# PATTERNS IN THE DISTRIBUTION OF VOLCANIC GLASS ACROSS SOUTHERN IDAHO

by

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## ABSTRACT

Straight-line distance from southern Idaho's volcanic glass sources to the sites where artifacts matching their geochemical characterization are located does not account for the varied terrain prehistoric consumers had to traverse. Within a geographic information systems environment, levels of difficulty based on terrain slope were factored into the distance equation to determine a reasonable estimate of how far glass tool stone was transported. Spatial analyses produced isoline maps based on 30-minute density grids to compensate for the numerical inequity of artifacts analyzed. These depict unique patterns of distribution for the six sources most frequently represented in the data. Distance fall-off curves for these sources indicate the glass tool stones were valued differently. An overlapping concentration of Bear Gulch and Owyhee glass correlates to ethnographic accounts of trading at Camas Prairie. The positive correlation between tool stone quality and distance of material displacement shows potential for social interaction studies.

# CHAPTER ONE

# INTRODUCTION

Humans have been using stone for tools for more than two million years (Schick and Toth 1993:26). A variety of lithic materials was used and knowledge of each material's properties, such as texture, elasticity, and flexibility, was essential for the production of specialized tools for specific tasks (Crabtree1967). While material selection was tempered by what was locally available, toolmakers often selected tool stones that had high silica content and fine micro-crystalline structure. The archaeological record of southern Idaho documents a preference by highly mobile hunters and gatherers for obsidian tool stone (Holmer 1997:186; Plew 2000) as many of the lithic tools and projectile points were crafted from this lustrous stone. Based on his years of flintknapping experience, Crabtree (1967:18) appreciated the workability of obsidian and pondered that "it must have been a time of much rejoicing among ancient toolmakers, when a source of good obsidian was located." Locally available, this amorphous volcanic glass was selected for its predictable conchoidal fracture and precision sharpness.

Chalcedony, flint, and other non-volcanic glass tool stones selected by past artisans are also highly siliceous and exhibit the characteristic conchoidal fracture. What makes volcanic glasses like obsidian and ignimbrite unique, particularly in how they might inform archaeologists on past consumer behavior, is that their chemical composition is considerably more uniform than other vitrified materials. Characterization methods such as X-ray fluorescence (XRF) and neutron activation analysis (NAA) have shown that most magma or ash flows are chemically homogenous in their trace element composition within a specified range of variation. This formulation provides a unique geochemical signature that distinguishes a particular geologic event. Thus, the correlation of the distinct chemical characteristics of volcanic glass allows the parent source of an obsidian artifact's raw material to be identified.

The sweeping arc of the Snake River Plain is the focal point of southern Idaho physiography and numerous quarries of obsidian and ignimbrite are exposed along its periphery (Figure 1). In the western part of the state, its broad expanse separates the mountains of the Owyhee Plateau from the Boise Mountains and Timber Butte to the north. The central Plain is bordered on the north by the Mount Bennett Hills that form the southern boundary of Camas Prairie lying at the feet of the Smoky Mountains, locus of Cannonball Mountain chatoyant obsidian. South of the central Plain, river terraces merge with rolling hills and the expansive Browns Bench welded tuff. Trending northeast, the Snake River Plain continues to bisect Idaho's Basin and Range topography. The Lost River Range, Beaverhead Mountains, and Centennial Mountains lie to the north where the widely known Bear Gulch source is located. Fingers of the Bannock, Bear River, and Wasatch ranges extend to

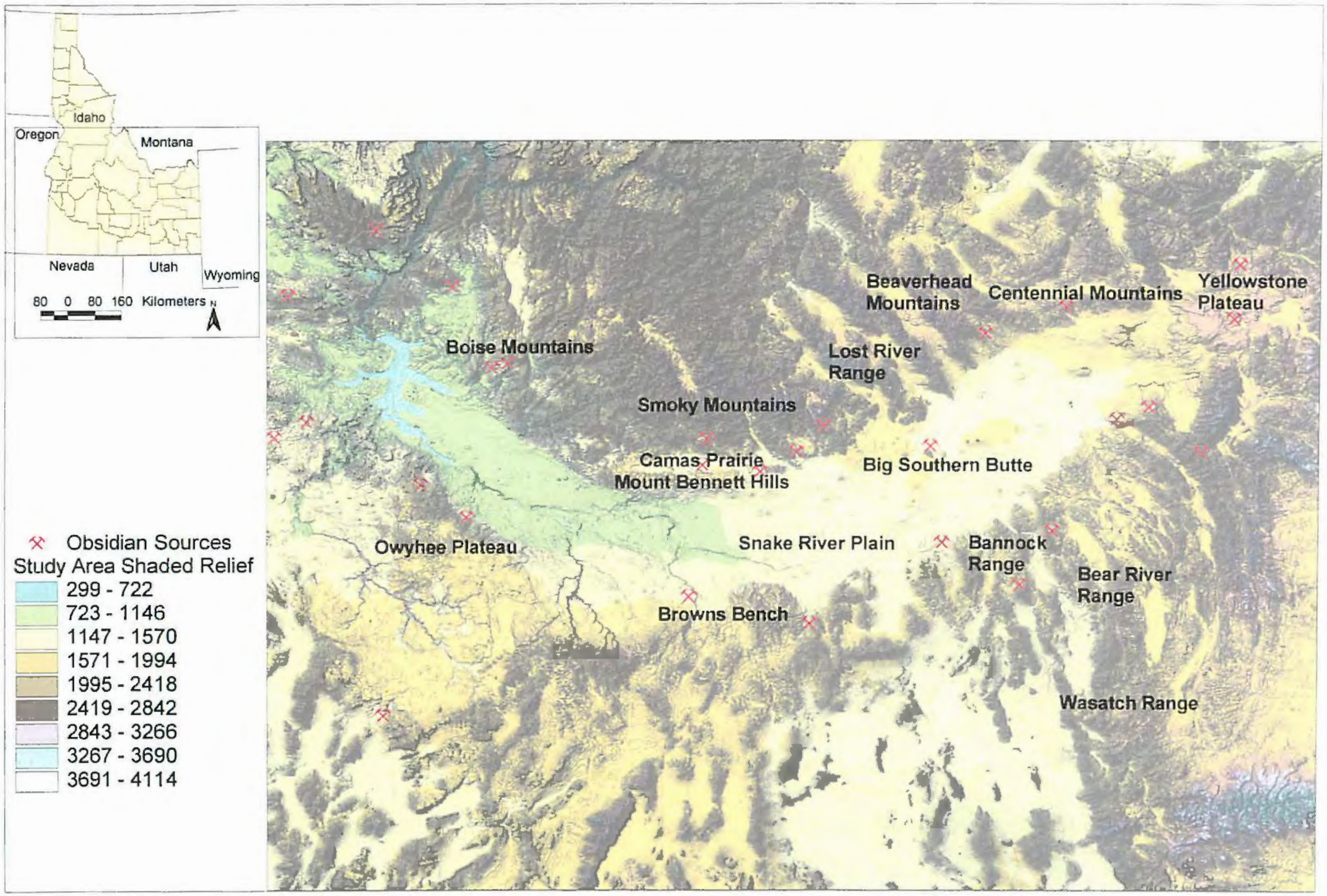



Figure 1. Shaded relief of the study area with obsidian sources and prominent land features identified.

the southeast where Malad obsidian can be found. The Plain gains elevation as it rises to the Yellowstone Plateau and the Obsidian Cliff tool stone source. The lake bed sediments of the western Plain are contrasted by extensive lava fields and isolated buttes, such as Big Southern Butte, on the eastern Plain. The dynamic geological history of the Snake River Plain (for a general overview see Maley 1987; Orr and Orr 1996) has been punctuated by explosive volcanic episodes and turbulent floods. These events shaped the varied landscape and uneven terrain encountered by ancient inhabitants providing not only tool stone materials, but obstacles to its access and procurement.

Geochemical research has correlated artifacts recovered during archaeological excavation and survey collections with 20 unique chemical signatures in Idaho, although some of these identifications are being redefined as more sophisticated technology and standardized measures are employed. While sample collections from numerous exposures of obsidian glass indicate a broad expanse to some formations, it is possible, through the characterization of an artifact to its parent source, to determine the approximate distance volcanic tool stone was transported by people prior to its final deposition. These "archaeological provenance studies" as defined by Hughes and Smith (1993:79) have been utilized to interpret economic behavior at sites in Idaho and surrounding states. While informative, these isolated reports do not reveal the much broader scope likely entailed in past decisions made by highly mobile consumers procuring volcanic glass from widely spaced quarries or the distribution patterns of the glass tool stone that would necessarily result. Holmer (1997) initiated a regional approach for 24 counties in southeastern Idaho, but quickly realized the limitations of his data for defining broader spatial patterns. This paper builds on Holmer's preliminary research and incorporates known geochemical data for all of southern Idaho. Examining this broader distribution of source materials across the landscape provides information on what resources were most widely used, the distance traveled to procure volcanic glass, and probable transport patterns. This information can be correlated with ethnographic data to formulate interpretations regarding past behaviors such as consumer preferences, the movements of people, or possible interactions and networks of trade.

As the shaded relief (Figure 1) clearly indicates, southern Idaho's varied topography requires unique strategies to maneuver uneven terrain. Simply calculating the straight-line (Euclidean) distance from the point of origin of a particular volcanic glass tool stone to the point of its final deposition does not account for such maneuvers or the additional travel distance. To approach a more reasonable approximation of distance, simulated pathways were computer generated based on a slope model. The underlying assumption focuses on the relations of energy expenditure and economic necessity, specifically the "*Law of least effort*, which holds that people will adopt the least energy-expending course of action to achieve their aims" (Dark 1995:122, italics in original). It is important to keep in mind that while the path distance may approach the actual distance tool stone materials were transported, it is likely only the minimum distance. It is impossible to anticipate how long and how far tool stone may have been carried, particularly as a finished tool. Also, while it is possible to arrive at an equation for predicting path distance, it is expected that, due to the irregularity in southern Idaho's landscape, the formula would incorporate a range of variation.

Spatial analysis provides a mechanism for exploring patterns in data that are geographically distributed. Geochemical analysis has been conducted on 2,607 artifacts recovered from 279 sites in southern Idaho. When plotted spatially, I hoped these data would reveal clusters of similar characteristics. My analysis tests Holmer's (1997:191) hypothesis regarding the frequent transport of obsidian along the Snake River Plain corridor but little movement perpendicular to the Plain. I expected to find a general pattern of local resource use particularly to the north and south of the Snake River, with a variety of glass tool stone scattered across the Plain discarded by small groups as they foraged the riverine and foothill resources. I anticipated that if isoline maps were created that monitored the density of material from the various obsidian sources, these would lead to productive lines of inquiry regarding the behavior that might account for the observed distributions. Also, while looking at small side-notched points in southern Idaho, Reed (1985) cited the confines of his study area as a restricting factor for distance-decay analysis and found little variation in the distances arrow points were transported and no relationship between the number of points made from a particular glass and the distance from the tool stone source. I was curious if this model would hold true for all projectile point styles and, consequently, over time. Notably, caution is warranted, as perceived patterns may not reflect actual behavioral relationships in the present and are even more suspect when applied to past interactions (Schiffer 1972). However, it is important to identify and explore possible explanations for those patterns that do exist in a broadened, if somewhat biased, data set for, while individuals make choices in various and random ways, their collective decisions and practices reflect more predictable patterns. As Clark (1978:132) aptly notes, "Only by vitiating the randomness assumption can patterning which may be interpretable in behavioral terms be demonstrated to exist."

Geochemical research has a short and recent history. Chapter Two summarizes some of the initial groundbreaking efforts and highlights the interest in Idaho obsidian sources. The excitement that surrounded early sourcing analyses was dampened by an often incomplete understanding of the origins of obsidian and its primary and secondary source contexts, inconsistency in instrument calibration, as well as quantitative reporting which precluded correlation between laboratories (Hughes 1998d). In light of these difficulties, however, some of the initial analyses of materials from the Mississippi Mounds identified Idaho tool stone and prompted the application of geoprospection to spatial studies and economic behaviors.

This project's goal was to determine the feasibility of a large scale project, to determine a more realistic measure of transport distance, and to explore different methods of spatial analysis in anticipation that the resulting patterns might inform on past procurement strategies. The utility of using geographic information systems (GIS) to address archaeological questions has been demonstrated in a number of reference works (for a general overview refer to Kvamme 1989, 1999; Maschner 1996). The methods and computer applications I employed in this study are detailed in Chapter Three. Problems within the data set as well as with the implied assumptions of spatial analysis are identified. However, the results in Chapter Four do indicate some interesting if not "significant" patterns. Of particular importance, is the illumination of the direction that future research needs to take to arrive at meaningful explanations for ancient procurement strategies. Chapter Five provides suggestions and closing remarks.

# CHAPTER TWO

## PREVIOUS RESEARCH

Archaeological sites are static composites of debris. Faunal and, to an even greater extent, floral remains indicate the local resources utilized by a site's occupants, but the preservation of either is subject to the natural decay process in relation to fluctuations in the temperature and moisture of their depositional environment. Tool stone materials are considerably more durable and, while their presence or absence at a site can to varying degrees be altered by the more dynamic events of their immediate surroundings, lithic materials can provide clues to the geographic range exploited by past consumers. If the location of the parent source can be identified, the distance from the source to the point where the tool stone was displaced or discarded can be ascertained. The extent of procurement territory can be estimated from this distance calculation.

Obsidian or volcanic glass is exposed in numerous locations across southern Idaho with many potential and known quarries in close proximity to the Snake River Plain. This abundance of quality tool stone likely accounts for the fact that obsidian dominates many of the archaeological assemblages in southern Idaho. The introduction of technologies that measured the unique minor and trace elements in obsidian's chemical composition have made it possible to characterize individual sources of tool stone and to assign artifacts to their parent materials. Advances are also being made in chert and quartzite geochemical research (Julig 1994), but obsidian remains at the forefront. Trace element characterization of parent tool stone and the association of recovered artifacts have contributed greatly to our understanding of not only how far lithic materials have been transported, but how sources were utilized differentially across the landscape and over time. Frison, et al. (1958:216) suggest that in some instances, specific sources may even serve as "horizon markers" reflecting ethnicity in cultural occupations.

Plotting the distribution of volcanic glass across the landscape from a particular source helps us to visualize the patterns associated with tool stone transport. Examination of the archaeological record indicates that in the use of volcanic glass, consumption and discard activities may occur at considerable distances from the locus of procurement. This phenomenon is directly related to curation practices (Bamforth 1986; Binford 1977:265; Nash 1996; Odell 1996) and provides the basis for research issues aimed at a greater understanding of past dynamic human behavior. As "curation" has been used somewhat ambiguosly, I have followed Nash's (1996: 85) application: "curation is considered here to (have the potential to) affect behavior at four general stages in the tool production, maintenance, and use process" of which the first two stages are the most relevant to the purpose of this study. These are the acquisition of volcanic glass tool stone and the transport of prepared cores, blanks, or usable tools made from the acquired material.

Terminology often arises as an issue in the discussion of obsidian analysis and there is no clear consensus between geologists and archaeologists as to the usage of terms such as ignimbrite and vitrophyre. Following Bailey (1992:24), this study has adopted the term volcanic glass to identify igneous siliceous materials lacking crystalline structure and retaining a predictable conchoidal fracture quality capitalized upon by flintknappers in the manufacture of stone tools. In the following chapters, obsidian and volcanic glass are used interchangeably regardless of whether the formation was a magma flow, a welded ash tuff, or pyroclastic event. For information regarding the formation and geology of obsidian refer to Hughes and Smith (1993).

## OBSIDIAN CHARACTERIZATION STUDIES

Prior to recent advances in archaeometry, formal and expedient tools, as well as waste flakes, were associated with parent glass material based on visible physical characteristics - color, translucency, opaqueness, or textural quality. As early as 1888, Iddings (Skinner 2000b) noted the lithophysae (bubble-like holes) and spherulites (crystals) common in the columns of obsidian at Obsidian Cliff in Yellowstone National Park, Wyoming (Figure 2). Bettinger (1984) and Ammerman (1979:99) make a pragmatic argument for the use of visual identification, particularly in locations where sites indicate a predominant use of

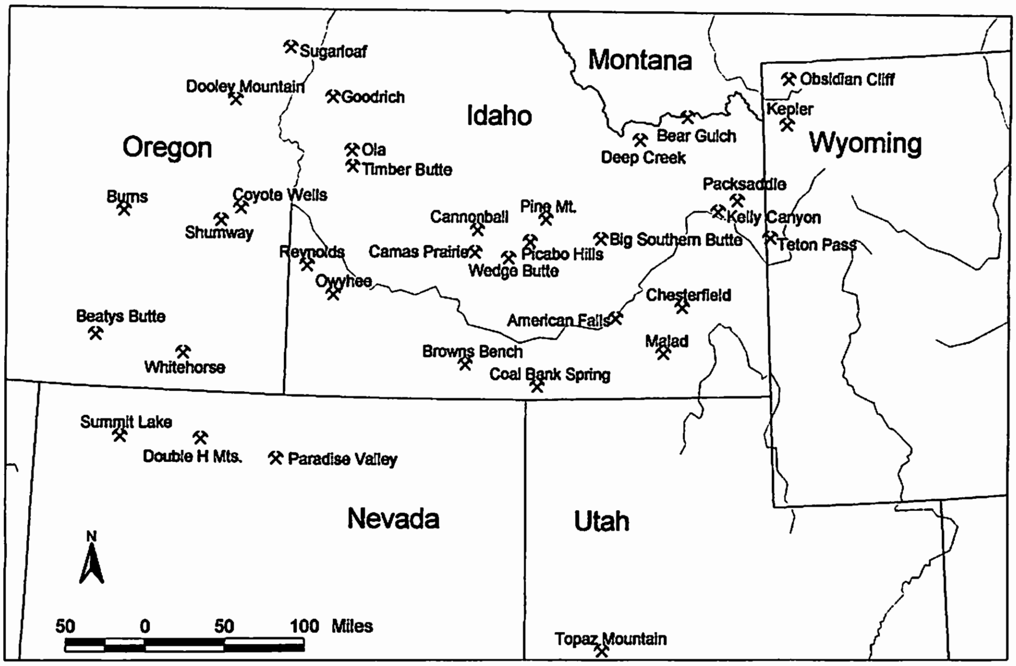



Figure 2. Sources identified in characterization analyses and summarized in these data.

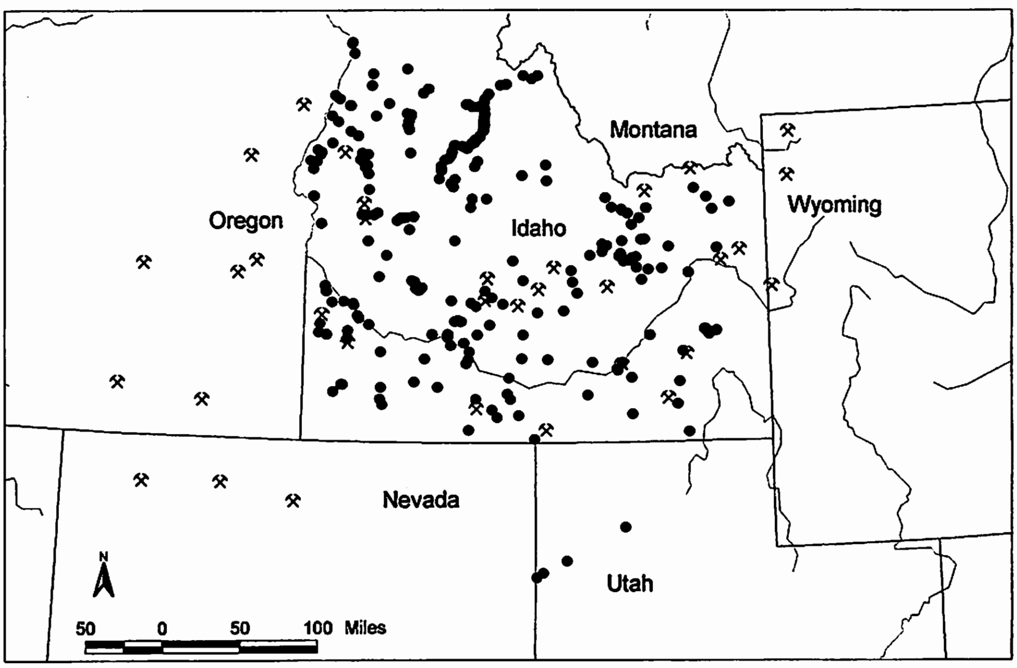



Figure 3. Sites with artifacts characterized to parent sources within the study area.

local tool stones that exhibit unique qualities visible with no or low magnification. However, when exotic materials have been introduced to a site or multiple local materials retain similar visible characteristics, appearance is rarely a valid criterion for discerning source chemical characterization (Griffin, et al. 1969:2). With caution, observable differences continue to form the basis for initial separations (Baumler 1997:154; Frison, et al. 1958:214; Godfrey-Smith and Magne 1987:119) or are considered in the selection of artifacts to be analyzed (Kingsbury 1997:16).

The numerous exposures of volcanic glass in southern Idaho situated the area in a propitious location for geochemical research. While the source of obsidian for artifacts recovered in various Middle Woodland sites in Illinois, Ohio, Wisconsin and Michigan had been the subject of inquiry for more than a hundred years, technological advances in the late 1950s provided a means of accurately distinguishing the "fingerprint" of a particular magma flow or welded ash tuff. Spearheaded by Griffin and Gordus (1969) at the University of Michigan, the initial results of neutron activation characterization studies found sources of Hopewellian glass adjacent to Idaho. The manganese (Mn) content of flow samples consistently illuminated the variation between source materials, as much as 1,000 percent, compared to the within source variability of about 30 to 40 percent. The percentage of sodium (Na) and Mn content proved to be a productive means for initially sorting samples into geochemical groups. Na/Mn ratios were computed for source samples collected from 44 locations in the western United States as well as locations in Alaska, South America, and Mesoamerica. Further analysis of the trace element composition precisely identified the unique geochemistry of individual flows. Characterization studies identified two groups: Obsidian Cliff (Group 150, Na/Mn ratio = 150) in Yellowstone National Park was the parent tool stone source for the majority of the Hopewellian artifacts recovered, however the source of the Group 90 (Na/Mn ratio = 90) samples remained unknown. Two patterns of use were associated with the distribution of obsidian in Hopewell sites (Griffin, et al. 1969:7, 13, Table 5): in Ohio, artifacts of volcanic glass were recovered from burial contexts while most of the glass artifacts recovered in Illinois were surface finds suggesting a utilitarian function.

The geochemical identification of Idaho artifacts with their parent volcanic glass was initiated by Earl Swanson, Jr. in the late 1960s (Wright, et al. 1969). Swanson sent artifacts recovered from Veratic Rockshelter (10CL3) to the University of Michigan where neutron activation analysis determined the chemical composition of 20 formal tools and flakes. The Na and Mn content and, particularly, the Na/Mn ratio proved effective (Griffin, et al. 1969) for separating specimens into initial groups reflecting averaged ratios: Groups 90, 110, and 150 were identified with one sample having an extremely high Mn content which distinguished it from all the other artifacts. Further testing for concentrations of La (lanthanum), Fe (iron), Rb (rubidium), Sc (scandium), and Sm (samarium) provided results comparative to glass samples collected from Yellowstone Park. While Obsidian Cliff (150 Group) was confidently identified, the positive identification of artifacts to other Wyoming exposures in the Kepler Cascades or Falls River Basin (110 Group) required the analysis of more samples from those locations. The one high Mn anomaly closely resembled materials collected from Silver Lake, Oregon, but the characterization of additional elements for this glass tool stone had not been completed.

At that time, the source location for the 90 Group series was also not positively identified. The one source specimen used to identify the 90 Group series was from the Field Museum of Natural History in Chicago. It was simply labeled "Yellowstone" and became known as the Field Museum Yellowstone (F.M.Y.) 90 Group. The comparative geochemistry of artifacts found in north central Wyoming led researchers to initially believe that the source was in fact located in Yellowstone National Park. However, later investigations in western Wyoming (Wright and Chaya 1985) suggested patterns of material distribution inconsistent with a Yellowstone locality. The distribution of 90 Group obsidian was predominantly to the north and west of Yellowstone. While absent from deposits within the park, its presence in sizeable proportions at Hopewell sites would have been supported by trade along the Missouri or Yellowstone Rivers. In a diligent effort to locate the 90 Group source, samples were collected from several possible locations. The analysis of glass materials collected from the West Camas Creek and Dry Creek localities in northeast's Idaho's Centennial Range provided the best comparative results with the F.M.Y. sample. It also correlated with the geochemistry of an obsidian projectile point recovered from the Snyders Hopewell site in Illinois (Wright, et al. 1986), indicating that the potential source contributed to the exchange network.

In 1973, Gallagher (1979) submitted randomly selected artifacts from each excavation level at Sheepeater Battleground (10CR202) in central Idaho to Nelson at the University of Massachusetts. Included in the analysis were samples from nine source locations in Idaho, Glass Buttes in Oregon and Obsidian Cliff in Wyoming. Recognizing that possibly not all sources of volcanic glass had been identified, Gallagher (1979:104) tentatively reported that "nearly all the Sheepeater obsidian is Timber Butte" based on relative amounts of rubidium (Rb), strontium (Sr), and zirconium (Zr). If reliable, the study documents the consistent use of Timber Butte, Idaho material over a period of 7000 years.

In 1978, Sappington (1981c:4) undertook an extensive project to inventory volcanic glass exposures in Idaho and surrounding states as well as neighboring Canadian provinces. He proposed that the correlation of glass artifacts with the chemical signatures of identified sources be used to determine the economic significance of the source to prehistoric groups. Sappington employed XRF analysis to determine Fe, Rb, Sr, yttrium (Y), Zr, niobium (Nb), tin (Sn), barium (Ba), lanthanum (La), and cerium (Ce) concentration ratios for each source sample. Zr and Rb accounted for most of the variability between his source samples and were the criteria for discriminant categories used in the classification of artifacts to their parent material. Using one standard deviation as an acceptable probability of correlation, 33 artifacts from two sites at Givens Hot Springs were analyzed: 48.5 percent (*n* = 16) resembled the Timber Butte, Idaho signature, 15.1 percent (*n* = 5) correlated with the source at Petroglyphs, Oregon, one artifact was identified to the Owyhee, Idaho source, and one to each of the Oregon sources at Whitehorse, Mesa, and Hurley Creek. However, in noting that "it is possible that artifacts from sources not known or not included in this analysis have been assigned to improper groups," Sappington (1981c:7) acknowledged the limitation of discriminant analysis in correctly assigning artifacts to their parent material.

Excavations at Lydle Gulch, 10AA72, (Sappington 1981b) indicated an increasing selection for obsidian throughout the six strata. Using energy dispersive x-ray fluorescence (EDXRF), Sappington quantified the elements Fe, Rb, Sr, Y, Zr, Nb, Sn, Ba, La, and Ce. He found cerium and barium to be the two most discriminating variables and used statistical discriminant analysis to create distinct groups based on element concentrations with which the 802 artifacts from Lydle Gulch (10AA72) were classified. Sappington's results suggest that the site's inhabitants were manufacturing tools from 20 different source locales in southern Idaho and eastern Oregon. The presence of nodules, decortification flakes, and cores of both Timber Butte and Owyhee materials indicated direct procurement and on-site manufacture while finished tools, projectile points, and bifaces of more distant source materials suggested possible trade networks or introduction by nonlocal groups temporarily moving into the area to exploit local fisheries.

Sappington's (1981c:10) interest in the distribution of source material noted the presence of Oregon obsidian in southwest Idaho yet a virtual absence of Idaho obsidian in Oregon. This phenomenon supports Hoebel's (1938:412) ethnographic data in which informants identified the Big Salmon Eaters living in the Snake River Canyon west of the Bruneau River as "Those Who do Not Roam." Hoebel continues, "They were famous as makers of arrows for trade with other Shoshone bands." Sappington (1981c:10) alleges that sites at Lower Salmon Falls indicate similar behavior: people from eastern Idaho and northern Nevada migrated to the Falls discarding glass materials there that they had transported from their place of origin. However, while ethnohistoric observations and oral histories contribute greatly to our understanding of recent past events, it is important to keep in mind that they may not accurately represent the dynamics of distant past or prehistoric behaviors (Hughes 1998d:112).

Anderson, et al. (1986) employed XRF spectrometry conducted at

Brigham Young University to identify geochemical signatures for 31 artifacts recovered from 19 sites in Iowa. Discriminant function analysis (DFA) differentiated Fe, followed by Sr, then Zr as the best discriminating variables. Comparing trace element composition of artifacts to fingerprints of known sources located in Idaho and Wyoming, the authors correlated 74.2 percent (*n* = 23) to Obsidian Cliff. However, 25.8 percent could not be correlated although their composition suggested three distinct parent formations: source A (*n* = 6), source B (*n* = 1), and source C (*n* = 1). The similarity in trace element composition of the three unknown sources to geochemical signatures of known Yellowstone National Park sources led the authors to suggest that the localities of these parent materials might also be within the park. The authors confirm the predominant use of Obsidian Cliff obsidian in the Upper Mississippi Valley, but document the utilization of glass from multiple sources over a similar time frame from the Middle Woodland period through the Late Prehistoric (Anderson, et al. 1986:Table 6; see also Hatch, et al. 1991). Of particular relevance is the pattern of use associated with the obsidian found in Iowa; a utilitarian context is suggested for the two tools and waste flakes recovered at the Iowa sites in contrast to the burial context associated with Ohio obsidian artifacts (Griffin, et al. 1969:Table 5). This leads the authors to postulate that while obsidian may have initially been introduced as an exotic material with ceremonial or spiritual significance, it soon became part of "a generalized exchange system involving trading partners" (Anderson, et al. 1986:850).

Using energy dispersive XRF, Godfrey-Smith and Magne (1987) identified 40 artifacts from 18 sites in Alberta, Canada to sources in the Western United States. Obsidian Cliff was the parent source for 10 of the artifacts with one artifact characterized to Burns, Oregon and two artifacts to the Snake River (also known as Walcott or American Falls), Idaho source. Twenty artifacts correlated to two previously identified yet unknown sources: British Columbia source identifier (BCSI) A (*n* = 19) and BCSIB (*n* = 1). The authors (Godfrey-Smith and Magne 1987:133) note these geochemical types are often found in association with Obsidian Cliff materials and hypothesize that the source locations may also be in the United States.

Interest increased within the archaeological community as the nondestructive methods of XRF were introduced to geochemical research and standardized measures facilitated comparative laboratory analyses. Numerous samples of source materials were collected and added to geochemists' inventories which aided our understanding of inter- and intra-source variability and identified previously unknown sources. Hughes and Nelson (1987:314) performed comparative analyses between wavelength dispersive and energy dispersive XRF techniques. The authors found the results to be in "close agreement" and were able to identify the elemental composition of unknown source A in the Iowa study (Anderson, et al. 1986:842, Table 5) as the Bear

Gulch, Idaho source.

Willingham (1995) proposed that the Bear Gulch, Camas-Dry Creek, and 90 Group sources be subsumed under Big Table Mountain. He cites the secondary context of previous sample collections from West Camas and Dry Creeks (Wright, et al. 1986), as well as Bear Gulch (Hughes and Nelson 1987), used to identify the source's geochemical signature and proposes that the samples collected from West Camas and Spring Creeks (Gallagher 1979:appendix 1) provide a primary locality within the boundaries of Big Table Mountain as defined by prehistoric quarry sites and lithic workshops. Several samples (*n* = 33) collected by Willingham were analyzed at the Missouri University Research Reactor (MURR) using neutron activation analysis (Glascock and Ambroz 1996). Two unique geochemical compositions were identified: the Big Table Mountain specimens were easily separated from samples collected at Argument Ridge, Lost Spring, and Point Lookout located across the Snake River Plain approximately 100 km (60 miles) southeast of Big Table Mountain, while one sample from the Lost Spring location fell outside the definitive boundaries of either of the other two groups.

While various techniques with increased precision have been incorporated into geochemical analysis, Shackley (1998:261) provides a cautionary statement that merits repeating, "nothing is ever really 'sourced'. The best we can do is provide a chemical characterization and a probable fit to known source data." A thorough examination of the landscape is required to determine the extent of secondary deposits in older geological formations as well as primary glass exposures. Underlying the concept of source type is the principle that there is more variability between chemical compositions of two separate obsidian events than within any single flow. When only a limited number of samples from a source are analyzed, the inherent intraflow variability may not be adequately characterized and could lead to the incorrect identification of a new source.

