Chapter 11

The Southern Columbia Plateau Projectile Point Sequence: An Informatics-Based Approach

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Introduction

This paper defines a projectile point sequence for the Southern Columbia Plateau Cultural Area. Prior classifications are summarized but emphasis is placed on use of a neural network (SIGGI) to objectively classify projectile points within types and series proposed by Lohse (1985). Results are robust and possible new research directions for typology and sequence building are outlined.

The Southern Columbia Plateau Cultural Area lies within the physiographic region of the Columbia-Snake River Plateau (Hunt 1974). Prehistoric and ethnographic cultures occupying this area over the past 11,500 radiocarbon years BP had similar adaptive strategies focused on exploitation of large riverine systems that cut across a unique landscape encompassing lava flows, high desert plains and mountains (cf. definition of cultural area by Willey and Phillips 1958:20–21). These aboriginal societies certainly comprised different linguistic and ethnic groups, but exhibited comparable socioeconomic organizations and maintained a high degree of intense cultural interaction. Remarkable trends can be identified over time and space, with similar developments in similar physical settings at about the same periods of time.

Archaeological research on the Southern Columbia Plateau encompasses a number of accepted culture-historical syntheses that use artifact types with discrete temporal distributions to construct site sequences and local and regional sequences (e.g., Ames et al. 1998; Chatters 1995; Davis 2001; Leonhardy and Rice 1970; Lohse 1985; Warren 1968). Many researchers correlate changes in these cultural sequences with postulated macroshifts in prehistoric socioeconomic organization, often coincident with inferred environmental or climatic shifts. The cultural-historical sequence defined by Leonhardy and Rice (1970), although occasionally modified to match local conditions, remains a handy scheme for cultural-historical reconstructions.

Prior to 1985, projectile point types and type names overlapped, were redundant, or were contrary, with researchers having little success in identifying or naming common projectile point types. The recovery of hundreds of projectile points from securely dated, well-defined archaeological contexts by the Rufus Woods Lake Project, Upper Columbia River (see Campbell 1985 for a project summary), allowed Lohse (1985) to develop a statistically-based classification system of the points recovered at Rufus Woods Lake and other points from type sites across the Southern Columbia Plateau. Lohse's (1985) typology was the first explicit Plateau point classification system based on a large, documented, dated collection.

This paper briefly summarizes Lohse's 1985 typology and presents recent work by the authors to create an automated expert classification system. This neural network, nicknamed "SIGGI" after sigmoid curve, can classify Southern Columbia Plateau projectile points, having "learned" from Lohse's original work. It is important to note that the SIGGI classification does not force matches of specimens to established types, rather it serves as a smart user interface giving the expert operator information necessary to refine decision-making. This operational decision structure depends upon preferential vector scores that compare individual specimens to statistical populations along multiple dimensions.

The Lower Snake River Cultural Sequence

The Lower Snake River cultural sequence can be cited as a basic standard for comparison of archaeological assemblages (Leonhardy and Rice 1970). Six phases were identified as the basis for ordering "archaeological manifestations" on the lower Snake River: Windust Phase (10,000–9000 BP); Cascade Phase (8000–5000 BP); Tucannon Phase (5000–2500 BP); Harder Phase (2500–700 BP); Piqunin Phase (700–350 BP); Numipu Phase (350–50 BP). The Leonhardy and Rice sequence is summarized briefly below and phases, types, and traits are presented as idealizations.

Windust Phase (10,000–9000 BP)

The earliest archaeological components for the Lower Snake River region were found at Windust Caves (45-FR-46) (Rice 1965), Marmes Rockshelter (45-FR-50) (Hicks 2004; Rice 1969, 1972), and at Granite Point Locality 1 (Leonhardy 1970). Windust assemblages are marked by Windust point types, with short blades, weak shoulders, and straight to contracting squat stems. Other types include lanceolate and ovate knives, large end scrapers, burins, and numerous cobble implements. Tools were made on tabular flakes and from prismatic blades struck off polyhedral cores. Stone used is mostly cryptocrystallines, with some fine-grained basalt. Societies hunted elk, deer, antelope, and various smaller game. There is no evidence of plant processing. Burials were cremations.

