Desert Research Institute

Quaternary Sciences Center

University and Community
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HUNTER - GATHERER ADAPTATIONS AND ENVIRONMENTAL CHANGE IN THE SOUTHERN GREAT BASIN: THE EVIDENCE FROM PAHUTE AND RAINIER MESAS

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ABSTRACT

This paper reviews the evidence for fluctuations in past environments in the southern Great Basin and examines how these changes may have affected the strategies followed by past hunter and gatherers in their utilization of the resources available on a highland in this region. The evidence used to reconstruct past environments for the region include botanical remains from packrat middens, pollen spectra from lake and spring deposits, faunal remains recovered from archaeological and geologic contexts, tree-ring indices from trees located in sensitive (tree-line) environments, and eolian, alluvial and fluvial sediments deposited in a variety of contexts. Interpretations of past hunter and gatherer adaptive strategies are based on a sample of 1,311 archaeological sites recorded during preconstruction surveys on Pahute and Rainier mesas in advance of the U.S. Department of Energy's nuclear weapons testing program. Although survey locations were not chosen through any random sampling scheme, a nearest neighbor analysis indicates that these areas are randomly distributed over the general region and should provide an adequate sample. Projectile point chronologies and available tree-ring, radiocarbon, thermoluminescence and obsidian hydration dates were used to assign these archaeological sites to specific periods of use. Although about half of these archaeological sites were redundantly used through a considerable period of time, a multi-dimensional scaling of the cooccurrence of projectile points at the archaeological properties and the examinations of the landforms and aspects occupied by these sites indicate that this redundant use occurred during a specific period and that past patterns of land use were different during other times.

The evidence suggests that Pahute and Rainier mesas, now blanketed by a pinyon-juniper woodland and associated sagebrush steppe, housed a limber pine forest with fluctuating occurrences of white fir during the terminal Pleistocene. While there is evidence that hunters and gatherers were in the region at this time, there is no evidence that they utilized the resources on Pahute and Rainier mesas. However, with the gradual retreat and thinning of the subalpine forest on the mesas and its replacement with a juniper woodland about 9,000 years ago, foraging parties began to exploit the mesa top environs. The low diversity in artifact assemblages at localities used by these peoples and the positioning of these localities near environments conducive for windfall hunting implies that large game were the primary resources sought. This emphasis on the exploitation of large game on the mesas appears to have continued for the next three to four thousand years. It was during this period, however, that the environments in the lowlands around the mesas changed significantly. The lakes, ponds and marshes that once characterized these lowland environments dried up and the vegetation in the valley bottoms started to assume its present day desert character. Pinyon, which had been in general region since the end of the Pleistocene, also began to expand in its distribution and density in the woodlands on the mesas.

By about 5,000 years ago these environmental changes began to effect how hunters and gatherers utilized the changing resources on Pahute and Rainier mesas. At first hunting probably remained to be a significant activity, but the inclusion of milling implements in artifact assemblages on the mesas started to increase not long after 5,000 years ago and by 3,000 years ago features interpreted to be rock caches for pinyon nuts joined this assemblage. Mobility patterns also gradually changed to be more logistically organized and resources started to be

exploited within the foraging radius of residential bases established directly on the mesas. Although it is argued that this gradual change in adaptive strategies conforms well with models of how increases in population density may affect hunter and gatherer behavior, the presence of pinyon on the mesas was a necessary prerequisite for this population growth.

There appears to have further changes in the way that the resources on the mesas were exploited during the last 900 years. The evidence suggests that there was a shift from monitoring those resources from within the foraging radius of winter camps established on the mesas to one of monitoring those resources in the logistic radius of camps established off the mesas. This change in exploitive strategies, however, does not appear to conform with models of the spread of the present day Numa in the Great Basin. Rather, it is suggested that this shift may have been due to a major drought between 900 to 500 years ago when water was scarce on the mesas.

ACKNOWLEDGMENTS

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INTRODUCTION

Many Great Basin anthropologists, as well as other students of hunters and gatherers, have long believed that there is an important link between fluctuations in past environments and changes in hunter - gatherer adaptations (Baumhoff and Heizer, 1965; Campbell et al., 1937; Cressman, 1977; Elston, 1982, 1986; Grayson, 1993; Madsen and O'Connell, 1982; Ranere, 1970; Swanson, 1962). This is only reasonable, as hunters and gatherers are regularly used as the classic example of how environmental variables shape cultural adaptations (Kelly, 1995; Steward, 1938). Since the days of Morgan (1877), Powell (1898), and Spencer (1870), it has been commonly accepted that the more "primitive" the adaptation, the more it is subject to the influences of its environment. Glacken (1967) traces this theorem back to the ancient Greek philosophers, such as Hippocrates, who portrayed the history of humankind as one of overcoming the governance of nature. Bettinger (1991a:1-45) notes that environmental influence was also central to the development of early evolutionary theories in which hunters and gatherers represented the most simple form of adaptations "whose institutions were most extensively patterned by subsistence activities" (Steward, 1938:1). If hunters and gatherers are so intimately tied to their environments, then any changes in those environments must have had an effect on their lifestyles (Baumhoff and Heizer, 1965:697,698). This line of reasoning is so persuasive that Baumhoff and Heizer (1965:705) took it one step further in suggesting that changes in the archaeological record may actually provide evidence for past climatic change:

> "While it may be true that there were people living in the Great Basin during the Altithermal, the evidence of occupation becomes very much more abundant after 2500 B.C., indicating a marked increase in population density. This seems to us to argue strongly that there was an improvement in climate. Whether this improvement involved rising temperature or increasing precipitation, or both, we are not able to say, but we assume that the indicated increase in population reflects more surface water and greater amounts of plant and animal food."

But Mehringer (1977:114, 1986:31) warned us that as the most intelligent and most adaptable of all creatures, humans may not qualify as a sensitive biological indicator species of climatic change. Based on excavations at Danger Cave, Jennings (1957) argued that Steward's (1938) model of Great Basin hunter and gatherer adaptations as a lifeway characterized by low population densities, kin-based band structure, simple technology, and an annual cycle of exploitation of available plant and animal resources remained unchanged in many parts of the Great Basin for ten millennia. He named this stable adaptation the Desert Culture.[1] Likewise, Thomas (1982a or b:163)

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[1] The claim for continuity of the Desert Culture made by Jennings (1957) and Jennings and Norbeck (1955) initiated one of the more interesting debates to occur in Great Basin archaeology; and, although he wrote an obituary for his concept of the Desert Culture (Jennings, 1973), the question of just how much environmental change has influenced the prehistoric life ways in the Great Basin remains to be answered (O'Connell and Madsen, 1982; Grayson, 1993).

concluded that there are "no archaeological data from the central Great Basin which cannot be comfortably subsumed under Steward's ethnographic Western Shoshone model." But research concerning the paleoenvironments of the Great Basin clearly demonstrates that major changes occurred in its physiology, hydrology, and biotic composition (Grayson, 1993; Mehringer, 1986). What happened to the requisite changes in culture? Warren and Ranere (1968:6-8) argued that Danger Cave occupied a relatively unique, atypical environment on the end of a peninsula and "may well represent specialized economic activities that cannot be taken as typical of the Great Basin as a whole." Likewise, Thomas' (1971, 1983, 1985, 1988) record for the central Great Basin pertains only to the last 5000 years during which the environment was similar to that of today and adaptations may not have had to change (Grayson, 1993:221, 256). Or just perhaps, as Mehringer implies, hunting and gathering adaptations by their very generalized nature may be relatively insensitive to minor fluctuations in the environment. Mehringer (1986:50) concluded that most in stability of the last 10,000 years in Great Basin environments was perhaps no more dramatic than what Great Basin inhabitants may have experienced within a single year. If hunting and gathering adaptations were already tailored to account for this variability, then they may not have had to change with changing environments.

This paper examines the relationships between changing hunter and gatherer adaptations and environments on Pahute and Rainier mesas in the southern Great Basin (fig. 1). The archaeological record of this important highland spans the last 9000 years or more, and this record should provide a means to examine these relationships (Pippin, 1995). Likewise, considerable research has been conducted concerning past environmental changes in this general region (Forester et al., 1996; Grayson, 1993, Mehringer, 1986; Spaulding, 1990; Thompson, 1990). If the hunters and gatherers in the southern Great Basin had to modify their behavior due to long term shifts in environmental conditions, then we should expect to see those behavioral modifications in the archaeological record of the mesas. But we should be careful not to fall into the same *faux pas* common to several previous attempts to examine the influence of changing environments on cultural adaptations. More specifically, we do not want to follow Baumhoff and Heizer's (1965:698) reasoning that "if geologic and/or biologic evidence for a change in climate coincides with considerable culture change, then this may be regarded as evidence *a priori* that the two are related, regardless of the precise nature of the climatic (cultural) change." This may be a false, or at least, misleading assumption.

As a spot on the landscape, the Pahute and Rainier mesa highland was only one of several resource patches exploited by past peoples. Thus, as recognized by Warren and Ranere (1968) for Danger Cave, the archaeological record on the Pahute and Rainer mesas codifies only a portion of the total adaptive system; and changes in the exploitation of this resource patch may or may not be matched by changes in the exploitation of other resource patches or changes in overall adaptive systems. It is important that we try to understand how the exploitation of the resources on the mesas was related to the exploitation of other environments and how changes in past climates might have affected the mesas and these other environments as well. Unless we have this understanding, we may not know which changes in the environment were significant and which were not and which changes in the archaeological record were significant and which were not. With this

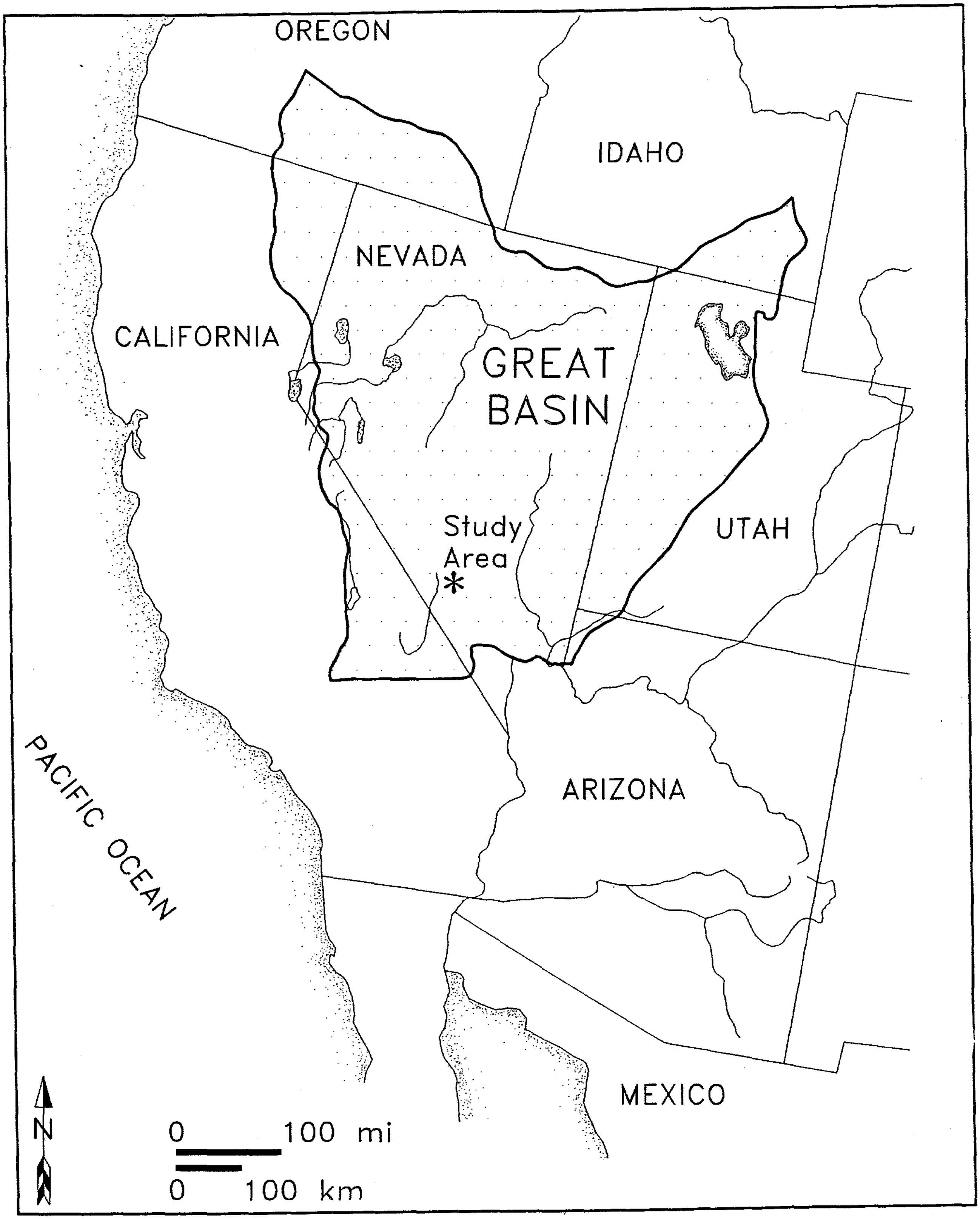

Fig. 1. Map showing the location of Pahute and Rainier mesas in the southern Great Basin.

knowledge, we are in a better position to evaluate what changes in the archaeological record may have been due to changing parameters in the environment, which may have been due to other factors such as fluctuation in population densities, adoption of new technologies, immigration of more competitive peoples. or which reflect ordinary fluctuations in a highly variable adaptive strategy.

THE NATURE OF HUNTER AND GATHERER ADAPTATIONS

During the last three decades, considerable research has been conducted concerning the nature of hunter and gatherer adaptations and their relationship to environmental variables. Beginning with Lee and DeVore's (1968) *Man the Hunter*, anthropologists came to the revelation that hunters and gatherers could no longer be considered as a uniform, primitive adaptation (the patrilocal band) that represented the lowest rung on the evolutionary ladder. In some cases, hunters and gatherers were actually "affluent" and/or socially quite complex and displayed a wide range of variability in their behavioral characteristics including their mobility, foraging strategies, and social structure (Koyama and Thomas, 1979; Price and Brown, 1985; Sahlins, 1968). With this revelation came a host of different anthropological, ethnoarchaeological, and archaeological studies that attempted to delineate, categorize, and/or explain this variability (see Kelly, 1995:14-36). Although a number of these studies continued to focus on sociological factors that might explain why hunters and gatherers behaved differently in different contexts, those who pointed to ecological variables have advanced the way in which we now conceptualize how hunters and gatherers adapt to different environments.

At first, most research centered on trying to understand these adaptations as functioning "systems" that revolved around obtaining food (Bicchieri, 1972; Damas, 1969; Lee, 1969; Meehan, 1983; Winterhalder, 1984). These studies, conducted under the rubric of cultural ecology, helped us understand why some hunters and gatherers were more mobile than others and why some groups relied more on hunting, others on gathering, and still others on fishing for their subsistence. The notion of the "seasonal round" and its functional significance was well delineated by these types of studies, and we began to realize the great variability that characterized hunters and gatherers as a whole as well as their specific adaptations and how they dealt with short-term fluctuations in the environment. Thomas' (1972, 1973) model of Steward's (1938) depiction of the Western Shoshone economic cycle remains a classic example. This model, presented as a flowchart, clearly illustrates the seasonal and annual variability in the FNFFdecision making processes regarding what resources might be exploited as well as when and where they might be found.[2] For example, the Western Shoshone that were utilizing the Pahute and Rainier mesa environs at the time of contact followed several alternative strategies in pinyon nut exploitation (see Pippin, 1996). Depending on local environment and other conditions, such as the intensity of contact with the *Tiabo*,[3] they would: (1)

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[2] See Mithen (1990:21-88) for a thoughtful treatment of this decision making process.

[3] *Tiabo* (from the East) is a Western Shoshone term referring to all non-Indians who encroached upon their traditional homelands.

establish their winter camps in the pinyon zone and stay there until spring, (2) establish temporary residences in the pinyon zone while they gathered enough nuts to transport back to winter camps located off the mesas, or (3) choose to exploit the pinyon nut crop in other mountain environments away from the mesas. During a decade, or even within a single year, all three strategies of resource exploitation might be followed.

In the attempt to explain and understand this type of observed variability, many cultural anthropologists and archaeologists soon turned to optimal foraging theory (MacArthur and Pianka, 1966). This theory provided the analytical sophistication necessary to measure the precise relationships between characteristics of the environment and foraging behavior and to relate this behavior to the adaptiveness (fitness) of different foraging strategies in an evolutionary sense. Although only a few anthropologists would still argue that actual foraging strategies are truly optimal (i.e., maximize the rate of return for the energy expended), the central axiom in these studies is that successful strategies tend toward optimization and that this goal provides a yardstick with which to measure the adaptiveness (fitness) of different strategies (see Bailey, 1991; Smith, 1991; Smith and Winterhalder, 1992). In order to measure this optimization, biologists and anthropologists have devised a series of models that relate the energy return from the exploitation of particular resources to the costs in exploiting them (see Bettinger, 1991a:83-130; Kelly, 1995:73-110). Although these models were relatively simple at first, researchers soon found that the benefits (return rates) from the exploitation of resources could be and were measured in various currencies (calories, protein, prestige, kinship relations, sexual favors, etc.) and that the costs for exploiting resources embraced a host of variables. These included the consumption of energy used in : (1) searching for the resources; (2) traveling between patches in which the resources occur (related to resource abundance and distribution); and (3) harvesting, processing, and transporting the resources once they were found. Furthermore, costs were different and often variable for each type of resource exploited. Available technologies (e.g., horses, dogs, snowmobiles, seed beaters, nets, bows and arrows, shotguns, storage facilities, etc.) were also found to greatly affect the cost of resource exploitation as were group composition and competition, information availability and sharing, and variability in the intensity, frequency, spatial extent and predictability of resources (Cashdan, 1990, 1992; Dwyer, 1983, 1985; Hayden, 1981; Hill et al., 1987; Hurtado and Hill, 1989, 1990; Minic and Smith, 1989; Smith, 1991:58-61; Stephens, 1990; Winterhalder, 1986).

Two important generalizations concerning the relationship between foraging behavior and the environment arose from these optimal foraging models. First, a resource's abundance (biomass) in the environment alone cannot be used to predict whether or not the resource will be utilized by foragers. Rather, its use depends on the perceived benefits from its exploitation and the abundance of all other resources that are perceived to have higher benefits. However, if the costs of exploiting a higher ranked resource increase because of a decrease in its availability, then the perceived benefits of utilizing lower ranked resources will increase regardless of their abundance. This utilization would increase diet breadth. Hence, we must know the nature (abundance and distribution) of resources within a resource zone like Pahute and Rainier mesas as well as the nature of those around that zone. Secondly, the mobility of hunters and gatherers is intrinsically tied to the nature of exploited resources in their environment (Binford, 1980; Kelly, 1983, 1995:111-160). Where exploited resources are homogeneously distributed and/or continuously available, maximum foraging efficiency is obtained by dispersing populations through frequent residential moves.[4] Where exploited resources are unevenly distributed and are only seasonally available, they are most efficiently obtained by aggregating populations in a central place (usually ecotones) and utilizing task groups (foraging parties) to exploit various resource patches.[5] For both patterns, the length of time spent at any one particular residence is related to the physical costs of moving and establishing a new residence, the distance to the new residence, the perceived difference between the benefits (return rates) of staying put and increasing the foraging radius to those of moving to a new locality, the storability of the exploited resources, and the anticipated yield of resources (risk assessment) at the new locality (see Binford, 1990; Jones and Madsen, 1989; Kelly, 1983, 1995:132-160; Simms, 1987).

Although the great advantage of the optimal foraging models rests with their ability to mathematically measure the specific relationships between characteristics of the environment and foraging behavior, this very precision has been the major obstacle in their application to archaeological studies since data requirements of the models far exceed data availability. In this regard, it is little wonder that the most thorough applications of optimal foraging models have been in an ethnographic context. Concomitantly, the focus of these models tends to be rather fine-grained: why was this resource or resource patch used rather than another? But, as with the case for the archaeological record on Pahute and Rainier mesas, we may not know what specific resources were utilized, how they were ranked by their exploiters, or how specific resources were distributed in the environment. Hence, the total range of variability displayed in the ethnographic record of hunters and gatherers has been examined in this study. It is this kind of data, combined with what we have learned concerning how specific groups deal with environmental variability (i.e., optimize returns), that may be most useful for examining the question of how hunters and gatherers respond to long-term changes in their environment.

Several researchers, primarily Binford (1980), Hayden (1981), Lee (1968), Martin (1974) and most recently Kelly (1983, 1995), have examined the variability exhibited in the hunting and gathering societies listed in Murdock's (1967a) *Ethnographic Atlas*. Although all of these societies are products of their individual histories and few, if any, can be considered truly "aboriginal" (see Schrire, 1984; Headland and Reid, 1989), they should reflect the variability in hunter and gatherer adaptations to a diversity of environments that range from equatorial to arctic conditions. Martin (1974) categorized the 179 foraging societies listed in the *Ethnographic Atlas* into: (1) highly mobile *equestrian hunters and gatherers*, a product of contact, who tended to focus on the hunting of migratory herds; (2) inland *pedestrian foragers* who predominately focused on gathering plant foods (also see Lee, 1968:48; Hayden, 1981:357), but who also often relied on fishing as well as hunting; and (3) coastally located *aquatic foragers* who relied on fishing for more than half of their

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4 This residential mobility pattern conforms to Binford's (1980:5-10) depiction of foragers.

5 This logistically organized mobility pattern conforms to Binford's (1980:10-12) depiction of collectors.

subsistence.[6] For the inland environments of the southern Great Basin, we might be more interested in the variability exhibited by the pedestrian hunters and gatherers, but we should not forget that much of the Great Basin features, or at least once featured, considerable wetlands that could have favored more aquatic(fishing) adaptations.

Based on the principle that resource diversity and abundance generally decrease with increasing latitude, Hayden (1981:353-360), Hiatt (1970), Lee (1968:41-43), and Martin (1974:17) have examined the relationship between the reliance on hunting, gathering, and fishing with respect to latitude.[7] The notion behind these analyses is that at higher latitudes, where plant foods become more scarce, fishing and hunting should, by default, contribute more to the total diet (see Belovsky, 1987). Although the estimates concerning the percentage of reliance on hunting, gathering, and fishing in each of these analyses differ slightly and are undeniably subjective, these analyses clearly indicate that, with ethnographic populations, the gathering of plant resources dominates subsistence activities in societies located below approxiamtely 40° latitude and decreases in importance with increasing latitude.[8] Fishing, on the other hand, appears to increase in importance with increasing latitude and becomes the dominant food-getting activity above approximately 40° latitude. According to Martin's (1974) data, hunting varies in importance only within small limits (28 to 40%) and never appears as the primary subsistence activity. In Lee's (1968:42) data, however, hunting is recalculated to include the hunting of sea mammals and thus becomes the dominant food-getting activity above approximately 60° latitude.

Kelly (1995:66-73) re-examined the above relationships more directly. He reasoned that the abundance of edible plants in the environment could be more directly measured using: (1) effective temperature (ET)[9] as a measure of the intensity of solar radiation and its annual distribution and (2) primary production (PP) to measure annual net above-ground plant production (g/m^2/yr). Primary production was calculated using Sharpe's (1975) formula[10]; and diet estimates were again made for a sample of 123 ethnographic societies, 77% of which were from North America. Kelly (1995:70-71) found that these variables predicted the dependence on gathering quite well ($p < .01$) but did not

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6 Martin (1974) did not distinguish between what have been called "traditional" and "commercial" hunters and gatherers; the latter group either relying to a large extent on foodstuffs bought or bartered from more complex societies or in which the hunting and gathering of commodities is for trade purposes to more complex societies (see Hayden 1981; Woodburn 1980:98-99).

7 Martin's (1974) data included 147 societies in her aquatic and pedestrian categories; Lee's (1968) data included 58 societies, 58% of which were from North America north of the Rio Grande; and Hayden's (1981) and Hiatt's (1970) data included 49 societies, 55% of which were from North America.

8 Pahute and Rainier mesas fall at 37° 15' latitude.

9 Effective temperature was calculated from the mean annual temperature, the average temperature during the coldest and warmest months, and the annual range in temperatures following Bailey (1960).

10 $PP = .0219 E^{1.66}$ where E is evapotranspiration, a product of effective precipitation and solar radiation.

predict the dependence on hunted foods very well ($p > .05$). However, once he removed those societies that relied on aquatic resources (fish, shellfish, and marine mammals) for more than 25% of their subsistence, the predictions improved considerably for both hunting and gathering ($p < .01$). Hence, foragers in environments with high primary plant productivity and high effective temperatures tended to rely more on gathering, whereas those with low primary plant productivity and effective temperatures relied more on hunting and fishing. He then notes that the use of aquatic resources tends to replace hunting more than gathering and postulates that this may be a function of an inability to hunt as much as necessary in colder environments where large territories would be required. Those groups that appeared to hunt more than predicted included: (1) several tropical groups (Mbuti, Aeta, and Aweikoma) that traded meat for carbohydrates; (2) the Nunamiut and Tanana that did not have direct access to substantial aquatic resources; and (3) many of the Plains Indians (Kiowa, Comanche, Cheyenne, Crow, Kiowa-Apache, Sarsi, and Blackfoot) who also traded meat for carbohydrates and lived where most of the primary production consisted of grasses that could not be eaten and also lacked substantial aquatic resources.

In her analysis, Martin (1974) found that the majority of pedestrian foragers, including some of those who relied more heavily on fishing and hunting, tended to follow a seminomadic settlement strategy where populations dispersed and nucleated according to the seasons.[11] The mobility strategy followed by most, if not all, of these societies probably conforms to what Binford (1980:10-12) has modeled as logistically organized *collectors* who supplied themselves with foodstuffs by using task groups that brought the resources to seasonally shifting and centrally located residential locations. She found that only approximately 20% of the pedestrian foragers wandered in nomadic bands. Binford (1980:5-9) models this "mapping on" mobility strategy as foragers who tend to move their residences to the resource zones, utilize those resources, and then move on. The remaining 18% of the societies in Martin's (1974) sample maintained permanent villages which they occupied on a year-round basis (or seasonally in rotation) and represented the least mobile, logistically organized hunters and gatherers in the sample. Most (67 %) of the aquatic foragers in Martin's (1974) sample also followed the collector's mobility strategy with either seasonally dispersed and nucleated settlements or semisedentary settlements that were serially occupied during transhumance. Only four societies that relied predominantly on fishing could be considered as foragers wandering in nomadic bands. These societies occupied either the extreme northern and southern latitudes or Southeast Asia.

Binford (1980:15-17, fig. 4) conducted a similar analysis in regard to the importance of foraging versus collecting (logistic) mobility using a sample of 31 ethnographic populations. He reasoned that since logistically organized strategies of mobility and the associated storage of resources tend to mitigate incongruity in the availability of critical resources, "the greater the seasonal variability in temperature, the greater the expected role of logistical mobility in the

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[11] Martin (1974) used Murdock's (1967b) classifications of groups as fully nomadic, seminomadic, semisedentary and fully sedentary that were, in turn, based on Beardsley et al.'s (1956) definitions of free-wandering, restricted-wandering, central-based wandering, and semipermanent sedentary groups, respectively.

settlement or 'positioning' strategy." Using Bailey's (1960) effective temperature as a measure of growing season plus solar energy and thus resource productivity, he found that the storage of resources, a hallmark of logistic mobility, was regularly practiced among hunters and gatherers in environments with effective temperatures of less than 15°C (average growing seasons less than 200 days). Most exceptions to this generalization included such high latitude groups as the Yahgan, Slave, and Copper Eskimo who Binford (1980:16) felt, although technically conforming to the model of foragers, were of a "different type than most equatorial foragers."[12] Accordingly, mobility among the equatorial foragers was seen as solving problems of spatial incongruity in resources whereas the mobility among the cold-environment foragers was focused on solving temporal incongruity in resource availability.

Kelly (198, 1995:111-160) also examined the relationship between patterns of mobility and environmental parameters, specifically primary biomass. He argued that in areas of high primary biomass, plants invest most of their energy in structural maintenance and growth resulting in a high primary productivity[13] that is largely inedible; whereas in areas of low primary biomass, plants invest more energy in reproduction components (seeds and tubers) that tend to be edible. Hence, primary biomass is envisioned to be inversely related to both the effective availability of plant and faunal food, since animals in high primary biomass environments tend to be small or, if large, few in number and widely spaced. He then calculated the primary biomass (kg/m^2) for some 88 ethnographic groups using two regression equations (one for arid and another for humid environments).[14] Finally, he measured the annual mobility of these groups using the number of residential moves, average distance moved, total distance moved, and total areas used over the course of a year. He also attempted to extract the average length of a logistical foray for the 88 groups. Although he found it difficult to acquire accurate data for most of these groups and his data is admittedly inferential and normative, he found several interesting patterns involving the environment, subsistence, and mobility.

As expected, in tropical settings with high, primary biomass, the increased frequency of annual residential moves was well correlated with decreasing primary biomass; and the same was true for some groups (Ona, Micmac, Montagnais) living in boreal forests. These groups tend to be highly mobile and conform to Binford's (1980) depiction of foragers. In non-tropical high primary biomass environments, the number of residential moves also seemed to be correlated with primary biomass as long as there was not a high reliance on aquatic resources, which almost always resulted in low residential mobility. Kelly (1995:125) noted that for groups heavily dependent on aquatic

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12 Binford (1980:16) would also include the Micmac, Mistassini Cree, Igloolik, and Polar Eskimo as other examples of highly mobile, cold-climate groups that did not rely on storage.

13 Kelly (1995:69) uses primary production to refer to the annual net above-ground plant production (g/m^2/yr) and calcultes it using Sharpe's (1975) equation where $PP = .0219\ E^{1.66}$ where E is the evapotranspiration.

14 For arid environments, $\log_{10}$ Primary Biomass (g/m^2) $= 2.66 + .0009X$; and for humid environments, $\log_{10}$ Primary Biomass (g/m^2) $= 4.2 + .00013X$ where X is the net above-ground primary production (g/m^2/yr).

resources, those groups living in lower primary biomass settings were more mobile than those in high primary biomass settings. Groups living in desert environments, however, presented a high degree of variability in their residential mobility regardless of biomass. Kelly (1995:126-127) related this to the need for water and noted that where water sources are localized in deserts, residential mobility (foraging efficiency) is often sacrificed in favor of remaining close to a water source.[15] He argued that this tethering probably resulted in increased diet breath and foraging radii as well as the group's reliance on logistic mobility. Kelly (1995:130) also noted a strong correlation between the size of the area exploited by logistic mobility (foraging radius) and the reliance on hunting with the foraging radii increasing dramatically as the reliance on hunting increases. Finally, Kelly (1995:130-132) argued that hunters should use long logistical forays and cover less of their large territories through residential mobility; whereas gatherers can be expected to cover their territory more thoroughly through residential mobility (also see Binford, 1983).

Based on the above, then, we may conclude that although there is considerable variability in ethnographic populations of hunters and gatherers, this variability occurs within definite limits around a middle latitude nucleus that tends to organize their subsistence activities around the gathering of plant resources, supplementing this with either fish or wild game or both, and following a logistical mobility pattern that conforms to Binford's (1980) collectors strategy. This norm, to use a much disdained term, conforms to Jennings and Norbeck's (1955) conception of the Desert Culture, to Steward's (1938) so-called Western Shoshone model, and to the recorded ethnographic adaptations on Pahute and Rainier mesas (Pippin, 1996). However, various extremes from this norm can be recognized; and it is in these extremes that we may anticipate how the hunters and gatherers who utilized Pahute and Rainier mesas may have modified their behavior to conform to changing environments. But first, we should examine the current environmental context for Pahute and Rainier mesas and how this context may have changed during human occupation. In doing this, it is important that we pay particular attention to the nature (abundance and distribution) of specific resources that might have been available in addition to the general trends in temperature and precipitation.

ENVIRONMENTAL CONTEXT: PAHUTE AND RAINER MESAS

The Present

Pahute and Rainier mesas, situated near the far southeastern border of the hydrographic Great Basin, comprise a large, west-east trending, rhyolitic plateau that slopes in elevation from approximately 1524 m (5000 ft) in the west -- where it forms the northeastern boundary of Sarcobatus Flat -- to slightly more than 2345 m (7694 ft) on Rainier Mesa in the east where it joins the southern extensions of the north-south trending Kawich and Belted ranges (fig. 1, 2). The plateau's southern margin is clearly marked by the precipitous slopes of the Timber Mountain and Sleeping Butte calderas; and, except where it joins the Kawich and Belted ranges, its northeastern

[15] Taylor (1964, 1972) called these groups tethered forages.

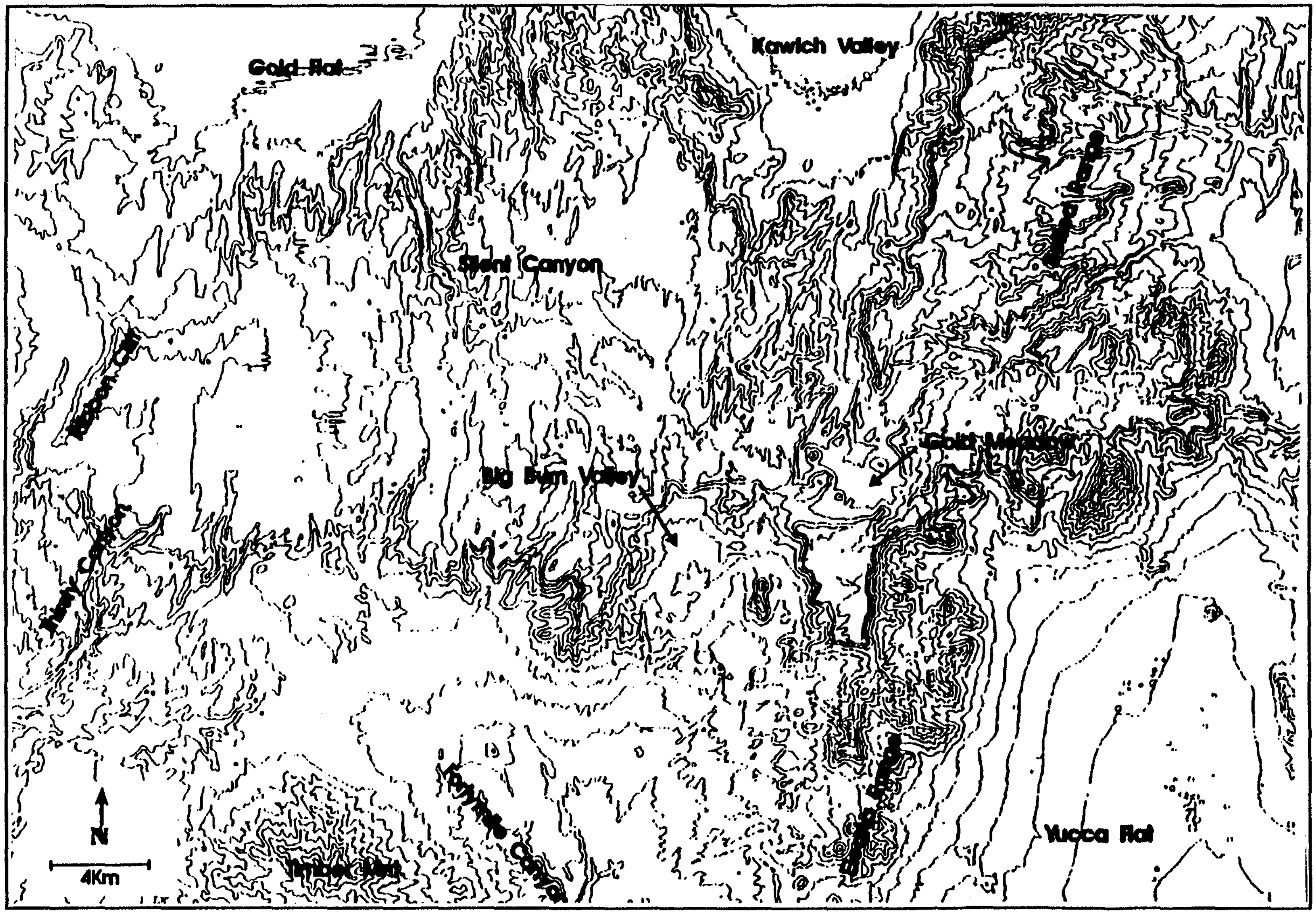

Fig. 2. Map of Pahute and Rainier mesas showing major physiographic features. The dashed line shows the current distribution of the pinyon-juniper woodland.

and far western margins are similarly marked by steep slopes into the Gold Flat, Sarcobatus Flat, and Kawich Valley basins. However, its northwestern boundary is less well defined where the plateau gently slopes into the western portion of Gold Flat and gradually grades into the highlands around Mount Helen and Stonewall Mountain that mark its northernmost extent.

The plateau may be divided into two broad topographic zones. East of Ribbon Cliff, which denotes the eastern edge of the Black Mountain caldera, the plateau is characterized by a series of rather broad, north-south trending, step-faulted bedrock benches separated by shallow alluvial valleys.[16] The western edges of these flat-topped benches may be quite abrupt and precipitous, but the eastern edges usually grade into the alluvial valleys, the largest of which is called Dead Horse Flat. The plateau is separated from the similar, flat-topped, bedrock benches of the Belted Range only by Kawich Canyon and a small, low-lying (2050 m; 6700 ft) amphitheater called Gold Meadows at the headwaters of that canyon. A series of narrow drainages (Lambs Canyon, Gritty Gulch, etc.) and steep-edged intervening ridges change the character of the plateau just west of Kawich Canyon, and topographic relief of the eastern plateau is perhaps the roughest in this area. Just southeast of Rainier Mesa, the plateau abuts onto the Eleana Range, an uplifted block of argillite underlain by limestones and dolomites and overlain in places by volcanic tuffs. Big Burn Valley, known as Sunken Park prior to the big burn (Wheeler, 1940), is another larger and lower (1950 m; 6300 ft) amphitheater on the southwestern side of Rainier Mesa. West of Ribbon Cliff, the topography of the plateau changes somewhat as several overlapping calderas have resulted in a landscape composed of rounded tuffaceous domes with associated rhyolitic and basaltic lava flows, alluvial fans, and bajadas. Black Mountain (2205 m; 7235 ft) is the easternmost and most recent of the resurgent domes, but others include Quartz Mtn. (1908 m; 6260 ft), Tolicha Peak (2154 m; 7066 ft), Obsidian Butte (1889 m; 6197 ft), Mt. Helen (2183 m; 7162 ft), Stonewall Mountain (2530 m; 8300 ft) and several lesser buttes and knolls. Alluvial fans and bajadas emanate from these domes and provide a gradually sloping landscape that is occasionally interrupted by low-relief lava flows along the northeastern boundary of the plateau.

Thirsty Canyon, which eventually flows into the Amargosa River and thence into Death Valley, drains the southwestern portion of Pahute Mesa via a dendritic pattern of steep-walled, ⊔-shaped canyons which provide natural and highly channeled routes of travel to the mesas from Oasis Valley situated only approximately 20 km from the mesa top. Numerous, highly productive perennial springs occur in Oasis Valley, and this potential travel corridor may have been quite important to the aboriginal populations utilizing the mesas. Fortymile Wash, another major tributary of the Amargosa River, drains surface runoff along the southeastern margin of Pahute Mesa via several steep and relatively short, v-shaped canyons entrenched into the mesa's edge. This corridor of travel to the mesas, also highly channelized, traverses the Timber Mountain Caldera east of Timber Mountain and west of Shoshone Mountain. From there, the corridor runs southward, east

[16] This eastern portion of Pahute Mesa is actually a collapsed caldron, the Silent Canyon Caldera, that has been filled with flat-lying ash-flow tuffs of the Timber Mountain and Thirst Canyon Tuffs (Byers et al., 1976; Cornwall, 1972:33). Rainier Mesa is considered to be the southernmost extension of the Belted Range.

of Yucca Mountain, into the northern Ash Meadows region of the Amargosa Desert. Ash Meadows, like Oasis Valley, is a well-watered area where aboriginal populations ethnographically based their winter settlements (Powell and Ingalls, 1874:10-11; Steward, 1938:181-183).

Most surface runoff from Pahute Mesa, however, drains northward into Gold Flat which contained a 67 km^2 pluvial lake during the Late Pleistocene (Mifflin and Wheat, 1979:54). Silent Canyon is the most prominent of the drainages leading to Gold Flat; but others include Grass Spring Canyon from the Dead Horse Flat portion of the mesas and a host of smaller ephemeral drainages from Black Mountain, Quartz Mountain, and Tolicha Peak in the western portion of the mesa. Although Silent Canyon could have served as a natural travel corridor to the mesa, access from the north could have been along or between any number of these drainages as there are no barriers to travel anywhere in the 57 km stretch between Stonewall Mountain and the southern Kawich Range. The nearest concentration of perennial springs, like those in Oasis Valley and Ash Meadows, occurs in the far northern portion of the Kawich Range over 50 km north of the mesas. The only springs that are available on the plateau itself occur in the western portion of Pahute Mesa at Monte Cristo, at Pillar, at the base of Tolicha Peak, and at two other seeps at the base of Black Mountain and Quartz Mountain, respectively. Today these ephemeral springs generally produce less than 0.5 l/min when they are flowing at all.

Basket Valley, Lambs Canyon, Grimy Gulch, Gritty Gulch, and Kawich Canyon drain the far northeastern portion of Pahute and Rainier mesas into Kawich Valley that, like Gold Flat, contained a small (57 km^2) pluvial lake during the Late Pleistocene (Mifflin and Wheat, 1979:54). Kawich Canyon may have served as the best natural route of travel to the mesas from Kawich Valley, but access to the northeastern region of the mesas could have occurred along any one of these drainages or from elevationally equivalent areas on the north-south trending Belted Range. If travel were along Kawich Canyon or from the Southern Bench area of the Belted Range, it would have been channeled into the Gold Meadows area. Tongue Wash and The Aqueduct, as well as several other steeper washes, drain the eastern portion of Rainier Mesa into Yucca Flat and served as travel corridors from Whiterock, Oak, and Tub springs along the southeastern end of the Belted Range and Captain Jack Spring in the Eleana Range. Although not as productive as the springs in Oasis Valley, Ash Meadows, or even the Kawich Range, the springs in the southern Belted range perennially produce anywhere from 0.5 to 6 l/min. Stockade Wash, a tributary to Fortymile Wash, drains the far southeastern portions of Pahute and Rainier mesas and provides a travel corridor from that direction.

Vegetation growing on the plateau today may be categorized into three or four overlapping vegetation zones that somewhat correspond in their distribution to the physiographic divisions outlined above (Beatley, 1976:58-68, fig. 3). A pinyon-juniper woodland (*Pinus monophylla* and *Juniperus osteosperma*) covers the flat-lying bedrock benches on the eastern portion of the plateau above approximately 1830 m (6000 ft) in elevation. This woodland is best developed and incorporates shrub oak (*Quercus gambelii*) at the higher elevations above approximately 2100 m (6900 ft) and in the two lower-lying amphitheaters (Gold Meadow and Sunken Park) which are cold air sinks. In these locations, pinyon may occur in pure, or almost pure, stands with little or no juniper and limited shrubaceous understory. However, in most areas on this portion of the plateau, pinyon and juniper form a more or less open woodland with park-like areas of big sagebrush (*Artemisia tridentata*) occupying the broader alluvial valleys between bedrock benches.[17] Other important shrubs found in this woodland, particularly along the cliffs and narrow canyons in this portion of the plateau, include lemonade berry (*Rhus trilobata*), squaw currant (*Ribes cereum*), gooseberry (*Ribes velutenum*), mountain mahogany (*Cercocarpus ledifolius*), serviceberry (*Amelanchier utahensis*), buckbrush (*Ceanothus cordulatus* and *C. greggii*), bitterbrush (*Cowania mexicana* and *Purshia tridentata*), creambush (*Holodiscus microphyllus*), linanthus (*Linanthus nuttallii*), and prickly phlox (*Leptodactylon pungens* var. *pulchriflorum*). Juniper becomes the dominant tree along the lower, western edge of this woodland and eventually completely replaces pinyon around the heads and upper margins of the drainages east of Ribbon Cliffs. Likewise, small patches of juniper woodland grow on the tops of Black Mountain, Quartz Mountain, and the higher buttes around these two domes, but recent fires on the western portion of the plateau have greatly reduced this woodland.

Although pine nuts are the most valuable food resource for calories in these woodlands, most of the associated shrubs also provided useful products. Hence, juniper, lemonade berry, squaw currant, gooseberry, and serviceberry produce fruits that are edible as well as medicinally useful (Chaberlin, 1911:372; Fowler, 1986; Steward, 1938:29). The inner bark from mountain mahogany could be boiled into a medicinal tea and its roots used for dyes; wood from mountain mahogany, as well as the wood found in the other shrubs identified above, could be used to make bows, arrow shafts, digging sticks, pinyon hooks, shelters, etc. (Chamberlin, 1911:346; Kelly, 1964:101; Reed, 1967:8, 20; Train et al., 1941:55). Creambush roots were used in a tea by both the Shoshone and the Southern Paiute (Steward, 1938:25). Finally, although most references to the aboriginal use of oak have focused on the California black oak (*Quercus kelloggii*), the acorns of the shrub oak did not require leaching and could be roasted and ground into flour; the wood used for rabbit sticks, digging sticks, pinyon hooks, structures, etc.; and the bark and tannic acids for tanning hides (Clarke, 1977; Fowler, 1986:67; Lange, 1959:150).