## SPATIAL ANALYSIS STUDIES

As noted, characterization studies led to conjectures regarding not only the distribution of obsidian, but also possible mechanisms of conveyance. Both land and river routes have been postulated. The predominance of Obsidian Cliffs obsidian in the Midwest led to speculation regarding its preference as well as patterns and method of distribution. However, in examining artifacts from several sites in Yellowstone National Park, Montana, Wyoming, North Dakota, Alberta, Saskatchewan, and Manitoba, Davis, et al. (1995) found that a surprising number of artifacts were manufactured from Bear Gulch glass as well as obsidian from other Idaho and Wyoming sources. Comparing artifact percentages identified to Obsidian Cliff and Bear Gulch implies a regional distribution pattern in which "Bear Gulch appears to be predominant in the

Intermountain area while Obsidian Cliff dominates on the Northwestern Plains" (Davis, et al. 1995:52, Figure 19). This suggests to Davis, et al. (1995:51) that different routes were associated with the procurement or exchange of the respective source materials. As to the dynamics involved in the actual exchange of obsidian, the authors note that artifacts characteristic of Hopewell Culture have not been recovered from sites along the Yellowstone River or proximal to Obsidian Cliff, indicating that obsidian was not being directly procured by individuals from Hopewell sites as proposed by Griffin (1965; cf. Baugh and Nelson 1988:85) but reached the Midwest through trade networks facilitated by middlemen (cf. Anderson, et al. 1986:850).

The identification of the source material from which an artifact was manufactured initiates discussions on how the tool stone was transported from its point of origin to its point of discard (Wright, et al. 1969:27). Compiling information from journals and site reports which published XRF analysis of artifacts taken from excavation collections and survey projects within 24 counties in southeast and central Idaho, Holmer's (1997:191-192) research indicates definite patterns of procurement, transport, and use. Within Idaho, it appears that people in the central and southeast mountains were utilizing local volcanic glass resources with relatively no exchange in materials across the Snake River Plain. Yet within the Plain corridor there appears to be an almost equal exchange of materials between the northeast and the southwest.

Equally informative is the research conducted on the Payette National Forest (Dixon, et al. 1999:19-20; Kingsbury 1996; Kingsbury 1997:16-17). There is no known volcanic glass source within the Payette National Forest: when glass is recovered from a site, it documents the relative distance traveled by prehistoric consumers. Kingsbury (1996:3) notes that while Timber Butte materials are predominant, the presence of eastern Oregon and northwest Wyoming tool stone indicates that neither the Snake River to the west nor the numerous mountain ranges to the east presented a formidable barrier. He intuitively estimates that a "meandering" distance, allowing for local terrain and geographic features, would be from six to 30 percent greater than the straight line distance.

Reed (1985) employs chemical characterization to define Shoshone procurement territories in southern Idaho. Reed found a high representation of Timber Butte material in his study collection of small side-notched projectile points. Sappington (1984), on the other hand, noted an almost exclusive concentration of Timber Butte glass within debitage flakes recovered from areas extending 200 km to the north of the source location. Reed interprets this contrast as an indication that Timber Butte was a Nez Perce source, but access to Timber Butte tool stone was obtained by Shoshone groups either through trade or direct procurement. On a similar note, Reed argues that the absence of Malad tool stone in his collection, yet its relative abundance at sites in Utah

(Nelson and Holmes 1979), supports the view that Malad was utilized by the Fremont who prohibited access to the Shoshone. Reed (1985:67-68) found little difference in transport distance across southern Idaho: Desert side-notched points were recovered an average distance of 180 km from their geologic parent source. He interprets this distance as a product of curation practices rather than an indicator of trade or exchange. (I assume that Reed considers the additional time and energy expended in the production of arrow points would merit measures to maintain these investments for longer periods of time and at greater distances from the origin of their raw material. This assumption relates to Shott's (1989:24) interpretation of curation as "the practice of maximizing utility of tools by carrying them between successive settlements.") Plotting chemically similar points against distance indicated that there was no relationship between the number of points of a particular source material and the distance to that source. This deviates from Hodder's (1978b:158) prediction that as distance from a source increases the relative abundance of that source's material will decrease. Reed (1985:68) attributes this unique phenomenon to the limitations imposed by the expanse of his study area.

The attribution of artifacts to parent sources have formed the basis of this recent research. Following the assumption that the manufacture of stone tools commonly reflects the use of local resources, the presence of exotic, nonlocal tool stone led to hypotheses regarding past consumer decisions, resource utilization, degrees of mobility, and mechanisms of exchange (Beck and Jones 1990; Binford 1979; Goodyear 1989; Meltzer 1989). Regional studies incorporating spatial analysis can potentially contribute to our understanding of these issues.

# CHAPTER THREE

## DATA AND METHODS

This study focuses on geochemical analyses conducted in the southern two-thirds of Idaho, doubling the database initially compiled by Holmer for southeast Idaho. Data for 2,607 artifacts were acquired from X-ray fluorescence (XRF) and atomic absorption spectroscopy (AAS) analyses included in archaeological survey and site reports. Table 1 provides an expanded bibliographic reference to reports incorporated into this project's database, which includes geochemist laboratory reports as yet unpublished at the completion of this project. As some of these reports include sites and sources outside of Idaho, the actual study area extends beyond Idaho's political boundaries (Figure 1). Data have been compiled for source analyses that have been conducted at 279 Idaho sites located in 32 southern Idaho counties (Figure 3). Table 2 lists the frequency of artifacts by state and county. Appendix A identifies the number of artifacts by site that have been characterized to their parent source. One site in the database is located in Union County, Oregon, and four sites are located in Tooele and Box Elder counties, Utah. Sources were identified for 2,512 formal tools and flakes. The remaining 95 artifacts' trace element densities do not match any of the currently inventoried geochemical types. Volcanic glass signatures correlated to these artifacts total 34: these are identified with 20 sources located in Idaho, seven in Oregon, three in Nevada, three in Wyoming, and one in Utah (Figure 2). The frequency and proportion of artifacts characterized to these inventoried volcanic glass sources are listed in Table 3.

Data from numerous survey and excavation reports were compiled for this project, although the compiled data may not reflect all the analyses that have been conducted in southern Idaho. Much of the geochemical research is reported in the "gray literature." While an effort was made to recover as much of this information as possible, published data comprises the majority of the this compilation. The database design also precludes the use of composite percentages, therefore, only documents that reported actual counts of artifacts identified to parent material, rather than percentages, were included.

Obsidian artifacts from some of Idaho's most informative archaeological sites have been analyzed to determine their geochemical "fingerprint" and the point of origin for the source material. This data set includes 506 formal tools and flakes from Lydle Gulch (10AA72: Sappington 1981b), 241 from Wilson Butte (10JE6: Bailey 1992), 157 from Rock Creek (10CA33: Green 1982), 153 from Weston Canyon (10FR4: Arkush 1999; Green 1982), 120 from Silver Bridge (10BO1: Plew, et al. 1984), 42 from Wasden (10BV30: Green 1983; Reed 1985), 69 from the Hetrick site (10WN469: Rudolph1995), and 20 from Wahmuza (10BK26: Holmer 1986) to name just a few of the more prominent sites. However, a review of the sites listed in Appendix A with the number of

Table 1. Bibliographic References to Studies Incorporated into the Expanded Database Used in this Study.

| Reference | Frequency | Percent | Analysis | Analyst |
|---|---|---|---|---|
| Arkush 1996 | 41 | 1.57 | XRF | Geochemical Research |
| Arkush 1999 | 26 | 1.00 | XRF | Geochemical Research |
| Bailey 1992 | 239 | 9.17 | XRF | Simon-Frasier University |
| Cresswell 1998 | 17 | 0.65 | XRF | Geochemical Research |
| Dixon et al. 1999 | 16 | 0.61 | XRF | Geochemical Research |
| Green 1982 | 358 | 13.73 | XRF | UC Berkeley/U of Idaho |
| Green 1983 | 27 | 1.04 | XRF | University of Idaho |
| Green 1984 | 42 | 1.61 | XRF | University of Idaho |
| Greiser et al. 1992 | 6 | 0.23 | XRF | Simon-Frasier University |
| Huter et al. 2000 | 6 | 0.23 | XRF | Northwest Research |
| Holmer 1986 | 19 | 0.73 | AAS | Mohlab |
| Hughes 1996 | 2 | 0.08 | XRF | Geochemical Research |
| Hughes 1998a | 20 | 0.77 | XRF | Geochemical Research |
| Hughes 1998b | 39 | 1.50 | XRF | Geochemical Research |
| Hughes 1999c | 1 | 0.04 | XRF | Geochemical Research |
| Hughes 1999b | 7 | 0.27 | XRF | Geochemical Research |
| Hughes 1999d | 3 | 0.12 | XRF | Geochemical Research |
| Hughes 1999a | 38 | 1.46 | XRF | Geochemical Research |
| Jackson 1995 | 5 | 0.19 | XRF | Pacific Legacy, Inc. |
| Kingsbury 1996 | 162 | 6.21 | XRF | Geochemical Research |
| Kingsbury pers. com. 2000 | 17 | 0.65 | XRF | University of Idaho |
| Lewarch and Benson 1988 | 116 | 4.45 | XRF | Geochemical Research |
| Moore and Ames 1979 | 7 | 0.27 | XRF/AAS | U of Idaho/Mohlab |
| Plew et al. 1984 | 158 | 6.06 | XRF | University of Idaho |
| Plew et al. 1987 | 14 | 0.54 | XRF/AAS | Mohlab |
| Reed 1985 | 283 | 10.86 | XRF | University of Idaho |
| Reid and Chatters 1997 | 3 | 0.12 | AAS | Geochemical Research |
| Reid et al. 1997 | 18 | 0.69 | XRF | Geochemical Research |
| Reid and Ferguson 1998 | 7 | 0.27 | XRF | Geochemical Research |
| Reid and Gallison 1994b | 2 | 0.08 | XRF | Geochemical Research |
| Reid and Gallison 1994a | 8 | 0.31 | XRF | Geochemical Research |
| Sappington 1981 | 498 | 19.10 | XRF | University of Idaho |
| Sappington 1982 | 260 | 9.97 | XRF | University of Idaho |
| S.A.I.C. 1995 | 69 | 2.65 | XRF | Pacific Legacy, Inc. |
| S.A.I.C. 1996 | 24 | 0.92 | XRF | Pacific Legacy, Inc. |
| Torgler 1993 | 28 | 1.07 | XRF | Geochemical Research |
| Yohe II 1996 | 16 | 0.61 | XRF | Pacific Legacy, Inc. |
| Yohe II and Neitzel 1999 | 3 | 0.12 | XRF | Pacific Legacy, Inc. |
| Yohe II and St.Clair 1998 | 2 | 0.08 | XRF | Pacific Legacy, Inc. |
| Total | 2607 | 100.00 | | |

Table 2. Frequency of Analyzed Artifacts by State and County.

| State | County | Frequency | Percent |
|---|---|---|---|
| Idaho | Ada | 510 | 19.56 |
| Idaho | Adams | 72 | 2.76 |
| Idaho | Bannock | 118 | 4.53 |
| Idaho | Bingham | 13 | 0.50 |
| Idaho | Blaine | 17 | 0.65 |
| Idaho | Boise | 281 | 10.78 |
| Idaho | Butte | 44 | 1.69 |
| Idaho | Bonneville | 65 | 2.49 |
| Idaho | Cassia | 174 | 6.67 |
| Idaho | Clark | 37 | 1.42 |
| Idaho | Camas | 6 | 0.23 |
| Idaho | Canyon | 6 | 0.23 |
| Idaho | Custer | 63 | 2.42 |
| Idaho | Caribou | 11 | 0.42 |
| Idaho | Elmore | 24 | 0.92 |
| Idaho | Fremont | 39 | 1.50 |
| Idaho | Franklin | 153 | 5.87 |
| Idaho | Gooding | 15 | 0.58 |
| Idaho | Gem | 3 | 0.12 |
| Idaho | Idaho | 17 | 0.65 |
| Idaho | Jerome | 243 | 9.32 |
| Idaho | Jefferson | 10 | 0.38 |
| Idaho | Lemhi | 86 | 3.30 |
| Idaho | Lincoln | 4 | 0.15 |
| Idaho | Madison | 1 | 0.04 |
| Idaho | Oneida | 41 | 1.57 |
| Idaho | Owyhee | 83 | 3.18 |
| Idaho | Payette | 6 | 0.23 |
| Idaho | Power | 9 | 0.35 |
| Idaho | Twin Falls | 53 | 2.03 |
| Idaho | Valley | 275 | 10.55 |
| Idaho | Washington | 107 | 4.10 |
| Oregon | Union | 2 | 0.08 |
| Utah | Box Elder | 4 | 0.15 |
| Utah | Tooele | 15 | 0.58 |
| Total | | 2607 | 100.00 |

Table 3. Frequency and Proportion of Artifacts Characterized to Inventoried Obsidian Sources.

| State | Obsidian Source | Frequency | Percent |
|---|---|---|---|
| Idaho | American Falls | 15 | 0.57 |
| Idaho | Bear Gulch | 138 | 5.28 |
| Idaho | Big Southern Butte | 153 | 5.86 |
| Idaho | Browns Bench | 143 | 5.47 |
| Idaho | Camas Prairie | 9 | 0.34 |
| Idaho | Cannonball Mountain | 48 | 1.84 |
| Idaho | Chesterfield | 4 | 0.15 |
| Idaho | Coal Bank Spring | 27 | 1.03 |
| Idaho | Deep Creek | 2 | 0.08 |
| Idaho | Goodrich | 1 | 0.04 |
| Idaho | Kelly Canyon | 16 | 0.61 |
| Idaho | Malad | 438 | 16.77 |
| Idaho | Ola | 7 | 0.27 |
| Idaho | Owyhee | 145 | 5.55 |
| Idaho | Packsaddle | 6 | 0.23 |
| Idaho | Picabo Hills | 16 | 0.61 |
| Idaho | Pine Mountain | 1 | 0.04 |
| Idaho | Reynolds | 2 | 0.08 |
| Idaho | Timber Butte | 1205 | 46.29 |
| Idaho | Wedge Butte | 2 | 0.08 |
| Nevada | Double H Mountain | 12 | 0.46 |
| Nevada | Paradise Valley | 4 | 0.15 |
| Nevada | Summit Lake | 1 | 0.04 |
| Oregon | Beatys Butte | 2 | 0.08 |
| Oregon | Burns | 9 | 0.34 |
| Oregon | Coyote Wells | 11 | 0.46 |
| Oregon | Dooley Mountain | 18 | 0.69 |
| Oregon | Shumway | 1 | 0.04 |
| Oregon | Sugarloaf | 35 | 1.34 |
| Oregon | Whitehorse | 5 | 0.19 |
| Utah | Topaz Mtn | 1 | 0.04 |
| Wyoming | Kepler | 2 | 0.08 |
| Wyoming | Obsidian Cliff | 25 | 0.96 |
| Wyoming | Teton Pass | 8 | 0.31 |
| | unknown | 95 | 3.64 |
| Total | | 2607 | 100.00 |

analyzed artifacts from each shows that these prominent sites introduce considerable bias to the data. The bulk of geochemical analysis has been conducted at slightly more than 21 percent (*n* = 60) of the sites: 44.7 percent (*n* = 127) of the sites have had only one artifact analyzed; 78.9 percent (*n* = 224) of the sites have fewer than six artifacts analyzed.

This compilation reflects the inherent problem of summarizing data generated in a technology's adolescent years when there was little standardization in terms of how chemical elements were measured or reported (Hughes 1998d:108). Currently, more attention is paid to the calibration of equipment in compliance with internationally recognized standards and to the reporting of data in comparative units such as parts per million or relative intensity ratios. Advances in geochemical technology have not only increased awareness of corroborative efforts (Shackley 1998), but have broadened our understanding of variation within, as well as between, glass flows. Geoprospection has highlighted the need for identifying the extent of primary and secondary flow exposures. As Hughes (1998d:107) notes, "As a consequence of improved sampling and quantitative analysis, some of yesterday's sources have become today's *source areas*" (italics in original). Baugh and Nelson (1987:317) argue that distinctions should be made between "source systems" for less precise determinations and "source subsystems" for well-characterized locales. Without the benefit of these more recent insights, it is possible that earlier assignments of artifacts to sources may well be in error. Accurate error assessment will require earlier results to be reexamined, but in lieu of further analysis, this summarization assumes that sourcing errors are minimal and evenly disbursed with limited influence on general distribution patterns (Holmer 1997:188).

Volcanic glass formations exhibit a general homogeneity in major chemical element composition. This facilitates the use of a formation's trace elements to characterize its chemical signature or "fingerprint" and to correlate the geochemistry of artifacts to particular tool stone. While variability does occur, it is assumed that variation in element composition is more extreme between flows than within flows (Griffin and Gordus 1969). In some instances, such as the multiple glass exposures in the Owyhee Mountains, on Cannonball Mountain, and at Camas Prairie in Idaho, as well as at Jackson Hole (Teton Pass), Wyoming (Schoen 1997), chemical composition of collected samples varies significantly enough that separate sources have been identified. The primary source locations of these independent sources have not been determined and analysis results (particularly from earlier research) do not always clarify to which of these sources an artifact is correlated, such as Owyhee A or Owyhee B. As this study is more concerned with general distribution patterns of source material, sample collection locations for these separate sources have been considered in determining a single 'source system' location. Thus, geochemical results correlated to Owyhee A or Owyhee B have been subsumed under the Owyhee source, with similar treatment to artifacts correlated to Camas Prairie 1 and 2, Cannonball 1 and 2, and Teton Pass 1 and 2.

It is also possible, with continued research and a greater knowledge of the variation within individual geologic formations, that sources identified as unique in the past may now be grouped with sources of similar chemical composition. This may be the case with the Ola source whose collection location is in close proximity to the Timber Butte source. Samples characterized to Timber Butte have been collected from eroding hill slopes in both Boise and Gem counties as well as in stream gravels along Squaw Creek (Moore 1995:61, Sappington 1984:23). Therefore, the Ola materials may represent a secondary deposit of Timber Butte glass. Artifactual materials were associated with the Ola source (Moore and Ames 1979) in some of the first characterization studies conducted in Idaho and were identified in only one report. It is also not listed as an independent source in the more recently compiled inventories (Bailey 1992, Moore 1995). However, it is reported here as an independent source to remain consistent with initial reporting.

Table 3 summarizes the number of artifacts characterized to each of the sources. Timber Butte tool stone is the predominant volcanic glass representing 46.3 percent of the artifacts analyzed from southern Idaho sites. However, this most likely reflects where the greatest amount of geochemical research has been conducted rather than material preference or behavioral pattern: 56.6 percent of the analyzed artifacts came from sites located within the northwest portion of the study area. Malad has the second largest number of artifacts (16.8 percent, $n = 438$) correlated to its geochemistry, followed by Big Southern Butte (5.9 percent, $n = 153$), Owyhee (5.6 percent, $n = 145$), Browns Bench (5.5 percent, $n = 143$), and Bear Gulch (5.3 percent, $n = 138$). Notably, over 85 percent of the volcanic glass characterized for southern Idaho comes from these six sources. As further research enlightens our understanding of the volcanic events that account for these source materials and, particularly, the extent of flow deposits at Browns Bench (Holmer, et al. 2001) the percentage will likely increase. A source could not be identified for 3.6 percent ($n = 95$) of the artifacts analyzed.

The data set contains seven artifact classes: tools, scrapers, bifaces, cores, drills, projectile points, and flakes (Table 4). Flakes represent the largest classification and comprise 35.6 percent ($n = 928$) of the artifacts while projectile points make up 28.9 percent ($n = 754$). Utilitarian tools associated with domestic, processing, or manufacturing activities contribute 18 percent ($n = 470$) while cores represent 1.9 percent ($n = 49$). The majority of the analyzed utilitarian tools were collected from Lydle Gulch (10AA72: $n = 286$), although several bifaces were from Wilson Butte (10JE6: $n = 22$), Dagger Falls (10VY76:

$n$ = 18), and the Bird Rock cache site ($n$ = 18). Forty-three of the cores represented in this data set were recovered from Lydle Gulch. Information on artifact class was unknown or not provided for 15.6 percent ($n$ = 407) of the analyzed artifacts.

Table 4. Distribution of Artifact Classes Represented in this Study.

| Artifact Class | Frequency | Percent |
|---|---|---|
| biface | 221 | 8.48 |
| core | 49 | 1.88 |
| drill | 8 | 0.31 |
| flake | 928 | 35.60 |
| point | 754 | 28.92 |
| scraper | 79 | 3.03 |
| tool | 161 | 6.18 |
| unknown | 12 | 0.46 |
| no information | 395 | 15.15 |
| Total | 2607 | 100.00 |

Projectile points were further separated into morphological types which are temporally diagnostic. This provides an assessment of source use over time. Time periods extend from 150 years to 11,000 years B.P. Table 5 summarizes the frequency and percentages of point typologies represented in the data set and the time periods associated with them. Note that the time periods used here reflect the more conservative dates proffered by Holmer

(1997:Table 3b, 200; Holmer and Plager 1998) for eastern Idaho and do not account for alternative chronologies that attempt to provide an encompassing projectile point sequence for the entire Snake River Plain (Plew 2000:Figure 4, 23). Small side-notched points with a temporal range of 150 to 750 years B.P. are predominant representing slightly more than 37 percent of the points in the data set. Large corner-notched points represent the second largest category

Table 5. Frequency and Proportion of Points within Temporal Periods Associated with Point Typologies.

| Point Typology | Time Period (years B.P.) | Frequency | Percent |
|---|---|---|---|
| Small Side-notched | 150-750 | 281 | 37.27 |
| Small Corner-notched | 700-1,700 | 63 | 8.36 |
| Large Corner-notched | 1,500-7,500 | 115 | 15.25 |
| Stemmed Indented | 3,000-5,000 | 22 | 2.92 |
| Large Side-notched | 4,400-7,500 | 85 | 11.27 |
| Lanceolate (Wahmuza) | 150-5,000 | 41 | 5.44 |
| Large Stemmed | 7500-10,200 | 28 | 3.71 |
| Fluted | 10,200-11,000 | 8 | 1.06 |
| Unknown | | 111 | 14.72 |
| Total | | 754 | 100.00 |

with a temporal range of 1500 to 7500 years B.P. (Holmer and Plager 1998). The greatest time depth, 10,200 to 11,000 years B.P., is represented by the fluted points. While eight fragments were analyzed, one from Wilson Butte

(Bailey 1992:Appendix 5) and seven from Wasden (Green 1983:Table 2), six of the fragments from Wasden can be matched, such that only three individual points are represented. Information regarding typology was unavailable for 14.7 percent of the artifacts identified as projectile points.

## PATHWAY SIMULATIONS

For archaeologists, geochemical research has generally been conducted to determine not only what obsidian source or sources hunters and gatherers were utilizing but how far they were traveling to procure glass tool stone. While straight line or Euclidean distance is easily calculated, rarely does the landscape allow for traveling in straight lines. This instigated the initial stage of this project which explored how topography may have affected the actual distances traveled. It was assumed that slope would be the most influential factor in determining the direction a route would take, with level or gentle slopes requiring less effort to traverse. This, of course, doesn't take into account actual ground surface, such as the rough Aa or Pahoe-hoe flows of Idaho's Craters of the Moon, or other landforms such as rivers that could prohibit travel along a particular route. While these factors would have been considerations in prehistoric travelers' decisions, they most likely represented challenging, but not necessarily formidable, obstacles. As the intent of this exercise was to determine possible path distances, not to anticipate past decisions or actual path routes, only landscape features at the macro scale were incorporated into the simulation process.

Geographic information systems software provides a means to simulate a pathway between two points within a computer environment where decisions as to which direction to proceed are made based on specific criteria, in this case, on the terrain gradient or percent of slope. Raster data systems are integral in this process as they provide a continuous surface divided into numerous grid cells which are assigned a numeric value which pertains to qualitative or quantitative data. USGS one-degree (1:250,000 scale) digital elevation models (DEM) are digital data files in grid or raster format. These raster layers provide elevation data for each georeferenced grid or cell spaced at three arc-second intervals (or 90 m resolution). The distance between and the difference in elevation at each grid point are the factors from which percent or degree slope can be calculated. Due to the extent of the study area, 70 DEMs were concatenated using Idrisi 3.2 (Idrisi Production copyright © 1987-2000 Clark Labs) software to create a continuous surface from 40° to 47° latitude and 108° to 118° longitude. While the use of one-degree DEMs allowed broad coverage, the accuracy of the elevation data is compromised. One-degree DEMs are derived from hypsographic and hydrographic data with an acceptable root-mean-square error of one-third the contour interval. An absolute accuracy of 130 m horizontally and 30 m vertically is the USGS standard for small scale DEMs

(U.S. Department of Interior and U.S. Geological Survey 1998).

Site location information was obtained from an antiquities record search of the Intermountain Antiquities Computer System (IMACS) conducted at Idaho's Western Repository, the State Historic Preservation Office, and Eastern Repository, the Idaho Museum of Natural History. When an archeological site is recorded its provenience is reported using the Universal Transverse Mercator (UTM) coordinate system. If UTM coordinates were not available, the coordinates for the center of the recorded quarter section were determined using a UTM Coordinate Grid. Within the data set, private collections (Reed 1985) and isolated finds have been assigned an arbitrary number of 9999 along with the state and county prefix. When collections called for two arbitrary numbers in a single county, 9998 was used. As exact provenience was not usually available for these collections, the UTM coordinates for the center of the recorded quarter section (if provided) or the center of the county were used as the site location. Location information was unavailable for 16 sites and these have been removed from the data set. However, these data represent only four percent of the total sites compiled. On occasion, proveniences indicated in reports did not match UTM locations as recorded on Intermountain Antiquities Computer System (IMACS) forms. When discrepancies were discovered, the IMACS location was used, however, a thorough cross-check of all site locations was not conducted and the provenience data may reflect such errors.

Section as well as township and range have been reported for many of the obsidian quarries in Idaho where comparative collections of parent material have been made (Bailey 1992; Nelson 1984; Sappington 1981b; Sappington 1981c). In those instances, the UTM coordinates for the center of the section have been used for the compiled data. Volcanic glass exposures generally cover a large area with chemically homogeneous materials reported in flows exposed across a broad geographic expanse. As several collection locations have been reported for these formations, a central point was selected for source provenience. The geologic formation process (such as magma versus ash flow) and full extent of many of Idaho's volcanic glasses are not completely understood, thus the use of this more general source location is acceptable.

Several steps were necessary to produce a simulated pathway. As the study area spans two UTM zones (zone 11 and zone 12), UTM coordinates were converted to decimal degrees using the National Imagery and Mapping Agency's (NIMA) Datum Transformation and Coordinate Conversion(DTCC) 4.1 software. Each site and source location were plotted on a map of Idaho (Figure 3) within ArcView® GIS 3.2 (copyright © 1992-1999 Environmental Systems Research Institute Inc. [ESRI]) to visually assess locations and to locate and correct outliers. Arc second grid locations were calculated from the decimal degree proveniences to comply with the DEM scale. As the site and source locations are vector point data, it was necessary to convert each point to a separate raster image using Idrisi's POINTRAS module.

One problem that arises with the concatenation of numerous DEMS is that the final image is extremely large and processing time becomes a prime consideration. To expedite the pathway simulation, the concatenated image was clipped using Idrisi's WINDOW module to narrow the area expanse to the distance from a particular source to an area of proximal sites. Theoretically, the restricted area and consequent limited choices may have introduced some bias as the computer could make decisions only with the available data. However, it was assumed that prehistoric travelers would have essentially followed a direct route, sometimes choosing a steeper, more direct path to conserve both time and energy even when a more circuitous route would be easier to traverse. As the restricted coverage allows for a direct route, any bias it introduces may actually effectuate decisions more closely representative of prehistoric behaviors.

Idrisi's SURFACE context operator was used to create a new data layer with each cell of the windowed image assigned a value based on the calculated percentage of slope derived from the elevations. SURFACE uses a rook's case procedure to determine slope for a cell based on the cell resolution and the elevation values of the immediate neighboring cells to the top, bottom, left and right of the cell in question:

$$\text{tan\_slope} = \sqrt{((\text{right-left})/\text{res}*2)^2 + ((\text{top-bottom})/\text{res}*2)^2}$$

Tan_slope is the tangent of the angle exhibiting the maximum downhill slope. Multiplying tan_slope by 100 yields the percent gradient. Using Idrisi's RECLASS analysis module, percent slope values were classed into seven levels of difficulty, one being the easiest and 10 being the most difficult to traverse. As indicated in Table 6, the first six levels represent increments of five percent. Assuming that slopes greater than 30 percent would be avoided, all cells with a value of 30 or greater were assigned a value of 10. While I determined the levels of classification, they correlate with the tables presented by Knight (1998). The resulting classed image is referred to as a friction surface as it reflects the impediments to travel across cells.

Table 6. Reclassification of Percent Slope into Graduated Levels of Difficulty.

| Level | % Slope Ranging From | To % Slope Less Than |
|---|---|---|
| 1- least difficult | 0 | 5 |
| 2 | 5 | 10 |
| 3 | 10 | 15 |
| 4 | 15 | 20 |
| 5 | 20 | 25 |
| 6 - most difficult | 25 | 30 |
| 10 - avoided | 30 | 100 |

Idrisi's cost modeling function (Eastman 1999) was employed to create a terrain gradient cost surface which combines distance from a target (in this case, the source location) with costs (the levels of difficulty obtained from the friction surface) associated with moving across cells. To minimize processing time, Idrisi's COSTPUSH module was used. While this module doesn't allow the incorporation of absolute barriers, assigning a value of 10 to those areas with slopes greater than or equal to 30 percent created high cost areas that would be avoided. The resultant cost distance surface was then used with each associated site's raster image within Idrisi's PATHWAY module to determine the least-cost pathway from a source of obsidian tool stone to its locus of deposition. At each grid point of the anisotropic surface, the levels of difficulty in the surrounding cells are compared and the path continues in the direction of least difficulty. It is important to note that this reflects only one direction of transport. For a number of sites examined, the simulated pathway from a site to the source of its tool stone often resulted in a different route, although there was little variation in the overall distance traveled. The source to site direction of movement was selected as it was based only on the assumption that the tool stone had followed a direct route to its final destination. While people from a site may have made purposeful forays to glass sources to acquire tool stone that they disposed of back at the site (particularly when the locations are in close proximity), calculating the distance from site to source or even averaging the two, requires that assumption and obscures other possible behaviors.

The restricted area of the windowed images did help to reduce processing time, but it became apparent that processing each of the source/site combinations would be prohibitive in terms of efficiency or productivity. Using Krejcie and Morgan's sample size formula (Bernard 1994:77) and calculating for a 95 percent probability sample with a five percent confidence interval, it was determined that 164 sites would be a representative sample of the 284 sites in the compiled data set. These were randomly selected using SPSS (Statistical Package for the Social Sciences) for Windows 8.0 (copyright © 1989-1997 SPSS, Inc.) data analysis software. Pathways were simulated for glass materials identified at the 164 sites with the exception of four pathways to Lydle Gulch (10AA72). These pathways would have correlated with XRF analysis that matched two artifacts to Beatys Butte, nine to Burns, and five to Whitehorse, all located in Oregon, and one to Summit Lake in Nevada.

Further processing was required to convert the simulated pathways from raster data measured in arc seconds into vector data measured in kilometers. Each pathway was exported from Idrisi as an ERDAS® Imagine 7.4 (copyright © 1997-2000 ERDAS Inc.) image that could be brought into ArcView. Images were converted to grids which could be manipulated in ArcInfo 7.2 (copyright © ESRI Inc. 1995-2000). Each grid was converted to vector line data in ASCII text file format using ArcInfo's UNGENERATE command. The text files were opened in

Microsoft ® Excel 2000 (copyright © 1985-1999 Microsoft Corporation) and proveniences were converted from arc seconds to decimal degrees. Each file was modified to conform to ArcInfo's format and converted into a line coverage using the GENERATE command. Line coverages were then added as themes within ArcView and projected into Idaho Transverse Mercator where distance was calculated in kilometers.

## SPATIAL ANALYSIS

A second phase of this study was to examine how glass tool stone was being distributed across the landscape. As noted, for many of the sites in the data sample only a small number of artifacts were analyzed, often only one flake or point, while for other sites several artifacts were analyzed. This bias can be partially corrected by combining proximal sites with low densities. To accomplish this, the study area was divided into 30 minute latitude/longitude grid sections. Sites within each grid section were combined as shown in Figure 4, but there are still some grid sections with only one XRF sample (the number in each grid of Figure 4 represents the analyzed samples from the combined sites). A roving average was employed which incorporated the sum of samples from the nearest group of four cells and assigned the percentage of glass by source to the center point of those adjoining cells. Thus, each block of four cells, moving from west to east across the state, contained a comparative sample.

