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Upland Land Use and Intersite Lithic Assemblage Variation Across Two Rockshelter and Three Open-Air Archaeological Sites in Mount Rainier National Park

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UPLAND LAND USE AND INTERSITE LITHIC ASSEMBLAGE VARIATION ACROSS TWO ROCKSHELTER AND THREE OPEN-AIR ARCHAEOLOGICAL SITES IN MOUNT RAINIER NATIONAL PARK

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by

Caitlin Paige Limberg

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ABSTRACT

UPLAND LAND USE AND INTERSITE LITHIC ASSEMBLAGE VARIATION ACROSS TWO ROCKSHELTER AND THREE OPEN-AIR ARCHAEOLOGICAL SITES IN MOUNT RAINIER NATIONAL PARK

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Two sites from the Late Holocene period, the Fryingpan and Berkeley Rockshelters, are analyzed using an evolutionary archaeology model to test hypotheses about site-type expectations. Under the existing theoretical model, rockshelter sites on the slopes of Mount Rainier were used for a more limited activity set than some open-air sites. Rockshelter sites are thought to be places of short-term occupancy consistent with hunting and/or overnight residence activities. Large open-air sites with relatively dense and materially diverse lithic artifacts are thought to be longer-term residential base camps. Technological and functional paradigmatic lithic classifications are used to measure how rockshelter and larger open-air sites vary. The analysis is reduced further to focus on how the two rockshelter sites vary independent to each other, compared to the open-air Sunrise Ridge Borrow Pit site. Non-random associations of data frequencies across technological variables exhibited by the lithic assemblages determined that rockshelter lithic assemblages are representative of a truncated range of variability compared to open-air site assemblages.

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This thesis could not have been completed without the prior work done by the individuals who analyzed the lithics from the open-air residential sites used for comparison in this thesis: Kevin Vaughn, Patrick Lewis, David Davis, and Joy Ferry. Numerous friends and colleagues contributed large and small to the completion of this document, and for that, I am eternally grateful. Finally, I would like to thank Mount Rainier National Park and the National Park Service for lending me the Fryingpan and Berkeley Rockshelter collections so I could perform this research.

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CHAPTER I

INTRODUCTION

Burtchard's (1998:112-120) archaeological site taxonomy model proposes functional, content, and location expectations for archaeological site types found on the slopes of Mount Rainier. Rockshelter sites are included among his *Limited-task Field or Hunting Camps* category (Burtchard 1998:113-114), and were used as places of short-term residence for small hunting groups. Burtchard suggests that tasks performed at field camp sites were limited to direct or indirect associations with hunting or overnight residence, including moderate butchering and cooking activities. Lithic assemblages from these sites are expected to be dominated by late stage debitage and light tools (e.g., cores, bifaces, flake tools, and projectile points). Heavy stone tools (e.g., hammer and grinding stones) and early stage reduction of locally available tool stone raw materials may occur in low frequency in these settings, while debitage from stone tool maintenance, repair, and late stage manufacture would be expected in a higher frequency. Rockshelters may have associated hearth features and/or stacked stone walls for windbreaks. Rockshelters are generally found in subalpine contexts, their location dictated by local geology. Recent analyses indicate Burtchard's (1998:112-120) predictions for rockshelter sites appear to be correct (Andrews et al. 2016). However, it is unclear how rockshelter lithic assemblages compare to larger, open-air sites that are not constrained by small spaces.

Burtchard (1998:112-113) suggests that several large, open-air sites on Mount Rainier supported longer-term residential groups, and thus were associated with more types of functionally varied activities and longer residence. Lithic assemblages from sites he classifies as *Multi-task, Mixed Group, Residential Base Camps or Residential Field*

Camps (Burtchard 1998:112-113) should be diverse; consisting of heavy and light tools, a high density of debitage from various stages of manufacture, and high raw material variability. Hearth features, and features associated with smaller limited-task sites (including rockshelters) and from plant and animal processing locations, also should be found at open-air residential base camps (Burtchard 1998:113). These base camp locations are expected to be found in upper forest to lower sub-alpine settings, which provide the most effective access to upland resources while maintaining more stable and predictable weather conditions (Burtchard 1998:113).

If limited-task field camps genuinely represent differential use of the upland landscape compared to residential base camps, then the organization of technology at these contrasting locations also should differ in quantifiable, if subtle, ways. Using paradigmatic classification, a high-resolution lithic analysis, I hope to identify these differences, if any. By assessing the degree to which lithic assemblage technological and functional traits vary between large upland open-air (ostensibly residential base camp) sites and rockshelter limited-task field camp sites, this research will contribute towards the regional knowledge of how people used upland environments differently in the past.

Problem

While there has been theoretical development of what we should expect to find in the upland archaeological record on Mount Rainier and in the western Washington Cascades (e.g., Burtchard 2007), formal analyses of chipped stone tool assemblages associated with that record have primarily focused on the characterization of individual sites (e.g. Andrews et al. 2008; Andrews et al. 2016; Dampf 2002; Ferry 2015; Lewis

2015; Schurke 2011; Vaughn 2010). There has been little formal comparison focusing on differences across Burtchard's (1998) site types.

Purpose

The primary research question for this thesis is: are the selective conditions under which past people made and used stone tools different across site types on Mount Rainier? This research determines the degree to which rockshelter site assemblages are technologically and functionally similar or different when compared to three open-air sites (as described in Burtchard 1998:112-120), and if the composition of a rockshelter assemblage is unique, or if these assemblages are subsets of larger, open-air site lithic assemblages.

The purpose of this research is to evaluate whether the selective conditions for stone tool manufacture and use at Mount Rainier rockshelter sites (Fryingpan [45PI43] and Berkeley [45PI303]) were sufficiently different from those at Mount Rainier's larger open-air archaeological sites (Tipsoo Lakes [45PI406], Sunrise Ridge Borrow Pit [45PI408], and Forgotten Creek [45PI429]) to be reflected in their respective archaeological assemblages. This comparison focuses on the relative frequencies of functional and technological lithic artifact traits to determine if limited task field or hunting camp rockshelter lithic assemblages represent a truncated range of variability compared to multitask residential base or field camp open-air site assemblages, as suggested by Burtchard's (1998:112-120) site type model. This purpose is achieved through the following four objectives.

Objective one uses an existing model of stone tool cost and performance (McCutcheon 1997:207-212) that that identifies the variables necessary for describing the selective conditions under which stone tools were manufactured and used at any particular location. The selective conditions were those environmental conditions that may have influenced assemblage structure, frequency, and distribution. The model as adapted for this research asks as its central question whether or not the selective conditions that influenced stone tool manufacture and use varied among rockshelter and open air sites. An application of a theoretically-based technological and functional classification allows for analytical decision-making to be phrased as a hypothesis, which provides a testable and replicable measure of technological and functional variation (Dunnell 1978a, 1978b). Limiting comparisons to artifact traits allows for variable frequencies of technological and functional traits from different archaeological deposits to be used for testing established expectations for the archaeological record on the slopes of Mount Rainier.

Objective two is to generate data for Fryingpan Rockshelter and Berkeley Rockshelter by applying the analytical units defined by the cost and performance model, and assess for quality control and sample size adequacy. All three of the large open-air sites (45PI406, 45PI408, and 45PI429) have been classified by Burtchard (1998:113) as residential base camp sites. These three sites were selected for this study due to their functional site type classifications. Data from the residential open-air site lithic assemblages have been generated in previous studies using the same analytical key used in this study, making the data directly comparable.

A random 10% sample of all artifacts analyzed was checked for quality control by the author and her mentor, Dr. Patrick T. McCutcheon. To ensure sample size adequacy, a computer-based statistical technique known as resampling was used to compare the shape and characteristics of frequency counts within the resampling curves (after Evans 2009; Ferry 2015; Lewis 2015; McCutcheon 1997:290; Vaughn 2010). Conclusions drawn from representative sample sizes were made with higher levels of confidence than unrepresentative ones (following Vaughn 2010).

Objective three is to statistically analyze the data. All statistical analyses performed for this research were performed at a 95% confidence level ($\alpha = 0.05$). To determine what differences/similarities exist among the sites, a stepwise analytical approach was followed. The statistical approach consists of first testing for associations among sites using a chi-square test, followed by an analysis of residuals if significant non-random associations were found. Finally, an application of Cramér's *V* identifies the strength of magnitude of non-random associations. This statistical approach is similar to those used in previous research analyzing lithic assemblages (after Evans 2009; Ferry 2015; Kassa and McCutcheon 2016; Lewis 2015) and is effective for determining the differences attributable to differences in selective conditions across time, or in the case of this research, across space.

Objective four will place rockshelter sites 45PI043 and 45PI303 into technological and functional contexts compared to large open-air sites 45PI406, 45PI408, and 45PI429. Any meaningful associations found from statistical analyses will be interpreted with respect to the site-type expectations (as described in Burtchard 1998:112-120), and the relative robustness versus subtlety of the patterns evaluated.

Significance

Although Mount Rainier's upland landscapes were used for thousands of years (Burtchard 2007:3), archaeologists are still refining their understanding of how land use patterns varied across space, how they changed through time; and, importantly, whether or not there are unique archaeological signatures left by these various uses. This research focuses on contributing towards the goal of improving our understanding of spatial variation in pre-contact human land use patterns (*sensu* Burtchard 1998:147-153). The addition of 45PI034 and 45PI303 into Central Washington University's Mount Rainier lithic database contributes to information generated by previous undergraduate and graduate students at the university (Dampf 2002; Ferry 2015; Lewis 2015; Vaughn 2010). As more assemblages are analyzed using this protocol, a wealth of information grows that is readily comparable for a number of archaeological studies. Additionally, the proposed research will benefit cultural resource management by furthering the scientific understanding of the spatial data in human land use patterns. Understanding that data will allow us to make empirically based judgments about how to preserve and conserve the archaeological record.

In Chapter 2, the environmental zones, flora, fauna, and geological resources surrounding the sites included in this study are explained. Brief histories of prior excavations and analyses of the five sites are provided, as well as the details of the assemblage compositions. Chapter 3 provides a literature review that is structured around the four research objectives outlined above, including: application of an existing stone tool analysis model, data generation and resampling, statistical analysis of the data, and interpreting the data as other have done before me. Chapter 4 details the method and technique used for generating the two rockshelter lithic datasets, and provides the paradigmatic classification keys used in analysis.

Chapter 5 provides results and discussion of one permutation of data analysis: dividing the five sites into two site types (open-air residential base camps and rockshelter limited-task hunting camps), and comparing the collapsed site-type assemblages. Chapter 6 is a journal manuscript based on a more limited comparison of only three sites, to assess the variability of rockshelter lithic assemblages, compared to a well-documented open-air residential base camp site. Following this chapter are the comprehensive references and appendices containing raw analysis data from this research.

CHAPTER II

STUDY AREA

Because of Mount Rainier's significant altitudinal range, several distinct environmental zones characterize its lower to upper slopes. These differences affect the abundance and variety of economically valued resources on the mountain. Resource availability, for example, is influenced broadly by forest maturity, or seral state, which is dictated primarily by elevation and associated snow-load.

The ecological maturation process of forests can be broken into several seral succession stages (Hall et al. 1995), which are more of a continuum than simple linear sequence. Forest associations in the maritime Pacific Northwest tend to mature to a high seral stage relative to dryer forest associations further inland. These late seral stage maritime habitats typically support more limited and less diverse biota than do places where the succession process has been suppressed by mechanisms such as fire, seasonal inundation, persistent snow-load, land-slides, and the like. These differences had consequences for precontract human populations which, all else being equal, benefitted from the food resource diversity and relative abundance of the more open lower seral stage habitats (cf., Burtchard 1998:15-16, 2007-4).

There are several distinctive climatic-biotic zones represented on the slopes of Mount Rainier (Burtchard 1998, 2007; Smith 2006:4; St. John and Warren 1937). Mid to early seral stage habitats tend occur in mid to upper elevation subalpine to alpine zones. Lower seral stage forest associations dominate the lower slopes. The five sites featured in this analysis span two of these zones: the upper fringe of the northwest maritime forest (residential sites 45PI408 and 45PI429), and subalpine parkland (rockshelter sites 45PI043, 45PI303, plus residential site 45PI406).

While varying somewhat with wetter windward versus dryer leeward settings, late seral stage northwest maritime forest dominates Mount Rainier habitats from about 1070 m (3500 ft) to about 1370 m (4500 ft) in elevation. In this zone, western white pine, white noble fir, silver fir, spruce, Douglas-fir, western red cedar, and western hemlock occur in dense stands; although the trees here tend to be smaller than those found at lower elevations (Burtchard 1998:20; Smith 2006:5; St. John and Warren 1937:953). Animal species common to northwest maritime forests include several species of woodpecker, the Stellar jay, brown bat, bobcat, black-tailed deer, elk, black bear, Cooper chipmunk, mountain and American beavers, and snowshoe rabbit (Burtchard 1998:20; Smith 2006:4-5).

Again, varying by setting, Mount Rainier's lower seral stage subalpine parklands grade from the upper margin of the northwest maritime forest to about 1830 m (6000 ft) in elevation. Within this ecological zone, large meadows can be found between hardy stands of timber such as the subalpine fir, mountain hemlock, Alaska yellow cedar, white-bark pine, and others (Burtchard 1998:20; Smith 2006:5; St. John and Warren 1937:953-954). Animal species common to subalpine communities include the golden eagle, saw-whet owl, calliope hummingbird, western sparrow, red fox, hoary and whistling marmots, mantled ground squirrel, pika, coyote, black bear, mountain lion, elk, and black-tailed deer, as well as mountain goats, alpine grouse and ptarmigan (Burtchard 1998:28; Smith 2006:5).

While faunal variation does not seem readily apparent across these two ecological zones, overall diversity is greater in the subalpine community, and importantly, there is a substantially higher abundance of larger and fatter animals seasonally at higher elevations (Burtchard 1998:28).

Treeless alpine tundra ranges from about 1830 m (6000 ft) to about 2320 m (7600 ft). While rising with climatic warming, the landscape above this elevation is dominated by permanent snowpack. Mountain glaciers extend down major valleys into alpine and subalpine habitats below.

Lower alpine, subalpine, upper forest ecozones are of particular interest here, because of their tendency to support a higher density and diversity of economically useful plant and animal species relative to more barren habitats above, and denser forest associations below (Burtchard 2007:4). The open to patchy quality of these places (at least for alpine and subalpine zones) on Mount Rainier is due to persistent, late-melting snow. In the subalpine parklands, the valleys and slopes tend to be covered with snow for approximately eight to nine months of the year. However, when the snowpack melts in early summer, the meadows bloom with Mount Rainier's famously picturesque mountain flowers.

Rapid-growth plants provide the best forage for ungulates, smaller mammals, and birds, and the maturity suppressing effect of heavy snowpack and a short growing season enhance the productivity of the subalpine meadow (Burtchard 1998:25). Huckleberries and alpine lilies found in the subalpine parkland produce directly consumable plants, which also have been important resources. Emphasizing the resource qualities, large scale, and interconnected quality of subalpine to low alpine habitats on Mount Rainer, Burtchard (1998:28; 2007:4) suggests that they have been the focus of human foraging and collecting practices throughout much of human prehistory in the region.

Open forest-tundra habitats may have become established at low to mid-elevation landscapes on Mount Rainier as early as 12,000 ^{14}C years B.P. (Burtchard 2007:16). Currently, the oldest known archaeological site on Mount Rainier is the Buck Lake site (45PI438), which contains lithic artifacts dating to 7173 ± 49 ^{14}C years B.P. from a pre-Mazama stratigraphic context (Burtchard 2007:17). Burtchard believes that persistent glacial ice probably precludes earliest human use of upper elevation landscapes on the mountain before about 9,000 ^{14}C years B.P., though new environmental data may set this time frame back even further (Burtchard 2007:17; personal communication 2014).

Geology and Volcanism

Mount Rainier has been built over millions of years by the subduction of the Juan de Fuca Plate beneath the North American Plate off the western coast of the Pacific Northwest (United States Geological Survey 2013). Two different deposits were created between 25 and 30 million years ago, these being the Fifes Peak Formation, a bed of basalt and andesite (Fiske et al. 1963:30), and the Stevens Ridge Formation, which consisted of welded tuff and pumice flows (Crandell 1969:7; Fiske et al. 1963:21). Additional eruptions intruded granodiorite flows, which cooled and remained underground primarily, but also spread to the surface, where it remains as one of the most conspicuous rocks in Mount Rainier National Park, with a distinctive salt-and-pepper appearance, known today as the Tatoosh pluton (Crandell 1969:8-9, Fiske et al. 1963:42-46).

Throughout the Pliocene and Pleistocene, the Cascade Range went through several periods of uplift and erosion, as well as repeated events of glaciation. According to Crandell and Miller (1974:3), the area's last major glaciation ended about 10,000 years ago. Since that time, several large rock and debris flows have occurred on Mount Rainier; the most notable being the Osceola Lahar, responsible for the destruction of Mount Rainier's previous summit approximately 5,800 years ago (Crandell 1969:36-38). Holocene volcanism resulted in widespread, thin, surface deposits of pumice and pyroclastic material around Mount Rainier and twenty-two well stratified tephra layers have been identified across the park; tephra layers represent eleven eruptive sequences from Mount Rainier, ten from Mount St. Helens, and one from prehistoric Mount Mazama (Mullineaux 1974).

Eruptions of the central vent at Mount Rainier's summit 2340 ± 200 ^{14}C years B.P. are likely those that formed the present summit cone of the volcano (Mullineaux 1974:18), known today as the Columbia Crest (Graham 2005:20). This later sequence of eruptive events is known as the Mount Rainier-C ("MR-C") tephra. Because the deposits are relatively conspicuous and widespread (Mullineaux 1974:23-26), they are useful for archaeologists when establishing the relative ages of artifacts found within the tephra layers. The MR-C tephra has been used to broadly split artifact assemblages associated with precontact occupation of Mount Rainier's flanks into two coarse components, the later "above MR-C" component, and the older, underlying "below MR-C" component.

Recent analysis of the observed stratigraphy and depositional context at the large Sunrise Borrow Pit site 45PI408 indicates that using the broad "above and below" MR-C stratigraphic layer to interpret depositional history appears to be valid means to distinguish between pre-and post- MR-C cultural events. The above MR-C component, consisting of the MR-C tephra, the Mount Saint Helens-W tephra, and the buried soils between and above them, appears to be reliably recorded in field observations according to pH, grain-size and elemental analyses (Stcherbinine and McCutcheon 2017).

Toolstone

Toolstone found in the Park consists of locally derived fine-grained volcanic stone cobbles (primarily andesite), as well as cryptocrystalline silicate rock (Burtchard 1998:92-93). The presence of raw material sources on the slopes and in river gravels around Mount Rainier suggests that local materials were used for expedient tools. However, imported materials such as obsidian and exotic cherts also are common components of lithic assemblages in the Park. Several potential lithic raw material source locations have been noted in the Park, including crypto and mesocrystalline silicates found in granodiorite outcrops in Mystic Park on the mountain’s northwest quadrant, and other places in the geologically older Tatoosh pluton flanking the edifice of Mount Rainier, which contains precipitate pockets of chert (McCutcheon and Dampf 2002:37; Bergland 1988:15). Tool stone has also been reported trailside at Berkeley Park and the Mount Fremont Lookout on the north, as well as the Pyramid Peak Quarry Site, located on the northwestern side of the park near Pyramid Mountain (Burtchard et al. 2007).

Site Descriptions and Previous Research

This research focuses on five archaeological sites found in Mount Rainier National Park (Figure 1); two rockshelter sites, Fryingpan Rockshelter (45PI043) and

Berkeley Rockshelter (45PI303) will be compared to the larger, open-air Tipsoo Lakes (45PI406), Sunrise Ridge Borrow Pit (45PI408) and Forgotten Creek (45PI429).

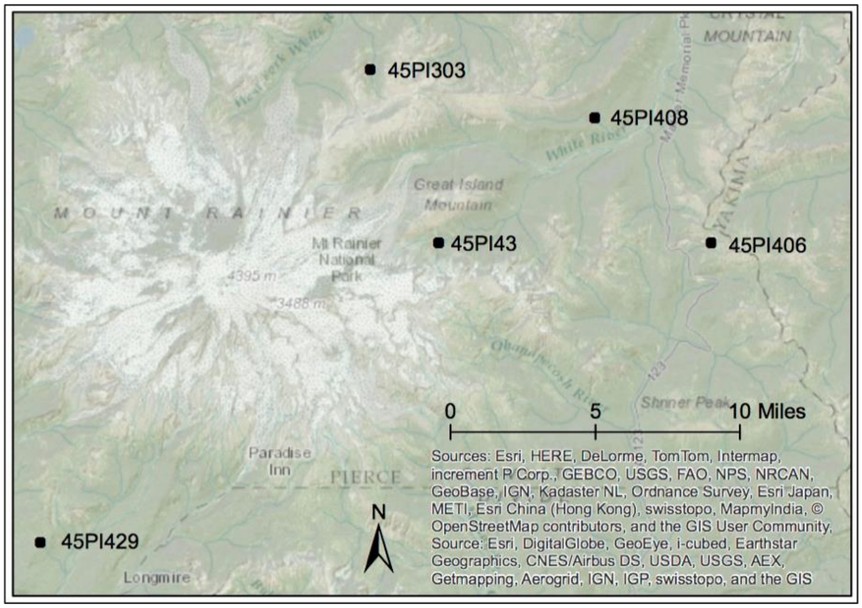

Figure 1: Map of archaeological sites included in study (created by the author from ESRI basemap).

Fryingpan Rockshelter (45PI043)

The Fryingpan Rockshelter site (45PI043) covers an area of 36 m^2, and contains a single small overhang, about 11 m wide by 4 m deep, with a roof about 5 m from the floor (Rice 1965:3; Lubinski and Burtchard 2005:35). The north-facing shelter is set into an andesite cliff at 1646 m (5400 ft) elevation above sea level providing shelter from south and southwest storms, and hosting a panoptic view of Fryingpan Creek, which is fed by the Fryingpan Glacier (Rice 1965:1-2; Burtchard and Hamilton 1998:9-10). The shelter itself is located roughly 30 m above the valley floor and 70 m south of Fryingpan Creek, and was once bisected by a large Pacific silver fir tree that grew at its approximate center (Rice 1965:2; Burtchard and Hamilton 1998:10; Lubinski and Burtchard 2005:35), but has since been removed to preserve site context.

45PI043 was recorded initially during the first formal archaeological resource survey of the Park in 1963 (Daugherty 1963; Burtchard 1998:51). The site was first excavated in 1964 (Rice 1965). In Rice and Nelson's 1964 excavation, artifacts were recovered from one 1.25 x 1.85 m excavation unit that was 40 cm deep (Lubinski and Burtchard 2005:36; Rice 1965). Possible looting at the site was noted when the site was revisited and tested in 2001. During the 2001 project, backfill from the original test unit was removed and rescreened with 1/8 inch mesh screen; as well as a pile of fill that had been removed by possible wrong-doers (Lubinski and Burtchard 2005:36). In addition, two new 50 x 60 x 94 cm units were excavated adjacent to the original unit, and the original unit was excavated an additional 20 cm to confidently reach the range of culturally relevant sediments (Lubinski and Burtchard 2005:36). A calculation of volume excavated is approximately 2 cubic meters. All artifacts from 45PI043 were recovered above the MR-C tephra layer. Deposits at the site date between 250 ± 40 ^{14}C years B.P. and 1150 ± 40 ^{14}C years B.P. (Lubinski and Burtchard 2005:37). More recent radiocarbon assay of charcoal and calcined bone samples from one of two hearth features indicate use approximately 529 to 314 cal. B.P. (Chatters et al. 2017) consistent with the previously established range. Over 2100 lithic artifacts were recovered from the site, of which 1593 tools and flakes were 1/8-inch and greater in size and were analyzed for this study.

Berkeley Rockshelter (45PI303)

The Berkeley Rockshelter site (45PI303) covers approximately 100 m^2, and contains two double-ended rockshelters formed under three large granodiorite boulders resting upon each other in a roughly east-west line (Bergland 1988:3). The westernmost, “upper,” shelter is about 3.5 m wide by 7.6 m deep, with a roof about 2 m from the floor, while the easternmost, “lower,” shelter is slightly larger measuring 9.1 m deep by 3.0 meters wide with a roof height varying from 1.8 to 2.5 m (Bergland 1988:3).

The shelters are set in roughly north-south linear orientations at an elevation of 1719 m (5640 ft) in the upper reaches of the Lodi Creek Valley, 125 m east of Lodi Creek; there is no view of Mount Rainier from the site (Bergland 1988:2). 45PI303 was first test excavated in 1987; all visible historic and lithic surface artifacts were collected, one 1 x 1 m excavation unit was set into the lower shelter, and one 50 x 50 cm unit was placed in the upper shelter (Bergland 1998:7).

In 2002, one constant volume sample (CVS) shovel test unit (after Burtchard and Miss 1998:75-79), and an additional 1 x 0.5 m excavation unit was placed in the lower shelter (Andrews et al. 2016:169). In total, approximately 1.5 cubic meters have been excavated at 45PI303. Radiocarbon samples from 45PI303 site had a ranged between 1070 ± 90 B.P. (Bergland 1988:33) and the modern ground surface. Consistent with this range, all artifacts were recovered from above the MR-C component.

The collection of lithic artifacts from 45PI303 consists of 1,709 pieces. This assemblage recently was analyzed using a six-stage system developed by Flenniken (1981) (Andrews et al. 2016). Andrews et al. (2016:176) focused on only formed tools and 585 flakes, which were deemed “technologically diagnostic.” They concluded that the lithic assemblage from 45PI303 fits the limited suite of activities associated with a field hunting camp. Specifically, Andrews et al. conclude that functions at the rockshelter focused primarily around projectile point repair/maintenance and arrow shaft creation/maintenance (2016:184).

Interesting as it was, the analytical dimensions of the Andrews et al. (2016) study were not directly comparable with those used for the analyses of 45PI406, 45PI408, and 45PI429. In order to answer the research questions posed in this study, I generated a new dataset for the Berkeley assemblage by analyzing 1,096 flakes and tools from 45PI303. Flakes less than 1/8 inch in size (n=613) were removed from the sample and were not analyzed for this study.

Sunrise Ridge Borrow Pit (45PI408)

Sunrise Ridge Borrow Pit (45PI408) is located on the eastern slope of Mount Rainier at an elevation of 1310 m (4300 ft) above sea level. The large site is scattered with lithic debitage across most of the bench formation, and contains a borrow pit near the middle of the site, associated with construction of the Sunrise Park Road in the 1930s (Dampf 2002:11). The Borrow Pit landform is a natural south-facing mid-slope bench or glacial kame terrace (McCutcheon and Dampf 2002:19) overlooking the White River canyon. The site covers 2,550 m^2 and is defined by the kame terrace edge and Sunrise Park Road skirting the southern edge of the landform (Burtchard and Hamilton 1998:61).

The site was first recorded by Rick McClure in 1990, and documented again by Burtchard and Hamilton in 1995 (see Burtchard 1998:57). Testing and excavation at 45PI408 has been the focus of research for Central Washington University's field schools directed by Dr. Patrick McCutcheon between 1997 and 2001, and again from 2011 to 2013.

Systematic efforts to document the scope of artifacts horizontally and vertically at the site began in 1997 with the first of the CWU archaeological field school projects.

Over the course of five archaeological field schools, 182 subsurface test pits were conducted at the site; test pits were excavated as CVS units and as 50 x 50 cm square units (Dampf 2002:15-16; McCutcheon and Dampf 2002:19-20; Lewis 2015:22-23; McCutcheon 1999:14).

From 2011 through 2013, field schools resumed at 45PI408; focusing on data recovery in large block excavation. During this time, nineteen 1 x 1 m units were excavated by naturally occurring depositional layers (Lewis 2015:23). A total of 14,317 chipped stone artifacts were recovered over the eight years of investigations at 45PI408, and 34.14 cubic meters of sediment was excavated. The site is well-stratified and has both above and below MR-C components, and has numerous radiocarbon and luminescence dates ranging from 4,086 to 100 cal. years BP (McCutcheon et al. 2017, in preparation). A subset of 4,601 of the recovered lithic artifacts from 45PI408 are from above the MR-C unit. Analytical data generated for this assemblage has been the focus of several research projects and was the undertaking of many students throughout the years (Dampf 2002; Davis et al. 2016; Lewis 2015; McCutcheon et al. 2017, in prep; Vaughn 2010).

Tipsoo Lakes (45PI406)

The Tipsoo Lakes (45PI406) site covers 4,000 m^2 of terrain surrounding and connecting several small lakes, a location now used as hiking trails and a paved picnic area. The site is located 1622 m (5320 ft) above sea level, approximately 350 m southwest of Chinook Pass, near the eastern edge of the Park boundary (Burtchard and Hamilton 1998:53).

45PI406 was originally recorded in 1988 (Forrest 1989), and surveyed again in 1995 (Burtchard and Hamilton 1998:63). Subsurface testing was conducted at the site in association with various road, parking lot and visitor service revisions between 1995 and 2010. These include testing by park archaeologist Gregg Sullivan ca. 1995-1996, field school testing in 2000, and testing by park archaeologists in 2002 and 2007 (Vaughn 2010 and Burtchard pers. com.) Total excavated volume from these projects is between two and four cubic meters extracted from various locations within site boundaries.

At excavation, the presence of historic artifacts in some units was noted, as well as mixed tephra layers due to bioturbation and possibly freeze/thaw action (Vaughn 2010), which have resulted in an inability to segregate the assemblage into distinct temporal components; limiting the collection to whole site comparison. The 45PI406 analytical lithic data were generated by Vaughn (2010) using the same methods and techniques employed here; 770 chipped stone tools and flakes from his analysis are included in this research.

Forgotten Creek (45PI429)

The Forgotten Creek site (45PI429) is a 2700 m^2 flat situated between two north and south trending ridges on the southwestern slope of the mountain (Burtchard and Hamilton 1998:145). Forgotten Creek is located at 1286 m (4220 ft.) elevation. The site is on level ground at the top of a small spring in the upper Nisqually River Valley.

45PI429 was first recorded by Burtchard and Hamilton in 1995. In 2010, Burtchard and crew discovered artifacts in nine of eighteen CVS test units excavated across the site surface; continued testing in 2011 guided by CVS results yielded lithic debitage from two more CVS units, and from two 1 x 1 m excavation units (Burtchard 2010 and 2011; Ferry 2015:10). An estimate of volume excavated at 45PI429 is just over 2 cubic meters. The site consists of both historic and prehistoric artifacts, and 1,104 tools and pieces of lithic debitage were analyzed by Joy Ferry (2015). A total of 716 of these lithic artifacts were excavated from above the 2,260 cal. years BP MR-C tephra layer and were selected to be used in this study.

Table 1. Archaeological Site and Assemblage Information

Site	Volume Excavated	Site Size	Sample Size	Approximate Lithic Density
45PI043 – Fryingpan Rockshelter	2 m^3	36 m^2	1,593	1050/ m^3
45PI303 – Berkeley Rockshelter	1.5 m^3	100 m^2	1,096	1139/ m^3
45PI406 – Tipsoo Lakes	2 to 4 m^3	4,000 m^2	770	256/ m^3
45PI408 – Sunrise Ridge Borrow Pit	34.14 m^3	2,550 m^2	4,601	419/ m^3
45PI429 – Forgotten Creek	2+ m^3	2,700 m^2	1,104	501/ m^3

Overall, the approximate lithic density is much higher at the two rockshelter sites (45PI043 and 45PI303) than at the three open-air residential sites (45PI406, 45PI408, and 45PI429) (Table 1). However, it is important to note that the overall area of the rockshelter sites (both under 100 m^2) is significantly smaller than the area of any of the open-air residential sites (all three are over 2,500 m^2), which likely inflates the approximate calculated lithic density at the rockshelter sites. The open-air residential Sunrise Ridge Borrow Pit site is the most extensively excavated and investigated site included in this study: its multiple-temporal component assemblage is comprised of almost three times more artifacts than at any of the other comparative sites, and the volume excavated is more than eight times that excavated at any other site.

The following chapter reviews relevant literature contextualizing the research performed in this study, and establishes the relative location of this research in the context of relevant previous studies.

CHAPTER III

LITERATURE REVIEW

The following section will provide literature review for the fundamental ideas and context of my research. This section will be structured per the objectives set in Chapter 1, and will review relevant previous research setting the context for each objective.

Objective 1: Application of Existing Models

Burtchard (1998:125) states "dominant cultural patterns at any given point in time and place reflect dynamic system states rooted in complex and ongoing feedback relationships between humans and the environments within which they strive to survive and reproduce (*cf.* Leonard and Reed 1993:649-650)." It is reasonable to argue that the variation in technological and functional traits in the archaeological record on the northeastern slopes of Mount Rainier is a result of natural selection acting on people. Distinguishing the kind of selection observed in the lithic assemblages may help to identify the precise selective conditions responsible for changes in technological and functional trait frequency (Ferry 2015; McCutcheon 1997:213) across space. In this research context, this distinction will identify how lithic assemblages in rockshelter settings are different or similar to assemblages from open-air settings and permit a narrative to be written about why those differences, or the lack there of, exist. It is, however, possible that selective constraints common to montane environments may override, and limit assemblage variability (Lewis 2015:14).

Andrefsky (1994) notes a correlation between raw material availability and lithic assemblage characteristics such as abundance, quality, location, and knowledge of tool stone sources. Where lithic quality and abundance are both high, formal and informal tool production occur; where lithic quality is high but lithic abundance is low, primarily formal tool production will take place; where lithic quality is low but lithic abundance is high, there will be primarily informal tool production, and likewise, when lithic abundance and quality are both low, primarily informal tool production will occur (Andrefsky 2005:159).

Kassa and McCutcheon (2016) evaluate these predictions about lithic raw material quality and abundance; as Andrefsky's (1994) model predicted, the dominant local source was a lower quality, as was exhibited by a statistically significant presence of random solid inclusions and void inclusions that affect tool-stone quality. The presence of these inclusions increases the cost of using these materials by decreasing the predictability of fracture (Kassa and McCutcheon 2016: 93). Despite this increased cost, local obsidian was predominant, indicating that the nearby location reduced the material costs, while materials from nonlocal sources contained almost no inclusions.

Two kinds of strategies are expected for facilitating human uses of the environment: expediency and curation (Nelson 1991:62-64). Curated technologies include advanced manufacture, transport, reshaping, and caching or storage, while expedient technologies involve planned stockpiles of raw material, availability of time for tool manufacture, and a residential base for raw material stockpiling. Artifact forms and assemblage composition are outcome of humans implementing expediency and curation in different ways, and thus leads to expectations about how humans organized on the landscape, or how humans mapped onto resources on that landscape (Binford 1980; Dunnell 1978b; Dunnell and Dancey 1983). Nelson (1991) raises the issue that there are factors that interact with humans creating lithic assemblages outside of general organizational principles such as source location and the surrounding environment. Nelson (1991:81) suggests that there is also an opportunistic element to the organization of technology responsive to immediate, unanticipated conditions, producing irregularity.

While researchers have found utility in modeling past human land use across different geographies (e.g., Binford 1980) and time periods (Schalk and Cleveland 1983, Burtchard 1998 and 2007), difficulties in applying these units to the archaeological record emerge because of a lack of mutual exclusion among the technological organizations (Lewis 2015). Sullivan and Rozen (1985) have shown the benefit created by mutually exclusive attributes in lithic technological studies, and the issues created by their absence. One of the benefits of using an evolutionary approach lies in the adherence to variables and units of analysis that are mutually exclusive (Dunnell 1971:71). By using mutually exclusive classificatory schema, small differences in lithic assemblage characteristics can be identified, and thus the differences in the selective conditions under which past people made and used stone tools can also be identified.

According to Darwinian evolutionary theory, analyzing the distribution of a phenotypic trait allows for one to identify the effects of natural selection on the fitness of that particular trait, which can act on both the cost and performance traits of lithic technology (McCutcheon 1997:207). Under evolutionary archaeology, lithic artifacts can be interpreted as an extension of the human phenotype, and thus fitness of any given trait is assessed as replicative success and selective mechanisms can be identified (Leonard and Jones 1987).

In the context of evolutionary archaeology, there is a mechanism beyond natural selection that is also responsible for sorting the variation in artifact traits: cultural transmission (Dunnell 1978a, 1978b; O'Brien and Lyman 2000; Parfitt and McCutcheon 2017:38). The process of cultural transmission is how ideas are transferred within and between populations: ideas can be passed down from generation to generation over time, or can blend together from populations existing at the same time (Lipo et al. 2006). When variation found in archaeological assemblages does not fit the expected variation driven by natural selection, cultural transmission may provide an alternative explanation for the occurrence of these ostensibly neutral artifact traits. Selectively neutral variation in artifact traits, like ceramic and projectile point styles are sorted by transmission processes and have a different distribution across space and through time (Dunnell 1978a; O'Brien and Lyman 1999). If culturally diverse groups are using similar environments, neutral traits may provide another comparative dimension.

Objective 2: Data Generation and Resampling

The variables developed in previous Mount Rainier research (Dampf 2002; Ferry 2015; Lewis 2015; Vaughn 2010) are useful to achieving my research goals here as they are already operationalized into units of analysis (paradigmatic classifications) that can be used to compare across sites. This method and technique, developed by McCutcheon (1997), outlines the relationships between the variables cost and performance in stone tool manufacture and use.

