PREHISTORIC OBSIDIAN USE IN THE TRUCKEE MEADOWS AND ITS IMPLICATIONS FOR SETTLEMENT PATTERNS ALONG THE SIERRAN FRONT

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Krisstin I. Sibley

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Dr. Michael Delacorte   Date

Department of Anthropology

Abstract

of

PREHISTORIC OBSIDIAN USE IN THE TRUCKEE MEADOWS AND ITS IMPLICATIONS FOR SETTLEMENT PATTERNS ALONG THE SIERRAN FRONT

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This thesis offers just a glimpse into settlement patterns in the Truckee Meadows area. In an attempt to gain insight into prehistoric human adaptation, this thesis focuses on two major issues. The first is a study of Truckee Meadows obsidian hydration involving: (1) an attempt to generate radiocarbon-hydration pairs for Sutro Springs and Bodie Hills obsidian from discrete feature contexts; and (2) assessment of existing hydration rates for Sutro Springs and Bodie Hills obsidian. The second focus was an assessment of Delacorte's (1997a) regional settlement model, which implies that the Truckee Meadows was part of more extended settlement systems earlier in time and a localized system later in time.

The development of radiocarbon-hydration pairs was hampered by the limited size of obsidian samples. The assessment of existing hydration rates worked reasonably well on projectile points, suggesting that obsidian hydration is, indeed, a reliable technique for estimating artifact age in the Truckee Meadows. Finally, analysis of Delacorte's (1997a)

model that mobility generally decreased through time appears to be more complex, with distinct patterns occurring north and south of the Truckee River.

_______________________, Committee Chair
Dr. David Zeanah

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Date

DEDICATION

I dedicate this thesis

in memory of my grandparents,

Frederic and Ursula Sibley

my biggest fans

ACKNOWLEDGEMENTS

I am indebted to many individuals who provided their encouragement and support throughout the completion of this thesis. I would first like to thank my committee, David Zeanah and Michael Delacorte for providing their guidance and expertise along the way. Their endurance through numerous drafts and comments provided valuable insights.

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My deepest and heartfelt appreciation are likewise owed to my family. Their unconditional love and support were invaluable, and their push to keep me going and never give up essential.

Most important of all, I would like to thank my husband, Peter Thorburn. He put up with my often prolonged absences of locking myself away in the office to finish writing this thesis. Through the stressful and tedious nights, he offered his support and encouragement. Thank you for all of your patience.

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CHAPTER 1. INTRODUCTION

Relationships between mobility and technological organization are important topics in archaeology, especially in the Great Basin. Open-air lithic scatters that lack subsistence residues, features, and architectural remains dominate this area; thus, mobility and settlement patterns are more difficult to reconstruct. The Truckee Meadows is a valley in western Nevada located within the western Great Basin. Named for the Truckee River, which flows through the valley from west to east, this area contains archaeological evidence of aboriginal human occupation. Using data from previous collections, reports, and my own testing, this thesis will explore obsidian patterns within the Truckee Meadows region.

Three major obsidian conveyance systems have been proposed and defined in areas to the north, south, and east of the Truckee Meadows. The first system to the north is reconstructed from sites in the Pah Rah Uplands and the northern Truckee Meadows, where the emphasis on obsidian use becomes more focused on local Truckee Meadows obsidian through time. The second system, to the south, is centered in Owens Valley, where local Mono and Mineral county sources are progressively emphasized through time. Finally, the third system to the east concentrates on the Stillwater Marsh and Mountains in western Nevada, where obsidian use reveals that northern sources were employed more frequently in later assemblages.

The primary goal of this thesis is to test Delacorte's (1997a) model, which argues that the Truckee Meadows was part of more extended settlement systems earlier in time and a localized system later in time. However, testing Delacorte's model requires that the utility of obsidian hydration in the Truckee Meadows be established on the basis of radiocarbon-hydration pairs for Sutro Springs and Bodie Hills obsidians.

This document is organized into eight chapters. This chapter introduced the major research questions. Chapter 2 *(Environment)* provides background information on the Truckee Meadows region. An overview of the prehistoric occupation and previous archaeological research in the area is presented in Chapter 3 *(Cultural Background).* Chapter 4 *(Theoretical Background)* focuses on theoretical research pertaining to the main research topics. Chapter 5 *(Methods)* discusses the methods used to conduct this thesis research, as well as the limitations and issues encountered. The next chapter (Chapter 6, *Results)* presents the data gathered from previous research, existing archaeological collections, and my own testing results. Chapter 7 *(Direct Implications of Results)* addresses the results against initial research questions in this thesis. Finally, Chapter 8 (*Conclusions and Future Directions*) concludes with an answer to each research question and presentation of a new Lake Archaic settlement pattern in the Truckee Meadows.

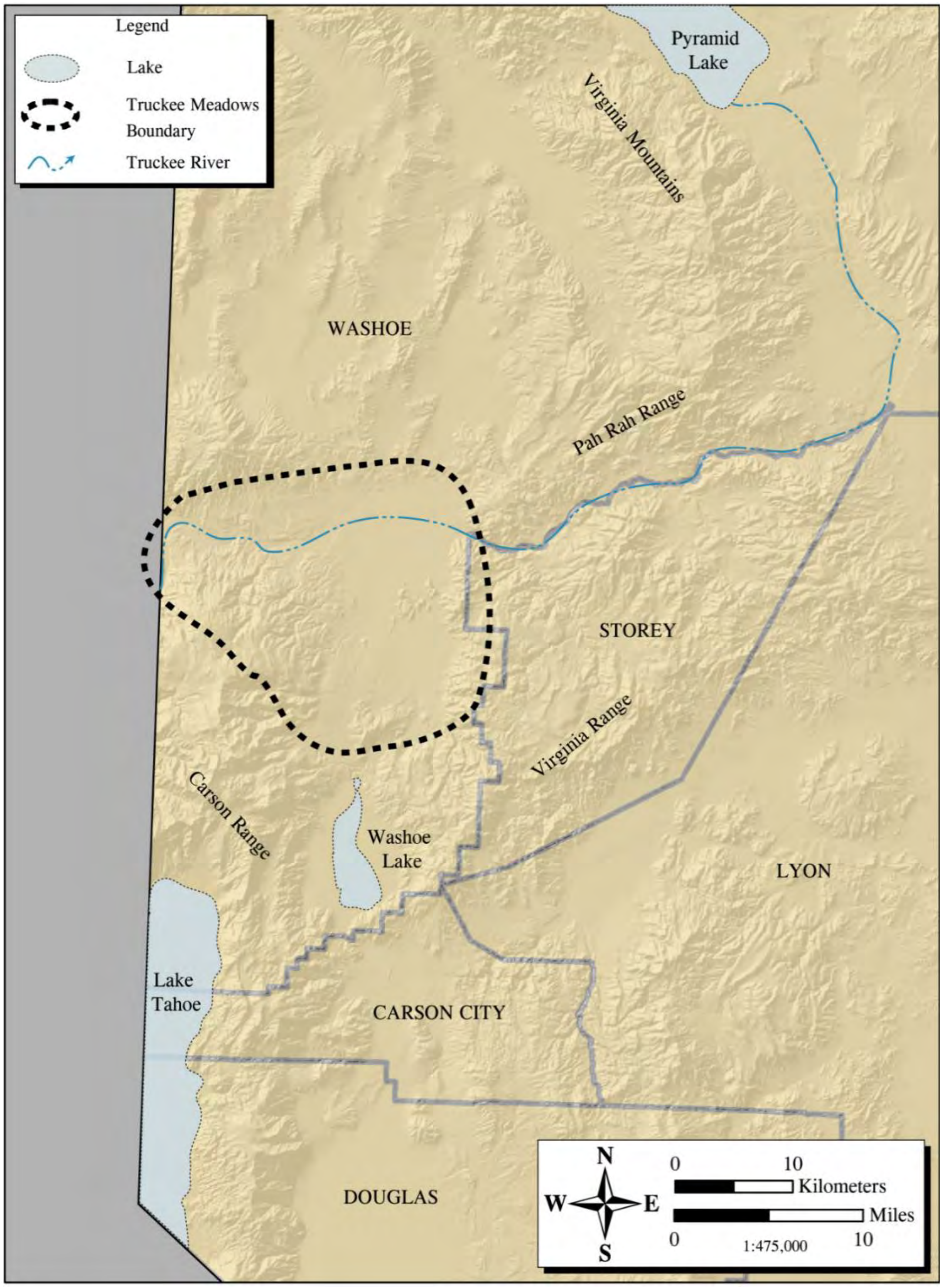
CHAPTER 2. ENVIRONMENT

The Truckee Meadows is a north-south trending basin covering approximately 94 square miles in western Nevada. It is bounded on the west by the Carson Range, on the east by the Virginia Range, on the south by the Steamboat hills, and by Peavine Mountain to the north (Map 1). The average elevation of the basin is 4,500 ft., although Mount Rose in the Carson Range reaches 10,776 ft., with the Virginia Range containing numerous peaks above 6,000 ft. Peavine Mountain to the north rises to 8,266 ft., and Steamboat Hills to the south reaches an elevation of 6,178 ft. Spanish Springs and Lemon valleys lie immediately north of Truckee Meadows, and Pleasant and Washoe valleys immediately to the south (Hutchins and Simons 2000:152).

The Truckee River originates at Lake Tahoe in the Sierra Nevada Range and flows from west to east across Truckee Meadows, exiting the valley through a deeply incised canyon within the Virginia Range into Pyramid Lake (Gates and Watters 1992; Glancy et al. 1984). Steamboat Creek is the main tributary supplying the Truckee River, and flows north from Pleasant Valley (Stockton et al. 2003).

PHISIOGRAPHIC SETTING

The climate is semi-arid characterized by cold winters and hot summers. Average annual temperatures are 32°F during January and 69°F in July. Extreme temperatures in the area range from 106°F to a low of -19°F (Stoner et al. 2006).



Map 1: Project Area

The Truckee Meadows basin lies in the "rain shadow" east of the Sierra Nevada Range (Gates and Watters 1992). Mean annual precipitation is approximately 7 in., and mean annual snowfall approximately 26 in. Snow depths can reach 20 ft. at the crest of the Carson Range (Stoner et al. 2006).

The Truckee Meadows is similar to most Great Basin valleys, comprising a structural depression bounded by fault-block mountains. The oldest rocks date to the Mesozoic era and are found on Peavine Mountain to the northwest of the Truckee Meadows (Bonham 1969). Sediments within the valley of the Truckee Meadows date to the Late Pleistocene epoch of the Quaternary period. Early Pleistocene terrace gravels cap high terraces of the Hunter Creek formation. Basin-fill deposits within the Truckee Meadows can be divided into three general units: sedimentary rocks of Tertiary age, older alluvium of Quaternary age, and younger alluvium of more narrowly Holocene age. Tertiary material consists of unconsolidated to partly consolidated diatomaceous sediments interbedded with coarse-grained sandstones, shales, gravels, and tuffs that were deposited mainly in fluvial environments. Quaternary deposits consist of glacial silt, sand, gravel, and boulder outwash material, along with poorly sorted sediment and alluvial-fan deposits (Huntington 2010:37). Three major categories of Quaternary deposits are recognized: mainstream gravel deposits of the Truckee River, a long complex history of alluvial fan deposition along the margins of the Truckee Meadows, and the reworking of older deposits and deposition of relatively fine-grained clastic debris throughout the central part of the basin (Bingler 1975:1).

CONTEMPORARY FLORA AND FAUNA

Historically, the Big Sage plant series dominated the Truckee Meadows on alluvial fans, with the Sedge Meadow series prevailing on the basin floor and flood plains (USFS n.d.). Along Steamboat Creek and portions of the Truckee River, lush grasses, including Great Basin wild rye (*Leymus cinereus*) and tule (*Scirpus* sp.), were the most common plants. Riparian vegetation included black cottonwood (*Populus trichocarpa*), willow species (*Salis* sp.), and silver buffaloberry (*Shepherdia argentea*). Slightly elevated and better-drained valley margins were covered with a typical sagebrush-grass zone (Billings 1951). Common plants in this habitat consisted of big sagebrush (*Artemisia tridentate*), rabbitbrush (*chrysothamnus* sp.), greasewood (*Sarcobatus vermiculatus*), horsebrush (*Tetradymia glabrata*), and spiny hopsage (*Grayia spinosa)*. Common bunch grasses included wheatgrass (*Agropyron spicatum*), bluegrass (*Poa* sp.), Great Basin Wild rye (*Elymus cinereaus*), Indian ricegrass (*Achnatherum hymenoides*), squirreltail (*Sitanion hystrix*), and needle and thread (*Stipa comate*) (Stoner et al. 2006).

Varieties of faunal resources were available as well, including fish in the Truckee River, numerous rodents and lagomorphs, and large mammals. Mule deer (Odocoileus hemionus) and antelope (Antilocapra americana) comprise the largest animals of significance, but mountain sheep (Ovis Canadensis) may have also found a home on the steep hillsides in the past.

CHAPTER 3. CULTURAL BACKGROUND

The prehistory of the western Great Basin is divided in broad intervals marked by changes in adaptive strategy (Elston 1982): Pre-Archaic, Early Archaic, Middle Archaic, and Late Archaic. At the regional level, finer archaeological phases (Willey and Phillips 1958:22) are recognized and summarized below within each of the chronological intervals.

PRE-ARCHAIC

The Pre-Archaic period is divided into the Washoe Lake and the Tahoe Reach phases. The Washoe Lake Phase (also known as the Western Clovis Phase) dates between 11,500 and 10,000 B.P and is characterized by large fluted projectile points (Elston 1986; Willig and Aikens 1988). It derives its name from the only Clovis finds along the Eastern Sierran Front east of Washoe Lake, Nevada (Davis and Shutler 1968). Given the absence of meaningful artifact samples or faunal assemblages for this period, little can be said about it.

The regional manifestation of the Western Stemmed Complex on the Eastern Sierran Front is the Tahoe Reach Phase dating between 10,000 and 8000 B.P. (Elston et al. 1977). Most Tahoe Reach finds in the region consist of isolated large stemmed, edge-ground projectile points, usually made of basalt. Flaked stone toolkits (including bifaces, scrapers, choppers, gravers, and crescents) associated with Stemmed points seem well suited for hunting and large game processing. Although there is no dietary evidence from the Eastern Front, elsewhere in the Great Basin a broad diet of birds, fish, shell fish, rabbits, and large game is indicated (Dansie 1987; Layton 1979). Flaked stone materials are extremely diverse and suggest that settlement patterns were both variable and highly mobile (Delacorte 1997a). The absence of storage facilities and shelters at sites also supports the concept of high mobility (Elston et al. 1994). The lack of ground stone in Early Holocene assemblages suggests that seeds were not commonly exploited. Overall, the small, low-density scatters of flaking debris and the handful of tools that characterize these sites suggest brief occupations by groups that practiced extremely flexible settlement and subsistence patterns (Delacorte 1997a).

EARLY ARCHAIC

Archaic strategies, involving less mobility and more intensive reliance on plant foods, begin to emerge throughout the Great Basin at the end of the Early Holocene. The Spooner Phase, assigned to the Early Archaic, has a hypothetical age range from 8000 to 5000 B.P., given the lack of temporally diagnostic projectile points or other time-sensitive artifacts (Elston et. al 1995). Evidence does show, however, that Early Archaic cultural activity in the western Great Basin is more widespread and represented by various split-stem projectile points, numerous flake tool scrapers, bifacial knives, heavy core tools, and, for the first time, an abundance of milling equipment. Milling gear includes numerous carefully prepared grinding platforms and handstones, often made of non-local rock, indicating a profound increase in the use of plant foods (Delacorte 1997a). The generalized function of Early Archaic settlements can be characterized by the assemblage diversity at nearly every site, regardless of its size or location. Specialized sites with restricted artifact assemblages are generally lacking, as are major residential encampments with large and diverse assemblages (Delacorte et al. 1994). Aside from the milling gear, simple tool-kits of this type could be fashioned quickly and re-supplied any time or place, allowing for extreme flexibility in the annual settlement-subsistence round. Based on this, Early Archaic people appear to have foraged over extensive ranges exploiting a wide array of plants and animals from a variety of short-term encampments and fewer residential hubs (Delacorte 1997a).

MIDDLE ARCHAIC

The Middle Archaic (cf. "Martis") period in the Western Great Basin was characterized by the emergence of logistically well-organized adaptive patterns. Over the years, the time period of the Martis Phase has been vigorously debated by researchers and continuously modified by Robert Elston, Charles Zeier, and their associates (see Elston 1971; Elston et al. 1977, 1994; Zeier and Elston 1986). Diagnostic artifacts have led researchers to debate a two-phase (early, late) or a three-phase (early, middle, late) division. The most recent iteration (Elston et al. 1994:11) divides the Martis Phase in two. Martis Contracting Stem, Steamboat points, and Martis Split Stem Points define the Early Martis Phase, ranging from 5000 to 3000 B.P. The Late Martis Phase spans from 3000 to 1300 B.P. and is characterized by Martis Corner-notched, Elko Corner-notched, and Elko Eared points.

Changes in assemblage content and structure during the Middle Archaic suggest that settlement patterns had become highly regularized and winter camps began to be reoccupied seasonally (Delacorte 1997a; Elston et al. 1977; Elston et al. 1994; Zeier and Elston 1986, 1988). Well built houses, elaborate construction of hunting facilities, and caches of non-portable gear were common at these sites (Delacorte 1997a). An increase in the richness and variety of textiles, other perishable remains, and rock art demonstrate cultural complexity within the Martis Complex (Delacorte 1997a; Zeier and Elston 1986, 1988). Lithic diversity decreases substantially during the Middle Archaic, while large, highly formalized bifaces increase in the archaeological record. Lithic materials suggest that settlement patterns incorporated stops to collect toolstone at one or more prominent quarries, with the material gradually exhausted and eventually replaced when another quarry was reached (Delacorte 1997a). "Raw material preference in Truckee Meadows appears to have been in this order: Steamboat sinter, basalt, other cryptocrystalline rocks (cherts), exotic obsidian and local obsidian" (Elston et al. 1994:17). Large game and seed gathering were emphasized and marked by the frequent presence of faunal remains and milling equipment (Delacorte 1997a; Hutchins and Simons 2000; Zeier and Elston 1986, 1988).

LATE ARCHAIC

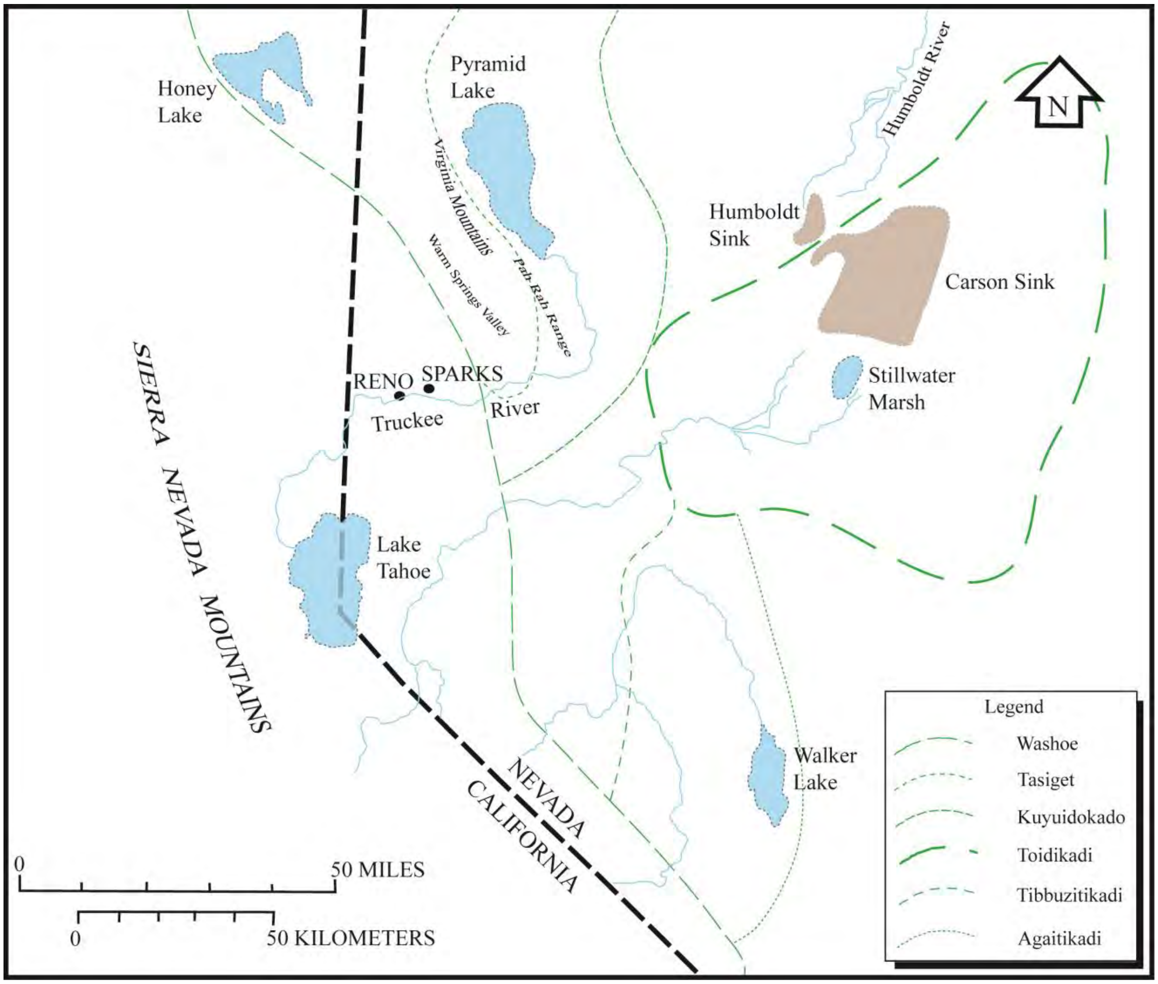
The Late Archaic Period has been temporally divided into two phases: the Early Kings Beach Phase (700 – 1300 B.P.) and the Late Kings Beach Phase (150 – 700 B.P.). The Early Kings Beach Phase is marked by the introduction of the arrow, greater use of cryptocrystalline toolstone, reduction in tool size, possible reduction in house size, introduction of shallow bedrock mortars, and use of stone hullers. Temporally diagnostic projectile points include Rosegate and Gunther series forms (Delacorte 1997a, Drews 1986; Elston et. al 1977, Zeier and Elston 1986, 1988).

