

Utah State University

DigitalCommons@USU

All Graduate Plan B and other Reports

Graduate Studies

5-2013

Intensification, Storage, and the Use of Alpine Habitats in the Central Great Basin: Prehistoric Subsistence Strategies in the Toquima and Toiyabe Ranges

Tod W. Hildebrandt

Follow this and additional works at: <https://digitalcommons.usu.edu/gradreports>

 Part of the [Archaeological Anthropology Commons](#)

Recommended Citation

Hildebrandt, Tod W., "Intensification, Storage, and the Use of Alpine Habitats in the Central Great Basin: Prehistoric Subsistence Strategies in the Toquima and Toiyabe Ranges" (2013). *All Graduate Plan B and other Reports*. 240.

<https://digitalcommons.usu.edu/gradreports/240>

This Report is brought to you for free and open access by the Graduate Studies at DigitalCommons@USU. It has been accepted for inclusion in All Graduate Plan B and other Reports by an authorized administrator of DigitalCommons@USU. For more information, please contact digitalcommons@usu.edu.



**INTENSIFICATION, STORAGE, AND THE USE OF ALPINE
HABITATS IN THE CENTRAL GREAT BASIN:
PREHISTORIC SUBSISTENCE STRATEGIES IN THE TOQUIMA
AND TOIYABE RANGES**

by

TOD W. HILDEBRANDT

A Plan B Paper submitted to the faculty of Utah State University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE IN ANTHROPOLOGY
Specialization in Archaeology and Cultural Resource Management

UTAH STATE UNIVERSITY
Department of Sociology, Social Work, and Anthropology

May 2013

**Intensification, Storage and the Use of Alpine Habitats
In the Central Great Basin:
Prehistoric Subsistence Strategies in the Toquima and Toiyabe Ranges**

TOD W. HILDEBRANDT
Utah State University, Old Main Hill, Logan UT 84321

Alpine villages are extremely rare in the Great Basin. To date, villages located at elevations above 10,000 ft. are only known to occur in the White Mountains and the Toquima Range. Demographic forcing has been used to explain the existence of these villages, but this proposition does not identify the selective pressures that led to the establishment of high-elevation villages in some ranges but not others. Comparison of artifact distributions and environmental structure in the Toquima Range, where a village exists, and the Toiyabe Range, where one does not, is consistent with the hypothesis that alpine villages were subsidized by intensive exploitation of mid-elevation pinyon groves associated with low-cost travel corridors, which facilitated transport of pine nuts to upland village locations. This study also reveals that limber pine may have played a role in alpine village subsistence, and identifies the need for further research on the value of this resource.

High elevation villages are extremely rare in the Great Basin. To date, only the White Mountains of eastern California and the Toquima Range of central Nevada (Figure 1) are known to have supported summer villages above tree line within the hydrological Great Basin. For much of the Middle Archaic (roughly 2500 cal B.C. – cal A.D. 1300), Great Basin alpine environments were visited by prehistoric by hunters who did not establish long-term summer residences. (Bettinger 1991; Thomas 1982, 1994). This hunting pattern dominates the archaeological record in the Toquima Range until cal A.D. 470 and the White Mountains until cal A.D. 1433, when significant changes occurred (Canaday 1997; Thomas 1994). At these respective times, sites rich with plant processing tools were established, and residential structures possibly representing sizable groups of people were established near the mountain crests at elevations exceeding 10,000 feet.

Why did this mountain adaptation occur in these two places while similar sites are absent from comparable environmental contexts elsewhere in the Great Basin?

The lack of villages in most alpine habitats in the Great Basin is not surprising due to the short growing season, high metabolic costs and low biotic productivity of these locations (Aldenderfer 2006: 356-357; Bettinger 1991). Alpine zones include useful hunting opportunities in the form of bighorn sheep and marmots, but neither of these animals mandates a village for their procurement. Alpine terrain was hunted in the absence of villages for thousands of years before villages were established. In fact, larger numbers of people in areas previously used only for hunting may have pushed game into more distant places of difficult access, only increasing search and pursuit times for hunters (Geist 1971: 87, 1999: 200). Zooarchaeological assemblages from the White Mountains are consistent with such a development, as they show declines in the abundance of large game after villages were established (Broughton and Grayson 1993; Grayson 1991). Plant productivity at high altitude is problematic, as the subsistence potential of most species is less relative to lower elevation areas. *Lewisa pygmaea* does provide returns comparable to pinyon (Simms 1987), but is not associated with many other important resources due to its isolated alpine location. As a result of the sparse resource distributions at high altitude Bettinger argues that:

This dynamic shift in alpine land use appears to have been a response to regional population growth that decreased rates for lowland subsistence activities to the point where it became cost-effective to use alpine plants and other costly resources (e.g., pinyon, small seeds) previously used casually or ignored altogether (Bettinger 1991: 675).

While the population pressure model may explain why alpine villages were established late in time, the use of this concept as the comprehensive “cause” of alpine village complexes is less than satisfying, as they should have been established in every alpine zone associated with high population densities. But this is not the case. Canaday (1997: 254), for example, found that alpine patches were ignored in the Ruby Mountains, despite relatively high proto-historic population densities in adjacent habitats. This was also the case for the Toiyabe Range where a strong alpine hunting signature was found, but the village pattern never developed (Canaday 1997:254). From this perspective, the question of why alpine villages were established becomes an issue of selective pressures brought on by local environmental structure and socio-economic conditions. For example, Delacorte (1994) proposes that intensive pine nut procurement may have been essential to sustaining alpine villages. The primary purpose of this study, then, is to isolate the specific factors that facilitated alpine villages in the Toquima Range and impeded this adaptive strategy elsewhere. This goal is achieved through a comparison of the environmental and cultural pressures in the Toquima Range and the adjacent Toiyabe Range that shaped the evolution of alpine behavior in these locations.

The Toquima and Toiyabe Ranges of central Nevada are good places to tackle the question of alpine habitation, as these two ranges share the Big Smokey Valley on the west flank of the Toquima Range and the eastern slopes of the Toiyabe Range. As human populations increased in the Late Holocene in the lowlands, why was there a village established at Alta Toquima, but not on the crest of the adjacent Toiyabe Range? The answer to this question may lie in the environmental structure that shaped human decision making about when and where alpine environments were suitable for village

habitation. Previous studies in the White Mountains of California suggest that high altitude villages may have been subsidized by low and mid-elevation resources such as pinyon nuts and other resources. Scharf (2009) shows these resources dominated the botanical assemblages at Midway, a village site located at 11,286 ft., which dovetails with Delacorte's (1994) expectation that a mid-elevation subsidy was necessary to sustain summer alpine residences. Scharf's (2009) data stimulates the hypothesis that that intensive exploitation of sub-alpine and mid-elevation pine nut resources was a necessary prerequisite that underwrote the shift to alpine summer villages; without stored pine nuts from the previous fall the decision to move larger groups into the alpine zone was simply too risky.

Comparison of the Toquima and Toiyabe Ranges indicates that larger mid-elevation (pinyon) and sub-alpine (limber pine) conifer stands in the Toquima Range, combined with intensive methods of their extraction, may have led to the annual accumulation of surplus pine nut resources that were stored over the winter and later used upslope to subsidize the establishment of the Alta Toquima Village complex. This hypothesis is tested by building on the work of Thomas (1982) and Canaday (1997) in the Toquima and Toiyabe ranges, as well as other surveys conducted in the area, including those conducted by the author. Data from alpine settings are compared to those from surrounding sub-alpine, mid-elevation, and lowland areas placing the alpine assemblages in larger context and enabling comparison of the Toquima Range where alpine villages are present, to the Toiyabe Range where they are not. This analysis supports the hypothesis that intensive exploitation of pine nuts at mid-elevation, and subsequent

transport upslope, was crucial to successful living above tree line in the prehistoric Great Basin.

HIGH ALTITUDE ARCHAEOLOGY OF THE WHITE, TOQUIMA, AND TOIYABE RANGES

Research in the White Mountains, the Toquima Range, and the Toiyabe Range provides the conceptual foundation of this effort. As outlined above, important contrasts exist among all three mountain ranges. Although the only alpine villages known in the Great Basin occur in the White Mountains (Bettinger 1989, 1991) and the Toquima Range (Thomas 1982), Alta Toquima was established 700-800 years earlier than the villages in the White Mountains, suggesting different circumstances shaped the decision making about alpine residence in the two cases. Canaday's (1997) work, in contrast, shows that alpine environments were only used logistically throughout prehistory in the Toiyabe Range.

White Mountains

Survey conducted by University of California, Davis field schools in the White Mountains during the 1980s encountered a rich archaeological record in the alpine zone (Bettinger 1989, 1991, 1994). Large rock ring house features associated with extensive milling assemblages were found on the alpine plateaus along the crest of the mountain range. These villages were intensively occupied beginning in A.D. 1433 (Table 1). Bettinger's excavations produced multiple datasets, including rich assemblages of both faunal and floral remains (Grayson 1991; Scharf 2009).

In a general sense, faunal assemblages from village and pre-village contexts in the White Mountains characterize how Great Basin environments were exploited through time. Both village and pre-villages faunal assemblages are dominated by marmot and bighorn sheep (Grayson 1991). Moving into the village period, however, the densities of marmot remains jump up significantly, while bighorn sheep decline slightly. This jump in marmot, a lower ranked prey item based on body size, corresponds with the general intensification of subsistence systems during the late Holocene, indicating that foragers expanded their diet breadth and began exploiting lower ranked resources more intensively (Bettinger 1999).

Floral assemblages from the White Mountains also reveal much about alpine village subsistence systems. Surprisingly, these assemblages are dominated by mid-to-low elevation resources, specifically pinyon pine (Scharf 2009). As pinyon is not available locally, it is clear that these resources had to be transported upslope for consumption at alpine villages. This botanical record from the village phase demonstrates the intensive economic system that facilitated living in marginal alpine environments. The current study identifies archaeological evidence from the Toquima Range that may represent a similar subsistence system that was necessary to support village populations there as well.