This cost-performance model (Figure 2) will be used to answer the research question: are the selective conditions under which past people made and used stone tools different across site types on Mount Rainier?

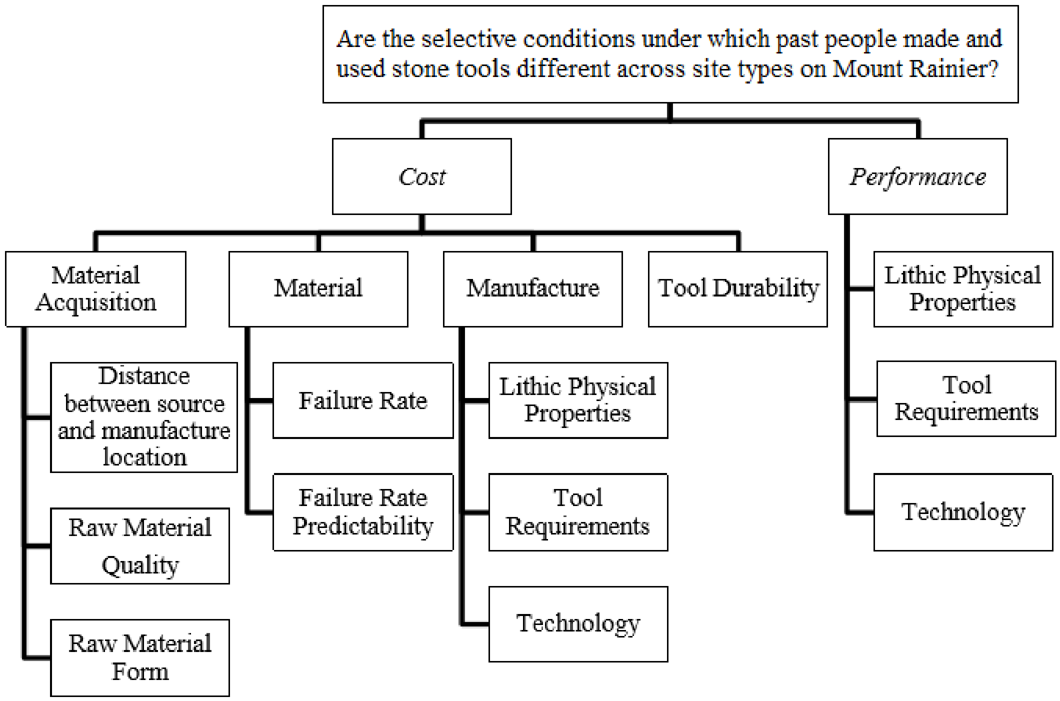

Figure 2. Cost-Performance Model, adapted to an upland context (Ferry 2015:16; Lewis 2015: 6; McCutcheon 1997:208; Vaughn 2010:34).

Because they were used previously in analyses of lithic assemblages from within Mount Rainier National Park (Dampf 2002; Ferry 2015; Lewis 2015; Vaughn 2010), the same three paradigmatic classifications will be used in this analysis: technological, rock physical properties, and wear attributes. Data generated from the analysis of 45PI43 and 45PI303 will be comparable to these previous analyses, aiding in a direct comparison at a much higher resolution than in previous comparative studies to compare trait frequency across archaeological and microenvironmental contexts.

Once generated, rockshelter site 45PI043 and 45PI303 data will be joined with the above MR-C assemblage data from larger open-air sites 45PI406, 45PI408, and 45PI429.

Diversity will be measured in terms of richness, the number of functional and technological classes represented in the assemblages; and evenness, the manner in which artifacts are distributed among the technological and functional classes (Evans 2009:83; Leonard and Jones 1989:2).

To determine whether the richness and evenness of the samples are representative of a population, a technique called *resampling*, based in the statistical strategy of *bootstrapping* (Efron and Tibshirani 1993) is used. The computer program *Resampler* (Mohr et al. n.d.), has been used in similar archaeological studies (see Evans 2009; Ferry 2015; Lewis 2015; McCutcheon 1997; Vaughn 2010) to assess sample size adequacy. *Resampler* generates sampling curve graphs based on frequency data of assemblage dimensions. Rank 1 curves represent data that is rich with even class distributions (Figure 3). Rank 2 curves are generated for data that is rich with uneven distributions (Figure 4). Rank 3 curves represent data with very uneven distribution regardless of richness (Figure 5) (see Evans 2009:84-86; Ferry 2015:21-22, 52-53; Lewis 2015:62-65; McCutcheon 1997:289-290; Vaughn 2010:56-60). Samples falling into Rank 1 or 2 curves are considered representative, and the data is sufficient for intersite assemblage comparisons accurately. Rank 3 curves are considered insufficient for accurately performing intersite comparisons (see Ferry 2015:52; Lewis 2015:62-65; Vaughn 2010:59).

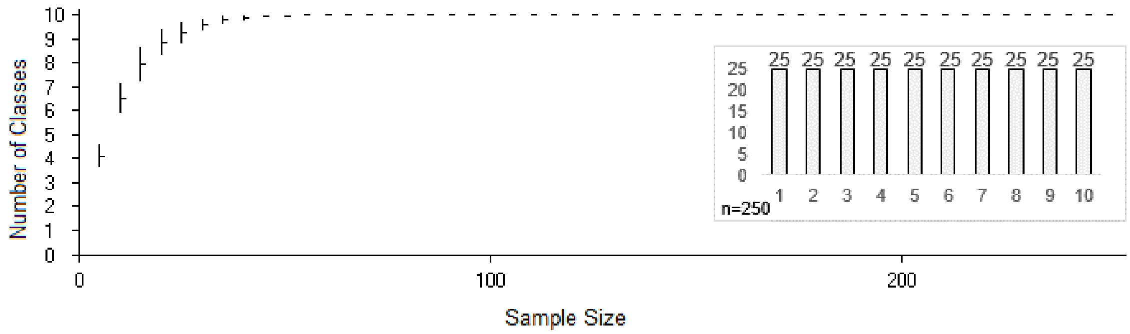

Figure 3. Hypothetical resampling curve generated by the *Resampler* program of a Rank 1 curve. Reaches asymptote before 75% of sample size is reached. Included bar graph indicates the richness and evenness characteristic of datasets generating this shape of curve. Error bars depict standard deviation. Modified from Vaughn 2010:57.

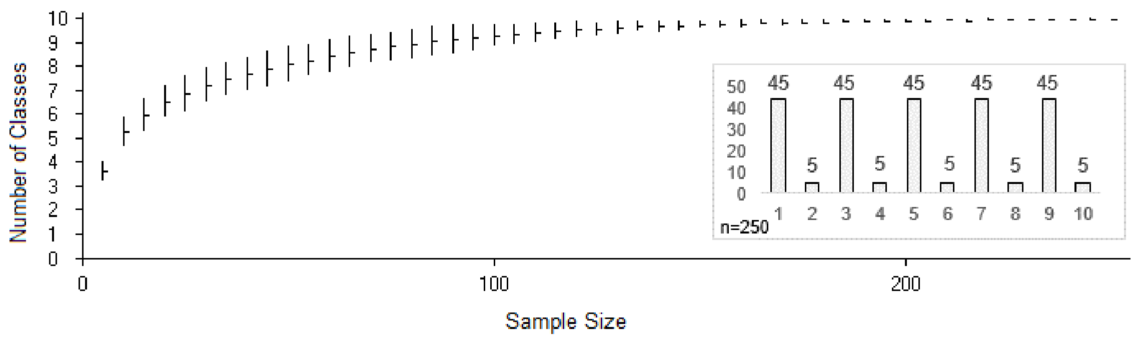

Figure 4. Hypothetical resampling curve generated by the *Resampler* program of a Rank 2 curve. Asymptote, but not before 75% of sample size. Included bar graph indicates the richness and evenness characteristic of datasets generating this shape of curve. Error bars depict standard deviation. Modified from Vaughn 2010:57.

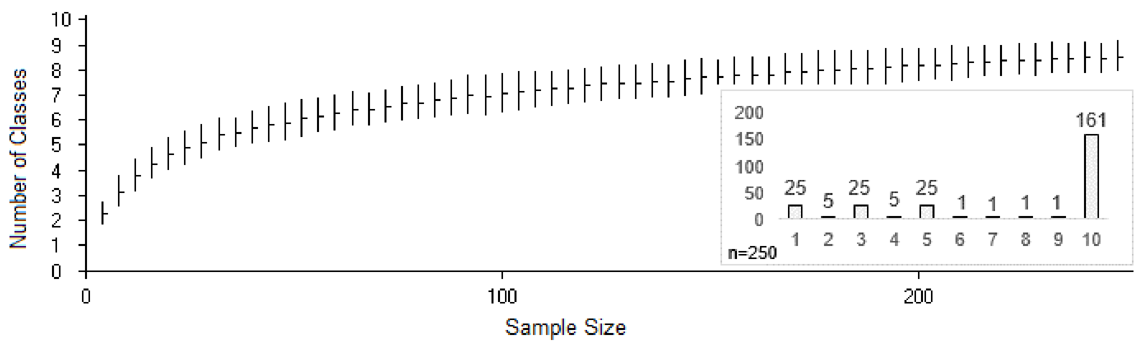

Figure 5. Hypothetical resampling curve generated by the *Resampler* program of a Rank 3 curve. Asymptote never reached. Included bar graph indicates the richness and evenness characteristic of datasets generating this shape of curve. Error bars depict standard deviation. Modified from Vaughn 2010:57.

Objective 3: Statistical Analysis

In order to detect randomness in the sample, a traditional Chi-square (χ^2) test will be used; Chi-square is used to compare observed frequencies with expected frequencies to test for association between one or more variables (Fletcher and Lock 2005:129). When the difference between the observed and expected frequencies is too great to be random, Chi-square can reject a null hypothesis (Zar 1974:46). Chi-squared calculations are made through the use of contingency tables, which utilize the expected and observed frequencies of a dataset, compared to a statistical critical value using the degree of freedom (*df*), or number of independent categories being compared, and an alpha level of 0.05 (Table 2) (Lewis 2015:77-79). When the chi-square value is greater than the critical value, the occurrence of differences is so unlikely to be due to random sampling, a firm rejection of the null hypothesis is determined (Zar 1998:464). Similarly, Log-likelihood ratio (*G*-value) will be calculated when Chi-square is insufficient because of sample size (Lewis 2015:78; Vaughn 2010:60). To calculate the *G*-value, the observed frequencies are used to calculate a test statistic that measures the distance of the actual data from the null expected frequencies; Chi-square distribution is then used to estimate the probability of actually obtaining the value of the test statistic (McDonald 2014:54).

Differences between observed and expected data identified through Chi-square are expressed in the form of residuals, or leftover variation (Drennan 1996:220). These residuals are adjusted for sample size, and the adjusted residuals identify the modes with the most variance from expectations, which are the largest contributors to the rejection of the null hypothesis. Any cell that generates an adjusted residual greater than the critical value for the 0.05 alpha level (± 1.96) is identified as a mode that contributes significantly to the variation in the assemblage. To measure how strong relationships are between variables, Cramér's *V* is calculated. This statistic is based on the chi-square result, and provides a value of magnitude between 0.00 and 1.00 (Cramér 1946:443; Shennan 1997:115). Values closer to 0.00 mean the associations between variables are weaker relationships, values near 0.25 are considered moderately strong, and any value above a 0.40 signifies extremely strong associations between variables (Lewis 2015:81).

Table 2. Equations Used for Statistical Tests (Lewis 2015:79).

Test	Equation	Variables
Chi-Square	$\chi 2 = \frac{\sum(Fo - Fe)^2}{Fe}$	χ^2 – Chi-Square $\sum$ - Sum *Fo* – Frequency Observed *Fe* – Frequency Expected
Cramér's *V*	$V = \sqrt{\frac{\chi 2}{n(k-1)}}$	*V* – Cramér's *V* χ^2 – Chi-Square *n* – Grand Total *k* – the total number or rows or the total number of columns (whichever is fewer)
Log-Likelihood (*G*-value)	$G = 2\left(\sum Fo \cdot \ln\left(\frac{Fo}{Fe}\right)\right)$	*G* – Log-likelihood (G-value) ln - Natural Log
Degree of Freedom	$df = (r-1) \cdot (c-1)$	*df* – Degree of Freedom *r* – number of rows *c* – number of columns
Adjusted Residual	$R = \frac{(Fo - Fe)}{\sqrt{Fe \cdot (1 - RP) \cdot (1 - CP)}}$	*R* – Residual *RP*- Row Proportion *CP* – Column Proportion

Objective 4: Interpretations

To interpret rockshelter and open-air site technological and functional diversity, expectations can be generated and compared to the archaeological record (see Burtchard 1998:112-120). This will identify how lithic assemblages in rockshelter settings are different or similar to assemblages from open-air settings and permit a narrative to be written about why those differences, or the lack there of, exist.

Other researchers have generated and tested hypotheses about precontact land use in the region. Vaughn (2010) compared lithic technology and function across environmental zones at six sites in the southern Washington Cascades. While he notes significant diversity across and within environmental zones, Vaughn (2010) identifies a shift towards bifacial technologies in higher elevation assemblages, particularly in the 45PI406 (Tipsoo Lakes) assemblage (Vaughn 2010:86-87). In addition, Vaughn (2010:89) classifies the 45PI406 and 45PI408 assemblages as Tool Manufacture locations, following Sullivan and Rozen (1985).

Ferry (2015) investigated four sites from the slopes of Mount Rainier, making synchronic and diachronic comparisons above and below the Mount Saint Helens Y (MSH-Y) tephra layer. Ferry (2015:54-55) placed the above MSH-Y components of 45PI429 and 45PI408, and the whole site of 45PI406 into the Tool Manufacture classification. She also found an increase in heat-treated materials after 4400 cal years B.P. at 45PI429, and after 3000 cal years B.P. at 45PI408.

Lewis (2015:143) found that lithic variation at 45PI408 is related to environmental selective conditions, rather than a shift in settlement or subsistence strategy. He also found an increase in heat-treated artifacts and artifacts with evidence of high-temperature alteration throughout time (Lewis 2015:142).

CHAPTER IV

METHODS AND TECHNIQUE

I assume, like others (McCutcheon 1997; Kassa and McCutcheon 2016), that the selective conditions (e.g., lithic raw material source availability [Andrefsky 2009; Teltser 1991] and limited activities [Burtchard 1998:112-120; Andrews et al. 2016]) will determine largely the structure of a lithic assemblage; and that if different activities from open-air residential sites were being carried out at rockshelter limited-task sites, the lithic assemblages will reflect those differences. The cost of stone tool manufacture refers to the relative amount of energy needed to produce an artifact. Four sub-variables, material acquisition, material preparation, tool manufacture, and tool durability, allow for the interpretation of lithic assemblage variation (McCutcheon 1997:209-211). These elements are measured by reference to the form and abundance of raw materials, the distance between areas of lithic material procurement and places of lithic manufacture and use, and the amount of energy expended in the manufacture and use of tools. With all else being equal, lower cost materials will have a selective differential in pre-contact use over that of higher cost materials.

The performance level of the produced tool can offset the cost of producing lithic technology. Performance refers to the use of a stone tool, or the work done by an object as it interacts in its environment (McCutcheon 1997:211-213). The performance of a tool can be measured by three sub-variables: rock physical properties, tool requirements, and technology. The interrelationships between these sub-variables can greatly affect the durability, manufacture, and use of a stone tool, as different functional requirements influence the technologies and materials utilized (Dunnell and Campbell 1977).

The technological paradigm used in this thesis (Table 3) consists of eight mutually exclusive dimensions of analysis. The dimensions that will be recorded for each artifact are object type, amount of cortex, presence of wear, other modification, material type, platform type (Vaughn 2010; Lewis 2015), completeness (Sullivan & Rozen 1985:758), thermal alteration (McCutcheon 1997), complexity of dorsal surface, and reduction class.

Table 3. Technological Paradigm (modified from Dampf 2002:68-69, Lewis 2015:51-53, and McCutcheon 1997:255-261).

I. **Object Type**

- 0. **Biface**: two-sided rock exhibiting negative flake scars only, which were principally initiated from the edge of the rock.
- 1. **Flake/Flake Fragment**: rock exhibiting attributes of conchoidal fracture, especially positive flake scars, bulb of percussion, eraillure scars, and/or point of impact.
- 2. **Chunk**: rock exhibits noncortical surfaces but does not exhibit attributes of conchoidal fracture.
- 3. **Cobble**: rock that exhibits unbroken, cortical surfaces.
- 4. **Core**: rock exhibiting noncortical surfaces with attributes of conchoidal fracture with only negative flake scars initiated from a variety of directions.
- 5. **Spall**: “flake” shaped chunk that exhibits evidence of thermal shock (e.g., potlidding, crazing, crenulation, etc.).
- 6**. Gastrolith**: rock that exhibits a smooth lustrous surface and rounded edges

II. **Amount of Cortex**: cortex is that part of a rock that is the outer layer that forms as a transition zone between the chert body and its bedrock matrix (Luedtke 1992:150).

- 1. **Primary**: covers external surface (or dorsal side in the case of flake/flake fragments) of rock (with exception of point of impact, in the case of a flake).
- 2. **Secondary**: external surface has mixed cortical and noncortical surfaces.
- 3. **Tertiary**: no cortex present on any surface except point or area of impact.
- 4. **None**: no cortex present on any surface.

III. **Wear**: damage to an object’s surface as a result of use.

- 1. **Absent**: no evidence of wear on any surface.
- 2. **Present**: wear present on at least one surface.

IV. **Other Modification**: additional technological manipulations to rock fragments that may be related to other trajectories (bone tools) or additional steps in stone tool maufacture.

- 1. **None**: no attrition other than that explained by wear.
- 2. **Flaking**: fragment removed by conchoidal fracture.
- 3. **Grinding**: surfaces smoothed by abrasion.
- 4. **Pecking**: irregular or regular patterns of attrition due to dynamic nonconchoidal fracture.
- 5. **Incising**: linear grinding.
- 6. **Other**: types of modification not described above.

V. **Material Type—Lewis Types**

- 1. **Black Opaque and Translucent**
- 2. **Solid White Opaque and Translucent**
- 3. **Mottled White Opaque and Translucent**
- 4. **White and Grey Opaque**
- 5. **Light Brown Mottled opaque and translucent**

Table 3 Continued

6. **Light Brown Translucent**
7. **Grey Mottled Opaque and Translucent**
8. **Brown Translucent**
9. **Brown Mottled Translucent**
10. **Red Brown/Black Opaque**
11. **Red Mottled Translucent**
12. **Red/Brown Translucent and Opaque**
13. **Dark Grey Translucent and Opaque**
14. **Orange/Brown Translucent**
15. **Orange Mottled Translucent and Opaque**
16. **Pink Mottled**
17. **Yellow**
18. **Blue/Brown Translucent**
19. **Clear Translucent**
20. **Quartz Crystal**
21. **Obsidian**
22. **Light Grey/Black Opaque**
23. **Purple**
24. **Light Brownish White**
25. **Light Pink (Mottled)**
26. **Metasediment**
27. **Petrified Wood**
28. **Unknown Material**
29. **Green**

VI. **Platform Type**: area struck to cause flake removal.

1. **Cortex**: refers to cortical platforms.
2. **Simple**: platform with only one flake scar.
3. **Faceted**: platform with more than one flake scar.
4. **Bifacial unfinished**: platform is bifacially flaked, exhibiting a single stratum of flake scars.
5. **Bifacial unfinished, wear present**: platform is bifacially flaked, exhibiting wear superimposed over a single stratum of flake scars.
6. **Bifacial finished**: platform bifacially flaked, exhibiting several strata of flake scars.
7. **Bifacial finished, wear present**: platform bifacially flaked, exhibiting wear superimposed over several strata of flake scars.
8. **Potlids**: typically small, round flakes with convex side; point of force located at apex of convex side.
9. **Fragmentary**: platform is absent; "missing data."
10. **Not applicable**: (e.g., bifaces, cores, etc.).
11. **Pressure flakes**: platform is very thin, bulb of percussion is intact but very diffuse; this platform occurs on small flakes.
12. **Technologically absent**: results from indirect percussion where a precursor focuses the force such that as the flake is detached, an additional flake from the ventral side removes the bulb of percussion.

VII. **Completeness**

1. **Whole flake**: discernable interior surface and point of force apparent; all margins are intact; no broken edges.
2. **Broken flake**: discernable interior surface and point of force apparent; margins of flake exhibit step fractures (> 60°).
3. **Flake fragment**: interior surface discernable, but point of force is not apparent.
4. **Debris**: interior surfaces not discernable.
5. **Other**: (e.g., bifaces, cores, etc.).

VIII. **Thermal Alteration**: physical act of heating rock to make it more workable into a stone tool. Thermal alteration leaves color changes, lustrous flake scars, crenulated surfaces, crazing, and potlidding. The division of modes 1 and 2 below provides the means to separate those heat-treated objects that have had all of their post-heating surfaces removed from those objects that have not.

Table 3 Continued

0. **No Heating**: no attributes of thermal alteration exhibited.
1. **Lustrous/Non-lustrous Flake Scars**: object exhibits lustrous flake scars either intersecting or juxtaposed to non-lustrous flake scars.
2. **Lustrous Flake Scars**: lustrous flake scars only, where the luster is equivalent to that exhibited on objects exhibiting mode 1 above.
3. **High-Temperature Alteration**: object exhibits potlidding, crazing, and/or crenulated surfaces (as defined in Purdy 1974).

IX. **Complexity of Dorsal Surface**

1. **Simple**: surface exhibits few arrises from prior flaking and all are of the same scale.
2. **Complex**: surface exhibits 2 or more arrises and displays two or more scales of prior flaking.
3. **Not Applicable**: not a flake (e.g. core, chunk).

X. **Reduction Class Key**

1. **Initial**: Presence of cortex on dorsal surface.
2. **Intermediate**: Absence of cortex on dorsal surface, absence of complex dorsal surface.
3. **Terminal**: no lipped platform, presence of complex dorsal surface.
4. **Bifacial Reduction/Thinning**: Presence of lipped platform, no wear on platform.
5. **Bifacial Resharpening**: presence of lipped platform, presence of wear on platform.
6. **Not Applicable**

The rock physical property paradigm (Table 4) pertains to how rocks break, which in turn affects the reductive strategy in stone tool manufacture. The dimensions of this classification focus on the macroscopic properties of tool stone that affect the mechanics of fracture (McCutcheon and Dunnell 1998). The dimensions consist of rock ground mass, solid inclusions, void inclusions, and the distribution of those inclusions. Identifying tool stone raw material variability helps us understand subtle differences in lithic assemblages from different contexts.

The macroscopic wear paradigmatic classification (Dancey 1973:48-58; Dunnell and Lewarch 1974; McCutcheon 1997:238) (Table 5) focuses on macroscopic use wear attributes. Four dimensions of observable phenomenon are measured: kind of wear, location of wear, shape of worn area, and orientation of wear. Use wear analysis is used in an attempt to determine the function of stone tools by observing direct evidence in the form of wear on tool surfaces (Andrefsky 2005:5) and thus, data generated by this analysis provides information on functional traits of the lithic assemblage. This is a coarse-grained method of identifying object function (McCutcheon 1997:264) by presence without making assumptions about the nature of the function performed.

Table 4. Rock Physical Property Paradigm (Dampf 2002; Ferry 2015; Lewis 2015:54-55; McCutcheon 1997:208; Vaughn 2010)

I. **Groundmass**
- 1. **Uniform**: a consistent and unvarying structure, where the distribution of color, texture, or luster is even.
- 2. **Bedding Planes**: linear striae superimposed upon and parallel to one another. Individual stria can be distinct in color and/or texture.
- 3. **Concentric Banding**: concentric layers of different color and/or texture.
- 4. **Mottled**: abrupt and uneven variations (e.g., swirled or clouded) in color or texture.
- 5. **Granular**: a consistent structure composed of many individual grains.
- 6. **Oolitic**: the matrix is composed of small round or ovoid shaped grains.

II. **Solid Inclusions**
- 1. **Present**: particles present that are distinct from the rock body (e.g., oolites, sand grains, filled

Table 4 Continued

cracks, grains, fossils, minerals).
- 2. **Absent**: particles are absent from the rock body at 40X magnification or lower (unaided eye).

III. **Void Inclusions**
- 1. **Present**: areas devoid of any material are present in the rock body (e.g., vugs, fossil and mineral casts, unfilled cracks).
- 2. **Absent**: areas devoid of any material are absent from the rock body at 40X magnification or lower (unaided eye).

IV. **Distribution of Solid Inclusions**
- 1. **Random**: the distribution of inclusions is irregular and not patterned in any fashion.
- 2. **Uniform**: the distribution of inclusions is unvarying and even throughout the rock body.
- 3. **Structured**: the distribution of inclusions is patterned or isolated within the rock body.
- 4. **None**: inclusions are absent from the rock body at 40X or lower magnification (unaided eye).

V. **Distribution of Void**
- 1. **Random**: the distribution of inclusions is irregular and not patterned in any fashion.
- 2. **Uniform**: the distribution of inclusions is unvarying and even throughout the rock body.
- 3. **Structured**: the distribution of inclusions is patterned or isolated within the rock body.
- 4. **None**: inclusions are absent from the rock body at 40X or lower magnification (unaided eye).

There are some challenges to interpreting tool wear because post-depositional wear and trampling, and excavation and curation wear, can damage artifacts with chipping-type damage (Andfresky 2005:197; McCutcheon 1997:264). To minimize recording false presence of wear caused by post-depositional damage, chipping wear was recorded only when 5 or more overlapping flake scars were present (per McCutcheon 1997:264).

Table 5. Macroscopic Wear Paradigm (McCutcheon 1997; Dampf 2002; Ferry 2015; Lewis 2015; Vaughn 2010)

I. **Kind of Wear**

1. **Chipping**: small conchoidal fragments broken from edge; a series of flake scars.
2. **Abrasion**: striations and/or gloss or polish on edge or point or surface.
3. **Crushing**: irregular fragments removed from object leaving pitted surface.
4. **Polishing** (as in Witthoft 1967).
5. **None** - no wear is visible.

II. **Location of Wear**

1. **Angular Point**: intersection of three or more planes at a point, including the point.
2. **Angular Edge**: intersections of two planes including the line of intersection.
3. **Angular Plane**: a single planar surface.
4. **Curvilinear Point**: a three-dimensional parabola or hyperbola.
5. **Curvilinear Edge**: a curved plane bent significantly in only one axis (two-dimensional parabola or hyperbola).
6. **Curvilinear Plane**: a curved plane with spherical or elliptical distortion of large radius.
7. **Non-localized**: a closed curve.
8. **None**: wear absent.

III. **Shape or Plan or Worn Area**

1. **Convex**: an arc with a curve away from a flat surface.
2. **Concave**: an arc with a curve toward a flat surface.
3. **Straight**: a straight or flat surface.
4. **Point**: a point.
5. **Oblique notch**: two lines whose intersection forms an oblique angle.
6. **Acute notch**: two lines whose intersection forms an acute angle.
7. **None**: wear absent.

IV. **Orientation of Wear**: this dimension describes the linear orientation of the wear itself relative to the Y-plane of the object. The Y-plane will be taken to be a plane that is perpendicular to a line or plane connecting the wear to the body of the tool (X-axis or -plane). For example, if the object is a flake and is placed on a horizontal surface, ventral side down, the Y-plane is parallell to the horizontal surface for all edge damage (e.g., chipping, crushing, etc.).

1. **Perpendicular to Y-plane**: mainly pitting, edge-on crushing, etc.
2. **Oblique to the Y-plane**: a single direction is noted (e.g., unifacial chipping).
3. **Variable to the Y-plane**: a number of different orientations, all linear, turning from a left oblique through perpendicular to right oblique (e.g., bifacial chipping, crushing, pounding, etc.).
4. **Parallel to the Y-plane**: precludes most percussive wear.
5. **No orientation**: non-linear wear (e.g., heating).
6. **None**: wear absent.

A fourth analytical key is used to classify projectile points assigning them to morphological point types. Carter (2002) has produced a practical, morphology-based typological key for identifying projectile points from the central Columbia Basin (*cf.* Lohse 1985). Several metric attributes of complete formed tools must be recorded: haft length, maximum length, maximum basal width, shoulder length, maximum width, neck width, and maximum thickness (Carter 2002). Based on these metrics and visible nonmetric characteristics, the dichotomous key divides the tools into five major categories: shouldered or notched, side-notched, corner-notched, basal notched, or shouldered or stemmed (Carter 2010:7).

According to Sullivan and Rozen (1985:762-766), lithic assemblages can be classified into four technological groups that are based on how object types are represented in an assemblage. By looking at the proportion of complete flakes, broken flakes, flake fragments, debris, cores, and retouched pieces, an assemblage is assigned a technological group. Group IA types focus on unintensive core reduction, Group II types focus on tool manufacture, Group IB1 types focus on core reduction and tool manufacture, and Group IB2 types focus on intensive core reduction (Table 6) (Sullivan and Rozen 1985).

Table 6. Technological Groups from Sullivan and Rozen (1985:763).

	Technological Group			
Artifact Category	IA	IB1	IB2	II
Complete Flakes	53.4	32.9	30.2	21.0
Broken Flakes	6.7	13.4	8.1	16.8
Flake Fragments	16.0	35.3	34.7	51.3
Debris	6.1	7.9	23.0	7.3
Cores	14.7	2.8	2.0	0.6
Retouched Pieces	3.1	7.5	2.0	3.1

While eighteen dimensions of lithic technology, function, and rock physical properties were recorded for each artifact, not all of these dimensions can be utilized for comparison of the archaeological record. In this study, expectations for the rockshelter and open-air sites derive from four dimensions: object type, reduction class, platform type, and thermal alteration. Expectations about functional traits of the assemblages can be assessed by focusing on the number of filled functional codes at each site.

Because rockshelter sites are expected to be limited-task field or hunting camps, it is expected that light tool *object types* such as bifaces and a low frequency of cores should be highly represented (Burtchard 1998:113). Open-air, residential field camp assemblages, are expected to be varied with both light and heavy tools, with a high density of debitage (Burtchard 1998:113).

Only flakes that retain their original point of impact (whole and broken flakes) can be placed into a *reduction class*. Because open-air site types are expected to be places where a wide-range of activities took place, it is expected that a more even distribution amongst the stages of reduction will be present in the 45PI408 assemblage. Because the activities at rockshelter sites should be limited to only late stage and retouch activities, the assemblages should show an overrepresentation of flakes from the terminal, bifacial reduction/thinning and bifacial resharpening modes.

The *platform type* dimension focuses on the point of impact which was struck to cause flake removal. Only flakes with completely intact platforms can be assigned a platform type; flakes that do not retain some or any of their platform are assigned to the fragmentary mode, and tools are classified as not applicable. The activities related to creating the lithic assemblages found at rockshelters, and other limited-task field camp sites, should be focused on tool maintenance, repair, and late stage manufacture (Burtchard 1998:113). This should be represented in the platform type dimension of the rockshelter assemblages compared to the open-air sites as a higher representation of the following modes: faceted platforms, bifacial unfinished platforms, bifacial unfinished platforms with wear present, bifacial finished platforms, bifacial finished platforms with wear present, and pressure flake platforms. Open-air sites should thus show an underrepresentation of the above modes, and may show a higher representation in the other modes of the platform type dimension: cortex platforms, simple platforms, potlids, fragmentary, not applicable, and technologically absent.

The *thermal alteration* of many rocks improves the “workability” (McCutcheon 1997:1) of the material as toolstone by aiding in more predictable, intergranular crack propagation (McCutcheon 1997). While not all rocks are affected the same way by heating processes, the results of heat treatment can be identified as post-heating flake-scar surfaces that are smooth, and more lustrous than scars removed prior to thermal alteration (McCutcheon 1997). Over-heated break unpredictably because of large, thermally induced such as crenulation, crazing, and potlidding. At open-air sites, it is reasonable to assume that one of the many residential camp activities performed could be heat-treatment of tool stone. Untreated objects and over-heat-treated objects may be greater represented at open-air sites than the rockshelter sites. Objects at the rockshelter sites should display lustrous/non-lustrous flake scars and lustrous only flake scars in considerable amounts. It is not expected that there will be as many unheated or high temperature alteration (over-heating) objects at the rockshelter sites as only a limited toolkit is expected to be brought to these locations. Where studied previously (Vaughn 2010; Ferry 2015; Lewis 2015), stone tool heat treatment evidence occurs in intermediate reduction. Later reduction efforts on heat-treated stone tools are identified analytically as heat treated. The absence or low frequency rock shelter sites of unheated and over-heated objects are expected as they have less predictable failure behavior than those materials that were heat-treated effectively.

While it is hard to draw specific expectations about use wear at rockshelter and open-air site types without making assumptions about the specific functions performed by the tools, it is reasonable to expect that there will be more filled functional classes at open-air sites than at rockshelter sites. The limited-activity use of a rockshelter site should mean that there are fewer overall uses of tools at these locations, and this should be represented as fewer filled functional classes in the assemblage data from rockshelter sites.

CHAPTER V

RESULTS AND CONCLUSION

All object frequencies were analyzed with the statistical protocol in three permutations: across site type, within site type, and across all individual assemblages. Object frequency data for all sites and site types is located in Appendix A. The data from 45PI043 and 45PI303 were collapsed together as the "rockshelter sites," while the data from 45PI406, 45PI408, and 45PI429 were collapsed together as the "open-air sites." Doing so allowed for maximizing the sample size from each site type.

Ideally, comparison of each site type assemblage would determine whether such an aggregation effort was justified. Here I do it only as an exercise in maximizing disparate sample sizes and to establish the analytical protocols I use below. Given the overlap in my approach to that of others cited above, this approach makes my results comparable to those, which I will return to in the interpretation of my results.

In this chapter, I discuss the results of comparing the two "rockshelter sites" to the three "open-air sites." Following this discussion are some conclusions and a transition to a journal manuscript based on a more limited comparison. Results of these analyses are provided in the following chapter.

Resampling Results

The resampling curves for all dimensions of analysis are located in Appendix B, and summarized below in Table 7. A majority of dimensions in the technological and rock physical properties classifications were sufficient for intersite comparisons across all sites, generating mostly Rank 1 or 2 curves. The functional classification data was found to be generally unrepresentative in all assemblages, and insufficient for intersite comparisons, generating mostly Rank 3 curves.

Table 7. Ranking of Resampling Curves for All Dimensions of All Assemblages

Dimension of Analysis	45PI043	45PI303	45PI406	45PI408	45PI429
Fragment Type	1	2	3	3	1
Amount of Cortex	1	1	1	1	2
Presence of Wear	1	1	1	1	1
Other Modification	1	1	2	3	1
Material Types	1	1	1	1	1
Platform Types	1	2	3	1	3
Completeness	1	1	1	1	1
Thermal Alteration	1	1	1	1	1
Complexity of Dorsal Surface	1	1	1	1	1
Reduction Class	1	1	1	1	1
Kind of Wear	3	3	3	3	1
Location of Wear	3	1	3	3	3
Wear Shape	1	1	3	3	3
Orientation of Wear	1	1	3	3	1
Groundmass	1	1	1	3	1
Solid Inclusions	1	1	1	1	1
Void Inclusions	1	1	1	1	1
Distribution of Solid	1	1	1	1	2
Distribution of Void	1	1	3	1	3

Collapsed Site Type Results

Focusing on the dimensions related directly to the site type expectations, the general trends of the rockshelter versus open-air site type analyses support the Burtchard (1998) site type expectations (Tables 8 and 9). The frequency differences between open-air and rockshelter sites for biface and flake/flake fragment modes of the object type dimension were insignificant, or random differences. Cores were significantly overrepresented at open-air sites and significantly underrepresented at rockshelter sites. The high representation of cores found here is what would be expected at a repeatedly used basecamp setting (open-air site). The low representation of cores found at the rockshelter sites is what would be expected with the restricted tool kit used on short-term forays to limited-task field or hunting camps (rockshelter sites).

