University of Nevada, Reno

Developing a Geomorphic and Archaeological History of Painters Flat

A thesis submitted in partial fulfillment of the
requirements for the degree of Master of Arts
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By

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ABSTRACT

Painters Flat is a small basin that sits along the northern California-Nevada border. It has never been studied in detail. During 2020 fieldwork, I collected geomorphic and sedimentological data to construct the hydrologic history of the basin throughout the late Pleistocene and Holocene. I used a hydrologic model to determine the changes in temperature and precipitation needed to form a lake or wet meadow and, along with marsh potential estimations, identified likely environmental conditions in Painters Flat across time. Using the distributions of archaeological sites and time-sensitive projectile points, I determined how people utilized Painters Flat and how hydrologic changes drove them to alter their settlement-subsistence strategies. Peoples' responses to changes in larger lake systems (e.g., Lake Lahontan) have been extensively studied in the Great Basin; however, how they responded to changes in small hydrologic basins remains poorly understood. Painters Flat offers an opportunity to test the hypothesis that smaller systems – and humans living in them – responded differently to the onset of the Holocene.

ACKNOWLEDGMENTS

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CHAPTER 1

INTRODUCTION

Geoarchaeology has long played an important role in anthropological research in the Great Basin. Geoarchaeological studies have and continue to contribute to our understanding of basins' hydrologic histories and, in turn, how humans adapted to changing landscapes. In this thesis, I report on recent geoarchaeological investigations in Painters Flat, a small and understudied basin on the California-Nevada border that I conducted to construct its hydrologic and cultural history.

Overview

The Great Basin is characterized by Basin and Range topography formed from fault blocks uplifted by crustal stretching in the Cenozoic Era (30 million years ago [mya]) (Danielson 2000; Grayson 2011). Pluvial lakes, which formed from relatively high precipitation rates, dominated this landscape at various times throughout the late Pleistocene (126,000-11,500 cal BP) and, in some instances, well into the Holocene (11,500 cal BP to present) (Figure 1.1; Tables 1.1 and 1.2). Many of these lake systems formed during the Late Glacial period (17,000-14,000 cal BP) but declined by 13,000 cal BP after highstands ~15,000 cal BP (Benson et al. 1995; Lyle et al. 2012; Santi et al. 2019). Many lakes rebounded during the Younger Dryas (12,900-11,500 cal BP) before they retreated significantly toward the end of the early Holocene (11,500-8000 cal BP)

(Benson et al. 1995; Duke and King 2014; Minckley et al. 2004). As the regional climate produced dry conditions, many lakes completely desiccated during the middle Holocene (8000-4500 cal BP) (Wriston 2009). The Neopluvial period (4500-2700 cal BP) saw the rejuvenation of many lakes in the northwestern Great Basin (Grayson 2011; Mensing et al. 2014), although its timing varied throughout the region (Adams and Rhodes 2019). Following the Neopluvial period, the Great Basin experienced extensive droughts with oscillating dry/wet cycles within the last couple millennia (Mensing et al. 2014). Throughout humans' tenure in the region, lake basins fostered productive ecosystems (Madsen and Kelly 2008) and, ultimately, shaped hunter-gatherer settlement-subsistence strategies. As lake margins shifted and productivity changed, people adjusted these strategies. Peoples' responses to changes in larger lake systems (e.g., Lake Lahontan and Lake Bonneville) have been extensively studied (e.g., Adams et al. 2008; Madsen et al. 2015); however, their responses to changes in smaller lake systems that may have responded differently (Duke and King 2014), remain poorly understood.

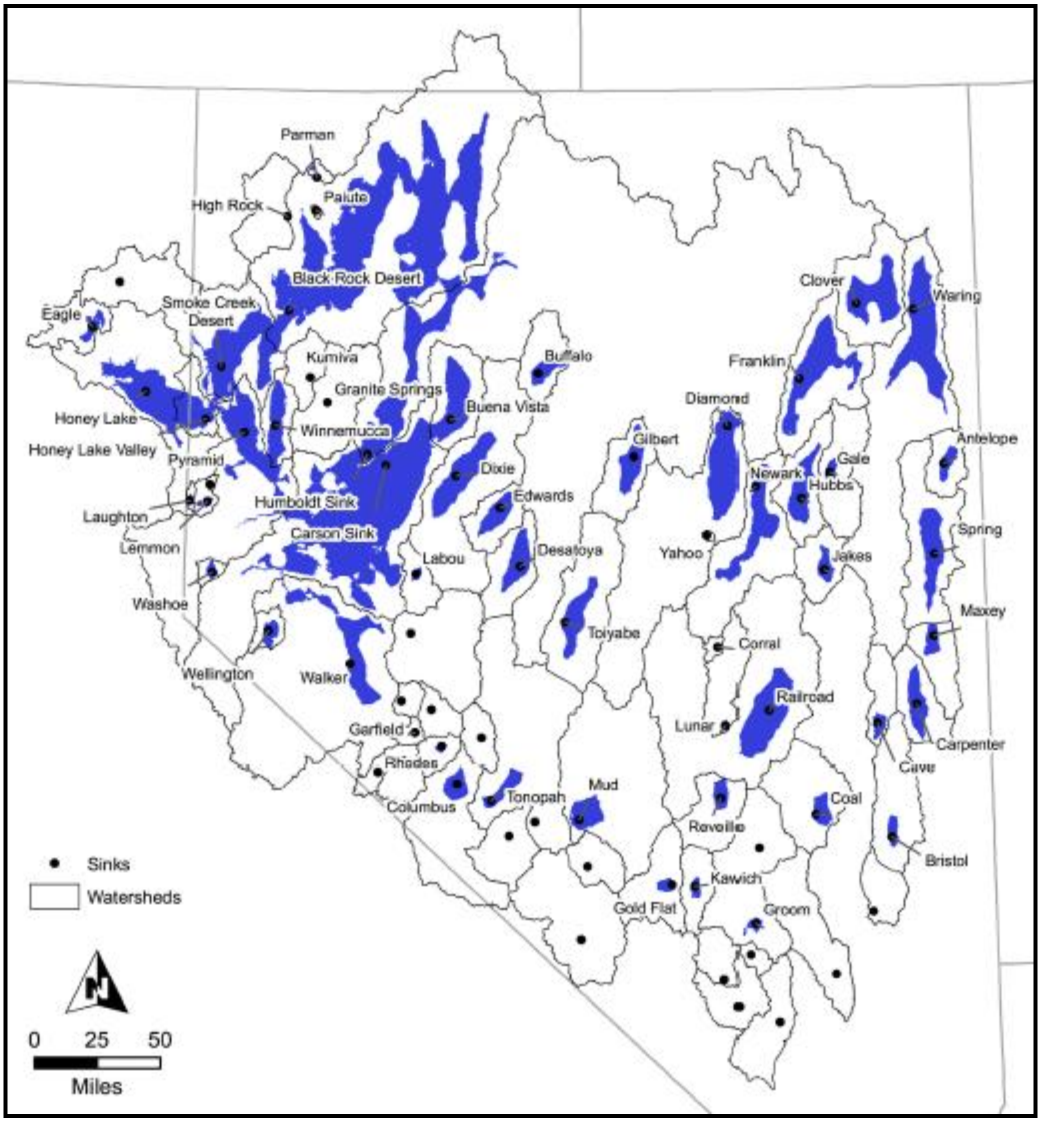

Figure 1.1. Pluvial lake highstands and GIS-modeled sinks and watersheds of the western and central Great Basin (adapted from Duke and King 2014).

Table 1.1. Climatic Periods (adapted from Grayson 2011; Lyle et al. 2012; Mensing et al. 2004; Santi et al. 2019; Wriston 2009).

Climatic Period	**Cal BP Range**
Late Pleistocene	~126,000-11,500
Late Glacial Highstands	~16,700-15,300
Bølling-Allerød	~14,600-12,900
Younger Dryas	~12,900-11,500
Early Holocene	~11,500-8000
Middle Holocene	~8000-4500
Initial Middle Holocene	~8000-5800
Middle Holocene Gap	~5800-5200
Terminal Middle Holocene	~5200-4500
Late Holocene	post-4500
Neopluvial	~4500-2700

Table 1.2. Cultural Periods (adapted from Delacorte 1997; King et al. 2004; McGuire 2000; Oetting 1994).

Cultural Period	**Cal BP Range**
Paleoindian	pre-8000
Post-Mazama	~8000-4500
Early Archaic	~4500-3800
Middle Archaic	~3800-1300
Late Archaic	~1300-600
Terminal Prehistoric	post-600

Great Basin Geoarchaeology

Climate Change and Settlement-Subsistence Patterns

Researchers have studied the geoarchaeology of Great Basin pluvial lake systems for almost a century. Early on, archaeologists recognized the association between early sites and relict pluvial lake landforms (Bedwell 1970; Campbell 1937; Clewlow 1968; Layton 1970). Campbell (1937) initially recognized the relationship between Paleoindian (pre-8000 cal BP) projectile points and Lake Mohave shorelines and concluded that people occupied the basin when a lake was present. Later, Bedwell (1970) proposed the Western Pluvial Lakes Tradition (WPLT) and suggested that Paleoindians moved extensively throughout the region, rarely leaving the marshes that rimmed most valleys during the late Pleistocene. Layton (1970) similarly suggested that early groups focused on marshes until a widespread drying trend prompted them to increasingly exploit upland resources. Further investigations in the Black Rock Desert and High Rock Lake Basin of northwestern Nevada supported Layton's (1970) interpretations, showing a paucity of time-sensitive projectile point types in upland locations until the middle Holocene (Elston and Davis 1979; McGonagle 1979).

Continued research has largely shown these earlier ideas to be correct, and while we now know that Paleoindian groups did sometimes venture beyond the confines of wetlands and certainly pursued a more diverse subsistence strategy than Bedwell's (1970) WPLT model suggests, most diagnostic Paleoindian tools (e.g., Western Stemmed Tradition (WST) points, Black Rock Concave Base points, fluted points, and crescents) do occur in and around pluvial lake basins (Grayson 2011; Smith and Barker 2017). More than a decade of work in Utah's Old River Bed (ORB) revealed that early sites cluster along the delta's distributary channels (Duke and Young 2007; Madsen et al. 2015). Duke and Young (2007) examined local and nonlocal toolstone sources and found that people occupied sites for longer periods because wetlands were abundant. Madsen and colleagues (2015) then mapped the channel systems to construct a relative dating sequence that they correlated with associated archaeological sites. Occupation intensity peaked 12,500-9800 cal BP and consisted predominately of residential base camps (Madsen et al. 2015). Madsen and colleagues (2015) viewed the ORB delta as a "megapatch" in which foragers moved around and encountered essentially the same resources, leaving it only occasionally to procure toolstone or other extra-local resources.

Madsen and colleagues' (2015) model stands in contrast to other studies of Paleoindian mobility in the region (e.g., Jones et al. 2003; Smith 2011). Jones and others (2003) compared a regional compilation of Paleoindian and Holocene toolstone source profiles and found high transport distances and high toolstone diversity in Paleoindian assemblages (Jones et al. 2003). They suggested that this trend reflects peoples' movements through large territories, which decreased considerably during the early Holocene. Smith (2010) tested Jones and others' (2003) model by sourcing numerous artifacts from sites in northwestern Nevada. He suggested that Jones and colleagues' (2003) single western conveyance zone was better characterized as two, a northern and southern zone, and although these territories were smaller, their sizes still suggest that Paleoindians were more mobile and far-ranging than later groups (Smith 2010). Since then, other researchers have investigated obsidian conveyance in the northwestern Great

Basin (King 2016; McGuire et al. 2018; Reaux 2020; Smith et al. 2017). Reaux (2020) determined that Guano Valley's large Paleoindian assemblage, though containing a high proportion of local toolstone, also consisted of a diverse suite of obsidian types. He ultimately determined that hunter-gatherers made short but frequent stays in Guano Valley (Reaux 2020). Working in Five Mile Flat, which housed one of the region's smallest documented pluvial lakes during the late Pleistocene, Smith and colleagues (2013) found that Paleoindians stayed only briefly, likely because the wetland was small. These and other studies suggest that early groups adjusted their settlement strategies depending on wetland size and productivity, rather than employing a single adaptive strategy across time and space (*sensu* Bedwell 1970).

With the onset of the Holocene, groups adjusted their lifeways, probably in part due to the changing landscape. The early Holocene climate gradually warmed and dried, a shift that intensified at the beginning of the middle Holocene (Hildebrandt et al. 2016; Wriston 2009). Plant and animal communities shifted to predominantly xeric-adapted species and lakes and marshes disappeared in many basins (Grayson 2011; Hildebrandt et al. 2016; Louderback et al. 2010). Elston and colleagues (2014) found that Paleoindian occupations cluster along riparian zones at the edges of many basins and suggest that these locations allowed groups to both collect plants and hunt artiodactyls. If large enough, these riparian zones as well as marshes and other productive settings may be conceived of as *patch* resources, which provide a wide range of food resources within a given area (Duke and Young 2007; MacArthur and Pianka 1966; Madsen et al. 2015). Patch resources may be compared to *point* resources, which provide a narrower range of food resources typically within a smaller area. Paleoindians' apparent focus on patches would likely have led them to quickly deplete higher-ranked resources, prompting people to either move on to another patch or incorporate lower-ranked resources such as hard-coated seeds into their diets (Elston et al. 2014). As wetlands disappeared during the Holocene, people seem to have responded by increasing their residence time in basins and while high-ranking resources would have been collected when available, people began to emphasize lower-ranked resources (Duke and King 2014; Rhode 2008). As part of this process, Archaic populations adopted ground stone tools (Elston and Zeanah 2002; Rhode 2008). Archaic sites are not clustered like Paleoindian sites, suggesting that later groups expanded their foraging ranges to include multiple patches (Elston et al. 2014).

Although many basins saw climatic and cultural shifts during the middle Holocene, people responded to these changes in different ways. In the Black Rock Desert, Northern Side-notched points (7800-5700 cal BP) are infrequent (McGuire et al. 2018) but in the High Rock Country just to the north, they outnumber WST points (Hildebrandt et al. 2016). High numbers of Northern Side-notched points and other post-Mazama (8000-4500 cal BP) markers likely reflect locally persistent moist conditions at a time when other locations grew more arid (Hildebrandt et al. 2016). People seem to have completely abandoned other basins (e.g., High Rock Lake) or used them far less (e.g., the Massacre Lake Basin) than during earlier times (Leach 1988; McGonagle 1979). Post-Mazama groups also shifted to larger residential camps, which are generally absent in Paleoindian contexts (Elston and Zeanah 2002; Hildebrandt et al. 2016), though the extent to which this reflects taphonomic biases remains unclear (Smith and Barker 2017).

Peoples' occupation of dune landforms also increased with middle Holocene climate changes. Wriston and Smith (2017) found that Paleoindian sites clustered above or along Lake Warner's shorelines, dated between 14,385 and 12,090 cal BP. These shorelines and lagoons would have fostered waterfowl, fish, small mammals, cattail, and large game. As the lake receded, people shifted to occupy areas closer to the dunes-and-sloughs landforms, which likely provided marsh resources during mesic cycles (Young 2000). In Surprise Valley, O'Connell (1975) found that post-Mazama groups lived in residential camps along a dune/beach ridge field with nearby spring-fed marshlands during wetter phases. Many of these dune fields formed following early Holocene lake desiccations and attracted people long after the lakes had disappeared (Colgan et al. 2017; Hildebrandt et al. 2016; Mehringer and Wigand 1986).

While people generally occupied larger residential camps and focused on spring resources (Hildebrandt et al. 2016; McGonagle 1979), the middle Holocene was somewhat variable in temperature and precipitation – something that is reflected in the archaeological record (Wriston 2009). The initial middle Holocene (8000-5800 cal BP) was the warmest and driest period, the middle Holocene gap (5800-5200 cal BP) was relatively mesic with cooler temperatures, and the terminal middle Holocene (5200-4500 cal BP) saw a return to warmer and drier conditions (Wriston 2009). Cooler and moister conditions gradually returned during the late Holocene; however, change was asynchronous across the region (Wriston 2009). During the middle Holocene gap, people returned to lakeside residential sites where groups exploited plant and animal resources including bulrush and waada (Helzer 2004). Middle Holocene shifts in summer versus winter-dominated precipitation resulted in fluctuating animal populations and, in turn, human subsistence strategies (Leach 1988; O'Connell 1975; Wriston 2009). The increase in ground stone during the post-Mazama period may signal a widening diet breath and increased reliance on seeds (Leach 1998; Rhode 2008).

The late Holocene archaeological record shows multiple changes in settlement strategies. In the northwestern Great Basin, people expanded their ranges during the Early (4500-3800 cal BP) and Middle Archaic (3800-1300 cal BP) periods to occupy uplands as well as valley bottoms and canyons (Leach 1988; McGonagle 1979; O’Connell 1975). In some basins, groups continued to occupy a range of habitats into the Late Archaic period, 1300-600 cal BP (Leach 1988). In others, Late Archaic groups abandoned higher elevations and occupied the lake valleys and canyons (McGonagle 1979). O’Connell (1975) noted a decline in resource productivity during the Late Archaic period and a shift to year-round occupations rather than shorter stays. Peoples’ settlement strategies shifted to seasonal occupations in ethnographic times (Tiley and Rucks 2011).

Reconstructing the Natural and Cultural Landscape

Archaeologists have long recognized pluvial lakes to be environments conducive to the preservation of sediments useful for climatic reconstructions. Lakes provide sediments for sedimentological analysis as well as organic material useful for establishing hydrologic chronologies (Reheis et al. 2014). Radiocarbon, luminescence, and ^{230}Th-U dating, and tephra identification can give absolute dates to geologic events (Adams and Rhodes 2019; Benson et al. 1995; Ibarra et al. 2014). Proxies for environmental conditions can include pollen and microfossil samples, stable isotopes, and elemental chemistry (Minckley et al. 2007; Rapp and Hill 2006; Reheis et al. 2014).

Archaeological sites dated by radiocarbon, luminescence, or typological cross-dating can also provide constraints on the presence and areal extent of lakes or wetlands (Adams and Rhodes 2019).

To further constrain lake reconstructions, researchers may map relevant landforms including shorelines, berms, bars, and spits and correlate them with stratigraphic profiles (Waters 1997). As I have noted, archaeologists quickly recognized that these landforms, especially shorelines, often contain evidence of human occupation (Campbell 1937; Smith and Barker 2017). Shorelines and berms provided well-drained places for human habitation close to marshes and the resources they offer (Young 2000). Sites associated with these landforms tend to manifest as surface assemblages with erosional processes preventing the preservation of subsurface features. Datable materials are frequently absent, forcing researchers to develop other ways of interpreting human settlement (Smith and Barker 2017).

Spatial distribution models of archaeological sites that take into consideration lake histories and humans' preference to live near water are one example of how Great Basin researchers have considered settlement and subsistence strategies in the absence of preserved food residues or other organics capable of providing radiocarbon dates. To best correlate human settlement patterns with lake histories, researchers must first develop detailed lake histories. Larger lake systems like Lake Lahontan have been the subject of numerous studies conducted to this end. Adams et al. (2008) refined Lake Lahontan's history and examined the relationship between lakestands of known ages and the distribution of archaeological sites. They found an inverse relationship between lake-level and site frequency, with little evidence for human occupation during the Younger

Dryas lakestand (12,500-12,000 cal BP). Adams and colleagues' (2008) findings suggest that people occupied the Lahontan Basin when shallow lakes and marshes, rather than deep lakes, covered the valley bottoms. Paleoindian groups occupied nearshore locations and, in the western Black Rock Desert, settled around a deltaic system. This pattern stands in contrast to later Archaic groups, who apparently occupied a wider range of environments (Adams et al. 2008).

Adams and colleagues' (2008) study prompted Mohr (2018) to further explore the possibility that Paleoindian sites in the Lahontan Basin clustered around 1200-1235 m ASL – the elevation range in which Lake Lahontan varied during the Younger Dryas. She concluded that lake-level fluctuations greater than this elevation range occurred during the late Pleistocene and suggested that burial and redeposition may account for some of the early sites' deviations from the 1200-1235 m ASL range (Mohr 2018). Mohr (2018) also suggested that higher elevation sites may reflect people leaving marsh-side camps to hunt large game or travel between wetland camps. Conversely, lower elevation sites may represent places where people followed the receding marshes at end of the Younger Dryas.

While researchers have studied Lake Lahontan in detail, smaller lake basins are increasing featured in Great Basin studies. Wriston and Smith (2017) investigated the lake-level history and archaeological record of Warner Valley in the northwestern Great Basin. They used geomorphic and sedimentological analyses to reconstruct the history of Lake Warner and found that the lake likely reached its highstand between 18,340 and 14,385 cal BP, with subsequent transgressions and regressions (Wriston and Smith 2017). Stemmed and Clovis points cluster just above the 1390 m ASL shoreline, dated to around

12,800 cal BP. Clovis points disappeared with the lake’s regression but people continued to discard WST points along its shore as the lake moved southward (Smith et al. 2015; Wriston and Smith 2017). Although lakes continued to desiccate during the early and middle Holocene, wetlands persisted, and people continued to occupy Warner Valley throughout the Holocene (Wriston and Smith 2017; Young 2000). Warner Valley has thus provided information both about how smaller lakes responded to changing climate conditions and how hunter-gatherers adapted to these changes.

Correlating the ages of archaeological sites, landforms, and geologic sequences can be problematic without appropriate methodologies. Often archaeological sites can deflate onto older landforms or become redeposited via post-depositional processes. Research in the Dietz Basin in Lake County, Oregon has highlighted this fact and demonstrates the important role that geoarchaeology plays in archaeological investigations. Willig (1984) conducted geoarchaeological investigations to determine if Clovis and WST sites found at different elevations correlated with different lake highstands to help place those sites into a relative chronological sequence. Because she did not find material to directly date either the lakestands or the archaeological sites, Willig (1984) used archaeological site and wave-cut terrace elevations and trench profiles to generate lake-level and cultural histories. She determined that Clovis point users occupied the Dietz Basin following the lake’s highstand when a shallow lake was present, and that Clovis point users visited the area before WST point users, who occupied the basin when a prograding shallow lake returned after the initial Clovis lake retreat (Willig 1989). In her subsequent work in the Dietz Basin, Pinson (2008) noted a lack of sedimentological evidence supporting Willig’s lake-level sequence and evaluated

Willig's hypothesis through an extensive backhoe trenching program. Pinson (2008) used pumice, radiocarbon dating, and relative dating along with the elevations of Clovis and WST projectile points to construct a natural and cultural history of the Dietz Basin. Pinson (2008) found both projectile point types on the same buried surfaces that deposited after the pluvial lake deposits. The last lakestand predated both occupations and, at most, a wet meadow covered the basin floor during the Younger Dryas. This case study demonstrates the inherent biases in relating shoreline terraces with archaeological sites and stratigraphy. To avoid these problems, researchers need detailed descriptions, dating methods, and multiple profiles to accurately characterize the history of a lake basin and how and when people used it.

Reconstructing lake histories may also determine whether a basin held a lake or wetland during human occupation. The Great Basin followed the same general patterns of environmental change during the late Pleistocene and Holocene, but local conditions varied. In turn, such differences probably influenced how groups living in those areas altered their lifeways. This interplay between environmental and cultural change may have produced unique cultural histories for each lake basin. Lakes occupied many basins, but some predated humans' use of those areas (Beck and Jones 2009), while other places saw Paleoindian occupation along stream or river channels rather than lakeshores (Reaux et al. 2018). Just east of the Black Rock Desert, Smith and colleagues (2004) recorded Paleoindian points around springs, now dried. Productive marshes require minerals, shallow water (<1.8 m), and specific water chemistry (Hamilton and Auble 1993; Young 2000). Low-grade deltaic systems often foster productive palustrine habitats by adding minerals to lake waters. These deltaic systems attracted early groups, as evident in the large archaeological sites situated on and along these channels (e.g., Reaux et al. 2018); however, with high local to non-local toolstone ratios, groups likely occupied places like Guano Valley's Catnip Creek Delta for frequent but short stays rather than prolonged periods (Reaux 2020). This variability in the timing and locations of lake, marsh, spring, and stream systems, and humans' use of those places, demonstrates the complexity of understanding hunter-gatherer settlement and subsistence systems and the need to consider multiple factors when inferring human decision-making from the archaeological record.

Other basins show little evidence of late Pleistocene occupations despite the fact that they held lakes or marshes (Leach 1988; McGonagle 1979; O'Connell 1975). Lake-level, basin shape, and water chemistry control marsh productivity (Hamilton and Auble 1993; Young 2000), so these basins and the lakes they held may have lacked factors important to grow productive emergent vegetation. Shallow versus steep-sided basins can promote or hinder marsh habitat formation since vegetation development is limited to <1.8 m of water (Young 2000). Gradually sloping basins tend to offer more littoral area, which can lead to more marsh habitat; however, such basins generally require more time and water to increase in depth (Young 2000; Figure 1.2). Conversely, steeply sloping basins offer less littoral area and, consequently, less marsh habitat, but they tend to fill more quickly (Young 2000; see Figure 1.2). This variability in basin morphology can result in asynchronous periods of resource productivity and, in turn, human use (Young 2000). Periods of low marsh productivity seem to have contributed to less human occupation or even abandonment in drier basins and long-term residential stays in more productive basins (Kelly 2001; Mensing et al. 2008; Smith et al. 2017; Wriston and Smith

2017; Young 2000). Additionally, steeply sloping basins usually form erosional features such as shorelines, whereas gradually sloping basins form barriers and spits (Reheis et al. 2014). Basins with many embayments, peninsulas, or headlands result in more surface area for marsh habitats and human occupation (Waters 1997; Young 2000; Figure 1.3). While there were later occupations within these basins, they tended to focus on streams and springs rather than lake margins (Leach 1988; McGonagle 1979; O'Connell 1975).

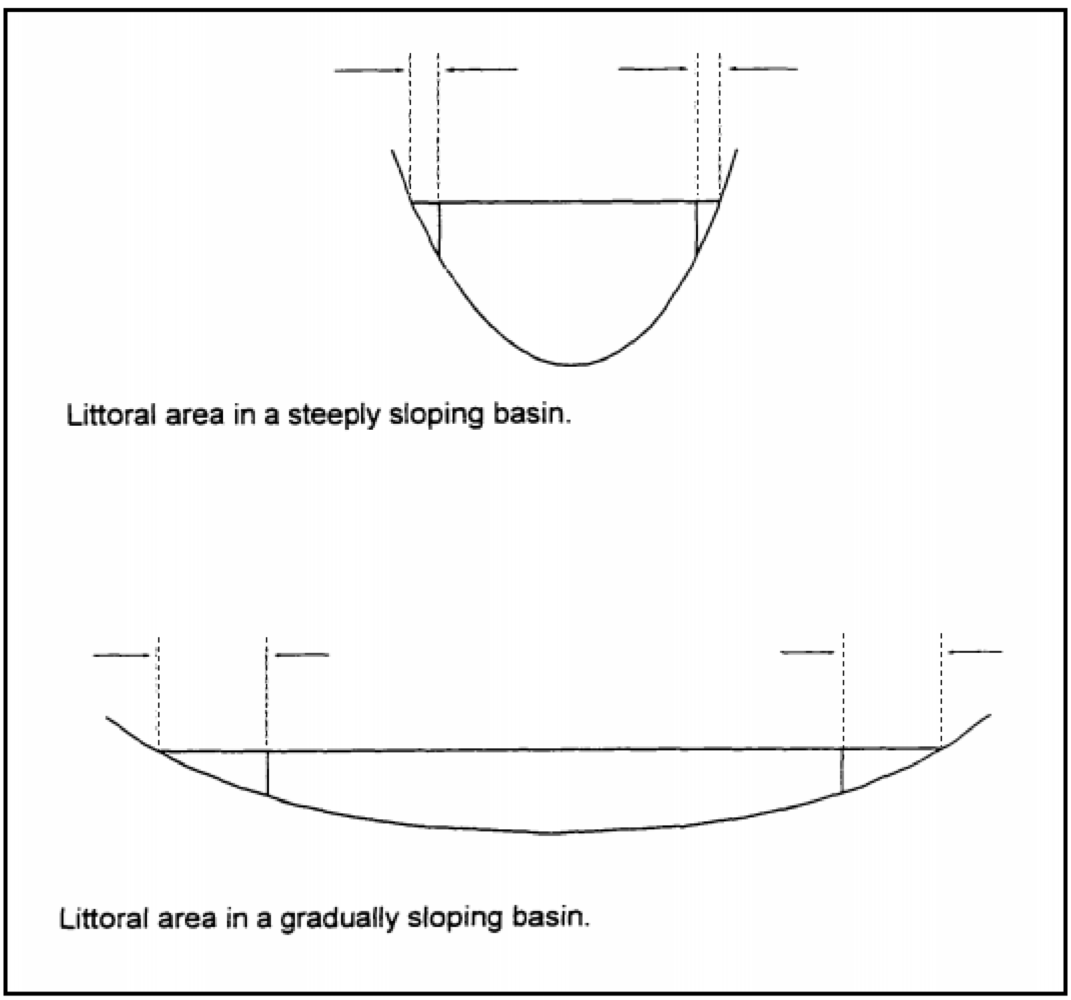

Figure 1.2. Schematic comparison of littoral areas of generalized basin shapes (adapted from Young 2000).

Hydrologic Modeling

Hydrologic models can correlate climate change with archaeological data and estimate marsh potential. In the Great Basin, hydrologic models have generally focused on larger lake systems like Lake Lahontan (Hostetler and Benson 1990) and Lake Bonneville (Ibarra et al. 2019) or regional changes in lake systems (Matsubara and Howard 2009). Hostetler and Benson (1990) used a thermal evaporation model to determine the magnitude of climate changes needed to form Lake Lahontan's highstand at 15,500 cal BP (Adams and Rhodes 2019). They found that a 42% reduction in the evaporation rate and an increase of 1.8 times the historical precipitation rate was required to produce the lake highstand and suggested the jet stream's position drove increased moisture into the northern Great Basin (Hostetler and Benson 1990). On the other hand, Ibarra and colleagues (2018) modeled precipitation multipliers needed to form the Bonneville shoreline highstand at 18,500 cal BP and the Provo shoreline stillstand around 15,000 cal BP (Miller et al. 2015). They determined that the Bonneville highstand required a 37% increase in annual precipitation whereas the Provo stillstand required a 26% increase in annual precipitation (Ibarra et al. 2019).

Matsubara and Howard (2009) then compared Lake Manly in eastern California to both Lake Lahontan and Lake Bonneville and found that Lake Manly required wetter climate conditions during the late Pleistocene than the larger lake systems. They suggested that the polar jet stream had a greater effect in the southern Great Basin and/or groundwater contributed to increased input into the basin (Matsubara and Howard 2009). In the Great Basin, groundwater proxies tend to be deemed as negligible and are generally excluded from hydrologic models (e.g., Ibarra et al. 2014); however, this assumption is often exaggerated and can lead to inaccurate simulations (Matsubara and Howard 2009). While basaltic bedrock tends to prevent near-surface groundwater accumulation (Ibarra et al. 2014), bedrock composed of sedimentary rocks, especially limestones, tend to have a near-surface groundwater table that can affect the local hydrologic system (Matsubara and Howard 2009). USGS geologic maps and websites such as the Web Soil Survey provide bedrock and sediment information throughout the United States and can be used to determine the likelihood of groundwater contributions.