Toquima Range

Extensive survey and excavation in the Toquima range was conducted by David Hurst Thomas in the late 1970s and early 1980s. The resulting archaeological record shares many similarities with the White Mountains. House structures associated with

large groundstone assemblages were superimposed on older hunting complexes. These houses compose the Alta Toquima Village complex. This signature mirrors the archaeological record of the White Mountains in that pre-village exploitation of the highlands was focused on logistical procurement of bighorn sheep, while during village times there appears to have been less emphasis on large game (Thomas 1982). What is distinctly different about the Alta Toquima Village period is the timing of its establishment. The contrasting periods of occupation between the Toquima Range and White Mountains invite exploration of the underlying process of village establishment in each case, precisely the goal of this study. The historical commonality between the two cases is the intensification of subsistence systems in the late Holocene Great Basin (Bettinger 1999, Simms 2008) while the reasons for the timing of village establishment are local.

Despite the fact that the villages were occupied at different times the similarities between the Toquima Village complex and those of the White Mountains are striking. Evidence of lowland resources in midden deposits from each range demonstrate that people living at altitude did not subsist solely on resources procured from the alpine zone. Excavation results from Alta Toquima confirm the presence of limber pine nuts in village deposits, however a variety of small seed plants from low elevations were also noted (Grayson 2011:321; Thomas 1982). These data indicate that transported resources were used to subsidize village populations during summer habitation above treeline.

Toiyabe Range

The highest reaches of the Toiyabe Range were surveyed extensively by Tim Canaday as a part of his dissertation research in hopes of shedding light on the nature of alpine archaeology in the Great Basin. In addition to the Toiyabe Range, Canaday selected four additional ranges throughout the Great Basin that had significant acreage above tree line for survey. These ranges included the Snake Range, Jarbridge Mountains, Ruby Mountains and Deep Creek Mountains. Interestingly, Canaday encountered the highest density of archaeology in the Toiyabe Range.

His survey effort in the Toiyabe Range produced a total of 25 sites, many of which were associated with stacked rock features, which he interpreted as hunting facilities (Canaday 1997). Although there was a rich archaeological record associated with hunting, no evidence of residential sites was found. Projectile point frequencies indicate that much of hunting activity took place during the Middle Archaic (roughly 2500 cal A.D. – cal A.D. 1300). Although Desert Side-notched points were identified during survey, the primary point type was Elko corner notched, with low densities of earlier forms recorded as well (e.g. Great Basin Stemmed, Gatecliff).

All three mountain ranges were used logistically for hunting beginning in the Middle Archaic (roughly 2500 cal A.D. – cal A.D. 1300) (Bettinger 1991, Canaday 1997, Thomas 1982). The shift to residential exploitation of a broader array of plant resources, accompanied by a decline in large game resources occurred at significantly different times in the White Mountains and the Toquima Range, and archaeological evidence suggests it never occurred in the Toiyabe Range. The following analysis evaluates the

circumstances of selection that influenced ancient human decision-making in these three behaviorally and temporally distinct cases.

THE SEASONAL ROUND AND THE ROLE OF PINYON AMONG THE WESTERN SHOSHONE

The ethnographic record provides a glimpse of prehistoric lifeways. Throughout his travels in the early 20th century Julian Steward did not visit the Big Smokey Valley or the Monitor Valley. Steward surmises that population densities and social organization may have been very similar to the people living in the neighboring Reese River Valley, though he notes that the area around the Big Smokey Valley “is comparatively more arid and likely has a sparse scattered population” (Steward 1938:109).

In his discussion of the Reese River Valley, Steward states that the “pine nut continues to be of outstanding importance” (Steward 1938: 104). Steward describes the seasonal fission-fusion of groups typical of Great Basin foragers. Several familial groups would gather at the pinyon-valley ecotone for pine nut harvests, rabbit drives in the valleys below, and to engage in social activities (Steward 1938: 106). Pinyon tracts were thought to be owned, at least in terms of usufruct rights, by small “camp” groups, often organized along familial lines, but potentially of diverse composition (Fowler 1982). Winter villages were centered on stored resources, including pinyon pine nuts (Steward 1938: 104).

In the spring and summer months, groups would disperse to collect locally available resources, typically centered on wetlands in the valley floors. In the valleys sand bunch grass or rice grass (*Oryzopsis hymenoides*), wild rye (*Leymus cinereus*), and

yamba root (*Carum gairdneri*) were collected in the spring and late summer (Steward 1938), along with various other low elevation resources such as dogbane (*Apocynum cannabinum*) fibers that were collected for use in the manufacture of utilitarian goods (Thomas et al. 1986). Many of these seed resources were stored and cached for winter consumption (Fowler 1986:65; Steward 1938). Other resources such as berries, ground squirrels and migratory water fowl were also taken from valley contexts (Thomas et al. 1986).

Ethnographic accounts of the Western Shoshone often mention the importance of generating surplus resources that could be cached and used to subsidize winter villages in the pinyon zone (Steward 1938, Thomas et al. 1986). By late fall, when the pinyon crop was coming in and sufficient summer resources had been procured, winter camps could be re-established in the pinyon belt and the seasonal cycle would be complete.

Steward notes the importance of stored resources to winter encampments, but there no mention of transporting resources from mid-elevations to the alpine zone, though ample archaeological data indicates that pinyon was transported beyond the pinyon zone at various points in prehistory (Basgall and McGuire 1988; Madsen 1979; Rhode and Madsen 1998; Wells 1983), with Scharf (2009) being the best example of alpine transport. Steward also makes little mention of alpine residential use, referring to the alpine zone as bighorn sheep hunting habitat (Steward 1941: 335). While his report is consistent with the archaeological record for the Toiyabe Range (Canaday 1997), it implies either a gap in the ethnographic record for the Toiyabe Range, or that alpine villages had fallen into disuse by the late 19th century ethnographic period that Steward was ostensibly reconstructing.

PINE NUT CONVEYANCE HYPOTHESIS AND EXPECTATIONS

The working hypothesis is that intensive exploitation of pinyon nuts and, perhaps limber pine nuts, was necessary to establish and maintain Alta Toquima Village; village occupation of the alpine tundra was not possible without the development of surplus nut resources at lower elevations. If this is the case, there will be more productive and accessible mid-elevation (pinyon) and sub-alpine zone (limber pine) habitats in the Toquima Range than in the Toiyabe Range and the archaeological record will show that these habitats were exploited more intensively in the Toquima Range.

My analysis includes the archaeological assemblages in each range, an assessment of environmental variables to determine the productivity of pine nut stands in each range, and analysis of the cost of transporting resources to the locations of alpine villages. Corollaries of my hypothesis are expectations that more extensive pine stands occur in the Toquima Range than in the Toiyabe Range, and the costs of transporting nuts to the alpine zone are lower in the Toquima Range than in the Toiyabe Range. This expectation differs from that proposed by Zeanah (2002) who ranked pinyon productivity higher in the Toiyabe Range than the Toquima Range. Zeanah's (2002) model was based on surveys conducted by West et al. (1998) that included the west slope of the Toiyabe Range and the east slope of the Toquima Range, but did not include the extremely steep eastern slope of the Toiyabe Range, which does not have extensive distributions of limber or pinyon pine stands. These areas are included in the analysis here, and indicate that the Toquima Range may have superior pinyon productivity due to the presence of moderate slope gradients on its western *and* eastern slopes.

Seasonality is a significant aspect of environmental structure in this study. The presence of pinyon pine nuts in the midden at Midway village in the White Mountains (Scharf 2009) indicates that the nuts were stored through the winter at mid-elevations, as it is not possible to over winter in the alpine zone, and a forager cannot harvest pine nuts in the spring. Therefore, if pine nuts were transported to alpine villages in the late spring when winter groups dispersed, these nuts must have been surpluses that were not consumed during the winter occupation at lower elevations. Consequently, it seems likely that more intensive pine nut procurement was necessary to generate the stored surpluses for transport upslope to subsidize Alta Toquima Village.

Alternatively, if pine nuts were harvested in the late summer to early fall while they are still in green cones (Bettinger and Baumhoff 1982, 1983; Eerkins et al. 2002, Hildebrandt and Ruby 2006) or gathered later as brown cones (Chamberlin 1911, Coville 1892, Dutcher 1893, Steward 1938, Wheat 1967), it is possible that they could have been transported to the high country at that time if the onset of winter storms was delayed. This alternative is less likely however, because there is no evidence of storage at Alta Toquima; nuts would have been transported and stored only in baskets or bags for a relatively brief time before being consumed.

Regardless of the extraction strategy or the season of transport, more pine nuts had to be harvested and stored than were needed in a settlement system that did not include alpine villages, and this difference should be reflected in the mid-elevation archaeological records of each mountain range. It is also important to consider transport and field processing costs (Metcalf and Barlow 1992). Decisions about whether to transport pinyon as hulled nuts, in the hull, or even in green or brown cones drastically

alter the transport costs. This study considers those alternatives to evaluate the selection pressures shaping the decision to subsidize alpine villages.

Intensive pine nut processing will result in distinctive artifacts and features on the landscape. More intensive use of pine nut groves should result in higher densities of groundstone (Chamberlin 1911; Coville 1892; Dutcher 1893; Steward 1938; Wheat 1967) and storage facilities in the Toquima Range than in the Toiyabe Range for both brown cone and green cone extraction strategies. Intensive green cone processing is indicated by rock ring features (Bettinger 1977), used to cache the cones (Bettinger and Baumhoff 1982; Hildebrandt and Ruby 2006). Higher groundstone site densities in the pine nut zones may also serve as a proxy for more intensive exploitation of nut resources. Increased volumetric returns on pine nuts would have potentially provided the nut surpluses required for transport upslope. These surpluses would have been temporarily cached over winter to facilitate the residential shift to the alpine zone. The use of cached resources would not have required tethering to these resources at other times of the year, storage can also be used means of subsidizing residential mobility (Binford 1977; Morgan 2008: 256). In order to test the pine nut conveyance hypothesis, the abundance of pine nut resources are quantified for both of the mountain ranges, as are the transport costs for moving these foods up into the alpine zone. Once this is accomplished the archaeological records of the range can be compared.