Table 8. Rockshelter vs. Open-Air Comparisons where H_0 is Rejected

Dimension	*df*	Critical Value $\chi^2.05$ (p)	Collapsed Site Type Comparisons			
			Chi-Square (χ^2)	Cramér's *V*	Actual *p*-value	Rejects H_0?
Object Type	2	5.99	17.26	0.05	< 0.01	Yes
Completeness	4	9.49	1143.33	0.35	< 0.01	Yes
Reduction Class	4	9.49	157.09	0.22	< 0.01	Yes
Platform Type	6	12.49	241.33	0.28	< 0.01	Yes
Thermal Alteration	3	7.82	632.36	0.27	< 0.01	Yes

Table 9. Collapsed Site Type Frequencies and Adjusted Residuals Where H_0 is Rejected

Dimension	Mode	Rockshelter Sites		Open-Air Sites	
		Count	Residuals	Count	Residuals
Object Type	Bifaces	58	1.59	92	-1.59
	Flakes/Flake Fragments	2574	0.69	5296	-0.69
	Cores	5	**-3.86**	52	**3.86**[a]
Completeness	Whole Flake	643	**29.75**	212	**-29.75**
	Broken Flake	884	**7.03**	1557	**-7.03**
	Flake Fragment	925	**-19.38**	3459	**19.38**
	Debris	168	**2.60**	298	**-2.60**
	Other	69	**-11.11**	560	**11.11**
Reduction Class	Initial	42	**3.03**	23	**-3.03**
	Intermediate	179	**-9.44**	439	**9.44**
	Terminal	1029	0.80	1181	-0.80
	Bifacial Reduction/Thinning	262	**9.20**	123	**-9.20**
	Bifacial Resharpening	33	-0.47	43	0.47
Platform Type	Simple	149	**-13.21**	497	**13.21**
	Faceted	321	-1.24	405	1.24
	Bifacial Unfinished	177	**7.81**	77	**-7.81**
	Bifacial Unfinished, w/ Wear	11	-1.49	22	1.49
	Bifacial Finished	86	**4.85**	42	**-4.85**
	Bifacial Finished, w/ Wear	23	-0.03	27	0.03
	Pressure Flakes	726	**5.87**	666	**-5.87**
Thermal Alteration	No Heating	85	**-14.64**	820	**14.64**
	Lustrous/Non-Lustrous	553	**20.92**	354	**-20.92**
	Lustrous Only	1664	**2.13**	3619	**-2.13**
	High Temperature Alteration	387	**-7.52**	1293	**7.52**

[a] Values in bold are statistically significant contributors towards rejection of null hypothesis

All differences in representation of the modes in the completeness dimension were statistically significant, or non-random differences (Table 9, complete statistics in Appendix C). Whole flakes, broken flakes, and debris are overrepresented at the rockshelter sites, and underrepresented at the open-air sites. Flake fragments and “other” types (e.g. bifaces, cores, etc.) were underrepresented at the rockshelter sites and overrepresented at the open-air sites. Using the proportions of modes from the completeness dimensions, the upper components of open-air sites 45PI406, 45PI408, and 45PI429 were classified as assemblages representative of the technological organization Group II, or tool manufacture, by Ferry (2015) (per Sullivan and Rozen 1985). When the proportions from 45PI043 and 45PI303 are collapsed together as the rockshelter assemblage, the proportions closely resemble Group II, tool manufacture (Sullivan and Rozen 1985).

Differences between the frequencies of the dimension reduction class modes of terminal and bifacial resharpening were random (Table 9). Differences between the initial mode and bifacial reduction/thinning mode at each site type were significant; both two reduction classes were overrepresented at the rockshelter sites, and underrepresented at the open-air sites. The intermediate reduction class was significantly underrepresented at rockshelter sites and significantly overrepresented at open-air sites. The high representation of bifacial reduction and thinning reduction class flakes at the rockshelter sites suggests a focus on late stage reduction of lithic materials. The high representation of initial reduction class flakes could be due to expedient use of locally available materials, as the initial reduction class means there is cortex on the dorsal surface, and no scaling of negative flake scars on dorsal surface. The high representation of intermediate flakes found at the open-air sites can be explained by the more intensive core reduction which is expected to take place at these locations, and is supported by the overrepresentation of the object type of cores at these sites, as well.

Three of the modes from the platform type dimension (Table 9) showed only random differences: faceted, bifacial unfinished with wear, and bifacial finished with wear. The simple platform type was significantly underrepresented at the rockshelter sites and significantly overrepresented at the open-air sites. Bifacial unfinished, bifacial finished, and pressure flake platform types were all significantly overrepresented at the rockshelter sites and significantly underrepresented at the open-air sites. These differences suggest that there was, as predicted, more of a focus on late stage reduction of lithic materials and tool maintenance at the rockshelter sites compared to the open-air sites.

The dimension of thermal alteration showed statistically significant differences across all modes at the rockshelter and open-air sites. The no heating and high-temperature alteration modes were underrepresented in the rockshelter assemblages and overrepresented in the open-air assemblages. The lustrous/non-lustrous flake scar and lustrous flake scar only modes were overrepresented in the rockshelter site assemblages and underrepresented in the open-air site assemblages. It is reasonable to assume that one of the many residential camp activities performed at the open-air sites could be heat-treatment of tool stone which could be an explanation for why untreated objects and over-heat treated objects are more highly represented at the open-air sites assemblage than the rockshelter sites assemblage. Results from the analysis of another dimension, reduction class, can be used to aid in the interpretation of thermal alteration at these sites. It is likely that heat treatment would occur to material after the cortex has been removed. These heat-treated intermediate flakes can then be worked more easily, and transported as a prepared material. This could explain the increase in lustrous only and lustrous/non-lustrous flake scars at the rockshelter sites, which also lacked cores as discussed above.

The functional paradigm yielded the least representative samples from both site types; indicating that the data are insufficient for performing statistically significant intersite comparisons, however by looking at the number of filled functional classes at each site typeone can gain a general understanding of how lithics were used. There are nearly three times as many filled functional classes the residential open-air sites than at the rockshelter sites; indicating that there was less limit to the activities, or function, at the open-air sites, as expected.

Comparisons of Un-Collapsed Site Assemblages

The assemblages were also compared amongst their site type; Fryingpan Rockshelter site 45PI043 was compared to Berkeley Rockshelter site 45PI303; and Tipsoo Lake site 45PI406, Sunrise Ridge Borrow Pit site 45PI408, and Forgotten Creek site 45PI429 were compared to each other to determine the validity of assemblage data collapse by site type (Appendix C).

When the two rockshelter sites were compared to each other, the null hypothesis was rejected for ten of the possible eighteen dimensions analyzed. That is, there were only random differences between eight of the dimensions between the two rockshelter assemblages, while the differences between the rockshelter assemblages were non-random for ten of the dimensions. These statistically significant non-random differences between the two rockshelter sites imply that despite sharing similarities across some dimensions of analysis, significant difference exists between the sites classified as limited-task hunting or field camps.

When all five sites were compared to each other as unique assemblages, rockshelter sites 45PI043 and 45PI303 were similarly over- or under-represented together in a total of seventy-eight of the ninety-two modes represented in the assemblages. Fifty of these modes with shared directionality (similar over- or under-representation) were statistically significant, and twenty-eight of them had mixed statistical significance while still trending the same direction (similarly over- or under-represented). The null hypothesis was rejected in all eighteen dimensions for the comparison across all five assemblages. These significant differences between the open-air sites could be due to extraneous variables about each site, incorporating variables that cannot be accounted for in this analysis and therefore make the assemblages appear unique. Tipsoo Lake site 45PI406, for example; is a stratigraphically mixed site, and may include artifacts from a period before the MR-C event. 45PI429 is located on the western flank of Rainier, and may have been exposed to different environmental or functional variables.

Further discussion of un-collapsed site assemblages continues in the journal manuscript in the following chapter.

Discussion and Recommendations

Some elements of this analysis were not able to be achieved, or were limited due to uncontrollable factors. A closer investigation into cost and performance could be made with a more thorough understanding of material type distribution among the assemblages, and of local toolstone geology. This topic and others are discussed below, as well as in the following journal article manuscript, and recommendations are made for future research.

Material type has been analyzed at all five sites in a very coarse-grained fashion (Figure 6). All five sites are dominated by chert, and have a small presence of igneous materials. 45PI406 and 45PI408 have both obsidian and other materials present in their collections. This overall greater variability at the open-air type sites does fit expectations. There was no obsidian found at either rockshelter site, and none found in the assemblage of the open-air 45PI429 site. There is, however, obsidian in the open-air 45PI429 below MR-C component, which is not included in this study, however its presence is of note.

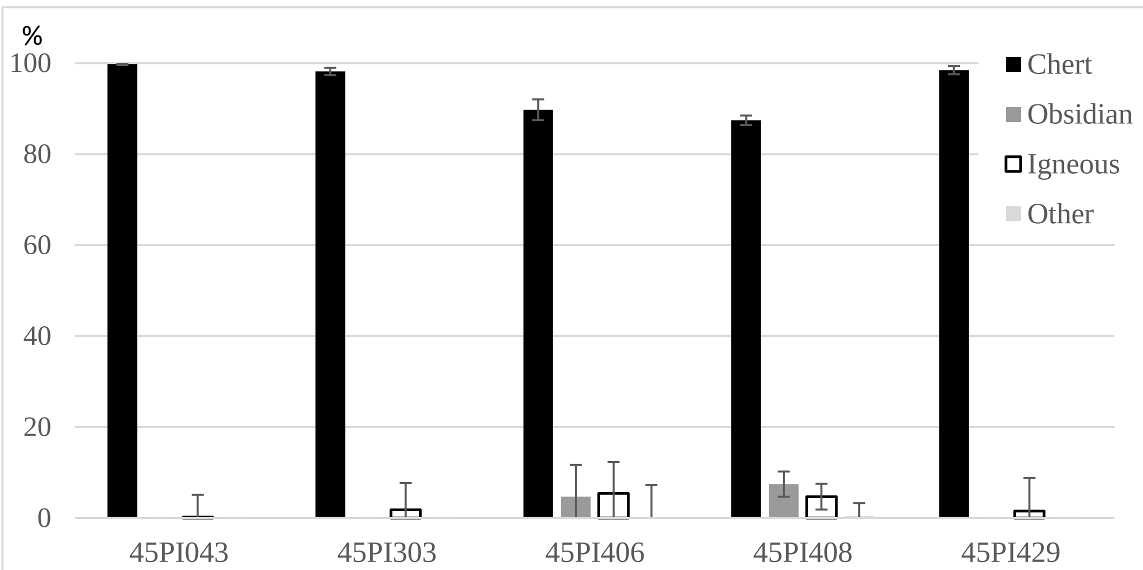

Figure 6. Distribution of material type. Coarse-grained classification at rockshelter sites (45PI043 and 45PI303) and open-air residential sites (45PI406, 45PI408, and 45PI429).

An attempt has been made to create a finer-grained material classification to examine the variability in chert present in upland lithic assemblages (Lewis 2015:138). This twenty-eight mode material type dimension, the Lewis Type, assumes that rocks that resemble each other in groundmass, color, and opacity, came from similar geological contexts (Lewis 2015:50, 138). An additional mode, green, was added during this analysis. Looking solely at the frequency of Lewis Types at rockshelter sites 45PI043 and 45PI303 (Figure 7) indicates a much larger representation of modes 9 and 10, brown mottled translucent, and red brown/black opaque, at 45PI043. Lewis Type is distributed more evenly at 45PI303, the most unique representation at 45PI303 is mode 19, clear translucent (Table 10).

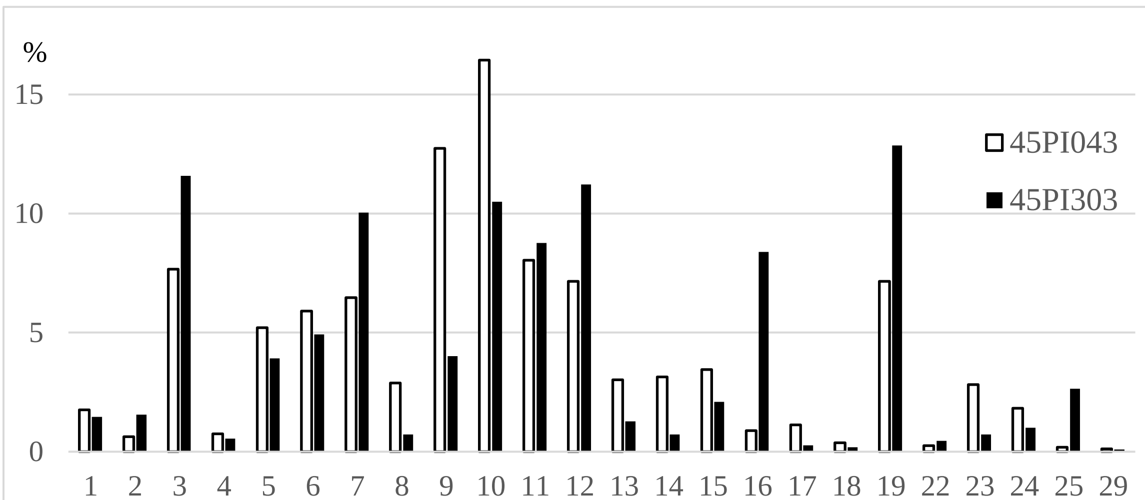

Figure 7. Distribution of Lewis Types at 45PI043 and 45PI303.

Table 10. Lewis Type Key

1. Black Opaque and Translucent	16. Pink Mottled
2. Solid White Opaque and Translucent	17. Yellow
3. Mottled White Opaque and Translucent	18. Blue/Brown Translucent
4. White and Grey Opaque	19. Clear Translucent
5. Light Brown Mottled opaque and translucent	20. Quartz Crystal
6. Light Brown Translucent	21. Obsidian
7. Grey Mottled Opaque and Translucent	22. Light Grey/Black Opaque
8. Brown Translucent	23. Purple
9. Brown Mottled Translucent	24. Light Brownish White
10. Red Brown/Black Opaque	25. Light Pink (Mottled)
11. Red Mottled Translucent	26. Metasediment
12. Red/Brown Translucent and Opaque	27. Petrified Wood
13. Dark Grey Translucent and Opaque	28. Unknown Material
14. Orange/Brown Translucent	29. Green
15. Orange Mottled Translucent and Opaque	

The Lewis Type was not recorded consistently or in a fashion that permits direct comparison for artifacts from the 45PI406 and 45PI429 assemblages. The rock physical property characteristics needed to record a Lewis Type were recorded for these sites, and could be systematically converted. The Lewis Type is recorded for only a portion of the 45PI408 collection (n=832). Unfortunately, a data recording and entry error in the 45PI408 assemblage has created issues that affect the operationalization of this dimension for looking closely at chert variability across site types. Fortunately, the error appears to be systematic and should be confidently resolvable.

To look more closely at chert variability across upland lithic assemblages, I recommend that an attempt be made to classify or correct the 45PI406, 45PI408, and 45PI429 assemblages into Lewis Types. Doing so would allow for not only a finer resolution of analysis across material type, but would allow for an analysis of intersecting variables based on this fine resolution material dimension. This could be helpful for looking at object type such as bifaces, or platform types. In addition, I, like Lewis (2015:145), recommend effort be taken to develop more of an understanding of lithic material source characteristics and locations that surround Mount Rainier.

In addition, it should be noted that potential bias in this study may have been introduced by minimum limits of the scale used to weigh artifacts. In the assemblages from 45PI043 and 45PI303, flakes recorded as 0.01 grams were actually less than or equal to 0.01 grams, to avoid recording flakes less than 0.01 grams as having no weight. It is also possible that these less than 0.01 gram flakes when recorded as simple platform types, could actually be pressure flakes. Furthermore, in an effort to prevent sampling bias, many flakes that were less than $1/8^{th}$ inch in maximum dimension were removed from the sample of 45PI043 and 45PI303 assemblages using geological nested screens. The density of lithic debitage is another analytical focus that could be investigated productively. A bivariate plot of artifact frequency and artifact density could show potential relationships or trends between these variables.

Lastly, all results are limited by sample size. Further excavation at 45PI429, as recommended by Ferry (2015:80), might be helpful in assessing the technological and functional traits of open-air sites. In addition to 45PI429, there are other high-elevation sites in the Park and Washington Cascades that could be investigated to learn more about upland land use. I recommend that any further artifacts be analyzed using the paradigmatic lithic classification used here to generate replicable and comparable dimensions of analysis. Following the statistical protocol used here, rather than focusing solely on observed frequencies of lithic traits, can help to mitigate issues associated with smaller sample sizes (Lewis 2015:134).

In summary, this thesis has been successful in attempting to determine the context of rockshelter site type assemblages within the greater scheme of upland lithic technology and function. Through this, it has been possible to determine that the composition of a rockshelter assemblage is not the result of a unique adaptation, but rather are subsets of larger, open-air site lithic assemblages; in other words, a limited suite of the same types of activities going on at open-air sites were performed at the rockshelter sites. Further research into lithic technology and function across space and site type could reveal more about the selective conditions under which this lithic industry was created.

The results of these analyses suggest that while the two rockshelter sites (45PI043 and 45PI303) are not similar in all respects, they are not entirely dissimilar from each other when compared to open-air sites 45PI406, 45PI408, and 45PI429, or in other words, significant variation exists between the sites classified as limited-task hunting or field camps. This called for a finer-grained focus to investigate how the two rockshelter-type site assemblages vary when compared to an assemblage from a nearby, contemporaneous, open-air site type (45PI408, the Sunrise Ridge Borrow Pit). This meant removing Forgotten Creek site (45PI429) located furthest from the others, and Tipsoo Lake site (45PI406) with mixed stratigraphic integrity. Frequencies were then compared in two independent permutations: the 45PI043 assemblage to the above MR-C component of 45PI408, and the 45PI303 assemblage to the above MR-C component of 45PI408. Discussion and results of this more restricted analysis are included in the following chapter, which is a manuscript that will be submitted for publication.

CHAPTER VI

ARTICLE

INVESTIGATING ROCKSHELTER LITHIC TECHNOLOGY AND FUNCTION USING PARADIGMATIC CLASSIFICATION ON THE SLOPES OF MOUNT RAINIER

This manuscript will be submitted to *Journal of Northwest Anthropology* for publication after acceptance by the CWU School of Graduate Studies and Research. It was coauthored by Caitlin Limberg, committee chair Patrick McCutcheon, and committee member Greg Burtchard. The final manuscript, if accepted, may result in differences after editorial and peer-review commentary. The manuscript of the article begins on the following page.

INVESTIGATING ROCKSHELTER LITHIC TECHNOLOGY AND FUNCTION USING PARADIGMATIC CLASSIFICATION ON THE SLOPES OF MOUNT RAINIER

Caitlin Limberg, Patrick T. McCutcheon, and Greg Burtchard

ABSTRACT

Two sites from the Late Holocene period, the Fryingpan and Berkeley Rockshelters, are analyzed to test Burtchard's prediction that rockshelter sites on the slopes of Mount Rainier were used for a more limited activity set than some larger open-air sites. Rockshelter sites are thought to be places of short-term occupancy consistent with hunting and/or overnight residence activities. Large open-air sites with relatively dense and materially diverse lithic artifacts are thought to be longer-term residential base camps. Technological and functional paradigmatic lithic classifications are used to measure how the two rockshelter sites vary and compare to the larger, open-air Sunrise Ridge Borrow Pit site. Non-random associations of data frequencies across technological variables exhibited by the lithic assemblages determined that rockshelter lithic assemblages are representative of a truncated range of variability compared to an open-air site assemblage.

Introduction

Burtchard's (1998:112-120) archaeological site taxonomy model proposes functional, content, and location expectations for archaeological site types found on the slopes of Mount Rainier. Rockshelter site types are included among his *Limited-task Field or Hunting Camps* category (Burtchard 1998:113-114), and were used as places of short-term residence for small hunting groups. Burtchard suggest that tasks performed at field camp sites were limited to direct or indirect associations with hunting or overnight residence, including moderate butchering and cooking activities. Late stage debitage and light tools (e.g., cores, bifaces, flake tools, and projectile points) are expected to dominate rockshelter site type lithic assemblages. Heavy stone tools (e.g., hammer and grinding stones) and early stage reduction of locally available tool stone raw materials may occur in low frequency in these site types, while debitage from stone tool maintenance, repair, and late stage manufacture would be expected in a higher frequency. Rockshelter site types may have associated features like fire hearths and/or stacked stone walls for windbreaks. Rockshelter site types are found generally in subalpine contexts, where their formation is dictated by geology. Recent analyses indicate Burtchard's (1998:112-120) predictions for rockshelter sites appear to be correct (Andrews et al. 2016). However, it is not yet known how rockshelter site type lithic assemblages compare to larger, open-air site types that are not constrained by small spaces.

Burtchard (1998:112-113) suggests that several large open-air sites on Mount Rainier supported longer-term residential groups, and thus were associated with more types of functionally varied activities. Lithic assemblages from sites classified as *Multi-task, Mixed Group, Residential Base Camps or Residential Field Camps* (Burtchard 1998:112-113) should be diverse; consisting of heavy and light tools, a high density of debitage from various stages of manufacture, and high raw material variability. Hearth features, and features associated with smaller limited-task sites (including rockshelters), and from plant and animal processing locations also should be found at open-air residential base camps (Burtchard 1998). These base camp locations are expected to be found in upper forest to lower sub-alpine settings, which provide the most effective access to upland resources while maintaining more stable and predictable weather conditions (Burtchard 1998:113).

If limited-task field camps genuinely represent differential use of the upland landscape than residential base camps, then the organization of technology at these contrasting locations also should differ in quantifiable, if subtle, ways. Using paradigmatic classification, a high-resolution lithic analysis, these subtle differences can be hopefully be identified. By assessing the degree to which lithic assemblage technological and functional traits vary between large upland open-air (ostensibly residential base camp) sites and rockshelter limited-task field camp sites, this research will contribute towards the regional knowledge of how people used upland environments differently in the past.

Study Sites

This research focuses on three archaeological sites found in the northeast quadrant of Mount Rainier National Park (Figure 1; Table 1); two rockshelter sites, Fryingpan Rockshelter (45PI043) and Berkeley Rockshelter (45PI303) will be compared to the open-air Sunrise Ridge Borrow Pit site (45PI408).

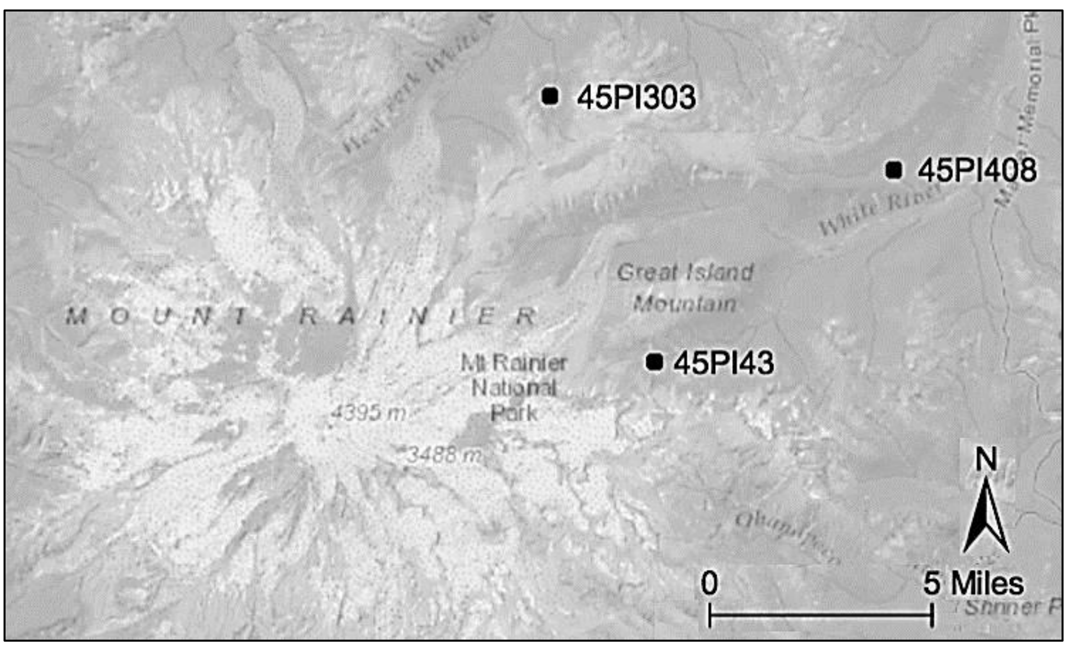

Figure 1. Location of archaeological sites within Mount Rainier National Park, Washington State (base map provided by ESRI).

TABLE 1. ARCHAEOLOGICAL SITE AND ASSEMBLAGE INFORMATION

Site	Volume Excavated (m^3)	Site Size (m^2)	Sample Size	Site Age
45PI043 – Fryingpan Rockshelter	2	36	1,593	250 to 1150 B.P. [a]
45PI303 – Berkeley Rockshelter	1.5	100	1,096	290 to 1070 B.P. [b]
45PI408 – Sunrise Ridge Borrow Pit	34.14	2,550	4,601	100 to 4,086 cal. B.P. [c]

[a] From Lubinski and Burtchard 2005

[b] From Bergland 1988

[c] From McCutcheon et al. 2017 (in prep)

Fryingpan Rockshelter (45PI043)

The Fryingpan Rockshelter site (45PI043) is a single north-facing overhang set into an andesite cliff at 1646 m (5400 ft) elevation above sea level (Rice 1965:1-3; Burtchard and Hamilton 1998:9-10; Lubinski and Burtchard 2005:35).

45PI043 was located during the first formal archaeological resource survey of the Park in 1963 (Burtchard 1998:51; Daugherty 1963) and first excavated in 1964 (Rice 1965). In Rice and Nelson's 1964 excavation, artifacts were recovered from one 1.25 x 1.85 m excavation unit that was 40 cm deep (Lubinski and Burtchard 2005:36; Rice 1965). Possible looting at the site was noted when the site was revisited and tested in 2001. During the 2001 project, backfill from the original test unit was removed and rescreened with 1/8-inch mesh screen; as well as a pile of fill that had been removed by possible wrong-doers (Lubinski and Burtchard 2005:36). In addition, two new 50 x 60 x 94 cm units were excavated adjacent to the original unit, and the original unit was excavated an additional 20 cm to confidently reach the range of culturally relevant sediments (Lubinski and Burtchard 2005:36). A calculation of volume excavated is approximately 2 cubic meters. All artifacts from 45PI043 were recovered above the MR-C tephra layer. Deposits at the site date between 250 ± 40 ^{14}C years B.P. and 1150 ± 40 ^{14}C years B.P. (Lubinski and Burtchard 2005:37). More recent radiocarbon assay of charcoal and calcined bone samples from one of two hearth features indicate use approximately 529 to 314 cal. B.P. (Chatters et al. 2017) consistent with the previously established range. Over 1,900 lithic artifacts were recovered from the site, of which 1,593 chipped stone tools and flakes were 1/8-inch and greater in size and were analyzed for this study.

Berkeley Rockshelter (45PI303)

The Berkeley Rockshelter site (45PI303) contains two double-ended rockshelters formed under three large granodiorite boulders at an elevation of 1719 m (5640 ft) (Bergland 1988:3). 45PI303 was excavated in 1987; and all visible historic and lithic surface artifacts were collected. One 1 x 1 m excavation unit was set into the lower shelter, and one 50 x 50 cm unit was placed in the upper shelter (Bergland 1998:7). In 2002, one constant volume sample (CVS) test unit (after Burtchard and Miss 1998), and an additional 1 x 0.5 m excavation unit was placed in the lower shelter (Andrews et al. 2016). Radiocarbon samples from 45PI303 show multiple discrete occupations, dating to as early as 1070 ± 90 B.P. (Bergland 1988:33), and all artifacts were recovered from above the MR-C volcanic layer. In total, approximately 1.5 cubic meters have been excavated at 45PI303.

1,709 lithic artifacts were collected from 45PI303. A subsample of the collection of lithic artifacts was recently analyzed using a six-stage system developed by Jeffrey Flenniken (1981) (Andrews et al. 2016). Andrews et al. (2016:176) focused on only formed tools and 585 flakes, which were deemed to be “technologically diagnostic.” Andrews et al. (2016) concluded that the lithic assemblage from 45PI303 does fit the limited suite of activities associated with a field hunting camp. Specifically, Andrews et al. (2016:184) conclude that functions at the rockshelter focused primarily around projectile point repair/maintenance and arrow shaft creation/maintenance.

The analytical dimensions of the Andrews et al. (2016) study were not directly comparable with those used for this research. In order to answer the research questions posed in this study, a new lithic dataset was generated by analyzing 1,096 flakes and tools from 45PI303. Flakes less than 1/8 inch in size (n=613) were removed from the sample and were not analyzed for this study.

Sunrise Ridge Borrow Pit (45PI408)

The Sunrise Ridge Borrow Pit (45PI408) is a natural south-facing mid-slope bench or glacial kame terrace (McCutcheon and Dampf 2002). Sunrise Ridge Borrow Pit is located on the eastern slope of Mount Rainier at an elevation of 1310 m (4300 ft) above sea level.

Most recently, testing and excavation at 45PI408 has been the focus of research for Central Washington University’s field schools directed by Dr. Patrick McCutcheon. The site was first recorded by Rick McClure in 1990, and documented again by Burtchard and Hamilton in 1995 (see Burtchard 1998:57). Systematic efforts to document the scope of artifacts horizontally and vertically at the site began in 1997 with the first of the CWU archaeological field school projects. Over the course of five archaeological field schools, 182 subsurface test pits were conducted at the site; test pits were excavated as CVS units and as 50 x 50 cm square units (Dampf 2002:15-16; McCutcheon and Dampf 2002:19-20; Lewis 2015:22-23; McCutcheon 1999:14). From 2011 through 2013, field schools resumed at 45PI408, focusing on data recovery in large block excavation. During this time, nineteen 1 x 1 m units were excavated by naturally occurring depositional layers (Lewis 2015:23). A total of 15,459 chipped stone artifacts were recovered over the eight years of investigations at 45PI408, and 34.14 cubic meters of sediment was excavated. The site is well-stratified, has both above and below MR-C components, and has numerous radiocarbon and luminescence dates ranging from 4,086 to 100 cal. years BP (McCutcheon et al. 2017, in preparation).

The Sunrise Ridge Borrow Pit site has been tentatively classified as a multi-task, mixed group, residential base camp (Burtchard 1998:113). A subset of 4,601 of the recovered lithic artifacts from 45PI408 are from above the MR-C unit. Analytical data generated for this assemblage has been the focus of several research projects and was the undertaking of many students throughout the years (Dampf 2002; Davis et al. 2016; Lewis 2015; McCutcheon et al. 2017, in prep; Vaughn 2010).

Methods

This project involved new analysis of lithics from two rockshelter sites (45PI043 and 45PI303), and comparison of this data to previously-generated data from the Sunrise Ridge Borrow Pit Site (45PI408). Analytical data from all three sites was generated using the same methodological paradigm; involving recording attributes in a matrix of variables organizing the concepts of cost and performance developed by McCutcheon (1997). Here we discuss these concepts and the paradigmatic classification employed in this study, followed by statistical methods and hypotheses to be tested.

The cost of stone tool manufacture refers to the amount of energy needed to produce an artifact. Four sub-variables of cost, material acquisition, material preparation, tool manufacture, and tool durability, allow for the interpretation of lithic assemblage variation (McCutcheon 1997:209-211). These elements are measured by reference to the form and abundance of raw materials, the distance between areas of lithic material procurement and places of lithic manufacture and use, and the amount of energy expended in the manufacture and use of tools. With all else being equal, lower cost materials will have a selective advantage in pre-contact use over that of higher cost materials.

The performance level of the produced tool can offset the cost of producing lithic technology. Performance refers to the use of a stone tool, or the work done by an object as it interacts in its environment (McCutcheon 1997:211-213). The performance of a tool was measured by three sub-variables: rock physical properties, tool requirements, and technology. The interrelationships between these sub-variables greatly affects the durability, manufacture, and use of a stone tool, as different functional requirements influence the technologies and materials utilized (Dunnell and Campbell 1977). When variation found in archaeological assemblages does not fit the expected variation driven by natural selection, cultural transmission may provide an alternative explanation for the occurrence of these traits. This cost-performance model is used to answer the research question: are the selective conditions under which past people made and used stone tools different across site types on Mount Rainier? (Figure 2).

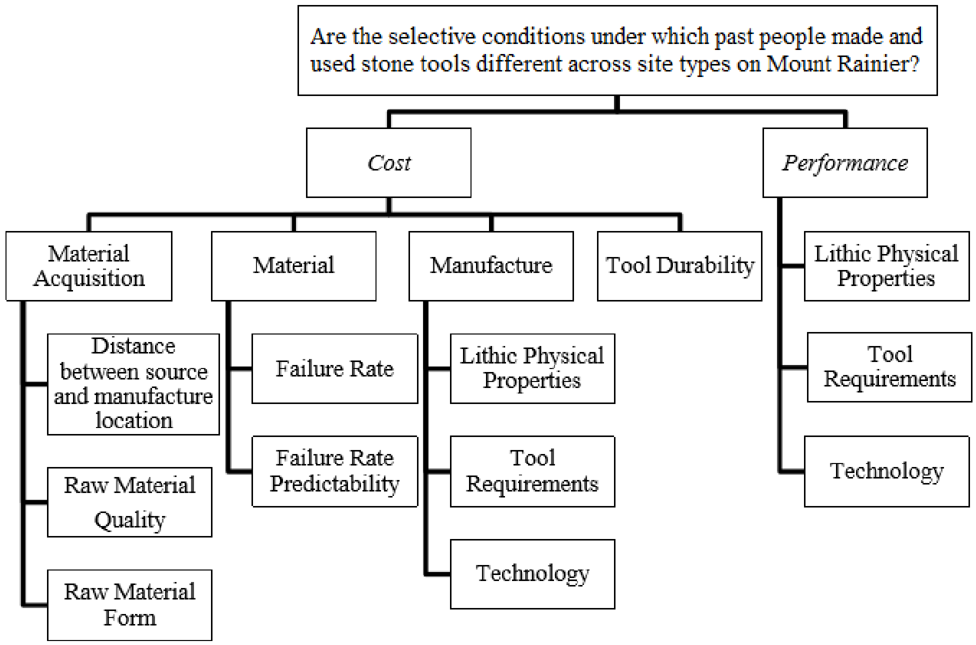

Figure 2. Cost and performance model (adapted from McCutcheon 1997: Figure 60).

The cost and performance model is operationalized into technological, functional, and rock physical property lithic analysis paradigms (Table 2). The technology paradigm focuses on dimensions that define stone tool technological classes. The functional paradigm focuses on macroscopic wear attributes to identify object function (Dancey 1973; Dunnell and Lewarch 1974; McCutcheon 1997). The dimensions of the rock physical properties classification focus on the macroscopic properties of tool stone that affect the mechanics of fracture (McCutcheon and Dunnell 1998).

A fourth paradigmatic classification (Carter 2002) is used to classify complete projectile points through a morphology-based dichotomous key.

TABLE 2. PARADIGMATIC CLASSIFICATIONS, DIMENSIONS, AND MODES

Paradigmatic Classifications	Dimensions	Modes
Technology	Object Type	Biface, Flake/Flake Fragment, Chunk, Cobble, Core, Spall
	Amount of Cortex	Primary, Secondary, Tertiary, None
	Wear	Absent, Present
	Other Modification	None, Flaking, Grinding, Pecking, Incising, Other
	Material Type	Chert, Obsidian, Igneous, Other
	Platform Type	Cortex, Simple, Faceted, Bifacial Unfinished, Bifacial Unfinished w/ Wear, Bifacial Finished, Bifacial Finished w/ Wear, Potlids, Fragmentary, Not Applicable, Pressure Flakes, Technologically Absent
	Completeness (following Sullivan and Rozen 1985)	Whole Flake, Broken Flake, Flake Fragment, Debris, Other
	Thermal Alteration	No Heating, Lustrous/Non-Lustrous Flake Scars, Lustrous Flake Scars Only, High Temp. Alteration
	Complexity of Dorsal Surface	Simple, Complex, Not Applicable
	Reduction Class	Initial, Intermediate, Terminal, Bifacial Reduction/Thinning, Bifacial Resharpening, Not Applicable
Function	Kind of Wear	Chipping, Abrasion, Crushing, Polishing, None
	Location of Wear	Angular Point, Angular Edge, Angular Plane, Curvilinear Point, Curvilinear Edge, Curvilinear Plane, Non-Localized, None
	Shape or Plan of Wear	Convex, Concave, Straight, Point, Oblique Notch, Acute Notch, None
	Orientation of Wear	Perpendicular to Y-Plane, Oblique to Y-Plane, Variable to Y-Plane, Parallel to Y-Plane, No Orientation, None
Rock Physical Properties	Groundmass	Uniform, Bedding Planes, Concentric Banding, Mottled, Granular, Oolitic
	Solid Inclusions	Present, Absent
	Void Inclusions	Present, Absent
	Distribution of Solid Inclusions	Random, Uniform, Structured, None
	Distribution of Void Inclusions	Random, Uniform, Structured, None

Statistical hypothesis testing was used in this study to determine if evidence for significant non-random associations were found in the samples from 45PI043, 45PI303 and 45PI408, across site types. Following Leonard and Jones (1989:2) diversity was measured in terms of richness (the number of functional and technological classes represented in the assemblages); and evenness (the manner in which artifacts are distributed among the technological and functional classes).

To determine whether the richness and evenness of the samples are representative of a population, a computer-based statistical technique known as resampling was used to compare the shape and characteristics of frequency counts within the resampling curves (after McCutcheon 1997:290; Vaughn 2010). To determine what differences/similarities exist among the sites, a stepwise analytical approach was followed. The statistical approach consists of first testing for associations among sites using a chi-square test, followed by an analysis of residuals if significant non-random associations were found. Finally, Cramér's *V* identifies the strength of non-random associations.

Site Type Expectation Hypotheses

While eighteen dimensions of lithic technology, function, and rock physical properties were recorded for each artifact, not all of these dimensions can be utilized for comparison of the archaeological record. In this study, expectations for the lithic assemblages from rockshelter and open-air sites derive from five dimensions: object type, completeness and reduction class, platform type, and thermal alteration. When a Chi-Square value rejects the null hypothesis, indicating significant differences between assemblages, modes can be identified that reveal a focus on a particular lithic industry. Expectations about functional traits of the assemblages can be assessed by focusing on the number of filled functional codes at each site. How these site-type expectations can be determined from the dimensions and modes of analysis in this study are outlined below.1.

Object Type: Because rockshelter sites are expected to be limited-task field or hunting camps, it is expected that light tool object types such as bifaces and a low frequency of cores should be highly represented (Burtchard 1998:113). Open-air, residential field camp assemblages, 45PI408 in this study, are expected to be varied with both light and heavy tools, with a high density of debitage (Burtchard 1998:113).