Black sagebrush (*Artemisia nova*) forms a low, closely-spaced shrub cover on the shallow, residual soils found on bedrock benches that are below the current woodlands east of Ribbon Cliff. This community also occurs in a mosaic with big sagebrush on the west portion of the plateau with black sagebrush again restricted to shallower, rocky soils and the big sagebrush on the deeper, better drained alluvial deposits. Sticky-leaved rabbitbrush (*Chrysothamnus viscidiflorus*) is the most commonly associated shrub, but joint-fir (*Ephedra nevadensis*), banana yucca (*Yucca baccata*), and several cacti (*Coryphantha vivipara, Echinocereus engelmannii, Opuntia erinacea* and *E. triglochidiatus*) are also consistently, if only sparsely, present. Sticky-leaved rabbitbrush provides a good browse for deer and sheep and was used by aboriginal hunters and gatherers for the treatment of colds, rheumatism, and toothaches as well as for a yellow dye (Train et al., 1941:58; Reed, 1967:21). The seeds of joint-fir and the flowers, fruits, and hearts of the banana yucca provided a

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[17] See discussion of the big sagebrush zone below for the list of other shrubs common to these parklands.

potential food source as did the tunas and fruits of the various cacti (Coville, 1892:352; Kroeber, 1925:84; Laird, 1976:107).

As mentioned above, big sagebrush (*Artemisia tridentata*) is the dominant ground cover on the deeper, better drained alluvial fans and bajadas on the western end of the plateau and in the valley bottoms between the bedrock benches on the eastern end of the plateau. Joshua trees *(Yucca brevifolia*) grow in the upper portions and other more mesic settings in the sagebrush steppe on the western portion of the mesa. Likewise, in areas below the eastern and southeastern portions of the plateau, big sagebrush occurs in narrow ecotones with either blackbrush *(Coleogyne ramosissima*) and/or spiny hop-sage (*Grayia spinosa*) and desert thorn (*Lycium andersonii*) or with four-wing saltbush (*Atriplex canescens*) and/or winterfat (*Ceratoides lanata*). These zones characterize the transition to the Mojave Desert which lies primarily to the south of the mesas (see Beatley, 1976:41-52). On the northern and northwestern portions of the plateau, where the broad alluvial fans and bajadas flow into Gold Flat and Kawich Valley, this big sagebrush ecotone is usually found with shadscale (*Atriplex confertifolia*) and winterfat that are more typical of the bolson and valley bottoms in the Great Basin Desert (see Billings, 1949).

Shrubs associated with big sagebrush on the top of the plateau include winterfat, sticky-leaved rabbitbrush, green joint-fir (*Ephedra viridis*), horsebrush (*Tetradymia glabrata*), wild buckwheat (*Eriogonum microthecum*), and cliffrose (*Cowania mexicana*); but these taxa usually comprise less than 5% of the total shrub coverage. Rubber rabbitbrush (*Chrysothamus nauseosus*) may codominate or even dominate along valley bottom washes on the mesas; whereas, cliffrose, service berry (*Amelanchier utahensis*), bitterbrush (*Purshia glandulosa*), snowberry (*Symphoricarpos longiflorus*), and wormwood (*Artemisia ludoviciana*) grow along the more rocky washes and around bedrock outcrops. Big sagebrush seeds were roasted, ground into flour, and eaten by the Paiute, Cahuilla, and other Indian groups during the fall but are said to be quite bitter and were probably only important when other foods were scarce (Mead, 1972:27; Steward, 1938:22). In addition, the leaves, flowers, and stems were used to make a tonic purportedly effective for treating chest colds, fever, rashes, rheumatism, and other such ailments (Chamberlin, 1911:352; Reed, 1967:22; Train et al., 1941:45-46). Finally, strips of bark from big sagebrush could be used in textiles for covering houses and caches; and the wood provided building materials and fuel (Mead, 1972:27; Reed, 1967:18, 23; Steward, 1938:22).

Common native grasses found on the plateau include wheatgrass (*Agropyron spicatum*), blue grama (*Bouteloua gracilis*), wild rye (*Elymus cinereus*), galleta (*Hilaria jamesii*), Indian rice grass (*Oryzopsis hymenoides*), bluegrass (*Poa fendleriana),* squirreltail (*Sitanion hystrix*), drop-seed (*Sporobolus cryptandrus*), and needle-and-thread grass (*Stipa comata*). Seeds from all these grasses could have been eaten, but the cool season grasses, such as Indian rice grass and drop seed, were particularly important because they provided aboriginal populations with food during the spring (May to June) when most other edible resources were still unavailable (Coville, 1892:353; Steward, 1938:26-27, 30, 96). The harvest period for these seeds is quite limited, and proper timing is essential for their exploitation. Because the yields of cool season grasses are greatly influenced by winter precipitation, aborigines could probably have predicted what areas might be best to visit in any particular year.

Beatley (1976:58-68) listed more than 160 different taxa of perennial and annual herbs and forbs that grow in the pinyon-juniper woodlands, another 62 taxa from the big sagebrush zone on the plateau, and 45 different taxa of herbs found in the black sagebrush zone. These herbs overlap greatly in their distribution and are quite variable from season to season and year to year. Known -- and probably used -- foods among these taxa include: the roots or bulbs of the wild onions (*Allium atrorubens, A. nevadense, A. bisceptrum*), wild parsley (*Lomatium foeniculaceum* and *L. nevadense*), mariposa lily (*Calochortus bruneaunis*), stickseed (*Lappula occidentalis*), brodiaea (*Dichelostemma pulchellum*), purplespot (*Fritillaria atropurpurea*), bitterroot (*Lewisia rediviva*), and broomrape (*Orobanche corymbosa*); the seeds of various small Compositae (*Balsamorhiza hookeri, Lygodesmia spinosa, Viguiera multiflora*), stickseed, mustards (*Arabis holboellii, Descurainia pinnata, Stanleya pinnata*), chenopods (*Chenopodium fremontii, C. incanum*), gromwell (*Lithospermum ruderale*), stickleaf (*Mentzelia albicaulis, M. laevicaulis*), gilia (*Gilia leptomeria*), and buckwheat (*Eriogonum baileyi*); and the leaves or stalks of scale bud (*Anisocoma acaulis*), thistle (*Cirsium neomexicanum*), goosefoot (*Chenopodium fremontii*), Nevada onion (*Allium nevadense*), broomrape (*Orobanche fasciculata*), and miner's lettuce (*Montia perfoliata*).[18]

Faunal resources on the plateau today reflect the Great Basin character of this environment (Jorgensen and Hayward, 1965; O'Farrell and Emery, 1976). The larger mammals, all of which were potential sources of food, include mule deer (*Odocoileus hemionus*), pronghorn (*Antilocapra americana*), mountain lion (*Felis concolor*), bobcat (*Lynx rufus*), coyote (*Canis latrans*), kit fox (*Vulpes macrotis*), badger (*Taxidea taxus*), long-tailed weasel (*Mustella frenata*), jackrabbit (*Lepus californicus*), and both desert and Nuttall's cottontails (*Sylvilagus audubonii* and *S. nuttallii*). The Nuttall's cottontail is largely restricted to higher locations on the plateau, but jackrabbits and desert cottontails range through all elevations. Woodlands on the plateau provide the sheltered environments preferred by mule deer during all but the winter months, whereas the sagebrush steppe on the western portion of the plateau provides an excellent habitat for pronghorn throughout the year. Likewise, although absent today, bighorn sheep (*Ovis canadensis*) could have occupied the steep valleys and hill slopes and were reported in the area during the early 20th Century (Ball, 1907:23).

The smaller mammals on the mesas that are known to have been used by historic hunters and gatherers include Townsend's ground squirrel (*Spermophilus townsendii*), Ord's kangaroo rat (*Dipodomys ordi*), Great Basin kangaroo rat (*Dipodomys microps*), Great Basin pocket mouse (*Perognathus parvus*), and sagebrush vole (*Lemmiscus curtatus*). Important resident and edible birds consist of the golden eagle (*Aquila chrysaetos*), red-tailed hawk (*Buteo jamaicensis*), rough-legged hawk (*B. lagopus*), prairie falcon (*Falco mexicanus*), common raven (*Corvus corax*), horned lark (*Eremophila alpestris*), mourning dove (*Zenaida macroura*), scrub jay (*Aphelocoma coerulsecens*),

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[18] See Fowler (1986) and Steward (1938:14-33) for a discussion of Great Basin hunter and gatherer subsistence practices and Kelly (1995, table 3-3) and Simms (1987) for the caloric value of some of these plant resources.

pinyon jay (*Gymnorhimus cyanocephalus*), mockingbird (*Mimus polyglottos*), hairy woodpecker (*Picoides villosus*), Gambel's quail (*Calipepla gambelli*), burrowing owl (*Athene cunicularia*), and great horned owl (*Bubo virginianus*). Among these, the mourning dove and Gambel's quail would have been the more important food sources. Lizards found on the mesas include the sagebrush lizard (*Sceloporus graciosus*), western fence lizard *(S. occidentalis),* western skink *(Eumeces skiltonianus),* and the ever present side-blotched lizard (*Uta stansburiana*). However, these relatively small lizards are not representative of the rich lizard populace of the surrounding region that includes many larger lizards of both the Great Basin and Mojave Desert assemblages. Finally, a highly diverse and rich assemblage of invertebrates occur throughout the plateau. From a hunter and gatherer's perspective, the most important of these might include cicada, grasshoppers, and ants (Fowler 1986:88-91).

The Pleistocene (> 11,500 B.P.)

Using evidence from packrat middens found at various localities around Pahute and Rainier mesas, Spaulding (1985, 1990) and Spaulding and Graumlich (1986) have argued that the climate of this region has changed significantly during the last 45,000 years. Spaulding (1985:49-51) postulated that during the glacial maximum, approximately 18,000 years ago, average annual temperatures were at least 6° to 7°C colder than those of today; and, while winter precipitation may have been some 70% above current values, average annual precipitation probably exceeded present quantities only by approximately 30% to 40% as summers presumably received less precipitation than today.[19] Although Woodcock (1986) agrees with Spaulding's (1985) estimate for the full-glacial decrease in summer temperatures by approximately 6° C, she points to the presence of Whipple yucca (*Yucca whipplei*) in Death Valley middens as evidence that winter temperatures were equable or may have been slightly warmer than present rather than colder. Van Devender (1973, 1990:154-157), Van Devender and Spaulding (1979:708), and Wells (1979:311) had previously interpreted Pleistocene winter temperatures in the Sonoran Deserts to the south to have been equable with those of today. Spaulding (1985:51) attributed this discrepancy to regional climatic variations, specifically a more pronounced maritime pattern south of approximately 36° N latitude.

More recently, however, Wigand et al. (1994) and Forester et al. (1996:27-33) have postulated that the cyclic presence of white fir (*Abies concolor*) in several Late Pleistocene age packrat middens in the region north of 36° N latitude indicates that the climate between 34,000 and 12,000 B.P. apparently varied between long periods of cold-dry continental climate dominated by weak storm systems as envisioned by Spaulding (1985; 1990) and much briefer episodes dominated by a warmer maritime climate pattern characterized by meridional flow of storms off the Pacific (see Petersen, 1994; Thompson et al., 1993). Much of the difference between these two patterns may have been the result of a significant elevational lowering of effective moisture. Plant distributions suggest that this may have been as much as twice what it is today. That is, the lowered temperatures

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[19] This reconstruction for full-glacial climate is intermediate between previous scenarios that envisioned a slightly more moist and less cold pluvial climate (Antevs, 1952; Broecker and Orr, 1958; Mifflin and Wheat, 1979; Snyder and Langbein, 1962) and those that postulated a drier and colder late glacial maximum (Brackenridge, 1978; Dohrenwend, 1984).

that are currently encountered at 2440 m (8000 ft) would have been the norm around 1220 m (4000 ft). The effect on storms crossing the Sierra Nevada during the Pleistocene would have been significant. At the glacial maximum, one could expect that much of the precipitation that is currently removed by oreographic effect at the 2440 m elevation would already have been removed at the 1220 m elevation. These are the periods that would have been typified by dry continental climate in the interior and are evidenced by limber pine (*Pinus flexilis*) dominance. Lower mean annual temperature would have accounted for much of the apparent increase in effective precipitation during these periods.

During the slightly warmer periods on either side of the glacial maximum, the lapse would have approached conditions more like today's and would have allowed more precipitation to gain access into the Intermountain West. These periods (26,000 - 21,000 B.P., 16,000 - 14,000 B.P., and 13,000 - 11,500 B.P.) are evidenced by white fir expansion and probably by the invasion of Whipple yucca into Death Valley. Because white fir favors warmer temperatures than does limber pine and the apparent precipitation was greater than during periods dominated by limber pine, it is clear that there were significant real increases in mean annual rainfall that cannot simply be explained by reduced mean annual temperature (Forester et al., 1996:30-33). The last major advance on the mesas of the limber pine woodland containing white fir ended approximately 11,500 B.P., just as people were first entering the area below Pahute Mesa (see Pippin, 1996).

Packrat middens at elevations of approximately 1800 m (5900 ft) in the Eleana Range and at about the same elevation at Ribbon Cliffs on Pahute Mesa and Stockade Wash below Rainier Mesa indicate that the understory of this fluctuating montane and subalpine forest during the late Pleistocene included big sagebrush, rabbitbrush (*Chrysothamnus nauseosus* and *C. viscidiflorus*), and horsebush (*Tetradymia* sp.) with dwarf-golden weed (*Haplopappus nanus*), creambush (*Holodiscus microphyllus*), bitterbrush (*Purshia/Cowania*), mountain mahogany (*C. ledifolius*), and prickly phlox (*Leptodactylon pungens*). Grasses and herbs in this sagebrush steppe included asters (Asteraceae), Boraginaceae, fern bush (*Chamaebatiaria millefolium*), lupines (*Lupinus* cf. *argenteus*), Indian rice grass, and needle grass (*Stipa* spp.). Although most of this understory can be found on the mesas today, Spaulding (1990:185) notes such important associates as service berry, lemonade berry, buckbrush, Gambel's oak, and four-wing saltbush were conspicuously absent. Hence, as noted by Spaulding (1985:34, fig. 21) and Grayson (1993:142-148) for other Pleistocene age assemblages, the association of this understory with limber pine and sometimes white fir is anomalous as a plant community.

The nature of vegetation communities below the mesas during the terminal Pleistocene is codified in packrat middens from Eureka Valley (1430 - 1510 m), Death Valley (425 - 1280 m), Alabama Hills (1265 -1535 m), Fortymile Canyon (1230 - 1310 m), the Specter Range (1100 - 1190 m), Little Skull Mountain (1173 m), Skeleton Hills (910 - 940 m), Point of Rocks (900 - 910 m), Owl Canyon (790 m) and mountains south and east of Frenchman Flat (1100 - 1830 m) as well as from pollen records from Tule Springs and Owens Valley (Koehler and Anderson, 1994, 1995; Mehringer, 1967; Mehringer and Warren, 1976; Spaulding, 1983, 1985, 1990, 1994; Spaulding et al., 1983; Van Devender et al., 1987; Van Devender and Spaulding, 1979; Wells and Berger, 1967;

Wells, 1983; Wells and Woodcock, 1985; Woodcock, 1986). These data consistently indicate that the landscape at lower elevations, which are now occupied by a highly diverse Mojave Desert shrub flora, probably supported a juniper (*Juniperus osteosperma*) woodland with an understory and intervening parklands containing shrubs now more commonly found in the Great Basin than the Mojave Desert.[20] Although single-leaf pinyon may have grown at elevations as low as 925 m (3035 ft), this species was not very important anywhere, if present at all. Spaulding (1990:176) noted that single-leaf pinyon has not been found in full glacial age middens north of approximately 36°40' N.[21] Joshua trees (*Yucca brevifolia*), on the other hand, appear to have been an important component of this woodland, although probably edaphically controlled in their distribution and not always present.

Based on pollen spectra from Tule Springs and the then available packrat midden data, Mehringer (1967:186, 189-192) hypothesized that this woodland occupied an almost continuous corridor between the San Bernardino Mountains and the Las Vegas Valley.[22] Although this reconstruction was not far off, Spaulding (1983; 1990:195, fig. 9.10) noted that, with the varied nature of the landscape, we should expect some heterogeneity in habitat types within this woodland. Spaulding used the evidence from the Skeleton Hills and Point of Rocks to suggest that the juniper woodlands occupied the more mesic north to southeast-facing slopes, while the cold desert scrub occupied the more xeric southwest facing exposures. The cold-desert shrubs included such plants as sagebrush, joint-fir, shadscale, rubber and viscid rabbitbrush, horsebrush, goldenbush (*Haplopappus* sp.), purple sage (*Salvia dorrii*), woolly scale-broom (*Lepidospartum latisquamum*), prickly pear (*Opuntia* sp.), matchweed (*Gutierrezia microcephalla*), desert almond (*Prunus fasciculata*), barrel cactus (*Echinocactus polycephalus*), horsebrush (*Tetradymia* cf. *glabrata*), twinfruit (*Menodora spinescens*), and snowberry. However, there is no evidence of frost-sensitive Mojave desert plants such as creosote bush (*Larrea tridentata*), desert spruce (*Peucephyllum schottii*), or bursage (*Ambrosia dumosa*).

Pluvial lakes occurred immediately to the north and east of Pahute Mesa during the Late Pleistocene (Mifflin and Wheat, 1979). While the chronology and paleohydrology of these particular lakes -- which included Groom Lake, Kawich Lake, Gold Flat Lake, and Mud Lake -- have not been well studied, it is reasonable to believe that their histories roughly paralleled those of Lake Lahontan and Lake Bonneville which have been studied in much more detail (Benson, 1993; Benson et al., 1990; Benson and Thompson, 1987; Curry, 1980, Curry and Oviatt, 1985; Oviatt, Currey, and Miller, 1990; Sack, 1989; Thompson et al., 1990). Current interpretations indicate that both Lake Lahontan and Lake Bonneville were full to their maximums about 15,000 to 14,500 years ago, and

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20 Spaulding (1985; 1990) referred to this woodland as a pygmy conifer woodland.

21 Dated to 17.9 ka at the Skeleton Hills Sk-4 locality (Spaulding, 1990:176). Also see Cole (1983, 1990), Koehler and Anderson (1994), and Spaulding (1994) for other northern occurrences of pinyon pine during the glacial maximum.

22 See Grayson (1993:146-147) for a good discussion of the notion for continuous woodlands across the Great Basin during the Pleistocene.

it is likely the lakes around Pahute and Rainier mesas also were at their maximum high stands at that time. By approximately 14,000 years ago, or possibly slightly later in the Lahontan Basin, the water levels of Lake Lahontan and Lake Bonneville dropped dramatically and apparently extremely rapidly. So much so, that by 12,000 years ago Pleistocene Lake Bonneville may have fallen to historic levels or below, and Lake Lahontan may have decreased in depth by over 100 m (Benson and Thomson, 1987; Curry and Oviatt, 1985). Smith and Street-Perrott (1983:05-206) noted that, although fluctuations in lake levels may not have been precisely synchronous, this major event apparently occurred throughout the West; and Groom, Kawich, Gold Flat, and Mud lakes also may have been greatly reduced in size approximately 12,000 years ago (also see Forester et al., 1996:19-23; Smith, Benson, and Currey, 1989). However, Brown et al. (1990) have amassed considerable evidence that the Silver Lake and Soda Lake basins to the southwest of Pahute and Rainier mesas may have housed deep pluvial lakes between 14,000 and 11,400 years ago and suggested that this pronounced difference in lake histories indicated a time-transgressive change during the terminal Pleistocene. Hence, it is possible that lake levels remained high in the pluvial lakes just north and east of the mesas until sometime around 11,500 years ago.[23]

Local riparian environments, such as along Fortymile Canyon directly south of the mesas, also may have periodically supported perennial water during the Late Wisconsin. Lundstrom and others (1995) postulated that the existing incision of the Fortymile Wash fan occurred before the glacial maximum (35,000 to 25,000 B.P.) due to perennial or sustained seasonal flows fed by spring snowmelt, but during the Pleistocene/Holocene transition (15,000 to 8,000 B.P.) the wash may have been aggrading, at least in its lower reaches where ephemeral or seasonal flows infiltrated (also see Forester et al., 1996:35-39; Paces et al., 1996). Spaulding (1994:22-26) did recover a seed of Scouler's heliotrope (*Plagiobothrys* cf. *scouleri*) and a few *Salix*, *Typha*, and *Cyperaceae* pollen grains from packrat middens near the middle of this major tributary to the Amargosa River; but if perennial waters were consistently present, we might expect a better showing of hydrophiles and phreatophytes. Possible riparian plants that were also recovered from these middens included the single-leaf ash (*Fraxinus anomala*), mountain mahogany, fern bush, and creambush -- all of which reflect more montane species. Limber pine with some white fir probably grew along the high canyon rim.

Haynes (1967), Quade (1986), Quade and Pratt (1989), Quade et al. (1995), and Paces et al. (1996) reconstructed the geologic and hydrologic nature of the broad alluvial Indian Springs, Pahrump, and Las Vegas valleys to the south and southeast of the Pahute and Rainier mesas region during the terminal Pleistocene. Although several previous researchers (Hubbs and Miller, 1948; Bowyer et al., 1958; Haynes, 1967) had originally interpreted the pale green clays and white clayey silts of Unit D (radiocarbon dated between approximately 30,000 to 15,000 B.P.) to represent pluvial lakes, Quade (1986) used terrestrial mollusks and cicada burrows incorporated in these units to convincingly argue that these sediments were deposited in a mosaic of shallow ponds and marshes along the valley bottoms. Mehringer's (1967) pollen profiles indicated that cattails and sedges

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23 See continued discussion of these pluvial lakes during the Early Holocene in the next section.

probably skirted these ponds and marshes; and these environments, as well as those around the margins of the pluvial lakes north and northeast of the mesas, may have been the most productive resource zones in the entire region during the Late Wisconsin. Quade and Pratt (1989:366) painted a scene of springs and seeps along the valley flanks with sluggish, perennial streams flowing to wet meadows and ponds in the valley bottoms. The intervening dry areas would have supported the juniper savannas reconstructed for the late Pleistocene.

Now extinct megafauna, including ground sloth *(Nothrotherium shastense* and *Megalonyx* sp.), Columbian mammoth (*Mammuthus columbi*), horses (*Equus* cf *caballus* and *E.* cf. *asinus*), camels (*Camelops hesternus*), bison (*Bison* sp.), pronghorn (*Tetrameryx* sp.), and the giant jaguar (*Panthera atrox*) as well as pumas *(Felis* sp.), coyotes (*Canis latrans*), deer (*Odocoileus* sp.), rabbits (*Lepus* sp., *Sylvilagus* sp. and *Brachylagus idahoensis*), muskrats (*Ondatra zibethica*), voles (*Microtus* sp.), large and small kangaroo rats (*Dipodomys* sp.), pocket gophers (*Thomomys* spp.), antelope ground squirrels (*Ammospermophilus leucurus*), packrats (*Neotoma* sp.), meadow mice (*Microtus* cf. *californicus*), and deer mice (*Peromyscus* spp.) represent some of the available Late Pleistocene faunal resources (Mawby, 1967; Reynolds et al., 1991a, 1991b). Various birds (*Fulica* spp, *Aythya* spp., *Mergus merganser*, *Bubo* sp. and *Teratornis merriami*), lizards (*Sceloporus* cf *occidentalis*, cf *Callisaurus dracoinides*, and *Phrynosoma* sp.), snakes (*Colubridae*), frogs (*Hyla* spp.), toads *(Bufo* sp.), and tortoise (*Gopherus* sp.*)* are also present (Reynolds et al. 1991a). Haynes (1967:82) noted that the now extinct species in this fauna may have disappeared from the area by 11,500 years ago and were definitely gone by 11,000 years ago (also see Grayson, 1993:164-165).

The juniper woodlands in the valleys and the montane and subalpine forests of the highlands also probably housed boreal mammals such as pika (*Ochotona princeps*), golden-mantled ground squirrel (*Spermophilus lateralis*), Townsend's ground squirrel *(Spermophilus townsendii*), least chipmunk (*Tamis minimus*), pine marten (*Martes americana*), least weasel (*Mustela nivalis*), yellow-bellied marmot (*Marmota flaviventris*), and wolverine (*Gulo gulo*).[24] They too may have vanished from the lowlands around 11,500 years ago, but the lowland records of these fauna are extremely sparse (Grayson, 1993, tables 7-13 and 7-14).

The Early Holocene (11,500 to 8,000 B.P.)

Although postglacial warming probably began earlier (Ruddiman and Duplessy, 1985), the gradual vegetational response to these changing climatic conditions became noticeable shortly after approximately 11,500 years ago in the region around Pahute and Rainièr mesas. Spaulding (1985:51) postulated that the period between about 11,500 and 8,000 years ago witnessed concurrent increases in annual temperatures and summer rain, as well as a slight decline in winter precipitation. Hence, although average annual precipitation may have been within 20% of current values, Spaulding (1985, 1990) and Spaulding and Graumlich (1986) felt that summer precipitation may

[24] See Brown (1971, 1978), Brown and Gibson (1983), Cutler (1991), Grayson (1987; 1993), and Patterson (1990) for discussions of the Pleistocene biogeography for these montane mammals.

have been as much as 50% higher than today. Likewise, Spaulding and Graumlich (1986) argued that while average annual temperatures may have approached or even exceeded those of today, there was probably a greater annual range in temperatures with cooler winters and warmer summers.

For the Sonoran Desert to the south, Van Devender (1990) argued that the persistence of California juniper woodlands at low elevations until 8000 years ago or so suggests that summer temperatures were still cooler than today. Likewise, based on the Whipple Mountains record, Van Devender (1990) questioned the penetration of summer monsoons into the Mojave Desert at this time. Thompson (1990) concurred. Using an optimal photosynthesis temperature for limber pine of 15°C, Thompson (1990:228) felt that the persistent prevalence of limber pine in packrat middens in the eastern Great Basin during the early Holocene could have reflected summer temperatures that were 4° to 5°C cooler than today. Likewise, the absence of pinyon in the central and eastern Great Basin at this time implies that summer precipitation values were not yet sufficient to support its migration (also see Thompson, 1984 and Thompson and Hattori, 1983). Finally, Grayson (1993:206) pointed to the presence of pikas in early Holocene deposits at Hidden Cave (Grayson, 1985) and other more northern Great Basin sites as indicating temperatures still must have been cooler than today.

However, Spaulding's (1985, 1990) and Spaulding and Graumlich's (1986) interpretations of the climatic conditions south of Pahute and Rainier mesas may not be too far off the mark. It is not unreasonable to expect that average annual temperatures south of Pahute and Rainier mesas would be higher than those in the central and northern Great Basin, and Grayson (1993:202) noted that pikas are conspicuously absent from early Holocene records in the southern Great Basin.[25] Likewise, the persistence of xerophytic woodlands at lower elevations in both the Mojave and Sonoran deserts could be due to lag rates as the lower elevational ranges of such woodlands may be controlled more by effective moisture than temperature. In addition, enriched hydrogen-deuterium ratios from 9000 year old packrat middens in the Lahontan Basin also imply increased temperatures and/or increased summer rainfall (Thompson et al., 1993:488-489). Finally, the argument for increased summer precipitation was derived primarily from the increased northern distribution of pinyon which needs adequate summer precipitation to germinate and reduced winter cold stress to survive (Neilson, 1987; Tueller and Clark, 1975; Tueller et al., 1979).

Regardless of this disagreement, it is clear that the gradually increasing temperatures of the early Holocene, whether they were still cooler than those of today or not, resulted in significant vegetational change. Spaulding (1990:192-194) portrayed the dynamics of this vegetational change as being quite complex with individual species displaying their own particular patterns of time and space transgressive migration. The juniper and sometimes joshua tree woodlands that characterized the lowlands south of Pahute and Rainier mesas began to move up slope, and pinyon began appearing in this woodland at more northern latitudes. Hence between 11,700 and 10,600 years ago,

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[25] Pikas were present in the Las Vegas Valley at an elevation of 1082 m (3550 ft) some 14,300 years ago (Mead and Spaulding, 1995).

pinyon and juniper were apparently growing with some remnant limber pine at 1810 m (5940 ft) in the Eleana Range only approximately 5 km south of Rainier Mesa (Spaulding, 1985, table 23). Limber pine also was still growing at 1950 m (6400 ft) on the southern slopes of Rainier Mesa 11,400 years ago. But by 10,000 years ago, only juniper was growing there, apparently without pinyon (Wigand, personal comm.).[26] The understory continued to contain big sagebrush, mountain mahogany, prickly phlox, asters, and grasses but now also included purple sage, snowberry (*Symphoricarpos* sp.), and prickly pear (*Opuntia erinaceae*). Finally, at least some pinyon was growing with juniper and an understory of bitterbrush, goldenbush, prickly pear (*Opuntia* cf *polyacantha*), tarragon (*Artemisia dracunculus*), and grass around 9500 years ago at 1225 m (4020 ft) at Twin Springs in Fortymile Canyon approximately 25 km south of the mesas (Spaulding, 1994, table 2). Based on this admittedly meager data and what we know concerning vegetation changes in the surrounding mountain ranges, it is likely that pockets of limber pine remained on the higher, more mesic slopes in the eastern portion of the mesas and possibly in the two amphitheaters into the early Holocene. Pinyon, although nearby, was yet to be an important component of the vegetation on the mesas. Rather, juniper with an understory and parklands of big sagebrush and other Great Basin Desert shrubs probably occupied most of the plateau.

This interpretation is supported by packrat middens in both the Sheep and Pahranagat ranges to the southeast and east of Pahute and Rainier mesas, respectively. Bristlecone (*Pinus longaeva*) and limber pine were growing with prostrate juniper (*Juniperus communis*) between 2380 and 2400 m (7800- 7880 ft) in the southern Sheep Range around 12,000 years ago; but by 10,000 years ago, both Rocky Mountain (*J. scopulorum*) and Utah juniper, ponderosa pine (*Pinus ponderosa*), white fir, and pinyon had been added to this community (Spaulding, 1981:145-150). At slightly lower elevations, between 1860 and 2080 m (6100 to 6820 ft), on the western side of the Sheep Range where both bristlecone and limber pine had grown during glacial maximum times, middens dated between 9300 and 9500 B. P. contained vegetation much like that of today with juniper, joshua tree, some pinyon, little-leaved mahogany (*Cercocarpus intricatus*), pinyon brickellia (*Brickellia oblogifolia*), Apache plume (*Fallugia paradoxa*), and purple sage (Spaulding, 1981, tables 23 and 25). Although further south in latitude (36° 35' to 36° 38'), this site is comparable in elevation to most of the eastern portions of Pahute Mesa. Pinyon also was growing with juniper and some joshua trees with a similar understory on xeric south and east facing slopes in the southeastern Sheep Range at an elevation of 1580 m (5200 ft) approximately 11,550 years ago. By 8100 years ago, this site was probably just below some straggling juniper with joshua trees, little-leaved mahogany, desert almond (*Prunus fasciculata*), blackbrush, joint-fir, agave (*Agave utahensis*), and some sagebrush (Spaulding 1981, table 14). Hence, we might infer that the western portions of Pahute Mesa around 1580 m (5200 ft) also would have been near the lower boundary of a pinyon-juniper woodland at 8000 years

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[26] Two *Pinus monophylla* needles were found in a midden [STW220594ARM1(1,3)] containing limber pine needles dated around 11,500 years ago, but these pinyon needles have not been dated and could be contaminants (Wigand, personal commun.).

ago.[27] Further north in the Pahranagat Range, at approximately the same latitude (37° 22' N latitude) and elevation as Pahute and Rainier mesas, Wigand (personal commun.) has dated pinyon needles in middens at 1790 m (5873 ft) in elevation at 9230 and 8810 B.P. However, because middens containing juniper are about twice as common as those containing pinyon or juniper and pinyon, Wigand et al.(1994:55) felt that pinyon "seems to have been a much less important component of the early Holocene woodland than was juniper."

Evidence for the nature of what the vegetation may have looked like below and to the south and west of Pahute and Rainier mesas during the early Holocene comes from packrat middens in the Eureka Valley due west of the mesas, Fortymile Canyon due south of the mesas, Point of Rocks between Mercury Valley and the Amargosa Desert, Little Skull Mountain and Skeleton Hills in the northern end of the Amargosa Desert, Owl Canyon near Devil's Hole at Ash Meadows, Sandy Valley between the Spring Range and the Mesquite Mountains to the south, and the Last Chance Range along the southeastern margins of the Amargosa Desert (Spaulding, 1983, 1985, 1990, 1994; Wigand, 1990). Based on pollen profiles from Tule Springs, Mehringer (1967:189-192, fig. 38) postulated that a marked change from juniper-sagebrush to sagebrush-shadscale vegetation occurred approximately 12,000 years ago in the Las Vegas Valley. This hypothesis is sustained and clarified by the above packrat midden data. Middens from approximately 800 m (2625 ft) in elevation at Owl Canyon where the juniper woodland had grown during the Pleistocene (Mehringer and Warren, 1976:125) were characterized by desert almond, purple sage, Utah agave, butterfly bush (*Buddleja utahensis*), and beaver-tail (*Opuntia basilaris*) at 10,000 years ago (Spaulding 1983, table 2; 1985, table 16). Likewise, middens dated at 9800 years ago at the Point of Rocks (900 m; 2950 ft) still contained big sagebrush, bitterbrush and copious grasses with shadscale, winterfat, joint-fir, prickly phlox, and ground-thorn (*Menodora spinescens*). By 9500 years ago, the big sagebrush was apparently gone from this site; and by 9200 years ago, blackbrush, agave, joint-fir, and rockworth (*Scopulophila rixfordii*) were characteristic (Spaulding, 1983, tables 17 and 18). At approximately the same elevation (910 - 940 m; 2980 - 3080 ft) in the Skeleton Hills, the local juniper woodland on northern, more mesic exposures was gone by 9200 years ago; and the joshua tree, rabbitbrush, joint-fir, desert-rue (*Thamnosma montana*), ground-thorn, and desert thorn community that occupied more xeric, southern exposures around 10,000 years ago was replaced around 8500 years ago or slightly before by shadscale, bursage, desert spruce, and brittle bush (Spaulding, 1990:174-179, fig. 9.13). Finally, some big sagebrush also was found in middens dating approximately 9470 B.P. at Twin Springs in Fortymile Canyon (1225 m; 4020 ft), but it was apparently gone by 9390 B.P. However, juniper and some pinyon were still growing there approximately 9400 years ago (Spaulding, 1994, table 2).

On the southern slopes of Little Skull Mountain (1190 m; 3900 ft), just north and approximately 200 m higher in elevation than the Skeleton Hills, Wigand (1990:33-35) reported that the juniper woodland there also was gone by 9500 years ago; but at 8500 years ago, it reappeared

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[27] Wigand (1990:36) reports a radiocarbon date of 9330 B. P. on juniper in a packrat midden at the head of Thirsty Canyon (1524 m; 5000 ft) on the western portion of Pahute Mesa.

briefly with hackberry (*Celtis reticulata*). The occurrence of juniper this low in elevation at this late date is truly remarkable, and it is possible that juniper also increased its distribution on Pahute Mesa and the surrounding mountains at this time. Wells and Jorgensen (1964, table 1) dated juniper twigs at 7800 years ago in a midden at 1250 m (4100 ft) on Mercury Ridge, and this occurrence also could reflect the same brief resurgence during the end of the early Holocene. Wigand (1990:47) attributed this reappearance of juniper on Little Skull Mountain to a penetration of summer rainfall from either the Gulf of Mexico or the Gulf of California (also see Kutzbach, 1986); but, as suggested by Van Devender (1990), it also could mean that temperatures dipped below those of today. Bursage, however, made its first appearance on Little Skull Mountain at this same time as well as in the Skeleton Hills, and purple sage and other cold desert species were absent. Hence by 8000 years ago, the vegetation in the lowlands to the south of Pahute and Rainier mesas, although still vastly different from that of today, was beginning to assume the flavor of a warmer desert.

The marshes and shallow ponds that characterized portions of the bottoms of Las Vegas, Pahrump, Indian Springs, and Three Lakes valleys during the terminal Pleistocene persisted throughout the early Holocene, although they were diminished in extent (Quade, 1986; Quade and Pratt, 1989; Quade et al., 1995). Quade et al. (1995, table 2) dated the black mats associated with Unit E_2, which probably represent decayed marsh plants, to clearly fall between 11,900 and 8,500 years ago. They (Quade et al., 1995:218-219) inferred that ground waters were still sufficiently high to form free-faced and/or fault-controlled discharge in these valleys and explained the difference between these localized perched ground water systems and those of the large, deep regional carbonate system. The carbonate system was shown by Winograd et al. (1985, 1992) and Szabo et al. (1994, fig. 4) to have dropped sharply beginning 15,000 years ago or approximately the same time that Lake Lahontan and Lake Bonneville were rapidly declining in depth and size.

Although Groom, Kawich, Gold Flat, and Mud lakes north and east of Pahute and Rainier mesas could have been relatively shallow 12,000 years ago, these lakes may have increased in size and depth during the early Holocene. There appeared to have been an increase in the levels of Lake Lahontan and Lake Bonneville sometime around 10,300 to 11,000 years ago.[28] Apparently Lake Gunnison, located in the Sevier Basin of Utah and once connected to Lake Bonneville, rose to such a level that it actually overflowed into the basin to the north (Oviatt, 1988). Likewise, although interpretations differ, the evidence for the Late Pleistocene history of Searles Lake, Lake Mojave, and Lake Russell in the Mono Lake Basin also indicates that these lakes, which were at times interconnected with Pluvial Lake Manley in Death Valley, also experienced late high stands at this time (Smith and Street-Perrott, 1983:205-206). Silver Lake was above its overflow level into Dumont Lake at 11,800 years ago and again at 10,300 years ago and was again near that level around 9000 years ago (Brown et al., 1990; Wells et al., 1987). However, the Late Pleistocene and Early Holocene history of lake fluctuations in the Silver Lake and Soda Lake basins is quite complex; and

[28] In the Bonneville Basin, this lake level is evidenced by the Gilbert Shoreline; whereas in the Lahontan Basin this lake level may correspond with Morrison's (1964) First Fallon Lake which Curry (1988) has called the Russel shoreline (also see Benson et al., 1990; Dansie et al., 1988 and Elston et al., 1988).

there appear to have been several periods of lake filling and subsequent desiccation during this time (Brown et al., 1990; Wells et al., 1990). By approximately 8700 years ago, both basins were dry. Finally, cores taken by Peterson (1980:176-178) indicated that at least a small lake was present in Panamint Valley up to 10,000 years ago and Hooke (1972:2086-2087) proposed that a 90 m deep lake occurred in Death Valley between 11,000 and 10,000 years ago.

As discussed by Grayson (1993:202-206), the evidence of what the fauna were like during the Early Holocene on and around Pahute and Rainier mesas, or anywhere else in the southern Great Basin, is extremely sparse to nonexistent. The sloth, mammoth, horses, camels, and other large mammals that so characterized the Pleistocene were definitely gone by 11,000 years ago or perhaps slightly earlier (Haynes, 1967:82). Although some large mammals, such as deer, pronghorn, bighorn sheep, and bison did survive, the diversity of species was consequently greatly reduced. Despite the dearth of direct evidence, however, we can speculate about what the distribution of fauna may have been during the early Holocene based upon their modern distributions in biotic communities (see Bradley and Deacon, 1967). The caveat being, of course, that there are few true modern analogs to the vegetation communities of the Early Holocene.

The riparian environments between and around the lakes and marshes in the valley bottoms all around the mesas would have attracted waterfowl, muskrats, beavers, turtles, amphibians, fresh water shrimp, and a host of insects and their larva. We also might expect increased concentrations of rodents and other terrestrial mammals in surrounding areas. Minnows (*Cyprinidae*), suckers (*Catostomidae*), and killifish (*Cyprinodontidae*) probably comprised the available fish in the waters (Bradley and Deacon, 1967, Appendix II; Miller, 1948; Hubbs and Miller, 1948:77-88, 100-102). Although chub (*Gila* spp.) and suckers (*Catostomus latipinnis* and *Pantosteus* spp.) were perhaps the more important from a hunter and gatherer perspective, the evidence from Lovelock Cave, Hidden Cave, and nearby Spirit Cave indicates that the much smaller minnows and killifish also were eaten by the peoples there (Follett, 1970; Smith, 1985; Wigand, personal commun.).[29]

The terrestrial fauna on the mesas was perhaps already close to that of today with a few notable exceptions. While some of the boreal mammals, like pikas, could have been gone from their Pleistocene habitats on and around Pahute and Rainier mesas, others -- like the yellow-bellied marmot, golden-mantled ground squirrel, least chipmunk, weasel, and pygmy rabbit -- may well have still been on the mesas. In fact, the Townsend's ground squirrel is still there today. Likewise, although it may have made little difference to hunters and gatherers, *Sylvilagus nuttallii* rather than *S. audubonii* may have been the more common cottontail. Finally, although deer may not have been as common as today and may have been outnumbered by bighorn sheep and antelope, they were undoubtedly present (see Grayson, 1982; Pippin, 1979; Thomas, 1970, 1983).

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29 Also see Fowler (1986:88) for ethnographic uses of these small fish.

Middle Holocene (8000 to 4500 B.P.)

Although the previous age assignments for periods of environmental change on and around Pahute and Rainier mesas were reasonably clear cut, the 8000 to 4500 B.P. range for the middle Holocene might be viewed with some suspicion. Grayson (1993:208-221), for example, bracketed this period between 7500 and 4500 years ago; Van Devender and Spaulding (1979) placed it between 8000 and 4000 years ago; Thompson (1990) used 7000 to 4000; and Antevs' (1948) neothermal sequence positioned his "Altithermal" between 7000 and 4500 years ago. There are two good reasons for these discrepancies. First, and perhaps most important, the empirical evidence for what environments were like during the middle Holocene is decidedly sparse. It is hard to place precise boundaries around something for which we have limited evidence. Secondly, we must consider multiple moving targets. Although the ultimate climatic events that caused the changes in environments around the mesas during the middle Holocene may well have been synchronous, the subsequent rates of change in the distribution of plants, animals, and sediments were perhaps more varied and gradual than those of earlier periods taking place at different times in different places (see Van Devender et al., 1987:343-346). For example, although the northern limit of pinyon was probably around Pahute and Rainier mesas 9000 years ago and at comparable elevations (above 1830 m; 6000 ft) on the northwestern slopes (Falls Canyon) of the White Mountains to the northwest by 8800 B.P., it did not reach the Schell Creek Range until approximately 6300 years ago, was not in the area around Gatecliff Shelter in the northern Toquima Range until approximately 6000 years ago, and did not reach the southern Lahontan Basin until after 3000 B.P. (Jennings and Elliott-Fisk, 1993; Nowak et al., 1994; Thompson, 1990; Thompson and Hattori, 1983; Thompson and Kautz, 1983). Other plants may have taken longer or shorter times to react. Hence, joint-fir and snowberry, common associates of the pinyon and juniper woodlands in the Toquima Range today and found in early Holocene middens around Pahute and Rainier mesas, apparently did not arrive in the Toquima Range until approximately 4000 years ago, some 2000 years after pinyon (Thompson and Hattori, 1983; Thompson, 1990).

There are no middle Holocene packrat middens that have yet been analyzed from Pahute and Rainier mesas. Thus, direct evidence is lacking as to the nature of the climate and the associated vegetation at this time.[30] Nevertheless, several important studies have been conducted in the surrounding region which support reasonable speculation. First, the evidence cited above concerning the distribution of pinyon would imply that pinyon became a more important component of the woodlands on the mesas during the middle Holocene than it was during the early Holocene. Thompson (1990:229) and Thompson and Hattori (1983:66-167) argued that the middle Holocene distributions of pinyon and juniper around 6000 years ago may have reflected an increase in summer rainfall over early Holocene levels and perhaps over modern levels. The middle Holocene sedimentary record of Gatecliff Shelter has been used to confirm this hypothesis; but this record also could have been due to reduced vegetation cover around the shelter, suggesting that by 5000 years

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30 A series of packrat middens that may date to this period have been collected from the Ribbon Cliffs area just below and to the southeast of Black Mountain, and other middens have been found in the Big Burn amphitheater.

ago summer precipitation may have returned to present values or lower at least in the latitudes of the Toquima Range (Davis, 1982, 1983:83-84).

LaMarche (1973, 1974) documented changes in tree line on the White Mountains of eastern California and southwestern Nevada. The position of upper tree line in this and other high mountain ranges appears to be most closely related to summer temperatures (LaMarche, 1973:647-652). Tree-ring dated remains of bristlecone pine (*Pinus longaeva*) now growing approximately 150 m (500 ft) above present tree line in the White Mountains indicate that between 7350 and 4000 years ago summer temperatures may have been as much as 2° to 3.5° F higher than today. From this evidence, it might be inferred that woodlands on the mesas during the middle Holocene could have risen in elevation by a comparable amount. This may be true of upper tree line, and packrat midden evidence from Silver Canyon in the White Mountains tends to support this conclusion (Jennings and Elliot-Fisk, 1993:216). However, the upper elevations of Pahute and Rainier mesas lie below the upper tree line of pinyon and juniper, and lower tree line would have to move to make a difference. Jennings and Elliot-Fisk (1993:216) noted that the lower reaches of the subalpine woodland at the Silver Canyon site (3048 m; 10,000 ft) did not move at this time (5640 B.P.), nor did the limits of the pinyon-juniper woodlands at the Wyman 4(A) site (2560 m; 8400 ft) dated at 4510 B.P. (also see LaMarche, 1978, fig. 4). Lower tree line tends to react more to changes in precipitation than temperature, and the warmer summer temperatures of the middle Holocene may not have changed the distribution of the pinyon-juniper woodland on the mesas.