MODELING ENVIRONMENTAL STRUCTURE AND RESOURCE DISTRIBUTIONS IN THE TOIYABE AND TOQUIMA RANGES

Two scales of environmental modeling are used in this study. The first provides course-grained vegetation community distributions that provide context for the spatial

analysis of artifacts and features. The second modeling strategy incorporates more detailed vegetation data extracted from the USGS GAP system to evaluate specific resource distributions within a foraging radius of Alta Toquima Village and a hypothetical village location in the Toiyabe Range. The hypothetical village was selected based on elevation, slope and aspect.

Course Grained Environmental Zones

The environment of the Toiyabe and Toquima Ranges is typical of the central Great Basin. Greasewood and sagebrush populate the valley floors and transition into the pinyon-juniper woodland that characterizes moderate elevations throughout much the region. What is unique about the Toquima and Toiyabe ranges is the high elevation of their peaks, relative to other central Great Basin mountain ranges. Grayson (2011) characterizes the project area for this study in his descriptive transect moving from the lowest point in Monitor Valley (6,090 ft.), to the crest of the Toquima Mountains reaching an altitude of 11,941 ft. His transect traverses six environmental zones: low elevation shadscale, sagebrush-grass, pinyon juniper, upper sagebrush-grass, limber pine-bristle cone pine, and alpine tundra. These zones are employed in this study to organize the more specific data on vegetation within each zone, save for two exceptions. The shadscale and sagebrush zones are considered as one unit called the lowland zone and the upper sagebrush-grass and limber pine zones are combined to form the subalpine zone.

The *lowland* zone occupies elevations between 6,000 and 7,000 ft. and is characterized by dense distributions of greasewood at its lowest elevations and low black sage at slightly higher elevations. The *pinyon zone* ranges from 7,000 to 8,200 ft. The

limber pine and aspen stands of the *subalpine zone* extend upslope to 11,000 ft. The *alpine tundra* takes over above 11,000 ft., where vegetation is sparse (Figure 2).

In order to place archaeological data in these four large-scale environmental/elevation zones, 30 meter digital elevation models (DEMs) for the project are correlated with each zone. These elevation-derived environmental zones were checked with U.S. Geological Survey GAP data, and found to be quite accurate. The zones are used to plot the distribution of artifacts and features to evaluate the intensity of human activity in each zone.

Foraging Radii, Resource Distributions and Transport Costs of Moving Pine Nuts to the Alpine Zone

The purpose of this analysis is to evaluate the productivity of pine nut stands in the Toquima and Toiyabe ranges within specific foraging radii from Alta Toquima Village and a hypothetical village location in the Toiyabe Range. A predictive model that considers elevation, slope, aspect and distance to known springs found at Alta Toquima was built to identify a comparable location for the hypothetical village in the Toiyabe Range. This exercise resulted in a village located on the western slope of the Arc Dome table lands, near the head of Saw Mill Creek in the vicinity of the hunting facilities recorded by Canaday.

Figure 3 shows the distribution of pinyon and limber pine stands within an eight hour round trip from the alpine villages in the Toquima and Toiyabe ranges¹, which equal roughly a seven mile radius around each village. Rather than use a model based on

¹ The foraging radius was developed based on a cost surface that used time as the unit of measurement. This surface was generated based on Whitley and Hicks (2003) and Tobler (1993)

distance, the eight-hour-round-trip boundary was generated to create a spatial unit of analysis for each village that took into account topographic differences between the two mountain ranges. For example, there are certain directions where travel is much easier than others (compare south in the Toquima Range; Figure 3). By accounting for these differences the cost surface/time analysis provides travel costs in terms of time associated with travel in each range. This phase of analysis was necessary to create bounded spatial units within the GIS framework to evaluate variables in each range, while excluding areas, and resource patches that are not pertinent to this analysis.

Note the continuous ring of pinyon and limber pine stands surrounding Alta Toquima Village. These forests cover a total of 31,070 acres: 24,506 acres of pinyon and 6,564 acres of limber pine. The Toiyabe range features much a more discontinuous, scattered distribution of forest covering 25,621 acres: 20,581 acres of pinyon and 5,040 acres limber pine (Table 2). The Toiyabe Range contains 18% less pine nut stands than the Toquima Range.

The next step is to provide a more detailed assessment of the pine nut subsistence potential for each mountain range that could be exploited with an eight hour round trip foraging radius from Alta Toquima Village and the hypothetical Toiyabe village. This modeling exercise takes into account the differences in foraging costs dependent on the patchiness of the pinyon stands; with the continuous forests of the Toquima Range being less costly to exploit than the patchy distribution of groves in the Toiyabe Range.

Ethnographic accounts document that a family could collect and store 680 kg of nuts during a productive year (Cook 1941; Price 1962; Steward 1938). Zeanah (2002) uses the 680 kg value as a means evaluating productivity of Great Basin pinyon stands. In

moderately productive years, woodlands with 20% pinyon coverage would require 185 acres to produce 680 kg of nuts, whereas only 124 acres would be required in areas of 80% coverage with a moderate crop yield (Zeanah 2002). In order isolate pinyon stands that would provide moderate to high pine nut productivity, coverage and productivity data are built into this environmental modeling effort.

To control for differential returns between patchy and continuous forest the model excludes pinyon stands of 10 acres or less from those within the eight hour round trip foraging radii. Since the distribution of pinyon is more patchy in the Toiyabe Range, 1,753 acres of small pinyon stands are not included in the model, (reducing the total to 18,828 acres) while 1,076 acres of similarly small pinyon stands are excluded from Toquima Range (reducing the total to 23,428). This analysis increases the difference in pinyon and limber distributions between the two mountain ranges to about 20%. Limber pine is so patchy wherever it occurs, no modification of the acreage was attempted (Table 2). This exercise not only takes into account the effect of resource patchiness, but streamlines the model so that cache locations are located within productive pinyon stands enabling a more useful comparison of the productivity of the two mountain ranges.

The conveyance hypothesis posits that stored pine nuts subsidized summer occupations above treeline. Therefore, pine nuts would have to have been transported upslope to summer residences. Limber pine nuts are excluded from this phase of analysis due to their proximity to both the Alta Toquima Village complex and to the hypothetical Toiyabe village. To evaluate the relative costs of transporting pine nuts from mid-elevation caches to high elevation villages, 20 hypothetical cache locations were randomly generated within productive pinyon stands. In order to create a finite

environment for the generation of cache locales, an eight hour round-trip site catchment was created for Alta Toquima Village and the hypothetical Toiyabe village (Figures 4 and 5). The cache locales were randomly generated in moderate-to-high density pinyon stands, within an eight hour round trip of each alpine village location.

Table 3 lists each randomly generated cache location and the distance from the cache to the central place. Distance was used as the unit of measurement to assess the relative costs of transporting resources from caches to the village locales. Distance was used as the unit of analysis due to the fact that it is the most basic and powerful measure of relative transport cost (Brannan 1992). The average distance from Alta Toquima village to cache locations is 8.57 kilometers, while it is 10.45 kilometers for the Toiyabe Range village, or 18% farther. Based on previous work on processing and optimal transport, whole cones would likely not have been transported this distance (Barlow and Metcalfe 1996; Zeanah 2002). Metcalfe and Barlow (1992) devised an optimal field processing model, which they applied to pinyon pine nuts (Barlow and Metcalfe 1996). This model demonstrates that whole cones could not be transported economically over 2.5 kilometers away from the central base camp. Field processing would be the most efficient option beyond this 2.5 kilometer radius around the base camp, as packing whole cones simply created too much volume to be an efficient means of transporting calories (see Jones and Madsen 1989). Given the distances involved in this model, processing is assumed to have occurred prior to transport, during periods of pinyon habitation throughout fall and winter months.

These two analyses indicate that pinyon and limber pine stands cover 20% more land within an eight hour round trip of the Toquima alpine village than is the case for the

hypothetical Toiyabe alpine village, and that pinyon pine nuts can be moved to the top of the Toquima Range at a 18% reduction in cost compared to the Toiyabe Range. To illustrate the significance of those differences, assume a person can buy a 100 pound bag of nuts for \$10.00 (or 10¢ per pound). By increasing the bag weight by 20% the price decreases to 8.33¢ a pound and to 6.83¢ per pound if the cost is further discounted by 18% (from 10 to 8.20 per pound). This simple analysis shows that it was 32% cheaper to obtain nuts and move them in the alpine zone, and fully consistent with the pine nut conveyance hypothesis.

ARCHAEOLOGICAL FINDINGS

Archaeological data were generated from 1,197 site records within NVCRIS (The Nevada Cultural Resource Information System) from the Toiyabe and Toquima ranges and adjacent valleys (Figure 6). Archaeological attributes for each site record were recorded in an Access database. These data compose the primary dataset used to compare land-use patterns between the Toiyabe and Toquima Ranges. The data set is supplemented by Canaday (1997) and Thomas (1982) because they provide important data from the alpine zone generated using similar survey methods. Furthermore, some of the data comes from excavations at Alta Toquima Village, and are important to accurately characterize the village occupation.

To test the hypothesis that intensive pine nut exploitation helped underwrite the shift to alpine villages in the Toquima Range, an analysis of the temporal distribution of groundstone tools is employed under the assumption that these tools are a proxy measure of intensity of exploitation. Calculations of the number of sites with and without

groundstone (Table 4) shows that groundstone is more common in the Toquima Range, where 24.7% of sites in the pinyon zone have groundstone compared to only 4.7% of sites in the Toiyabe Range. The difference between the two ranges is especially apparent in the sub-alpine zone (limber pine stands); ground stone occurs at 17.8% of sites in the Toquima Range compared to zero sites in the Toiyabe Range. This is also the case for the alpine tundra where 16.7% of sites in the Toquima Range contain groundstone while only 7.6% of sites in the Toiyabe range include groundstone.