Cascade Phase (8000–5000 BP)

Leonhardy and Rice (1970) originally defined the Cascade Phase based on ten site components. They used occurrence of the Cold Springs Side-notched projectile point type to demarcate an earlier and later subphase. Both subphases were identified at Windust Caves, Marmes Rockshelter, Granite Point, and Thorn Thicket. The hallmark artifact type is the Cascade point. Both subphases have comparable artifact assemblages, except for the distinctive point types. Characteristics include large, well-made lanceolate and triangular knives, tabular and keeled end scrapers, large utilized flakes, and cobble implements that include grinding stones. Lithic technology includes production of tabular flakes and prismatic blades, principally in fine-grained basalt. A distinctive hammerstone for the prepared blade industry is the edge-ground cobble defined by Crabtree and Swanson (1968). These societies hunted large and small game, gathered mussels from the rivers, and fished for salmon and steelhead. Burials include flexed and extended.

Tucannon Phase (5000–2500 BP)

This phase was defined based on components at the Tucannon site (Nelson 1966), Marmes Rockshelter, and Granite Point. The earmarks are a short, shouldered projectile point with a contracting stem, and barbed point with an expanding stem (Leonhardy and Rice suggest these are crude early versions of the later Snake River Corner-notched type). The artifact assemblage contains small side and end scrapers, cobble scrapers and utilized cobble spalls, and pounding stones. Sinkers, hopper-mortar bases and pestles are present. Lithic technology is geared to a generalized flake industry in basalt, which Leonhardy and Rice characterize as crude and impoverished (1970:14). Large and small game were hunted, mussel gathering was emphasized, and fishing for salmonids continued. A singled flexed burial was found at Marmes Rockshelter (Rice 1972).

Harder Phase (2500–700 BP)

Components from the Harder site (45-FR-40) (Kenaston 1966), Three Springs Bar (45-FR-39) (Daugherty et al. 1967), the Tucannon site (45-CO-1), Granite Point (45-WT-41), and Wawawai (45-WT-39) were used to define this phase. Leonhardy and Rice postulated two subphases, based on differences in settlement type and stratigraphy. The earlier subphase is marked by camp sites, and the later subphase by house pit villages. The early subphase artifact assemblage is characterized by large basal-notched and corner-notched projectile point types (Snake River Corner-notched). The points become smaller and more finely made in the later subphase.

The artifact assemblages for both are marked by small end scrapers, lanceolate and pentagonal knives, cobble implements, hopper mortar bases, and sinkers. Large and small game were hunted, and now bison and mountain sheep are well represented. Fishing may be more important than previously. Housepit settlements become well-established.

Piqunin Phase (700–350 BP)

This phase was defined based on a late component at Wexpusnime, an extensive housepit settlement. The cultural markers are variable forms of small basal-notched, corner-notched and side-notched projectile points (Leonhardy and Rice refer to Columbia Valley Corner-notched and Wallula Rectangular Stemmed types). The artifact assemblage includes small end scrapers, a distinctive scraper with a concave bit, lanceolate and pentagonal knives, cobble implements, pounding stones, pestles, hopper mortar stones, and sinkers. Large and small game were hunted, and salmon fishing was important. Burials appear to have been single flexed internments.

Numipu Phase (350–50 BP)

Leonhardy and Rice put this forward as a putative phase held to represent archaeological manifestations of ethnographic aboriginal culture from the time of horse introduction c. AD 1700 up to reservation confinement. At the time of their writing this phase designation was based entirely on historic period burials (Sprague 1965, 1967). "Numipu" is the Nez Perce word for their people, and Leonhardy and Rice acknowledge that both Nez Perce and Palus might be found in the archaeological record under this designation.