Packrat midden data from the Pahranagat and Sheep ranges (Spaulding, 1981:117-120; Wigand, 1990:36; Wigand et al., 1995) are of more value for examining the changes at the lower limits of the pinyon-juniper woodland. Two packrat middens presently located in an open joshua tree forest on Hancock Summit in the Pahranagat Range just below the pinyon-juniper woodland around 1600 m (5250 ft) have been dated at 7030 and between 5820 B.P. and 6690 B.P. The older of these middens contains both pinyon and juniper; but the younger one lacks pinyon, apparently because it was above this elevation around 6000 years ago. Pinyon is nevertheless present with juniper in two 4500 to 5000 year old middens on nearby north facing slopes between 1700 m and 1800 m (5600 ft to 5900 ft). Evidence for a lower tree line around 5000 years ago also comes from the Desert View locality on the lower flanks of the Sheep Range (Spaulding, 1981:117-120). Here, a packrat midden now located in a blackbrush community at 1810 m (5940 ft) in elevation, about 150m lower than the current tree line, contained juniper dated at 5200 B.P. Perhaps due to increased summer precipitation, these data imply that juniper and pinyon may have increased slightly in their distribution on the Pahute and Rainier mesas during the middle Holocene (see Spaulding, 1981:209, 1983:120, 1985:44-45).[31]

The Pahranagat Range middens also indicate that sagebrush, joint-fir, and blackbrush at 1600 m (5250 ft) in elevation were important components of the understory during the middle Holocene

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[31] The lower limits of pinyon on the mesas is currently about 1830 m (6000 ft) with juniper descending to around 1770 to 1670 m (5800 to 5500 ft).

(similar to today). However, Joshua trees, desert thorn, and winterfat -- all also components of the understory today at 1600 m in elevation -- did not join this vegetation association until approximately 6000 years ago. Spaulding (1981, table 21) also noted that prickly pears (*Opuntia polyacantha* and *O. phaeacantha*) that now grow approximately 150 m above this site, were present in the Desert View midden on the Sheep Range. Finally, Koehler and Anderson (1995:241, 245) noted that, although juniper had risen above 1460 m (4800 ft) in the Alabama Hills by 8000 years ago, many of the other early Holocene plants remained at this site until 5000 years ago and were joined by increased shadscale and a diversity of grasses. They also noted a marked increase in pine pollen in these middens around 6000 years ago (Koehler and Anderson, 1995, fig. 5). These data indicate that the understory associated with the pinyon-juniper woodlands on the mesas during the middle Holocene was slowly increasing in diversity as species which were once around the mesas during the early Holocene rose or dropped in their elevational distribution.

Only a few packrat middens around the mesas codify what the vegetation was like below the mesas during the middle Holocene.[32] As discussed above, the region south of the mesas was assuming the character of a warmer desert by the end of the early Holocene but was yet to become the Mojave Desert of today. Hence, bursage, shadscale, and desert spruce were present on the more xeric slopes of the Skeleton Hills by the beginning of the middle Holocene; but creosote bush was still conspicuously absent, and relic juniper were growing on Little Skull Mountain and Mercury Ridge. But by 6700 years ago, the xeric slopes of Little Skull Mountain just to the north contained both bursage and creosote bush; and we may assume that sometime between 8000 and 6700 years ago the Amargosa Desert and other low valleys to the south of the mesas assumed their modern vegetation composition (Wigand, 1990:35). It took slightly longer for these Mojave Desert species to reach the low valleys to the west of the mesas. Spaulding's data (1985, table 25; 1990:172-173) from the Eureka View locality (1430 - 1510 m; 4700 - 4950 ft) in the north end of Eureka Valley at about the same latitude as Pahute and Rainier mesas contains five middens dating between 8300 and 3900 years ago. These middens indicate that while shadscale was there throughout the Holocene, bursage, desert thorn, indigo bush (*Psorothamnus fremontii*), and beavertail cactus (*Opuntia basilaris*) did not arrive until approximately 6800 years ago; and it was not until after 5600 years ago that creosote bush arrived and desert thorn moved further up slope.

The rising and lowering of tree line and the northward migration of pinyon into the central Great Basin during the middle Holocene have been interpreted to reflect increased summer precipitation and temperature. However, Grayson (1993:208-215) painted a picture of a middle Holocene characterized by relatively high temperatures and relatively low effective moisture (also see Mehringer, 1985). This interpretation may be correct for the central and northern portions of the Great Basin during the Middle Holocene. Today, these portions of the Great Basin fall under a winter-dominant precipitation pattern (Mitchell, 1976). But, in the south, where today

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[32] Grayson (1993:215) and Wigand (1990:35) felt that the dearth of middle Holocene middens may be due to a climatically induced restricted distribution of packrats, but Webb and Betancourt (1990:91) interpreted this pattern, which is present throughout the west, to represent a sampling bias.

approximately 25% of the total annual precipitation is derived from summer thunder showers, it is quite possible that the summer monsoons penetrated more to the northwest during the middle Holocene. Spaulding (1991) has used the middle Holocene packrat midden record in the McCullough Range, located in the far southern tip of Nevada, to test this hypothesized incursion. Four middens, dated between approximately 6800 and 5000 B.P., show an increase in frequency of thermophiles (Spaulding, 1991, table 2), as well as desert spruce and creosote bush; and this evidence implies that the middle Holocene in far southern Nevada was more arid than today. Spaulding (1991:432), however, noted that this aridity could have been due to a lack of winter frontal storms rather than lower summer precipitation. Van Devender et al. (1987:347-348) appear to be correct when they postulated that, while the middle Holocene witnessed the maximum westward penetration of the summer monsoon, it was also a time of maximum winter drought; and warm-season rainfall was probably only significantly greater than today in the higher mountains and not in the desert lowlands. The orographic effects of the higher mountains, such as Pahute and Rainier mesas, were probably much greater than that of the low lying McCullough Range and thereby the mesas probably experienced enhanced summer convective showers.

Recently published tree-ring data from Methuselah Walk in the White Mountains provides the best evidence to date concerning the nature of precipitation at the latitude of Pahute and Rainier mesas (Graybill et al., 1994). This record clearly shows a marked period of decreased rainfall between 7250 and 6600 B. P. after the onset of the middle Holocene and two subsequent marked droughts. One between 4650 and 4400 B.P. near the end of the middle Holocene and another between 3700 and 3400 B.P. after the close of the middle Holocene. The intervening period, that comprises the bulk of the middle Holocene is marked by numerous periods of above average rainfall interspersed with several short 25 - 50 year long droughts. These would have been favorable conditions for the gradual spread of pinyon-juniper woodlands on the mesas. It is also important to note that the reliability of this precipitation data, as indicated by a reduction in the standard deviation of ring indices during this time, increased between 6500 B.P. and 4650 years ago.

Nevertheless, the overall aridity of the middle Holocene around Pahute and Rainier mesas is well documented in the demise of the lakes, streams, and ponds that characterized the valleys during the Pleistocene and through the early Holocene. By 8000 years ago, the localized and perched water tables in the Las Vegas, Indian Springs, Three Lakes, and Pahrump valleys apparently dropped sufficiently to dry up the springs that fed the ponds, marshes, and wet meadows there. Likewise, surface run-off was sufficiently reduced so that the lakes in the Emigrant, Kawich, Gold Flat, and southern Ralston valleys probably became deflated playas that, at the most, only held ephemeral waters. Based on radiocarbon assays of 5000 B.P. and 4500 B.P. in the dune facies of Unit F_1 at Corn Creek Dunes and a 7500 year old date from the middle of the upper fill of Unit E_2, Haynes (1967) noted that the change from E_2 aggradation to degradation in the Las Vegas Valley probably began between 7000 and 6000 years ago. Further, Haynes (1967) interpreted the F_1 and F_2 deposits at Tule Springs to represent repeated cycles of sand and gravel deposition within channels eroded during degradation. The weak soil ($S5_a$) found atop the eroded E_2 unit has been correlated with the Toyeh soil of the Lake Lahontan basin (Haynes, 1967, fig. 7; Morrison, 1964; Quade and Pratt, 1989).

With the exposure and deflation of the relatively fine-grained sediments deposited during earlier, more mesic periods, eolian activity probably redeposited these sediments as sand ramps, sheet dunes, and dunefields leeward from the basins containing marshes, ponds, and lakes during the early Holocene (Lancaster, 1994, 1995). Unfortunately, systematic studies of eolian deposition around Pahute and Rainier mesas have not been conducted. Field observations indicate, however, that -- with the exception of the well known dune fields at Corn Creek Dunes, Ash Meadows, Big Dune, and Death Valley -- most of these eolian sediments were deposited as sand ramps along the bases of low mountains, as either sheet dunes or vesicular A horizons on exposed fans and bajadas, or as loess on highland surfaces such as Pahute and Rainier mesas.[33] As pointed out by Mehringer (1986:40) and Mehringer and Warren (1976:143), these deposits would have acted as sponges catching the limited rains and enhancing the growth of resources such as mesquite (*Prosopis juliflora*, *P. pubescens*) and Indian ricegrass.

The best dated dune chronology for the entire region comes from the Kelso Dunes more than 240 km south of the mesas (Lancaster et al., 1994). Infra-red stimulated luminescence (IRSL) dates indicate that this dune field formed during several periods of deposition that have stacked, shingled, and/or redeposited eolian sediments atop one another on the piedmont of the Providence and Granite Mountains during the last 30,000 years or more. Major periods of accumulation occurred between 13,000 and 8000 B.P. and then again between 8000 and 4000 years ago. More limited accumulation at West Cronese and Kelso occurred between 2000 and 1500 B.P., 800 and 350 B.P. and again between 250 and 150 years ago (Lancaster et al., 1994; Clarke et al., in press). The known chronologies from Corn Creek Dunes (Williams and Orlins, 1963) and Ash Meadows (Mehringer and Warren, 1976; Livingston and Nials, 1990) closely match, and it is possible that this chronology also applies to the region around Pahute and Rainier mesas.

Almost no information is available concerning the nature of faunal resources around Pahute and Rainier mesas during the middle Holocene. The nearest archaeological sites that contain fauna dating to this period include Gatecliff Shelter (Grayson, 1983) some 185 km to the north and O'Malley Shelter (Fowler et al., 1973, table 16) approximately 170 km to the east. Pygmy rabbits (*Brachylagus idahoensis*) were present in the middle Holocene levels at both sites and appeared to decrease in frequency in later levels. Grayson (1983:124) noted that these small rabbits are typically associated with dense stands of big sagebrush and attributed this decrease at Gatecliff to the expansion of the pinyon-juniper woodland. Pygmy rabbits are not found on or around Pahute and Rainier mesas today, although they were apparently in this area during the Pleistocene. It is possible, then, that pygmy rabbits met their demise on and around the mesas with the decrease in sagebrush steppes due to both the lowering of tree line and the rising of Mojave desert elements at the expense of big sagebrush. Likewise, with the exception of the Townsend's ground squirrel, the early

[33] Mehringer and Warren (1976) and Livingston and Nials (1990) have studied the dunes at Ash Meadows; Williams and Orlins (1963) provided a chronology for the Corn Creek Dunes; and Hunt and Mabey (1966:82) have used prehistoric artifacts to date dunes in Death Valley.

Holocene montane mammals also were probably pinched off the mesas during the middle Holocene. The small mammals that remained were probably the same that occupy the mesas today.

Bison (*Bison bison*) were also recorded in the middle Holocene levels at O'Malley Shelter (Fowler et al., 1973, table 16). While this occurrence could have reflected an incursion of bison into the eastern portions of southern Nevada at that time, it is unlikely that many, if any, bison were present in the region on or immediately around the mesas. Rather, deer, bighorn sheep, and antelope were probably the large game available to middle Holocene hunters and gatherers. Thomas (1983: table 22) noted that bighorn sheep dominated the large mammals at Gatecliff and, in fact, may have been the only Artiodactyl represented in the middle Holocene deposits there. Mule deer and bighorn sheep were found in the middle Holocene deposits at O'Malley Shelter.

Late Holocene (< 4500 B.P.)

Grayson (1993:221) felt that, if forced to choose, he would select approximately 4500 years ago as the time when Great Basin environments became similar to those of today. But he also noted that today's environment in the Basin is quite dynamic, and significant vegetational changes have obviously occurred even within the last 100 years (see Hastings and Turner, 1965 and Rogers, 1982). In fact, the fine-scale records for the late Holocene display an impressive amount of environmental variability and Grayson (1993:226) pointed out that this type of variability probably also characterized earlier periods (also see Mehringer, 1986). Hence, as was the case with categorizing what might have been significant variability among ethnographic hunters and gatherers, we are again faced with deciding how to normalize this variability into meaningful units. For the region around Pahute and Rainier mesas, four periods appear to stand out during the late Holocene: the Neoglacial (3800 - 2300 B.P.), a major drought between 900 and 500 B.P., the Little Ice Age (400 - 300 B.P.), and historic woodland expansion during the last 150 years.

Between 4000 to 5000 years ago, the thermal maximum of the middle Holocene began to gradually cool off, although not without variation (LaMarche, 1973, fig. 17; 1974, fig. 5; 1978, fig. 4; Wigand et al., 1994). This cooling trend, combined with a moderate increase in precipitation, culminated in a period variously called the Neoglacial (Denton and Karlén, 1973; Porter and Denton, 1967) or Neopluvial (Curry, 1990). Finely-laminated, fine-grained sediments found in cores taken from Silver Lake have been isotopically dated at 3600 years ago and probably indicate that the bottom of this basin was briefly characterized by wet playa, marshy, and/or lacustrine conditions at that time (Brown et al., 1990:63; Enzel et al., 1992). Although undated, there is also evidence that two other lakes may have briefly existed in this basin either during the late or early Holocene or both. Other low basins in the Mojave Sink south of Pahute and Rainier mesas displayed similar histories (Smith, 1979; Brown, 1990; Enzel et al., 1992:69-70). Although these hydrologic events could have been due to increased precipitation as far away as the Transverse Ranges in southern California (Wells et al., 1990), Stine (1985, 1990) also reported high Mono Lake stands 3500 years ago; and Davis (1982:66-67) noted that several other lake basins to the north also may have held more water around this time (see Born, 1972; Davis and Pippin, 1979; Mehringer, 1986:34-37; Morrison, 1964; Smiley and Mehringer, n.d.). Two major periods of peat formation also occurred at Ash Meadows between 4450 and 3600 B.P. (Mehringer and Warren, 1976:146), and it is possible that shallow or at least more prolonged bodies of water could have occurred in the playas north and northeast of Pahute and Rainier mesas during the Neoglacial. However, if this were the case, field observations indicate that they did not extend much, if at all, beyond the modern playa margins.

Ely et al. (1993) have provided a history of floods on the Colorado and Gila river drainages in Utah and Arizona. They noted that floods were most numerous between 4800 and 3600 B.P. but declined significantly between 3600 and 2200 B.P. Increases in flood frequency were also noted for the period around 1000 B.P. and again after 500 B.P. with a decrease in flood frequency between 800 and 600 years ago. Ely et al. (1993) correlated the periods of high magnitude floods with transitions from cool to warm climatic conditions and El Niño conditions.

An abundance of woodrat middens containing juniper and pinyon macrofossils around Pahute and Rainier mesas evidence a major Neoglacial reexpansion and/or increase in density of woodland between 3800 and 2300 years ago (Wigand et al., 1995). Middens in the Sheep Range suggest that there may have been as much as a 200 m depression in lower tree line approximately 3300 years ago (Spaulding, 1985, fig. 14), and Wigand (1987) and Miller and Wigand (1994) have noted similar trends in the northern Great Basin. Pollen spectra from Lower Pahranagat Lake, 100 km east of the mesas and from Coffer Spring, only 20 km to the southwest, show marked increases in pine and juniper pollen with respect to saltbush (*Chenopodiaceae*) during the Neoglacial (Wigand, 1990:41; Hemphill and Wigand, 1995). The pollen profile from O'Malley Shelter east of the mesas also indicates an expansion of pinyon and juniper at the expense of grass after approximately 3700 years ago (Madsen, 1973). In that pollen profile, pine pollen, presumably from pinyon, shows a marked increase in frequency after 3000 years ago. Hence, there is good evidence that the pinyon-juniper woodland on the mesas was either expanding or becoming more densely laced with pinyon during the Neoglacial.

Following the Neoglacial, the climate around Pahute and Rainier mesas appeared to gradually became warmer and drier (Graybill et al., 1994; Wigand, 1987; Wigand and Nowak, 1992; Davis, 1982; Wigand and Rose, 1990). The spread of woodland evident in the pollen profile from Lower Pahranagat Lake and O'Malley Shelter had reversed by 1000 B.P.; and a severe drought was apparently evidenced in the northern, central, and southern Great Basin between approximately 1100 and 500 years ago (Hemphill and Wigand, 1995; Wigand and Rose, 1990). Tree-ring indices from Methuselah Walk indicate a drought in the southern Great Basin similar in magnitude to that of the early middle Holocene (Graybill et al., 1994, fig. 1). This reconstruction was confirmed by other Sierran and Great Basin tree-ring studies (Holmes et al., 1986; LaMarche, 1974, fig 5). Additional evidence indicates that severe drought occurred in the Mono Lake Basin at that time (Stine, 1990).

The Little Ice Age was apparently a global period of stronger winter precipitation and cooler temperatures beginning 300 to 400 years ago. In the central and southern Great Basin, this period is evidenced by increasing frequencies of pine pollen over juniper pollen; and it appears that pinyon benefited more from the shift toward mesic climate conditions (Grove, 1988; LaMarche, 1974, fig. 5; Thompson et al., 1986; Wigand and Nowak, 1992). Cole and Webb (1985) and Hunter and

McAuliffe (1994) also noted that the lower boundary of blackbrush dropped approximately 100 m in elevation in the Mojave Desert to the south of Pahute and Rainier mesas during this period; and we might surmise that other transition species -- like desert thorn, spiny hop-sage, and Joshua trees -- also increased their distributional boundaries. Likewise, Silver Lake and other playas in the region may have held water again briefly (Enzel et al., 1992) and the 400 B.P. peat deposits at Ash Meadows probably reflect a period of increased spring discharge (Mehringer and Warren, 1976).

Since the Little Ice Age, mean annual temperature apparently has been rising (Ghil and Vautgard, 1991). But at the time that the *Tiabo* first entered the area, yet another reexpansion of Great Basin woodlands was apparently underway (Blackburn and Tueller, 1970; Rogers, 1982; Tausch, West, and Nabi, 1981; West, 1984). Based on observations of the density of old trees, early reports by trappers and settlers, and old photographs, it appears that the juniper woodlands in the Great Basin at the time of initial *Tiabo* immigration usually formed savannahs rather than dense woodlands. Burkhardt and Tisdale (1976) felt that this might have been due to frequent range fires during warm periods that maintained both shrubs and trees at low densities providing a savannah-like appearance. But surveys of pinyon-juniper woodlands in Nevada and adjacent southwestern Utah indicate that tree populations, primarily pinyon, have increased in density and perhaps more than 2.5 fold in areal distribution during the past 150 years (Cottam and Stewart, 1940; Tausch et al., 1981). This observation is in direct conflict with models that predict a reduced woodland and increased fire frequency during periods of aridity. Rather, with increasing immigration and *Tiabo* settlement, fires may have been suppressed by a combination of political policy, reduced light fuels (grasses and forbs) due to overgrazing and arid conditions, increased seed dissemination of shrubs that provided nursery for woodland seedlings, a decline in fires set by hunters and gatherers as native populations shrank, and the construction of fence lines that provided roosting sites for juniper seed-eating birds (Johnsen, 1962; Blackburn and Tueller, 1970; Burkhardt and Tisdale, 1976; Young and Evans, 1981; Miller and Wigand, 1994).

CHANGING CULTURAL ADAPTATIONS ON THE MESAS

Some Preliminaries: Background and Sampling

The above review demonstrates that there have been major environmental changes on and around Pahute and Rainier mesas during the last 12,000 years. But what about the evidence for how the use of mesas by humans may have changed during this time? Likewise, how might these changes in environment have affected utilization? In order to address these questions, we need to first consider several preliminary concerns. For example, what observations should be made from the archaeological record that would help measure the influence of environmental change? How does the nature of this record affect our ability to make these measurements?

The majority of the evidence concerning how past hunters and gatherers used the mesas was gathered during a time that Great Basin prehistorians had been focusing their attention on delineating and understanding past settlement and subsistence systems (Bettinger, 1975, 1977, 1980; Davis, 1963; Elston, 1971, 1982; Jennings, 1986; O'Connell, 1971, 1975; Swanson, 1972; Thomas, 1971, 1973, 1983; Thomas and Bettinger, 1976; Weide, 1968). The continued prominence of this research direction in the Great Basin despite recent national and international trends toward more post-processual approaches might be viewed by some to indicate that Great Basin archaeologists are simply too provincial. But as Thomas (1996) pointed out at the 25th Great Basin Anthropological Conference, perhaps it is also because they have found it more useful in addressing the archaeological record of hunters and gatherers. After all, the popularity of this research perspective has been based on the realization that, in order to survive, nomadic hunters and gatherers had to develop adaptive strategies that allowed them to obtain the basic provisions necessary to maintain and, hopefully, expand their populations. As reviewed above, without technologies for food production, these strategies involved moving the populations to the areas which provided basic provisions so that those resources could be exploited when they were available. What settlement and subsistence strategies were best suited for what environments and what resources? What strategies allowed or required prehistoric peoples to develop more complex cultures? How much choice did prehistoric hunters and gatherers have and how much did environmental variability influence the strategies that were followed?

Although most previous studies focused on discerning or predicting correlations between gross environmental variability, particularly plant communities and archaeological site distributions, particular attention needed to be paid to actualized subsistence and settlement patterns in an attempt to discern how the prehistoric peoples organized their use of space and resources on the mesas. This approach followed Fowler's (1982:134) and Bettinger's (1980:194) suggestions. Hence, as argued by Binford (1982), it was believed that variability in the differentiation of activities among places in both form and frequency of use was likely to carry direct information about the organization of a past system of adaptation (also see Ebert, 1992; Kroll and Price, 1991). An archaeological site, then, is simply a spot on the landscape that may have been repeatedly utilized by different peoples in different ways. Hence, the research endeavors for Pahute and Rainier mesas were originally designed to provide a detailed look at how hunters and gatherers differentially employed this geographical place through time (Pippin, 1992).

This all sounds appropriate for our needs, but in actuality most of the research that was conducted on the mesas was in response to the U. S. Department of Energy's requests for preconstruction surveys. This is classic contract or applied archaeology[34]. Hence, research areas were selected based on their ability to be used for the testing of nuclear devices, not for addressing questions concerning how prehistoric peoples may have differentially used Pahute and Rainier mesas through time. This reality has been long recognized as a major difference between contract archaeology and more academically focused research archaeology (Jennings, 1959:681-683). To be sure, this applied research sampling design does not assure that an adequate sample will be retrieved

[34] Although the term cultural resource management (CRM) is commonly applied to this sort of endeavor, it is the federal agency that is responsible for the management of the resources and contracting archaeologists, whose perspectives may be more research oriented, can only provide recommendations toward that goal.

in order to address questions concerning differential land use. However, Durand and Pippin (1992) have evaluated the sample from Pahute and Rainier mesas using a nearest neighbor analysis and found that these preconstruction surveys were randomly distributed across the eastern portion of the mesas (fig. 3).[35] Consequently, for that area, they should provide an adequate representation (pseudo random sample) of the archaeological record and be useful for examining changes in land use patterns.

Some may worry that the use of survey data, particularly that gathered under applied archaeology, may not accurately reflect the history of aboriginal utilization of the mesas (see Beck and Jones, 1992:25-26; Clewlow, 1968:1; Lewarch and O'Brien, 1981). In this regard, more intensive surface collections and limited excavations have been conducted at 19 different, but often overlapping, locations on the mesas (Pippin et al., 1993).[36] Unlike the original survey data, these data recovery projects, also driven by nuclear testing program schedules, were heavily clustered in only four general areas on the mesas; and they do not represent an adequate sample ofgeographic space (fig. 4). Hence, they are less useful than the survey data for examining changes in land use patterns. However, they do provide a good measure of the adequacy of the survey data to record what was actually in the archaeological record on the mesas and the structure and nature of the artifact assemblages at those archaeological sites (Pippin et al., 1993:20-34). In addition, they have provided the only direct evidence of the kinds of biotic and abiotic resources exploited by past hunters and gatherers on the mesas (Pippin et al., 1993:43-46).

Following formally defined and quality assurance approved field procedures, survey crews on the mesas typically subdivided the archaeological sites they discovered into spatial components and recorded samples of the artifact content of these components (Reno, 1989). As with any research program, methods generally improved through time. Data recovery programs later conducted at some of these sites indicate that, although there is not perfect concordance, these defined subdivisions accurately reflect the general nature of the various artifact concentrations (see Henton and Pippin, 1991a; Hicks et al., 1991; Pippin et al., 1992; Simmons, 1990). In addition, in order to test how representative of subsurface deposits the surface distribution of these artifacts may be, a series of chi-square tests were also performed comparing surface and subsurface components at several of the study sites (Henton and Pippin, 1991a; Hicks et al., 1991; Jones, et al., 1993; Pippin et al., 1992; Reno et al., 1989). With only a few exceptions, these studies generally indicate no significant statistical difference between surface and subsurface components on the mesas. Consequently, it is assumed for the purposes of this paper that cultural materials noted during the preconstruction surveys accurately reflect the artifact and feature composition of those archaeological sites recorded.

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[35] These survey reports are on file in the Nevada State archives at the Harry Reid Center, University of Nevada, Las Vegas and at the Desert Research Institute in both Reno and Las Vegas.

[36] The results of these data recovery programs have been presented in Desert Research Institute technical reports available from the Desert Research Institute and the National Technical Information Service in Springfield, Virginia.

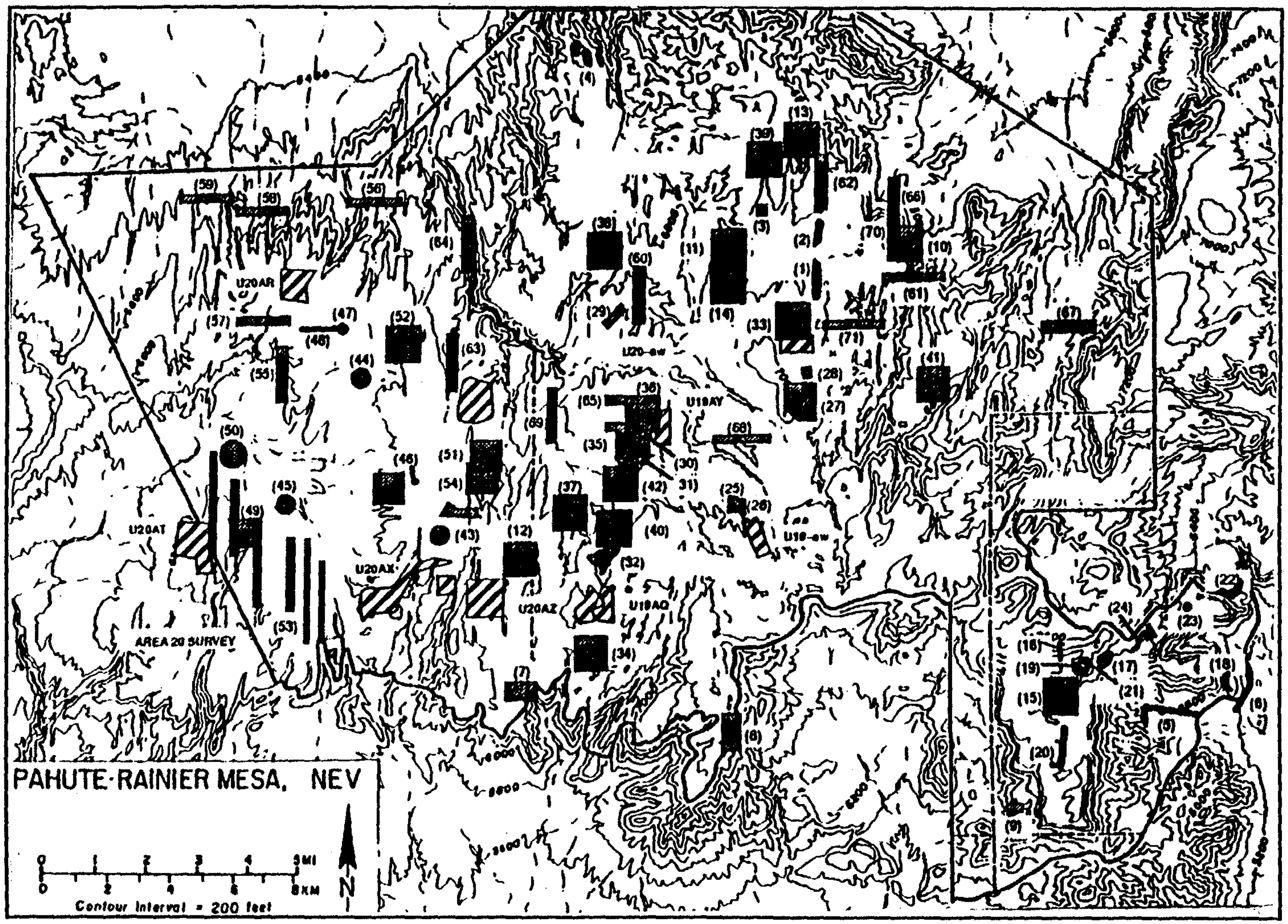

Fig. 3. Map of the eastern portion of Pahute and Rainier mesas showing the distribution and area of preconstruction surveys used in Durand and Pippin's (1992) nearest neighbor analysis. Hatched areas are surveys that were conducted after Pippin's (1986) overview.

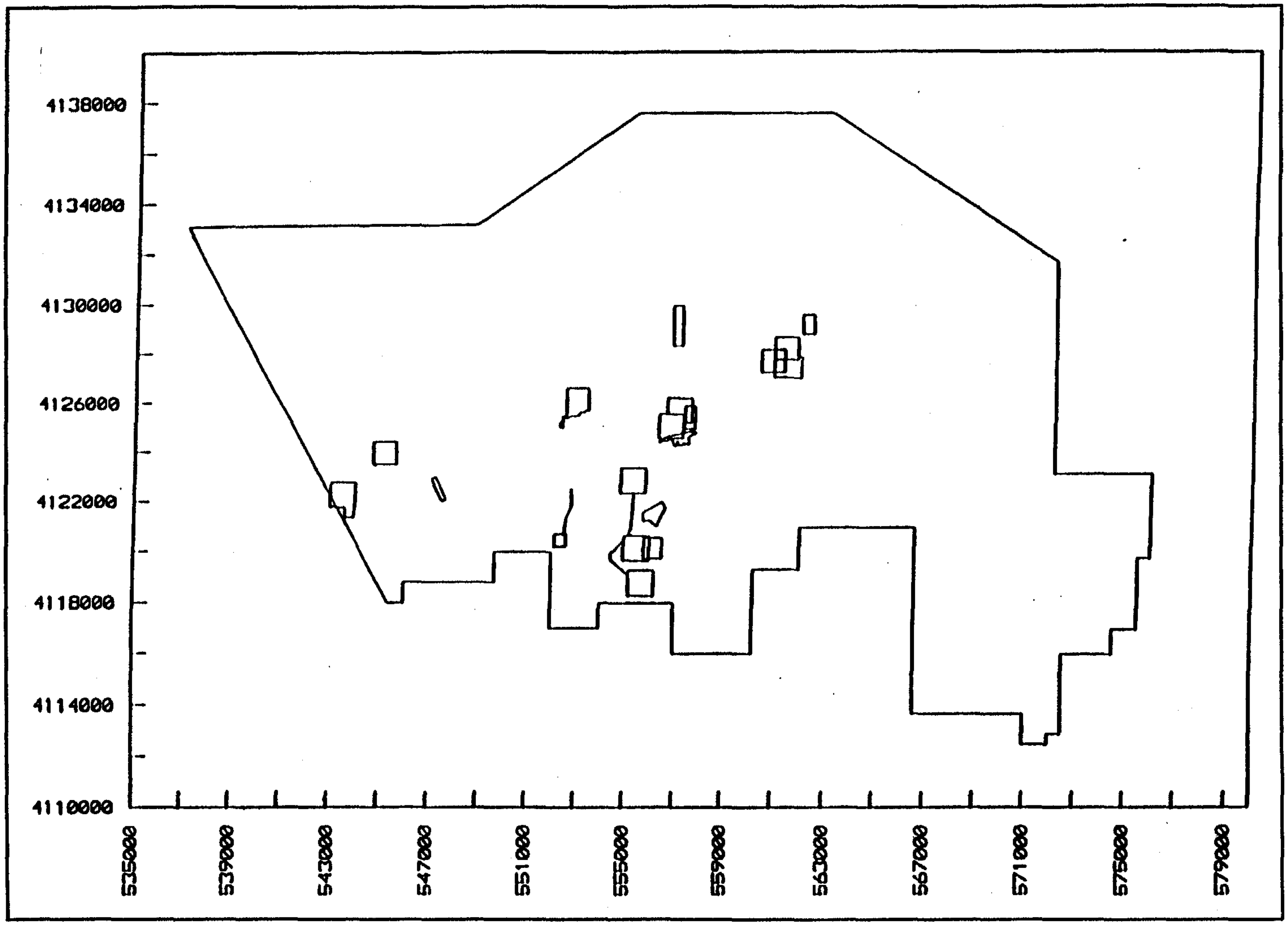

Fig. 4. Map of the eastern portion of Pahute and Rainier mesas showing the distribution and area of data recovery projects conducted under the Long Range Study Plan (Pippin, 1992).

More Preliminaries: Some General Trends

Chronology

Before examining this record in detail, it is first valuable to review several trends in the archaeological record of the mesas so that the discussion of specific periods can be placed in perspective. The first task is to review what is known about the chronology of the utilization of the mesas. Then scales need to be devised for measuring changes in the intensity of utilization, changes in the artifact content of the various archaeological sites, and changes in patterns of land use.

A chronological sequence of the prehistoric use of Pahute and Rainier mesas has been previously hypothesized (Pippin, 1995, see fig. 5 this volume). Although the cultural periods are sharply defined, their time spans are based on the cross-dating of temporally diagnostic artifacts (projectile points, pottery, and *Tiabo* manufactured artifacts) which overlap in time (Pippin, 1995, figs. 26 and 27). The use of periods, therefore, might be questioned and others (Beck and Jones, 1992:28; Braun, 1985) have argued that continuous seriation (time-series) should replace such normative constructs. However, when we begin to assign archaeological sites to specific time spans and then try to compare and contrast these sites in regard to questions of land use through time, we recognize the analytical value of defined periods, particularly when dealing with survey data.

For example, consider two archaeological sites in the Pahute and Rainier mesas data set (table 1). The first, 26Ny1408, contains two Large Side-notched Series points, one Gatecliff Series point, three Humboldt Series points, twelve Elko Series points, and thirteen Rosegate Series points. Using a simple time-series perspective, it appears that this location was continuously used between approximately 7000 years ago (Prow Pass Period) when Large Side-notched points first appeared in the archaeological record to approximately 350 years ago (Silent Canyon Period) which marked the latest dated occurrence of Rosegate Series points in the Great Basin.[37] But the assemblage is clearly dominated by Elko and Rosegate Series points, and some might want to use statistical techniques (seriation profiles, percents, ogival curves, etc.) to refine its chronological placement to a shorter (more precise?) time span.

The second site, 26Ny3121, contains three Pinto Series points, a Humboldt Series point, three Gatecliff Series points, an Elko Series Point, and a Desert Side-notched Series point. The time series perspective would assign the site to a time span between 10,000 years ago (Barren Wash Period) that corresponds to the earliest radiocarbon date (AA-12405) for Pinto Series Points to approximately 1000 years ago (Rainier Mesa Period) that marks the latest available date on Elko Series points (Gak-3608). But then Desert Side-notched points have been dated as early as 1270 B.P. (WSU-2633), and we could also make an argument for continued occupation until historic times when these small side-notched points were still being used. The assemblage from 26Ny3121 is dominated by

[37] The earliest date for Large Side-notched points is from O'Malley Shelter (Fowler et al., 1973); whereas the latest date for Rosegate Series is from Dirty Shame Rockshelter (Aikens et al., 1977).

Years B.P.	Cultural Period	Diagnostic Projectile Points	Other Diagnostics
	Split Ridge	Cottonwood Series	Historic Artifacts
	Silent Canyon	Desert Series	Brownware Pottery
1000	Rainier Mesa	Rosegate Series	Anasazi Pottery Bow & Arrow
2000 3000	Pahute Mesa	Elko Series	
4000	Dead Horse Flat	Gatecliff Series	↑
5000 6000 7000	Prow Pass	Humboldt Series Large Side-notched Pinto Series	Atlatl ↓
8000			↑
9000 10,000	Barren Wash	Western Stemmed Series	Crescents Spear Steep-edged Scrapers Gravers/ Burins
11,000	Rattlesnake Ridge	Western Clovis	↓

Fig. 5. Hypothesized chronological sequence of the cultural utilization of Pahute and Rainier mesas, southern Great Basin (from Pippin, 1995, fig. 29).

Pinto and Gatecliff Series points. and thus statistically we can also argue that it should date earlier than the assemblage from 26Ny1408.

Table 1
Worksheet Comparing the Temporal Profiles for Archaeological Sites 26Ny1408 and 26Ny3121 on Pahute and Rainier Mesas

Time Diagnostic	26Ny1408		26Ny3121		
	n	cum. %	n	cum. %	difference
Pinto Series	-	0.00	3	0.33	0.333
Large Side-notched	2	0.06	-	0.33	0.268
Humboldt Series	3	0.16	1	0.44	0.283
Gatecliff Series	1	0.19	3	0.77	0.584
Elko Series	12	0.58	1	0.88	0.308
Rosegate Series	13	1.00	-	0.88	0.111
Desert Series	-	1.00	1	1.00	0.000

Kolmogorov-Smirnov $D_{05} = 1.36\sqrt{(n_1 + n_2)/n_1 n_2} = 0.515$

Thomas (1988:394-405) wrestled with this problem when he was placing the surface scatters in the Monitor Valley into temporal periods. Thomas (1988:401) argued that sample sizes play a significant role in this process and that no matter how different the distribution of time-markers may be at two separate sites, if a sufficiently large number of diagnostics are not found, then we can not be sure that they represent temporally distinct occupations. Using Thomas' (1988:394-405) criteria, the sample from 26Ny3121 is statistically different from that at 26Ny1408 since the maximum observed difference between the cumulative proportions (0.584) is greater than the calculated Kolmogorov-Smirnov D statistic (0.515). Hence, we could validly argue that the assemblage from 26Ny3121 was earlier than that at 26Ny1408. But how do we use this to compare the two sites in regard to how they may represent different environmental adaptations? And what about those sites containing isolated projectile points that do not have large enough populations of points to be statistically significant? Do we just ignore them?

These questions raise a serious problem when working with survey data, since it is rare to find large numbers of temporally diagnostic artifacts at small localities used by hunters and gatherers. Nevertheless, individual time diagnostic artifacts can be considered *fossils directeurs* and, by themselves, do reflect specific periods in time. Thus, the fact that Large-Side notched points occur at 26Ny1408 indicate that the site was used at the same general time (Prow Pass Period) as 26Ny3121, although statistically, the total assemblage at the site can be argued to be later than that at 26Ny3121. The fact that both sites contain artifacts that are temporally diagnostic of several periods in time indicates that the assemblages at both represent different periods of use. To use statistics in an attempt to overcome this fact may obscure important information.

The time spans for the periods defined in figure 5 are based on the means of all radiocarbon dates associated with time diagnostics listed for that period (see Pippin, 1995, fig. 27). Hence Pinto points, although dating as early as 10,000 B.P. in one instance, have a mean date of approximately 7500 B.P. and are taken as diagnostic of the early end of the Prow Pass Period. Large Side-notched points have a mean date of approximately 6000 B.P., are statistically later than the Pinto Series, and are considered diagnostic of the later end of the Prow Pass period. The temporal span for Humboldt Series points, as defined statistically by notched box plots, overlaps both the defined span for the Prow Pass Period and the Dead Horse Flat Period and could be assigned to either period. When assessing the ages of archaeological sites, it seems reasonable then to simply examine the temporal profile of the diagnostics found at the site and then place the site within the periods covered by those diagnostics.

In the following analysis, if a temporally diagnostic artifact is found in the archaeological record, regardless of quantity, then it is assumed to represent an activity at that time at that locality. Although this assumption would be false in cases where artifacts have been scavenged, recycled, reused, and/or curated, these processes can be recognizable by examining whether or not the specific diagnostic had to be reworked or was in a context suggesting the operation of such processes. In addition, even when we can not recognize this process, the available obsidian hydration data from the mesas (see Pippin, 1995:46-47) indicate that it probably would not totally mask the overall chronological patterns. Hence, site 26Ny1408 would be considered to have been utilized during the Prow Pass, Dead Horse Flat, Pahute Mesa, and Rainier Mesa Periods, even though its assemblage was dominated by diagnostics of the Pahute and Rainier Mesa Periods. Likewise, 26Ny3121 would be assigned to use during the Prow Pass, Dead Horse Flat, and Pahute Mesa Periods. But because the assemblage from 26Ny3121 lacks diagnostics of the Rainier Mesa Period, it would not be considered to have been utilized at that time. The presence of Desert Series points would indicate use only during the subsequent Silent Canyon Period. However, in assigning an archaeological site to a cultural period using this method, a combination of factors needed to be considered. If the temporal assignment of a particular site were based on only one type of time diagnostic artifact -- two Elko Series projectile points, for example -- the median date of that artifact was used. However, if the site contained two different but temporally overlapping types of diagnostic artifacts, then the period of occupation was assumed to be that period of overlap. If the site contained two types of noncontiguous, temporally diagnostic artifacts -- an Elko Series projectile point and brownware pottery, for example -- then the median date of each artifact was used; and the site was assigned to two different cultural periods. Using this procedure, then, each archaeological site in the Pahute and Rainier mesas data set can be coded according to the period(s) of its use.

While several methods could be used to postulate the intensity of use of the mesas during these periods, site area might be the most appropriate measure of this utilization, although the number of sites also should be considered. Out of the 1311 archaeological sites recorded on Pahute and Rainier mesas, 846 sites could be assigned to one or more of the defined cultural periods. Figure 6 presents a simple bar graph of the total area occupied by these sites divided by the number of years covered by each cultural period. The number of sites per period is also shown by the dashed line. Several factors should be considered when interpreting this graph. First, although the scales are given in hectares/year and sites/year, these are only relative scales. The actual number of hectares exploited or sites utilized during these periods was probably much larger as not all archaeological sites that occurred on the mesas have been recorded, and the graph is based only on those sites that can be assigned to a period. Likewise, one would expect that the total area utilized on the mesas would have been larger, although perhaps proportional to the total area covered by cultural remains. A total of 1476 hectares is covered by all sites, whereas sites assignable to cultural periods encompass only 1162 hectares. Secondly, as discussed above, many sites can be assigned to two or more cultural periods. In these cases, the total site area occupied by that site was tallied for each period although the actual site area used during each period may have been smaller than the combined total site area.

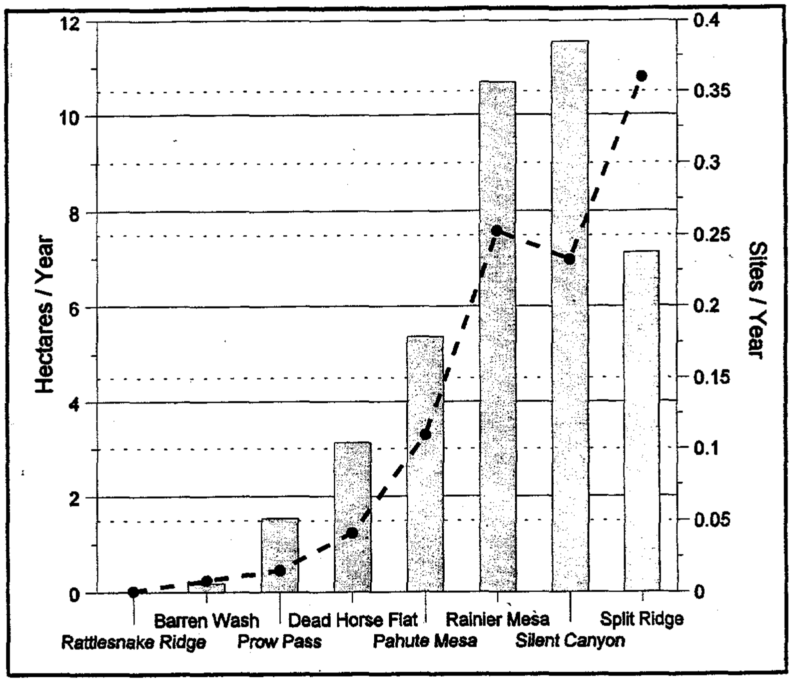

Fig. 6. Postulated intensity of exploitation of Pahute and Rainier mesas for each cultural period. Bar graph displays total site area per period. The number of sites in each period is shown by the dashed line. All values have been standardized by dividing by the number of years in each period.