Table 5 shows the average *number* of groundstone tools at groundstone bearing sites. Again, not only are there more sites with groundstone in the high elevations of the Toquima Range, the frequency of groundstone at sites is also higher; 2.3 and 2.2 items per site in the pinyon and limber pine zone, and only 1.0 and 0.0, respectively, in the Toiyabe range.

These data show more intensive use of the pinyon and limber pine habitats in the Toquima Range, but temporal control is necessary to evaluate the pine nut conveyance hypothesis. Thomas (1994) provides radiocarbon dates from the Alta Toquima Village complex of 1,590-620 cal B.P. (cal A.D. 470-1350), placing it largely within Rosegate times.

Table 6 presents the distribution of projectile point types by environmental zone for each range. These data do not indicate that the pinyon and sub-alpine zone featured more intensive use during the Late Archaic, but show a huge presence of Elko/Early points in all habitats, including the pinyon and subalpine zones in both the Toquima and Toiyabe Ranges.

The picture does not become much clearer when the co-occurrence of projectile point types with groundstone is calculated (Table 7). A higher percentage of projectile points from the Toquima Range are associated with groundstone than in Toiyabe Range, but little patterning is evident in comparisons between the frequency of projectile points at sites with and without groundstone. Desert Side-notched points in the Toquima Range do correlate strongly with groundstone in the pinyon and sub-alpine zones, while only half of Desert Side-notched points in the lowlands and Alpine tundra zones are associated with groundstone. Rosegate and Elko/earlier points have similar percentages of association with groundstone, but do not vary significantly from low to high elevations. In the Toiyabe Range, points on sites with groundstone are generally low across all environmental zones, save the pinyon zone where the percentages are slightly higher.

The lack of strong patterning between time sensitive projectile points and groundstone is probably due to the spatial overlap of temporally discrete occupations, as sites in the study area are nearly all multi-component making it difficult to determine the true association between groundstone and time period. Creating a groundstone/projectile point ratio for each component provides some clarification regarding these problematic associations (Table 8). This analysis shows that the groundstone/projectile point ratio for the Elko/Earlier component is much lower than Rosegate and DSN times in the alpine tundra and sub-alpine zones in the Toquima range, while it is roughly the same in the pinyon zone.

The Toiyabe Range shows virtually no evidence of residential use of the uplands and little intensive use of the pinyon-zone during any time period and thus contrasts with the evidence for intensive use of the Toquima Range. Although the numbers are small,

these data also show an additional important distinction between the upland zones in the Toquima and Toiyabe ranges (Table 9). Rosegate projectile points are much more abundant than Desert Side-notched points in the alpine and sub-alpine zones in the Toquima range which is consistent with the Late Archaic age of Alta Toquima Village complex. The opposite is the case in the Toiyabe Range, where Desert Side-notched points outnumber Rosegate, which could reflect a time lag in the intensive use of the Toiyabe Range and providing additional evidence for the lower subsistence potential of this area.

DISCUSSION: THE ROLE OF LIMBER PINE

The abundance of groundstone in pine nut stands of the Toquima Range combined with lower frequencies of this material in the Toiyabe Range provides strong support for the pine nut hypothesis. Another intriguing result from this analysis is the presence of groundstone in both limber pine and pinyon stands in the Toquima Range. The finding is intriguing due to the poorly understood caloric return rates for limber pine nuts.

Rhode (2010) presents two dramatically different return rates on limber pine. Limber pine nuts are much smaller than pinyon nuts, and thus take much more time and energy to produce clean, hulled nut meats. Rhode (2010) calculates that processed limber pine nut meats produce a caloric return of 191 kcal per of hour work. Table 9 shows how this low return rate stacks up against other Great Basin resources, as outlined by Simms (1987). The return rate of 191 kcal is among the lowest among utilized plant resources in the Great Basin, particularly when compared to the return rates for hulled pinyon nuts

which range between 841 and 1,408 kcal per hour. Rhode (2010) provides a second return rate for limber pine of 13,437 kcal/hr., which is possible only if the nuts are eaten whole. This return rate places limber pine nuts as the highest ranked non-meat resource in prehistoric diets. Whether or not limber pine nuts were actually eaten whole remains an open question. The large difference between the high and low return rate for pinyon in the experiments by Rhode (2010) arises from the processing costs. Given that only several experiments were attempted, it is likely that the processing costs are overestimated in the 191 kcal/hour return rate. Further, for the purposes of comparing limber pine nuts with pinyon nuts, a return rate for *hulled* pinyon and *hulled* limber pine must be employed, as returns on hulled nuts from Simms (1987) are the accepted return rates used to evaluate pinyon pine nuts currently. Alternatively, a return rate for un-hulled pinyon and limber pine nuts could be employed, but there is little evidence that such nuts were eaten hulls and all, at least not as a dietary staple. Simms (1987:86) shows that pinyon return rates that exclude processing range from 2,416-9,631 kcal/hour. While additional data on the costs of procuring and processing limber pine are desirable, it is likely that the two nuts are comparable. Each has some advantages such as pinyon nuts are larger while limber pine nuts fall from the cone a bit more readily than pinyon.

One advantage that limber pine nuts certainly do have over pinyon pine is their proximity to alpine village locations (they are largely adjacent to these occupations in the Toquima Range). It could be argued that the extra transport costs of moving hulled pinyon nuts up to the alpine village might compensate for the differences in their return rates. It is clear, however, that even the addition of transport costs to the procurement of pinyon, the lowered returns of pinyon would still not drop to 191 kcal (Rhode 2010) from

841-1,408 kcal (Simms 1987) return on pinyon pine. The discrepancy between the return rates on hulled nuts is simply too large.

It is also important to note that Barlow and Metcalfe (1996) predict that whole cones can be transported profitably for distances less than 2.5 kilometers. Limber pine stands are present within this foraging radius at Alta Toquima Village. If this occurred, then the high processing time associated with limber pine could be minimized, given that processing resources at a central place is often not considered a significant cost because it can be done by older people or during non-foraging times of the day (see Bettinger et al. 1997:888). But, the relatively high density of groundstone tools in the Toquima limber pine zone seems to rule out the cone transport hypothesis. The ground stone in the limber pine zone indicates that limber pine nuts are being utilized and processed to remove them from the hulls. The evidence indicates that both limber and pinyon nuts are subsidizing the establishment of alpine villages.

SUMMARY

The alpine villages of the White Mountains and Toquima Range are an exception in Great Basin antiquity. These ranges feature the only known alpine residences in the entire Great Basin. Harsh, unpredictable weather patterns, scant resources and fleeting summers, limited the use of alpine zones to hunting forays for most of prehistory (Bettinger 1991; Canaday 1997; Thomas 1982, 1994). Due to the marginal nature of alpine environments, Bettinger (1991) posits that demographic forcing may have been responsible for the shift to alpine habitation. Given the high population densities in the late-prehistoric Owens Valley this proposal makes good sense, however, it does not

account for why this adaptation was so rare. Moreover, Canaday (1997) found the alpine village pattern to be absent in the Ruby Mountains, despite the presence of sporadically high populations densities throughout prehistory. The question of why alpine villages were established in these two specific ranges begs for explanation.

Floral assemblages from Midway Village, in the White Mountains, reveal that mid-elevation resources made up a major part of what people were eating while they lived there. Scharf (2009) demonstrates that mid-elevation resources were staples in the diets of the inhabitants of Midway Village, particularly pinyon pine nuts. Scharf (2009) also notes that alpine plant resources were often ignored by the foragers that occupied Midway Village. These findings led to the pine nut conveyance hypothesis: that intensive procurement of mid-elevation resources was a necessary subsidy for alpine villages. To test this hypothesis this study compares the Toquima Range with the Toiyabe Range of central Nevada. Different environmental structures and archaeological assemblages in these two ranges provide an opportunity to identify variables that helped support alpine habitation in the Toquima Range, while isolating less advantageous environmental components of the Toquima Range, which never supported an alpine village.

The comparison of these ranges demonstrates three major differences between the two: (1) pinyon and limber pine stands cover 20% more acreage in the Toquima Range than in the Toiyabe Range; (2) transport costs from the pinyon zone to Alta Toquima Village are 18% lower than a comparable location in the Toiyabe Range and; (3) archaeological assemblages indicate that more intensive pine nut exploitation occurred in the pinyon zone in the Toquima Range at all times in prehistory, particularly in time

periods leading up to and during the occupation of Alta Toquima Village. These three findings provide substantial support for the pine nut conveyance hypothesis.

Another interesting result from this study is the frequency of groundstone artifacts within limber pine stands. Groundstone is present in the limber pine stands of the Toquima Range nearly as frequently as in the pinyon zone. This finding is somewhat surprising due to the very low caloric return rates assigned to this (processed) resource (Rhode 2010) and may indicate that Great Basin researchers undervalued the importance of this food. It follows, therefore, that the exact way this resource was exploited and its role in the larger economy, remains an avenue for future investigation.

On a more general level, the results of this study show that local environmental structure and subsistence strategies impact how people chose to exploit alpine habitats. Hunting opportunities and tubers are available in most alpine settings, but the alpine zone was used for hunting for thousands of years throughout the Great Basin. As diets broadened during the late Archaic period, and economic intensification swept across the Desert West (see Bettinger 1999), the investment in transporting resources from mid-elevation settings enabled the subsidy of a new ecological niche – alpine villages. But the decision to establish alpine villages was not made in all cases, and in fact, this occurred on very few occasions. Based on the results of this study, adjacent pine nut habitats needed to surpass a certain threshold of productivity capable of subsidizing alpine villages. This threshold was achieved in the Toquima Range, but not in the Toiyabe Range. It is predicted, therefore, that pine nut productivity should be high in the White Mountains, but significantly lower elsewhere in the Great Basin.