Ordering Data: Imposing Structure

Leonhardy and Rice's (1970) archaeological reconstructions are pockmarked with "data holes." While several troublesome topics persist (including questions as to the origins of sedentism, equating frequency of radiocarbon dates with numbers of people, and sample size variability), an overriding basic problem is that the archaeological record lacks consistent data structure. Excavation rationales and methods vary, data recovery and recording methods are not comparable, and reporting is often inadequate. Lack of a consistent conceptual scheme forces researchers to stretch interpretations to a general level to integrate pieces of the archaeological record. In order to ensure reliable data analysis and interpretation, it is imperative that researchers agree on rules of inclusion when considering which data to use to address certain problems. Culture history traits (e.g., Leonhardy and Rice's 1970 subjective projectile point type characterizations marking phase designations) cannot be effectively employed to answer questions of prehistoric socioeconomic organization but they can form significant stringers for organizing research.

We must attempt to standardize archaeological data sets as the primary foundation on which to build defensible archaeological interpretations. As Ames et al. (1998) acknowledge, there have been too few systematic analytical frameworks developed on the Columbia Plateau (cf. Bicchieri 1975; Davis 2001; Lohse and Sammons 1994).

Projectile point typologies are a primary key in building reliable chronological sequences. To date, the only attempt to statistically analyze a large, dated projectile point collection remains Lohse's (1985) projectile point typology developed as part of the Rufus Woods Lake archaeological project (Campbell 1985; Ames et al. 1998).

Southern Columbia Plateau Projectile Point Classification (1985)

Lohse (1985; various) produced a classification system from a study collection that included over 1500 projectile points, spanning the last 7000 years of the Archaic Period, and representing 60 separate cultural components indexed by 161 radiocarbon dates. This classification exercise had three explicit goals: (1) classify the Rufus Wood Lake projectile points within established Columbia Plateau types; (2) create a descriptive or morphological classificatory framework to drive further definition of distinctive styles; (3) assess the efficacy of established types by comparing identifications to radiocarbon dated components from excavated sites (Cowgill 1990; Read 1989; Read and Russell 1996).

An index collection was prepared by photographing and digitizing recognized projectile point type collections that formed the basis for established point types and cultural sequences on the Columbia Plateau (Lohse 1985). Collections selected were those that (a) constituted the originally defined type specimens or contained specimens clearly identified by authors as recognized types or type variants, (b) were reasonably well dated, and (c) were clearly illustrated to scale in published plates and figures. Large seminal collections, as at Marmes Rockshelter, the Fraser River drainage, and Rufus Woods Lake Reservoir, were handled, measured, photographed, paradigmatically encoded, and digitized for statistical analysis.

Figures 1 and 2 illustrate the historical projectile point types and type variants used in the Lohse (1985) analysis, cross-indexed with basic morphological divisions and series. Type assignments within the classification were made using discriminant analyses based on measurements derived from the two-dimensional outline of projectile point forms. These measurements were coded as distance, width, and angle measurements.

Discriminant analysis was used for two purposes: (1) to identify diagnostic elements of the recognized historical types by exploring how typologists could discriminate among groups on the basis of some set of characteristics; (2) to develop a consistent classification based on discriminant functions that would combine group characteristics to allow assignment of individual cases to defined groups. The goals were automating accepted typologies and revising these within an explicit, replicable, statistically based classification system.

Multivariate discriminant analysis was employed to classify the collection of Plateau projectile points. Discriminant rather than cluster analysis was chosen so that the specimens would be forced into recognized categories. An SPSS subprogram was used that employed a stepwise discrimination method to select the best discriminating variables by minimizing Wilke's lambda. The resulting classification tables provided the number of cases classified into each group and the percentage of correct classifications for the known cases. Statistics for each case included the discriminant score and classification, the