The data recovered from the 1311 archaeological sites recorded on the mesas indicate that a large percentage (≈ 50 %) of the sites have artifact assemblages containing temporal markers diagnostic of several different periods. In other words, like 26NY1408 and 26Ny3121, the assemblages represent different periods of use of these localities. Binford (1982) argued that this occupational redundancy may carry direct information concerning the organization of past cultural adaptations. This redundancy on the mesas has been previously examined (Pippin, 1986a:86-89) by studying the cooccurrence of diagnostics at archaeological sites, but that analysis was based on a limited number of sites and was performed prior to the rigid definition of what constitutes temporal diagnostic projectile points (Pippin, 1995). Table 2 presents the cooccurrence of diagnostics at the sites on the mesas using the current data set and the typology presented by Pippin (1995). These data record the number of times that each diagnostic was found at the same archaeological site, disregarding the frequency of individual items at those sites. Hence, Desert Series projectile points occurred with Rosegate Series projectile points at 20 sites; Elko and Rosegate series projectile points occurred together at 48 sites; and so on.

Table 2
Frequency in the Cooccurrence of Projectile Point Series at Archaeological Sites on Pahute and Rainier Mesas

Type	Desert	Rosegate	Elko	Gatecliff	Humboldt	LSN	Pinto	W-Stemmed
Desert	--	20	27	15	12	9	7	8
Rosegate	20	--	48	37	19	13	20	10
Elko	27	48	--	36	20	13	17	9
Gatecliff	15	37	36	--	19	14	15	9
Humboldt	12	19	20	19	--	9	8	8
LSN	9	13	13	14	9	--	8	5
Pinto	7	20	17	15	8	8	--	6
W-Stemmed	8	10	9	9	8	5	6	--

LSN = Large Side-notched Series; W-Stemmed = Western Stemmed Series; Pinto = Pinto, Pinto Square Base and Paradise Pinto.

Some of this cooccurrence may be due to temporal overlap in the use of projectile point styles, but it is obvious that the coterminous use and discarding of projectile points does not explain the entire range of cooccurrence. Likewise, it is improbable that this redundancy in the deposition of projectile points is due simply to these particular places being preferred as sites to establish residences or to the scavenging of earlier point forms by later peoples. Rather, as modeled by Binford (1982), these locations probably represent activity nodes at different times and under different adaptive systems. If this is the case, then we should expect that the same place would be used differently under various adaptive strategies and that the patterning of the redundant use of places would be different for different adaptive strategies. For example, although residentially mobile hunting parties may well use some of the same localities as logistically based seed collectors, the overall patterning of this redundant use of places should be different for these contrasting adaptive strategies.

If the cooccurrence of diagnostics in table 2 is treated as a table of similarities (i.e., the similarities in the distribution of projectile points), then multidimensional scaling may assist in the definition of different patterns of redundant site use. In this application, an entry in the table reflects the statistical distance between diagnostic assemblages based on the cooccurrence of all diagnostics at sites on the mesas. Hence, the physical distance between points on a multidimensional scattergram should replicate the similarities inherent in the data; and the more different the patterns of occupational redundancy, the further apart the points should be on the spatial map. Figure 7 presents a three-dimensional scattergram of the multidimensional scaling using 70 iterations of the data in table 2. The stress of the final configuration was 0.01658 and the proportion of variance represented by the plot is 0.99832.

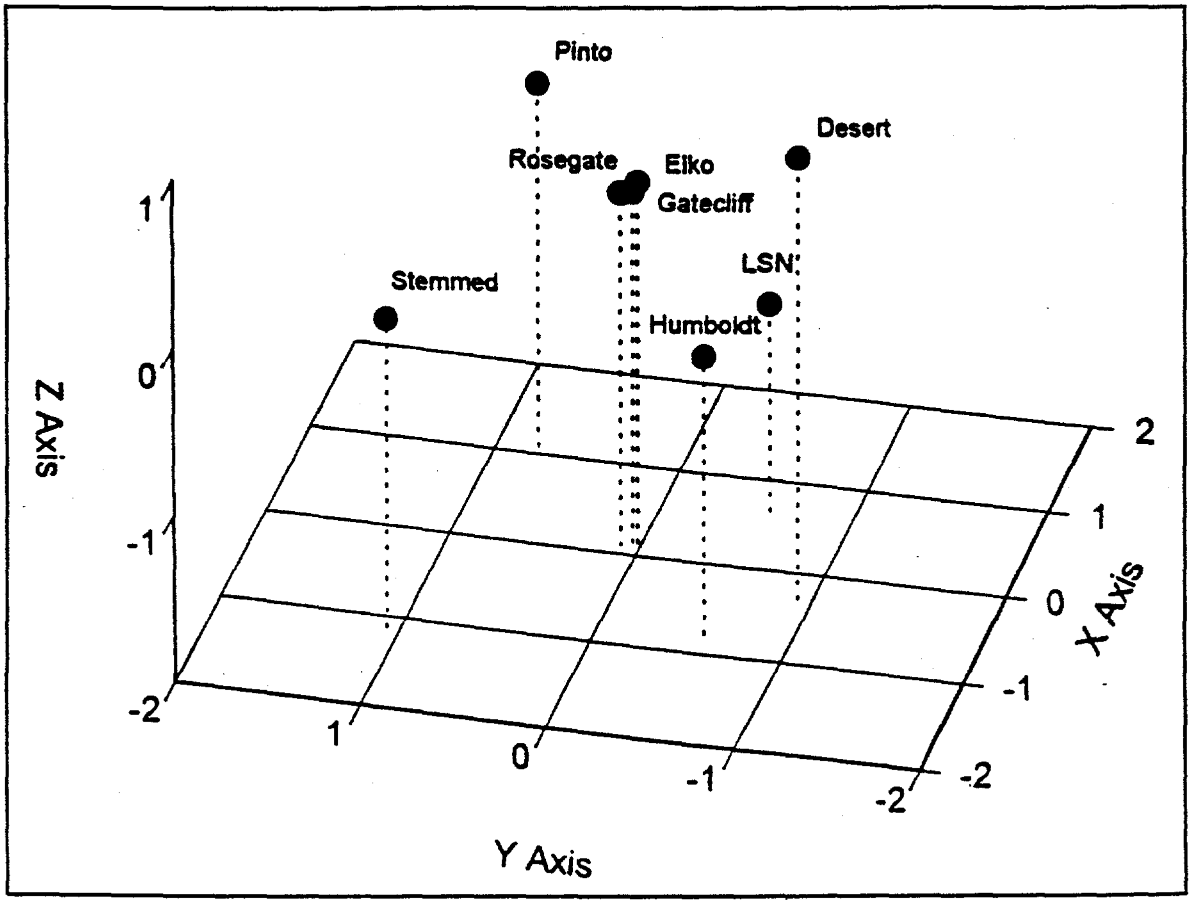

Fig. 7. Three-dimensional scatterplot of the multi-dimensional scaling for the cooccurrence of projectile points (occupational redundancy) at archaeological sites on Pahute and Rainier mesas.

Based on this analysis, it appears that Rosegate, Elko, and Gatecliff series projectile points have highly similar distributions in their cooccurrence at various sites. However, the Pinto and Large Side-notched forms, markers of the Prow Pass Period, show quite different patterns in relationship to this core and to each other. Pinto and Western-stemmed series points, on the other hand, are more similar to each other in their distribution except along the x axis where they differ greatly. Although it is difficult to interpret what each dimension represents in this analysis, the general similarity in the distribution of the Western Stemmed and Pinto projectile point forms along the y and z axes could reflect similar factors influencing the choice of localities at which prehistoric hunters and gatherers conducted their activities. This conclusion is consistent with the analysis of several researchers (Campbell and Campbell, 1935; Douglas et al., 1988; Jenkins, 1987; Jenkins and Warren, 1984; Warren, 1980, Warren and Crabtree, 1986) who have previously noted a similarity in the distribution of Pinto and Western Stemmed series points and have used this similarity to suggest temporal continuity between these point types. On the other hand, the distribution of Pinto and Western Stemmed projectile points differs more than any other series on the x axis. An examination of table 2 indicates that this may be due to the increased frequency with which the Pinto Series cooccurs with the Rosegate, Elko, and Gatecliff series. In other words, the makers of Pinto points tended to more frequently use the same localities later occupied by the makers of Rosegate, Elko, and Gatecliff series points than did the makers of Western Stemmed points. These general trends reflect important differences in the selection of site localities. An interpretation of the meaning of these trends follows.

Assemblage Diversity

Prior to getting to specifics, however, there is an additional trend that should be considered: how artifact assemblages may have changed through time in their content and diversity. This is important for inferring what changes might have occurred in residential mobility as outlined in the above review for ethnographic hunters and gatherers. Less heterogenous assemblages may reflect more temporary, even diurnal, occupations (high mobility) at a site since the activities at those sites would be limited in both time and scope. More heterogenous assemblages would be expected to occur from long-term (low mobility) residential utilization of a site (see Thomas, 1989, fig. 9.1).

Although the concept of diversity has been around for quite some time, archaeologists have only recently attempted to rigorously define and measure it in this application (see Leonard and Jones, 1989). Recent work has clarified the distinction between measuring the richness (variety of classes) in an assemblage, the evenness in the distribution of items within these classes, and the overall heterogeneity of that assemblage (evenness and richness). Hence, although heterogeneity may seem more intuitively coterminous with the concept of diversity, it is a second order measure and dependent on both richness and evenness (Dunnell, 1989:143). In archaeological applications, the richness of an assemblage is directly tied to typologies (lumpers vs. splitters), but as long as typologies are consistent among the compared assemblages and the defined classes are mutually exclusive, this is not thought to be a problem (Thomas, 1988:382). Thomas (1983:425-430, 1989) and Jones, Grayson, and Beck (1983) have noted a strong statistical correlation between the richness of an assemblage and the size of that assemblage. This correlation apparently does not go away with typological splitting and lumping (Thomas, 1988:382). However, Dunnell (1989:146) noted that assemblages that represent diverse activities or longer spans of accumulation may simply be larger by their very nature; and this correlation actually could be due to cultural and natural processes. In other words, just because there is a statistical correlation between sample size and richness does not render this measure meaningless. It does mean, however, that in our statistical representation of diversity, graphs comparing richness to sample size may not be very useful.[38]

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38 See Thomas (1989) for an extended discussion of some solutions to this problem.

Evenness in the distribution of items within a classificatory scheme is also greatly affected by decisions made by the archaeologist. All the statistics that have been devised for measuring diversity in ecological populations assume that the classes (species) are mutually exclusive and equal in nature (i.e., the researcher is not comparing species versus genera or families). But in archaeological collections, bone fragments, pottery sherds, and projectile points do not reflect equal kinds of things or activities and are definitely not the same as biological species in a population. Because evenness measures the distribution of items within classes, it makes a significant difference how we treat such things as differential fragmentation and typological grouping in artifact assemblages, i.e., whether or not we count pottery sherds or pots, beads or necklaces, etc. (see Grayson, 1984:179; Thomas, 1988:383; Rindos, 1989:14). Populations with a large number of items within any one class will be calculated as being less diverse than populations with equal numbers of items in each class even though that increase in items may actually reflect more diverse activities at a site.

Several conventions were followed in order to evaluate and minimize the effect of artifact classification and fragmentation for the analysis of artifact diversity in the assemblages at sites on Pahute and Rainier mesas. First, the problem with fragmented pottery was addressed by considering pottery as the estimated minimum number of vessels (MNV) rather than as sherds.[39] The same approach was used for broken millingstones. It was more difficult, however, to devise any realistic measure of the number of beads or pendants that might be representative of a single necklace or the number of debitage pieces that may have resulted from the knapping of a single artifact. Since beads and pendants were not very common in the archaeological record, it was assumed that each spatial association of these artifacts represented a single item. Hence, if two, or even hundreds of, beads were found together at one spot they were tallied as representing only one artifact. Debitage, on the other hand, was usually the most common component of archaeological assemblages and this spatial approach did not work due to the difficulty in defining defendable spatial limits around diffuse scatters. However, in this case, it was assumed that the more toolstone types represented at a site and the greater the relative number of specimens within each of these types, the more diverse the assemblage. This distinction would be particularly applicable in assessing differences between residential sites and those used for limited activities.

Three major types of knappable toolstone occur on and in the region around Pahute and Rainier mesas: an off-white (pinkish to yellowish) to translucent silicified volcanic, obsidian, and a host of multicolored jaspers, cherts, and silicified volcanics. The off-white silicified volcanics occur directly on the mesas and represent the most accessible but lowest quality toolstone type. Geochemical analyses have identified four major sources of obsidian (Split Ridge, Silent Canyon, Obsidian Butte, and Fortymile/Topopah Washes) that lie directly around the mesas, primarily to the west and south (Pippin, 1995, fig. 11). Finally, the multicolored jaspers, cherts, and silicified volcanics occur throughout the general region, but mainly to the north and east and not on the mesas.

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[39] This requires refitting or detailed typological analyses but is preferable to simply using an arbitrary number to reduce sherd counts (see Lockett and Pippin, 1990; Thomas, 1988:384).

Hence, we could typologically split the debitage into these three classes and thereby measure the diversity in obtaining toolstone for tool manufacture. We could then standardize these numbers but retain the diversity inherent in the collections by calculating the percentage of each class to the total debitage assemblage. But it is unclear how this approach might compare with estimates of assemblage diversity based on counting whole artifacts. Consequently, following Thomas' lead (1988:384), it was prudent to calculate multiple diversity measures with and without consideration of debitage to assess this effect of this convention.

In selecting the population from which to make our calculations, the high frequency of occupational redundance on the mesas also presented a problem. Again consider 26Ny1408 and 26Ny3121. Although we could make the argument that the entire artifact assemblage at 26Ny3121 was earlier than that at 26Ny1408, we really have no way of knowing which portions of those assemblages belong to which periods. During one period, the site may have been used under an adaptive strategy that was in direct contrast to its use during other periods. Hence, the assemblages that we need to sample are only those which we have some reason to believe represent the same general types of adaptive strategies. For this analysis then, only those sites which were assigned to a single period (single component) were considered. This approach still left between 35% and 52% of the sites for each period that could be used for the caluculations.

Table 3 presents the character of the artifact assemblages at these sites. Again the counting of debitage presented a challenge. Although the site records contain a fairly thorough documentation of the types and numbers of other artifacts and features at a site, debitage density and proportions were characteristically recorded from a sample, usually placed in the densest concentrations of debitage at the site. For some sites, however, the record simply noted debitage as being present and, at other sites, the record only estimated debitage density without sampling. The debitage data presented in table 3 reflect only those assemblages that were adequately recorded either through samples or total debitage counts. Hence, they do not accurately reflect the total quantity of debitage found at sites in any one particular period. However, they probably do accurately reflect the proportions of the three debitage toolstone categories found at those sites and that is the data that is most applicable to estimates of heterogeneity. The other artifact categories are fairly straightforward.

Heterogeneity was measured using the Simpson's (1949) concentration index of $C = \sum_j \{n_j (n_j \;\; 1)\} / \{N(N \;\; 1)\}$ where $n_1, n_2 \ldots n_j$ represent the number of items within each class and N is the total number of items in the data set. This concentration index was then converted to an index of diversity by rescaling using $D = \;\; \log C$ (Pielou, 1975). Although other measures of heterogeneity are available, previous experience (Pippin, 1996) indicates that the Simpson's index tends to work best in comparing censused collections at sites of known function on the mesas and is not as affected by sample sizes as the other measurements (see Rindos, 1989:16-18). This index was calculated using three data sets: the raw numbers of all artifacts including debitage, the raw numbers of all artifacts excluding debitage, and the raw numbers of all artifacts other than debitage plus the percentage of debitage.

Table 3
Character of Artifact Assemblages Recorded at Single Component (Period) Archaeological Sites on Pahute and Rainier Mesas

Assemblage Composition	Barren Wash	Prow Pass	Dead Horse Flat	Pahute Mesa	Rainier Mesa	Silent Canyon
Number (%) of Sites	11 (52)	16 (35)	37 (44)	74 (46)	70 (47)	77 (47)
Area (m^2)	14,066	79,353	315,488	659,266	376,263	463,101
Total Items	156	742	2,016	13,476	2,872	1,930
Total Classes (richness)	5	10	12	13	13	16
Density (artifacts/m^2)	0.011	0.009	0.006	0.020	0.008	0.004
- log Simpson's C (all)	*0.190*	*0.366*	*0.314*	*0.216*	*0.244*	*0.496*
- log Simpson's C (w/o deb)	*0.157*	*0.576*	*0.724*	*0.777*	*0.710*	*0.894*
- log Simpson's C (w/% deb)	*0.218*	*0.609*	*0.777*	*0.878*	*0.806*	*0.996*
Obsidian debitage (%)	124 (86)	234 (34)	590 (31)	2769 (21)	449 (17)	439 (28)
Local volcanic debitage (%)	16 (11)	425 (61)	1274 (67)	10,138 (77)	2119 (80)	981 (63)
Other debitage (%)	4 (3)	34 (5)	32 (2)	253 (2)	82 (3)	128 (8)
Projectile points	10	18	38	74	65	29
Milling equipments[a]	-	1	24	42	18	64
Utilized flakes	-	1	3	9	4	10
Flaked stone tools	-	3	3	17	10	22
Early Stage Bifaces	-	9	22	50	32	28
Late Stage Bifaces	2	16	14	83	61	67
Cores	-	1	8	15	7	21
Pecked / Pounded Stone	-	-	3	8	-	9
Anasazi/Fremont Pottery[a]	-	-	-	-	6	6
Brownware Pottery[a]	-	-	-	-	-	65
Ornaments	-	-	-	1	2	2
Petroglyphs	-	-	-	-	-	1
Facilities	-	-	5	27	17	58

[a] Estimated minimum number of implements (vessels, manos, millingstones, etc.); all = all items; w/o deb = without debitage; w/% deb = with percentages of debitage.

Figure 8 plots the Simpson's C concentration statistic rescaled to the -log for all three data sets. It is obvious that the inclusion of debitage in the calculations greatly affects the measure of heterogeneity: those periods which contain large samples of debitage are indicated as less diverse than those with small samples. However when the percentages of debitage toolstone types are used, the plot closely, but not precisely, parallels that excluding consideration of debitage. It is this measure of heterogeneity, then, that will be used in estimating the diversity of artifact assemblages at single component sites on the mesas.

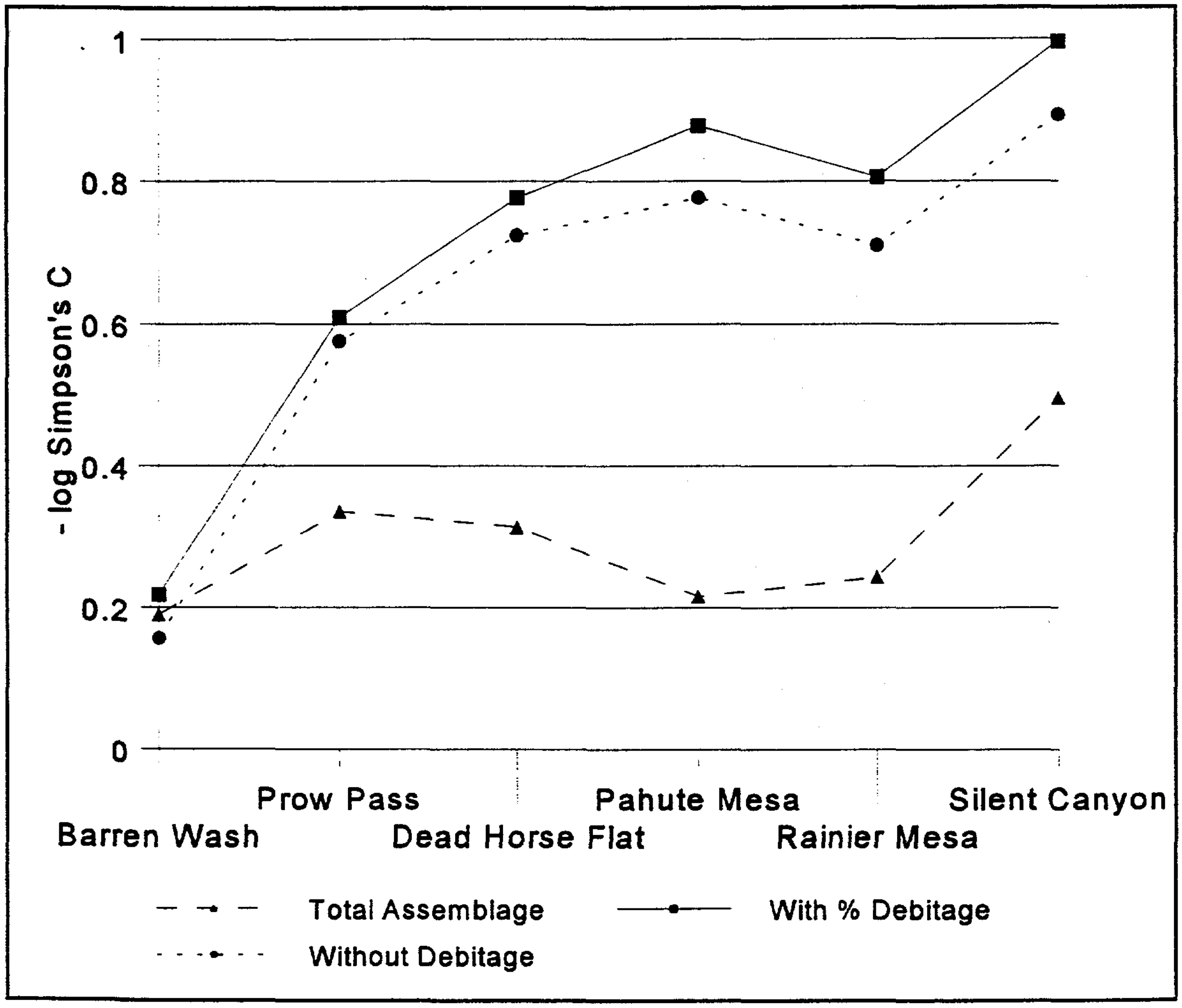

Fig. 8. Graph of the -log of Simpson's (1949) index of concentration (C) of artifact assemblages at single component archaeological sites on Pahute and Rainier mesas (see Table 3).

Topographic Setting

Finally, since we are interested in measuring differences in land use patterns through time, the topographic setting of the sites within our survey data set should be considered. Problems were initially encountered with recording consistency despite the rigidly defined landform categories presented in Reno (1989). This was undoubtedly due to both differences in the geomorphology training of field personnel and differences in perception. Hence, what was perceived as a "valley side" by one individual was also observed to be the "base of bench" by another. In order to rectify this situation, map plots for each site in the data set were examined, and the topographic settings were recoded following the categories presented in table 4. Two main topographic settings were considered to be available on the top of the plateau: bedrock benches and the intervening valleys. Sites were then coded based on their position in relation to the steep edges of the step-faulted benches

Table 4
Frequency in the Utilization of Landforms for the Placement of Activities on Pahute and Rainier Mesas

Landform	BW # (%)	PP # (%)	DHF # (%)	PM # (%)	RM # (%)	SC # (%)
Bench						
Edge (above)						
Drainage Head	4 (19)	10 (22)	4 (5)	6 (4)	14(9)	11 (7)
Valley Edge	-	8 (17)	3 (4)	5 (3)	6 (4)	6 (4)
Canyon Edge	3 (14)	3 (7)	-	1 (1)	1(1)	1 (1)
Side (off top)	-	-	-	3 (2)	7 (5)	10 (6)
Interior						
Flat	3 (14)	3 (7)	19 (23)	29 (18)	26 (17)	32 (19)
Rise (Ridge, Knoll, etc.)	2 (10)	3 (7)	12 (14)	33 (20)	32 (21)	22 (13)
Saddle	-	2 (4)	3 (4)	11 (7)	7 (5)	16 (10)
Drainage Head	2 (10)	-	4 (5)	6 (4)	3 (2)	4 (2)
Drainage Margin	-	-	2 (2)	3 (2)	5 (3)	4 (2)
Valley						
Broad						
Bottom	-	-	20 (24)	24 (14)	23 (15)	18 (11)
Side	2 (10)	7 (15)	14 (17)	25 (15)	14 (9)	23 (14)
Head	1 (5)	1 (2)	1 (1)	6 (4)	2 (1)	4 (2)
Mouth	1 (5)	-	-	1 (1)	-	-
Narrow						
Bottom/Edge	-	3 (7)	1 (1)	8 (5)	4 (3)	7 (4)
Head	1 (5)	2 (4)	-	-	-	-
Mouth	-	1 (2)	-	-	1(1)	-
Off Mesa Edge						
Canyon/Valley						
Bottom	-	-	-	-	4 (3)	1 (1)
Edge	1 (5)	-	-	-	2 (1)	2 (1)
Head	-	1 (2)	-	1 (1)	-	
Mouth	-	-	-	-	-	
Bajada	1 (5)	2 (4)	-	3 (2)	-	3 (2)
Ridge/Cliff	-	-	-	-	-	2 (1)
number of sites	21	46	83	165	152	166
-log Simpson's C	*1.000*	*0.904*	*0.791*	*0.866*	*0.914*	*0.953*

Period[a] spans BW–RM columns.

[a] BW = Barren Wash; PP = Prow Pass; DHF = Dead Horse Flat; PM = Pahute Mesa; RM = Rainier Mesa; SC = Silent Canyon.

and the major geomorphic feature below those edges (broad valley, narrow canyon, or drainage head). Bench interiors often contained other features such as rounded knolls, lineal ridges, and drainages; and sites were also coded based on their positioning on these landforms. The remaining categories in Table 4 should be self-explanatory.

A plot of the frequency at which the archaeological sites occur on these various landforms indicates a relatively wide diversity of landform use for each chronological period (fig. 9), and Simpson's C concentration statistic rescaled to the -log confirms this notion (see able 4). However, there appears to be two important exceptions to this generalization. First, bench edge environments, particularly those next to drainage heads and canyons, were more frequently used during the Barren Wash and Prow Pass periods than during other periods. Conversely, bench interior and valley environments tended to be more frequently used during the Dead Horse Flat and later periods. In fact, this shift seems to have resulted in a reduction in the diversity of exploited environments during the Dead Horse Flat and Pahute Mesa periods (table 4). Likewise, saddle and bench side environments, although never very commonly exploited, tended to be more frequently used during the later periods.

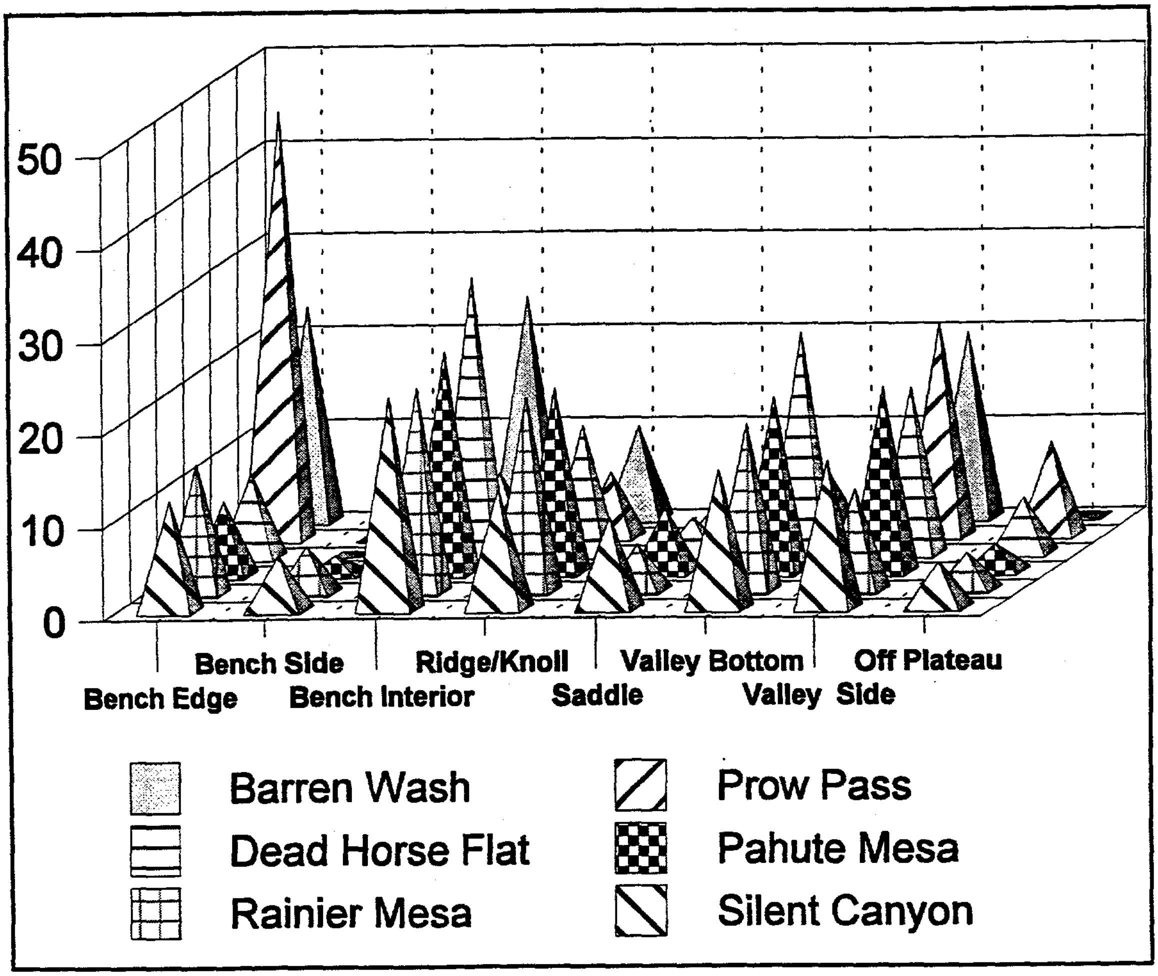

Figure 9. Plot of the frequency (percent) of landform use during each chronological period on Pahute and Rainier mesas.

Thomas (1988:569-577) found that aspect clearly conditioned the positioning of archaeological sites in the central Great Basin where, depending on both the nature of the site (rockshelter vs. structure) and elevation, site locales tended to be south or east facing in order to maximize solar gain. Figure 10 plots the frequency of aspect for archaeological sites on Pahute and Rainier mesas for each chronological period. Although northern aspects (316° to 45°) appear to be quite commonly exploited during all periods and all aspects appear to be represented, there is some variability between periods. To be sure, southwestern aspects were quite frequently used during the latest Silent Canyon Period and the earliest Barren Wash Period. Slightly more southeast facing exposures were also frequently used during the Dead Horse Flat, Pahute Mesa, and Rainier Mesa periods. However, the curve for the Prow Pass Period assumes a pattern sightly different from those of the other periods with a clear focus toward eastern and northeastern exposures rather than southern or western exposures. This variability makes some sense in regard to the postulated climates during these periods and lends support to the chronology depicted in figure 5. Hence, climates were apparently cooler during the early Holocene and Little Ice Age of the late Holocene, and the trend toward southeastern exposures following the middle Holocene also makes sense. But southern and western exposures would not be favorable during the warmer middle Holocene (Prow Pass Period).

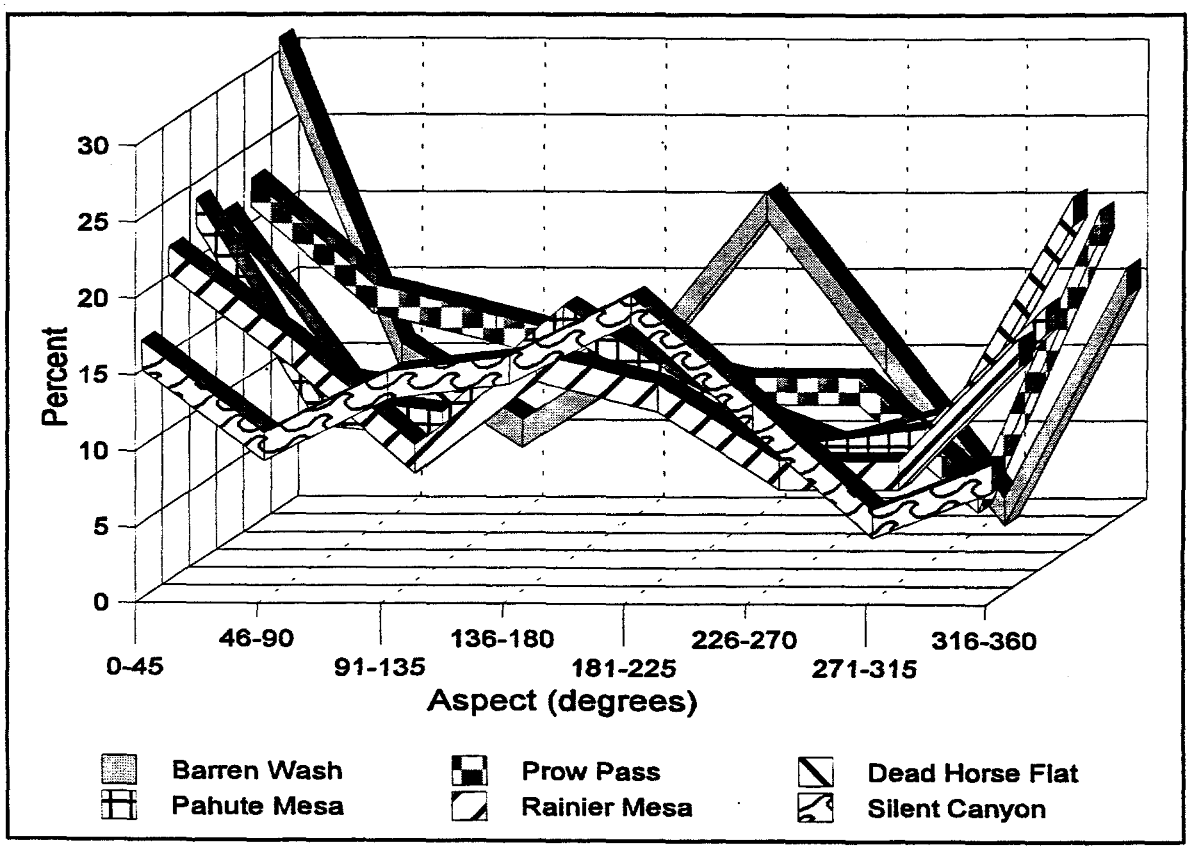

Figure 10. Line graphs displaying the frequency of the aspect (exposure) of archaeological sites on Pahute and Rainier mesas during each chronological period.

Armed with these general trends in the data set from archaeological sites on Pahute and Rainier mesas, specific changes in those sites through time can be examined.

The Rattlesnake Ridge Period (11,500 to 10,600 B.P.)

Three Clovis points, indicators of the Rattlesnake Ridge Period, have been found at archaeological sites around Pahute and Rainier mesas and indicate that people were in this region between approximately 11,500 and 10,600 years ago (Pippin, 1995:51-53). One of these was found at site 26Ny8062 on an eroded colluvial slope at approximately 1760 m in elevation near the base of Rainier Mesa. Worman (1969) reported another from the McKinnis Site (26Ny218) situated at an elevation of approximately 1600 m on the eastern flank of Timber Mountain above Fortymile Canyon. Finally, Reno (1985) and Reno et al. (1989:51) describes a third from a site (26NY3193) on an alluvial terrace of Fortymile Wash due east of Yucca Mountain at an elevation of 1027 m. All three of these specimens were found on the surface in areas containing numerous other projectile points belonging to the Barren Wash and early Prow Pass periods. It is unclear whether or not the Clovis points were left by their manufacturers or scavenged by later peoples. Warren and Phagan (1988) reported a similar situation in the Mojave Desert to the south where Clovis points are typically found in assemblages dominated by Western Stemmed Series points (also see Basgall and Hall, 1991, 1994). Other tool forms that are commonly associated with Clovis projectile points -- such as steeply retouched blades, blade cores, gravers, and burins (Stanford, 1991:1-6; Willig, 1991) -- are lacking or are rare from these sites; and this observation may support the scavenged hypothesis (Warren and Phagan, 1988).

That people were in the area around Pahute and Rainier mesas during the Rattlesnake Ridge Period, however, is well demonstrated by cultural remains dated between 10,000 and 11,000 B.P. at Tule Springs (Shutler, 1967) and by other Clovis points found throughout the Great Basin (Davis and Shutler, 1969; Grayson, 1993:236-238; Tuohy, 1985, 1986, 1988). The perspective that these hunters and gatherers of the Rattlesnake Ridge Period relied solely on large game (now extinct) was derived primarily from comparisons with the "Paleoindians" of the American Southwest and Rocky Mountains piedmont, but this theory has largely been discounted (see Grayson, 1993:238). Despite considerable effort to find associations between Clovis remains and extinct fauna anywhere in the Great Basin, no unquestionable associations have been found. Perhaps this is because of limited data, as Grayson (1993:238) suggested, or perhaps because many of the Pleistocene fauna were already extinct by the time the makers of the Clovis point arrived in the Great Basin (see Jennings, 1986:115-116). Grayson (1993:238) pointed out that, although the subsistence base for these people is undetermined, the association between their remains and highly productive bodies of shallow water is clear; and whatever resources they were using probably occurred there (see Willig, 1991). Grayson (1993) felt that if fluted point makers had been heavily involved in the hunting of megafauna, the distribution of their points would not be this restricted. Furthermore, he argued that the subalpine woodlands that occupied the highlands such as Pahute and Rainier mesas during the terminal Pleistocene would have been relatively unproductive, particularly in comparison to the rich marshes, meadows, and savannahs of the lower elevations. Why not use the lower cost, more productive resources of the lowlands? Such a pattern would have made "good ecological sense" (Grayson, 1993:238).

The previous review of the variability exhibited by ethnographic hunters and gatherers indicated two alternative trends that may be important in interpreting the subsistence patterns of these Rattlesnake Ridge adaptations. First, based on this data, we might expect an emphasis on hunting and fishing with reduced effective temperatures around Pahute and Rainier mesas during the terminal Pleistocene, even during periods of white fir expansion. Hence, optimal foraging studies indicate that the hunting of large game, especially in cold climates, may be much more cost efficient (adaptive) than the exploitation of plant resources (Hawkes et al., 1982; Hill and Hawkes, 1983; Simms, 1984). The concentrated exploitation of fish during the Rattlesnake Ridge Period may have required technologies that were not yet available. Conversely, with the preponderance of lakes, ponds, and marshes around the mesas at this time, we might expect the use of aquatic resources which, among ethnographic populations, tended to replace hunting more than gathering in colder environments. But before concluding that the mighty mammoth hunters of the American Southwest and Rocky Mountain piedmont were fishers and gatherers of lacustrine plant resources in the Great Basin, we should consider the possibility that, like the environments to which they were adapting, there might not be any modern analogs to their subsistence patterns.

Using Guthrie's (1984) model of increased selective pressures on the large ungulate populations due to increased seasonality and assuming that Clovis were the first peoples of the New World, Kelly and Todd (1988) constructed a model envisioning a highly mobile adaptation that would have been responsive to large scale migrations of ungulates as selective pressures increased. Kelly and Todd (1988:233-234) argued that these hunters, although probably opportunists in the procurement of plant foods, may have found themselves in an environment in which they had to rely on the continuously available and widely dispersed faunal resources that were dying or moving in response to climatic change. Because these were the first peoples in the region, emigration would have been easy; and because the resource geography would have been poorly known for each new region occupied, reliance on the already known faunal resources would have continued despite their reducing numbers.

The scattered Clovis points around Pahute and Rainier mesas could well represent summer hunting localities. After all, they do represent implements used in hunting. Large game -- particularly the elk, sheep, antelope, and bison that survived the terminal Pleistocene -- also would have avoided the snow-laden, closed-canopy forest of limber pine and white fir on the mesas most of the year and probably would have been more common in the more open juniper/sagebrush savannas around the base of the mesas (as they are today). Deer and the smaller montane mammals may not have had such a restricted distribution; but in comparison to the larger, more easily procured game, probably would have ranked lower as optimal resources. An adaptation like that postulated by Kelly and Todd (1988) which focused around the hunting of large game that were decreasing in density and diversity is reasonable. This subsistence focus was probably supplemented by the gathering of easily procured plant and fish resources that required little or no processing.

The association between abundant Clovis remains and now extinct bodies of water in the valley bottoms most likely reflects the fact that, during the long cold winters of the terminal Pleistocene, these valley bottom environments attracted the primary large game resources. It is possible, as observed by Willig (1991: 109-111), that the Clovis hunters tended to redundantly use these "sweet spots" and took advantage of a diversity of easily obtained resources while there. However, these "sweet spots" were fairly common around the mesas during the terminal Pleistocene; and, as argued by Kelly and Todd (1988), residential and logistical territories were probably quite large. Residential mobility, consequently, was probably not "tethered" around these sources of water as argued by Willig (1991) but instead conformed more to Binford's (1980) forager pattern where the large game were continuously available and geographically dispersed primarily below the subalpine forests. All of the Clovis points from around Pahute and Rainier mesas have been found well away from what would have been standing bodies of water during the terminal Pleistocene. This observation directly conflicts with the notion that these hunters and gatherers were tethered to large bodies of water. While it is possible, and even likely, that these points represent secondary refuse, it seems unlikely that they were transported great distances from where they were originally deposited since they were made from toolstone (white silicified volcanics) available from the region on and immediately around the mesas.

Barren Wash Period Adaptations (10,500 to 8000 B.P.)

The initial use of the mesa tops appears to have occurred during the Barren Wash Period when Western Stemmed Series projectile points were being made and discarded (fig. 6). The available evidence suggests this period probably began approximately 10,500 radiocarbon years ago (Pippin, 1995). The terminal date for the Barren Wash Period has been placed at 8000 radiocarbon years ago with the slow demise of the Western Stemmed style of projectile points. Sometime before this, there appears to have been an overlap in the styles of projectile points used by aboriginal peoples, and this overlap is taken to mark a transition period (see Pippin, 1995, figs. 26 and 27). That prehistoric peoples were consistently using the mesas by at least 8000 B.P., and probably earlier, is amply illustrated by the significant number (28) of Barren Wash Period points recovered from 20 separate archaeological sites on the mesas and one site (26Ny4892) directly below them (table 5, fig. 11).

Table 5
Barren Wash Period Archaeological Sites Found on Pahute and Rainier Mesas

Site Number	Elev. (m)	Area (m^2)	Density / m^2	Site Type	Topographic Setting
Is101992RJ2[a]	2200	1	1.00	Isolate	Alluvial fan in Kawich Canyon
26Ny965	1829	2827	Unknown	Lithic scatter	Ridge top overlooking canyon
26Ny1046	2030	12,566	Unknown	Lithic scatter	Drainage head on bench prominence
26Ny3172[a]	1871	7854	0.12	Lithic scatter	Ridge edge near drainage head
26Ny3391	2033	31,416	0.023	Lithic scatter	Ridge top near drainage head

Table 5
Barren Wash Period Archaeological Sites Found on Pahute and Rainier Mesas (Continued)

Site Number	Elev. (m)	Area (m^2)	Density / m^2	Site Type	Topographic Setting
26Ny3624	2027	38,700	0.001	Quarry	Shallow valley between benches
26Ny4139[a]	2062	1	1.00	Isolate	Drainage on bench top
26Ny4203	2085	33,929	0.082	Lithic scatter	Bench top overlooking drainage
26Ny4588	2066	117,810	0.310	Lithic scatter	Interior of bench top
26Ny4858[ab]	1960	1	1.00	Isolate	Bench edge above major drainage
26Ny4869	2008	153,742	0.018	Lithic scatter	Bench top near drainage head
26Ny4871[ab]	1996	1	1.00	Isolate	Shallow valley at base of ridge
26Ny4892[b]	1665	Unknown	Unknown	Quarry	Alluvial bajada below Pahute Mesa
26Ny4998[a]	2018	2827	0.006	Knapping station	Bench top at head of drainage
26Ny5007[a]	1899	1	1.00	Isolate	Interior of bench top
26Ny5207	1998	2121	11.5	Quarry	Valley edge near head of drainage
26Ny5468	2259	8954	0.005	Lithic scatter	Bench top on Rainier Mesa
26Ny5524[a]	1945	1	1.00	Isolate	Side of knoll on bench interior
26Ny5560[a]	1881	1	1.00	Isolate	Ridge top
26Ny8250[a]	1942	79	0.127	Knapping station	Toe of fan in Kawich Canyon
26Ny8264[a]	1774	3299	0.006	Lithic scatter	Fan at mouth of Kawich Canyon

[a] = Single component sites used in table 3.
[b] = Recorded as a subdivision of a larger site.

Seven of these sites consist simply of isolated Western Stemmed Series projectile points found at least 200 m from the nearest artifact, and another two sites appear to represent localities where limited knapping episodes accompanied the deposition of the point in the archaeological record.[40] These nine sites, therefore, appear to represent separate, single-episode, resource extraction activities on the mesas. The remaining ten sites require further discussion in regard to their meaning for Barren Wash Period adaptations.