Desert series points characterize the Late Kings Beach Phase (700 – 150 B. P.) (Drews 1986; Zeier and Elston 1986). The flaked stone toolkits are comprised of points and bifaces (Moore and Burke 1992), with evidence of small triangular bifaces made entirely by pressure reduction.

Overall, the Late Archaic is defined by an increase in settlement centralization, subsistence intensification, and decrease in the area over which groups forged. House structures are smaller and built less substantially, caches are fewer and less elaborate, and many perishable artifacts seem to disappear from the archaeological record (Elston 1982, 1986; Pendleton et al. 1982). A shift towards more expedient and disposable tools also suggests that Late Archaic populations were less mobile and foraged more intensively over a limited area. Evidence for resource intensification includes the adoption of numerous, high-cost storage strategies for pine nuts (Hagerty 1970; Pippin 1980; Wells 1983; cf. Thomas 1971, 1973) and other seeds (Delacorte 1995). Selective hunting of small mammals such as rodents and lagomorphs, birds, and intensive use of previously ignored habitats such as wetlands and upland areas are also observed (Dansie 1979; Dansie and Ringcob 1979; Delacorte 1994; Livingston 1988a, 1988b).

ETHNOGRAPHIC BACKGROUND

The Truckee Meadows region lies on the ethnographic boundary between the Washoe people and five Northern Paiute bands (*Tasiget Tuviwari*, *Kuyuidokado*, *Toidikadi*, *Tibbuzitikadi*, and *Agaitikadi* [Map 2]). Washoe territory included a long chain of valleys along the eastern slopes of the Sierra Nevada. Lake Tahoe served as a major base, with other settlements located in Long Valley, south of Honey Lake and along the Truckee, Carson, and Walker rivers (Downs 1966). Stewart (1944) assigned the tribal affiliation of the community of Coleville to both Paiute and Washoe, but later (in 1966) placed the Northern Paiute/Washoe boundary west of Slinkard Valley, with Coleville in Northern Paiute territory. The *Tasiget Tuviwari* band occupied the region incorporating Winnemucca and Spring Valleys and the Lower Truckee Meadows (Stewart 1939). The *Kuyuidokado* (Pyramid Lake Paiute) inhabited the area east of the *Tasiget Tuviwari* band, including all of Pyramid Lake and lower reaches of the Truckee River (Delacorte 1997a). The *Toidikadi* (or Cattail-eaters) territory is bounded on the north by the West Humboldt Range, to the east by the Clan Alpine Mountains, to the south by the Desert Mountains, and to the west by the Virginia Range, encompassing the entire Stillwater area. The *Tibbuzitikadi* tribe occupied the upper Walker River, and the *Agaitikadi* band lived around the lower Walker River and Walker Lake (Fowler 2002).



Map 2. Tribal Distribution

Washoe

Washoe is a Hokan language, which suggests that it originated in California (Heizer and Elsasser 1953). The Washoe practiced a seasonal round trading east-to-west as resources dictated (Downs 1966). Their seasonally mixed strategy of high mobility foraging and logistically organized collecting included gathering, fishing, and hunting (Binford 1980). At the first sign of spring, when snow began to melt from the lower foothills, younger men and women trekked into the mountains to fish. Their departure allowed older people and children, who remained in lowland settlements, to survive on what few resources remained. As the weather improved, people in lowland settlements moved into the mountains (Downs 1966). By early June, most Washoe were encamped at Lake Tahoe to fish (Zeier and Elston 1986, 1988).

Gathering also began in the spring with the appearance of early plants (Downs 1966; Zeier and Elston 1986, 1988), which served as a temporary hedge for families headed to Lake Tahoe for fishing. As summer progressed, women spent more time gathering, as men continued to fish. Toward the end of summer, as fishing waned, gathering became more important (Downs 1966), with residence shifting between temporary shelters in natural caves and brush structures (Elston et al. 1994). Fishing, hunting, and gathering occurred simultaneously during the early fall. As fish were depleted, men shifted to hunting. Hunting occurred throughout the year, but most intensively for a brief period in the late summer and fall until the first snowfall. Hunting was an exclusively male pursuit, with young boys beginning their training early in childhood (Downs 1966). Special headmen were chosen by the people to lead the hunt (Lowie 1939). Hunting was conducted as communal drives or undertaken by individual men (Zeier and Elston 1986, 1988), while women gathered pinyon nuts and vegetables (Downs 1966).

The Washoe survived the harsh winter months subsisting on stored pine nuts, seeds, and dried meat at permanent base camps (Zeier and Elston 1986, 1988). Winter camps were occupied for many months by large groups and consisted of houses, storage facilities, pits, and hearths (Elston et al. 1994). Houses were constructed of stout poles set around a shallow pit to form a conical framework that was covered with slabs of bark; a central hearth, a smoke hole at the top, and an eastern doorway were also characteristic. These winter homes were set apart from each other to create a sense of privacy (Delacorte 1997a; McCarthy 1997).

Northern Paiute Bands

Each of the 22 independent Paiute bands followed settlement and subsistence patterns closely geared to fluctuations in the seasonal availability and distribution of wild foods (Delacorte 1997a). The five Northern Paiute bands listed above (*Tasiget Tuviwari*, *Kuyuidokado*, *Toidikadi*, *Tibbuzitikadi*, and *Agaitikadi*) exploited a large area in the Truckee Meadows (Fowler 2002). The Pyramid Lake Paiute were unique among western Nevada bands in that they had access to a major fishery (Delacorte 1997a). Aside from local environmental distinctions, all of the Northern Paiute shared similar annual settlement patterns. During winter months, multi-family villages of three to ten houses were located in sheltered areas near critical resources (Delacorte 1997a). “Winter houses were constructed of a conical pole framework built around a shallow depression and covered with mats of tules or other brush tied to the frame” (Delacorte 1997a:7). Interior furnishings were scarce, but a small fire was built at the center of the structure to provide both light and warmth. During summer months, people would form smaller household or family groups and transition between a series of temporary field camps, as they followed available resources. Simple brush enclosures were used at these camps to provide protection from the sun and wind. Local materials were used to make tools as needed, rather than carry equipment while traveling (Delacorte 1997a).

Use of resources from three environmental zones—marshes or wet meadows, desert, and mountain uplands—resulted in a wide variety of exploitation. Plants comprised the majority of exploited resources during the spring through early fall, when seeds and roots were gathered and stored for winter use. Fish were exploited at Pyramid Lake and the Truckee River. In hilly, snow-free areas, where fish were of limited availability, greens, shoots, and early ripening seeds were available. In the fall, trips were made to procure pine nuts. Although gathering was more important, hunting also played a role in resource procurement. Communal antelope drives were traditionally held in the spring and fall. Mountain sheep and deer were pursued throughout the year and waterfowl captured at marshes when available. Small game, such as rabbits and hares, provided not only important sources of meat, but also skins for weaving blankets used as winter garments (Delacorte 1997a; Fowler 2002).

Senior household members made all social and political decisions with little interference from outside. The camp chief, or headman, decided when groups would move camp and dealt with inter-group conflicts. Headmen were selected by group consensus; this was not an inherited position. Among the Northern Paiute, individuals were free to gather resources wherever they liked, since there was no real ownership of resources or territory (Delacorte 1997a).

PREVIOUS ARCHAEOLOGICAL RESERACH

In the early 1950s, archaeologists from the Berkeley campus of the University of California undertook the first study of the Eastern Front of the Northern Central Sierra (Moratto 1984:294-295). Brief surveys and testing of sites on the Eastern Front near Lake Tahoe led to identification of the Martis and Kings Beach cultures (Heizer and Elsasser 1953). Based on W. A. Davis's hypothesis, Elston (1971) studied four sites on the east side of Lake Tahoe to resolve questions about the relationship between Martis and Kings Beach cultures and the postulated identification of the latter as ancestral Washoe. Resolving that further research would be needed, subsequent work by Elston et al. (1977) concentrated less on Washoe culture history and focused more on the relationship between environment and cultural adaptation. The Middle Archaic culture chronology was derived from various studies in the 1970s (Davis and Elston 1972 and Elston et al. 1977); more recently, Moratto (1984:295) found Martis affinities in sites on the western slopes of the foothills. For the past three decades, most archaeological studies on the Eastern Front have emphasized changing settlement and subsistence patterns developed in response to changing paleoenvironmental conditions (Stoner et al. 2006:3.5). Models derived from evolutionary biology and economics have been used to understand lithic production and raw material and tool use (Zeier and Elston 1986, 1992). Archaeological studies in the Truckee Meadows have followed the same research interests (Elston et al. 1994; Elston et al. 1995; Kautz 1991, 1996; Miller and Elston 1979; Moore and Burke 1992; Simons 1997a; Simons and Hutchins 1996; Simons and Kautz 1996; Zeier and Elston 1986).

Archaeology of the Eastern Sierran Front

Reconstruction of mobility strategies in the Great Basin focuses largely on open-air lithic scatters, because subsistence residues, features, and architectural remains are poorly preserved. Sites that contain features along the Sierran Front, in the Long Valley Creek area, Truckee Meadows and Washoe, Eagle, and Carson valleys are discussed below.

The six northernmost sites considered in this overview include two in the Long Valley Creek and four in the Dry Creek Valley area. The first is Hallelujah Junction (CA-LAS-317), excavated by Elston (1979a). He identified at least five housepits and numerous associated features. Typeable points recovered include Desert, Rosegate, Martis, Elko, Humboldt, and Pinto series points. Millingstones, debitage, and faunal remains were also recovered. The second site, Bordertown (26WA1676), was also excavated by Elston (1979b), who described it as 11 housepits with numerous associated features, including cache pits, hearths, postholes, debitage, and faunal remains. Points recovered include Desert, Rosegate, Martis, Elko, Humboldt, and Pinto series forms.

Giambastiani excavated the four Dry Creek Valley sites (26WA8386, 26WA8387, 26WA8388, and 26WA8391) in 2008 for the Intermountain Water Project (IWP). All are prehistoric sites, aside from site 26WA8386 that also has a historic ranch. These sites include abundant ground stone, cores, projectile points, bifaces, formed flake tools, and debitage (Giambastiani n.d.).

Features have been found at 32 sites in the Truckee Meadows area. In 1968, Elston and Turner discovered nine of these sites (26WA1117/1416, 26WA1418,

26WA1442, 26WA1443, 26WA1444, 26WA1446, 26WA1447, 26WA1450, and 26WA1481) near Steamboat Hot Springs and flanks of the Huffaker Hills. All were described as possible winter villages, containing housepits, cache pits, ground stone, debitage, and projectile points (Elston and Turner 1968).

A survey by Elston and Davis (1972) led to the discovery of both the Towne (26WA1416) and Thompson (26WA1435) sites. The Towne Site, a probable winter village, had been looted, but three basalt points, blade fragments, flakes, and ground stone were collected. The Thompson Site, is another winter village, containing a housepit, a hearth, a Desert series projectile point, and Martis complex materials.

In 1975, Townsend and Elston discovered two large base camps, a midden, and possible houses represented by rock-ringed circles on the surface (26WA2012, 26WA2035/2054, 26WA2010). Associated artifacts included Desert and Elko series projectile points and chert and basalt debitage (Townsend and Elston 1975).

Miller and Elston (1979) discovered the Glendale site (26WA2065) on the banks of the Truckee River at the Reno-Sparks boundary. This winter village contained housepits, external features, and a distinct midden area away from the habitation. Artifacts recovered included Desert, Rosegate, Martis, and Elko series, and Humboldt, and Pinto points, debitage, and faunal remains (Miller and Elston 1979).

Matranga (1983) excavated a camp at Steamboat Hot Springs (26WA1414) that produced seven hearths. Associated materials included chert and basalt flakes.

In 1986, Zeier and Elston located the Vista site (26WA3017) on the eastern margin of the Truckee Meadows at the southwest base of the Pah Rah Range and confluence of Steamboat Creek and the Truckee River. Cultural remains included Desert, Rosegate, Gunther, Elko, Martis, Pinto, Humboldt, and Stemmed points, as well as ground stone, debitage, and faunal remains (Zeier and Elston 1986). In 1997, Delacorte expanded on the Vista site research, conducting obsidian sourcing and hydration studies on 43 pieces of obsidian associated with radiocarbon dated features (Delacorte 1997a).

In 1992, Moore and Burke identified 10 base camps (most being possible winter villages) and another seven base field camps within the Truckee Meadows. Only a few features and radiocarbon dates were identified, with most dating to the Kings Beach phases. Sites considered to be base camps or potential winter villages included 26WA148, 26WA1456, 26WA1480, 26WA1486, 26WA1488/1489, 26WA1495, 26WA4330, 26WA4331, 26WA4332, and 26WA5197. Burke and Clay (1988) suggested that 26WA1486 was a Kings Beach winter village; however, Kautz (1991) failed to find features there and concluded that it and site 26WA4331 were a field camps.

Matranga and DeBunch (1993) uncovered 22 dated hearth features at site 26WA1696, located on the lower southern flank of Peavine Mountain. Artifacts recovered at the site consisted of Desert, Rosegate, Martis, and Elko series, and Humboldt, and Pinto points, as well as debitage.

McCabe and Clay (1995) identified a number of sites on the Damonte Ranch property, including three with housepits (26WA1481, 26WA5726, and 26WA5577). All features are in the southern Truckee Meadows area adjacent or near the Steamboat Creek drainage. Clay et al. (1995) investigated site 26WA5747 along the lower section of Whites Creek on the Eccles Ranch property. It yielded a buried cultural deposit containing thousands of sinter biface reduction flakes similar to those found on Damonte Ranch at 26WA5577. Hutchins and Kautz (1995) undertook further investigations around the Huffaker Hills and Double Diamond Ranch area.

The Crane Ranch site (26WA1444) analyzed by Elston (1988) is located along Steamboat Creek near Geiger Grade. Investigations resulted in 10 or 11 housepits with Desert and Rosegate series projectile points and small biface reduction technology (Elston 1988).

Stoner et al. (2006) discovered the ReTRAC site (26WA7522), located in downtown Reno, Nevada, along the Union Pacific Railroad (UPRR) corridor. Two phases of excavation resulted in the discovery of human remains, 69 features, and various tools.

Young et al. (2009) conducted data recovery at five sites (26WA5678, 26WA8146, 26WA8147, 26WA8148, 26WA8150) within the Vidler Water Project APE, between the Honey Lake Basin and North Valley region of Reno. Two additional sites (26WA2460 and 26WA8149) were encountered during geo-testing and also mitigated. Site 26WA5678 was the only historic site evaluated, and site 26WA8149 produced no subsurface data. A total of 16 radiocarbon dates was gathered.

Washoe Valley has two known sites containing subsurface features. In 1975, Townsend and Elston recorded Old Washoe City (26WA1436), an ethnohistoric Washoe settlement (Townsend and Elston 1975). In 1992, Clay discovered a small buried midden (26WA5462) on the east side of Little Washoe Lake. It may represent a buried housepit, but no dates were obtained (Clay 1992).

Fifteen sites with features are known from Eagle and Carson valleys. Elsasser (1960) excavated the Hobo Hot Springs area (26DO12), recovering more than 300 projectile points and abundant burned fauna and one human burial. No obvious features or dates were gathered (Elsasser 1960).

Elston's (1970, 1979b) excavations at Saratoga Hot Springs (26DO1) resulted in the discovery of a midden, possible house floors, a hearth, and Martis, Elko, and Rosegate projectile points. In 1971, Elston analyzed the Daphne Creek site (26DO37), located on the northern periphery of Carson Valley, Douglas County, which includes two cultural features with Late Kings Beach dates (Elston 1971).

The Carson Bypass Project resulted in numerous surveys within Eagle Valley by NDOT (1979, 1983, 1984) and Ingbar (1994). Large midden sites (26OR1 and 26OR9) were tested, and other possible winter encampments (26OR2 and 26OR21) identified. NDOT (1985) tested a large site (26DO326) located on the Carson River floodplain in Carson Valley about one mile south of Cradlebaugh Bridge. It included several features, as well as obsidian and basalt Martis points.

The Clear Creek site (26OR187), located near the confluence of the Carson River and aforementioned creek, was analyzed by Kuffner (1987). Middens were discovered in three areas, but no features were found. Artifacts included Rosegate series, Martis, Elko, and Humboldt points, as well as ground stone, debitage, and faunal remains.

Clay and Reno (1989) tested five sites in the Buckeye Creek area of eastern Carson Valley. Site 26DO381 produced numerous surface and subsurface features, but no house structures during testing.

Kolvet (1996) uncovered 377 features at the winter village site 26DO439. Associated artifacts included Desert, Rosegate, and Martis series projectile points. Zeier and Elston (1988) completed data recovery at two sites (CA-ALP-212 and CA-ALP-223) in Diamond Valley. These contained housepits, pit features, hearths, projectile points, and debitage.

Clay et al. (1996) excavated and recorded remains from the Eagle Valley Village site (26OR214, Area J). Artifacts included numerous projectile points, lithic tools, ground stone, and faunal remains.

Finally, Stoner and Rusco (2002) completed data recovery at the Sunridge site (26DO439), located on private property in the northern Carson Valley, near the intersection of Jacks Valley Road and U.S. Hwy. 395. It revealed 361 features, including assorted pits, sediment stains, and deposits of fire-cracked rock.

CHAPTER 4. THEORETICAL BACKGROUND

This thesis tests implications of Delacorte's (1997a) model by examining stone tools and manufacturing debris produced by prehistoric populations in the Truckee Meadows. Patterns of lithic acquisition have implications for understanding hunter-gatherer settlement and land-use patterns, with mobility patterns often correlated to the material remains of human occupation (Binford 1973, 1977; Jones et al. 2003; Kuhn 1995; Parry and Kelly 1987; Shott 1989).

Binford was the first to discuss the association between mobility patterns and lithic technology (1973, 1977), and went on to coin the forager/collector dichotomy that is frequently discussed in archaeological studies (1977, 1979). Foragers, or residentially mobile groups, move in response to seasonal resource availability and do not practice food storage. As such, processing, manufacturing, and maintenance activities take place at residential base camps. Structures or facilities are rarely found at forager sites in the Truckee Meadows (Zeier and Elston 1988), because forager groups were highly mobile and shifted residence frequently. Such groups encounter multiple toolstone sources, and find it easy to embed toolstone procurement in their seasonal round (Giambastiani 2004).

Collectors move their residential bases infrequently and procure resources on longer logistical forays, bringing food back to the rest of the population. In the western Great Basin, archaeological signatures identifying such limited residential mobility include pit houses, earth ovens, storage features, ceremonial features, intensive processing of animal bone, midden accumulations, ground stone, and high proportions of cores and choppers. Such collector systems were less mobile and restricted to smaller territorial areas than foragers. Because of this, fewer toolstone sources were usually accessible within their daily foraging rounds (Giambastiani 2004), requiring logistical forays to procure non-local toolstone. Raw materials were stored at residential base camps, where tools and debitage reflecting the entire lithic reduction sequence should be present (Zeier and Elston 1986, 1988).

The relationship between mobility and technological organization in the Great Basin has become an increasingly popular research topic through analysis of chipped stone assemblages (Amick 1995, 1997; Basgall 1988; Beck and Jones 1988, 1990a, 1990b, 1997; Beck et al. 2002; Goebel 2005; Graf 2001, 2002; Jones and Beck 1999; Jones et al. 2003; Kelly 1988, 1982, 2001; Smith 2005a, 2005b). Obsidian has been a major focus of these studies, because it can be traced to its point of origin to determine how prehistoric hunter-gatherers procured, used, and transported obsidian from quarries (Basgall 1989:111). When quarries were visited, broken or spent cores and tools were easily replaced with local materials (Gramly 1980). As a result, quarry assemblages may reflect temporal disparities in toolstone acquisition, containing debris from the initial working of local material, as well as discarded projectile points and other curated artifacts made of non-local stone. Locally acquired toolstone would likely have been taken to nearby locations for further reduction into finished artifacts (Giambastiani 2004:106).

Logically, toolstone should diminish through damage, reduction, and re-use, as it is moved farther from the source. It is this conveyance and use of lithic materials as one moves away from quarries that creates observable source patterning within the archaeological record (Giambastiani 2004). Binford (1979) identifies special purpose sites, or "locations," as those involving full-scale tool discard (broken points, bifaces, and other implements), whereas residential sites are locations where tool manufacture occurs, given the availability of adequate time, food, and facilities. In the first scenario, debitage produced from the maintenance of tools should comprise a variety of source materials. In the second instance, debitage from the shaping and reduction of blanks or preforms should consist of source materials obtained during the most recent procurement cycle. Tools discarded at residential sites should comprise a greater range of sources than those represented in the debitage. Based on this assumption, different source profiles for tools and debitage imply that both tool discard and manufacture were taking place. However, if source profiles are more or less the same, then tool production alone is implied (Giambastiani 2004:107).