2. *Completeness and Reduction Class:* The dimension of completeness (following Sullivan and Rozen 1985) distributed the assemblages into five modes: whole flake, broken flake, flake fragment, debris, and other. Based on the proportion of these modes, the assemblages can be classified into technological categories. Sullivan and Rozen (1985:763) identify four technological group categories: un-intensive core reduction (IA), tool manufacture (II), intensive core reduction (IB2) and core reduction and tool manufacture (IB1).

The completeness dimension is not used to form expectations about site types, however it does directly influence the data in the reduction class dimension. Only flakes that retain their original point of impact (whole and broken flakes) can be placed into a reduction class. Because open-air residential site types are expected to be places where a wide-range of activities took place, it is expected that a more even distribution amongst the stages of reduction will be present in the 45PI408 assemblage. Because the activities at rockshelter sites should be limited to only late stage and retouch activities, the assemblages should show an overrepresentation of flakes from the terminal, bifacial reduction/thinning and bifacial resharpening modes.

3. *Platform Type:* The platform type dimension focuses on the point of impact which was struck to cause flake removal. Only flakes with completely intact platforms can be assigned a platform type; flakes that do not retain some or any of their platform are assigned to the fragmentary mode, and tools are classified as not applicable.

The activities related to creating the lithic assemblages found at rockshelters should be focused on tool maintenance, repair, and late stage manufacture (Burtchard 1998:113). This should be represented in the platform type dimension of the rockshelter assemblages compared to 45PI408 as a higher representation of the following modes: faceted platforms, bifacial unfinished platforms, bifacial unfinished platforms with wear present, bifacial finished platforms, bifacial finished platforms with wear present, and pressure flake platforms. 45PI408 should thus show an underrepresentation of the above modes, and may show a higher representation in the other modes of the platform type dimension: cortex platforms, simple platforms, potlids, fragmentary, not applicable, and technologically absent.

4. *Thermal Alteration:* Heat treatment of many rocks improves the material as toolstone by aiding in more predictable, intergranular crack propagation (McCutcheon 1997). While not all rocks are affected the same way, the results of heat treatment are flake-scar surfaces that are smooth, and more lustrous than scars removed prior to heat treatment (McCutcheon 1997). Over-heated objects have incredibly decreased "workability," and contain large flaws such as crenulation, crazing, and potlidding.

At 45PI408, it is reasonable to assume that one of the many residential camp activities performed could be heat-treatment of tool stone. Untreated objects and over-heat treated objects may be greater represented at 45PI408 than the rockshelter sites. Objects at the rockshelter sites should be represented highly in the lustrous/non-lustrous flake scars mode and the lustrous flake scars mode. It is not as likely that there will be as many high temperature alteration (over-heating) objects at the rockshelter sites.

5. *Use Wear:* There are some challenges to interpreting tool wear because post-depositional wear and trampling, and excavation and curation wear, can damage artifacts with chipping-type damage (Andfresky 2005:197; McCutcheon 1997:264). To minimize recording false presence of wear caused by post-depositional damage, chipping wear was recorded only when 5 or more patterned overlapping flake scars were present (per McCutcheon 1997:264).

It is difficult to draw specific expectations about usewear at rockshelter and open-air site types without making assumptions about the specific functions performed by the tools. Nonetheless, it is reasonable to expect that there will be more filled functional classes at 45PI408 than at 45PI043 or 45PI303.

Results

When the two rockshelter sites were compared to each other, the null hypothesis was rejected for ten of the possible eighteen dimensions analyzed, that is, there were only random differences between eight of the dimensions between the two rockshelter assemblages, while the differences between the rockshelter assemblages were non-random for ten of the dimensions. These statistically significant non-random differences between the two rockshelter sites imply that despite sharing similarities across some dimensions of analysis, significant variation exists between the sites classified as limited-task hunting or field camps.

To investigate how the two rockshelter-type site assemblages vary independent to each other, each rockshelter assemblage is compared individually to the same assemblage from a relatively nearby, contemporaneous, open-air site type, focusing specifically on the dimensions that relate to site type expectations. Lithic frequencies were compared in two independent permutations: the 45PI043 assemblage to the above MR-C component of open-air site 45PI408, and the 45PI303 assemblage to the above MR-C component of 45PI408.

Step 1: Assessing Data for Representativeness

Results from resampling indicate that the assemblages from 45PI043, 45PI303, and 45PI408 were found representative enough (in terms of evenness and richness) of a population to be sufficient for intersite assemblage comparisons for most recorded dimensions (Table 3).

Resampling results indicated that the dimension of *object type* was unrepresentative (Rank 3) at 45PI408. The object type dimension was, however, representative at 45PI043 (Rank 1) and 45PI303 (Rank 2). While the object types of chunks, cobbles, and spalls were also represented in the assemblages, they were not included in analysis as they contribute little technological or functional data. Three object types were focused upon: bifaces, flakes/flake fragments, and cores. When only these three modes of the object type dimension are analyzed for representativeness, all three sites generate Rank 1 curves, meaning the data is rich with even class distributions.

TABLE 3. RESAMPLING CURVES FOR REPRESENTATIVENESS OF LITHIC ASSEMBLAGES

Classification	Dimension	Curve Ranking		
		45PI043	45PI303	45PI408
Technological	Object Type	1	2	3
	Platform Types	1	2	1
	Thermal Alteration	1	1	1
	Reduction Class	1	1	1
	Technological Representativeness	100%	100%	80%
Functional	Kind of Wear	3	3	3
	Location of Wear	3	1	3
	Wear Shape	1	1	3
	Orientation of Wear	1	1	3
	Functional Representativeness	50%	75%	0%

Rank 1 and Rank 2 = representative data, Rank 3 = unrepresentative data

The dimension of *reduction class* generated Rank 1 curves of representativeness for all three sites in this study. Similarly, the assemblages for all three sites were deemed acceptable for the dimension of *platform type*, with rockshelter 45PI043 and open-air 45PI408 generating Rank 1 curves, and rockshelter 45PI303 generating a Rank 2 curve.

The dimension of *thermal alteration* generated Rank 1 curves at all three sites, indicating that data was rich and even at all three sites. Because of this, functional paradigmatic data will be used to indicate general trends, but interpretations will not be made with statistical significance.

Step 2: Detecting Significant Difference

Statistical tests were run in two independent permutations: the 45PI043 assemblage to the above MR-C component of open-air site 45PI408, and the 45PI303 assemblage to the above MR-C component of 45PI408. The detection of meaningful differences in the object type, reduction class, platform type, and thermal alteration dimensions allow for an evaluation of results pertaining to site-type expectations from the Burtchard (1998) model.

For all four dimensions, chi-square values generated were higher than the critical value from the chi-square distribution table; indicating that differences identified between the rockshelters sites and 45PI408 were not random, and thus rejecting the null hypothesis (Table 4).

Cramér's *V* values identify the strength of non-random associations between variables with a ranking between 0.00 (no relation) and 1.00 (completely related). For the dimension of object type, the low value generated in both comparisons indicated a very weak relationship between variables. For comparisons across the dimensions of reduction class, platform type, and thermal alteration, Cramér's *V* values are in the middle range for association, indicating that there is a moderate to strong association between variables in all three dimensions.

TABLE 4. STATISTICALLY SIGNIFICANT DIFFERENCES PERTAINING TO DIMENSIONS RELATED TO SITE TYPE EXPECTATIONS WHERE H_0 IS REJECTED

Dimension	*df*	Critical Value $\chi 2.05$ (p)	45PI043 to 45PI408			45PI303 to 45PI408		
			Chi-Square ($\chi 2$)	Cramér's *V*	Actual *p*-Value	Chi-Square ($\chi 2$)	Cramér's *V*	Actual *p*-Value
Object Type	2	5.99	21.46	0.07	< 0.01	11.37	0.07	< 0.01
Reduction Class	4	9.49	102.36	0.21	< 0.01	101.97	0.23	< 0.01
Platform Type	6	12.49	128.49	0.25	< 0.01	115.62	0.26	< 0.01
Thermal Alteration	3	7.82	567.90	0.30	< 0.01	689.57	0.33	< 0.01

Step 3: Identifying Significant Differences

Once significant differences were identified by Chi-Squared testing, each dimension could be analyzed to identify which modes were driving the meaningful differences (Table 5). Any cell that generates an adjusted residual greater than the critical value for the 0.05 alpha level (± 1.96) is identified as a mode that contributes significantly to the variation in the assemblage.

TABLE 5. ADJUSTED RESIDUALS WHERE H_0 IS REJECTED

Dimension	Mode	45PI408 Count	45PI043 to 45PI408 Count	45PI043 to 45PI408 Residuals	45PI303 to 45PI408 Count	45PI303 to 45PI408 Residuals
Object Type	Bifaces	76	24	-0.91	34	**2.47**[a]
	Flakes/Flake Fragments	3588	1532	**3.42**	1042	-0.64
	Cores	52	0	**-4.53**	5	**-2.33**
Reduction Class	Initial	15	34	**3.72**	8	0.47
	Intermediate	272	138	**-4.37**	41	**-7.27**
	Terminal	905	620	**-3.68**	409	1.21
	Bifacial Reduction	73	166	**8.61**	9	**7.86**
	Bifacial Resharpening	23	27	1.54	6	-1.14
Platform Type	Simple	288	103	**-7.94**	46	**-7.51**
	Faceted	263	234	1.38	87	**-2.71**
	Bifacial Unfinished	55	102	**5.39**	75	**6.89**
	Bifacial Unfin., wear	17	9	-1.01	2	-1.93
	Bifacial Finished	22	63	**5.63**	23	**2.98**
	Bifacial Fin., wear	8	18	**4.13**	5	0.60
	Pressure Flakes	551	427	-0.62	299	**3.82**
Thermal Alteration	No Heating	696	70	**-11.22**	15	**-12.39**
	Lustrous/Non-Lustrous	161	282	**18.96**	271	**23.85**
	Lustrous Only	2532	1044	**7.31**	620	0.91
	High Temp. Alteration	1211	197	**-11.46**	190	**-6.21**

[a]Values in bold indicate statistically significant contributors to rejection of null hypothesis

Object Type

An analysis of the residual value of each cell indicates that not all cells are significant contributors to the rejection of the null hypothesis. While bifaces are underrepresented at 45PI043, the amount of difference is random, and not a statistically significant value. The overrepresentation of bifaces at 45PI303 is, however, a significant contributor to the rejection of the null hypothesis. Flakes and flake fragments were significantly overrepresented at 45PI043 and insignificantly underrepresented at 45PI303. Cores were significantly underrepresented at both rockshelter sites.

Reduction Class and Completeness

The initial and intermediate reduction classes were overrepresented and underrepresented respectively at both 45PI043 and 45PI303. Focusing on the modes that relate to site type expectations, the mode which contributes most significantly to the rejection of the null hypothesis is the bifacial reduction/thinning class, which is overrepresented at both rockshelter sites. Bifacial resharpening flakes were overrepresented in the 45PI043 assemblage and underrepresented in the 45PI303 assemblage, but only randomly, and not with statistical significance. Terminal flakes were significantly underrepresented at 45PI043 and randomly overrepresented at 45PI303. 45PI043 and 45PI303 are similar in three of the five modes of the reduction class dimension, though only two of those are both statistically significant contributors to the rejection of the null hypothesis.

An analysis of the proportions of modes in the completeness dimension placed the sites in technological groups (per Sullivan and Rozen 1985). The assemblage from 45PI408 can be assigned to Group II, indicative of tool manufacture. Completeness proportions at the rockshelter sites vary significantly from the technological group model. Because of the high percentage of broken flakes and flake fragments, the rockshelter sites could tentatively be placed into Group II, however the dominance of whole flakes at 45PI043 and broken flakes at 45PI303 is not typical to the model.

Platform Type

The simple platform type was significantly underrepresented at both 45PI043 and 45PI303. The underrepresentation of faceted flakes at 45PI303 was significant, while the overrepresentation of faceted flakes at 45PI043 was insignificant (random). There was a significantly high representation of both bifacial unfinished and bifacial finished flakes at the rockshelter sites. Bifacial unfinished flakes with wear were underrepresented at the rockshelter sites, though not significantly (randomly). At 45PI043, bifacial finished flakes with wear are significantly overrepresented and pressure flakes are insignificantly (randomly) underrepresented. At 45PI303, bifacial finished flakes with wear are insignificantly (randomly) overrepresented, and pressure flakes are significantly overrepresented. 45PI043 and 45PI303 are similar in five of the seven modes of the platform type dimension; three of these similarities are from cells that are statistically significant contributors towards rejecting the null hypothesis at both sites.

Thermal Alteration

Seven of the eight modes of the thermal alteration dimension were statistically significant contributors towards the rejection of the null hypothesis. 45PI043 and 45PI303 had the same general trend in all four modes, however only three contributed significantly across both sites. The modes of no heating and high temperature alteration were significantly underrepresented at the two rockshelter sites. Lustrous/non-lustrous flakes were highly represented at 45PI043 and 45PI303, and lustrous only flakes were also highly represented, though only significantly at 45PI043, and randomly at 45PI303.

Use Wear

The functional paradigm yielded the least representative samples from all three sites; indicating that the data are very uneven, regardless of richness, and thus considered insufficient for performing intersite comparisons. Because of this, it is not possible to draw statistically significant results from this data.

One way to assess lithic use wear at the sites without following the statistical protocol, however, is to look at the functional characteristics of each dataset (Table 6). The number of filled functional classes is representative of how lithics were used and shows how many combinations of modes are represented in the data. There are nearly three times as many filled functional classes at 45PI408 than at 45PI043 or 45PI303; indicating there was less limit to the activities, or function, at the open-air site. Twenty-seven of the thirty-six functional codes filled at 45PI408 were unique to that site. Only five of the codes were found at all three sites. Five unique codes were found only in the 45PI043 and 45PI303 assemblages, respectively. Three codes were filled at only 45PI043 and 45PI408, and only one code was shared between just 45PI303 and 45PI408.

TABLE 6. NUMBER OF FILLED FUNCTIONAL CODES BY SITE

Site	Number of filled Functional Codes	% of Possible Codes Filled
45PI043	13	1.54%
45PI303	11	1.31%
45PI408	36	4.28%
	Total Possible Functional Codes - 841	

Discussion and Conclusions

The evolutionary archaeology model used here identified the manner in which rockshelter sites 45PI043 and 45PI303 vary independently of one another compared to the open-air 45PI408. That is, the differences and similarities of each rockshelter compared to the open-air 45PI408, derived from two separate statistical permutations, were compared to each other. The first goal of this research was to determine the degree to which rockshelter site assemblages are technologically and functionally similar or different when compared to an open-air assemblage (as described in Burtchard 1998:112-120). The second goal of this research was to determine if the composition of a rockshelter assemblage is unique, or if these assemblages are random samples of larger, open-air site lithic assemblages.

The characteristics of the two rockshelter sites independently support the current site-type interpretation that they were limited task field or hunting camps (Burtchard 1998) in that their primary lithic reduction activities were focused on late stage reduction and the maintenance of stone tools. This also is congruent with previous interpretations of site function at these locations (Andrews et al. 2016; Bergland 1988; Burtchard 1998). It is to be noted, however, that while the assemblages from these sites are similar to each other when compared to the open-air assemblage, there also is variation between the rockshelter site assemblages.

Statistically significant similarities between the two rockshelter sites include high representations of 1) flakes from the bifacial reduction and thinning reduction class mode; 2) flakes with bifacial unfinished and bifacial finished platform type modes; and 3) lithics assigned to the lustrous and non-lustrous flake scars mode. Other statistically significant similarities at the rockshelter sites are the underrepresentation of cores; flakes from the intermediate reduction class; simple platform types; and objects with no heating or high temperature thermal alteration.

Random similarities, with mixed significance, include an overrepresentation of initial reduction class modes, bifacial finished with wear present platform types, and lithics with lustrous flake scars only. This means that one site has a statistically significant non-random overrepresentation or underrepresentation, while the similar trend seen at the other site is a statistically insignificant random over- or underrepresentation. The decrease of bifacial unfinished with wear present platform types was statistically insignificant, or random, at both rockshelter sites.

The differences between rockshelters sites have mixed statistical significance, much like the statistically insignificant similarities. This means that one site has a statistically significant non-random over- or underrepresentation, while the opposite representation seen at the other site is a random, and not statistically significant.

These random differences are seen in the data through the object type mode. The bifaces mode, for example, is significantly overrepresented at 45PI303, and insignificantly underrepresented at 45PI043. 45PI043 also had a significant overrepresentation of flake and flake fragment object types, while 45PI303 had an insignificant underrepresentation of flakes and flake fragments.

There also are differences in the platform type dimension. Faceted flakes were non-randomly underrepresented at 45PI303, and randomly overrepresented at 45PI043. Pressure flakes were randomly underrepresented at 45PI043, and non-randomly overrepresented at 45PI303.

Additionally, the reduction class dimension shows differences between the rockshelter sites. The terminal reduction class is significantly underrepresented at 45PI043, and randomly overrepresented at 45PI303.

The bifacial resharpening reduction class is overrepresented at 45PI043 and underrepresented at 45PI303. However, the adjusted residuals for both are below the threshold for statistical significance, and thus these differences are random.

Another noticeable difference between rockshelter sites 45PI043 and 45PI303 is found when assigning typology to projectile points from each rockshelter. 45PI043 had three points from which the necessary metrics could be measured. Two of the points were Columbia Corner-Notched Type B, and one was the smaller Columbia Stemmed variant. These point types are both representative of the last 2,000 years of the Columbia Plateau archaeological record (Carter 2002; Lohse 1985).

The two points that could be classified from 45PI303 were both Plateau Side-Notched types. While overlapping temporally, these points generally are considered to be slightly younger, and used only in the last 1,500 years (Carter 2002; Lohse 1985). While not all of the biface fragments from the assemblages could be assigned to a typology, those recognized did not overlap between rockshelter sites. While all of the point types found were from generally the same time period, stylistic variation may reflect differences in social groups occupying these areas. We recognize inferential limitations in the dataset, and point them out here only to stimulate discussion. A deeper discussion of the projectile point artifacts from 45PI303 can be found in Andrews et al. 2016.

Addressing the second goal of this research, the data indicate that rockshelter assemblages are not unique adaptations, but are subsets samples of larger, open-air site lithic assemblages. All three sites tentatively share the same technological organization group of tool manufacture (Sullivan and Rozen 1985). This means that the limited activities proposed to be happening at rockshelter site types also occur at the open-air sites. The reason for the limitations of activity could be due to restricted space at the rockshelter sites; there simply is not enough flat, open space at the rockshelter locations to perform many of the tasks that could be performed in the larger, flatter, open-air site locations.

While the functional data generated from this analysis was not entirely statistically representative at any of the three sites, the number of filled functional codes is indicative of the general function of sites. Fourteen of the filled functional classes at 45PI043 and 45PI303 are found within the sample at 45PI408. This is to say, eight of the thirteen classes represented in the 45PI043 assemblage, and six the eleven classes in the 45PI303 assemblage were codes represented in the thirty-six filled functional codes at 45PI408. This indicates that a limited suite of the same types of activities going on at open-air sites were performed at the rockshelter sites. Primary differences between function at rockshelters versus open-air site 45PI408 include a significant overrepresentation of chipping-type wear at 45PI408. 45PI408 also contains more functional variation (more filled classes) in location of wear, shape of wear, and orientation of wear.

In short, the technology and function of limited-task field camps and residential base camps from Burtchard's (1998) site type model for Mount Rainier archaeological sites is supported by the technological and functional organization of the 45PI043, 45PI303, and 45PI408 assemblages. There is, however, more variation between rockshelter sites than was previously expected. Further research into lithic technology and function across space and site type could reveal more about the selective conditions under which this lithic industry was created.

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APPENDIX A.

Frequency Data

Table A1. Frequency Counts for Object Type Dimension

Object Type	45PI043	45PI303	RS[a] Total	45PI406	45PI408	45PI429	OA[b] Total
Biface – 0	24	34	58	4	76	12	92
Flake/Flake Fragment - 1	1532	1042	2574	747	3855	694	5296
Chunk - 2	28	5	33	6	485	9	500
Cobble - 3	0	0	0	8	3	0	11
Core - 4	0	5	5	0	52	0	52
Spall - 5	9	10	19	4	126	1	131
Gastrolith - 6	0	0	0	1	4	0	5
Total	1593	1096	2689	770	4601	716	6087

[a] "RS" = collapsed rockshelter sites; [b] "OA" = collapsed open-air sites

Table A2. Frequency Counts for Amount of Cortex Dimension

Amount of Cortex	45PI043	45PI303	RS Total	45PI406	45PI408	45PI429	OA Total
Primary - 1	4	1	5	11	16	5	32
Secondary - 2	51	26	77	13	75	7	95
Tertiary - 3	14	12	26	1	2	3	6
None - 4	1524	1057	2581	745	4508	701	5954
Total	1593	1096	2689	770	4601	716	6087

Table A3. Frequency Counts for Presence of Wear Dimension

Presence of Wear	45PI043	45PI303	RS Total	45PI406	45PI408	45PI429	OA Total
Absent - 1	1546	1070	2616	691	2899	692	4282
Present - 2	47	26	73	79	1702	24	1805
Total	1593	1096	2689	770	4601	716	6087

Table A4. Frequency Counts for Other Modification Dimension

Other Modification	45PI043	45PI303	RS Total	45PI406	45PI408	45PI429	OA Total
None - 1	1566	1031	2597	760	4467	166	5393
Flaking - 2	27	65	92	9	132	550	691
Grinding - 3	0	0	0	1	1	0	2
Pecking - 4	0	0	0	0	1	0	1
Incising - 5	0	0	0	0	0	0	0
Other - 6	0	0	0	0	0	0	0
Total	1593	1096	2689	770	4601	716	6087

Table A5. Frequency Counts for Material Type Dimension

Material Type	45PI043	45PI303	RS Total	45PI406	45PI408	45PI429	OA Total
Chert - 1	1590	1076	2666	683	4023	705	5411
Obsidian - 2	0	0	0	36	343	0	379
Igneous - 3	3	20	23	41	216	11	268
Other - 4	0	0	0	1	18	0	19
Total	1593	1096	2689	761	4601	716	6077

Table A6. Frequency Counts for Platform Type Dimension

Platform Type	45PI043	45PI303	RS Total	45PI406	45PI408	45PI429	OA Total
Cortex – 1	19	9	28	0	7	4	11
Simple – 2	103	46	149	14	288	195	497
Faceted – 3	234	87	321	71	263	71	405
Bifacial unfinished – 4	102	75	177	14	55	8	77
Bifacial unfinished, wear – 5	9	2	11	5	17	0	22
Bifacial finished – 6	63	23	86	19	22	1	42
Bifacial finished, wear – 7	18	5	23	15	8	4	27
Potlids – 8	10	7	17	9	44	4	57
Fragmentary – 9	533	498	1031	582	2596	288	3466
Not applicable – 10	75	45	120	21	737	21	779
Pressure flakes – 11	427	299	726	19	551	96	666
Technologically absent - 12	0	0	0	1	11	24	36
Total	1593	1096	2689	770	4599	716	6085

Table A7. Frequency Counts for Completeness Dimension

Completeness	45PI043	45PI303	RS Total	45PI406	45PI408	45PI429	OA Total
Whole Flake - 1	616	27	643	7	175	30	212
Broken Flake - 2	364	520	884	148	1048	361	1557
Flake Fragment - 3	513	412	925	590	2589	280	3459
Debris - 4	72	96	168	9	264	25	298
Other - 5	28	41	69	16	524	20	560
Total	1593	1096	2689	770	4600	716	6086

Table A8. Frequency Counts for Thermal Alteration Dimension

Thermal Alteration	45PI043	45PI303	RS Total	45PI406	45PI408	45PI429	OA Total
No Heating – 0	70	15	85	72	696	52	820
Lustrous/Non-Lustrous - 1	282	271	553	12	161	181	354
Lustrous Only - 2	1044	620	1664	639	2532	448	3619
High Temp. Alteration - 3	197	190	387	47	1211	35	1293
Total	1593	1096	2689	770	4600	716	6086

Table A9. Frequency Counts for Complexity of Dorsal Surface Dimension

Complexity of Dorsal Surface	45PI043	45PI303	RS Total	45PI406	45PI408	45PI429	OA Total
Simple - 1	348	99	447	50	1653	173	1876
Complex - 2	1114	861	1975	694	2167	203	3064
Not Applicable - 3	131	136	267	26	764	340	1130
Total	1593	1096	2689	770	4584	716	6070

Table A10. Frequency Counts for Reduction Class Dimension

Reduction Class	45PI043	45PI303	RS Total	45PI406	45PI408	45PI429	OA Total
Initial – 1	34	8	42	2	15	6	23
Intermediate – 2	138	41	179	0	272	167	439
Terminal - 3	620	409	1029	90	905	186	1181
Bifacial Reduction/Thinning - 4	166	96	262	33	73	17	123
Bifacial Resharpening - 5	27	6	33	20	23	0	43
Not Applicable - 6	608	536	1144	625	3311	340	4276
Total	1593	1096	2689	770	4599	716	6085

Table A11. Frequency Counts for Kind of Wear Dimension

Kind of Wear	45PI043	45PI303	RS Total	45PI406	45PI408	45PI429	OA Total
Chipping – 1	40	27	67	87	2097	26	2210
Abrasion – 2	2	1	3	2	3	0	5
Crushing - 3	3	4	7	2	3	0	5
Polishing - 4	0	0	0	0	0	0	0
None - 5	1554	1068	2622	693	2938	690	4321
Total	1599	1100	2699	784	5041	716	6541

Table A12. Frequency Counts for Location of Wear Dimension

Location of Wear	45PI043	45PI303	RS Total	45PI406	45PI408	45PI429	OA Total
Angular Point - 1	0	0	0	1	13	5	19
Angular Edge - 2	37	30	67	88	2080	6	2174
Angular Plane - 3	3	0	3	2	3	6	11
Curvilinear Point - 4	1	0	1	0	1	1	2
Curvilinear Edge - 5	3	0	3	0	4	8	12
Curvilinear Plane - 6	1	1	2	0	2	0	2
Non-localized - 7	0	0	0	0	1	0	1
None - 8	1554	1069	2623	693	2937	690	4320
Total	1599	1100	2699	784	5041	716	6541

Table A13. Frequency Counts for Shape or Plan of Worn Area Dimension

Shape or Plan of Worn Area	45PI043	45PI303	RS Total	45PI406	45PI408	45PI429	OA Total
Convex – 1	6	5	11	3	878	9	890
Concave – 2	8	10	18	82	397	1	480
Straight - 3	31	16	47	5	821	12	838
Point - 4	0	0	0	1	5	4	10
Oblique notch - 5	0	0	0	0	1	0	1
Acute notch – 6	0	0	0	0	2	0	2
None - 7	1554	1069	2623	693	2937	690	4320
Total	1599	1100	2699	784	5041	716	6541

Table A14. Frequency Counts for Orientation of Wear Dimension

Orientation of Wear	45PI043	45PI303	RS Total	45PI406	45PI408	45PI429	OA Total
Perpendicular to Y-Plane - 1	1	0	1	0	1771	0	1771
Oblique to Y-Plane - 2	30	22	52	84	242	19	345
Variable to Y-Plane - 3	14	9	23	6	86	7	99
Parallel to Y-Plane - 4	0	0	0	1	4	0	5
No Orientation - 5	0	0	0	0	3	0	3
None - 6	1554	1069	2623	693	2935	690	4318
Total	1599	1100	2699	784	5041	716	6541

Table A15. Frequency Counts for Groundmass Dimension

Groundmass	45PI043	45PI303	RS Total	45PI406	45PI408	45PI429	OA Total
Uniform - 1	166	88	254	268	365	275	908
Bedding Planes - 2	16	5	21	26	36	20	82
Concentric Banding - 3	0	0	0	0	1	0	1
Mottled - 4	1395	937	2332	447	4169	379	4995
Granular - 5	16	66	82	29	26	29	84
Oolitic - 6	0	0	0	0	5	13	18
Total	1593	1096	2689	770	4602	716	6088

Table A16. Frequency Counts for Presence of Solid Inclusions Dimension

Solid Inclusions	45PI043	45PI303	RS Total	45PI406	45PI408	45PI429	OA Total
Present - 1	820	654	1474	634	3929	389	4952
Absent - 2	773	442	1215	136	673	327	1136
Total	1593	1096	2689	770	4602	716	6088

Table A17. Frequency Counts for Presence of Void Inclusions Dimension

Void Inclusions	45PI043	45PI303	RS Total	45PI406	45PI408	45PI429	OA Total
Present - 1	1309	890	2199	16	1695	48	1759
Absent - 2	284	206	490	754	2907	668	4329
Total	1593	1096	2689	770	4602	716	6088

Table A18. Frequency Counts for Distribution of Solid Inclusions Dimension

Distribution of Solid Inclusions	45PI043	45PI303	RS Total	45PI406	45PI408	45PI429	OA Total
Random - 1	820	654	1474	573	3676	376	4625
Uniform - 2	1	0	1	9	139	4	152
Structured - 3	0	0	0	53	113	4	170
None - 4	772	442	1214	135	674	332	1141
Total	1593	1096	2689	770	4602	716	6088

Table A19. Frequency Counts for Distribution of Void Inclusions Dimension

Distribution of Void Inclusions	45PI043	45PI303	RS Total	45PI406	45PI408	45PI429	OA Total
Random - 1	1308	890	2198	11	1500	40	1551
Uniform - 2	0	0	0	3	11	4	18
Structured - 3	2	0	2	3	187	1	191
None - 4	283	206	489	753	2904	671	4328
Total	1593	1096	2689	770	4602	716	6088