Within the past 10 years, research has shifted to small basin systems to better understand local climate changes and regional variability (Barth et al. 2016; Hatchett et al. 2015; Ibarra et al. 2014). Smaller systems respond more rapidly to climate changes than larger systems (Barth et al. 2016), so researchers frequently use them in paleoenvironmental studies. Studies of smaller basins have incorporated pluvial lake histories but lack archaeological comparisons and interpretations (Barth et al. 2016; Hatchett et al. 2015; Hudson et al. 2019). Numerous studies have demonstrated variability in lake response throughout the Great Basin during the late Pleistocene. Barth and colleagues (2016) used a modified water balance model with additional area-specific proxies to reconstruct Jakes Lake, a small lake that once covered Jakes Valley in the central Great Basin. They determined that a range of ΔT (0 to -8 ºC) and ΔP (1.9-2.4) from the modern climate was needed to generate a lake highstand at 16,800 cal BP. Hudson and colleagues (2019) then reconstructed a lake-level curve for Lake Chewaucan in the northwestern Great Basin. They found that Lake Chewaucan reached its highstand at 14,500-13,400 cal BP before separating into the Lake Abert and Summer Lake subbasins. Lake Abert then reached a lakestand at 11,500-9500 cal BP with no evidence to support a similar lakestand in the Summer Lake sub-basin (Hudson et al. 2019). This record contrasts with those from other basins with highstands that took place earlier during the Late Glacial period, also known as the Heinrich Stadial 1b (HS1b) (16,100-14,600 cal BP), or a little later during the Younger Dryas (Adams and Rhodes 2019; Barth et al. 2016; Hudson et al. 2019; Kirby et al. 2018; Munroe and Laabs 2013). Hudson and colleagues (2019) suggested that this dichotomy was the result of a wet/dry dipole with a transition zone along 40ºN latitude. Climatic simulations revealed a shift of atmospheric circulation cells southward during the HS1b and a retreat northward with the Laurentide retreat, increasing precipitation in the northwestern Great Basin (Hudson et al. 2019); however, the forces behind the proposed dipole remains ambiguous.

Ibarra and others (2014) demonstrated that Lake Surprise rose rapidly in response to increased precipitation from westerly storm tracks at 15,100 cal BP but gradually regressed until 10,700 cal BP before completely desiccating. Egger and colleagues' (2018) model showed that an increase of 35% annual precipitation relative to modern with a 5°C decrease in mean annual temperature generated a lake during the Late Glacial period in Surprise Valley. Their modelling has also indicated that Lake Surprise's highstand represented a rapid shift in the westerly storm tracks to northern California (Egger et al. 2018) and/or Lake Surprise marked the transition zone between the north/south dipole (Hudson et al. 2019). On the other hand, other basins' lake-levels fluctuated throughout the late Pleistocene. Lake Warner reached its highstand ~17,000-16,100 cal BP before it began to recede, with an additional transgression at 12,800 cal BP (Wriston and Smith 2017). Lake Warner never returned after the Younger Dryas, and for

Lake Alkali even cooler conditions during the Younger Dryas failed to revive the lake (Pinson 2008). Continued hydrologic modeling may reveal details regarding the climatic variability and local responses of these northwestern basins.

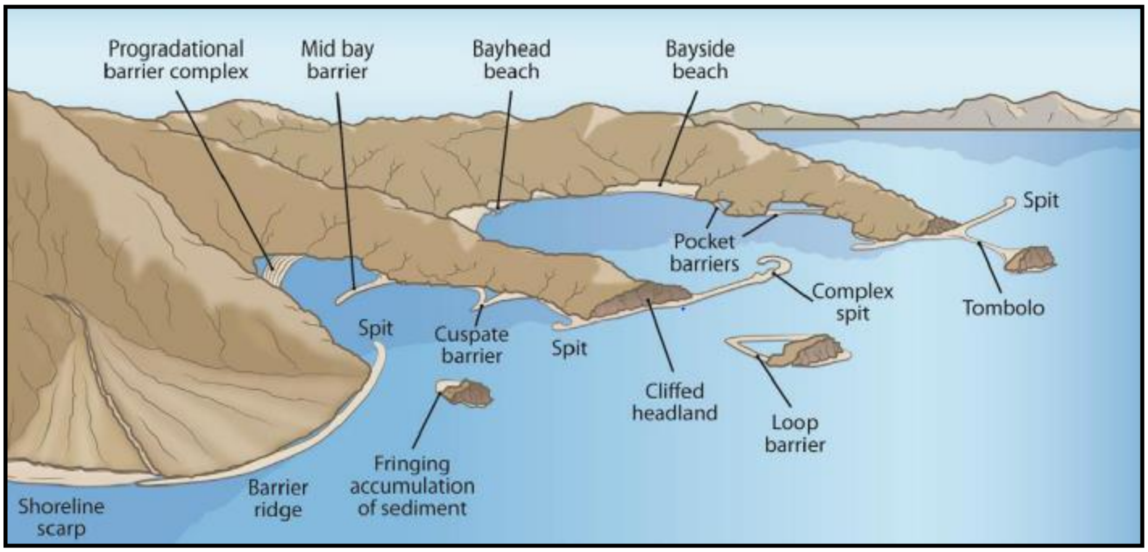

Figure 1.3. Shoreline features found around margins of pluvial lake basins (adapted from Reheis et al. 2014).

While most studies focus on the late Pleistocene, Hatchett et al. (2015) looked at the late Holocene levels of Walker Lake. They determined that 50-year wet cycles could result in increased lake-levels while a drought of 60-200 years was required to cause lake regression (Hatchett et al. 2015). Hatchett and others (2018) then investigated how enhanced or reduced storm track activity and moisture transport effected lake-levels throughout the late Holocene using a coupled water balance and lake evaporation model at Walker Lake. They found that the control simulation and lower reductions in storm track activity and moisture transport (on the order of ΔP [1.0-1.01]) produced lake-levels similar to those recorded during the Neopluvial period, Medieval pluvial (880-830 cal BP), and Little Ice Age (600-100 cal BP) (Hatchett et al. 2018). Conversely, moderate and extreme reductions in storm track activity and moisture transport (on the order of ΔP [0.52-0.77]) produced reduced lake-levels similar to those during Medieval Climatic Anomaly droughts (1100-880 cal BP and 830-650 cal BP). These results demonstrate that smaller lake basins respond rapidly to climate changes and, specifically, wetter cycles (Hatchett et al. 2018). Further, lake response on smaller timescales has implications for resource productivity and hunter-gatherer settlement within human lifespans.

Hydrologic modelling is of relevance not only to climate scientists but archaeologists as well. In the Great Basin, only two published studies to date focus on hydrologic modeling and archaeology. Duke and King (2014) used a regional water balance model with incorporated basin bathymetry to predict lake-levels in the Great Basin during the late Pleistocene. For each model iteration, they filled the valleys to their highstand elevations and used an evaporation rate equation to determine water loss every 25 years (Duke and King 2014). Their results showed that while smaller basins responded to climate change more rapidly, the basins potentially fostered marshes for a time before drying out completely (Duke and King 2014). Duke and King's (2014) results also suggest that smaller high elevation basins should only contain early site occupations and that groups should have reduced inter-basin mobility with the decline in lakes. Furthermore, lakes in basins with high groundwater discharge, flowing streams from the uplands, or increased precipitation, may have persisted longer than those in less well-watered basins (Duke and King 2014). Duke and King (2014) then compared three archaeological localities to determine if the occupational histories correlated with their results. They found that a decrease in wetland extent throughout the region resulted in decreased residential mobility indicated by a greater frequency of flake blank tools and an increase in local raw material usage (Duke and King 2014). This study demonstrated that hydrologic modeling on a regional scale can correlate archaeological site occupations to broad cultural trends and provide testable hypotheses for marsh potential in individual basins (e.g., Duke and Young 2018).

Adams (2003) used hydrologic modeling in conjunction with geomorphic data to reconstruct lake-levels in the Carson Sink during the late Holocene. Using a simple water balance model that incorporated evaporation, precipitation, lake volume, and surface area, he produced seven models under different environmental conditions to determine which situations could produce a highstand during the late Holocene (Adams 2003). His findings showed that lakestands likely formed during the late Holocene, contrary to previous interpretations that suggested lakestands only occurred during the late Pleistocene (Adams 2003). Furthermore, the lake's presence would inundate Stillwater Marsh, a wetland with both evidence for extensive human occupation and periodic hiatuses that corresponded to wetter periods (Adams 2003). Adams' (2003) study demonstrates the relationship between archaeological site distributions and lake-level histories during the late Holocene.

Modeling Wetland Potential

Early groups likely targeted marshes more than lakes. Groups seemingly focused on such places for both food and raw materials, as marshes provide a wide variety of resources including plants, waterfowl, fish, and materials for basket manufacture (Madsen and Kelly 2008). Even so, marsh potential varied from basin to basin – something that is reflected in both the archaeological record and climatic reconstructions.

Researchers have modeled the marsh potential of past environments to investigate why people favored some basins over others. To reconstruct the cultural history of Warner Valley during the late Holocene, Young (2000) incorporated lake bathymetry and history to estimate wetland potential across time. He then correlated this potential with archaeological sites and inferred cultural settlement and change due to fluctuating resource patches. Young (2000) found that after 2000 cal BP, retreating waters resulted in increased marsh productivity. Late Archaic groups settled along the edges of these marshes, as evinced by the remnants of large residential features (Young 2000). While the Neopluvial period resulted in the rejuvenation of many lakes, Warner Valley's bathymetry resulted in decreased marshlands rather than the increased marshlands noted in other basins (e.g., the Humboldt Sink) (Heizer and Napton 1970; Livingston 1988; Young 2000). Young (2000) determined that rather than changing strategies with resource productivity, people responded by alternating components within a flexible strategy. Instead of fully changing their adaptative strategy, people repositioned themselves on the landscape to account for resource shifts (Young 2000). Young's (2000) ideas offer an alternative view from the longstanding assumption that people substantially altered their settlement-subsistence strategies in response to climate change (Jones and Beck 2012).

To examine the correlation between marsh potential and archaeological site distributions, Duke and Young (2018) compared two basins, Cave and Lake valleys, and their respective lake highstands. They based their predictions on Duke and King's (2014) study that predicted lake-levels at different intervals using hydrologic modeling. Duke and King (2014) predicted that those pluvial lakes that desiccated earlier should contain mostly early Paleoindian sites. In Duke and King's (2014) model, Lake Cave lasted one iteration while Lake Carpenter (the lake that occupied Lake Valley) lasted three. Using these results to develop their expectations, Duke and Young (2018) found that both lakes were relatively deep and expansive with linear margins, but they reacted differently during early Holocene climate change. Cave Valley contained north-south trending distributary channels that promoted productive habitats during mesic conditions; however, its system was sensitive to climate change and fluctuated greatly. Lake Valley's Lake Carpenter is lower in elevation and formed a series of small lakes supported by groundwater into the Holocene. Differing frequencies of time-sensitive projectile points and sites corresponded to Duke and Young's (2018) predictions. Cave Valley contained mostly early Paleoindian occupations while Lake Valley contained more late Paleoindian occupations (Duke and Young 2018). Their study demonstrates the importance of individual basins' characteristics and histories in constructing a cultural history for a locality.

Summary

Researchers in the Great Basin have long focused on pluvial lake basins to reconstruct past environments and human settlement patterns. Sedimentological analysis together with hydrologic modeling has expanded our understanding of how basins respond to changing climatic conditions. These responses often include increases and decreases in marsh potential, which in turn influenced people's decisions on where and when to visit different places. These studies, coupled with the special distribution of time-sensitive projectile points and provenance studies, allow archaeologists to understand hunter-gatherer lifeways and how they changed across time. Painters Flat provides an opportunity to look at climate change and the resulting shifts in environmental conditions in a small upland basin. Painters Flat contains evidence of human occupations during various cultural periods, providing an opportunity to understand how humans responded to these changes.

CHAPTER 2

MATERIALS AND METHODS

In this chapter, I provide an overview of the natural, ethnographic, and archaeological history of Painters Flat that is currently available. I then discuss the geologic and archaeological materials that I used to construct Painters Flat's history. I explain the methodologies that I used including stratigraphic profiling, landform identification, archaeological site distributions, projectile point classifications, marsh potential modeling, and hydrologic modeling. Finally, I outline my hypotheses and expectations for the geomorphic and archaeological history of Painters Flat and how it may fit into previous northwestern Great Basin studies.

Study Area Background

The Natural History of Painters Flat

Painters Flat is a small basin located at 40.8ºN latitude along the California-Nevada border (Figure 2.1). The basin measures 8 km long by 6 km wide and the basin floor sits at 1715 m ASL. Today, Painters Flat's basin floor is occupied by a seasonally wet meadow with playa sediments covering the meadow's margins. Two elevated "islands" sit on the basin floor to the northwest and southeast at about 1722 m ASL. The Cottonwood Delta, which features active fluvial channels, lies to the northeast. The basin’s sill, which is consists of a Holocene fan dissected by arroyo channels, lies to the northwest (see Figure 2.1). Seasonally active springs are distributed throughout the surrounding uplands, in particular to the west and southeast (see Figure 2.1). Vegetation consists of both xeric and mesic taxa including greasewood (*Sarcobatus vermiculatus*) on the playa, and big sagebrush (*Artemisia tridentata*), rabbitbrush (*Ericameria nauseosa*), lupine (*Lupinus* sp.), and bunchgrasses (e.g., Great Basin wild rye [*Leymus cinereus*]) on the basin floor and along the channels. Mule deer (*Odocoileus hemionus*), pronghorn (*Antilocapra americana*), jackrabbits (*Lepus* sp.), wild horses (*Equus ferus*), and domestic cattle (*Bos primigenius taurus*) are common throughout the area. The Bureau of Land Management (BLM) manages much of Painter’s Flat but some land around the Cottonwood Delta is privately owned.

Prior to my work, which took place as part of a larger undertaking by Far Western Anthropological Research Group (FWARG), the basin had never been described in detail and available information was limited to aerial imagery, archaeological surveys in the surrounding uplands, and a possible lake feature on a reconnaissance in 2018 (D. Craig Young, personal communication, 2020). Using aerial imagery, I identified possible shorelines and channel systems for geomorphic investigation. General information on Painters Flat’s geologic bedrock is available at the state level and geomorphic and soils series data are available at the county level (NRCS 2020). I created maps using Esri’s ArcGIS 10.7.1 and included the USDA-NRCS Soil Survey Geographic database (SSURGO) and the USGS State Geologic Map Compilation (SGMC) Geodatabase. I clipped these datasets to the 12-digit watershed obtained from the USGS-NRCS Geospatial Data Gateway. Geologic maps indicate that the basin floor consists of

Quaternary lake, alluvium, and marine deposits (Figure 2.2). In the surrounding uplands, bedrock consists of Tertiary (2-24 mya) volcanic flow rocks – mostly Miocene (5-24 mya) basalts and Pliocene (2-5 mya) andesites (see Figure 2.2; Horton et al. 2017). The basin and the surrounding watershed have no recorded faults; however, predominately north-south trending faults occur to the northwest and northeast of Painters Flat (Horton et al. 2017; see Figure 2.2). Major geomorphic landforms consist of mountains, plateaus, and the basin floor. Minor landforms include floodplains, alluvial plains, fan piedmonts, and fan remnants (Figure 2.3). I targeted these minor landforms in my geomorphic investigations since they are most likely to preserve late Pleistocene and Holocene deposits (Peterson 1981). I also identified and mapped potential strandlines noted on a previous investigation (D. Craig Young, personal communication, 2020). Finally, soils orders included Aridisols (warm arid soils with an A horizon over a weak B horizon), Mollisols (warm semi-arid soils with dark surface horizons), and Vertisols (soils with swelling clays) (Waters 1997; Figure 2.4). Soils mainly consist of A-Bt-C or R profiles from weathered residuum; however, there are less extensive Epiaquerts, Endoaquolls, and Argixerolls with moderately to well-developed profiles, paleosols, and fine-grained materials that may contain intact late Pleistocene deposits.

Painters Flat is located just east of the Madeline Plains. During the late Pleistocene, Painters' pluvial lake may have drained into pluvial Lake Madeline. Little is known about pluvial Lake Madeline; however, geomorphic fieldwork has revealed lake and shorezone sediments within the basin, as well as a possibly substantial groundwater system (California Groundwater Bulletin 2004). Additionally, geoarchaeological work by Young, reported in McGuire (2002), identified Trego Hot Springs tephra in clay-rich lake deposits. Though not well understood, the histories of Painters Flat's pluvial lake and Lake Madeline likely somewhat mirrored that of the larger Lake Lahontan system to the east during the late Pleistocene.

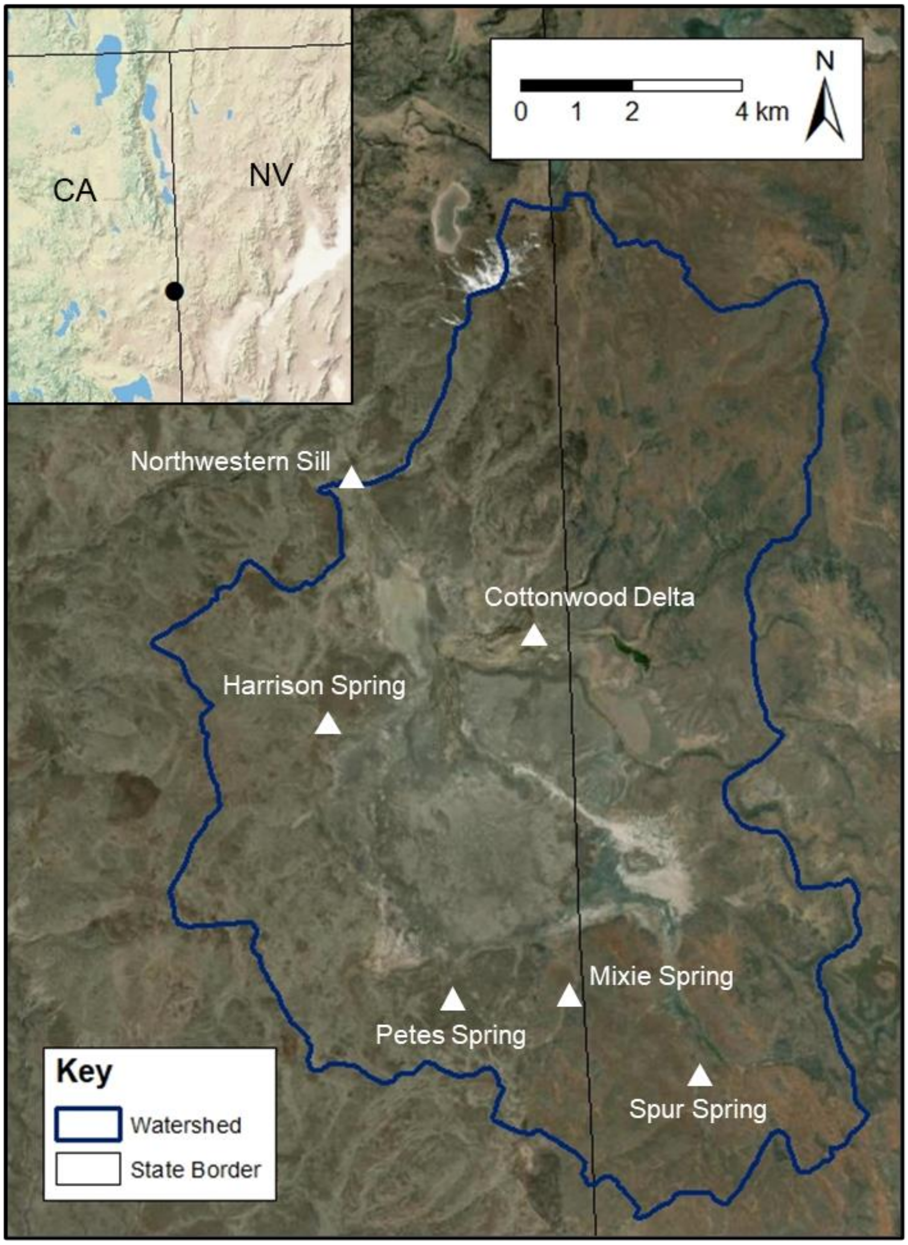

Figure 2.1. Location of Painters Flat and its delta, sill, and springs.

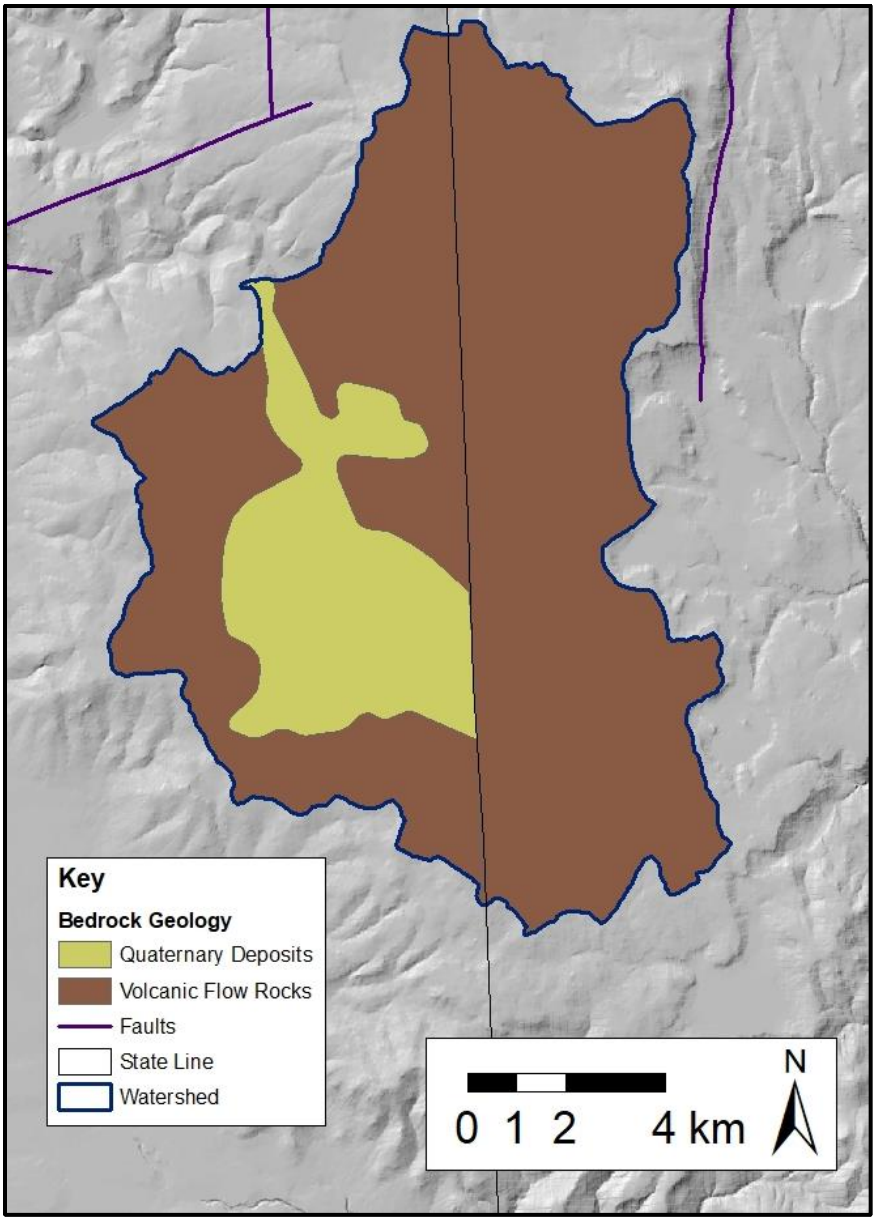

Figure 2.2. Bedrock geology of the Painters Flat Basin and watershed.

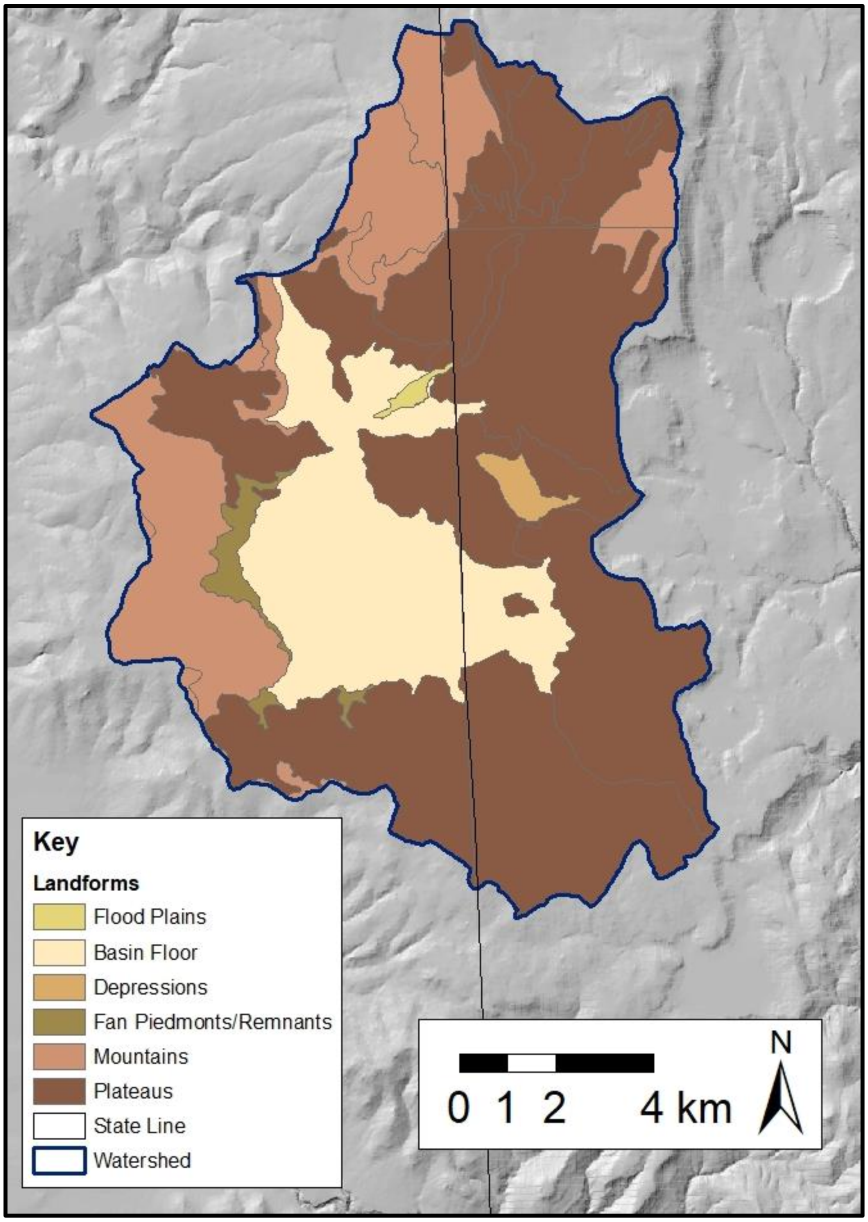

Figure 2.3. Geomorphic landforms in the Painters Flat Basin and watershed.

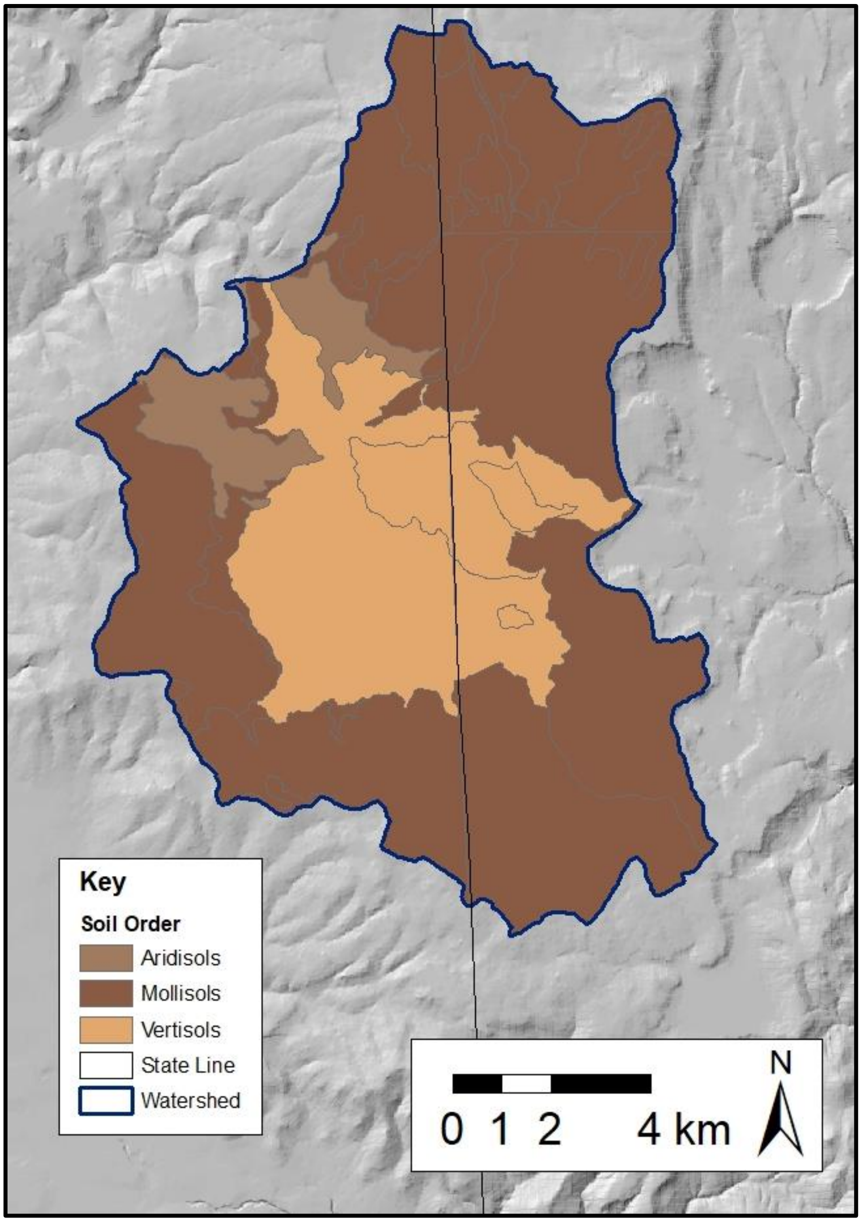

Figure 2.4. Soil orders in the Painters Flat Basin and watershed.

Ethnographic Background

Painters Flat is located in the Numu's (Northern Paiute) traditional lands (Fowler and Beierle 2012). The *Kamödökadö* ("jack rabbit-eaters") occupied the area around

Painters Flat, although the neighboring *Wadadökadö* ("wada seed-eaters") also periodically visited the area (Stewart 1939; Tiley and Rucks 2011). The eastern half of the Madeline Plains from McDonald Peak to Horse Lake acted as a boundary between these Numu groups and the neighboring Achomawi (Pit River Tribe) (Riddell 1960). Trade and marriage occurred between the Numu, Achomawi, and other nearby groups such as the Maidu and Washoe (Tiley and Rucks 2011).

Ethnographically, these groups hunted and gathered, spending winters in Granite Basin hunting rabbits (Fowler and Beierle 2012; Tiley and Rucks 2011). The Numu avoided the Madeline Plains and, likely, Painters Flat in the winter due to colder conditions (Riddell 1960). In the spring, the *Kamödökadö* moved southwest, with the youngest and oldest members of the group making their way to Secret and Honey Lake valleys (Tiley and Rucks 2011). The rest of the group would continue to Pyramid Lake to trade rabbit skin blankets and buckskin for cui-ui, later rejoining the young and old members in Secret Valley in late summer (Tiley and Rucks 2011). Groups often congregated in neighboring valleys to hunt and gather. The *Kamödökadö*, *Wadadökadö*, and, occasionally, the Achomawi gathered on the Madeline Plains for antelope and rabbit drives (Riddell 1960; Tiley and Rucks 2011). Archaeologists have found large village sites that likely reflect these gatherings in the Madeline Plains (Riddell 1960). Periodic hunting forays into the Madeline Plains and Painters Flat from Secret Valley also occurred until September (Riddell 1960; Tiley and Rucks 2011). After September, the *Kamödökadö* would travel northeast to Leadville on their way to Granite Basin for the winter, passing near Painters Flat (Tiley and Rucks 2011). A second group would alternatively travel to the Sunrise Pass for pinenuts before traveling to Granite Basin

(Tiley and Rucks 2011). While groups' seasonal rounds focused on valleys that contained reliable resources for the winter, in the summer hunting and gathering parties made multiple forays based on the annual productivity of an area (Tiley and Rucks 2011). Overall, these ethnographic accounts describe valleys as resource-rich areas – something that the archaeological record also suggests, specifically in the Madeline Plains where archaeologists have recorded large residential sites (Tiley and Rucks 2011).