Morphological Division	Morphological Series	Type
Lanceolate	1. Lanceolate	1.1. Clovis
		1.2. Folsom
		1.3. Windust C
		1.4. Cascade A
		1.5. Cascade B
		1.6. Cascade C
	2. Shouldered Lanceolate	2.1. Lind Coulee
		2.2 Windust A
		2.3. Windust B
		2.4. Mahkin Shouldered
Triangular	3. Side-notched Triangular	3.1. Cold Springs Side-notched
		3.2. Plateau Side-notched
	4. Corner-removed Triangular	4.1. Nespelem Bar
		4.2. Rabbit Island Stemmed A
		4.3. Rabbit Island Stemmed B
	5. Corner-notched Triangular	5.1. Columbia Corner-notched A
		5.2. Columbia Corner-notched B
		5.3. Quilomene Bar Corner-notched A
		5.4. Quilomene Bar Corner-notched B
		5.5 Wallula Rectangular Stemmed
	6. Basal-notched Triangular	6.1. Quilomene Bar Basal-notched A
		6.2. Quilomene Bar Basal-notched B
		6.3. Columbia Stemmed A
		6.4. Columbia Stemmed B
		6.5. Columbia Stemmed C

Figure 1. Morphological divisions, series and historical types (after Lohse 1985).

probability of a case being that far from the group centroid, the probability of the case being in that group, and the probability of membership in the second closest group. Scatter plots were used to show locations of group centroids in n-dimensional space defined by the first two discriminant functions.

This indexing analysis resulted in identification of six distinct major type series. Plots identified group centroids and distributions of identified types within these series as scores plotted on coordinates within the n-dimensional space.

Success in separating out recognized types and type series allowed generation of classification functions to permit classification of new cases with unknown memberships. These were used to classify the Rufus Woods Lake specimens. Discriminant runs were made within the lanceolate and triangular divisions for simplicity. Results were robust, with 80% of lanceolate specimens correctly classified and 96% of triangular specimens correctly assigned. Types were then manually sorted into groups, errors checked, and anamolous forms dropped. Early types not well represented in the Rufus Woods Lake archaeological record were also removed. Discriminant runs were again performed, with improved type assignments as a result. At this stage, lack of resolution concentrated in lanceolate and triangular forms with slight to moderately well-defined shoulders (Mahkin Shouldered and Nespelem Bar types).

Figures 3 and 4 show lanceolate and triangular types as centroids arranged in n-dimensional space. These are illustrative of general relatedness and serve as concept maps for approaching classification of points on the Columbia Plateau.

Of interest for this study is that the discriminant functions revealed those variables with the greatest value for differentiating between recognized types. For lanceolate projectile points, the first two discriminant functions (F1 = haft length; F2 = neck width, blade width, shoulder angle and shoulder length) accounted for 91% of the variation observed. For triangular points, three functions accounted for 94%