MOBILITY AND SETTLEMENT PATTERNS

Trends in aboriginal mobility and settlement patterns have been linked to patterns in lithic source distribution. Many archaeologists have analyzed lithic source distributions among hunter-gatherers. Goodyear (1979) and Binford (1979) were among the first to explore the implications of raw material source patterns and settlement shifts in terms of group mobility. Since then, numerous studies have shown that groups traveled long distances to obtain toolstone (Basgall 1988, 1989; Gould and Saggers 1985; Hughes 1986; Kelly and Todd 1988; Meltzer 1985; Roth 2000; Shackley 1990, 1996). Researchers can use these toolstone distributions across the landscape to interpret the distances and/or direction artifacts were transported. These areas have been referred to as lithic conveyance zones, presumably reflecting the geographic territory of prehistoric groups (Jones et al. 2003).

X-ray fluorescence (XRF) analysis has proven especially useful for tracking obsidian and fine-grained volcanic artifacts to their source of origin and inferring lithic conveyance zones (Hughes 1986). For example, obsidian studies in central-eastern California have shown a tendency toward greater source diversity in early assemblages and more localized materials in later assemblages (Basgall 1989; Basgall and Giambastiani 1995; Basgall and McGuire 1988; Delacorte et al. 1995; Delacorte and McGuire 1993). This pattern suggests that earlier populations were more mobile and had expansive subsistence-settlement systems that brought them in contact with a wider range of lithic resources (Basgall 1989). A gradual intensification in local obsidian procurement suggests that later groups became more centralized in smaller annual foraging areas due to pressures from population growth (Giambastiani 2004).

Ultimately, we can use lithic conveyance zones to infer regional and local patterns of subsistence-settlement. During residential moves, highly mobile foraging groups traveled long distances and encountered many food and toolstone patches. Groups confined to smaller foraging areas moved less often and employed a smaller number of lithic sources, perhaps by direct acquisition. It is generally held that the farther away obsidian is found from its source, the less it should be represented in an assemblage, although it may occur among highly curated tools. For this reason, obsidian sources obtained later in time should be well represented among debitage and tools, while sources visited earlier in time should occur in steadily decreasing quantities as increasingly finished tools (Giambastiani 2004).

LITHIC CONVEYANCE MODELS IN THE WESTERN GREAT BASIN

Three previous studies of lithic conveyance zones are discussed below and provide some sense of the prehistoric settlement systems operating in and around the Truckee Meadows. They suggest similar patterns to that which would be expected in other areas under similar circumstances.

Pah Rah Range

Delacorte (1997a) reconstructed settlement systems based on obsidian sourcing and hydration from sites in the Pah Rah Range. He divides the Early Component into two categories: old ($\geq 4.0\mu$) and young ($< 4.0\ \mu$). Older Early Component assemblages contain obsidian from as far north as the Warner Mountains and as far south as Bodie Hills. The conveyance zone of the younger Early Component period extends only as far north as the Patrick obsidian source and south to the Mono Basin. A final shift occurs during the Late Component ($< 2.0\mu$), when obsidian was acquired locally in significant amounts for the first time at Patrick and Sutro Springs near the Pah Rah Uplands.

Delacorte suggests that this trend of intensified use of local, but less desirable, materials supports the idea that territory size and population mobility diminished through time. Assemblages from the initial part of the Early Component (old) contained the greatest toolstone variability, with obsidian obtained from sources up to 150 km to the north and south. This suggests that early populations accessed areas extending from the Mono Basin to the eastern flank of the Warner Mountains. The later part of the Early period (young) displayed a reduction in the area over which groups foraged with Sutro Springs and a few southern sources (e.g., Bodie Hills, Mt. Hicks) present. This suggests that annual mobility remained high, but was characterized by fewer forays from more restricted home ranges. Early Component tools are fashioned from more non-local sources and comprise a greater proportion of curated implements, suggesting higher mobility. Finally, the Late Component shows evidence for a second decrease in territory size. Local obsidian of inferior quality (Patrick) is now used in significant amounts and much of the other obsidian toolstone is scavenged from older archaeological deposits. This suggests that late prehistoric groups were exploiting limited areas and primarily local obsidian sources, with residential shifts confined to short distances, not widely separated areas as in earlier times. Late Component assemblages contain significantly more expedient flake and pressure retouched implements, or a technology compliant with more localized and intensive land use.

Volcanic Tableland

Giambastiani (2004) identifies a similar pattern centered around the Volcanic Tableland in Mono County, California. During the Early-Middle Holocene, the Volcanic Tableland was incorporated in a wide-ranging settlement pattern that extended along the eastern flank of the Sierra Nevada from Bridgeport to the Coso Volcanic Field. Hydration data also support the existence of a contemporaneous settlement system in the Coso region to the south. Based on Delacorte's (1997a) findings and the appearance of Mono Basin glasses at Hidden Cave, Nevada by the Middle Archaic, Giambastiani proposes that a neighboring long-range settlement pattern probably occurred to the north as well.

With the early Late Holocene comes a shift in Inyo-Mono settlement patterns that became more restricted in geographic scale and oriented along a north-south trajectory. Two separate systems emerged, both making regular visits to the Volcanic Tableland. First was a northern system, centered in the Mono Basin or somewhere to the northeast that regularly used the northern half of the Volcanic Tableland. Second was a southern system, centered in Owens Valley that procured Casa Diablo obsidian from Long Valley and made regular use of the southern half of the Volcanic Tableland.

These settlement systems continued to contract through the Late Holocene, given resource competition brought about by growing populations. By the Terminal Prehistoric period, obsidian patterns suggest increased settlement centralization in Owens Valley that evolved into the ethnographic pattern described by Steward (1933, 1938), where populations were tethered to highly localized areas.

Stillwater Mountains

The lithic conveyance system defined for the Stillwater Mountains area in western Nevada, comes from work done at Hidden Cave (Hughes 1985), the Carson Desert (Kelly 2001), and at Mustang rockshelter (Kelly 2007). Archaeological evidence suggests that early in time foragers residentially occupied Stillwater Mountains. A transition occurred approximately 1,500 B.P, when the mountains were logistically exploited from more permanent settlements in wetland areas of the Carson Desert. Using projectile points and obsidian hydration, Kelly (2001) showed more intensive use of quarries located to the north and a gradual decrease in the use of southern quarries in later assemblages. This suggests that less mobile groups inhabited the Stillwater area after 1500 B.P.

In sum, all three conveyance systems indicate that groups became less residentially mobile over time. Here, we consider Delacorte's (1997a) research that proposes a locally based obsidian procurement in the Late Archaic Truckee Meadows. Elston et al.'s (1995) report hints at similar trends in the Truckee Meadows, but more research is needed.

HYDRATION RATES

The utility of obsidian hydration is restricted to relative age estimates if hydration rates have not been calculated. Many attempts have been made to develop hydration rates that can convert rim readings to calendric age estimates (Delacorte 1997b). These have included both laboratory-induced hydration experiments (Friedman and Long 1976; Friedman and Trembour 1978, 1983; Michels and Tsong 1980) and rates derived on the basis of archaeological remains. Geophysically induced rates have met with limited success when tested against archaeological remains of known age (Michels 1982, 1983); greater success has been achieved by correlating hydration rims with other temporally diagnostic archaeological materials. One method employs hydration measurements on projectile point types of known temporal span and calculating a correlation with the mean and/or maximum age ranges of different point forms (Basgall 1983; Basgall and

Giambastiani 1995; Bettinger 1980, 1989; Delacorte and McGuire 1993; Garfinkel 1980; Hall 1984; Hall and Jackson 1989; Weaver 1992). Results of this technique have yielded reasonably accurate age estimates when tested against radiocarbon dates. However, the results are not very reliable when working with archaeological remains older than 5000 B.P., because few of the samples or point types used to develop the rates date to such ancient times. Another technique to infer obsidian hydration rates, correlates radiometric assays with hydration rims. Here, source-specific obsidian hydration samples are compared directly against dates from associated depositional contexts. This method requires a significant number of paired radiocarbon and hydration measurements to be successful (Delacorte 1997b).

Sutro Springs Hydration

Delacorte (1997a) compiled previous hydration analysis data (Moore and Burke 1992; Zeier and Elston 1986) from the Pah Rah Uplands area, and analyzed additional obsidian samples from the Vista site. A total of 40 pieces of obsidian was identified as Sutro Springs glass, with one each of Bodie Hills, Mt. Hicks, and Buffalo Hills (Unknown B) obsidian. Table 1 depicts the raw Sutro Springs obsidian hydration and radiocarbon data compiled by Delacorte for the Truckee Meadows. Most of the Sutro Springs hydration rinds cluster tightly between 1.7 and 3.7μ, yielding an average of 2.7 ± 0.5μ. Delacorte compared these results to 14 Rose Spring points made of Sutro Springs material. These furnished hydration readings of 1.9-3.2μ and a mean of 2.5 ± 0.4μ, suggesting that the most intensive use of Sutro Springs glass coincided with the time of

Rose Spring points (1300-600 B.P.). Hydration readings for two Elko series points of Sutro Springs obsidian further supported this notion, producing larger (older) values of 3.8 and 4.1μ (4.0 ± 0.2).

Table 1. Delacorte's (1997a) Table of Sutro Springs Obsidian Hydration Measurement and Radiocarbon Assays for Sites in the Truckee Meadows.

Provenience	Sutro Springs Hydration (μ)	n	$\bar{x}$	sd	Radiocarbon (Years B.P)
Feature 38	2.0	1	2.0		930 ± 150
Feature 89b	1.7, 1.9, 2.5, 3.3	4	2.4	0.7	1040 ± 100
Feature 48f	2.9	1	2.9		770 ± 70
Feature 48a, c	2.4, 2.4, 2.5, 2.7, 2.9, 3.0, 3.0, 3.0, 3.4, 3.4, 3.5, 3.5, 4.0	13	3.1	0.5	1320 ± 320
Other Contexts	1.9, 2.2, 2.4, 2.5, 2.5, 2.5, 2.5, 2.5, 2.5, 2.6, 2.6, 2.7, 2.7, 2.9, 3.0, 3.0, 3.0, 3.1, 3.1, 3.2, 3.3	21	2.7	0.4	210 ± 170 (Feature 48d) 590 ± 70 (Feature 3) 830 ± 6 (Feature 4) 1360 ± 110 (Feature 26) 1360 ± 170 (Feature 50)
26WA1480	2.3, 2.5	2	2.4	0.1	1060 ± 70 (Feature 1)
26WA1488/89	1.7, 2.0, 2.3, 2.4, 2.5, 3.0	6	2.3	0.4	820 ± 150 (Feature 3)
Other Contexts	4.5	1	4.5	-	990 ± 100 (Feature 2)
26WA5183	2.4, 2.6	2	2.5	0.1	-
26WA5186	2.5, 2.6	2	2.6	0.1	-
26WA5197	2.7	1	2.7	-	480 ± 70 (20 cm below surface)
Other Contexts	1.8	1	1.8	-	-
26WA5204	2.7, 3.2	2	3.0	0.4	-

Griffin (2013) expanded on Delacorte's (1997a) data to develop a hydration rate for Sutro Springs obsidian using nine radiocarbon-hydration pairs from seven archaeological sites in the Truckee Meadows and Tahoe Sierra (Ataman 1999; Delacorte

1997a; Bloomer and Lindstrom 2006; Kautz and Simons 2004; and Simons and Malinky 2006). Radiocarbon dates were calibrated using the University of Cologne Radiocarbon lab calibration curve (CALPAL2007_HULU), and by employing a power regression, Griffin found a strong and significant correlation between log calibrated radiocarbon dates and log hydration readings (Pearson's R^2=0.844). The data from Griffin's (2013) analysis yield the following rate equation:

Cal Years B.P. = $182.72021\mu^{1.90}$

Griffin (2013) attempted no temperature correction, and his sites ranged in elevation from 1370 m to 1675 m (4500 feet to 5500 feet), such that temperature may have been an important distorting factor. However, Griffin (2013) tested his hydration rate against nine projectile points in the Tahoe Sierra and found that it performed reasonably well, overestimating dates by no more than one or two hundred years.

Bodie Hills Hydration

Hutchins and Simons (2000) gathered information on obsidian samples from 27 archaeological sites in and around the Truckee Meadows. They argued that their combined sample contradicts Delacorte's (1997a) age estimates. Suggesting that the data show extreme variability in hydration rind formation, they proposed that obsidian hydration is an unreliable technique for determining artifact age.

Although Hutchins and Simons lacked radiometric data with which to assess their hydration measurements, they nonetheless produced some interesting results. They analyzed a total of 401 specimens, 79 of which derive from Bodie Hills. Preliminary results showed that use of Bodie Hills and Sutro Springs obsidian peaking between 2.0 to 4.9 microns, but the wide range of hydration values suggests that both sources were exploited over a long period of time.

In the absence of an acceptable Bodie Hills hydration rate, measurements have been interpreted using empirical rates developed for Casa Diablo obsidian (Delacorte et al. 2000; Francis 1999; Giambastiani and Basgall 2000; Halford 2001; Milliken and Hildebrandt 1997) or Napa Valley glass (Baker 2000a, 2000b; Stewart and Gerike 1994). Tremaine's (1991) induced-hydration research indicates that all three sources hydrate at roughly comparable rates, with the equation developed by Hall and Jackson (1989) for Casa Diablo obsidian employed here. This gives:

$$\textit{Cal Years B.P.} = 129.656\mu^{1.826}$$

A primary problem in applying hydration rates regionally along the western slope of the Sierra is the significant temperature variability along an elevational continuum (Hildebrandt and Ruby 1999; Hull 2001; Hull and Moratto 1999:333; Onken 1991). To compensate for this, Rosenthal and Meyer (2011) formulated hydration models based on 18 radiocarbon-hydration pairs from 11 lower elevation sites in the western Sierra Nevada foothills and adjacent Central Valley of California to calculate rate equations.

Seven Bodie Hills hydration rates were calculated. Rate Model A used all 18 radiocarbon-hydration pairs and was based on the diffusion model. Rate Model A1 was derived from the same radiocarbon-hydration pairs, but was calculated as a best-fit regression. In addition to the archaeological pairs, Rosenthal and Meyer also employed several estimated data points when modeling hydration rates. The first estimated pair was a value of 150 years for one micron of hydration, with an error of one or two tenths of a micron and 50 to 150 years (Origer 1989). The youngest archaeological pair in the sample consists of a Bodie Hills value of 1.3 microns and associated radiocarbon date of 300 years. This suggests that the 150 year to 1.0 micron estimate is reasonable. Model B was developed using the estimated pairs and the 18 archaeological samples. Three rates (C-E) were developed using maximum estimated hydration radiocarbon-pairs. Finally, Model F was calculated using only 10 archaeological radiocarbon-hydration pairings with more than one hydration reading.

Rosenthal and Meyer (2011) concluded that models A1, C, and D work reasonably well at sites dating from the Middle through Late Holocene. Model C may be preferable given the greater age estimate it provides for the Early Holocene Black and Green Clay stratum at the Skyrocket site. However, Griffin (2013) chose Model B as the most appropriate, because it was computed as a power function. Many researchers have concluded that obsidian hydration may not be a linear process. Instead, obsidian may hydrate faster when it is younger and slower through time. While power function equations produce often better results for late dates, they too are far from perfect, yielding often spurious estimates for earlier time frames (Hall and Jackson 1989).

For the purposes of this thesis, Griffin's (2013) Sutro Springs, Hall and Jackson's (1989) Casa Diablo, and Rosenthal and Meyer's (2011) Model B rates will be used. Griffin's (2013) rate was chosen, because it is the only available one for Sutro Springs glass, and his study area in the Tahoe Basin is in close proximity to the Truckee Meadows. The Casa Diablo rate (Hall and Jackson 1989) was chosen, because it is the traditional Bodie Hills rate used in archaeological studies. Finally, Rosenthal and Meyer's (2011) Model B rate will be used, because it is the most recent attempt to develop a working Bodie Hills formula.

CHAPTER 5. METHODS

I first assembled available data from previous obsidian studies along the Eastern Sierra Front. In order to test Delacorte's (1997a) research further, I then reviewed sites with radiocarbon-dated features associated with obsidian. This allowed me to generate radiocarbon-hydration pairs to gain a better understanding of obsidian patterns in the Truckee Meadows region.

Chapter 3 outlines numerous sites containing archaeological features in the region. Although numerous features have radiocarbon dates, many of them lack associated obsidian. For this reason, I chose four sites (Vista - 26WA3017, ReTRAC - 26WA7522, Eagle Valley Village - 26OR214, Area J, and Sunridge - 26DO439) that have securely dated archaeological deposits with associated obsidian.

Using Delacorte's (1997a) chronology for reconstructed settlement systems in the Pah Rah Range, I selected features for the Early (old), Early (young), and Late Components for further obsidian hydration and sourcing analysis. For the purpose of this thesis, I will refer to these components as Early, Middle, and Late.

Features 53 and 57 represent the Early Component from the ReTRAC site and Feature 116 from the Sunridge site (see Table 2, highlighted in yellow). Feature 52 represents the Middle Component from the ReTRAC site, Features 50 and 89b from the Vista site, and Features 1a, 3, and 26 from the Eagle Valley Village site (see Table 2, highlighted in green). Lastly, the Late Component is represented by Feature 48d from the Vista site, Feature 6 from the Eagle Valley Village site, and Features 52 and 95 from the Sunridge site (see Table 2, highlighted in blue).

These features were selected based on a number of criteria. I chose hearths and house pits when available and features that contained associated obsidian and projectile points when possible. Unfortunately, many of the features lacked obsidian. In order to include samples of Early, Middle, and Late Components, radiocarbon dates were used to identify discrete temporal/depositional contexts. There were many Late Component features from Eagle Valley Village, but few met the necessary criteria.

Table 2. Site Components

Site	Provenience	Context	Lab No.	RC Date	Associated Diagnostics	Other Tools / Debitage
26WA3017 Vista Site	Feature 4	Hearth	N/A	830 ± 6	-	-
	Feature 3		N/A	590 ± 70	-	-
	Feature 89B	House Pit	N/A	1040 ± 100	1 Rosegate	39 flakes
	Feature 48B	Soil Stain	N/A	1320 ± 320	1 unidentified point	-
	Feature 48D	House Pit	N/A	210 ± 70	-	2 cores, 1 biface, 202 flakes
	Feature 48F	Rock Feature	N/A	770 ± 70	-	-
	Feature 26	Soil Stain	N/A	1360 ± 110	-	-
	Feature 38	Rock Feature	N/A	930 ± 150	-	8 flakes
	Feature 50	Oval Dep.	N/A	1360 ± 170	-	2 flakes
n26WA7522 ReTRAC	Feature 10	Rock cluster	203884	1250 ± 40	-	-
	Feature 11	Hearth	203885	1240 ± 40	-	-
	Feature 13	Soil Stain	203886	2080 ± 40	-	-
	Feature 21	Hearth	196395	50 ± 50	-	-
	Feature 25	Hearth	203887	4210 ± 40	-	-

Table 2 continued

Site	Provenience	Context	Lab No.	RC Date	Associated Diagnostics	Other Tools / Debitage
	Feature 29	Hearth	203888	270 ± 50	-	-
	Feature 30	Hearth	203889	1180 ± 50	-	-
	Feature 32	Cache Pit	196543	1200 ± 80	-	8 flakes
	Feature 34	Hearth	203890	1260 ± 40	-	-
	Feature 37	Hearth	203891	440 ± 40	-	-
	Feature 41	Soil Stain	203892	110 ± 40	-	-
	Feature 42	Hearth	203893	1160 ± 40	-	4 flakes
	Feature 48	Large Pit	203894	530 ± 40	-	4 flakes
	Feature 49	Large Pit	203895	1260 ± 40	-	4 flakes
	Feature 52	House Pit	203897	1200 ± 70	-	64 flakes
	Feature 53	Hearth	203896	4500 ± 40	-	1 flake
	Feature 57	Large Pit	205645	2990 ± 40	-	7 flakes
	Feature 59	House Pit	205646	2100 ± 40	-	-
26OR214 Eagle Valley Village	Feature 1	House Floor Fill		890 ± 90	2 Desert, 2 Rosegate, 2 Elko (or Martis) / 3 Desert, 3 Rosegate, 2 Elko, 1 Martis	-
	Feature 1a	Hearth	N/A	860 ± 70	-	87 flakes, 2 -SFT
	Feature 3	House Floor Fill	N/A	890 ± 80	2 Martis / 1 Rosegate	36 flakes, 2 bifaces
	Feature 3	House Floor Fill	N/A	940 ± 90	-	-
	Feature 6	House Floor Fill	N/A	120 ± 80	/ 1 Desert	11 flakes, 1 SFT
	Feature 8E	Posthole Fill in House Floor	N/A	1200 ± 140	/ 2 Rosegate	133 flakes
	Feature 9	House Floor Fill	N/A	1210 ± 80	-	12 flakes

Table 2 continued

Site	Provenience	Context	Lab No.	RC Date	Associated Diagnostics	Other Tools / Debitage
	Feature 10	House Floor and Upper Fill	N/A	950 ± 110	/ 1 Rosegate	7 flakes
	Feature 15	House Floor Fill	N/A	880 ± 70	/ 1 Elko	42 flakes, 1 FFT
	Feature 16	House Floor Fill	N/A	330 ± 60	1 Rosegate	-
	Feature 18	House Floor Fill	N/A	1110 ± 100	1 Rosegate	8 flakes
	Feature 20	House Fill above floor and floor fill	N/A	1010 ± 100	1 Elko / 2 Martis	32 flakes
	Feature 26	House Floor Fill	N/A	880 ± 60	/ 1 Rosegate	104 flakes
	Feature 46	Storage Pit	N/A	900 ± 50	-	-
	Feature 55	Roasting Pit	N/A	880 ± 60	-	9 flakes, 1 core
	Feature 61	Hearth	N/A	1150 ± 90	-	11 flakes, 1 core, 1 SFT
	Feature 69	House Floor Fill	N/A	1190 ± 80	/ 1 Martis, 1 Rosegate	11 flakes, 1 biface
	Feature 71	House Fill above floor and floor fill	N/A	1030 ± 70	-	8 flakes
	Feature 76	House Floor Fill	N/A	480 ± 90	1 Rosegate / 2 Rosegates	8 flakes
	Feature 77	House Floor Fill	N/A	900 ± 70	-	2 flakes
26DO439 Sunridge	Feature 52	House Pit	N/A	510 ± 50	1 Martis Corner-notched, 2 Desert Side-notched, 1 unknown	245 flakes, 3 bifaces
		House Pit	N/A	450 ± 50		
		House Pit	N/A	600 ± 40		
	Feature 80	Windbreak	N/A	390 ± 80	-	36 flakes
	Feature 73	Earth oven	N/A	700 ± 70	-	23 flakes
	Feature 76	Earth oven	N/A	570 ± 80	-	27 flakes
	Feature 95	House Pit	N/A	370 ± 80	1 Martis Contracting-Stem, 3 Rosegate Series, 1 unknown	1140 flakes, 1 RTF, 2 bifaces

Table 2 continued

Site	Provenience	Context	Lab No.	RC Date	Associated Diagnostics	Other Tools / Debitage
	Feature 99	Unknown pit	N/A	570 ± 80	-	31 flakes
	Feature 102	Hearth	N/A	410 ± 80	-	12 flakes
	Feature 137	Depression	N/A	470 ± 40	-	73 flakes
	Feature 116	Cache Pit (in Ft. 95)	N/A	2960 ± 40	-	42 flakes

RESTRICTIONS ON COLLECTIONS

Originally, I hoped to collect a sample of at least 15 obsidian flakes larger than 1 cm diameter, but this proved impossible (see Table 3). The first obstacle I encountered was with the Sunridge (26DO439) site, excavated on private property. I was directed to the Las Vegas Paving Company that had contracted Western Cultural Resource Management, Inc. (WCRM) to undertake data recovery excavations. Upon completion of the project in 2002, Las Vegas Paving instructed WCRM to place the collection in a storage unit in Carson City. Despite numerous e-mails and telephone calls to the company, they never responded to my queries regarding the whereabouts or access to the collection.