Nine of the sites in table 5 are listed as lithic scatters with Barren Wash diagnostics. Two also contain quarry areas for locally available silicified volcanic toolstone (which two?), and one (26Ny4892) is an obsidian quarry.[41] A closer examination of the spatial distributions of the Western Stemmed Series points at six of these sites (26Ny1046, 26Ny3624, 26Ny4203, 26Ny4588,

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[40] Knapping stations are defined as consisting only of debitage derived from the same core based on characteristics of the raw material. Refitting and/or geochemical analyses which would confirm this classification have not been conducted at these sites.

[41] The term quarry only refers to the source area for toolstone and does not imply any technology associated with its exploitation (see Jones, DuBarton and Holz, 1995:25).

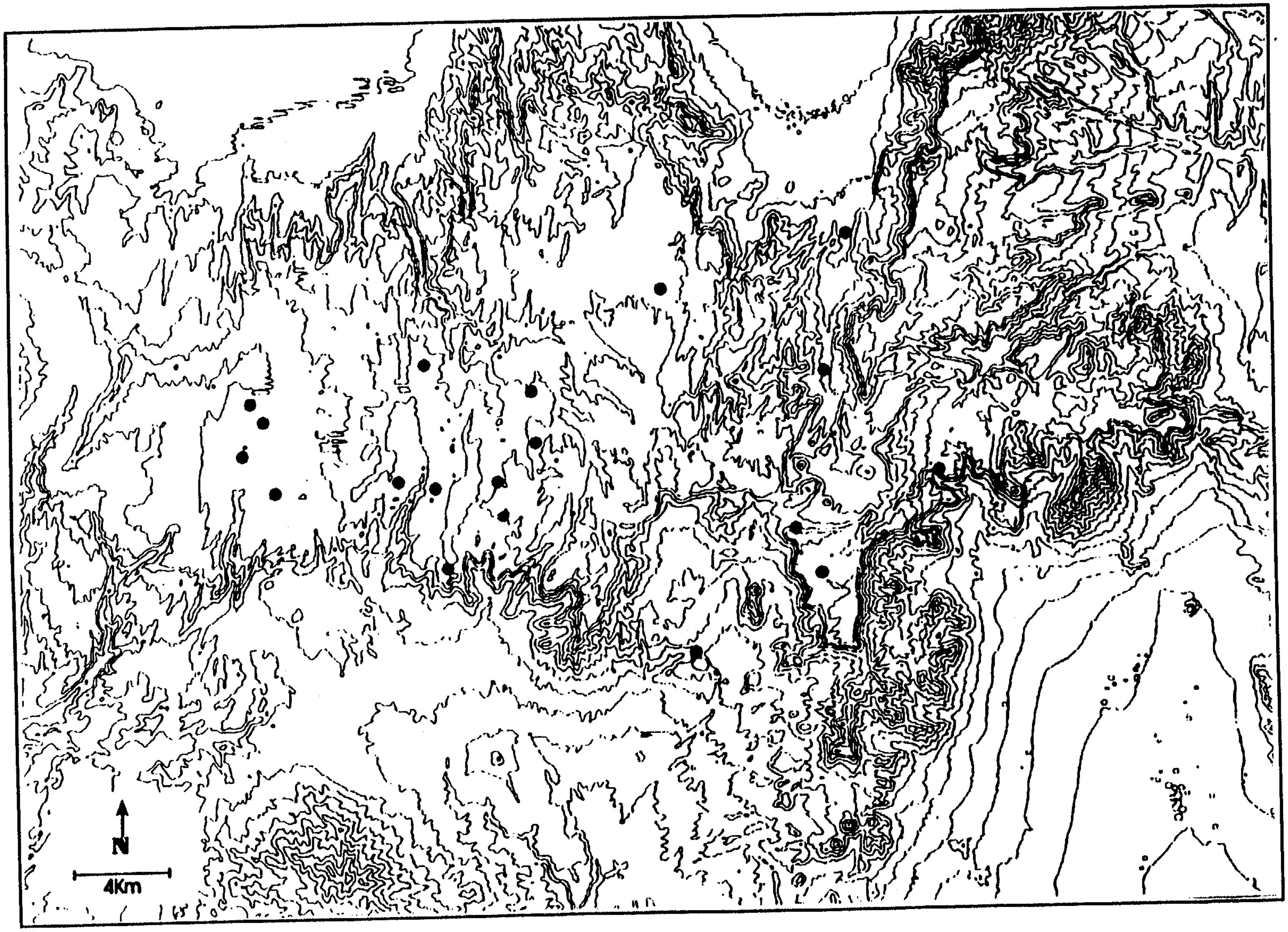

Fig. 11. Map showing the distribution of Barren Wash Period archaeological sites on Pahute and Rainier mesas (see Fig. 2 for geographic labels).

26Ny4869 and 26Ny5468), however, reveals that those projectile points may have been deposited at the sites as isolates prior to the lithic scatters. The three Silver Lake points found at 26Ny4869, for example, were all found near the edge of that extensive scatter and were positioned between 1200 and 1600 m apart. Other diagnostics found more directly in the lithic scatter indicate continued use of this locality through the Prow Pass and Dead Horse Flat periods with intensive use during the Pahute and Rainier Mesa periods (Hicks et al., 1991). Likewise, the two Silver Lake style points found at 26Ny4203 were approximately 150 m apart; and other, more common diagnostics indicate this locality was frequently used from the Prow Pass through the Pahute Mesa periods (Amick, 1992). The three Silver Lake Series points found at 26Ny3624 were situated approximately 170 m from the toolstone quarry on the site; and the extensive, but diffuse, lithic scatter associated with this quarry contained numerous diagnostics of the Dead Horse Flat, Pahute Mesa, and Rainier Mesa periods (Drollinger, 1993). Rainier and Silent Canyon period diagnostics were common in the small lithic scatter at 26NY1046 which contained the Large Straight Stemmed point, and the lithic scatter at that site also probably dates to a later time. Pippin et al. (1992:123) noted that the Lake Mojave point at 26Ny4588 was isolated from other remains and that the Silver Lake point at that site occurred in a lithic scatter that probably dated to the Pahute Mesa and Rainier Mesa periods. Finally, the Silver Lake style point at 26Ny5468, the highest elevational occurrence of this style on the mesas, was found on the edge of lithic scatter containing a mano, two millingstones, a drill, and several bifaces. Five rock ring features, interpreted to be pinyon caches, occur within 50 m of this lithic scatter; and, although no other temporally diagnostic artifacts were found, this scatter was probably associated with the use of the caches during a period later than the early Holocene when pinyon was either absent or rare on the mesas.

Interpreting the association of the Western Stemmed Series points with the lithic scatters at the remaining five sites on Pahute and Rainier is more difficult. There is simply not enough known about the remains at 26Ny965 to make any supportable judgments. The two Silver Lake style points at 26Ny3391 were found with a diffuse scatter of debitage, several bifaces, four indeterminate projectile point fragments, and a Gatecliff Series point between two more definable concentrations of debitage (Klimowicz et al., 1992).[42] Although Dead Horse Flat, Pahute Mesa and Rainier Mesa period diagnostics were found in the more definable lithic concentrations, it is quite possible that some of the remains in these concentrations could belong to the Barren Wash period. The Silver Lake style point at 26Ny3172 was the only diagnostic found in a diffuse scatter of obsidian debitage from bifacial reduction (Pippin et al., 1987). The Silver Lake style point found at 26Ny5207 was the only diagnostic found directly within the silicified volcanic quarry on the site; however, extensive camp sites dating to the Dead Horse Flat and Pahute Mesa periods occur along a small cliff face 40 to 100 m to the east, and the quarry was probably most heavily used during that time (Simmons, 1990:99-139). The occurrence of the Barren Wash Period diagnostic at this quarry, as well as at 26Ny3624 mentioned above, could indicate these hunters and gatherers were also exploiting the quarries during the early Holocene; but table 3 indicates that obsidian comprised the bulk (86 percent) of the debitage at single component Barren Wash Period sites and, if so, this

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[42] These points were misclassified as Elko Series in the report (Klimowicz et al., 1992, fig. 9i).

exploitation was minimal. Finally, the Silver Lake style point found at the mouth of Kawich Canyon (26Ny8264) was the only diagnostic found in this diffuse scatter of approximately twenty pieces of debitage and a biface.

Previous views of the adaptive strategies followed by the peoples from the Barren Wash Period envision four possible subsistence patterns: (1) the specialized hunting of now extinct large game throughout the seasonal cycle, (2) the generalized hunting of a variety of large and small game, (3) a specialized adaptation to lacustrine resources throughout the seasonal cycle, and (4) a generalized utilization of both marsh and other plant resources and the seasonal hunting of both small and large game. All these perspectives, when specified, generally envision mobility strategies involving low population densities and highly mobile groups that are, in Binford's terms, mapped onto their environment (foragers/travelers). Two of the views -- that the hunters and gatherers of the Barren Wash period specialized in the hunting of now extinct megafauna and that they specialized in the exploitation of lacustrine resources -- must be discarded.[43] The now extinct late Pleistocene megamammals of the Great Basin were simply not contemporaneous with the makers of the Western Stemmed projectile points (Willig and Aikens, 1988; Grayson, 1993, tables 7-2, 7-4; Pippin, 1995). Furthermore, data from Last Supper Cave (Parmalee, 1988:75-76), Buffalo Flat (Oetting, 1993), the Old Humboldt site (Dansie, 1987), Spirit Cave (Wigand, personal comm.), and Fort Irwin (Basgall and Hall, 1994; Douglas et al., 1988) indicate that these early peoples exploited a fairly wide range of faunal resources including freshwater mollusks, fish, artiodactyla, rabbits, hares, small rodents, and lizards. Likewise, the early views that these cultural manifestations lacked equipment (mano and millingstones) to process plant remains also appears to be vanishing as data accumulates (see Aikens, 1993:13-83; Basgall, 1994; Basgall and Hall, 1994; Grayson, 1993:273).

Grayson (1993:243) envisioned a broadening, not a complete shift, from a generalized resource base building out of the earlier more lacustrine (or at least valley based) subsistence pattern (also see Amick, 1993). This scenario is somewhat similar to that originally envisioned by Davis (1978) who felt that these early adaptations reflected a generalized hunting and collection economy in which the lakeside sites represented a "marsh orientation" only during a portion of the seasonal round (also see Elston, 1986:137). Warren (1967) had earlier postulated that the makers of Western Stemmed projectile points followed a more generalized hunting adaptation. This paper previously questioned the notion that the earlier Clovis hunters were reliant on marsh resources other than opportunistic exploitation, suggesting instead that subsistence efforts were focused on the game attracted to those environments. Given this base, Grayson's (1993:243) scenario of a broadening subsistence base for the Barren Wash hunters is reasonable. Although diminished in size and extent, the ponds and marshes of the lowlands around Pahute and Rainier mesas remained until

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43 Also see Madsen (1982) and Janetski (1986).

approximately 9000 years ago and probably continued to attract a variety of large and small game animals.[44] But how did the mesas fit within the subsistence activities of the Barren Wash hunters?

At this time, as reconstructed above, the mesas were probably still covered with scattered remnant populations of limber pine in an otherwise developing juniper woodland. Patches of white fir may also have been present. Oaks were not present; and pinyon, although in the region, was not a significant resource nor very widely distributed. The woodlands that still extended down to elevations around 1225 m (4000 ft) were gradually retreating upward and apparently formed patchy savannas at these lower elevations. The understory was composed primarily of big sagebrush, joint-fir, mountain mahogany and purple sage; but other cold desert shrubs also may have been present Although prickly pears and a few annuals may have provided plant foods on the mesas, this environment was probably much more homogeneous than today.

If the Barren Wash hunters and gatherers utilized a variety of large and small animal resources on the mesas, their settlement patterns might be expected to reflect a strategy of high residential mobility (forager/traveler) with activities to be positioned in a variety of environments reflecting the immediate, opportunistic exploitation of several different game resources. Concomitantly, the lithic assemblages associated with these sites would then reflect an intrasite diversity of task-specific tools with an intersite homogeneity of these types of tools. On the other hand, if the mesas were utilized by these peoples primarily to exploit only larger game animals as postulated by Warren (1967), then these short-term camps would tend to be loosely tethered to environments along which these mobile animals congregated or moved (i.e., drainage heads and other movement-constricting environments); and the lithic assemblages associated with these sites would be rather homogeneous within each site. Localities under both schemes would reflect the opportunistic exploitation of resources with little occupational redundancy of sites. However, Binford has (1991:281-282) suggested that hunters armed only with thrusting spears might have followed a "windfall" hunting strategy in which success depended on conditions that naturally disadvantaged the prey (snow cover, water crossing, topographic constriction, panicked behavior, etc.) and we might expect that localities associated with the hunting of only large game to be concentrated in environments that offered such unusual opportunities to exploit these specific resources.

A review of the topographic positioning of Barren Wash Period sites on the mesas (table 4; fig. 9) indicates a very wide diversity in exploited environments that may lead to the conclusion that a variety of resources might have been exploited. However, many of these sites are positioned overlooking or around the heads of major drainages that would have been natural routes of travel for large game (tables 4 and 5, fig. 9). The two sites (26Ny3624 and 26Ny5207) at toolstone quarries clearly do not fit this pattern nor do the supposedly isolated points at 26Ny4139, 26Ny4588,

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44 The tule mat and basketry associated with mummy from Spirit Cave (Amy Dansie, personnel commun.) clearly indicates that these early hunters utilized marsh plants for their artifacts and probably for some food; but their overall subsistence strategy was still probably focused on game (also see Basgall and Hall, 1994).

26Ny4871, 26Ny5007, 26Ny5468, 26Ny5524, and 26NY5567. Yet, this diversity in topographic setting could simply reflect the fact that large game are quite mobile resources that could be opportunistically taken in almost any topographic setting. It is important to note that all of the Barren Wash Period sites on the mesas lack great diversity in their artifact assemblage (able 3, fig. 8): the crescents, steep-edged scrapers, gravers, and other artifacts that are typically illustrated to accompany the Western Stemmed points at lower elevations are absent (see Basgall, 1994; Bryan, 1979, fig. 6; Elston, 1986, fig. 3; Fagan, 1988, figs. 8, 9; Hutchinson, 1988, figs. 4, 5; Warren and Crabtree, 1986, fig. 2). This is true even if the remains from the six sites at the extensive lithic scatters are not considered to be isolates. In fact, the only artifacts which appear to accompany the Western Stemmed points on the mesas appear to be debitage and an occasional biface.[45] This implies that the activities conducted at these sites were limited, probably uniform, and most likely focused on the hunting of large game that tended to traverse the tree-covered drainage bottoms or sides. Elk, deer, and bighorn sheep are the only three large game species present during the early Holocene that fit this behavioral pattern (Geist, 1981; Murie, 1979:59-67, 259-265; Simmons, 1980).

The obsidian sourcing analyses of the Western Stemmed points left at these sites indicate a high frequency (69%) use of obsidian from the Fortymile/Topopah Wash sources far to the south of the mesas with the remaining 31% of the specimens made from obsidian found around Obsidian Butte on the west side of the mesas (Pippin, 1995, table 6). There is no representation of any of the locally available obsidian at the Split Ridge sources although the evidence from 26Ny4892 does indicate that the local obsidian may have been exploited at this time. Hence, unlike the massive quarries along lower Fortymile Wash that contained abundant points of the Western Stemmed Series (Haynes, 1996; Reno et al., 1989), the assemblages from 26Ny4892 contain only a few of these specimens and are dominated by points belonging to later periods (Amick, Henton, and Pippin, 1991; Jones, DuBarton, and Holz, 1995). This observation suggests that the peoples responsible for the Barren Wash Period sites on the mesas were highly mobile hunters who did not cover the territory around the mesas thoroughly enough to exploit that source very intensely (see Binford, 1983; Kelly, 1995:130-132).

Grayson (1993:242) argued that as the unproductive subalpine forests on the highlands in the Great Basin -- like Pahute and Rainier mesas -- thinned during the early Holocene, the extent of the environments utilized by the makers of Western Stemmed projectile points would have increased over earlier periods. The above data from Pahute and Rainier mesas helps to confirm this hypothesis, but Elston (1982:192) already noted that, at least in the western Great Basin, sites dating to this time were "by no means restricted to large lake basins" and Western Stemmed projectile points have been recorded as high as 2597 m (8520 ft) in elevation at Five Points in the central Great Basin (see Bryan, 1979; Elston, 1979; Elston et al., 1977, 1981; Layton, 1970, 1979; Price and Johnston, 1988; Roney, 1978; Rusco and Davis, 1979). Grayson (1993:242) noted that, if his

[45] Elston (1982:192) also noted that, like those on Pahute and Rainier mesas, most of the upland and riverine sites dating to this period in the western Great Basin are either isolated finds or very small components.

hypothesized correlation between the distribution of Western Stemmed points and the gradually receding elevational limits of subalpine forests is correct, the higher elevation sites should not date until after the up slope movement of the subalpine conifers. Chronometric data are not yet available from any of the Barren Wash Period sites on the mesas to test this hypothesis, but it seems clear from the packrat middens below Rainier mesa that the subalpine forest on the mesas was either gone or greatly diminished by 9000 years ago.

The Prow Pass Period Adaptations (8000 to 5000 B. P.)

Three projectile point styles appear to have been made during the period between 8000 and 5000 years ago: Pinto, Large Side-notched, and Humboldt (Pippin, 1995, fig. 26). However, as Thomas (1981:37) pointed out, the Humboldt Series covers a considerable time span extending beyond the boundaries of this period (also see Pippin, 1995:73, table 21). Table 6 lists the archaeological sites on the mesas that contain either Pinto or Large Side-notched projectile points and figure 12 shows their distribution on the mesas. Sites containing the Aberrant Pinto styles (Pinto Square Base and Paradise Pinto) as defined by Pippin (1995:57-64) are also included; but because the temporal positioning of these aberrant forms is not well known, those sites that contain only aberrant Pinto types are appropriately denoted. Likewise, because there may be a difference in the age of the Pinto and Large Side-notched styles, those sites containing only Large Side-notched projectile points are also denoted. The remaining sites all contain the Pinto style of projectile point as defined by Pippin (1995:57-64).

Table 6
Archaeological Sites on Pahute and Rainier Mesas Containing Diagnostics of the Prow Pass Period

Site Number	Elev. (m)	Area (m^2)	Density / m^2	Site Type	Topographic Setting
26Ny1007	2068	200	Unknown	Locality	Base of ridge in Gold Meadow
26Ny1016	2066	29,452	0.05	Locality	Saddle on ridge top
26Ny1023	2240	65,974	High	Locality	Bench top on edge of mesa
26Ny1408[a]	2073	137,445	0.007	Quarry	Alluvial fan at ridge base
26Ny1931[c]	2237	26	Unknown	Lithic scatter	Flat bench top (Split Ridge)
26Ny2609[a]	2060	785	0.333	Locality	Drainage at base of bench
26Ny2614	2060	1885	0.100	Locality	Drainage at base of bench
26Ny2615[a]	2060	6283	0.066	Locality	Drainage at base of bench
26Ny2627	2650	6	0.080	Locality	Side of bench on Rainier Mesa
26Ny2650[bc]	1990	1	1.00	Isolate	Side of ridge in Big Burn Valley
26Ny3168[bc]	1862	4084	0.005	Temporary camp	Ridge side above drainage
26Ny3393	2033	281,500	0.009	Lithic scatter	Bench top at drainage head
26Ny3620	2045	450,000	0.137	Lithic scatter	Valley near mesa edge

Table 6
Archaeological sites on Pahute and Rainier Mesas containing diagnostics of the Prow Pass Period (continued)

Site Number	Elev. (m)	Area (m^2)	Density / m^2	Site Type	Topographic Setting
26Ny3624[a]	2027	38,700	0.001	Quarry	Shallow valley between benches
26Ny3647[c]	2097	157	0.200	Locality	Saddle on ridge in Lambs Cyn.
26Ny3651[b]	2030	11,780	Unknown	Temporary camp	Rockshelters at base of bench
26Ny3930	1603	6676	0.015	Lithic scatter	Alluvial fan below Rainier Mesa
26Ny4015	1996	44,169	0.073	Lithic scatter	Bench slope into shallow valley
26Ny4048[b]	1996	4241	0.033	Lithic scatter	Ridge top above small drainage
26Ny4131[bc]	2066	450	Unknown	Lithic scatter	Bench top above valley
26Ny4177	2146	212,058	Unknown	Lithic scatter	Bench edge above N. Silent Cyn.
26Ny4182B&C[c]	2128	1257	0.020	Locality	Bench above Dead Horse Flat
26Ny4183[c]	2135	23,562	0.001	Lithic scatter	Bench top above N. Silent Cyn.
26Ny4201	2076	25,447	0.435	Lithic scatter	Bench top above small valley
26Ny4203	2085	33,929	0.082	Lithic scatter	Bench top overlooking drainage
26Ny4209	2060	99,998	0.003	Lithic scatter	Narrow valley between benches
26Ny4535[bc]	1890	12,488	0.010	Locality	Bench edge at drainage head
26Ny4588[ac]	2066	220,000	0.310	Isolate	Interior of bench top
26Ny4786[ac]	1899	18	0.056	Locality	Ridge side at drainage
26Ny4871	1996	62,832	0.101	Lithic scatter	Ridge side and valley bottom
26Ny4892	1665	Unknown	Unknown	Quarry	Alluvial bajada below Pahute Mesa
26Ny4957[c]	1862	9425	0.007	Temporary camp	Shallow valley near drainage head
26Ny5207[a]	1998	76,341	0.013	Quarry	Valley edge near head of drainage
26Ny5418	2045	7,068	0.015	Temporary camp	Valley edge at drainage mouth
26Ny5422	2112	1	1.00	Isolate	Ridge top above narrow canyon
26Ny5490[ac]	2249	1	1.00	Isolate	Ridge side at head of drainage
26Ny5501	2012	99,268	Unknown	Lithic scatter	Bench top at drainage head
26Ny5504[c]	1969	7	0.031	Locality	Bench top at drainage head
26Ny5886[ac]	2085	4,315	0.066	Temporary camp	Bench top above small valley
26Ny5914	2124	2,240	0.057	Temporary camp	Alluvial fan below bench cliff
26Ny5916[b]	2234	2826	0.059	Temporary camp	Bench top at drainage head
26Ny5917[b]	2134	25,504	0.163	Lithic scatter	Bench top at drainage head
26Ny7358	2137	27,488	0.084	Lithic scatter	Bench top at drainage head
26Ny7843[c]	2112	23,561	0.013	Temporary camp	Bench top at drainage head
26Ny8246[b]	2053	16,4934	Unknown	Lithic scatter	Drainage head in Gold Meadow
26Ny8840	1682	28,274	Unknown	Lithic scatter	Drainage head off mesa

[a] = Sites with only Large Side-notched points.
[b] = Sites with only Aberrant Pinto points.
[c] = Single component sites used in table 3.

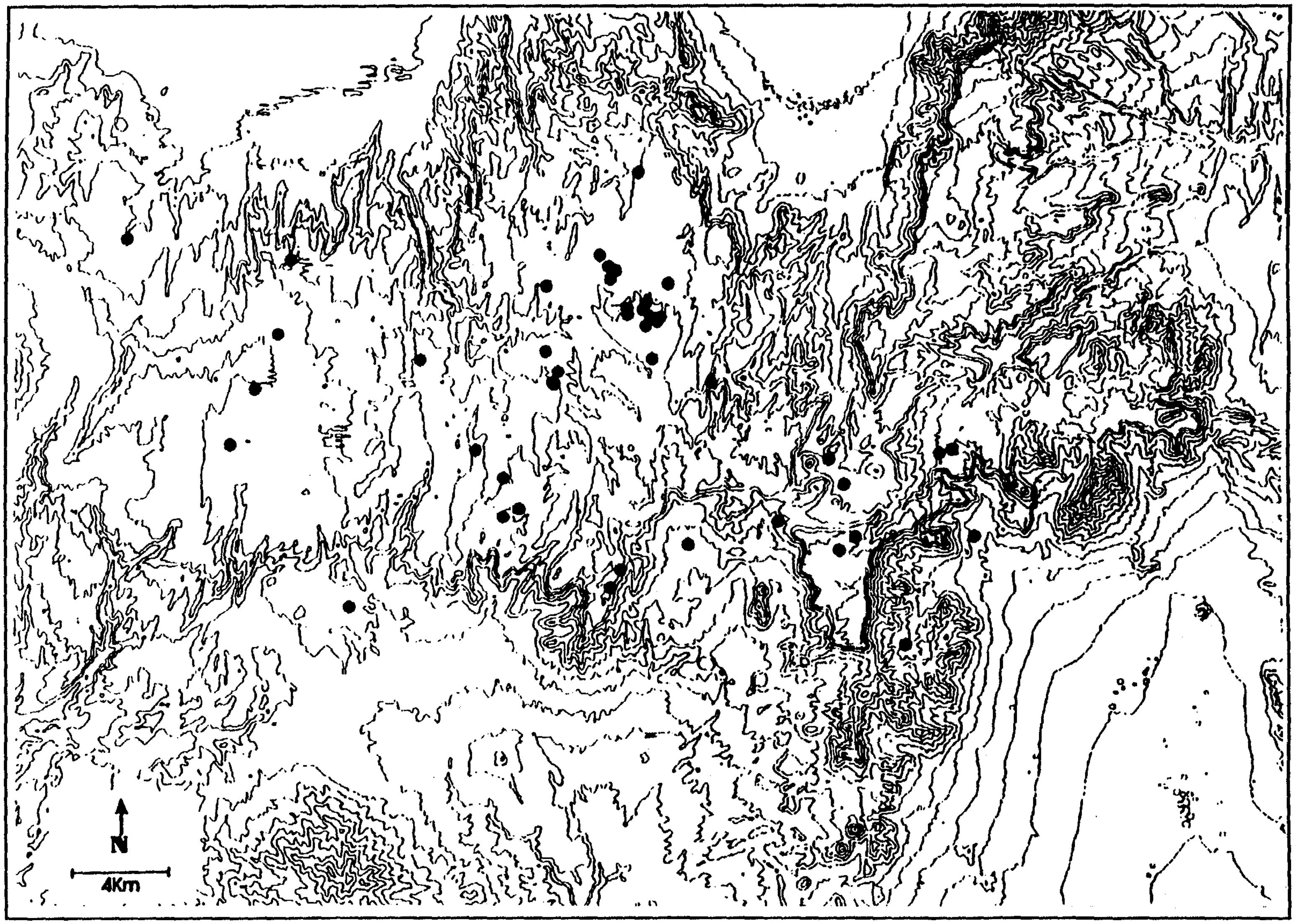

Fig. 12. Map showing the distribution of Prow Pass Period archaeological sites on Pahute and Rainier mesas.

Only 16 (35%) of these sites appear to represent single component sites pertaining to the Prow Pass Period (tables 3, 6). Five of the single component sites (26Ny2627, 26Ny3647, 26Ny4957, 26Ny5422, and 26Ny5504) are marked only by Pinto points, and another four (26Ny4588, 26Ny4786, 26Ny5490 and 26Ny5886) are marked only by Large Side-notched points. Pinto and a Pinto Square Base cooccur at site 26Ny4183, and Large Side-notched (Concentration C) and Pinto points (Concentration B) cooccur in separate artifact concentrations at 26Ny4182. Paradise Pinto points were the only diagnostic found at 26Ny3168, 26Ny4131, and 26Ny4535; and Pinto Square Base points are the only diagnostics to occur at 26Ny2650 and 26Ny8246. Four of the above 16 sites contain isolated projectile points. Another three sites are interpreted to be temporary camps. The remaining Prow Pass Period single component sites are classified as localities with knapping stations or limited debitage and bifaces and look much the same as those of the earlier Barren Wash Period sites.

The remaining 32 sites listed in table 6 have Prow Pass Period diagnostics found with temporal diagnostics of other periods. Although reasonable arguments could be made for several of the above Barren Wash diagnostics as separate from the later cultural remains, segregation of the different Prow Period components at the sites on the mesas is much more difficult. For example, Drollinger (1993, figs. 30, 31) indicated that the six Pinto, two Paradise Pinto, and seven Large Side-notched points at 26Ny3620 occurred on the margins of the dense lithic scatter that also contained numerous diagnostics of later periods. The continuous nature of the artifact scatter on the site makes it impossible to confidently separate these site components.

As indicated, several of the Prow Pass Period single occupation sites away from the redundantly used localities are similar to those of the Barren Wash Period; but it appears that there was a significant increase in the diversity of artifact assemblages left at these sites (fig. 8). As indicated in table 3, this increase is due to the inclusion of flaked stone tools, utilized flakes, cores, and milling equipment in the assemblage as well as an increase in the diversity of bifaces. In addition, while it is difficult to identify any temporary camps of the Barren Wash hunters, flaked stone and debitage assemblage diversity at several of the Prow Pass Period archaeological sites may suggest that these were temporary camps (table 6).. For example, the assemblage at 26Ny3168 includes a Paradise Pinto point, three bifaces (all made from different toolstone), a steep-edged uniface with hafting notches, and debitage from five different types of toolstones (Reno, 1982). This inference is strengthened when it is noted that, although transported obsidian comprised the bulk (86%) of the debitage assemblage at Barren Wash sites, locally available silicified volcanic toolstone comprises the majority (61%) of debitage at Prow Pass Period sites (table 3). Because this locally available silicified volcanic rock is of rather poor quality, it would have taken some effort to exploit it. Hence, in their analysis of the quarry at 26Ny1408, Jones, DuBarton, and Edwards (1993:93) noted that shatter comprised the vast majority of the byproducts associated with exploitation of the locally available rock (also see Simmons et al., 1990:114-119). We might expect that this level of effort would have been rewarding only if people were logistically exploiting this resource from a nearby camp.

As noted, based on the multidimensional scaling presented in figure 7, the Pinto and Western Stemmed projectile point forms had a similar distribution in their cooccurrence at archaeological sites on the mesas except that the Pinto style appears to more frequently occur at localities used during later periods (table 2). This may reflect a slight shift in settlement patterns from those of the Barren Wash Period. The plot of frequency of land use for the Prow Pass Period (fig. 9) indicates an even higher frequency utilization of bench edge environments over the Barren Wash Period. However, Prow Pass Period sites also tended to occur more frequently in the valley (broad and narrow) side. Hence, although sites continued to be positioned on high points near the heads of drainages and other vantage points near game routes, sites were also more frequently positioned in the valleys between benches (table 5). Figure 12 also indicates a slightly more clustered occurrence of Prow Pass localitities. The overall diversity of landforms used, however, appears to have decreased sightly. This might reflect reliance on both large and small game as well as the plant resources that grew in the deeper, better drained soils in the valley bottoms.

The cooccurrence of Large Side-notched points with other projectile point forms on the mesas clearly shows a difference on all three dimensions of the multidimensional scaling of this cooccurrence and is more similar to that of the Humboldt Series than any other projectile point series (fig. 7). The plot of radiocarbon dates associated with Large Side-notched projectile points throughout the Great Basin indicates that they may well be later in time than the Pinto Series and overlap with the Humboldt Series (Pippin, 1995, figs. 26, 27). It is possible then that there was a further shift in settlement strategies when the preferred point form gradually changed from Pinto to Large Side-notched and the lanceolate Humboldt form first began to appear. The available radiocarbon data indicates that this may have occurred approximately 7000 years ago. Although there appears to have been an increased use of the mesas during the Prow Pass Period compared to the earlier Barren Wash Period (fig. 6), it is possible that this increase occurred after the onset of Large Side-notched points. The cooccurrence of Pinto and Western Stemmed projectile points at Rogers Ridge and other lowland sites in the Mojave Desert suggests a continuity in the occupation of these lowland sites, and the increased emphasis on using highland environments may have not occurred until after 7000 years ago when the tree-ring records show an extended drought.

In order to examine this possibility, site areas were summed for those sites containing Pinto and large Side-notched projectile points and then each sum was divided by the total age range of each projectile point style (fig. 13). These data indicate an increase in total area. But if simply the number of sites or the number of projectile points are considered, there is a sharp decrease between these times. Some of this discrepancy may be due to the fact that, although more sites contain Pinto points and there are more Pinto points than Large Side-notched points at sites on the mesas, the time span for the Pinto Series is much longer than for the Large Side-notched Series (Pippin, 1995, fig. 26). The discrepancy may also be due to an extensive and more intensive use of the mesas after approximately 7000 years ago. This hypothesis is supported by the figures in table 2 that indicate a reduction in the cooccurrence of Large Side-notched points with other point forms in comparison to the earlier Pinto Series and the later Humboldt and Gatecliff forms.

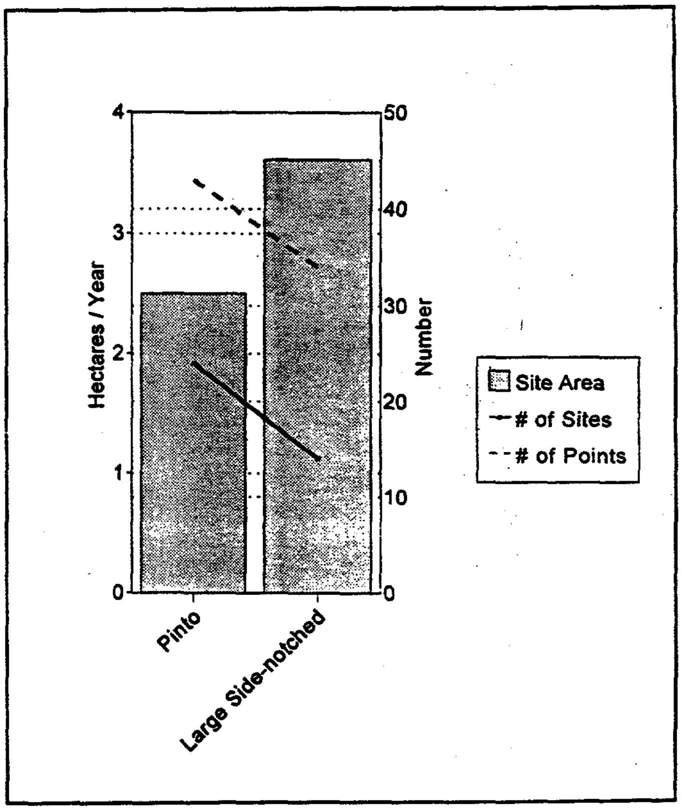

Fig. 13. Plot of total site area, total number of sites and total number of projectile points for archaeological sites containing Prow Pass Period diagnostics on Pahute and Rainier mesas.

Elston (1982:191-194; 1986:148), Grayson (1993:242-249, 255), and Warren and Crabtree (1986) all perceived that environmental changes between the early and middle Holocene resulted in shifts in aboriginal adaptive strategies. For Elston (1982; 1986), these shifts resulted from the drying of valley lakes and marshes and involved a shift from dependence on a few abundant high-ranked resources (large game) to the intensive exploitation of "whatever ecological diversity existed" (increased diet breadth) "... in a smaller annual territory" (decreased mobility and patch choice). In general, these shifts are quite similar to the shifts that Bettinger (1991a:100-103) and Bettinger and Baumhoff (1982) attributed to increased population. For Warren and Crabtree (1986), who also saw the drying of valley lakes and marshes as the critical environmental factors, these shifts involved only the "beginnings of a technology for processing hard seed" (minor increases in diet breadth) and withdrawal (abandonment of subregions and substantial population movement) to the margins of the desert or to a few oases in the deserts. Finally, for Grayson (1993) the critical environmental factors involved both the desiccation of valley bottoms and the increase in higher ranked resources in the surrounding highlands. First, he hypothesized that with the retreat of subalpine forests at the beginning of the early Holocene, highland environments became more productive and population densities increased. Then at the end of the early Holocene, he considered the loss of shallow-water habitats (reduced biological productivity, loss of higher ranked resources) to be responsible for the incorporation of seeds (increased diet breadth) in the diet and a decline in population densities. Finally, Grayson (1993:248, 255) noted that the few middle Holocene sites that continued to be occupied were near springs and that those away from springs were often abandoned or used only ephemerally.

The data from Pahute and Rainier mesas may be used to expand, clarify, or modify these hypotheses. An increase in diet breath during the Prow Pass Period may well be indicated by the increased utilization of the mesas, the slight decrease in diversity of site locations, and the increase in assemblage heterogeneity as shown at single component sites (fig. 8). However, hunting still appears to have been the major economic endeavor; and activities, at least on the mesas, appear to have increased. Since no springs are present on the portion of Pahute and Rainier mesas sampled by this data set, the notion that middle Holocene sites were tethered to water can be questioned. However, although activities on the mesas may have increased during the middle Holocene, there is little evidence that these activities were any more than ephemeral. Although Warren and Crabtree (1986:187) noted lightly used millingstones at sites in the Mojave Desert during this time (also see Grayson, 1993:244-246; Jenkins, Warren, and Wheeler, 1984), there is only minimal evidence that millingstones are part of the site assemblage at Prow Pass Period sites on the mesas. The single specimen listed in table 3 for this period is from a subdivision of 26Ny3651, and it is possible that this association is spurious. The other single component Prow Pass sites on the mesas continue to display rather homogeneous artifact assemblages and to be positioned in good hunting localities. Thus, the change in environments used on the mesas could reflect a change in weaponry as the atlatl replaced the spear and small game ranked higher as an optimal resource. Hence, the windfall hunting strategy that relied on natural features to disadvantage prey may have become less important as the atlatl increased the efficiency of encounter hunting. Overall, then, an intensification and expansion in the use of the mesas is postulated but not a major shift in how they were used. While temporary camps may have been present, residential bases were not; and mobility patterns probably still were like those of the foragers modeled by Binford (1980). The reduction in number of sites that contain Large Side-notched projectile points and the apparent difference in the positioning of these sites on the mesas remain to be explained, but Grayson (1993:255) may have been correct when he argued that a decrease in population densities occurred during the middle Holocene in the Great Basin. If so, however, this decrease occurred on the mesas after the time that Large Side-notched points began to be used (ca 7000 years ago), not before. Finally, it is interesting to note that the use of southern and southwestern exposures on the mesa tended to decrease in favor of more northern and northeastern exposures during the Prow Pass Period (fig. 10). This appears to be consistent with the transition to hotter environments postulated for the middle Holocene as solar radiation would have been two to three times greater on the more southern exposures.

Dead Horse Flat Period Adaptations (5000 to 3000 B.P.)

Table 7 lists the archaeological sites on Pahute and Rainier mesas that have been assigned to the Dead Horse Flat Period and figure 14 shows their distribution. Based on both the number of sites (n = 84) and their area (fig. 6), there appears to have been an increase in the intensity of use of the mesas during this period that is marked primarily by the Gatecliff Series of projectile points. Although the Humboldt style projectile point also occurs at a number of these sites, that style point was not used to define membership in this period unless it occurred in conjunction with the Gatecliff Series since the Humboldt style overlaps the Prow Pass, Dead Horse Flat, and Pahute Mesa periods (Pippin, 1995, figs. 26, 27) . Seventeen Dead Horse Flat Period sites (20%) were also occupied during the earlier Prow Pass Period, and eight sites (9%) appear to have been reoccupied Barren Wash Period localities.[47] Overall, however, there appears to have been a marked

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[47] Seven of these sites were also utilized during the Prow Pass Period and are included in that statistic.

shift in the locations selected for most activities on the mesas (fig. 12, 14): thirty seven of the Dead Horse Flat Period sites on the mesas (44%) appear to be single component sites, and another 27 sites (32%) with Dead Horse Flat Period diagnostics were utilized during later but not previous periods. This shift is further indicated by the clustering of Gatecliff, Elko, and Rosegate projectile point styles in multidimensional scaling of the cooccurrence of projectile point types on the mesas (fig. 7).

Table 7
Archaeological Sites on Pahute and Rainier Mesas that Contain Diagnostics Assignable to the Dead Horse Flat Period

Site Number	Elev. (m)	Area (m^2)	Density / m^2	Site Type	Topographic Setting
26Ny1014[a]	2045	9425	Unknown	Temporary camp	Ridge top
26Ny1032[a]	2234	236	0.040	Temporary camp	Rockshelter on bench top
26Ny1035	2227	4595	Unknown	Locality	Bench top
26Ny1046[b]	2030	12,566	0.005	Locality	Saddle between valleys
26Ny1050	2051	3142	0.003	Temporary camp	Ridge top on bench interior
26Ny1408[b]	2073	137,445	0.007	Quarry	Valley bottom
26Ny1915	2006	193,915	0.001	Temporary camp	Valley side
26Ny2609[b]	2060	28,274	0.001	Locality	Edge of drainage on valley side
26Ny2611[a]	2073	79	0.038	Temporary camp	Side of drainage on bench interior
26Ny2618	2070	76,176	0.002	Locality	Valley bottom
26Ny2621[a]	2078	1	1.00	Locality	Valley side
26Ny2622[a]	2083	9111	0.048	Quarry	Valley side
26Ny2628[a]	2249	79	0.089	Locality	Bench interior
26Ny2678[a]	1989	25	0.040	Locality	Bench interior
26Ny3173	1865	687,225	0.039	Temporary camp	Drainage edge on bench interior
26Ny3388[a]	2073	864	0.002	Locality	Valley bottom
26Ny3390[a]	2054	94,248	0.001	Locality	Valley side
26Ny3391[b]	2033	31,416	0.023	Temporary camp	Bench interior
26Ny3393[b]	2033	281,500	0.009	Temporary camp	Bench top at drainage head
26Ny3620[b]	2045	450,000	0.137	Temporary camp	Valley near mesa edge
26Ny3624[b]	2027	38,700	0.001	Quarry	Valley bottom
26Ny3629	1993	36,756	0.048	Quarry	Valley bottom
26Ny3642[a]	2033	70,686	0.001	Locality	Valley bottom
26Ny3646[a]	2100	628	0.003	Locality	Bench interior
26Ny3664	2048	94,248	0.043	Quarry	Valley bottom
26Ny3665[b]	2045	62,832	0.007	Temporary camp	Valley side
26Ny3934[a]	2042	236	0.025	Locality	Ridge side
26Ny4015[b]	1996	682,510	0.073	Temporary camp	Bench slope
26Ny4016[a]	2006	20	0.211	Locality	Ridge side
26Ny4025[a]	1998	5498	0.010	Quarry	Valley bottom

Table 7
Archaeological Sites on Pahute and Rainier Mesas that Contain Diagnostics Assignable to the Dead Horse Flat Period (continued)

Site Number	Elev. (m)	Area (m^2)	Density / m^2	Site Type	Topographic Setting
26Ny4040	1993	1649	0.013	Locality	Valley side on bench slope
26Ny4058[a]	1990	2827	0.007	Temporary camp	Valley bottom
26Ny4071[a]	1996	5891	0.001	Temporary camp	Bench interior
26Ny4098[a]	1999	9425	0.004	Locality	Valley side
26Ny4131[a]	2067	471	0.246	Locality	Ridge top
26Ny4154[a]	2094	23,562	0.002	Temporary camp	Bench interior
26Ny4176	2137	42,412	0.200	Temporary camp	Bench top at drainage head
26Ny4190	2099	6597	1.080	Temporary camp	Ridge top and sides
26Ny4201	2076	25,447	0.425	Lithic scatter	Bench top above small valley
26Ny4203[b]	2085	33,929	0.082	Lithic scatter	Bench top overlooking drainage
26Ny4205	2073	144,317	0.06	Locality	Valley bottom
26Ny4212	2262	47,124	2.73	Temporary camp	Bench interior
26Ny4502[?]	1908	9425	2.75	Locality	Drainage edge in valley bottom
26Ny4524[a]	1896	102	0.029	Locality	Drainage edge in valley bottom
26Ny4544	2249	106,029	0.007	Temporary camp	Valley bottom
26Ny4583[a]	2073	1	1.00	Isolate	Ridge top
26Ny4588[b]	2067	220,000	0.310	Temporary camp	Bench interior
26Ny4589	2073	32,830	0.410	Temporary camp	Valley edge
26Ny4596[a]	1926	471	0.004	Locality	Bench top at drainage head
26Ny4614	1920	117,810	0.090	Locality	Drainage edge on bench
26Ny4787[a]	1905	1	1.00	Isolate	Ridge top
26Ny4854	1896	4,400	0.011	Locality	Rise at base of ridge
26Ny4869[b]	2008	153,742	0.018	Temporary camp	Bench top near drainage head
26Ny4871[b]	1996	62,832	2.380	Temporary camp	Base of bench
26Ny4875[a]	1905	1	1.00	Isolate	Ridge top
26Ny4945[a]	2048	2,627	Unknown	Locality	Saddle on ridge
26Ny4963[a]	1984	1	1.00	Isolate	Ridge top
26Ny4980[a]	1957	1	1.00	Isolate	Valley side
26Ny5000[a]	1890	23,562	Unknown	Temporary camp	Drainage edge on bench
26Ny5001[a]	1899	14,137	0.016	Locality	Bench near drainage head
26Ny5012[a]	1902	1	1.00	Isolate	Bench interior
26Ny5197[a]	2262	50,894	0.102	Temporary camp	Valley side
26Ny5207[b]	1998	92,300	0.013	Quarry	Valley edge near drainage head
26Ny5211	1996	8900	0.220	Locality	Bench near drainage head
26Ny5414[a]	1931	1	1.00	Isolate	Base of ridge along drainage

Table 7
Archaeological Sites on Pahute and Rainier Mesas that Contain Diagnostics Assignable to the Dead Horse Flat Period (continued)

Site Number	Elev. (m)	Area (m^2)	Density / m^2	Site Type	Topographic Setting
26Ny5416	2012	3,519	7.50	Temporary camp	Ridge top
26Ny5418[b]	2045	45,000	0.027	Temporary camp	Valley bottom
26Ny5430[b]	2135	35,343	Unknown	Locality	Bench interior
26Ny5466	2256	225,030	0.020	Temporary camp	Bench interior
26Ny5513	1978	1257	0.050	Temporary camp	Bench interior
26Ny5562[a]	1868	1	1.00	Isolate	Bench interior
26Ny5614[a]	1999	1	1.00	Isolate	Valley side
26Ny5630[a]	1829	1685	0.005	Locality	Bench interior
26Ny5902	2059	15,708	Unknown	Quarry	Valley bottom
26Ny5906[a]	1932	565	0.004	Temporary camp	Bench edge near drainage head
26Ny5914[b]	2124	2240	0.018	Temporary camp	Bench edge
26Ny5917	2134	15,072	Unknown	Temporary camp	Bench interior
26Ny7358[b]	2137	19,101	0.022	Temporary camp	Bench interior
26Ny8066	1829	5890	0.001	Locality	Valley bottom
26Ny8083	1939	137,445	Unknown	Temporary camp	Valley bottom
26Ny8245[b]	2164	1,413,719	Unknown	Locality	Valley bottom
26Ny8265[a]	1884	79	Unknown	Locality	Unknown
26Ny8559	1768	59,690	Unknown	Temporary camp	Valley bottom
26Ny8773	1890	8	0.255	Locality	Ridge top

[a] Single component sites used in Table 3
[b] sites occupied during previous periods.