Previous Archaeological Research

Though little archaeological work has been carried out in Painters Flat, northwestern Nevada has been the subject of more than 50 years of intensive investigations. This work has demonstrated that people have called the area home since the late Pleistocene. In general, the first visitors – Paleoindians – focused on pluvial lakeshores and marshes (Smith and Barker 2017). With the onset of the middle Holocene, occupations shifted to springs and canyon drainages (Hildebrandt et al. 2016; McGonagle 1979). After the middle Holocene, Middle Archaic hunter-gatherers expanded to basin floors, drainages, and uplands (Leach 1988). That said, because individual basins respond differently to climate change, so too did the groups who occupied those different basins. The few BLM surveys that have taken place in Painters Flat have revealed a small amount of archaeological material concentrated along a probable shoreline and upland springs (Figure 2.5). This work has produced 26 recorded sites and six isolates in the basin and surrounding uplands (see Figure 2.5; Tables 2.1 and 2.2). Only one survey has taken place on the basin floor and it produced one lithic scatter of unknown age. Most surveys were situated on the uplands adjacent to the basin floor and the springs located there (see Figure 2.5). These sites, both of known and unknown ages, are predominately lithic scatters some of which contain ground stone tools. Ground stone artifacts (n=38) are comprised of millingslabs, handstones, mortars, and pestles mostly clustered around spring drainages above 1731 m ASL. Rock stacks are relatively common near the springs and on mountain slopes with hunting blinds and rock art recorded as well. While most recorded sites are of unknown age (n=19), those sites containing time-sensitive artifacts are evenly spread across different cultural periods (Figure 2.6; Tables 2.1 and 2.2), including some late Pleistocene or early Holocene markers (four WST projectile points including one Parman and one Windust point). Painters Flat shows a similar trend as other northwestern basins in that there seems to have been a decrease in post-Mazama occupations (Leach 1988; McGonagle 1979); however, the even spread of projectile points differ from other basins that either contain large Paleoindian assemblages (Reaux et al. 2018; Smith et al. 2017) or almost no Paleoindian sites (Leach 1988; O’Connell 1975). Previous surveys in the Madeline Plains show dominantly Middle Archaic projectile points (n=251) and smaller post-Mazama (n=25) and Early Archaic (n=17) assemblages (Delacorte and Basgall 2012). The goals of my fieldwork included determining if Painters Flat mirrored Lake Madeline’s geomorphic history and use by indigenous populations.

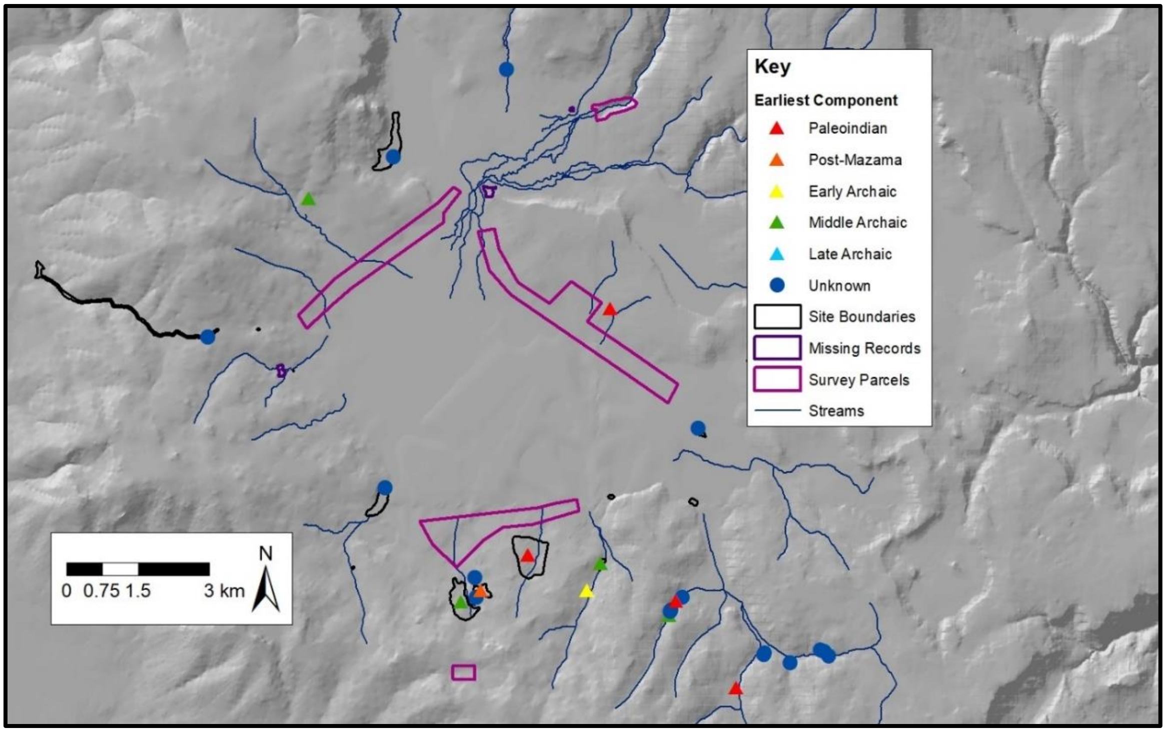

Figure 2.5. Previously recorded sites and survey parcels for the 2020 field season.

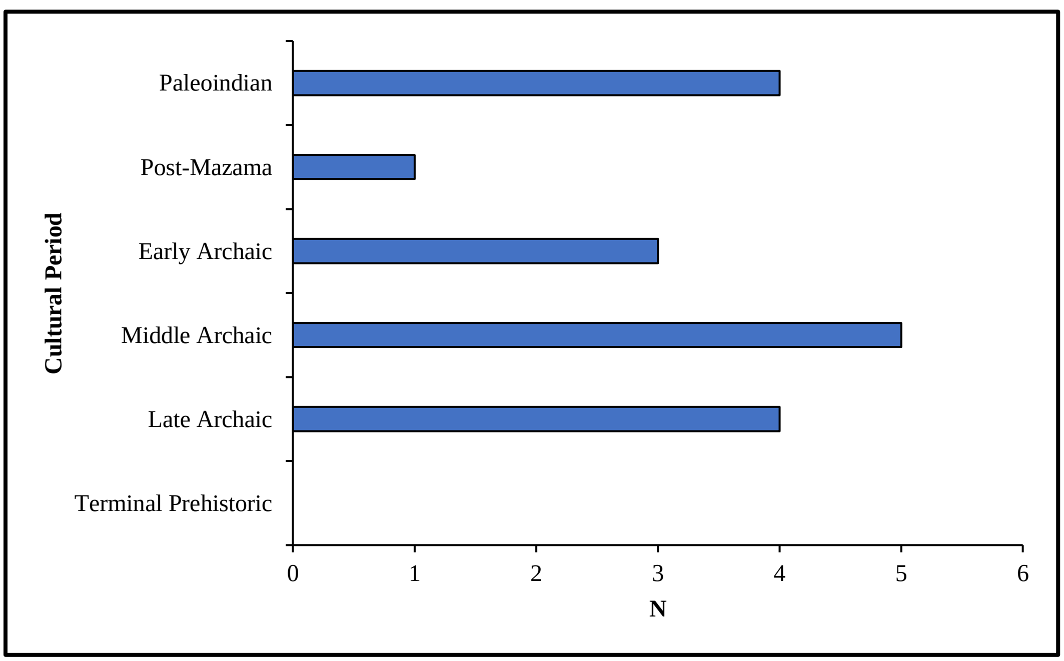

Figure 2.6. Previously recorded component ages of archaeological sites in Painters Flat.

Table 2.1. Projectile Points Assigned to Specific Cultural Periods (adapted from Martin et al. 2018; Rosencrance et al. 2020; Smith and Barker 2017; Thomas 1981).

Cultural Period	**Cal BP Range**
Paleoindian	pre-8000
Western Stemmed Tradition	~13,000-8800
Parman	~11,200-8800
Windust	~11,200-8900
Crescent	~12,500-8000
Concave Base	pre-8000
Post-Mazama	~8000-4500
Northern Side-notched	~7000-4500
Early Archaic	~4500-3800
Gatecliff Series	~4500-2000
Middle Archaic	~3800-1300
Humboldt	~4900-1200
Elko Series	~4500-1000
Late Archaic	~1300-600
Rosegate	~1800-600
Terminal Prehistoric	Post-600
Desert Side-notched	~600-200

Table 2.2. Previously Recorded Archaeological Sites.

Site Number	Site Type	Cultural Periods	Elevation (m ASL)	Diagnostic Artifacts	Record/Report Number
33.17.03.01	Lithic scatter	Unknown	1716	N/A	SU2-2013-25
33.17.11.01	Petroglyphs/groundstone assemblage/lithic scatter	Middle Archaic/Late Archaic/Historic	1749	Elko Eared and Rosegate	SU2-2016-11
33.17.11.02	Lithic scatter/rock feature/groundstone assemblage	Unknown	1757	N/A	SU2-2016-11
33.17.11.03	Groundstone assemblage	Post-Mazama/Early Archaic/Middle Archaic/Late Archaic	1756	Northern Side-notched, Elko Series, Gatecliff Series, and Rosegate Series	SU2-2016-11
33.17.11.04	Lithic scatter	Unknown	1736	N/A	SU2-2016-11
33.17.11.05	Lithic scatter/rock feature	Paleoindian/Early Archaic	1739	Parman and Gatecliff Split Stem	SU2-2016-11
33.17.12.25	Lithic scatter	Early Archaic	1737	Gatecliff Split Stem	SU2-2013-06
33.17.12.26	Lithic scatter	Middle Archaic/Late Archaic	1731	Elko Series, Rosegate, and Gypsum	SU2-2013-06
33.17.13.01	Lithic scatter	Unknown	1724	N/A	BLM
33.18.04.02	Lithic scatter	Unknown	1727	N/A	BLM
33.18.05.00	Lithic scatter	Unknown	1716	N/A	SU2-2010-19
33.18.08.25	Lithic scatter	Unknown	1716	N/A	SU2-2013-06
34.17.13.01	Lithic scatter	Not available	1722	N/A	BLM
34.17.14.01	Petroglyphs	Unknown	1750	N/A	BLM
34.17.21.01	Lithic scatter	Middle Archaic	1743	Elko Eared	BLM
34.17.22.01	Lithic scatter	Unknown	1719	N/A	SU2-2013-25
34.17.23.01	Lithic scatter	Not available	1721	N/A	SU2-2018-20
34.17.32.25	Rock feature	Unknown	1786	N/A	SU2-2013-06
34.17.33.01	Lithic scatter	Not available	1732	N/A	SU2-2015-05

Site Number	Site Type	Cultural Periods	Elevation (m ASL)	Diagnostic Artifacts	Record/Report Number
35.16.11.01	Lithic scatter	Unknown	1718	N/A	SU2-2010-19
33.18.16.26	Groundstone assemblage	Unknown	1743	N/A	SU2-2016-11
33.18.16.02	Lithic scatter	Unknown	1744	N/A	SU2-2016-11
33.18.21.25	Groundstone assemblage/lithic scatter	Paleoindian/Late Archaic	1737	Western Stemmed Tradition, Foliate, and Rosegate	SU2-2016-11
33.18.16.01	Groundstone assemblage/lithic scatter	Unknown	1732	N/A	SU2-2016-11
33.18.17.02	Lithic scatter	Unknown	1735	N/A	SU2-2016-11
33.18.17.01	Lithic scatter	Unknown	1752	N/A	SU2-2016-11
ISO-23	Isolate	Paleoindian	1728	WST	SU2-2016-11
ISO-43	Isolate	Unknown	1743	N/A	SU2-2016-11
ISO-44	Isolate	Unknown	1733	N/A	SU2-2016-11
ISO-40	Isolate	Middle Archaic	1762	Elko Eared	SU2-2016-11
ISO-41	Isolate	Unknown	1754	N/A	SU2-2016-11
ISO-42	Isolate	Paleoindian	1740	Windust	SU2-2016-11

Materials

Geologic Materials

I collected sediments including tephra samples for analyses from both exposures and auger profiles. Sediments included bulk carbon samples for radiocarbon dating and sediments likely to contain ostracod fossils. I sampled sediments in 10-cm thick sections unless the sediment package was too thin or the sediment composition required a larger sample area. I collected sediments for laser particle size analysis (LPSA) from two exposures. For comparisons, I took samples from each visible stratum and horizon 5 cm from the top and bottom of each boundary.

Archaeological Surveys

Part of the impetus for my Painters Flat research was FWARG's agreement with the BLM to survey parcels in the northwest, northeast, and south-central margins of the basin. I worked with FWARG to collect spatial, technological, and chronological data for archaeological sites within Painters Flat. For my work, I focused on the presence and location of time-sensitive projectile points because they offer some degree of chronological control for sites that might not otherwise be dated. I also noted the presence of ground stone implements because they greatly increased in frequency during the middle Holocene and indicate less residentially mobile strategies (Rhode 2008). We recorded 51 sites and 32 isolates in the Painters Flat Basin and watershed (Table 2.3). Of these, 33% (n=27) contain ground stone (87 total pieces). Sixty-one percent of the sites and isolates of unknown age (n=51) (see Table 2.3). We recorded 58 diagnostic projectile points that correspond to particular cultural periods (see Figure 2.7; Table 2.3).

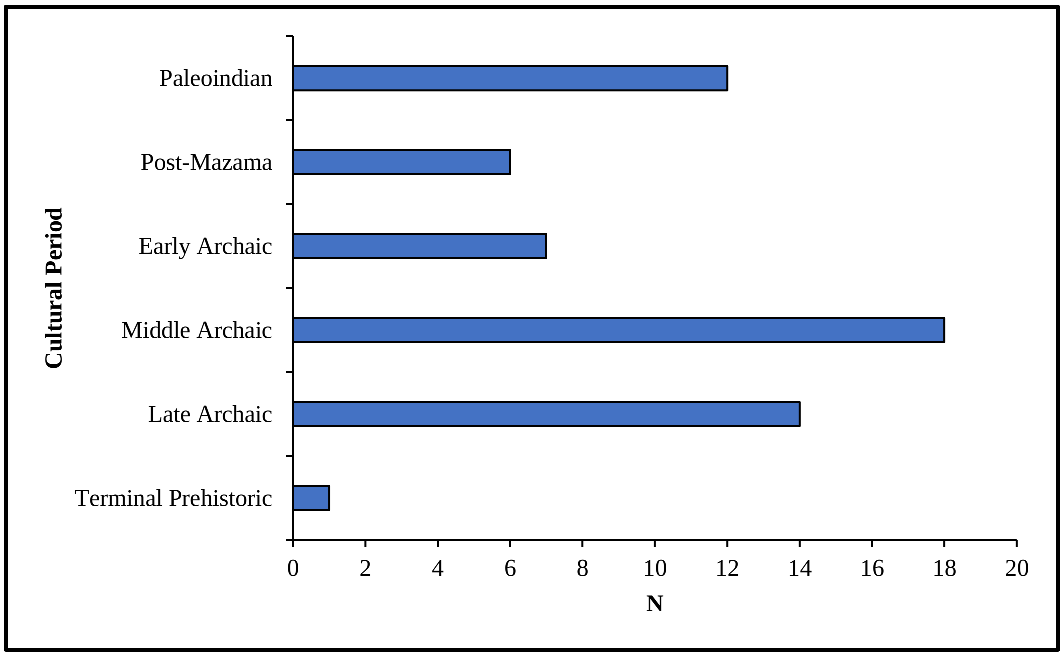

Figure 2.7. Component ages of archaeological sites in Painters Flat.

Table 2.3. Archaeological Sites and Isolates within Painters Flat Recorded in 2020.

Site Number	Type	Site Type	Cultural Periods	Artifact Descriptions[1]
33.17.02.01	Site	Lithic scatter	Unknown	N/A
33.17.02.02	Site	Lithic scatter	Unknown	Bifaces (4), Formed flake tools (2)
33.17.02.03	Site	Lithic scatter	Paleoindian	Projectile point (Concave Base [1])
33.17.02.04	Site	Lithic scatter	Unknown	Core
33.17.02.05	Site	Lithic scatter	Unknown	Bifaces (3), Formed flake tool, Handstone
33.17.10.02	Site	Lithic scatter	Post-Mazama	Bifaces (6), Flake tools (2), Formed flake tool, Handstones (2), Portable slabs (12), Projectile points (5, Northern Side-notched [2])
33.17.02.06	Site	Lithic scatter	Middle and Late Archaic	Flake tools (2), Portable slab, Projectile point (Elko Eared [1], Rosegate [1])
33.17.02.07	Site	Lithic scatter	Unknown	Bifaces (2), Handstone, Portable slab
33.17.02.08	Site	Lithic scatter	Middle Archaic	Bifaces (6), Flake tools (2), Formed flake tool, Portable slabs (10), Projectile points (Elko Eared [1], Humboldt [1])
33.17.11.06	Site	Lithic scatter	Unknown	Biface, Portable slabs (2)
33.17.11.07	Site	Lithic scatter	Archaic	Drill (Corner-notched [1])
33.17.11.08	Site	Lithic scatter	Early Archaic	Projectile point (Gatecliff Split Stem [1])
34.17.26.01	Site	Lithic scatter	Middle Archaic	Bifaces (2), Handstone, Portable slab (2), Projectile point (Elko Eared [1])
34.17.26.02	Site	Lithic scatter	Post-Mazama, Early, Middle, and Late Archaic	Bifaces (3), Flake tool, Formed flake tool, Portable slabs (3), Projectile points (Corner-notched [1], Elko Eared [1], Gatecliff Series [1], Rosegate [2], Northern Side-notched [1])
34.17.26.03	Site	Lithic scatter	Unknown	Biface, Core, Drill, Flake tool, Formed flake tool, Portable slabs (2)
34.17.26.04	Site	Lithic scatter	Late Archaic	Bifaces (3), Flake tool, Handstone, Portable slabs (9), Projectile points (1, Rosegate [1])
34.17.26.05	Site	Lithic scatter	Unknown	Core, Flake tools (2), Portable slab
34.17.23.02	Site	Lithic scatter	Late Archaic	Biface, Handstone, Portable slab, Projectile point (Rosegate [1])

[1] Terms are derived from a FWARG typology (see Martin et al. 2018 for more information).

Site Number	Type	Site Type	Cultural Periods	Artifact Descriptions
34.17.26.06	Site	Lithic scatter	Unknown	N/A
34.17.26.07	Site	Lithic scatter	Late Archaic	Bifaces (4), Flake tools (2), Handstone, Portable slabs (2), Projectile points (Lanceolate [1], Rosegate [1])
34.17.26.08	Site	Lithic scatter	Post-Mazama and Late Archaic	Bifaces (2), Flake tools (2), Formed flake tool, Projectile point (Northern Side-notched [1], Rosegate [1])
34.17.26.09	Site	Lithic scatter	Unknown	Core, Formed flake tool
34.17.26.10	Site	Lithic scatter	Unknown	Bifaces (2)
34.17.26.11	Site	Lithic scatter	Middle Archaic	Bifaces (2), Handstone, Portable slabs (3), Projectile point (Elko Series [1])
34.17.25.01	Site	Lithic scatter	Unknown	N/A
34.17.25.02	Site	Lithic scatter	Unknown	N/A
34.17.25.03	Site	Lithic scatter	Unknown	Biface
34.17.25.04	Site	Lithic scatter	Unknown	N/A
34.17.25.05	Site	Lithic scatter	Unknown	N/A
34.17.25.06	Site	Lithic scatter	Unknown	Biface
34.17.25.07	Site	Lithic scatter	Unknown	Core, Flake tool
34.17.25.08	Site	Lithic scatter	Unknown	N/A
34.17.25.09	Site	Lithic scatter	Unknown	Biface
34.17.25.10	Site	Lithic scatter	Unknown	Formed flake tool
34.17.26.12	Site	Lithic scatter	Paleoindian and Middle Archaic	Bifaces (2), Portable slab, Projectile points (Elko Eared [3], Parman [1])
34.17.26.14	Site	Lithic scatter	Early Archaic	Biface, Projectile point (Gatecliff Series [1])
34.17.26.13	Site	Lithic scatter	Unknown	Bifaces (3), Handstones (2), Portable slab (3)
34.17.33.03	Site	Lithic scatter	Paleoindian	Crescent
ISO-EM-01	Isolate	Lithics	Unknown	Milling fragment
ISO-EM-04	Isolate	Lithics	Unknown	Biface
ISO-EM-05	Isolate	Lithics	Unknown	Biface

Site Number	Type	Site Type	Cultural Periods	Artifact Descriptions
ISO-EM-06	Isolate	Lithics	Unknown	Portable slab
ISO-EM-07	Isolate	Lithics	Unknown	Portable slab
ISO-EM-08	Isolate	Lithics	Unknown	Portable slab
ISO-EM-09	Isolate	Lithics	Unknown	Formed flake tool
ISO-EM-10	Isolate	Lithics	Unknown	Flake tool
ISO-EM-11	Isolate	Lithics	Early Archaic	Projectile point (Gatecliff Split Stem, refit [1])
ISO-EM-12	Isolate	Lithics	Unknown	Flake tool
ISO-EM-13	Isolate	Lithics	Archaic	Projectile point (Corner-notched [1])
ISO-EM-14	Isolate	Lithics	Unknown	Biface
ISO-EM-15	Isolate	Lithics	Unknown	Formed flake tool
ISO-EM-16	Isolate	Lithics	Late Archaic	Projectile point (Rosegate [1])
ISO-EM-17	Isolate	Lithics	Middle Archaic	Projectile point (Elko Series [1])
ISO-EM-18	Isolate	Lithics	Post-Mazama	Projectile point (Northern Side-notched [1])
ISO-EM-19	Isolate	Lithics	Unknown	Biface
ISO-EM-20	Isolate	Lithics	Unknown	Biface
ISO-EM-21	Isolate	Lithics	Unknown	Portable slab
ISO-EM-22	Isolate	Lithics	Unknown	Biface
ISO-EM-23	Isolate	Lithics	Unknown	Flake tool
ISO-EM-24	Isolate	Lithics	Unknown	Biface
ISO-EM-25	Isolate	Lithics	Unknown	Handstone
ISO-EM-26	Isolate	Lithics	Middle Archaic	Projectile point (Elko Series [1])
ISO-EM-28	Isolate	Lithics	Unknown	Biface
ISO-EM-29	Isolate	Lithics	Unknown	Biface
ISO-SR-10	Isolate	Lithics	Unknown	Flake tool
ISO-SR-11	Isolate	Lithics	Middle Archaic	Projectile point (Humboldt [1])

Site Number	Type	Site Type	Cultural Periods	Artifact Descriptions
ISO-SR-12	Isolate	Lithics	Unknown	Flake tool
ISO-SR-13	Isolate	Lithics	Paleoindian	Biface, obsidian, Possible stemmed point midsection, and two small obsidian flakes
ISO-SR-14	Isolate	Lithics	Unknown	Core
ISO-SR-15	Isolate	Lithics	Unknown	Biface
34.18.20.01	Site	Lithic scatter	Late Archaic and Terminal Prehistoric	Formed flake tools (2), Projectile points (Rosegate [1], Desert Side-notched [1])
34.17.23.03	Site	Lithic scatter	Archaic	Bifaces (4), Drill, Formed flake tools (3), Portable slab, Projectile point (Dart [1])
34.17.22.02	Site	Lithic scatter	Unknown	N/A
34.17.22.03	Site	Lithic scatter	Archaic	Formed flake tool, Projectile point (Corner-notched [1])
34.17.27.01	Site	Lithic scatter	Middle Archaic	Portable slabs (2), Projectile point (Elko Corner-notched [1])
34.17.27.02	Site	Lithic scatter	Paleoindian	Bifaces (2), Handstones (2), Portable slabs (4), Projectile points (WST [1], Parman [1])
34.17.28.26	Site	Lithic scatter	Late Archaic	Bifaces (2), Formed flake tool, Handstones (2), Portable slab (1), Projectile point (Rosegate [1])
34.17.27.03	Site	Lithic scatter	Unknown	N/A
34.17.27.04	Site	Lithic scatter	Archaic	Projectile point (Corner-notched - Graver [1])
34.17.28.27	Site	Lithic scatter	Unknown	Biface, Handstones (2), Portable slabs (2),
34.17.28.28	Site	Lithic scatter	Unknown	Biface
33.18.05.02	Site	Lithic scatter	Paleoindian	Projectile point (Western Stemmed Tradition [1])

Methods

Geomorphic Data

To construct Painters Flat's geomorphic history, I collected information about the basin's alluvial system and possible lacustrine setting. Before conducting fieldwork, I identified potential landforms and exposures for investigation using ArcGIS World Imagery, which provides 0.5 m resolution satellite imagery in the continental United States. My methods consisted of both field and lab-based approaches. In terms of field methods, I mapped relevant landforms, augered for subsurface profiles, and documented sediment exposures to identify shoreline/shorezone, wetland, and lacustrine landforms and deposits. For exposures, I recorded stratum and horizon depth, boundary distinctness, texture, color, structure, and noted any soil features or sedimentary structures. For auger profiles, I recorded stratum and horizon depth and boundary distinctness when possible. I guided my observations following Birkland's (1984) soil classifications and Waters' (1997) basic stratigraphic descriptions. For more detailed interpretations, I relied on Stow (2005) for stratigraphic profiles and Reheis (2014) for landforms. For landform identification, I recorded geographic location, shape, extent, and, for depositional landforms, grain size and degree of sorting.

In terms of lab-based methods, I collected sediments to construct a chronology of the basin's hydrologic history using radiocarbon dating and tephra identification. I also collected sediments for LPSA to estimate flow velocity and ostracod identification for approximate water depths. I sent samples for AMS radiocarbon dating to DirectAMS and

Beta Analytic, Inc. These labs obtained bulk sediment dates by sieving the sample to remove modern roots and pretreating it to remove carbonates. I calibrated radiocarbon dates using OxCal 4.4 and the IntCal 20 curve and report ranges within 95.4% probability (Bronk Ramsey 2009; Reimer et al. 2020). I then rounded all dates following the conventions of Stuiver and Polach (1977). I sent tephra samples to the Washington State University's Peter Hooper GeoAnalytical Laboratory for electron microprobe analysis (i.e., identification). Dr. Manuel R. Palacios-Fest at Terra Nostra Earth Sciences Research, LLC identified the ostracod samples. Finally, I sent sediment samples to the Soil Characterization and Quaternary Pedology Laboratory (SCQPL) at the Desert Research Institute for LPSA.

Archaeological Site Distributions

To compare sites and isolates to landforms and environmental settings, I used ArcGIS to display site and projectile point locations. For sites with completed site forms, I used the recorded elevation and coordinates. For isolates and those sites without completed forms, I overlaid the points' coordinates with a 10 m digital elevation model (DEM) from the USGS EROS Data Center available on the Geospatial Data Gateway for Lassen and Washoe counties to estimate elevation. Additionally, I mapped the locations of sites and isolates with ground stone assemblages and noted the ages of the components also present.

Projectile Point Classifications

I generally relied on the in-field projectile point classifications made by the FWARG team and previous site records from the NVCRIS database. In cases where projectile points were not assigned to types in the field, I used images along with Thomas' (1981) Monitor Valley Key to type dart and arrow points, recognizing that the Monitor Valley point types do not necessarily possess the same age ranges in the northwestern Great Basin as they do in the central Great Basin (Smith et al. 2013). I recognized WST points by their shape, size, and presence of diagnostic attributes (e.g., edge grinding, collateral flaking). To assign WST points to specific subtypes (e.g., Parman, Haskett, etc.), I relied on Beck and Jones' (2009) criteria. I assigned all points to defined cultural periods (Table 2.1).

Marsh Potential

To construct the marsh potential of Painters Flat, I measured the surface area of lake margins (≤2 m) since shallow waters promote marsh vegetation growth (Hamilton and Auble 1993; Young 2000). To construct the bathymetry of Painters' pluvial lake, I generated 2 m contour lines from the 10 m DEM and corrected the 1720 m ASL contour line to elevation data for prominent strandlines. The 10 m DEM lacked the resolution needed to accurately estimate the shape and extent of the island and basin center. To address this shortcoming, I removed inaccurate contours and corrected the strandline and the two elevated "islands" on the basin floor using elevation data I collected in the field. I converted the shoreline and 1718 m ASL contours to a polygon using the Feature to Polygon tool to calculate marsh surface area. I then determined the marsh potential for the 1716-1718 m ASL, 1715-1716 m ASL, and 1715 m ASL areas to determine if marsh potential increased with decreasing water depth. Finally, I calculated the lake surface area for each elevation and calculated the wetland habitat index (WHI) following Duke and King (2014) to compare my results to other northwestern basins' marsh potential.

$$WHI = (LA * WHA) * 100 \quad (2.1)$$

where *LA* is the surface area of the lake and *WHA* is the surface area of the predicted wetland potential within 2 m (Duke and King 2014; Hamilton and Auble 1993; Young 2000).

Hydrologic Modeling

To determine the conditions under which a pluvial lake or a wet meadow would form in Painters Flat, I conducted hydrologic modeling once I constructed the basin's bathymetry. The basin is currently occupied by a seasonally wet meadow, and historical aerial imagery from the USGS EROS Archive available on the EarthExplorer database shows the basin has not held standing water since 1951. Prior to modeling, I generated a map including the 12-digit Painters' watershed from the USGS and USDA:NRCS for Lassen and Washoe counties. Using the corrected lake shoreline, I determined the lake, wetland, and watershed surface areas, excluding the lake's surface. To calibrate my model, I used PRISM 4 km resolution 1981-2010 30-year normals from the Northwest

Alliance for Computational Science & Engineering (NACSE) at Oregon State University (Daly et al. 1994). PRISM provide average monthly precipitation and temperature data for the continental United States. I included grid cells that encompassed both the lake and watershed components. I then converted the raster grid cells to polygons using the Times, Int, and Raster to Polygon tools. I used the Intersect tool to calculate the area of overlap to separate the proportion of cells that overlapped with the watershed and lake. Finally, I calculated the weighted average temperature within the lake versus the watershed components for each month as well as the weighted average depth of precipitation.