APPENDIX B – Resampling Curves

Individual Site Assemblage Resampling Curves

Type of Fragment/Object Type Resampling Curves

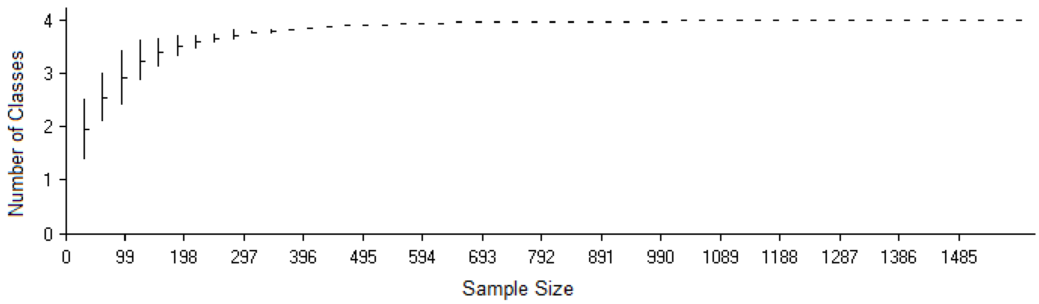

Figure B1. Resampling Curve for 45PI043 Type of Fragment/Object Type Dimension

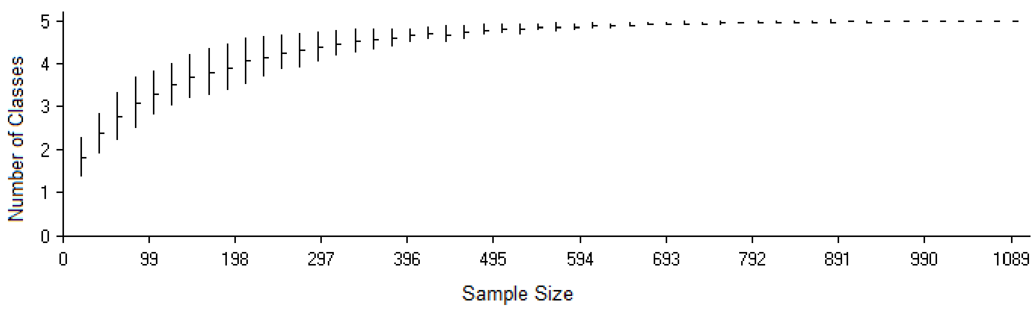

Figure B2. Resampling Curve for 45PI303 Type of Fragment/Object Type Dimension

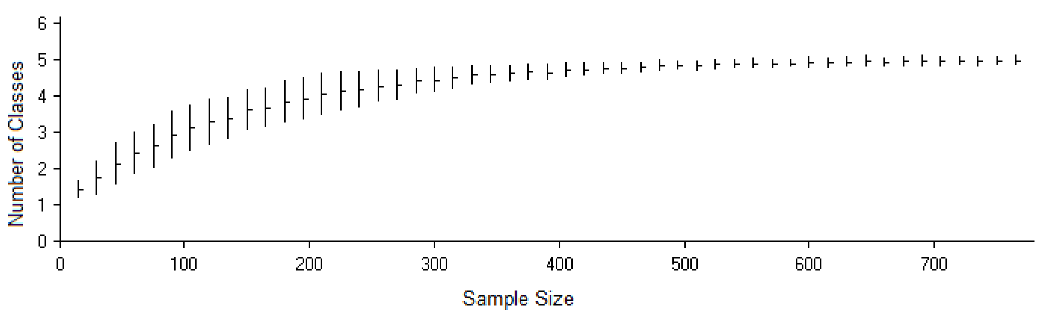

Figure B3. Resampling Curve for 45PI406 Type of Fragment/Object Type Dimension

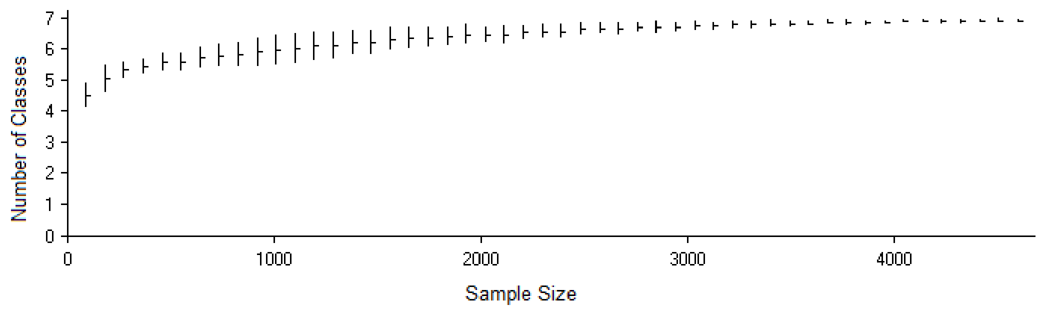

Figure B4. Resampling Curve for 45PI408 Type of Fragment/Object Type Dimension

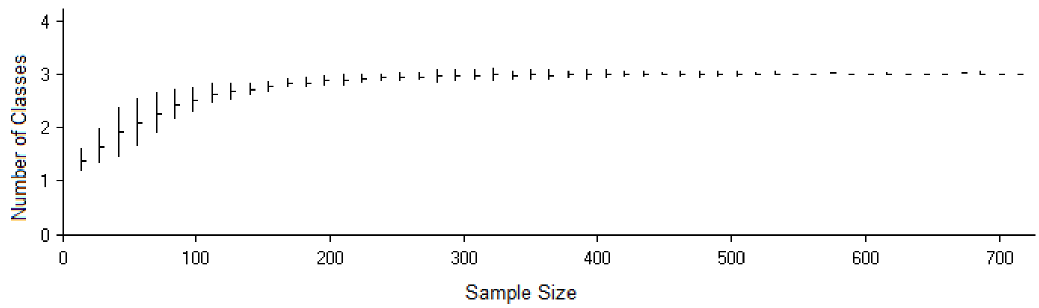

Figure B5. Resampling Curve for 45PI429 Type of Fragment/Object Type Dimension

Amount of Cortex Resampling Curves

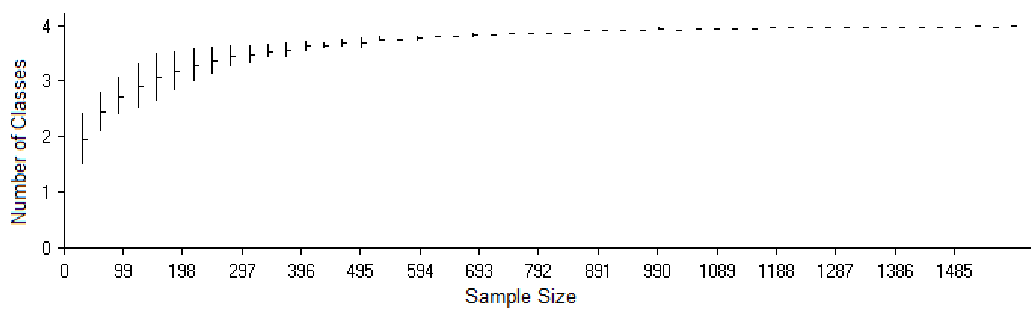

Figure B6. Resampling Curve for 45PI043 Amount of Cortex Dimension

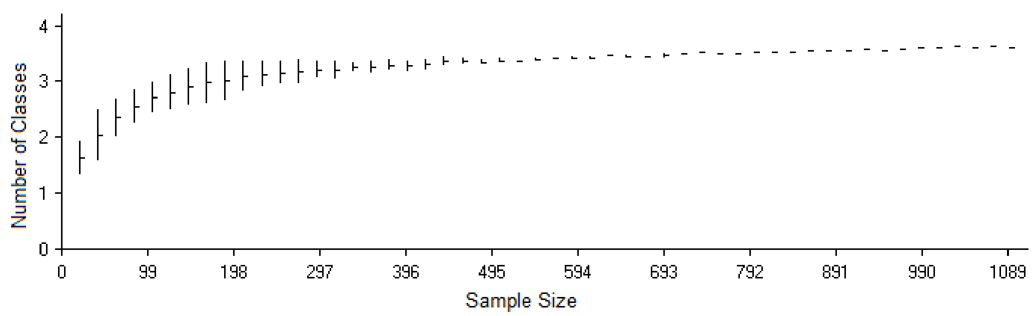

Figure B7. Resampling Curve for 45PI303 Amount of Cortex Dimension

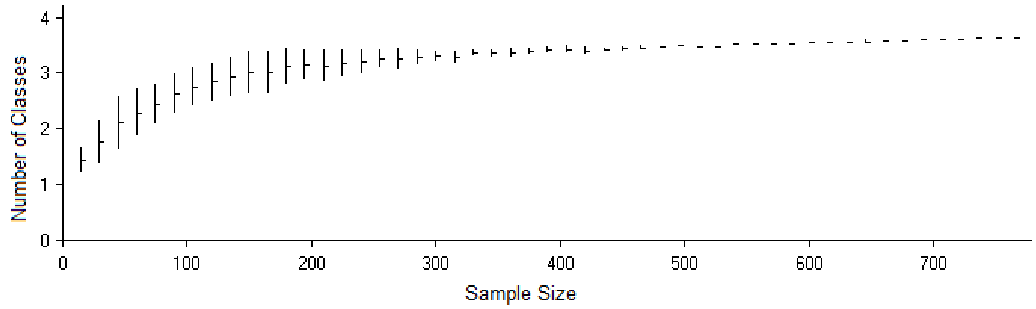

Figure B8. Resampling Curve for 45PI406 Amount of Cortex Dimension

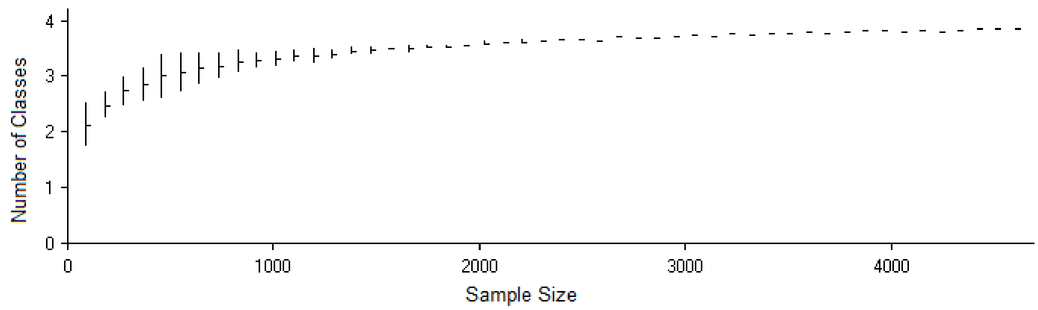

Figure B9. Resampling Curve for 45PI408 Amount of Cortex Dimension

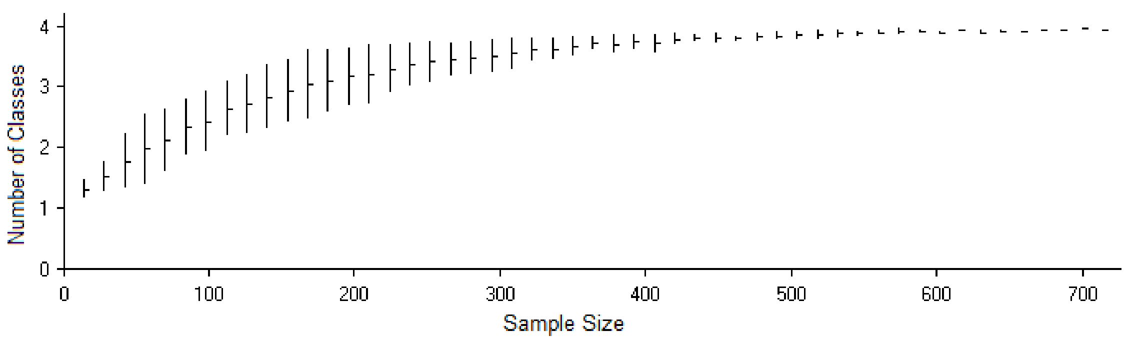

Figure B10. Resampling Curve for 45PI429 Amount of Cortex Dimension

Presence of Wear Resampling Curves

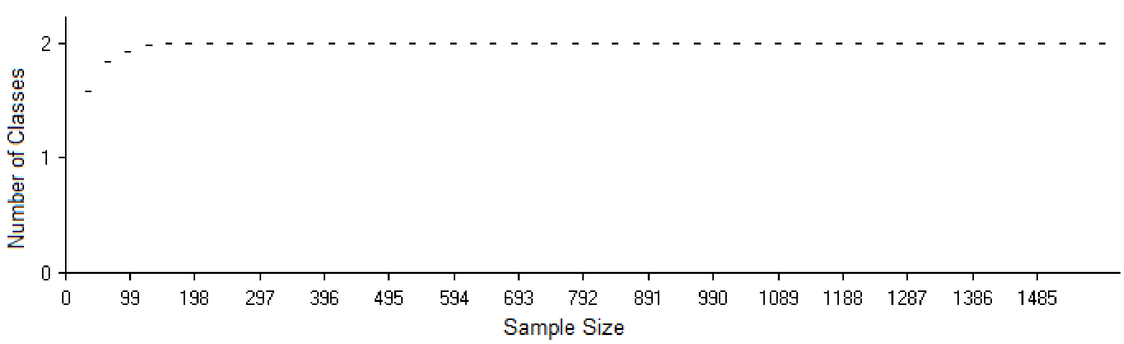

Figure B11. Resampling Curve for 45PI043 Presence of Wear Dimension

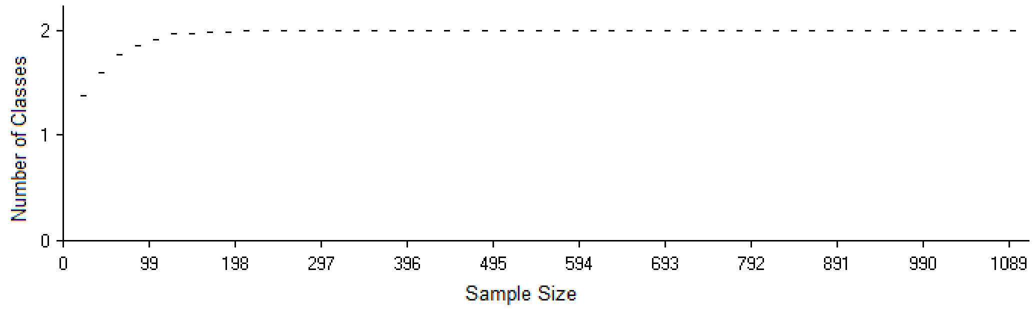

Figure B12. Resampling Curve for 45PI303 Presence of Wear Dimension

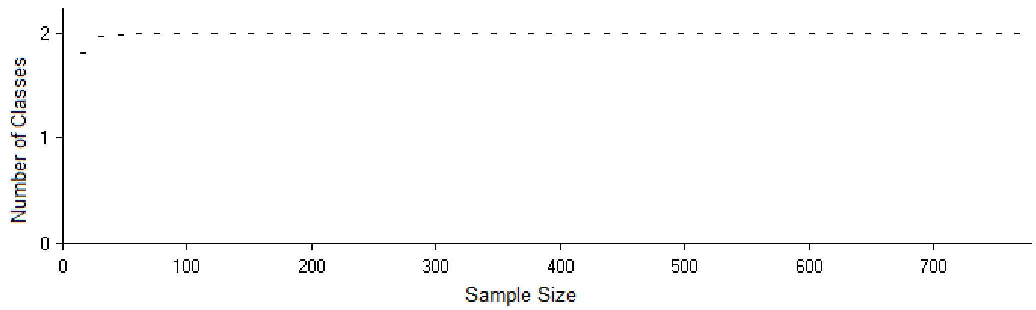

Figure B13. Resampling Curve for 45PI406 Presence of Wear Dimension

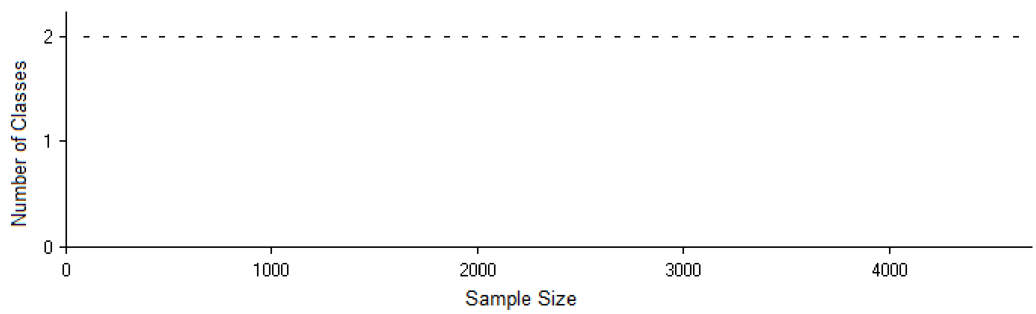

Figure B14. Resampling Curve for 45PI408 Presence of Wear Dimension

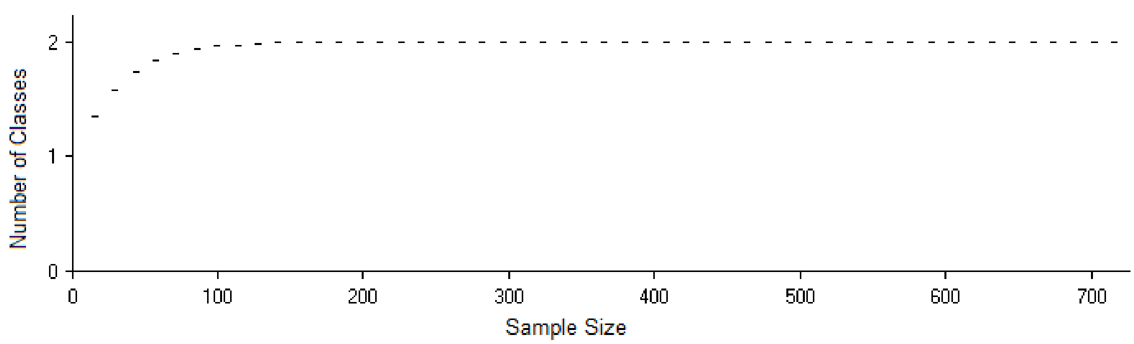

Figure B15. Resampling Curve for 45PI429 Presence of Wear Dimension

Other Modification Resampling Curves

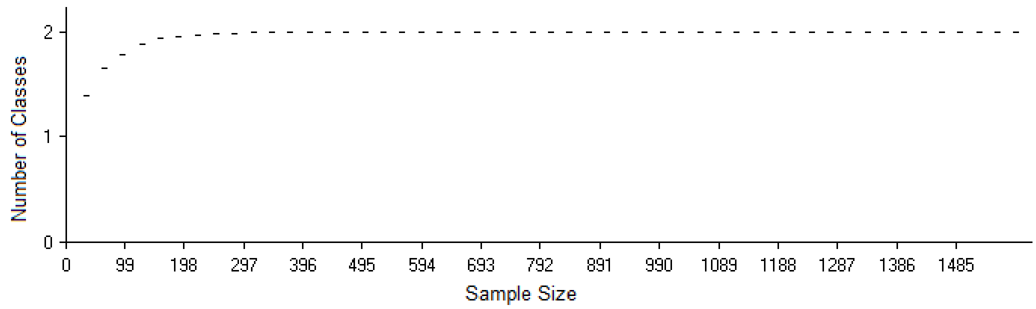

Figure B16. Resampling Curve for 45PI043 Other Modification Dimension

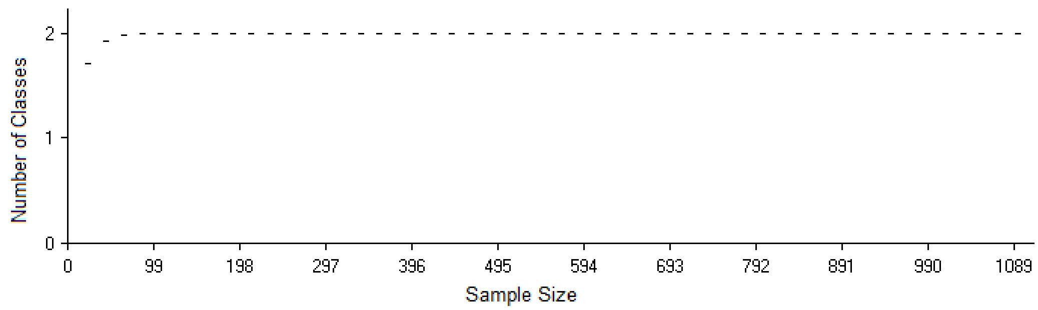

Figure B17. Resampling Curve for 45PI303 Other Modification Dimension

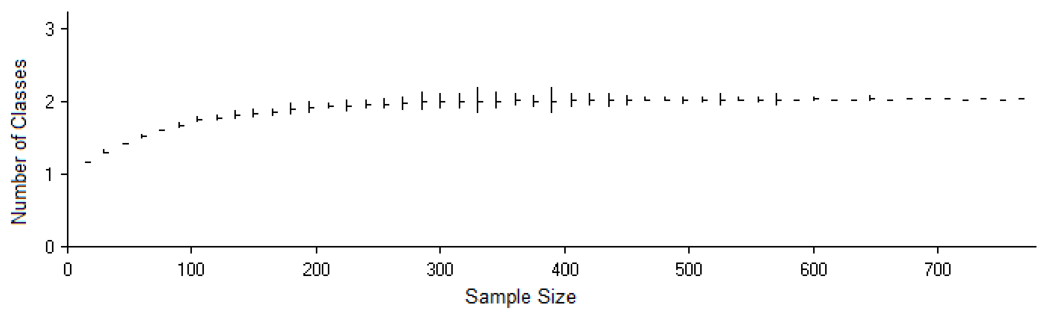

Figure B18. Resampling Curve for 45PI406 Other Modification Dimension

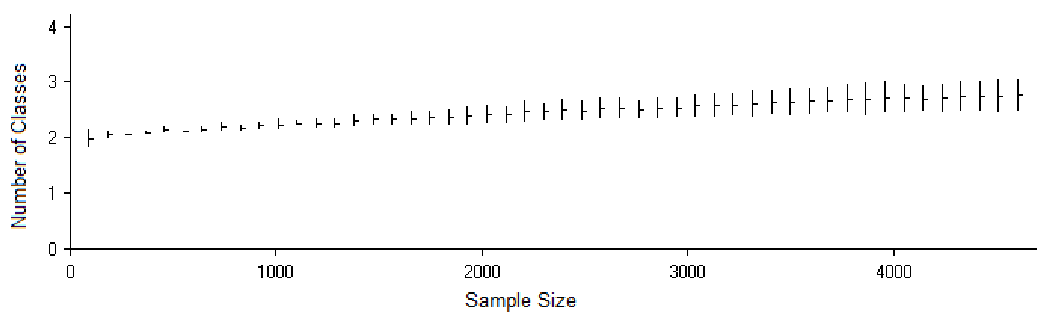

Figure B19. Resampling Curve for 45PI408 Other Modification Dimension

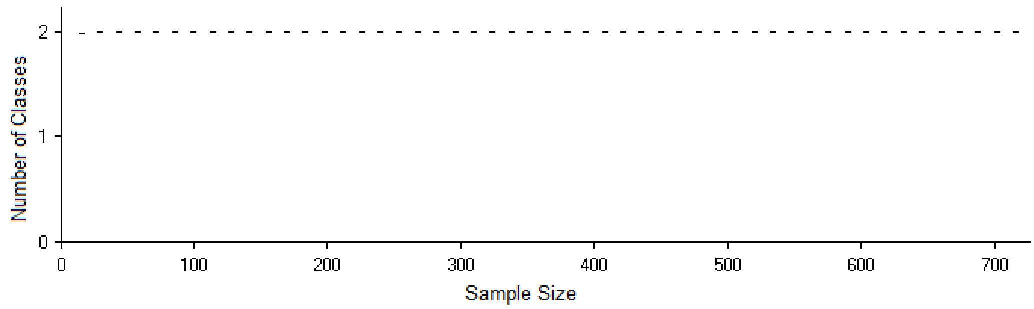

Figure B20. Resampling Curve for 45PI429 Other Modification Dimension

Material Type Resampling Curves

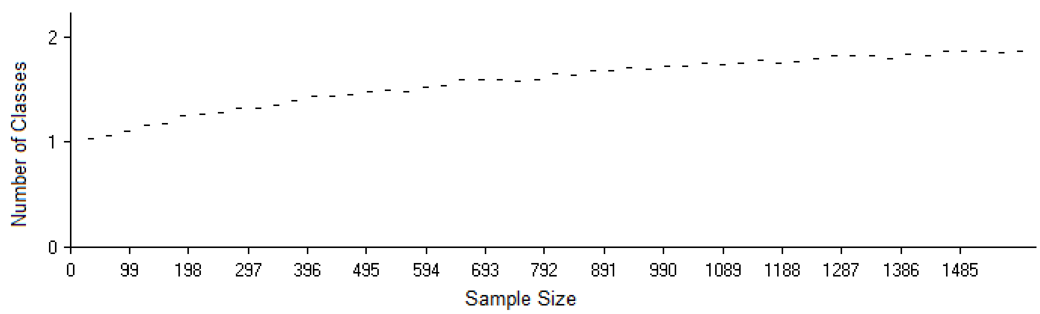

Figure B21. Resampling Curve for 45PI043 Material Type Dimension

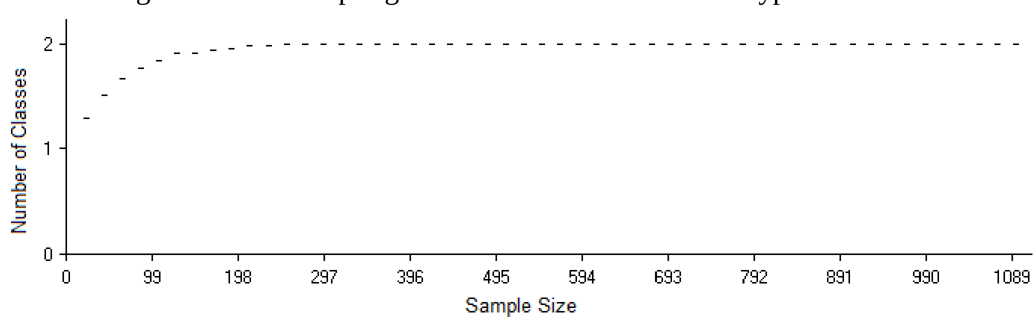

Figure B22. Resampling Curve for 45PI303 Material Type Dimension

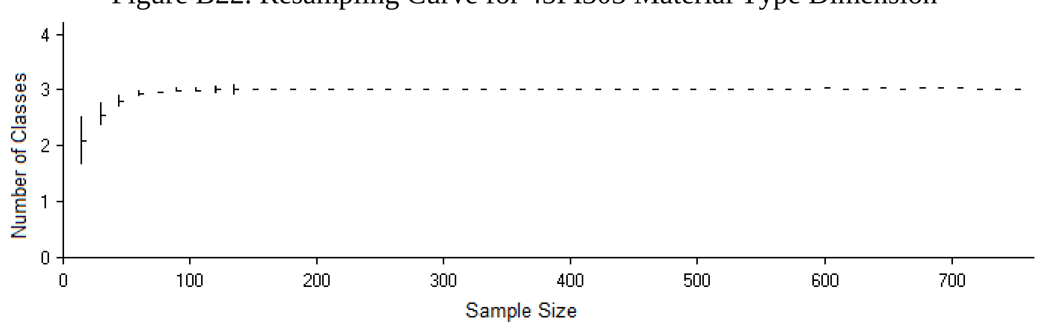

Figure B23. Resampling Curve for 45PI406 Material Type Dimension

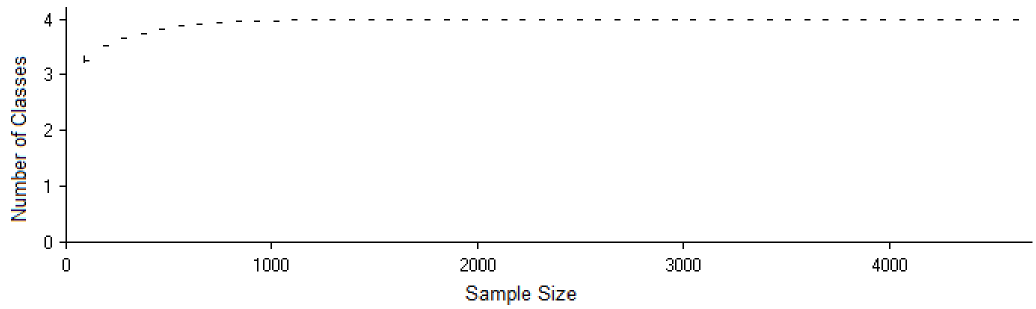

Figure B24. Resampling Curve for 45PI408 Material Type Dimension

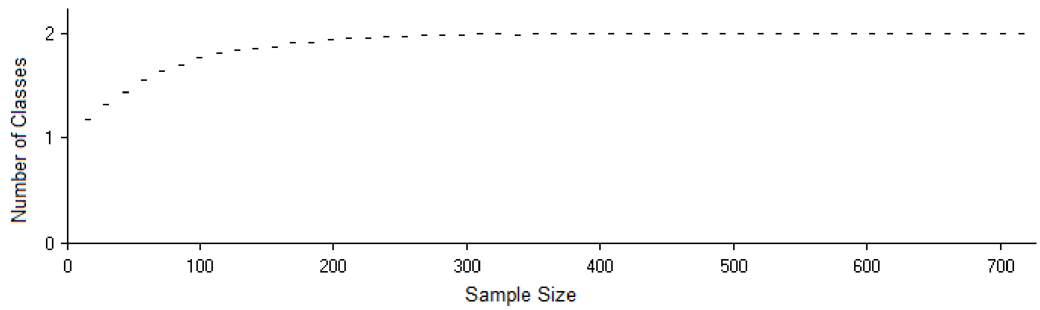

Figure B25. Resampling Curve for 45PI429 Material Type Dimension

Platform Type Resampling Curves

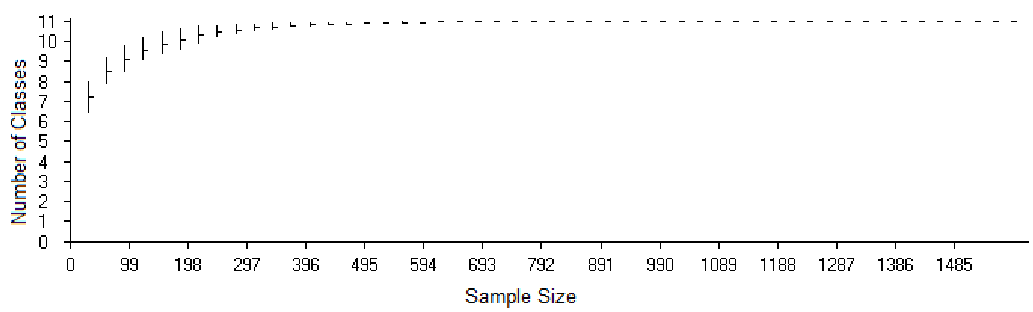

Figure B26. Resampling Curve for 45PI043 Platform Type Dimension

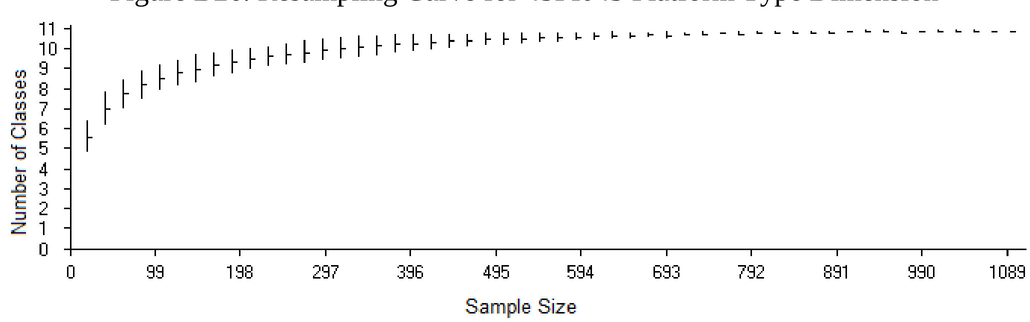

Figure B27. Resampling Curve for 45PI303 Platform Type Dimension

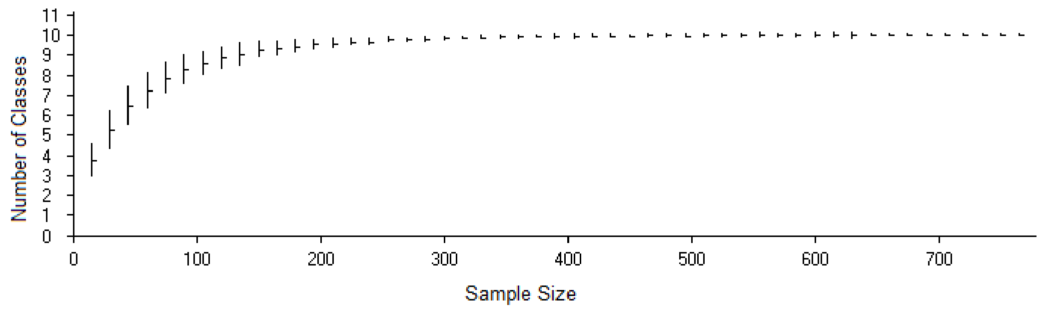

Figure B28. Resampling Curve for 45PI406 Platform Type Dimension

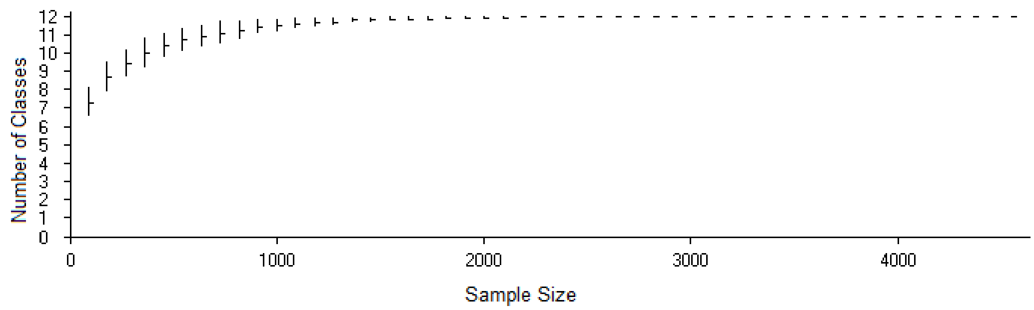

Figure B29. Resampling Curve for 45PI408 Platform Type Dimension

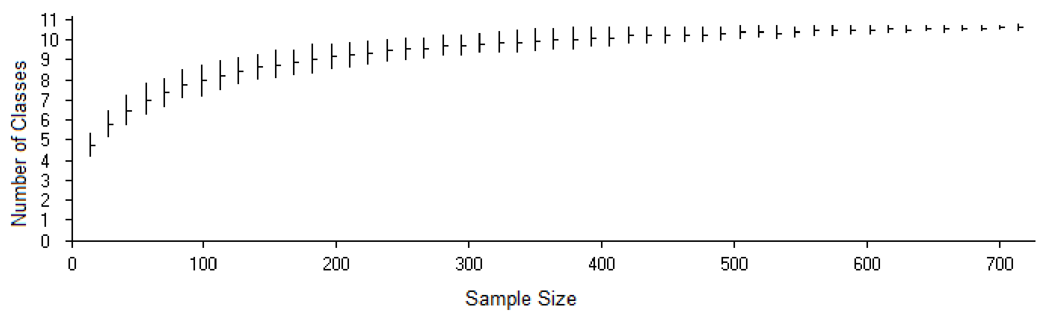

Figure B30. Resampling Curve for 45PI429 Platform Type Dimension

Completeness Resampling Curves

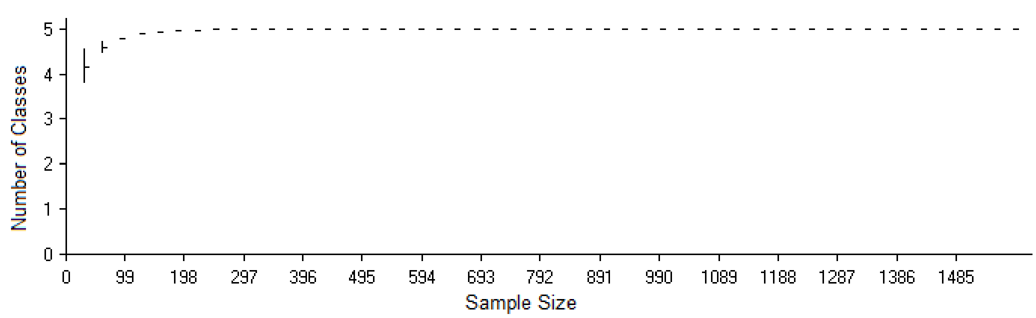

Figure B31. Resampling Curve for 45PI043 Completeness Dimension

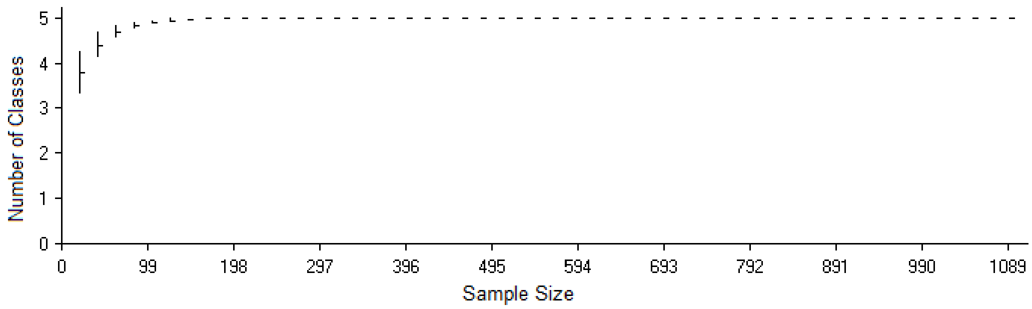

Figure B32. Resampling Curve for 45PI303 Completeness Dimension

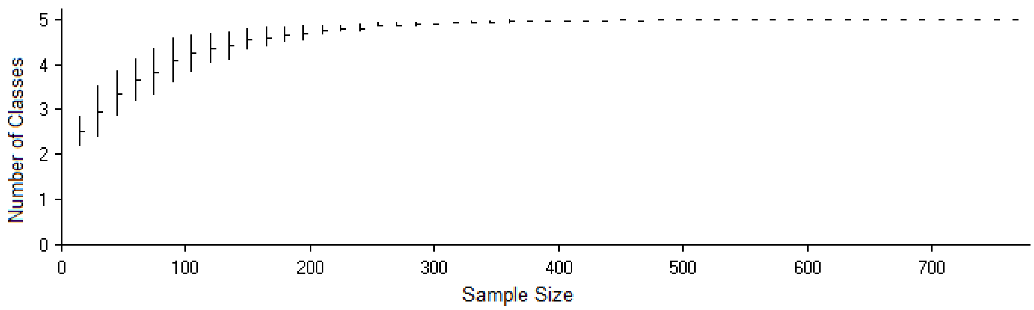

Figure B33. Resampling Curve for 45PI406 Completeness Dimension