REFERENCES

- Aldenderfer, M.
 2006 Modeling Plateau Peoples: The Early Human Use of the World's High Plateaux. *World Archaeology* 38(3):357-370.
- Barlow, K. R., and D. Metcalfe
 1996 Plant Utility Indices: Two Great Basin Examples, *Journal of Archaeological Science* 23:351– 371.
- Basgall, M. E., and McGuire, K. R.,
 1988 *The Archaeology of CA-INYO-30: Prehistoric Culture Change in Southern Owens Valley, California*. Far Western Anthropological Research Group, Inc., Davis, CA.
- Bettinger, R. L.
 1977 Aboriginal Human Ecology in Owens Valley: Prehistoric Change in the Great Basin. *American Antiquity* 42(1):3-17.
- 1989 Aboriginal Occupation of Pinyon House, Two Eagles and Crater Middens: Three Residential Sites in Owens Valley, Eastern California. *Anthropological Papers* 67. New York: American Museum of Natural History.
- 1991 Aboriginal Occupation at High Altitude: Alpine Villages in the White Mountains of Eastern California. *American Anthropologist* 93(3): 656-679.
- 1994 How, When and Why Numic Spread. In *Across the West: Human Population Movement and the Expansion of the Numa*. D.B. Madsen and D. Rhode, eds., pp. 44-55. Salt Lake City: University of Utah Press.
- 1999 What Happened in the Medithermal? In *Models for the Millennium: Great Basin Anthropology Today*, C. Beck, ed., pp. 62-74. Salt Lake City: University of Utah Press.
- Bettinger, R. L. and M. A. Baumhoff
 1982 The Numic Spread: Great Basin Cultures in Competition. *American Antiquity* 47(3): 485-503.
- 1983 Return Rates and Intensity of Resource Use in Numic and Prenumic Adaptive Strategies. *American Antiquity* 48(4): 830-834.
- Bettinger, R. L., R. Malhi and H. McCarthy
 1997 Central Place Models of Acorn and Mussel Processing. *Journal of Archaeological Science*. 22:887-909.

- Binford, L.R.,
 1977 Forty-seven Trips: A Case Study in the Character of Archaeological Formation Processes in *Stone Tools as Cultural Markers: Change, Evolution and Complexity*, R.V .S. Wright ed., pp. 24-36. Humanities Press Atlantic Highlands, NJ: Humanities Press.
- Brannan, J. A.
 1992 On Modeling Resource Transport Costs: Suggested Refinements. *Current Anthropology*. 33(1):56-60.
- Broughton, J.M. and D. K. Grayson
 1993 Diet Breadth, Adaptive Change and White Mountain Faunas. *Journal of Archaeological Science* 20:331-336.
- Canaday, T.W.
 1997 *Prehistoric Alpine Hunting Patterns in the Great Basin*. Ph. D. dissertation, University of Washington, Seattle.
- Chamberlin, R. V.
 1911 The Ethno-Botany of the Goisute Indians of Utah. *American Anthropological Association Memoirs* 2:331–404.
- Cook, S. F.
 1941 The Mechanisms and Extent of Dietary Adaptation Among Certain Groups of California and Nevada Indians. *Ibero-Americana* 18:1–59.
- Coville, F. V.
 1892 The Panamint Indians of California, *American Anthropologist* 5:351–361.
- Delacorte, M. G.
 1994 The Role of Population in Relation to the Use of Alpine Environments in the White Mountains of California/Nevada. *Acta Anthropologica Carpathica* 32:55-64.
- Dutcher, B.H.
 1893 Pinyon Gathering Among the Panamint Indians, *American Anthropologist* 6:376–380.
- Eerkins, J.W., J.H. King, and E. Wohlgemuth
 2002 The Prehistoric Development of Intensive Green-Cone Pinyon Processing in Eastern California. *Journal of Field Archaeology* 29(1-2): 17-27.
- Fowler, C.S.
 1982 Settlement Pattern and Subsistence Systems in the Great Basin: An Overview. In *Man and the Environment in the Great Basin*, D. B. Madsen and J. F. O'Connell eds., pp.

- 1986 Subsistence. In *Handbook of North American Indians, Vol. 11: Great Basin*, W. L. d'Azevedo, ed., pp. 64-97. Washington, D.C.: Smithsonian Institution.

Geist, Valerious

- 1971 *Mountain Sheep: A Study of in Behavior and Evolution*. Chicago. University of Chicago Press
- 1999 Adaptive Strategies in American Mountain Sheep: Effects of Climate, Latitude and Altitude, Ice Age Evolution and Neonatal Security. In *Mountain Sheep of North America*. E. Valdez and P.R. Krausman, ed., pp.192-208. Tucson. University of Tucson Press.

Grayson, D. K.

- 1991 Alpine Faunas from the White Mountains, California: Adaptive Change in the Late Prehistoric Great Basin? *Journal of Archaeological Science* 18(3): 483-506.
- 2011 *The Great Basin: A Natural Prehistory*. Berkeley, Los Angeles, London. University of California Press.

Hildebrandt, W.R. and A. Ruby

- 2006 Prehistoric Pinyon Exploitation in the Southwestern Great Basin: A View from the Coso Range. *Journal of California and Great Basin Anthropology*. 26(2)11-32.

Jones, K. T. and D. B. Madsen

- 1989 Calculating the Cost of Resource Transportation: A Great Basin Example. *Current Anthropology*. 30(4)529-534.

Madsen, D. B.,

- 1979 Prehistoric Occupation Patterns, Subsistence Adaptations, and Chronology in the Fish Springs Area, Utah. In *Archaeological Investigations in Utah*, D. B. Madsen and R. E. Fike ed., *Cultural Resource Series* 12. Salt Lake City.

Metcalf, D., and Barlow, K.R.

- 1992 A Model for Exploring the Optimal Trade-off between Field Processing and Transport. *American Anthropologist* 94:349-356.

Morgan, C.

- 2008 Reconstructing Prehistoric Hunter-Gatherer Foraging Raddii: A Study From California's Southern Sierra Nevada. *Journal Archaeological Science*. 35(2):247-258.

Price, J.A.

- 1962 Washoe Economy. In *Nevada State Museum Anthropological Papers* 6. Carson City, NV.

Rhode, D.

- 2010 Food Values and Return Rates for Limber Pine (*Pinus Flexilis*). Poster Presented at the biennial meeting of Great Basin Anthropological Conference, Layton, Utah.

Rhode, D., and Madsen, D. B.,

- 1998 Pine Nut Use in the Early Holocene and Beyond: The Danger Cave Archaeobotanical Record. *Journal of Archaeological Science* 25:1199–1210.

Scharf, E.A.

- 2009 Foraging and Prehistoric Use of High Elevations in the Western Great Basin: Evidence from Seed Assemblages at Midway (CA-MNO-2196), California. *Journal of California and Great Basin Anthropology*. Vol. 21(1)

Simms, S.R.

- 1987 Behavioral Ecology and Hunter-Gatherer Foraging: An Example from the Great Basin. BAR International Series; 381. Oxford England.

- 2008 *Ancient Peoples of the Great Basin and Colorado Plateau*. Walnut Creek, CA: Left Coast Press.

Steward, J.H.

- 1938 *Basin-Plateau Aboriginal Sociopolitical Groups*. Bureau of American Ethnology Bulletin No. 120, Smithsonian Institution, Washington, DC.

- 1941 Culture Element Distributions: XIII Nevada Shoshoni. *University of California Anthropological Records*. Vo. 4, no. 2.

Stuiver, M., and Reimer, P. J.

- 1993 Extended 14C database and revised CALIB radiocarbon calibration program. *Radiocarbon*. 35:215-230.

Thomas, D.H.

- 1982 The 1981 Alta Toquima Village Project: A Preliminary Report. *Desert Research Institute Social Science Center Technical Report Series* 27. Reno: Desert Research Institute.

- 1994 Chronology and the Numic Expansion. In *Across the West: Human Population Movement and the Expansion of the Numa*. D.B. Madsen and D. Rhode, eds., pp. 56-61. Salt Lake City: University of Utah Press.

Thomas, D.H., L.S.A. Pendleton and S.C. Cappanari

- 1986 Subsistence. In *Handbook of North American Indians, Vol. 11: Great Basin*, W. L. d'Azevedo, ed., pp. 262-283. Washington, D.C.: Smithsonian Institution.

Tobler, W.

- 1993 Non-Isotropic Geographic Modeling. In *Three Presentations on Geographic Analysis and Modeling*. National Center for Geographic Information and Analysis, University of California Technical Report 93-1. Santa Barbara, CA.

Wells, H. F.,

- 1983 *Historic and Prehistoric Pinyon Exploitation in the Grass Valley Region, Central Nevada: A Case Study in Cultural Continuity and Change*, Ph.D. Dissertation, University of California, Riverside.

West, N. E., R.J. Tausch, and P.T. Tueller

- 1998 A Management-Oriented Classification of Pinyon-Juniper Woodlands of the Great Basin. *General Technical Report 12*, USDA Forest Service, Rocky Mountain Research Station, Ogden UT.

Wheat, M. M.

- 1967 *Survival Arts of the Primitive Paiutes*. University of Nevada-Reno, Reno.

Whitely, T.G. and L.M. Hicks

- 2003 A Geographic Information Systems Approach to Understanding Potential Prehistoric and Historic Travel Corridors. *Southeastern Archaeology*. 22(1)77-91.

Zeanah, D.W.

- 2002 Central Place Foraging and Prehistoric Pinyon Utilization in the Great Basin. In *Beyond Foraging and Collecting: Evolutionary Change in Hunter-Gatherer Settlement Systems*. B. Fitzhugh and J. Habu ed., pp. 231-256. New York : Kluwer Academic/Plenum Publishers.

Table 1. Village Radiocarbon and AD Calibrated Dates
Between Mt. Jefferson and White Mountain Sites*.