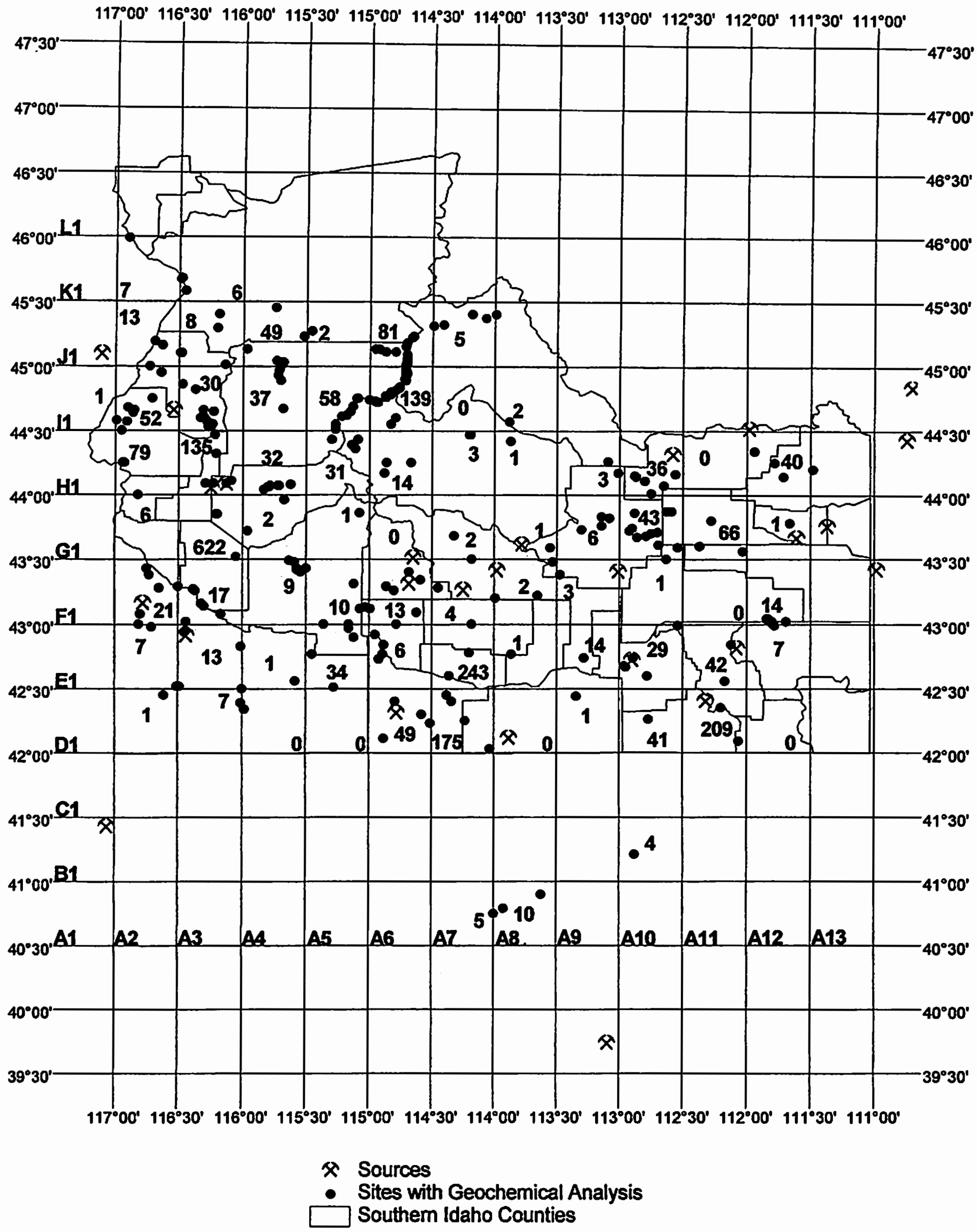



Figure 4. Distribution of analyzed samples within 30-minute cells.

This had the effect of smoothing the data, but general patterns were still identifiable. These patterns are reflected in the isoline maps presented in the following chapter.

As noted previously in Chapter 2, six sources (Table 3) exhibit the highest density of materials: Bear Gulch, Big Southern Butte, Browns Bench, Owyhee, and Timber Butte. Figures 5 through 10 show the sites that have geochemical correlates to these major sources. Using ArcView, concentric bands (buffer zones) were created at 50 km intervals around each of the six sources. Figure 11 provides a schematic of the buffered zones for the Owyhee source. For each source, the number of artifacts matching its geochemistry was compared to the total number of artifacts that have been analyzed within each sequential band. At the source location (zero distance), it was assumed that 100 percent of the tool stone would match its unique signature. Percentages were plotted at each band's midpoint distance for the six sources to determine the density of source material and the subsequent fall-off pattern associated with each of the glass tool stones.

Hodder and Orton (1976) have examined several methods that explore the relationship of the density of materials and distance from the source of origin. Using regression analysis, density fall-off curves were presented that relate to simulated random walk processes where number of steps (locations where material is found) and step length (distance between these locations) are

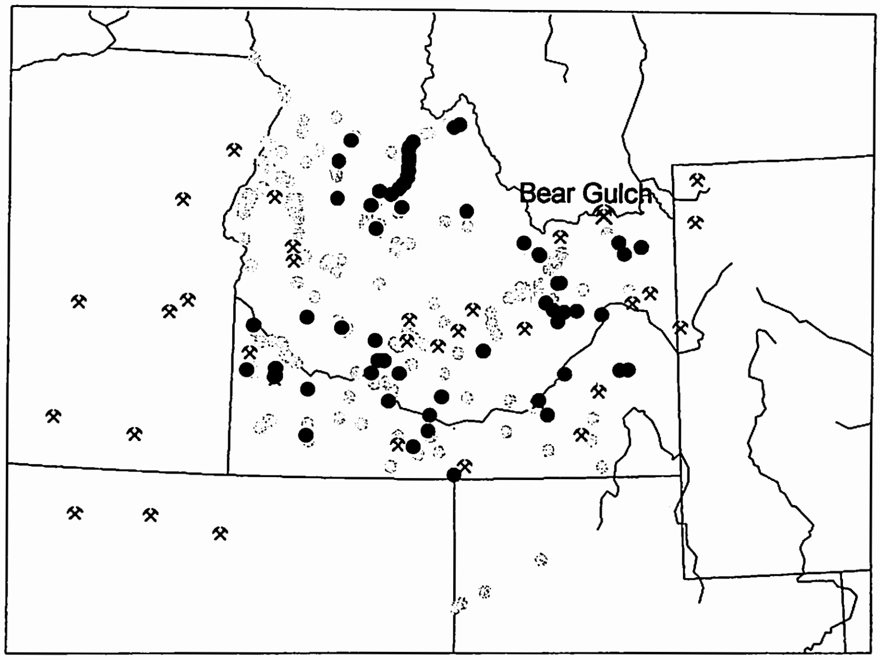



Figure 5. Sites with artifacts whose geochemistry correlates with Bear Gulch tool stone.

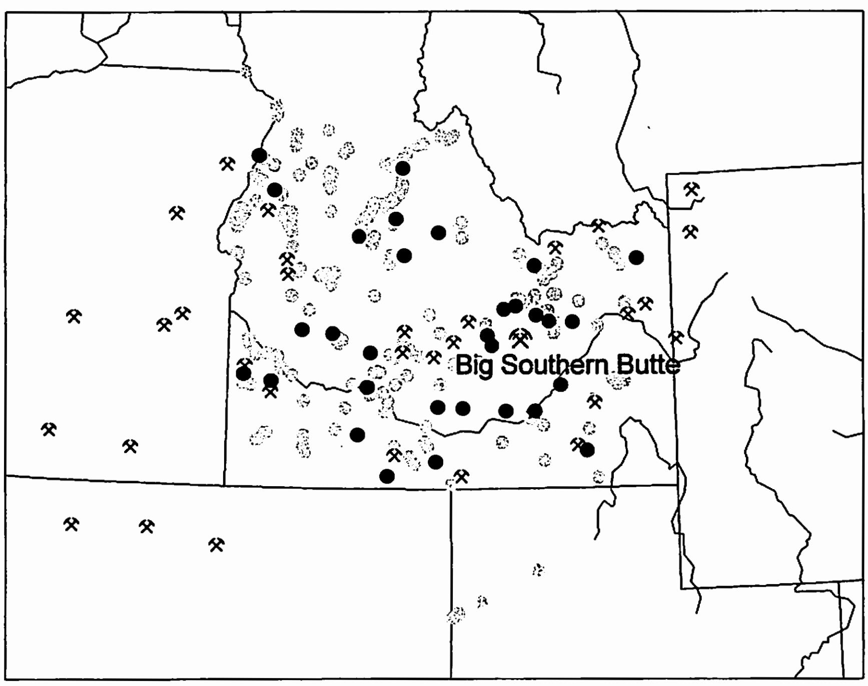



Figure 6. Sites with artifacts whose geochemistry correlates with Big Southern Butte tool stone.

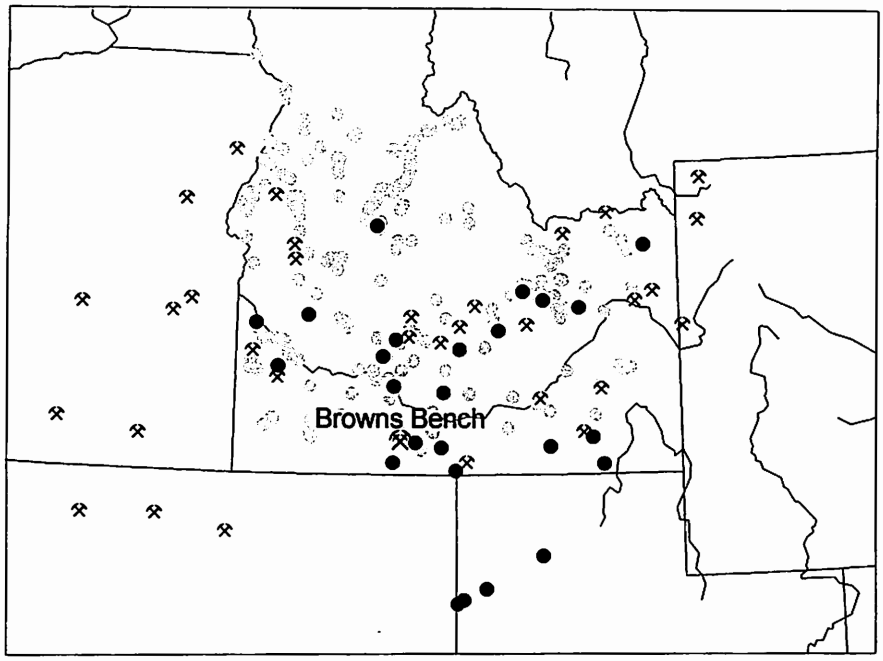



Figure 7. Sites with artifacts whose geochemistry correlates with Browns Bench tool stone.

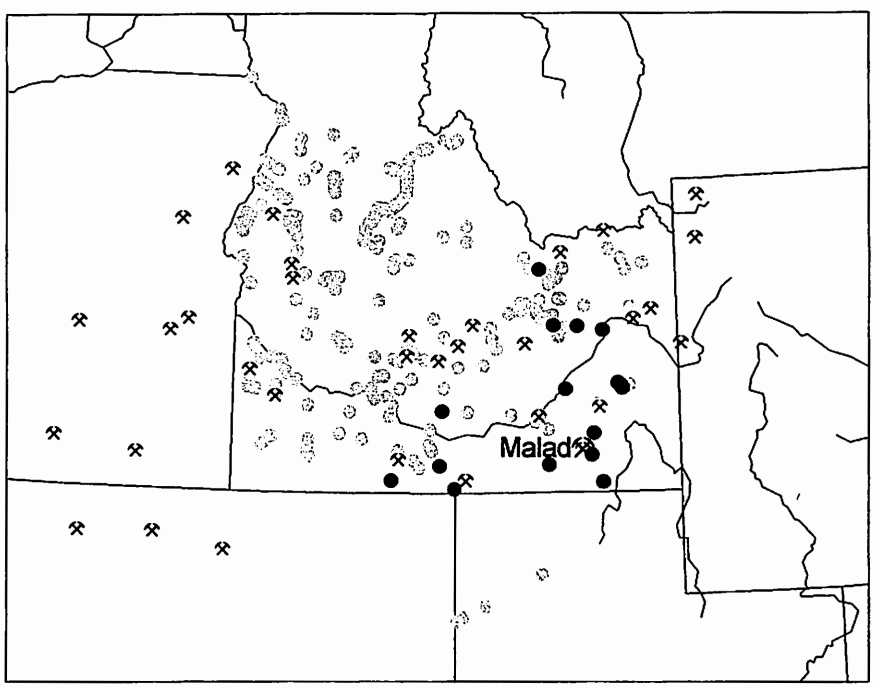



Figure 8. Sites with artifacts whose geochemistry correlates with Malad tool stone.

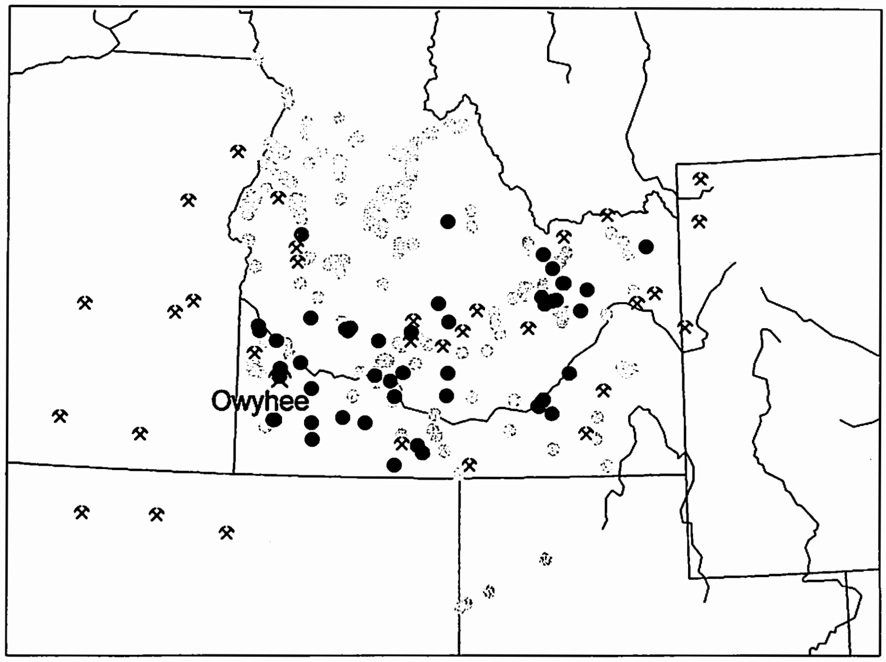



Figure 9. Sites with artifacts whose geochemistry correlates with Owyhee tool stone.

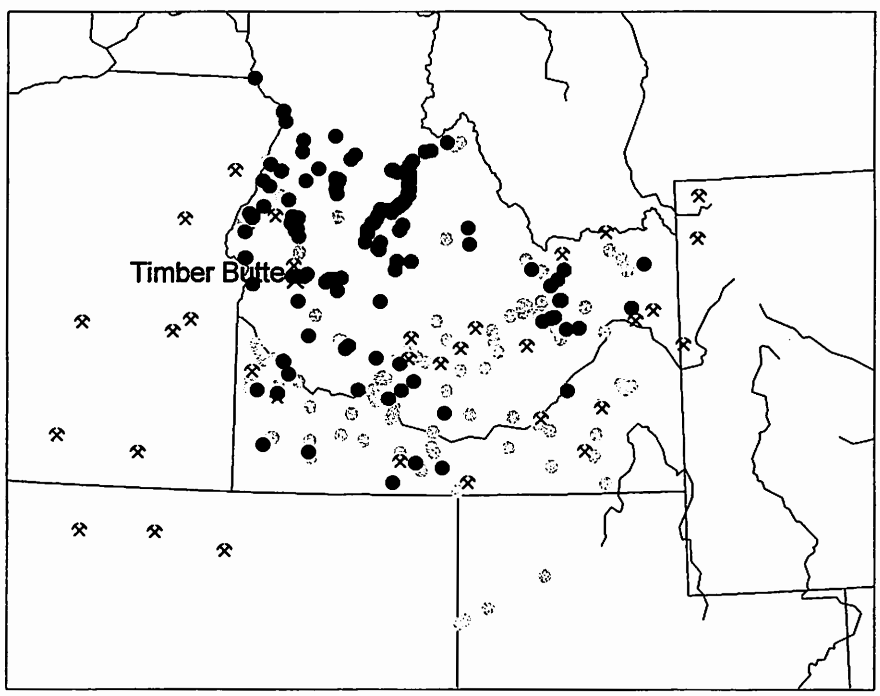



Figure 10. Sites with artifacts whose geochemistry correlates with Timber Butte tool stone.

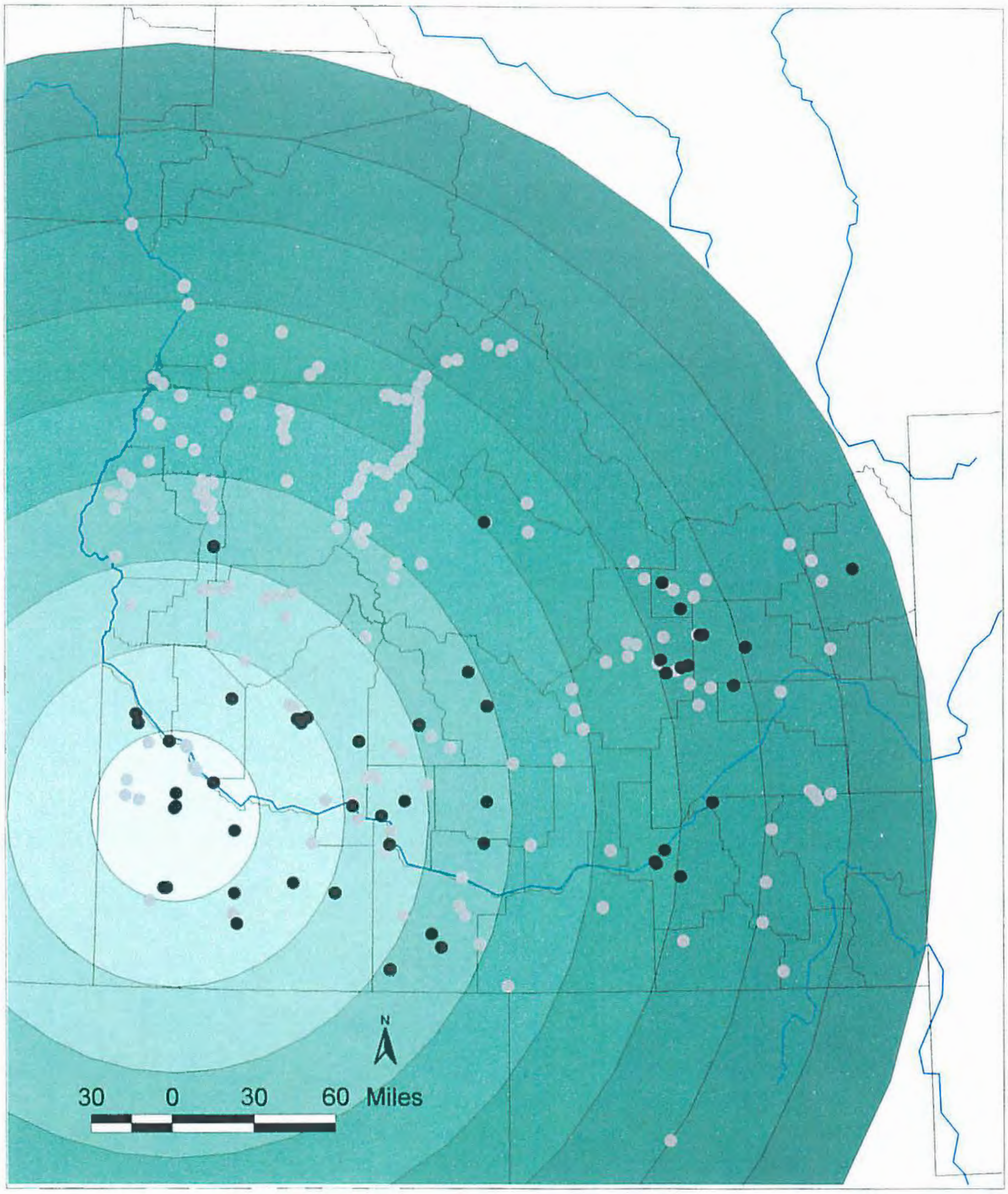



Figure 11. Concentric rings (buffer zones) at 50 km intervals from the Owyhee obsidian source. Sites with artifacts characterized to Owyhee glass are shown in black.

both predetermined and selected randomly. To compare the patterns presented by Hodder and Orton's simulation data to the archaeological data compiled for this project, Table Curve™ 2D 3.0 (copyright © 1989-1994 AISN Software Inc.) was employed to plot the percentage of material for the six major sources at the sequential distance intervals. The resultant fall-off curves are discussed in Chapter Four.

# CHAPTER FOUR

## SIMULATION AND SPATIAL ANALYSIS RESULTS

The simulated pathways demonstrate that glass tool stone was transported substantial distances across southern Idaho. Descriptive statistics (mean, minimum, maximum, and standard deviation) for Euclidean and path distances are provided in Table 7 and Table 8. The greatest path distance glass tool stone was transported away from its parent source was 614 km. Volcanic glass from Obsidian Cliff, Wyoming was found at Mud Springs in the Owyhee Mountains of southwest Idaho. This considerable distance is not surprising, as Obsidian Cliff glass has been identified in several eastern Middle Woodland sites (Griffin, et al. 1969), however the extent of its distribution to the west is relatively unknown. Other well known source materials, Bear Gulch, Big Southern Butte, and Timber Butte, were not transported as far, 509 km, 511 km, and 530 km respectively, but this may be a factor of the circumscribed nature of the study area and the inclusion of predominantly Idaho sites. Double H Mountain, Nevada glass was found in eight deposits in southern Idaho, the farthest at 610 km from its source. This is possibly more revealing, as extra-local glass tool stone is being brought in, used, and discarded in a region of abundant glass materials. Considering straight line distance only, one-third of the sources documented in this study were deposited at distances greater than 300 km (186 miles) with two-thirds at distances greater than 200 km (124 miles).

Table 7. Euclidean Distance (km) Descriptive Statistics for Each of the Volcanic Glass Sources.

| Obsidian Source | Site N | Sample N | Mean | Minimum | Maximum | Std. Deviation |
|---|---|---|---|---|---|---|
| American Falls | 4 | 15 | 84.19 | 31.24 | 276.78 | 64.68 |
| Bear Gulch | 70 | 138 | 201.14 | 36.26 | 423.22 | 109.74 |
| Beatys Butte | 1 | 2 | 293.60 | 293.60 | 293.60 | |
| Big Southern Butte | 31 | 153 | 120.49 | 33.72 | 355.30 | 55.08 |
| Browns Bench | 25 | 143 | 124.42 | 5.43 | 363.76 | 53.51 |
| Burns | 1 | 9 | 245.61 | 245.61 | 245.61 | |
| Camas Prairie | 4 | 9 | 121.17 | 57.32 | 276.85 | 68.68 |
| Cannonball Mountain | 15 | 48 | 101.90 | 15.44 | 243.50 | 43.03 |
| Chesterfield | 3 | 4 | 42.07 | 33.01 | 50.94 | 10.24 |
| Coal Bank Spring | 3 | 27 | 36.99 | 31.45 | 83.70 | 16.01 |
| Coyote Wells | 3 | 11 | 124.70 | 98.20 | 128.21 | 9.16 |
| Double H Mountain | 8 | 12 | 377.83 | 190.02 | 506.52 | 120.26 |
| Deep Creek | 1 | 2 | 210.57 | 210.57 | 210.57 | |
| Dooley Mountain | 10 | 18 | 111.29 | 61.80 | 169.90 | 36.98 |
| Goodrich | 1 | 1 | 18.32 | 18.32 | 18.32 | |
| Kelly Canyon | 14 | 16 | 217.21 | 69.93 | 416.30 | 120.33 |
| Kepler | 2 | 2 | 438.72 | 398.15 | 479.28 | 57.37 |
| Malad | 18 | 438 | 76.86 | 10.58 | 213.67 | 60.61 |
| Obsidian Cliff | 20 | 25 | 303.28 | 92.58 | 531.91 | 124.10 |
| Ola | 2 | 7 | 46.36 | 45.78 | 46.59 | 0.40 |
| Owyhee | 51 | 145 | 157.87 | 8.50 | 433.65 | 122.29 |
| Packsaddle | 4 | 6 | 88.80 | 86.97 | 89.49 | 1.00 |
| Paradise Valley | 4 | 4 | 291.49 | 197.00 | 455.96 | 113.36 |
| Picabo Hills | 1 | 16 | 70.63 | 70.63 | 70.63 | |
| Pine Mountain | 1 | 1 | 86.27 | 86.27 | 86.27 | |
| Reynolds | 2 | 2 | 183.52 | 35.52 | 331.52 | 209.30 |
| Shumway | 1 | 1 | 255.49 | 255.49 | 255.49 | |
| Sugarloaf | 4 | 35 | 89.29 | 39.01 | 93.36 | 13.56 |
| Summit | 1 | 1 | 324.51 | 324.51 | 324.51 | |
| Teton Pass | 7 | 8 | 347.33 | 79.58 | 460.27 | 122.02 |
| Timber Butte | 163 | 1205 | 85.25 | 6.04 | 382.17 | 62.28 |
| Topaz Mtn | 1 | 1 | 166.60 | 166.60 | 166.60 | |
| Wedge Butte | 1 | 2 | 51.82 | 51.82 | 51.82 | |
| Whitehorse | 1 | 5 | 223.88 | 223.88 | 223.88 | |
| Summary | 478 | 2512 | 105.99 | 5.43 | 531.91 | 85.25 |

Table 8. Path Distance (km) Descriptive Statistics for Each of the Volcanic Glass Sources Utilized by the Selected Sample.

| Obsidian Source | Artifact N | Mean | Minimum | Maximum | Std. Deviation |
|---|---|---|---|---|---|
| American Falls | 15 | 89.71 | 33.49 | 315.14 | 72.78 |
| Bear Gulch | 120 | 265.89 | 47.31 | 509.15 | 125.71 |
| Big Southern Butte | 149 | 133.36 | 38.65 | 510.99 | 65.89 |
| Browns Bench | 126 | 130.71 | 5.68 | 400.88 | 66.74 |
| Camas Prairie | 9 | 140.22 | 58.97 | 312.38 | 79.95 |
| Cannonball Mountain | 47 | 115.41 | 18.20 | 322.88 | 60.89 |
| Chesterfield | 4 | 51.27 | 40.44 | 61.49 | 11.82 |
| Coal Bank Spring | 27 | 42.62 | 36.80 | 91.03 | 16.79 |
| Coyote Wells | 10 | 187.50 | 128.13 | 194.10 | 20.86 |
| Double H Mountain | 11 | 450.30 | 288.22 | 609.85 | 141.62 |
| Deep Creek | 2 | 227.40 | 227.40 | 227.40 | |
| Dooley Mountain | 6 | 139.46 | 104.27 | 233.36 | 52.09 |
| Goodrich | 1 | 20.87 | 20.87 | 20.87 | |
| Kelly Canyon | 16 | 245.50 | 76.58 | 470.82 | 139.17 |
| Malad | 437 | 93.15 | 14.59 | 253.55 | 73.06 |
| Obsidian Cliff | 22 | 324.86 | 104.57 | 613.84 | 134.33 |
| Ola | 7 | 58.89 | 58.37 | 59.10 | 0.36 |
| Owyhee | 128 | 191.00 | 12.51 | 489.65 | 140.58 |
| Packsaddle | 6 | 100.83 | 97.99 | 102.25 | 1.74 |
| Paradise Valley | 4 | 325.68 | 232.16 | 523.51 | 133.55 |
| Picabo Hills | 16 | 74.86 | 74.86 | 74.86 | |
| Pine Mountain | 1 | 91.36 | 91.36 | 91.36 | |
| Reynolds | 1 | 413.45 | 413.45 | 413.45 | |
| Sugarloaf | 35 | 104.26 | 54.69 | 108.61 | 14.44 |
| Teton Pass | 5 | 377.11 | 107.64 | 496.45 | 158.14 |
| Timber Butte | 1074 | 107.29 | 6.62 | 529.52 | 89.64 |
| Wedge Butte | 2 | 52.96 | 52.96 | 52.96 | |
| Summary | 2281 | 125.78 | 5.68 | 613.84 | 104.43 |

This clearly documents a pattern of high mobility (Goodyear 1989) attested to in ethnographic reports (Liljeblad 1957; Murphy and Murphy 1960; Steward 1938) and suggested by the archaeological record (Plew 2000) for southern Idaho.

Regression analysis provides a mechanism for predicting the average increase in distance when allowances are made for terrain gradient. The formula for the least-squares regression line (Figure 12) follows the simple equation for a straight line: $y = a + bx$. In this case, $y$ = the path distance and $x$ = the Euclidean distance. This equation ($y = 4.362 + 1.202x$) fits the data relatively well with $r^2 = .946$. Thus, the path distance is predictably 20 percent greater than the easily derived Euclidean distance. Appendix B provides the minimum, maximum, and mean Euclidean distance in kilometers for each site, as well as the mean path distance and mean predicted distance. It is important to note that the residuals along this regression line are not normally distributed and violate one of the required assumptions necessary to test hypotheses derived from this regression model. One standard deviation from the mean of the residuals is ± 14 percent. However, this is exactly what one would expect when dealing with the varied terrain encountered in southern Idaho. As a number of factors would need to be considered to approximate the actual distance tool stone was transported before it was discarded, an estimation of path distance to be 20 percent greater than straight line distance is offered merely as a general rule of thumb.

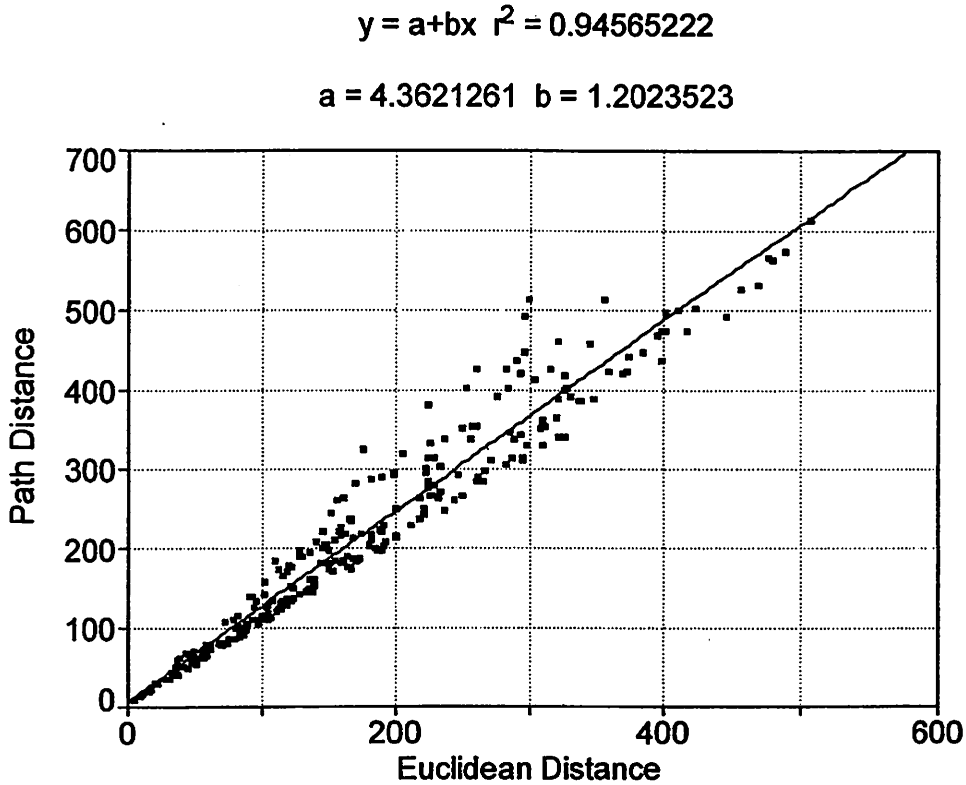



Figure 12. Scatter plot of Euclidean and path distance with least squares regression line.