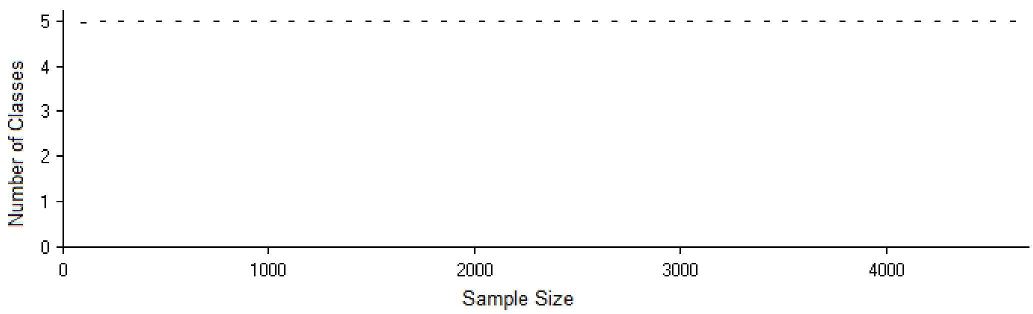

Figure B34. Resampling Curve for 45PI408 Completeness Dimension

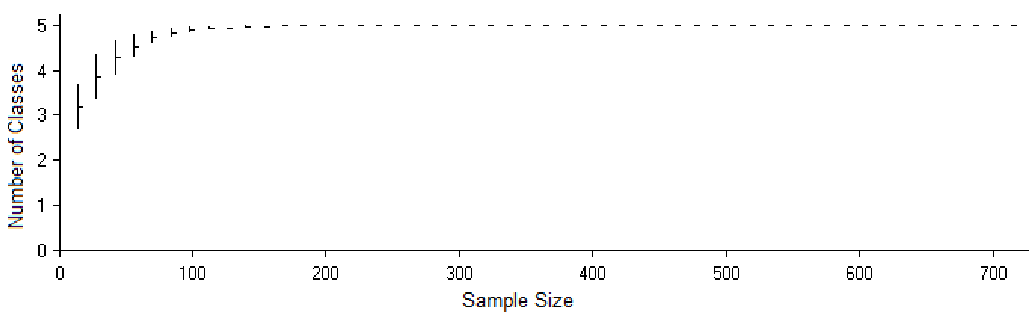

Figure B35. Resampling Curve for 45PI429 Completeness Dimension

Thermal Alteration Resampling Curves

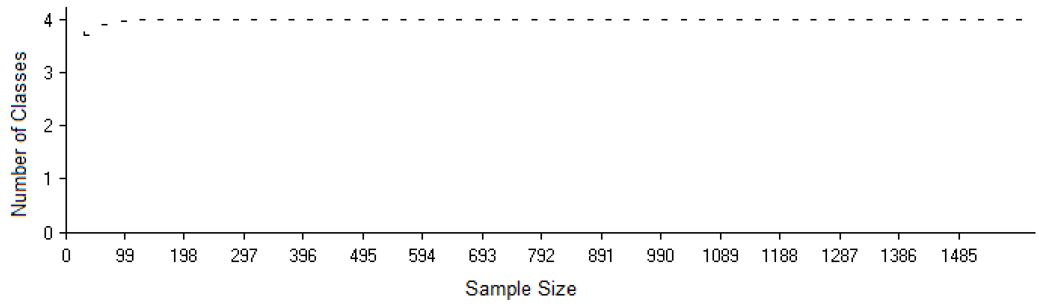

Figure B36. Resampling Curve for 45PI043 Thermal Alteration Dimension

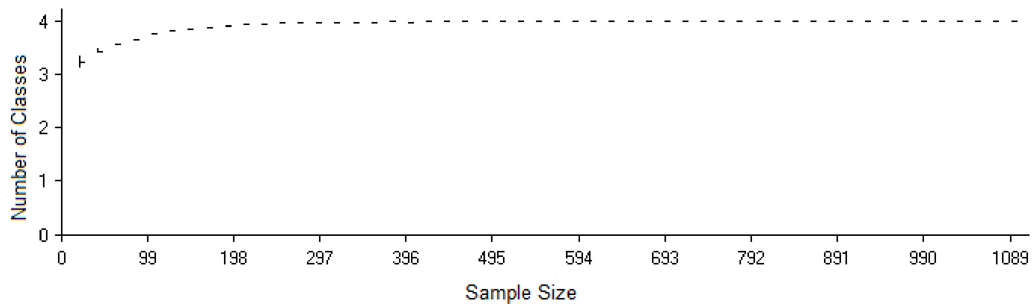

Figure B37. Resampling Curve for 45PI303 Thermal Alteration Dimension

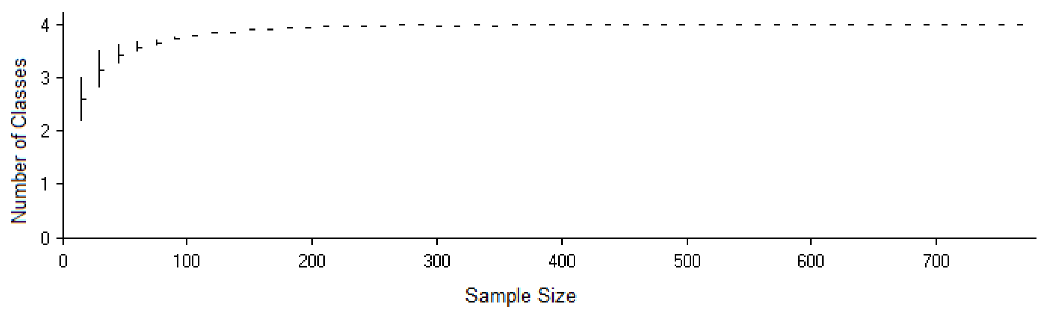

Figure B38. Resampling Curve for 45PI406 Thermal Alteration Dimension

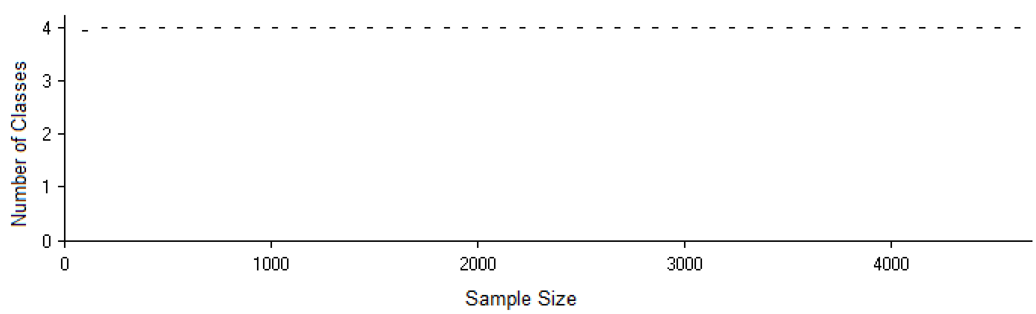

Figure B39. Resampling Curve for 45PI408 Thermal Alteration Dimension

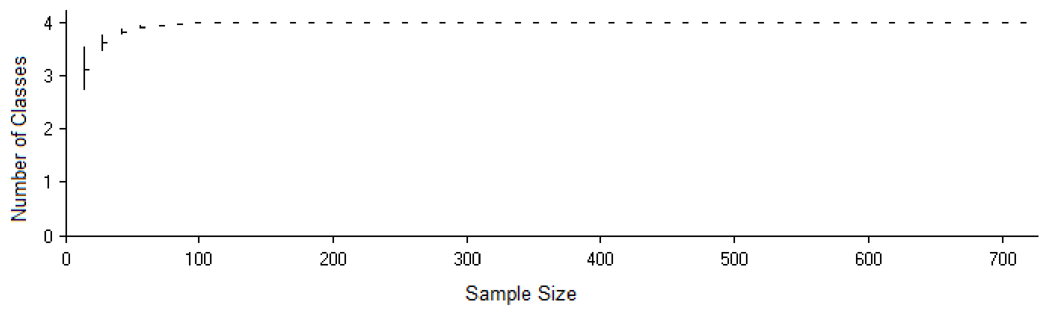

Figure B40. Resampling Curve for 45PI429 Thermal Alteration Dimension

Complexity of Dorsal Surface Resampling Curves

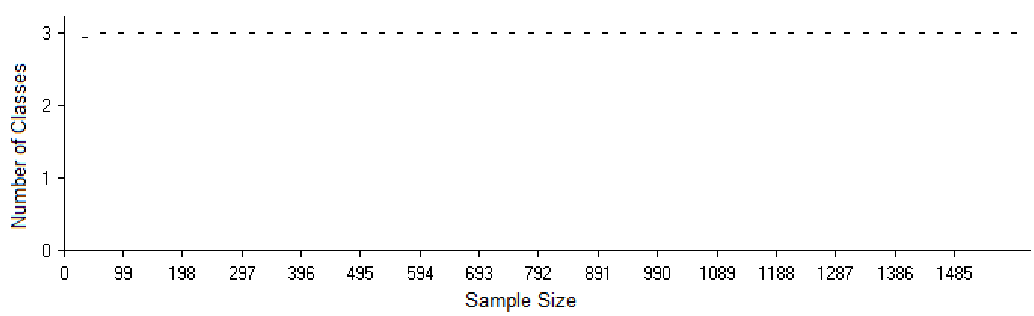

Figure B41. Resampling Curve for 45PI043 Complexity of Dorsal Surface Dimension

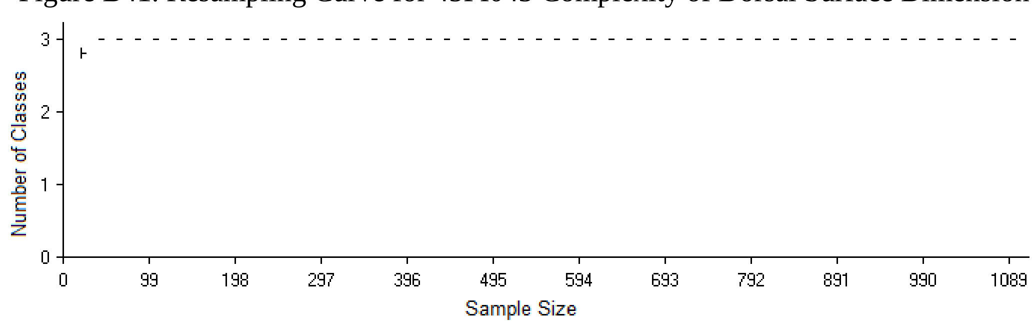

Figure B42. Resampling Curve for 45PI303 Complexity of Dorsal Surface Dimension

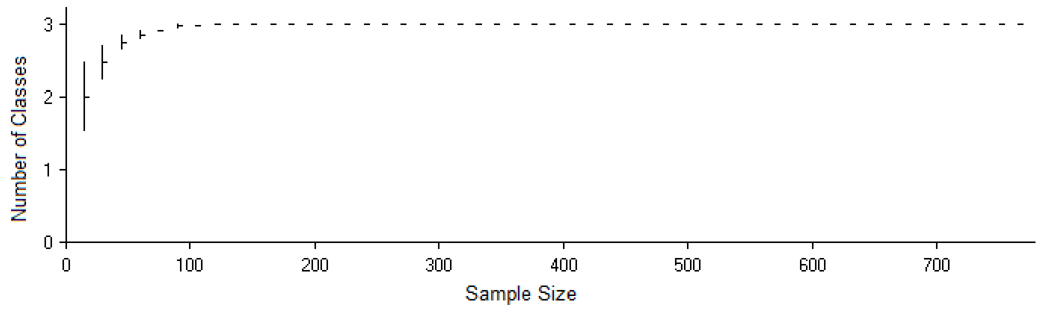

Figure B43. Resampling Curve for 45PI406 Complexity of Dorsal Surface Dimension

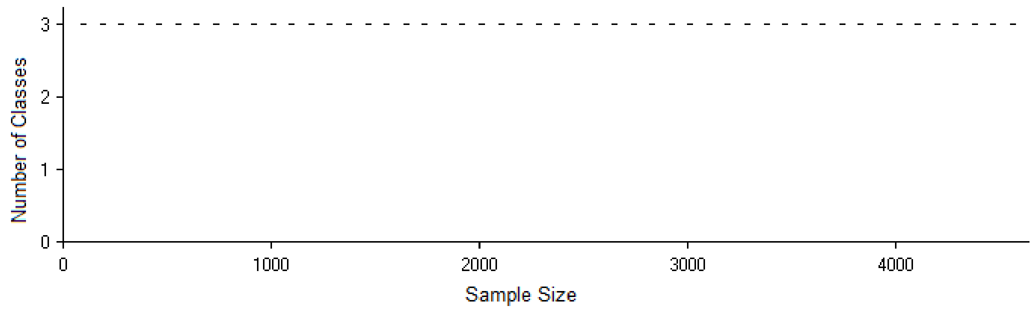

Figure B44. Resampling Curve for 45PI408 Complexity of Dorsal Surface Dimension

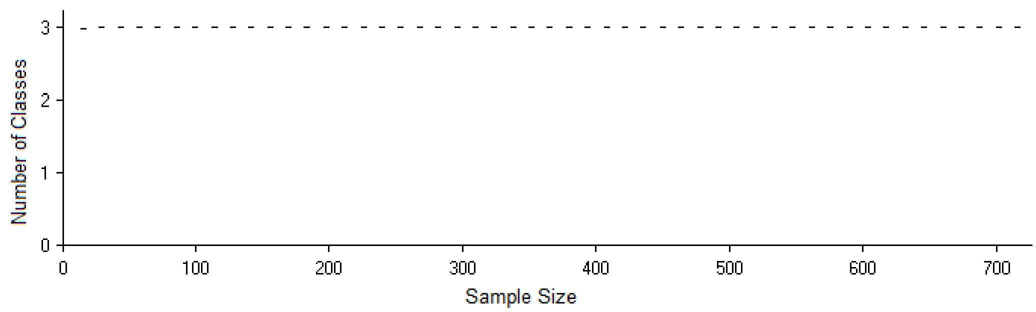

Figure B45. Resampling Curve for 45PI429 Complexity of Dorsal Surface Dimension

Reduction Class Resampling Curves

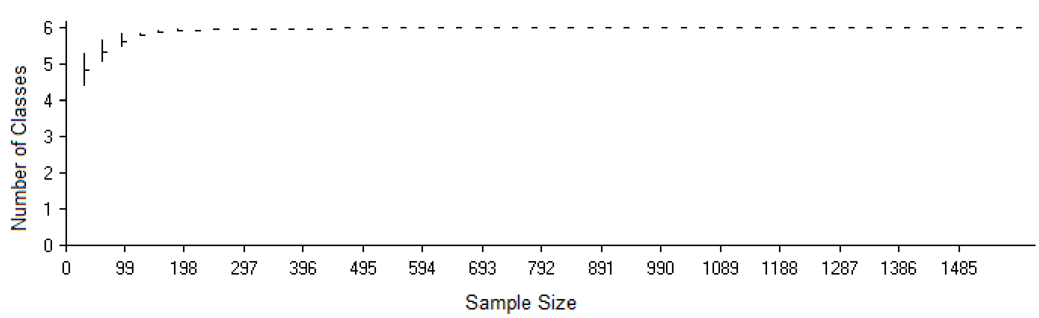

Figure B46. Resampling Curve for 45PI043 Reduction Class Dimension

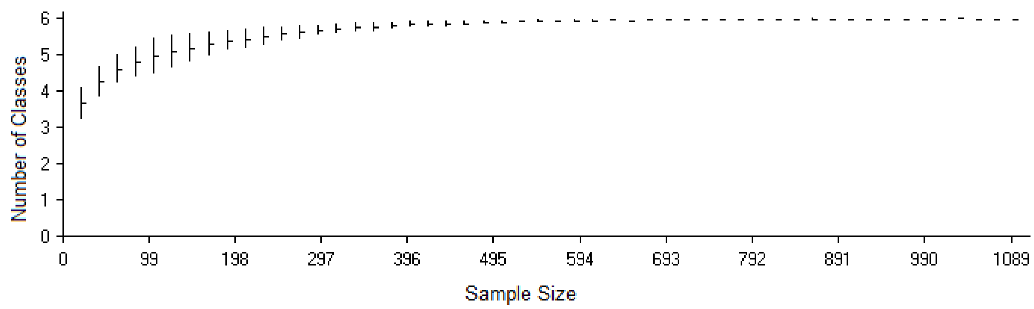

Figure B47. Resampling Curve for 45PI303 Reduction Class Dimension

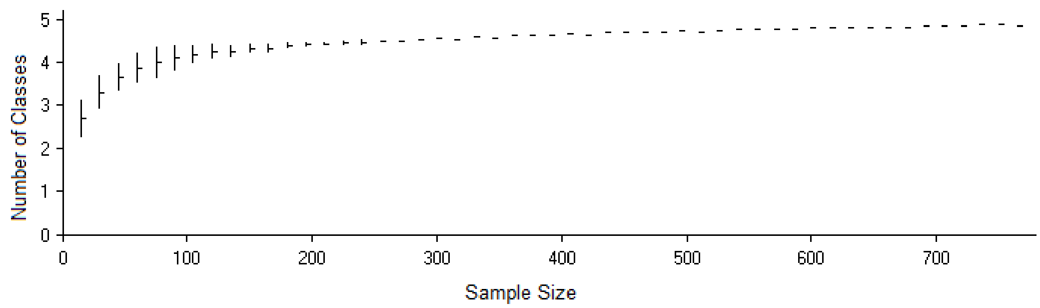

Figure B48. Resampling Curve for 45PI406 Reduction Class Dimension

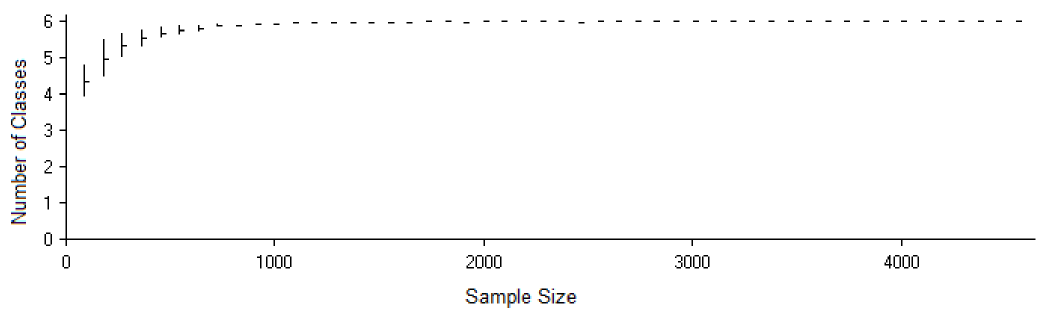

Figure B49. Resampling Curve for 45PI408 Reduction Class Dimension

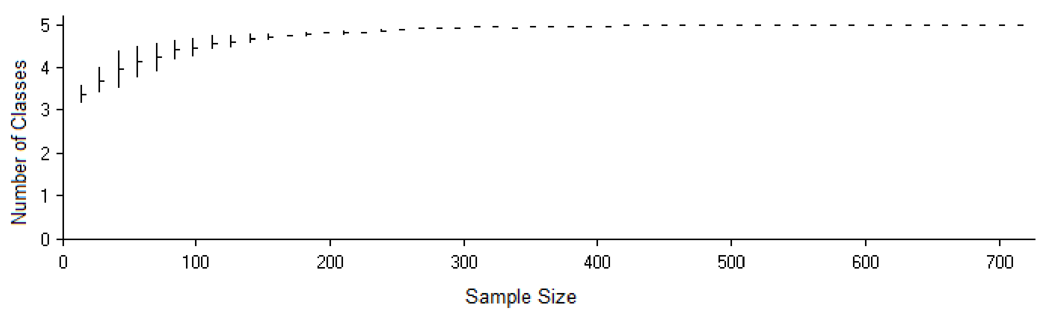

Figure B50. Resampling Curve for 45PI429 Reduction Class Dimension

Kind of Wear Resampling Curves

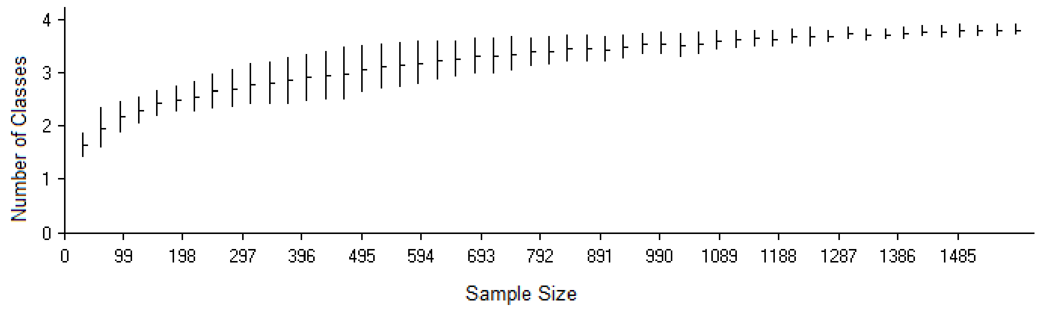

Figure B51. Resampling Curve for 45PI043 Kind of Wear Dimension

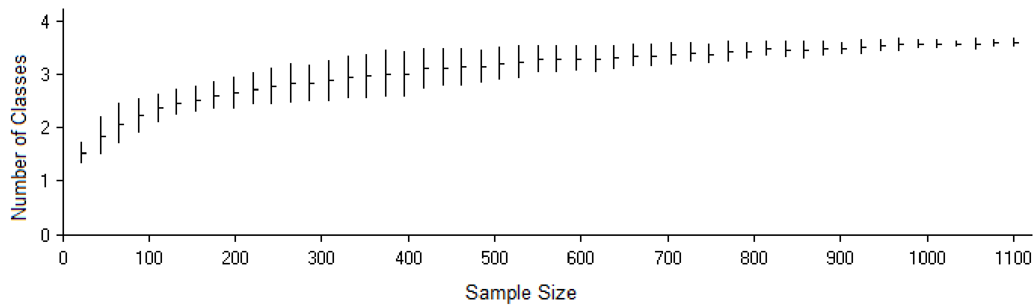

Figure B52. Resampling Curve for 45PI303 Kind of Wear Dimension

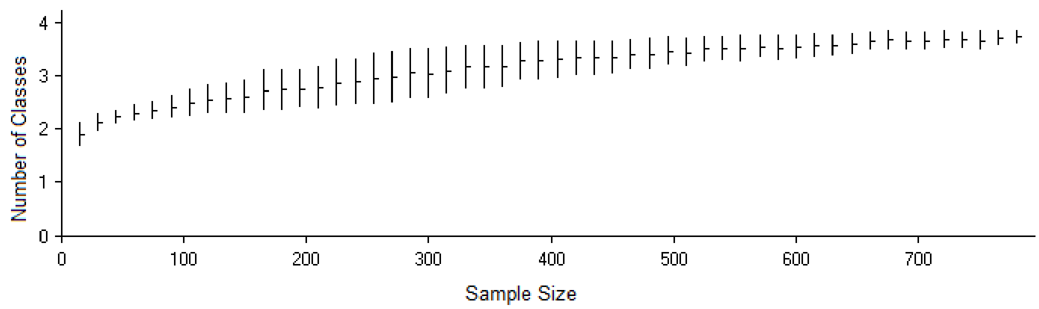

Figure B53. Resampling Curve for 45PI406 Kind of Wear Dimension

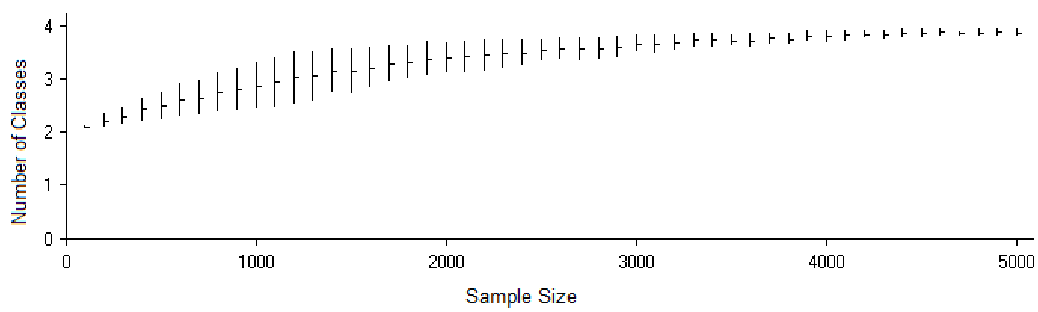

Figure B54. Resampling Curve for 45PI408 Kind of Wear Dimension

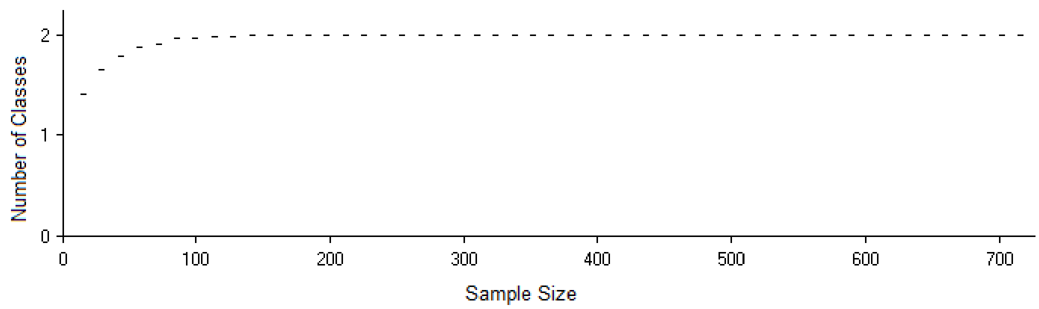

Figure B55. Resampling Curve for 45PI429 Kind of Wear Dimension

Location of Wear Resampling Curves

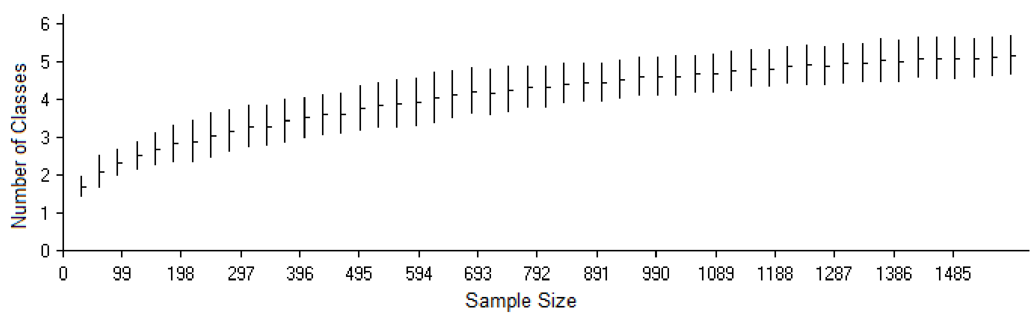

Figure B56. Resampling Curve for 45PI043 Location of Wear Dimension

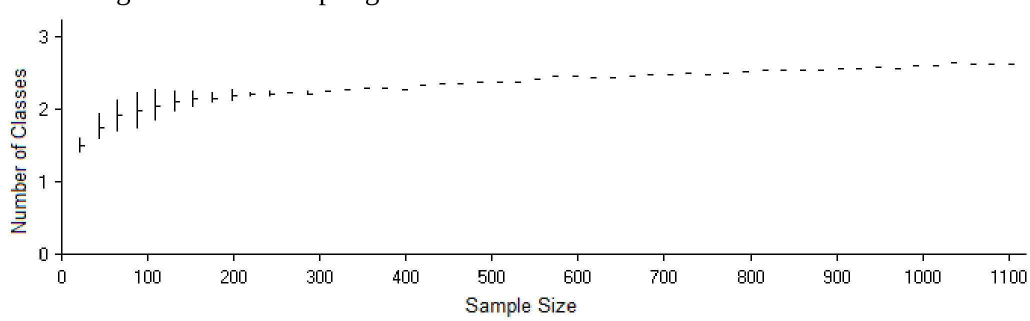

Figure B57. Resampling Curve for 45PI303 Location of Wear Dimension

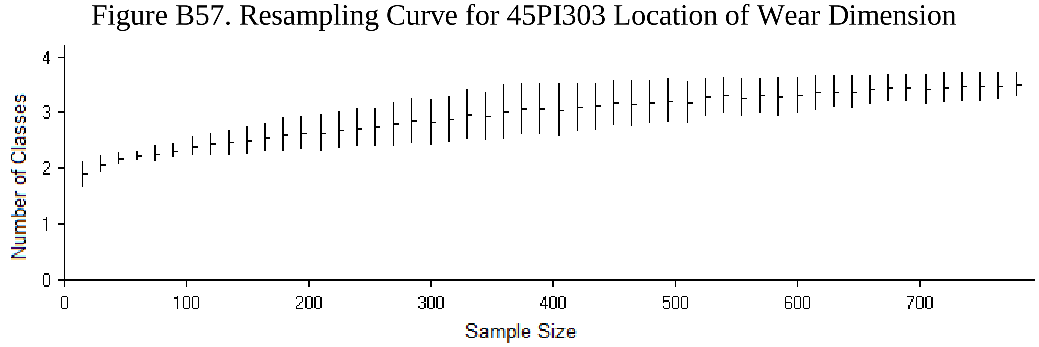

Figure B58. Resampling Curve for 45PI406 Location of Wear Dimension

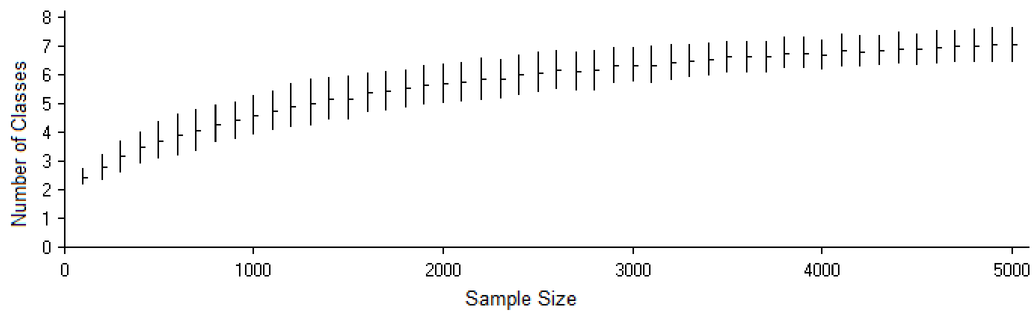

Figure B59. Resampling Curve for 45PI408 Location of Wear Dimension

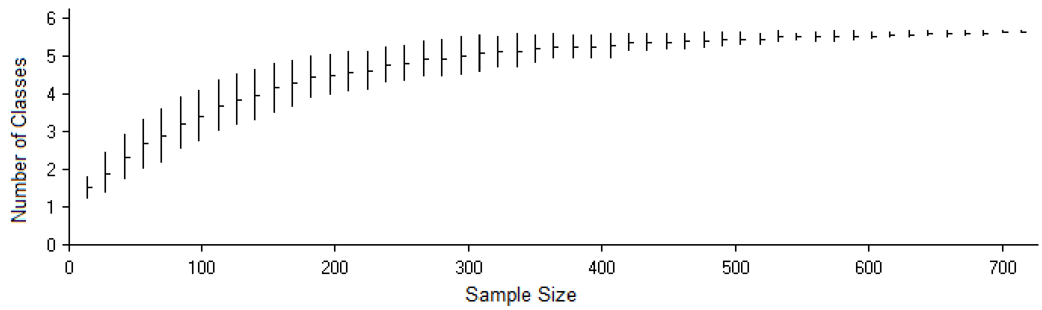

Figure B60. Resampling Curve for 45PI429 Location of Wear Dimension

Shape of Plan of Wear Resampling Curves

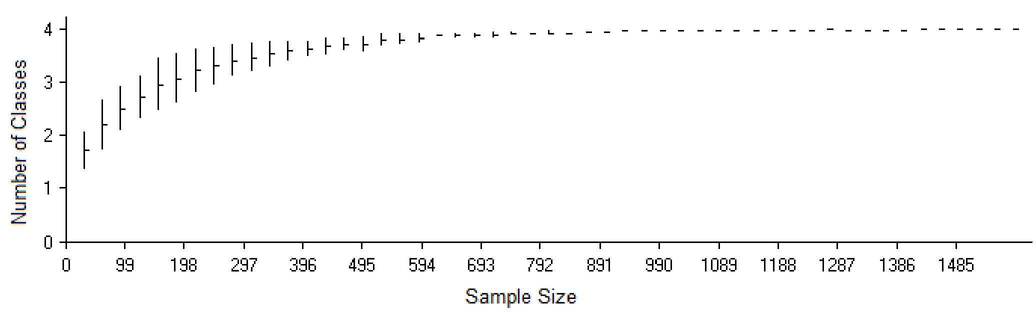

Figure B61. Resampling Curve for 45PI043 Shape of Plan of Wear Dimension

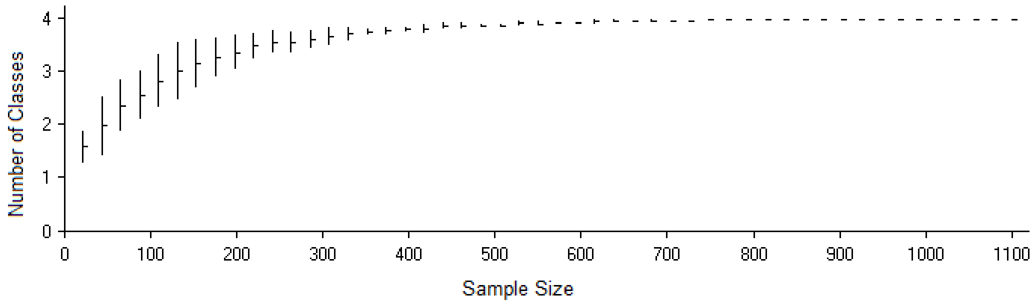

Figure B62. Resampling Curve for 45PI303 Shape of Plan of Wear Dimension

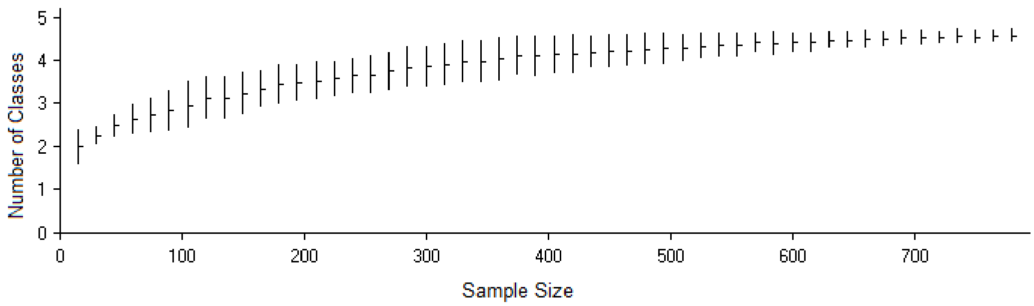

Figure B63. Resampling Curve for 45PI406 Shape of Plan of Wear Dimension

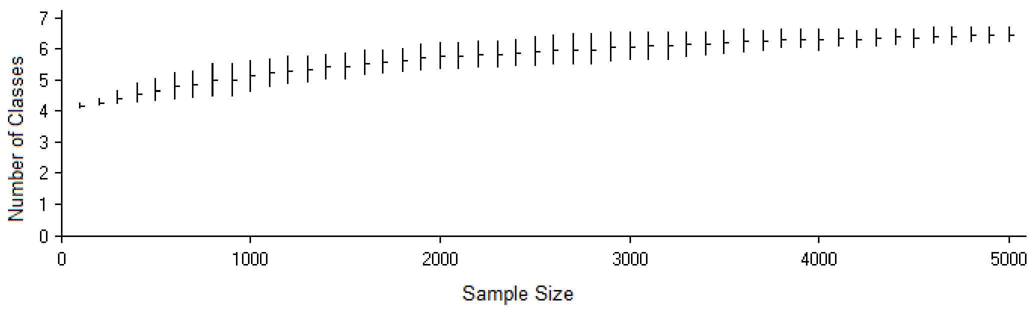

Figure B64. Resampling Curve for 45PI408 Shape of Plan of Wear Dimension

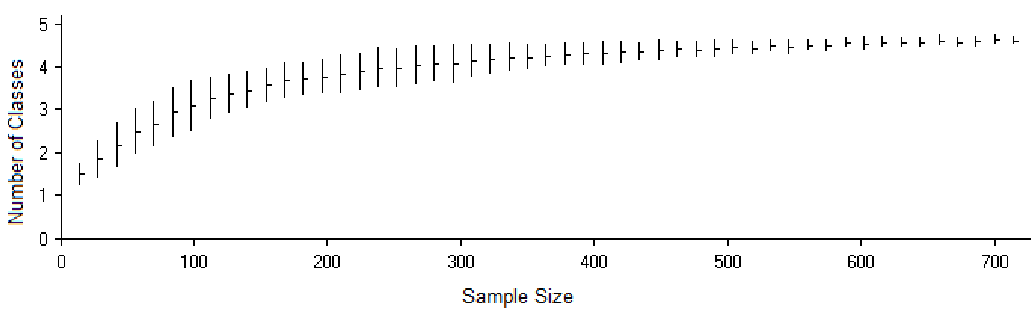

Figure B65. Resampling Curve for 45PI429 Shape of Plan of Wear Dimension

Orientation of Wear Resampling Curves

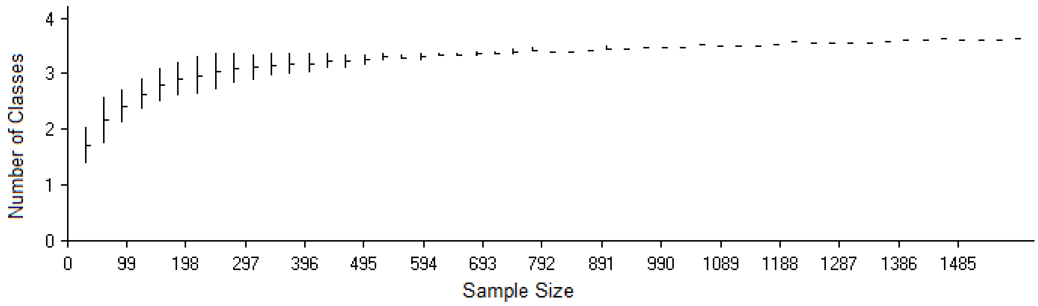

Figure B66. Resampling Curve for 45PI043 Orientation of Wear Dimension

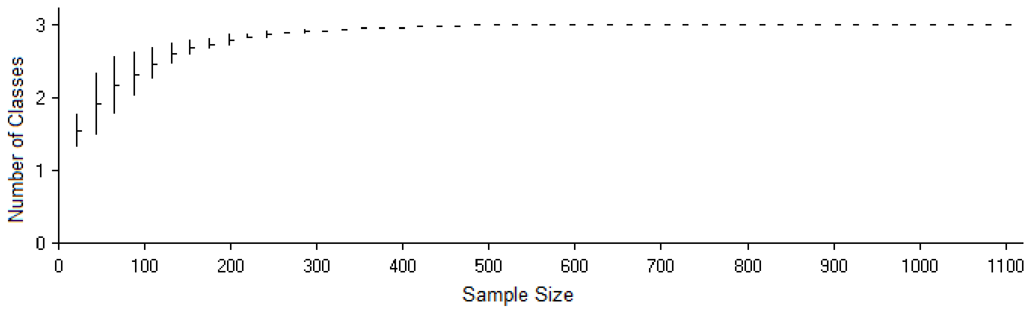