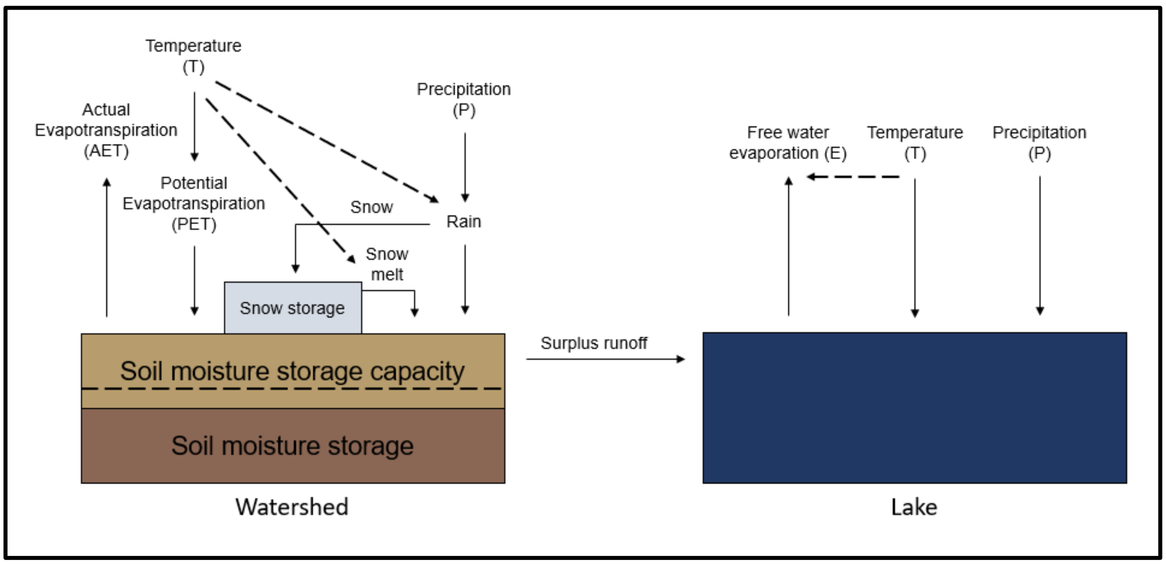

Figure 2.8. Diagram of water balance model and the simplified hydrologic cycle (adapted from McCabe and Markstrom 2007).

To simulate the hydrologic cycle, I used a water balance model with a watershed and lake component. I used an altered version of the Thornthwaite Model for the watershed component (Barth et al. 2016; Dingman 2001). The model estimates the hydrologic response to changes in temperature and/or precipitation (Appendix 1; Figure 2.8). The watershed component uses mean monthly temperature and precipitation, soil water storage, and latitude to compute snow processes, runoff, and potential evapotranspiration (PET) (see Figures 2.8 and 2.9). My modeling results using the modern climate did not sustain a lake over the year, supporting the absence of a lake in historical imagery (Figure 2.9). The use of high spatial resolution watershed modeling for runoff generation in the Thornthwaite model addresses spatial variability in the local climate, topography, and soil (Barth et al. 2016; Hatchett et al. 2018). Due to the basin's size and lack of topographic variability within and around Painters Flat, I did not account for spatial variability and used a single watershed component. To compute soil water capacity, I followed the protocol outlined by Garner and others (2017) after testing the USGS recommended method. I excluded a groundwater proxy in this model because the basin's bedrock is majority basalt which tends to prevent near-surface groundwater accumulation without structural deformation (Ibarra et al. 2014). To simplify my model, I excluded cloudiness, storm tract variability, and seasonality proxies from my model. Ultimately, I used the climate variables to determine the amount of surplus water in the hydrologic system. For the lake component, I simulated free-water evaporation using the PET from the lake's mean monthly changes in temperature (see Appendix 1). I subtracted the lake's evaporation rate from the mean monthly precipitation onto the lake (see Appendix 1). I calculated the lake volume and surface area using the USGS 10 m DEM and the corrected shoreline contour. Finally, I subtracted inflow from the watershed's runoff and direct precipitation onto the lake from evaporative losses off the lake surface to determine whether a lake could be sustained at the specified conditions.

$$Input_{lake} = Surplus_{watershed} + P_{lake} \text{ (2.2)}$$

where P is the mean monthly precipitation (mm).

$$E_{lake} = PET \text{ (2.3)}$$

$$Output_{lake} = E_{lake} \text{ (2.4)}$$

where E_{lake} is the evaporation off the lake surface for a given lake-level.

$$Input_{lake} - Output_{lake} = \Delta S = 0 \text{ (2.5)}$$

where ΔS is the change in lake storage.

While I used the PRISM temperature and precipitation data to establish a baseline for the absence of a lake, I ran multiple iterations to determine which changes in temperature and precipitation would promote the formation of a lake at 1720 m ASL. I then looked to other predicted values in the northwestern Great Basin to determine which model best fit the climate conditions during the late Pleistocene. To model conditions required to form a wetland, I then adjusted the evapotranspiration rate to account for marsh vegetation for the wet meadow's surface. I multiplied the PET by the evapotranspiration rate of mixed vegetative marshes (70% bulrush, 15% cattail, and 15% wocus [i.e., water lily]) from Upper Klamath Lake (Stannard et al. 2013).

$$Input_{meadow} = Surplus_{watershed} + P_{meadow} \text{ (2.6)}$$

where P is the mean monthly precipitation (mm).

$$E_{meadow} = PET * 0.903 \text{ (2.7)}$$

$$Output_{meadow} = E_{meadow} \text{ (2.8)}$$

where E_{meadow} is the evapotranspiration from given water level and 0.903 m per year is the evapotranspiration of a mixed vegetative marsh (Stannard et al. 2014).

$$Input_{meadow} - Output_{meadow} = \Delta S = 0 \quad (2.9)$$

where ΔS is the change in lake storage.

I ran iterations for wetland extents at 1716 m ASL and 1715 m ASL. Finally, I correlated the wet meadow climatic combinations to dated wet meadow deposits on the basin floor to determine what climate conditions occurred throughout the Holocene.

Expectations

Based on previous work in the surrounding region, I expect that a pluvial lake occupied Painters Flat during the late Pleistocene (Table 2.4). Landforms and sediments should reflect the presence of such a lake; specifically, clays, deltaic deposits, and shoreline features. If a lake was sustained at a specified level, then my hydrologic model results should indicate that the conditions required to form the lake occurred during the late Pleistocene. Since Painters Flat sits at 40.8ºN, I expect that hydrologic modeling results should reflect a transitional zone between northern and southern basins along the proposed dipole. Hudson and colleagues (2019) suggest that Lake Surprise represents the transition zone between the north/south wet/dry conditions with higher lake-levels throughout the HS1b, Bølling-Allerød, and Younger Dryas (Egger et al. 2018). Painter Flat sits just south of Surprise Valley and might reflect similar trends. Additionally, I expect landforms and sediments to reflect activated eolian and alluvial systems with the pluvial lake's desiccation during the early Holocene. In terms of human use of the basin, I expect early Paleoindian occupations to have occurred near shallow lake habitats and late Paleoindian and post-Mazama occupations to have focused on upland springs and the drainages that connected them to the basin floor. Early and Middle Archaic occupations should have remained focused on springs but shifted to the Cottonwood Delta and its channel systems during the Late Archaic period with fluctuating environmental conditions. These northeastern channel systems contain multiple active channels capable of supporting a large area of plant an animal resources, so I refer to these as patch resources (Duke and Young 2007; MacArthur and Pianka 1966; Madsen et al. 2015). Single springs and their associated drainages provide smaller productive areas; therefore, I refer to these as point resources.

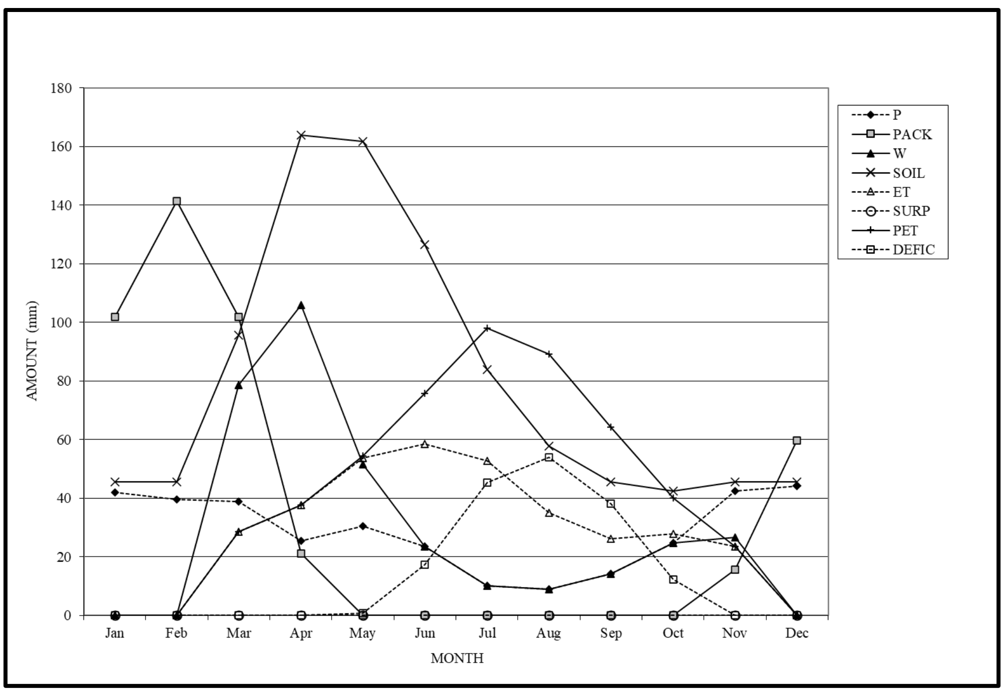

Figure 2.9. Annual water balance for Painters Flat with modern average precipitation and temperature data from PRISM dataset (see Appendix 1 for climate variable definitions).

Table 2.4. Hypotheses, Expectations, and Analyses.

Hypothesis	Expectations	Analysis
H1. A pluvial lake occupied Painters Flat during the late Pleistocene.	Landforms and sediments should reflect lake conditions. The hydrologic model results should indicate conditions required to form a lake only occurred during the late Pleistocene.	Landforms Present Profile Chronology Hydrologic Model
H2. The pluvial lake retreated to a wet meadow during the early Holocene leaving active springs by the early to middle Holocene boundary.	Landforms and sediments should reflect a wet meadow with activated eolian and alluvial systems after desiccation. The hydrologic model results should indicate conditions required to form a wet meadow occurred periodically throughout the Holocene.	Landforms Present Profile Chronology Hydrologic Model
H3. Paleoindian settlements were focused on shallow lake and marsh habitats, transitioning to springs during the later early Holocene.	Early WST projectile points should be above the lake shoreline. Late WST projectile points should be associated with spring features.	Distribution of Time-sensitive artifacts Distribution of Time-sensitive artifacts
H4. Early and Middle Archaic groups remained linked to springs but shifted their occupations to the northern channel systems during the late Holocene.	Early and Middle Archaic projectile points should be associated with springs (point resources). Later Middle Archaic and Late Archaic projectile points should be associated with the patch rather than point resources.	Distribution of Time-sensitive artifacts

CHAPTER 3

RESULTS

In this chapter, I discuss the results of my stratigraphic profiles and identified landforms. I determined the marsh potential and the temperature and precipitation combinations required to form a lake or wet meadow in Painters Flat. I then discuss the locations of time-sensitive projectile points and ground stone artifacts' positions to specific landforms and water sources.

Stratigraphic Profiles

I described 14 profiles in Painters Flat and one in the Madeline Plains (Figure 3.1; Table 3.1). I assigned these profiles to four areas: (1) the Cottonwood Delta; (2) the basin floor; (3) the northwestern sill; and (4) the Madeline Plains Delta. The Cottonwood Delta (Locality 134) is in the northeastern corner of Painters Flat and consists of alluvial plains and both active and abandoned channel systems (see Figure 3.1). Profiles Wa134-1 and Wa134-2 lie within an arroyo of an abandoned fluvial channel, an area occupied by a wet meadow and dominated by floodplain processes[2]. Wa134-1 and Wa134-2 contain four corresponding strata of low to medium velocity fluvial deposits with an eolian component (Figure 3.2). Stratum I consists of medium-energy channel system deposits that show a

[2]Profiles are named based on county (e.g., Wa), locality (e.g., Wa1), and profile (Wa1-1).

soil with clay films and increased organics. An organic bulk sediment sample from Stratum I returned a date of 4515±30 ^{14}C BP (5305-5050 cal BP) indicating that the profile stabilized during the middle Holocene gap (Table 3.2). The stratum is missing the A horizon because only the B horizon is present, so an erosional episode occurred before Stratum II was deposited. Therefore, the organics dated from the B horizon are the oldest organics incorporated into the profile and provide a minimum date of deposition for Stratum I and a maximum date of soil development. Stratum II contains medium velocity fluvial deposits with an eolian component and a paleosol. Both Wa134-1 and Wa134-2's Stratum II contain dominantly silt with fine grained sands and gravels and overall similar grain size trends with the LPSA results (Figure 3.3). Stratum II became buried by Stratum III, which is a loam with increased gravels indicative of higher energy fluvial deposits. Stratum III's surface stabilized and shows a well-developed Aridisol with calcium carbonate deposits. Stratum III became buried by floodplain deposits and dust from Stratum IV. Stratum IV shows a soil that was subsequently dissected by a channel system that cut into the deposits and exposed the profile. Wa134-2's Stratum IV contains finer sands when compared to Wa134-1 (see Figure 3.2). Wa134-2 lies downstream of Wa134-1, so the LPSA results show the coarse sands accumulated upstream before the finer sands.

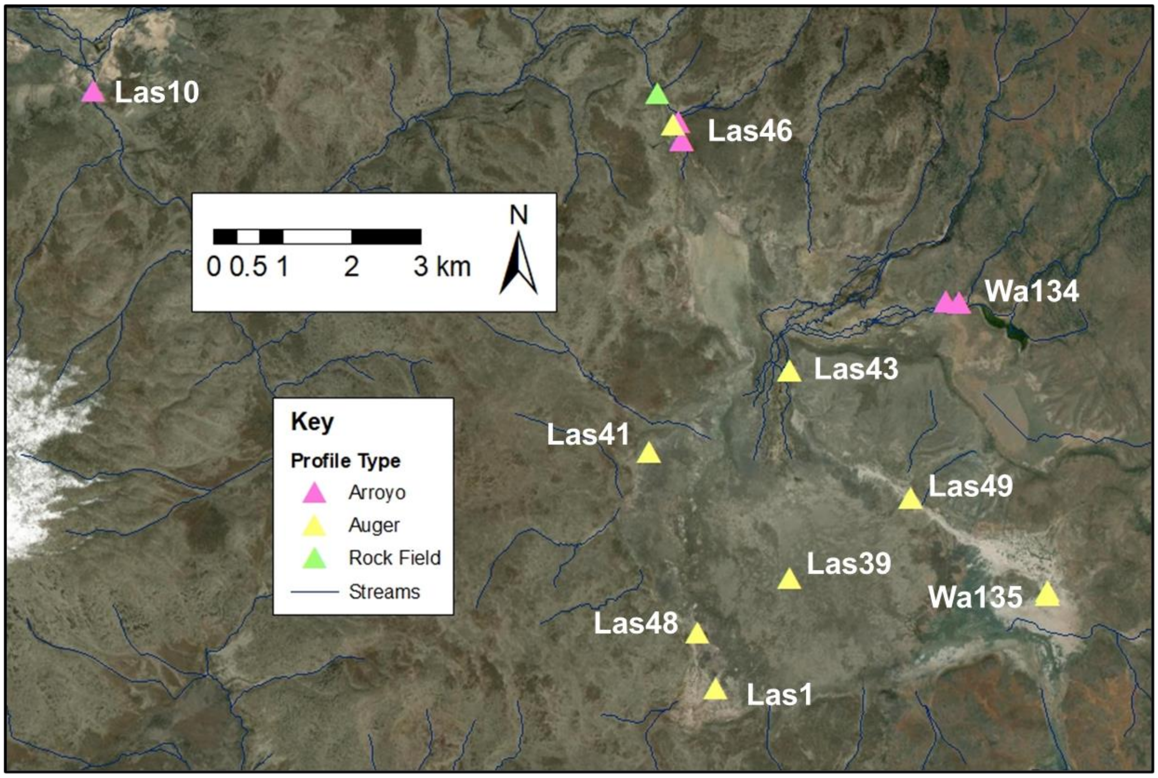

Figure 3.1. Profile locations in Painters Flat and the Madeline Plains.

Table 3.1. Localities and Corresponding Profiles.

Locality	**Profile**	**Type**	**Elevation (m ASL)**
Las1	Las1-1	Auger	1715
Las10	Las10-1	Arroyo	1617
Las39	Las39-1	Auger	1716
Las41	Las41-1	Auger	1718
	Las41-2	Auger	1718
Las43	Las43-1	Auger	1718
Las46	Las46-1	Arroyo	1722
	Las46-2	Same as Las46-1	1724
	Las46-3	Arroyo	1724
	Las46-4	Auger	1724
Las48	Las48-1	Auger	1718
Las49	Las49-1	Auger	1715
Wa134	Wa134-1	Arroyo	1724
	Wa134-2	Arroyo	1723
Wa135	Wa135-1	Auger	1720
	Wa135-2	Auger	1719

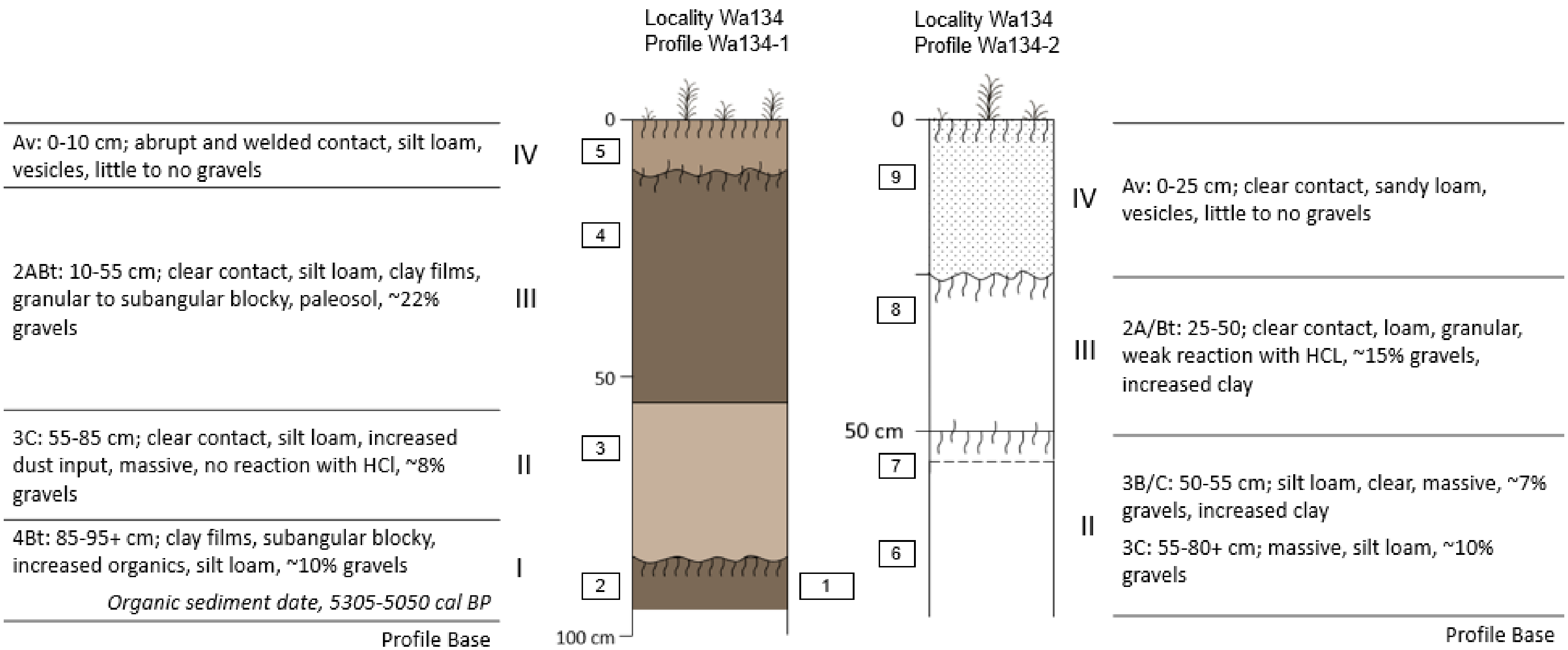

Figure 3.2. Wa134-1 and Wa134-2 profile descriptions.

I augered seven at localities at the basin floor (Las1, Las39, Las41, Las43, Las48, Las49, Wa135) for stratigraphic sequencing (Appendix 2; Figures 3.4-3.8). I included profile Las46-4 in the basin floor area because the strata are more consistent with basin floor deposits than the northwestern sill deposits (see Figure 3.5). The strata consist of wet meadow deposits with a paleosol that correspond with Las43-1 wet meadow deposits (see Figures 3.5 and 3.6). The basin floor profiles contain two main stratigraphic units, Stratum II and Stratum III. Stratum II consists of colloidal eolian silts with desiccation cracks and paleosols (Appendix 3). The basin floor is occupied by a seasonal wet meadow that traps wind-blown silt when wet. Underlying Stratum II was Stratum I, which shows multiple paleosols on the stabilized surface. I obtained two radiocarbon dates from paleosols on bulk sediment within Stratum I: (1) 5955±30 ^{14}C BP (6885-6675 cal BP) from Las43-1; and (2) 4025±25 ^{14}C BP (4570-4420 cal BP) from Las46-4 (see Figures 3.5 and 3.6; Table 3.2). Profiles Las46-4, Las39-1, and Las41-1 only contain Stratum II and they are currently stabilized by vegetation preventing erosion. Las43-1 contains Stratum I with a date of 5955±30 ^{14}C BP (6885-6675 cal BP), which indicates that Strata II and III were deposited after that time because they are stratigraphically above Stratum I. Wa135-1 differs from these profiles in that it contains poorly sorted subrounded pebbles and cobbles underlying Stratum III instead of colloidal silts (Figure 3.7). The deposit is single-grained eolian silt mixed with lag gravels and is situated on the spit that I discuss later in this chapter. I was unable to auger further to determine the chronologic relationship between the eolian silts and gravels and Stratum I.

Profiles Las1-1, Las41-2, Las43-1, Las48-1, Las49-1, Wa135-1, and Wa135-2 have Stratum III with a surficial Av horizon (see Appendix 2)[3]. Stratum III contains predominately silty tephra and alluvial sands reworked by eolian processes. Cobbles and gravels occasionally lay atop of these vesicular horizons forming stone pavements. Stratum III initially deposited as a low-grade alluvial deposit, as evinced by the dendritic distribution of drainages entering the basin (see Figure 3.1); however, wind has eroded, transported, and redeposited the silty deposits around the basin. These eolian deposits form accretionary profiles that support stone pavements, so the pavement remains at the surface (Dietze and Kleber 2012; McFadden et al. 1998). Vesicular horizons form from a rapid influx of water during a precipitation event (Dietze and Kleber 2012; Dietze et al. 2012). Water within the deposits evaporates rapidly and bubbles of escaping gas form. Local dust is added to the deposit with repeated events, building the horizon vertically (Dietze and Kleber 2012; Dietze et al. 2012; McFadden et al. 1998; Pelletier et al. 2007). This process can cause older rocks and artifacts to remain at the surface while smaller clasts become buried or remain on their original surface (Adelsberger et al. 2013). The large clasts decrease in frequency towards the center of the basin, which suggests a pluvial lake that would freeze and allow boulders to ice-raft onto the basin floor (Allen et al. 2015; Appendix 3). A sample of Stratum III from Las1-1 contained Trego Hot Springs and Mazama tephra sherds in addition to two unknown tephras (see Figure 3.8; Table 3.2). Since Stratum III is reworked and contains multiple chemical groups, the tephras are secondary deposits. Because the youngest identified tephra (Mazama) dates to 6730±40

[3]Locality Wa135 contains two profiles that occur along the arroyo's length (Wa135-1 and Wa135-2).

^{14}C BP (7670-7515 cal BP) (Hallet et al. 1997), this provides the maximum age that the Mazama tephra was deposited, reworked shortly thereafter, and then accumulated on the basin floor with additional tephras. The tephra sample is relatively clean, which indicates deposition soon after entrainment from the source area, proximity to the source area, or deposition shortly after the eruption. Since deposits beneath Stratum III are younger than about 7600 cal BP, deposition soon after entrainment from the source area and proximity to the source area are the most likely scenarios Wa135-2 and Las49-1 also contain paleosols (Ao horizons) within Stratum III (see Figures 3.7 and 3.8). These Ao horizons are darkened by organic material and contain silty sediments and vesicles. I obtained bulk sediment radiocarbon dates from each paleosol. Wa135-2 returned a date of 735±35 ^{14}C BP (725-575 cal BP) and Las49-1 returned a date of 1215±30 ^{14}C BP (1265-1060 cal BP) (see Table 3.2). The dates from Wa135-2 and Las49-1 indicate that Stratum III is a recent deposit into the basin, likely from floods carrying fire affected sediments from the surrounding uplands.

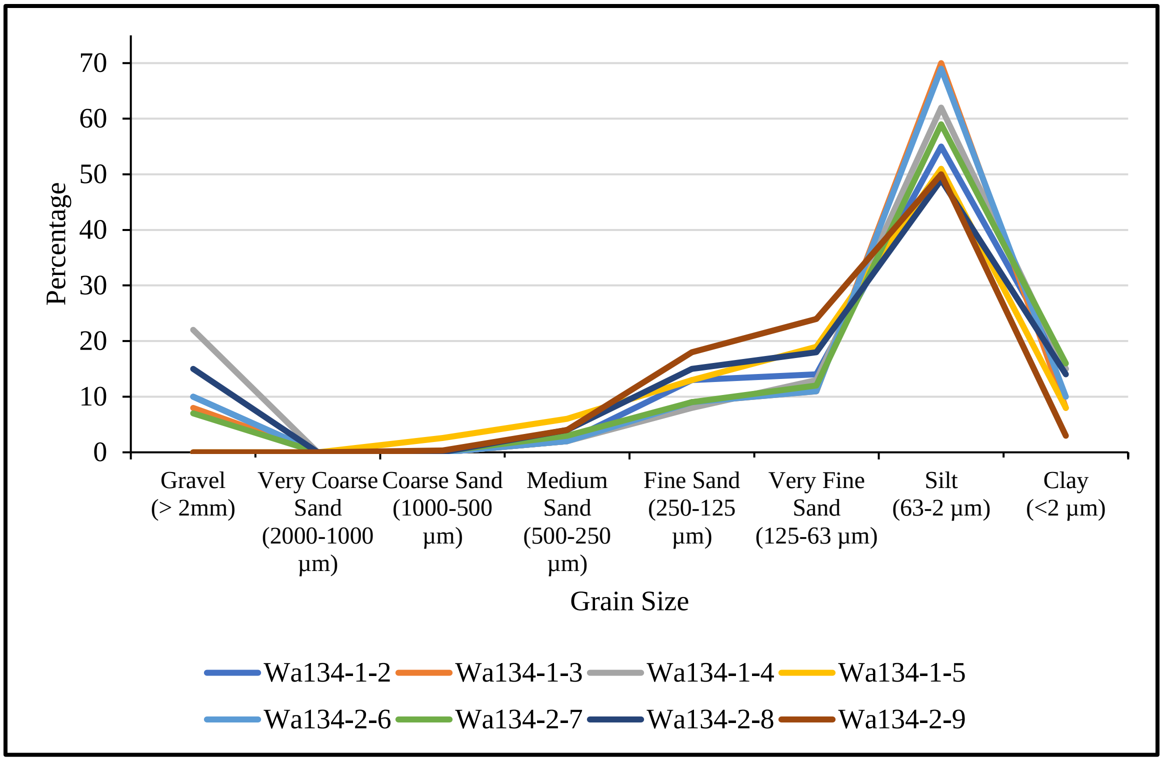

Figure 3.3. Wa134-1 and Wa134-2 LPSA results. Gravels are a percentage of the whole. Sands through clays are a percentage of grain sizes <2 mm.

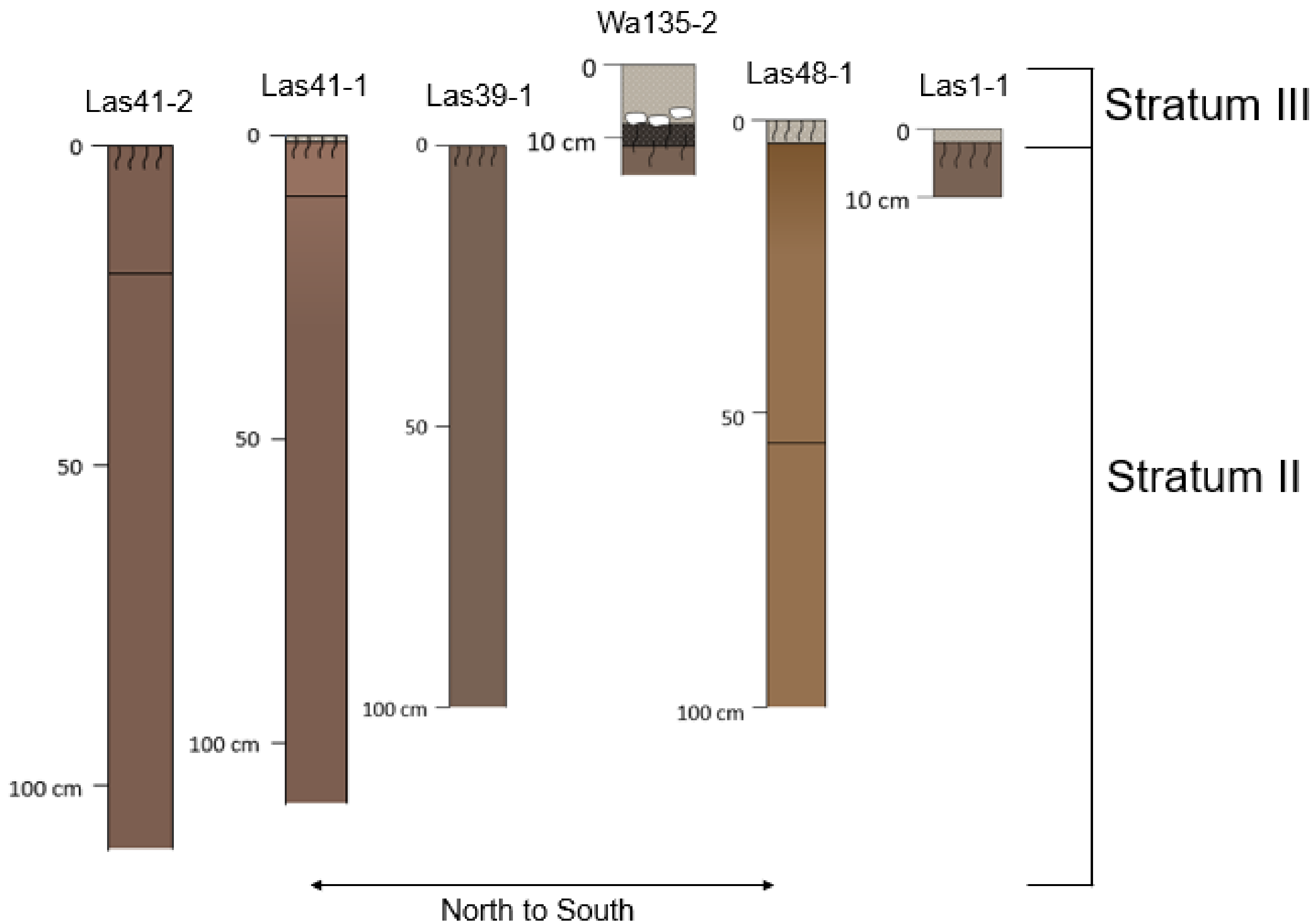

Figure 3.4. Selected basin floor profiles and corresponding strata.

