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High-Altitude Intensification and Settlement in Utah's Pahvant Range

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Recent excavations at Pharo Heights, a residential site in the subalpine region of the Pahvant Range in central Utah, and the dating of a storage feature associated with Pharo Village, a Fremont hamlet at the base of the eastern side of the range, indicate contemporaneous occupations between approximately 1,650 and 500 cal B.P. Combined with survey data suggesting a long period of Archaic hunting along the crest of the Pahvants, this information suggests intensive exploitation and seasonal residential occupation of the high country developed alongside population growth and economic intensification in the lowlands, likely as a way of increasing hunting returns, but probably not as a way of facilitating trade or travel. This interpretation suggests that Fremont farming and hunting intensification were interlinked, a model in accord with both regional and global perspectives identifying economic intensification as the primary impetus for intensive, residential occupation at high altitude.

The subject of why people intensively exploit and live at high elevations is an important one, especially in the Great Basin, which is of course characterized as much by mountain ranges as by basin floors. Though somewhat contentious (see Walsh 2005; and Walsh et al. 2006), most thinking along these lines has it that high mountains (i.e., regions above 2,700 m.) are marginal environments where biotic productivity, growing season, temperature, oftentimes water, and even oxygen are limiting to human occupation (Aldenderfer 2006; Beall 2001). So the question is asked: why would people choose to live for any extended period of time under such circumstances? Recent survey and excavation in Utah's Pahvant Range and a new radiocarbon date on a storage feature associated with Pharo Village, a Fremont hamlet near the base of the northeastern part of the range, provide evidence pointing to an intimate relationship between highland and lowland occupations. This close relationship suggests that increasing population density associated with economic intensification in the lowlands also elicited intensive exploitation of alpine-subalpine settings and the establishment of seasonally-occupied, residential highland camps.

These conclusions are based on a survey of 518 acres along the crest of the Pahvant Range, the excavation of a subalpine residential site known as Pharo Heights, also along this crest, and the dating of a subterranean storage feature associated with Pharo Village, on the valley floor immediately east of the range. This brief paper presents evidence supporting the findings described above. It begins with an overview of the study area's setting, continues with a presentation of field and lab results, explores these results using a GIS settlement pattern analysis, and concludes with a discussion of

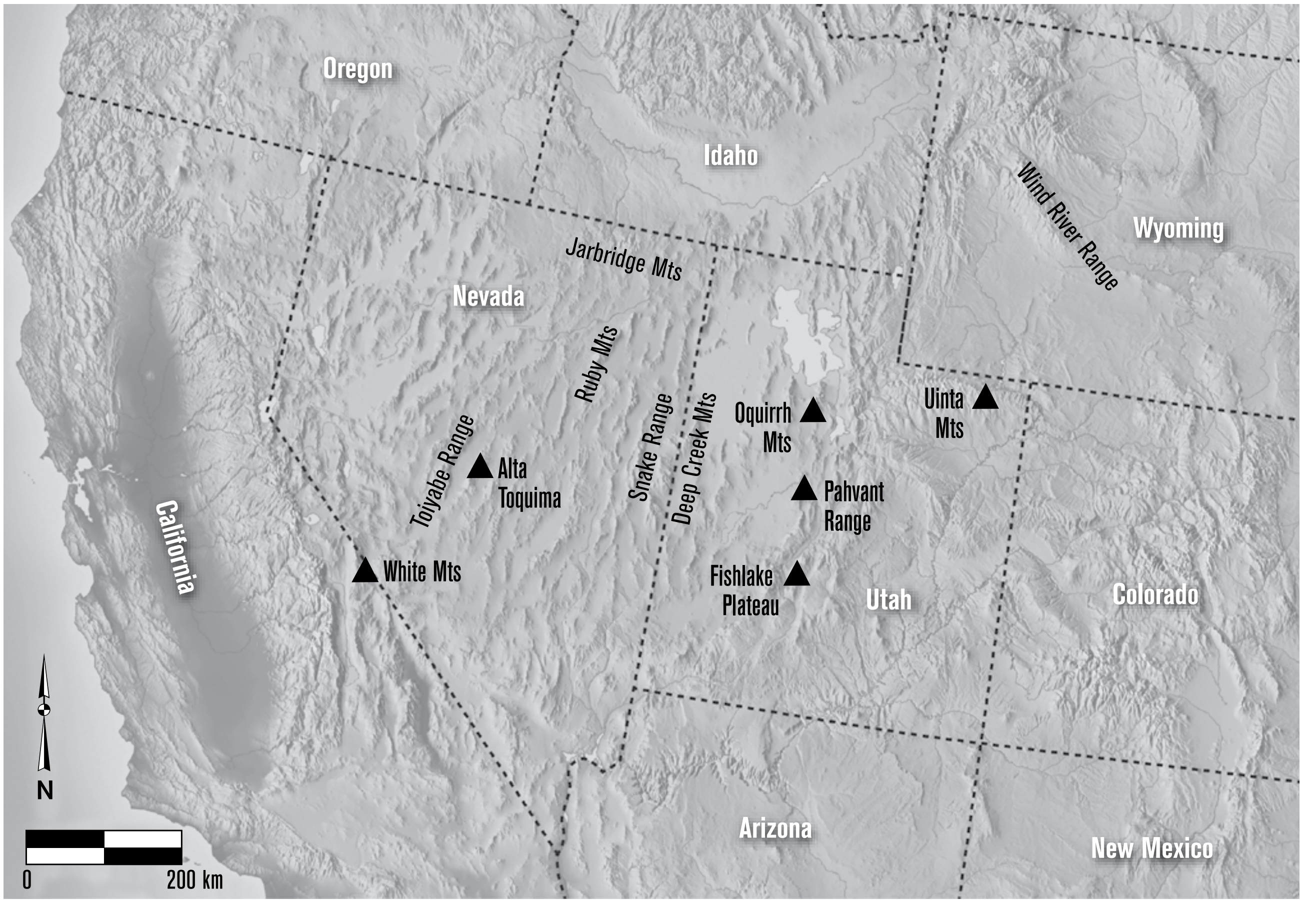

Figure 1. Study area showing Pahvant Range and other high altitude studies mentioned in text.

the relevance of these results to the local and regional archaeological record, particularly as they relate to high-altitude archaeology in and around the Great Basin.

PAHVANT RANGE ARCHAEOLOGY

The Pahvant Range is a relatively short, steep, and narrow (roughly 70 km. long by 15 km. wide) mountain range in central Utah, bounded on the north by the town of Scipio and Scipio Pass, on the west by Fillmore, on the east by Richfield and the Sevier River, and on the south by Interstate 70, Clear Creek Canyon, and the Tushar Mountains (Fig. 1). Like most Great Basin ranges, the Pahvants are a generally north-south trending, fault-block chain composed of sedimentary and metasedimentary rocks like sandstones, quartzites, limestones, and shales. In its northern portion, near Scipio, there are conglomerate cliffs containing, among other larger clasts, toolstone-quality chert nodules. Elevations range from approximately 6,000 ft. (ca. 1,800 m.) in Upper Round Valley at the eastern base of the range to 10,222 ft. (3,116 m.) at Mine Camp Peak. The base of the range is some 800 feet lower on its western side (at ca. 1,600 m.). Biotic distribution conforms to that seen elsewhere in the Great Basin (Grayson 1993), with a sagebrush (*Artemisia* spp.) steppe at the base of the range, a mixed hardwood and coniferous (*Acer-Pinus*) forest between roughly 6,000 and 7,000 ft. (1,800–2,100 m.), coniferous forest (*Pinus-Abies*) and shrublands (mainly *Cercocarpus* and *Prunus* spp.) between 7,000 and 9,000 ft. (2,100–2,743 m.), and a narrow swath of subalpine sagebrush-grasslands above about 9,000 ft. (2,743 m.) that also contains small stands of aspen (*Populus tremuloides*) in the lee of steeper slopes. Deeply incised, steep-sided canyons containing mostly seasonal, but also a few perennial streams (in the northeast, notably Willow and Ivie creeks; Pharo Creek, mapped as intermittent, has continuous flows most years), dissect the range (USGS 2002).

