influenced green-cone harvesting (Madsen 1986). Ethnographically, drives of antelope and rabbits took place in the fall on the valley bottom (Steward 1933: 253–254, 1938: 34–36), and mountain sheep were hunted during fall as they migrated from summer pastures at higher elevations into lower elevations. Increases in these activities after 500 b.p. may have led to intensified use of green-cone piñon nuts.

In all three hypotheses, green-cone harvesting allowed people to undertake new activities or intensify existing ones (i.e., irrigation, wetland seed harvesting, festivals, hunting), while still allowing them to harvest piñon. By shifting piñon harvesting earlier in the season people could remain in the lowlands during fall. Caching nuts in rock rings allowed people to retrieve unused nuts after the fall season was over.

Conclusions

Test excavations at rock rings and burn features on Sherwin Summit suggest they are the byproduct of caching and processing piñon green-cones. Rock rings are too large to have been used as shelled-nut caches and are unlike residential structures. Burn features often contain dense accumulations of burned piñon cones. Ethnographic descriptions of piñon harvesting support these conclusions.

Radiocarbon dates suggest a late prehistoric and historic focus on green-cone processing in Owens Valley, predominantly after 500 years ago. The reasons for this shift may relate to scheduling conflicts that developed late in prehistory. The need to oversee and harvest irrigated seed plots, to harvest wetland seed resources, to participate in and sponsor festivals, and to hunt game may have created time conflicts with traditional brown-cone piñon harvesting activities. Green-cone harvesting may also have allowed new communities to engage in feast-giving by allowing them to schedule their annual festivals earlier in the season.

Each of these activities occurred in the fall, and while brown-cone harvesting took place in the uplands, these other activities happened in the valley bottom. Green-cone harvesting was pursued in Owens Valley and other parts of the Great Basin to permit individuals to continue collecting piñon, while pursuing some or all of the other activities. While green-cone harvesting was important in many parts of the Great Basin (Steward 1938), it is unclear whether it was more intense in some parts than others. The importance of irrigation in Owens Valley suggests it may have been more intense in this area. The reasons, however, behind the inception and intensification of green-cone processing may have been complex and multi-faceted, and may have varied from valley to valley. We hope that additional research will address this important question.

Acknowledgments

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Jelmer W. Eerkens (Ph.D. University of California, Santa Barbara) is an Assistant Professor at the University of California, Davis. He maintains research interests in California and the Great Basin of North America, cultural transmission processes, and the development of incipient agricultural strategies and ceramic technologies among hunter-gatherers. Mailing address: Department of Anthropology, University of California, One Shields Avenue, Davis, CA 95616.

Jerome King (M.A. Simon Fraser University) is Staff Archaeologist at Far Western Anthropological Research Group. His interests are in obsidian studies, stable isotope analysis, and the application of Geographic Information Systems to the archaeological record of western North America. Mailing address: Far Western Anthropological Group, 2727 Del Rio Place, Suite A, Davis, CA 95616.

Eric Wohlgemuth (University of California, Davis) is Staff Archaeobotanist at Far Western Anthropological Group, and a doctoral candidate in anthropology at the University of California, Davis. His research interests are in California and the evolution of intensive plant food use among hunter-gatherers. Mailing address: Far Western Anthropological Group, 2727 Del Rio Place, Suite A, Davis, CA 95616.

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