Table 3. Selected Features and Obsidian to be Tested

Site	Provenience	Context	RC Date	Obsidian to be Tested
26WA3017 Vista Site	Feature 89B	House Pit	1040 ± 100	15 flakes and 1 Rosegate points
	Feature 48D	House Pit	210 ± 70	15 flakes
	Feature 50	Oval Dep.	1360 ± 170	2 flakes
26WA7522 ReTRAC	Feature 52	House Pit	1200 ± 70	15 flakes
	Feature 53	Hearth	4500 ± 40	1 flake
	Feature 57	Large Pit	2990 ± 40	7 flakes
26OR214 Eagle Valley Village	Feature 1a	Hearth	860 ± 70	15 flakes
	Feature 3	House Floor Fill	890 ± 80	15 flakes, 2 Martis points, and 2 Rosegate points
	Feature 6	House Floor Fill	120 ± 80	12 flakes and 1 Desert Side-notched point
	Feature 8E	Posthole Fill in House Floor	1200 ± 140	15 flakes and 2 Rosegate points
	Feature 26	House Floor Fill	880 ± 60	15 flakes and 1 Rosegate point
26Do439 Sunridge	Feature 52	House Pit	510 ± 50	15 flakes, 1 Martis Corner-notched point, and 2 Desert Side-notched points
		House Pit	450 ± 50	
		House Pit	600 ± 40	
	Feature 95	House Pit	370 ± 80	15 flakes, 1 Martis point, and one Rosegate point
	Feature 116	Cache Pit (in Ft. 95)	2960 ± 40	15 flakes

The second issue related to the poor cataloguing of sites; some of the older reports did not identify the exact contents of specific features. When information like the amount of debitage was noted, it rarely specified how many flakes were obsidian. Review of the catalogues was often little better. Most of the collections contained boxes where historic and prehistoric material was comingled, catalogues that failed to specify where specific material could be found, nor any clear indication of the feature provenience for specific artifacts. This required that the contents of each box and catalogue tag be examined, with the results that fewer artifacts could be reliably associated with features than originally reported. As a result, only features reflecting Middle and Late Components are represented in the sample, from which 55 pieces of obsidian were sent to the Northwest

Research Obsidian Studies Laboratory for geochemical source and hydration analysis (Table 4).

Table 4. Obsidian from Features Sent for XRF and Hydration Analysis

Site	Feature	Radiocarbon Date	Component	Obsidian
26WA7522	52	1200 ± 70	Middle	Two Flakes
26WA3017	48d	210 ± 70	Late	Eight Flakes
	48	48d is 210 ± 70	Late	One Core
	50	1360 ± 170	Middle	Two Flakes
	89	89B is 1040 ± 100	Middle	One Point
26OR214	1	890 ± 90	Middle	One Point and Seven Flakes
	1a	860 ± 70	Middle	One Flake
	3	890 ± 80	Middle	Five Flakes
	6	120 ± 80	Late	Two Points, Two Bifaces, and Five Flakes
	8	8E is 1200 ± 140	Middle	One Biface, One Edge-modified Flake, and Seven Flakes
	26	880 ± 60	Middle	Nine Flakes

Another issue arose with regard to source analysis. It was assumed, based on Delacorte's (1997a) report that most Truckee Meadows obsidian would derive from the South Warner and Sutro Springs sources. Earlier dates were expected to correlate with South Warners obsidian and later dates with Sutro Springs material. Accepting this premise and veracity of the radiocarbon dates, it was assumed that northern sources would dominate early and local sources later sample contexts. If there were inconsistencies, the next step would be to compare hydration readings with previous results. Sutro Springs hydration measurements could be compared to Delacorte's (1997a) data for later sites, and South Warners' hydration measurements could be compared to Hildebrandt and King's (2002) data for earlier sites. However, given the lack of early material and limited sample of obsidian, no South Warners glass was found.

CHAPTER 6. RESULTS

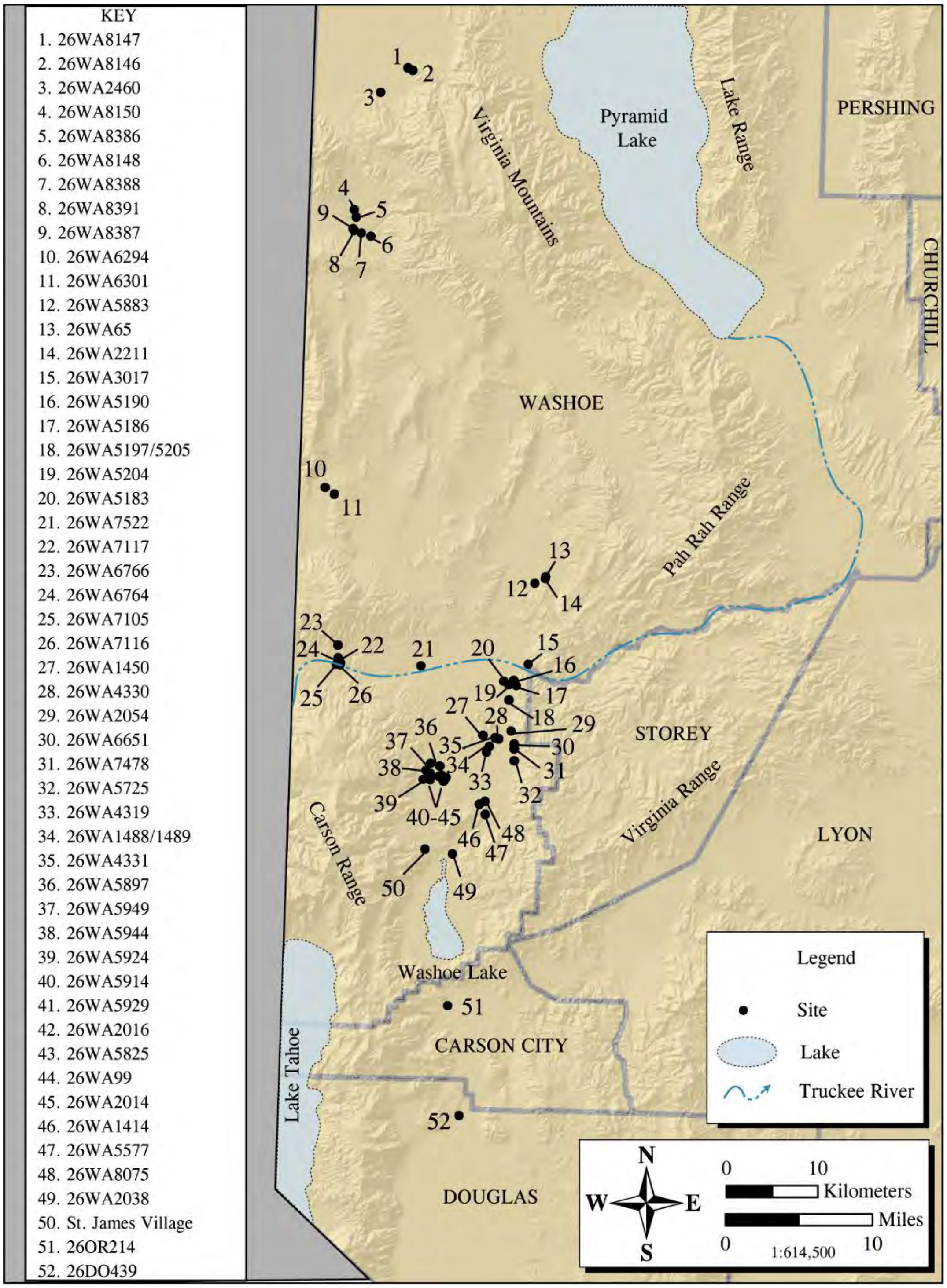
The following results derive from a total of 52 previously investigated sites in the Truckee Meadows region (Map 3). From these, a total of 904 obsidian pieces was sourced (Table 5), and 530 of them subjected to obsidian hydration.

The first collection (Zeier and Elston 1986) is from the Vista site (26WA3017) located on the eastern margin of the Truckee Meadows, at the confluence of Steamboat Creek and the Truckee River. Archaeological investigations revealed significant subsurface deposits, excavated between May 21 and June 22, 1984. A total of 50 10-x-10-m units was surface-collected, 13 trenches were excavated by backhoe, and five test pits were excavated by hand. Features included three historic features, six housepits, six oval-shaped depressions, 56 pit features, 15 rock features, four ground stone features, five soil features, and four bone features. Artifacts recovered included 126 projectile points (73 temporally diagnostic), 196 bifaces, eight bifacial scrapers, 82 small cores, 356 flake tools, 2,202 flakes, 52 hammer-choppers, 578 ground stone specimens, one stone disc, one pecked stone, two incised stones, 49 bone artifacts, 30 shell beads, one glass bead, and one stone bead. More than 40,000 faunal specimens and 1,459 shell fragments were also recovered. The report also notes that many bifaces from the Vista site could not be assigned to a particular trajectory with confidence, but the number of specimens is not clear from the report (Zeier and Elston 1986). A total of nine features at the Vista site was radiocarbon-dated, with five of the dates falling within the middle period, and four of the dates falling within the late period.

Delacorte (1997a) conducted obsidian sourcing on the Vista collection. A total of 43 selected pieces was sourced, resulting in 40 geochemically identified as Sutro Springs, one as Bodie Hills, one as Mt. Hicks, and one as Buffalo Hills (Unknown B). It is important to note that, while Sutro Springs obsidian appears dominate, Delacorte deliberately selected for it on the basis of visual criteria.

Obsidian hydration on the 40 Sutro Springs specimens resulted in micron readings that ranged from 1.7 to 4.0 microns, with the majority tightly clustered between 1.7 to 3.7 microns. Using projectile points to furnish a better sense of the age of these hydration values, 14 Rose Spring and two Elko series points were also measured for obsidian hydration. The 14 Rose Spring points made of Sutro Springs glass gave hydration readings of 1.9 to 3.2 microns, and a mean of 2.5 ± 0.4 microns. Hydration readings for two Elko series points of the same material returned higher (older) values of 3.8 and 4.1 microns, respectively. This, compared with the radiocarbon dates, suggests that Sutro Springs was used most intensively during the Late Archaic period (Delacorte 1997a).

The second set of data (Clay 1996) derives from the Eagle Valley Village site (26OR214, Area J) on the northwestern edge of Eagle Valley. The historic Raycraft Ranch was surveyed and ten cultural resources areas (areas A-J) were identified within the site (26OR214). Area J was described as a prehistoric lithic and grinding rock scatter with depth potential. Subsequent work consisted of four phases: 1) surface gridding, artifact collection, and mapping in 10-m^2 grids; 2) excavation of seven 1-x-1-m units; 3) backhoe trenching; and 4) documenting, excavating, and sampling 77 features.



Map 3. Sites with Obsidian Studies Analyzed in this Thesis

Cultural remains consist of 77 projectile points, 23 bifaces, four formed flake tools, 22 simple flaked tools, 13 battered cobbles, three cores, one quartz crystal, 2,022 flakes, 478 pieces of ground stone, two perforators, one awl, and 3,038 faunal remains. A total of 20 features was radiocarbon-dated, resulting in 17 middle and three late period features. A total of 22 obsidian flakes was selected from good feature contexts and submitted for sourcing; no obsidian hydration was conducted. Results indicated one piece of northeastern obsidian, five pieces of Truckee Meadows glass, and 13 specimens from Mono Basin sources.

Hutchins and Simons (2000) compiled obsidian samples from 27 sites (Clay 1990; Matranga 1992; Moore and Burke 1992; Hughes 1995; Origer 1995; Kautz 1996; Kautz and Christensen 1996; Simons and Hutchins 1996; Simons and Kautz 1996; Delacorte 1997a; Hutchins et al. 1997a, 1997b; Simons 1997a, 1997b; and Mires and Hutchins 1998) within and around the Truckee Meadows. One of these sites, 26WA3017, was discussed above and will not be retabulated here. This leaves 26 sites, with 359 obsidian XRF and hydration specimens. Hutchins and Simons' results show a high concentration of both Truckee Meadows and Mono Basin obsidian, especially Bodie Hills. Their data also show that Bodie Hills and Sutro Springs obsidian were in use between 2.0 to 4.9 microns.

In 2002, Stoner and Rusco excavated the Sunridge Site (26DO439), on private property in the northern Carson Valley. Four types of excavation were conducted at the site. These include the use of backhoe trenches in or near features, 1-x-1-m and 2-x- 2-m excavation units, auger probes, and mechanical striping. A total of nine backhoe trenches was dug. Excavation units were placed in all pit and house features and another 113 locations. A total of 361 features was identified at the site, including assorted pits, sediment stains, and deposits of fire-cracked rock. Cultural materials included 240 projectile points, 319 bifaces, seven scrapers, eight gravers, six drills, two knives, 13 retouched flakes, 74 utilized flakes, 22 cores, 335 pieces of ground stone, 28 ornaments/beads, six fish bones, approximately 225 pieces of freshwater mussel shell, and 871 seeds. A total of nine Sunridge features was radiocarbon dated. All fall in the late period, save one of middle period age. In all, 27 specimens were submitted for XRF analysis, including 17 flakes, three tools, and seven projectile points. Two pieces were sourced to the northeast, 12 to the Truckee Meadows and 13 to Mono Basin sources (Stoner and Rusco 2002).

Stoner et al. (2006) conducted excavations for the ReTRAC project (26WA7522) in Reno, Nevada, along the Union Pacific Railroad corridor established in 1868. The project extended from just west of the old Second Street underpass (now removed) east to Sutro Street through downtown Reno. Two prehistoric sites (26WA7838 and 26WA7522) were found within the terrace deposits. Site 26WA7838 was highly disturbed with mostly historic fill, and after 17 square meters were excavated, it was determined that further testing was unnecessary. Site 26WA7522 included 23 square meters of early excavation, which revealed 14 cultural features, including hearths, pits, a possible house floor, and human remains. Phase II investigations included the excavation of 80 square meters down to sterile deposits. This resulted in the identification of 23 pit, 15 rock, seven soil, five burial and two human remains, two historic, one ground stone,

one house pit, and one unknown feature and recovery of 30 projectile points, three preforms, three assayed pieces of raw material, 44 cores, 144 bifaces, eight choppers, seven scrapers, one knife, three drills, seven retouched flakes, 29 utilized flakes, 15 retouched and utilized flakes, 18,824 unmodified flakes, 139 pieces of ground stone, 18 pieces of modified bone, 25,316 vertebrate faunal specimens, 50 grams of freshwater shell, and 297 burned seeds. A total of 18 features was radiocarbon-dated, resulting in eight middle and five late period assays. Obsidian hydration was not conducted, but chemical source analysis was performed on 23 obsidian projectile points. It revealed that nine of the points are of northeastern obsidian sources, six made from Truckee Meadows glass, and seven manufactured from Mono Basin obsidian (Stoner et al. 2006).

In 2008, Giambastiani conducted data recovery at four sites (26WA8386, 26WA8387, 26WA8388, 26WA8391) in Dry Valley for the Intermountain Water Project. A total of 13 projectile points and 77 flakes was sent for obsidian sourcing. The results showed that 84 pieces are from northern sources, with the majority from Buffalo Hills, Bordwell Spring/Pinto Peak/Fox Mountain (BS/PP/FM), and South Warners. Two pieces of obsidian were sourced to Sutro Springs, three pieces to Mt. Hicks, and one piece to an unknown source. Given the site locations along or near Dry Valley Creek, it is to be expected that most of the obsidian would come from northern sources. Hydration data for 71 obsidian artifacts from the IWP sites show the presence of Buffalo Hills, BS/PP/FM, and South Warners glass throughout the sequence with use of South Warners peaking from 1.0 to 2.4 microns and from 5.0 to 6.9 microns, Buffalo Hills from 2.0 to 2.4 and 3.0 to 5.9 microns, and BS/PP/FM from 5.0 to 7.4 microns. Sutro Springs is represented by a

2.8 and a 10.1 micron reading. All three pieces of Mt. Hicks obsidian range from 9.1 to 10.2 microns (Giambastiani n.d.).

Young et al. (2009) gathered source-specific obsidian hydration readings from 44 projectile points, one biface, two flake tools, one core, and 176 flakes at sites in the Honey Lake Basin and Dry Valley (26WA8146, 26WA8147, 26WA8148, 26WA8150, 26WA2460). All showed a high reliance on northeastern obsidian sources. Buffalo Hills, BS/PP/FM, and South Warners glass comprise most of the obsidian in all time periods. Buffalo Hills material increases in the Middle Archaic, however, and use of South Warners glass in the subsequent Late Archaic interval. The Middle and Late Archaic also see the use of small amounts of Sutro Springs and Bodie Hills obsidian.