Beyond an initial recording of Fremont mounds along Ivie Creek (not to be confused with the more famous Ivie Creek, which drains Old Woman Plateau some 85 km. to the east) by Elmer Smith in 1936 (Smith 1937) and the occasional Forest Service survey or site evaluation (e.g., Leonard 1993), very few archaeological investigations have been conducted in the northern part of the Pahvant Range. In the south, however, expansion of I-70 through Clear Creek Canyon resulted in particularly substantial, though lower-elevation, investigations (Janetski et al. 1985; 2000; Talbot et al. 1998, 1999, 2000). The exception to this was the University of Utah's excavation of Pharo Village, originally described as a Fremont hamlet extending some 200 m. along the banks of Pharo Creek, at an average elevation of 6,000 ft., in 1967 (Marwitt 1968). The work here was considerable, and was focused on clearing excavations in the site's northeastern locus (a second locus, to the southwest, was test-trenched, but never systematically excavated). Excavations revealed three roughly rectilinear pithouses, six above-ground granaries, two human burials, a dog burial, two "activity areas," and several other features characteristic of Fremont residential sites. Recovered artifacts were more or less typical of the region: Sevier, Snake Valley, and Ivie Creek ceramics, Parowan Basal-notched and other Formative Period projectile points, abundant flaked-stone artifacts and milling tools (including Utah-type metates), worked-bone artifacts, charred corncobs and cornstalks, and animal bone, particularly that of mountain sheep (*Ovis canadensis*) and mule deer (*Odocoileus hemionus*). Based on these findings, Marwitt (1968) interpreted the site as a small, permanent horticultural settlement that supplemented its diet with locally-available large game like sheep and deer. Two radiocarbon dates, one from a structural member in the floor of the first pithouse, the other from a granary, bracket the site occupation between 690 ± 80 and 760 ± 90 rcy B.P. (744–832 and 805–619 cal B.P. at 2 sigma, respectively; all radiocarbon dates in this article were calibrated with CALIB 6.1.1 [Stuiver and Reimer 1993] using the IntCAL09 calibration curve [Reimer et al. 2009]). A third date of 1,490 ± 80 rcy B.P. (1,545–1280 cal B.P. at 2 sigma), from a wood fragment recovered from what was described as the crawlway of the third pithouse, was rejected because it was "incompatible with the archaeological data," probably because it did not correspond to the later (e.g., Ivie Creek Black-on-White) ceramics at the site (Marwitt 1968:5).

FIELD INVESTIGATIONS IN 2009

Within this context, and drawing on previous studies of Fremont mountain adaptations and settlement patterns (e.g., Janetski 1985, 2010; Johnson and Loosle 2002; Knoll 2003; Loosle and Johnson 2000; Talbot and Richens 2004), volunteers from Utah State University's anthropology program set out to investigate high-altitude prehistoric land use in the vicinity of Pharo Village in the summer of 2009. This work consisted of survey along the crest of the range, excavation of a site known as Pharo Heights, and a rather serendipitous sampling and dating of a subterranean storage feature associated with Pharo Village itself.

High-Elevation Survey

The survey portion of the study focused on the subalpine-alpine region of the northern Pahvant Range and was geared towards elucidating high-altitude aboriginal land use and its relationship (if any) to Pharo Village. Operating on this basis, a DEM of the region was queried to identify all areas above 9,100 ft. (2,774 m.), a robust proxy for alpine-subalpine habitats in the region (Grayson 1993), and an 8.5 km. Euclidian buffer was generated around Pharo Village; this is a more-or-less typical central-place foraging radius (Morgan 2008). The intersection of these two polygons resulted in a 6,397-acre parcel representing those areas both above timberline and within 8.5 km. of Pharo Village. Within this area, 518 acres (an 8.1% sample) were intensively surveyed with a crew of five walking 15-meter-wide, line-abreast transects. Findings were few, consisting of the occasional isolate (most often an isolated chert flake) and three archaeological sites. The first two sites are small lithic scatters, with projectile point types ranging in age from Archaic to Late Prehistoric (i.e., one Elko Corner-Notched and one Rosegate Series point, together dating to ca. 4,500–500 B.P.) (Thomas 1981). The third site was Pharo Heights, initially identified by Fishlake National Forest Archaeologist Robert Leonard and described in the succeeding subsection. These findings, admittedly somewhat unremarkable, are commensurate with those from nearly every other surveyed range in the American

West (e.g., Benedict 1975; Canaday 2001; Wright et al. 1980) in that they characterize a low-intensity, sporadic use of the region (mostly for hunting) during the Archaic and latter half of the Holocene.

Pharo Heights

The Pharo Heights site is located at an elevation of 9,465 ft. (2,885 m.) on an exposed north-south trending, low-angle saddle between Pioneer Canyon, which drains toward the town of Holden to the west, and Rock Canyon, a tributary of Pharo Creek, which drops precipitously to the east. The site was initially reported to contain at least ten possible housepit depressions and an extensive artifact scatter of flaked and ground stone artifacts, as well as a small quantity of pottery. A well-travelled, USFS-maintained dirt road passes through the western edge of the site. Cattle regularly graze and vehicles occasionally park or are driven on-site.

The 2009 field investigations consisted of a complete inventory of the site's surface artifact assemblage (using 2-meter-wide, line-abreast transects) and the excavation of ten 50 x 50 cm. shovel probes and one 1 x 1 m. unit (all excavated in 10 cm. arbitrary levels and screened using 1/8" mesh). Excavations were conducted to ascertain the composition of the site's subsurface deposit and to determine the nature of the possible housepit depressions. To this end, four shovel probes and the single unit were excavated in five of the most distinct depressions; the remaining probes were used to judgmentally test other portions of the site, particularly a higher-density artifact scatter near a seep in the northern portion of the site. These excavations identified a mostly-shallow subsurface deposit extending no more than 30 cm. below surface (cmbs.), save in Shovel Probes 6 and 10, which revealed deposits extending to 80 and 60 cmbs., respectively. In general, the site deposit contained a diverse artifact assemblage comprised of groundstone, ceramics, abundant flaked stone, and faunal remains; anthropogenic midden soils were found in the southern portion of the site (Fig. 2).

Features. Site features consisted of eight 3–4 m. diameter, 5–10 cm. deep depressions resembling wickiup or housepit floor features on the site's surface (our investigations could confidently identify only eight of the original 10 noted at the site by Leonard). There were also at least two subsurface features. The first of these was a 4-cm.-thick lens of charcoal-stained soil and fire-cracked rock adjacent to a small sandstone boulder, found 28.5 cmbs. in Shovel Probe 1, excavated in the center of the most obvious possible housepit depression. Carbon samples were recovered from this feature. The second subsurface feature was a discrete 2 to 3-cm.-thick clay lens resembling a compacted house floor found 12 cm. deep in Shovel Probe 8, also excavated within a distinct depression (Fig. 3). Less discrete paraconformities between sandy surface soils and clayey subsurface horizons and indicators of subsurface compaction were identified in an additional two shovel probes. These findings are equivocal, however, given the frequency of cattle grazing and other impacts at the site (which may have compacted surface and subsurface soil horizons) and the fact that house floors associated with ephemeral structures like wickiups are oftentimes difficult to identify, particularly with regard to soil or sediment compaction (Janetski 2010; Metcalf et al. 1993). All together, identified features included at least one hearth, one compacted house (probably a wickiup) floor, and perhaps as many as two other house floors. The remaining depressions showed little or no evidence of use as housepits, though this fact alone does not preclude their use as such, given problems associated with identifying such short-lived residential structures (see also Simms 1989; Stapert 1990; Surovell and Waguespack 2007).

Artifacts. Surface inventory, surface collection, and excavations identified a diverse assemblage composed of a single ceramic sherd, groundstone, and flaked stone (the vertical distribution of artifacts is shown in Table 1). Based especially on the diversity and temporal variability of the projectile point types found in both surface and subsurface contexts, it appears that stratigraphic mixing has occurred, at least in the shallow subsurface deposits that characterize most of the site.

