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Functional Attributes and the Differential Persistence of Great Basin Dart Forms

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Since the early 1970s, Great Basin archaeologists have debated projectile point chronology, most specifically focusing on the duration of certain types in different parts of the Basin. Large corner-notched types play a central role in this debate, since in some areas they appear during the Early Holocene and persist until recent times, while in other areas they represent much shorter time spans. Further, the occurrence of large side-notched types is limited primarily to those areas in which the large corner-notched types have long temporal distributions. This paper examines the component attributes of large side-notched and corner-notched point types and offers a functional explanation for their differential distribution in time and space.

MOST Great Basin archaeologists, at some time in their careers, have been interested in the Great Basin projectile point typology, especially since that typology often provides the sole measure of age for an artifact assemblage. Many have also taken part in discussions and debates concerning this typology, focusing on issues such as the temporal sensitivity of the Humboldt type, the temporal and/or spatial relationships between the Pinto and Gatecliff types, and most recently, whether it is even valid to use projectile point types for typological cross-dating, a debate generated by Flenniken and Wilke (1989) a few years ago. One of the oldest debates, and one that continues to surface, is that regarding the "long" and "short" chronologies—that is, whether there are separate chronologies in the eastern and western portions of the Basin (e.g., Aikens 1970; Adovasio and Fry 1972; Bettinger and Taylor 1974; Thomas 1975, 1981; Holmer 1978; O'Connell and Inoway 1994). This debate centers primarily on the corner-notched dart types—specifically the Elko Eared and Elko Corner-notched types—and whether they occur earlier in the east than in the west. Most Great Basin archaeologists now recognize that there are different geographical as well as temporal

patterns with respect to these point types, but most discussions have focused on the validity of the distributions rather than why they occur. This paper addresses the distributional differences in dart point morphologies in time and space throughout the Basin, and attempts to explain some of these differences, while commenting on aspects of the Flenniken and Wilke (1989) hypothesis.

THE PATTERNS

The Great Basin projectile point typology was formulated over many years by a number of researchers, but the largest contribution was made by Heizer and his co-workers (e.g., Baumhoff 1957; Baumhoff and Byrne 1959; Grosscup 1960; Heizer and Baumhoff 1961; Lanning 1963; Clewlow 1967, 1968; O'Connell 1967; Heizer and Clewlow 1968; Heizer et al. 1968; Heizer and Berger 1970; Hester 1973; Heizer and Hester 1978). The purpose of the types was—and is—chronology; that is, certain types represent bounded periods of time and can be used as "index fossils" to connote these periods of time. For years type assignment was intuitive, until Thomas (1970) devised a key to standardize the identification process. In 1981,

Thomas revised his key, based on the new data from Monitor Valley. Although Thomas (1981) cautioned that the revised key should be tested in other areas before it was applied in those areas, this key is used unreservedly throughout the Basin by most archaeologists for the identification of projectile points (but see Boaz 1984; O'Connell and Inoway 1994).

In his 1981 revision of the key, Thomas suggested that basal attributes, such as distal shoulder angle (DSA), proximal shoulder angle (PSA), and basal width, are less likely to be affected by breakage and resharpening than are basic measures of size, such as length, width, and weight, and thus are the more dependable measures for type assignment. Thomas thus relied heavily on basal attributes in his key for type definition. Thomas' reasoning has been challenged by several archaeologists on experimental grounds (e.g., Flenniken 1985; Flenniken and Raymond 1986; Titmus and Woods 1986); this challenge is discussed below.

Problems in using the projectile point typology began to arise as the types were applied further afield from their area of definition. For example, Aikens (1970) suggested much longer time spans for the Elko types than had been previously suggested, and the debate concerning the long and short chronologies was launched. After 20 years of debate, however, most archaeologists have grudgingly accepted the fact that certain types date to different periods in the "east" and in the "west." Further, many archaeologists also recognize that there are different geographical patterns with respect to these types (e.g., Holmer 1980; Thomas 1981); some types are present in almost all parts of the Basin while others have more restricted distributions.

One possible explanation for these different patterns is that they are the result of the effects of the transmission process, i.e., diffusion. A trait undergoing transmission will date earliest in its area of origin, and successively later as it moves outward (Hagerstrand 1967; Mahajan and

Peterson 1985). Since not all traits are expected to arise in the same area, however, two traits diffusing from different areas of origin but whose paths cross may show a reverse temporal order after they have crossed. Further, several traits moving outward from the same location may or may not move at the same rate or even in the same direction. In concert, these effects can yield complex temporal and spatial patterns archaeologically with respect to artifact classes constructed of a number of different traits. For example, if clusters of traits (i.e., types) are transmitted together, then it is the cluster that will have a distinctive temporal and spatial pattern, but if individual traits are being transmitted separately, each may have its own temporal and spatial pattern.

Recently, these effects were investigated with respect to Great Basin projectile point types (Beck n.d.; Beck and Jones 1994a), with attention focused on the attributes Thomas used for type definitions in his 1981 key. Since several researchers (e.g., Plog 1980; Plog and Hantman 1984) have shown that all of the attributes defining temporal types are not necessarily temporally sensitive, the attributes in Thomas's key were first examined to determine if, in fact, all *are* temporally sensitive. Using the projectile point assemblage from Gatecliff Shelter (Thomas 1983), the relationship between Thomas's attributes and time was investigated. As Table 1 shows, only two variables, neck width (Wn) and PSA, have what might be considered significant correlations with mean horizon date at Gatecliff. When "large" (or dart) and "small" (or arrow) points were considered separately, somewhat different results were obtained (Table 2). For large points, both length and PSA measurements show significant correlations with mean date, an interesting result given the suggested problems with breakage and resharpening of the blade (e.g., Flenniken and Raymond 1986; Titmus and Woods 1986). For small points, however, thickness and PSA are highly correlated with mean

Table 1
CORRELATION COEFFICIENTS FOR NINE
PROJECTILE POINT ATTRIBUTE MEANS
BY MEAN HORIZON DATE
AT GATECLIFF SHELTER

Variable ^a	Pearson's r	Probability
Lm	.299	.346
La	.264	.408
Wm	.290	.337
Wb	.468	.107
Wn	.717	.030
TH	.410	.164
WT	.464	.151
PSA	-.600	.088
DSA	.111	.776

^a Lm = total length; La = medial length; Wm = maximum width; Wb = basal width; Wn = neck width; TH = thickness; WT = weight; PSA = proximal shoulder angle; DSA = distal shoulder angle.

date; length shows the lowest correlation. Overall, then, it is PSA that proved to be consistently correlated with time; thus, it is PSA that is in large part responsible for the temporal sensitivity of the Great Basin point types, at least in the Gatecliff assemblage.

In the formulation of these projectile point types, however, PSA actually conflates two different qualitative attributes: the type of haft—that is, whether a point is corner-notched or side-notched—and if corner-notched, whether the haft is expanding, parallel, or contracting. With respect to the type of haft, which is the focus of this discussion, Thomas (1981:19) defined the break between corner-notching and side-notching at a PSA of 150° for dart points and of 130° for arrow points. That these divisions are valid is evidenced by the bar graphs in Figures 1 and 2, which show PSA in five-degree intervals for small (Fig. 1) and large (Fig. 2) points in an assemblage of 1,319 projectile points from the Steens Mountain area in south-eastern Oregon

Table 2
CORRELATION COEFFICIENTS FOR NINE PROJECTILE POINT ATTRIBUTE MEANS
BY MEAN HORIZON DATE WITHIN TWO SIZE GROUPS AT GATECLIFF SHELTER

Variable ^a	Large Points		Small Points	
	Pearson's r	Probability	Pearson's r	Probability
Lm	-.756	.011	.128	.725
La	-.721	.019	.042	.908
Wm	-.451	.164	-.277	.438
Wb	-.059	.862	-.406	.244
Wn	-.430	.288	.089	.807
TH	.160	.639	.661	.038
WT	-.404	.248	.126	.730
PSA	-.796	.018	-.608	.082
DSA	.262	.531	.092	.814

^a Lm = total length; La = medial length; Wm = maximum width; Wb = basal width; Wn = neck width; TH = thickness; WT = weight; PSA = proximal shoulder angle; DSA = distal shoulder angle.