## DISTRIBUTION PATTERNS

Examining the data further, certain patterns begin to emerge that inform on past procurement behavior. Hierarchical cluster analysis using the percentage of geochemical types within each 30-minute grid cell identifies three areas which can be associated with southern Idaho's major physiographic regions. Figure 13 provides a graphic representation of the regional divisions. The first cluster identifies sites located in Idaho's central mountains (the northwest region of the study area) that are dominated by Timber Butte glass

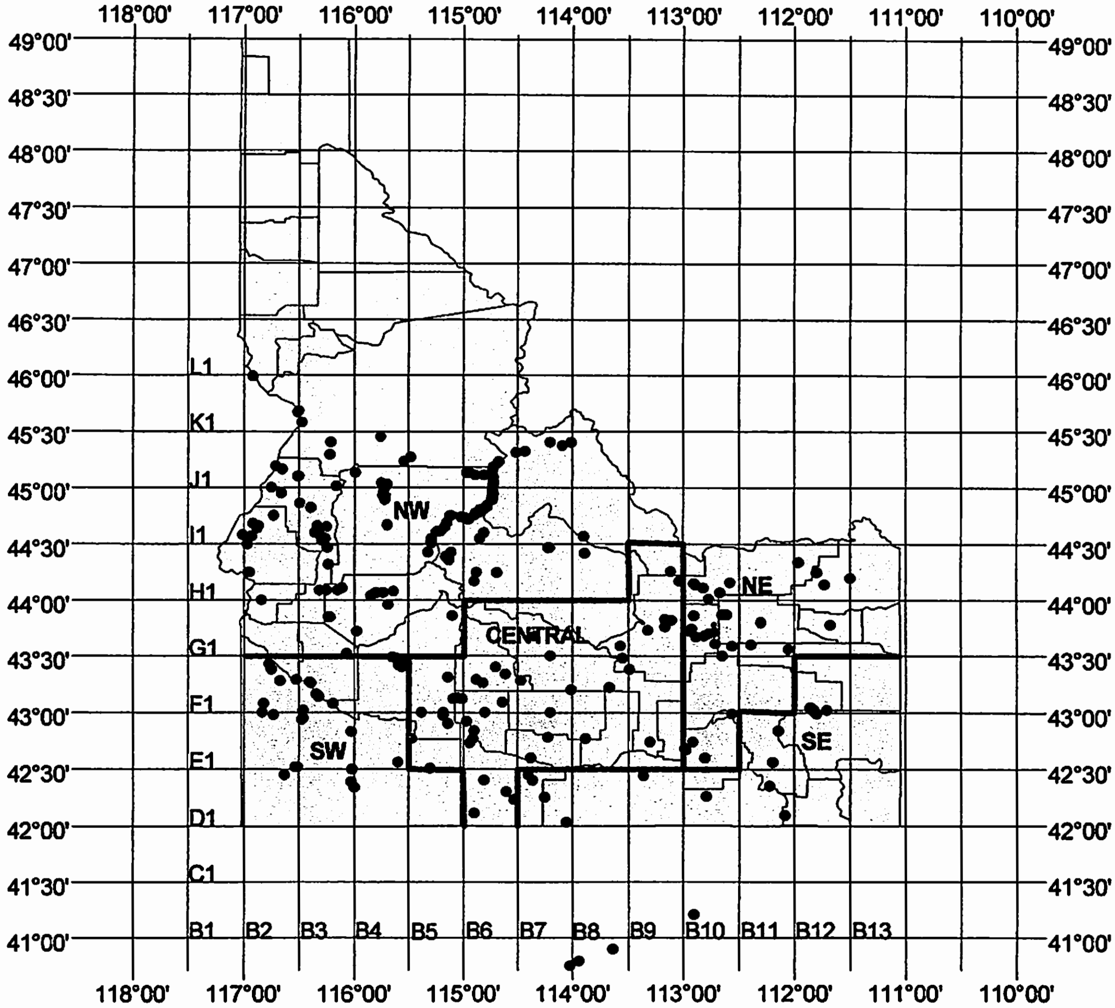



Figure 13. Regional tool stone patterns based on hierarchical cluster analysis.

(84 percent). Sites located in southeast-central Idaho and the southeastern mountains (the southeast region) comprise the second cluster and reflect the predominant use of Malad material (80 percent). The third cluster contains sites located across the Snake River Plain. While Big Southern Butte and Browns Bench tool stone accounts for almost 50 percent of the discarded glass, over 60 percent of all the known sources in southern Idaho's archaeological record are

percent of all the known sources in southern Idaho's archaeological record are represented in various proportions across this central region. This is exactly the pattern that would be expected from highly mobile consumers whose patchy resources along a major river system required a subsistence strategy in concert with ripening seeds and berries, maturing roots, and available fish and game. These general distribution patterns confirm Holmer's (1997:191) argument that transport perpendicular to the Plain was limited, while a relatively established network was evident along the Snake River corridor.

The third cluster was further divided into three regions based on the predominance of material in each grid cell: northeast, southwest, and central. As expected, Bear Gulch, located in the Centennial Mountains between Idaho and Montana, is predominant at sites located in the northeast region. Sites located in the southwest region exhibit a high percentage of glass from the Owyhee source in the Owyhee Mountains. Of particular interest is the comparatively high percentage (16 percent) of Owyhee glass in the northeast region and the reverse pattern reflected in an equally high percentage (21 percent) of Bear Gulch found at sites in the southwest. These percentages were significantly higher than I expected. Both patterns are indicative of materials being transported over 400 km (250 miles) in straight line distance or possibly over 500 km (310 miles) in path distance from the parent source.

The regional distributions of volcanic glass materials (Table 9) reveal the

Table 9. Percent of Volcanic Glass Tool Stone Found in Each Geographic Region.

| SOURCE | NW | NE | SE | SW | CENTRAL |
|---|---|---|---|---|---|
| American Falls | .07 | 0 | .21 | 0 | 3.53 |
| Bear Gulch | 3.39 | 24.52 | .82 | 20.55 | 5.98 |
| Beatys Butte | .15 | 0 | 0 | 0 | 0 |
| Big Southern Butte | .74 | 15.87 | 2.26 | 4.11 | 26.09 |
| Browns Bench | .37 | 1.44 | 6.37 | 2.74 | 23.10 |
| Burns | .66 | 0 | 0 | 0 | 0 |
| Camas Prairie | .37 | .48 | 0 | 0 | .82 |
| Cannonball Mountain | 0 | 1.92 | .41 | 2.74 | 10.87 |
| Chesterfield | 0 | 0 | .82 | 0 | 0 |
| Coal Bank Spring | 0 | 0 | 4.93 | 0 | .82 |
| Coyote Wells | .74 | 0 | 0 | 1.37 | 0 |
| Double H Mountain | .15 | 2.88 | 0 | 0 | 1.09 |
| Deep Creek | 0 | 0 | 0 | 0 | .54 |
| Dooley Mountain | 1.33 | 0 | 0 | 0 | 0 |
| Goodrich | .07 | 0 | 0 | 0 | 0 |
| Kelly Canyon | .15 | 1.92 | .82 | 2.74 | 1.09 |
| Kepler | .15 | 0 | 0 | 0 | 0 |
| Malad | 0 | 17.79 | 79.88 | 0 | 3.26 |
| Obsidian Cliff | .37 | 4.81 | .41 | 6.85 | .82 |
| Ola | .52 | 0 | 0 | 0 | 0 |
| Owyhee | 3.76 | 15.87 | 0 | 39.73 | 8.70 |
| Packsaddle | 0 | 0 | 1.23 | 0 | 0 |
| Paradise Valley | .07 | .48 | 0 | 0 | .54 |
| Picabo Hills | 0 | 0 | 0 | 0 | 4.35 |
| Pine Mountain | 0 | 0 | 0 | 0 | .27 |
| Reynolds | 0 | .48 | 0 | 1.37 | 0 |
| Shumway | .07 | 0 | 0 | 0 | 0 |
| Sugarloaf | 2.58 | 0 | 0 | 0 | 0 |
| Summit Lake | .07 | 0 | 0 | 0 | 0 |
| Teton Pass | .29 | 0 | .21 | 2.74 | .27 |
| Timber Butte | 83.58 | 11.54 | 1.64 | 15.07 | 7.34 |
| Topaz Mountain | 0 | 0 | 0 | 0 | 0 |
| Wedge Butte | 0 | 0 | 0 | 0 | .54 |
| Whitehorse | .37 | 0 | 0 | 0 | 0 |
| Percent Totals | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |

variety of volcanic glass materials represented in each of the regions. Appendix C provides a table of the 30-minute grid cells with the number of sites and their number of associated sources along with minimum, maximum, and average straight line distances. While the diverse use of locally available materials (half of the geologic sources represented in the central region are actually located within the central Snake River Plain or along its periphery) is characteristic of mobile strategies, the presence of materials from numerous non-local sources in the central, northeast, and southeast regions, and particularly in the northwest region indicates the expanse of territory that was necessarily exploited by past procurers. Ignoring for the moment the broad time depth reflected in the data, as the distance to these various sources increases, other procurement strategies would be reasonable considerations.

Goodyear (1989:5) notes that, when tool stone distributions exceed 200 miles, interpretations regarding prehistoric procurement strategies include the possibility of exchange. Beck and Jones (1990:285) suggest that "Curation of exotic items . . . would likely be less given [an] abundance of raw material throughout the yearly cycle than if raw material sources are sporadically distributed across the landscape and the group does not encounter a source at each locality." Following their argument, the presence of Bear Gulch tool stone in western Idaho and Owyhee glass in eastern Idaho would suggest that either the groups in possession of these exotic materials traveled great distances to acquire glass directly and did not encounter any of the numerous sources exposed across southern Idaho or that they participated in an exchange network which may have involved either singular or multiple transactions. A number of factors, such as the type, quantity, and size of formal artifacts manufactured from the nonlocal glass as well as the stage of reduction, quantity, and size of debitage found at a particular site (Ammerman 1979; Ammerman and Polglase 1993), would need to be considered before a sound argument for exchange could be supported, but distance and variety of volcanic glass materials contribute to informative avenues of research regarding procurement strategies.

The investment of time necessary for tool manufacture should also be reflected in curation practices and thus greater transport distance. However in the compiled data, points are the only formal tools that exhibit greater transport distances. All other tools indicate similar transport distances to flakes. Mann-Whitney U non-parametric tests verify that distances are only significantly different ($p < .000$) when comparing any class with points. Table 10 gives the Euclidean and path distances in kilometers for each of the artifact categories. Points are transported 50 percent farther than any of the other categories.

The presence of obsidian cores at a site has contributed to inferences regarding the curation of materials as well as possible trade or exchange as opposed to direct procurement strategies (Sappington 1984:31; Ammerman 1979:102). Of the 45 cores in the data set, 39 are from Lydle Gulch (10AA72).

Of these, 31 are from the closest source, Timber Butte, and six are from the second closest source, Owyhee. This would suggest that past consumers were procuring material directly from the source and returning to Lydle Gulch (10AA72) with nodules for the production of flake tools. However, material from non-local tool stones indicates a bimodal procurement strategy (Sappington 1981b:150). Sappington (1981b) interprets the high density of decortification flakes, particularly flakes sourced to Timber Butte at 60 km (37 miles)

Table 10. Average Euclidean and Path Distance for Each Artifact Category.

| Artifact Class | Number | Average Euclidean Distance (km) | Average Path Distance (km) |
|---|---|---|---|
| point | 729 | 148.11 | 169.75 |
| biface | 206 | 87.36 | 100.85 |
| core | 45 | 79.95 | 89.61 |
| drill | 7 | 91.84 | 77.05 |
| scraper | 76 | 71.14 | 81.41 |
| flake | 904 | 96.04 | 123.32 |
| tool | 158 | 96.06 | 119.13 |
| unknown | 6 | 45.80 | 48.60 |

and Owyhee at 81 km (50 miles), as direct procurement of locally available resources. Prehistoric consumers could have incorporated tool stone acquisition into their subsistence forays when they traveled to harvest tubers in the Timber Butte and Camas Prairie areas or hunted deer in the Owyhee Mountains.

However, an exchange relationship is suggested for the continuous presence of nonlocal materials over time. While Sappington (1981b:150) overlooks results that indicate Big Southern Butte and Browns Bench tool stones were present at Lydle Gulch (10AA72), he argues that all the materials from eastern Oregon and northwest Nevada represent "the material record of trade" even though the distances for the Oregon sources are comparable to the Idaho sources and, for Coyote Wells, considerably closer: Coyote Wells, Oregon is 128 km (80 miles) from Lydle Gulch compared to Browns Bench which is 189 km (117 miles). However, Reed's (1985) report of the geochemical analysis of eight Lydle Gulch points demonstrates an exchange procurement strategy more convincingly, involving sources from much greater distances. While four points were again characterized to Owyhee, four were alternately characterized to Bear Gulch (2), Kelly Canyon, and Teton Pass located at distances (344 km, 359 km, and 411 km respectively) which extend the Lydle Gulch "network of communication" over 100 km beyond Sappington's (1981b) proposed perimeter.

Projectile points are additionally informative as their similar morphological characteristics found across southern Idaho have been identified with specific temporal periods. Appendix D shows the number of points assigned to each temporal period along with the minimum, maximum, and mean straight line distances the various tool stones were being transported. Distance between parent source and locus of deposition is greater in more recent times, although considerable distances, over 300 km in all temporal periods but the early Paleo-Indian period, have been documented over time.

Unfortunately, while the data contain over 754 points, consumer behavior can be compared at only a limited number of sites as few sites have more than one or two points with parent source characterization. Only 13 sites or collections (Fremont and Twin Falls counties) have had ten or more points analyzed and these include the collections reported by Reed (1985) who was only interested in large and small side-notched points representative of the middle and late periods respectively. One site, 10OE1114, was eliminated from this subset, as the point types were not identified. Interestingly, as shown in Table 11, the twelve remaining sites indicate the use of a variety of glass tool stone over at least the last 10,000 years. Jimmy Olsen (10CL40) shows the least variety in the late period. This is most probably due to the small number of points (two) analyzed for this period. Malad Hill (10BK74) exhibits the least diversity in source material over its period of occupation. Materials from the nearby Malad source are prevalent throughout each time period, but glass characteristic of Big Southern Butte and Browns Bench (at distances up to 222 km) was also present. The greatest time depth is represented at Wasden (10BV30), where fluted points have been characterized to Big Southern Butte and Malad, and at Wilson Butte (10JE6) with a "'fluted' point fragment" (Bailey (1992:Appendix 5) of Browns Bench glass. Lydle Gulch (10AA72), discussed

Table 11. Sites Reflecting Use of Obsidian and the Euclidean Distances Materials Were Transported During Various Time Periods.

| Site/Geochemist | Period (yr BP) | Source | Points | Distance (km) |
|---|---|---|---|---|
| **Fremont Co. Sites** University of Idaho | 150-750 | Bear Gulch | 3 | 51.97 |
| | | Big Southern Butte | 2 | 152.85 |
| | | Browns Bench | 1 | 363.76 |
| | | Camas Prairie | 1 | 276.85 |
| | | Obsidian Cliff | 1 | 92.58 |
| | | Owyhee | 9 | 433.65 |
| | | Timber Butte | 1 | 382.17 |
| | 4,400-7,500 | Bear Gulch | 1 | 51.97 |
| | | Big Southern Butte | 1 | 152.85 |
| | | Double H Mountain | 1 | 376.83 |
| | | Obsidian Cliff | 1 | 92.58 |
| | | Owyhee | 2 | 433.65 |
| **Jimmy Olsen (10CL40)** Geochemical Research | 150-750 | Bear Gulch | 2 | 81.65 |
| | 1,500-7,500 | Bear Gulch | 9 | 81.65 |
| | | Big Southern Butte | 3 | 85.02 |
| | | Malad | 1 | 200.48 |
| | | unknown | 5 | |
| **Wasden (10BN30)** University of Idaho | 150-750 | Bear Gulch | 3 | 104.51 |
| | | Owyhee | 4 | 347.45 |
| | | Timber Butte | 5 | 315.86 |
| | 4,400-7,500 | Browns Bench | 1 | 266.36 |
| | | Cannonball Mountain | 1 | 189.66 |
| | | Paradise Valley | 1 | 455.96 |
| | 10,200-11,000 | Big Southern Butte | 6 | 57.27 |
| | | Malad | 1 | 134.97 |
| **Wahmuza (10BK26)** Mohlab | 150-750 | Malad | 5 | 69.53 |
| | | Obsidian Cliff | 1 | 251.28 |
| | | Timber Butte | 4 | 321.81 |
| | 150-5,000 | Bear Gulch | 1 | 173.39 |
| | | Big Southern Butte | 1 | 58.70 |
| | | Malad | 2 | 69.53 |
| | | Obsidian Cliff | 4 | 251.28 |
| | | Owyhee | 1 | 326.50 |
| | | Timber Butte | 1 | 321.81 |
| **Malad Hill (10BK74)** University of Idaho | 150-750 | Browns Bench | 1 | 222.12 |
| | | Malad | 5 | 10.58 |
| | 700-1,700 | Malad | 4 | 10.58 |

Table 11. Sites Reflecting Use of Obsidian and the Euclidean Distances Materials Were Transported During Various Time Periods (continued).

| Site/Geochemist | Period (yr BP) | Source | Points | Distance (km) |
|---|---|---|---|---|
| **Malad Hill (10BK74)** continued | 1,500-7,500 | Browns Bench | 1 | 222.12 |
| | | Malad | 15 | 10.58 |
| | 3,000-5,000 | Big Southern Butte | 1 | 133.22 |
| | | Malad | 11 | 10.58 |
| | 4,400-7,500 | Browns Bench | 1 | 222.12 |
| | | Malad | 8 | 10.58 |
| | 150-5,000 | Chesterfield | 2 | 50.94 |
| | | Malad | 4 | 10.58 |
| **Wilson Butte (10JE6)** Simon-Frazer | 150-750 | Big Southern Butte | 1 | 117.58 |
| | | Browns Bench | 3 | 97.40 |
| | | Cannonball Mountain | 1 | 84.04 |
| | | Kelly Canyon | 1 | 231.33 |
| | 700-1,700 | American Falls | 1 | 106.77 |
| | | Bear Gulch | 1 | 261.50 |
| | | Browns Bench | 9 | 97.40 |
| | | Camas Prairie | 1 | 57.32 |
| | | Cannonball Mountain | 5 | 84.04 |
| | | Picabo Hills | 5 | 70.63 |
| | | Timber Butte | 1 | 216.82 |
| | | unknown | 1 | |
| | 1,500-7,500 | American Falls | 1 | 106.77 |
| | | Bear Gulch | 1 | 261.50 |
| | | Big Southern Butte | 1 | 117.58 |
| | | Browns Bench | 17 | 97.40 |
| | | Cannonball Mountain | 6 | 84.04 |
| | | Coal Bank Spring | 2 | 83.70 |
| | | Malad | 2 | 160.48 |
| | | Owyhee | 2 | 191.42 |
| | | Picabo Hills | 5 | 70.63 |
| | | Timber Butte | 3 | 216.82 |
| | 3,000-5,000 | American Falls | 1 | 106.77 |
| | | Big Southern Butte | 2 | 117.58 |
| | | Browns Bench | 3 | 97.4 |
| | 4,400-7,500 | Big Southern Butte | 1 | 117.58 |
| | | Browns Bench | 5 | 97.4 |
| | | Cannonball Mountain | 5 | 84.04 |
| | | Picabo Hills | 1 | 70.63 |

Table 11. Sites Reflecting Use of Obsidian and the Euclidean Distances Materials Were Transported During Various Time Periods (continued).

| Site/Geochemist | Period (yr BP) | Source | Points | Distance (km) |
|---|---|---|---|---|
| **Wilson Butte (10JE6)** | 4,400-7,500 | Timber Butte | 1 | 216.82 |
| continued | | Wedge Butte | 1 | 51.82 |
| | 150-5,000 | Bear Gulch | 1 | 261.50 |
| | | Big Southern Butte | 1 | 117.58 |
| | | Browns Bench | 2 | 97.40 |
| | | Cannonball Mountain | 1 | 84.04 |
| | | Malad | 1 | 160.48 |
| | 7,500-10,200 | American Falls | 2 | 106.77 |
| | | Bear Gulch | 1 | 261.50 |
| | | Big Southern Butte | 7 | 117.58 |
| | | Browns Bench | 6 | 97.4 |
| | | Cannonball Mountain | 2 | 84.04 |
| | | Malad | 1 | 160.48 |
| | 10,200-11,000 | Browns Bench | 1 | 97.40 |
| **Twin Falls Co. Sites** | 150-750 | Bear Gulch | 2 | 322.62 |
| University of Idaho | | Browns Bench | 1 | 35.57 |
| | | Owyhee | 6 | 173.54 |
| | | Teton Pass | 1 | 318.60 |
| | | Timber Butte | 6 | 236.23 |
| | 4,400-7,500 | Owyhee | 3 | 173.54 |
| | | Timber Butte | 4 | 236.23 |
| **Browns Bench (10TF1)** | 150-750 | Big Southern Butte | 1 | 209.03 |
| University of Idaho | | Browns Bench | 1 | 5.43 |
| | | Double H Mountain | 1 | 304.55 |
| | | Timber Butte | 1 | 242.14 |
| | 1,500-7,500 | Big Southern Butte | 2 | 209.03 |
| | | Malad | 1 | 213.67 |
| | | Owyhee | 2 | 161.77 |
| | 3,000-5,000 | Double H Mountain | 1 | 304.55 |
| | | Owyhee | 1 | 161.77 |
| | 150-5,000 | Malad | 1 | 213.67 |
| | | Timber Butte | 1 | 242.14 |
| | 7,500-10,200 | Malad | 1 | 213.67 |
| **Lydle Gulch (10AA72)** | 150-750 | Bear Gulch | 2 | 344.07 |
| University of Idaho | | Burns | 1 | 245.61 |
| | | Coyote Wells | 1 | 128.21 |
| | | Owyhee | 5 | 80.53 |

Table 11. Sites Reflecting Use of Obsidian and the Euclidean Distances Materials Were Transported During Various Time Periods (continued).

| Site/Geochemist | Period (yr BP) | Source | Points | Distance (km) |
|---|---|---|---|---|
| **Lydle Gulch (10AA72)** continued | 150-750 | Teton Pass | 1 | 410.56 |
| | | Timber Butte | 15 | 59.98 |
| | 700-1,700 | Burns | 1 | 245.61 |
| | | Coyote Wells | 1 | 128.21 |
| | | Owyhee | 2 | 80.53 |
| | | Timber Butte | 18 | 59.98 |
| | | unknown | 4 | |
| | 1,500-7,500 | Camas Prairie | 1 | 121.25 |
| | | Owyhee | 3 | 80.53 |
| | | Timber Butte | 11 | 59.98 |
| | 4,400-7,500 | Kelly Canyon | 1 | 358.93 |
| | | Owyhee | 3 | 80.53 |
| | | Timber Butte | 11 | 59.98 |
| | | unknown | 1 | |
| | 150-5,000 | Owyhee | 3 | 80.53 |
| | | Timber Butte | 3 | 59.98 |
| | 7,500-10,200 | Browns Bench | 1 | 189.16 |
| | | Summit Lake | 1 | 324.51 |
| | | Timber Butte | 4 | 59.98 |
| **Dagger Falls (10VY76)** Geochemical Research | 150-5,000 | American Falls | 1 | 276.78 |
| | | Timber Butte | 4 | 94.43 |
| | 1,500-7,500 | Timber Butte | 4 | 94.43 |
| **Mud Springs (10OE2614)** University of Idaho | 150-750 | Bear Gulch | 5 | 400.87 |
| | | Browns Bench | 1 | 217.51 |
| | | Kelly Canyon | 1 | 416.30 |
| | | Obsidian Cliff | 1 | 507.95 |
| | | Owyhee | 2 | 62.73 |
| **Bachman Cave (10OE565)** University of Idaho | 150-750 | Bear Gulch | 3 | 395.30 |
| | | Big Southern Butte | 1 | 281.71 |
| | | Browns Bench | 1 | 168.05 |
| | | Cannonball Mountain | 1 | 148.93 |
| | | Kelly Canyon | 1 | 398.22 |
| | | Owyhee | 2 | 15.92 |
| | | Teton Pass | 1 | 445.98 |

earlier, and Wilson Butte provide the largest percentage of points and may indicate the general pattern of past procurement behavior. Wilson Butte presents a greater variety of tool stone probably due to its almost central location between foothill sources to the north and south and its accessibility to the Snake River Plain corridor. In earlier times, occupants of both sites were using glass from multiple sources within their respective regions with the tool stone in closest proximity representing the largest percentage. This pattern continues in later periods, but additional glass materials from sources at greater distances were added to the tool kit. This probably reflects increased mobility or greater contact with individuals who had access to the more distant sources. The increased use of tool stone from nonlocal sources is particularly evident from the analyses reported by Reed (1985). The Fremont County collections and the Owyhee County sites, Mud Springs (10OE2614) and Bachman Cave (10OE565), contain materials characterized to sources across Idaho including glass from Nevada and Wyoming. The Twin Falls County collections from south-central Idaho are correlated to sources from western and eastern Idaho.

Contrary to Reed's (1985:67) observation of little difference in transport distance across southern Idaho, the data compiled here reflects a great deal of difference both for various sites where small side-notched points have been recovered as well as for all varieties of projectile points over time. The Euclidean distance, minimum, maximum, mean, and standard deviation for each of the point typologies are presented in Table 12. Reed's observation that a greater number of projectile points made from a particular glass did not necessarily correlate with greater distance from source held true. However, this may be a factor of the sample bias.

The projectile points are not a true random sample of points from their associated sites and the Euclidean distances from the parent source that each projectile point was transported prior to discard do not represent a normal distribution (either collectively or for each individual type). While the data do not conform to analysis of variance assumptions, the Kruskal-Wallis nonparametric test can be used to determine if distance in one temporal period is greater than another temporal period. An asymptotic significance value of .000 suggests that

Table 12. Descriptive Statistics of Euclidean Distance (km) for Each of the Temporal Periods.

| Point Type | Period (yr B.P.) | Points | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|---|
| Sm Side-notch | 150-750 | 281 | 5.43 | 531.91 | 213.98 | 130.55 |
| Sm Corner-notched | 700-1,700 | 58 | 10.58 | 305.46 | 95.58 | 69.18 |
| Wahmuza | 150-5,000 | 41 | 10.58 | 486.73 | 140.73 | 104.94 |
| Lg Corner-notched | 1,500-7,500 | 110 | 10.58 | 320.92 | 98.12 | 61.74 |
| Stemmed Indented | 3,000-5,000 | 22 | 10.58 | 304.55 | 70.63 | 76.69 |
| Lg Side-notched | 4,400-7,500 | 83 | 10.58 | 455.96 | 138.60 | 115.34 |
| Lg Lanceolate | 7,500-10,200 | 28 | 59.98 | 324.51 | 125.04 | 60.92 |
| Fluted | 10,200-11,000 | 8 | 57.27 | 134.97 | 72.00 | 29.06 |

distances do vary for the temporal periods and that the overall pattern merits attention. Since the late Pleistocene, either consumers have been traveling substantial distances or have been engaging in exchange relationships to acquire their tool stone. Distances traveled were even greater in more recent history at 150 to 750 years B.P. prior to Euro-American contact, perhaps facilitated by the acquisition of the horse or by more sophisticated and effective trade mechanisms.

Distance-decay models predict that as distance from the volcanic glass source increases the quantity of quarried glass used and discarded at prehistoric sites should decrease. These models are based on regression analysis. As noted, the compiled data set is not a random selection of archaeological sites and may not be representative of the total population. However, six sources provide a sufficiently large sample ($n = 2222$) such that the patterns they reflect merit some attention. The distance fall-off curves for these six quarries - Bear Gulch, Big Southern Butte, Browns Bench, Malad, Owyhee, and Timber Butte - clearly indicate that the characterized data from southern Idaho conforms to the distance-decay model. Figure 14 compares the pattern of each of the fall-off curves. As only collected data have been incorporated into this graph, the curves do not originate at 100 percent, the expected material density at a quarry site.

Hodder and Orton (1976) used regression analysis to examine simulated

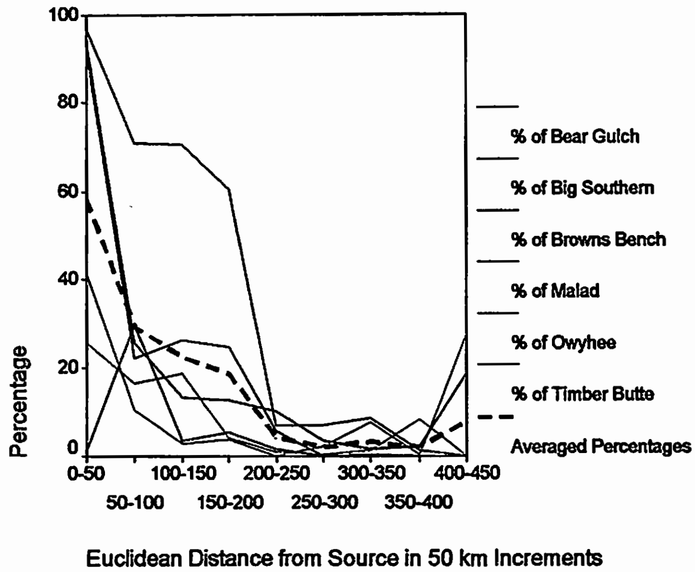



Figure 14. Material fall-off curves for the six sources with the highest frequencies of characterized artifacts.

artifact dispersals created from computer-generated simple and complex random walk processes and to explore the various factors that might inform on transport behavior. Viewed together the lines representing the six individual sources indicate different patterns of distribution, yet all are somewhat different from Hodder and Orton's simulation patterns. However, the regression line representing the averaged data reflects a pattern similar to a simulated walk involving as many as four randomly selected steps (residential moves) of varying lengths (distance between camp locations). This may be informative as it correlates to the expected behavior of mobile hunters and gatherers moving in response to seasonal variability within patchy resources.

Hodder and Orton (1976:101) base their exercise on economic theory stating that "the most common distance-decay functions met with in interaction data can be divided into single-log and double-log cases." Distance-decay models are generally best represented by a curvilinear relationship. In a single-log case, curves follow the general form log $y = a - bx^{\alpha} + e$. The constants a and b represent the y-intercept and slope of the line respectively, just as in the equation for a straight line. In the single-log equation, $\alpha$ is the distance transformation and e is the error term which expresses the inexact relationship between x and y. It is assumed that x (distance) is a non-random variable while y (material density) is more random. The inclusion of the error factor implies a measure of accuracy that is not supported by these data. Thus, it has been dropped from the formula for the purposes of this comparison.

When $\alpha = 2$, the curve follows a "normal" or Gaussian fall-off (Renfrew 1977:75). In the exponential form of a curve, $\alpha = 1$, and in the square root exponential form $\alpha = 0.5$. The distance transformation can vary from these forms which is reflected in the curvature of the line. The value of $\alpha$ correlated with the slope coefficient provides insight into possible behavioral explanations for the observed distance-decay phenomena.

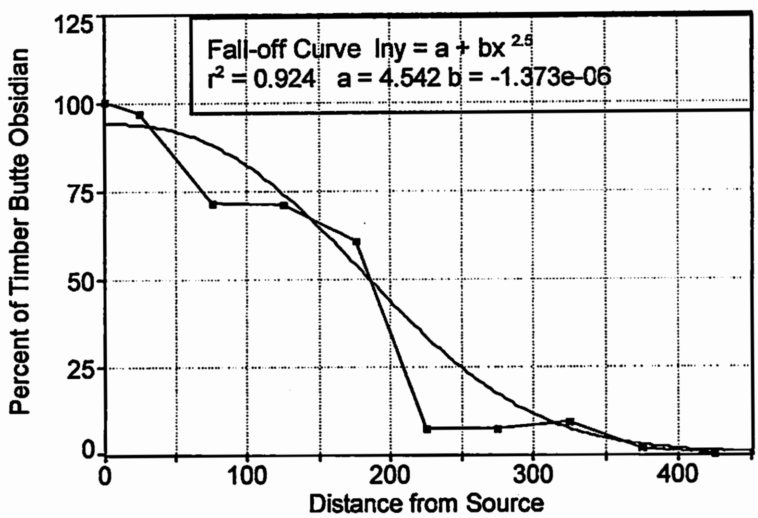
To compare the southern Idaho data to Hodder's fall-off curves, it was assumed that 100 percent of the glass deposited at a source would be characterized to that source. Plotting each of the six sources separately (see figures 15 through 17), the regression or fall-off curves represented by single-natural log functions factor in varying exponents of distance or α which can be compared to Hodder and Orton's (1976:Table 5.3, 142) simulated spatial processes. As indicated by the square of the correlation coefficient, this function's goodness of fit varies for each source. The interval densities, α and b factors for each of the six sources are presented in Table 13. Hodder and Orton interpret gradients or slope indicated by the b values as being a function of the value of the commodity - higher valued items would have a lower b value and the fall-off curve would taper off gradually instead of abruptly. A high α value also indicates commodities are valued more highly, an observation that gains support from the archaeological record. Renfrew (1969) argues that the Early Bronze Age I broad dispersal of small quantities of Near East obsidian suggests that glass tool stone was significant, and therefore of value, because it provided a reason for contact, suggesting its pattern of distribution reflects exchange occurring in 'down-the-line' transactions (see Hodder 1978:Figure 1a,157). Lower α values correlate with patterns that show commodities falling-off quickly close to a source, but at least some materials being carried to greater distances.