Table 5. Obsidian Sourcing for 52 Previously Recorded Sites

Geographic Area	Obsidian Sources	PROJECT SITES								TOTAL
		26WA 3017	26OR 214, Area J	Hutchins and Simons	26DO 439	26WA 7522	IWP	Young	14 Sites	
Northeastern	BS/PP/FM			12	2	6	27	85	3	**135**
	BH	1				2	26	88	6	**123**
	BM			1			1			**2**
	DHM					1				**1**
	EML		1	1			2	1		**5**
	GF/LIW/RS			1			2			**3**
	ML/GV						1	1		**2**
	MM			3			1			**4**
	PV			1						**1**
	SH			1						**1**
	SW			4			24	42	1	**71**
Truckee Meadows	CBC			37	2	1			14	**54**
	SS	40	5	108	10	6	2	2	29	**202**
Mono Basin	BO	1	10	78	12	4		3	21	**129**

Table 5 continued

Geographic Area	Obsidian Sources	PROJECT SITES								TOTAL
		26WA 3017	26OR 214, Area J	Hutchins and Simons	26DO 439	26WA 7522	IWP	Young	14 Sites	
	CD			2						**2**
	MH	1	3	52		2	3	1	2	**64**
	MO					1				**1**
	PGH		1	16						**17**
	TQ		1	1	1					**3**
Coast Ranges	MK			1						**1**
	NV			1						**1**
Sacramento Valley	TU			1				1		**2**
UNKNOWN	UNK		1	38			1		6	**46**
TOTAL		**43**	**22**	**359**	**27**	**23**	**90**	**224**	**82**	**870**

*BS/PP/FM = Bordwell Springs/Pinto Peak/Fox Mountain; BH = Buffalo Hills; BM = Buck Mountain; BO = Bodie Hills; CBC = C.B. Concrete; CD = Casa Diablo; DHM = Double H Mountains; EML = East Medicine Lake; MH = Mt. Hicks; ML/GV = Massacre Lake/Guano Valley; MK = Mt. Konocti; MM = Mt. Majuba; MO = Mono Glass; NV = Napa Valley; PGH = Pine Grove Hills; PV = Paradise Valley; SH = Sugar Hill; SS = Sutro Springs; SW = South Warners; TQ = Truman Queen; TU = Tuscan

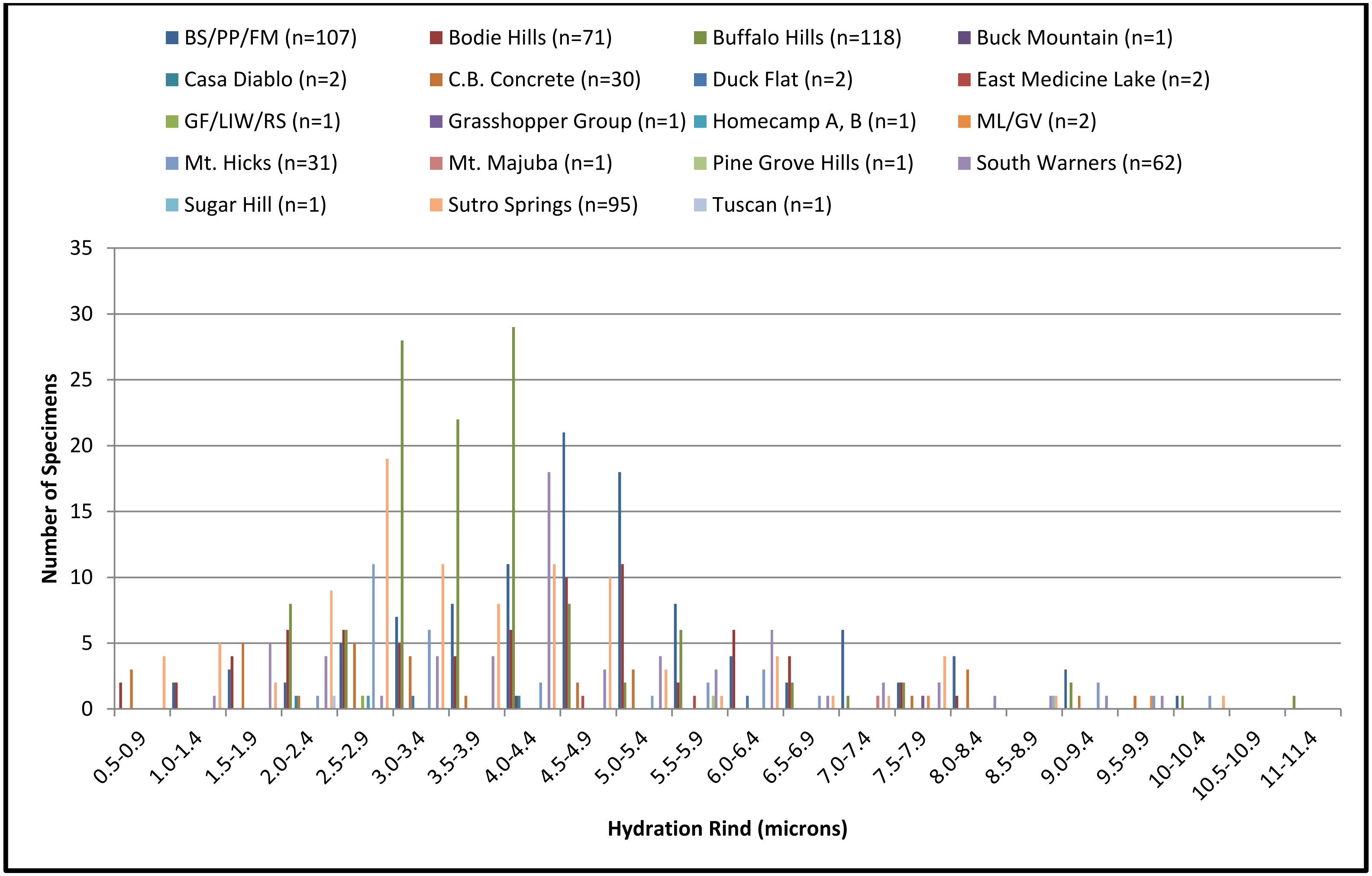


Figure 1. Obsidian Hydration for 50 Previously Recorded Sites

I then collected sourcing data from 14 other sites (26WA2054, 26WA5577, 26WA5725, 26WA6294, 26WA6301, 26WA6651, 26WA6764, 26WA6766, 26WA7105, 26WA7116, 26WA7117, 26WA7478, 26WA8075, and St. James Village) within and around the Truckee Meadows. This provided 82 additional source and 69 hydration specimens, 43 of which are attributed to Truckee Meadows sources and 21 to the Bodie Hills quarry.

Lastly, additional data were generated on the work at four sites (26WA3017, 26WA7522, 26OR214 Area J, 26DO439), by submitting 55 obsidian pieces for obsidian hydration/sourcing, five of which were previously analyzed to source (Table 6). These resulted in four pieces identified to northeastern sources, 24 pieces matching Truckee Meadows source types, 27 specimens attributable to southern source groups and one piece form the North Coast Ranges (Table 7).

Table 6. XRF and Hydration Results for Thesis Data

<table>
<tr><th>Site</th><th>C14</th><th>Feature</th><th>Type</th><th>XRF</th><th>Rim 1</th><th>Rim 2</th></tr>
<tr><td rowspan="2">26WA7522</td><td rowspan="2">1200 ± 70</td><td rowspan="2">52</td><td>DEB</td><td>Borax Lake</td><td>3.7 ± 0.1</td><td>NM</td></tr>
<tr><td>DEB</td><td>Mt. Hicks</td><td>5.5 ± 0.1</td><td>NM</td></tr>
<tr><td rowspan="13">26WA3017</td><td>210 ± 70 (48D)</td><td>48</td><td>DEB</td><td>Sutro Springs</td><td>3.9 ± 0.1</td><td>NM</td></tr>
<tr><td rowspan="9">210 ± 70</td><td rowspan="9">48D</td><td>DEB</td><td>Sutro Springs</td><td>4.5 ± 0.0</td><td>NM</td></tr>
<tr><td>DEB</td><td>Buffalo Hills</td><td>4.6 ± 0.1</td><td>NM</td></tr>
<tr><td>DEB</td><td>Buffalo Hills</td><td>3.9 ± 0.1</td><td>NM</td></tr>
<tr><td>DEB</td><td>Sutro Springs</td><td>4.5 ± 0.1</td><td>NM</td></tr>
<tr><td>DEB</td><td>Sutro Springs</td><td>3.9 ± 0.1</td><td>NM</td></tr>
<tr><td>DEB</td><td>Sutro Springs</td><td>5.0 ± 0.1</td><td>NM</td></tr>
<tr><td>DEB</td><td>Sutro Springs</td><td>5.9 ± 0.1</td><td>NM</td></tr>
<tr><td>DEB</td><td>Sutro Springs</td><td>4.2 ± 0.1</td><td>NM</td></tr>
<tr><td>1040 ± 100 (89B)</td><td>89</td><td>PPT</td><td>Bodie Hills</td><td>5.4 ± 0.1</td><td>NM</td></tr>
<tr><td rowspan="2">1360 ± 170</td><td rowspan="2">50</td><td>DEB</td><td>Sutro Springs</td><td>3.7 ± 0.1</td><td>NM</td></tr>
<tr><td>DEB</td><td>Sutro Springs</td><td>3.7 ± 0.1</td><td>NM</td></tr>
</table>

Table 6 continued

Site	C14	Feature	Type	XRF	Rim 1	Rim 2
26OR214	860 ± 70	1A	DEB	Mono Glass	3.0 ± 0.1	NM
	880 ± 60	26	DEB	Sutro Springs	3.7 ± 0.1	NM
			DEB	Sutro Springs	3.7 ± 0.1	NM
			DEB	Bodie Hills	NA	NM
			DEB	Sutro Springs	4.5 ± 0.1	NM
			DEB	Mt. Hicks	5.9 ± 0.1	NM
			DEB	Bodie Hills	6.2 ± 0.0	NM
			DEB	Mt. Hicks	5.9 ± 0.1	NM
			DEB	Bodie Hills	5.3 ± 0.1	NM
			DEB	Bodie Hills	5.9 ± 0.1	NM
	890 ± 80	3	DEB	BS/PP/FM	4.4 ± 0.1	NM
			DEB	Mono Glass	4.1 ± 0.1	NM
			DEB	Bodie Hills	6.8 ± 0.1	NM
			DEB	Sutro Springs	2.6 ± 0.1	NM
			DEB	Bodie Hills	1.8 ± 0.1	9.8 ± 0.1
	890 ± 90	1	DEB	Sutro Springs	NA	NM
			DEB	Sutro Springs	NA	NM
			DEB	Bodie Hills	3.2 ± 0.1	NM
			DEB	Mt. Hicks	6.1 ± 0.1	NM
			PPT	Bodie Hills	2.9 ± 0.1	5.9 ± 0.1
			DEB	Mt. Hicks	3.1 ± 0.1	NM
			DEB	Sutro Springs	3.0 ± 0.1	NM
			DEB	Mt. Hicks	6.0 ± 0.1	NM
	120 ± 80	6	BIF	Bodie Hills	3.8 ± 0.1	NM
			PPT	Mono Glass	2.3 ± 0.1	NM
			PPT	Buffalo Hills	1.9 ± 0.1	NM
			BIF	Sutro Springs	3.7 ± 0.1	NM
			EMP	Mono Glass	3.0 ± 0.1	NM
			DEB	Bodie Hills	5.2 ± 0.1	NM
			DEB	Bodie Hills	1.8 ± 0.1	NM
			DEB	Sutro Springs	3.4 ± 0.1	NM
			DEB	Sutro Springs	4.9 ± 0.1	NM
	1200 ± 140 (8E)	8	DEB	Sutro Springs	3.5 ± 0.1	NM
			DEB	Sutro Springs	4.0 ± 0.1	NM
			DEB	Bodie Hills	3.2 ± 0.1	NM
			DEB	Mt. Hicks	4.2 ± 0.1	NM
			BIF	Sutro Springs	3.2 ± 0.1	NM
			EMP	Mt. Hicks	7.7 ± 0.1	NM
			DEB	Bodie Hills	6.1 ± 0.1	NM
			DEB	Sutro Springs	4.5 ± 0.1	NM
			DEB	Sutro Springs	3.8 ± 0.1	NM

Table 7. Obsidian Source Results for Thesis Data

Geographic Area	Obsidian Sources	Project Sites			TOTAL
		26WA7522	**26WA3017**	**26OR214**	
Northeastern	BS/PP/FM	-	-	1	**1**
	Buffalo Hills	-	2	1	**3**
Truckee Meadows	Sutro Springs	-	9	15	**24**
Mono Basin	Bodie Hills	-	1	13	**14**
	Mono Glass	-	-	4	**4**
	Mt. Hicks	1	-	7	**8**
North Coast Range	Borax Lake	1	-	-	**1**
TOTAL		**2**	**12**	**41**	**55**

CHAPTER 7. DIRECT IMPLICATIONS OF THE RESULTS

The goal of this thesis was to look in-depth at two major issues. The first involved a study of Truckee Meadows obsidian hydration involving: (1) an attempt to generate radiocarbon-hydration pairs for Sutro Springs obsidian using independently dated feature contexts; and (2) an assessment of existing hydration rates for Sutro Springs and Bodie Hills obsidians. This chapter reviews the results and implications of the analytical results in order to address questions regarding prehistoric settlement systems in the Truckee Meadows area. The second was an assessment of Delacorte's (1997a) regional settlement model, which implies that the Truckee Meadows was part of more extended settlement systems earlier in time and a localized system later in time.

RADIOCARBON-HYDRATION PAIRS FOR SUTRO SPRINGS OBSIDIAN

Delacorte (1997a) assigned age estimates to artifacts of Sutro Springs obsidian based on radiocarbon-hydration pairings generated from sites in the Pah Rah Range. Hutchins and Simons (2000) challenged Delacorte's (1997a) findings, suggesting that the data he collected demonstrated extreme variability in hydration rind formation due to variables such as moisture, ambient temperature, depositional context, and subsurface movement. Hutchins and Simons argued that hydration analysis with Sutro Springs obsidian is unreliable for determining artifact age in the Truckee Meadows.

I compiled obsidian sourcing and hydration data from total of 27 features at several sites along the Sierran Front in order to assess the efficacy of hydration analysis with Sutro Springs obsidian. Table 8 organizes these data from oldest to youngest radiocarbon date. A cursory look indicates that some artifact samples display a wide range of hydration rim measurements. However, different obsidian sources hydrate at variable rates, such that samples are not directly comparable (for example, 26OR214, Feature 8).

Table 9 presents paired radiocarbon-hydration data for Sutro Springs artifacts organized as before. Each hydration reading represents an individual specimen from each feature. Hydration measurements were averaged when multiple readings were available to provide a workable pairing.

Twelve features have radiocarbon dates that place them in the Middle Component (1350-700 B.P.). These features combined have 43 hydration readings that range from 1.7-5.2 microns, with mean readings per feature sample ranging from 2.0 to 5.2 microns. For Middle Component features with multiple obsidian specimen readings, the mean hydration range narrows to 2.8-3.9 microns. Only four features date to the Late Component (700-120 B.P.); together these contain 20 rim readings that range from 1.9-5.9 microns and have feature-specific hydration means between 2.5 and 4.0 microns.

Table 8. Radiocarbon-Hydration Data from 27 Sites

Site	Feature	C14	Source	Hydration
26WA2460	Locus 1	3530 ± 40	South Warners	4.3
			Buffalo Hills	3.1, 3.3, 3.6, 4.2, 4.2, 4.2, 4.2, 4.3, 4.4
	3	3260 ± 40	South Warners	4.4, 4.4
			BS/PP/FM	4.4, 4.4, 6.0

Table 8 continued

Site	Feature	C14	Source	Hydration
			Buffalo Hills	3.2, 3.2, 3.5, 3.6, 4.8
	10	3170 ± 40	South Warners	4.0, 4.0
			BS/PP/FM	4.1, 4.6, 4.7, 4.7, 4.8, 4.8, 4.9, 5.4, 5.6
			Buffalo Hills	3.4, 3.5, 3.5, 4.0
	4	2910 ± 40	South Warners	4.7, 4.7
			BS/PP/FM	4.4
			Buffalo Hills	3.0, 3.6, 3.6, 3.7, 3.9, 4.4, 4.8
	9	2700 ± 40	South Warners	4.0, 4.0, 4.0, 4.9
			Buffalo Hills	2.2, 2.6, 3.1, 3.2, 3.5, 3.6, 4.3, 4.4, 7.4
			Bordwell Spring	4.3, 4.3
26WA3017	50	1360 ± 170	Sutro Springs	3.3, 3.7, 3.7
	26	1360 ± 110	Sutro Springs	3.0, 3.0, 3.1, 3.1, 3.2
	48A,C	1320 ± 320	Sutro Springs	2.4, 2.4, 2.5, 2.7, 2.9, 3.0, 3.0, 3.0, 3.4, 3.4, 3.5, 3.5, 4.0
26WA7522	52	1200 ± 70	Borax Lake	3.7
			Mt. Hicks	5.5
26OR214	8	1200 ± 140 (8E)	Sutro Springs	3.2, 3.5, 3.8, 4.0, 4.5
			Bodie Hills	3.2, 6.1
			Mt. Hicks	4.2, 7.7
26WA3017	89B	1040 ± 100	Sutro Springs	1.7, 1.9, 2.5, 3.3
	89	1040 ± 100 (89B)	Bodie Hills	5.4
26WA8148	9	940 ± 40 / 910 ± 40	BS/PP/FM	3.0, 3.8, 4.7, 4.7, 4.7, 4.7, 5.0, 5.0, 5.0, 5.3, 5.7, 6.8
			Buffalo Hills	2.0, 2.0, 2.2, 2.6, 3.1, 3.1, 3.3, 4.1, 4.3, 4.3, 4.4, 4.4, 4.5
			South Warners	1.9, 2.6, 4.2, 4.3, 4.3, 4.4, 5.0, 6.4
			GF/LIW	4.3
			Sutro Springs	5.2
26WA3017	38	930 ± 150	Sutro Springs	2.0
26OR214	1	890 ± 90	Sutro Springs	3.0
			Bodie Hills	2.9, 3.2
			Mt. Hicks	3.1, 6.0, 6.1
	3	890 ± 80	BS/PP/FM	4.4
			Sutro Springs	2.6
			Bodie Hills	1.8, 6.8
			Mono Glass	4.1
	26	880 ± 60	Sutro Springs	3.7, 3.7, 4.5
			Bodie Hills	5.3, 5.9, 6.2
			Mt. Hicks	5.9, 5.9
	1A	860 ± 70	Mono Glass	3.0
26WA3017	4	830 ± 6	Sutro Springs	2.6, 2.7, 2.7, 2.9, 3.0
	48F	770 ± 70	Sutro Springs	2.9
	3	590 ± 70	Sutro Springs	2.5, 2.5, 2.5, 2.5, 2.6
26WA8146	3	590 ± 40	BS/PP/FM	1.8, 2.4, 2.7, 4.4
			Buffalo Hills	1.5, 2.9, 3.1

Table 8 continued

Site	Feature	C14	Source	Hydration
			Tuscan	2.0
26WA8148	16	600 ± 60	BS/PP/FM	4.1, 4.7, 4.8, 5.9, 7.5
26WA8150	1	630 ± 70	BS/PP/FM	3.4
			Buffalo Hills	3.3, 3.4, 4.4
			South Warners	2.4, 3.4, 6.0, 9.1
			Bodie Hills	4.9
			Mt. Hicks	5.6
26WA3017	48D	210 ± 70	Buffalo Hills	3.9, 4.6
			Sutro Springs	1.9, 2.2, 2.4, 2.5, 2.5, 3.9, 4.2, 4.5, 4.5, 5.0, 5.9
	48	210 ± 70 (48D)	Sutro Springs	3.9
26OR214	6	120 ± 80	Buffalo Hills	1.9
			Sutro Springs	3.4, 3.7, 4.9
			Bodie Hills	1.8, 3.8, 5.2
			Mono Glass	2.3, 3.0

To evaluate the effects of mixing, hydration rim means from features in both components were compared using Mann-Whitney test. The resulting p-value of 0.8684 indicates that Middle and Late Component rim values are not appreciably different.

Table 9. Sutro Springs Radiocarbon-Hydration Pairings

Component	Site	Feature	C14	Hydration	Mean	Standard Deviation	Coefficient of Variation
Middle	26WA3017	50	1360 ± 170	3.3, 3.7, 3.7	3.6	0.23	0.06
		26	1360 ± 110	3.0, 3.0, 3.1, 3.1, 3.2	3.1	0.08	0.03
		48A,C	1320 ± 320	2.4, 2.4, 2.5, 2.7, 2.9, 3.0, 3.0, 3.0, 3.4, 3.4, 3.5, 3.5, 4.0	3.1	0.49	0.16
	26OR214	8	1200 ± 140 (8E)	3.2, 3.5, 3.8, 4.0, 4.5	3.8	0.49	0.13
	26WA3017	89B	1040 ± 100	1.7, 1.9, 2.5, 3.3	2.4	0.72	0.30

Table 9 continued

Component	Site	Feature	C14	Hydration	Mean	Standard Deviation	Coefficient of Variation
	26WA8146	9	940 ± 40 / 910 ± 40	5.2	5.2	N/A	N/A
	26WA3017	38	930 ± 150	2.0	2.0	N/A	N/A
	26OR214	1	890 ± 90	3.0	3.0	N/A	N/A
		3	890 ± 80	2.6	2.6	N/A	N/A
		26	880 ± 60	3.7, 3.7, 4.5	4.0	0.46	0.12
	26WA3017	4	830 ± 6	2.6, 2.7, 2.7, 2.9, 3.0	2.8	0.16	0.06
		48F	770 ± 70	2.9	2.9	N/A	N/A
Late		3	590 ± 70	2.5, 2.5, 2.5, 2.5, 2.6	2.5	0.04	0.02
		48D	210 ± 70	1.9, 2.2, 2.4, 2.5, 2.5, 3.9, 4.2, 4.5, 4.5, 5.0, 5.9	3.6	1.34	0.37
		48	210 ± 70 (48D)	3.9	3.9	N/A	N/A
	26OR214	6	120 ± 80	3.4, 3.7, 4.9	4.0	0.79	0.20

Chauvenet's Criterion was used to remove outliers from the Sutro Springs radiocarbon-hydration pairings that contained three or more hydration samples. Revised calculations of mean and standard deviation are presented in Table 10. With statistical outliers removed, the p-value for the Mann-Whitney test is 0.2198. Again, results indicate that the hydration rims in the Middle Component sample are not significantly thicker than hydration rims in the Late Component sample. A coefficient of determination was also obtained by running a correlation, due to the smaller number of observations. The

Pearson correlation equals 0.096 with a p-value of 0.521 still suggesting a lack of correlation.

Table 10. Sutro Springs Radiocarbon-Hydration Pairings with Three or More Hydration Samples (Outliers Removed)

Site	Feature	C14	Hydration	Mean	Standard Deviation	Coefficient of Variation
26WA3017	50	1360 ± 170	3.3, 3.7, 3.7	3.6	0.23	0.06
	26	1360 ± 110	3.0, 3.0, 3.1, 3.1, 3.2	3.1	0.08	0.03
	48A,C	1320 ± 320	2.4, 2.4, 2.5, 2.7, 2.9, 3.0, 3.0, 3.0, 3.4, 3.4, 3.5, 3.5, 4.0	3.1	0.49	0.16
26OR214	8	1200 ± 140 (8E)	3.2, 3.5, 3.8, 4.0	3.6	0.35	0.10
26WA3017	89B	1040 ± 100	1.7, 1.9, 2.5	2.0	0.42	0.21
26WA3017	4	830 ± 6	2.6, 2.7, 2.7, 2.9, 3.0	2.8	0.16	0.06
	3	590 ± 70	2.5, 2.5, 2.5, 2.5, 2.6	2.5	0.04	0.02
	48D	210 ± 70	1.9, 2.2, 2.4, 2.5, 2.5, 3.9, 4.2, 4.5, 4.5	3.2	1.07	0.33

Finally, a linear regression (Figure 2) was used to find the best fitted straight line for the micron values for Sutro Springs obsidian. The plotted micron values represent the errors of prediction from the regression line. The points the lie far from the line can be seen as outliers and are poorly fitted to the regression line. It should also be noted that a point that lies far from the other data in the horizontal direction is considered an influential observation that may impact the slope of the regression line. In this figure, the micron mean value of 3.2 for the radiocarbon date 210 ± 70 is likely skewing the regression line.