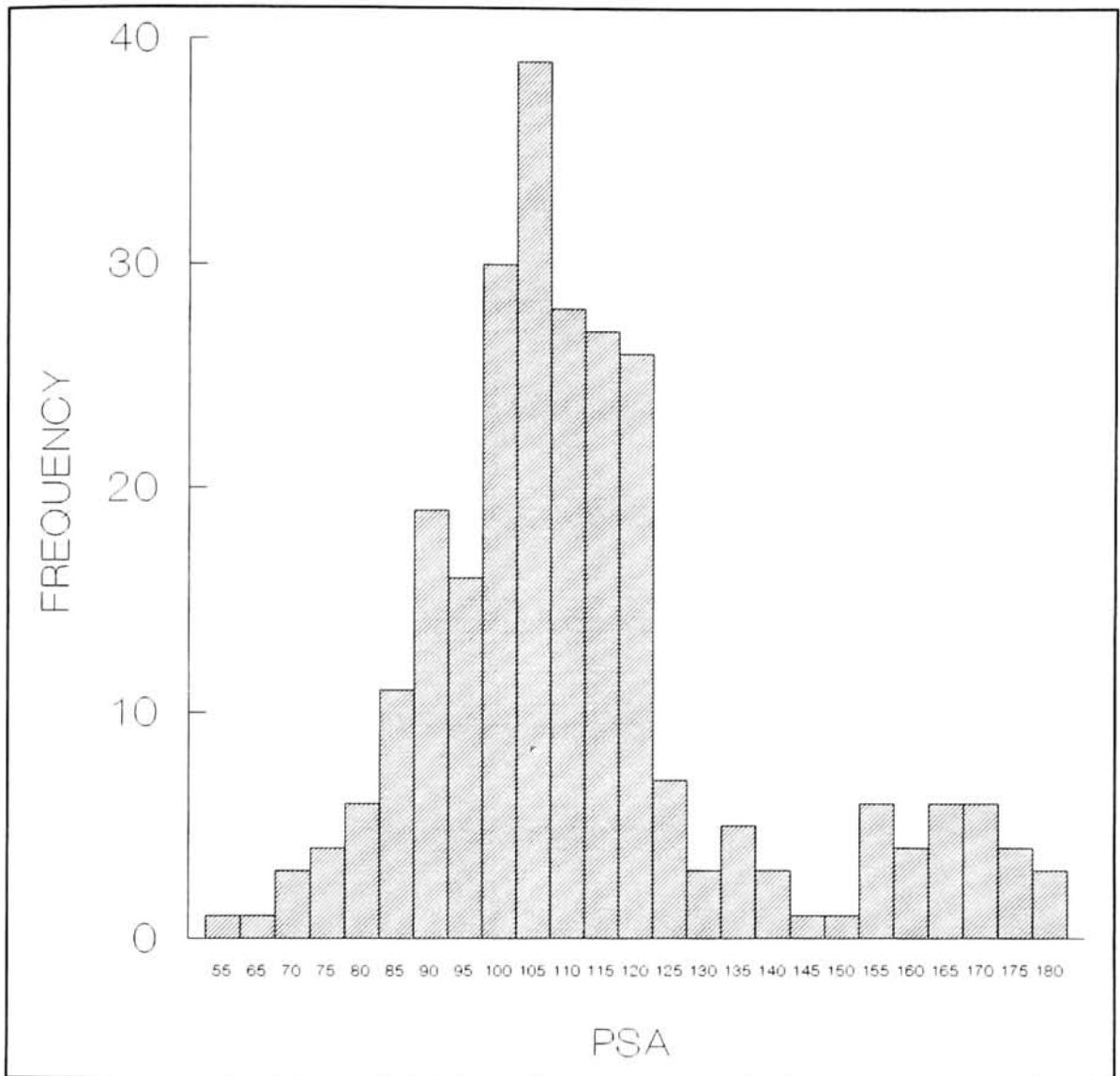


Fig. 1. Distribution of proximal shoulder angle (PSA) in five-degree intervals for small points in the Steens Mountain projectile point assemblage from southeastern Oregon.

(the Gatecliff assemblage cannot be used here because there are so few side-notched dart points). For small points a break is indicated at 130° (Fig. 1), while for large points a break is indicated at 150° (Fig. 2).¹

Turning now to an examination of the temporal and spatial patterns of these two hafting alternatives, Figure 3 shows the earliest dates of

occurrence of side-notching and corner-notching² at 17 archaeological sites throughout the Great Basin and two sites just outside the Basin.³ Data from these sites are variable in quality due to a number of factors, including when and how the sites were excavated, differing formational histories, and quality and availability of datable materials. Consequently, small differences in