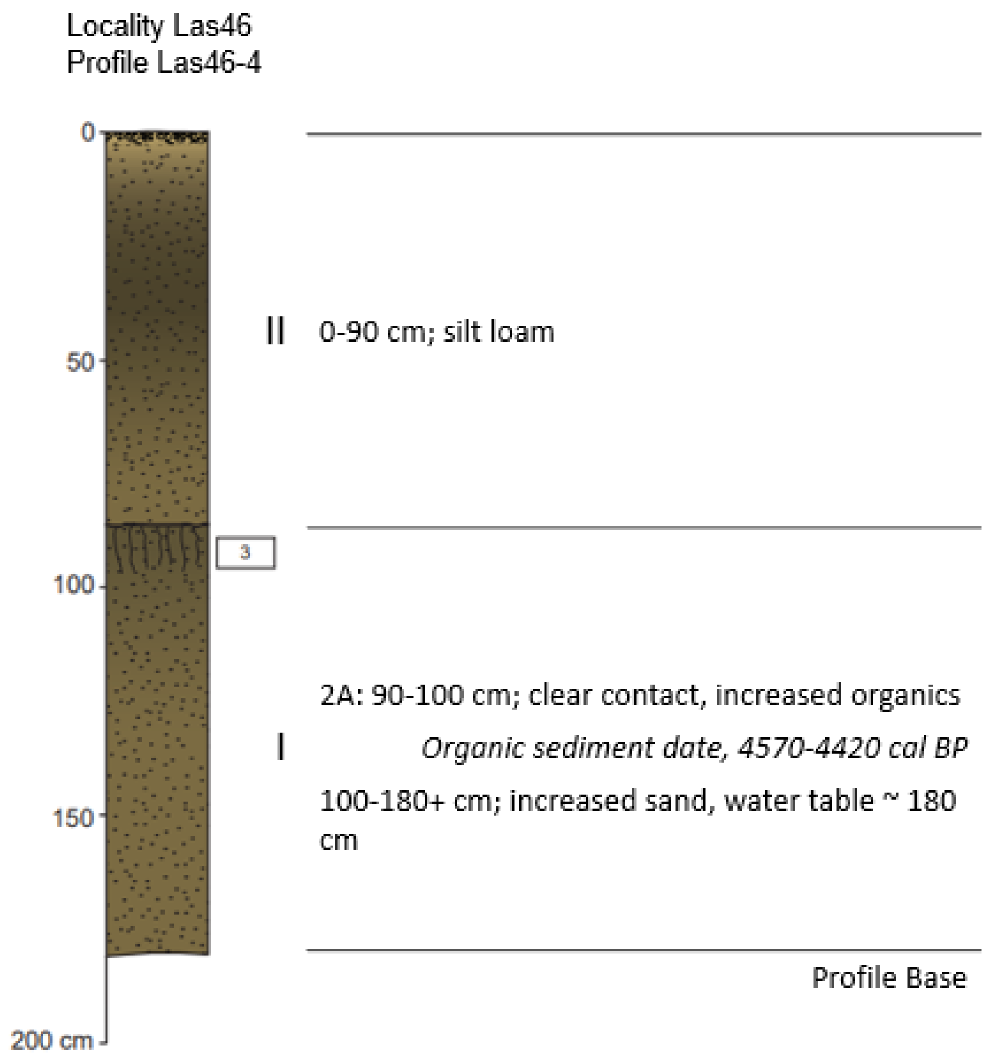

Figure 3.5. Las46-4 profile description.

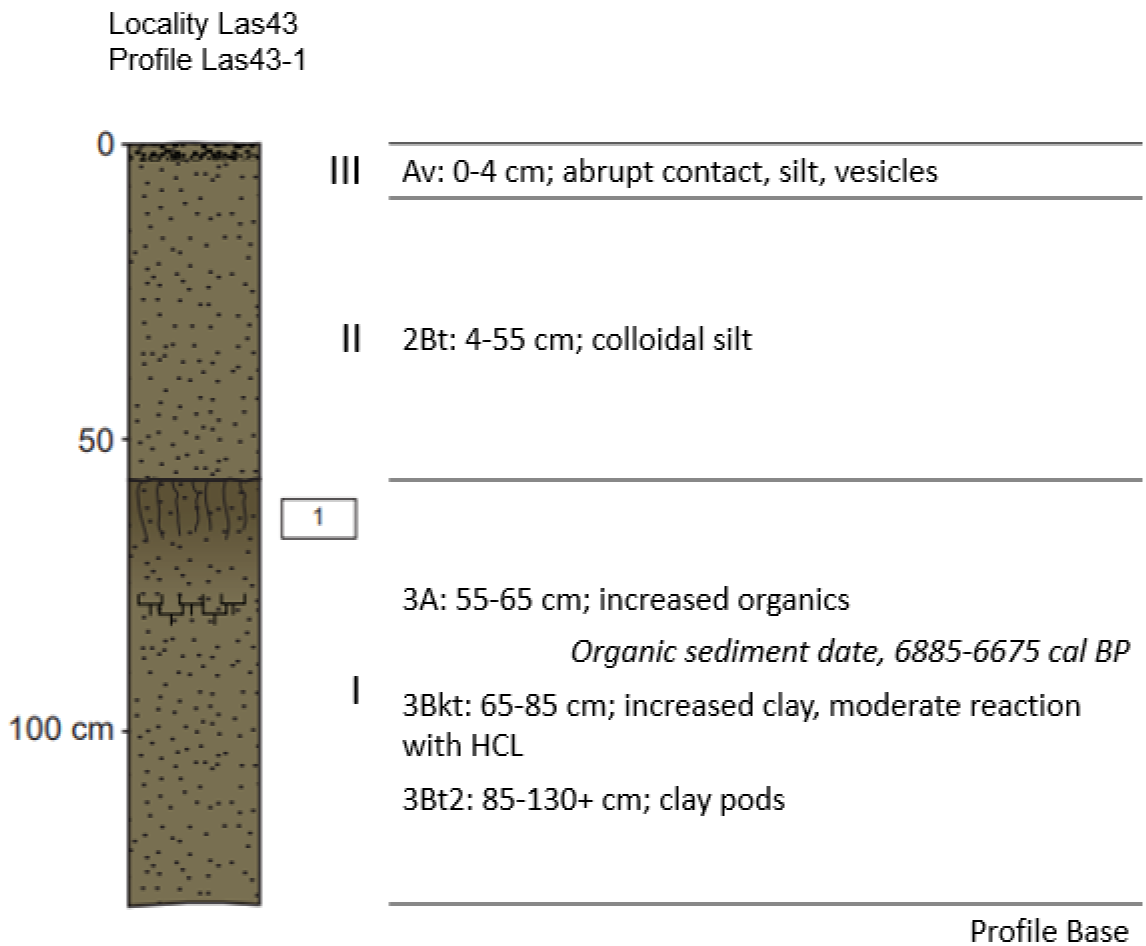

Figure 3.6. Las43-1 profile description.

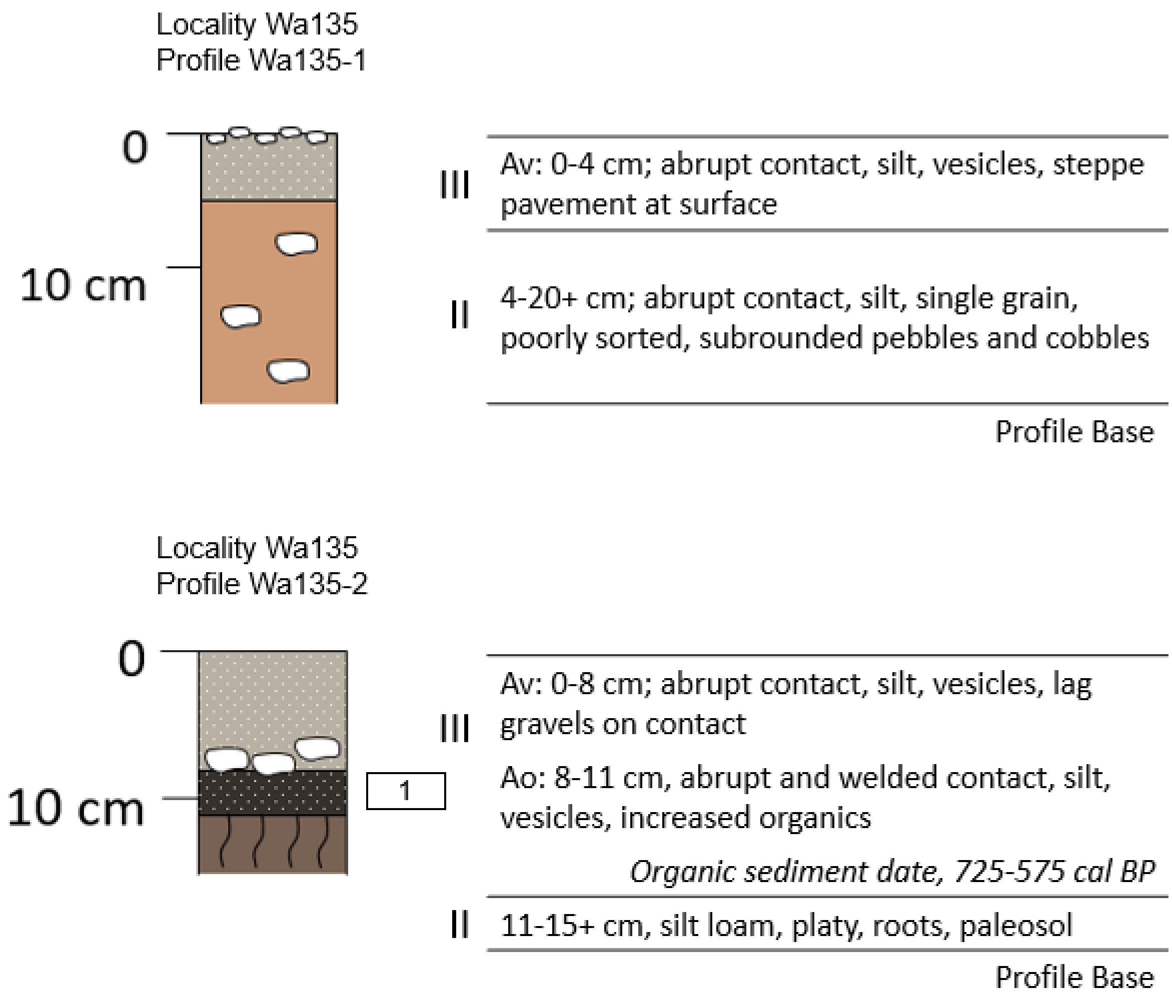

Figure 3.7. Wa135-1 and Wa135-2 profile descriptions.

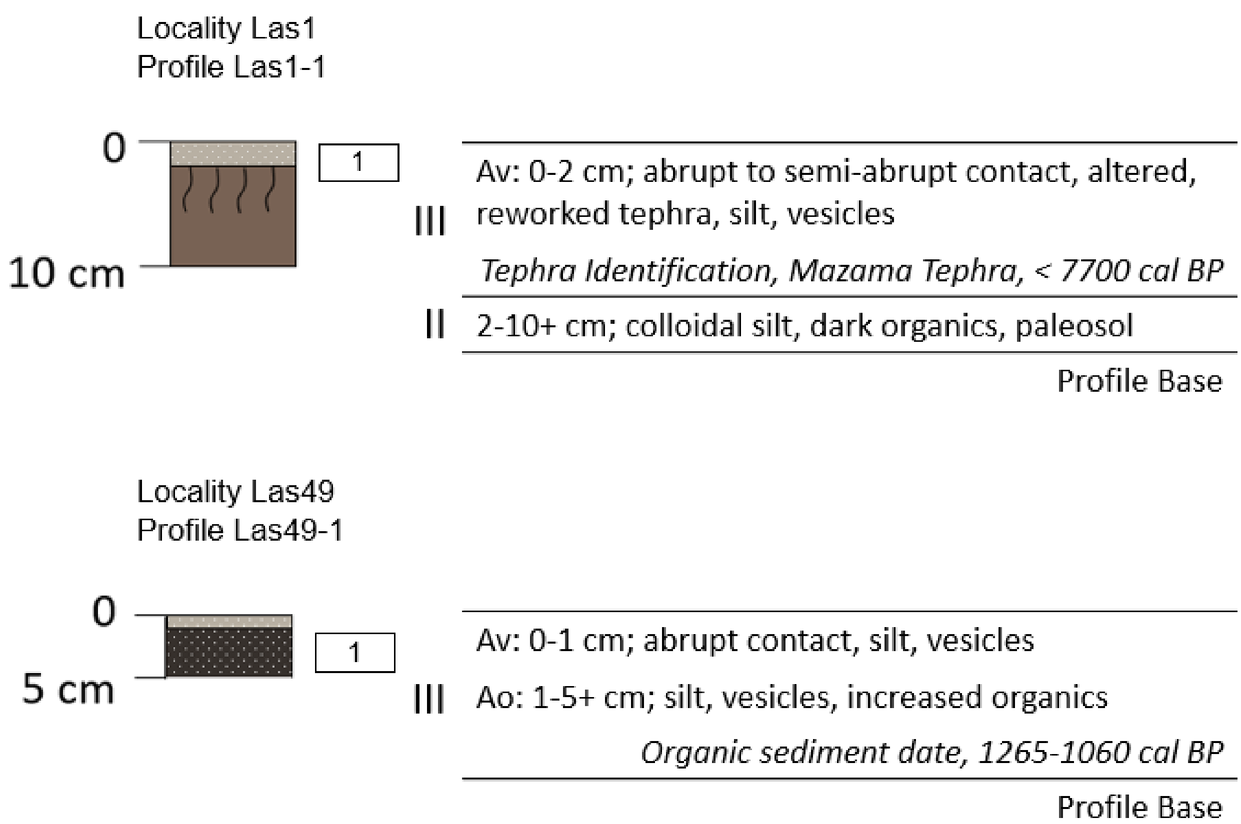

Figure 3.8. Las1-1 and Las49-1 profile descriptions.

Table 3.2. Sediment Sample Results from Profiles.

Sample	Depth (cm)	Lab Number	Results
Radiocarbon dating (Bulk Sediment, Humics, and Humins)			
Las10-1-1	244-249	D-AMS 040169	15,450-15,080 cal BP
Las43-1-1a	55-65	D-AMS 039059	6885-6675 cal BP
Las46-1-4a	95-100	Beta-568061	4765-4625 cal BP
Las46-1-5a	75-90	Beta-568062	3455-3355 cal BP
Las46-3-1a	35-50	D-AMS 039062	5900-5660 cal BP
Las46-4-3a	90-100	D-AMS 039061	4570-4420 cal BP
Las49-1-1a	1-5	D-AMS 039063	1265-1060 cal BP
Wa134-1-1a	85-95	D-AMS 039058	5305-5050 cal BP
Wa135-2-1a	8-11	D-AMS 039060	725-575 cal BP
Tephra Identification			
Las1-1-1	Surface	SMG2123	7600 cal BP
Las10-1-2	213-218	GRD2230	31,000 cal BP
Ostracod Identification			
Las41-1-1	100-110	N/A	Not present
Las41-2-1	100-110	N/A	Not present
Las43-1-1b	55-65	N/A	Not present
Las48-1-1	90-100	N/A	Not present
Wa135-2-1b	8-11	N/A	Not present
Laser Particle Size Analysis			
Wa134-1-2	85-95	C21-309	Silt loam
Wa134-1-3	60-80	C21-310	Silt loam
Wa134-1-4	15-50	C21-311	Silt loam
Wa134-1-5	0-10	C21-312	Silt loam
Wa134-2-6	60-80	C21-313	Silt loam
Wa134-2-7	50-55	C21-314	Silt loam
Wa134-2-8	30-45	C21-315	Loam
Wa134-2-9	0-20	C21-316	Sandy loam

Two exposures are within the northwestern sill (Locality 46), a Holocene-age alluvial fan (Figure 3.9). Las 46-3 lies upstream in an arroyo on the eastern side of the fan and contains two strata. Stratum I consists of well-sorted medium sands towards the bottom of the profile and then coarsens to well-rounded pebbles and sands at the top, indicating increasingly high energy flows with time (see Figure 3.9). The deposit shows a well-developed Aridisol that produced a bulk sediment radiocarbon date from the organics in the paleosol (2Bk horizon) of 5025±40 ^{14}C BP (5900-5660 cal BP) (see Table 3.2), suggesting soil development during the middle Holocene gap. The surface horizon was eroded, and deposition of Stratum II began. Stratum II contains poorly sorted well rounded gravels indicating a high energy depositional alluvial fan and subsequent channel migration with an eolian dust component. The well-rounded gravels extend up the drainage and likely represent reactivated deposits from the watershed rather than reworked shorezone deposits. Las46-1 lies downstream of Las46-3 and contains three strata. Stratum I is low-energy deposits with a buried well developed Aridisol. I obtained one radiocarbon date from each horizon within Stratum I: a date of 4170±30 ^{14}C BP (4765-4625 cal BP), and a date of 3170±30 ^{14}C BP (3455-3355 cal BP) (see Table 3.2), indicating soil development during the Neopluvial period. The surface horizon eroded, and Stratum II was subsequently deposited by alluvial processes. Stratum II is a silt loam that weathered into a Mollisol and was capped subsequently by Stratum III, a mix of low energy alluvium and dust. Stratum III shows a surface soil horizon that corresponds to those in the Cottonwood Delta and Stratum II in Las46-3.

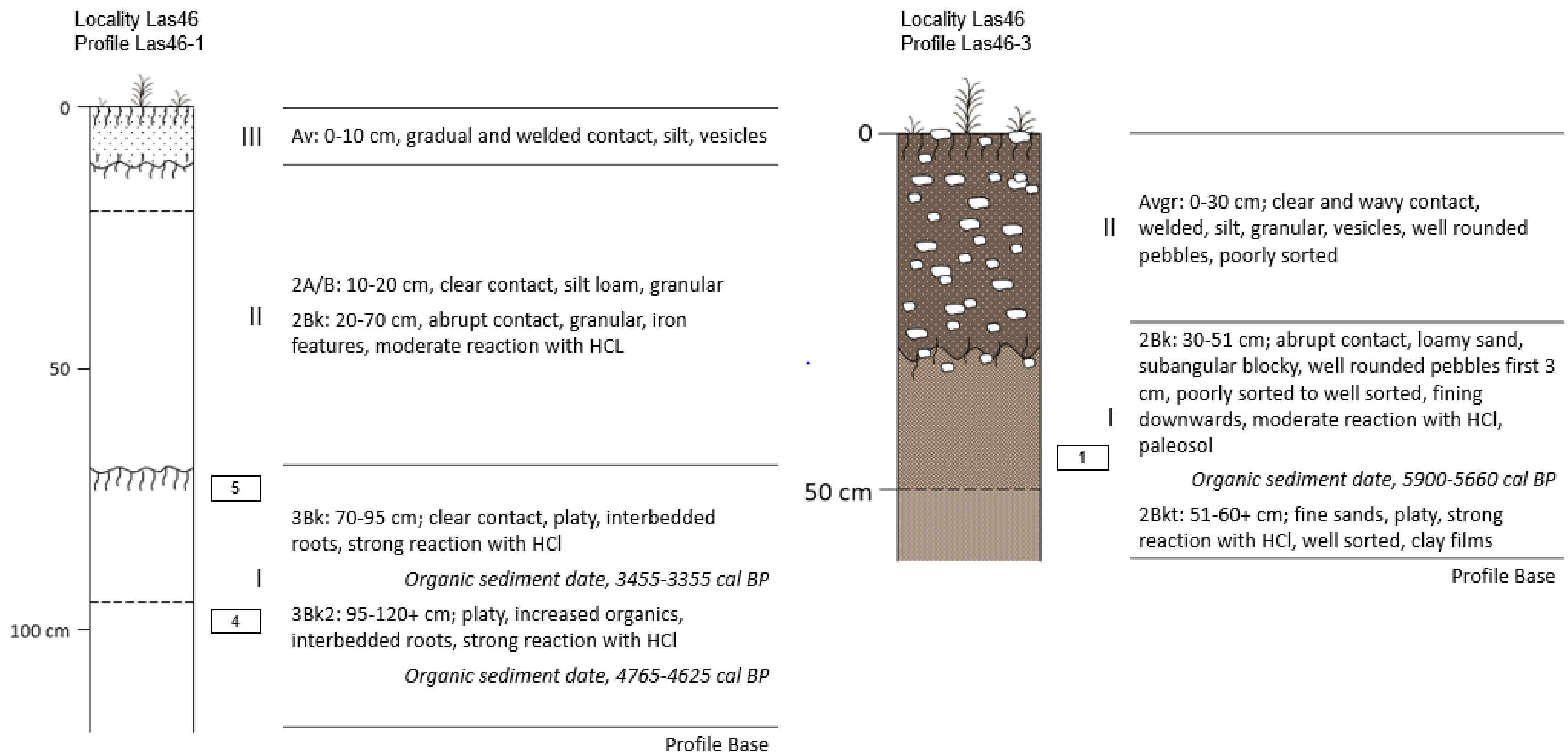

Figure 3.9. Las46-1 and Las46-3 profile descriptions.

Finally, I described one profile in the Madeline Plains Delta (Locality 10). Las10-1 lies within the deltaic system of pluvial Lake Madeline where the outflow of Painters Creek terminates and the pluvial lake in Painters Flat likely spilled during wet periods (see Figure 3.1). I focus on the lower profile below the surficial dune deposits in an arroyo exposure (see Appendix 2; Figure 3.10). Stratum I consists of low-energy bottomset deposits of a prodelta that show a moderately developed soil and a period of sub-aerial stability after the prodelta became exposed with the lake's regression (see Figure 3.10). Organics from bulk sediment in Stratum I returned a radiocarbon date of 12,775±45 ^{14}C BP (15,450-15,080 cal BP). Stratum II comprises of alternating layers of finely laminated sands and silty deposits with paleo-surface horizons that likely represent oscillating subaqueous foreset deltaic deposits and surface exposure after lake regressions. Reworked Wono tephra dated to 27,300±300 ^{14}C BP (31,875-30,990 cal BP) is present in Stratum II (Benson et al. 1997; see Table 3.2), providing a maximum age. Stratum III contains oxidized coarse sands with alternating planar laminae and cross-beds indicative of foreset beds or a distal bar and a migrating delta front. Stratum IV contains turbidite deposits of fine sands indicative deltaic system in a pluvial lake. The deposits then return to Stratum V foreset deposits indicative of lake desiccation.

I subsampled sediments from Las41-1, Las41-2, Las43-1, Las48-1, and Wa135-2 for ostracod identification, but no ostracods were present (see Table 3.2). Though the sill deposits suggest that the environment once provided an ideal setting for ostracods, Painters Flat contains a large amount of tephra deposits and silica-rich environments, which often prevent ostracod colonization (Manuel Palacios, personal communication, 2021).

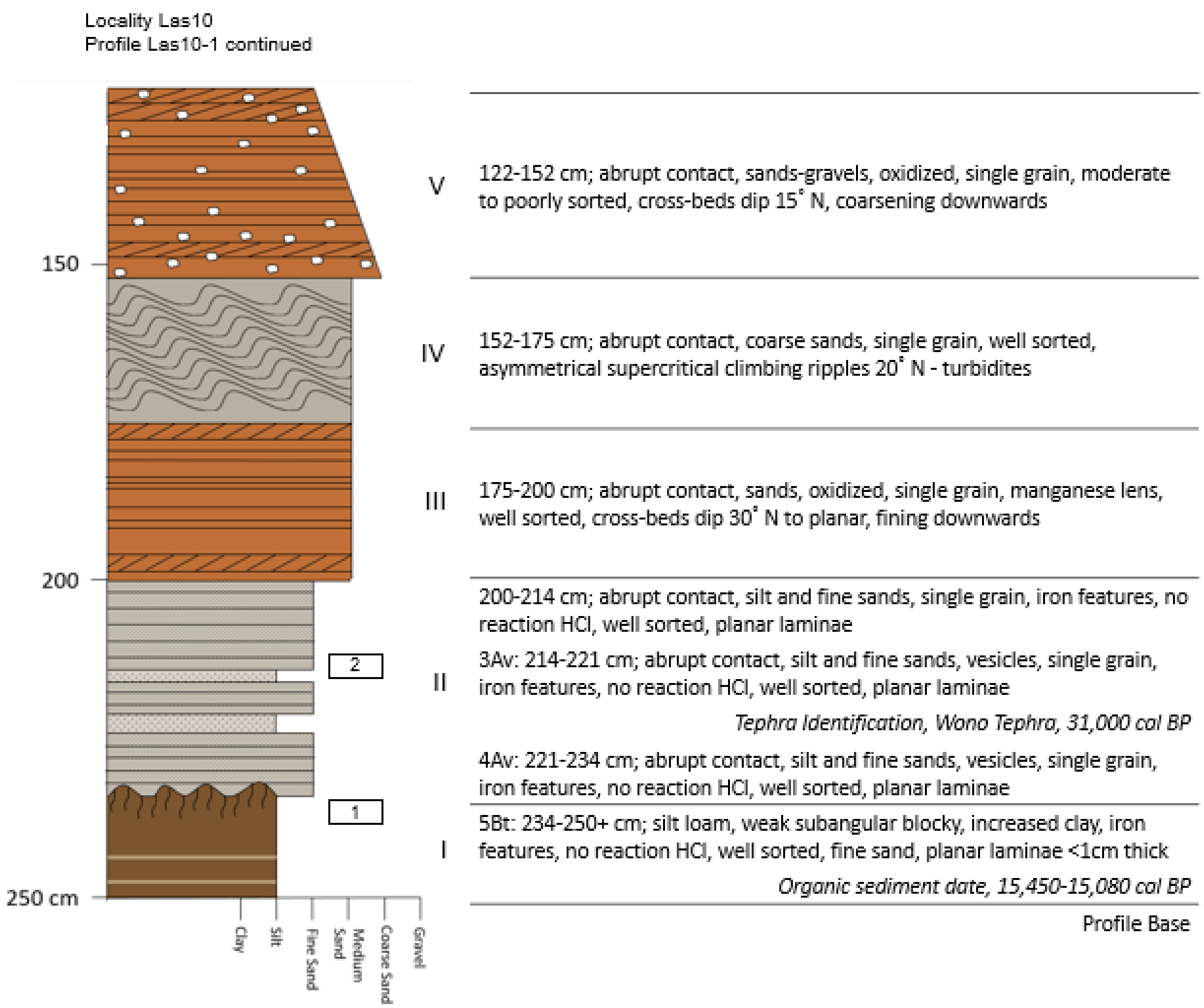

Figure 3.10. Las10-1 profile description: Strata I-V.

Geomorphic Landforms

My investigations revealed numerous landforms that reflect past conditions in Painters Flat. They indicate the presence of a pluvial lake, its subsequent desiccation, and the activation of alluvial systems. Direct evidence of a pluvial lake is evident from shoreline landforms including the strandline and shorezone (Figure 3.11). The strandline is an erosional landform that rims the basin margins (see Appendix 3; see Figures 3.11 and 3.12). It varies in elevation from 1719 to 1721 m ASL, and the slight variation is likely due to wave fetch. Rounded gravels and pebbles occur just below the strandline, indicating the presence of a shorezone (see Appendix 3). These deposits are present along the southwest and southeast strandlines (see Figure 3.11). A spit formed from lake lag deposits lies between the southeastern island and strandline (Figure 3.12). Rounded gravels and pebbles are visible on the surface of the playa/tephra deposits, and rodent burrows indicate that the gravels continue beneath the ground surface (see Appendix 3). I was unable to obtain organic material for radiocarbon dating beneath the spit with the auger, and mechanical exposure is likely necessary for further subsurface investigations.

I also identified landforms that provide indirect evidence of a pluvial lake, including multiple dune fields, a sill, and a possible deltaic system (see Figure 3.11). The northeastern dune field north of the peninsula consists of well-sorted fine sands and classifies as a falling dune field (see Appendix 3; Figure 3.11). Conversely, the northeastern dune south of the peninsula consists of linear and barchan dune forms, also with well-sorted fine sands, oriented NE-SW (see Appendix 3; Figure 3.11). Previous studies in the region have suggested that dunes became activated during the early Holocene after lake desiccation exposed nearshore sediments, and the direction of both the linear and barchan and falling dune fields suggest erosion of these sediments from the lake margins (Colgan et al. 2017; Mehringer and Wigand 1986). To the northwest lies the northwestern sill (Locality 46), a Holocene alluvial fan that has diverted water from Painters Creek to Painters Flat rather than draining to the Madeline Plains (see Figure 3.11). The sill sits at 1724 m ASL but a radiocarbon date of 4025±25 ^{14}C BP (4570-4420 cal BP) at 90-100 cm below the surface suggests the sill likely sat at 1721-1722 m ASL during the late Pleistocene. If deposition rates have remained relatively constant, ~1-2 m of sediment has accumulated since ~13,500-9000 cal BP so the fan would have sat at an elevation of ~1721-1722 m ASL, 2-3 m lower than today. This landform acted as a dam and prevented overflow into the Madeline Plains watershed and controlled the lake-level of Painter Flats' pluvial lake.

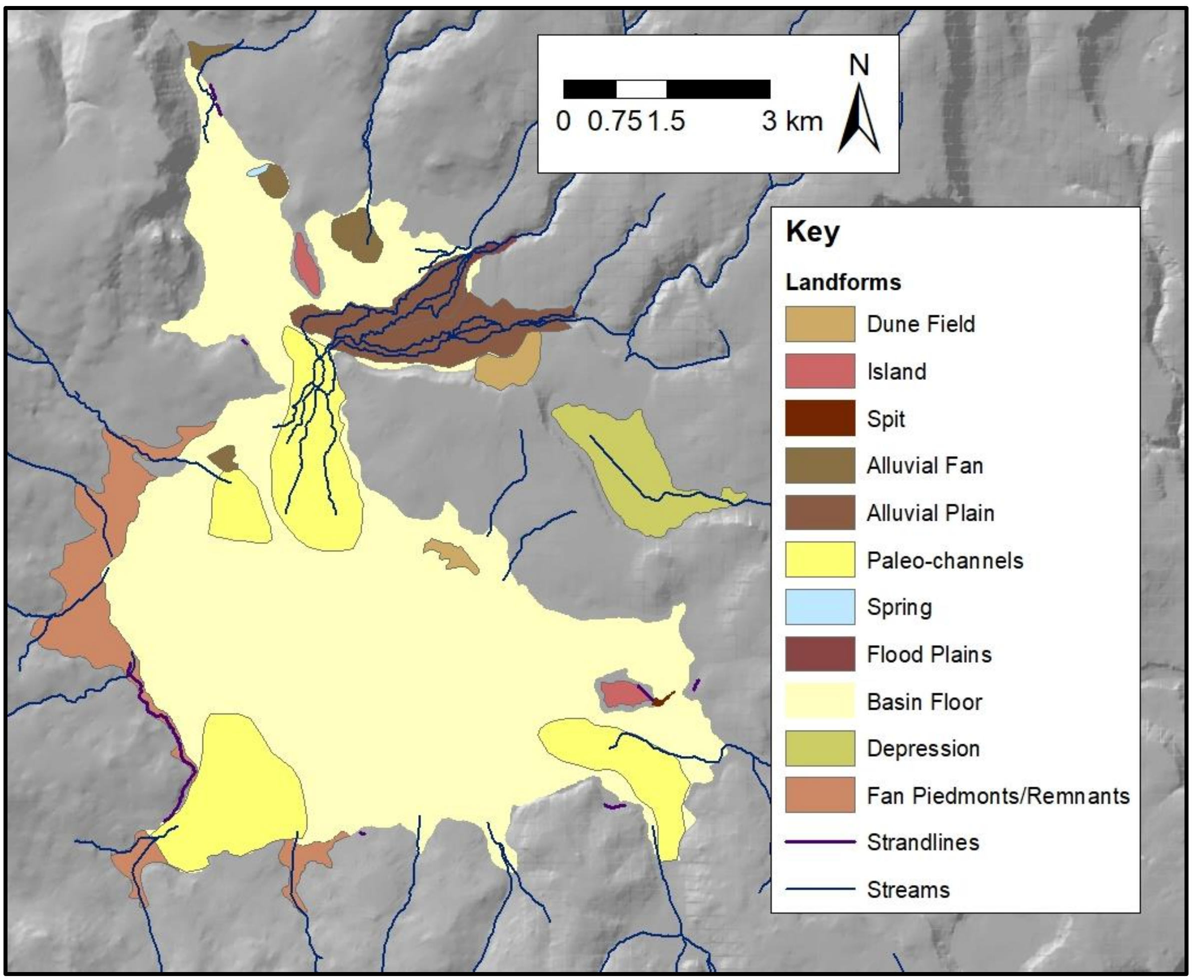

Figure 3.11. Painters Flat landforms.