The sherd is gray, with a uniform, fine-grained, quartz temper, suggesting it is a fragment of a Snake Valley grayware vessel (Madsen 1977). Local landowners report that large vessel fragments and complete pots have been collected from the surface of the site over the last 50 years (Dick Probert and Richard Wasden, personal communications 2009). Groundstone consists of seven manos and three milling slab fragments. The manos are all small (long axis mean = 7.2 cm.), single-handed, unifacially or bifacially worn, and made of locally-

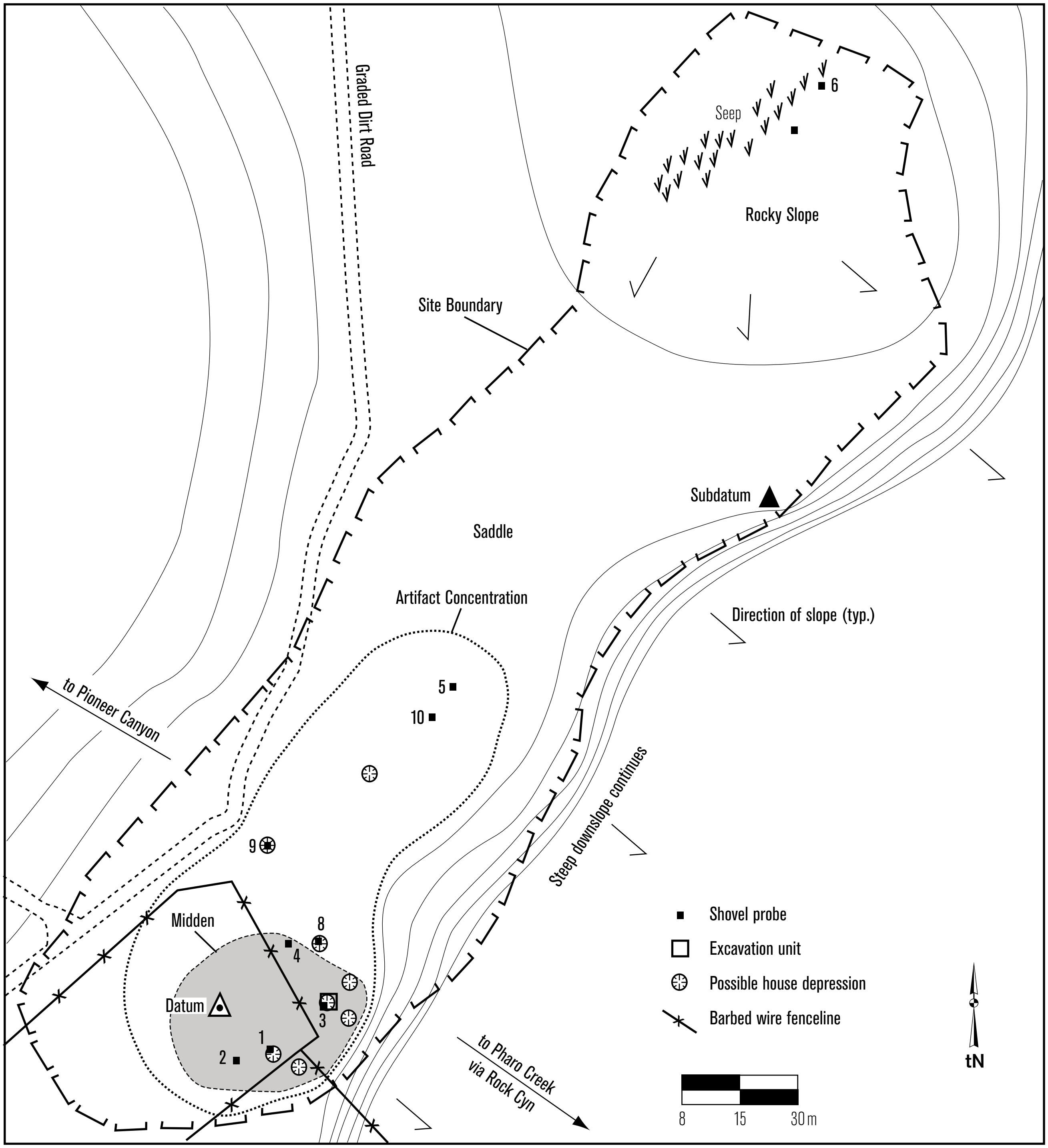

Figure 2. Pharo Heights site map.

available quartzite cobbles. All save one is unshaped. These are somewhat similar to the Archaic manos Schroedl identified at Sudden Shelter (see Jennings et al. 1980), yet clearly represent the expedient use of the abundant, naturally-occurring quartzite cobbles found in and around the site (for a description of expedient groundstone tool attributes, see Madsen and Schmitt 2005:115–119). The three milling slab fragments are likewise lightly-worn milling surfaces developed on locally-available quartzite slabs.

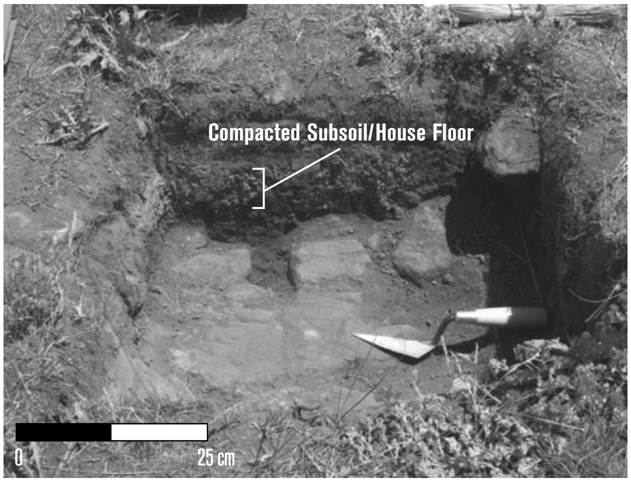

Figure 3. Photograph of possible compacted house floor in Shovel Probe 8.

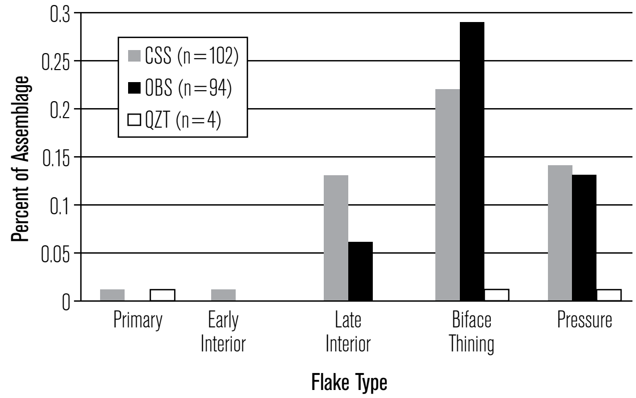

Figure 4. Debitage analysis: Flake type frequencies.

A total of 3,132 pieces of debitage was recovered; 61.6% of the total consisted of chert, 37.8% of obsidian, and less than 1% of quartzite, the latter indicative of testing naturally-occurring cobbles at the site. A random sample of 10 flakes from each of the 10 shovel probes and a second random sample of 100 flakes from the excavation unit (n=200) indicates that the debitage is dominated by small biface-thinning and pressure flakes associated with bifacial tool manufacture and retouch (Fig. 4). An X-ray fluorescence (XRF) analysis of 21 obsidian specimens indicates that roughly 71% of the assemblage is from the Black Rock source and 12% is from the Wild Horse Canyon source, which is not surprising given their location 66 and 88 km., respectively, southwest of the Pahvant Range. A single sample came from an as-yet unidentified source.

Flaked stone tools consist of edge-modified flakes, bifaces, and projectile points. Edge-modified flakes (flakes showing unifacial retouch along one or more margins) consist of two chert, one obsidian, and one quartzite tool. Three obsidian and 25 chert biface fragments were recovered from the site; all save three are mid- to late-stage specimens (i.e., Stages 3–5; Andrefsky 2000:180–181), indicating initial reduction and thinning occurred elsewhere. Importantly, 12 of these bifaces are classed as Stage 5, indicating that they represent finished and perhaps hafted tools or broken projectile points. Nine projectile point fragments were also identified: a heat-treated chert Elko base, an obsidian Nawthis type missing its tip, an obsidian Rose Springs base, an obsidian Cottonwood Triangular missing its tip, a possible crude chert Bull Creek fragment, one unidentifiable chert point tip, and four unidentifiable obsidian point fragments.