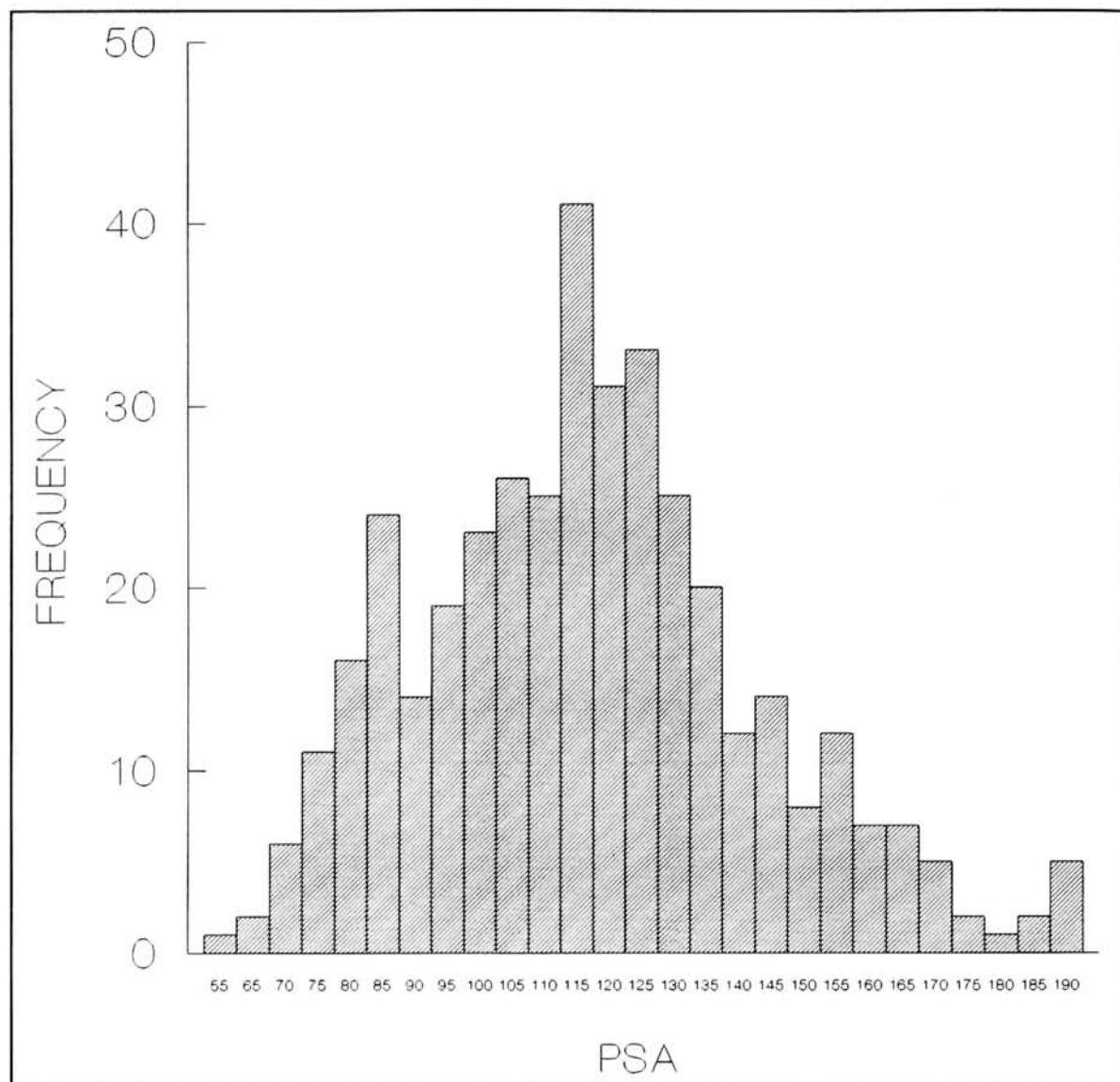


Fig. 2. Distribution of proximal shoulder angle (PSA) in five-degree intervals for large points in the Steens Mountain projectile point assemblage from southeastern Oregon.

dates and occurrences should not be assumed to be meaningful, and thus general temporal and spatial patterns are emphasized here.

As can be seen from Figure 3, both side-notching and corner-notching appear earliest in northwestern Utah, appearing slightly later to the south and west. What is striking is that the early dates for both hafting techniques occur only around the northern, eastern, and south-

eastern peripheries of the Basin; neither appear in the central, western, or southwestern Basin earlier than ca. 4,500 B.P. This distribution, of course, is essentially what led archaeologists into the debate over the long and short chronologies. A second, less obvious pattern is the near absence of side-notching in the central, western, and southwestern areas (Fig. 4). That is, when the record of dart points begins in these areas, it

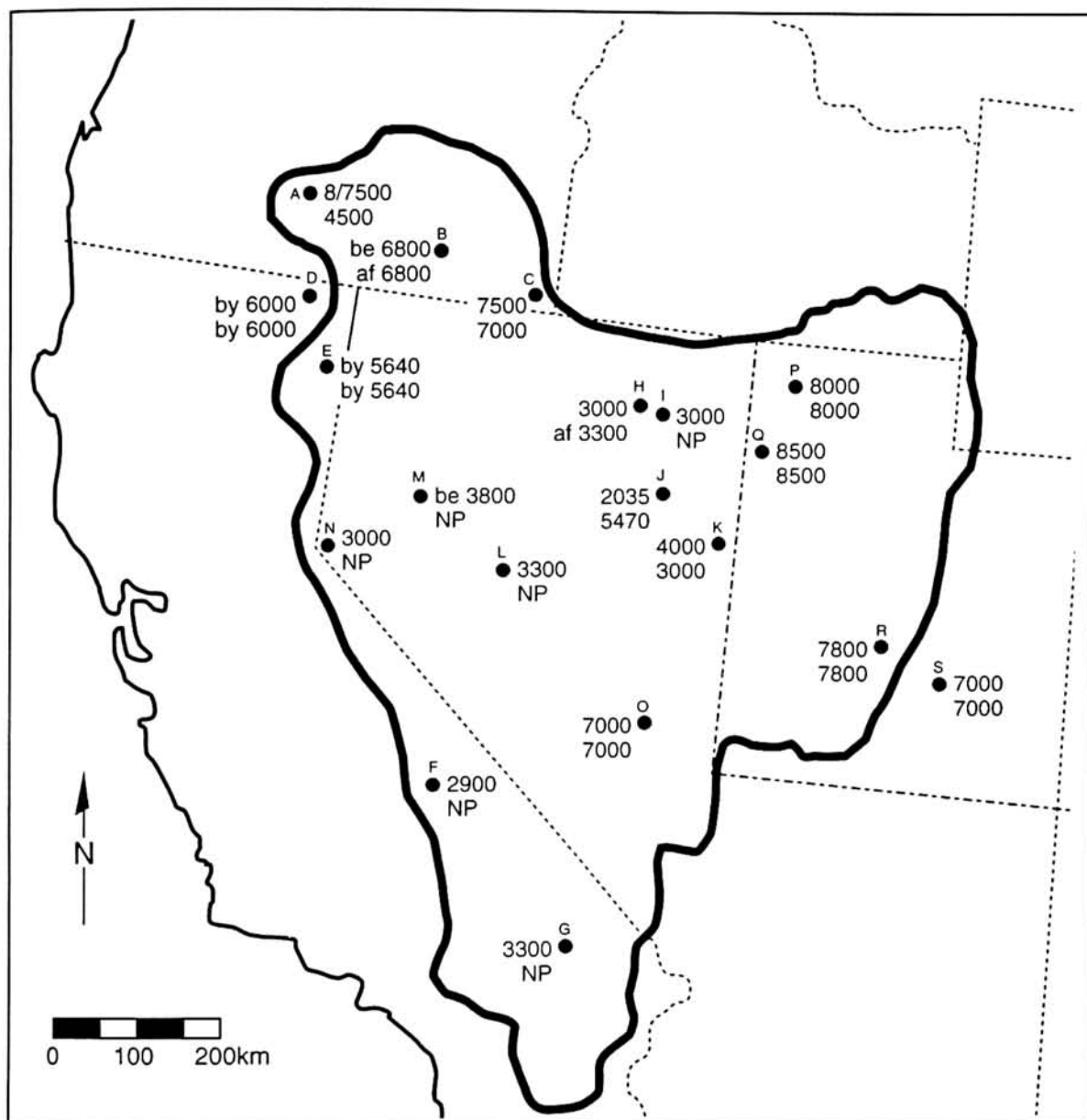


Fig. 3. Earliest date of occurrence of corner-notching and side-notching at each of 17 sites within and two sites just outside the Great Basin. These sites are: (A) Connley Caves, (B) Skull Creek Dunes, and (C) Dirty Shame Rockshelter in Oregon; (D) Nightfire Island, (E) Surprise Valley (King's Dog, Rodriguez, Menlo Baths), (F) Rose Spring, and (G) Newberry Cave in California; (H) South Fork Shelter, (I) James Creek Shelter, (J) Newark Cave, (K) Amy's Shelter, (L) Gatecliff Shelter, (M) Hidden Cave, (N) Spooner Lake, and (O) O'Malley Shelter in Nevada; and (P) Hogup Cave, (Q) Danger Cave, (R) Sudden Shelter, and (S) Cowboy Cave in Utah. For each site, the upper date refers to corner-notched points, the lower date to side-notched points. NP = not present; be = occurs before the date given; by = occurs at least as early as the date given; af = occurs after the date given.