Figure B67. Resampling Curve for 45PI303 Orientation of Wear Dimension

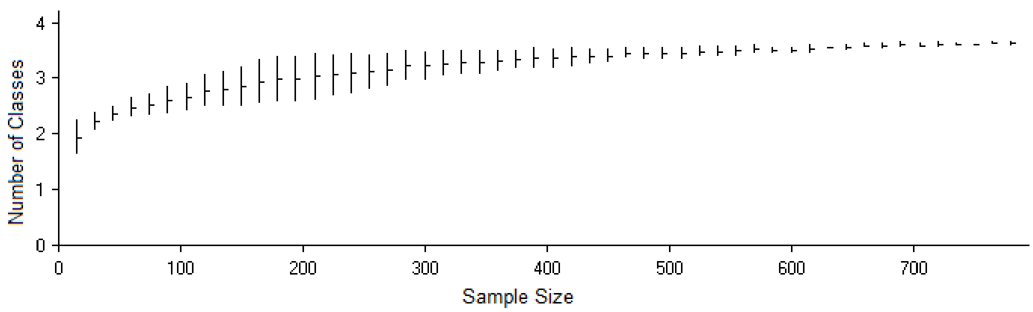

Figure B68. Resampling Curve for 45PI406 Orientation of Wear Dimension

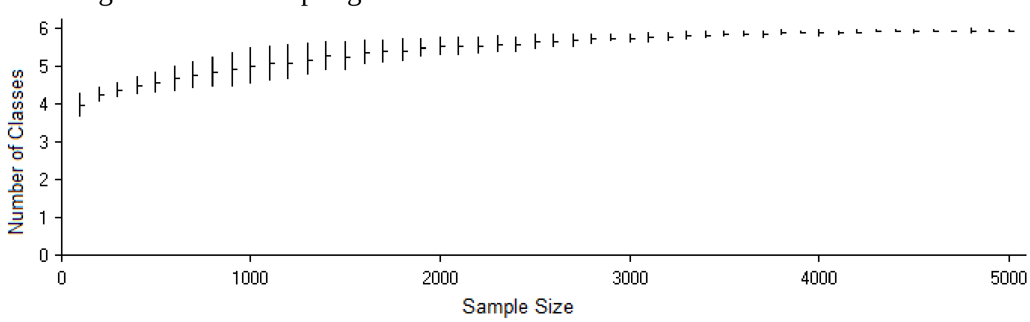

Figure B69. Resampling Curve for 45PI408 Orientation of Wear Dimension

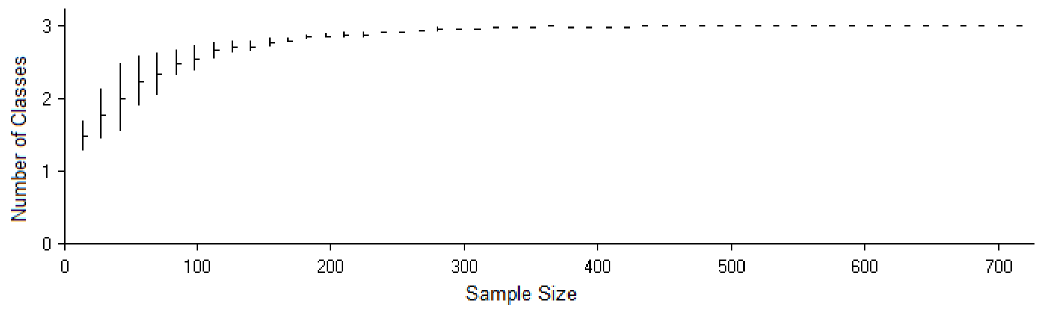

Figure B70. Resampling Curve for 45PI429 Orientation of Wear Dimension

Groundmass Resampling Curves

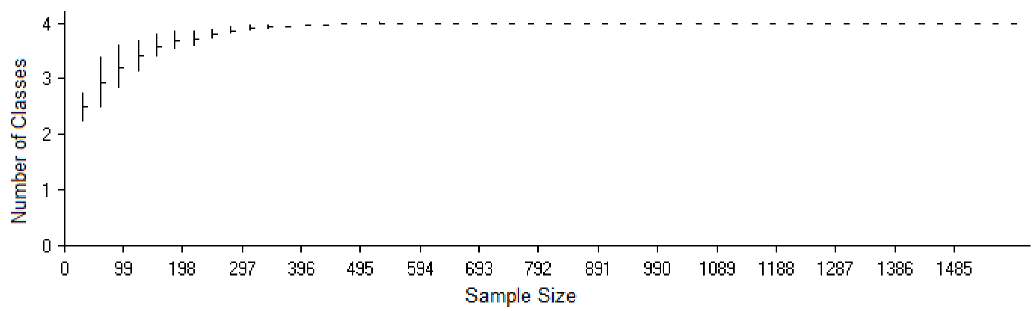

Figure B71. Resampling Curve for 45PI043 Groundmass Dimension

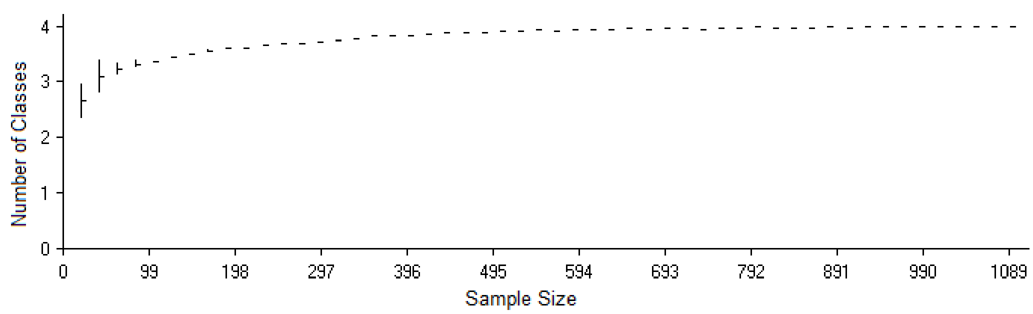

Figure B72. Resampling Curve for 45PI303 Groundmass Dimension

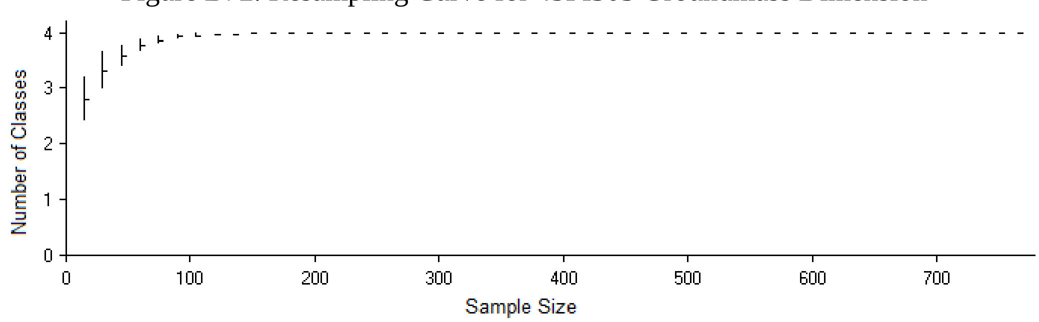

Figure B73. Resampling Curve for 45PI406 Groundmass Dimension

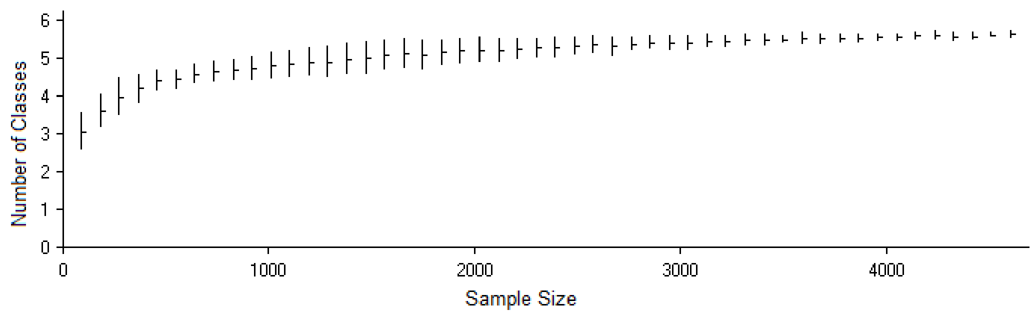

Figure B74. Resampling Curve for 45PI408 Groundmass Dimension

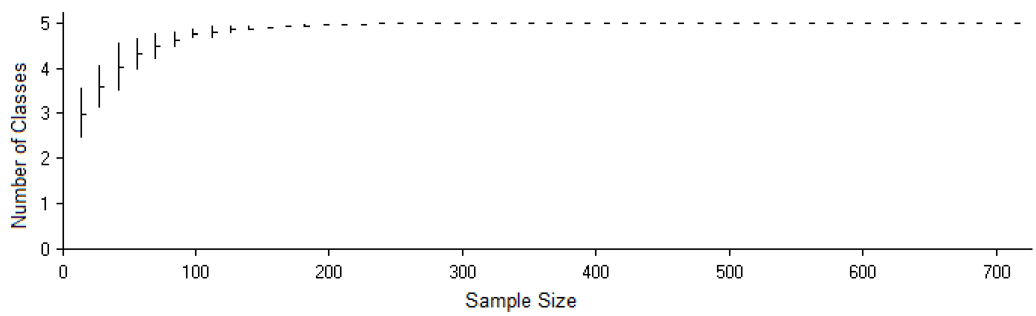

Figure B75. Resampling Curve for 45PI429 Groundmass Dimension

Presence of Solid Inclusions Resampling Curves

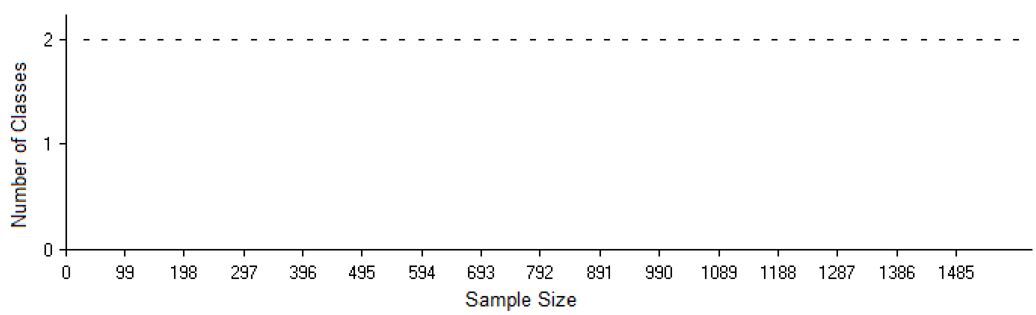

Figure B76. Resampling Curve for 45PI043 Presence of Solid Inclusions Dimension

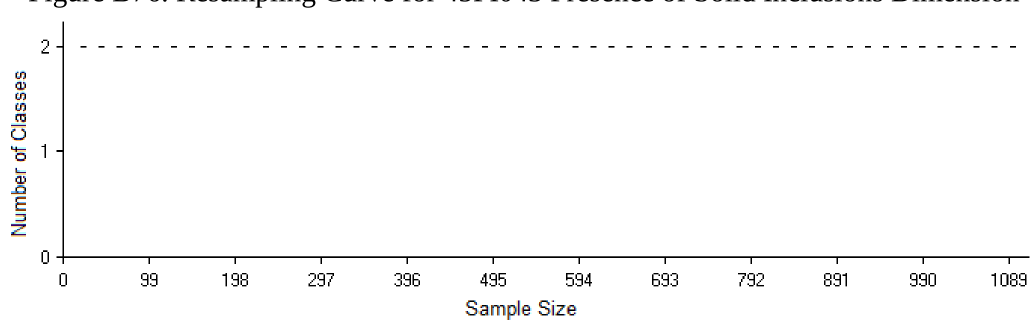

Figure B77. Resampling Curve for 45PI303 Presence of Solid Inclusions Dimension

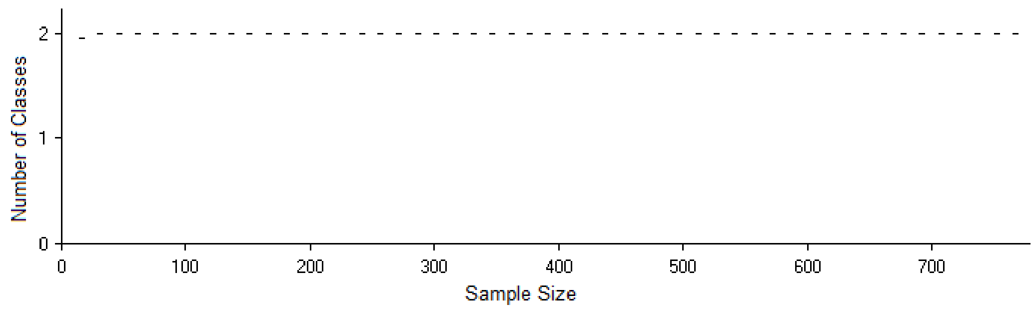

Figure B78. Resampling Curve for 45PI406 Presence of Solid Inclusions Dimension

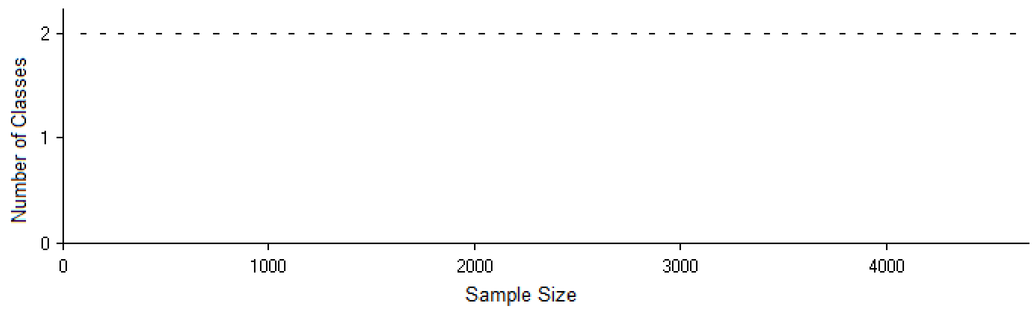

Figure B79. Resampling Curve for 45PI408 Presence of Solid Inclusions Dimension

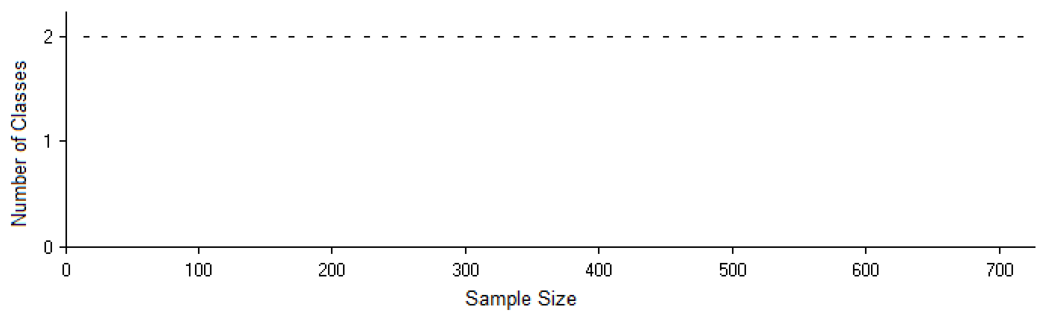

Figure B80. Resampling Curve for 45PI429 Presence of Solid Inclusions Dimension

Presence of Void Inclusions Resampling Curves

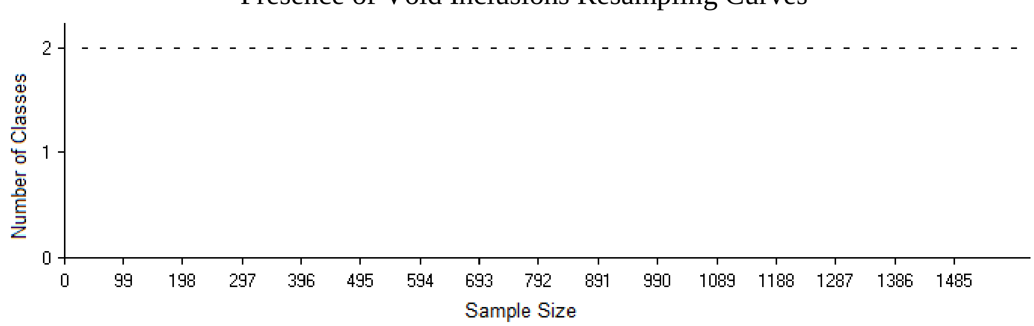

Figure B81. Resampling Curve for 45PI043 Presence of Void Inclusions Dimension

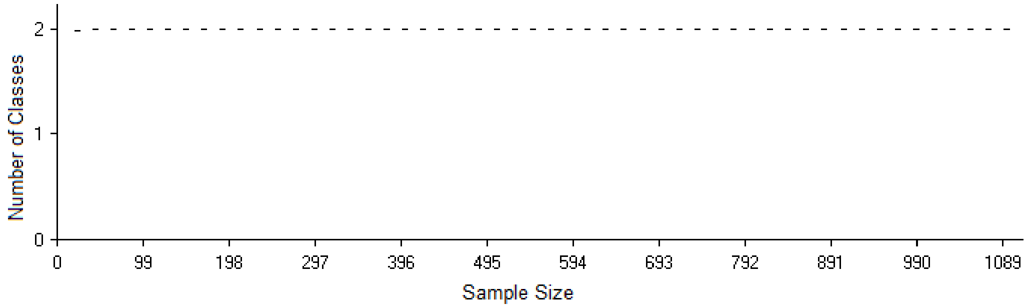

Figure B82. Resampling Curve for 45PI303 Presence of Void Inclusions Dimension

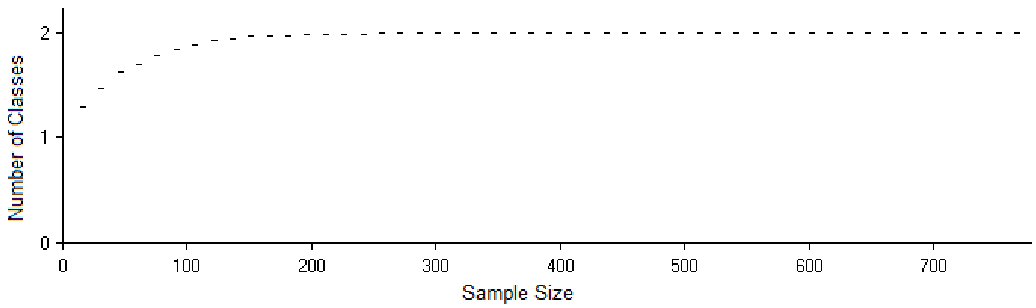

Figure B83. Resampling Curve for 45PI406 Presence of Void Inclusions Dimension

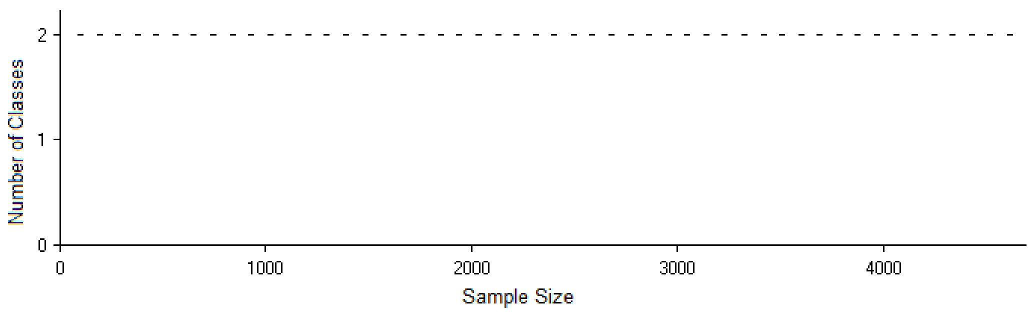

Figure B84. Resampling Curve for 45PI408 Presence of Void Inclusions Dimension

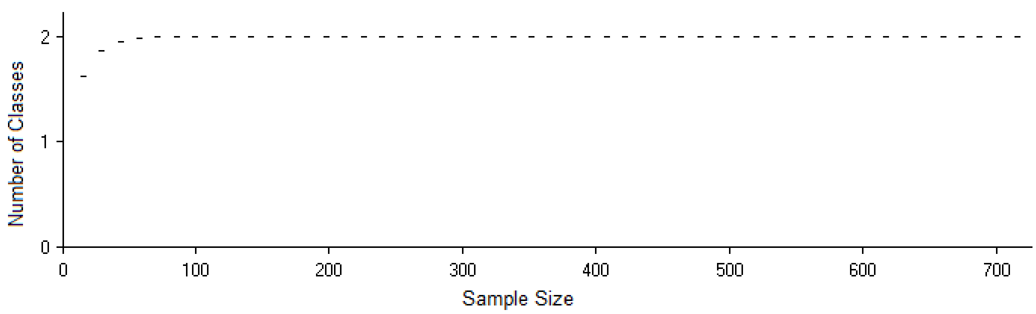

Figure B85. Resampling Curve for 45PI429 Presence of Void Inclusions Dimension

Distribution of Solid Inclusions Resampling Curves

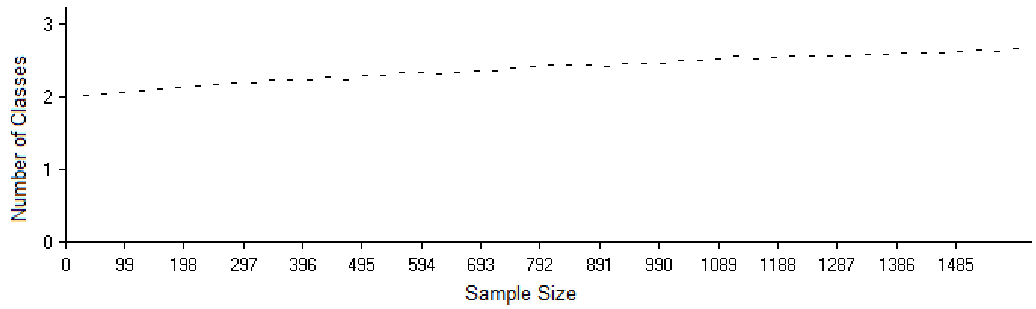

Figure B86. Resampling Curve for 45PI043 Distribution of Solid Inclusions Dimension

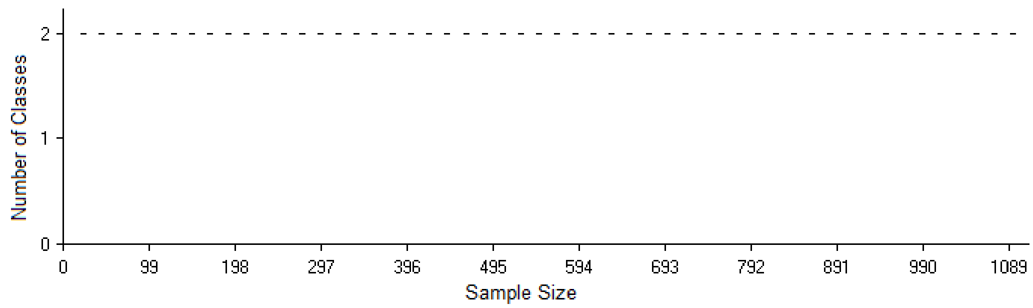

Figure B87. Resampling Curve for 45PI303 Distribution of Solid Inclusions Dimension

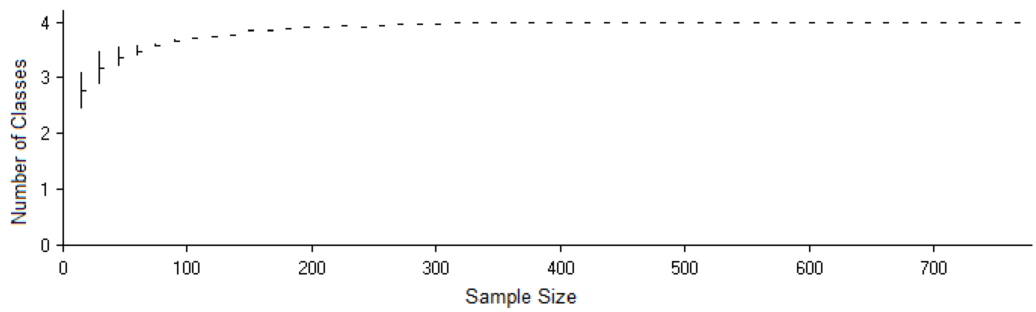

Figure B88. Resampling Curve for 45PI406 Distribution of Solid Inclusions Dimension

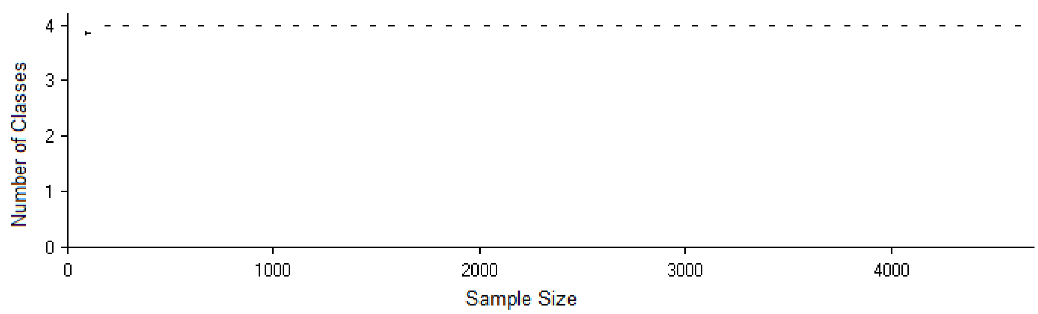

Figure B89. Resampling Curve for 45PI408 Distribution of Solid Inclusions Dimension

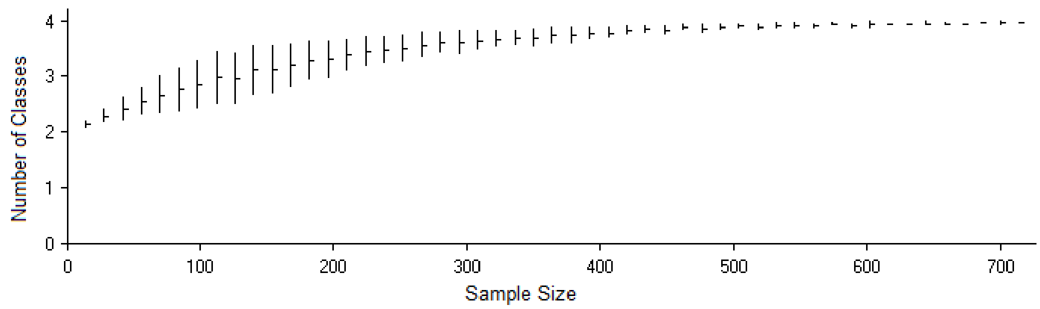

Figure B90. Resampling Curve for 45PI429 Distribution of Solid Inclusions Dimension

Distribution of Void Inclusions Resampling Curves

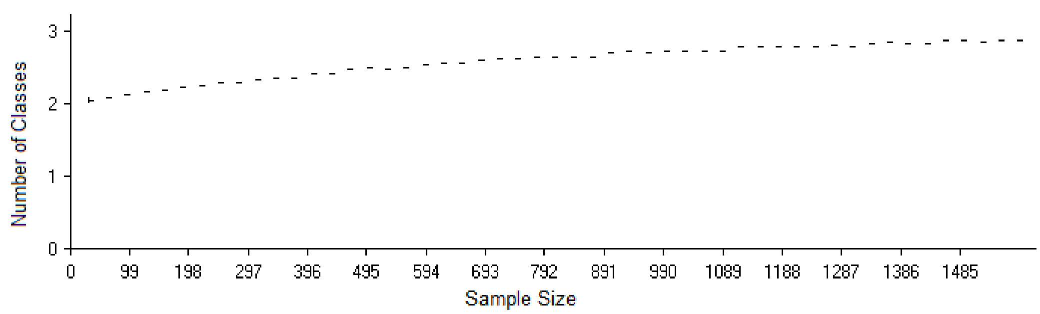

Figure B91. Resampling Curve for 45PI043 Distribution of Void Inclusions Dimension

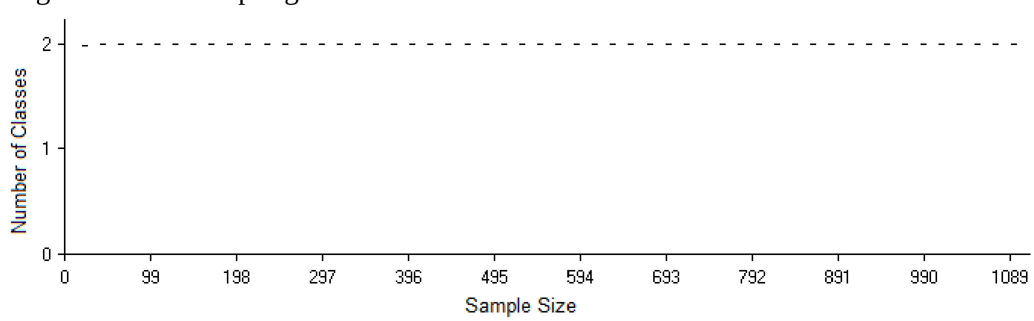

Figure B92. Resampling Curve for 45PI303 Distribution of Void Inclusions Dimension

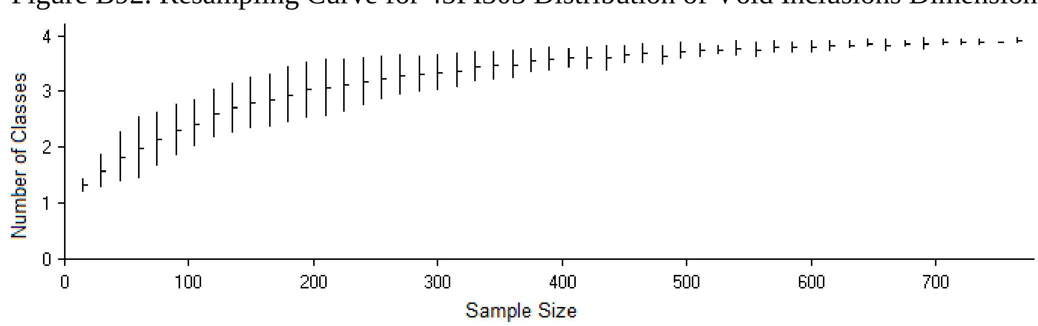

Figure B93. Resampling Curve for 45PI406 Distribution of Void Inclusions Dimension

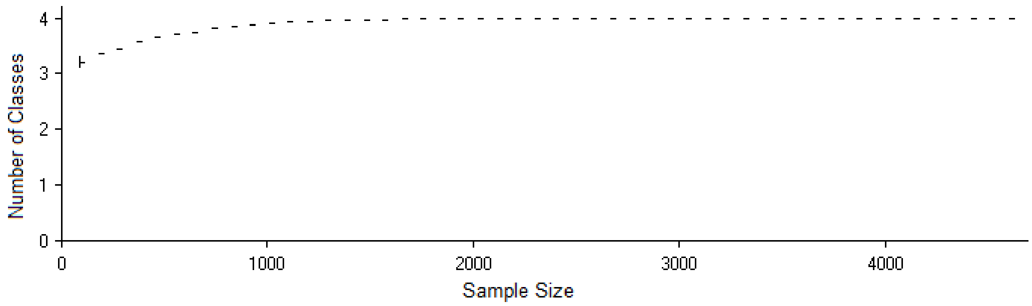

Figure B94. Resampling Curve for 45PI408 Distribution of Void Inclusions Dimension

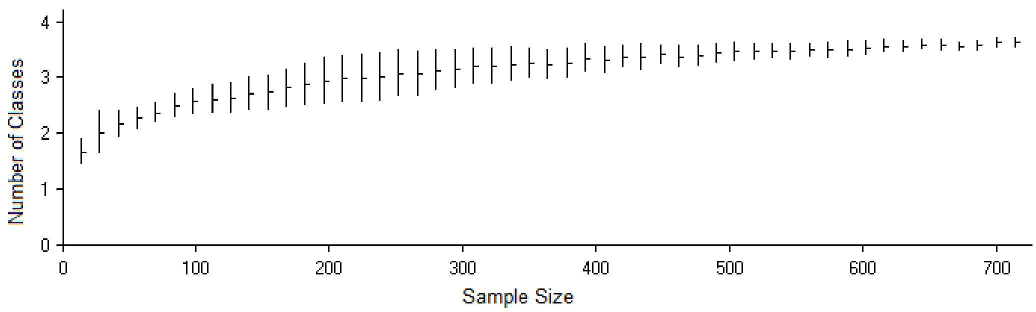

Figure B95. Resampling Curve for 45PI429 Distribution of Void Inclusions Dimension

Site Type (Combined) Assemblage Resampling Curves

Type of Fragment/Object Type Resampling Curves

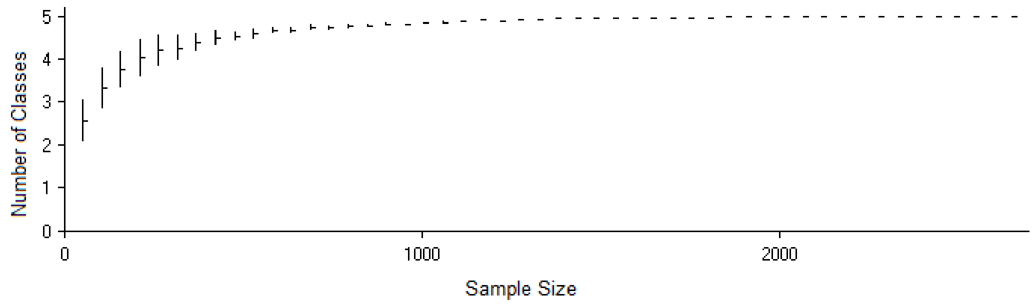

Figure B96. Resampling Curve for Rockshelter Sites Type of Fragment/Object Type Dimension

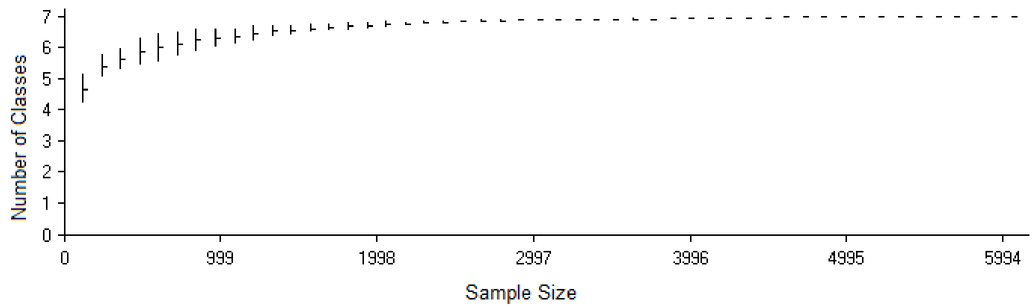

Figure B97. Resampling Curve for Open-Air Sites Type of Fragment/Object Type Dimension