Fauna. Faunal remains consist of 590 specimens of mostly fragmentary burnt bone, with a relatively low number of specimens identified to the ordinal level (Table 2) and only 23 specimens confidently identified below the class level (i.e., Mammalia). One specimen was

Table 1

FREQUENCY DISTRIBUTION OF PHARO HEIGHTS ASSEMBLAGE BY ARTIFACT CLASS

	Biface	Core	Debitage	EMF[a]	Faunal Bone	Mano	Milling-slab	Sherd	Proj. Point	Total
Subsurface	6	1	3,132	0	602	1	1	1	3[b]	3,748
Surface	22	5	0[d]	4	1	6	2	0	6[c]	48
Total	28	6	3,132	4	603	7	3	1	9	3,796

[a] Edge modified flake

[b] one Bull Creek, one Elko and one unidentifiable fragment

[c] one Nawthis, one Cottonwood, one Rose Springs and three unidentifiable fragments

[d] debitage not collected from site surface

Table 2

SUMMARY OF TAXA PRESENT IN THE PHARO HEIGHTS FAUNAL ASSEMBLAGE

Taxon	Count
Rodentia	1
Artiodactyla	21
Ovis canadensis	1
Unidentified, size class 2	1
Unidentified, size class 3	20
Unidentified, size class 4	1
Unidentified, size class 5	57
Unidentified, unknown size	488
Total NISP	**23**
Total Unidentified	**567**
Total Specimens	**590**

identified at the species level, a malleolus of mountain sheep (*Ovis canadensis*). An additional 21 specimens of highly fragmented tooth enamel and a single lumbar vertebra centrum fragment were identified as Artiodactyla. The single rodent specimen is a fragmented upper incisor of a Class 2 size animal (approximately the size of *Neotoma* or *Thomomys*). Based on the single specimen, it cannot be determined whether this specimen is intrusive or cultural.

The Pharo Heights faunal assemblage exhibits a high proportion of burning based on the presence of carbonized (charred) and calcined specimens. Excluding specimens with "indeterminate" burning, 194 specimens (35.6%) exhibit some degree of heat exposure. Most burned specimens were calcined (83.0%). No other cultural markers, such as cutmarks, were identified on the remains aside from burning.

The high frequency of burning in the assemblage warrants a brief discussion. Quite a few researchers have suggested that scrap bone may have been added to fires at high elevation sites to help fuel wood fires (Costamagno et al. 2005; Grayson 1991; Grayson and Millar 2008; Thèry-Parisot 2002; Thèry-Parisot et al. 2005). The rate of burning as a whole is lower in the Pharo Heights assemblage than that observed by Grayson (1991) for high elevation sites in the White Mountains, California, where between 50% and 74% of the faunal remains were either charred or calcined. However, between 10% and 68% of the burned bone in the White Mountain alpine assemblages was calcined, which is comparable to the high rate of calcined specimens observed at Pharo Heights. Although it is tempting to interpret this as the result of using bones as fuel (or perhaps simply as discards into cooking fires—see Janetski et al. 2000:78–79), the high rate of burning in the Pharo Heights assemblage may also simply be due to preservation biases.

Dating. The dating of Pharo Heights relies on one AMS date, source-specific obsidian hydration measurements, and diagnostic artifact types. The single AMS date (Beta-26872), on charcoal recovered from the hearth identified in Shovel Probe 1, returned a date of 1,720 ± 40 rcy B.P. (1,713–1,538 cal B.P. at 2 sigma). The taxon of the charcoal was not identified prior to dating. This datum is consistent with a fairly early Formative Period occupation of the site, but could possibly be confounded by an "old wood" problem (Schiffer 1986), though at present only short-lived species grow near the site (i.e., aspen, which lives to a maximum of about 220 years [Fitzgerald 2010]). Obsidian hydration (OH) measurements for 20 source-identified obsidian specimens range from 1.2 to 3.6 microns (Fig. 5). Using the relative temporal framework for these two obsidian sources devised by Seddon (2005), dates range from "confidently Archaic" (n = 2) to "confidently Late Prehistoric" (n = 3), with most dates falling into "Late Prehistoric/Formative" (n = 10) or "confidently Formative" categories (n = 4) (Table 3). Combined, 15 of 20 OH measurements fall into a Formative Period category, skewing towards the younger end of the Formative range. Finally, AMS and OH data are consistent with the almost exclusively Formative Period diagnostic artifacts at the site: Snake Valley grayware pottery arguably dates to between 1,050 and 700 B.P. (Berry 1972); Cottonwood Triangular points generally post-date 650 B.P., Rose Springs points date to between 1,350 and 650 B.P. or perhaps later (Bettinger and Taylor 1974; Garfinkel 2010); Bull Creek points, though more often associated with Ancestral Puebloan sites, date from 900–650 B.P. (Holmer and Weder 1980:61; Woods 2009); and Nawthis projectile points date to between 1,150 and 750 years B.P. (Holmer and Weder 1980; Lyndon 2005). The single Elko Eared point, a generally poor temporal marker (but see Lyndon 2005), corresponds to the Archaic to early Formative obsidian hydration dates, arguably between about 3,250

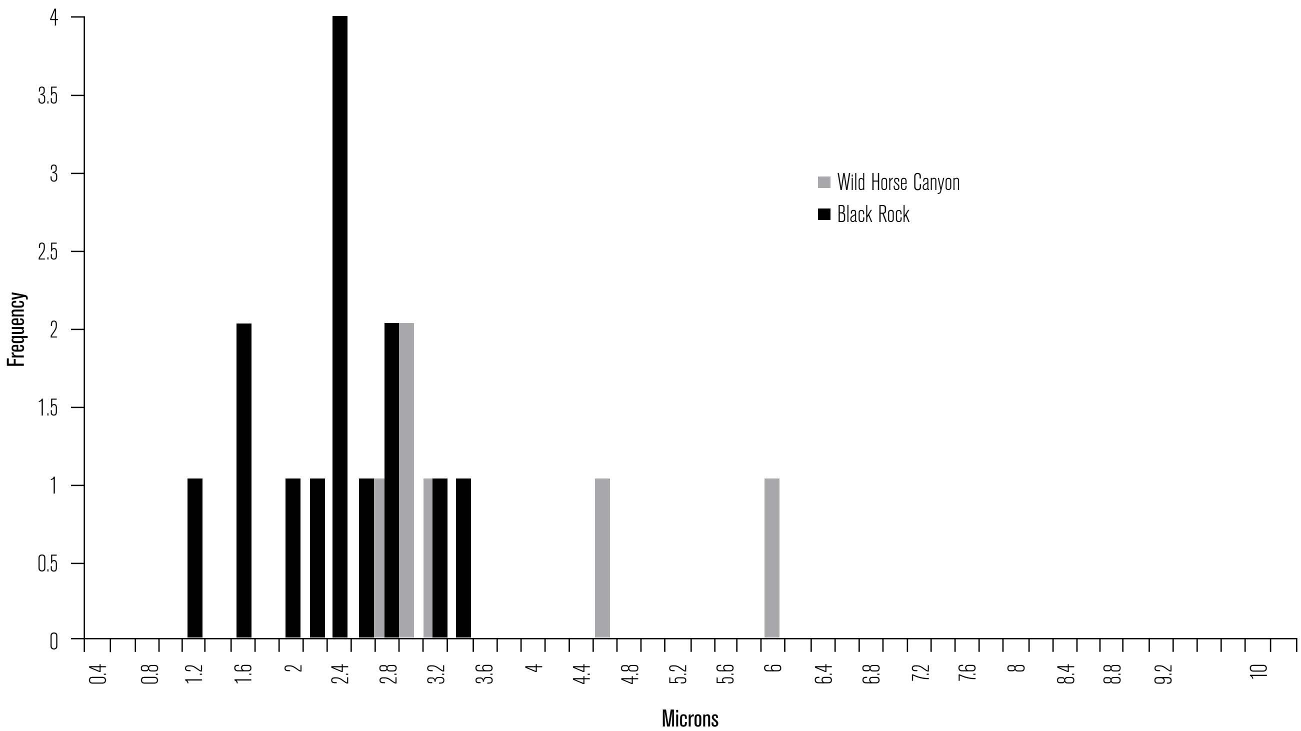

Figure 5. Obsidian hydration histogram by source.

and 1,250 B.P. (O'Connell 1967; Thomas 1981). In any event, chronological data for the site clearly indicate mainly Formative Period occupations, between about 1,650 and 500 cal B.P. (Fig. 6).