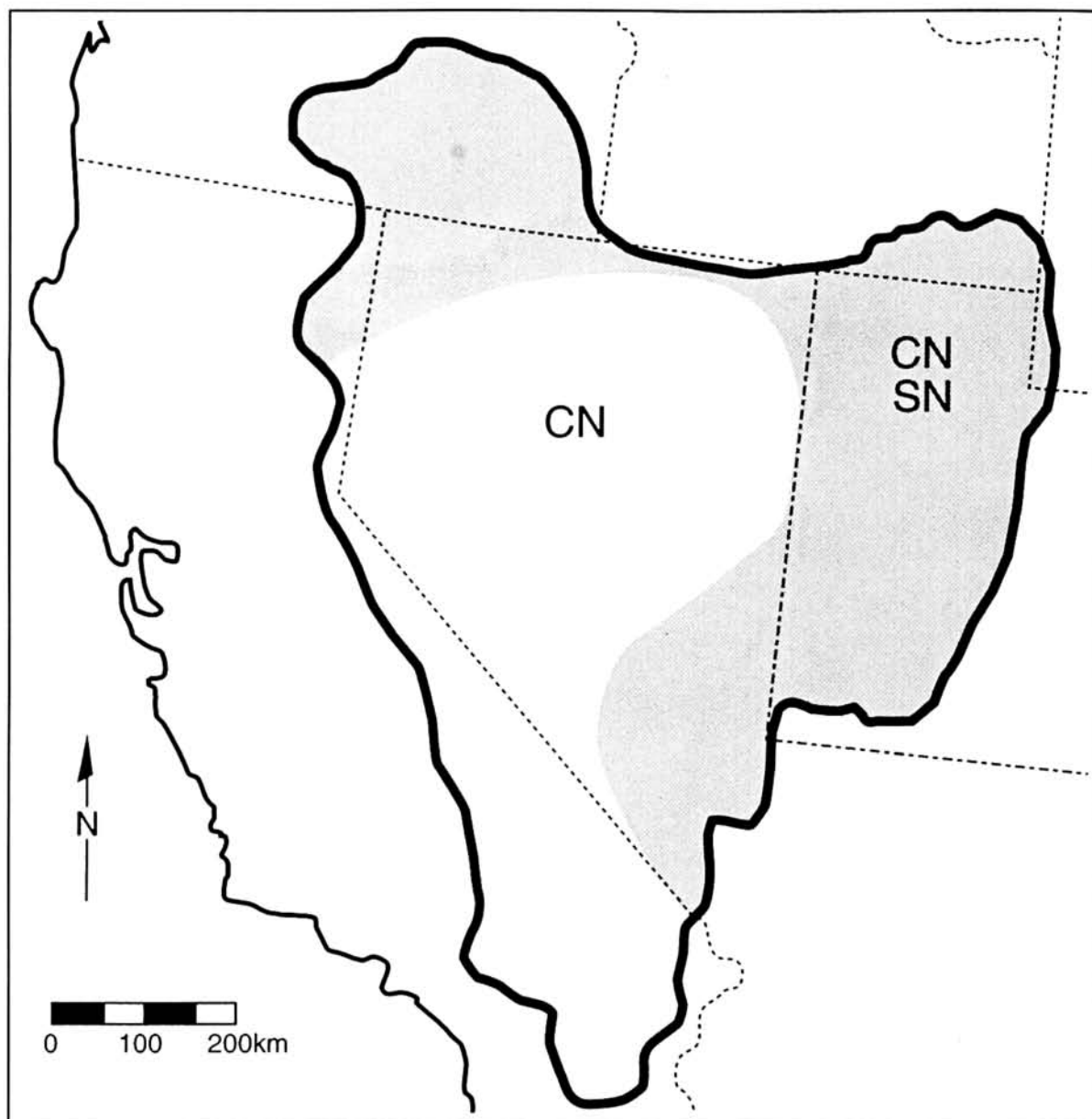


Fig. 4. Schematic of the Great Basin showing the areas where side-notching and corner-notching both occur and those where hafting is predominantly corner-notching.

is primarily a record of corner-notching; side-notching is extremely rare. These two patterns are the focus herein, beginning with the first.

THE EXPLANATIONS

In his recent book on the natural prehistory of the Great Basin, Grayson (1993) examined

the distribution of archaeological sites during the early, middle, and late Holocene. The rarity of Mid-Holocene sites suggested to him, as it did to Baumhoff and Heizer (1965) and others 30 years ago, that population density was much reduced in many parts of the Basin during this period. The Middle Holocene interval, of course, cor-

Table 3
MIDDLE HOLOCENE HIATUS AT SITES WITH EARLY OCCURRENCES
OF CORNER-NOTCHED AND SIDE-NOTCHED POINTS

Site	Early Occupation Interval (years B.P.)	Late Occupation Interval (years B.P.)
Connley Cave No. 5	9,800-7,430	4,320-3,330
Nightfire Island	6,256-5,917	4,630-957
Dirty Shame Rockshelter	9,500-5,855	2,740-365
O'Malley Shelter	7,100-6,520	4,630-870
Sudden Shelter	7,900-6,310	4,670-3,360
Cowboy Cave	8,275-6,675	3,635-1,580

responds roughly to the warmer-drier period known as the Altithermal (Antevs 1955). At the time Baumhoff and Heizer (1965) made this observation, many researchers argued that Middle Holocene sites had simply not yet been found, and when more work was completed there would be ample evidence of continuous human occupation throughout the Holocene. But as Grayson (1993:255) stated, we cannot so easily make that argument today—more sites have been excavated and evidence of Middle Holocene occupation is still rare.

An examination of the early dates for the occurrence of corner-notched and side-notched dart points reveals that these dates are, for the most part, at the end of the Early Holocene or at the beginning of the Middle Holocene. With the exception of those in the Bonneville Basin, which Grayson (1993) observed still had water sources close by,⁴ all of the sites with early occurrences have a hiatus in occupation corresponding to much of the Mid-Holocene period. Table 3 shows the two periods of occupation at six of these sites; occupation ends between ca. 7,000 and 6,000 years ago and does not resume until after 5,000 B.P. The rockshelter record in the central, western, and southwestern Basin does not actually begin until about this same time (i.e., post-5,000 B.P.).

Lower population density during the Middle Holocene, however, does not explain why there

are no earlier rockshelter records in this area, or records from open sites for that matter, especially since there is ample evidence of Late Pleistocene/Early Holocene occupation—represented by points of the Great Basin Stemmed series (e.g., Hutchinson 1989; Price and Johnston 1989; Tuohy 1989; Beck and Jones 1990a)—in many locations. This is a difficult problem since there is no clear idea when the thrusting spear and/or javelin gave way to the atlatl and dart, or how much temporal overlap there might have been between them. Points of the Great Basin Stemmed series are more likely to have tipped the former rather than the latter because of their (often) large size and lack of symmetry and also because of evidence that suggests they served many functions and had longer use-lives than points known to have tipped atlatl darts (e.g., Basgall and Hall 1991; Beck and Jones 1993). Existing data suggest that this change in projectile technology occurred between 8,500 and 7,500 B.P. It is possible that population began to dwindle in the core of the Basin earlier than along the periphery, and thus by the time the atlatl and dart took hold, population in that area was already significantly reduced.

This argument can never be tested in any other way than in the collection of more datable sites. But as Grayson (1993:255) argued, more sites are likely to yield the same pattern—very little evidence of Mid-Holocene occupation.

Most important in solving this problem is the establishment of the temporal relationship between the thrusting spear and/or javelin and atlatl/dart technologies—that is, establishing the terminal dates for the general use of Great Basin Stemmed points.

At the same time that the rockshelter record begins in the central, western, and southwestern Basin, other sites, such as Connley Caves, Dirty Shame Rockshelter, Sudden Shelter, and Cowboy Cave, are reoccupied. In fact, the evidence of human occupation picks up everywhere at this time, reinforcing the hypothesis that during the previous period people simply were scarce. When this record begins in the central, western, and southwestern Basin, side-notching is rarely present. At those sites where it does occur, frequency of side-notching is very low: eight points at South Fork Shelter, three at Newark Cave, and five at Amy's Shelter. Side-notched points are found in some of the surface records in these areas, but again, they are few in number.