LAB NO.	WHITE MOUNTAINS AGE (BP)	CALIBRATED DATES** (AD)	LAB NO.	MT. JEFFERSON AGE (BP)	CALIBRATED DATES** (AD)
UCR-2173	160 ± 60	1791	-	-	-
UCR-2290	210 ± 50	1763	-	-	-
-		-	WSU-2630	220 ± 70	1741
-		-	WSU-2639	220 ± 70	1741
UCR-2178	250 ± 60	1653	-		-
UCR-2276	250 ± 100	1665	-		-
UCR-2283	260 ± 50	1637	-		-
UCR-2285	270 ± 70	1621	-		-
UCR-2291	290 ± 50	2291	-		-
UCR-2287	300 ± 60	1572	-		-
UCR-2193	330 ± 80	1564	WSU-2644	310 ± 50	1564
UCR-2189	340 ± 60	1554	-		-
UCR-2352	360 ± 100	1554	-		-
-		-	WSU-2634	350 ± 80	1553
UCR-2292	350 ± 60	1549	-		-
UCR-2188	360 ± 60	1544	-		-
UCR-2359	400 ± 90	1520	-		-
UCR-2360	460 ± 50	1442	-		-
UCR-2176	490 ± 70	1425	-		-
UCR-2180	490 ± 100	1433	-		-
-		-	WSU-2638	620 ± 80	1347
-		-	WSU-2636	640 ± 70	1342
-		-	WSU-2637	640 ± 80	1340
-		-	WSU-2641	710 ± 70	1287
-		-	WSU-2645	720 ± 60	1279
UCR-2189	760 ± 60	1249	-		-
-		-	WSU-2628	770 ± 80	1236
-		-	WSU-2640	860 ± 50	1174
UCR-2288	870 ± 50	1163	-		-
-		-	WSU-2629	940 ± 80	1101
-		-	WSU-2623	980 ± 80	1070
-		-	WSU-2622	1090 ± 70	938
-		-	WSU-2648	1150 ± 120	873
-		-	WSU-2626	1260 ± 90	771
-		-	WSU-2627	1260 ± 90	771
-		-	WSU-2633	1270 ± 80	759
-		-	WSU-2624	1310 ± 70	723
-		-	WSU-2642	1350 ± 80	684
-		-	WSU-2647	1420 ± 80	616
-		-	WSU-2646	1590 ± 80	468
UCR-2179	1780 ± 60	246	-		-
-		-	WSU-2643	1840 ± 80	178

Notes: *Radiocarbon Dates from Thomas (1994), Dates Calibrated using Calib 6.0 Software (Stuiver and Reimer 1993; Version 6.0).

**Calibrated Dates Report Median Probability.

Table 2. Acres of Pinyon and Limber Pine within an Eight Hour Radius of the Alpine Village Locations in the Toquima and Toiyabe Ranges.

RANGE	PINYON	LIMBER	TOTAL
Toquima	23,054	6,564	29,618
Toiyabe	18,119	5,040	23,159

Notes: Stands of less than ten acres are not included.

Table 3. Distance from Random Set of Caches Back to the Alpine Village

TOIYABE	DISTANCE	TOQUIMA	DISTANCE
1	9.66	21	9.60
2	12.68	22	10.15
3	9.59	23	8.09
4	12.37	24	7.61
5	11.88	25	8.28
6	9.78	26	9.56
7	13.40	27	6.30
8	7.33	28	5.66
9	11.80	29	11.36
10	9.24	30	8.51
11	10.26	31	11.21
12	8.02	32	6.67
13	9.11	33	10.10
14	7.83	34	6.84
15	10.76	35	8.80
16	11.38	36	8.36
17	11.67	37	11.27
18	12.01	38	6.50
19	8.33	39	8.54
20	11.90	40	8.00
TOTAL	208.98	-	171.38
AVERAGE	10.45	-	8.57

Table 4. Number of Sites With and Without Groundstone by Mountain Range and Environmental Setting.

SETTING (FEET)	LOWLANDS (ELEVATION 6,000-7,000)			PINYON (ELEVATION 7,000-8,200)			SUB-ALPINE (ELEVATION 8,200-11,000)			ALPINE TUNDRA (ELEVATION 11,000+)		
	WITH	WITHOUT	%	WITH	WITHOUT	%	WITH	WITHOUT	%	WITH	WITHOUT	%
Toiyabe	15	187	7.4	5	101	4.7	0	22	0.0	2	6	25.0
Toquima	16	167	8.7	39	119	24.7	21	97	17.8	2	8	16.7

Notes: % - Percentage.

Table 5. Frequency of Groundstone Tools per Site by Mountain Range and Environmental Setting.

SETTING (FEET)	LOWLANDS (ELEVATION 6,000-7,000)			PINYON (ELEVATION 7,000-8,200)			SUB-ALPINE (ELEVATION 8,200-11,000)			ALPINE TUNDRA (ELEVATION 11,000+)		
	WITH	TOTAL	AVERAGE	WITH	TOTAL	PER SITE	WITH	TOTAL	PER SITE	WITH	TOTAL	PER SITE
Toiyabe	15	36	2.4	5	7	1.4	0	0	0.0	2	2	1.0
Toquima	16	34	2.1	39	90	2.3	21	46	2.2	2	7	3.5

Table 6. Projectile Point Distributions by Mountain Range and Environmental Setting.

SETTING (FEET)	LOWLANDS (ELEVATION 6,000-7,000)		PINYON (ELEVATION 7,000-8,200)		SUB-ALPINE (ELEVATION 8,200-11,000)		ALPINE TUNDRA (ELEVATION 11,000+)	
	TOTAL	%	TOTAL	%	TOTAL	%	TOTAL	%
<i>TOIYABE RANGE</i>								
DSN	11	10.0	9	15.5	8	21.6	2	16.6
Rosegate	39	35.8	26	44.8	4	10.8	1	8.3
Elko/Earlier	59	54.1	23	39.7	25	67.6	9	75.0
<i>TOQUIMA RANGE</i>								
DSN	10	19.6	6	15.0	2	3.3	7	3.1
Rosegate	12	23.5	12	30.0	14	23.3	11	4.9
Elko/Earlier	29	56.8	22	55.0	44	73.3	205	91.9

Notes: DSN – Desert side-notched.

Table 7. Projectile Point and Groundstone Associations by Mountain Range and Environmental Setting.

SETTING (FEET)	LOWLANDS (ELEVATION 6,000-7,000)			PINYON (ELEVATION 7,000-8,200)			SUB-ALPINE (ELEVATION 8,200-11,000)			ALPINE TUNDRA (ELEVATION 11,000+)		
	YES	NO	%	YES	NO	%	YES	NO	%	YES	NO	%
<i>TOIYABE RANGE</i>												
DSN	1	10	0.9	3	6	33.3	0	8	0.0	0	2	0.0
Rosegate	2	37	5.2	5	21	19.2	0	4	0.0	0	1	0.0
Elko/Earlier	1	58	1.7	4	19	17.4	0	25	0.0	6	3	66.6
<i>TOQUIMA RANGE</i>												
DSN	5	5	50.0	6	0	100.0	2	0	100.0	3	4	42.9
Rosegate	3	9	25.0	7	5	58.3	8	6	57.1	7	4	63.6
Elko/Earlier	10	19	34.5	15	7	68.2	27	17	61.4	107	98	52.2

Notes: DSN – Desert side-notched.

Table 8. Groundstone to Projectile Point Index by Mountain Range and Environmental Setting.

SETTING (FEET)	LOWLANDS (ELEVATION 6,000-7,000)	PINYON (ELEVATION 7,000-8,200)	SUB-ALPINE (ELEVATION 8,200-11,000)	ALPINE TUNDRA (ELEVATION 11,000+)
<i>TOIYABE RANGE</i>				
DSN	3.00	1.00	0.00	0.00
Rosegate	0.50	1.20	0.00	0.00
Elko/Earlier	0.33	0.75	0.00	0.16
<i>TOQUIMA RANGE</i>				
DSN	2.20	4.83	2.00	2.33
Rosegate	3.67	3.29	2.37	1.00
Elko/Earlier	1.00	3.26	0.96	0.07

Notes: DSN – Desert side-notched.

Table 9. Distributions of Rosegate to DSN Projectile Points by Mountain Range and Environmental Setting

SETTING (FEET)	LOWLANDS (ELEVATION 6,000-7,000)		PINYON (ELEVATION 7,000-8,200)		SUB-ALPINE (ELEVATION 8,200-11,000)		ALPINE TUNDRA (ELEVATION 11,000+)	
	TOTAL	%	TOTAL	%	TOTAL	%	TOTAL	%
<i>TOIYABE RANGE</i>								
DSN	11	22.0	9	25.7	8	66.7	2	66.7
Rosegate	39	78.0	26	74.3	4	33.3	1	33.3
<i>TOQUIMA RANGE</i>								
DSN	10	45.5	6	33.3	2	12.5	7	38.9
Rosegate	12	54.5	12	66.7	14	87.5	11	61.1

Notes: DSN – Desert side-notched.

Table 10. Return Rates for 32 Great Basin Resources Following Simms 1987, with New Returns on Limber Pine Included (Rhode 2010).

RANK	RESOURCE	RETURN RATE
1	Deer/Bighorn Sheep	17,971-31,450
2	Antelope	15,725-31,450
3	Jackrabbit	13,475-15,400
	Limber Pine (no processing)*	13,437
4	Gophers	8,983-10,780
5	Cottontail Rabbit	8,983-9,800
6	Cattail Pollen	2,750-9,360
7	Ground Squirrel	5,390-6,341
8	13-lined Ground Squirrel	2,837-3,593
9	Ducks	1,975-2,709
10	Gambel Oak	1,488
11	Tansymustard	1,307
12	Pinyon Pine (Hulled)	841-1,408+
13	Bitterroot	1,237
14	Salina Wild Rye	921-1,238
15	Nuttall Shadescale	1,200
16	Shadescale	1,033
17	Bulrush	302-1,699
18	Barnyard Grass	702
19	Peppergrass	537
20	Sunflower	467-504
21	Bluegrass	418-491
22	Great Basin Wild Rye	266-473
23	Indian Rice Grass	301-392
24	Reed Canary Grass	261-321
25	Scratchgrass or Dropseed	162-294
26	Foxtail Barley	138-273
27	Sedge	202
28	Cattail Seeds	128-267
29	Bulrush	160-257
	Limber Pine (Hulled)*	191.4
30	Salt Grass	146-160
31	Pickleweed	90-150
32	Squirrel tail Grass	91

Notes: *Return Rates From Rhode 2010.