Site Summary. Based on the preceding, Pharo Heights appears to be a seasonal residential locus that was likely repeatedly occupied for short spans in the summer and fall when the ridge upon which it is located was snow-free. Features indicate the construction of one to three, and possibly more, wickiups, brush shelters, or other expedient living structures, as well as campfires, particularly in the southern portion of the site. Plant (and possibly small animal) processing is indicated by the relatively abundant groundstone on the site, as well as the small quantity of pottery that could have been used to boil such items. Hunting and animal processing, including but not necessarily limited to mountain sheep, is indicated by projectile points, bifaces, expedient flake tools and artiodactyl bone. Tool manufacture and maintenance is evidenced by the prevalence of biface thinning and pressure flakes in the debitage assemblage. Combined with multiple dating proxies, it appears that the site served as a seasonal residential locus focused on plant procurement, processing, and hunting that was occupied repeatedly, mainly between 1,650 and 500 cal B.P.

Table 3

DISTRIBUTION OF PHARO HEIGHTS OBSIDIAN HYDRATION DATES (SEDDON 2005)

Age	Black Rock	Wild Horse	Total
Confidently Late Prehistoric	3	0	3
Late Prehistoric/Formative	6	4	10
Confidently Formative	4	0	4
Formative/Archaic	1	0	1
Confidently Archaic	0	2	2
Total	**14**	**6**	**20**

Pharo Village

During a visit to Pharo Village, a large sinkhole was identified near what appears to have been the southwestern locus of the site (as described by Marwitt 1968:3), in an area blanketed with chert flakes and sherds (Fig. 7). The sinkhole was roughly 8 m. in diameter, 3 m. deep and had perfectly sectioned an anomalous (for central Utah) slab-lined storage cist. The cist measured

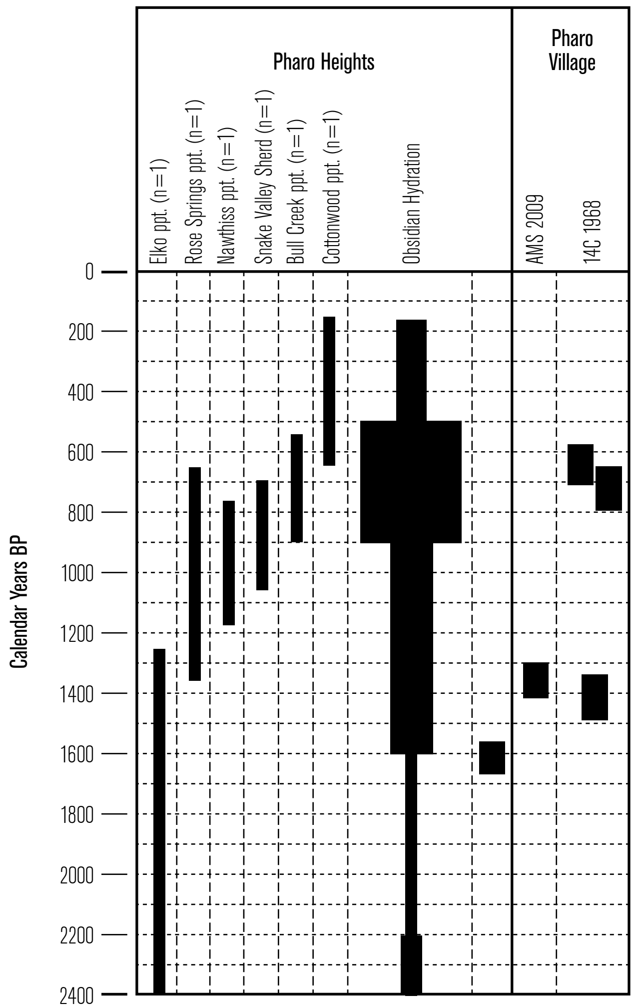

Figure 6. Dating comparison: Pharo Heights : Pharo Village.

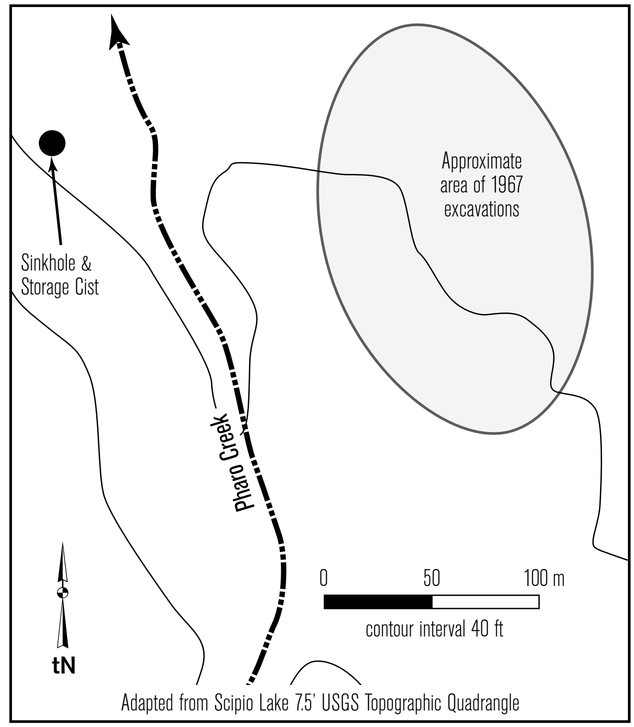

Figure 7. Map showing 1967 Pharo Village excavations and cist sampled in 2009. The exact location and extent of Pharo Village and its two loci are estimated based on written descriptions and an aerial photograph in Marwitt (1968:2) and the site map from the original excavations. Almost no artifacts and no evidence of excavation, however, are present in the location depicted in the figure, though abundant artifacts are present in and around the sampled storage cist.

95 cm. wide by 63 cm. deep, was capped by a 10- to 15-cm.-thick weakly-developed soil, and was filled with cobbles, small boulders, and burned midden soils. A 1- to 2-cm.-thick lens of burned organic material lined the base of the pit (Fig. 8). In an effort to salvage information from the feature, the section was cleaned, mapped and photographed, and carbon samples were collected from the burned base of the pit. A single AMS date (Beta-268171) from carbon collected from the lens at the base of the pit indicates it burned at 1,460±40 rcy B.P. (1,410–1,269 cal B.P. at 2 sigma). This date is consistent with Marwitt's (1968) discarded date of 1,490 rcy B.P. for the third Pharo Village pithouse, suggesting that these earlier dates likely do represent legitimate occupations of the site. All together, dates from Pharo Village indicate either a continuous occupation between about 1,400 and

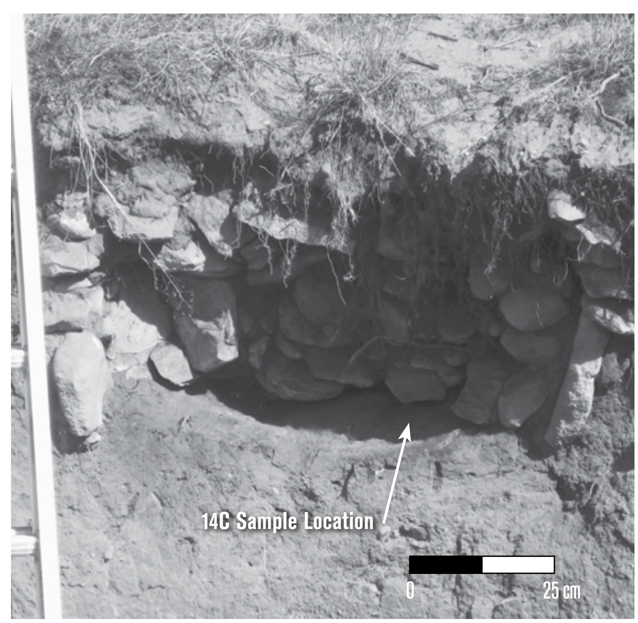

Figure 8. Photograph of sectioned storage feature near Pharo Village.

650 cal B.P. or two separate occupations at either end of this temporal span (Fig. 6).

SYNTHESIS: DATING, SETTLEMENT, AND SUBSISTENCE PATTERNS

The preceding data suggest that the Pharo Village and Pharo Heights sites were occupied roughly between 1,500 and 650 cal B.P. (Fig. 6), during the emplacement and fluorescence of regional Fremont lifeways that were at least partially dependent on maize farming. The geographic and temporal proximity of these sites thus suggests that Pharo Heights was part of a larger settlement system associated at least in part with Pharo Village (and likely associated with Fremont sites near Holden and Fillmore on the west side of the Pahvant Range as well). The question remains, however, as to the role that Pharo Heights played in this system.