Table 3 and figure 8 also show a marked increase in the diversity of artifact assemblages at the single component archaeological sites of this period. This change is due to both the increased occurrence of milling equipment, pounded and pecked stone, and cores in the artifact assemblages as well as to the occurrence of facilities at these sites. The facilities include two rockshelters at 26Ny1032 and single rock ring features at 26Ny2628, 26Ny4154, and 26Ny5197. However, the evidence for a direct association between these facilities and the Dead Horse period sites is not strong. Gatecliff Series and Humboldt Series projectile points were found in the vicinity but not in the rock ring feature at 26Ny2628. The rock ring features at 26Ny4154 and 26Ny5197 are associated only with Humboldt Series projectile points which, as previously indicated, are poor time markers for this period. Likewise, the rockshelters at 26Ny1032 occur in an area that contains numerous other archaeological sites of various periods, and the association between the single Gatecliff Series projectile point found there and the utilization of these rockshelters is equivocal.

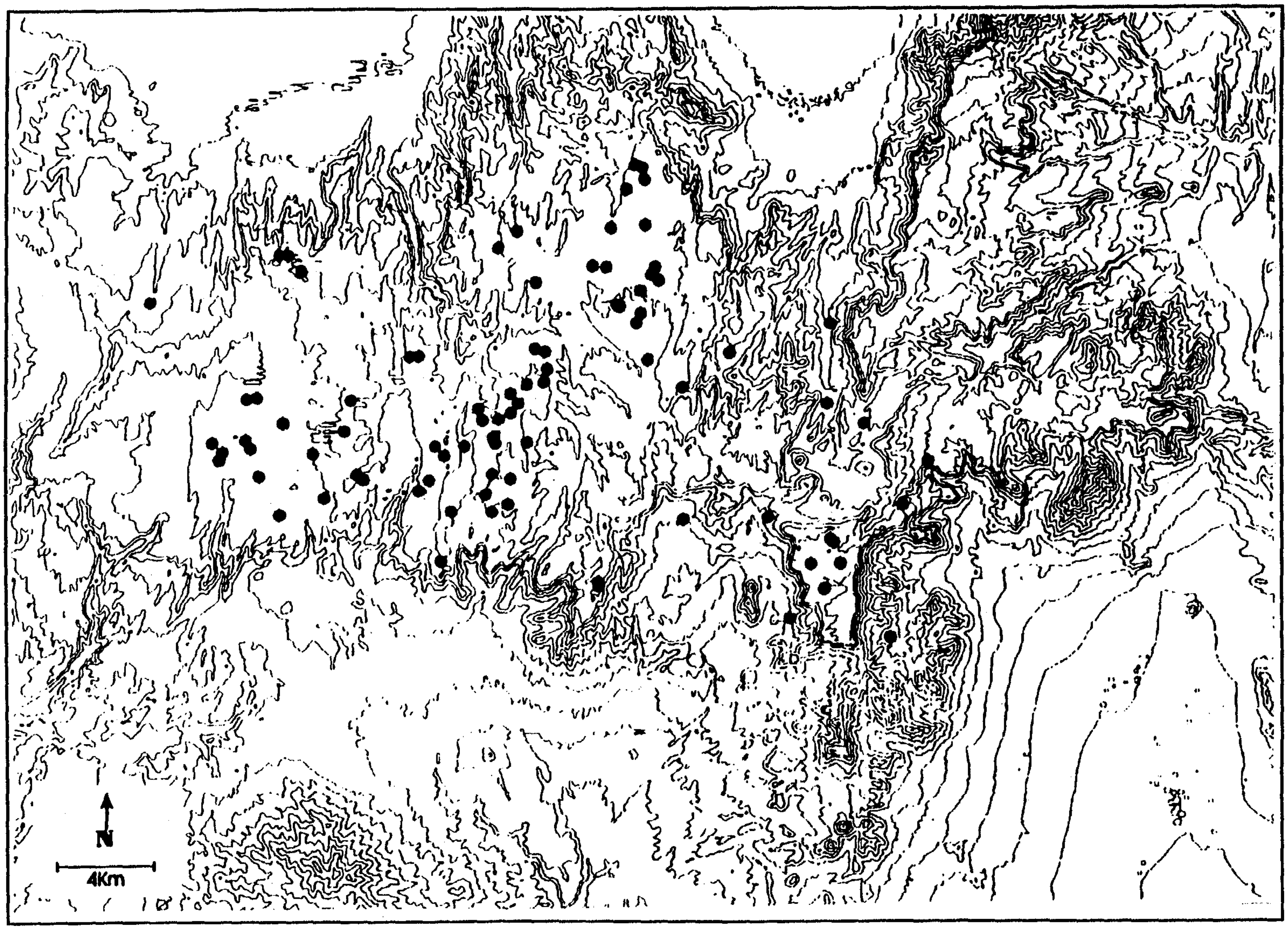

Fig. 14. Map showing the distribution of Dead Horse Flat Period archaeological sites on Pahute and Rainier mesas.

The -log of Simpon's C statistic indicates that the diversity in the utilization of various landforms on Pahute and Rainier mesas appears to have decreased during the Dead Horse Flat period (table 4). As previously explained, this statistic is heavily influence by the number of cases within any one category and the concentration of activities on the interiors of benches, including ridges and knolls, and on the bottoms and sides of the broader valleys appears to be responsible for this low statistic (table 4, fig. 9). This significant change in settlement patterns might reflect a shift to a more logistically organized mobility pattern with residential camps located primarily in those environments. This could be due to (1) an increase in the use of an encounter strategy during short logistical forays to procure game animals as hypothesized for the earlier Prow Pass Period, (2) the exploitation of a wider diversity of game animals, and/or (3) the exploitation of plant resources as well as game. The paleoenvironmental information for this time period indicates that the pinyon-juniper woodlands and cool desert shrubs on the mesas may have increased in their areal extent, and Grayson (1993:255-258) felt that this is the time when adaptive strategies throughout the Great Basin became comparable to those recorded in the ethnographic literature. While the perceived shifts in adaptive strategies during this period could be due to the exploitation of pinyon (see Thomas, 1982a, 1983; Madsen, 1986), Grayson argued that comparable shifts in adaptive strategies occurred in areas where pinyon never reached. "What counted everywhere was that it was no longer as arid as it had been" (Grayson, 1993:258). If this were the case, then the marked shift in settlement patterns on the mesas during the Dead Horse Flat Period could reflect an increase in general plant food exploitation rather than just a shift in hunting strategies as hypothesized for the Prow Pass Period.

In order to examine this possibility, the sites recorded to contain milling equipment on the mesas were plotted (fig. 15). Although milling equipment may not accompany the exploitation of some soft tissue and root-like plant foods and could have been used to process bone, ocher, and other materials, the primary development and use of this equipment probably signifies that the relative benefits of plant food exploitation exceeded the costs of their intensive processing (see O'Connell and Hawkes, 1981; O'Connell, Jones, and Simms, 1982:234). Hence, the presence of milling equipment should be a good indicator of the relative importance of plant resources. In order to standardize this information by period, the number of sites containing milling equipment was divided by the number of years in the corresponding period. The scale is presented as milling implements per year. Sites containing milling equipment that could not be assigned to a particular period are presented as unknown. Although a number of Barren Wash and Prow Pass Period sites contain milling equipment, all but one of those sites also have components dating to later periods. As discussed above, it is likely that the milling equipment at these sites belonged to those later components. Hence, like those sites of unknown age, the inclusion of these Barren Wash and Prow Pass period sites in figure 15 probably only reflects insignificant "noise" in the data.

There does appear to be a significant showing of Dead Horse Flat Period sites with milling equipment. However, only ten (27%) of the single component Dead Horse Flat Period sites on the mesas contain millingstones, manos, or both (see table 3). Nine other sites (24%) are simply isolated projectile points, and almost half (49%) of the single component Dead Horse Flat Period sites on the mesas do not contain milling equipment. Hence, although there is ample evidence that there was some processing of plant resources at these sites, the data also indicate that hunting probably remained a significant activity during the Dead Horse Flat Period. As noted above, milling equipment has been found in several middle Holocene age archaeological sites below the mesas; but it was not until the beginning of the late Holocene (Dead Horse Flat Period) that this equipment was evident on the mesas. Even during this period, the equipment appeared to be of secondary importance. Yet the shift in the selection of activity areas on the mesas during the Dead Horse Flat period probably reflects an increased emphasis on plant foods and a change in how the mesas were exploited.

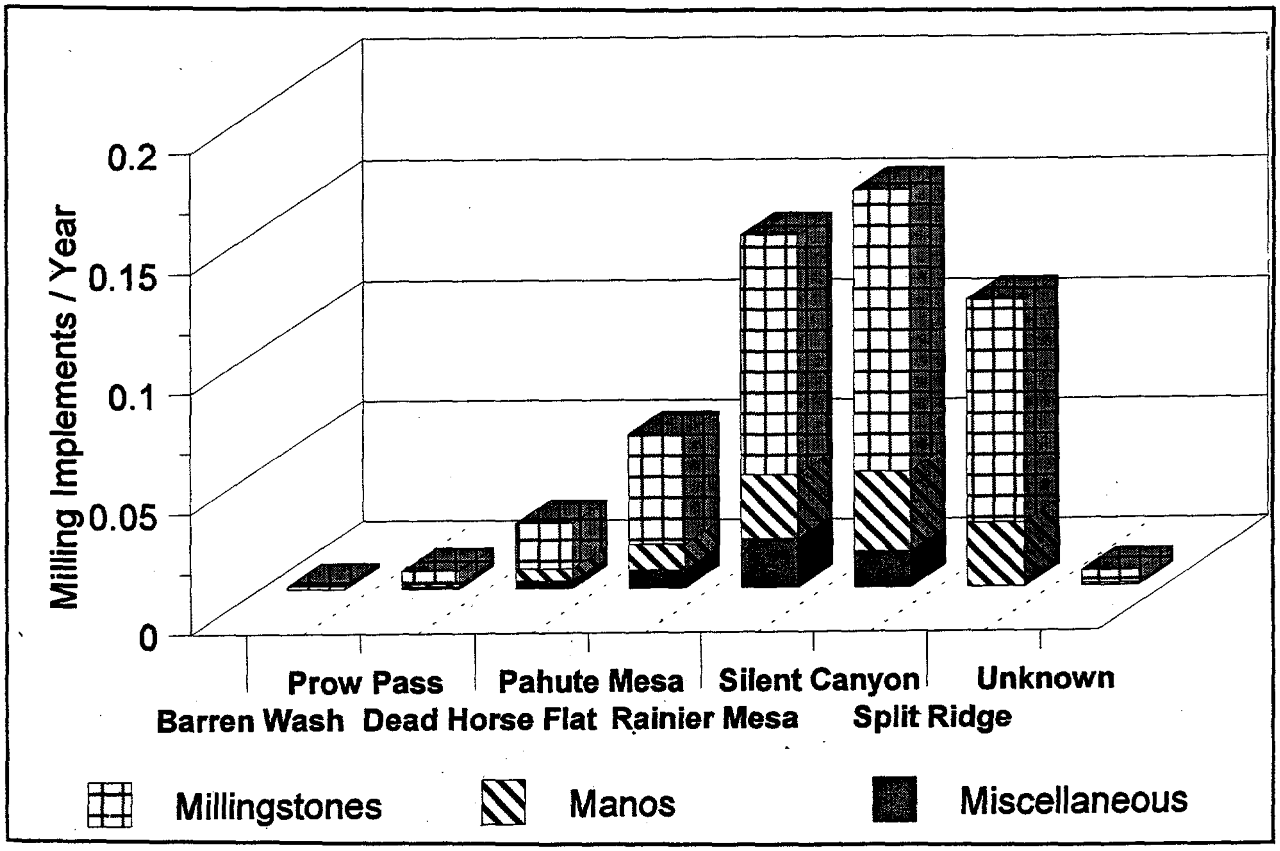

Fig. 15. Graph displaying the relative frequency of milling equipment at archaeological sites in each chronological period on Pahute and Rainier mesas. Values have been divided by the number of years in each period.

The end of the middle Holocene was previously hypothesized to be a period when environmental variability resulted in conspicuous changes in adaptive strategies throughout the Great Basin (see Grayson, 1993; Baumhoff and Heizer, 1965). With the decrease in aridity, rebirth of marsh environments, and arrival of pinyon following the end of the middle Holocene, Elston (1986:141-142) felt that although environmental productivity may have increased under such conditions, "there is little information regarding the ways ecosystems were actually affected."

He felt that while these Neoglacial conditions might have made the exploitation of higher elevation resources more difficult (costly), this may have been balanced by increased productivity in the lowlands. Consequently, as noted above, Elston (1986:142) perceived only a gradual change in adaptive strategies during the shift from middle to late Holocene environments. However, he noted that there were changes in settlement patterns, stylistic elaboration, and apparent population density. But Elston's (1986, fig. 1) chronological periods reflect somewhat different divisions than those used in this paper, and he discussed most of these changes in reference to the Elko Series of projectile points which were markers of the Pahute Mesa Period, not the Gatecliff Series of the Dead Horse Flat Period. The same is true of other nearby regional syntheses (i.e., Warren and Crabtree, 1986). Hence, examination of the evidence for the Pahute Mesa Period should be made prior to drawing any further conclusions and comparisons regarding the significance of the above changes.

Pahute Mesa Period Adaptations (3000 to 1500 B.P.)

There appears to have been a continued intensification of activities on Pahute and Rainier Mesas during the Pahute Mesa Period which is marked by the presence of the Elko Series of projectile points (figs. 5, 6). Again, the Humboldt Series of projectile points continued to occur at sites assigned to the Pahute Mesa Period but were not used as signifiers of this period. In fact, the Humboldt Series of projectile points were almost evenly distributed between sites of the Prow Pass, Dead Horse Flat, and Pahute Mesa periods with 14 specimens (24%) occurring as the only diagnostic at a site (table 2). More than half (54%) of the sites assigned to the Pahute Mesa Period have diagnostics of other periods. Of those, more than half (52%) have diagnostics of later periods but not of earlier periods. Another 20% have diagnostics of earlier periods but not later periods, and the remaining 28% have diagnostics of both earlier and later periods (table 8). Although these statistics could indicate a continued shift in settlement patterns from the earlier Dead Horse Flat Period, the multidimensional scaling of the cooccurrence of projectile points indicated that this may not be the case. The analysis of landforms that were used for Pahute Mesa Period activities indicated no significant changes in the selection of these localities from the earlier Dead Horse Flat Period, although bench interiors were used slightly more often (table 4, fig. 9). Finally, although the density increases, there is no significant overall difference in the geographic distribution of Pahute Mesa and Dead Horse Flat period sites on the mesas (figs. 14, 16). Hence, the selection of new site locales may have been due simply to an increase in the utilization (population growth) of the mesas (fig. 6).

Analysis of artifact diversity at the single component Pahute Mesa Period sites, however, did show an increase in the heterogeneity of assemblages and ornaments in the record for the first time (table 3, fig. 8). Likewise, the frequency of milling equipment increased significantly (fig. 15); and there is little doubt that plant foods were being consistently exploited and processed on the mesas. However, like those of the Dead Horse Flat Period, only a few (n = 13; 18%) of the single component sites contained milling equipment, and most are either isolates (31%) or small

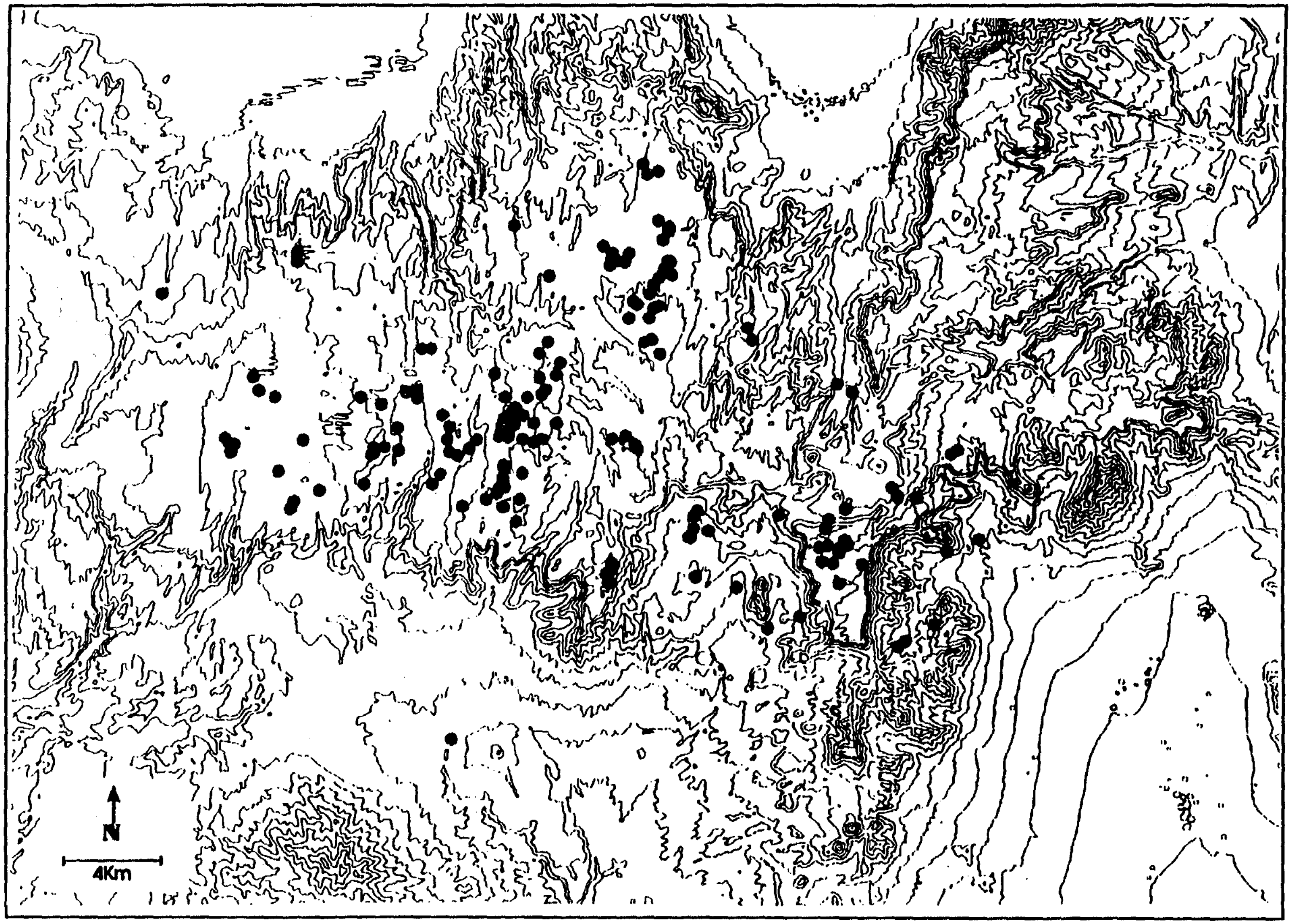

Fig. 16. Map showing the distribution of Pahute Mesa Period archaeological sites on Pahute and Rainier mesas.

Table 8
Archaeological Sites on Pahute and Rainier Mesas Containing Diagnostics Assignable to the Pahute Mesa Period

Site Number	Elev. (m)	Area (m^2)	Density / m^2	Site Type	Topographic Setting
IS072392RJ8 [b]	1975	1	1.000	Isolate	Valley side at base of slope
26Ny952 [a]	1972	206,168	0.057	Temporary camp	Valley bottom
26Ny996 [b]	1892	7850	Unknown	Locality	Ridge top
26Ny1016 [c]	2067	29,452	0.050	Locality	Saddle on ridge top
26Ny1024 [a]	2237	58,905	0.002	Locality	Valley bottom
26Ny1026 [a]	2243	491	0.016	Locality	Valley interior
26Ny1034 [a]	2231	79	0.026	Locality	Valley interior
26Ny1040 [a]	2225	2749	0.004	Locality	Bench interior
26Ny1050	2051	3142	0.003	Temporary camp	Ridge top on bench interior
26Ny1408	2073	137,445	0.007	Quarry	Valley bottom
26Ny1918 [b]	2039	38,405	Unknown	Temporary camp	Edge of bench top
26Ny1920 [a]	2033	192,787	Unknown	Temporary camp	Bench top
26Ny1932 [b]	2234	14,530	0.102	Locality	Side of ridge on bench
26Ny2606 [b]	2060	1	1.000	Isolate	Edge of drainage on valley side
26Ny2607 [a]	2060	707	0.011	Locality	Edge of drainage on valley side
26Ny2609	2060	28,274	0.001	Locality	Edge of drainage on valley side
26Ny2612 [b]	2067	785	0.032	Locality	Edge of drainage on valley side
26Ny2613 [b]	2060	785	0.057	Locality	Edge of drainage on valley side
26Ny2614 [c]	2060	1885	0.007	Locality	Edge of drainage on valley side
26Ny2623 [b]	2084	7697	cat	Temporary camp	Low bench on valley side
26Ny2625 [b]	2079	1	1.000	Isolate	Slope of ridge
26Ny2626 [b]	2234	39,270	Unknown	Lithic scatter	Valley interior
26Ny2631 [b]	2234	962	0.333	Temporary camp	Saddle on ridge top
26Ny2640 [b]	2262	1178	0.040	Temporary camp	Rockshelter on bench interior
26Ny2650 [b]	1990	1	1.000	Isolate	Ridge top
26Ny2677 [a]	2304	4712	Unknown	Temporary camp	Ridge top at drainage head
26Ny2678 [c]	1989	25	0.040	Locality	Bench interior
26Ny2680 [b]	1,950	2827	0.125	Locality	Drainage edge on bench top
26Ny2682 [a]	1951	353	Unknown	Locality	Ridge top
26Ny2683	1957	6283	Unknown	Temporary camp	Saddle on ridge
26Ny3157 [b]	2076	15,708	0.200	Temporary camp	Rockshelter on narrow bench
26Ny3167 [b]	1865	1	1.000	Isolate	Side of ridge
26Ny3173	1856	687,225	0.039	Temporary camp	Drainage edge on bench interior
26Ny3182 [b]	2118	17,662	Unknown	Lithic Scatter	Saddle in Gold Meadows
26Ny3391	2033	31,416	0.023	Temporary camp	Bench interior

Table 8
Archaeological Sites on Pahute and Rainier Mesas Containing Diagnostics Assignable to the Pahute Mesa Period (continued)

Site Number	Elev. (m)	Area (m^2)	Density / m^2	Site Type	Topographic Setting
26Ny3393	2033	281,500	0.009	Temporary camp	Bench top at drainage head
26Ny3620	2045	450,000	0.137	Temporary camp	Valley near mesa edge
26Ny3621[a]	2048	2500	4.948	Temporary camp	Rockshelter on valley side
26Ny3622[b]	2036	24	0.083	Locality	Side of small valley
26Ny3624	2027	38,700	0.001	Quarry	Valley bottom
26Ny3625[b]	2018	20	0.080	Locality	Ridge top
26Ny3629	1993	36,756	0.048	Quarry	Valley bottom
26Ny3633[a]	1975	47	0.293	Locality	Side of drainage in valley bottom
26Ny3651[a]	2030	11,781	Unknown	Temporary camp	Rockshelters on bench side
26Ny3655[b]	2042	25,133	0.318	Temporary camp	Bench interior
26Ny3665	2045	62,832	0.007	Temporary camp	Valley side
26Ny3666[a]	2044	2356	Unknown	Temporary c amp	Valley interior
26Ny3677[b]	2225	1	1.000	Isolate	Side of ridge
26Ny3931[a]	1576	3770	Unknown	Temporary camp	Alluvial fan at base of mesa
26Ny3933[b]	2042	1	1.000	Isolate	Side of ridge
26Ny4015	1996	682,510	0.073	Temporary camp	Bench slope
26Ny4017[a]	1993	47,124	0.036	Temporary camp	Valley side / bench bottom
26Ny4021[a]	1990	6283	0.095	Temporary camp	Valley side / bench bottom
26Ny4022[a]	2000	1767	0.154	Temporary camp	Valley side / bench bottom
26Ny4023[a]	2000	3,142	0.054	Temporary camp	Valley side / bench bottom
26Ny4024[a]	1996	2749	Unknown	Locality	Valley side / bench bottom
26Ny4038[b]	2012	6	1.166	Locality	Side of ridge
26Ny4040	1993	1649	0.013	Locality	Valley side below bench
26Ny4041[a]	1996	3927	Unknown	Locality	Toe of ridge into valley bottom
26Ny4048[a]	1996	863	0.081	Temporary camp	Ridge top
26Ny4051[b]	2012	236	0.002	Locality	Ridge base at valley head
26Ny4053[a]	2000	31,416	Unknown	Temporary camp	Slope of bench top
26Ny4054[a]	1993	1,728	0.050	Temporary camp	Valley side / bench bottom
26Ny4067[a]	1990	1,060	Unknown	Locality	Valley bottom
26Ny4081[a]	1996	58,905	Unknown	Locality	Valley bottom
26Ny4086[a]	2000	5891	Unknown	Temporary camp	Bench top
26Ny4112[a]	2021	8247	0.049	Temporary camp	Bench top
26Ny4126[b]	2042	471	0.108	Knapping station	Bench top
26Ny4138[b]	2079	177	0.028	Knapping station	Bench top
26Ny4174[b]	2143	35,343	0.026	Lithic Scatter	Bench top

Table 8
Archaeological Sites on Pahute and Rainier Mesas Containing Diagnostics Assignable to the Pahute Mesa Period (continued)

Site Number	Elev. (m)	Area (m^2)	Density / m^2	Site Type	Topographic Setting
26Ny4175 [a]	2128	59,376	0.032	Temporary camp	Valley bottom
26Ny4176 [c]	2137	42,412	0.200	Temporary camp	Bench top at drainage head
26Ny4182 [c]	2128	326,560	0.112	Lithic scatter	Bench above Dead Horse Flat
26Ny4190 [c]	2099	6,597	1.080	Temporary camp	Ridge top and sides
26Ny4201 [c]	2076	25,447	0.425	Lithic scatter	Bench top above small valley
26Ny4202 [b]	2073	16,965	0.066	Locality	Toe of ridge top
26Ny4203 [c]	2085	33,929	0.082	Lithic scatter	Bench top overlooking drainage
26Ny4205 [c]	2073	144,317	0.060	Locality	Valley bottom
26Ny4207 [b]	2054	8836	0.100	Temporary camp	Head of drainage on valley side
26Ny4208 [b]	2060	5498	0.018	Locality (quarry)	Bench top
26Ny4209 [c]	2060	123,637	0.004	Temporary camp	Bottom of narrow valley
26Ny4213 [b]	2274	2199	0.011	Locality	Top of bench near edge
26Ny4542 [b]	2231	1	1.000	Isolate	Valley bottom
26Ny4544 [c]	2249	106,029	0.007	Temporary camp	Valley bottom
26Ny4567 [b]	2030	5655	0.333	Locality	Valley side at base of bench
26Ny4575 [b]	2079	1	1.000	Isolate	Ridge top
26Ny4582 [b]	2073	20	1.350	Locality	Bench interior
26Ny4584 [b]	2073	2121	0.680	Temporary camp	Bench interior
26Ny4585 [a]	2073	14,137	0.555	Temporary camp	Bench interior
26Ny4588	2067	220,000	0.310	Temporary camp	Bench interior
26Ny4589	2073	32,830	0.410	Temporary camp	Valley edge
26Ny4594 [b]	2152	1	1.000	Isolate	Pinnacle on bench
26Ny4602 [b]	1932	1	1.000	Isolate	Top of knoll on bench
26Ny4612 [b]	1932	3299	0.010	Locality	Bench edge near drainage head
26Ny4788 [b]	1905	1	1.000	Isolate	Ridge top
26Ny4791 [c]	1896	8150	0.035	Temporary camp	Bench near canyon head
26Ny4854 [c]	1896	4400	0.011	Locality	Rise at base of ridge
26Ny4855 [b]	1902	1	1.000	Isolate	Base of ridge on bench
26Ny4869	2008	153,742	0.018	Temporary camp	Bench top near drainage head
26Ny4871	1996	62,832	2.380	Temporary camp	Base of bench
26Ny4896 [b]	2134	235,620	0.224	Temporary camp	Narrow valley bottom
26Ny4915 [b]	2158	1257	0.009	Locality	Saddle on ridge
26Ny4917 [a]	2158	17,279	0.088	Temporary camp	Saddle on ridge
26Ny4919 [a]	1871	942	0.450	Temporary camp	Rockshelter below bench
26Ny4941 [b]	1856	157	0.089	Locality	Saddle on ridge

Table 8
Archaeological Sites on Pahute and Rainier Mesas Containing Diagnostics Assignable to the Pahute Mesa Period (continued)

Site Number	Elev. (m)	Area (m^2)	Density / m^2	Site Type	Topographic Setting
26Ny4944 [a]	1737	157	0.115	Temporary camp	Rockshelter below bench
26Ny4952 [a]	1926	62,832	0.096	Temporary camp	Valley bottom near head
26Ny4953 [b]	2109	32,673	0.201	Temporary camp	Saddle on ridge
26Ny4954 [a]	2118	12,566	0.003	Temporary camp	Saddle on ridge
26Ny4958 [b]	1984	1	1.000	Isolate	Side of bench
26Ny4965 [a]	1981	127,235	0.383	Temporary camp	Narrow valley off bench
26Ny4968 [b]	1975	2827	0.018	Temporary camp	Side of narrow valley off bench
26Ny4984 [b]	1939	2827	0.019	Locality	Valley head at base of bench
26Ny4990 [b]	1905	1	1.000	Isolate	Side of ridge on bench interior
26Ny4994 [b]	1899	32,987	0.059	Temporary camp	Drainage head off mesa
26Ny4997 [b]	1893	36,128	0.040	Temporary camp	Drainage head off mesa
26Ny5196 [b]	2256	1	1.000	Isolate	Side of drainage off ridge
26Ny5202 [a]	1829	1885	0.050	Temporary camp	Bench interior
26Ny5205 [a]	2012	1200	0.031	Locality	Bench interior
26Ny5207	1998	92,300	0.013	Quarry	Valley edge near drainage head
26Ny5211	1996	8900	0.220	Locality	Bench near drainage head
26Ny5215 [a]	2012	3700	0.513	Temporary camp	Low saddle on bench
26Ny5236 [a]	1640	471	Unknown	Locality	Head of drainage off ridge
26Ny5408 [b]	2242	3142	0.020	Temporary camp	Valley edge on bench
26Ny5409 [b]	1996	11	0.091	Locality	Side of knoll on bench interior
26Ny5411 [b]	1942	1	1.000	Isolate	Base of bench at drainage head
26Ny5418	2045	45,000	0.027	Temporary camp	Valley bottom
26Ny5428 [a]	2106	118	1.000	Temporary camp	Rockshelter in narrow valley
26Ny5430 [c]	2135	35,343	Unknown	Locality	Bench interior
26Ny5465 [a]	2257	6597	0.009	Temporary camp	Narrow valley on bench interior
26Ny5466	2256	225,030	0.020	Temporary camp	Bench interior
26Ny5467 [b]	2249	10,996	0.005	Temporary camp	Bench interior
26Ny5474 [b]	2271	9	0.222	Locality	Drainage head on bench interior
26Ny5480 [b]	2298	1	1.000	Isolate	Bench interior
26Ny5542 [b]	1935	408	0.039	Locality	Drainage head on bench interior
26Ny5566 [b]	1871	10,923	0.005	Temporary camp	Drainage head on bench interior
26Ny5607 [b]	2094	1	1.000	Isolate	Ridge side on bench
26Ny5609 [b]	2088	353	0.045	Locality	End of ridge on bench
26Ny5613 [b]	2009	1	1.000	Isolate	Ridge top on bench
26Ny5629 [a]	1817	4,710	0.031	Locality	Valley head below mesas

Table 8
Archaeological Sites on Pahute and Rainier Mesas Containing Diagnostics Assignable to the Pahute Mesa Period (continued)

Site Number	Elev. (m)	Area (m^2)	Density / m^2	Site Type	Topographic Setting
26Ny5742 [b]	1978	1	1.000	Isolate	Valley side below bench
26Ny5751 [b]	1980	1	1.000	Isolate	Ridge side at drainage head
26Ny5763 [b]	1971	1	1.000	Isolate	Drainage head below bench
26Ny5816 [b]	1939	33,279	0.056	Locality	Drainage head below bench
26Ny5895 [b]	2070	59	0.034	Locality	Side of drainage on bench
26Ny5902 [c]	2059	15,708	Unknown	Quarry	Valley bottom
26Ny5917	2134	15,072	Unknown	Temporary camp	Bench interior
26Ny5918 [b]	2195	71	0.563	Locality	Side of ridge on bench
26Ny5922 [b]	2109	1,625	0.044	Locality	Side of ridge on bench
26Ny6087 [b]	2006	5	0.400	Locality	Side of ridge on bench
26Ny7358	2137	27,488	0.084	Lithic scatter	Bench top at drainage head
26Ny8066 [c]	1829	5890	0.001	Locality	Valley bottom
26Ny8245	2164	1,413,719	Unknown	Locality	Valley bottom
26Ny8248 [a]	1932	5655	0.074	Locality	Base of alluvial fan below mesas
26Ny8360 [a]	1981	63,6174	0.200	Temporary camp	Narrow valley between benches
26Ny8402 [b]	1963	59	0.068	Locality	Valley bottom
26Ny8405 [b]	2018	118	0.025	Locality	Valley bottom
26Ny8559 [c]	1768	59,690	Unknown	Temporary camp	Valley bottom
26Ny8773 [c]	1890	8	0.255	Locality	Ridge top
26Ny8776 [b]	1887	47	0.064	Locality	Side of drainage

[a] Later, but no previous components.
[b] Single component.
[c] Previous, but no later components.

sites lacking any milling equipment. For example, the Elko and Humboldt series projectile points at 26Ny4871, radiocarbon dated between 1900 and 2400 B.P., were in association with artifacts (debitage, two cores, a biface, a perforator, a flake tool, and three bone fragments) more indicative of hunting than plant gathering activities (Hicks, Pippin, and Henton, 1991:103-109). Hence, we might conclude that hunting continued to be the more significant subsistence activity. However, there is also some evidence for a shift in activity locations in the western portion of the sampled area lying below the current distribution of pinyon-juniper woodlands. Evidence of this shift is provided by sites 26Ny4209, 26Ny4994, and 26Ny4997 which are positioned in the heads of drainages off the mesa. Each of these drainages contain several *poh*[48], and all three archaeological sites contain milling equipment and artifact assemblages indicating that they may have been temporary camps (Pippin, McLane, and Henton, 1987; William, 1989). Two of these sites are single component Pahute Mesa Period sites; the third was utilized during the earlier Dead Horse Flat period as well as during the Pahute Mesa Period. This pattern contrasts to that of the earlier Prow Pass Period sites that tend to be located on the higher landforms around these drainage heads in this portion of the mesa. The positioning of temporary camps in the pathway of migrating game would not be advantageous for an intercept strategy; and although these camps could have been used to base hunting activities, these activities were apparently not the same as during the Prow Pass Period.

It is also important to note that various facilities also occur at several of the sites that were used during the Pahute Mesa Period. These facilities include rockshelters at 10 sites, *poh* at 4 sites, circular rock alignments at 22 sites, a circular area cleared of rocks at 1 site, and petroglyphs at 1 of the sites with rockshelters. Three radiocarbon dates between 2000 and 3000 years B.P., an Elko Series projectile point, and a millingstone and mano were recovered from excavations in front of the small rockshelter at 26Ny5428 (Drollinger et al., 1992; Henton and Pippin, 1991b). Likewise, a radiocarbon date of 1190 B.P. and two Elko Series points were recovered in sediments approximately 3 m in front of a much larger rockshelter at 26Ny3621. The assemblage from these sediments is also mixed with Rainier Mesa and Silent Canyon Period artifacts, and radiocarbon dates from the rockshelter itself fall only within the last 300 years (Drollinger, 1993:122-156; Pippin, 1995:12). Single component sites with rockshelters only include 26Ny2640 and 26Ny3157, both also interpreted to be temporary camps. This limited data indicates that rockshelters were being used as temporary residences on Pahute and Rainier mesas at least by the Pahute Mesa Period if not before.

At several of these sites, however, it is even more difficult to ascertain whether the features are directly associated with either the Elko Series projectile points or radiocarbon dates that were used to place the sites in the Pahute Mesa Period. The circular rock alignments on Pahute and Rainier mesas are an important case in point. These features, illustrated in figure 17, contain anywhere between 20 to 350 fairly large sized (0.20-1.0 m) rocks that have been stacked in roughly circular or oval patterns. The centers of most of these features are devoid of rocks-- leading to the "rock ring" descriptor-- but a few of the features are simply piles of rocks or circles with some rocks scattered within their centers. Outside diameters range between 1.5-6.2 m, and the average diameter is 4.2 m (sd = 0.95). A total of 285 of these features have been identified on the mesas.

Based on ethnographic analogy, the ratios between inside and outside diameters, associated artifacts, and geographic location, Vierra (1986) classified these features as either pinyon caches,

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[48] *Poh* is the Western Shoshone term for small water catchment basins in bedrock exposures and is analogous to the Spanish term of *tinaja* (see Bryan, 1925).

roasting ovens, hunting blinds, or rocks around habitational structures.[49] Although his distinction between roasting ovens and pinyon caches may be valid, the hunting blind and habitational structure categories are questionable. Most, if not all, of the features in these classifications are probably rock caches in various states of decay. This impression is based on three factors: (1) that earlier features would have provided a low cost and exploited source of rocks for the builders of later ones, (2) the strong tendency (> 75%) for these features to be located on bedrock exposures or substrates with only a thin (1-5 cm) mantel of sediment, and (3) their almost perfect (> 99%) association with pinyon trees.

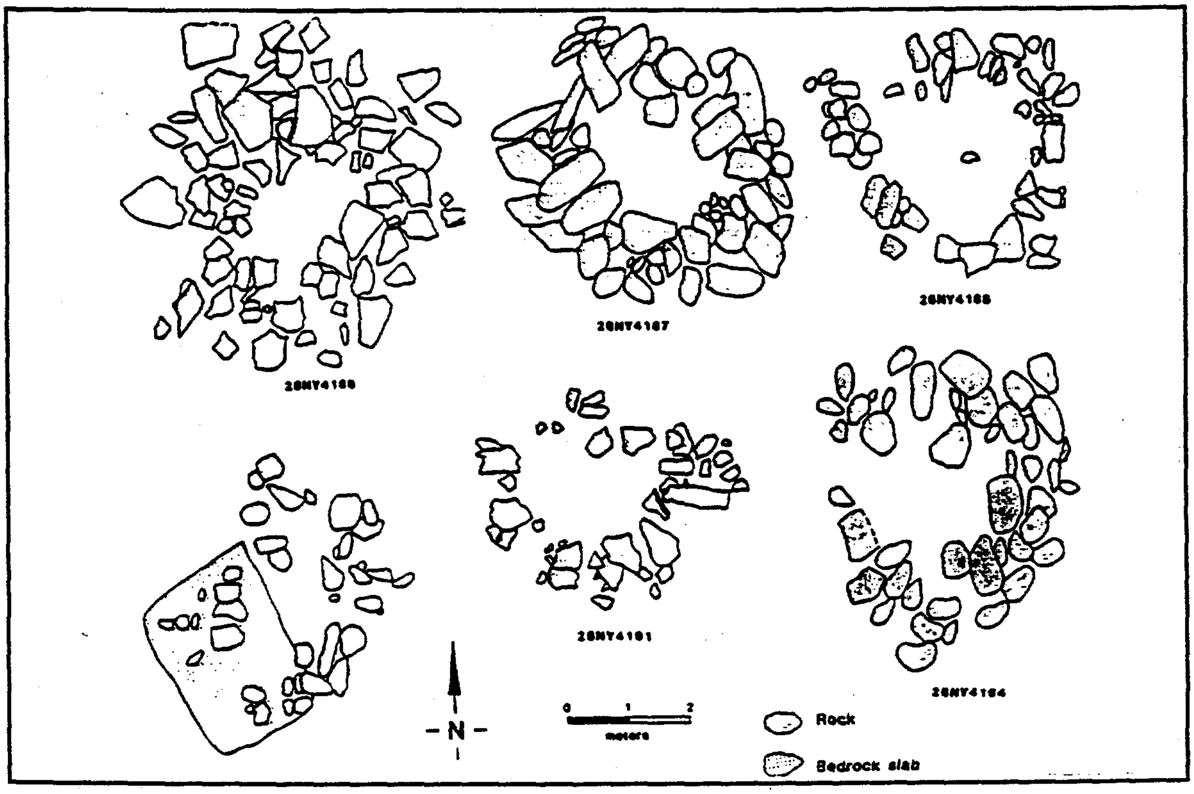

Fig. 17. Sketches of some rock ring features found at archaeological sites on Pahute and Rainier mesas.

Pollen samples have been analyzed from ten of these features in hopes of confirming their contents and function, but comparisons between the spectra of these samples and control samples outside of the features generally showed no significant statistical differences (Pippin et al., 1993:43-44). Pine pollen dominates both samples. The only exception is the rock ring feature at 26Ny5216, a Silent Canyon Period site, that contained unusually high frequencies of pine pollen in comparison to its control sample. But even here, this difference may be due to sampling error rather than any

[49] Vierra's (1986) sample included only 130 of these features.

culturally induced difference (Hemphill, 1990). Flotation samples from nine of these features have likewise provided little information. Twigs, seeds, and needles of pinyon-- some of which are charred-- commonly occur in these features; and several features have been filled in with pine nuts. But all those occur in environments containing pinyon trees; and litter from those trees, including pine nuts, abound in the area surrounding the features. Hence, the only evidence that these features were used to cache pine nuts is their association with the distribution of pine trees on the mesas. Nonetheless, the nearly perfect association of these features with pine tree distribution supports the caching of pine nuts as the primary function of these rings. It is interesting to note, however, that two of the rock caches--one at 26Ny4186 and the other at 26Ny4187--contained high counts of balsamroot (*Balsamorhiza hookeri*) seeds in comparison to their control samples; and one of these (26Ny4186) also had unusually high frequencies of Indian ricegrass (*Oryzopsis hymenoides*) seeds (Henton and Pippin, 1987:59-60). Unfortunately, neither of these sites can be assigned to a chronological period; but both Elko and Rosegate projectile points occur within approximately 300 m of these features. Seeds, roots, and young leaves of balsamroot are reported to have been commonly eaten by ethnographic populations in the Great Basin, and the economic importance of Indian ricegrass is well known (Fowler, 1986). Hence, there is some indication that these features may have been used to cache other foodstuffs as well as pine nuts. Balsamroot is generally harvested in the late summer while Indian ricegrass seeds are gathered in the spring.

What then is the chronology and intensity of use of the rings? None of the rock ring features have been dated directly, and their chronology can only be ascertained by artifact cross-dating. The difficulty is that diagnostic artifacts were rarely recovered directly within the rings; and even when they were, there is no compelling evidence that the artifacts were deposited there during the use of these features. When dealing with the lid-covered *poh* on Yucca Mountain, Pippin (1984) previously found that graphs of the distance between these features and sites dating to the Rainier Mesa and Silent Canyon periods were leptokurtic and skewed strongly to the right when compared to the normal distribution of distances between *poh* and archaeological sites in the region. This analysis was quite valuable in ascertaining the ages of those features.[50] However, the relative density of both rock rings and archaeological sites on Pahute and Rainier mesas limits the value of a similar analysis in this case. Hence, the relative frequency of the rock ring features at those sites that could be assigned to a chronological period on the mesas have simply been plotted in figure 18. Single component sites have been separated from all other datable sites, and the number of rock ring features within each period has been divided by the number of years in that period to provide a relative index of the intensity of use.