Examining the fall-off patterns of the six source materials, Browns Bench and Big Southern Butte have the steepest gradients (i.e. greatest b values), curves exhibiting the greatest concavity, and the lowest α values equal to .5.

Table 13. The Results of Fitting Regression Curves to Fall-off Patterns for the Six Sources Showing Predominant Use.

| Distance/ constants | % Bear Gulch | % Big Southern | % Browns Bench | % Malad | % Owyhee | % Timber Butte |
|---|---|---|---|---|---|---|
| 0 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| 25 | 93.75 | 25.58 | 1.42 | 91.84 | 41.30 | 96.86 |
| 75 | 25.68 | 16.36 | 29.58 | 22.22 | 10.50 | 71.04 |
| 125 | 13.21 | 18.51 | 3.45 | 26.09 | 2.79 | 70.69 |
| 175 | 12.50 | 4.20 | 5.30 | 24.63 | 3.82 | 60.43 |
| 225 | 10.08 | 1.10 | 1.55 | 5.71 | 0 | 7.05 |
| 275 | 3.44 | 0.23 | 0 | 0 | 2.24 | 6.93 |
| 325 | 1.54 | 1.15 | 0.40 | 0 | 7.62 | 8.63 |
| 375 | 2.19 | 8.33 | 0 | 0 | 0.34 | 1.26 |
| 425 | 18.75 | 0 | 0 | 0 | 27.5 | 0 |
| $\alpha$ | 1.50 | 0.50 | 0.50 | 1.00 | 1.00 | 2.50 |
| b | -.0025 | -.1755 | -.1513 | -.0098 | -.0338 | -1.3725 |
| c | .0001 | | | | 7.272 | |

Malad exhibits a less concave fall-off curve with $\alpha = 1$. Malad's data conform to an exponential model, whereas Big Southern Butte and Browns Bench follow the square root exponential model (Taylor 1971:222). Timber Butte has the highest $\alpha$ value as well as the lowest b value which is reflected in its gradually sloping convex curve. The linear regression model does not fit the Bear Gulch and Owyhee data which conform more to a quadratic relationship. This probably reflects the imposed limitations of the data set and likely indicates a bimodal



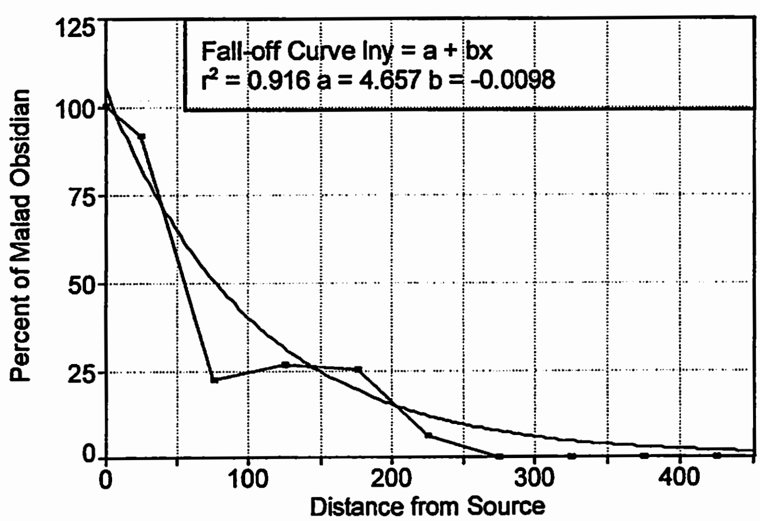
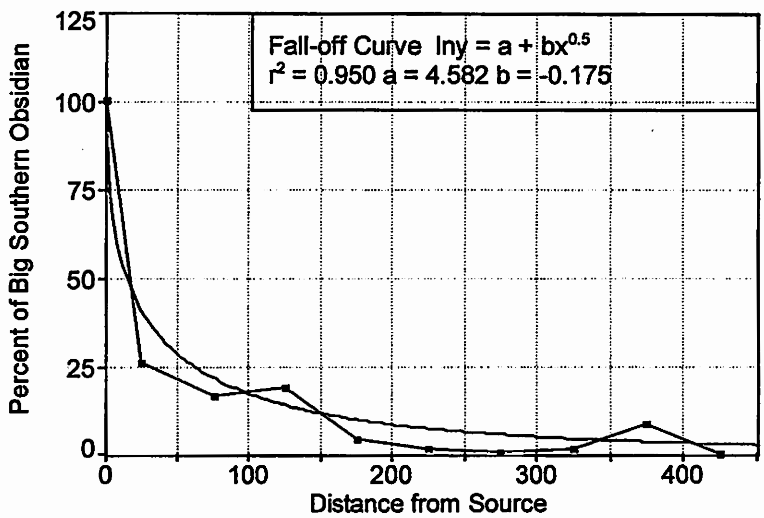




**Figure 15. Material fall-off patterns for Timber Butte and Malad glass tool stone.**



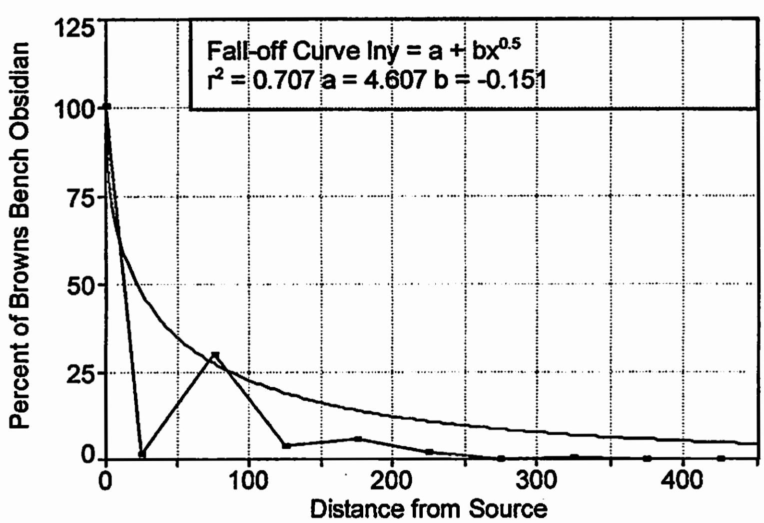
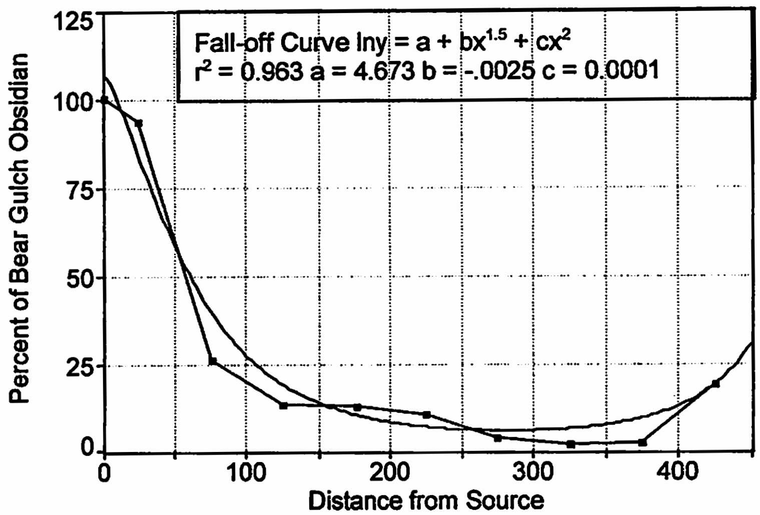




Figure 16. Material fall-off patterns for Big Southern Butte and Browns Bench glass tool stone.



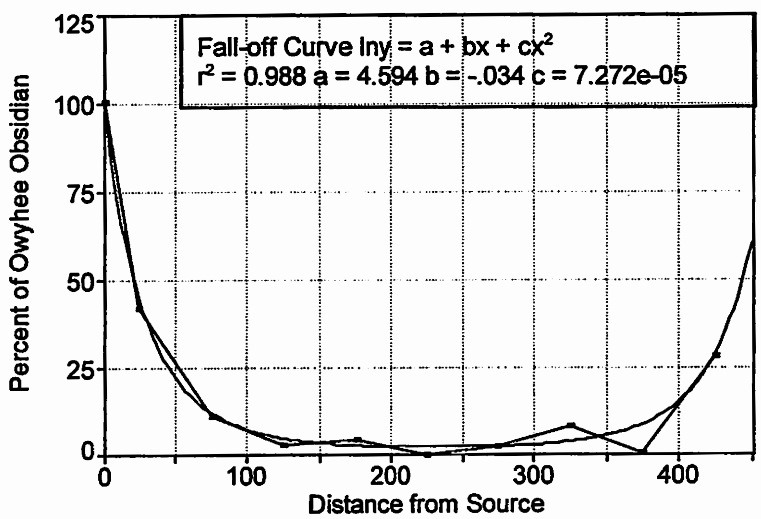




Figure 17. Material fall-off patterns for Bear Gulch and Owyhee glass tool stone.

fall-off curve that would result if additional data were incorporated from beyond the political boundaries of southern Idaho. Even without the additional data, it is apparent that the distribution and discard pattern for Owyhee and Bear Gulch glass varies considerably from the other sources and suggests a different method of procurement, possibly some method of exchange.

Exploring prehistoric trade behaviors, Renfrew (1969:157) proposed a model for early Neolithic sites in the Near East which extends a quarry's supply zone limit to a distance of 300 km and defines the contact zone as those areas beyond the supply zone which still have quarried material present but in increasingly smaller quantities at greater distances. Similar to patterns reflected in the northwest and southeast regions of Idaho, Neolithic supply zones contain over 80 percent obsidian. This high percentage holds true for Timber Butte and Malad but their respective distance-decay patterns indicate a more limited supply zone extent. Indeed, the density of materials from all six sources visibly decreases at closer to 200 km. Hodder and Orton (1976:145 ) note that archaeological data appear to have more concave fall-off curves than the computer generated walks. They (Hodder and Orton 1976:145 ) assert that "the spatial process behind the archaeological data involved extremely close and frequent contact with a centre, perhaps with only one-step moves being most common." Therefore, the distance-decay patterns for Malad, Big Southern Butte, and Browns Bench are what one might expect. The convexity of Timber

Butte's fall-off curve indicates that it was valued more highly, but it is important to keep in mind that most of the geochemical research has been conducted in western Idaho and probably biases the data. The quadratic relationship exhibited by Bear Gulch and Owyhee suggests noticeably different behavior. As noted previously, this relationship may indicate a truncated bimodal redistribution curve (Hodder and Orton 1976:figure 5.38, 149). As the data are circumscribed by Idaho's political boundary, incorporating data from states surrounding Idaho should give a more complete picture.

Trend surface analysis allows the data to be presented as regional maps with isolines representing the percentage of characterized volcanic glass present within each of the one-degree quadrats derived from the roving average described earlier. Surfer® 6.04 Surface Mapping System(copyright © Golden Software, Inc. 1994-1997) was used to interpolate a density grid using the assigned source frequency data at the center point of each quadrat. The kriging with linear variogram interpolation method was employed and a spline smoothing factor was applied. The derived surface "allows generalisations to be made from complex patterns, and makes interpolation and prediction possible" (Hodder and Orton 1976:155). Distribution maps for each of the six sources are presented in Figures 18 through 23 which portray material densities in 10 percent contour intervals. Note that the isolines reflect actual characterized data: only Malad and Timber Butte indicate densities over 85 percent, the maximum densities for the other four sources range from 25 to 45 percent. Also notable is the fact that the area of highest density for each of the sources is not always at the quarry location (the quarry location is identified by the source name on the maps). Hodder and Orton (1976:157) point out "the quadrat size has a great effect on the location of the highest point on the smoothed density surface." For this study, the incongruity of the geochemical research in southern Idaho determines the quadrat or cell size. In an attempt to correct the location of high density areas, trend surfaces were created under the assumption that the quarry location would exhibit a density of 100 percent. This did not correct the locus of high density (in some instances it moved it only slightly) and artificially produced isolines of greater densities that are not presently supported by the data.

The distribution maps clearly portray the patterns indicated by the other spatial analyses. Big Southern Butte glass is widely distributed along the Snake River Plain corridor but only small quantities appear to be carried into the foothills that outline its perimeter. The distribution of Browns Bench material is even more restricted, although higher densities may occur to the south in Utah or Nevada beyond the limits of the present data. Malad also indicates a trend to the south with moderate densities to the east and west. Timber Butte shows the reverse pattern with the concentration of material trending to the north. The numerous streams and tributaries of the Payette River may have facilitated its transport to more distant areas. The distribution patterns of Owyhee and Bear Gulch glass are of particular interest. The density of Owyhee tool stone falls off away from the quarry, but increases around the Camas Prairie region. Another high density area is indicated in the northeastern area along the Henry's Fork. The reverse is true for Bear Gulch: the second area of high density is again at Camas Prairie with a third area along the Snake and Boise rivers. Both distribution maps indicate that Camas Prairie was a redistribution center. The Camas Prairie was a vital resource in prehistoric subsistence strategies for the Snake River and Fort Hall peoples (Murphy and Murphy 1960:320, 322; Steward 1938:167, 203) as well as Boise-Weiser groups (Murphy and Murphy 1960:319) and served as a trade center where Shoshone exchanged buffalo hides for horses (Steward 1938:191). In Meatte's (1990:20) synthesis, he refers to Camas Prairie as "the focus of an important trade fair each summer as family groups came here to harvest resources and exchange goods before proceeding to other resource areas . . . the indigenous Northern Shoshone and Northern Paiute brought dried salmon, otter furs, tanned buckskins, seeds, roots, and various obsidians and ignimbrites." It would not have been necessary to carry tool stone to Camas Prairie as several good quality volcanic glass sources are available locally: Camas Prairie, Cannonball Mountain, Pine Mountain, Picabo Hills, and Wedge Butte. Considering the transport costs involved in carrying tool stone long distances, Owyhee and Bear Gulch glass must have been valuable

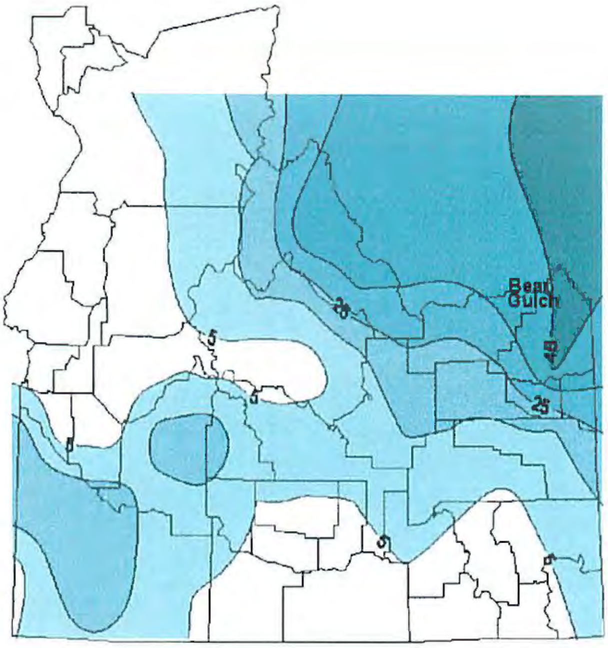



Figure 18. Distribution of Bear Gulch obsidian in 10 percent isoline intervals.

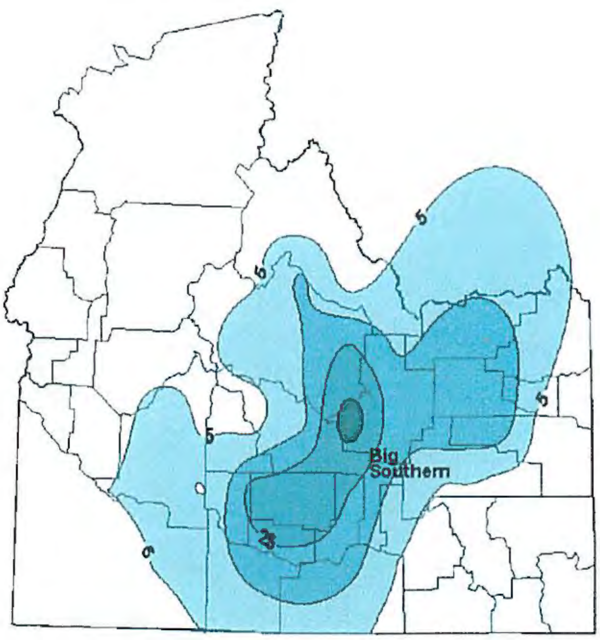



Figure 19. Distribution of Big Southern Butte obsidian in 10 percent isoline intervals.

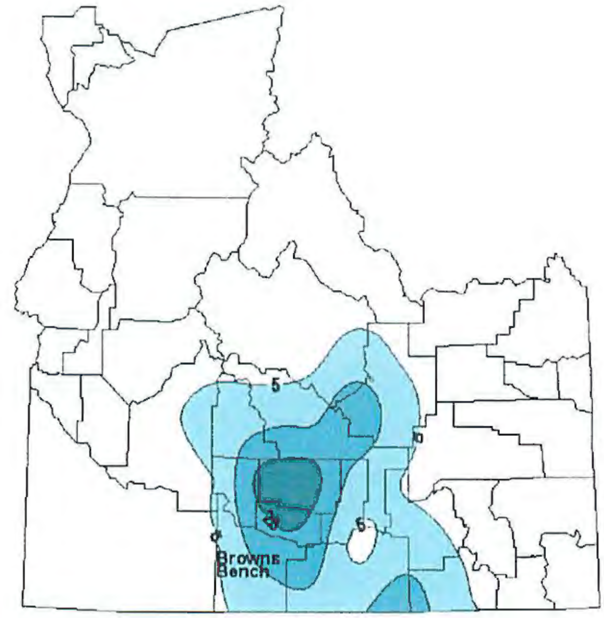



Figure 20. Distribution of Browns obsidian in 10 percent isoline intervals.

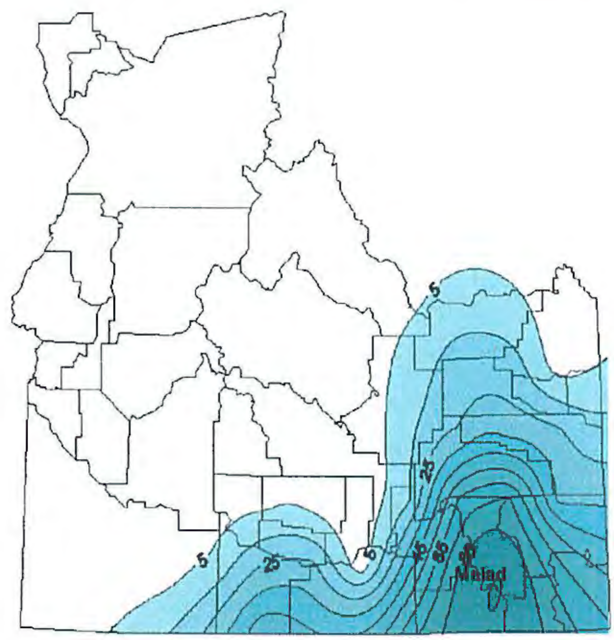



Figure 21. Distribution of Malad obsidian in 10 percent isoline intervals.

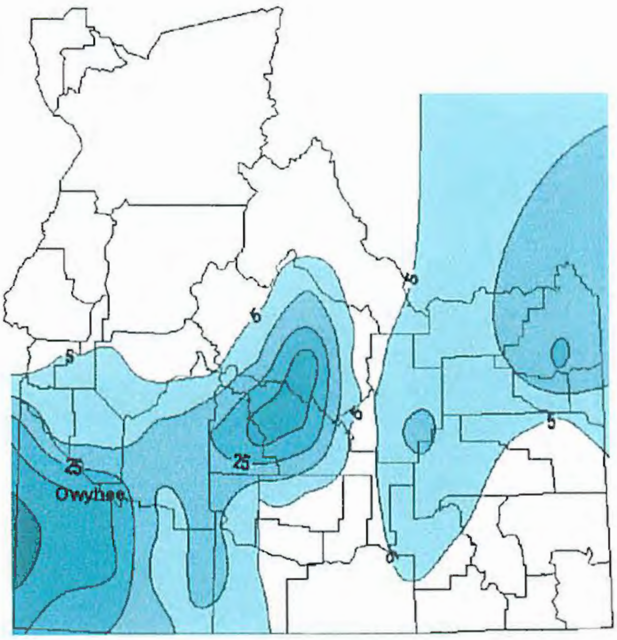



Figure 22. Distribution of Owyhee obsidian in 10 percent isoline intervals.

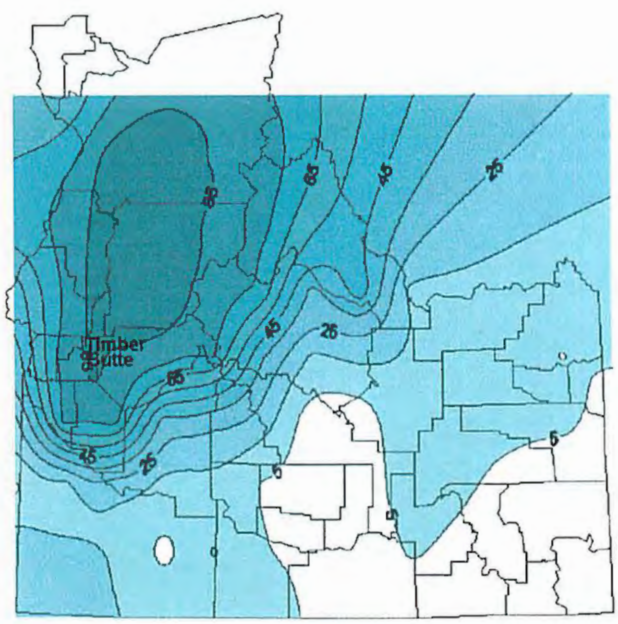



Figure 23. Distribution of Timber Butte obsidian in 10 percent isoline intervals.

trade items which is consistent with the regression analysis presented earlier.

Examining the transport distances of each of the tool stones (Table 8) indicates that there is a great deal of difference in how far materials were being carried. The following paragraphs provide a summarization of the compiled data and distances for each of the sources. Unless indicated otherwise, Euclidean distances rounded to the next whole number are given. As a description of each tool stone's physical characteristics as well as township and range location has been published in previous research (individual source summaries provide references) and alternate names for the sources have been identified (Bailey 1992:27; Holmer 1997:201), they have not been repeated here.

## SOURCE SUMMARIES

### American Falls

Fifteen artifacts from four sites match the geochemistry of the American Falls glass (Bailey 1992:appendix 6; Moore 1995:44; Sappington 1981:14). Sappington (1981a:14) notes that it is available at several locations. He found some exposures to be over 100 km apart. The collection location southwest of the town of American Falls was chosen for this study. American Falls tool stone was found at Baker Cave (10BN153), 31 km to the west, Rock Springs (10OA210), 51 km to the south, Wilson Butte (10JE6), 107 km to the west, and Dagger Falls (10VY76), 277 km to the northwest. A variety of sources (*n* = 15) were used by the occupants of Wilson Butte with American Falls representing less than 3 percent (7/241) of the tool stone analyzed. Only one artifact from Dagger Falls (1/28) and Rock Springs (1/41) matched its geochemical characterization. However, it comprises 43 percent (6/14) of the material analyzed at Baker Cave. The presence of material from American Falls, located on the southern periphery of the Snake River Plain, at the Dagger Falls site in the mountains of Central Idaho documents that volcanic glass was being transported across the plain, if only in minimal amounts (Holmer 1997:191).

Bear Gulch

The source location of the well-defined Bear Gulch geochemistry, initially referred to as Group 90, eluded geologists, archaeologists, and amateur collectors for decades. Positively identified by Hughes and Nelson (1987), Bear Gulch materials continue to be recovered from Plains and Hopewell assemblages, most recently at Blood Run in western Iowa (Logan, et al. 2001). Several exposures have resulted in various names for the source located in Idaho's Centennial Mountains and perhaps Big Table Mountain is the most specific identifier (Willingham 1995). The compiled southern Idaho data continue a pattern of distribution along the Snake and Salmon rivers similar to the one noted by Davis, et al. (1995b:52) that follows tributaries of the Missouri north and east across Montana. Bear Gulch (Bailey 1992:appendix 6; Moore

1995; Sappington 1981:14) volcanic glass occurs frequently in the Idaho archaeological record at considerable distances from the source location. Artifacts (*n* = 138) from 70 sites indicate that Bear Gulch materials were transported from 36 to 423 km with an average transport distance of 201 km. The Snake River Plain would have provided an accessible corridor for the conveyance of tool stone to sites in Ada, Bannock, Elmore, Gooding, Jerome, and Owyhee Counties, while Custer, Lemhi, and Valley sites may have been accessed by crossing over Lemhi Pass and following the Salmon River. The latter route is supported by the work of Murray, et al. (1977b:56), who attribute the extensive use of the Centennial Valley (which lies directly north of Bear Gulch and the Continental Divide) by Plains and Plateau cultures to the east-west corridor the valley provides for travel. Geochemical analysis of artifacts recovered from sites in Centennial Valley has not been conducted, although three quarry sites were identified; one being described as "a buried parent deposit" (Murray, et al. 1977:53).

The distribution of Bear Gulch material is unique for southern Idaho sources in that 50 percent of the sites having Bear Gulch glass are over 300 km from the tool stone source. It is also important to note that at forty-one of the sites (58.6 percent) where Bear Gulch tool stone was identified, only one or two artifacts were analyzed. Thus it may or may not have been the predominant volcanic glass utilized by the site's occupants.

Beatys Butte

Two artifacts from Lydle Gulch (10AA72) were characterized to the Beatys Butte (Sappington 1981:16) source located in southwest Oregon at a distance of 294 km. While only a limited representation has been analyzed from Idaho, Beatys Butte glass has been found at several sites in southwest and central Oregon, including the Fort Rock Lake Basin, Harney-Malheur Basin and Malheur National Forest (Skinner 2000).

Big Southern Butte

Rising almost 762 m above the eastern Snake River Plain, Big Southern Butte (Sappington 1981:13) glass tool stone (*n* = 153) has been identified at 30 sites at distances ranging from 34 to 355 km. Its visual prominence and accessability would suggest that it would be prevalent at sites in Butte, Bingham, and Blaine Counties, yet less than 18 percent of the total artifacts (*n* = 74) analyzed for sites within these counties was characterized to Big Southern Butte. However, it is the dominant source of the twelve material types that have been identified at these sites. The presence of a variety of glass materials in close proximity to a prominent source reflects the function of the Plain as a corridor for the movement of people. This phenomena accounts for the recovery of Big Southern Butte glass at sites in the Owyhee Mountains including Bachman Cave (10OE565), 282 km to the southwest, as well as sites in Adams County, 355 km to the northwest. Big Southern Butte glass is also found in limited quantities in Custer, Lemhi, and Valley counties to the north which is consistent with the routes depicted on Steward's (1938:figure 10, 136) villages and subsistence areas map of southern Idaho. Steward (1938:203) recorded Shoshone and Bannock families traveling from Fort Hall to Camas Prairie in the spring "on the northern side of the Snake River often along the foot of the mountains."

Browns Bench

Sappington (1981c:13) has reported that Browns Bench volcanic glass occurs in several exposures in the foothills of south central Idaho "portions of an area of some 2600 km$^2$ (1000 mi$^2$) may therefore be considered within the source area." Distance to sites where it has been identified depends on the location assigned: for this research, a midpoint between areas where glass has been collected was selected. It is interesting to note that, while there is a range in distance from 5 to 364 km, only a low percentage (2.2 percent) of Browns Bench tool stone occurs within 50 km. While 67.6 percent of the volcanic glass characterized to Browns Bench is within 100 km, 30.2 percent lies beyond 150 km ($\bar{x}$ = 124 km). It has been found at Owyhee County sites to the northwest, as far as Custer County to the north, in Fremont County to the northeast, and in Franklin County to the southeast. While only one artifact from 10CR202 was identified as Browns Bench glass, it is further evidence of tool stone being carried north perpendicular to the Snake River Plain. Artifacts analyzed from four sites in northwest Utah indicate a possible preference for Browns Bench glass: at Lakeside Cave 75 percent (*n* = 3) of the artifacts analyzed were characterized to Browns Bench, 80 percent (n = 4) at Danger Cave, and 100 percent (*n* = 5) at Floating Island and Spring Bog. It also comprised over 22 percent of the obsidian artifacts analyzed from sites in Butte Valley, east-central Nevada (Jones and Beck 1990: 289).

### Burns

Nine of the artifacts from Lydle Gulch (10AA72) were characterized to Burns (Sappington 1981:17) volcanic glass, a source located in central Oregon at a distance of 246 km. The Northwest Research Obsidian Studies Laboratory has recently identified four sources with unique geochemical signatures in the vicinity of the Burns locale. Further research will provide a clearer picture of the distribution of these materials.

### Camas Prairie

Only five artifacts from three sites were identified as similar to the central Idaho Camas Prairie (Sappington 1981:14) geochemistry and three of those were recovered from Wilson Butte (10JE6) 57 km to the southwest. One artifact in Custer County, 157 km to the north, and one in Fremont County, 277 km to the northeast, indicate that the glass was of sufficient quality to warrant curation into areas where other glass tool stone was available. The paucity of Camas Prairie material may be a byproduct of the sample bias or it may be due to incorrect classifications. Bailey (1992:appendix 6) reports that "significant overlap with the Brown's Bench chemical type makes discrimination of the Camas Prairie type difficult."

## Cannonball Mountain

Cannonball Mountain glass is another central Idaho tool stone that appears in areas where access to other volcanic glass exposures would have been possible. Analysis of forty-eight artifacts from fifteen sites indicates that Cannonball Mountain glass was carried distances up to 244 km ($\bar{x}$ = 102 km). It was identified at three Owyhee County sites comprising 41.6 percent (*n* = 10) of the analyzed material at 10OE1114. Its presence at the Owyhee sites, as well as two Twin Falls County sites, indicates the material was being transported across the Snake River. Thus while the Snake River Plain served as a corridor to facilitate movement east and west across Idaho, the Snake River itself was not a formidable barrier.

## Chesterfield

Four artifacts from three sites, 10BK74, 10BM479, and 10BM480, were identified with Chesterfield (Sappington 1981:14) geochemistry. All the sites are relatively close to the eastern Idaho source with distances ranging from 33 to 51 km. The characterization of the artifacts (*n* = 61) recovered from these sites reflects a pattern of local resource utilization.

## Coal Bank Spring

Materials from Coal Bank Spring located in southern Idaho also appear to be discarded relatively close to the source, although the average distance of 37 km may be a product of sample bias. Twenty-four of the twenty-seven artifacts analyzed were found at Rock Creek (10CA33) located 31 km from the source. Artifacts of Coal Bank Spring tool stone were also found at Wilson Butte (10JE6) 84 km to the north, as well as at Browns Bench (10TF1), 77 km to the west. Recent analysis of samples collected at Coal Bank Spring indicates that this is an exposure of the welded tuffs characterized as Browns Bench (Holmer, et al. 2001).

## Coyote Wells

Coyote Wells (Sappington 1981:17) volcanic glass is available from numerous exposures across a broad expanse in eastern Oregon. It shows up at two Idaho sites. In Canyon County, 98 km southeast, 10CN5 lies along the north terrace of the Snake River. Only one flake of six from 10CN5 was characterized to Coyote Wells; the other five flakes were identified as Timber Butte glass. The other site is 10WN562, located 120 km east in Washington County across the Snake River. Of the three flakes analyzed from 10WN562, two were from Oregon tool stone (Coyote Wells and Dooley Mountain) and one was from an unknown source.

<u>Deep Creek</u>

Only two artifacts have been identified with the Deep Creek source located in northeastern Idaho. Although "it was not possible to differentiate confidently between the Deep Creek and Snake River (American Falls) chemical types," Bailey (1992:appendix 6) matched the geochemistry of a flake and biface fragment from Wilson Butte (10JE6) to the Deep Creek geochemical signature. Wilson Butte lies 211 km southwest of Deep Creek. XRF results reported by Holmer, et al. (2001) confirm that Deep Creek and American Falls (Walcott) share similar geochemical signatures suggesting the welded tuff tool stone is from the same volcanic event.