To address this question, a pair of GIS-based analyses was developed to assess the costs and benefits of living at Pharo Heights in terms of two hypotheses explaining its relationship to Pharo Village: (1) that it facilitated trade and travel over the Pahvant Range; and (2) that it increased the overall efficiency of high altitude resource exploitation. In the first case, passes through alpine-subalpine regions often served as trade and travel corridors for regional hunter-gatherer groups, with hunting sometimes playing a subsidiary role in determining high-altitude settlement patterns (e.g., Morgan 2009a:389). Pharo Heights' location at a pass providing access to canyons draining to both the west and east superficially conforms to expectations derived from this hypothesis, especially given the abundance of obsidian from sources to the west and Pharo Village's location east of the site—the site provides access to both. To assess the possibility that Pharo Heights served as a camp geared mainly to facilitating travel from Pharo Village over the crest of the Pahvant Range to obtain or trade for local obsidians west of the range, paths were developed using the least-cost path extension in ArcGIS 9.3 to model the most economical routes of travel between Pharo Village and the Wild Horse and Black Rock obsidian sources (the obsidian source locations were modeled as single points by averaging the latitude and longitude for each subsource recorded by Northwest Research Obsidian Studies Laboratory [NROSL 2011]). This extension identifies the lowest-cost route of travel between points, determined by the cumulative cost of traveling through the cells in a raster separating these points (Conolly and Lake 2006:252–256; Surface-Evans and White 2012; but see Kanter 2012). Costs are based on the z-values (a measure of impedance) in a cost-surface raster, in this case an unweighted slope model derived from a 30 m. DEM of the study area (see ESRI 2001 for an explanation of the ArcGIS least-cost paths function). As shown in Figure 9, paths follow the current configuration of modern highways in the area, over Scipio Pass at the northern end of the Pahvant Range. This indicates that transit over the range via Pharo Heights provides a less economical way to access these quarries, and that (at least in terms of obsidian toolstone procurement) Pharo Heights was not primarily associated with facilitating this type of resource acquisition.

An extraction of plant and animal resources is certainly indicated by the faunal, groundstone, and flaked stone assemblages of Pharo Heights, but the way these subsistence activities articulated with those at Pharo Village is unclear. Operating on the assumption that artiodactyl, and in particular, sheep hunting was an economically-important activity associated with both the Pharo Heights and Pharo Village occupations (an interpretation bolstered by the artiodactyl remains and hunting equipment at each site, as well as the regional data showing long-range alpine hunting in subalpine-alpine locales [Knoll 2003; McGuire et al. 2007]), a GIS-based central-place transport analysis (see Morgan 2009b) was developed to model return rates for hunting mountain sheep when operating from each of these sites.

First, seven hypothetical sheep-hunting locales were generated by identifying subalpine regions with low slopes (i.e., <5 degrees) that currently have open exposure and abundant grasses available during the summer for grazers like mountain sheep. Within these areas, seven random points were generated and plotted using the "generate random points in polygon" tool in Hawth's Utilities for ArcGIS (Beyer 2007). Least-cost paths were then developed between both Pharo Village and Pharo Heights and these hypothetical hunting locales, and their distances measured and tabulated (Fig. 10). The costs of traveling over each path were then derived by multiplying the length of each

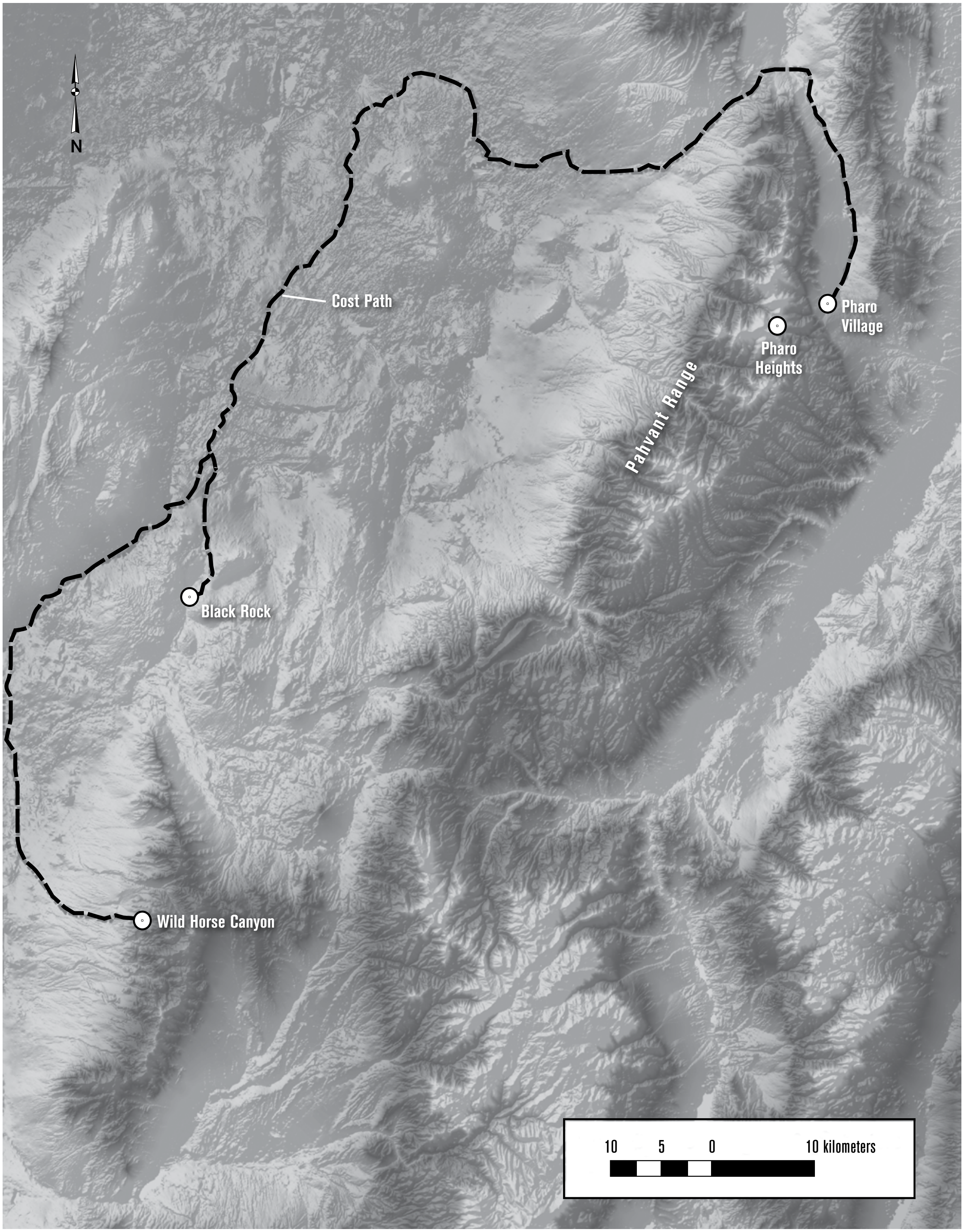

Figure 9. Map showing least-cost paths from Pharo Village to Black Rock and Wild Horse quarries.