The previously identified apprehensions regarding the use of these features during the Dead Horse Flat Period appears to be well founded as the curves during that period differ little from previous periods. Hence, the association between the rock ring features and diagnostic artifacts at sites dating to these early periods, like that already argued for site 26Ny5468, is probably spurious. Doesn't the following statement contradict the previous observation that the curves differed little

[50] See Thomas (1988:546-567) for a good example and explanation of this sort of analysis.

from previous periods? However, the slope of the curve changes during the Pahute Mesa Period for both single component and all other sites. Although specific associations between the diagnostics used to date these sites and the rock ring features may still be erroneous, particularly for those sites with multicomponents, the overall change in the frequency of these associations implies that rock ring features were beginning to be made and used during the Pahute Mesa Period.

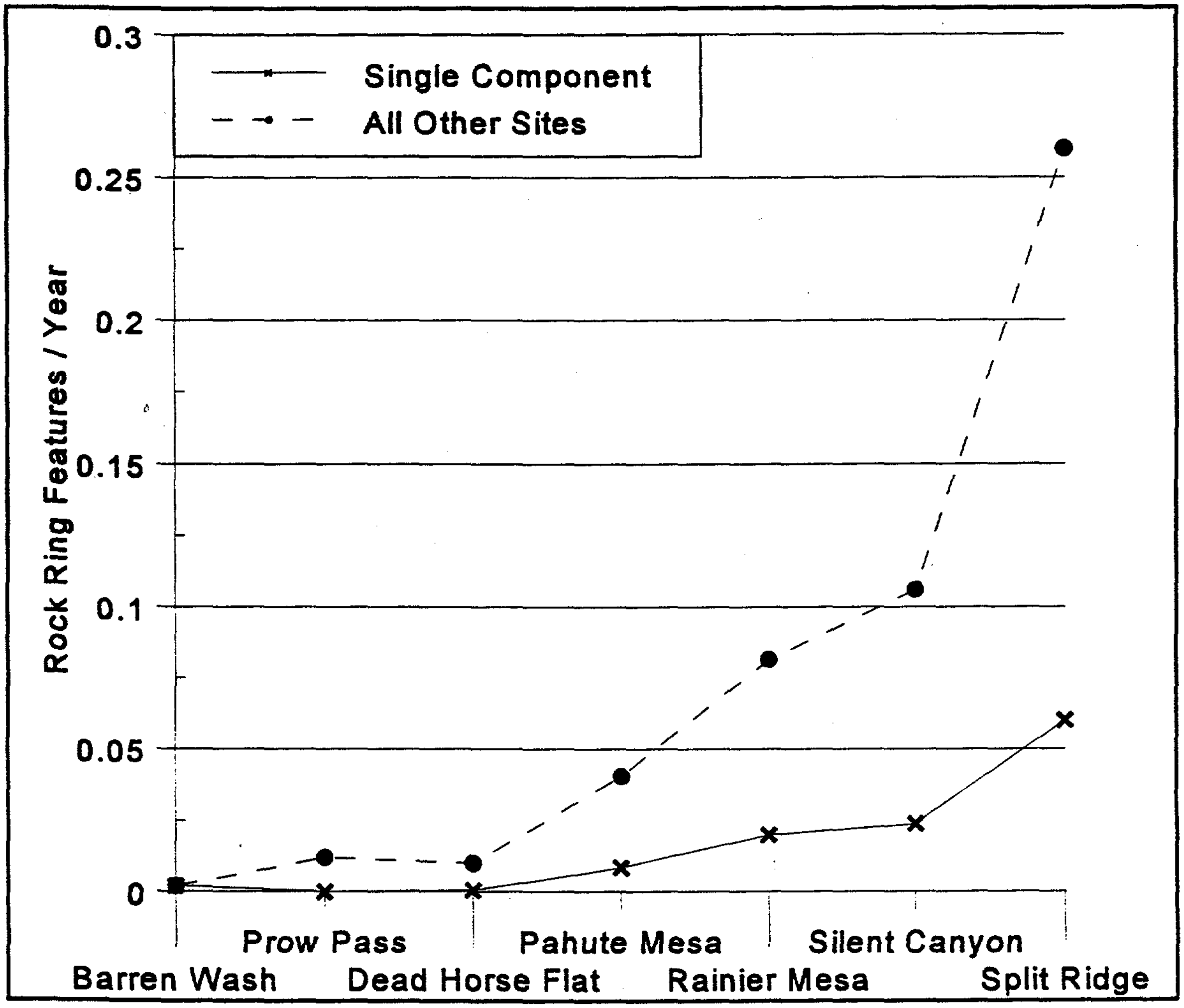

Fig. 18. Graph displaying the relative frequency of rock ring features at archaeological sites in each chronological period on Pahute and Rainier mesas. Values have been divided by the number of years in each period.

Single component Pahute Mesa Period sites containing these features include 26Ny1918, 26Ny2631, 26Ny3157, 26Ny4915, and 26Ny5467. In addition, site 26Ny4176-- which houses two of these rock ring features-- contains diagnostics of the Pahute Mesa and Dead Horse Flat periods, but none(?) of any later periods. Milling implements occur at all of these sites except for 26Ny4915. Also, unlike the other sites, the two rock rings at 26Ny4915 display evidence of burning and might fit Vierra's (1986) model of roasting ovens (see Lockett, 1986). However, this burning also could also have been due to forest fires; and these features have not been radiocarbon dated. Site 26Ny5467 has eight rock ring features and is approximately 300 m away from the nearest Rainier Mesa Period site (McLane, 1987a). Three rock ring features were found at 26Ny3157, two rings at 26Ny1918, and only one ring at 26Ny2631.

One additional aspect concerning resources exploitation during the Pahute Mesa period should be considered. As previously noted, an off-white silicified volcanic occurs on the mesas; and this rock was used as toolstone. In fact, table 3 indicates that toolstone made from this volcanic predominates in the debitage samples from single component sites since the Prow Pass Period. Hence, exploitation of the off-white volcanic started at least that early and from that time forward it comprises more that 60% of the debitage represented at single component sites. Archaeologists are only beginning to model the economy and cost-benefits associated with toolstone exploitation (for example, Elston, 1990; Torrence, 1989). Before examining how the exploitation of the off-white toolstone may have changed through time and the implications this may have concerning adaptive strategies (particularly during the Dead Horse Flat and Pahute Mesa periods), several important components of those models should be reviewed.

Costs associated with the exploitation of rock for artifact manufacture include its availability, distribution, transportability, and workability/suitability. The currencies used in measuring these costs may include both the direct energy required for its exploitation and, for hunters and gatherers, the stress caused by the need to exploit other resources at the same time (?) (see Elston, 1990; Gould, 1980:121-137; Jeske, 1989:34-15). Elston (1990:160) argued that-- because of higher failure rates and increased production costs--lower quality toolstone, like that on the mesas, would have been added to the resource pool when the costs of obtaining more distant and higher quality toolstone increased as residential mobility decreased. In this regard, at least three different strategies may have been followed in the exploitation of toolstone by the hunters and gatherers who visited the mesas. The first was modeled by Elston (1990:158-159) under conditions of very high residential mobility, which he associates with specialized big game hunting. Time stress during the exploitation of migrating game and large logistical territories would limit the amount of locally available lithic material that could be extracted and, among other things, require the use of high-quality materials that could be resharpened and refashioned as the need arose. Under this strategy the low-quality, off-white silicified volcanics on the mesas may have proved to be too expensive and risky to exploit (see Jeske, 1989:35-37). The second strategy, called *opportunistic extraction,* is the exploitation of this toolstone during subsistence forays (see Gould, 1980:121-137). Tools made during implementation of this extraction strategy may have been made, used, and discarded on the spot; and the search time and extraction costs would be "embedded" within the costs for the exploitation of primary food resources. The final strategy, called *quarried extraction*, differs in that the exploitation of toolstone becomes the predominate focus of forays, and the search time and extraction costs are calculated (perceived) separate from the exploitation of food resources (citation -?). Materials extracted under this strategy would be transported from the quarry after preliminary reduction, further modified at camps, and then used during later subsistence forays. These idealized strategies, however, should not be considered mutually exclusive and probably represent points along a continuum that proceeds from Elston's (1990) high residential mobility pattern to the logistically based quarried extraction of toolstone that could be used for external trade as well as to manufacture the tools necessary for subsistence activities (see Ericson and Purdy, 1984).

The focus on obsidian during the Barren Wash Period (table 3) appears to fit Elston's (1990) model for high residential mobility; and as previously noted, the obsidian used during this time appears to have come from sources away from the mesas, even though obsidian is locally available. However, it is obvious that the lower quality and locally available off-white toolstone was being exploited at least by the Prow Pass period. If an opportunistic strategy for the exploitation of this toolstone was being followed after that time, it might be difficult to recognize in the survey data. Other than this toolstone being in the substrate, the toolstone sites might look much the same as those used for food extraction. Nevertheless, four sites in the data set appear to exemplify this sort of opportunistic extraction. These sites include 26Ny2618 (William, 1989), 26Ny2622 (William, 1989), 26Ny4208 (Henton, 1984) and 26Ny5525 (McLane, 1987b). Nodules of both obsidian and the off-white silicified volcanic occur at 26Ny2618, 26Ny2622, and 26Ny4208; and the several debitage concentrations associated with the reduction of these nodules are diffusely scattered across the site areas. No bifaces or cores were noted, but single Rosegate and Gatecliff series projectile points and brownware pottery occur at 26Ny2618. At 26Ny5525, six cores of the off-white silicified volcanic were recovered with 170 pieces of debitage in a 253 m^2 area. No temporally diagnostic artifacts were noted.

These above sites contrast with eight other sites in data from the mesas (table 9). Data recovery has been conducted at four of these: 26Ny1408 (Jones, DuBarton, and Edwards, 1993:41-67), 26Ny3620 (Drollinger et al., 1993:45-120), 26Ny3629 (Drollinger et al., 1993:164-166), and 26Ny5207 (Simmons et al., 1990:99-140). Copious quantities of shatter from the off-white silicified volcanic toolstone comprises about half or more of all debitage recovered from these sites. As noted by Jones, DuBarton, and Edwards (1993:93), considerable effort was expended to isolate the finer-grained, more amorphous material usually found in the center of the rocks. Rejected cores, particularly assayed cores, are also extremely common; and, as noted by Gould (1980:126) for the Australian Aborigines, cores and waste flakes left behind at the quarry far exceed those found in the nearby camp sites. In fact, nearby camps are also a characteristic of this strategy of quarried extraction; and, as modeled by Elston (1990:159-161), residential mobility would have needed to be low to make the expenditure of energy represented by these quarries worthwhile.

Table 9 lists the diagnostic artifacts found at the quarried extraction sites. The diagnostics listed for 26Ny1408, 26Ny3620, and 26Ny5207 include those found at the nearby camps since the lithic scatters associated with these components are continuous and difficult to separate. The null hypothesis that these populations were drawn from the same population can not be rejected using the Kolmogorov-Smirnov statistic, and we may conclude that their temporal profiles are probably the same.[51] The Kolmogorov-Smirnov statistic ($D_{0.05}$) equaled 0.35 for the comparison between

[51] See discussion on page 41 for how this statistic was calculated (also see Thomas 1988:397-399)

26Ny3620 and 26Ny5207, but the largest difference in the cumulative percent for diagnostics at these sites was only 0.33 with the increase in frequency of Elko Series projectile points at 26Ny5207. Hence, even allowing that the assemblage at 26Ny5207 may be slightly later in time than that at 26Ny3620, quarried extraction of the off-white silicified volcanics was probably occurring at least by the Dead Horse Flat Period and definitely by the Pahute Mesa Period.

Table 9
Temporal Diagnostics at Sites Associated with the Quarried Extraction of the Off-White Silicified Volcanic Toolstone on Pahute and Rainier Mesas

Site No.	Western Stemmed	Large Side-notched	Gatecliff Series	Humboldt Series	Elko Series	Rosegate Series	Desert Series
26Ny1408	-	2	1	3	12	13	-
26Ny3620	2	6	24	5	61	54	35
26Ny3629	-	-	1	-	3	1	-
26Ny3664	-	-	1		-	1	-
26Ny4025	-	-	-	1	-	-	-
26Ny4515	-	-	-	-	-	-	-
26Ny5003	-	-	-	-	-	-	-
26Ny5207	1	1	2	1	9	2	-

As discussed when reviewing the apparent changes in adaptations during the previous Dead Horse Flat Period, knowledge of what happened during the Pahute Mesa Period might be necessary to evaluate the significance of those earlier changes. Elston (1986:141-145) combined both these periods into his "Middle Archaic" for the western Great Basin, and Warren and Crabtree (1986:187-189) considered both as the Gypsum Period for the Mojave Desert to the south and southwest of the mesas. Grayson (1993:255-258) also combined them in his discussion of Great Basin wide changes in adaptive strategies but clearly argued that the major changes with the advent of the late Holocene environments occurred when Gatecliff Series projectile points arrived on the scene. Following that into historic times, he saw a continuity in adaptations. For Elston (1986), as mentioned above, changes during this time were apparently gradual; but for Grayson, (1993:257) they were dramatic and pronounced. However, both saw a broadening of diet breadth in the environments exploited and in settlement patterns as well as an increase in apparent population density. In the lower Mojave Desert, it was "a time of intensive occupation of the desert together with a broadening of economic activities, and increasing contact with the California coast and the Southwest" (Warren and Crabtree, 1986:188-189). Hall and Basgall (1994:82) noted that archaeological sites of this age in the Fort Irwin area "appear to reflect short [sic] encampments by relatively small groups of people engaged in a range of subsistence-settlement activities." Hall and Basgall (1994:85) further noted that, although a wide range of game was apparently exploited, activities in the Drinkwater uplands focused on artiodactyls while those in the Tiefort Basin focused on lagomorphs, rodents, and tortoise. Concordantly, activities in the Drinkwater Basin appear to have placed a great emphasis on vegetal resources.

The evidence from Pahute and Rainier mesas appears to support the notion of a gradual change in the way the mesas were exploited between the Dead Horse Flat and Pahute Mesa Periods and a marked shift in settlement and subsistence patterns between the Prow Pass and Dead Horse Flat Periods. In total, then, by the end of the Pahute Mesa Period, the utilization of Pahute and Rainier mesas had changed considerably from that during the Prow Pass Period and the middle Holocene. The difference in Grayson's and Elston's perception of how activities changed then may be due to the fact that Grayson (1993:255-258) focused on sites with Gatecliff Series projectile points while Elston (1986:141-145) emphasized those with Elko (Martis) Series projectile points and placed some of the sites with Gatecliff Series points in his discussion of the Early Archaic. But this time span equals 2000 years or more and the rapidity of all these changes on the mesas is still open to question. Clearly there was a shift in settlement locations and a broadening of subsistence activities during the Dead Horse Flat Period, but our data also indicate that hunting may have remained a significant subsistence activity well into and probably through the Pahute Mesa Period. A comparison of changes in the intensity of use of milling equipment (fig. 15) and rock ring features (fig. 18) indicates that during the Dead Horse Flat Period there was a broadening of subsistence activities toward more vegetal resources but that facilities (i.e., rock ring features) associated with these activities did not begin to be used, at least very routinely, until the Pahute Mesa Period.

The packrat and pollen records in the southern Great Basin indicate that the pinyon-juniper woodland was probably thoroughly established on Pahute and Rainier mesas during the middle Holocene and that approximately 3000 years ago, about the beginning of the Pahute Mesa Period, this woodland may have been becoming even more densely laced with pinyon. Hence, there is no reason to suspect that pinyon was not an available and probably desirable food resource. Its exploitation may well explain the presence of the rock ring features. The caching of these resources, the increased presence of sites that may be interpreted to be temporary camps, the continued increase in the diversity of artifacts at these sites, and the decrease in the diversity of landforms used during the Dead Horse Flat and Pahute Mesa periods all appear to indicate that mobility patterns were becoming more logistically oriented than they had been earlier. In fact, it is tempting to conclude that adaptations may have approached those characterized by Steward's (1938; Thomas, 1973) Western Shoshone model and the norm for ethnographic hunters and gatherers. Bettinger (1977), Elston (1986), Grayson (1993), and Thomas (1973, 1982, 1988) have drawn this conclusion (however, see Bettinger, 1989:338-347; Bettinger and Baumhoff, 1982).

Rainier Mesa Period Adaptations (1500 to 900 B.P.)

Sites assigned to the Rainier Mesa Period are listed in table 10, and their distribution on the mesas is shown in figure 19. Diagnostics of this period include both Rosegate Series projectile

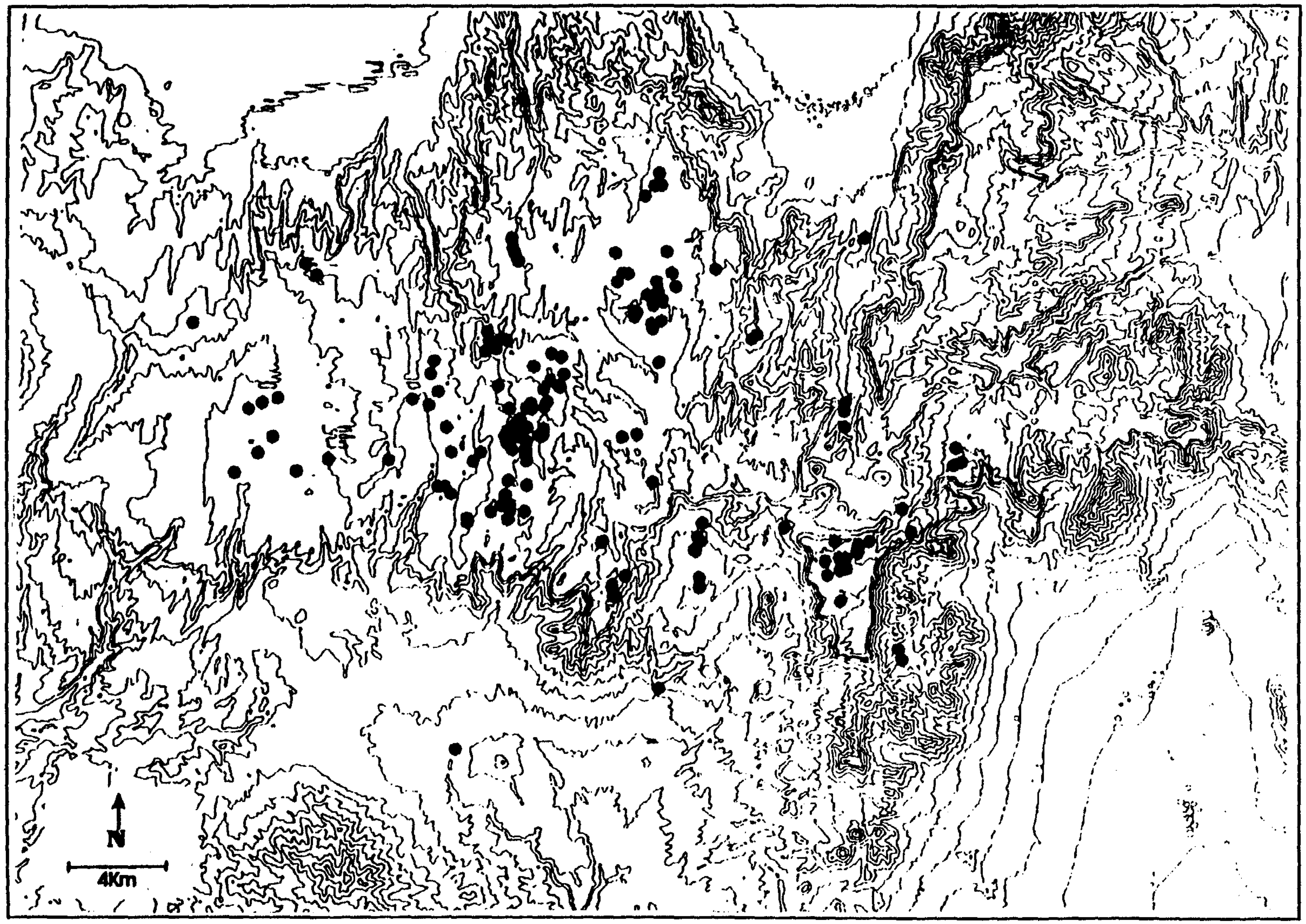

Fig. 19. Map showing the distribution of Rainier Mesa Period archaeological sites on Pahute and Rainier mesas.

Table 10
Archaeological Sites on Pahute and Rainier Mesas that Contain Diagnostics Assignable to the Rainier Mesa Period

Site Number	Elev. (m)	Area (m^2)	Density / m^2	Site Type	Topographic Setting
IS042693DW1 [b]	2009	1	1.000	Isolate	Alluvial terrace in valley
IS042693DW2 [b]	2012	1	1.000	Isolate	Alluvial terrace in valley
IS072392RJ4 [b]	1951	1	1.000	Isolate	Valley bottom
IS0090193LP2 [b]	1841	1	1.000	Isolate	Bench interior
IS102892CY15 [b]	1774	1	1.000	Isolate	Alluvial fan below knoll
26Ny933 [b]	2134	60,476	Unknown	Temporary camp	Valley bottom
26Ny943 [a]	1987	11,781	Unknown	Locality	Valley interior
26Ny975 [a]	2213	7850	Unknown	Temporary camp	Bench interior
26Ny1023	2240	65,974	High	Locality?	Bench top on edge of mesa
26Ny1034	2231	79	0.026	Locality	Valley interior
26Ny1035	2227	4,595	Unknown	Locality	Bench interior
26Ny1049 [b]	2051	16	0.063	Cache	Bench interior
26Ny1050 [c]	2051	3142	0.003	Temporary camp	Ridge top on bench interior
26Ny1360 [b]	2036	2356	Unknown	Locality	Ridge top on bench interior
26Ny1408	2073	137,445	0.007	Quarry	Valley bottom
26Ny1420 [b]	2036	2356	Unknown	Locality	Bench interior
26Ny1430 [b]	2048	1100	Unknown	Locality	Base of knoll on bench
26Ny1920	2033	192,787	Unknown	Temporary camp	Bench top
26Ny1925 [b]	2237	57	0.035	Locality	Ridge top on bench interior
26Ny1980 [b]	2073	1	3.000	Locality	Ridge top on bench interior
26Ny1984 [b]	2225	1	1.000	Isolate	Ridge top on bench interior
26Ny1990 [b]	1859	1	1.000	Isolate	Saddle on ridge
26Ny2607 [c]	2060	707	0.011	Locality	Edge of drainage on valley side
26Ny2609 [c]	2060	28,274	0.001	Locality	Edge of drainage on valley side
26Ny2615 [c]	2060	6283	0.066	Locality	Drainage at base of bench
26Ny2618	2070	76,176	0.002	Locality	Valley bottom
26Ny2620 [b]	2079	29,594	0.038	Quarry	Ridge top on bench interior
26Ny2627 [c]	2650	6	0.080	Locality	Side of bench on Rainier Mesa
26Ny2634 [b]	2246	707	0.200	Temporary camp	Ridge top on bench interior
26Ny2642 [b]	2262	2121	0.040	Locality	Ridge top on bench interior
26Ny2648 [b]	2243	2827	0.040	Locality	Ridge top on bench interior
26Ny2666 [b]	1957	0.01	1.000	Isolate	Narrow bench top
26Ny2677	2304	4712	Unknown	Temporary camp	Ridge top at drainage head
26Ny2679 [b]	1960	1257	0.037	Temporary camp	Bench interior
26Ny2682	1951	353	Unknown	Locality	Ridge top

Table 10
Archaeological Sites on Pahute and Rainier Mesas that Contain Diagnostics Assignable to the Rainier Mesa Period (continued)

Site Number	Elev. (m)	Area (m^2)	Density / m^2	Site Type	Topographic Setting
26Ny2683	1957	6283	Unknown	Temporary camp	Saddle on ridge
26Ny3171 [b]	1865	3927	0.034	Locality	Drainage head on bench
26Ny3173	1856	687,225	0.039	Temporary camp	Drainage edge on bench interior
26Ny3183 [b]	2225	31,416	0.012	Temporary camp	Bench interior near drainage head
26Ny3194 [b]	2006	1571	0.006	Locality	Ridge top on bench
26Ny3391 [c]	2033	31,416	0.023	Temporary camp	Bench interior
26Ny3393	2033	281,500	0.009	Temporary camp	Bench top at drainage head
26Ny3620	2045	450,000	0.137	Temporary camp	Valley near mesa edge
26Ny3621	2048	2500	4.948	Temporary camp	Rockshelter on valley side
26Ny3624 [c]	2027	38,700	0.001	Quarry	Valley bottom
26Ny3629 [c]	1993	36,756	0.048	Quarry	Valley bottom
26Ny3633	1975	47	0.293	Locality	Side of drainage in valley bottom
26Ny3651	2030	11,781	Unknown	Temporary camp	Rockshelters on bench side
26Ny3652 [a]	2048	1414	0.200	Temporary camp	Edge of bench top
26Ny3660 [b]	2030	314	0.038	Locality	Edge of drainage on bench interior
26Ny3664 [c]	2048	94,248	0.043	Quarry	Valley bottom
26Ny3665	2045	62,832	0.007	Temporary camp	Valley side
26Ny3935 [b]	2024	942	0.029	Locality	Side of drainage on bench
26Ny3938 [c]	2024	10,996	0.0004	Locality	Ridge top
26Ny3945 [b]	2036	1	1.000	Isolate	Side of ridge on bench
26Ny3950 [b]	2030	1	1.000	Isolate	Top of ridge on bench
26Ny4015	1996	682,510	0.073	Temporary camp	Bench slope
26Ny4017 [c]	1993	47,124	0.036	Temporary camp	Valley side / bench bottom
26Ny4019 [b]	1990	1	1.000	Isolate	Side of drainage on bench
26Ny4024 [c]	1996	2749	Unknown	Locality	Valley side / bench bottom
26Ny4040	1993	1,649	0.013	Temporary camp	Valley side below bench
26Ny4041	1996	3927	Unknown	Locality	Toe of ridge into valley bottom
26Ny4048	1996	863	0.081	Temporary camp	Ridge top
26Ny4053	2000	31,416	Unknown	Temporary camp	Slope of bench top
26Ny4054	1993	1728	0.050	Temporary camp	Valley side / bench bottom
26Ny4065 [b]	1984	1296	Unknown	Locality	Valley bottom
26Ny4067 [c]	1990	1060	Unknown	Locality	Valley bottom
26Ny4068 [a]	1987	7854	0.020	Temporary camp	Top of ridge on bench
26Ny4082 [b]	1999	707	0.025	Locality	Bottom of drainage in valley
26Ny4102 [b]	1999	628	Unknown	Temporary camp	Side of valley at base of bench

Table 10
Archaeological Sites on Pahute and Rainier Mesas that Contain Diagnostics Assignable to the Rainier Mesa Period (continued)

Site Number	Elev. (m)	Area (m²)	Density / m²	Site Type	Topographic Setting
26Ny4112	2021	8,247	0.049	Temporary camp	Bench top
26Ny4115 [a]	2018	19,635	Unknown	Temporary camp	Top of ridge on bench
26Ny4116 [b]	2042	1,885	Unknown	Locality	Top of ridge on bench
26Ny4119 [b]	2042	39	0.179	Locality	Top of ridge on bench
26Ny4127 [a]	2054	20	0.200	Locality	Saddle on ridge on bench
26Ny4135 [b]	2048	1,257	0.033	Temporary camp	Side of ridge on bench
26Ny4158 [b]	2149	1	1.000	Isolate	Bench interior
26Ny4177 [c]	2146	212,058	Unknown	Locality	Bench edge above N. Silent Cyn.
26Ny4178 [b]	2123	5,262	0.005	Locality	Top of bench near edge
26Ny4182 [c]	2128	326,560	0.112	Lithic scatter	Bench interior
26Ny4185 [a]	2102	1963	0.022	Temporary camp	Low ridge below bench edge
26Ny4189 [b]	2099	5891	0.146	Temporary camp	Low ridge below bench edge
26Ny4190	2099	6597	1.080	Temporary camp	Ridge top and sides
26Ny4192 [a]	2092	314	0.509	Locality	Top of bench near edge
26Ny4201	2076	25,447	0.425	Lithic scatter	Bench top above small valley
26Ny4203	2085	33,929	0.082	Lithic scatter	Bench top overlooking drainage
26Ny4209	2060	123,637	0.004	Temporary camp	Bottom of narrow valley
26Ny4212	2262	47,124	2.730	Temporary camp	Bench interior
26Ny4500 [b]	1908	19	0.474	Locality	Base of ridge at drainage head
26Ny4502 [c]	1908	9425	2.750	Locality	Drainage edge in valley bottom
26Ny4513 [b]	2118	7265	0.015	Temporary camp	Drainage head onto bench
26Ny4518 [b]	1987	1	1.000	Isolate	Base of bench edge
26Ny4534 [a]	1893	1,100	0.081	Temporary camp	Head of drainage onto ridge
26Ny4554 [b]	1884	1	1.000	Isolate	Ridge top
26Ny4569 [b]	2045	5498	0.103	Locality	Bench top above drainage head
26Ny4577 [b]	2039	2100	0.187	Locality	Bench interior
26Ny4581 [b]	2067	1	1.000	Isolate	Bench interior
26Ny4585	2073	14,137	0.555	Temporary camp	Bench interior
26Ny4586 [b]	2073	2827	0.141	Temporary camp	Bench top above drainage head
26Ny4588	2067	220,000	0.310	Temporary camp	Bench interior
26Ny4589 [c]	2073	32,830	0.410	Temporary camp	Valley edge
26Ny4598 [b]	1926	785	0.013	Locality	Ridge top above drainage head
26Ny4614 [c]	1920	117,810	0.090	Locality	Drainage edge on bench
26Ny4856 [b]	1893	500	0.058	Locality	Ridge top on bench
26Ny4869	2008	153,742	0.018	Temporary camp	Bench top near drainage head

Table 10
Archaeological Sites on Pahute and Rainier Mesas that Contain Diagnostics Assignable to the Rainier Mesa Period (continued)

Site Number	Elev. (m)	Area (m^2)	Density / m^2	Site Type	Topographic Setting
26Ny4872 [a]	1914	15,080	0.316	Temporary camp	Bench top in amphitheater
26Ny4904 [b]	2085	314	0.105	Locality	Valley side
26Ny4919	1871	942	0.450	Temporary camp	Rockshelter below bench
26Ny4940 [b]	1932	79	0.114	Temporary camp	Valley bottom
26Ny4947 [a]	1939	26,704	0.179	Temporary camp	Low saddle on bench
26Ny4952	1926	62,832	0.096	Temporary camp	Valley bottom near head
26Ny4954	2118	12,566	0.003	Temporary camp	Saddle on ridge on bench
26Ny4965	1981	127,235	0.383	Temporary camp	Narrow valley off bench
26Ny4987 [a]	1762	9425	0.429	Temporary camp	Narrow canyon off mesa top
26Ny5207	1998	92,300	0.013	Quarry	Valley edge near drainage head
26Ny5208 [b]	2003	1	1.000	Isolate	Bench edge near canyon head
26Ny5211	1996	8900	0.220	Locality	Bench near drainage head
26Ny5215	2012	3700	0.513	Temporary camp	Low saddle on bench
26Ny5236	1640	471	Unknown	Locality	Head of drainage off ridge
26Ny5417 [a]	2012	96,442	Unknown	Temporary camp	Valley side next to bench
26Ny5418	2045	45,000	0.027	Temporary camp	Valley bottom
26Ny5465	2257	6597	0.009	Temporary camp	Narrow valley on bench interior
26Ny5466	2256	225,030	0.020	Temporary camp	Bench interior
26Ny5481 [b]	2298	1	1.000	Isolate	Side of ridge on bench
26Ny5491 [b]	2256	6432	0.010	Temporary camp	Valley bottom
26Ny5493 [b]	2243	620	0.169	Locality	Side of ridge on bench
26Ny5494 [b]	2249	641	0.027	Temporary camp	Bench interior
26Ny5533 [b]	1978	82	0.085	Locality	Bench interior
26Ny5556 [b]	1896	1	1.000	Isolate	Ridge top on bench
26Ny5604 [b]	2227	1	1.000	Isolate	Bench interior
26Ny5612 [b]	2097	3299	0.021	Temporary camp	Ridge top on end of bench
26Ny5628 [a]	2042	236	0.064	Locality	Side of ridge on bench
26Ny5635 [b]	1849	12	0.250	Locality	Side of valley below mesa
26Ny5738 [b]	2012	785	0.018	Locality	Saddle on ridge on bench edge
26Ny5750 [b]	1983	38	0.079	Locality	Top of ridge on bench
26Ny5796 [a]	1884	295	0.092	Locality	Side of valley below mesa
26Ny5882 [b]	2063	1	1.000	Isolate	Valley bottom
26Ny5892 [b]	2076	25,290	0.040	Temporary camp	Valley bottom
26Ny5914 [c]	2124	2240	0.018	Temporary camp	Bench edge
26Ny5916 [c]	2234	2826	0.059	Temporary camp	Bench top at drainage head

Table 10
Archaeological Sites on Pahute and Rainier Mesas that Contain Diagnostics Assignable to the Rainier Mesa Period (continued)

Site Number	Elev. (m)	Area (m^2)	Density / m^2	Site Type	Topographic Setting
26Ny5917 [c]	2134	25,504	0.163	Lithic scatter	Bench top at drainage head
26Ny5923 [b]	2134	1	1.000	Isolate	Side of slope below bench
26Ny7357 [b]	2137	1178	0.048	Locality	Bench interior
26Ny7358 [c]	2137	27,488	0.084	Lithic scatter	Bench top at drainage head
26Ny8083	1939	137,445	Unknown	Temporary camp	Valley bottom
26Ny8245	2164	1,413,719	Unknown	Locality	Valley bottom
26Ny8252 [b]	1920	785	0.098	Locality	Valley bottom
26Ny8360	1981	63,6174	0.200	Temporary camp	Narrow valley between benches
26Ny8363 [b]	1989	118	0.068	Locality	Valley bottom

[a] Later, but no previous components.
[b] Single component.
[c] Previous, but no later components.

points and Anasazi and Fremont styles of pottery (see Pippin, 1995). A broken globular jar of Shivwits Plain (Lyneis, 1992:44-46) was recovered from 26Ny1408, and the 10 sherds of North Creek Corrugated at 26Ny3173 and 12 sherds of Snake Valley Grayware at 26Ny3393 also probably represent single vessels. However, the remaining Anasazi and Fremont pottery sherds from sites on the mesa--which include 2 sherds of Boulder Gray, 8 sherds of Moapa Black-on-gray, 26 sherds of North Creek Grayware, 5 sherds of Middleton Black-on-red, and a few sherds of an unknown grayware and a buff ware--are widely scattered and could represent antiquities collected and curated by later peoples using the mesa (see Pippin, 1995, table 31). Nonetheless, Rosegate Series projectile points were recovered from all the sites (n = 12) containing these Anasazi and Fremont styles except at 26Ny4051 where an Elko Series point was found with one of the sherds of Middleton Black-on-red and at 26Ny4566 where a Desert Series projectile point occurred with a sherd of an unknown grayware.

Based on site area, the intensity of activities on Pahute and Rainier mesas nearly doubled during the Rainier Mesa Period (fig. 6). Although the number of sites assigned to this period declined slightly from the previous Pahute Mesa Period, the postulated increase in the intensity of exploitation of the mesas remains proportional when these values are standardized by the number of years in each period. The relative frequency of milling equipment at Rainier Mesa Period sites also appeared to double (fig. 15) as did the frequency of rock ring features (fig. 18). Hence, this significant increase in activities on the mesas appears to be real. Nearly half (46%) of the Rainier Mesa Period sites on the mesas had been previously utilized by peoples of the Pahute Mesa Period, and multidimensional scaling of the cooccurrence of diagnostics on the mesas (fig. 7) reflects this redundancy in the selection of locations to conduct activities. Likewise, the landforms (fig. 9) and geographic areas (figs. 16, 19) utilized during the Rainier Mesa Period differed little from those of the previous period, although Simpson's index indicates a slight increase in diversity of exploited landforms (table 4).

Of the 67 Rainier Mesa Period single component sites listed in table 10, almost one third (31%) are isolated projectile points and approximately one half (48%) are localities. The remaining 14 sites (21%) have been classified as temporary camps. These proportions are similar to those noted for single component sites during the Dead Horse and Pahute Mesa Periods, and the sampling of single component sites in our data is evidently biased toward the smaller and simpler sites. In this regard, it is important to note that only approximately 12% of the single component Rainier Mesa Period sites on the mesas contain milling equipment. This reflects a reduction in milling equipment at these single component sites compared to both the Dead Horse Flat Period (27%) and the Pahute Mesa Period (18%). Yet figure 15 indicates that milling was an important activity on the mesas during the Rainier Mesa Period. Likewise, rock ring features appeared to increase in their frequency during the Rainier Mesa Period (fig. 18). This observation calls into question the conclusions concerning the overall emphasis on hunting for the earlier Dead Horse Flat and Pahute Mesa periods. Those previous conclusions were based, in part, on a lack of milling equipment and facilities at single component sites. Based on that line of reasoning, hunting would have been even more important during the Rainier Mesa Period than during the Dead Horse Flat Period.

This trend also may reflect changes in how the resources on the mesas were monitored during the Dead Horse, Pahute Mesa, and Rainier Mesa periods. If the mesas were within the logistical radius of residential bases situated off the mesas, then we might expect an increase in domestic (milling) activities at temporary camps and localities on the mesas. However, if the temporary camps and localities fell directly within the foraging radius of base camps established on the mesas, then there would be little need to conduct many of the domestic activities away from those base camps. This hypothesis might explain why the number of milling implements increases overall at Rainier Mesa Period sites but decreases for the smaller, simpler, single component sites. It may also explain the slight decrease in assemblage heterogeneity at the single component Rainier Mesa Period sites on the mesas (fig. 8). Finally, this hypothesis is congruent with the postulated increase in the quarried extraction of the local off-white silicified volcanic toolstone during the Pahute Mesa Period as discussed above. This is not to suggest, however, that there was a wholesale shift in how the mesas were used during the Rainier Mesa Period. An examination of how ethnographic groups used the mesas (Pippin, 1996) indicated that both strategies (monitoring from within the logistic radius and monitoring from within the foraging radius) were probably used during the Split Ridge Period. There is also reason to believe that both strategies were used during the Rainier Mesa Period and probably even early periods. Rather than a wholesale change, a gradual change is postulated in the emphasis of these two strategies between the Dead Horse and Rainier Mesa periods.

Although it was argued above that this shift may have been due to an increased reliance on pinyon nuts, the best evidence to date for the exploitation of pinyon nuts on the mesas comes from a rockshelter (26Ny3171) situated almost 1 km away from the nearest pinyon tree and 3 km from the nearest concentrated stand of these trees (McLane et al., 1992). High frequencies of pine and *Platyopuntia* pollen (in comparison to control samples) were noted in samples taken from Stratum C in the rockshelter (Hemphill, 1992:54-61). Numerous pinyon nut hulls and *Opuntia* seeds were also recovered from this stratum, and there is little doubt that activities at this site included the gathering or use of at least these plant resources. There is also some indication, although not as strong, that plants belonging to the *Chenopodiineae-Amaranthus* and *Poaceae* species might also have been exploited. Utilization of this rockshelter dates to the Rainier Mesa and Silent Canyon periods, and a radiocarbon date of 460 B.P. was obtained from charcoal on top of this stratum (McLane et al., 1992:43-44). The site is situated in the bottom of a tributary to East Thirsty Canyon near the canyon's head, and this topographic positioning conforms with the shift in location of activities to these environments initiated during the Pahute Mesa or earlier Dead Horse Flat Period (see discussion on pages 89-91). In fact, during the Rainier Mesa Period, temporary camps were commonly located in these environments (Pippin, McLane, and Henton 1987; William, Henton, and Pippin, 1992). As argued above, this settlement pattern seems incongruous with the intercept of large game that may have migrated along these drainages.

Elston (1982:197-198, 1986:145-148) noted "profound" changes during the late Archaic throughout the western Great Basin that, in his analysis, began with the introduction of the bow and arrow and the addition of the huller and mortar to the inventory or grinding implements.[52] Elston (1986:145) felt that these technological changes accompanied "the adoption of a subsistence strategy that entailed an increase both in the diversity of resources used and in the number of ecozones exploited. Plant foods and small game, especially rabbits, were emphasized at the expense of large game." But Elston (1986:145-148) combined both the periods marked by Rosegate Series projectile points and Desert Series projectile points, and it is unclear when all these changes occurred.

Warren and Crabtree (1986:189-191) separated these periods for the Mojave Desert south of the mesas. They noted that the large village sites reported in Antelope Valley in the western Mojave Desert (Sutton, 1981; McGuire, Garfinkel, and Basgall, 1981), as well as at Saratoga Springs (Wallace and Taylor, 1959) in Death Valley and Oro Grande on the Mojave River (Rector, Swenson, and Wilke, 1983), date to this period. Lyneis (1982:177) had earlier observed a shift from the "fairly heavy, semisedentary" villages in the lowlands during Death Valley III times (Pahute Mesa Period), as reconstructed by Wallace (1958:12), to more temporary camps of small groups (also see Wallace, 1962). But Warren and Crabtree (1986:191) largely saw a continuity in adaptations between the Saratoga Springs Period (Rainier Mesa Period) and the earlier Gypsum Period (Dead Horse Flat and Pahute Mesa periods) in the northern Mojave Desert. Yet Warren and Crabtree (1986:193) viewed regional diversification to be "characteristic" of this period and pointed to increased contact between

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[52] Mortars have been noted at 26Ny933, a single component Rainier Mesa Period site, and at 26Ny8245 which was continuously utilized between the Dead Horse Flat and Silent Canyon periods. Pestles were recorded at 26Ny4919, utilized during the Pahute Mesa, Rainier Mesa, and Silent Canyon periods, and at 26Ny4949, undated. Hullers, which are defined as very thin, oval, and well ground and polished milling stones (Elston, 1979:154), have not been found on the mesas.

the hunters and gatherers of the northeastern Mojave Desert with the Anasazi agriculturalists of the Muddy and Virgin river basins as well as those of the southern Mojave Desert with the Hakataya agriculturalists of the lower Colorado River. In fact, they pointed to Leonard and Drover's (1980:251-250) study of the turquoise mines near Halloran Springs, some 200 km south of the mesas, to indicate that the Anasazi "controlled" the mines during the Pahute Mesa Period. Shutler (1961:5-12) had earlier viewed most, if not all, of the occurrences of Anasazi pottery west of the Muddy and Virgin river basins to represent the camps of Anasazi foraging parties and Warren and Crabtree (1986:191) perpetuated that view.

If Anasazi/Fremont/Hakatayan agriculturalists were responsible for depositing the painted, grayware, and buff ware pottery on Pahute and Rainier mesas, we would expect that their sites would be organized somewhat differently from those of the hunters and gatherers who were already there. It is difficult to fathom that foraging parties from such strong logistically organized settlement and subsistence patterns would not be tied to relatively nearby base camps. Yet none of the sites on the mesas containing buff ware, grayware, and painted sherds have artifact inventories reminiscent of inventories usually found with Anasazi, Fremont, and Hakatayan base camps. If these sites were the base camps of these groups, then they do not differ much, if at all, from those used by the local hunters and gatherers. Hence, it seems more reasonable to hypothesize that the Anasazi, Fremont, and buff ware sherds on the mesas reflect items obtained by the local hunters and gatherers through contact with these groups or other hunter and gatherers who had contact with them. This is not to reject the notion that these agriculturalists sent foraging and/or trading parties into the Mojave Desert. It is evident that they did, at least to exploit deposits of salt and turquoise. But they probably did not send foraging parties to Pahute and Rainier mesas for food resources that would have been much more economically exploited nearer the agricultural fields in the Muddy and Virgin river valleys.

If the hunters and gatherers were responsible for depositing Anasazi, Fremont, and Hakatayan ceramics in the archaeological record on the mesas during the Rainier Period, then this has two distinct implications concerning their adaptations at that time (see Pippin, 1986b). First, as argued by Simms et al. (1993), the investment in ceramics by these hunters and gatherers probably indicates decreased residential mobility and/or an increase in the redundancy in residential moves. Secondly, these sherds are direct indicators that the Rainier Mesa Period is one marked by contact between two contrasting societies (Warren and Crabtree, 1986:191). It is during such periods that increased intellectual variability and potential for changes in adaptive strategies would be expected. Warren and Crabtree (1986:188) clearly pointed out that this sort of contact was probably already occurring during the earlier Gypsum (Pahute Mesa) Period. Yet during that earlier period, the differences in adaptive strategies of these societies would have been less pronounced.

Bettinger (1989:339-342) argued that adaptive strategies in the Owens Valley region reflected greater mobility (less settlement-tethered) prior to approximately 1400 years ago and that around that time, the ethnographic type of large permanent villages in the lowland desert scrub started to be utilized. With this change, he suggested that resource use had become more intensive within smaller local areas and that it was then that pinyon procurement became the central focus of subsistence activities. Although Bettinger (1989:342) favored population growth as the major driving force behind these changes, he noted that dwindling resources due to climate change could also have been a factor. Others pointed to the spread of pinyon to explain this intensive use, but Madsen (1986:37) argued that it was the introduction of the bow and arrow (historic event) that caused the shift to intensive pinyon exploitation. He argued that with the increased success resulting from the use of this weapon, animal populations "nose-dived" to a point where the benefits (overall dietary return) of pinyon exploitation exceeded those of hunting. The evidence from Pahute and Rainier mesas shows a marked increase in the intensity of resource exploitation (probably pinyon) on the mesas during the Rainier Mesa Period; and, as noted, there are several indicators that base camps (resource monitoring from within the foraging radius) were more frequently established on the mesas during the Pahute and Rainier Mesa periods. But it is important to note that all the indices that have been used to demonstrate these changes do not only appear during the Rainier Mesa Period. Rather, the evidence suggests that change was slow and directional and that the logistical exploitation of resources on the mesas probably began at least by the Dead Horse Flat Period, was well in place by the Pahute Mesa Period, and then intensified during the Rainier Mesa Period.