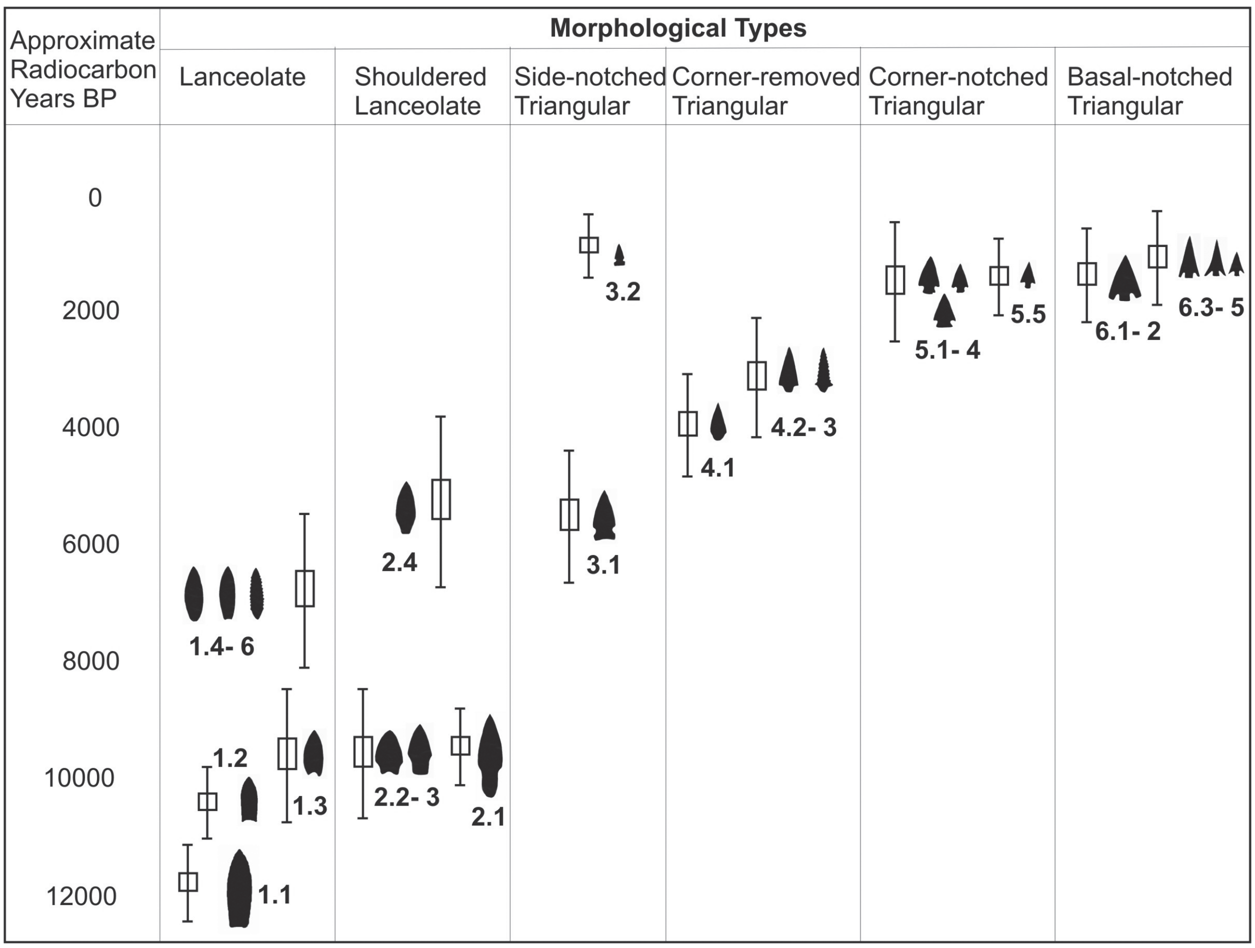


Figure 2. Projectile point type sequence for the Southern Columbia Plateau (after Lohse 1985).