<u>Dooley Mountain</u>

Dooley Mountain (Sappington [1981:6] refers to it as Ebell Creek) glass has been identified at 10 sites in west-central and central Idaho at distances from 62 to 170 km ($\bar{x}$ = 111 km). It is often found with Timber Butte material which dominates the glass tool stone in this area. The Dooley Mountain source is located in Oregon west of the Snake River. Its presence in Idaho indicates that, prehistorically, the Snake River did not present a territorial or geographical barrier.

## Double H Mountains

Ten artifacts from seven sites matched the geochemistry of the Double H Mountains (Sappington 1981:16) glass identified as a major aboriginal quarry in Humboldt County, Nevada. At most of the seven sites where it was found, only one of the analyzed artifacts matched the geochemistry of Double H material. However three artifacts, 12.5 percent of the sample analyzed from the Browns Bench site (10TF1), were identified as Double H tool stone. The Browns Bench site was also the closest (305 km) with distances to the other sites ranging to 507 km. This suggests that Double H glass was of sufficient quality to merit curation and transport into areas where other glass tool stone would have been locally available.

## Goodrich

The geochemistry of the Goodrich source was recently identified by Hughes (Hughes 1997:2) as a glassy basalt. One artifact from 10AM434 at a distance of 18 km was characterized to the source.

## Kelly Canyon

Kelly Canyon (Moore 1995:53) tool stone was identified at 14 site locations. Usually only one artifact from each site matched Kelly Canyon geochemistry, but it does appear at sites where a number of artifacts were analyzed: Lydle Gulch (10AA72), Wilson Butte (10JE6), Jacknife Cave (10BT46), Bison Rockshelter (10CL10), Rock Creek (10CA33), and Wild Horse Creek (10EL77). Transport distances from this eastern Idaho source range from 70 to 416 km with an average distance of 217 km. Considered to be of comparable quality to glass material found in association with it, the source's broad distribution was likely facilitated by the Snake River Plain corridor.

## Kepler

Identified at two sites, one in Adams County and one in Valley County, Kepler (Sappington 1981:5) glass was transported from 398 to 479 km utilizing the Plain network. The source is located in western Wyoming within Yellowstone National Park.

## Malad

The compiled data set reflects Malad's (Sappington 1981:14) tool stone distribution pattern as predominantly one of local resource utilization: 61.6 percent (270/438) of the artifacts characterized to Malad were found at four sites within 50 km - Weston Canyon (10FR4: $n = 149$), Malad Hill (10BK74: $n = 50$), Garden Creek Gap (10BK39: $n = 41$), and Rock Springs (10OA210: $n = 30$). However, Malad materials do show up at greater distances being transported to Jimmy Olsen (10CL40), 200 km to the north, and Browns Bench (10TF1), 214 km to the west. It was also the preferred material at Rock Creek (10CA33: 158 km), representing 71 percent (111/157) of the glass tool stone analyzed. From a review of the research conducted outside of Idaho, it is apparent that the distribution of Malad tool stone is truncated by the boundary of the study area as the Malad geochemical signature has been identified in artifacts recovered from the Provo and Grantsville, Utah areas (Nelson and Holmes 1979:72, Table V.), it dominated the obsidian recovered from two sites in Wyoming, as well as the Horn Ranch site in Colorado (Smith 1999:276-279), was evident at sites in Oklahoma, Texas, and New Mexico (Baugh and Nelson 1987:322-323), and was most recently identified as evidence of the Late Prehistoric exchange at the Warne site in northern Kansas (Logan, et al. 2001:62).

<u>Obsidian Cliff</u>

Obsidian Cliff (Sappington 1981:15) tool stone is found in numerous locations outside the study area. Its association with trade and exchange networks would suggest that it might be prevalent at site locations in Idaho. While it was found at twenty of the sites within the study area, there is usually only one artifact from a site that matches the Obsidian Cliff "fingerprint." However, at many of these sites, only one artifact was analyzed so the observed distribution pattern is distorted by the limited sample analyzed as well as the extent of the study area. Transport distances range from 93 to 532 km ($\bar{x}$ = 303 km).

Ola

The Ola source is most likely another exposure of Timber Butte glass, however the trace elements initially reported (Moore and Ames 1979:42, Plew, et al. 1984:283) indicate that it is chemically unique, so it has been treated separately in this study. It was identified at two locations in Boise County, both approximately 46 km from the source.

Owyhee

Owyhee (Sappington 1981:14) tool stone distribution reflects a pattern of local use as well as long distance transport. It's been identified at locations 8 to 434 km away: the average distance is 193 km. Its pattern of distribution, recognizing the inherent limitations of the data, is quite interesting: 17.6 percent of the 51 sites where Owyhee glass was recovered lie within 50 km; 15.7 percent of the sites lie between 50 and 100 km; and 29.4 percent of the sites lie at distances greater than 100 km, but less than or equal to 200 km. While 9.8

percent of the sites lie between 200 and 300 km, a pattern predicted by the distance-decay models, 27.4 percent lie at distances greater than 300 km.

## Packsaddle

The geochemical characterization of the Packsaddle source was identified from materials collected by Willingham at Argument Ridge, Point Lookout, and Lost Spring in eastern Idaho (Glascock and Ambroz 1996). Artifacts from four sites, located at an average distance of 89 km, indicate a pattern of local resource use.

## Paradise Valley

Four artifacts from four sites were identified to the Paradise Valley source located in north central Nevada (Moore 1995:56, Sappington 1981:16). Transport distances range from 197 to 456 km. Its appearance at sites with a variety of glass tool stone, Browns Bench (10TF1), Lydle Gulch (10AA72), Wasden (10BV30), and Wild Horse Creek (10EL77), indicates that its distribution in Idaho was likely facilitated by tributaries of the Snake River as well as the Plain corridor.

## Picabo Hills

Glass from Picabo Hills (Bailey 1992:appendix 6) was identified at Wilson

Butte (10JE6) at a distance of 71 km. It represents less than 7 percent ($n$ = 16) of the artifacts analyzed, but is consistent with the general pattern of local resource use evident at Wilson Butte. Almost 52 percent of the characterized artifacts are from sources less than 100 km away. Extending the parameters of "local" to 120 km would incorporate 88 percent of the artifacts.

<u>Pine Mountain</u>

One glass artifact characterized to Pine Mountain was also recovered from Wilson Butte (10JE6) at a transport distance of 86 km. While Bailey (1992:appendix 6) indicates that a good chemical profile was obtained for the Pine Mountain source, he (1992:Table 5, 31) notes that it may often be misclassified.

<u>Reynolds</u>

Only two artifacts from two sites are characterized to the Reynolds geochemistry. One site, Big Julie's Rockshelter (10OE722), is located less than 36 km away which supports Sappington's (1981a:4) assertion that "beyond the immediate area of its availability, the Reynolds source does not appear to be very significant archaeologically." However, its presence at 10CL100 (332 km from Reynolds) would suggest that, at least on occasion, its limited value warranted its transport to greater distances.

Shumway

Samples from this Malheur County, Oregon source were analyzed by Sappington (1981a:6) and Hughes (1998c:3). One artifact recovered from 10CR1231 (255 km) corresponded to its geochemical fingerprint.

Sugarloaf

Thirty-five glass artifacts have been characterized to Sugarloaf, another Malheur County, Oregon source, which is also referred to as Gregory Creek (Sappington 1981:17). The average transport distance of 89 km suggests a pattern of relatively local resource distribution, but as the source lies outside of the study area proper, this is only speculation. Its geochemistry corresponds to 46.4 percent of the glass recovered at the Hetrick site (10WN469), which is 93 km south of Sugarloaf. As noted for other Oregon tool stones, its transport would have entailed crossing the Snake River which is characteristic of the interactions between Northern Paiute, Bannock, Shoshone, and Nez Perce (Meatte 1990).

Summit Lake

One artifact recovered from Lydle Gulch (10AA72) was characterized to the Summit Lake source (Sappington 1981:6) located in Humboldt County, Nevada. Lydle Gulch lies along the Boise River. The conveyance of Summit

Lake glass 325 km across the Snake River lends support to Sappington's (1981b:6) assertion that it was possibly an important source.

Teton Pass

The distribution of Teton Pass glass also suggests it was a significant tool stone. Located in western Wyoming, its geochemistry was identified for eight artifacts from seven Idaho sites at distances ranging from 80 to 460 km. Its presence at Lydle Gulch (10AA72) and Bachman Cave (10OE565), where a variety of glass has been recovered, insinuates that it was part of the network utilizing the Snake River Plain as a travel corridor.

Timber Butte

Timber Butte glass dominates the compiled geochemical data for southern Idaho. While its significance as a source of glass tool stone is undeniable, its magnitude is also a product of where the majority of geochemical research has been conducted (Sappington 1981:7). The 1205 characterized artifacts have been recovered from 163 archaeological contexts that range in distance from 6 to 382 km ($\bar{x}$ = 85 km). The distribution of Timber Butte tool stone as reflected in the isoline map is misleading as it indicates that glass materials from Timber Butte were carried into southwest Montana. Frison, et al's (1995) data from southwest Montana support the use of Bear Gulch and Malad materials from Idaho, but the presence of Timber Butte was not noted.

## Topaz Mountain

Topaz Mountain is located in southern Utah (Moore 1995:61). One artifact from Lakeside Cave (42BO385), a northwestern Utah site, corresponded to its geochemical signature. XRF analysis results from Lakeside Cave were included in this data, as the other three artifacts recovered from the site corresponded to Browns Bench glass. The transport distance from Topaz to Lakeside Cave is 167 km; the distance to Browns Bench is 190 km.

## Wedge Butte

Two artifacts recovered from Wilson Butte (10JE6) matched the geochemistry of Wedge Butte (Bailey 1992:appendix 6). The presence of Wedge Butte tool stone at Wilson Butte, which lies 52 km to the south, is consistent with the site's pattern of local resource use.

## Whitehorse

Sappington (1981a:7) notes that exposures of geochemically similar glass are evident across the Whitehorse Ranch in southeastern Oregon. Five artifacts from Lydle Gulch (10AA72) were identified to the Whitehorse source. This provides evidence of material transport to 224 km.

## CHAPTER FIVE

## CONCLUSIONS

Interpreting past activities from the material deposits of prehistoric consumers, archaeologists have long recognized the high degree of mobility necessary for effective ancient lifeways in marginal and less productive environments. Goodyear (1989:4) posits that "Perhaps the only way to archaeologically monitor mobility patterns among Paleoindian groups is to examine the geographic distributions of the distinctive raw materials they utilized." To successfully harvest the often unpredictable and shifting resources of southern Idaho's sagebrush-steppe required an in-depth knowledge of its seasonality and the logistics of not only flora and fauna, but also tool stone essential for food procurement and processing. The association of stone artifacts with their parent raw material provided archaeologists with an approximation of how far tool stone was being transported and an estimate of procurement territory. The quantitative data gave life to inference and provided a means to rate mobility, to formulate fall-off models that imply trade networks (Renfrew 1969), and to monitor social change through trade indices (Sidrys 1977). Hughes (1998:110) cautions that "what we really get from sourcing is a measure of the physical displacement of materials, not *direct* evidence for trade, exchange, direct procurement, or mobility (emphasis added)." However, this study has shown that in providing the basis for distribution patterns, sourcing has the potential to illuminate anomalies that lead to behavioral explanations.

The calculation of Euclidean distance from parent source to the locus of material deposition is the framework for this regional analysis, however, the equation for path distance presented here provides a more reasonable measure of the far greater distances materials were likely transported. When terrain gradient is factored into the displacement equation, the additional 20 ± 14 percent "general rule of thumb" approximates minimum distance. The utility of the GIS environment lies in its capacity to incorporate other parameters that would necessarily influence travel decisions. Additional data layers might include barriers posed by land features (Limp 1990:240) or employ viewshed analysis that identifies areas of greater visibility (Madry and Rakos 1996). Madry and Rakos (1996:123) have shown that established travel routes were actually the result of a number of considerations, some of which may be cultural in nature. When these are identified and factored into spatial analysis, they expand the potential of understanding past behavior.

A similar project could focus on a subset of this study and questions could be derived from local patterns. The estimation of path distance is based on the assumption that ancient flintknappers were acquiring their tool stone directly from the parent source. This doesn't take into consideration the fact that tool stone cobbles could be collected from stream gravels and talus slopes or that some flows cover a broad geographic extent. In future research, when the extent of volcanic glass flows are better defined and secondary and primary source locations are better described, sources could be treated as polygons, or source areas, rather than points of origin. Also, the resolution of one-degree DEMs precludes the identification of minor land features such as intermittent streams or seasonal marshes that certainly influenced subsistence strategies, particularly during periods of higher annual rainfall. Large scale DEMs (1:24,000) could be used to isolate those potentially rich resource areas. The proximity of subsistence resources to tool stone source areas has the potential to define site catchments, to infer "local" procurement strategies, and to broaden our understanding of embedded strategies.

Importantly, the predicted path distance highlights the fact that past consumers either carried tool stone (most likely in various stages of reduction) far greater distances than would be efficient based on the costs of transporting stone and the presence of locally available stone, or they were participating in networks of exchange and trade. This is particularly evident in the distribution of Owyhee and Bear Gulch obsidian, for while the general pattern replicates Holmer's (1997) results, the patterns associated with these two sources suggest a bimodal curve and redistribution. As it applies to hunter-gatherer economies, no concept of organized, regulated trade is implied. Using Renfrew's (1977:72) definition "Exchange is here interpreted in the widest sense; indeed in the case of some distributions it is not established that the goods changed hands at all. Trade in this case implies procurement from a distance, by whatever mechanism." As a valued, utilitarian commodity (Pires-Ferreira and Flannery 1967:287), obsidian may have been formally traded between economic partners as in the case of Shoshone noted for their fine projectile points (Hoebel 1938:412), but was more likely casually exchanged between family members, friends, and others wishing to symbolically maintain relationships during periods of separation.

Whether lithic tool stone is acquired by direct procurement through embedded strategies (Binford 1979) or by a simple or sophisticated process of exchange, the matter of distance is a factor in its procurement costs and subsequent value. Contrary to Reed's (1985) conclusions, the data reflected considerable differences in transport distance. Regardless of whether the Euclidean or predicted path is considered, glass materials were transported at varying distance depending upon the parent source. A number of factors could account for this: 1) quality of the source material; 2) proximity to other resources; 3) ease of access; 4) quarrying difficulty; and 5) personal preference. The fall-off curves representative of the displacement of tool stone from the six major sources provide a means for evaluating these criteria. They suggest that Timber Butte glass was highly valued whether for its structural qualitites or, if it was a Nez Perce resource as suggested by Reed (1985), its significance in mediating relations between the Nez Perce and Shoshone. They may also provide a measure for comparing tool stone quality as Malad distance-decay exhibits a less-concave curve than Big Southern Butte or Browns Bench. The distance-decay functions presented by the Bear Gulch and Owyhee data reinforce the isoline maps derived from the trend surface analysis, which indicate both tool stones were being distributed further than the other four sources and support ethnohistoric accounts of trading at Camas Prairie.

The Snake River Plain certainly provided a conduit for the transport of tool stone and Camas Prairie, as the focus of root gathering activities, likely served as a redistribution center if only for casual exchange. The concentrations of Owyhee and Bear Gulch glass at Camas Prairie and further distribution at opposite ends of the Plain from the respective source locations are particularly noteworthy. Expanding the project to include data from the surrounding states of Montana, Wyoming, Utah, Nevada, Oregon, and Washington, as well as northern Idaho, would provide a more complete picture of the distribution of not only Bear Gulch and Owyhee materials, but other quality tool stones represented in the current data which have also been transported greater distances. It is interesting that although Timber Butte is widely distributed locally and is found on the Snake River Plain, it does not appear to have been used by peoples frequenting the mountains in southeast Idaho where Malad tool stone was preferred. As the Snake River didn't present a formidable barrier, it suggests that a degree of territoriality and perhaps ethnic boundaries may have been in place. If valid, circumscribed areas such as the one indicated by the distribution of Big Southern Butte tool stone, which may be related to the quality of tool stone and the presence of other locally available materials, would become more pronounced if the project area were extended beyond Idaho's political boundaries.

Hughes and Bennyhoff (1986:240) indicate obsidian trade was in place in southern Idaho, with exchange accounting for Timber Butte and Big Southern Butte obsidian found at Rock Creek. Arrows indicate the conveyance of Malad obsidian recovered at Garden Creek Gap, Weston Canyon Rockshelter, and Rock Creek in southern Idaho, and Hogup Cave, Danger Cave, and Grantsville in northwestern Utah. They (Hughes and Bennyhoff 1986:254) suggest that evidence of obsidian trade may date to the Early Archaic or roughly 7,000 years ago. However, Hughes and Bennyhoff (1986:238) caution "It is one thing to determine the geographic source area for a commodity, but it is quite another matter to infer the social mechanism responsible for the occurrence of that material at an archaeological site." While ethnographic accounts support their determinations of obsidian trade and, correlated with the archaeological record, provide unequivocal evidence of trade in Late Prehistoric and Protohistoric times (cf. Baugh and Nelson's [1987] interpretation of trade dynamics in the Southern Plains), trade can only be inferred on the past as one of many possible mechanisms that might result in the displacement of glass tool stone at greater distances from the point of origin.

Carlson (1983:Figure 1:4) illustrates three spheres of obsidian trade were in place along the Northwest Coast at 4,000 to 6,000 years ago. He (Carlson 1983:22) notes the presence of Oregon source materials 2,000 km to the north on the coast of British Columbia and suggests "widespread distribution [of obsidian] . . . indicates trade as the most probable distributive mechanism." While his map does not extend the southern-most sphere to include southern Idaho, he suggests additional analysis of glass artifacts would extend obsidian trade much further.

Meltzer (1989:13) suggests another avenue of research: "stone may have been transferred from one Paleoindian group to another, but that such may be the result of families of individuals moving among different groups." The spatial patterns presented highlight the potential of expanding the data beyond southern Idaho to address issues surrounding mobility, such as the movement of people, settlement patterns, or territoriality. While challenging, this project emphasizes many of the advantages of a regional approach (Flannery 1976). In expanding Holmer's (1997) data to include all of southern Idaho, transport patterns evident from his research began to crystalize and suggest new interpretations. Trend surface analysis was facilitated by the use of GIS as it provided visual representation which led to speculation not readily intuited from the numeric data.

Broadening the study area to include data from surrounding states will undoubtedly add depth and clarity to our understanding of volcanic glass distribution. While there appear to be definite patterns in the data presented here, these should be viewed with caution. The number of sites in the data set and their distribution would suggest that the sample size is approaching a representative sample of the total population. However, the data are biased by the number of artifacts analyzed from some sites as compared to others. Even where a greater number of artifacts are analyzed, they were not necessarily selected at random, and may or may not be representative of the tool stone material found at that particular site. Where fewer artifacts were selected for analysis, the problem of representation becomes even more pronounced. A research design incorporating a random selection of sites within a given quadrat, such as the 30-minute grid, and the geochemical analysis of a random selection of artifacts from those sites would result in more rigorous data. This design would also provide a measure of confidence as the results of earlier analyses could be evaluated.

The primary contribution of this study has been in the creation of a proxy by which one can look at mobility and social interaction. The mechanism by which obsidian reached its final point of deposition is only important to the degree in which it can inform us on past human behaviors. Renfrew (1984:81) applauds characterization studies in that the focus of interpretation shifted "to the social and economic processes which led to and sustained the exchange transactions responsible for the movement of goods in question, and the consequences of those processes." These consequences and behavioral interpretations have particular relevance to Shoshone, Bannock, and Paiute descendants, whose distant past is recorded in oral tradition, a tradition that has been given only nominal attention by western science. Recently archaeologists have recognized the diversity apparent in indigenous subsistence strategies and the complexity of hunter-gather economic and social organization. As distribution studies lead to greater understanding of the interactions and alliances between groups of individuals (Gamble 1982), their implications become more profound.

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# APPENDIX A

## Sites with Number of Artifacts Characterized to Individual Obsidian Sources

| County | Site | Artifact N | Obsidian Source |
|---|---|---|---|
| Ada | 10-AA-15 | 1 | Timber Butte |
| | 10-AA-19 | 1 | Timber Butte |
| | 10-AA-23 | 1 | Obsidian Cliff |
| | 10-AA-26 | 1 | Timber Butte |
| | 10-AA-72 Lydle Gulch | 2 | Bear Gulch |
| | | 2 | Beatys Butte |
| | | 1 | Big Southern |
| | | 4 | Browns Bench |
| | | 9 | Burns |
| | | 4 | Camas Prairie |
| | | 9 | Coyote Wells |
| | | 2 | Double H Mountain |
| | | 1 | Kelly Canyon |
| | | 49 | Owyhee |
| | | 1 | Paradise Valley |
| | | 1 | Summit Lake |
| | | 1 | Teton Pass |
| | | 389 | Timber Butte |
| | | 5 | Whitehorse |
| | | 26 | unknown |
| Subtotal | 5 | 510 | |
| Adams | 10-AM-23 | 1 | Timber Butte |
| | 10-AM-24 Switchback Site | 1 | Big Southern |
| | 10-AM-25 Squaw Creek Rockshelter | 1 | Big Southern |
| | 10-AM-69 | 4 | Timber Butte |
| | 10-AM-93 | 2 | Timber Butte |
| | 10-AM-107 | 1 | Dooley Mountain |
| | | 5 | Timber Butte |
| | 10-AM-108 | 17 | Timber Butte |
| | | 1 | Kepler |
| | | 6 | Dooley Mountain |
| | 10-AM-130 | 1 | Timber Butte |
| | 10-AM-131 | 1 | Timber Butte |
| | 10-AM-141 | 1 | Dooley Mountain |
| | | 3 | Timber Butte |
| | 10-AM-211 | 1 | Sugarloaf |
| | | 3 | Timber Butte |
| | 10-AM-261 | 4 | Timber Butte |
| | 10-AM-266 | 1 | Timber Butte |
| | 10-AM-375 | 1 | Dooley Mountain |
| | 10-AM-433 | 2 | Timber Butte |
| | 10-AM-434 | 1 | Goodrich |
| | | 3 | Timber Butte |
| | 10-AM-473 | 1 | Timber Butte |
| | 10-AM-475 | 1 | Timber Butte |
| | 10-AM-477 | 3 | Timber Butte |
| | Nonsite 9998 | 1 | Timber Butte |
| | Nonsite 9999 | 5 | Timber Butte |
| Subtotal | 21 | 72 | |

| County | Site | Artifact N | Obsidian Source |
|---|---|---|---|
| Bannock | 10-BK-3 | 1 | Cannonball Mountain |
| | 10-BK-26 Wahmuza | 1 | Bear Gulch |
| | | 1 | Big Southern |
| | | 7 | Malad |
| | | 5 | Obsidian Cliff |
| | | 1 | Owyhee |
| | | 5 | Timber Butte |
| | 10-BK-39 Garden Creek Gap | 41 | Malad |
| | 10-BK-74 Malad Hill | 1 | Big Southern |
| | | 3 | Browns Bench |
| | | 2 | Chesterfield |
| | | 50 | Malad |
| Subtotal | 4 | 118 | |
| Bingham | 10-BM-45 | 1 | Bear Gulch |
| | 10-BM-49 | 1 | Bear Gulch |
| | | 1 | Timber Butte |
| | 10-BM-50 | 1 | Bear Gulch |
| | 10-BM-50 (cont.) | 2 | Kelly Canyon |
| | | 1 | Obsidian Cliff |
| | 10-BM-479 | 1 | Chesterfield |
| | | 2 | Malad |
| | 10-BM-480 | 1 | Chesterfield |
| | | 1 | Malad |
| | 10-BM-486 | 1 | Packsaddle |
| Subtotal | 6 | 13 | 13 |
| Blaine | 10-BN-23 Elkhorn Spring | 1 | Owyhee |
| | 10-BN-54 Scurvy Dog | 1 | Bear Gulch |
| | 10-BN-153 Baker Cave | 6 | American Falls |
| | | 2 | Big Southern |
| | | 6 | unknown |
| | Nonsite 9999 | 1 | Owyhee |
| Subtotal | 4 | 17 | 17 |
| Boise | 10-BO-1 Silver Bridge | 120 | Timber Butte |
| | 10-BO-6 | 1 | Kelly Canyon |
| | | 3 | Timber Butte |
| | 10-BO-30 | 7 | Timber Butte |
| | 10-BO-41 | 2 | Timber Butte |
| | 10-BO-46 | 1 | Timber Butte |
| | 10-BO-47 | 9 | Timber Butte |
| | 10-BO-66 | 1 | Timber Butte |
| | 10-BO-112 | 6 | Timber Butte |
| | 10-BO-114 | 1 | Timber Butte |
| | 10-BO-115 | 1 | Timber Butte |
| | 10-BO-118 | 2 | Ola |
| | 10-BO-119 | 5 | Ola |
| | | 1 | Timber Butte |
| | 10-BO-122 | 1 | Obsidian Cliff |
| | 10-BO-217 | 4 | Timber Butte |
| | 10-BO-418 | 45 | Timber Butte |

| County | Site | | Artifact N | Obsidian Source |
|---|---|---|---|---|
| Boise (cont.) | 10-BO-419 | | 71 | Timber Butte |
| Subtotal | | 16 | 281 | |
| Butte | 10-BT-11 | | 1 | Big Southern |
| | 10-BT-29 | | 1 | Browns Bench |
| | | | 1 | Owyhee |
| | 10-BT-31 | | 1 | Owyhee |
| | | | 2 | Timber Butte |
| | 10-BT-39 | | 1 | Owyhee |
| | | | 1 | Timber Butte |
| | 10-BT-40 | | 1 | Bear Gulch |
| | 10-BT-46 Jacknife Cave | | 1 | Double H Mountain |
| | | | 1 | Kelly Canyon |
| | 10-BT-46 Jacknife Cave (cont.) | | 1 | Obsidian Cliff |
| | 10-BT-60 | | 1 | Timber Butte |
| | 10-BT-74 | | 1 | Big Southern |
| | | | 2 | Browns Bench |
| | 10-BT-82 | | 1 | Big Southern |
| | 10-BT-102 | | 1 | Big Southern |
| | | | 1 | Owyhee |
| | | | 1 | Timber Butte |
| | 10-BT-117 | | 1 | Double H Mountain |
| | 10-BT-119 | | 1 | Owyhee |
| | 10-BT-304 | | 1 | Kelly Canyon |
| | 10-BT-323 | | 1 | Obsidian Cliff |
| | 10-BT-363 | | 1 | Obsidian Cliff |
| | 10-BT-1582 Aviator Cave | | 3 | Bear Gulch |
| | | | 5 | Big Southern |
| | | | 7 | Malad |
| | | | 1 | unknown |
| | Nonsite 9999 | | 2 | Big Southern |
| | | | 1 | Browns Bench |
| Subtotal | | 17 | 44 | |
| Bonneville | 10-BV-30 Wasden | | 3 | Bear Gulch |
| | | | 19 | Big Southern |
| | 10-BV-30 Wasden (cont.) | | 1 | Browns Bench |
| | | | 1 | Cannonball Mountain |
| | | | 8 | Malad |
| | | | 4 | Owyhee |
| | | | 1 | Paradise Valley |
| | | | 5 | Timber Butte |
| | 10-BV-31 Coyote Cave | | 1 | Bear Gulch |
| | | | 1 | Cannonball Mountain |
| | | | 1 | Timber Butte |
| | Nonsite 9999 | | 4 | Bear Gulch |
| | | | 14 | Malad |
| | | | 2 | unknown |
| Subtotal | | 3 | 65 | |
| Cassia | 10-CA-33 Rock Creek | | 10 | Big Southern |
| | | | 1 | Browns Bench |

| County | Site | Artifact N | Obsidian Source |
|---|---|---|---|
| Cassia (cont.) | 10-CA-33 Rock Creek (cont.) | 24 | Coal Bank Spring |
| | | 1 | Kelly Canyon |
| | | 111 | Malad |
| | | 8 | Timber Butte |
| | | 2 | unknown |
| | 10-CA-35 | 1 | Kelly Canyon |
| | 10-CA-397 | 1 | Bear Gulch |
| | | 14 | Browns Bench |
| | | 1 | Malad |
| Subtotal | 3 | 174 | |
| Clark | 10-CL-3 Veratic Rockshelter | 1 | Obsidian Cliff |
| | 10-CL-10 Bison Rockshelter | 1 | Double H Mountain |
| | | 2 | Kelly Canyon |
| | | 1 | Owyhee |
| | 10-CL-40 Jimmy Olsen | 11 | Bear Gulch |
| | | 3 | Big Southern |
| | | 1 | Malad |
| | | 5 | unknown |
| | 10-CL-47 | 1 | Kelly Canyon |
| | | 1 | Owyhee |
| | | 2 | Timber Butte |
| | 10-CL-100 | 1 | Bear Gulch |
| | | 2 | Double H Mountain |
| | | 1 | Reynolds |
| | 10-CL-114 | 1 | Cannonball Mountain |
| | 10-CL-325 | 1 | Timber Butte |
| | 10-CL-346 | 1 | Timber Butte |
| | 10-CL-370 | 1 | Obsidian Cliff |
| Subtotal | 9 | 37 | |
| Camas | 10-CM-8 | 1 | Browns Bench |
| | 10-CM-12 | 1 | Cannonball Mountain |
| | 10-CM-33 | 1 | Cannonball Mountain |
| | 10-CM-70 | 1 | Timber Butte |
| | Nonsite 9999 | 2 | Owyhee |
| Subtotal | 5 | 6 | |
| Canyon | 10-CN-5 | 5 | Owyhee |
| | | 1 | Coyote Wells |
| Subtotal | 1 | 6 | 6 |
| Custer | 10-CR-196 | 1 | Obsidian Cliff |
| | 10-CR-201 Redfish Overhang | 2 | Teton Pass |
| | | 3 | Timber Butte |
| | 10-CR-202 | 1 | Bear Gulch |
| | | 1 | Browns Bench |
| | 10-CR-262 | 1 | Timber Butte |
| | 10-CR-322 | 1 | Big Southern |
| | | 1 | Owyhee |
| | 10-CR-575 Lower Jackass | 1 | Bear Gulch |
| | | 1 | Timber Butte |
| | 10-CR-576 White Creek | 3 | Timber Butte |

| County | Site | Artifact N | Obsidian Source |
|---|---|---|---|
| Custer (cont.) | 10-CR-586 Greyhound Creek | 1 | Timber Butte |
| | 10-CR-588 Dolly Lake | 1 | Timber Butte |
| | 10-CR-591 Pine Creek Flat | 1 | Timber Butte |
| | 10-CR-592 Whitie Cox | 5 | Timber Butte |
| | 10-CR-596 Ascher Creek | 4 | Timber Butte |
| | 10-CR-597 Knapp Creek | 1 | Timber Butte |
| | | 1 | unknown |
| | 10-CR-598 Loon Creek Trail Point | 2 | Bear Gulch |
| | | 3 | Big Southern |
| | | 1 | Camas Prairie |
| | | 11 | Timber Butte |
| | 10-CR-599 | 3 | Timber Butte |
| | 10-CR-602 Shake Creek | 3 | Timber Butte |
| | 10-CR-929 | 1 | unknown |
| | 10-CR-1231 | 1 | Shumway |
| | | 3 | Timber Butte |
| | | 3 | unknown |
| | 10-CR-1233 | 1 | Big Southern |
| | | 1 | Timber Butte |
| Subtotal | 19 | 63 | |
| Caribou | 10-CU-133 | 1 | Malad |
| | | 2 | Packsaddle |
| | 10-CU-208 | 1 | Bear Gulch |
| | | 1 | Malad |
| | 10-CU-209 | 1 | Packsaddle |
| | | 1 | Teton Pass |
| | 10-CU-212 | 2 | Malad |
| | | 2 | Packsaddle |
| Subtotal | 4 | 11 | |
| Elmore | 10-EL-1 Danskin Cave | 1 | Owyhee |
| | | 2 | Timber Butte |
| | 10-EL-22 Clover Creek | 2 | Bear Gulch |
| | | 1 | Cannonball Mountain |
| | 10-EL-68 | 1 | Owyhee |
| | | 1 | Timber Butte |
| | 10-EL-77 Wildhorse Creek | 1 | Bear Gulch |
| | | 1 | Big Southern |
| | | 1 | Kelly Canyon |
| | | 1 | Owyhee |
| | | 1 | Paradise Valley |
| | | 2 | Timber Butte |
| | 10-EL-80 | 1 | Big Southern |
| | | 1 | Kelly Canyon |
| | | 1 | Owyhee |
| | 10-EL-86 | 1 | Obsidian Cliff |
| | 10-EL-303 | 1 | Obsidian Cliff |
| | 10-EL-307 | 1 | Big Southern |
| | 10-EL-320 | 1 | Bear Gulch |
| | 10-EL-338 | 1 | Owyhee |