What might account for this pattern? Even if we accept the explanation that the late dart point record in these areas is due to low population density during the Mid-Holocene, this would not account for the virtual absence of side-notching once the record begins. The answer to this question may be a functional one; that is, these two hafting techniques are alternatives that may not have been equally effective. One of these, corner-notching, may have had a slight advantage over the other, side-notching, and thus corner-notching came to dominate over time. Corner-notching and side-notching appeared about the same time, late in the Early Holocene; during the Middle Holocene, where records exist, both were also present.

Nevertheless, the general trend is for the relative abundance of side-notched points to decline while the relative abundance of corner-notched points increases (Table 4). Corner-notching, once it appeared, was used for most of the remainder of the Holocene, almost until historic

times. When the bow and arrow was introduced, corner-notching was predominant and thus was carried over into arrow point times. Only very late were corner-notched points replaced with small, triangular, often side-notched points. This is the case in most of North America (e.g., Shott 1993), suggesting that in conjunction with the bow and arrow, side-notching may have been more effective than corner-notching. But in conjunction with the atlatl and dart technology, corner-notching may have been slightly more effective than side-notching, and thus by the beginning of the Late Holocene side-notching was on the wane. As people began moving back into the central, western, and southwestern Basin, it was primarily the corner-notched technology they carried with them.

Evaluation of Hypothesis

How might this hypothesis be evaluated? As a first step, it must be established that corner-notching and side-notching are indeed alternative hafting technologies rather than constructs of the archaeologist that have been imposed on a continuum. That is, the variation in notching may be continuous, with the mean gradually shifting from what we see as "corner-notched" to what we see as "side-notched." Figures 1 and 2 suggest that this is not the case; the break between corner-notched and side-notched points is clearly visible in Figure 1, and less so in Figure 2. The number of "side-notched" dart points is much smaller than the number of "corner-notched" points; thus, the notching pattern is less visible in Figure 2 than would be the case if the sample sizes were more nearly equal. O'Connell and Inoway (1994:Fig. 1) found a very clear division between corner-notching and side-notching in the Surprise Valley point assemblage, a sample in which the numbers of corner-notched and side-notched points are roughly equal. These data, then, suggest that the distinction between corner-notching and side-notching is a valid one.

Table 4
RELATIVE ABUNDANCES OF CORNER-NOTCHED AND SIDE-NOTCHED POINTS
DURING DIFFERENT TEMPORAL INTERVALS AT TEN GREAT BASIN SITES^a

Site/Strata	Temporal Interval ^b	Side-notched	Corner-notched
Sudden Shelter			
12-22	5,000-3,000	23.3%	53.4%
1-9	8,000-6,000	62.5%	37.5%
Cowboy Cave			
IVa-IVd	4,000-3,500	3.2%	96.8%
IIb-IIIk	8,000-6,500	72.7%	27.3%
O'Malley Shelter			
II-IV	4,500-3,000	15.4%	84.6%
I	7,100-6,500	40.0%	60.0%
Hogup Cave			
8-10	5,000-3,000	26.1%	73.9%
1-7	8,500-6,000	43.5%	56.5%
Danger Cave			
IV-V	6,500-3,000	37.6%	62.4%
III	7,100-6,560	24.2%	75.8%
II	10,000-8,000	53.5%	46.5%
Dirty Shame Rockshelter			
II	3,000-1,100	57.1%	42.9%
V-III	8,000-6,000	34.0%	66.0%
Menlo Baths			
III	no dates	67.9%	32.1%
II	no dates	78.1%	21.9%
I	5,250	93.3%	6.7%
King's Dog			
III	no dates	37.3%	62.7%
II	no dates	55.4%	44.6%
I	5,460	92.7%	7.3%
Nightfire Island			
5-10	4,600-3,000	55.0%	45.0%
1-4	6,300-6,000	57.1%	42.9%

^a For sources of data in this table see Note 3.

^b Dates are approximate.

As a second step, these two hafting alternatives must be evaluated in terms of their effectiveness or how well they perform the job they were designed to do. In a study focusing on the design of hunting weapons using principles of engineering, Bleed (1986:738) suggested that an effective design represents the best compromise between its benefits and its costs. Cost-related

factors are those such as energy and time expenditure in manufacture and what Bleed (1986:739) termed availability, or the length of time the resulting technology is available to do the job, a variable commonly referred to as use-life.

The benefits of a design can be evaluated in terms of what Schiffer and Skibo (1987:599) called performance characteristics, or "the beha-

vioral capabilities that an artifact must possess in order to fulfill its functions in a specific activity." They suggested that the performance characteristics of a knife for butchering, for example, are that it cuts cleanly, that it is easy to grasp, and that it does not wear out quickly (Schiffer and Skibo 1987:599). The performance characteristics, then, of a stone point used *exclusively* as a projectile on an atlatl dart would be balance and stability, impact resistance, and ability to penetrate the target (Van Buren 1974; Christenson 1986; Flenniken and Wilke 1989).

Stability and balance are a function of symmetry and weight (Christenson 1986); that is, if a point is symmetrical in both form and weight, then the balance should be good. If, on the other hand, the point is asymmetrical, such as is sometimes the case for points of the Northern Side-notched type (Aikens 1970:37, Fig. 19i; Beck 1984:95, Fig. 34d; Sampson 1985:318, Figs. 13-17g), weight must be distributed so as to offset that asymmetry.

The ability of a point to penetrate the intended target is a function of its cross-sectional area (Frison and Zeimens 1980), as well as the sharpness of its tip and blade edges (Frison 1973, 1976). Once penetration has been achieved, the presence of barbs helps to keep the point in the wound (Christenson 1986; Flenniken and Wilke 1989). Christenson (1986:117) suggested, however, that the eventual design is a balancing of the desired characteristics: a wide, barbed point will create a larger wound and cause more bleeding than a narrow, unbarbed one, but will not penetrate as deeply.

Impact resistance is somewhat more complex. In an attempt to distinguish breakage occurring during the manufacturing process and that occurring during use, Titmus and Woods (1986) found that use-related breakage is a result of three forces: bending, crushing, and shearing. These forces are a consequence of a combination of a number of variables, including the material impacted, the impact distance, and the

angle of impact (see also Van Buren 1974). When manufacturing points for their experimental study, Titmus and Woods (1986) held material constant so as not to introduce further variability. Thus, several factors may be important in impact resistance. The first concerns raw material selection, which, differential access aside, is likely a compromise. A brittle material, such as obsidian, will shatter more quickly but be easier to work with during manufacture and repair, while a tougher material, such as chert, will prove more difficult to work with during the manufacture and repair process, but will shatter less quickly.

The second factor is thickness. A very thin but large point will be more likely to break on impact than a thicker one of the same length and width. The final factor is hafting. If a point is notched for hafting, the depth of the notches can create a weak area on the blade (Flenniken and Wilke 1986). Deep notches create a narrow neck width that may break more quickly under impact loading. If these notches are located more centrally in the blade, rather than at the base, this weakness may increase, since there is less mass at the distal end to absorb the impact force and also because the blade is narrower at the mid-section than at the base. Thus, a point that is deeply notched midway up the blade may have less impact resistance than a point that is less deeply notched at the base of the blade.

The above discussion relates to points that are used exclusively as projectiles; but if the point also occasionally served other functions, such as that of a knife, we can imagine that the performance characteristics might be a compromise between those of a projectile and those of a knife. In such a case, the "sturdiness" of the point would become more important; not only must it have impact resistance, but it also must withstand the torque created by constant side-to-side twisting.