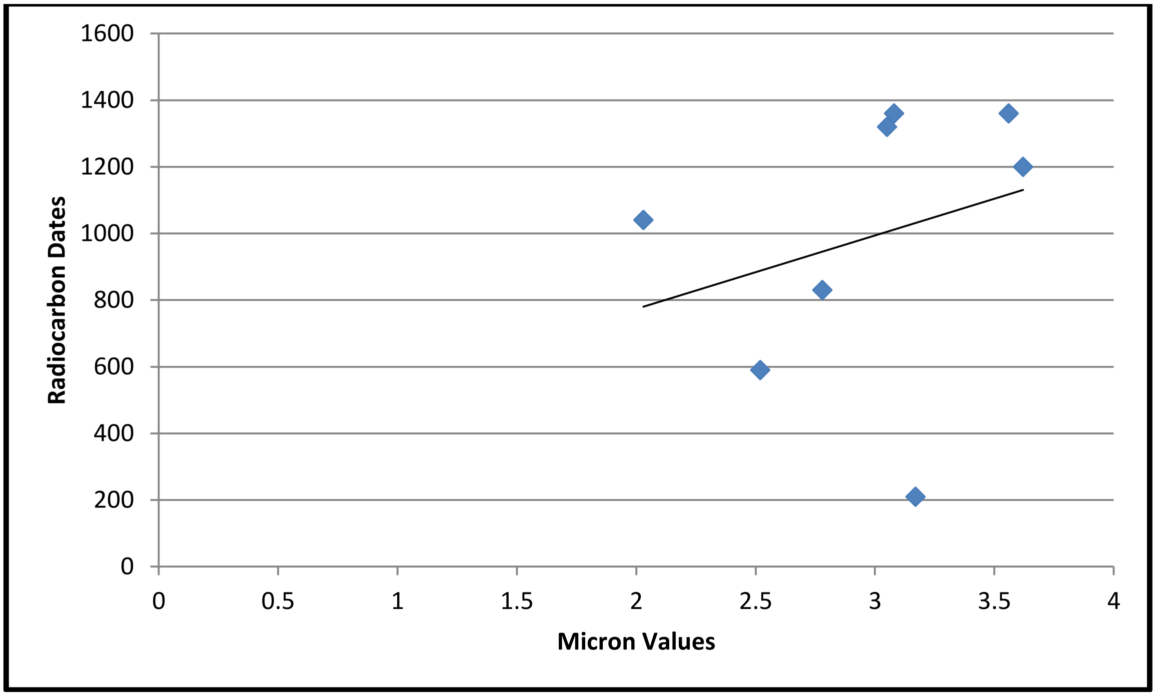


Figure 2. Linear Regression for Sutro Springs Obsidian

Thus far, all signs point to mixing of features with Sutro Springs obsidian. Hydration samples from Middle Component sites derive from three times as many features as the Late Component and reflect more than two times as many values (43 specimens compared to the Late Component that only had 20). Since all statistical tests used compare micron values between the Middle and Late Components, differences in sample size could be affecting the results.

Using Chauvenet's criterion failed to remove enough of the apparent mixing to result in any positive statistical results. However, many of the features do not appear to be mixed, and we know from both Delacorte's (1997a) and Griffin's (2013) data that there are good non-mixed features.

As a final test, features that were obviously mixed were removed from the data. By employing the coefficient of variation in Table 11; those above 0.10 or 10% were removed (Features 48A, C, 48D, and 89B).

A new linear regression (Figure 3) was created with the obvious mixed features removed. These plotted micron values fit well with the regression line suggesting that the points are well fitted. Once the obviously mixed features were removed, a significant correlation (0.766 with a p-value of 0.000) between hydration and radiocarbon date was observed.

RADIOCARBON-HYDRATION PAIRS FOR BODIE HILLS OBSIDIAN

Table 11 presents the radiocarbon-hydration data for Bodie Hills obsidian. As before, each hydration reading represents an individual specimen from a given feature. Five features from the Middle Component have a combined hydration range of 1.8-6.8 microns and feature-specific hydration means of 3.1 to 5.8 microns. Two Late Component features have only a few readings ranging from 1.8-5.2 microns, with feature-specific means of 3.6 and 4.9 microns.

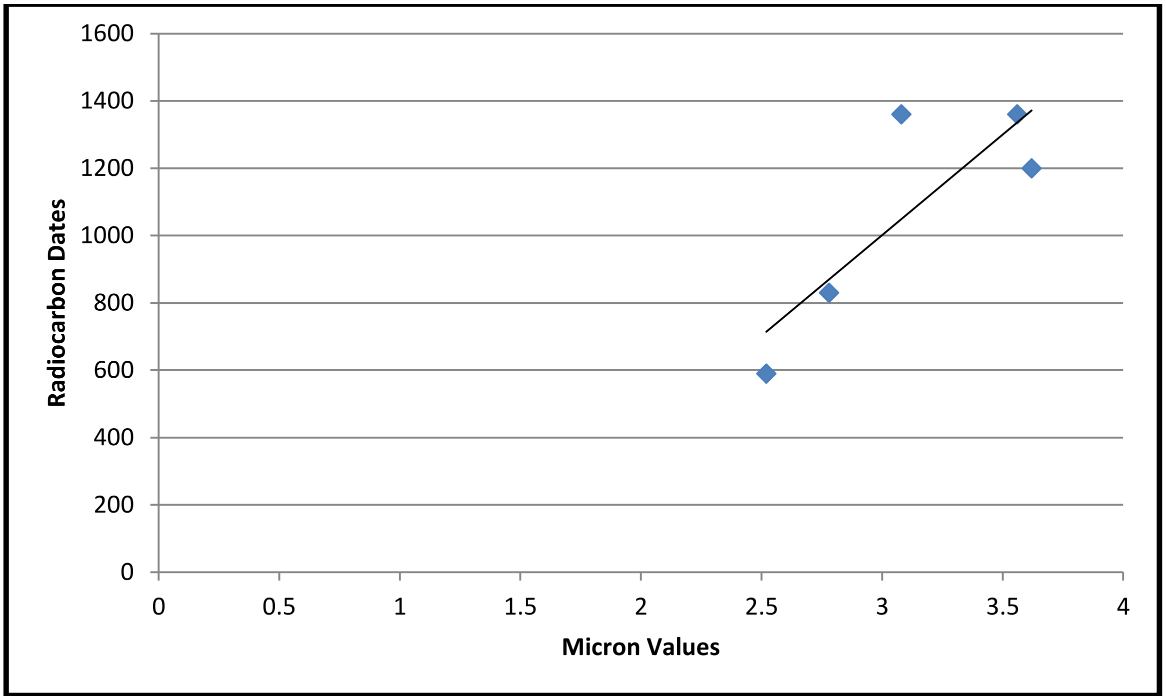


Figure 3. Linear Regression for Sutro Springs Obsidian with Outliers Removed

Table 11. Bodie Hills Radiocarbon-Hydration Data

Component	Site	Feature	C14	Hydration	Mean	Standard Deviation	Coefficient of Variation
Middle	26OR214	8	1200 ± 140 (8E)	3.2, 6.1	4.7	2.05	0.44
	26WA3017	89	1040 ± 100 (89B)	5.4	5.4	N/A	N/A
	26OR214	1	890 ± 90	2.9, 3.2	3.1	0.21	0.07
		3	890 ± 80	1.8, 6.8	4.3	3.54	0.82
		26	880 ± 60	5.3, 5.9, 6.2	5.8	0.46	0.08
Late	26WA8150	1	630 ± 70	4.9	4.9	N/A	N/A
		6	120 ± 80	1.8, 3.8, 5.2	3.6	1.71	0.48

A linear regression line (Figure 4) was created for the micron values for Bodie Hills obsidian. The 3.6 micron value plotted for the 120 B.P. radiocarbon date can be seen as an extreme outlier. The remaining micron values do not fit the regression line well. A correlation to determine the coefficient of determination resulted in 0.260 with a p-value of 0.370, indicating that hydration rim values do not significantly correlate with radiocarbon age. Due to the limited number of Late Component samples, Chauvenet's Criterion could not be successfully used to exclude outliers and a Mann-Whitney or Chi-Square test could not be calculated.

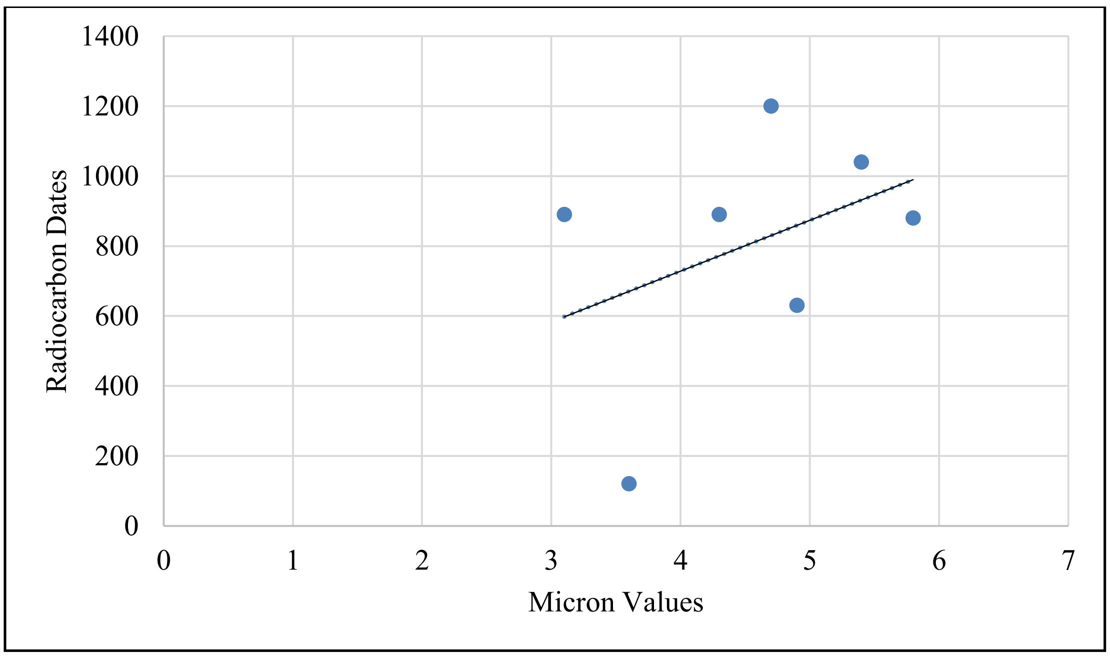


Figure 4. Linear Regression for Bodie Hills Obsidian

Although results suggest mixing of the Bodie Hills radiocarbon-hydration data, it should be emphasized again that the data only consists of 14 micron readings, or 11 when outliers are removed. This is a very small sample and a larger number of observations would give us more insight into Bodie Hills obsidian usage for the Truckee Meadows area.

ASSESSMENT OF EXISTING HYDRATION RATES FOR SUTRO SPRINGS AND BODIE HILLS OBSIDIAN

Given that hydration rates for Sutro Springs and Bodie Hills obsidians differ, comparison of the temporal spans of the two sources in the Truckee Meadows hinges on adjusting hydration rim values to age estimates using established hydration rates: Griffin's (2013) hydration rate for Sutro Springs and both Rosenthal and Meyer's (2011) Model B rate and traditional Casa-Diablo rate (Hall and Jackson 1989) for Bodie Hills. Here, I use the radiocarbon-hydration pairings to evaluate the three rates.

Using the new calculated mean hydration rims from Table 12 with outliers removed, I calculated dates from the non-mixed features using Griffin's (2013) hydration rate for Sutro Springs. Age estimates for Sutro Springs obsidian (Table 12) overestimate the age implied by radiocarbon dates by anywhere from 208 to 883 years. Some of these differences are surely attributable to variation in hydration rate influenced by differences in temperature by elevation. Sites examined by Griffin (2013) range in elevation from 4,500 ft. to 5,500 ft., whereas sites analyzed in this thesis range from approximately 3,750 ft. to 4,800 ft. Although close in elevation, obsidian exposed to relatively higher mean annual temperatures at lower elevations should hydrate faster and therefore produce older dates using Griffin's rate.

Table 12. Sutro Springs Hydration Age Estimates Using Griffin's 2013 Rate

Site	Feature	C14	Mean	Griffin's Rate $182.72071\mu^{1.90}$
26WA3017	50	1360 ± 170	3.6	2083
	26	1360 ± 110	3.1	1568
	48A,C	1320 ± 320	3.1	1568
26OR214	8	1200 ± 140 (8E)	3.6	2083
26WA3017	89B	1040 ± 100	2.0	681
26WA3017	4	830 ± 6	2.8	1292
	3	590 ± 70	2.5	1042
	48D	210 ± 70	3.2	1665

Since we know that the Bodie Hills sample is mixed, I used the individual hydration rims from Table 13 to calculate age estimates using Rosenthal and Meyers (2011) and Casa Diablo (Hall and Jackson 1989) hydration rates (Table 13). Both of the rates overestimate age by thousands of years, save Feature 1 at 26OR214 where the estimates are only 138 and 382 (Rosenthal and Meyer 2011) and 16 and 194 (Hall and Jackson 1989) years too old. Three of the rate calculations actually underestimate the accompanying radiocarbon dates. Rosenthal and Meyer's (2011) sites ranged in elevation from 0 ft. to 2,198 ft., or significantly lower than the sites analyzed in this thesis, yielding appropriately greater age estimates sans any adjustment for hydration temperature (EHT).

Overall, Griffin's (2013) rate works the best when used to calculate age estimates for the non-mixed Sutro Springs features. While Hall and Jackson's (1989) rate is closer in age estimates than Rosenthal and Meyer's (2011) rate for Bodie Hills obsidian, they both still grossly overestimate many of the samples. With the apparent mixing of Bodie Hills features, it is difficult to test the validity of these two rates on the samples available.

Table 13. Bodie Hills Hydration Age Estimates Using Rosenthal and Meyer's Model B Rate and Hall and Jackson's Casa Diablo Rate

Site	Feature	C14	Mean	Rosenthal and Meyer's Model B Rate $103.13\mu^{2.16}$	Hall and Jackson's Casa Diablo Rate $129.656\mu^{1.826}$
26OR214	8	1200 ± 140 (8E)	3.2	1272	1084
			6.1	5125	3522
26WA3017	89	1040 ± 100 (89B)	5.4	3938	2819
26OR214	1	890 ± 90	2.9	1028	906
			3.2	1272	1084
	3	890 ± 80	1.8	367	379
			6.8	6480	4294
	26	880 ± 60	5.3	3782	2724
			5.9	4768	3314
			6.2	5308	3628
26WA8150	1	630 ± 70	4.9	3193	2360
	6	120 ± 80	1.8	367	379
			3.8	1843	1484
			5.2	3630	2631

THE EFFECTIVENESS OF OBSIDIAN HYDRATION ANALYSIS IN THE TRUCKEE MEADOWS

Apart from the feature-based samples discussed previously, 14 diagnostic projectile points from the Truckee Meadows have also been identified as Bodie Hills or Sutro Springs obsidian and have associated hydration measurements (Table 14). These can serve as an independent assessment of the Sutro Springs and Bodie Hills hydration rates.

The two hydration readings for Desert Series points of Sutro Springs obsidian (4.0 and 4.8µ) produce age estimates that are too old (2545 and 3598 B.P.), reflecting likely reworked pieces. The range for Rosegate points (2.4 to 5.2), suggests a similarly temporally mixed collection.

Table 14. Hydration Measurements for Bodie Hills and Sutro Springs Projectile Points

Obsidian Source	Projectile Point Type	Hydration	Mean
Sutro Springs	Desert Series	4.0, 4.8	4.4
	Rosegate Series	2.4, 2.6, 2.6, 3.0, 4.1, 5.2	3.3
Bodie Hills	Desert Series	2.4, 2.5	2.4
	Rosegate Series	2.1, 2.1, 4.9, 5.2	3.5

Using all the data (Table 15), Griffin's (2013) rate overestimates the inferred age of the points by 465 years or 35.7%. Using Chauvenet's Criterion to remove outlier values 4.1 and 5.2 and recalculating the mean age for Rosegate points results in an age estimate of 1164 B.P. squarely within the inferred age range.

Table 15. Hydration Rate Calculations for Projectile Points

Obsidian Source	Projectile Point Type	Inferred Age Range	Hydration Mean	Griffin's Rate $182.72071\mu^{1.90}$	Rosenthal and Meyer's Model B Rate $103.13\mu^{2.16}$	Hall and Jackson's Casa Diablo Rate $129.656\mu^{1.826}$
Sutro Springs	Rosegate Series	1300-600 B.P.	3.3	1765	N/A	N/A
Bodie Hills	Desert Series	650-150 B.P.	2.4	N/A	683	665
	Rosegate Series	1300-600 B.P.	3.5	N/A	1543	1277

Rosenthal and Meyer's (2011) rate overestimates the Desert series point by 33 years and the Rosegate series point by 243 years. The traditional Hall and Jackson (1989) rate overestimates the Desert series point by 15 years and accurately estimates the age for the Rosegate series point.

Overall, statistical analysis of radiocarbon-hydration pairings for all data collected for Sutro Springs and Bodie Hills obsidian failed to temporally distinguish Middle from Late Component contexts. However, when obviously mixed features with Sutro Springs samples were excluded, the remaining features show a significant correlation between hydration and radiocarbon values. In addition, analysis of Sutro Springs (Griffin 2013) and Bodie Hills (Rosenthal and Meyer 2011; Hall and Jackson 1989) hydration rates resulted in overestimation of all accompanying radiocarbon dates. When the same hydration rates were used to estimate projectile point ages, however, the results are appreciably better, dating most of the point series to the right time-frames.

Spatial and temporal variations in temperature that influence hydration are difficult to evaluate. Variations also exist in sample chemical composition, and samples from different obsidian sources hydrate at different rates. Artifact reuse at sites can also lead to erroneous dates. It is interesting to note that similar issues are less apparent for the projectile points. Whether the projectile points have somehow better measurements than the feature flakes is unclear, but given the prevalence of mixed deposits, the problem probably arises from the sample context, not the hydration process (cf. Hutchins and Simons 2000).

ASSESSMENT OF DELACORTE'S MODEL

Delacorte's (1997a) regional settlement model implies that the Truckee Meadows was part of more extended settlement systems in early and more localized system in later times. This assessment looks at the spatial and temporal implications of the model from three different aspects: (1) differences in obsidian hydration profiles; (2) variability in obsidian source profiles for diagnostic projectile points; and (3) variability in obsidian source profiles north and south of the Truckee River.

BODIE HILLS VERSUS SUTRO SPRINGS HYDRATION

Generally speaking, smaller micron values indicate younger ages and larger values greater age. The wide range of hydration readings (Figure 5) for Bodie Hills (0.8 to 8.4) and Sutro Springs (0.9-10.1) obsidian indicate long histories of use for both material. Bodie Hills peaks between 4.5 and 5.4 microns, and Sutro Springs peaks between 2.5 and 2.9 microns. This implies an earlier peak in the use of Bodie Hills than Sutro Springs obsidian. If Hall and Jackson's (1989) hydration rate is employed, use of Bodie Hills peaked roughly between 1975 and 2750 B.P. Similarly, using Griffin's (2013) hydration rate, use of Sutro Springs peaked sometime after 1050 B.P. None of these dates can, of course, be entirely believed given the previously demonstrated limitations of existing hydration rates. Still, the raw micron values alone suggest that major use of Sutro Springs material came after that of Bodie Hills in time.

Comparing these results to the hydration rind measurements from my thesis data (Figure 6), some similar patterns emerge. Although the sample is smaller, both Bodie Hills (1.8-6.8) and Sutro Springs (2.6-5.9) appear to have been used over long periods of time, judging by their hydration ranges. Sutro Springs peaks between 3.5 and 3.9 microns, while Bodie Hills shows a less prominent pattern, with a minor peak between 5.0 and 5.4 microns.

Finally, when the data are combined (Figure 7), Bodie Hills peaks between 4.5 and 5.4 microns, and Sutro Springs peaks between 2.5 and 3.9 microns. Hydration profiles for the two obsidians appear quite distant; there are almost no Sutro Springs readings above 4.9 microns and, conversely, few Bodie Hills readings below 1.5 microns. This suggests that Sutro Springs obsidian had limited use earlier in time. The opposite appears true for Bodie Hills obsidian with a peak earlier in time and limited utilization later in time. This matches Delacorte's (1997a) model suggesting that settlement systems within the Truckee Meadows became more localized later in time with a major shift toward Sutro Springs obsidian use.