Amount of Cortex Resampling Curves

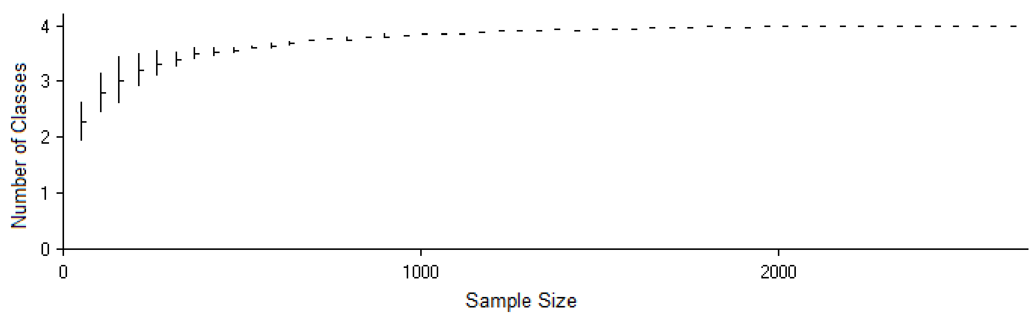

Figure B98. Resampling Curve for Rockshelter Sites Amount of Cortex Dimension

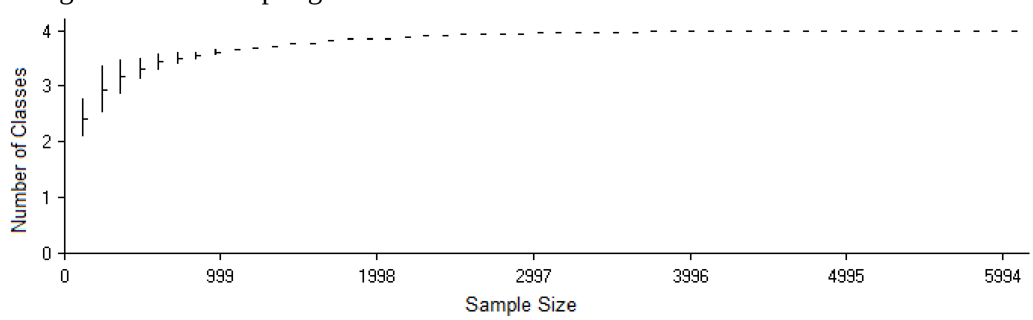

Figure B99. Resampling Curve for Open-Air Sites Amount of Cortex Dimension

Presence of Wear Resampling Curves

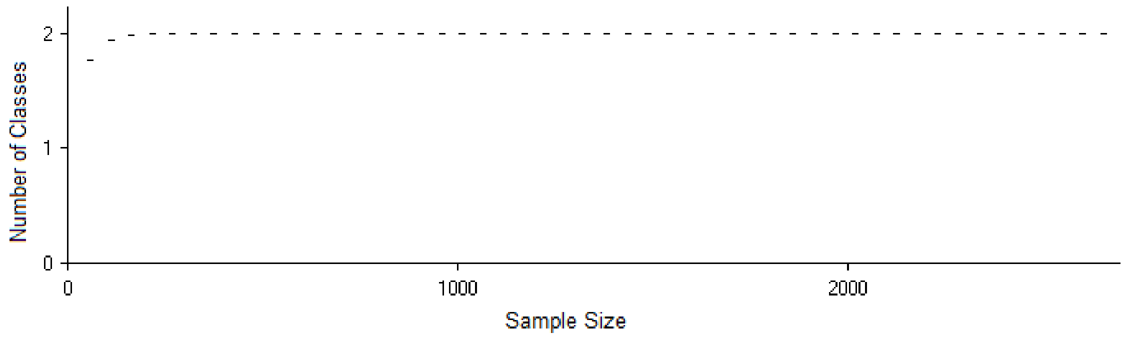

Figure B100. Resampling Curve for Rockshelter Sites Presence of Wear Dimension

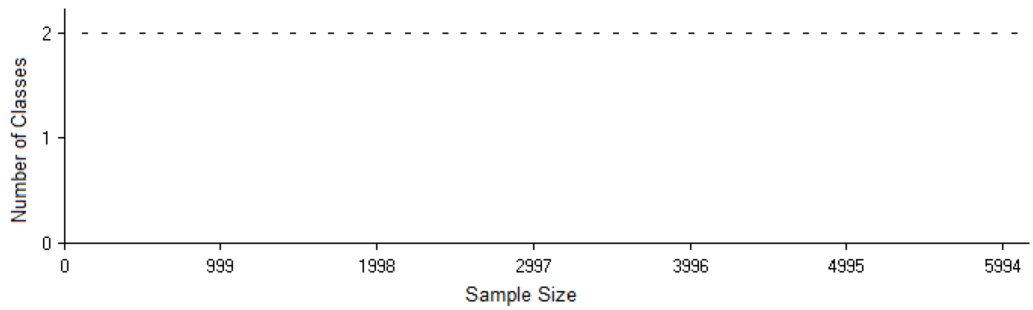

Figure B101. Resampling Curve for Open-Air Sites Presence of Wear Dimension

Other Modification Resampling Curves

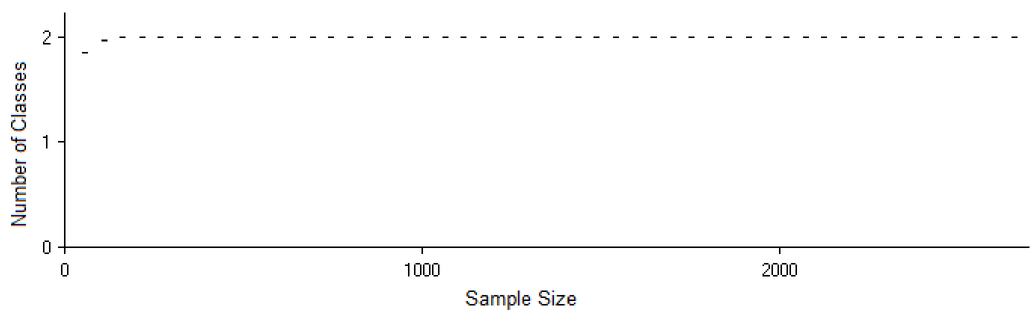

Figure B102. Resampling Curve for Rockshelter Sites Other Modification Dimension

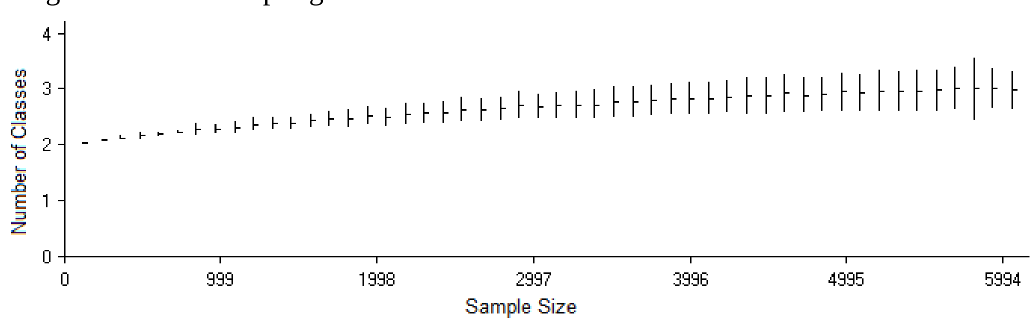

Figure B103. Resampling Curve for Open-Air Sites Other Modification Dimension

Material Type Resampling Curves

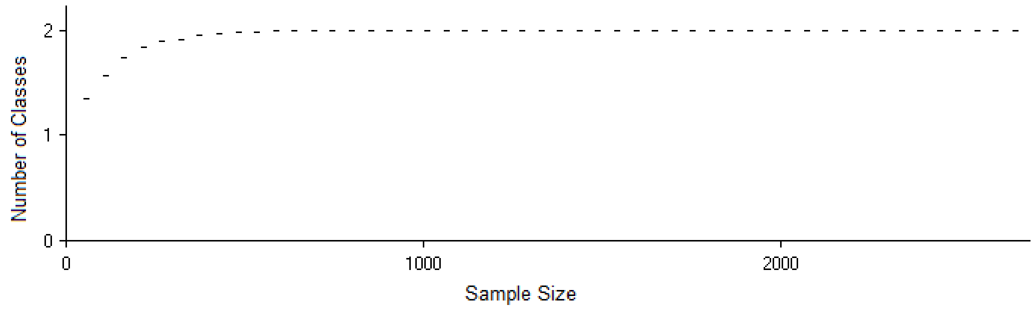

Figure B104. Resampling Curve for Rockshelter Sites Material Type Dimension

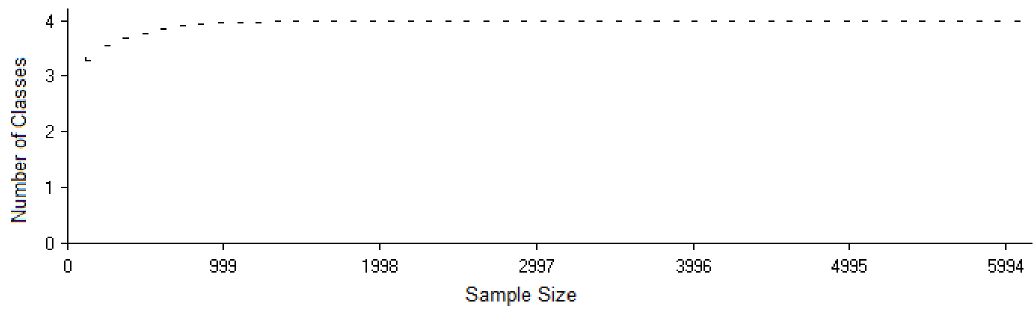

Figure B105. Resampling Curve for Open-Air Sites Material Type Dimension

Platform Type Resampling Curves

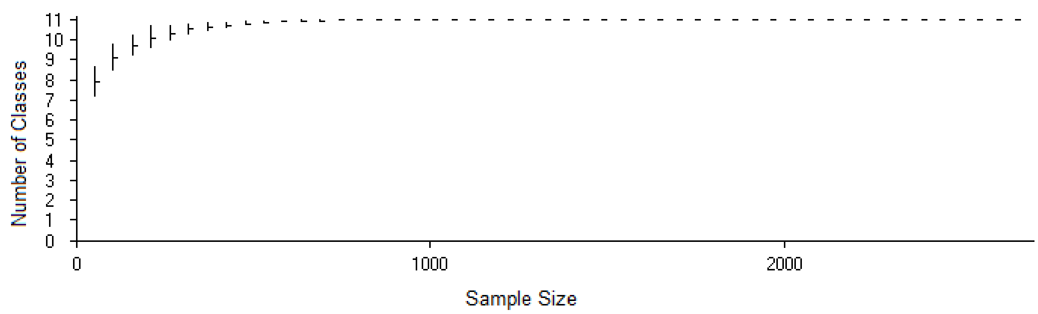

Figure B106. Resampling Curve for Rockshelter Sites Platform Type Dimension

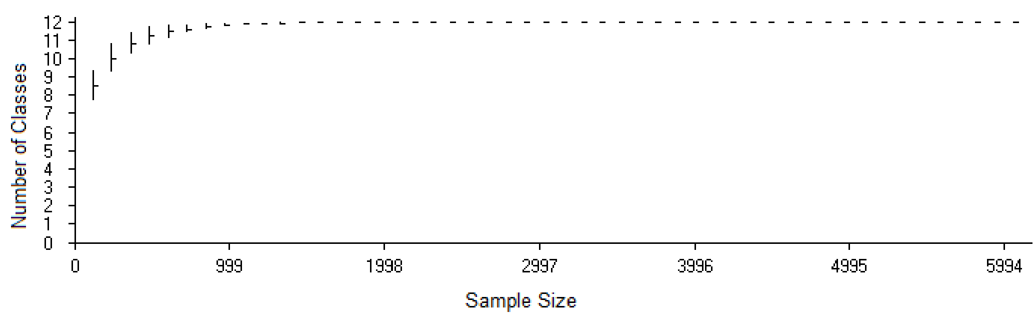

Figure B107. Resampling Curve for Open-Air Sites Platform Type Dimension

Completeness Resampling Curves

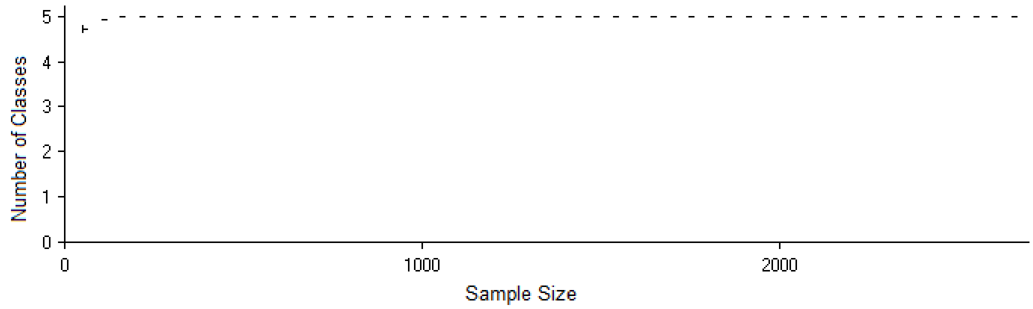

Figure B108. Resampling Curve for Rockshelter Sites Completeness Dimension

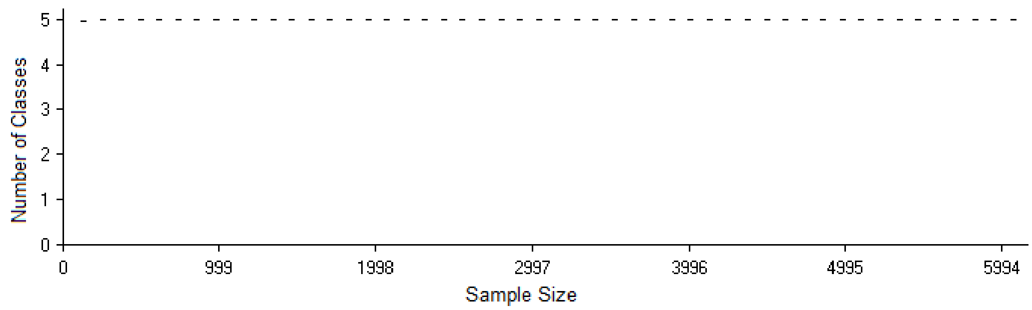

Figure B109. Resampling Curve for Open-Air Sites Completeness Dimension

Thermal Alteration Resampling Curves

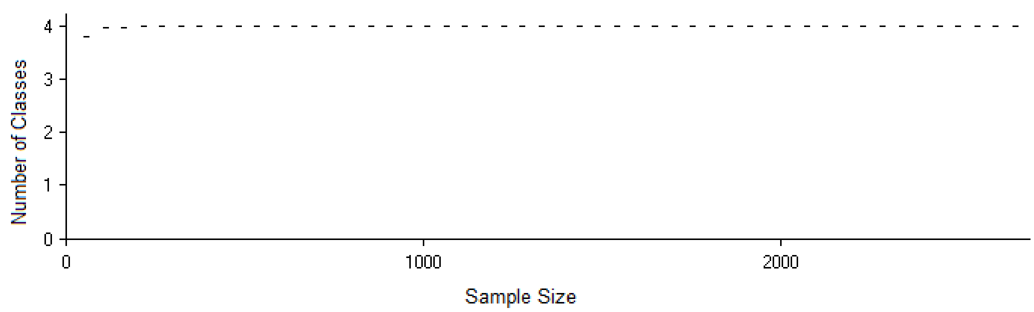

Figure B110. Resampling Curve for Rockshelter Sites Thermal Alteration Dimension

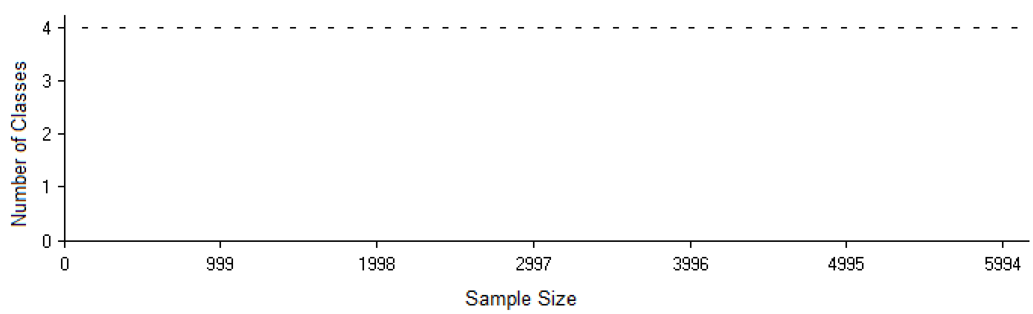

Figure B111. Resampling Curve for Open-Air Sites Thermal Alteration Dimension

Complexity of Dorsal Surface Resampling Curves

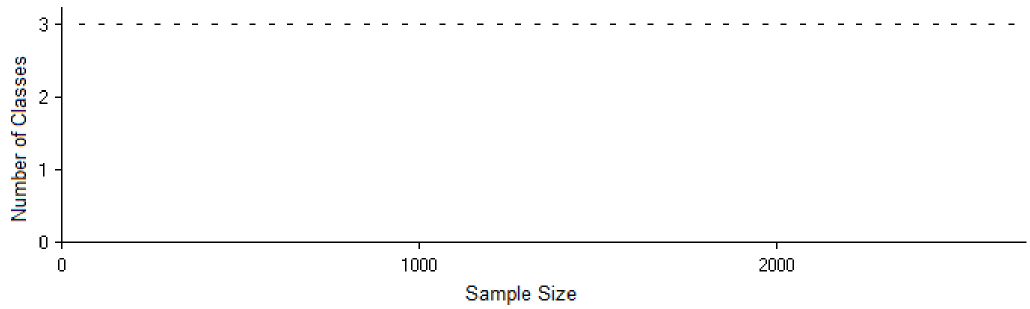

Figure B112. Resampling Curve for Rockshelter Sites Complexity of Dorsal Surface Dimension

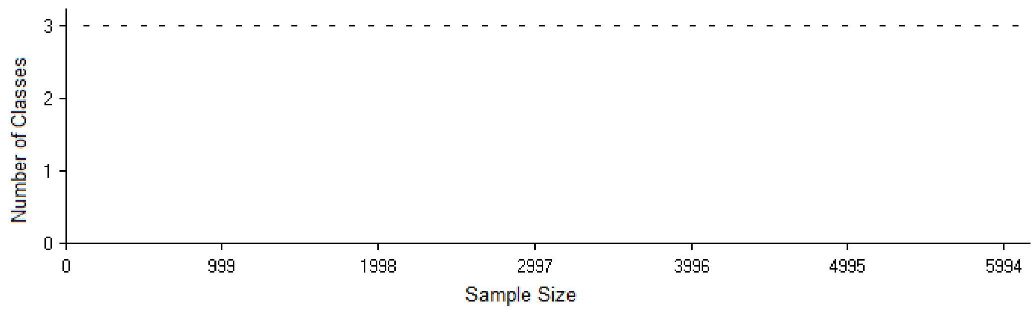

Figure B113. Resampling Curve for Open-Air Sites Complexity of Dorsal Surface Dimension

Reduction Class Resampling Curves

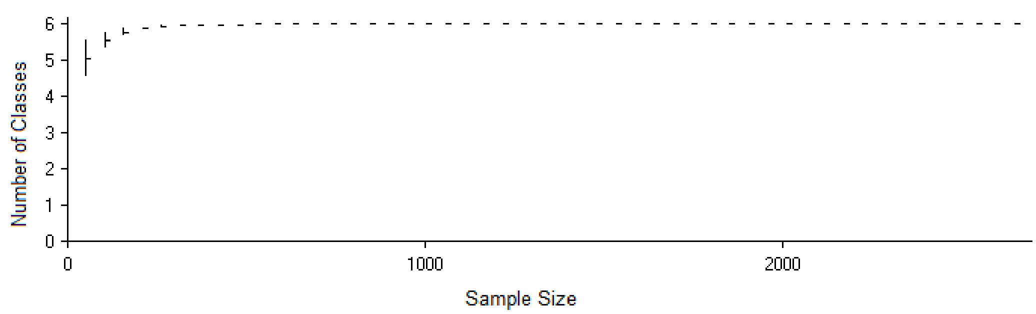

Figure B114. Resampling Curve for Rockshelter Sites Reduction Class Dimension

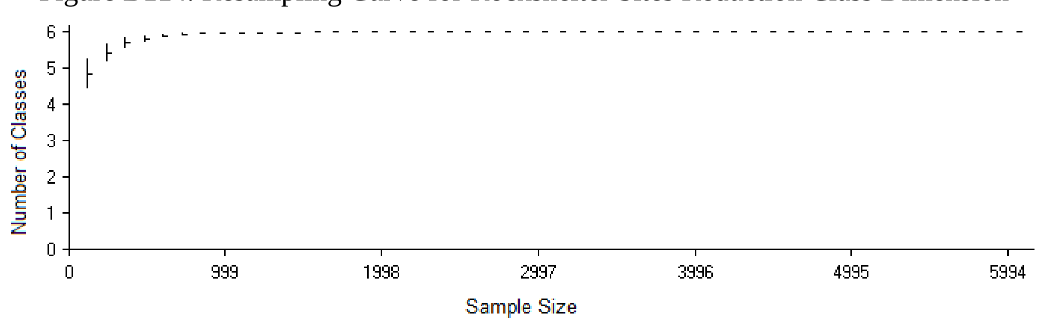

Figure B115. Resampling Curve for Open-Air Sites Reduction Class Dimension

Kind of Wear Resampling Curves

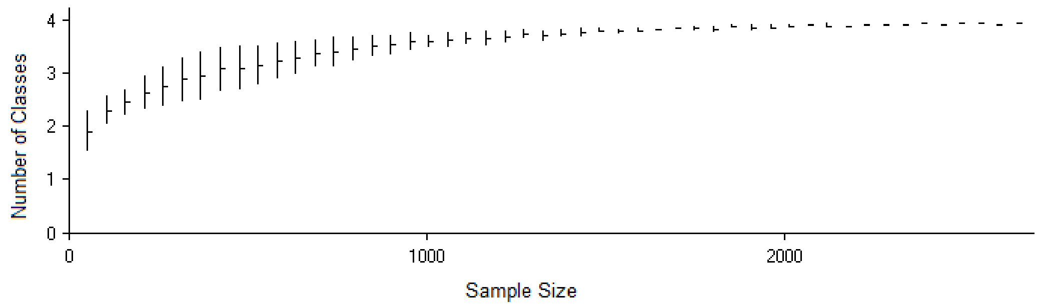

Figure B116. Resampling Curve for Rockshelter Sites Kind of Wear Dimension

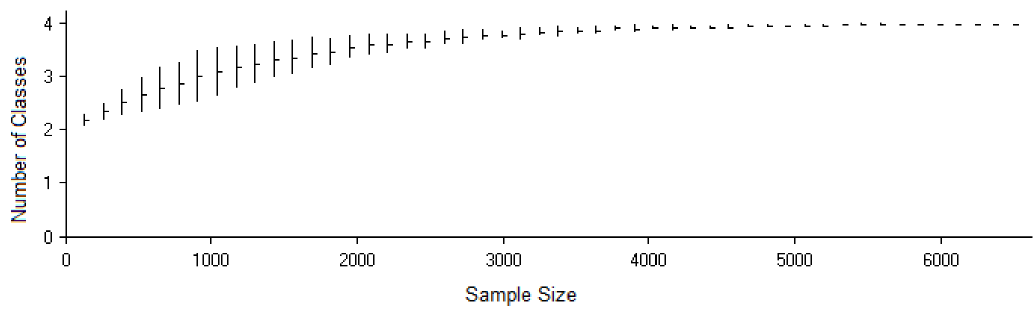

Figure B117. Resampling Curve for Open-Air Sites Kind of Wear Dimension

Location of Wear Resampling Curves

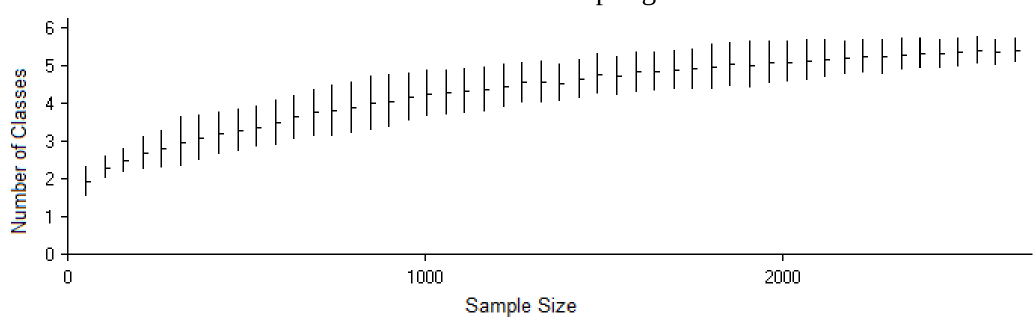

Figure B118. Resampling Curve for Rockshelter Sites Location of Wear Dimension

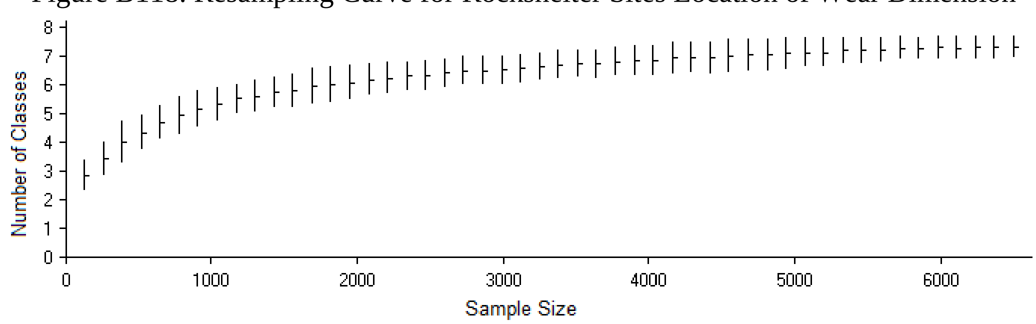

Figure B119. Resampling Curve for Open-Air Sites Location of Wear Dimension

Shape of Plan of Wear Resampling Curves

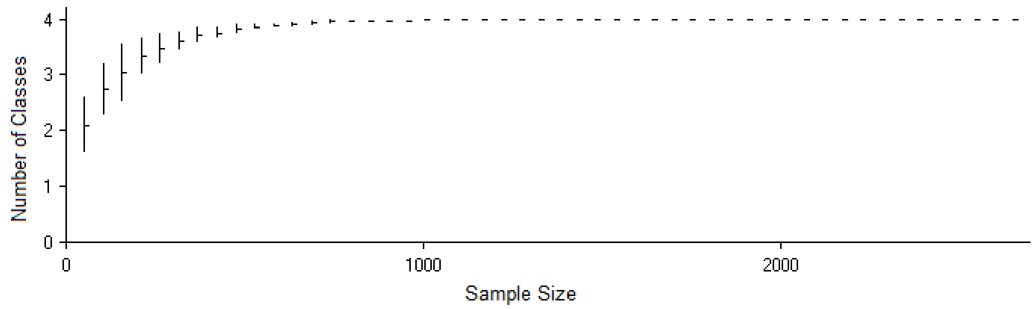

Figure B120. Resampling Curve for Rockshelter Sites Shape of Plan of Wear Dimension

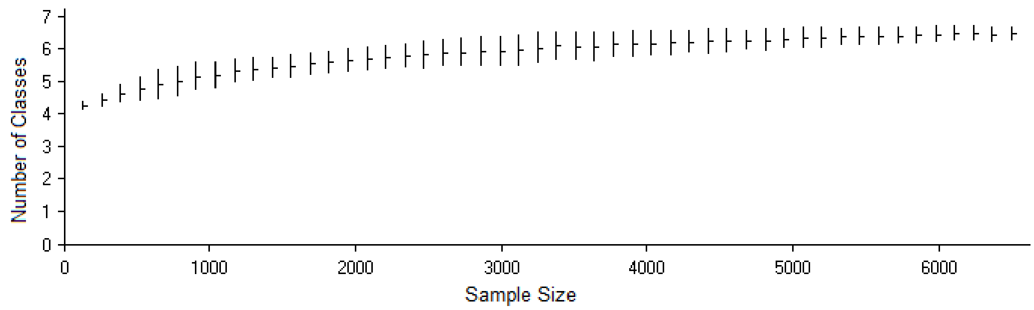

Figure B121. Resampling Curve for Open-Air Sites Shape of Plan of Wear Dimension

Orientation of Wear Resampling Curves

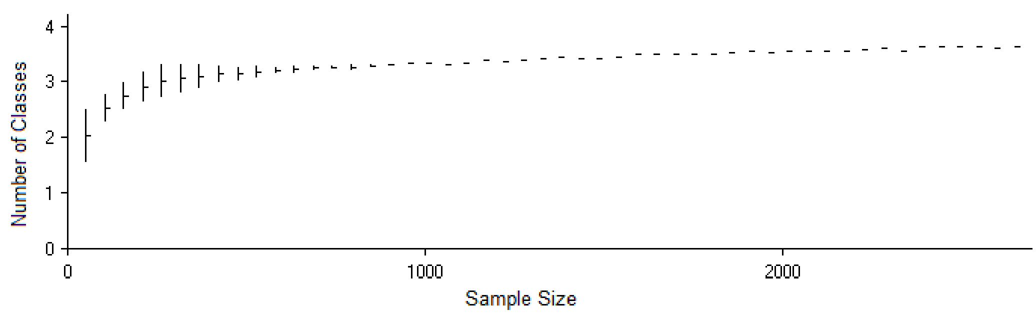

Figure B122. Resampling Curve for Rockshelter Sites Orientation of Wear Dimension

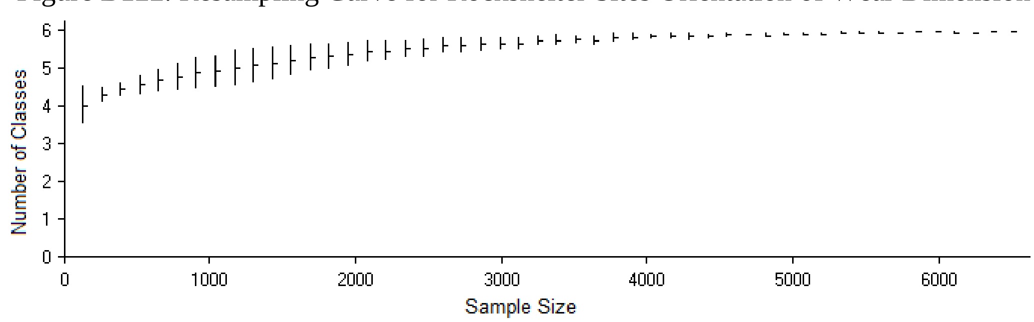

Figure B123. Resampling Curve for Open-Air Sites Orientation of Wear Dimension

Groundmass Resampling Curves

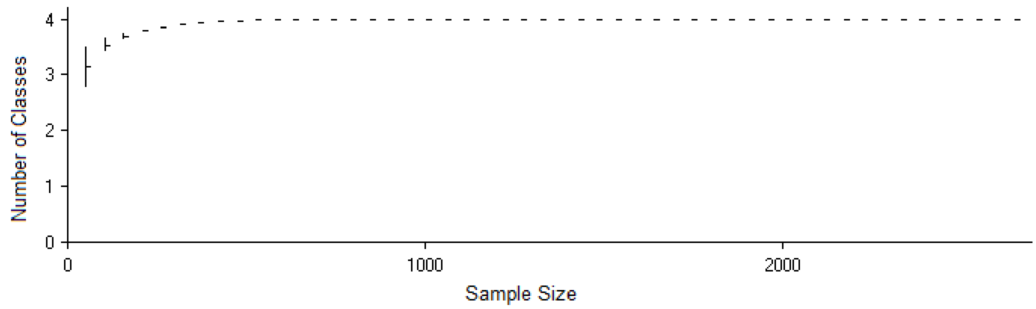

Figure B124. Resampling Curve for Rockshelter Sites Groundmass Dimension

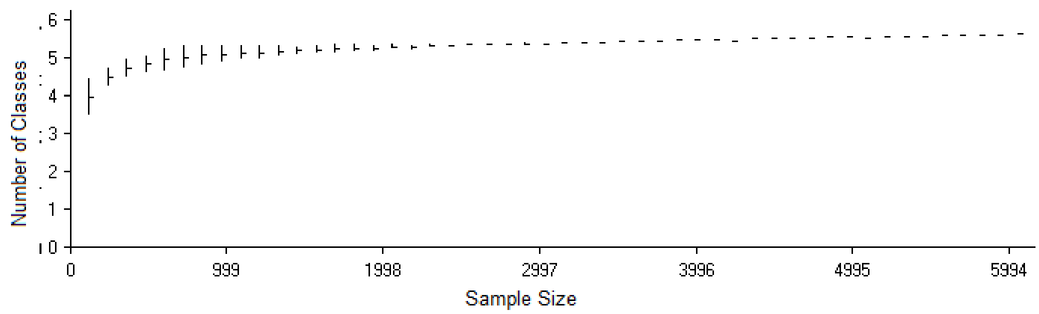

Figure B125. Resampling Curve for Open-Air Sites Groundmass Dimension

Presence of Solid Inclusions Resampling Curves

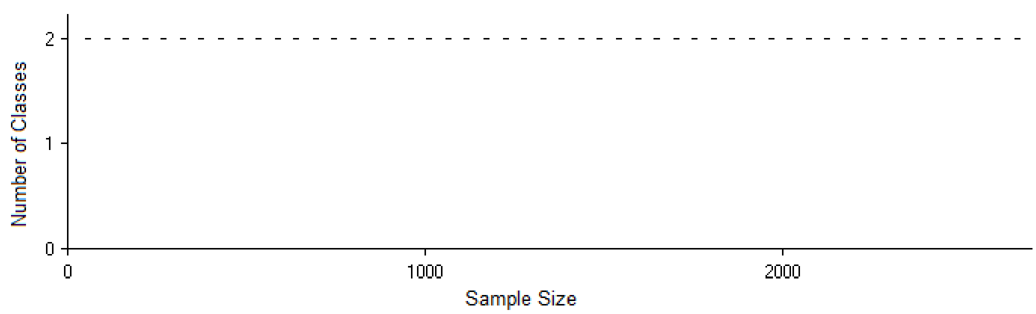

Figure B126. Resampling Curve for Rockshelter Sites Presence of Solid Inclusions Dimension

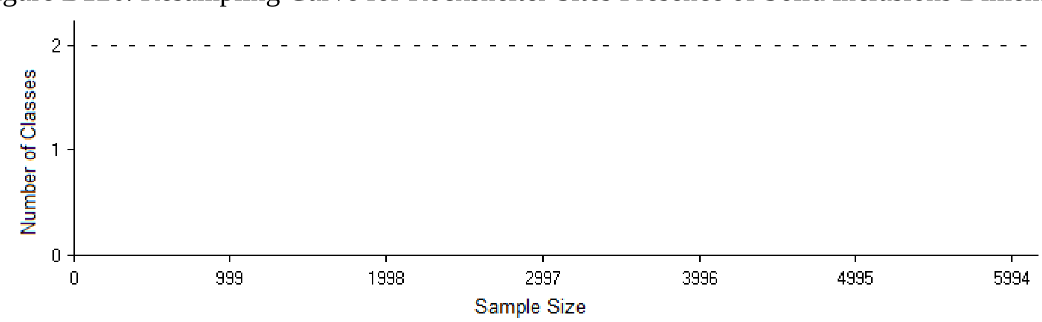

Figure B127. Resampling Curve for Open-Air Sites Presence of Solid Inclusions Dimension

Presence of Void Inclusions Resampling Curves

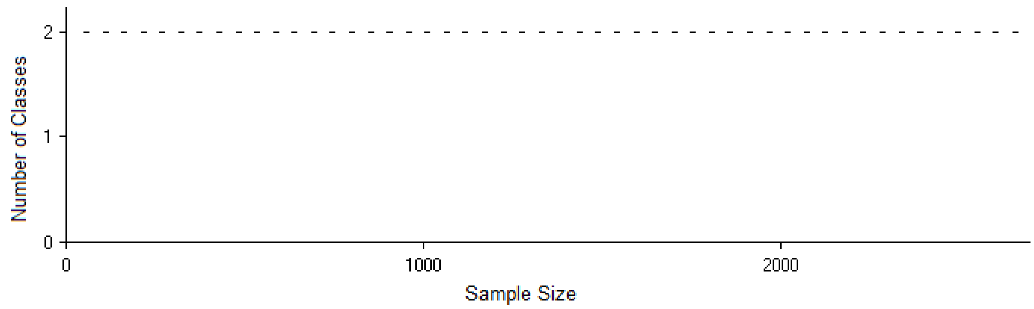

Figure B128. Resampling Curve for Rockshelter Sites Presence of Void Inclusions Dimension

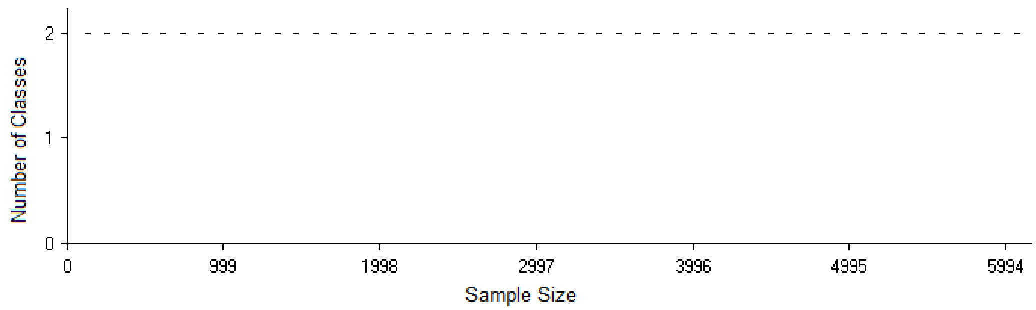

Figure B129. Resampling Curve for Open-Air Sites Presence of Void Inclusions Dimension

Distribution of Solid Inclusions Resampling Curves

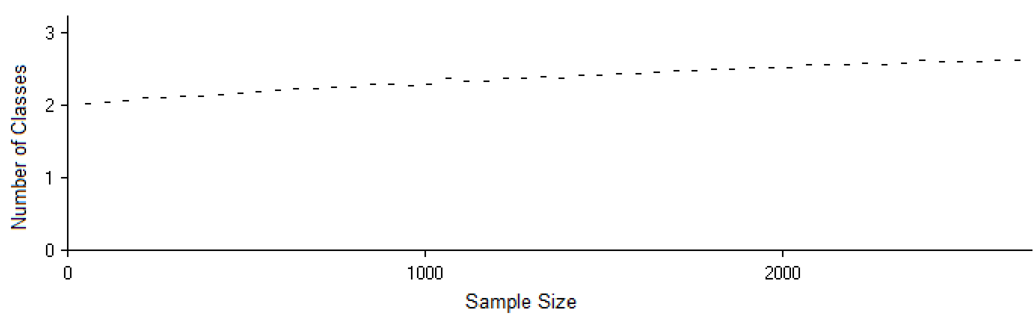

Figure B130. Resampling Curve for Rockshelter Sites Distribution of Solid Inclusions Dimension

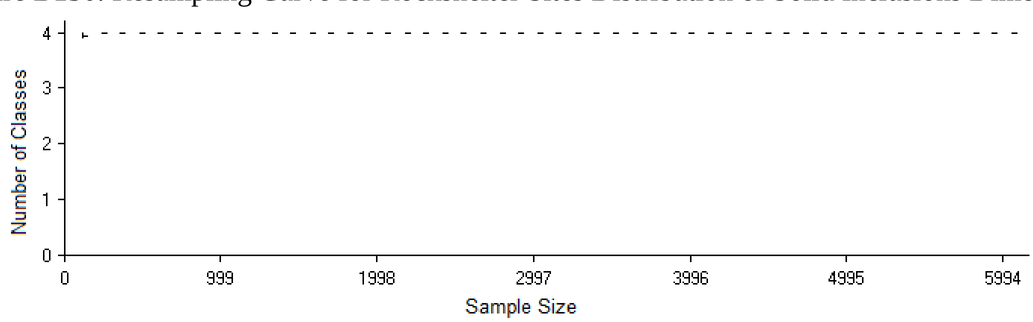

Figure B131. Resampling Curve for Open-Air Sites Distribution of Solid Inclusions Dimension

Distribution of Void Inclusions Resampling Curves

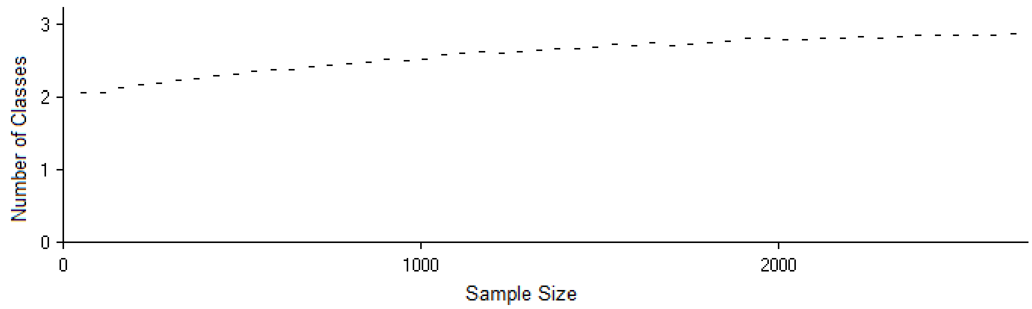

Figure B132. Resampling Curve for Rockshelter Site Distribution of Void Inclusions Dimension

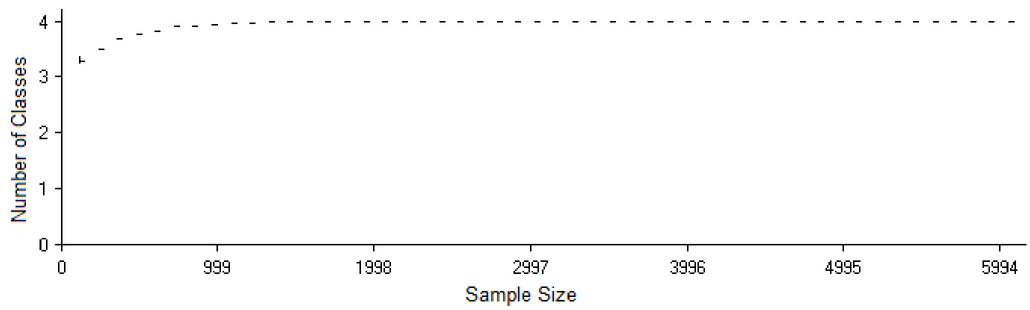

Figure B133. Resampling Curve for Open-Air Site Distribution of Void Inclusions Dimension