Costs and benefits, however, are not independent of one another. For example, time and

Table 5
MATERIAL MAKEUP OF CORNER-NOTCHED AND SIDE-NOTCHED
PROJECTILE POINTS FROM HOGUP CAVE AND STEENS MOUNTAIN

Hafting Technique	Material Type ^a		Totals
	Obsidian	Other	
Hogup Cave			
Corner-notched	79 (67.5%)	38 (32.5%)	117
Side-notched	48 (76.2%)	15 (23.8%)	63
Steens Mountain			
Corner-notched	536 (98.5%)	8 (1.5%)	544
Side-notched	118 (97.5%)	2 (2.5%)	122

^a Since the material for Hogup Cave points was most often presented as "obsidian" and "other," the same was done for the Steens Mountain points. For corner-notched points, six are of chert and two are of basalt; the two side-notched points are of chert.

energy of manufacture will include raw material procurement, which in part will be a function of availability. Holding availability constant, are there differences in raw material requirements (related to performance) between these two hafting techniques, one of which is more costly than the other? Impact resistance and use-life are also interrelated. A design that is more resistant to breakage on impact (related to performance) will have a longer use-life (related to cost). Thus, evaluation of costs and benefits of side-notching and corner-notching must be done in conjunction.

Beginning with raw material, the functional requirements of a particular design will often transcend local availability (Beck and Jones 1990b); so, if one hafting technique required more durable material than the other, this should be evident in relative material proportions within a particular assemblage, regardless of local availability. Table 5 shows material type for corner-notched points from Hogup Cave in the Bonneville Basin and Steens Mountain in southeastern Oregon. Although the two assemblages differ from each other with respect to the percentage of different raw materials represented, there are no differences within either assemblage

regarding raw material composition of corner-notched versus side-notched points. Thus, there is no indication that there are special raw material requirements for one or the other notched form ($\chi^2 = 1.484$, $p = 0.1164$ for Hogup; $\chi^2 = 1.223$, $p = 0.3412$ for Steens).

There also appear to be few differences among other aspects of the manufacturing process. In an experimental study on the use and breakage of corner-notched, side-notched, and lanceolate dart points, Flenniken (1985:267) used similar reduction techniques for both corner-notched and side-notched points until the final stage, in which "the preforms were pressure-flaked and notched into end products." There is some indication that this final stage may be slightly more problematic for corner-notched points, since the notches are slightly narrower than in side-notched points. According to Titmus and Woods (1986:38), the manufacture of narrow notches "usually produces a higher rate of damage due to limited space between the notching tool and the sides of the notch." Since no controlled studies have indicated a significant difference in this step in the manufacturing process, the cost of this process is held constant here.

Balance is influenced by symmetry and weight while penetration is influenced by point/edge sharpness and width. Considering the latter first, if the same reduction sequence is used for both types of points up until the notching process (Flenniken 1985), then it follows that the sharpness of tip and edges would be constant between the two. Maximum width also appears to be constant. A *t* test ($t = -0.282$, probability = 0.778) revealed no significant difference in maximum width between corner-notched and side-notched dart points in the Steens Mountain assemblage.

Balance is more difficult to evaluate. Again, Flenniken's (1985) experiment suggested balance is constant for both haft types, given the same reduction sequence. The majority of archaeological dart points is not perfectly symmetrical, in large part due to breakage and resharpening (see below), but also due to "mistakes" during manufacture that have been rectified. None of the points in Figure 5, for instance, are perfectly symmetrical, but an examination of thickness at different locations on these points suggests that variations in this variable, and thus weight, compensate for asymmetry in form. For this study, then, balance is held constant.

The final variable to be considered is impact resistance/use-life, referred to hereinafter as use-life. As stated above, use-life can be evaluated on the basis of how long an item is "available" for its designed use. Thus, use-life can be evaluated in terms of breakage and resharpening; that is, does one type of haft more often facilitate breakage in a way that renders the point unusable, while the other type of haft facilitates repair after breakage, rendering the point reusable? To answer these questions, breakage and resharpening patterns were examined in corner-notched and side-notched dart points in the Steens Mountain projectile point assemblage. For each point, several variables were recorded: the number of breaks;⁵ the location and type of each break; whether the point showed previous

resharpening, and if so, the location of that resharpening; and finally, if the point could be resharpened and reused as a dart point.⁶

Table 6 shows the number of resharpenable versus nonresharpenable points for each notching technology. As this table shows, a significantly larger number of the corner-notched points ($n = 200$; 36.7%) are reusable than is the case for side-notched points ($n = 21$; 17.5%) ($\chi^2 = 16.335$; $p < 0.001$). This is in large part due to the fact that side-notched points more often break at the notch than do corner-notched points—45% of side-notched points are broken at the notch compared with 20.6% of corner-notched points. Earlier, it was suggested that a point that was deeply notched midway up the blade may break more easily at the notch than one that is less deeply notched at the base of the blade. The relative depth of notches (neck width/maximum width) on corner-notched and side-notched points is not significantly different ($t = 1.465$, $p = 0.144$); the placement of the notches along the blade (total length/notch-to-base length), however, is significantly different ($t = -2.273$, $p = 0.024$), with side-notched points being notched further up the blade than corner-notched points.

A break at the notch most likely renders the point unusable as a dart point, especially if the notch is more distally located. Flenniken and Wilke (1989) actually suggested just the opposite—that side-notched dart points have the *most* potential for rejuvenation when broken at the notch, since such a break leaves a large, triangular blade to serve as a blank for a corner-notched or lanceolate point. In order to test this notion, the average length of side-notched point blades (notch-to-tip) was calculated and compared with the average total length of corner-notched and lanceolate (exclusive of fluted and Black Rock Concave Base) points. The length of many of the side-notched blades had to be estimated, but when this was the case, the largest possible estimate was used. The mean notch-to-