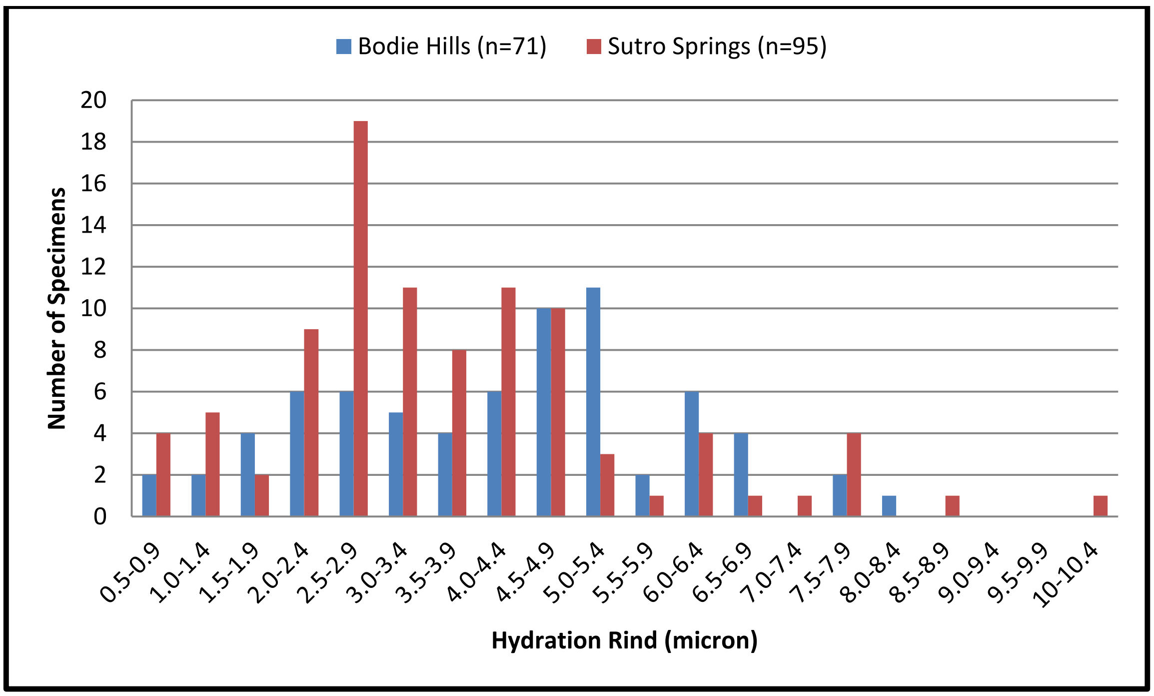


Figure 5. Hydration Results for Existing Data

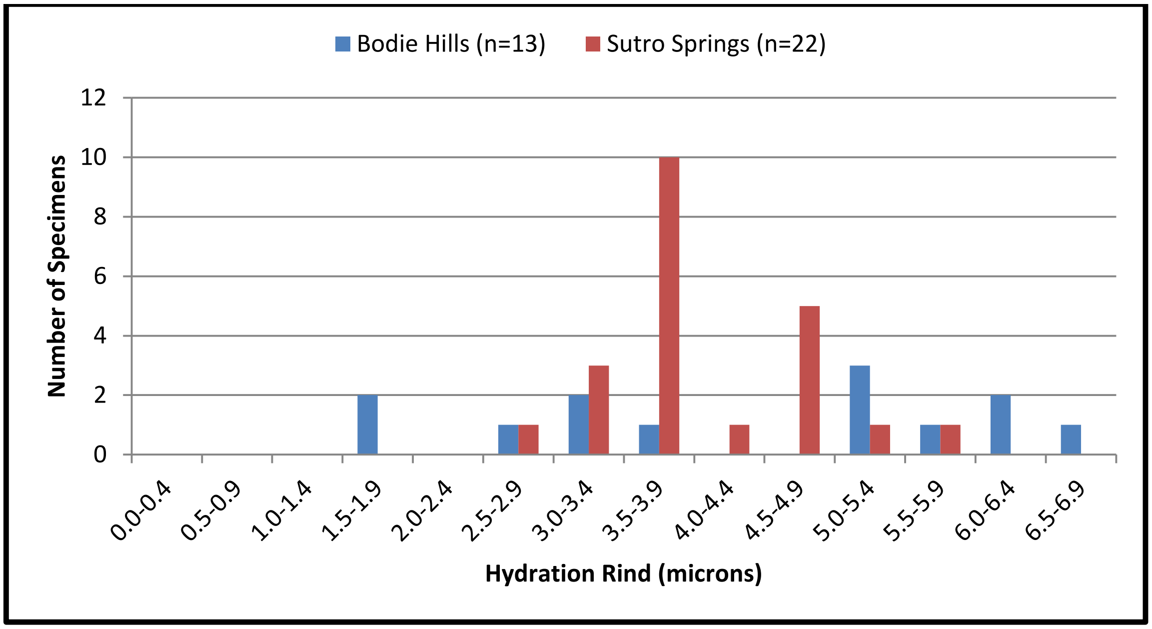


Figure 6. Hydration Results for Thesis Data

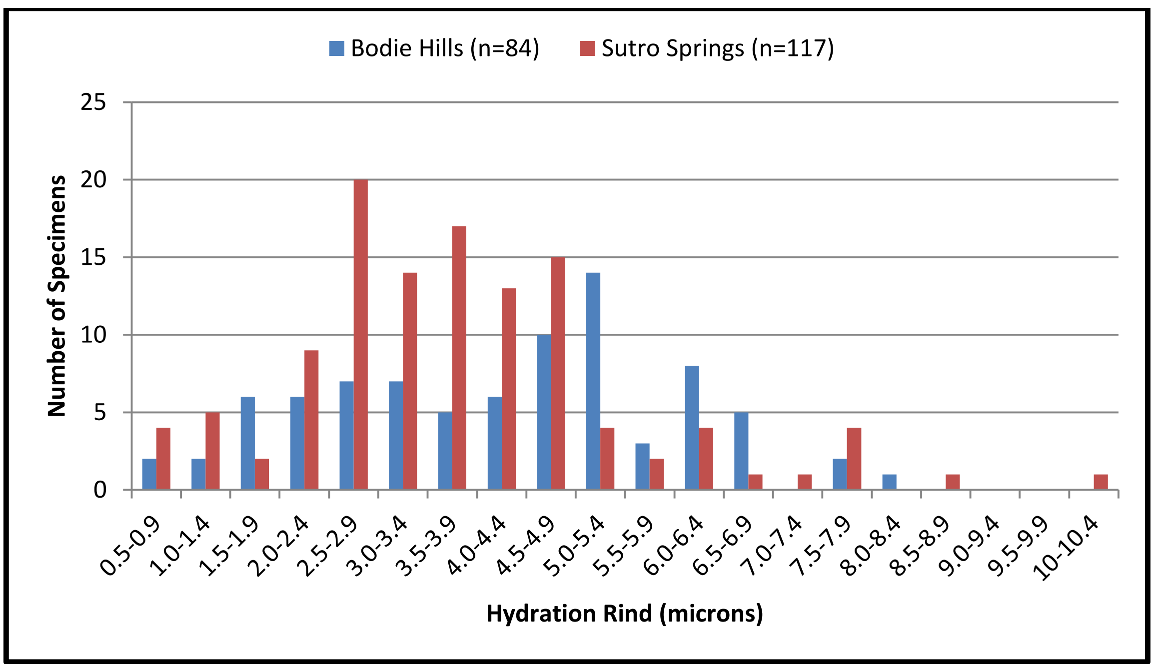


Figure 7. Hydration Results for All Data

TEMPORAL DISCUSSION

A total of 121 diagnostic specimens with obsidian source assignments can be brought to bear from existing data and thesis results (Table 16). Working from youngest to oldest types, five Desert series points (150 – 700 B.P.) are made of Truckee Meadows obsidians, three are of Mono Basin sources, and four are of Northeastern sources. Rosegate series (700 – 1300 B.P.) points include 14 of Truckee Meadows sources, ten of Mono Basin sources, 17 of Northeastern sources, and one of an unidentified source. A single Elko series point (1300 – 3000 B.P.) is made of Truckee Meadows obsidian, while four are of Mono Basin sources and 12 of Northeastern sources. Martis series (1300 – 5000 B.P.) points consist of four derived from Truckee Meadows sources, one from Mono Basin, one from Northeastern sources, and one from an unidentified source. Two Gatecliff series points (3300 – 5000 B.P.) are derived from Mono Basin sources. Finally, Humboldt points (5000 – 8000 B.P.) include three of Mono Basin obsidians and three of Northeastern sources. Despite this variability, Truckee Meadows, Mono Basin, and Northeastern obsidian sources all appear to have been used throughout the Middle and Late Archaic periods.

Looking at projectile point distributions for all but unknown types, 79% of points made of Truckee Meadows obsidian are either Desert or Rosegate series; 62% of Mono Basin obsidian points are Desert or Rosegate series; and only 55% of Northeastern obsidian points are Desert or Rosegate series. This pattern matches Delacorte’s (1997a) settlement model, indicating that Truckee Meadows obsidian was used later in time than other, non-local obsidians. A similar pattern holds for the relative number of Desert and

Table 16. Projectile Points in the Combined Sample

Geographic Area	Obsidian Source	Projectile Point Type	No. of Specimens
Truckee Meadows	Sutro Springs	Desert Series	4
		Rosegate Series	13
		Martis series	3
		Elko series	1
		Unknown	6
	C.B. Concrete	Desert Series	1
		Rosegate Series	1
		Martis series	1
Mono Basin	Bodie Hills	Desert Series	2
		Rosegate Series	9
		Martis series	1
		Humboldt series	1
		Elko series	3
		Unknown	3
	Mt Hicks	Rosegate Series	1
		Humboldt series	1
	Pine Grove Hills	Humboldt series	1
	Casa Diablo	Elko series	1
	Mono Glass	Desert Series	1
Northeastern	Majuba Mountain	Martis series	1
		Gatecliff series	1
		UNK	1
	Buffalo Hills	Rosegate Series	3
		Gatecliff series	1
		Humboldt	2
		Elko series	4
		Unknown	8
	BS/PP/FM	Desert Series	3
		Rosegate Series	7
		Humboldt	1
		Elko series	2
		Unknown	10
	South Warners	Desert Series	1
		Rosegate Series	7
		Elko series	6
		Unknown	3
Unknown	Unidentified Sources	Rosegate Series	2
		Martis series	3
		UNK	1
		TOTAL	**121**

Rosegate series points between sources, with few Desert and Rosegate series points made of Mono Basin glass (n=13) compared to those of Truckee Meadows (n=19) and Northeastern sources (n=21). This further supports Delacorte's model of more localized obsidian use later in time, or presence of a Late Archaic conveyance system centered to the north, not the south.

NORTHERN VERSUS SOUTHERN SITES

Although I was unable to source as many obsidian samples as desired, my results show an interesting pattern compared to previous data. Figure 8 shows the relative proportion of obsidian sources from 52 previously recorded sites. Of these, 36 are located in the Truckee Meadows, 14 are north of the region, and two are to the south. Forty percent of the obsidian originates from northeastern sources, 30 percent from local sources, and 25 percent from southern sources. The dominance of northern obsidian sources is expected given the preponderance of sites from northern locations. However, local and southern obsidian sources are also well represented within the sample.

A somewhat different pattern emerges in data collected for this thesis from one northern, one Truckee Meadows, and one southern site. (Figure 9). This sample is dominated by local sources (47%), followed by southern (43%) and rarely northern (8%) raw materials. The greatest number of specimens derives from the southern site, explaining the dominance of southern sources. Nonetheless, a high percentage of local Truckee Meadows obsidian is also present.

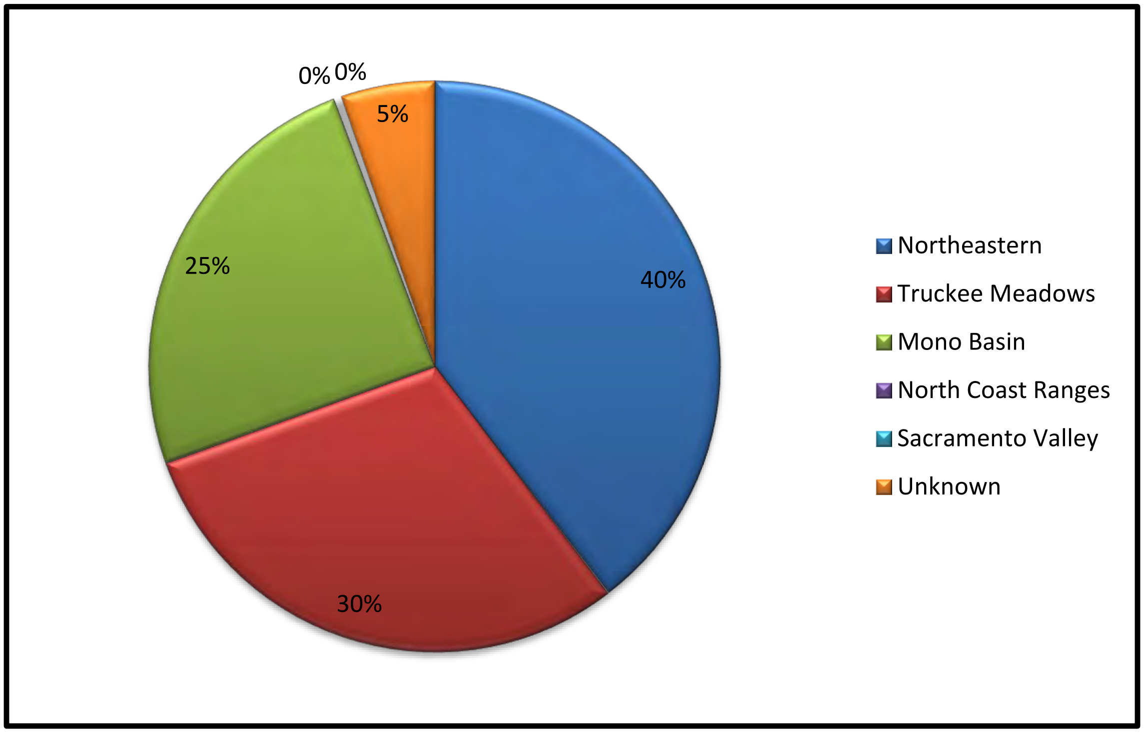


Figure 8. Proportional Distribution of Obsidian Sources for Existing Data

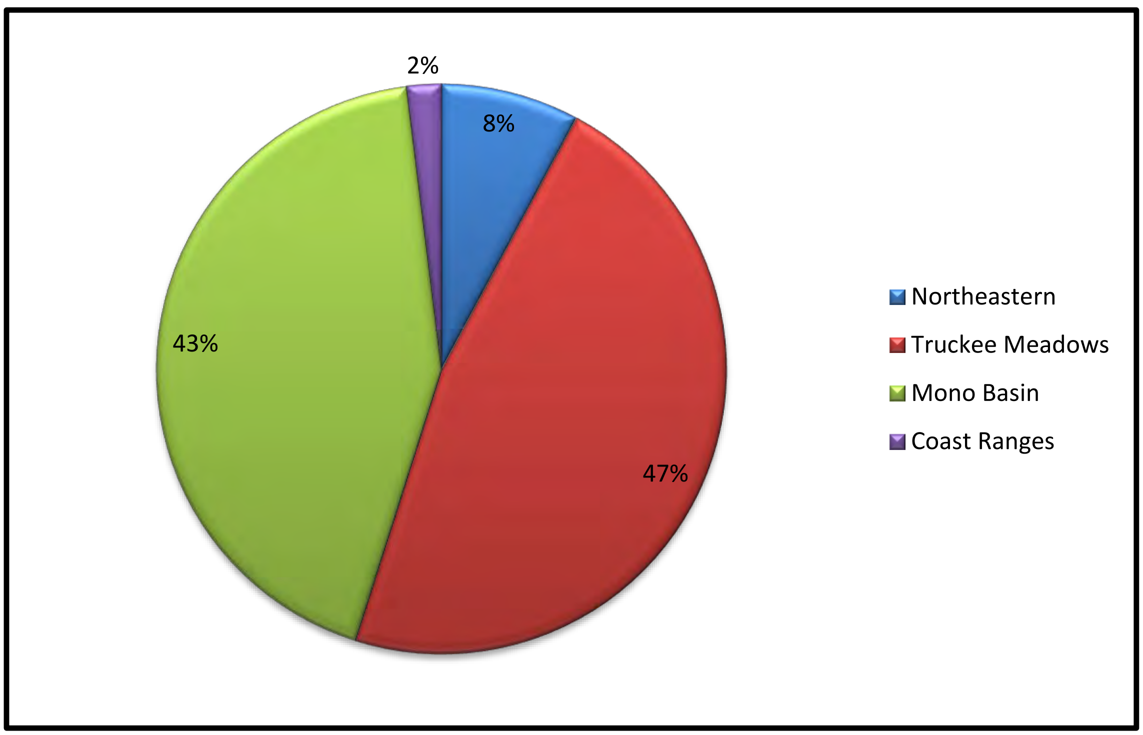


Figure 9. Proportional Distribution of Obsidian Sources for Thesis Data

Previous samples were biased toward northern sites, reflected by the greater proportion of northeastern obsidian in them. Looking at source distributions more closely, a pattern emerges in the Truckee Meadows along the Truckee River. By splitting the combined obsidian sourcing data between sites located north and south of the Truckee River (Table 20), a significant difference is apparent. Sites north of the river are dominated by northern obsidian sources and more Truckee Meadows glass, with little southern obsidian. In contrast, sites south of the Truckee River have little northern obsidian and high levels of both local and southern source materials. This is to be expected, with southern sources declining as one moves northward and vice versa for northern source types. This is especially true as populations increase, mobility declines and people make increasing use of local materials later in time.

To analyze this pattern further, a scatter plot of site location to obsidian source was performed (Figure 10). It shows the expected northern versus southern pattern, but it is interesting to note the high level of Truckee Meadows obsidian clustered around the Truckee River.

Inasmuch as this thesis focuses on sites east of the Sierra Nevada Range, a Chi-Square was calculated using only Northern, Truckee Meadows, and Mono Basin sources from Table 17; North Coast Range and other source types were excluded. It indicated a significant difference in the use of various obsidian types ($x^2 = 412.121$, p-value = 0.000).

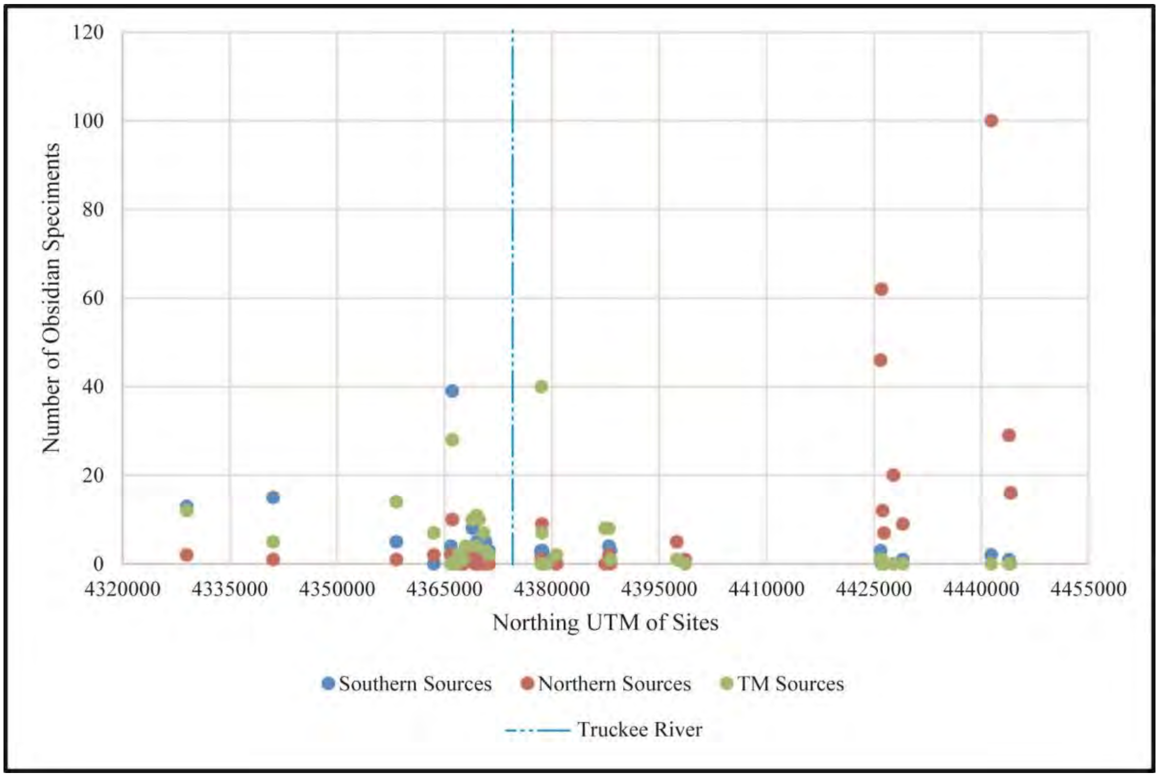


Figure 10. Scatter Plot for Southern and Northern Obsidian Sources

Table 17. Obsidian Sourcing Results for Sites Relative to the Truckee River

Geographic Area	North of Truckee River	South of Truckee River
Northern	320	32
Truckee Meadows	80	200
Mono Basin	34	208
Coast Ranges	1	2
Sacramento Valley	1	1

There is a temporal element to this pattern as well, judging by the 121 diagnostic projectile points. Table 18 lists projectile points from sites north and south of the Truckee River. At sites north of the river, most Middle and Late Archaic projectile points are made of northern obsidian sources and Late Archaic forms secondarily of local Truckee Meadows glass. This is consistent with Delacorte's (1997a) data that demonstrates a shift to Sutro Springs obsidian in later times. At sites south of the river, Middle and Late Archaic point types derive from local and southern obsidian sources, with more of the Late Archaic forms made of southern sources. This suggests continued use of southern obsidian later in time, as supported by the hydration data from sites north and south of the river.