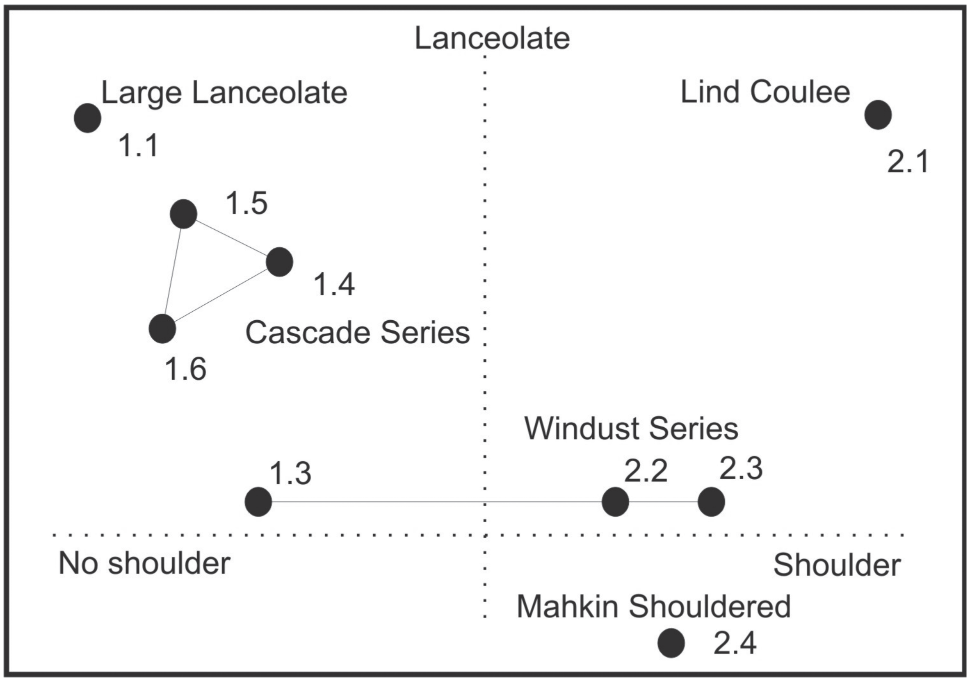


Figure 3. Lanceolate archetypes as group centroids in dimensional space. The nodes are arranged in space relative to the dimensions of shouldered and non-shouldered lanceolate forms. The nodes are placed conceptually along the dimensions, and lines connecting nodes indicate relationships within morphological series.

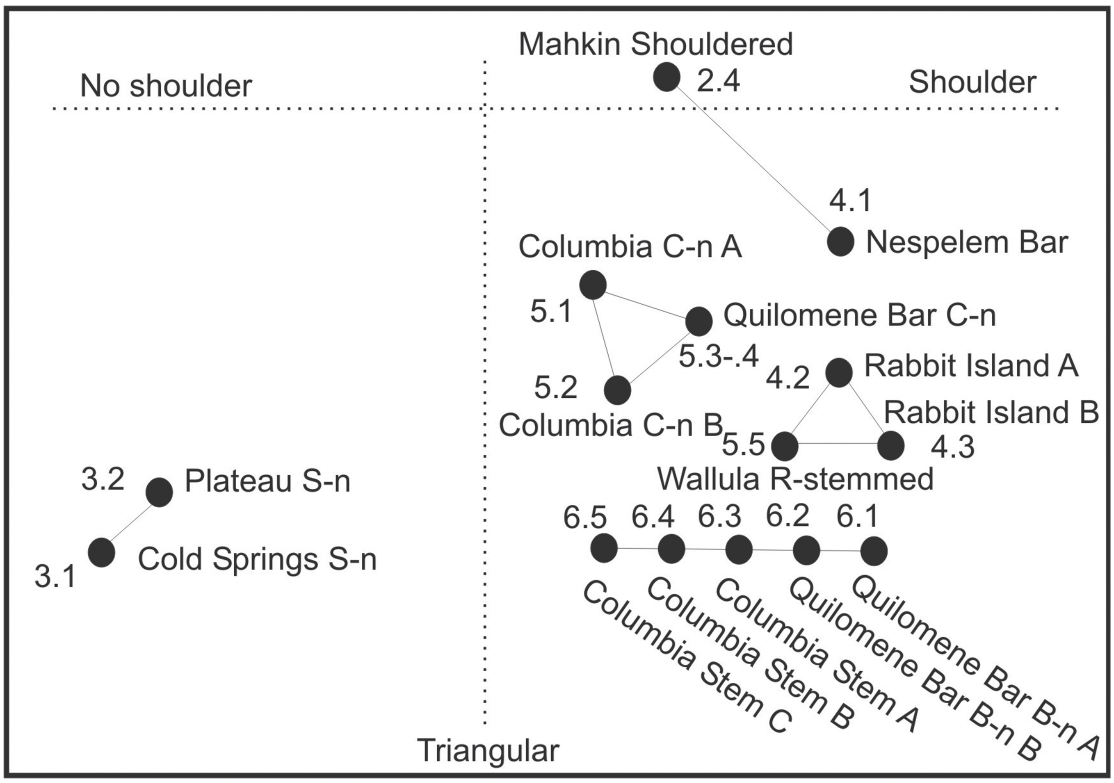


Figure 4. Triangular archetypes as group centroids in dimensional space. The nodes are arranged in space relative to the dimensions of shouldered and non-shouldered triangular forms. The nodes are placed conceptually along the dimensions, and lines connecting nodes indicate relationships within morphological series.

of the variation found (F1 = shoulder angle; F2 = basal margin angle; F3 = basal width, neck width/basal width ratio). Not surprisingly then, haft configuration, including stem and shoulder configurations and proportions, are the prime discriminating variables in defining the various accepted projectile point types. Distinctions remain relatively subtle in lanceolate forms and become more pronounced in triangular forms with diminishing size over time.