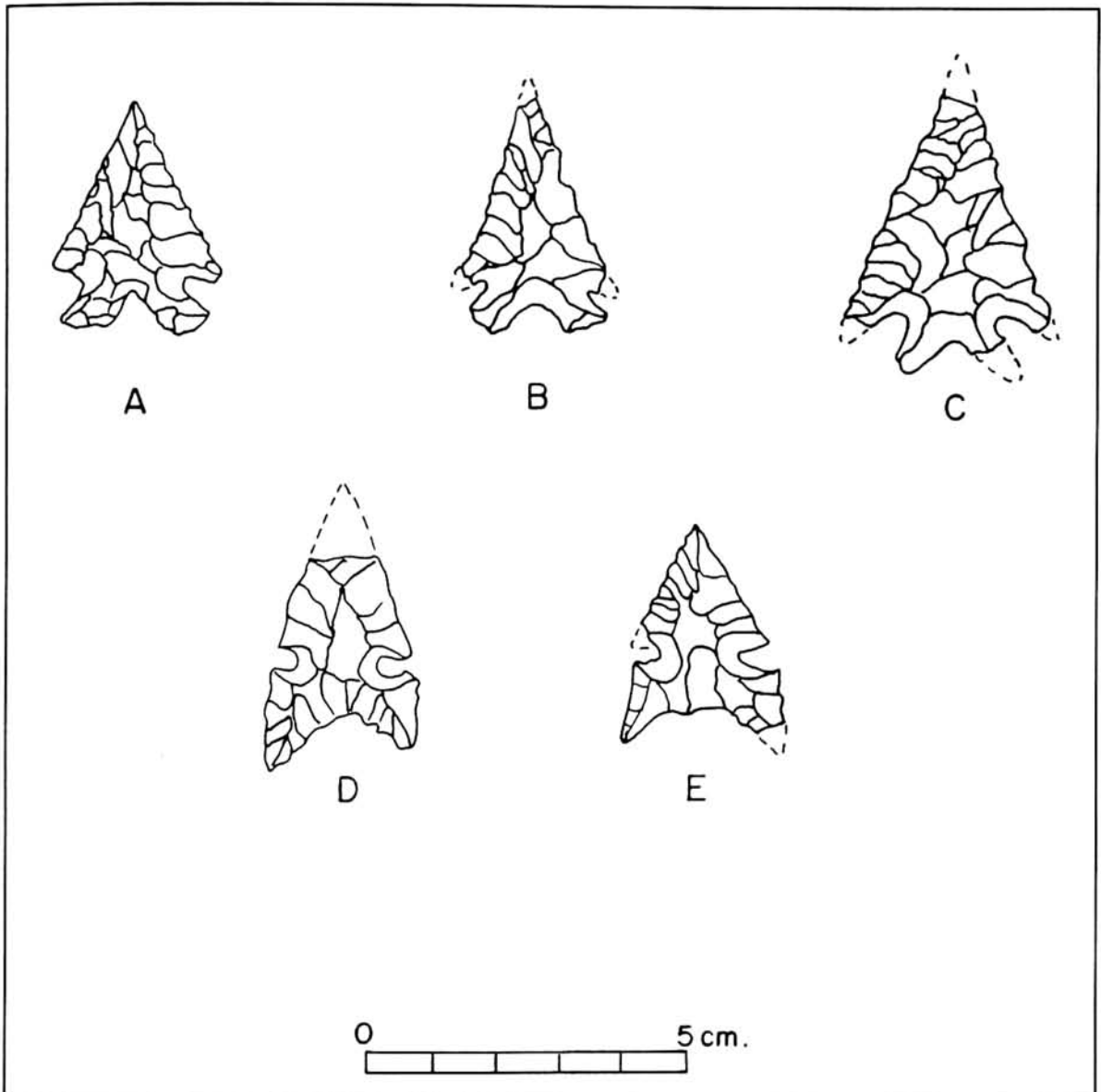


Fig. 5. Five projectile points from the Steens Mountain assemblage representing the Elko Eared type (a-c) and the Northern Side-notched type (d-e).

tip length for side-notched points is 32.76 mm., while the mean total length of corner-notched points is 35.83 mm., and for lanceolate points is 41.91 mm., indicating that neither the corner-notched nor lanceolate points in the Steens assemblage, on the average, could have been manufactured from the blades of side-notched points.

A similar test of Flenniken and Wilke's (1989) hypothesis was conducted by Bettinger et al. (1991), in which they compared the average weights of the supposed "archetypal" forms (Northern Side-notched and Elko Corner-notched) with the so-called "rejuvenated" forms (all others), the idea being that the former

Table 6
 NUMBER OF RESHARPENABLE AND NONRESHARPENABLE CORNER-NOTCHED AND
 SIDE-NOTCHED PROJECTILE POINTS IN THE STEENS MOUNTAIN ASSEMBLAGE

Haft Type	Resharpenable	Nonresharpenable	Totals
Corner-notched	200 (36.7%)	345 (63.3%)	545
Side-notched	21 (17.5%)	99 (82.5%)	120

should be larger, on the average, than the latter. This did not prove to be the case and thus Bettinger et al. (1991) concluded that not all Great Basin dart points are the result of the rejuvenation of Northern Side-notched and Elko Corner-notched points. This conclusion is supported here by the fact that a large number of the corner-notched points in the Steens assemblage have been resharpened on the blade (see discussion below), whereas very few of the side-notched points show resharpening at all, and thus the mean for corner-notched points is likely underestimated where the mean for side-notched points is not. This is not to say that some of these blades were not recycled as corner-notched or lanceolate points, or as some other tool; this is certainly possible. It does suggest, however, that not all corner-notched and lanceolate points were the result of reuse of side-notched blades.

Table 7 shows the number of breaks sustained by both corner-notched and side-notched points from the Steens Mountain assemblage that are resharpenable and those that are not. These data suggest that it takes fewer breaks to render a side-notched point unusable than it does for a corner-notched point. For instance, 30.3% of the nonresharpenable side-notched points have only one break compared with only 19.1% of corner-notched points. Additionally, 38.9% of resharpenable side-notched points have only one break as compared with 27.5% of corner-notched points. This suggestion gains support from the data regarding previous resharpening, shown in Table 8.

Each point was examined microscopically at low power (10x-70x) for evidence of previous resharpening on the blade, barb, or stem, or a

combination of these areas. It should be noted that 65.3% of corner-notched points and 42.9% of side-notched points are complete enough for evaluation. A total of 63.5% of corner-notched points exhibits resharpening compared with only 18% of side-notched points. The greatest amount of resharpening on corner-notched points occurs on the blade and/or barbs rather than on the stem (Table 9); this is true for breakage as well (Table 10).

These data suggest that corner-notched points can sustain more damage than side-notched points and still remain in use, which in turn suggests that corner-notched points have a longer use-life as the same tool—that is, as a dart point—than do side-notched points. Thus, these data suggest that corner-notching has a lower cost and is thus a more effective hafting technique than side-notching.

SUMMARY AND CONCLUSIONS

In summary, two archaeological patterns concerning the appearance and spread of the atlatl and dart projectile technology have been discussed. First, side-notching and corner-notching, two alternative hafting techniques, occur earliest, ca. 8,000 B.P. along the northern, eastern, and southeastern peripheries of the Basin; they do not appear in the central, western, or southwestern Basin until after 5,000 B.P. Second, once this technology appears in the latter area, side-notching is rare. As to the appearance of dart points later in the central, western, and southwestern areas than along the northern and eastern peripheries, it is suggested here, following Baumhoff and Heizer (1965), Grayson (1993), and others, that this pattern is the result

Table 7
NUMBER OF BREAKS FOR RESHARPENABLE AND NONRESHARPENABLE CORNER-NOTCHED AND SIDE-NOTCHED POINTS FROM THE STEENS MOUNTAIN ASSEMBLAGE

Hafting Technique	Number of Breaks							
	1	2	3	4	5	6	7	8
Resharpenable Points*								
Corner-notched	52 (27.5%)	69 (36.5%)	40 (21.2%)	22 (11.6%)	6 (3.2%)	—	—	—
Side-notched	7 (38.9%)	6 (33.3)	2 (11.1%)	2 (11.1%)	1 (5.6%)	—	—	—
Nonresharpenable Points								
Corner-notched	66 (19.1%)	102 (29.6%)	78 (22.6%)	70 (20.3%)	23 (6.7%)	5 (1.5%)	—	1 (0.3%)
Side-notched	30 (30.3%)	40 (40.4%)	18 (18.2%)	8 (8.1%)	3 (3.0%)	—	—	—

* Numbers do not include complete points.

of severely reduced population in these areas during the Mid-Holocene. The record of a Late Pleistocene/Early-Holocene occupation in these areas is fairly well documented, suggesting that population, while probably not dense, was much greater than during the Mid-Holocene. The record in the Bonneville Basin is the only one showing continuous occupation, which Grayson (1993) suggested is due to the continual presence of water near the occupied sites. In other areas, however, occupation ceases for about 2,000 to 2,500 years. The lack of an early dart point record in the central, western, and southwestern areas suggests that people moved out of these areas earlier than they did from the northern and eastern peripheries, before or at the time that the atlatl and dart took hold. When conditions began to improve, after 5,000 B.P., people began to return, and by 4,500 B.P. there is ample evidence throughout the Basin of human occupation.

When the atlatl and dart technology was introduced, two alternative hafting techniques—side-notching and corner-notching—were used in conjunction, but side-notching proved somewhat less effective, because side-notched points more often broke in a manner ending their use-life. Thus, corner-notching began to “outcompete”

side-notching—due to a better cost-benefit ratio—and when people began to move back into the central, western, and southwestern Basin, it was corner-notching they most often took with them, accounting for the rarity of side-notched points in these areas.