Silent Canyon (900 B.P. to 100 B. P.) and Split Ridge Period Adaptations

Thomas (1982b:97-99) found that two distinct strategies were used in the exploitation of high altitude resources of the Toquima Range approximately 170 km north of the mesas. He called the first the "Early" Hunting Complex and noted that it is marked by approximately 50 hunting blinds, early stratigraphic layers in middens, and a few rock ring features that appear to be houses. He associated this complex with a strategy marked by all male hunting parties that were logistically and communally exploiting game (yellow-bellied marmots and mountain sheep) from villages in the lowlands and dated it prior to Yankee Blade (Silent Canyon) times (primarily Gatecliff and Elko series diagnostics). The second strategy he found was characterized by the residential use of Alta Toquima and was marked by a diversity of artifacts--pottery, grinding implements, beads, drills, abrader/shaft straighteners, etc.--found in the later stratigraphic contexts (Silent Canyon Period) in the same rock rings and many other rock features that also appear to be houses. Bettinger (1991b) found a similar shift in adaptive strategies used to exploit the high altitude resources on the White Mountains approximately 150 km to the west-northwest of Pahute Mesa. However, as discussed above, he dated this shift to approximately 1400 years ago during the Rainier Mesa Period.

Bettinger (1991b, 1994:51-55) used these high altitude records, as well as his previous reconstructions of adaptive strategies in the Owens Valley region (1989:338-347), to support his model of ethnic spreads as it applies to the Numa (Bettinger and Baumhoff, 1982; Young and Bettinger, 1992; Bettinger, 1994). Based on optimal foraging models, he hypothesized that the pre-Numic adaptations (travelers) were focused on the exploitation of high yield and low cost resources such as large game, a strategy which required high mobility. The Numa (processors), on the other hand, focused on the intensive exploitation of a host of lower yield and higher cost resources and, thereby, did not need to move so much and could support larger populations. Because of this, the processor strategy would have been more adaptive under conditions of population growth and diminishing resources. Hence, according to Bettinger (1989), when these conditions arose in the Owens Valley, there was emigration into areas largely ignored previously except by the pre-Numic travelers.

The notion that the Numa had only relatively recently assumed their geographic distribution when the *Tiabo* first arrived has existed for quite some time (Sutton and Rhode, 1994). As clearly pointed out by Madsen (1994), there is little reason to doubt that the Numa did expand particularly into areas once utilized by the Anasazi and Fremont. However, the timing of this event is uncertain as well as where they might have come from if they were not indigenous. Currently, there are two prominent views concerning this issue. Bettinger's above model (Bettinger and Baumhoff, 1982; Young and Bettinger, 1992; Bettinger, 1994) represents what Rhode and Madsen (1994:213) called the "traditionalist" view, that the Numa spread from the far southwestern Great Basin (Mojave Desert) approximately 1000 years ago or so. The second view, represented in a model advanced by Aikens and Witherspoon (1986) and Aikens (1994) placed a much greater time depth to the Numa. They (Aikens and Witherspoon, 1986; Aikens 1994) located the homeland of proto-Numic ancestors in the "arid core" of the central Great Basin and noted the 5000 years or so of continuity in adaptations in this region as hypothesized by Thomas (1973, 1982a, 1983, 1988). By approximately 1500 years ago or so, this homeland would have been surrounded by the Anasazi to the southeast, the Fremont to the northeast, and the Lovelock and Chewaucanian adaptations to the northwest. Aikens and Witherspoon (1986) argued that these horticultural and marsh based adaptations were dependent on periods of adequate precipitation and that during the warm-dry episode recorded in the bristlecone pine record from the White Mountains approximately 1000 years ago (LaMarche, 1974, fig. 6), they were mortally disadvantaged and had to abandon traditionally occupied areas. It was this change in climate and the resulting territorial abandonment that initiated the expansion of the Numa out of their arid core in central Nevada into lands still worth occupying.

Both these models have implications concerning what we might expect in the archaeological record of Pahute and Rainier mesas. The homeland of the Numa probably would have included Pahute and Rainier mesa if Aikens' and Witherspoon's (1986) model is correct; and we might, therefore, expect a continuity in adaptations between the Silent Canyon Period and earlier periods. But according to Bettinger's (1994) model, Pahute and Rainier mesas would have been outside of the Numa homeland; and we should expect to see the shift between his traveler and processor adaptations somewhat later in the sequence on the mesas (Silent Canyon Period?) than in his Owens Valley reconstruction.

Table 11 lists the archaeological sites on the mesas that contain diagnostics of the Silent Canyon Period, and figure 20 shows their distribution. Diagnostics of this period include both the Desert Series of projectile points (Cottonwood and Desert Side-notched) and brownware pottery. Because both these diagnostics continue into the historic Split Ridge Period, some of the sites presented in table 11 also may represent Split Ridge adaptations. For right now, it is assumed that if historic artifacts were absent from the sites, then the sites dated only to the earlier Silent Canyon Period. However, several of the ethnohistoric sites identified by Pippin (1996) are subdivisions of

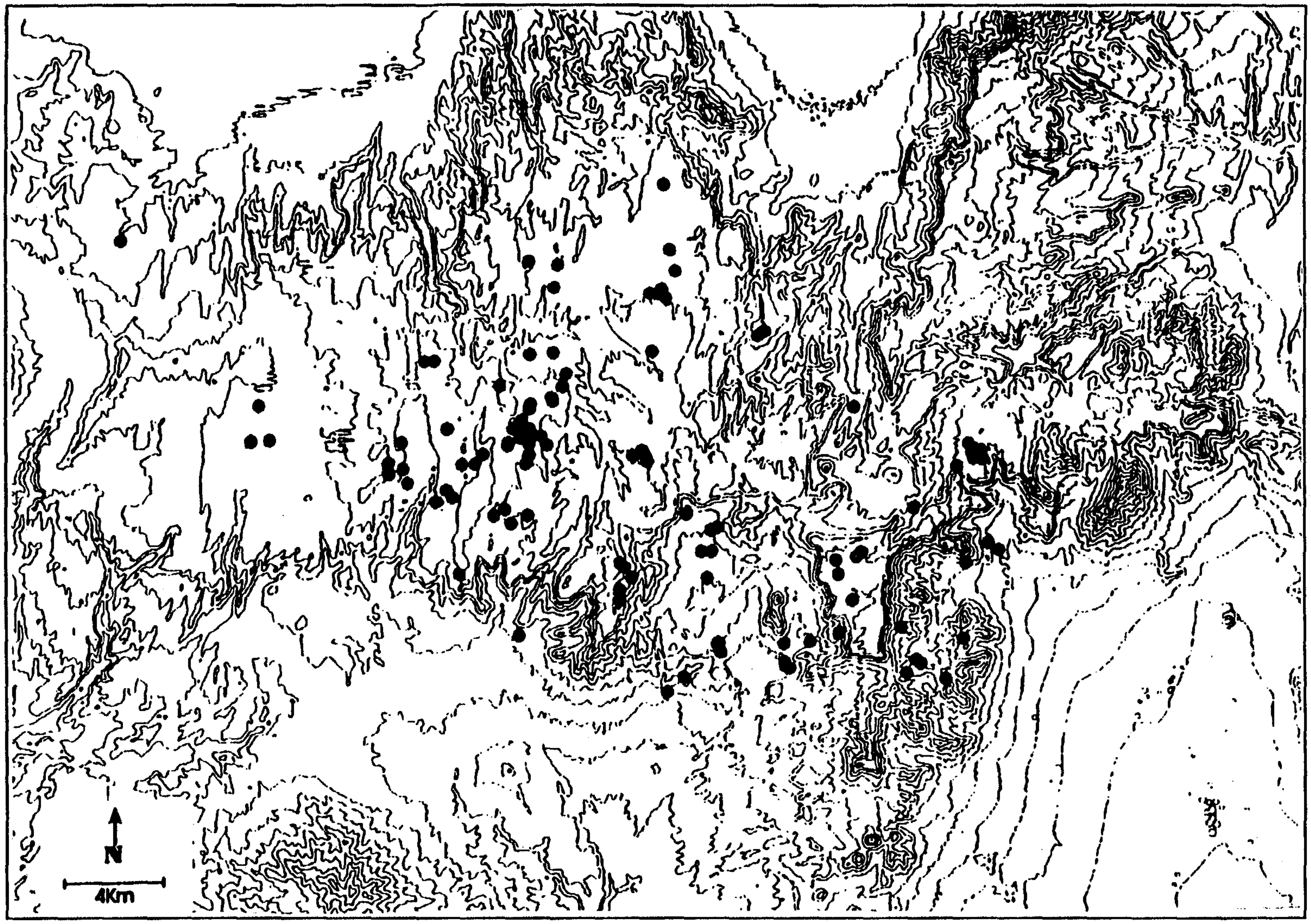

Fig. 20. Map showing the distribution of Silent Canyon Period archaeological sites on Pahute and Rainier mesas.

sites showing continued utilization during earlier periods. If these sites also have other subdivisions containing only Desert Series points or brownware pottery, then they are also included in table 11. Again, the sites have been marked as to whether they were considered single component Silent Canyon Period sites for the calculations in table 3.

Table 11
Archaeological Sites on Pahute and Rainier Mesas that Contain Diagnostics Assignable to the Silent Canyon Period

Site Number	Elev. (m)	Area (m^2)	Density / m^2	Site Type	Topographic Setting
Is042693DW2 [a]	2012	1	1.00	Isolate	Valley bottom
26Ny928 [a]	2042	33	Unknown	Temporary camp	Rockshelter on bench edge
26Ny929 [a]	2198	4700	Unknown	Temporary camp	Ridge top on bench interior
26Ny937 [a]	1829	7	Unknown	Temporary camp	Rockshelter on bench edge
26Ny938 [a]	1853	39	Unknown	Temporary camp	Rockshelter on bench edge
26Ny939 [a]	1853	13	Unknown	Temporary camp	Rockshelter on bench edge
26Ny940 [a]	1853	12	Unknown	Temporary camp	Rockshelter on bench edge
26Ny941 [a]	2243	5891	Unknown	Temporary camp	Valley side
26Ny942 [a]	2225	23,562	Unknown	Temporary camp	Valley side
26Ny943	1987	11,781	Unknown	Locality	Valley interior
26Ny944 [a]	1981	4712	Unknown	Locality	Valley interior
26Ny945 [a]	1798	2042	0.045	Temporary camp	Valley side
26Ny952	1972	206,168	0.057	Temporary camp	Valley bottom
26Ny975	2213	7,850	Unknown	Temporary camp	Bench interior
26Ny997 [a]	1862	706	0.016	Locality	Top of ridge on bench
26Ny1003 [a]	2036	1	2.000	Pot drop	Knoll on bench
26Ny1007	2068	200	Unknown	Locality	Base of ridge in Gold Meadow
26Ny1023	2240	65,974	High	Locality?	Bench top on edge of mesa
26Ny1024	2237	58,905	0.002	Locality	Valley bottom
26Ny1026	2243	491	0.016	Locality	Valley interior
26Ny1033 [a]	2234	177	0.062	Temporary camp	Rockshelter in saddle on ridge
26Ny1034	2231	79	0.026	Locality	Valley interior
26Ny1035	2227	4595	Unknown	Locality	Bench interior
26Ny1036 [a]	1929	1885	Unknown	Locality	Saddle on ridge
26Ny1037 [a]	1914	1414	Unknown	Locality	Saddle on ridge
26Ny1039 [a]	2225	38	Unknown	Temporary camp	Rockshelter on bench interior
26Ny1040	2225	2749	0.004	Locality	Bench interior
26Ny1041 [a]	2225	314	Unknown	Temporary camp	Drainage edge on bench
26Ny1043 [a]	2231	50	0.120	Temporary camp	Rockshelter on bench
26Ny1046	2030	12,566	0.005	Locality	Saddle between valleys
26Ny1369 [a]	2048	5891	Unknown	Temporary camp	Bench interior
26Ny1408	2073	137,445	0.007	Quarry	Valley bottom

Table 11
Archaeological Sites on Pahute and Rainier Mesas that Contain Diagnostics Assignable to the Silent Canyon Period (continued)

Site Number	Elev. (m)	Area (m^2)	Density / m^2	Site Type	Topographic Setting
26Ny1915	2006	193,915	0.001	Temporary camp	Valley side
26Ny1920	2033	192,787	Unknown	Temporary camp	Bench top
26Ny1939 [a]	1829	1178	0.400	Temporary camp	Saddle on ridge
26Ny1981 [a]	1814	1	2.000	Locality	Drainage edge on bench
26Ny1983 [a]	2237	1	1.00	Isolate	Ridge top on bench
26Ny2618	2070	76,176	0.002	Locality	Valley bottom
26Ny2627	2650	6	0.080	Locality	Side of bench on Rainier Mesa
26Ny2638 [a]	2115	70,686	0.497	Temporary camp	Bench interior
26Ny2651 [a]	1969	79	0.101	Locality	Saddle on ridge
26Ny2655 [a]	1996	628	Unknown	Locality	Ridge top on bench
26Ny2656 [a]	1981	2827	Unknown	Locality	Side of drainage off ridge
26Ny2659 [a]	1963	707	Unknown	Locality	Ridge top on bench
26Ny2662	1951	39	Unknown	Temporary camp	Rockshelter on bench edge
26Ny2670	1798	126	0.630	Temporary camp	Rockshelters on valley edge
26Ny2674 [a]	1818	314	0.025	Locality	Base of cliff on valley edge
26Ny2675 [a]	1987	78	0.256	Temporary camp	Base of ridge on valley side
26Ny2682	1951	353	Unknown	Locality	Ridge top
26Ny2683	1957	6283	Unknown	Temporary camp	Saddle on ridge
26Ny2687 [a]	1975	707	Unknown	Locality	Drainage head on ridge top
26Ny3157	2076	15,708	0.200	Temporary camp	Rockshelter on narrow bench
26Ny3159 [a]	1939	2356	0.020	Temporary camp	Top of knoll on bench
26Ny3173	1856	687,225	0.039	Temporary camp	Drainage edge on bench interior
26Ny3393	2033	281,500	0.009	Temporary camp	Bench top at drainage head
26Ny3620	2045	450,000	0.137	Temporary camp	Valley near mesa edge
26Ny3621	2048	2500	4.948	Temporary camp	Rockshelter on valley side
26Ny3633	1975	47	0.293	Locality	Side of drainage in valley bottom
26Ny3650 [a]	2030	21,206	0.160	Temporary camp	Rockshelters at base of bench
26Ny3651	2030	11,781	Unknown	Temporary camp	Rockshelters at base of bench
26Ny3652	2048	1414	0.200	Temporary camp	Edge of bench top
26Ny3665	2045	62,832	0.007	Temporary camp	Valley side
26Ny3670 [a]	1969	2356	0.037	Locality	Bench edge
26Ny3672 [a]	1963	39	0.205	Locality	Drainage head on bench
26Ny3931	1576	3770	Unknown	Temporary camp	Alluvial fan at base of mesa
26Ny3948 [a]	2045	1178	0.010	Temporary camp	Valley bottom
26Ny4015	1996	682,510	0.073	Temporary camp	Bench slope
26Ny4022	2000	1767	0.154	Temporary camp	Valley side / bench bottom

Table 11
Archaeological Sites on Pahute and Rainier Mesas that Contain Diagnostics Assignable to the Silent Canyon Period (continued)

Site Number	Elev. (m)	Area (m^2)	Density / m^2	Site Type	Topographic Setting
26Ny4023	2000	3142	0.054	Temporary camp	Valley side / bench bottom
26Ny4026 [a]	2006	1178	0.043	Locality	Bench interior
26Ny4034 [a]	1987	2749	0.168	Locality	Valley side
26Ny4040	1993	1649	0.013	Temporary camp	Valley side below bench
26Ny4041	1996	3927	Unknown	Locality	Toe of ridge into valley bottom
26Ny4045 [a]	1999	1	8.00	Locality	Valley side below bench edge
26Ny4048	1996	863	0.081	Temporary camp	Ridge top
26Ny4049 [a]	1999	23,562	0.054	Temporary camp	Valley side
26Ny4053	2000	31,416	Unknown	Temporary camp	Slope of bench top
26Ny4054	1993	1728	0.050	Temporary camp	Valley side / bench bottom
26Ny4057 [a]	1999	236	0.025	Locality	Valley side
26Ny4068	1987	7854	0.020	Temporary camp	Top of ridge on bench
26Ny4070 [a]	1984	471	Unknown	Temporary camp	Valley bottom
26Ny4075 [a]	2021	97	0.021	Locality	Bench interior
26Ny4076 [a]	2019	706	0.004	Locality	Bench interior
26Ny4079 [a]	2006	3	1.666	Locality	Bench interior
26Ny4081	1996	58,905	Unknown	Locality	Valley bottom
26Ny4085 [a]	2024	2827	Unknown	Temporary camp	Bench interior
26Ny4086	2000	5891	Unknown	Temporary camp	Bench top
26Ny4090 [a]	2039	1414	0.018	Locality	Ridge top on bench
26Ny4108 [a]	2006	212	0.057	Temporary camp	Valley side
26Ny4112	2021	8247	0.049	Temporary camp	Bench top
26Ny4114 [a]	2015	12,095	0.007	Temporary camp	Drainage head on bench
26Ny4115	2018	19,635	Unknown	Temporary camp	Top of ridge on bench
26Ny4125 [a]	2045	1414	0.017	Temporary camp	Top of ridge on bench
26Ny4127	2054	20	0.200	Locality	Saddle on ridge on bench
26Ny4132 [a]	2060	157	0.439	Temporary camp	Top of ridge on bench
26Ny4152 [a]	1637	236	Unknown	Temporary camp	Rockshelter at base of mesa
26Ny4175	2128	59,376	0.032	Temporary camp	Valley bottom
26Ny4185	2102	1963	0.022	Temporary camp	Low ridge below bench edge
26Ny4190	2099	6597	1.080	Temporary camp	Ridge top and sides
26Ny4192	2092	314	0.509	Locality	Top of bench near edge
26Ny4201	2076	25,447	0.425	Lithic scatter	Bench top above small valley
26Ny4209	2060	123,637	0.004	Temporary camp	Bottom of narrow valley
26Ny4212	2262	47,124	2.730	Temporary camp	Bench interior
26Ny4482 [a]	1911	9425	Unknown	Temporary camp	Rockshelter in saddle
26Ny4511 [a]	2121	2,199	0.010	Locality	Valley side near drainage head

Table 11
Archaeological Sites on Pahute and Rainier Mesas that Contain Diagnostics Assignable to the Silent Canyon Period (continued)

Site Number	Elev. (m)	Area (m^2)	Density / m^2	Site Type	Topographic Setting
26Ny4512 [a]	2121	314	0.025	Locality	Valley side near drainage head
26Ny4534	1893	1100	0.081	Temporary camp	Head of drainage onto ridge
26Ny4544	2249	106,029	0.007	Temporary camp	Valley bottom
26Ny4585	2073	14,137	0.555	Temporary camp	Bench interior
26Ny4588	2067	220,000	0.310	Temporary camp	Bench interior
26Ny4858 [ab]	1960	86,394	0.205	Temporary camp	Edge of bench at drainage head
26Ny4869	2008	153,742	0.018	Temporary camp	Bench top near drainage head
26Ny4871	1996	62,832	2.380	Temporary camp	Base of bench
26Ny4872	1914	15,080	0.316	Temporary camp	Bench top in amphitheater
26Ny4902 [a]	2155	2356	0.009	Temporary camp	End of ridge on bench
26Ny4907 [a]	2152	2356	0.072	Temporary camp	Saddle on ridge on bench
26Ny4908 [a]	2158	2121	0.006	Temporary camp	Bottom of narrow valley
26Ny4916 [a]	2158	7540	0.167	Temporary camp	Saddle on bench
26Ny4917	2158	17,279	0.088	Temporary camp	Saddle on ridge
26Ny4919	1871	942	0.450	Temporary camp	Rockshelter below bench
26Ny4944	1737	157	0.115	Temporary camp	Rockshelter below bench
26Ny4947	1939	26,704	0.179	Temporary camp	Low saddle on bench
26Ny4952	1926	62,832	0.096	Temporary camp	Valley bottom near head
26Ny4954	2118	12,566	0.003	Temporary camp	Saddle on ridge on bench
26Ny4965	1981	127,235	0.383	Temporary camp	Narrow valley off bench
26Ny4966 [a]	1984	1	1.00	Isolate	Ridge top on bench
26Ny4969 [a]	1975	39,270	1.620	Temporary camp	Bench edge at drainage head
26Ny4971 [a]	1975	236	0.114	Locality	Bench edge at drainage head
26Ny4987	1762	9425	0.429	Temporary camp	Narrow canyon thru hogback
26Ny4988 [a]	1832	24,332	0.119	Temporary camp	Narrow canyon thru hogback
26Ny5200	1859	3770	Unknown	Temporary camp	Ridge side off mesa
26Ny5202	1829	1885	0.050	Temporary camp	Bench interior
26Ny5205	2012	1200	0.031	Locality	Bench interior
26Ny5207	1998	92,300	0.013	Quarry	Valley edge near drainage head
26Ny5211	1996	8900	0.220	Locality	Bench near drainage head
26Ny5215	2012	3700	0.513	Temporary camp	Low saddle on bench
26Ny5216 [a]	2015	20	0.150	Locality	Low saddle on bench
26Ny5237 [a]	1759	2356	0.104	Locality	Base of cliff off mesa
26Ny5416	2012	3519	7.50	Temporary camp	Ridge top
26Ny5417	2012	96,442	Unknown	Temporary camp	Valley side next to bench

Table 11
Archaeological Sites on Pahute and Rainier Mesas that Contain Diagnostics Assignable to the Silent Canyon Period (continued)

Site Number	Elev. (m)	Area (m^2)	Density / m^2	Site Type	Topographic Setting
26Ny5418	2045	45,000	0.027	Temporary camp	Valley bottom
26Ny5425 [a]	2085	24	0.833	Locality	Base of ridge on bench
26Ny5465	2257	6597	0.009	Temporary camp	Narrow valley on bench interior
26Ny5466	2256	225,030	0.020	Temporary camp	Bench interior
26Ny5496 [a]	1914	52,509	0.003	Temporary camp	Bench interior
26Ny5501	2012	99,268	Unknown	Lithic scatter	Bench top at drainage head
26Ny5513	1978	1257	0.050	Temporary camp	Bench interior
26Ny5538 [a]	1935	94	0.298	Temporary camp	Bench interior
26Ny5539 [a]	1932	7	2.571	Locality	Bench interior
26Ny5540 [a]	1942	88	0.193	Locality	Bench interior
26Ny5554 [a]	1887	14,137	0.550	Temporary camp	Ridge top at drainage head
26Ny5606 [a]	1914	1	1.00	Locality	Ridge top on bench
26Ny5628	2042	236	0.064	Locality	Side of ridge on bench
26Ny5645 [a]	2022	491	0.010	Locality	Saddle on ridge
26Ny5795	1902	1178	0.021	Temporary camp	Side of canyon off mesa
26Ny5796	1884	295	0.092	Locality	Side of valley below mesa
26Ny5797 [a]	1844	17,593	0.017	Temporary camp	Valley bottom below mesa
26Ny5875 [a]	2057	1	1.000	Isolate	Side of small valley
26Ny5894 [a]	2074	160	0.019	Locality	Bench interior
26Ny8083	1939	137,445	Unknown	Temporary camp	Valley bottom
26Ny8245	2164	1,413,719	Unknown	Locality	Valley bottom
26Ny8248	1932	5655	0.074	Locality	Base of alluvial fan below mesas
26Ny8360	1981	63,6174	0.200	Temporary camp	Narrow valley between benches
26Ny8362 [a]	1984	589	0.177	Locality	Bench interior
26Ny8840	1682	28,274	Unknown	Lithic scatter	Drainage head off mesa

[a] Single component.
[b]Division clearly separated from BW component.

Based on site area (fig. 6), only a slight increase occurred in the intensity of activities on the mesas during the Silent Canyon Period. This information appears counter to what might be expected if Bettinger's (1994) model of the Numic spread is correct. In other words, the timing of the increased activity on Pahute and Rainier mesas during the Rainier Mesa Period appears to be almost exactly what Bettinger (1989:338-347) posits for Owens Valley, not later. It may be that Pahute and Rainier mesas should be included in Bettinger's Mojave Desert homeland of the Numa. As previously argued, however, the increase in the utilization of the mesas during the Rainier Mesa

Period was initiated during earlier periods; and the shift in adaptive strategies between what Bettinger and Baumhoff (1982) and Bettinger (1991:100-103) model as travelers (foragers) and processors (collectors) probably began much earlier during the Pahute Mesa Period or even the Dead Horse Flat period. Hence, the evidence from Pahute and Rainier mesas appears to support the Aikens and Witherspoon (1986) and Aikens (1994) model for a long-term, in situ history of the Numa in the region around Pahute and Rainier mesas.

However, there is a relatively sharp decline in the number of sites assigned to this period when the site numbers are standardized to the length of the period (fig. 6), and the multi-dimensional scaling of Desert Series projectile points on the mesas (fig. 7) indicates that there may well have been a shift in settlement locations during the Silent Canyon Period. Hence, the assumption that sites containing brownware pottery and Desert Series projectile points but lacking historic artifacts belong only to the Silent Canyon Period could be incorrect. But if so, then more sites should have been assigned to the Split Ridge Period than just those containing historic artifacts, exaggerating the discrepancy between site area and the number of sites, not explaining it. Because this relationship between the number of sites and site area is strongly reversed during the Split Ridge Period, it also may be that more of the Split Ridge Period sites should have been assigned to the Silent Canyon Period than were. But even the inclusion of all Split Ridge Period sites in the calculation for the number of sites in the Silent Canyon Period does not reverse this trend. Hence, there does appear to have been a shift in how the mesas were utilized during the Silent Canyon Period, supporting the "traditionalists" view of the Numic spread.

Brownware pottery occurs at 91% of the sites listed in table 11 and is the single best diagnostic of the Silent Canyon and Split Ridge periods on Pahute and Rainier mesas. In fact, Desert Series projectile points occur at only 17% of these sites. Lockett (1989, 1990, 1991a, 1991b) and Lockett and Pippin (1990) have examined both the nature of the various concentrations of pottery at these sites and their distribution within these sites. Surprisingly, most of the separate concentrations of brownware pottery at these Silent Canyon Period sites can be reconstructed (refitted) into a single vessel that was apparently dropped and broken at that spot. Hence, these brownware sherds were not secondarily deposited into areas of trash with other broken vessels. Schiffer (1987:58-64) argued that the larger the number of people that use an area and the longer they stay there, the higher the chances will be that their trash will be redeposited somewhere other than where it was first dropped. Even hunters and gatherers, who seldom stay in one spot very long, tend to practice at least some informal maintenance of their living areas (Meehan, 1982; Murray, 1980, O'Connell, 1979, Stevenson, 1985; Yellen, 1977). Hence, we can conclude that these people were not redundantly using the same spots for their brownware pottery activities, or if they were, then this redundancy was infrequent. In this regard, it is interesting to note that the data from Pinyon House in the White Mountains east of Owens Valley, an area where pinyon gathering localities were apparently "owned" and redundantly exploited (see Thomas, 1983:24-39), seem to indicate secondary disposal of pottery (Bettinger, 1989:100, fig. 4.1).

Approximately 60% of the sites listed in table 11 have been classified as temporary camps. In fact, approximately 55%of those considered to be single component sites are classified as temporary camps. This is a distinct increase in comparison to the trend noted for the earlier Rainier Mesa Period when only 21% could be classified as temporary camps. Likewise, 29% of the single component sites from the Silent Canyon Period contain milling equipment in comparison to approximately 12% for the single component Rainier Mesa Period sites. The artifact heterogeneity at these Silent Canyon Period single component sites also appears to have increased over that at the Rainier Mesa Period single component sites (table 3, fig. 8). These data, especially in combination with our conclusions regarding the distribution of brownware pottery above, indicate a reversal in the trends noted for the earlier periods (i.e., a trend toward more resource monitoring from within the foraging radius of base camps).

Yet to be explained, however, is why the distribution of Desert Series projectile points displays such a different pattern in comparison to the Dead Horse Flat, Pahute Mesa, and Rainier Mesa periods (table 2, fig. 7). Note that most of the sites assigned to the Silent Canyon Period actually show a geographic distribution similar to these earlier periods (compare figs. 14,16,19, and 20). Likewise, the use of land forms for the positioning of activities does not appear to vary significantly, except perhaps for the use of saddle and bench side environments (table 4, fig. 9). Yet the projectile points of the Desert Series do not tend to cooccur as frequently at the same sites as was the case in these earlier periods. However, as indicated, brownware ceramics are the most common diagnostic of the Silent Canyon period; and the above analysis is based largely on the distribution of sites containing this brownware. Also as noted, the Desert Series projectile points only occur at approximately 17% of these Silent Canyon Period sites. Only four (5%) of those sites contain isolated projectile points. This contrasts with 31% of the Rainier Mesa Period single component sites marked by isolated projectile points. Bettinger (1989:341) has hypothesized that the importance of large game diminished significantly during the last 900 years in Owens Valley and the above data may well indicate a similar trend in the exploitation of large game on Pahute and Rainier mesas. This pattern, of course, also matches that found by Thomas (1982b) in the high altitude sites in central Great Basin.

In conclusion, it appears that there were changes in the adaptive strategies used to exploit the resources on Pahute and Rainier mesas during the Silent Canyon Period. However, these changes do not appear to match those predicted by the Bettinger and Baumhoff model (1982) for the Numic spread. The evidence from the mesas indicates that the intensification of pinyon exploitation had already been initiated well before the Silent Canyon Period and that the shift toward the logistical organization of activities and the monitoring of resources from within the foraging radius of base camps had begun during the Rainier Mesa Period. Although pinyon exploitation--as measured by both the number of milling implements (fig. 15) and rock ring features (fig. 18) at Silent Canyon Period sites--continued to be intense, it was less intense than during the Rainier Mesa Period. There was a shift away from the monitoring of these resources from within the foraging radius of base camps established on the mesas toward monitoring within the logistical radius of base camps established off the mesas. The frequency of hunting appears to have decreased during the Silent Canyon Period, and the activities on the mesas appear to have been based on a narrower diet than previously. As outlined for the ethnohistoric utilization of the mesas (Pippin 1996), this trend toward the monitoring of resources from base camps located off the mesas was probably fairly short lived. Hence, in addition to the increased contact with the *Tiabo* during historic times, the mesas appear to have become a refuge for displaced *Ogwe'pi* (translate) from the nearby Oasis Valley.

The previous paleoenvironmental reconstructions for the mesas confirm Aiken's and Witherspoon's (1986) argument that an extended warmer and drier period (1100 - 500 B.P.) occurred at the beginning of the Silent Canyon Period. But the Numa, if they were the ones using the mesas at this time, did not significantly alter their exploitation of resources, except perhaps for the hunting of large game. Rather, they probably simply shifted their residential base location strategies to better watered areas below the mesas. The shift in the positioning of base camps off the mesas and the reduced emphasis on game could well be related to fact that water was not abundant on the mesas. This extended drought was followed by a period of stronger winter precipitation and cooler temperatures around 300 to 400 years ago (the Little Ice Age). Our chronological controls are not sufficient to detect any changes in the adaptive strategies that might have accompanied this brief period of glacial advance, but the overall shift in the selection of site locales with warmer southwestern exposures during the Silent Canyon Period (fig. 10) indicates that the mesas probably continued to be used as before. In fact, the complex plot of the frequency in aspect of the archaeological sites on the mesas clearly indicates the influence of climate change.

SUMMARY AND CONCLUSIONS: THE EFFECT OF CHANGING ENVIRONMENTS ON HUNTER-GATHERER ADAPTATIONS

The overall intent of this paper was to examine the relationships between changing hunter and gatherer adaptations and environments on Pahute and Rainier mesas. After reviewing the evidence concerning what is known about both, we are now in a position to assess the interaction of these dynamic processes and draw conclusions on just how intimately the two are tied together. Most early treatments of the relationship between environmental change and changing hunter-gatherer adaptions in the Great Basin focused on climatic parameters (Baumhoff and Heizer, 1965). For example, although he wisely changed his terminology in a later synthesis[53], Elston (1982:190) first characterized past environments in the western Great Basin as "good times" and "bad times." Good times were equated with cooler and more moist environments, and bad times were warmer and drier climatic intervals. There is little doubt that primary plant productivity, water availability, and game populations increased in the Great Basin during certain times (Neopluvial) when climates became cooler and more moist and that the reverse was true during certain periods (middle Holocene) of increased temperature and decreased precipitation. Likewise, Kelly (1995) and his predecessors categorized variability in ethnographic hunter-gatherer adaptive strategies in terms of temperature (latitude) and water availability. But to view changing environments in only these terms may mask certain important characteristics of the environment affecting how hunter-gatherers lived. Thus, a trend toward warmer and drier environments may have actually increased certain resources

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[53] Elston (1986).

thereby providing additional sustenance for hunter-gatherers. Hattori (1982:23-29) pointed out, for example, that the Winnemucca Lake Basin provided a richer and more varied resource base during shallow lake stands than during periods when the lake covered the entire basin bottom. Hence, just as ethnographic populations are products of their history (Schrire, 1984), so are environments; and in order to assess whether times were better or not, we must first know what came before. Finally, most current models of how hunter-gatherers adapt to their environments are couched in terms of specific resources and how they are ranked one to another (Bettinger, 1991). Thus, in the following synopsis it seems more prudent to focus on resources rather than climatic parameters which, after all, are generally hypothesized on the basis of the resources found in the paleoenvironmental record.

The current archaeological evidence suggests that Pahute and Rainier mesas were probably not utilized by the hunter-gatherers of the Rattlesnake Ridge Period. At this time, the mesas were apparently covered with a subalpine forest of limber pine and white fir. As argued by Grayson (1993:238), this environment may not have been too attractive to hunter-gatherers of the period, even though the canopy was probably not as closed as during times of glacial maximum. The lowlands around the mesas contained lakes, marshes, juniper woodlands, and parklands of cold desert shrubs that should have been much more attractive for both people and the large game that, for still unknown reasons, were finding the environment more and more inhospitable. All three of the Clovis projectile points from around the mesas were found in environments that, at that time, would have been covered by juniper woodlands and that have been hypothesized to represent large game hunting localities. Based on this meager evidence and the model advanced by Kelly and Todd (1988), these first foragers in the region were focused on large game and had very high residential mobility and large logistical territories. However, these logistical territories were focused toward the valley bottoms and edges, not the mountains and plateaus around them.

A gradual retreat and thinning of the subalpine forest on Pahute and Rainier mesas began approximately 10,500 years ago leading to replacement by a juniper woodland with an understory of sagebrush, purple sage, joint-fir, and mountain mahogany by approximately 9000 years ago. As a result of this change, the mesas may have provided a more attractive environment for both people and large game. The small boreal mammals that were already on the mesas probably remained. It appears that this was when the mesas first began to play a role in the adaptive strategies of the hunter-gatherers in the southern Great Basin. The lowlands around the mesas still contained lakes, ponds, and marshes up to approximately 9000 years ago or slightly later, and archaeological research in these lowlands has found that these environments were still probably the central focus in the adaptive strategies of local hunters and gatherers (citation - ?). However, the evidence from Pahute and Rainier mesas indicates that foraging parties from these valley bottom environments frequently visited the plateau. Because of the homogeneous nature of the Barren Wash Period remains and their distribution on the mesas, these remains probably reflect localities where large game (elk, deer, and bighorn sheep) were extracted. Hence, the ranking of large game as resources was probably still quite high--high enough, in fact, to make it worthwhile to travel some distance for their harvest. However, the fact that these hunters and gatherers did not utilize the available toolstone resources on the mesas probably indicates that they did not search their logistical territories very throughly and/or could obtain these needed resources closer to their base camps. This pattern of resource exploitation is consistent with models of highly mobile hunters with long logistical forays (Binford, 1983; Kelly, 1995:130-132). Although adaptations were undoubtedly changing from the earlier Rattlesnake Ridge Period, these changes probably only involved a slightly broader use of the landscape made possible by the changing environment.

Emphasis on the exploitation of game animals from the mesas appears to have continued during the subsequent Prow Pass Period (8000-5000 B.P.). The archaeological sites on the mesas that can be assigned to this period do not seem to differ significantly from the earlier Barren Wash Period sites in either their location relative to game exploitation or their overall nature. However, the area covered by these sites, as well as their numbers, increased; and artifact inventories seem to have become slightly more heterogenous. These observations, combined with the observation that local toolstones sources were now being exploited, indicate that the mesas were becoming more important in the overall adaptive strategies of the hunters and gatherers who occupied the region around them. The change from the spear to the atlatl as the weapon of choice appears to have been an important technological improvement that probably changed the ranking of game resources, particularly smaller game. Likewise, evidence from archaeological research in the lowlands around Pahute and Rainier mesas indicates that plant resources were becoming much more important in the overall subsistence patterns; and, as meager as they were, there is evidence that some plants were also being exploited on the mesas. Thus, diet breadth was increasing and, while mobility patterns were probably still more like what Binford (1980) modeled as foragers than collectors, resident times on the mesas were apparently increasing while logistical territories were decreasing in size. Although others have hypothesized the abandonment of certain resource zones during this period, the utilization of the mesas appears to have increased, except perhaps between approximately 7000 to 5000 years ago when the projectile point of choice changed to the Large Side-notched type.

The lakes, ponds, and marshes in the lowlands were drying out or gone by the beginning of the Prow Pass Period; and by 7300 years ago, the southern Great Basin started to experience a climatically complex, but major warming trend that lasted until approximately 4000 years ago. Variability in precipitation during this time appears to have been the rule rather than the exception. Although there were major droughts around 7000, 4500, and 3500 years ago, there were also several periods of above average precipitation; and summer rainfall may have become quite important for brief periods. The juniper woodlands that once occupied the lowlands during the terminal Pleistocene and the beginning of the early Holocene were now restricted only to higher elevations like Pahute and Rainier mesas. Pinyon, the mainstay of ethnographic hunters and gatherers who utilized the mesas, was also becoming a more important element in this woodland; and the other bushes, shrubs, and herbs found on the mesas today probably also were becoming more abundant. The xerophytes (shadscale, bursage, desert spruce, brittle bush, and creosote bush) that characterize the Mojave Desert vegetation of today were likewise slowly assuming their current distributions in the lowlands around the mesas. A host of other hot desert plants accompanied these hallmarks of the Mojave Desert; and, with increased dune activity, resources such as mesquite also may have increased in their availability. Overall, plant resource availability (or at least diversity) in the southern Great Basin may have actually increased, not decreased, during the middle Holocene. Hence, there are clear environmental reasons for the above hypothesized increase in diet breadth and reduction in logistical territories during the Prow Pass Period as well as an increase in use of the mesas.

As depicted in the quote by Baumhoff and Heizer (1965:705) at the beginning of this paper, populations on and around Pahute and Rainier mesas appear to have increased approximately 4500 years ago. Baumhoff and Heizer (1965:705) were correct in their analysis that the climate improved: there appears to have been an increase in both water availability and plant and animal foods. The playas in several of the basins around the mesas may have again periodically held water, although probably not nearly as much as during the early Holocene. Likewise, woodland boundaries may have lowered during this time; and pinyon and scrub oak were definitely important components in this woodland. But overall, as pointed out by Grayson (1993:221), the environment around the mesas was not significantly different than that of today. This is especially true of the kinds of plant and animal resources that were available. As previously hypothesized, the beginning of the Neopluvial probably saw a slow, but definite shift in how the hunters and gatherers in this region utilized the resources on the mesas. Although Thomas (1982, 1988) and Grayson (1993:256) felt that adaptations at this time did not differ significantly from those recorded by ethnographers, the Dead Horse Flat and Pahute Mesa periods were actually times of transition. It was during the 3000 year long time span between the beginning of the Dead Horse Flat Period and the beginning of the Rainier Mesa Period that the hunters and gatherers who utilized the resources on the mesas slowly changed their strategies of resource exploitation to be like the middle latitude norm and those recorded by Great Basin ethnographers.

At the beginning of the Dead Horse Flat Period, hunting probably remained a significant activity on the mesas; but the shift in adaptive strategies was toward an increasing reliance on plant foods as measured by the inclusion of milling implements in artifact assemblages first noticeable during the Dead Horse Flat Period. It was not until the subsequent Pahute Mesa Period that the caching of plant resources became prominent, and by then pinyon probably had become one of the highest ranked resources. Settlement patterns also changed during these two periods. The locations selected for the placement of temporary camps and other activities tended to focus more on plant food exploitation than on game animals by the Pahute Mesa Period. The locally available off-white silicified volcanics on the mesas also became a more important, or at least costly, target of resource exploitation between the Dead Horse and Pahute Mesa Periods. While this toolstone was undoubtedly exploited in an opportunistic way during earlier periods, the available evidence suggests that its quarried extraction increased during the Pahute Mesa and subsequent periods. Overall, the shift in adaptive strategies during the Dead Horse and Pahute Mesa periods appears to be toward a more logistically oriented subsistence strategy than before.

Bettinger and Baumhoff (1982) advanced a model of how increases in population from low to high densities may initiate increases in diet breadth, resource processing costs, and overall dietary costs. Because of a decrease in the return rates for the time spent foraging within patches, the benefits of travel between patches also decrease; and the intensity at which the resource patch is exploited increases. Patch selectivity also would decrease, and the time spent traveling between patches likewise decreases. This would lead to an increased emphasis on monitoring resources from within the foraging, rather than the logistic, radius of base camps. Concomitantly, there would be an increased emphasis on locating the base camps directly in or adjacent to the resource patch. These are exactly the changes that appear to have taken place on Pahute and Rainier mesas between the Dead Horse Flat and Rainier Mesa periods. If increases in population density were responsible, then it would make sense that these changes were gradual rather than sudden. The environment was changing at this time (Neopluvial); and the abundance and availability of resources, particularly water, may have increased. But Bettinger (1989:343-344) argued that this sort of "intensification" in settlement and subsistence systems is more likely due, from an optimal foraging point of view (Charnov, 1976), to responses to shortages in resources, not abundances. These shortages, according to Bettinger (1989:343-345), are created by increasing populations, not environmental change. The abundance of resources may have actually increased, but the demand for resources, because of growth in populations, became much higher. With the increased labor pool, however, it was more optimal (adaptive) to intensify existing strategies of resource exploitation than to change to patterns of increased mobility. This intensification climaxed during the Rainier Mesa Period.

It is ironic then that the period during which Baumhoff and Heizer (1965:705) saw such a clear relationship between the archaeological record and changing environments is that period of cultural change that appears to be explained best by Bettinger's and Baumhoff's (1983) model for changes due to increasing population densities. But that model was not advanced to explain the changes in hunter-gatherer adaptive systems on Pahute and Rainier mesas during the Neopluvial. Rather, it was developed to explain why the Numa were more successful (competitive) in their territorial expansion during the last 1000 years and displaced indigenous populations of travelers. However, if the above interpretation is correct, travelers were not utilizing Pahute and Rainier mesas at this time. Either the Numa were already exploiting the resources on the mesas in accordance with the model developed by Aikens (1994) and Aikens and Witherspoon (1986) or the signature of their arrival was completely different from that envisioned by Bettinger and Baumhoff (1983).

There were changes during the last 900 years (Silent Canyon and Split Ridge periods) in the way the resources on Pahute and Rainier mesas were utilized. As interpreted, the evidence from the mesas indicates that there was a narrowing of diet breadth, a slight reduction of the intensity of utilization of resources on the mesas, and a shift from monitoring those resources from within the foraging radius of winter camps established on the mesas to one of monitoring those resources in the logistic radius of camps established off the mesas. Hughes (1994:69) observed that these changes, which are also recognized by Aikens and Witherspoon (1986:17) in the central Great Basin, violate the "continuity rule" applied to the identification of the Numa. [54] Aikens and Witherspoon (1986:17) interpreted these changes to "represent only an adjustment by long resident Numics through a simple

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[54] In Madsen and Rhode's (1994) compilation of ideas regarding the Numic spread, a third perspective is proposed that, for numerous reasons, casts doubt on any attempt to associate the remains left in the archaeological record with ethnicity or language. My views on this issue largely correspond with that perspective (but see Pippin, 1996).

range shift - their primordial method of adjusting to local scarcity - to the drying conditions of the twelfth and thirteenth centuries, which would have reduced the biotic productivity, especially of the lower-lying parts of their county."

Two climatic events occurred during the Silent Canyon Period. The first was a major drought between 900 to 500 years ago which was followed by a period (Little Ice Age) of increased winter precipitation and cooler temperatures. As previously suggested, the shift in how resources were monitored on the mesas could well have been due to a lack of water during the drought; but this change in settlement patterns apparently did not change with the return to cooler, more moist times during the Little Ice Age. Rather, the final encroachment by the *Tiabo* during the last 100 years may have been necessary to shift the focus back to a pattern dominated by monitoring the resources on the mesas from within the foraging radius of winter camps established on the mesas (see Pippin, 1996).

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