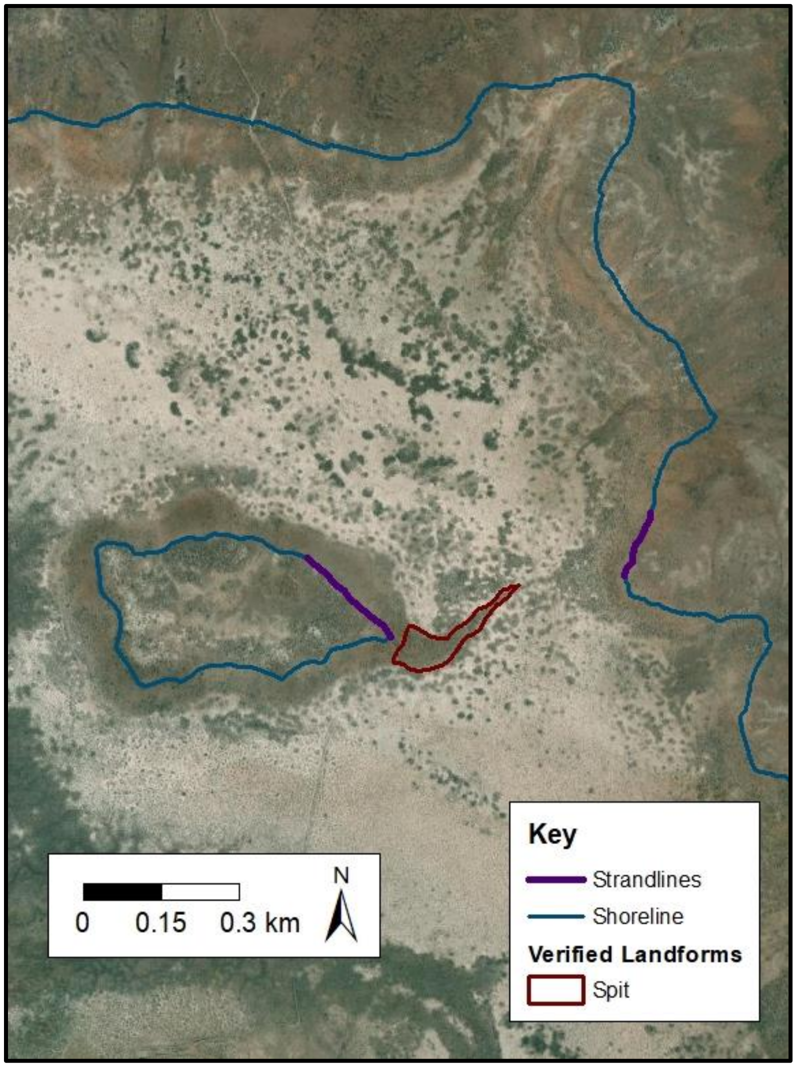

Figure 3.12. Spit landform connecting the southeast island to the basin margin.

I mapped various alluvial systems whose channels are still active today (see Figure 3.11). These streams are fed by springs in the surrounding mountains and plateaus. The Cottonwood Delta sits to the northeast in an alluvial plain where multiple paleo-channels are visible on aerial imagery (see Appendix 3; Figure 3.11). The fluvial systems consist of converging anabranching washes with multiple abandoned channels. These channels exhibit complex crosscutting relationships and silty infill indicative of a low gradient slope common in deltaic settings (Waters 1997). The channels lack evidence of dynamism (e.g., meander scrolls, cutoffs, oxbows) and evidence of high-energy flows (e.g., coarse sands and gravels, channel bars, steep gradient) (Waters 1997). This suggests that the paleo-delta transitioned to a fluvial channel system with the lake's desiccation. The original delta surface has been dissected by Holocene channels and infilled with floodplain deposits. I was unable to expose deltaic deposits with an auger and future work will require backhoe trenching or coring.

Marsh Potential and Hydrologic Modeling

My model suggests that Painters Flat had the lowest WHI of 6.64% during its highstand (Figure 3.13; Table 3.3). As the lake receded to 1718 m ASL, the model suggests that WHI increased to 17.67% (see Figure 3.13; Table 3.3). Finally, the model suggests that continued recession to 1716 m ASL would result in the lake being replaced by a wet meadow, increasing WHI to 100% (see Figure 3.13; Table 3.3). The basin's sides are too steep for most lakestands to produce extensive marshes; thus, the highest marsh potential is limited to times when the basin is a wet meadow. Consequently, there is little evidence for the highstand to have had significant potential for wetland habitats that can be observed in the geologic record and would have attracted early groups. Additionally, the Painters Flat alluvial systems foster marsh resources in the basin today, and likely fostered riparian resources in the past (see Figure 3.13).

Painters Flat's watershed is 114.03 km^2 excluding the 1720 m ASL lake surface area. To maintain a lake at 1720 m ASL, I changed the average precipitation and temperature values of the watershed and lake until the watershed surplus and lake precipitation minus lake evaporation neared 0. My hydrologic model resulted in a range of possible climate combinations (ΔT and ΔP) that could sustain a lake at 1720 m ASL (Figure 3.14). For example, $\Delta T=0$ºC and $\Delta P=1.25$ or $\Delta T=-4$ºC and $\Delta P=1.03$ are two possible combinations that resulted in a lake. Based on Hudson and others' (2019) study and preliminary unpublished modeling results (Douglas Boyle, personal communication, 2021), my ΔT and ΔP are similar to those found in the Chewaucan Basin during the Bølling-Allerød highstand at 14,500-13,400 cal BP; however, the results are lower than previous studies' changes in precipitation and temperature in the western and central Great Basin (Barth et al. 2016; Matsubara and Howard 2009). My hydrologic model resulted in a range of possible climate combinations (ΔT and ΔP) that could sustain a wet meadow at 1716 m ASL or 1715 m ASL (see Figure 3.14). For example, $\Delta T=0$ºC and $\Delta P=1.19$ or $\Delta T=-4$ºC and $\Delta P=0.95$ are two possible scenarios that resulted in a wet meadow at 1716 m ASL.

Table 3.3. Wetland Habitat Potential for the Highstand and Water Levels Lowered at 2 m Intervals.

Elevation (m ASL)	**Lake Area (LA) (km^2)**	**Wetland Habitat Area (WHA) (km^2)**	**Wetland Habitat Index (LA*WHA/100)**
1720	30.42	2.05	6.74
1718	28.41	6.87	24.18
1716	21.54	21.54	100.00
1715*	15.70	15.70	100.00

*Modern seasonal wet meadow

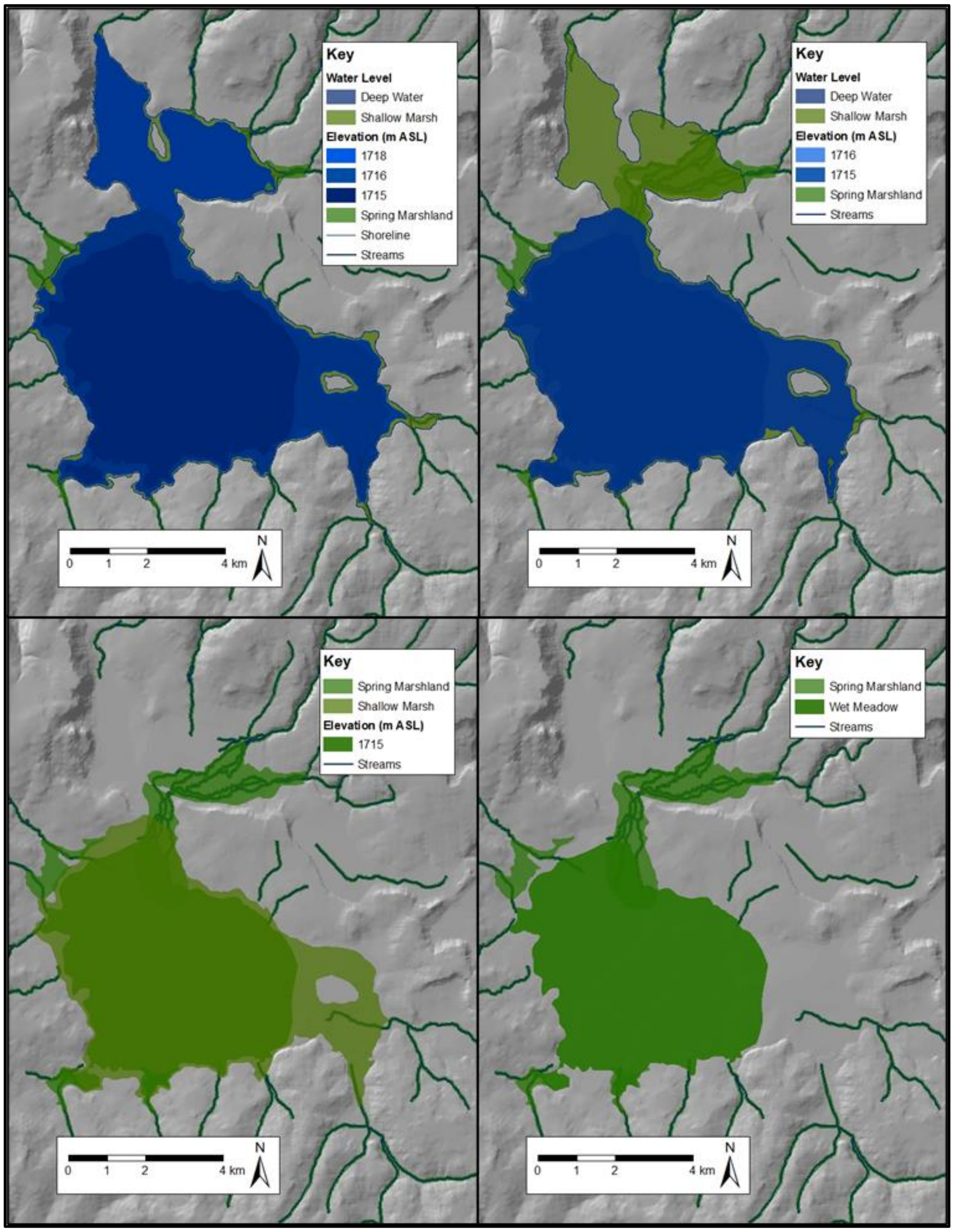

Figure 3.13. Upper left: lake-level at 1721-1719 m (ASL) shoreline with marsh potential. Upper right: lake-level at 1718 m (ASL) with marsh potential. Lower left: wet meadow at 1716 m (ASL) with marsh potential. Lower right: modern seasonal wet meadow at 1715 m (ASL) with spring marsh potential.

Archaeological Site Distributions

Since the strandline occupies elevations between 1719 and 1721 m ASL, I separated diagnostic artifacts into three groups: (1) those found below 1719 m ASL (n=14); (2) those found between 1719 and 1721 m ASL (n=12); and (3) those found above 1721 m ASL (n=32) (Figure 3.15). Only two of 12 Paleoindian projectile points occurred within the shoreline range, with five found below 1719 m ASL and five found above 1721 m ASL (see Figures 3.16-3.18; Table 3.4). One WST point occurred at 1723 m ASL; however, it is most closely associated with the shoreline landform on the northern island (Figure 3.16). We noted three Paleoindian points below the shoreline that occurred at multicomponent sites, and later groups may have moved them from their original locations. Additionally, the crescent is below the shoreline, but studies suggest these points often occur below shorelines because the crescents may have been thrown into marshes or lakes to stun waterfowl (Amick 2007; Lenzi 2015). Paleoindian projectile points occurred mostly on the plateau (n=7) with four found on the basin floor and one found on the fan remnants (Figure 3.19). Six Paleoindian projectile points were associated with active spring drainages and one was associated with an arroyo (Figure 3.18).

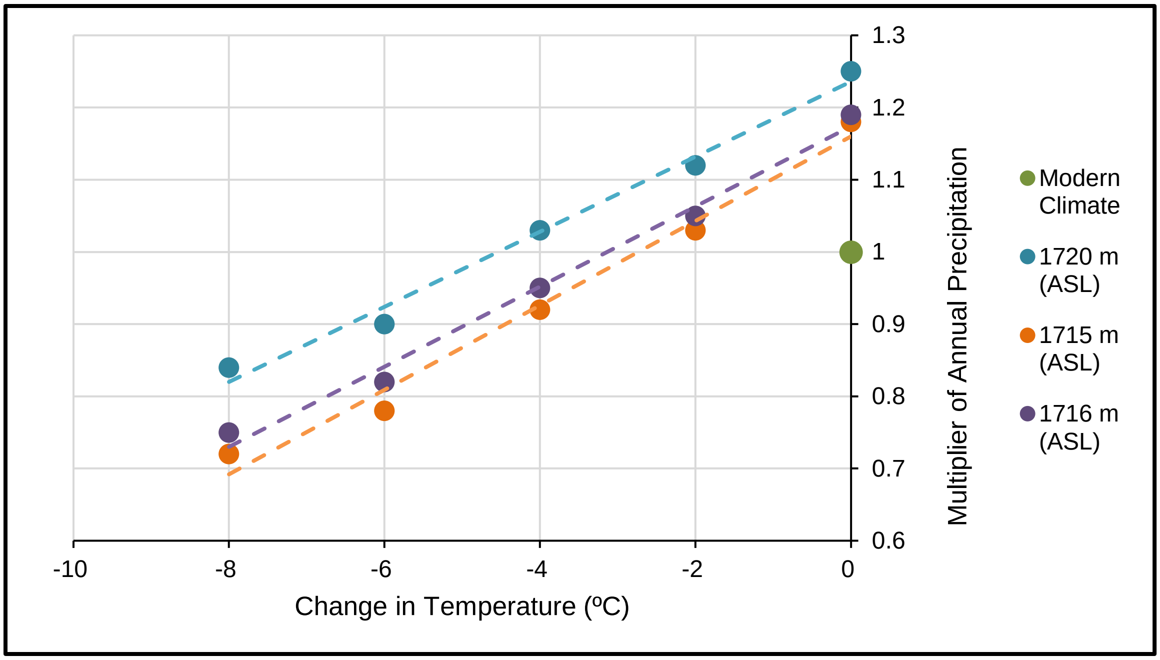

Figure 3.14. The range of climatic conditions that resulted in steady state model simulations of a pluvial lake at 1720 m ASL and a wet meadow at 1716 and 1715 m ASL.

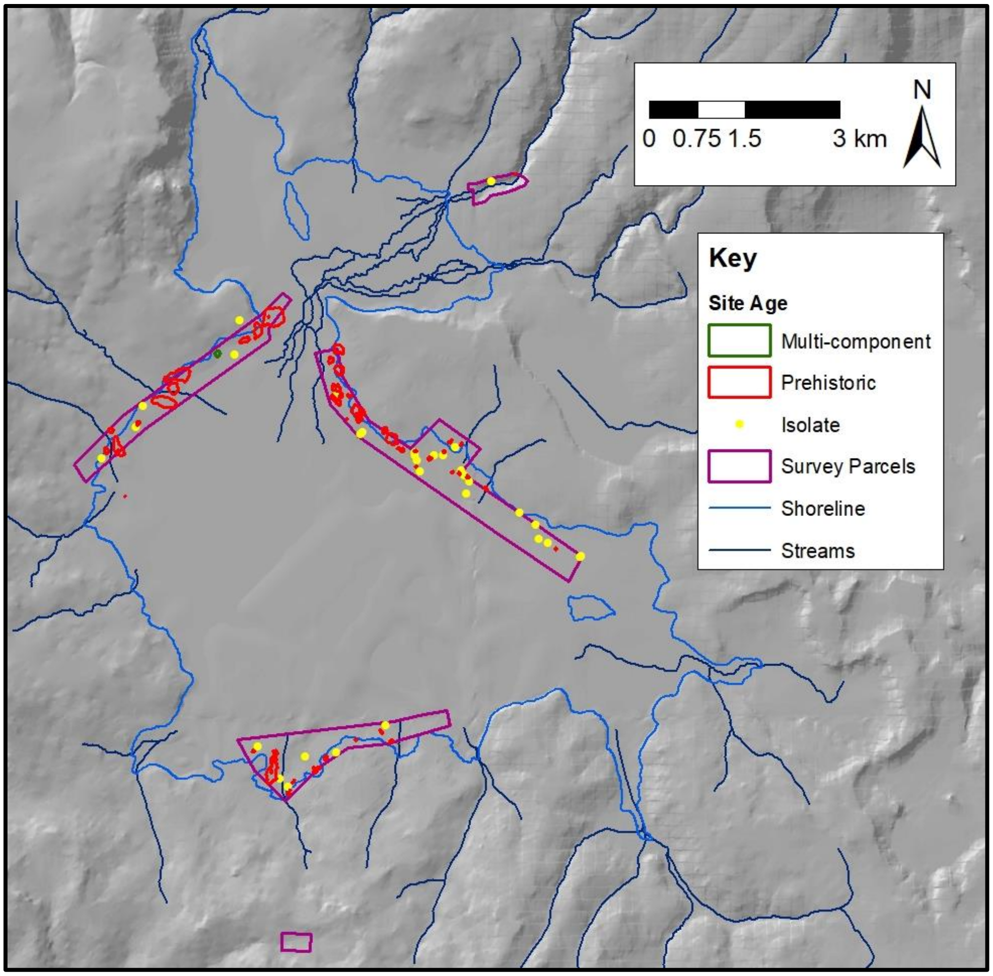

Figure 3.15. Archaeological sites and isolates recorded within FWARG's 2020 survey parcel.

Table 3.4. Projectile Points in Painters Flat.

Site Number	Cultural Period	Elevation (m ASL)	Diagnostic Artifacts
33.17.11.01	Middle Archaic	1749	Elko Eared
33.17.11.01	Late Archaic	1749	Rosegate
33.17.11.03	Post-Mazama	1756	Northern Side-notched
33.17.11.03	Early Archaic	1756	Gatecliff Series
33.17.11.03	Middle Archaic	1756	Elko Series
33.17.11.03	Late Archaic	1756	Rosegate
33.17.11.05	Paleoindian	1739	Parman
33.17.11.05	Middle Archaic	1739	Gatecliff Split Stem
33.17.12.25	Early Archaic	1737	Gatecliff Split Stem
33.17.12.26	Middle Archaic	1731	Elko Series
33.17.12.26	Late Archaic	1731	Rosegate
33.18.21.25	Paleoindian	1737	Western Stemmed Tradition
33.18.21.25	Late Archaic	1737	Rosegate
34.17.21.01	Middle Archaic	1743	Elko Eared
33.17.02.03	Paleoindian	1716	Concave base
33.17.10.02	Post-Mazama	1718	Northern Side-notched [2]
33.17.02.06	Late Archaic	1722	Rosegate
33.17.02.06	Middle Archaic	1722	Elko Eared
33.17.02.08	Middle Archaic	1715	Elko Eared
33.17.02.08	Middle Archaic	1717	Humboldt
33.17.11.08	Early Archaic	1722	Gatecliff Split Stem
34.17.26.01	Middle Archaic	1718	Elko Eared
34.17.26.02	Early Archaic	1719	Gatecliff Series
34.17.26.02	Middle Archaic	1720	Elko Eared
34.17.26.02	Late Archaic	1719	Rosegate
34.17.26.02	Late Archaic	1720	Rosegate
34.17.26.02	Post-Mazama	1719	Northern Side-notched
34.17.26.04	Late Archaic	1722	Rosegate
34.17.23.02	Late Archaic	1722	Rosegate
34.17.26.07	Late Archaic	1723	Rosegate
34.17.26.08	Post-Mazama	1720	Northern Side-notched
34.17.26.08	Late Archaic	1720	Rosegate
34.17.26.11	Middle Archaic	1723	Elko Series
34.17.26.12	Paleoindian	1718	Parman

Site Number	Cultural Period	Elevation (m ASL)	Diagnostic Artifacts
34.17.26.12	Middle Archaic	1719	Elko Eared [3]
34.17.26.14	Early Archaic	1724	Gatecliff Series
34.17.33.03	Paleoindian	1715	Crescent
ISO-23	Paleoindian	1726	Western Stemmed Tradition
ISO-40	Middle Archaic	1762	Elko Eared
ISO-42	Paleoindian	1740	Windust
ISO-EM-11	Early Archaic	1715	Gatecliff Split Stem
ISO-EM-16	Late Archaic	1716	Rosegate
ISO-EM-17	Middle Archaic	1716	Elko Series
ISO-EM-18	Post-Mazama	1722	Northern Side-notched
ISO-EM-26	Middle Archaic	1718	Elko Series
ISO-SR-11	Middle Archaic	1715	Humboldt
ISO-SR-13	Paleoindian	1720	Western Stemmed Tradition midsection
ISO-GB-1	Paleoindian	1723	Western Stemmed Tradition midsection
34.18.20.01	Late Archaic	1740	Rosegate
34.18.20.01	Terminal Prehistoric	1737	Desert Side-notched
34.17.27.01	Middle Archaic	1719	Elko Corner-notched
34.17.27.02	Paleoindian	1718	Parman
34.17.27.02	Paleoindian	1720	Western Stemmed Tradition
34.17.28.26	Late Archaic	1721	Rosegate
33.18.05.02	Paleoindian	1716	Western Stemmed Tradition

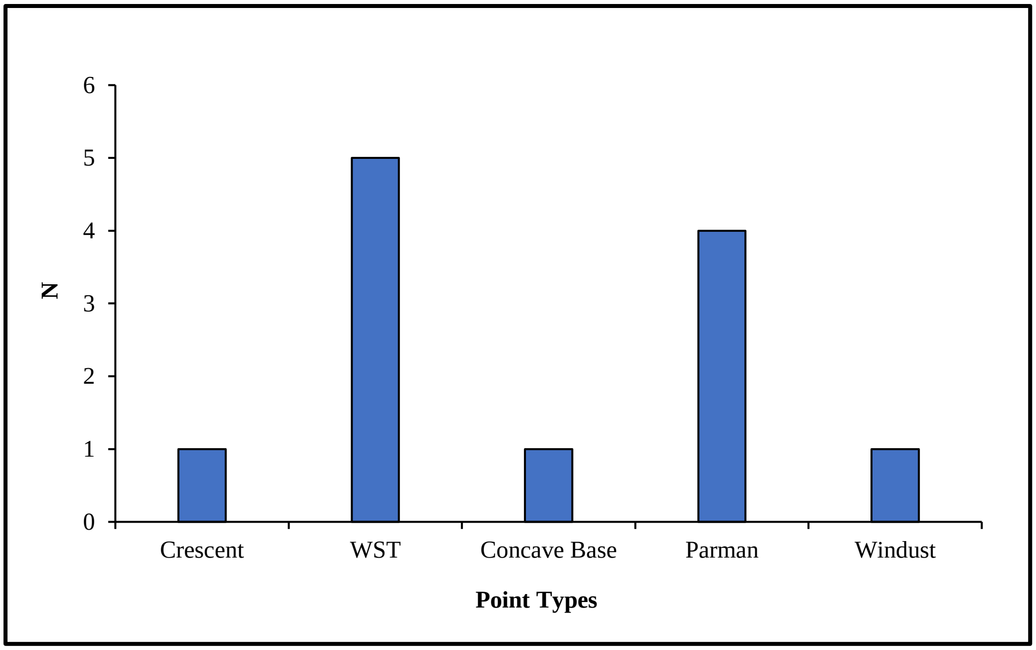

Figure 3.16. Paleoindian projectile point type counts from archaeological sites in Painters Flat.

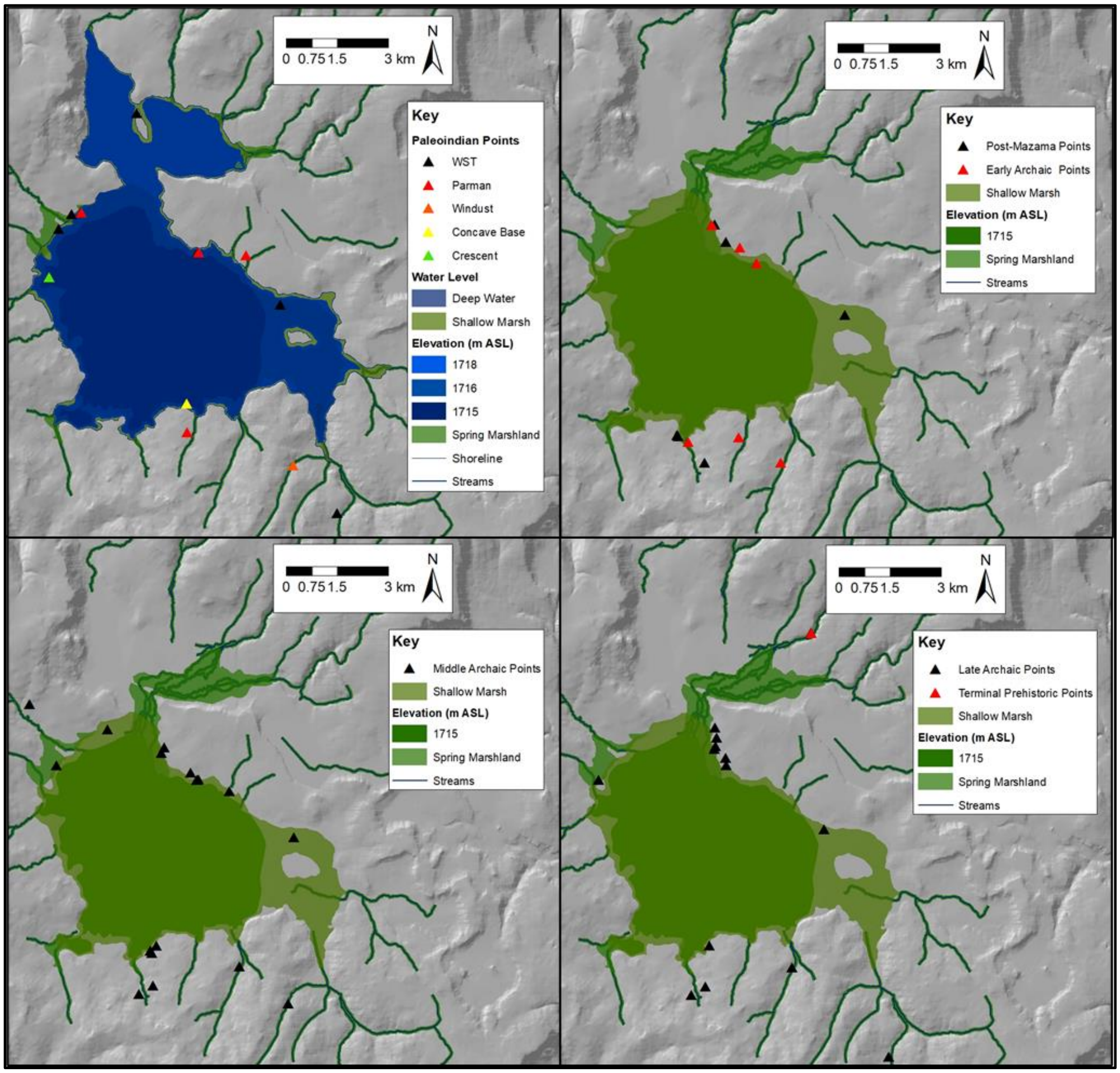

Figure 3.17. Projectile points by cultural period compared to highest water levels.

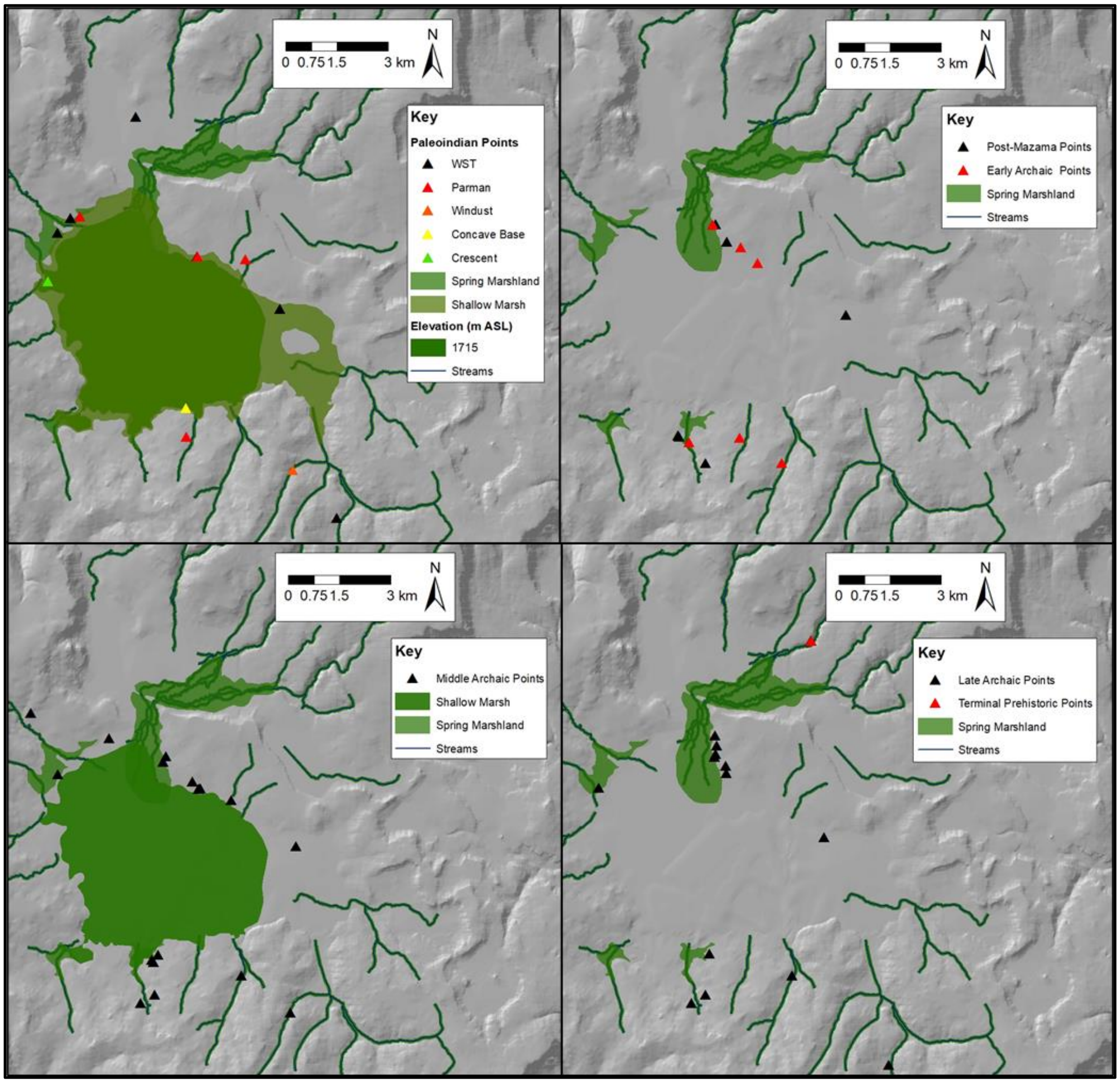

Figure 3.18. Projectile points by cultural period compared to lowest water level.