Two questions might be asked concerning these results. First, why did it take so long for corner-notching to outcompete side-notching? And second, why does side-notching return after A.D. 1000? The answers to these questions are not immediately obvious and need to be investigated, but some hypotheses may be offered. Regarding the second question, side-notching replaces corner-notching after about A.D. 1000 in the Great Basin, but this replacement takes place within a completely different technological context from that represented earlier—the bow and arrow. It appears that when this new technology was introduced, point tips were simply constructed in the image of dart tips, only smaller.

There is no reason to assume, however, that the same set of constraints operating on the formal attributes of dart point tips were operating on those of arrow point tips; in fact, there is every reason to assume otherwise (Beck n.d.). Thus, it is likely that as this new technology was

Table 8
CORNER-NOTCHED AND SIDE-NOTCHED POINTS
FROM THE STEENS MOUNTAIN ASSEMBLAGE
SHOWING PREVIOUS RESHARPENING

Hafting Technique	Resharpended	Not Resharpended	Total
Corner-notched	224 (63.5%)	129 (36.5%)	353
Side-notched	11 (18.0%)	50 (82.0%)	61

Table 9
LOCATION OF PREVIOUS RESHARPENING ON
CORNER-NOTCHED POINTS FROM THE STEENS
MOUNTAIN ASSEMBLAGE

Location of Resharpening	n ^a	Percentage
blade	172	76.8%
barb	173	77.2%
stem	64	28.6%

^a n refers to the number of points that show resharpening at each location.

refined, side-notching eventually proved to be more effective within this technological context. The fact that the replacement of corner-notching by side-notching took place in other parts of North America during the Late Prehistoric Period lends support to this hypothesis.

The issue of the very slow rate at which corner-notching came to dominate over side-notching among dart points is more difficult to evaluate. The fact that corner-notching never actually replaced side-notching in this technological context is important and suggests that side-notching remained a viable option in some cases. The data presented herein suggest that corner-notched points were more effective than side-notched points but not overwhelmingly so, and thus the latter remained in use. Further, it is likely that these patterns are not exclusively related to the point tips but to the overall technological unit, the entire dart. Unfortunately, only the point tip remains in the archaeological record in enough numbers to be evaluated as was done here.

One final factor may have played a role as

Table 10
LOCATION OF BREAKS ON CORNER-NOTCHED POINTS
FROM THE STEENS MOUNTAIN ASSEMBLAGE

Location of Break	n ^a	Percentage
tip	57	4.6%
blade	477	38.7%
barb	278	22.5%
neck	116	9.4%
stem	306	24.8%

^a n refers to the actual number of breaks in each location rather than the number of points broken at that location.

well. The arguments made here are based on the assumption that the points examined tipped atlatl darts and were used exclusively as projectiles, but this may not be the case. Atlatl darts may have been used expediently for various purposes, creating additional performance requirements for the point tip. As mentioned earlier, the best design in such a case would be a compromise due to the combined set of pressures resulting from different motions. It is possible that corner-notching provided a better solution in these circumstances than did side-notching. This issue deserves further investigation, perhaps through performance tests.

In closing, some comments are offered concerning the Flenniken and Wilke (1989) hypothesis, which is based on experimental studies of breakage and resharpening. First, the experimental studies, especially those offered by Flenniken and Raymond (1986) and Titmus and Woods (1986), have yielded useful data that allow an evaluation of manufacturing cost and use-life benefits. One should not believe, however, that these studies demonstrate that breakage and resharpening have completely obscured point morphologies that lead us to categorize projectile points into types, which are then used for chronological purposes. In reexamining the Steens Mountain points for resharpening, it was found that many were heavily reworked, but as a result, the type designation of only eight points

was changed, representing just 1.2% of the corner-notched/side-notched dart assemblage. Great Basin projectile point types do give us chronological information; the temporal sequence of these types as represented stratigraphically from site to site is difficult to deny. Their chronological behavior, however, is not due to their being stylistic, as I once believed (Beck 1984); but because in hindsight we can see technology replacing technology (Beck n.d.) and because these are technological changes, we have probably gone as far as we can in refining this typology to reflect time. That is, the types, especially the dart types, represent broad, overlapping periods of time that we will likely not be able to refine further. But the fact remains that they do provide a chronological tool, especially for surface material, and as was stated earlier, they are often the only tool we have.

NOTES

1. O'Connell and Inoway (1994), however, found the break between corner-notched and side-notched dart points to occur between 135° and 140° in the Surprise Valley assemblage (O'Connell and Inoway 1994:167, Fig. 2); as a result, they selected 140° as the threshold for dividing corner-notched from side-notched points. Another break is indicated at 90° (O'Connell and Inoway 1994:Fig. 2), which represents the distinction between expanding and parallel/contracting stems. This break occurs at a lower PSA value in the Steens Mountain assemblage than in the Monitor Valley and Surprise Valley assemblages (100° to 110°).

2. In these analyses, only those types that are known to be either atlatl dart or arrow points, those covered by Thomas (1981) in his key, are considered. Some researchers may believe the Pinto type to represent corner-notched dart points, but Pinto points are not considered here for several reasons. First, their temporal position is not well understood. For instance, they appear to date to early and mid-Holocene times in the eastern Great Basin (Beck and Jones 1994b) but may extend into the Late Holocene in the Mojave Desert (Warren 1980; Jenkins and Warren 1984; Jenkins 1987). Typologically, there is still some question as to their formal and temporal relation to the Gatecliff and Humboldt types (e.g., Vaughan and Warren 1987). Finally, because of

their generally crude construction, there is some question in my mind as to whether they represent atlatl darts or some other functional form. In eastern Nevada, they are commonly found in surface assemblages that also contain Western Stemmed Tradition forms, which they often resemble (Beck and Jones 1990a).

3. Data for the 19 sites used were taken from the following sources: Hogup Cave (Aikens 1970); Dirty Shame Rockshelter (Aikens et al. 1977, Haynes 1977); Skull Creek Dunes (Aikens et al. 1982; Wilde 1985); Connley Caves (Bedwell 1973); Newberry Cave (Davis and Smith 1981); Spooner Lake (Elston 1971); James Creek Shelter (Elston and Budy 1990); Newark Cave (Fowler 1968); O'Malley Shelter (Fowler et al. 1973); Amy's Shelter (Gruhn 1979); South Fork Shelter (Heizer et al. 1968); Cowboy Cave (Holmer 1980, Jennings 1980); Danger Cave (Jennings 1957); Sudden Shelter (Jennings et al. 1980); Rose Spring Site (Lanning 1963); Surprise Valley (O'Connell 1971, 1975; O'Connell and Inoway 1994); Nightfire Island (Sampson 1985); Gatecliff Shelter (Thomas 1983); Hidden Cave (Thomas 1985).

4. David Madsen (personal communication 1995), however, is not convinced by this argument. The water sources near the Bonneville Basin sites are springs, which he argued likely existed elsewhere as well. Why, then, do we not find continuous human occupation in these other areas adjacent to springs? Madsen admitted he does not have the answer but believes the issue is not yet closed.

5. No attempt was made to distinguish between manufacture-related and use-related breakage (see Titmus and Woods 1986).

6. Evaluation of whether a point could be resharpened was made on the basis of the point fragment in the assemblage; the missing portion was not considered. For example, if the point fragment consisted of the base of a corner-notched point, the point was deemed "not resharpenable." The missing blade may or may not have been usable, but since that blade is not available for analysis, it was not considered. Points were also categorized as nonresharpenable if more than one-third of the distal blade was missing. In most instances, this determination had to be made on a case-by-case basis, using several criteria, including where a break occurred, the severity of the break, and the effects of one break in combination with others.

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