| County | Site | Artifact N | Obsidian Source |
|---|---|---|---|
| Elmore (cont.) | 10-EL-407 | 1 | Timber Butte |
| Subtotal | 11 | 24 | |
| Fremont | 10-FM-78 | 14 | Bear Gulch |
| | 10-FM-98 | 1 | Bear Gulch |
| | Nonsite 9999 | 4 | Bear Gulch |
| | | 3 | Big Southern |
| | | 1 | Browns Bench |
| | | 1 | Camas Prairie |
| | | 1 | Double H Mountain |
| | | 2 | Obsidian Cliff |
| | | 11 | Owyhee |
| | | 1 | Timber Butte |
| Subtotal | 3 | 39 | |
| Franklin | 10-FR-4 Weston Canyon | 3 | Browns Bench |
| | | 149 | Malad |
| | | 1 | Obsidian Cliff |
| Subtotal | 1 | 153 | |
| Gooding | 10-GG-1 | 2 | Owyhee |
| | | 1 | Timber Butte |
| | 10-GG-5 | 1 | Timber Butte |
| | 10-GG-80 | 1 | Browns Bench |
| | 10-GG-97 | 1 | Bear Gulch |
| | 10-GG-116 | 1 | Bear Gulch |
| | 10-GG-257 | 1 | Browns Bench |
| | Nonsite 9999 | 2 | Bear Gulch |
| | | 3 | Owyhee |
| | | 2 | Timber Butte |
| Subtotal | 7 | 15 | |
| Gem | 10-GM-33 | 1 | Owyhee |
| | 10-GM-68 | 2 | Timber Butte |
| Subtotal | 2 | 3 | |
| Idaho | 10-IH-699 Kirkwood Bar | 3 | Timber Butte |
| | 10-IH-1583 | 2 | Timber Butte |
| | 10-IH-1892 Deep Gully | 2 | Dooley Mountain |
| | | 1 | Timber Butte |
| | 10-IH-2423 | 1 | Timber Butte |
| | 10-IH-2561 | 2 | Timber Butte |
| | | 1 | unknown |
| | Nonsite 9998 | 2 | Timber Butte |
| | | 3 | unknown |
| Subtotal | 6 | 17 | |
| Jerome | 10-JE-4 Pence-Duerig Cave | 1 | Bear Gulch |
| | 10-JE-6 Wilson Butte | 7 | American Falls |
| | | 8 | Bear Gulch |
| | | 80 | Big Southern |
| | | 76 | Browns Bench |
| | | 3 | Camas Prairie |
| | | 25 | Cannonball Mountain |
| | | 2 | Coal Bank Spring |

| County | Site | Artifact N | Obsidian Source |
|---|---|---|---|
| Jerome (cont.) | 10-JE-6 Wilson Butte (cont.) | 2 | Deep Creek |
| | | 1 | Kelly Canyon |
| | | 5 | Malad |
| | | 4 | Owyhee |
| | | 16 | Picabo Hills |
| | | 1 | Pine Mountain |
| | | 6 | Timber Butte |
| | | 3 | unknown |
| | | 2 | Wedge Butte |
| | 10-JE-11 Big Trap Dune | 1 | Bear Gulch |
| Subtotal | 3 | 243 | |
| Jefferson | 10-JF-3 | 1 | Bear Gulch |
| | | 1 | Timber Butte |
| | 10-JF-10 | 1 | Bear Gulch |
| | | 3 | Owyhee |
| | 10-JF-11 | 1 | Cannonball Mountain |
| | | 1 | Owyhee |
| | | 1 | Timber Butte |
| | Nonsite 9999 | 1 | Owyhee |
| Subtotal | 4 | 10 | |
| Lemhi | 10-LH-27 Cave Creek | 1 | Bear Gulch |
| | 10-LH-27 Cave Creek (cont.) | 1 | Timber Butte |
| | 10-LH-28 Cow Creek Camp | 1 | Timber Butte |
| | 10-LH-29 Loon Creek | 1 | Timber Butte |
| | 10-LH-32 Camas Creek | 1 | Bear Gulch |
| | | 1 | Obsidian Cliff |
| | | 10 | Timber Butte |
| | 10-LH-45 Bighorn Shelter | 1 | Bear Gulch |
| | | 1 | Cannonball Mountain |
| | 10-LH-132 | 1 | Timber Butte |
| | 10-LH-144 Cove Creek | 2 | Timber Butte |
| | 10-LH-155 Ebenezer Shelter | 1 | Timber Butte |
| | 10-LH-186 Woolard | 2 | Bear Gulch |
| | | 1 | Obsidian Cliff |
| | | 6 | Timber Butte |
| | 10-LH-188 Driftwood | 1 | Timber Butte |
| | 10-LH-190 Short Creek | 2 | Bear Gulch |
| | | 6 | Timber Butte |
| | 10-LH-191 Flying "B" Flat | 1 | Timber Butte |
| | 10-LH-314 Mormon Ranch | 3 | Bear Gulch |
| | | 14 | Timber Butte |
| | 10-LH-316 Horsetail | 3 | Timber Butte |
| | 10-LH-318 Pool | 1 | Bear Gulch |
| | | 5 | Timber Butte |
| | 10-LH-319 Cold Spring | 1 | Timber Butte |
| | 10-LH-320 Wilson Creek | 3 | Timber Butte |
| | 10-LH-321 Last Chance | 1 | Bear Gulch |
| | | 1 | Big Southern |
| | | 5 | Timber Butte |

| County | Site | Artifact N | Obsidian Source |
|---|---|---|---|
| Lemhi (cont.) | 10-LH-323 Tumble Creek | 2 | Timber Butte |
| | 10-LH-324 Cliffside | 1 | Bear Gulch |
| | 10-LH-439 | 1 | Bear Gulch |
| | | 1 | Timber Butte |
| | 10-LH-491 | 1 | unknown |
| | 10-LH-885 Donnelly Gulch | 1 | Bear Gulch |
| | 10-LH-887 | 1 | Bear Gulch |
| Subtotal | 24 | 86 | |
| Lincoln | 10-LN-12 | 1 | Big Southern |
| | 10-LN-33 | 1 | Browns Bench |
| | | 1 | Double H Mountain |
| | Nonsite 9999 | 1 | Owyhee |
| Subtotal | 3 | 4 | |
| Madison | Nonsite 9999 | 1 | Timber Butte |
| Subtotal | 1 | 1 | |
| Oneida | 10-OA-210 Rock Springs | 1 | American Falls |
| | | 10 | Browns Bench |
| | | 30 | Malad |
| Subtotal | 1 | 41 | |
| Owyhee | 10-OE-232 The "Y" Jump | 1 | Bear Gulch |
| | | 1 | Timber Butte |
| | 10-OE-269 Bonus Cove | 3 | Owyhee |
| | 10-OE-281 | 1 | Timber Butte |
| | 10-OE-285 | 1 | Bear Gulch |
| | 10-OE-424 | 1 | Owyhee |
| | 10-OE-532 | 1 | Owyhee |
| | 10-OE-533 | 1 | Bear Gulch |
| | 10-OE-539 | 1 | Owyhee |
| | 10-OE-565 Bachman Cave | 3 | Bear Gulch |
| | | 1 | Big Southern |
| | | 1 | Browns Bench |
| | | 1 | Cannonball Mountain |
| | | 1 | Kelly Canyon |
| | | 2 | Owyhee |
| | | 1 | Teton Pass |
| | 10-OE-586 Flo John | 1 | Bear Gulch |
| | | 1 | Obsidian Cliff |
| | | 1 | Owyhee |
| | | 2 | Timber Butte |
| | 10-OE-602 | 1 | Big Southern |
| | | 1 | Owyhee |
| | 10-OE-688 | 1 | Obsidian Cliff |
| | | 1 | Owyhee |
| | | 1 | Teton Pass |
| | 10-OE-697 | 3 | Owyhee |
| | 10-OE-722 Big Julie's Rockshelter | 2 | Bear Gulch |
| | | 2 | Owyhee |
| | | 1 | Reynolds |
| | 10-OE-1114 | 10 | Cannonball Mountain |

| County | Site | Artifact N | Obsidian Source |
|---|---|---|---|
| Owyhee (cont.) | 10-OE-1114 (cont.) | 14 | unknown |
| | 10-OE-1674 | 1 | Timber Butte |
| | 10-OE-2046 | 1 | Cannonball Mountain |
| | 10-OE-2065 | 1 | Big Southern |
| | 10-OE-2614 Mud Springs | 5 | Bear Gulch |
| | | 1 | Browns Bench |
| | | 1 | Kelly Canyon |
| | | 1 | Obsidian Cliff |
| | | 2 | Owyhee |
| | 10-OE-3158 | 1 | Owyhee |
| | | 1 | unknown |
| | 10-OE-3853 | 1 | Owyhee |
| | | 2 | unknown |
| | 10-OE-5968 Hardtrigger | 2 | Owyhee |
| Subtotal | 22 | 83 | |
| Payette | Nonsite 9999 | 6 | Timber Butte |
| Subtotal | 1 | 6 | |
| Power | 10-PR-6 Eagle Rock | 1 | Bear Gulch |
| | | 1 | Big Southern |
| | | 2 | Owyhee |
| | 10-PR-15 | 1 | Owyhee |
| | 10-PR-44 | 1 | Owyhee |
| | Nonsite 9999 | 2 | Bear Gulch |
| | | 1 | Owyhee |
| Subtotal | 4 | 9 | |
| Twin Falls | 10-TF-1 Browns Bench | 5 | Big Southern |
| | | 1 | Browns Bench |
| | | 1 | Coal Bank Spring |
| | | 3 | Double H Mountain |
| | | 7 | Malad |
| | | 4 | Owyhee |
| | | 1 | Paradise Valley |
| | | 2 | Timber Butte |
| | 10-TF-17 | 1 | Owyhee |
| | 10-TF-70 | 1 | Owyhee |
| | 10-TF-132 | 1 | Bear Gulch |
| | 10-TF-216 | 1 | Cannonball Mountain |
| | 10-TF-229 | 1 | Cannonball Mountain |
| | 10-TF-262 | 1 | Bear Gulch |
| | Nonsite 9999 | 2 | Bear Gulch |
| | | 1 | Browns Bench |
| | | 9 | Owyhee |
| | | 1 | Teton Pass |
| | | 10 | Timber Butte |
| Subtotal | 8 | 53 | |
| Box Elder | 42-BO-385 Lakeside Cave | 3 | Browns Bench |
| | | 1 | Topaz Mtn |
| Subtotal | 1 | 4 | |

| County | Site | Artifact N | Obsidian Source |
|---|---|---|---|
| Union | Nonsite 9999 Cache Creek | 1 | Dooley Mountain |
| | | 1 | Timber Butte |
| Subtotal | 1 | 2 | |
| Tooele | 42-TO-13 Danger | 4 | Browns Bench |
| | | 1 | unknown |
| | 42-TO-106 Floating Island | 5 | Browns Bench |
| | 42-TO-457 Spring Bog | 5 | Browns Bench |
| Subtotal | 3 | 15 | |
| Valley | 10-VY-19 Hospital Bar | 1 | Bear Gulch |
| | | 4 | Timber Butte |
| | 10-VY-21 Dry Cave | 2 | Bear Gulch |
| | | 2 | Timber Butte |
| | 10-VY-25 Sheep Creek | 1 | Timber Butte |
| | 10-VY-26 Survey | 1 | Bear Gulch |
| | | 4 | Timber Butte |
| | 10-VY-41 | 3 | Timber Butte |
| | 10-VY-44 | 1 | Timber Butte |
| | 10-VY-50 | 1 | Timber Butte |
| | 10-VY-54 | 2 | Timber Butte |
| | 10-VY-60 | 1 | Bear Gulch |
| | 10-VY-67 | 1 | Bear Gulch |
| | 10-VY-69 | 1 | Bear Gulch |
| | 10-VY-70 Bernard | 4 | Bear Gulch |
| | | 14 | Timber Butte |
| | 10-VY-71 | 1 | Timber Butte |
| | 10-VY-76 Dagger Falls | 1 | American Falls |
| | | 27 | Timber Butte |
| | 10-VY-77 Trail Flat | 1 | Bear Gulch |
| | | 6 | Timber Butte |
| | 10-VY-79 Sheepeater Hot Spring | 1 | Timber Butte |
| | 10-VY-80 Pungo Creek | 1 | Timber Butte |
| | 10-VY-81 Marble Creek | 4 | Timber Butte |
| | 10-VY-82 Rock Island | 1 | Timber Butte |
| | 10-VY-83 | 1 | unknown |
| | 10-VY-85 Johnny Walker | 1 | Timber Butte |
| | 10-VY-109 Poker Meadows | 1 | Big Southern |
| | | 19 | Timber Butte |
| | 10-VY-112 | 15 | Timber Butte |
| | 10-VY-118 Boundary Creek | 1 | Timber Butte |
| | 10-VY-119 Sulphur Creek Trail | 1 | Timber Butte |
| | 10-VY-122 Airplane | 1 | Bear Gulch |
| | 10-VY-122 Airplane (cont.) | 2 | Timber Butte |
| | 10-VY-123 Indian Creek | 10 | Timber Butte |
| | 10-VY-124 Pebble Beach | 5 | Bear Gulch |
| | | 1 | Obsidian Cliff |
| | | 10 | Timber Butte |
| | 10-VY-125 Bridge Creek | 2 | Timber Butte |
| | 10-VY-126 Cow Creek | 1 | Timber Butte |
| | 10-VY-127 Grassy Flat I | 7 | Timber Butte |

| County | Site | Artifact N | Obsidian Source |
|---|---|---|---|
| Valley (cont.) | 10-VY-128 Grassy Flat II | 1 | Bear Gulch |
| | | 4 | Timber Butte |
| | 10-VY-129 Redside | 1 | Bear Gulch |
| | 10-VY-131 Lightning Strike | 4 | Bear Gulch |
| | | 27 | Timber Butte |
| | 10-VY-133 Hood Ranch | 1 | Timber Butte |
| | 10-VY-134 High Bench | 1 | Timber Butte |
| | 10-VY-143 | 1 | Timber Butte |
| | 10-VY-167 Big Creek Cave | 1 | Bear Gulch |
| | 10-VY-222 | 10 | Timber Butte |
| | | 1 | Teton Pass |
| | 10-VY-224 | 8 | Timber Butte |
| | | 1 | Kepler |
| | 10-VY-226 | 2 | Timber Butte |
| | 10-VY-228 | 1 | Timber Butte |
| | 10-VY-233 | 18 | Timber Butte |
| | 10-VY-238 | 2 | Timber Butte |
| | | 1 | Dooley Mountain |
| | 10-VY-246 | 9 | Timber Butte |
| | 10-VY-250 | 1 | Timber Butte |
| | 10-VY-376 | 1 | Timber Butte |
| | 10-VY-454 | 1 | Timber Butte |
| | 10-VY-492 | 1 | Dooley Mountain |
| | | 3 | Timber Butte |
| | 10-VY-522 | 2 | Timber Butte |
| | 10-VY-1580 | 8 | Timber Butte |
| Subtotal | 51 | 275 | |
| Washington | 10-WN-117 Braden | 9 | Timber Butte |
| | 10-WN-167 | 1 | Timber Butte |
| | 10-WN-318 | 3 | Dooley Mountain |
| | | 1 | Sugarloaf |
| | | 11 | Timber Butte |
| | | 1 | unknown |
| | 10-WN-415 | 1 | Sugarloaf |
| | | 5 | Timber Butte |
| | 10-WN-444 | 1 | Timber Butte |
| | 10-WN-469 | 32 | Sugarloaf |
| | | 18 | Timber Butte |
| | | 19 | unknown |
| | 10-WN-498 | 1 | Timber Butte |
| | 10-WN-562 | 1 | Coyote Wells |
| | | 1 | unknown |
| | 10-WN-564 | 1 | Dooley Mountain |
| | Nonsite 9999 Waterhouse | 1 | Timber Butte |
| Subtotal | 10 | 107 | |
| Total | 284 | 2607 | |

# APPENDIX B

## Minimum and Maximum Euclidean Distance and Mean Euclidean, Path, and Predicted Distance in Kilometers for Each Site

| County | Site Number | Artifact Number | Source Number | Euclidean distance to source (km) minimum | Euclidean distance to source (km) maximum | Euclidean distance to source (km) mean | Path distance to source (km) mean | Predicted distance to source (km) mean |
|---|---|---|---|---|---|---|---|---|
| Ada | 15 | 1 | 1 | 85.71 | 85.71 | 85.71 | 92.17 | 104.87 |
| | 19 | 1 | 1 | 87.77 | 87.77 | 87.77 | 94.33 | 107.37 |
| | 23 | 1 | 1 | 486.73 | 486.73 | 486.73 | | 591.54 |
| | 26 | 1 | 1 | 100.08 | 100.08 | 100.08 | 106.66 | 122.30 |
| | 72 | 506 | 16 | 59.98 | 410.56 | 75.51 | 82.57 | 92.50 |
| Total/Sum/Mean | 5 | 510 | | | | 76.46 | 82.66 | 93.65 |
| Adams | 23 | 1 | 1 | 56.68 | 56.68 | 56.68 | | 69.64 |
| | 24 | 1 | 1 | 355.30 | 355.30 | 355.30 | 510.99 | 432.04 |
| | 25 | 1 | 1 | 321.48 | 321.48 | 321.48 | 458.58 | 390.99 |
| | 69 | 4 | 1 | 67.39 | 67.39 | 67.39 | | 82.64 |
| | 93 | 2 | 1 | 62.42 | 62.42 | 62.42 | | 76.61 |
| | 107 | 6 | 2 | 94.35 | 113.69 | 110.46 | 127.51 | 134.91 |
| | 108 | 24 | 3 | 94.16 | 479.28 | 123.66 | | 150.93 |
| | 130 | 1 | 1 | 119.48 | 119.48 | 119.48 | | 145.85 |
| | 131 | 1 | 1 | 119.69 | 119.69 | 119.69 | 134.69 | 146.11 |
| | 141 | 4 | 2 | 54.47 | 119.47 | 70.72 | 85.78 | 86.68 |
| | 211 | 4 | 2 | 39.01 | 128.06 | 105.80 | 119.89 | 129.25 |
| | 261 | 4 | 1 | 108.35 | 108.35 | 108.35 | | 132.35 |
| | 266 | 1 | 1 | 105.25 | 105.25 | 105.25 | 124.97 | 128.58 |
| | 375 | 1 | 1 | 121.62 | 121.62 | 121.62 | | 148.45 |
| | 433 | 2 | 1 | 62.86 | 62.86 | 62.86 | 73.86 | 77.14 |
| | 434 | 4 | 2 | 18.32 | 62.73 | 51.63 | 61.21 | 63.51 |
| | 473 | 1 | 1 | 58.83 | 58.83 | 58.83 | 73.95 | 72.25 |
| | 475 | 1 | 1 | 54.67 | 54.67 | 54.67 | 68.74 | 67.20 |
| | 477 | 3 | 1 | 59.05 | 59.05 | 59.05 | 73.95 | 72.52 |
| | 9998 | 1 | 1 | 87.16 | 87.16 | 87.16 | 95.53 | 106.63 |
| | 9999 | 5 | 1 | 68.51 | 68.51 | 68.51 | | 84.00 |
| Total/Sum/Mean | 21 | 72 | | | | 103.01 | 122.32 | 125.87 |
| Bannock | 3 | 1 | 1 | 220.77 | 220.77 | 220.77 | 248.53 | 268.78 |
| | 26 | 20 | 6 | 58.70 | 326.50 | 195.54 | 219.93 | 238.16 |
| | 39 | 41 | 1 | 22.90 | 22.90 | 22.90 | 24.34 | 28.65 |
| | 74 | 56 | 4 | 10.58 | 222.12 | 25.54 | 33.33 | 31.85 |
| Total/Sum/Mean | 4 | 118 | | | | 55.09 | 63.66 | 67.71 |
| Bingham | 45 | 1 | 1 | 122.71 | 122.71 | 122.71 | 130.55 | 149.77 |
| | 49 | 2 | 2 | 110.70 | 302.71 | 206.71 | 263.75 | 251.71 |
| | 50 | 4 | 3 | 69.93 | 215.21 | 130.20 | 138.51 | 158.87 |
| | 479 | 3 | 2 | 33.01 | 82.36 | 65.91 | 79.25 | 80.84 |
| | 480 | 2 | 2 | 33.40 | 82.14 | 57.77 | 68.77 | 70.96 |
| | 486 | 1 | 1 | 86.97 | 86.97 | 86.97 | 97.99 | 106.40 |
| Total/Sum/Mean | 6 | 13 | | | | 112.09 | 129.64 | 136.89 |
| Blaine | 23 | 1 | 1 | 200.04 | 200.04 | 200.04 | 247.37 | 243.62 |
| | 54 | 1 | 1 | 195.74 | 195.74 | 195.74 | 216.27 | 238.40 |
| | 153 | 14 | 3 | 31.24 | 74.92 | 42.16 | 44.82 | 52.02 |
| | 9999 | 1 | 1 | 203.12 | 203.12 | 203.12 | 243.36 | 247.36 |
| Total/Sum/Mean | 4 | 17 | | | | 85.11 | 96.87 | 104.14 |
| Boise | 1 | 120 | 1 | 15.42 | 15.42 | 15.42 | 18.97 | 19.57 |
| | 6 | 4 | 2 | 50.63 | 325.97 | 119.46 | 155.14 | 145.83 |
| | 30 | 7 | 1 | 11.20 | 11.20 | 11.20 | 13.28 | 14.44 |
| | 41 | 2 | 1 | 33.58 | 33.58 | 33.58 | 46.54 | 41.61 |
| | 46 | 1 | 1 | 36.19 | 36.19 | 36.19 | 49.48 | 44.78 |
| | 47 | 9 | 1 | 36.44 | 36.44 | 36.44 | 49.48 | 45.08 |
| | 66 | 1 | 1 | 47.30 | 47.30 | 47.30 | 71.13 | 58.26 |
| | 112 | 6 | 1 | 37.11 | 37.11 | 37.11 | 58.02 | 45.89 |
| | 114 | 1 | 1 | 37.12 | 37.12 | 37.12 | 56.91 | 45.91 |
| | 115 | 1 | 1 | 38.05 | 38.05 | 38.05 | 53.33 | 47.03 |
| | 118 | 2 | 1 | 45.78 | 45.78 | 45.78 | 58.37 | 56.41 |
| | 119 | 6 | 2 | 43.21 | 46.59 | 46.03 | 59.99 | 56.71 |
| | 122 | 1 | 1 | 437.04 | 437.04 | 437.04 | | 531.23 |

| County | Site Number | Artifact Number | Source Number | Euclidean distance to source (km) minimum | Euclidean distance to source (km) maximum | Euclidean distance to source (km) mean | Path distance to source (km) mean | Predicted distance to source (km) mean |
|---|---|---|---|---|---|---|---|---|
| Boise (cont.) | 217 | 4 | 1 | 6.04 | 6.04 | 6.04 | 6.62 | 8.19 |
| | 418 | 45 | 1 | 21.72 | 21.72 | 21.72 | 28.00 | 27.21 |
| | 419 | 71 | 1 | 21.24 | 21.24 | 21.24 | 27.74 | 26.63 |
| Total/Sum/Mean | 16 | 281 | | | | 23.12 | 28.00 | 28.92 |
| Butte | 11 | 1 | 1 | 44.27 | 44.27 | 44.27 | 49.04 | 54.58 |
| | 29 | 2 | 2 | 242.75 | 310.87 | 276.81 | 305.21 | 336.79 |
| | 31 | 3 | 2 | 287.76 | 326.39 | 300.64 | 390.99 | 365.70 |
| | 39 | 2 | 2 | 283.40 | 319.84 | 301.62 | 379.54 | 366.90 |
| | 40 | 1 | 1 | 111.85 | 111.85 | 111.85 | 118.32 | 136.59 |
| | 46 | 3 | 3 | 104.82 | 489.34 | 265.97 | 307.51 | 323.63 |
| | 60 | 1 | 1 | 260.07 | 260.07 | 260.07 | 421.95 | 316.47 |
| | 74 | 3 | 2 | 37.24 | 185.75 | 136.25 | 142.54 | 166.20 |
| | 82 | 1 | 1 | 43.27 | 43.27 | 43.27 | 47.82 | 53.37 |
| | 102 | 3 | 3 | 33.72 | 310.90 | 206.81 | 259.70 | 251.83 |
| | 117 | 1 | 1 | 479.44 | 479.44 | 479.44 | 561.25 | 582.70 |
| | 119 | 1 | 1 | 309.22 | 309.22 | 309.22 | 351.75 | 376.12 |
| | 304 | 1 | 1 | 125.17 | 125.17 | 125.17 | 134.73 | 152.76 |
| | 323 | 1 | 1 | 265.42 | 265.42 | 265.42 | 305.08 | 322.97 |
| | 363 | 1 | 1 | 219.77 | 219.77 | 219.77 | 253.37 | 267.56 |
| | 1582 | 16 | 4 | 36.08 | 139.41 | 99.84 | 107.35 | 122.01 |
| | 9999 | 3 | 3 | 42.34 | 235.62 | 106.77 | 113.56 | 130.43 |
| Total/Sum/Mean | 17 | 44 | | | | 175.86 | 206.18 | 214.28 |
| Bonneville | 30 | 42 | 8 | 57.27 | 455.96 | 151.49 | 177.38 | 184.70 |
| | 31 | 3 | 3 | 104.46 | 315.88 | 203.34 | 251.32 | 247.62 |
| | 9999 | 20 | 3 | 104.52 | 132.09 | 125.96 | 134.25 | 153.72 |
| Total/Sum/Mean | 3 | 65 | | | | 146.66 | 168.58 | 178.84 |
| Cassia | 33 | 157 | 7 | 31.45 | 264.10 | 143.77 | 174.70 | 175.33 |
| | 35 | 1 | 1 | 194.38 | 194.38 | 194.38 | 210.55 | 236.75 |
| | 397 | 16 | 3 | 68.80 | 320.92 | 89.41 | 101.43 | 109.37 |
| Total/Sum/Mean | 3 | 174 | | | | 139.01 | 168.09 | 169.55 |
| Clark | 3 | 1 | 1 | 188.48 | 188.48 | 188.48 | 231.54 | 229.59 |
| | 10 | 4 | 3 | 116.06 | 506.52 | 266.45 | 318.36 | 324.22 |
| | 40 | 20 | 4 | 81.65 | 200.48 | 90.25 | 115.87 | 110.38 |
| | 47 | 4 | 3 | 100.02 | 331.12 | 248.20 | 336.90 | 302.07 |
| | 100 | 4 | 3 | 81.46 | 506.46 | 356.48 | 435.69 | 433.47 |
| | 114 | 1 | 1 | 243.50 | 243.50 | 243.50 | 296.15 | 296.36 |
| | 325 | 1 | 1 | 288.76 | 288.76 | 288.76 | 433.14 | 351.29 |
| | 346 | 1 | 1 | 296.05 | 296.05 | 296.05 | 445.33 | 360.14 |
| | 370 | 1 | 1 | 184.56 | 184.56 | 184.56 | 223.07 | 224.83 |
| Total/Sum/Mean | 9 | 37 | | | | 188.74 | 241.59 | 229.90 |
| Camas | 8 | 1 | 1 | 136.62 | 136.62 | 136.62 | 141.00 | 166.65 |
| | 12 | 1 | 1 | 15.44 | 15.44 | 15.44 | 18.20 | 19.59 |
| | 33 | 1 | 1 | 27.74 | 27.74 | 27.74 | 32.37 | 34.52 |
| | 70 | 1 | 1 | 145.71 | 145.71 | 145.71 | 187.79 | 177.69 |
| | 9999 | 2 | 1 | 161.25 | 161.25 | 161.25 | 184.88 | 196.55 |
| Total/Sum/Mean | 5 | 6 | | | | 108.00 | 124.85 | 131.92 |
| Canyon | 5 | 6 | 2 | 43.67 | 98.20 | 52.76 | | 64.89 |
| Total/Sum/Mean | 1 | 6 | | | | 52.76 | | 64.89 |
| Custer | 196 | 1 | 1 | 279.28 | 279.28 | 279.28 | 379.78 | 339.78 |
| | 201 | 5 | 2 | 110.28 | 325.53 | 196.38 | 266.78 | 239.18 |
| | 202 | 2 | 2 | 252.11 | 260.20 | 256.16 | 341.54 | 311.72 |
| | 262 | 1 | 1 | 194.94 | 194.94 | 194.94 | 412.67 | 237.43 |
| | 322 | 2 | 2 | 153.12 | 257.78 | 205.45 | 260.02 | 250.19 |
| | 575 | 2 | 2 | 129.04 | 235.94 | 182.49 | 261.63 | 222.32 |
| | 576 | 3 | 1 | 146.00 | 146.00 | 146.00 | 223.20 | 178.04 |
| | 586 | 1 | 1 | 111.25 | 111.25 | 111.25 | 147.29 | 135.87 |
| | 588 | 1 | 1 | 115.22 | 115.22 | 115.22 | 162.32 | 140.68 |
| | 591 | 1 | 1 | 135.64 | 135.64 | 135.64 | 194.17 | 165.47 |

| County | Site Number | Artifact Number | Source Number | Euclidean distance to source (km) minimum | Euclidean distance to source (km) maximum | Euclidean distance to source (km) mean | Path distance to source (km) mean | Predicted distance to source (km) mean |
|---|---|---|---|---|---|---|---|---|
| Custer (cont.) | 592 | 5 | 1 | 139.57 | 139.57 | 139.57 | 204.59 | 170.24 |
| | 596 | 4 | 1 | 97.82 | 97.82 | 97.82 | 149.96 | 119.57 |
| | 597 | 2 | 2 | 97.96 | 97.96 | 97.96 | 151.09 | 119.74 |
| | 598 | 17 | 4 | 132.51 | 223.18 | 155.75 | 253.50 | 189.87 |
| | 599 | 3 | 1 | 126.94 | 126.94 | 126.94 | 189.59 | 154.91 |
| | 602 | 3 | 1 | 102.19 | 102.19 | 102.19 | 156.34 | 124.87 |
| | 929 | 1 | 1 | | | | | |
| | 1231 | 7 | 3 | 113.79 | 255.49 | 149.21 | | 181.93 |
| | 1233 | 2 | 2 | 146.56 | 146.56 | 146.56 | | 178.71 |
| Total/Sum/Mean | 19 | 63 | | | | 154.42 | 228.26 | 188.26 |
| Caribou | 133 | 3 | 2 | 80.47 | 89.49 | 86.48 | 102.25 | 105.81 |
| | 208 | 2 | 2 | 124.34 | 124.34 | 124.34 | 135.38 | 151.76 |
| | 209 | 2 | 2 | 83.95 | 83.95 | 83.95 | 103.54 | 102.74 |
| | 212 | 4 | 2 | 80.53 | 89.27 | 84.90 | 99.60 | 103.89 |
| Total/Sum/Mean | 4 | 11 | | | | 92.33 | 108.07 | 112.91 |
| Elmore | 1 | 3 | 2 | 91.69 | 99.01 | 94.13 | 125.64 | 115.09 |
| | 22 | 3 | 2 | 61.70 | 305.46 | 224.21 | | 272.95 |
| | 68 | 2 | 2 | 97.05 | 97.05 | 97.05 | 129.47 | 118.63 |
| | 77 | 7 | 6 | 122.23 | 286.61 | 196.51 | 230.45 | 239.33 |
| | 80 | 3 | 3 | 196.99 | 196.99 | 196.99 | 216.00 | 239.91 |
| | 86 | 1 | 1 | 414.17 | 414.17 | 414.17 | 472.99 | 503.48 |
| | 303 | 1 | 1 | 418.26 | 418.26 | 418.26 | 494.95 | 508.45 |
| | 307 | 1 | 1 | 211.98 | 211.98 | 211.98 | | 258.11 |
| | 320 | 1 | 1 | 311.35 | 311.35 | 311.35 | 390.50 | 378.70 |
| | 338 | 1 | 1 | 98.05 | 98.05 | 98.05 | | 119.84 |
| | 407 | 1 | 1 | 136.54 | 136.54 | 136.54 | 159.09 | 166.56 |
| Total/Sum/Mean | 11 | 24 | | | | 196.08 | 238.27 | 238.82 |
| Fremont | 78 | 14 | 1 | 36.26 | 36.26 | 36.26 | | 44.86 |
| | 98 | 1 | 1 | 45.43 | 45.43 | 45.43 | 47.31 | 55.99 |
| | 9999 | 24 | 8 | 51.97 | 433.65 | 292.56 | 329.91 | 355.90 |
| Total/Sum/Mean | 3 | 39 | | | | 194.22 | 318.13 | 236.55 |
| Franklin | 4 | 153 | 3 | 39.25 | 322.65 | 44.88 | 56.58 | 55.32 |
| Total/Sum/Mean | 1 | 153 | | | | 44.88 | 56.58 | 55.32 |
| Gooding | 1 | 3 | 2 | 129.63 | 163.35 | 140.87 | 155.02 | 171.81 |
| | 5 | 1 | 1 | 168.40 | 168.40 | 168.40 | 212.00 | 205.22 |
| | 80 | 1 | 1 | 119.94 | 119.94 | 119.94 | 125.68 | 146.41 |
| | 97 | 1 | 1 | 287.00 | 287.00 | 287.00 | 334.45 | 349.15 |
| | 116 | 1 | 1 | 291.58 | 291.58 | 291.58 | 340.57 | 354.71 |
| | 257 | 1 | 1 | 86.59 | 86.59 | 86.59 | 89.85 | 105.94 |
| | 9999 | 7 | 3 | 143.88 | 280.39 | 189.13 | 216.18 | 230.38 |
| Total/Sum/Mean | 7 | 15 | | | | 180.00 | 205.39 | 219.30 |
| Gem | 33 | 1 | 1 | 113.02 | 113.02 | 113.02 | 170.98 | 138.02 |
| | 68 | 2 | 1 | 6.09 | 6.09 | 6.09 | 9.28 | 8.24 |
| Total/Sum/Mean | 2 | 3 | | | | 41.73 | 63.18 | 51.50 |
| Idaho | 699 | 3 | 1 | 172.10 | 172.10 | 172.10 | | 209.71 |
| | 1583 | 2 | 1 | 150.12 | 150.12 | 150.12 | 194.66 | 183.04 |
| | 1892 | 3 | 2 | 158.16 | 183.32 | 166.55 | | 202.98 |
| | 2423 | 1 | 1 | 138.96 | 138.96 | 138.96 | 156.45 | 169.49 |
| | 2561 | 3 | 2 | 150.75 | 150.75 | 150.75 | 178.67 | 183.81 |
| | 9998 | 5 | 2 | 182.20 | 182.20 | 182.20 | 216.46 | 221.97 |
| Total/Sum/Mean | 6 | 17 | | | | 163.16 | 190.86 | 198.86 |
| Jerome | 4 | 1 | 1 | 285.79 | 285.79 | 285.79 | 311.58 | 347.68 |
| | 6 | 241 | 16 | 51.82 | 261.50 | 113.15 | 122.94 | 138.17 |
| | 11 | 1 | 1 | 261.90 | 261.90 | 261.90 | 286.61 | 318.69 |
| Total/Sum/Mean | 3 | 243 | | | | 114.49 | 124.41 | 139.80 |
| Jefferson | 3 | 2 | 2 | 189.18 | 189.18 | 189.18 | 257.68 | 230.43 |
| | 10 | 4 | 2 | 85.35 | 337.90 | 274.76 | 311.05 | 334.30 |
| | 11 | 3 | 3 | 268.07 | 268.07 | 268.07 | 374.55 | 326.18 |