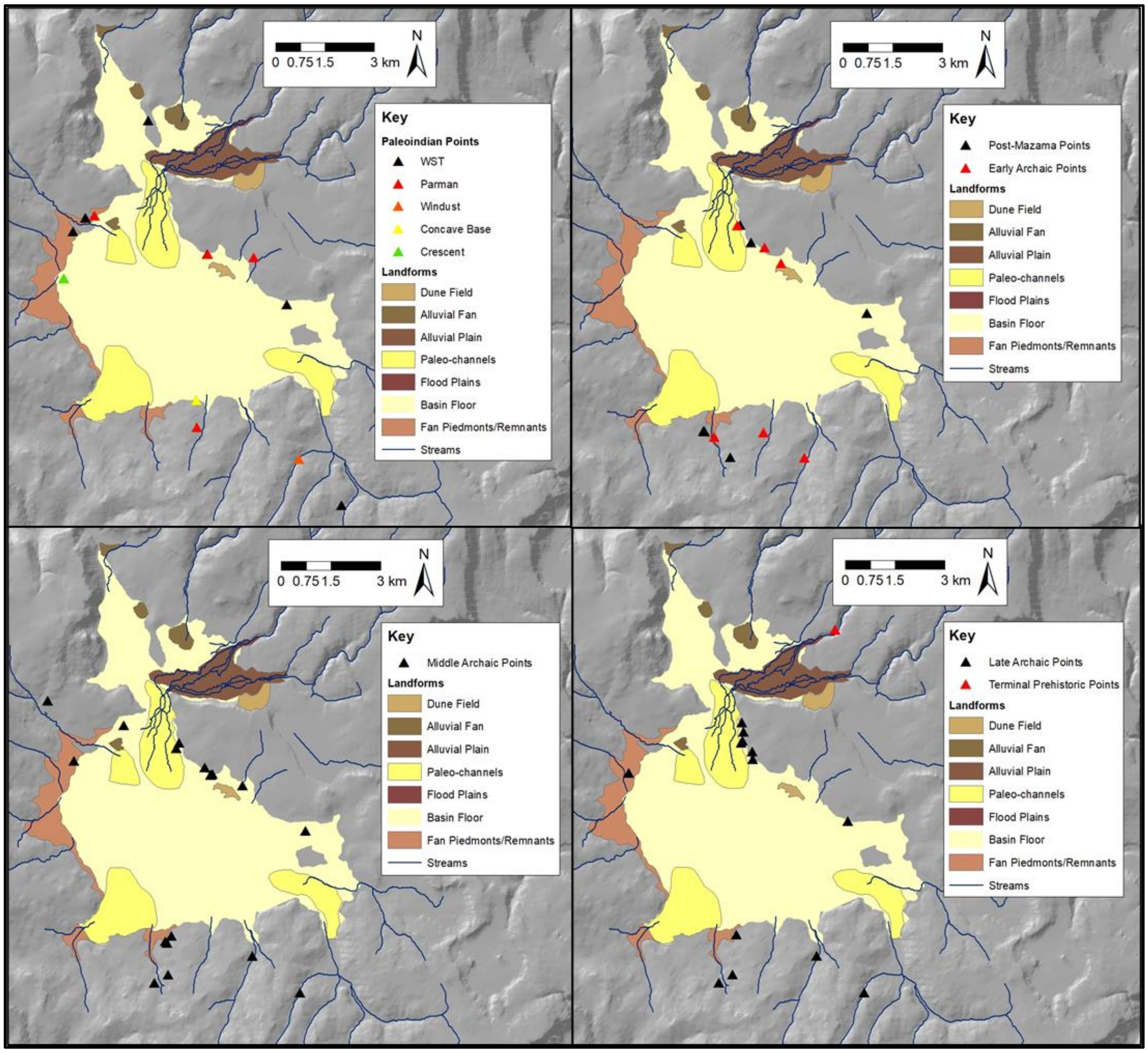

Figure 3.19. Locations of projectile points by cultural period compared to landforms.

Post-Mazama and Early Archaic points clustered along the plateau springs to the south and the basin edge along paleochannels to the north (see Figures 3.17 and 3.18). We noted one Early Archaic point atop the southern peninsula dune field (see Figure 3.19). Elko (n=7) and Rosegate (n=8) projectile points mostly occurred within the shoreline range. Middle Archaic groups continued to occupy the basin edge and southern springs, expanding to occupy the plateaus and the fan piedmont (see Figure 3.19). During the Late Archaic period, groups focused on the southern springs and basin edge, specifically around the northeastern paleochannels (see Figure 3.18). Paleoindian points were associated with the lake and projected wet meadow extent whereas post-Mazama, Early Archaic, and Late Archaic points were associated with spring and stream marsh distributions (see Figures 3.17 and 3.18). Middle Archaic points were associated with the projected wet meadow extent (see Figure 3.17).

Sixty-two ground stone artifacts occurred below the shoreline and 25 occurred between 1719 and 1723 m ASL (Figure 3.20). Twenty ground stone artifacts are associated with the northeastern paleochannels, with other clusters associated with Harrison Spring (n=14) and Petes Spring (n=35) (see Figure 3.20). All 87 ground stone artifacts occur within ~1 km of a seasonal or permanent water source (see Figure 3.20). Sixteen sites and isolates containing ground stone lacked diagnostic projectile points so we could not assign them to specific cultural periods (see Table 2.3). Ground stone artifacts occurred equally at Middle Archaic and Late Archaic sites (4 each) with most at multi-component sites (n=6) (see Table 2.3). One only Paleoindian site contained ground stone artifacts (n=6) (see Table 2.3).

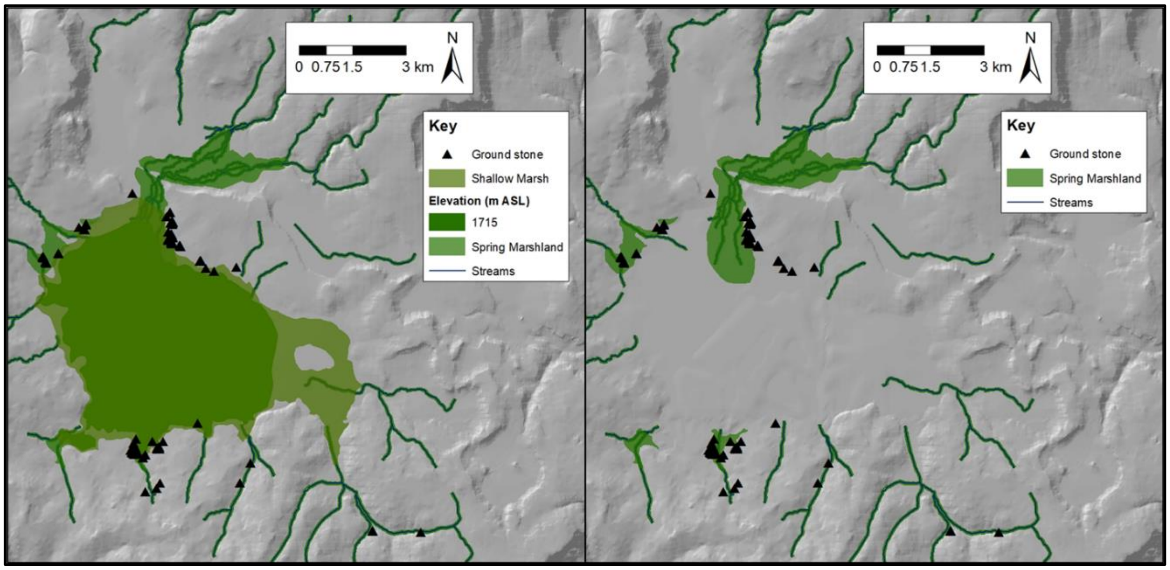

Figure 3.20. Ground stone from archaeological sites in Painters Flat.

CHAPTER 4

DISCUSSION

In this chapter, I revisit my hypotheses and discuss how my results conform to my expectations. I then discuss my data and their implications for the geomorphic and archaeological history of Painters Flat. Finally, I consider how Painters Flat relates to other basins in the northwestern Great Basin and how my results correspond with previous studies.

I hypothesized that Painters Flat held a pluvial lake during the late Pleistocene. I expected landforms and sediments to reflect the presence of such a lake and that my hydrologic model results would show that Painters required late Pleistocene conditions to form a lake. Additionally, I expected landforms and sediments to reflect wet meadow and then activated eolian and alluvial systems during the early Holocene. For hunter-gatherer occupations, I expected early Paleoindian occupations to have occurred near shallow lake habitats with late Paleoindian and post-Mazama occupations to be focused on upland springs and drainages. During the Early and Middle Archaic periods, groups should have remained focused on springs, but shifted to the Cottonwood Delta and its channel systems during the Late Archaic period.

The History of Painters Flat

The Late Pleistocene

My first hypothesis was that a pluvial lake occupied Painters Flat during the late Pleistocene. My profile chronology did not produce definitive evidence of a pluvial lake in Painters Flat dating to the late Pleistocene, though a lake was present prior to 6885-6675 cal BP and, potentially, earlier. Several lines of evidence suggest that a lake was present earlier. First, multiple strandlines and a spit indicate that a pluvial lake occupied Painters Flat for a prolonged period to redeposit sediments.

Second, boulders in the basin's center cannot be accounted for by alluvial processes. Instead, they most likely ice rafted when the lake froze over in a manner similar to that documented in other basins (Allen et al. 2015).

Third, the results of the hydrologic modeling that I presented in Chapter 3 indicate that to sustain a lake at 1720 m ASL, a ΔT and ΔP from the modern climate would be needed. For example, with modern average annual temperature, a 25% increase in annual precipitation would be needed to form a lake at 1720 m ASL. These temperature and precipitation changes are similar to changes necessary to produce the Bølling-Allerød highstand 14,500-13,400 cal BP in the Chewaucan Basin (Hudson et al. 2019; Douglas Boyle, personal communication, 2021). Conversely, these results are much lower than precipitation and temperature changes needed for Jakes Lake's Late Glacial period highstand ~16,800 cal BP (Barth et al. 2016). Modeling in Surprise Valley, just north of Painters Flat, suggests that the basin required a 5ºC decrease in average annual temperature and a 35% increase in average annual precipitation to sustain a lake at the Late Glacial highstand elevation (Egger et al. 2018; Ibarra et al. 2014). My results suggest that Painters Flat's hydrologic system operated within the north/south dipole transition zone and required lower temperature and precipitation changes when compared to southern and central Great Basin systems. Continued geoarchaeological research should reveal whether Painters Flat reached a Bølling-Allerød or Late Glacial highstand. Hydrologic modeling results of Walker Lake during the Holocene suggests that only a 1% increase in average annual precipitation was required to form late Holocene highstands (Hatchett et al. 2018). Additionally, these basins never returned to highstand levels during the Holocene (Barth et al. 2016; Hudson et al. 2015; Wriston and Smith 2017), so the modeled climate conditions necessary to reach these highstands only occurred during the late Pleistocene. My hydrologic modeling results are within the range of previously recorded late Pleistocene temperature and precipitation combinations; therefore, the model supports my first hypothesis that the conditions required to form a lake at 1720 m ASL only occurred during the late Pleistocene. On the other hand, while my model accounts for soil storage in the watershed, I did not account for groundwater. This is not uncommon in pluvial lake modeling in the Great Basin (e.g., Adams 2003; Duke and King 2014). Future modeling may reveal that groundwater storage beneath the basin caused water loss so that Painters Flat required wetter and cooler conditions than my model indicates. The importance of groundwater reservoirs is generally overlooked – a fact that may limit our understanding of early Holocene climate changes in Painters Flat and other basins.

Fourth, Lake Madeline transgressed to 1639 m ASL with turbidite deposits that suggest Painters Flat outflowed to Lake Madeline during the late Pleistocene. Therefore, Lake Madeline likely corresponds with a lake in Painters Flat if the sill remained at 1721-1722 m ASL throughout the late Pleistocene. Larger lake systems reached Younger Dryas lakestands after their Late Glacial highstands (Adams and Rhodes 2019), so Lake Madeline may have reached 1639 m ASL during the Younger Dryas. Since the tephra and bulk sediment dates from the Las10-1 are stratigraphically inversed, additional geoarchaeological work in the Madeline Plains Delta is required to determine when the lake transgressed. On the other hand, many small basins (e.g., the Dietz Basin) reached highstands during the Late Glacial period but did not return even as larger lake systems (e.g., Lake Lahontan) reached Younger Dryas lakestands (Adams and Rhodes 2019; Pinson 2008). Therefore, it is possible Painters Flat's watershed was able to sustain a lake during the Late Glacial period but only a wet meadow during the Younger Dryas. We noted WST points along the 1720 m ASL shoreline, so people may have visited Painters Flat during the Younger Dryas when a lake was present. This remains a hypothesis to be more fully tested with additional geoarchaeological work.

Whether Painters Flat's pluvial lake reached its last stand during the Late Glacial, Bølling-Allerød, or Younger Dryas, surface archaeological deposits suggest that people visited briefly when a lake was present. I originally hypothesized that Paleoindian settlement strategies initially focused on shallow lakes and later transitioned to springs. I expected early Paleoindian tools (e.g., Haskett points and crescents) to cluster along the shoreline, while later Paleoindian tools (e.g., Parman and Windust points) to be associated with springs with lake desiccation. We only recorded one WST point midsection and one Parman point along the shoreline (see Figure 3.17). We recorded a Parman point just above the shoreline near an arroyo and the stream was likely active even after lake desiccation. A WST point midsection occurred just above the northern island's shoreline with marshland separating the island from the basin edge at the highstand (see Figure 3.17). The remaining Paleoindian points occurred either below the shoreline or were associated with upland springs, further suggesting that few people occupied the basin when the lake was present. The crescent occurred below the shoreline and studies suggest these points occur below shorelines during lakestands (Amick 2007), so its location supports the presence of a lake or wet meadow when the crescent was discarded. On the other hand, many of these points occurred at multicomponent sites, and later visitors may have simply picked them up carried them to different locations.

Finally, my marsh potential model, which is based on the basin's bathymetry, indicates that marshes should have been most productive and extensive when the basin was covered by a wet meadow. A wet meadow might explain the presence of the Concave Base, Parman, and WST point on the basin floor (see Figure 3.19). A Younger Dryas lakestand and subsequent lake regression would have fostered marshes – attractive places for Great Basin hunter-gatherers. It is important to note that our archaeological investigations were restricted to the current ground surface. Stratigraphic data from my augers and exposures suggest that late Pleistocene deposits lie buried throughout the basin floor and delta system. Debitage is also present within the arroyo exposures confirming the presence of buried Holocene deposits. Archaeological sites dating to the late Pleistocene are likely buried if they exist in the basin. Regionally, many Paleoindian sites cluster around active or relict deltas (Madsen et al. 2015; Reaux et al. 2020). If this was also the case in Painters Flat, then they should lie buried beneath at least 2 m of sediment since Holocene deposits extend 1-2 m below the surface. Additionally, many large and small lake basins (e.g., Lahontan, Warner) have been subject to various erosional processes since the late Pleistocene, which has left many archaeological sites sitting atop eroded surfaces (Adams et al. 2008; Wriston and Smith 2017). Painters Flat responded differently than these larger basins and has acted as a catchment area for sediments that have buried older deposits. The basin maintains a seasonal wet meadow that prevents the extensive sediment erosion that other basins have experienced.

Duke and King (2014) found that many smaller basins disappeared shortly after reaching highstands but in doing so increased their marsh potential before completely desiccating. They predicted that such basins should contain early Paleoindian assemblages while other basins in which lakes or wetlands persisted should contain later Paleoindian assemblages. Duke and Young (2018) tested these predictions in the central Great Basin and found that people initially focused on basins with earlier lakestands. My results do not conform to Duke and King's (2014) lake highstand predictions. Painters Flat reached its highstand earlier, but likely reached a Younger Dryas lakestand and the resulting wet meadow and active springs attracted later Paleoindians to the basin during the early Holocene. Basin shape greatly influences the possible extent of marsh resources (Young 2000), and Painters Flat is a relatively steep-sided basin. Thus, marsh potential was highest not when there was a lake but instead a wet meadow. During the earliest chapter of human occupation of the Black Rock Desert-High Rock Country, people likely focused on other basins (e.g., the Parman Localities) in northwestern Nevada (Duke and King 2014).

The Early Holocene

With the onset of the early Holocene, climatic drying and warming resulted in the retreat and, in some cases, desiccation of numerous pluvial lakes. My second hypothesis stated that Painters' pluvial lake retreated during the early Holocene, leaving active springs and channel systems. None of the exposures or augers that I profiled contained early Holocene deposits to the depth that I investigated. Only the dune fields in the eastern portion of the basin indicate eolian activation sometime before an Early Archaic (4500-3800 cal BP) occupation. These dune fields formed from predominantly southwestern winds that became active following the late Pleistocene glacial retreat that caused changes in wind direction (Colgan et al. 2017). Furthermore, the basin is dry today, but the presence of lake landforms indicates a lakestand existed and desiccated at some point during the late Pleistocene and Holocene.

Painters Flat's pluvial lake likely desiccated near the beginning of the early Holocene. I expected my hydrologic modeling results to indicate conditions required to form a wet meadow occurred periodically throughout the Holocene. To form a wet meadow at its maximum extent (1716 m ASL) a combination of changes in precipitation and temperature had to occur (see Figure 3.14). A maximum change of -3ºC in temperature or a 19% increase in precipitation is lower than conditions needed to form pluvial lakestands throughout the late Pleistocene (Barth et al. 2016; Ibarra et al. 2014) and higher than conditions during the late Holocene (Hatchett et al. 2018). These model results suggest a wet meadow likely formed during the early Holocene when the regional climate conditions transitioned from the wetter late Pleistocene to the middle and late

Holocene. And while initially the retreat likely sustained a wet meadow, complete desiccation would have left sparce resources on the basin floor. Once that occurred, the basin's springs and their outlets acted as refugia and likely fostered riparian zones that terminated at the basin margins. We noted examples of later Paleoindian Windust and Parman points concentrated around those areas, suggesting that people shifted from the lake and wetland margins to the springs and channels – point resources still producing productive habitats. The distribution of these time-sensitive projectile points supports the second part of my third hypothesis: early Holocene occupations were focused on springs. Duke and King (2014) predicted that people should reduce their interbasin mobility as wetlands declined. Painters Flat's archaeological record suggests that this did occur, and that residential mobility decreased. Recent large-scale studies (e.g., Hildebrandt et al. 2016) in northwestern Nevada have demonstrated similar decreased mobility towards the end of the early Holocene and into the middle Holocene.

The Middle Holocene

The initial middle Holocene saw continued drying and warming. With these changes, many remaining lakes dried up and their sediments became available for transport, causing erosion of late Pleistocene deposits. In Painters Flat, the earliest radiocarbon date that I obtained (6885-6675 cal BP) dates to the initial middle Holocene. I obtained the date on organic material in colloidal silts near the northeastern channel systems. The context and age of the sample indicates that the area was stable when the organic material was deposited and translocated into the profile. Mesic-adapted vegetation fed from the remaining springs and groundwater likely stabilized the area, preventing sediment erosion. Therefore, the soil indicates that the local climate was wetter than other regions during the middle Holocene and promoted mesic vegetation growth. Additionally, the locality is within the areal extent of the 1716 m ASL wet meadow which required a maximum change of 19% in precipitation to form (see Figure 3.14). Either a wet meadow or the northeastern paleochannels acted as refugia during the initial middle Holocene, as further evinced by post-Mazama sites located along the peninsula (see Figure 3.18). On the other hand, the initial middle Holocene experienced volatile fluctuations in climatic conditions which likely caused varying conditions in the basin and influenced where people decided to settle (Wriston 2009). Calcium carbonates below the organic material in Las43-1 could have precipitated during the dry and warm conditions of the initial middle Holocene, working down into the profile along with organic materials during the middle Holocene gap.

Alongside the post-Mazama projectile point cluster along the channels were numerous ground stone artifacts that further suggest people were residentially stable to some degree. While, as a whole, the Painters Flat archaeological record suggests decreased occupation during the middle Holocene, the area was not wholly abandoned. Projectile points decreased from 12 to six from the early to middle Holocene. Some basins without permanent water sources were abandoned (e.g., High Rock Lake), while basins like Painters Flat saw persistent if not smaller wetlands, which may have prompted people to use those places less (McGonagle 1979). Both the Madeline Plains and Guano Valley contain evidence of frequent post-Mazama use likely indicative of larger or persistent wetland or riparian systems (Delacorte and Basgall 2012; Reaux et al. 2018).

The middle Holocene was neither uniformly dry nor uniformly warm (Wriston 2009). The middle Holocene gap was a period of relatively wet and cool conditions. Sediment profiles dated to the middle Holocene demonstrate the relationship between the embayment localities (the northwestern sill and Cottonwood Delta) and the basin floor. Conditions in one locality can reflect conditions in the other. Soil development in the northwestern sill and the Cottonwood Delta signifies wetter conditions. With wetter conditions, a wet meadow occupied the basin floor and acted as a catchment area for eolian silts. In Las43-1 and Las46-4, colloidal silty sediments are in stratigraphic alignment with the embayment localities' soils (see Figures 3.5 and 3.6). Therefore, a change in ΔT (e.g., -4-0ºC) and ΔP (e.g., 0.95-1.19) must have occurred during the middle Holocene gap (see Figure 3.14). An archaeological site containing a Northern Side-notched projectile point also occurred along the peninsula's southern edge (see Figure 3.17), so a wet meadow likely sat south of the peninsula because there is no surficial evidence of a stream in that area. Most post-Mazama projectile points are clustered around the northeastern channels and the Petes Spring outlet to the basin floor (see Figure 3.18). The middle Holocene gap may have provided the conditions necessary to activate the spring systems. Artifact clusters around the northeastern channels and Petes Spring outlet suggest that people focused on riparian resources. Petes Spring would have likely provided riparian resources along its alluvial fan, and 16 ground stone artifacts at site 33.17.10.02 suggest decreased residential mobility during the post-Mazama period.

With the onset of the terminal middle Holocene, climatic conditions once again changed. The climate became warmer and drier and caused shifts in environmental conditions. Base level dropped, causing erosional processes to dominate where soils once developed. In the northwestern sill and Cottonwood Delta profiles, unconformities separate the middle Holocene gap soils from late Holocene deposits. During this period, predominately alluvial deposition probably affected the basin floor. Mixed sands and colloidal silts below the Neopluvial paleosol in Las46-4 supports this interpretation. Additionally, gypsum concentrations at 55 cm below surface in Las48-1 suggest that arid conditions occurred on the basin floor sometime during the middle Holocene. We obtained one radiocarbon date of 4765-4625 cal BP from Las46-1 that falls within the terminal middle Holocene. The same soil column also returned a Neopluvial period date (3455-3355 cal BP) 5 cm above the older date, which suggests that the paleosol had additions throughout the terminal middle Holocene and late Holocene. The middle to late Holocene transition was gradual, so the stable landform developed along with the increasingly wetter conditions.

The Late Holocene

The middle to late Holocene transition marked a gradual return to wetter and cooler conditions (Wriston 2009). The timing of this transition varies throughout the Great Basin (Adams and Rhodes 2019; Grayson 2011; Mensing et al. 2004; Wriston 2009), though most records suggest that the Neopluvial period began ~4500 cal BP in the northwestern Great Basin (Grayson 2011; Mensing et al. 2004). The return of wetter and cooler conditions again caused a shift in geomorphic processes throughout Painters Flat by increasing the base level. Las46-1 showed evidence of continued soil formation.

Las46-4's Neopluvial paleosol also provided evidence of soil formation in the basin floor's Stratum I. Other basin floor profiles showed continued eolian silt deposition indicative of a wet meadow. In the Cottonwood Delta, sediment deposition and subsequent soil development above an unconformity indicate renewed wetter conditions (see Figure 3.2). With a wet meadow in the basin floor, climate conditions once again changed to the range of precipitation and temperature combinations demonstrated with my model (see Figure 3.14).

For my fourth hypothesis, I expected that post-Mazama foragers would have remained linked to springs while later groups would have shifted to the northern channel systems; however, even with increasingly wetter and cooler conditions Early Archaic hunter-gatherers remained clustered around the northeastern channels and the Petes Spring outlet. While there are multicomponent sites with ground stone and Early Archaic points, there are no single component sites linking ground stone to strictly the Early Archaic period. Because conditions leading up to and during the Neopluvial period changed gradually, the wet meadow and other springs may have not become active until the groundwater reservoir filled. Other studies in the northwestern Great Basin have proposed that people expanded their ranges during the Early Archaic period (Leach 1988; McGonagle 1979; O'Connell 1975). Conversely, some basins, including Guano Valley, Hawksy Walksy Valley, and Painters Flat, saw a sharp expansion in people's ranges during the Middle Archaic period (Grund 2020; Reaux 2020). Those basins may have responded differently to the Neopluvial period, so additional studies may help determine why settlement patterns differed. Additionally, the presence of an Early Archaic site atop the eastern linear and barchan dune field indicates that the dunes formed prior to the

Early Archaic period. Interdunal areas in other basins have provided marsh habitat during wet cycles, so the dune field may have provided plant resources (Wriston and Smith 2017; Young 2000).

Middle Archaic foragers occupied several new locations during the latter half of the Neopluvial period, including Harrison Springs, Mixie, and Spur Springs, along with Petes Spring and other unnamed springs (see Figure 3.18). Middle Archaic sites also occur along the southern side of the peninsula and north of Harrison Springs along the projected extent of the wet meadow (see Figure 3.17). Early versus Middle Archaic projectile point counts jump from seven to 18, and groundstone is common at single component Middle Archaic sites. The spatial distribution of Middle Archaic projectile points suggests that people targeted both point and patch resources. This finding counters my expectation that Middle Archaic groups focused strictly on point resources. As I previously mentioned, Early and Middle Archaic hunter-gatherers expanded to uplands and canyons throughout the Great Basin and decreased their residential mobility (Grund 2020; Leach 1988; McGonagle 1979). With decreased mobility, people could have expanded to new locations to target a wider range of resources within the same basin. Groups in Painters Flat may have established larger residential sites near patch resources and traveled to the surrounding uplands and drainages for other resources. Previous research suggests that people gathered plants and hunted small game on the basin floor while groups made logistical forays into the uplands for large game and geophytes (Pinson 2007; Prouty 1994). A study of technological organization using the sites' lithic assemblages may help to determine if decreased mobility may account for the spatial distributions of Middle Archaic sites.

Mensing and others (2004) suggested that the Neopluvial period ended 2700 cal BP, though Adams and Rhodes (2019) noted that its end date varies depending on location. The end of the Neopluvial period was marked by reoccurring and persistent droughts, with pollen, tree ring, and $\delta^{18}O$ records showing numerous wet/dry oscillations (Mensing et al. 2004). Two radiocarbon dates from Ao horizons (725-575 cal BP and 1265-1060 cal BP) fall into the latter portion of the late Holocene, indicating activated alluvial processes at that time. A wet cycle activated these streams, which then brought in charred plant remains from wildfires that likely occurred during a previous dry period. Tephra deposits capping these Ao horizons are recent additions to the basin floor. These vesicular horizons develop from oscillating dry and wet conditions, further supporting Mensing and colleagues' (2004) interpretations regarding late Holocene environmental conditions.

In terms of Painter Flat's archaeological signature for this period, current projectile point typologies and chronologies cannot distinguish between the middle and late Holocene boundary in the Middle Archaic record. Changes in settlement strategies occurred during the Late Archaic period, therefore supporting my fourth hypothesis: late Middle Archaic and Late Archaic groups shifted their occupations to the northern channel systems during the late Holocene. Late Archaic projectile points are clustered around the northeastern channels and Petes Spring (see Figure 3.18). However, three projectile points were found at Harrison Spring, Mixie Spring, and along the peninsula. Additionally, ground stone counts at single component sites are similar to those from the Middle Archaic period but focus around the northeastern channels and Petes Spring. Resource stress likely pushed Late Archaic groups to focus on reliable patch resources when other localities dried up. In that regard, Painters Flat's archaeological record aligns with previous research suggesting that groups limited their settlement locations in the face of declining resource productivity (McGonagle 1979; O'Connell 1975). As Painters Flat and other basins dried, basins that held lakes during the Neopluvial period increased their marsh extent with desiccating conditions (Young 2000). Late Archaic hunter-gatherers remained at their expanded ranges or expanded further in these wetter basins (Leach 1988; Young 2000). Basin shapes and their responses to climate changes may provide insight into how later groups adjusted their settlement strategies. Finally, Terminal Prehistoric projectile points were virtually absent except for one at an isolated northeastern spring. Ethnographic accounts indicate that the *Kamödökadö* and *Wadadökadö* utilized the area around Painters Flat (Tiley and Rucks 2011), so this paucity of late projectile points may suggest that visitors pursued other activities besides hunting.

Overall, Painters Flat demonstrates a bimodal response to climate change. Wet cycles activate the wet meadow and stabilize the northwestern sill and Cottonwood Delta systems. Dry cycles cause the wet meadow to dry, and alluvial processes dominate with active downcutting in the embayment localities. This relationship seems to be reflected in how people used the landscape. Rather than relying on point resources during dry periods, they focused on patch resources. During wet periods, people may have expanded their ranges. At no time did people completely abandoned point or patch resources, suggesting that while they tended to focus on one or the other under certain conditions, they maintained a persistent though flexible settlement strategy. When considered within a regional context, Painters Flat generally follows similar trends to those noted in other nearby basins. Deviations from these regional trends suggest that local rather than regional conditions probably influenced how people settled the landscape and moved between basins.

CHAPTER 5

CONCLUSIONS

Painters Flat held a pluvial lake prior the initial middle Holocene, and likely during the late Pleistocene. During the late Pleistocene, hunter-gatherers occasionally visited the basin, returning more often once a wet meadow occupied the basin's center. During the early Holocene, the wet meadow desiccated, and people shifted to upland springs. Post-Mazama groups then targeted patch resources such as Petes Spring and the northeastern channel systems. They likely occupied the basin's margins during the middle Holocene gap when a wet meadow and larger alluvial systems activated. The terminal middle Holocene resulted in the wet meadow's desiccation, and people remained tied to persistent patches. The Neopluvial period ushered in wetter and cooler conditions, and Painters Flat again housed a wet meadow that attracted people. Early Archaic hunter gatherers occupied additional southern springs along with the northern channels and Petes Spring. Middle Archaic groups expanded their ranges to encompass areas on the basin floor and uplands that had been abandoned since the Paleoindian period. Following the Neopluvial period, Painters Flat's sediments suggest wet/dry oscillating conditions. These variable and unpredictable conditions seem to have led Late Archaic visitors to focus on the northeastern channels and Petes Spring once again.

Overall, Painters Flat's geomorphic systems responded to changing temperatures and precipitation by bimodally shifting the dominant processes in an area. Wet cycles produced a wet meadow on the basin floor and soils in the embayment localities. Dry cycles activated erosional forces (represented by unconformities) in the embayment localities and alluvial sediments deposited and mixed with silts in the basin floor. These conditions prompted visitors to shift their settlement strategies. People focused on refugia during dry cycles and shifted to additional locations during wet cycles. During the early Holocene, people focused on springs and basin margins, while, during the middle and late Holocene they shifted to the northeastern channels and Petes Spring. These strategies may be best considered as points along a continuum because people never fully abandoned the springs or basin margins. Instead, they simply shifted the frequency and duration of stays in these places and employed a flexible adaptive strategy.

Duke and King (2014) predicted that earlier highstands in small hydrologically sensitive basins should contain an early Paleoindian record. Painters Flat likely reached an earlier highstand with a Younger Dryas lakestand but the archaeological record suggests people chose other basins during the late Pleistocene while later Paleoindian foragers mostly visited when a wet meadow existed. Painters Flat's Younger Dryas pluvial lake would have fostered prolonged wetlands resulting in patterns similar to those derived from Duke and King's (2014) highstand model. Because Painter Flat's hydrologic system responds rapidly to climate change, a wet meadow developed multiple times throughout the Pleistocene and Holocene. Painters Flat's middle and late Holocene archaeological records generally conform to those from other records in the northwestern Great Basin and show decreased occupation during the middle Holocene but a subsequent spike during the Middle Archaic period. The exact timing of these shifts vary somewhat between basins, suggesting that local rather than regional processes and, in turn, conditions drove people's settlement-subsistence decisions.