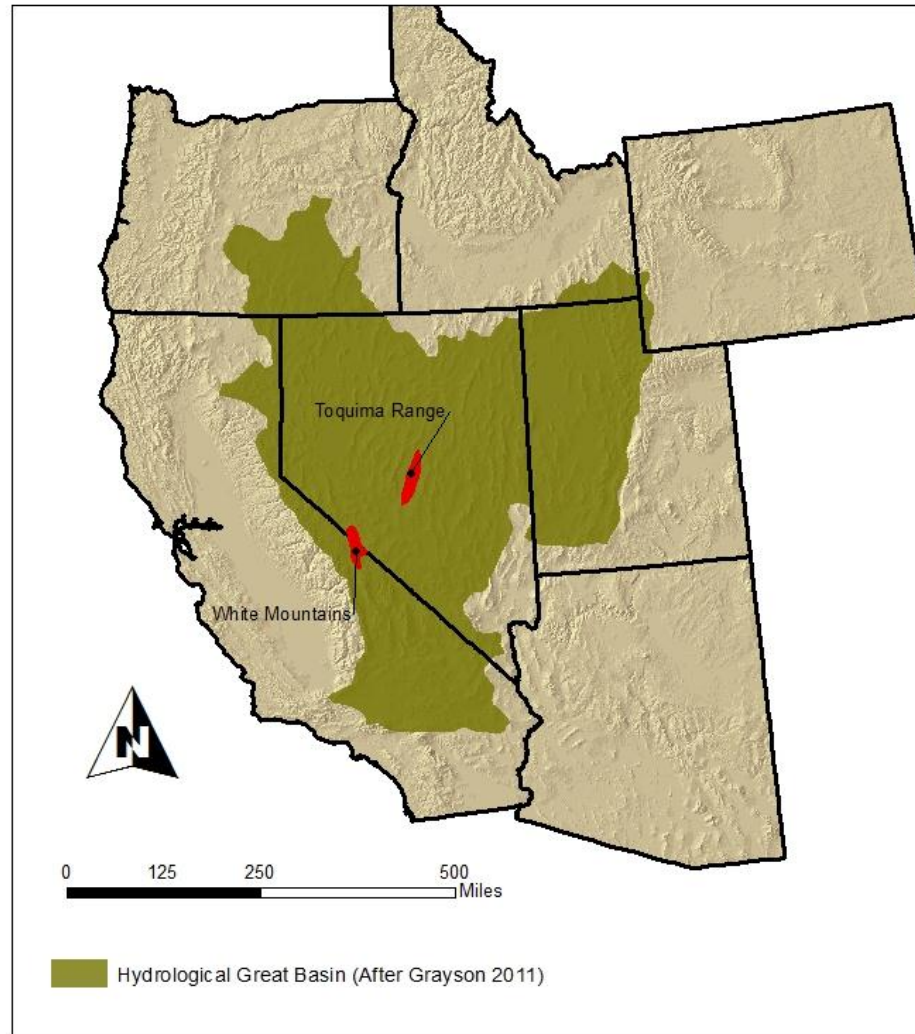


Figure 1. The White Mountains and Alta Toquima Range in the Context of the Hydrological Great Basin

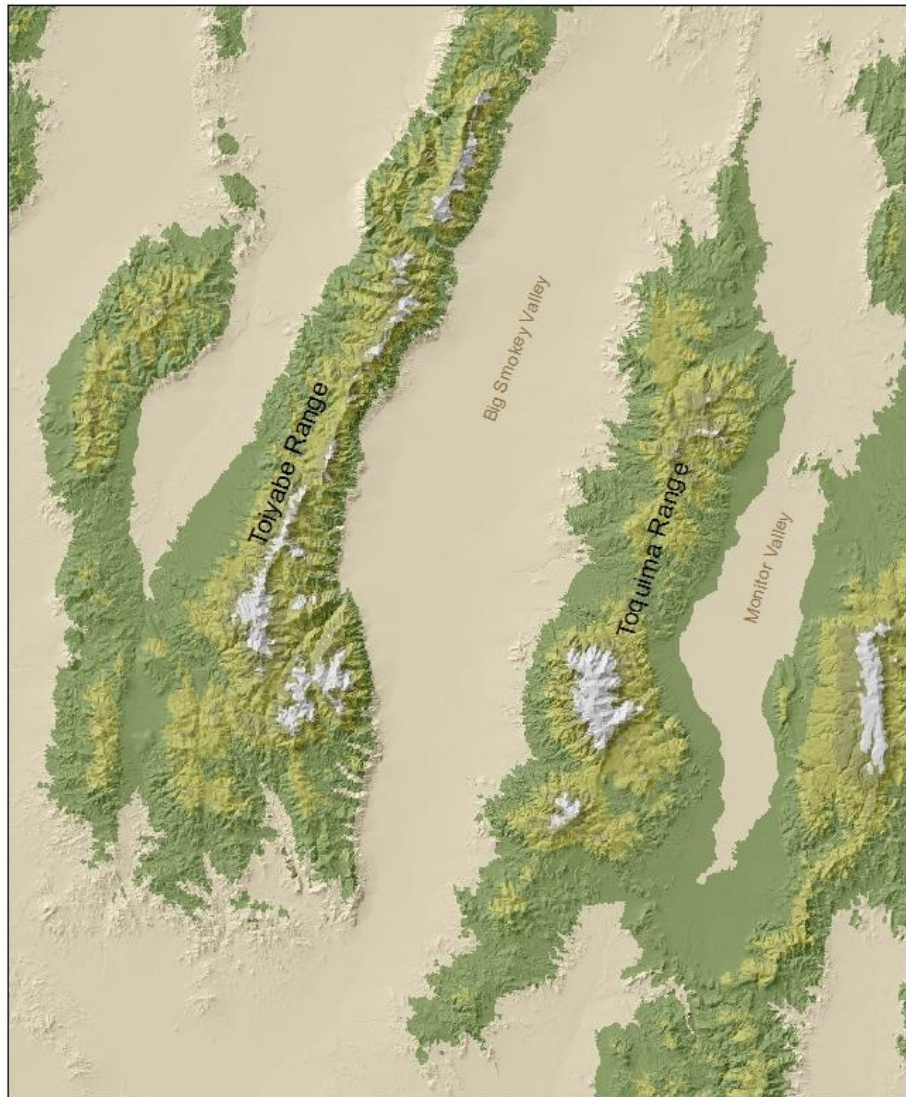


Figure 2. Environmental Zones of the Toiyabe and Toquima Ranges



0 10 20 Miles

-  Lowlands
-  Pinyon-Juniper Zone
-  Upper Sage Brush Grass Lands
-  Sub-Alpine Zone
-  Arctic Tundra

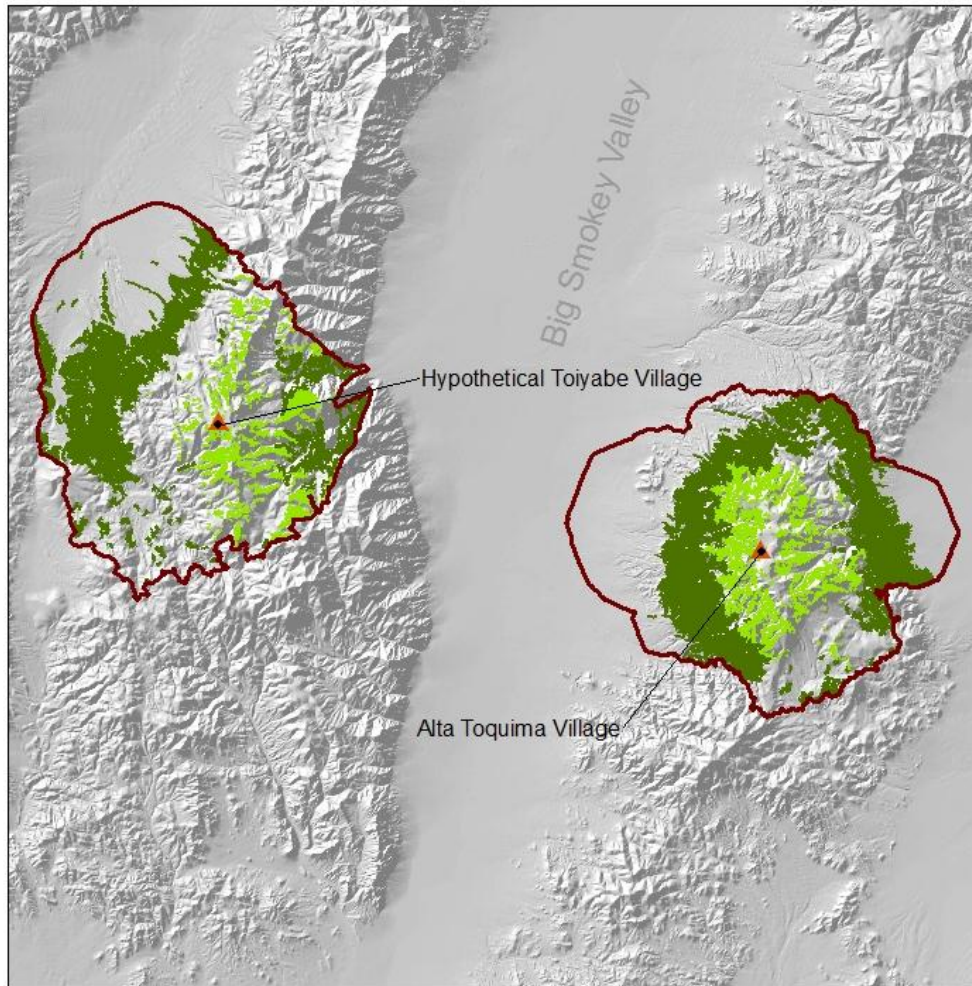
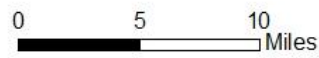