| County | Site Number | Artifact Number | Source Number | Euclidean distance to source (km) minimum | Euclidean distance to source (km) maximum | Euclidean distance to source (km) mean | Path distance to source (km) mean | Predicted distance to source (km) mean |
|---|---|---|---|---|---|---|---|---|
| Jefferson (cont.) | 9999 | 1 | 1 | 359.55 | 359.55 | 359.55 | 404.73 | 437.20 |
| Total/Sum/Mean | 4 | 10 | | | | 264.12 | 328.79 | 321.38 |
| Lemhi | 27 | 2 | 2 | 185.75 | 185.75 | 185.75 | 267.26 | 226.27 |
| | 28 | 1 | 1 | 144.54 | 144.54 | 144.54 | 218.38 | 176.27 |
| | 29 | 1 | 1 | 144.30 | 144.30 | 144.30 | 218.38 | 175.98 |
| | 32 | 12 | 3 | 154.48 | 316.72 | 173.53 | 230.86 | 211.45 |
| | 45 | 2 | 2 | 125.38 | 125.38 | 125.38 | 180.44 | 153.01 |
| | 132 | 1 | 1 | 222.77 | 222.77 | 222.77 | 376.83 | 271.20 |
| | 144 | 2 | 1 | 204.23 | 204.23 | 204.23 | 316.38 | 248.71 |
| | 155 | 1 | 1 | 198.01 | 198.01 | 198.01 | 292.69 | 241.16 |
| | 186 | 9 | 3 | 167.02 | 316.49 | 196.27 | 257.72 | 239.05 |
| | 188 | 1 | 1 | 164.13 | 164.13 | 164.13 | 214.41 | 200.04 |
| | 190 | 8 | 2 | 161.25 | 222.53 | 176.57 | 232.28 | 215.14 |
| | 191 | 1 | 1 | 160.16 | 160.16 | 160.16 | 217.54 | 195.22 |
| | 314 | 17 | 2 | 159.23 | 221.33 | 170.19 | 230.56 | 207.39 |
| | 316 | 3 | 1 | 148.00 | 148.00 | 148.00 | 205.32 | 180.47 |
| | 318 | 6 | 2 | 154.96 | 221.36 | 166.03 | 222.29 | 202.34 |
| | 319 | 1 | 1 | 163.01 | 163.01 | 163.01 | 213.17 | 198.68 |
| | 320 | 3 | 1 | 165.17 | 165.17 | 165.17 | 235.28 | 201.30 |
| | 321 | 7 | 3 | 169.69 | 232.57 | 186.64 | 276.93 | 227.36 |
| | 323 | 2 | 1 | 182.35 | 182.35 | 182.35 | 284.80 | 222.15 |
| | 324 | 1 | 1 | 225.98 | 225.98 | 225.98 | 263.23 | 275.10 |
| | 439 | 2 | 2 | 174.71 | 174.71 | 174.71 | 267.31 | 212.87 |
| | 491 | 1 | 1 | | | | | |
| | 885 | 1 | 1 | 187.99 | 187.99 | 187.99 | 220.85 | 229.00 |
| | 887 | 1 | 1 | 191.28 | 191.28 | 191.28 | 227.37 | 232.99 |
| Total/Sum/Mean | 24 | 86 | | | | 175.81 | 241.84 | 214.21 |
| Lincoln | 12 | 1 | 1 | 97.38 | 97.38 | 97.38 | 105.34 | 119.03 |
| | 33 | 2 | 2 | 260.26 | 260.26 | 260.26 | 289.94 | 316.70 |
| | 9999 | 1 | 1 | 192.72 | 192.72 | 192.72 | 205.12 | 234.74 |
| Total/Sum/Mean | 3 | 4 | | | | 202.65 | 222.59 | 246.79 |
| Madison | 9999 | 1 | 1 | 369.78 | 369.78 | 369.78 | 417.84 | 449.62 |
| Total/Sum/Mean | 1 | 1 | 1 | | | 369.78 | 417.84 | 449.62 |
| Oneida | 210 | 41 | 3 | 40.04 | 174.13 | 73.02 | 90.05 | 89.47 |
| Total/Sum/Mean | 1 | 41 | | | | 73.02 | 90.05 | 89.47 |
| Owyhee | 232 | 2 | 2 | 292.87 | 292.87 | 292.87 | 333.97 | 356.28 |
| | 269 | 3 | 1 | 36.38 | 36.38 | 36.38 | 41.92 | 45.01 |
| | 281 | 1 | 1 | 122.98 | 122.98 | 122.98 | 134.74 | 150.10 |
| | 285 | 1 | 1 | 423.22 | 423.22 | 423.22 | 500.93 | 514.47 |
| | 424 | 1 | 1 | 86.72 | 86.72 | 86.72 | | 106.09 |
| | 532 | 1 | 1 | 43.25 | 43.25 | 43.25 | | 53.34 |
| | 533 | 1 | 1 | 374.37 | 374.37 | 374.37 | 439.00 | 455.18 |
| | 539 | 1 | 1 | 43.25 | 43.25 | 43.25 | | 53.34 |
| | 565 | 10 | 7 | 15.92 | 445.98 | 266.06 | 301.03 | 323.74 |
| | 586 | 5 | 4 | 10.20 | 505.52 | 231.66 | 264.79 | 281.99 |
| | 602 | 2 | 2 | 160.00 | 160.00 | 160.00 | | 195.02 |
| | 688 | 3 | 3 | 344.36 | 344.36 | 344.36 | | 418.77 |
| | 697 | 3 | 1 | 41.04 | 41.04 | 41.04 | | 50.66 |
| | 722 | 5 | 3 | 8.50 | 400.02 | 170.51 | 470.26 | 207.78 |
| | 1114 | 24 | 2 | 96.40 | 96.40 | 96.40 | 106.61 | 117.84 |
| | 1674 | 1 | 1 | 178.83 | 178.83 | 178.83 | 194.24 | 217.88 |
| | 2046 | 1 | 1 | 158.83 | 158.83 | 158.83 | 178.25 | 193.61 |
| | 2065 | 1 | 1 | 309.73 | 309.73 | 309.73 | | 376.74 |
| | 2614 | 10 | 5 | 62.73 | 507.95 | 327.16 | 394.03 | 397.89 |
| | 3158 | 2 | 2 | 76.29 | 76.29 | 76.29 | 83.92 | 93.44 |
| | 3853 | 3 | 2 | 61.96 | 61.96 | 61.96 | 75.09 | 76.05 |
| | 5968 | 2 | 1 | 55.98 | 55.98 | 55.98 | 65.71 | 68.80 |
| Total/Sum/Mean | 22 | 83 | | | | 198.02 | 251.22 | 241.17 |

| County | Site Number | Artifact Number | Source Number | Euclidean distance to source (km) minimum | Euclidean distance to source (km) maximum | Euclidean distance to source (km) mean | Path distance to source (km) mean | Predicted distance to source (km) mean |
|---|---|---|---|---|---|---|---|---|
| Payette | 9999 | 6 | 1 | 45.54 | 45.54 | 45.54 | 64.15 | 56.12 |
| Total/Sum/Mean | 1 | 6 | | | | 45.54 | 64.15 | 56.12 |
| Power | 6 | 4 | 3 | 72.65 | 298.64 | 219.65 | 229.60 | 267.41 |
| | 15 | 1 | 1 | 293.32 | 293.32 | 293.32 | 308.45 | 356.82 |
| | 44 | 1 | 1 | 294.49 | 294.49 | 294.49 | 311.35 | 358.24 |
| | 9999 | 3 | 2 | 220.77 | 309.28 | 250.27 | 268.76 | 304.58 |
| Total/Sum/Mean | 4 | 9 | | | | 246.36 | 260.49 | 299.83 |
| Twin Falls | 1 | 24 | 8 | 5.43 | 304.55 | 202.70 | 228.71 | 246.85 |
| | 17 | 1 | 1 | 135.43 | 135.43 | 135.43 | 146.39 | 165.21 |
| | 70 | 1 | 1 | 181.99 | 181.99 | 181.99 | 206.95 | 221.71 |
| | 132 | 1 | 1 | 308.17 | 308.17 | 308.17 | 348.06 | 374.84 |
| | 216 | 1 | 1 | 119.44 | 119.44 | 119.44 | 125.76 | 145.81 |
| | 229 | 1 | 1 | 116.56 | 116.56 | 116.56 | 119.12 | 142.31 |
| | 262 | 1 | 1 | 299.17 | 299.17 | 299.17 | 320.59 | 363.92 |
| | 9999 | 23 | 5 | 35.57 | 322.62 | 214.07 | 231.88 | 260.64 |
| Total/Sum/Mean | 8 | 53 | | | | 206.59 | 228.02 | 251.57 |
| Box Elder | 385 | 4 | 2 | 166.60 | 189.84 | 184.03 | | 224.19 |
| Total/Sum/Mean | 1 | 4 | | | | 184.03 | | 224.19 |
| Union | 9999 | 2 | 2 | 196.29 | 196.29 | 196.29 | | 239.07 |
| Total/Sum/Mean | 1 | 2 | | | | 196.29 | | 239.07 |
| Tooele | 13 | 5 | 2 | 162.53 | 162.53 | 162.53 | | 198.10 |
| | 106 | 5 | 1 | 165.58 | 165.58 | 165.58 | | 201.80 |
| | 457 | 5 | 1 | 161.37 | 161.37 | 161.37 | | 196.69 |
| Total/Sum/Mean | 3 | 15 | | | | 163.20 | | 198.92 |
| Valley | 19 | 5 | 2 | 147.51 | 223.89 | 162.79 | 225.83 | 198.41 |
| | 21 | 4 | 2 | 157.18 | 221.46 | 189.32 | 255.03 | 230.61 |
| | 25 | 1 | 1 | 158.44 | 158.44 | 158.44 | 213.84 | 193.14 |
| | 26 | 5 | 2 | 166.84 | 223.94 | 178.26 | 240.67 | 217.19 |
| | 41 | 3 | 1 | 161.66 | 161.66 | 161.66 | | 197.05 |
| | 44 | 1 | 1 | 166.03 | 166.03 | 166.03 | | 202.34 |
| | 50 | 1 | 1 | 47.44 | 47.44 | 47.44 | | 58.43 |
| | 54 | 2 | 1 | 159.28 | 159.28 | 159.28 | | 194.16 |
| | 60 | 1 | 1 | 291.38 | 291.38 | 291.38 | | 354.46 |
| | 67 | 1 | 1 | 298.44 | 298.44 | 298.44 | 509.15 | 363.03 |
| | 69 | 1 | 1 | 222.88 | 222.88 | 222.88 | | 271.34 |
| | 70 | 18 | 2 | 160.99 | 222.60 | 174.68 | 230.42 | 212.85 |
| | 71 | 1 | 1 | 159.72 | 159.72 | 159.72 | 217.10 | 194.69 |
| | 76 | 28 | 2 | 94.43 | 276.78 | 100.94 | 139.93 | 123.36 |
| | 77 | 7 | 2 | 101.76 | 259.96 | 124.36 | 168.87 | 151.78 |
| | 79 | 1 | 1 | 107.47 | 107.47 | 107.47 | 145.88 | 131.28 |
| | 80 | 1 | 1 | 95.87 | 95.87 | 95.87 | 126.04 | 117.20 |
| | 81 | 4 | 1 | 126.79 | 126.79 | 126.79 | 180.56 | 154.73 |
| | 82 | 1 | 1 | 139.82 | 139.82 | 139.82 | 204.76 | 170.54 |
| | 83 | 1 | 1 | | | | | |
| | 85 | 1 | 1 | 154.86 | 154.86 | 154.86 | 209.66 | 188.79 |
| | 109 | 20 | 2 | 87.21 | 216.56 | 93.68 | 136.36 | 114.54 |
| | 112 | 15 | 1 | 116.84 | 116.84 | 116.84 | | 142.65 |
| | 118 | 1 | 1 | 95.20 | 95.20 | 95.20 | 131.24 | 116.39 |
| | 119 | 1 | 1 | 78.13 | 78.13 | 78.13 | | 95.67 |
| | 122 | 3 | 2 | 121.07 | 249.11 | 163.75 | 233.91 | 199.58 |
| | 123 | 10 | 1 | 121.64 | 121.64 | 121.64 | 174.42 | 148.48 |
| | 124 | 16 | 3 | 140.19 | 326.46 | 179.35 | 253.01 | 218.51 |
| | 125 | 2 | 1 | 142.03 | 142.03 | 142.03 | 206.71 | 173.22 |
| | 126 | 1 | 1 | 144.72 | 144.72 | 144.72 | 197.71 | 176.48 |
| | 127 | 7 | 1 | 165.08 | 165.08 | 165.08 | 235.60 | 201.19 |
| | 128 | 5 | 2 | 165.36 | 223.65 | 177.02 | 243.55 | 215.68 |
| | 129 | 1 | 1 | 227.49 | 227.49 | 227.49 | 276.58 | 276.93 |
| | 131 | 31 | 2 | 176.95 | 227.68 | 183.50 | 279.29 | 223.54 |

| County | Site Number | Artifact Number | Source Number | Euclidean distance to source (km) minimum | Euclidean distance to source (km) maximum | Euclidean distance to source (km) mean | Path distance to source (km) mean | Predicted distance to source (km) mean |
|---|---|---|---|---|---|---|---|---|
| Valley (cont.) | 133 | 1 | 1 | 127.89 | 127.89 | 127.89 | 185.68 | 156.06 |
| | 134 | 1 | 1 | 96.11 | 96.11 | 96.11 | 130.20 | 117.49 |
| | 143 | 1 | 1 | 160.73 | 160.73 | 160.73 | 260.34 | 195.92 |
| | 167 | 1 | 1 | 295.97 | 295.97 | 295.97 | 489.54 | 360.04 |
| | 222 | 11 | 2 | 104.28 | 412.63 | 132.31 | | 161.42 |
| | 224 | 9 | 2 | 117.16 | 398.15 | 148.39 | | 180.93 |
| | 226 | 2 | 1 | 118.34 | 118.34 | 118.34 | | 144.47 |
| | 228 | 1 | 1 | 119.17 | 119.17 | 119.17 | 131.06 | 145.47 |
| | 233 | 18 | 1 | 104.58 | 104.58 | 104.58 | | 127.77 |
| | 238 | 3 | 2 | 107.77 | 166.77 | 127.44 | 165.16 | 155.51 |
| | 246 | 9 | 1 | 119.01 | 119.01 | 119.01 | | 145.29 |
| | 250 | 1 | 1 | 162.16 | 162.16 | 162.16 | | 197.65 |
| | 376 | 1 | 1 | 141.39 | 141.39 | 141.39 | | 172.44 |
| | 454 | 1 | 1 | 136.36 | 136.36 | 136.36 | 193.32 | 166.33 |
| | 492 | 4 | 2 | 112.38 | 168.68 | 126.46 | | 154.32 |
| | 522 | 2 | 1 | 123.40 | 123.40 | 123.40 | 133.94 | 150.62 |
| | 1580 | 8 | 1 | 144.20 | 144.20 | 144.20 | 180.26 | 175.85 |
| Total/Sum/Mean | 51 | 275 | | | | 141.34 | 207.78 | 172.39 |
| Washington | 117 | 9 | 1 | 59.20 | 59.20 | 59.20 | 75.90 | 72.70 |
| | 167 | 1 | 1 | 87.00 | 87.00 | 87.00 | | 106.44 |
| | 318 | 16 | 4 | 50.97 | 83.97 | 79.59 | 94.13 | 97.45 |
| | 415 | 6 | 2 | 47.74 | 87.67 | 81.02 | 95.01 | 99.18 |
| | 444 | 1 | 1 | 75.74 | 75.74 | 75.74 | | 92.77 |
| | 469 | 69 | 3 | 59.67 | 93.36 | 81.23 | 94.34 | 99.44 |
| | 498 | 1 | 1 | 82.37 | 82.37 | 82.37 | 99.57 | 100.82 |
| | 562 | 2 | 2 | 119.59 | 119.59 | 119.59 | 128.13 | 145.99 |
| | 564 | 1 | 1 | 61.80 | 61.80 | 61.80 | | 75.85 |
| | 9999 | 1 | 1 | 59.20 | 59.20 | 59.20 | 75.90 | 72.70 |
| Total/Sum/Mean | 10 | 107 | | | | 78.61 | 92.60 | 96.25 |
| Total/Sum/Mean | 284 | 2607 | | | | 105.99 | 125.78 | 129.48 |

# APPENDIX C

## Distribution of Southern Idaho Sites and Sources with Minimum, Maximum, and Mean Euclidean Distances in Kilometers by 30-Minute Quadrats

C1

| | K1 | K2 | K3 | K4 | K5 | K6 | K7 | K8 | K9 | K10 | K11 | K12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| no. of sites | | 2 | 2 | | | | | | | | | |
| no. of known sources | | 2 | 2 | | | | | | | | | |
| minimum | | 169.90 | 158.16 | | | | | | | | | |
| maximum | | 222.68 | 183.32 | | | | | | | | | |
| mean | | 189.24 | 169.33 | | | | | | | | | |

| | J1 | J2 | J3 | J4 | J5 | J6 | J7 | J8 | J9 | J10 | J11 | J12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| no. of sites | | 5 | 3 | 10 | 1 | 17 | 4 | | | | | |
| no. of known sources | | 4 | 1 | 3 | 1 | 4 | 2 | | | | | |
| minimum | | 39.01 | 108.35 | 116.84 | 150.12 | 159.28 | 187.99 | | | | | |
| maximum | | 355.30 | 150.75 | 378.37 | 150.12 | 303.58 | 222.77 | | | | | |
| mean | | 129.27 | 124.84 | 135.67 | 150.12 | 180.86 | 202.10 | | | | | |

| | I1 | I2 | I3 | I4 | I5 | I6 | I7 | I8 | I9 | I10 | I11 | I12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| no. of sites | 1 | 8 | 13 | 5 | 11 | 32 | | 1 | | | | |
| no. of known sources | 1 | 5 | 4 | 4 | 3 | 5 | | 2 | | | | |
| minimum | 61.80 | 47.74 | 18.32 | 104.28 | 78.13 | 126.94 | | 151.18 | | | | |
| maximum | 61.80 | 459.53 | 321.48 | 412.63 | 276.78 | 308.61 | | 198.23 | | | | |
| mean | 61.80 | 101.96 | 74.32 | 122.21 | 112.33 | 165.70 | | 174.71 | | | | |

| | H1 | H2 | H3 | H4 | H5 | H6 | H7 | H8 | H9 | H10 | H11 | H12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| no. of sites | | 3 | 6 | 9 | 5 | 3 | 2 | 1 | 2 | 8 | | 4 |
| no. of known sources | | 2 | 2 | 3 | 4 | 4 | 3 | 1 | 3 | 9 | | 9 |
| minimum | | 59.20 | 6.04 | 33.58 | 87.21 | 110.28 | 153.12 | 194.94 | 92.30 | 81.46 | | 36.26 |
| maximum | | 93.36 | 113.02 | 325.97 | 260.20 | 325.53 | 257.78 | 194.94 | 260.07 | 506.52 | | 433.65 |
| mean | | 77.56 | 15.74 | 49.21 | 106.06 | 170.17 | 222.30 | 194.94 | 170.27 | 184.70 | | 193.10 |

| | G1 | G2 | G3 | G4 | G5 | G6 | G7 | G8 | G9 | G10 | G11 | G12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| no. of sites | | 1 | 3 | 2 | 1 | | 2 | 1 | 4 | 13 | 4 | 1 |
| no. of known sources | | 1 | 5 | 2 | 1 | | 1 | 1 | 4 | 10 | 8 | 1 |
| minimum | | 45.54 | 21.24 | 47.30 | 95.87 | | 200.04 | 225.02 | 42.34 | 33.72 | 57.27 | 369.78 |
| maximum | | 45.54 | 410.56 | 406.06 | 95.87 | | 203.12 | 225.02 | 235.62 | 489.34 | 455.96 | 369.78 |
| mean | | 45.54 | 64.99 | 226.68 | 95.87 | | 201.58 | 225.02 | 111.56 | 203.09 | 149.99 | 369.78 |

| | F1 | F2 | F3 | F4 | F5 | F6 | F7 | F8 | F9 | F10 | F11 | F12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| no. of sites | | 6 | 6 | 6 | 4 | 6 | 3 | 2 | 1 | 1 | | 6 |
| no. of known sources | | 8 | 9 | 5 | 7 | 5 | 4 | 2 | 2 | 1 | | 7 |
| minimum | | 43.67 | 15.92 | 90.99 | 119.94 | 15.44 | 27.74 | 43.27 | 37.24 | 122.71 | | 33.01 |
| maximum | | 475.80 | 451.33 | 384.03 | 291.58 | 280.39 | 375.24 | 195.74 | 185.75 | 122.71 | | 167.08 |
| mean | | 217.13 | 205.57 | 164.66 | 207.41 | 162.51 | 185.24 | 119.51 | 136.25 | 122.71 | | 91.83 |

| | E1 | E2 | E3 | E4 | E5 | E6 | E7 | E8 | E9 | E10 | E11 | E12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| no. of sites | | 3 | 5 | 1 | 6 | 4 | 3 | 1 | 1 | 5 | 2 | 2 |
| no. of known sources | | 4 | 5 | 1 | 7 | 4 | 15 | 1 | 2 | 6 | 2 | 2 |
| minimum | | 40.91 | 8.50 | 86.72 | 61.70 | 86.59 | 51.82 | 97.38 | 31.24 | 58.70 | 22.90 | 80.47 |
| maximum | | 492.32 | 468.68 | 86.72 | 372.77 | 308.17 | 285.79 | 97.38 | 74.92 | 326.50 | 220.77 | 89.49 |
| mean | | 177.09 | 187.30 | 86.72 | 152.84 | 158.80 | 114.49 | 97.38 | 42.16 | 202.54 | 27.61 | 85.58 |

| | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| no. of sites | | 1 | 3 | | | 4 | 4 | | 1 | 1 | 2 | |
| no. of known sources | | 1 | 3 | | | 11 | 8 | | 1 | 3 | 5 | |
| minimum | | 178.83 | 61.96 | | | 5.43 | 31.45 | | 194.38 | 40.04 | 10.58 | |
| maximum | | 178.83 | 401.37 | | | 322.62 | 320.92 | | 194.38 | 174.13 | 270.63 | |
| mean | | 178.83 | 181.00 | | | 205.86 | 139.50 | | 194.38 | 73.02 | 39.45 | |

# APPENDIX D

## Distribution of Sites and Sources with Minimum, Maximum, and Mean Euclidean Distances by 30-Minute Quadrats

| Time Period | Obsidian Source | Artifacts | Minimum | Maximum | Mean |
|---|---|---|---|---|---|
| 150-750 | Bear Gulch | 49 | 45.43 | 423.22 | 244.91 |
| | Big Southern | 16 | 33.72 | 355.30 | 183.53 |
| | Browns Bench | 15 | 5.43 | 363.76 | 154.79 |
| | Burns | 1 | 245.61 | 245.61 | 245.61 |
| | Camas Prairie | 1 | 276.85 | 276.85 | 276.85 |
| | Cannonball Mountain | 10 | 27.74 | 243.50 | 148.46 |
| | Coyote Wells | 1 | 128.21 | 128.21 | 128.21 |
| | Double H Mountain | 7 | 304.55 | 506.52 | 452.57 |
| | Kelly Canyon | 15 | 69.93 | 416.30 | 207.76 |
| | Malad | 10 | 10.58 | 69.53 | 40.06 |
| | Obsidian Cliff | 12 | 92.58 | 531.91 | 299.54 |
| | Owyhee | 70 | 8.50 | 433.65 | 216.92 |
| | Reynolds | 2 | 35.52 | 331.52 | 183.52 |
| | Teton Pass | 6 | 318.60 | 460.27 | 381.08 |
| | Timber Butte | 66 | 59.98 | 382.17 | 191.15 |
| | Total | 281 | 5.43 | 531.91 | 213.98 |
| 700-1700 | American Falls | 1 | 106.77 | 106.77 | 106.77 |
| | Bear Gulch | 3 | 261.50 | 305.46 | 290.81 |
| | Browns Bench | 11 | 97.40 | 235.62 | 118.00 |
| | Burns | 1 | 245.61 | 245.61 | 245.61 |
| | Camas Prairie | 1 | 57.32 | 57.32 | 57.32 |
| | Cannonball Mountain | 6 | 61.70 | 84.04 | 80.32 |
| | Coyote Wells | 1 | 128.21 | 128.21 | 128.21 |
| | Malad | 5 | 10.58 | 80.53 | 24.57 |
| | Owyhee | 5 | 55.98 | 124.10 | 79.42 |
| | Paradise Valley | 1 | 264.32 | 264.32 | 264.32 |
| | Picabo Hills | 5 | 70.63 | 70.63 | 70.63 |
| | Timber Butte | 19 | 59.98 | 216.82 | 68.23 |
| | Total | 59 | 10.58 | 305.46 | 95.32 |
| 500-7500 | American Falls | 1 | 106.77 | 106.77 | 106.77 |
| | Bear Gulch | 11 | 81.65 | 320.92 | 119.75 |
| | Big Southern | 10 | 37.24 | 209.03 | 107.78 |
| | Browns Bench | 26 | 97.40 | 222.12 | 124.65 |
| | Camas Prairie | 1 | 121.25 | 121.25 | 121.25 |
| | Cannonball Mountain | 6 | 84.04 | 84.04 | 84.04 |
| | Coal Bank Spring | 2 | 83.70 | 83.70 | 83.70 |
| | Malad | 23 | 10.58 | 213.67 | 50.03 |
| | Owyhee | 7 | 80.53 | 191.42 | 135.42 |
| | Picabo Hills | 5 | 70.63 | 70.63 | 70.63 |
| | Timber Butte | 19 | 59.98 | 216.82 | 95.62 |
| | Total | 111 | 10.58 | 320.92 | 97.34 |
| 3000-5000 | American Falls | 1 | 106.77 | 106.77 | 106.77 |
| | Big Southern | 4 | 42.34 | 133.22 | 102.68 |
| | Browns Bench | 4 | 97.40 | 161.37 | 113.39 |
| | Double H Mountain | 1 | 304.55 | 304.55 | 304.55 |

| Time Period | Obsidian Source | Artifacts | Minimum | Maximum | Mean |
|---|---|---|---|---|---|
| 3000-5000 (cont.) | Malad | 11 | 10.58 | 10.58 | 10.58 |
| | Owyhee | 1 | 161.77 | 161.77 | 161.77 |
| | Total | 22 | 10.58 | 304.55 | 70.63 |
| 4400-7500 | Bear Gulch | 5 | 51.97 | 401.37 | 209.59 |
| | Big Southern | 4 | 44.27 | 309.73 | 156.11 |
| | Browns Bench | 11 | 97.40 | 266.36 | 148.08 |
| | Cannonball Mountain | 8 | 15.44 | 189.66 | 98.02 |
| | Double H Mountain | 1 | 376.83 | 376.83 | 376.83 |
| | Dooley Mountain | 1 | 73.10 | 73.10 | 73.10 |
| | Kelly Canyon | 1 | 358.93 | 358.93 | 358.93 |
| | Malad | 9 | 10.58 | 146.51 | 25.68 |
| | Obsidian Cliff | 4 | 92.58 | 437.04 | 303.33 |
| | Owyhee | 12 | 43.25 | 433.65 | 163.70 |
| | Paradise Valley | 1 | 455.96 | 455.96 | 455.96 |
| | Picabo Hills | 1 | 70.63 | 70.63 | 70.63 |
| | Sugarloaf | 1 | 50.97 | 50.97 | 50.97 |
| | Timber Butte | 23 | 59.98 | 236.23 | 111.79 |
| | Wedge Butte | 1 | 51.82 | 51.82 | 51.82 |
| | Total | 83 | 10.58 | 455.96 | 138.60 |
| 150-5000 | American Falls | 1 | 276.78 | 276.78 | 276.78 |
| | Bear Gulch | 2 | 173.39 | 261.50 | 217.45 |
| | Big Southern | 2 | 58.70 | 117.58 | 88.14 |
| | Browns Bench | 5 | 97.40 | 189.84 | 141.71 |
| | Cannonball Mountain | 1 | 84.04 | 84.04 | 84.04 |
| | Chesterfield | 2 | 50.94 | 50.94 | 50.94 |
| | Malad | 8 | 10.58 | 213.67 | 69.44 |
| | Obsidian Cliff | 5 | 251.28 | 486.73 | 298.37 |
| | Owyhee | 4 | 80.53 | 326.50 | 142.02 |
| | Timber Butte | 10 | 59.98 | 321.81 | 120.56 |
| | Topaz Mtn | 1 | 166.60 | 166.60 | 166.60 |
| | Total | 41 | 10.58 | 486.73 | 140.73 |
| 7500-10200 | American Falls | 2 | 106.77 | 106.77 | 106.77 |
| | Bear Gulch | 1 | 261.50 | 261.50 | 261.50 |
| | Big Southern | 7 | 117.58 | 117.58 | 117.58 |
| | Browns Bench | 9 | 97.40 | 189.16 | 121.81 |
| | Cannonball Mountain | 2 | 84.04 | 84.04 | 84.04 |
| | Malad | 2 | 160.48 | 213.67 | 187.08 |
| | Summit Lake | 1 | 324.51 | 324.51 | 324.51 |
| | Timber Butte | 4 | 59.98 | 59.98 | 59.98 |
| | Total | 28 | 59.98 | 324.51 | 125.04 |
| 10200-11000 | Big Southern | 6 | 57.27 | 57.27 | 57.27 |
| | Browns Bench | 1 | 97.40 | 97.40 | 97.40 |
| | Malad | 1 | 134.97 | 134.97 | 134.97 |
| | Total | 8 | 57.27 | 134.97 | 72.00 |