Table 18. Projectile Point Types for Sites Located North and South of the Truckee River

Geographic Area	Projectile Point Type	No. of Specimens North of Truckee River	No. of Specimens South of Truckee River
Northern	Desert Series	4	0
	Rosegate Series	16	1
	Martis Series	0	1
	Elko Series	12	0
	Gatecliff Series	1	1
	Humboldt	3	0
	Unknown	22	0
Truckee Meadows	Desert Series	1	4
	Rosegate Series	13	1
	Martis Series	0	4
	Elko Series	0	1
	Unknown	1	4
Mono Basin	Desert Series	1	2
	Rosegate Series	1	9
	Martis Series	1	0
	Elko Series	0	4
	Humboldt Series	1	2
	Unknown	1	2
Source Unknown	Rosegate Series	0	2
	Martis Series	0	3
	Unknown	1	0

Table 19 presents the Bodie Hills obsidian hydration data for sites north and south of the Truckee River. All things being equal, northern sites contain thicker hydration rinds, with 13 of 15 readings (87%) 3.7 microns or higher. Most of these readings fall between 6.1 and 6.9 microns, suggesting that Bodie Hills material was used earlier in time. An appreciably larger sample is available for sites south of the Truckee River, where 36 of the 65 readings (55%) are 3.7 microns or greater and 29 (45%) less than 3.7 microns. This implies that use of Bodie Hills obsidian was earlier north of the Truckee River than south of it.

Using Chauvenet's criterion to remove outliers, north (1.8, 1.8, and 7.8) and south (7.9 and 8.4) of the river a Mann-Whitney test was computed to compare the hydration. The resulting p-value of 0.0021 indicates that the distributions or age of Bodie Hills obsidian use differs on either side of the river.

Table 19. Bodie Hydration Results for Sites Located North and South of the Truckee River

Northern Sites	1.8, 1.8, 3.7, 4.6, 4.8, 4.9, 4.9, 5.2, 5.4, 6.1, 6.2, 6.4, 6.4, 6.9, 7.8
Southern Sites	0.8, 0.8, 1.0, 1.0, 1.6, 1.7, 1.8, 1.8, 2.1, 2.1, 2.2, 2.2, 2.4, 2.4, 2.5, 2.5, 2.6, 2.7, 2.7, 2.9, 3.0, 3.0, 3.1, 3.1, 3.1, 3.2, 3.2, 3.5, 3.5, 3.8, 3.8, 4.2, 4.2, 4.2, 4.4, 4.4, 4.4, 4.5, 4.8, 4.8, 4.8, 4.9, 5.0, 5.0, 5.2, 5.2, 5.2, 5.2, 5.2, 5.3, 5.3, 5.3, 5.4, 5.6, 5.7, 5.9, 6.1, 6.2, 6.2, 6.3, 6.7, 6.8, 6.8, 7.9, 8.4

Figure 11 shows the micron values for Bodie Hills obsidian plotted against site location or Northing UTM coordinate. As can be seen, sites located adjacent and south of the river have variable micron values or ages. Conversely, sites north of the river display consistently high micron values or ages. This supports the idea that Bodie Hills obsidian remained in use throughout the Truckee Meadows sequence, but later in time primarily south of the river. This distinction between northern and southern sites may result in a change to Delacorte's (1997a) settlement model, as discussed in the following chapter.

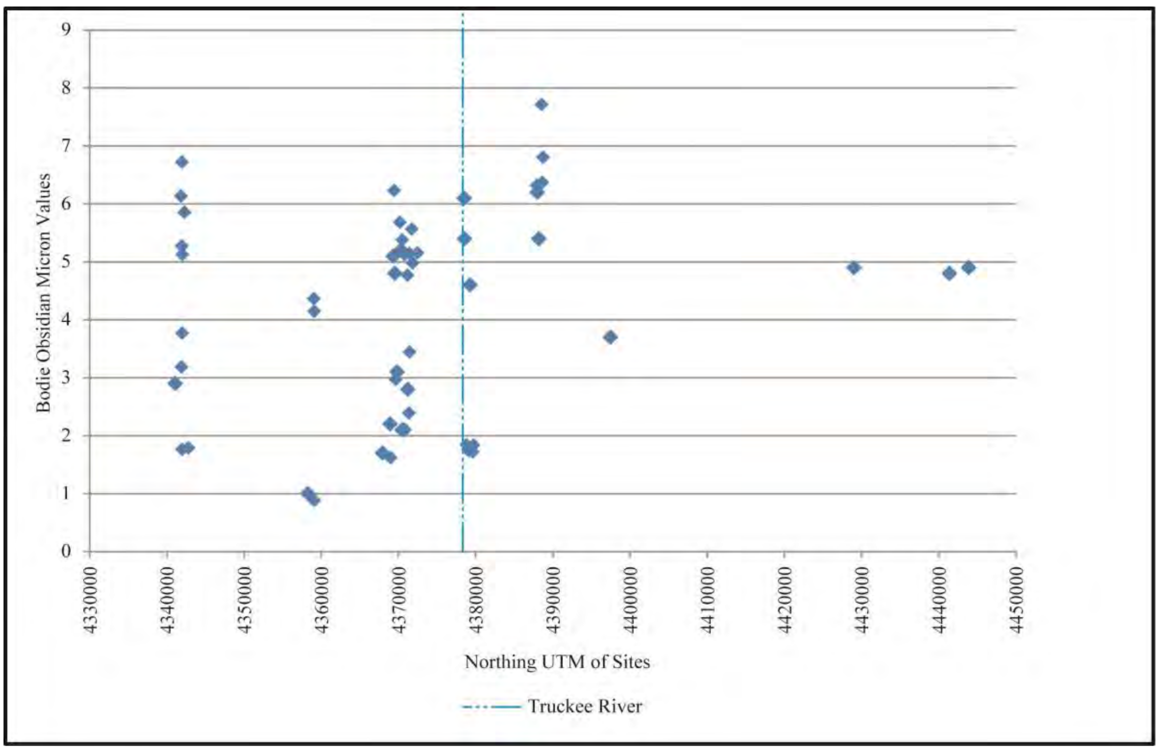


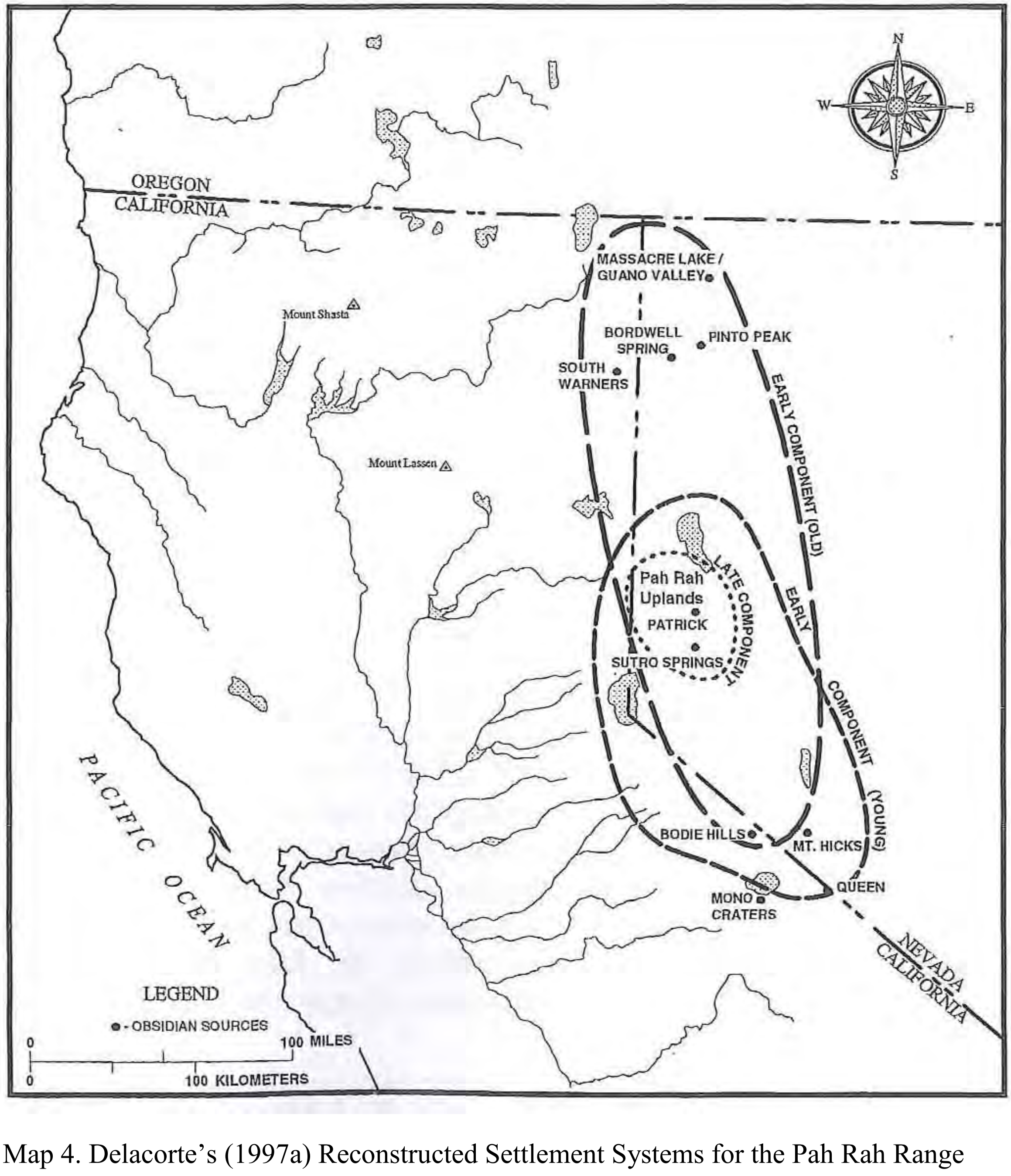
Figure 11. Bodie Hills Micron Values by Site UTM

CHAPTER 8. CONCLUSIONS AND FUTURE DIRECTIONS

This study examined several important issues regarding obsidian conveyance systems and prehistoric settlement mobility within the Truckee Meadows region. To assess the utility of existing hydration rates, I attempted to develop radiocarbon-hydration pairs for Sutro Springs and Bodie Hills obsidians. By excluding obviously suspect samples, I statistically demonstrated that not all radiocarbon-hydration pairs for Sutro Springs obsidian were mixed. Unfortunately, the limited number of Bodie Hills samples precluded such statistical testing, although all of the sample contexts appear to be mixed.

Next, I evaluated the relative accuracy of existing hydration rates for Sutro Springs and Bodie Hills obsidian. All of these rates appear to overestimate artifact age, when assessed against radiocarbon-hydration pairs. When assessed against the hydration for Desert and Rosegate series projectile points, however, the Hall and Jackson (1989) and Griffin's (2013) rates performed reasonably well, once outliers were removed. Temperature effects are difficult to evaluate over time, but given the lower elevation of the Truckee Meadows both the Hall and Jackson (1989) and Griffin (2013) rates would be expected to overestimate age. Given the better performance of the rates with projectile points, it is assumed that the point data are better, or less sensitive, given the temporal range of different point series. These issues demonstrate the need for better chronological control in formulating hydration rates. Additionally, efforts to identify older cultural deposits with dateable organic residues and Sutro Springs and Bodie Hills obsidian should be redoubled.

The major focus of this study employed new data to assess the validity of Delacorte's (1997a) regional settlement model for the Truckee Meadows. His analysis focused on previous hydration data (Moore and Burke 1992; Zeier and Elston 1986) and newly generated information from the Pah Rah Uplands and Vista site. Delacorte (1997a) concluded that both the range and annual movement of populations decreased substantially over time. This can be seen in a decline in both the number and distance of exploited toolstone sources over time. The Early Component displayed the greatest toolstone variability, with obsidian acquired from sources up to 150m north and south of the Pah Rah Uplands (Map 4). This suggests that early populations were extremely mobile, accessing a wide range of obsidian sources. A second shift occurred in the latter part of the Early period, when the settlement system contracted, as evidenced by an increase in Sutro Springs (68%) and decrease in southern (17%) obsidian sources. This suggests that annual mobility remained high, but entailed more restricted home ranges. The final shift, during the Late Component, saw an increase in the use of local, inferior-quality obsidian (Patrick) for the first time, and greater scavenging of older toolstone. This last shift suggests that prehistoric groups were exploiting limited areas in more intensive fashions. It is presumed that residential shifts still existed, but seasonal migrations between widely separated areas were nonexistent (Delacorte 1997a: 141-142).



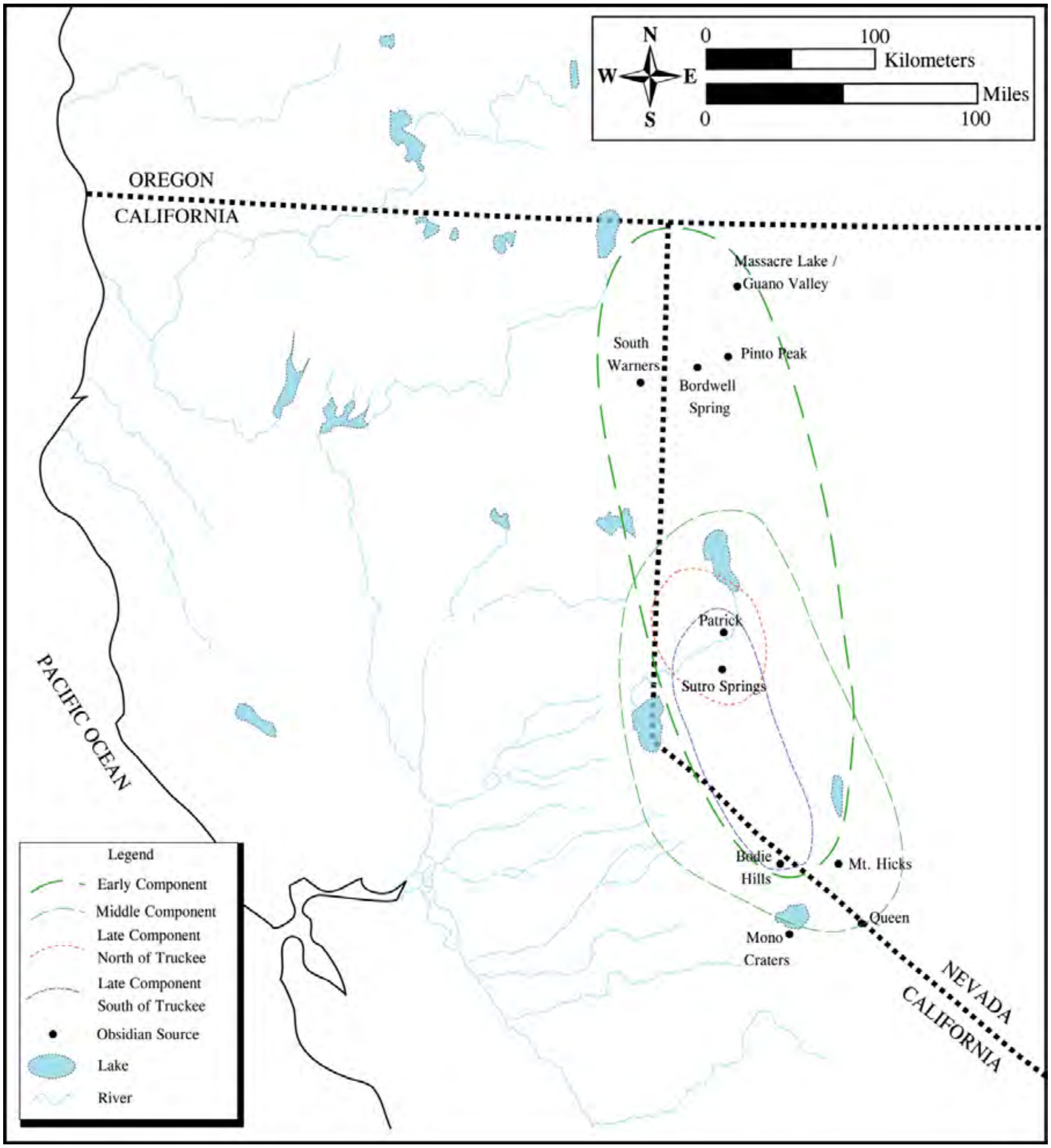
Map 4. Delacorte's (1997a) Reconstructed Settlement Systems for the Pah Rah Range

As discussed in Chapter 7, two parts of my analysis support Delacorte's (1997a) model: (1) obsidian hydration profiles for Bodie Hills and Sutro Springs obsidian; and (2) spatio-temporal trends in obsidian source uses. The first compares hydration results for Bodie Hills and Sutro Springs obsidian. It reveals that use of Bodie Hills obsidian peaked earlier in time than Sutro Springs. This matches Delacorte's (1997a) model, suggesting that groups in the Pah Rah area and Truckee Meadows became more localized over time, with a major shift toward Sutro Springs obsidian.

The second part of the analysis examined temporal trends in obsidian use. The distribution of projectile point types by geographic area shows that the majority of Desert and Rosegate series points are made of northeastern obsidian, followed by Truckee Meadows and then Mono Basin glass. Similarly, 79% of the points made of Truckee Meadows obsidian are either Desert or Rosegate series forms, followed by Mono Basin (62%) and northeastern (55%) sources. These patterns support Delacorte's (1997a) model of Late Archaic obsidian conveyance to the north, not the south. Finally, looking at temporal trends north and south of the Truckee River, there is a strong Late Archaic preference for local Truckee Meadows obsidian, supporting Delacorte's (1997a) data that demonstrates a shift to use of Sutro Springs obsidian.

Although parts of my analysis supports Delacorte's (1997a) model, other differed somewhat from it. Delacorte's (1997a) analysis included 52 specimens of Sutro Springs obsidian, 9 samples of Patrick obsidian, and no C.B. Concrete obsidian from sites along the Tuscarora Pipeline (Milliken and Hildebrandt 1997). In contrast, Hutchins and Simons (2000) had 148 pieces of Sutro Springs obsidian, 37 pieces of C.B. Concrete glass, and no Patrick obsidian. Given the data from 52 previously recorded sites, I assembled 202 Sutro Springs and 54 C.B. Concrete obsidian samples. In addition I tested 24 pieces of Sutro Springs obsidian. Of all these, Delacorte's (1997a) analysis of Pah Rah uplands sites was the only place where traces of Patrick obsidian were identified. The Patrick obsidian source is located along the Truckee River and would have been very accessible to prehistoric people in the Pah Rah uplands. In contrast, most of the Truckee Meadows saw greater use of Sutro Springs and C.B Concrete and no Patrick obsidian. In fact, use of Patrick obsidian appears to be limited to areas north of the Truckee River.

In addition to this, my analysis suggests that mobility may not have decreased consistently through time within the Truckee Meadows. By comparing areas north and south of the Truckee River, there are significant difference in obsidian use. More specifically, use of Bodie Hills obsidian is generally earlier north of the Truckee River, persisting later in the south. On the basis of this, I propose a more refined settlement model (Map 5) for the Truckee Meadows region. Early and Middle Component settlement matches that reconstructed by Delacorte (1997a), but Late Component settlement systems differ north and south of the Truckee River. Despite some overlap, populations south of the river appear to have maintained more regular access to Bodie Hills obsidian than people living to the north.



Map 5. Reconstructed Settlement System for the Truckee Meadows

CONCLUDING REMARKS

This thesis attempted three tasks: (1) develop radiocarbon-hydration pairs for Sutro Springs and Bodie Hills obsidian; (2) assess existing hydration rates for Sutro Springs and Bodie Hills obsidians; and (3) assess Delacorte's (1997a) regional settlement model.

The development of radiocarbon-hydration pairs was hampered by the limited size of the Bodie Hills sample and mixed nature of many feature contexts. When obviously mixed samples were removed, five of the eight Sutro Springs sample pairs are acceptable. One of the challenges with this type of analysis is the source diversity, which makes it difficult to isolate good samples from specific sources.

Hydration rates for Sutro Springs and Bodie Hills obsidians were used to assess the veracity of hydration analysis in the Truckee Meadows. All previously established rates overestimated the age of radiocarbon dates. Griffin's (2013) rate performed best and both it and the Hall and Jackson (1989) rate worked reasonably well on projectile points. This suggests that obsidian hydration is, indeed, a reliable technique for estimating artifact age in the Truckee Meadows (c.f. Hutchins and Simons 2000).

Finally, Delacorte's (1997a) model that mobility generally decreased through time, given a greater reliance on local Patrick obsidian, appears more complex, with areas north and south of the Truckee River displaying different patterns. This may reflect a (1) cultural division; (2) territoriality; or (3) a physical barrier. As reviewed in Chapter 3

(Map 2), three ethnographic groups (Washoe, Tasiget, and Kuyuidokado) made use of the area, so the river may have served as a cultural or physical boundary of some type.

In the end, this thesis offers just a glimpse into settlement patterns within the Truckee Meadows area, with additional work necessary to resolve still outstanding issues. This includes the need for a greater emphasis on obsidian hydration and sourcing studies, the efficacy and value of which have been more than substantiated here. This will, in turn, allow for the testing and refinement of the patterns identified in this study, and with it, a better understanding of Truckee Meadows prehistory.

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