Figure 3. Environmental Distributions within an Eight Hour, Round-Trip Foraging Radii



-  Pinyon Pine
-  Limber Pine
-  Eight Hour Site Catchement

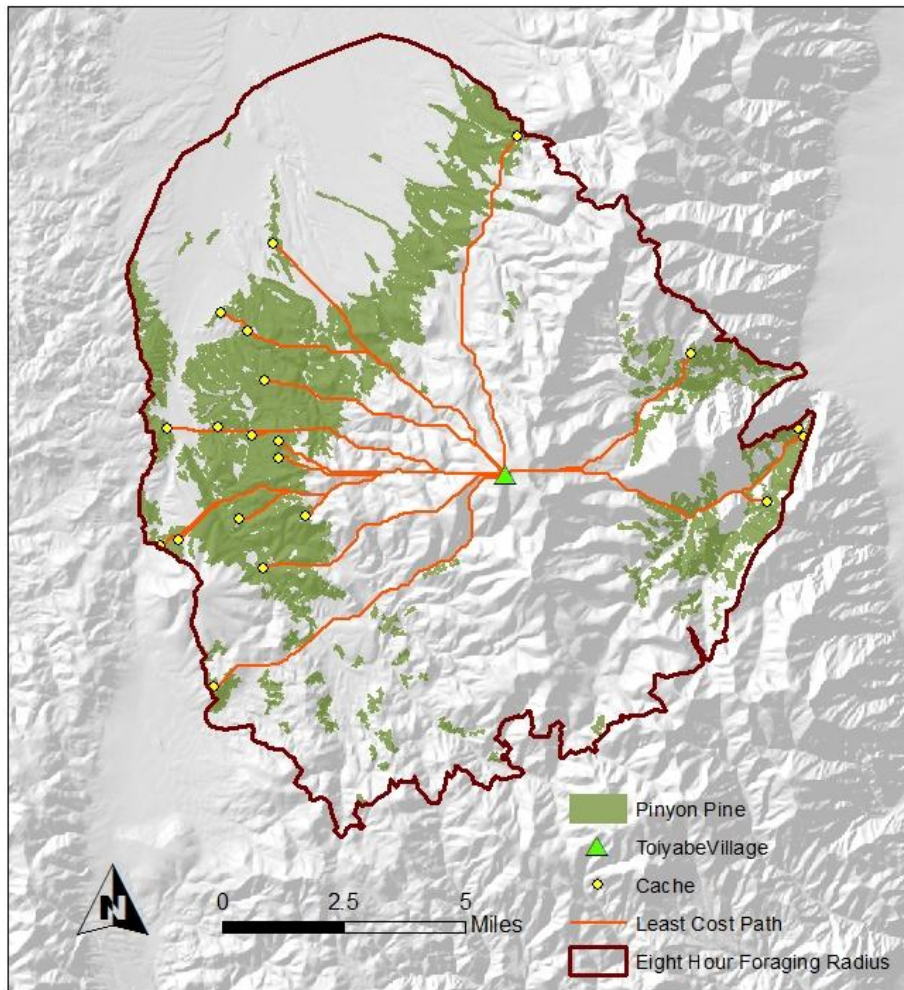


Figure 4. Least Cost Paths From 20 Randomly Generated Cache Locations in the Pinyon Zone, within an Eight Hour Foraging Radius to the Hypothetical Toiyabe Village Locale

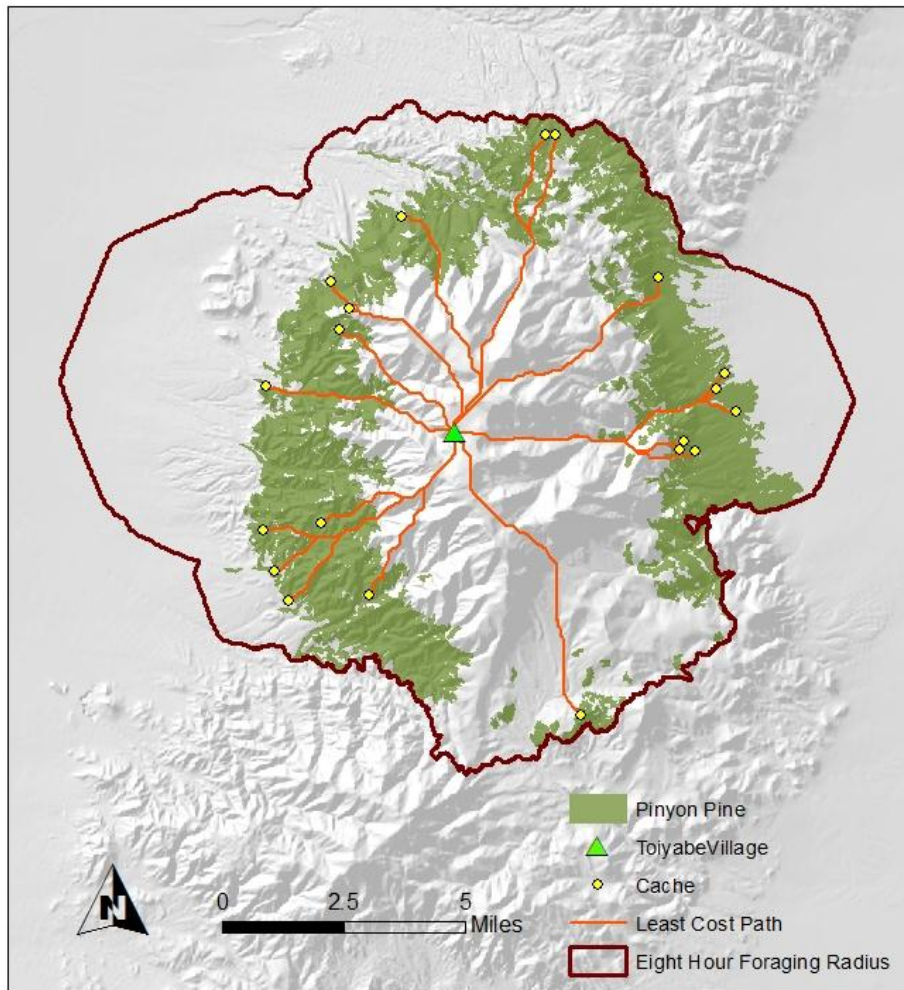


Figure 5. Least Cost Paths From 20 Randomly Generated Cache Locations in the Pinyon Zone, within an Eight Hour Foraging Radius to AltaToquima Village

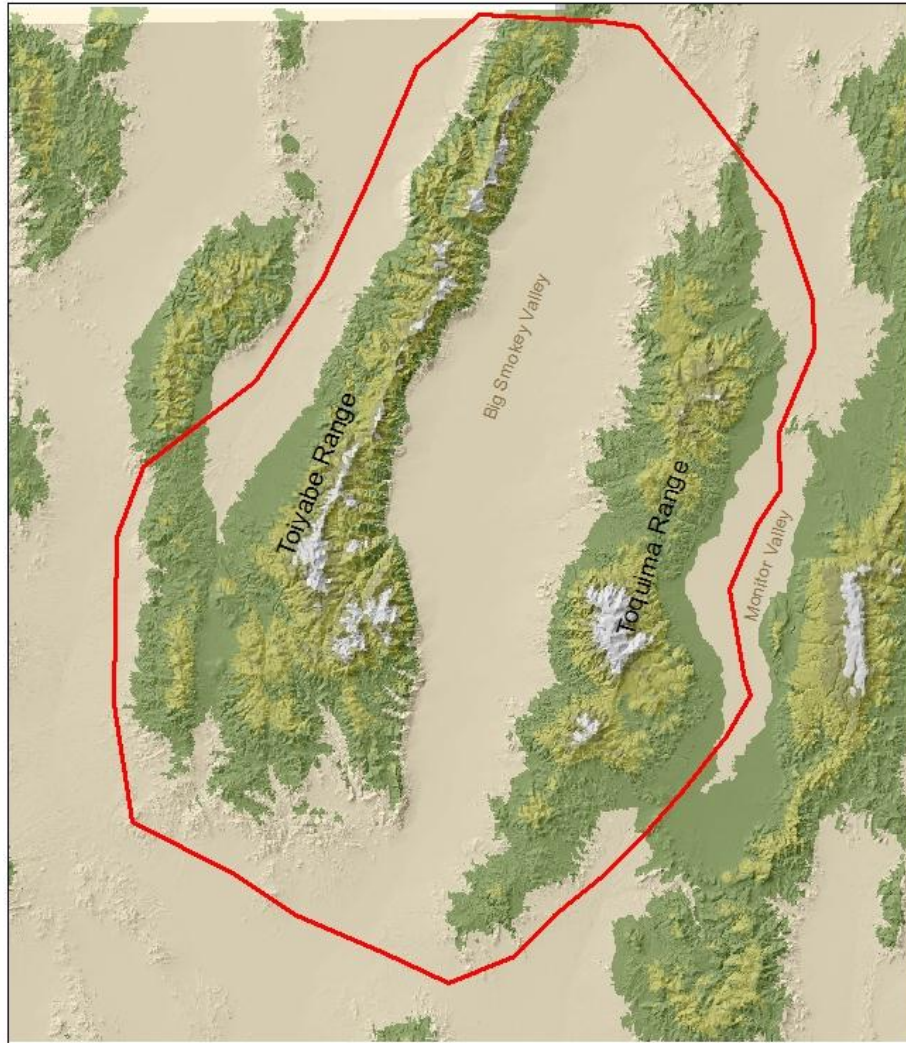


Figure 6. Project Area Sampled Using the NVCRIS System for the Toiyabe and Toquima ranges