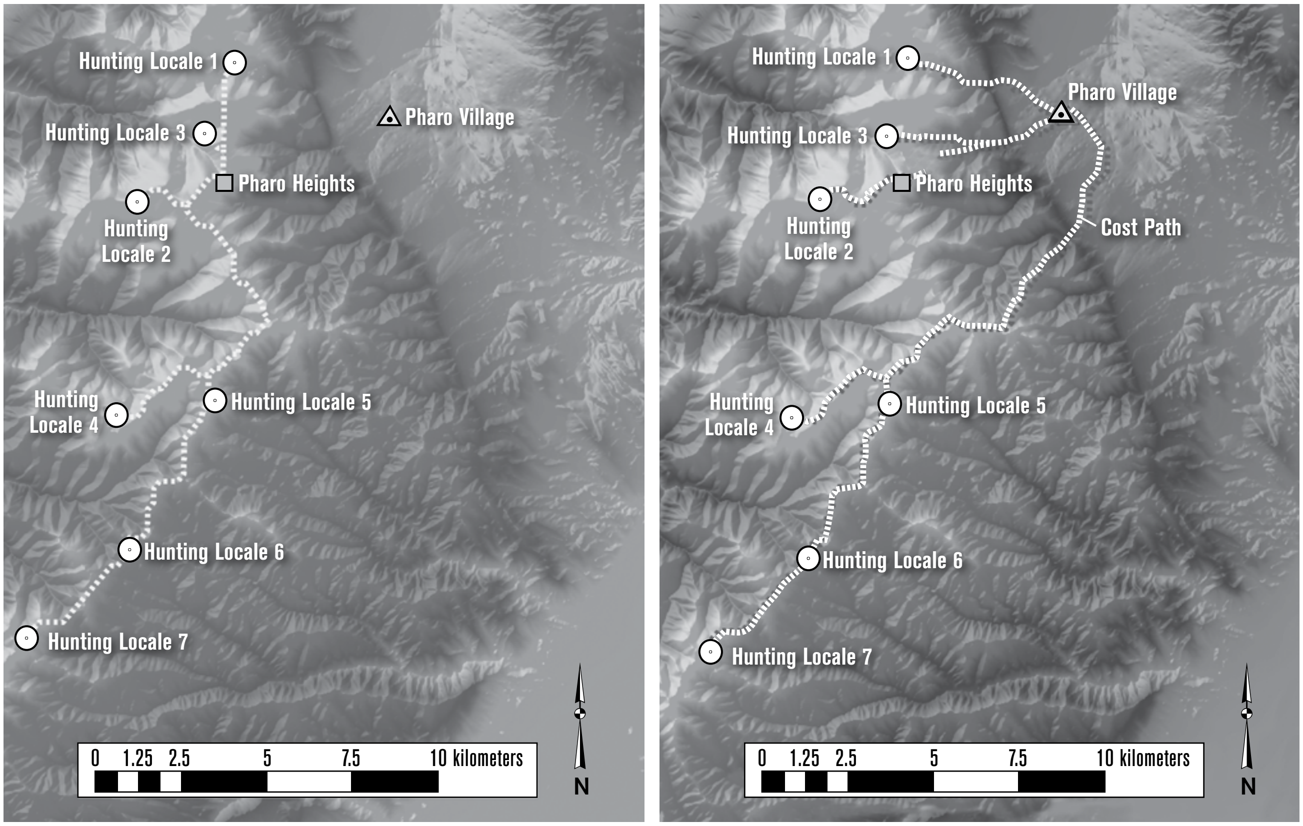

Figure 10. Map showing least-cost paths from hypothetical hunting locales to Pharo Heights (left) and Pharo Village (right).

path (in kilometers) by the average costs (110 kcal./km.) of unburdened travel for the trip leaving each site and adding this to the average costs (140 kcal./km.) of burdened travel (at 34 kg., the capacity of a typical burden basket) for the return trip to each site following a successful hunting foray (Bettinger et al. 1997; Jones and Madsen 1989; McGuire et al. 2007). Though caloric costs increase at higher elevations, especially for unacclimatized people, the difference in elevation between Pharo Village and Pharo Heights is relatively small (ca. 1,000 m.), and the crest of the Pahvants, at 2,885 m., is only about 180 m. above the point where elevation begins to substantively affect human physiological processes (Beall 2001), meaning that though the caloric costs used in this analysis may slightly underestimate actual costs of working at elevation, they would be roughly equivalent at both the eastern base and the crest of the range. Combined, these data result in a total travel and transport cost for hunting at each location. The average search (6,000 kcal.) and handling (126 kcal.) costs for 34 kg. of meat (McGuire et al. 2007:363) were then added to these data to arrive at a total cost for hunting and transporting sheep from and to each site, respectively. These data were then subtracted from the overall gross caloric benefit (42,900 kcal.) contained in 34 kg. of meat (Simms 1987; Zeanah 2000) to arrive at a return rate for each path and an average return rate, taking into account travel and transport costs from each site (Table 4).

The results of this analysis are not surprising, with return rates for hunting from Pharo Heights being 2,640 kcal. greater, on average, than from Pharo Village, this resulting from the average 5.28 km. greater distance to Pharo Village from the seven hypothetical grazer (sheep) hunting locales (the return rate mean differences are significant [$t = -9.95$; $\alpha = 0.5$; $p = 0.0000594$; $df = 6$]) (Fig. 11). The strength of these differences is of course more than just statistically significant, in that they represent enough additional calories to feed an average hunter-gatherer for a day or more (Kelly 1995:102). The returns on long-range hunting from Pharo Village are, however, certainly high enough to provide an incentive

Table 4

MOUNTAIN SHEEP HUNTING RETURN COMPARISON: PHARO VILLAGE VS. PHARO HEIGHTS

Hunting Locale	Distance (km.)	Out Trip Cost (kcal)[a]	In Trip Cost (kcal)[b]	Total Trip Cost (kcal)	Total Cost (kcal)[c]	Return (kcal)[d]
Pharo Village						
1	5.50	604.68	769.59	1,374.26	8,874.53	34,025.47
3	6.41	705.56	897.99	1,603.55	9,333.11	33,566.89
2	9.76	1,073.58	1,366.37	2,439.95	11,005.90	31,894.10
5	14.22	1,564.16	1,990.74	3,554.90	13,235.80	29,664.20
4	17.00	1,869.94	2,379.93	4,249.87	14,625.75	28,274.25
6	20.02	2,202.61	2,803.33	5,005.94	16,137.88	26,762.12
7	24.48	2,692.41	3,426.70	6,119.11	18,364.23	24,535.77
					Pharo Village Avg. Return	**29,817.55**
Pharo Heights						
1	5.50	604.68	769.59	1,374.26	8,874.53	34,025.47
1	3.27	359.90	458.06	817.96	7,761.93	35,138.07
2	3.28	360.79	459.19	819.97	7,765.95	35,134.05
3	1.27	139.90	178.06	317.96	6,761.93	36,138.07
4	11.27	1,239.82	1,577.95	2,817.77	11,761.53	31,138.47
5	8.29	912.03	1,160.76	2,072.79	10,271.58	32,628.42
6	14.30	1,572.49	2,001.35	3,573.83	13,273.67	29,626.33
7	18.75	2,062.28	2,624.72	4,687.01	15,500.01	27,399.99
					Pharo Village Avg. Return	**32,457.63**

[a] Distance x 110 kcal/km.

[b] Distance x 140 kcal/km.

[c] Total trip cost + combined search & handling costs (6126 kcal)

[d] Total cost – 42,900 kcal/34 kg. load

for this behavior as well, a finding similar to that of McGuire et al. (2007), who modeled similar behaviors in the eastern Sierra Nevada. This observation helps to explain the mountain sheep remains found by Marwitt at Pharo Village (1968). More importantly, this analysis indicates that living in a seasonal base camp at Pharo Heights would have increased returns on high-altitude logistical hunting by approximately 8% when compared to returns from operating out of Pharo Village. Further, it supports the idea that Pharo Heights served as a seasonal residential base camp occupied by Pharo Village residents who focused to a large degree on logistical sheep hunting in the highlands, an interpretation corroborated by the Snake Valley grayware ceramics and the admittedly somewhat spotty sheep remains found at Pharo Heights.

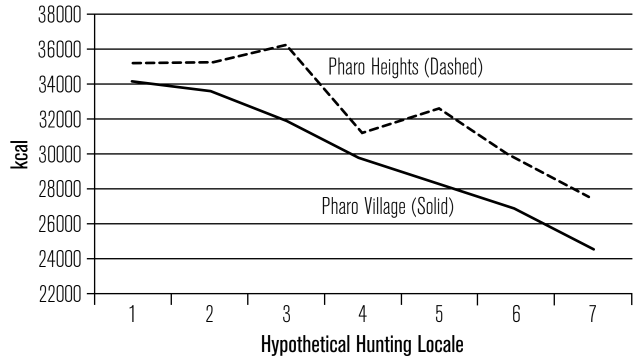

Figure 11. Hypothetical return rate comparison: Pharo Village : Pharo Heights.