Future Research Opportunities

Painters Flat contains a record of human occupation spanning the past ~10,000 years. Even with our recent investigations, very little work has been carried out in the basin. Thus, there are ample opportunities to build on my study. In terms of archaeological work, I see three productive avenues. First, while I suggested that people never completely abandoned point or patch resources and instead retained a flexible adaptive strategy, this hypothesis should be tested with a more robust sample of site and artifact location data and additional surveys in the delta, surrounding uplands, and basin floor. Second, I did not conduct any toolstone source provenance studies, so it remains unclear from where visitors to Painter's Flat traveled or the connections they shared with more distant groups. Third, I did not conduct an in-depth technological analysis of the lithic assemblages and doing so in the future will enhance arguments related to occupation span and mobility strategies.

In addition to these fairly straightforward methodological approaches to collecting additional archaeological data, Painters Flat also holds the potential for additional geoarchaeological work. Future work may inform our understanding of how small basins respond to climate change, and how that affected early groups' strategies. Painters Flat differs from many basins in the northwestern Great Basin in that it contains a relatively complete Holocene record. Further study of the geomorphic history of Painters Flat will require subsurface investigations because late Pleistocene and early Holocene deposits lie ~2 m below the surface in most places. There is a high potential for buried late Pleistocene deposits and sites, especially in the Cottonwood Delta, due to the presence of buried paleosols, visible debitage within arroyo walls, and the likelihood that early groups preferred such places (Madsen et al. 2015; Reaux et al. 2018). Archaeologists should conduct investigations into these deposits before any subsurface developments proceed. Holocene deposits and occupations are also likely buried and may preserve features not retained at surface sites. Investigating the dune deposits may increase our understanding of how Painters Flat responded to drying during the early Holocene. The dunes may also preserve post-Mazama occupations and provide insight into settlement and subsistence strategies during the middle Holocene.

Further investigating Painter Flat's potential to hold a lake or marsh is another possible direction for future research. More detailed hydrologic modeling including groundwater loss in the watershed, more precise temperature and precipitation data, and spatial variability within the watershed may allow us to better understand the history of Painters Flat's pluvial lake. Researchers often neglect the role of groundwater even though it likely contributed to water loss in pluvial systems in the northwestern Great Basin. The late Pleistocene experienced multiple climatic shifts and future subsurface investigations could allow researchers to develop a lake-level curve for Painters Flat. To do this, researchers will need to determine the height of the sill throughout the Pleistocene as well as the age and elevation of lake deposits in the basin. Chemical constitutes in the spring systems and basin floor deposits likely provide clues about whether standing water in the basin supported wetlands. Additional proxies such as microstratigraphy or microbotanicals may yield more information into the timing and magnitude of climate change to produce a wet meadow throughout the Holocene. Wet periods such as the middle Holocene gap and Neopluvial period varied in intensity and duration so further investigations into this variation would narrow the range of climatic combinations suggested in my model. Finally, the basin is currently steep-sided, which causes marsh potential to increase when the basin is in a wet meadow phase. Future efforts toward more detailed hydrologic models will require careful consideration of Painters Flat’s bathymetry during the Pleistocene and Holocene to determine if marsh potential would increase around the shoreline or instead be restricted the deltaic system.

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APPENDIX 1

Water Balance Model Equations

Thornthwaite-Type Monthly Water Balance Model

SOILmax is the soil storage capacity. *P* is the mean monthly precipitation (mm) and *T* is the mean monthly temperature (ºC).

Snowpack, Snowmelt, and Water Input

$$If\ (T > 6℃), F = 1 \quad \text{(A.1)}$$

$$If\ (T < 0℃), F = 0 \quad \text{(A.2)}$$

$$If\ (0℃ < T < 6℃), F = (1/6) * T \quad \text{(A.3)}$$

where *F* is the melt factor.

$$Rain = F * T \quad \text{(A.4)}$$

$$Snow = (1 - F) * T \quad \text{(A.5)}$$

$$Pack = (1 - F)^2 * P + (1 - F) * Pack_{-1} \quad \text{(A.6)}$$

$$Melt = F * (Snow + Pack_{-1}) \quad \text{(A.7)}$$

where *Pack* is the snowpack water equivalent at the end of the month *m*-1. *Melt* is the monthly snowmelt.

$$Input(W_m) = Melt + Rain \quad \text{(A.8)}$$

where W_m is water input.

Evapotranspiration and Soil Moisture

$$Radians = \left(\frac{Latitude}{360}\right) * 2 \quad \text{(A.9)}$$

$$Declination = \left(\frac{Radians}{360}\right) * 2 \quad \text{(A.10)}$$

$$Daylength = 2 * \frac{Acos\left(-Tan(Declination) * Tan(Radians)\right)}{0.2618} \quad \text{(A.11)}$$

$$If\ (T > 0), PET = 924 * Daylength * 0.611 * \frac{EXP\left(17.3 * \frac{T}{T+237.3}\right)}{T+273.2} \quad \text{(A.12)}$$

$$If\ (T < 0, PET = 0 \quad \text{(A.13)}$$

where *PET* is the potential evapo-transpiration and *Daylength* is the hours of sunlight available at a specified latitude.

$$If\ (W_m > PET), Soil = MIN(((W_m - PET) + Soil_{-1}), SOILmax) \quad \text{(A.14)}$$

$$If\ (W_m < PET), Soil = Soil_{-1} * EXP\left(-\frac{PET - W_m}{SOILmax}\right) \quad \text{(A.15)}$$

$$\Delta Soil = Soil - Soil_{-1} \quad \text{(A.16)}$$

where *Soil* is the soil moisture storage and *ΔSoil* is the amount of soil moisture that can be withdrawn.

$$If\ (W_m > PET), ET = PET \quad \text{(A.17)}$$

$$If\ (W_m < PET), ET = W_m + Soil_{-1} - Soil \quad \text{(A.18)}$$

where *ET* is the evapotranspiration.

Water Surplus and Deficit

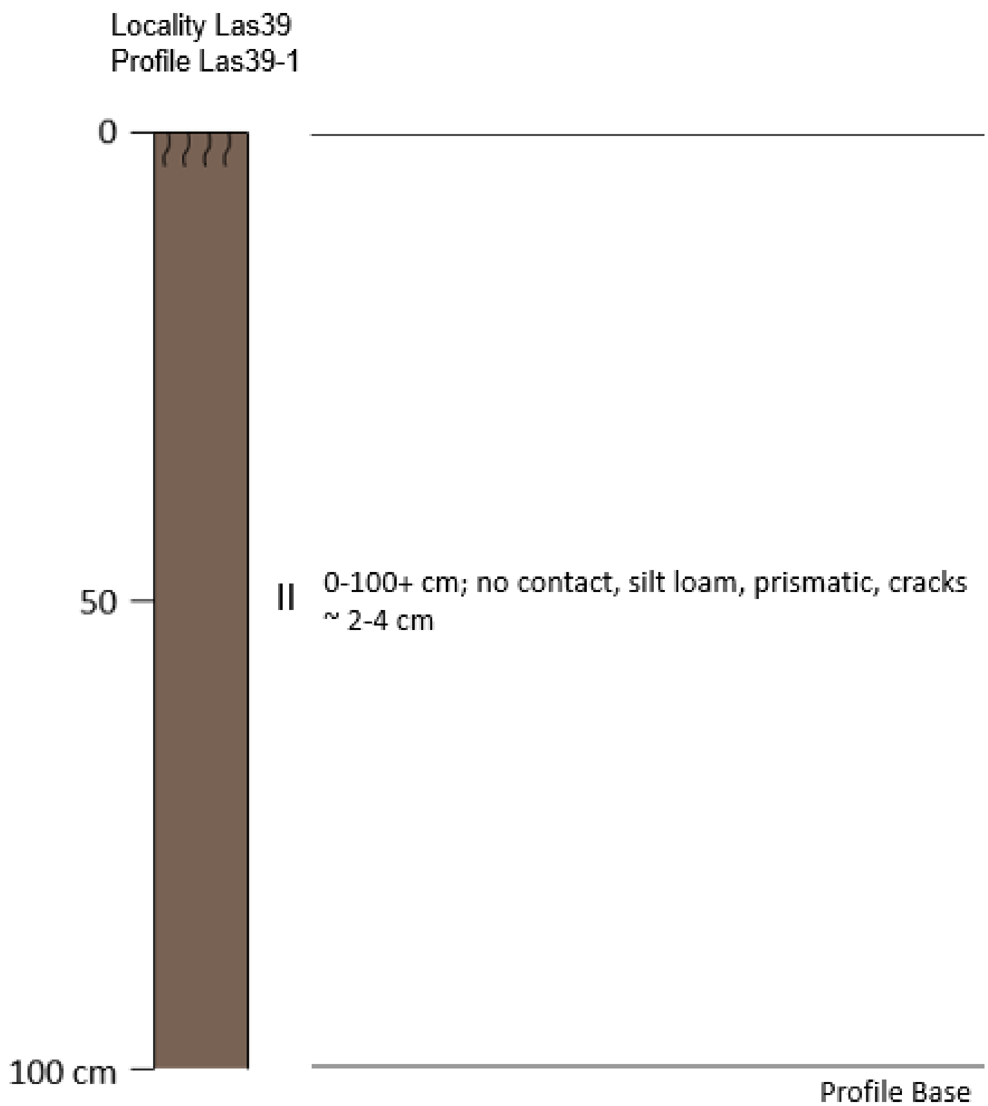
$$Surplus = W_m - ET - \Delta Soil \quad \text{(A.19)}$$

$$Defic = PET - ET \quad \text{(A.20)}$$

where *Surplus* is the amount of excess water and *Defic* is a water deficit.

APPENDIX 2

Profile Descriptions: Las39-1



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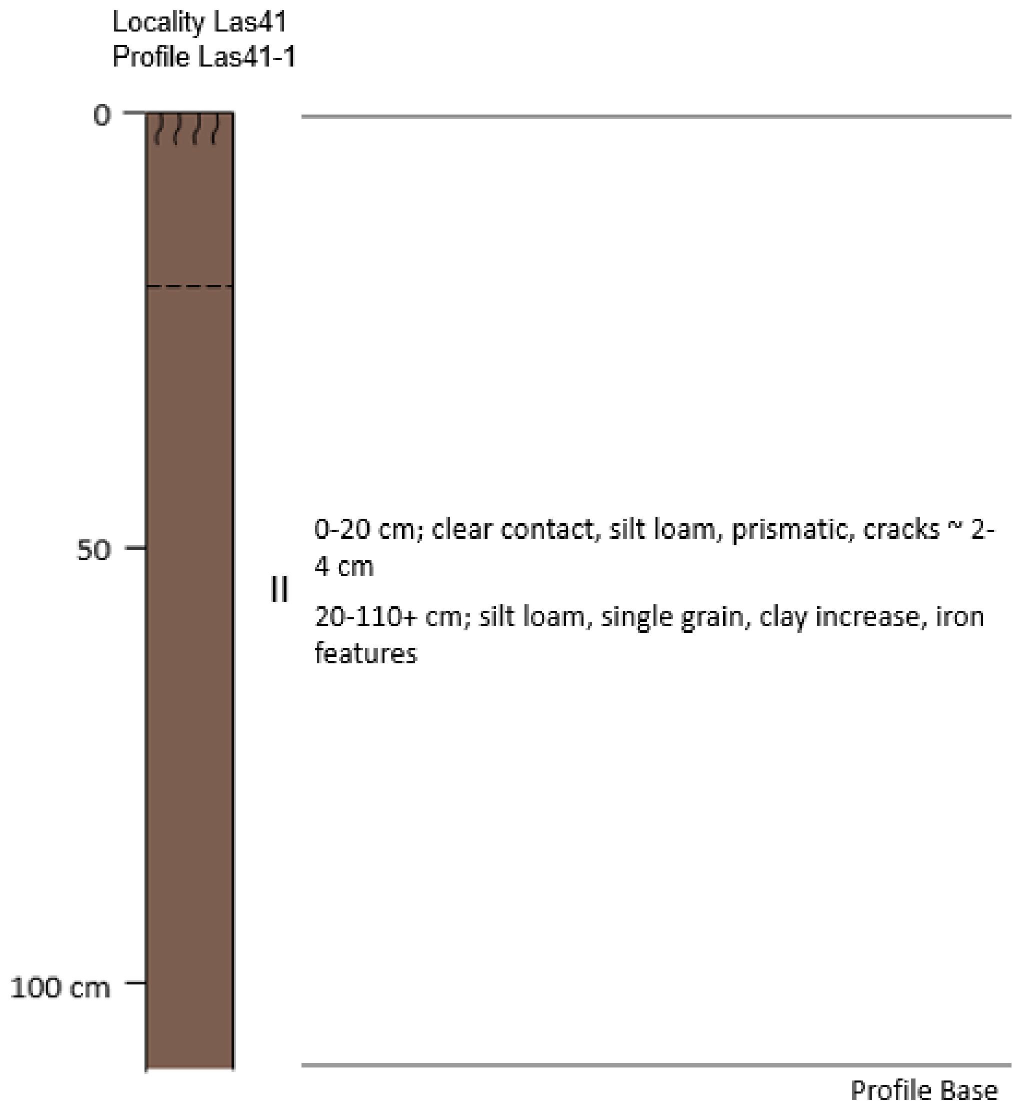

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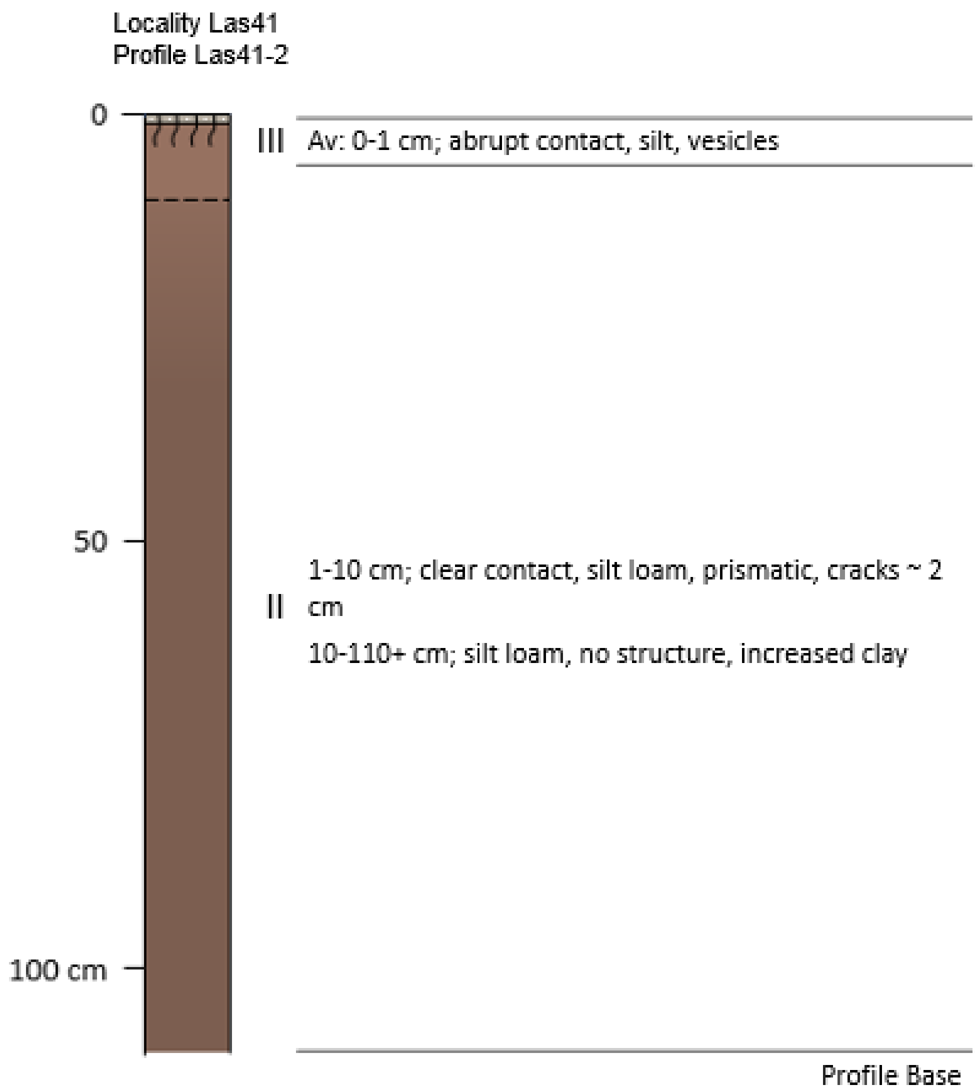
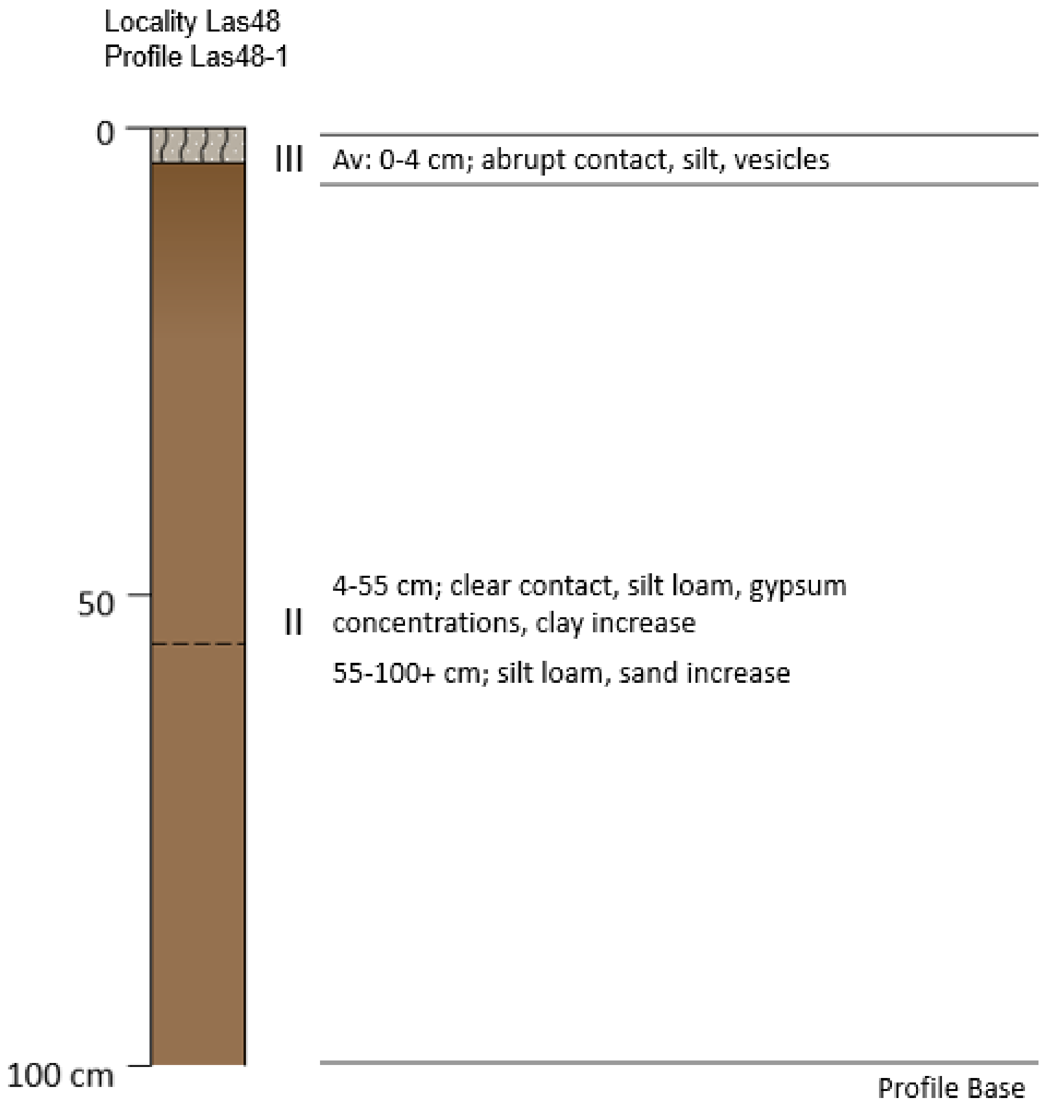
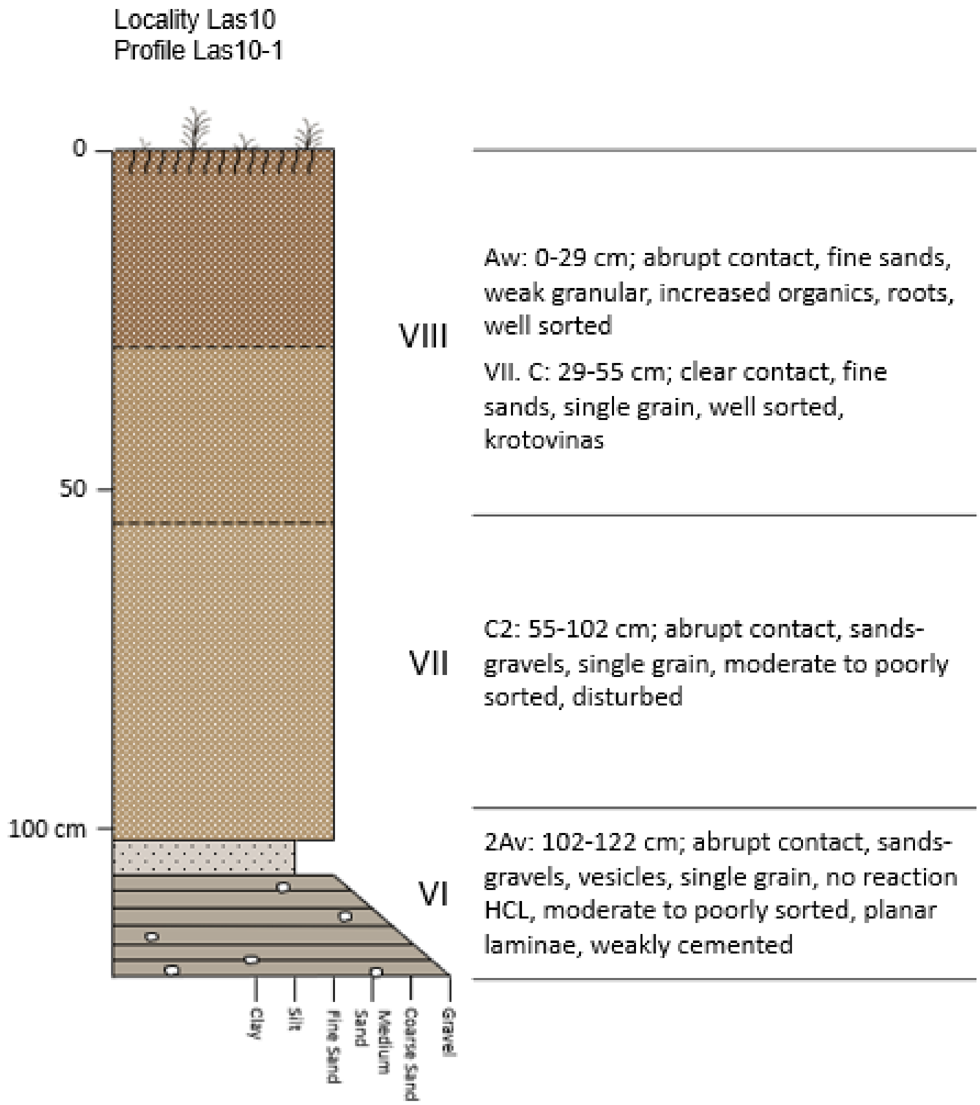


Profile Descriptions: Las48-1



Profile Descriptions: Las10-1: VI-VII



APPENDIX 3

Landform Photographs and Imagery: Desiccation Cracks

Left: small scale desiccation cracks ~3 cm width. Right: large scale desiccation cracks (~ 1 m width) and pedestals on basin floor.

Landform Photographs and Imagery: Rock Lag in Basin Center

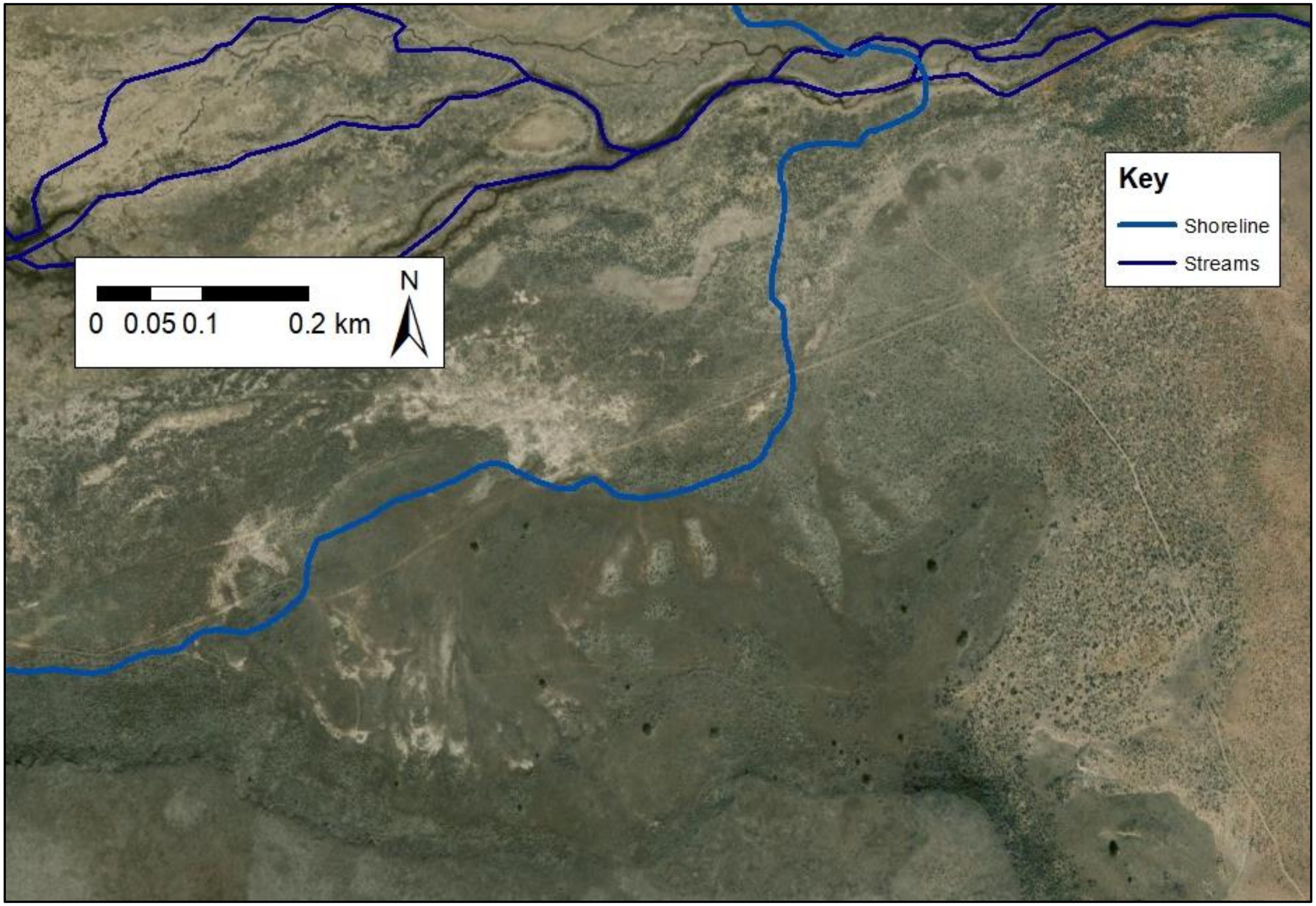
Landform Photographs and Imagery: Strandlines

Landform Photographs and Imagery: Rounded Gravels Along Strandline

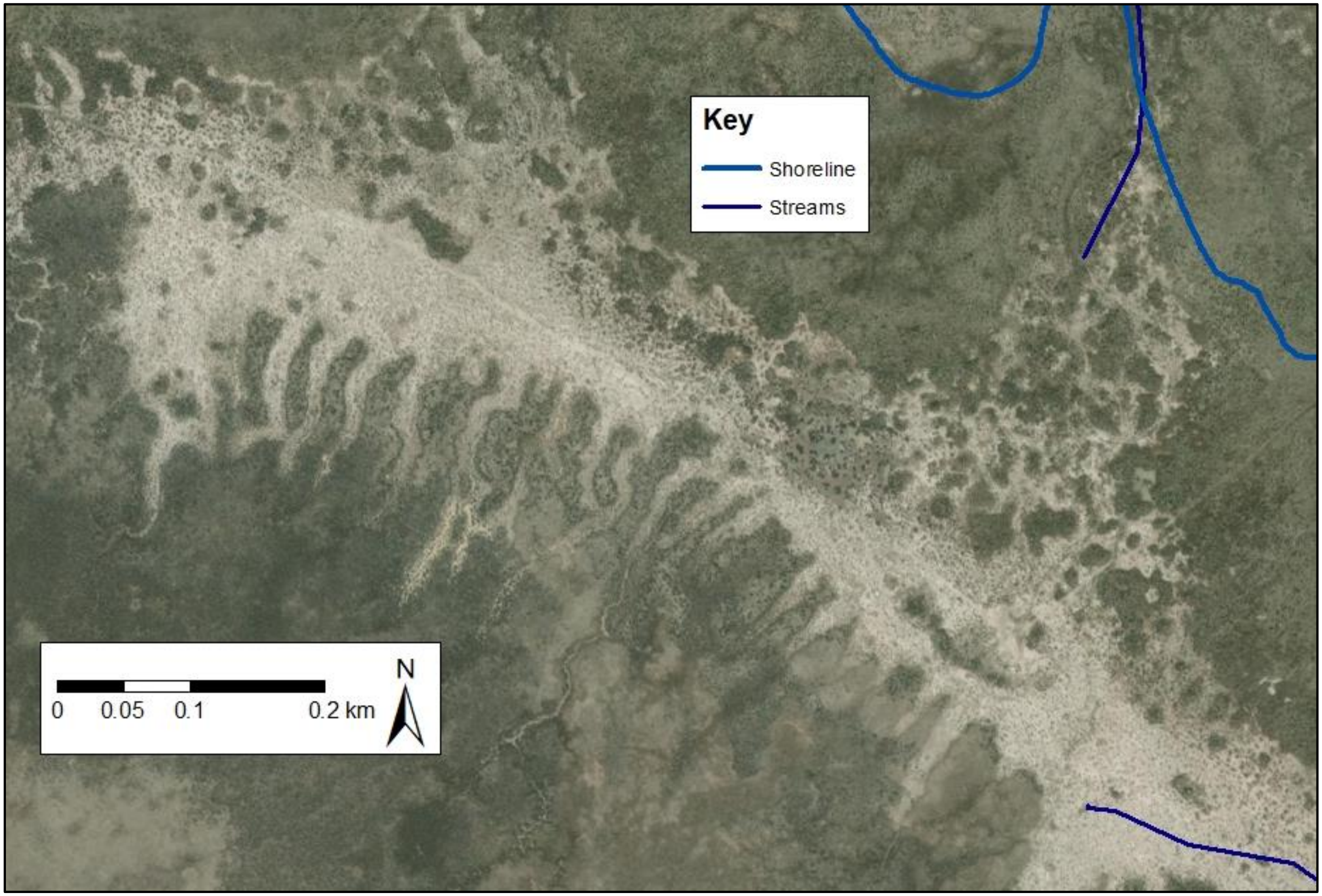
Landform Photographs and Imagery: Spit Lag Deposits

Left: Lag deposits on surface of spit with rodent burrows. Right top: Rodent burrow with exposed lag gravels present at depth. Right bottom: Rodent burrows on playa adjacent to the spit without lag gravels.

Landform Photographs and Imager: Falling Dune Field



Landform Photographs and Imagery: Linear and Barchan Dune Field



Landform Photographs and Imagery: Cottonwood Delta