GREAT BASIN AND FREMONT HIGH ALTITUDE ADAPTATIONS

The preceding interpretations have significant implications with regard to regional high-altitude prehistoric adaptations, both across the Great Basin and (more specifically) in the case of the Fremont. In the Great Basin, the most important studies of high-altitude adaptations are Canaday's (1997) surveys of the alpine regions of five high ranges in the central Great Basin, Thomas' (1982, 1994) work in the Toquima Range in south-central Nevada, and Bettinger's (1991) work in the White Mountains above Owens Valley, on the California-Nevada border; the latter two have been adequately summarized elsewhere (Bettinger 1996, 2008; Grayson 1993:261–269). Canaday's surveys in the Toiyabe and Snake ranges and in the Ruby, Jarbridge, and Deep Creek mountains focused specifically on determining aboriginal alpine land-use patterns. He found very few sites in a rather large survey, but did find numerous stacked-rock features that he interpreted as being used as hunting blinds, an interpretation consistent with Thomas' (1982) in the Toquima Range. Using regional projectile point chronologies to control for time, he concluded that most of the alpine Great Basin had been used sporadically for hunting since the middle Holocene, a pattern generally consistent with hunting in high elevation areas worldwide (Aldenderfer 2006), in the Sierra Nevada (Stevens 2005), and in the Rocky Mountains (e.g., Benedict 1975, 1992; Wright et al. 1980). Not surprisingly, this pattern also corresponds to the Archaic hunting pattern identified during survey in the Pahvant Range, as well as in several other Utah mountain ranges (DeBloois 1983).

Contrasting with this are data from the Toquima Range and the White Mountains, where alpine villages containing rock-ringed houses and substantial middens were investigated through the 1980s and early 1990s. The gist of these studies is that by approximately 1,100 years ago at Alta Toquima, and probably a bit later at the 13 residential sites Bettinger identified in the White Mountains, a long-lived logistical alpine hunting pattern similar to that identified by Canaday gave way to a residential pattern focused on house construction, intensive plant food gathering and processing (often of foodstuffs transported from the lowlands; e.g., Scharf 2009), and an increased reliance on hunting smaller-bodied game (Grayson 1991). Bettinger attributes this shift to a population increase causing resource stress in the Owens Valley, a phenomenon he argues was associated with the migration of Numic speakers with an intensive, seed-based economic focus into the region between about 1,000 and 600 B.P. (Bettinger and Baumhoff 1982). Basing her case on floral remains from Midway, one of the White Mountains alpine villages, Scharf (2009) reiterates Bettinger's population-based argument. Thomas (1994) is far more equivocal, arguing that Numic expansion (see Lamb 1958; Morgan 2010; Sutton 1987) is irrelevant to the patterns he identified at Alta Toquima. Needless to say, the topic is contentious but important as it draws attention to at least two possible explanations for the development of alpine residential adaptive patterns. Based on the dating at Alta Toquima, the effects of medieval warming between approximately 1,300 and 650 B.P. may have either made high altitudes more amenable to human occupation, or made surrounding valleys so resource-stressed that high mountains became attractive refugia for human populations. Alternatively, as Bettinger argues with regard to the White Mountains, population increases and resource stress may have brought about more intensive and even residential use of alpine ecozones.

Though residential villages like those found at Alta Toquima or the White Mountains have not been discovered in Utah (but see Adams 2010; Morgan et al. 2011; and Wingerson 2009 regarding high-altitude villages in Wyoming), there is substantial evidence for an intensified (including residential) use of subalpine-alpine settings akin to that seen at Pharo Heights during the Formative. For instance, at 7,840 ft. in the Oquirrh Mountains southwest of Salt Lake City, Janetski (1985) argues that use of a hunting camp intensified concomitantly with Fremont foraging and horticultural intensification in the valley below (see also Janetski 1997). He identifies a similar pattern at two sites near 9,000 ft. on the Fishlake Plateau, with site use switching to a residential focus and more intensive exploitive patterns between about 1,700 and 700 B.P. (Janetski 2010). In eastern Utah, in the high elevations of the Uinta Mountains, Watkins (2000) used groundstone residue analysis and radiocarbon dates to argue that the alpine processing of wild plants intensified between approximately 3,700 and 700 years ago. This interpretation corresponds well with Knoll's (2003) argument that high-elevation residential structures at nearly 11,000 ft. in the Uinta Mountains served as seasonally-occupied central places geared mainly towards increasing returns on Fremont logistical sheep hunting between approximately 1,600 and 1,300 B.P. Likewise, these results agree to some degree with Nash's (2011) assertion that transport and reliance on stored corn increased returns on Fremont high-elevation sheep hunting in this same range. The degree to which a reliance on either gathered or transported plant foods sustained and perhaps reduced risks (e.g., Morgan 2009a; Scharf 2009) associated with high altitude occupation and hunting in the Pahvant Range remains to be seen, but evidence of storage in both the Sierra Nevada (Morgan 2012) and the Uinta Mountains (Johnson and Loosle 2002; Loosle and Johnson 2000) indicates that such behaviors may indeed have played critical roles in regional high-altitude adaptive patterns. In any event, there is fairly abundant evidence for the increased exploitation and seasonal residential use of subalpine and alpine settings in at least four of Utah's mountain ranges between about 1,700 and 700 B.P. (but see Janetski et al. 2005, and Simms 1979), a pattern closely corresponding in time to the fluorescence of diverse Fremont lifeways (Madsen and Simms 1998), but also to the climatic and environmental changes associated with the Medieval Climatic Anomaly (Bradley et al. 2003; Fisher 2010).

These patterns, of course, correspond to the one identified in the Pahvant Range, where what appears to have been a long period of Archaic Period hunting gave way to high-altitude residential use, likely as a way of increasing hunting returns, approximately 1,500 – 650 B.P. Because of the contemporaneity of increasingly intensive high-altitude residential use across Utah and the central Great Basin (though not necessarily in eastern California), it might be tempting to attribute high-altitude intensification to the effects of medieval warming. But at least in the eastern Great Basin, two lines of evidence suggest otherwise. First, though droughts and their effects were no doubt felt throughout the greater Southwest during this time (Jones et al. 1999), this period also marks the most intensive residential occupations on valley floors, alluvial fans, and ridges emanating from the base of Utah's mountain ranges (Janetski et al. 2000; Reed 2005; Talbot et al. 1998; Talbot and Wilde 1989). If medieval droughts were limiting lowland occupations and encouraging highland ones, it would be expected that valleys would be abandoned, or at least less intensively occupied, while the highlands would witness more intensive occupations perhaps akin to those identified in the Uintas, the Pahvants, and the Fishlake Plateau. This was clearly not the case.

Second, concomitant intensification in lowland and highland settings would be expected if population was the impetus driving changes in settlement pattern. In the Fremont case, this might appear counterintuitive given the forager-farmer continuum model developed in various permutations by Madsen and Simms (Madsen 1982, 1989; Madsen and Simms 1998; Simms 1986). Despite a multitude of adaptive choices, interpretations of this model often see Fremont adaptive decision-making as essentially an either/or question—either one farms *or* one forages, depending on ecological-adaptive circumstances, but one may do one or the other repeatedly over the course of one's life. But the choice can also be inclusive rather than dichotomous—to solve population-resource imbalances, one hunts, gathers, *and* farms, which is the essence of the concept of intensification when using the diet breadth model (Macarthur and Pianka 1966), where low-ranking items are added to the subsistence base as diet expands, but higher-ranking items (in the Great Basin, large prey items like sheep and deer) never drop out of the diet, but are just as intensively pursued as before (outside the parameters of the model, perhaps even more so). This does not necessarily preclude evidence for decreasing hunting returns due to human overpredation during the Formative (Janetski 1997; Ugan 2005; but see Whitaker 2009); in fact this might be exactly what one might expect as both hunting and farming become more intensive and human pressure on both natural and modified environmental productivity increases.

This is the pattern identified in Upper Round Valley and the Pahvant Range. The Fremont hamlet of Pharo Village was established sometime around 1,400 cal B.P. Milling tools and corncobs indicate maize farming was an essential part of the subsistence economy here, while sheep and deer bone indicate hunting was important as well. Nearly the same pattern is evident some 1,000 m. (3,400 ft.) higher in elevation at Pharo Heights, where a seasonal residential base was established that likely featured expedient residential structures whose inhabitants relied on processed foodstuffs and locally-available artiodactyls like mountain sheep. High-altitude residential use here thus appears intrinsically linked to agricultural intensification in the valley below, a pattern consistent with those seen in several of Utah's other mountain ranges during this same period of time. Ultimately these lowland-highland settlement dynamics suggest economic intensification drove the development of eastern Great Basin high-altitude residential patterns; it remains to be seen whether such an assertion holds for the remainder of the Intermountain West.

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