The resulting classification resulted in robust discrimination between recognized projectile point types and proved able to consistently separate recognized forms over the span of Columbia Plateau prehistory. The type series, type variants, and individual types identified proved effective in demarcating periods of time important for development of regional and areal cultural sequences. Readers should consult recent work by Baxter (1994a, 1994b) and Benfer and Benfer (1981) with regard to strengths and limitations of multivariate statistical and step-wise discriminant analyses in analysis of archaeological data (cf. Carr 1985).

The Rufus Woods Lake classification (Lohse 1985) has also become the basis for an expert automated classification system using a neural agent labeled SIGGI.

Southern Columbia Plateau Projectile Point Classification (2006)

The authors have attempted to refine projectile point typologies on the Columbia Plateau through use of a neural network to develop both an automated classification system and an authoritative online database (Lohse, Sammons et al. 2005; Lohse, Shou et al. 2004). Past experiments with artificial intelligence (AI) systems have largely been confined to rule-based forced classifications as in that developed by van den Dries (1998) for teaching use-wear analysts. Use of a sophisticated neural network that is trainable and capable of making novel intelligent decisions is an important approach to improving information sharing and exploring theoretical tenets of archaeological classification and data design.

Although the initial application of the SIGGI autoclassification system uses specimens drawn from Lohse (1985), the system is extensible. SIGGI functions as a virtual analyst which, given some basic rules and concepts derived from Lohse (1985), is continuously trained by introduction of new data sets. To improve its accuracy, SIGGI must be continually exposed to new and amplifying data fields. SIGGI is capable of accurately applying extant projectile point typologies; however, SIGGI can also identify outliers or unique data sets and suggest that these represent new types or that previous analysis identifying types needs modification within new explicit data ranges. As with any student, we must be certain that the data we ask SIGGI to analyze has been authenticated, and that we gather samples that are clearly representative of defined research populations. Because SIGGI learns by mimicking expert's decisions, behaviors, and explicit rules, and then creates new decision frameworks integral to the compilation of new data, SIGGI eventually may generate insights into decisions made by human analysts and by prehistoric makers.

The principal criterion for training SIGGI is to retrieve collections that have fine excavation and analytical context. A primary assumption in archaeological typologies is that the knappers of the stone points were operating within a very well defined cultural model that laid out clear expectations regarding what a particular projectile point form should look like. Essential for training this virtual analyst is retrieval of sample populations that as nearly as possible represent these real time actors in the past. For training, SIGGI needs projectile point samples found in large numbers from a single site, within a specific layer, in association with cultural features representing clear prehistoric human activity, and bracketed by reliable radiocarbon dates. These samples supply the virtual analyst with numerous points made to a prehistoric standard, and reveal expected ranges of statistical variation in basic variables of form. This allows SIGGI to make intelligent decisions on where to draw lines demarcating the distinctive types of projectile points. SIGGI's ability to explicitly handle multiple variables in a multidimensional statistical environment promises insights into clarification and refinement of chronologies of prehistoric projectile point types, a result of considerable interest to the practicing archaeologist (cf. Lohse et al. 2004).

SIGGI's AI engine evaluates shapes provided from .jpg image files against a series of stored training sets. The training set contains a spectrum of examples drawn from known collections. The technical specifications of how SIGGI works has been reported elsewhere (Lohse, Sammons et al. 2005; Lohse, Shou et al. 2004). In basic, SIGGI compares an individual image to a collection of images for which type assignments are known. It then compares the outline of the input image with outlines held in the established data set. In the case of the Southern Columbia Plateau projectile points, SIGGI learned from the same set of projectile points classified by Lohse (1985).

First the image file of a projectile point is uploaded into the system. To speed analysis, the expert user can suggest size, general shape, and other significant attributes. The user can also indicate that the point is "small" or "large", "lanceolate" or "triangular." Simple and complex shape attributions are used to identify shoulders and edge complexity. Identifying these values for SIGGI can speed the process, since entry without these values identified can triple analysis time.

The thresholding value, if needed, is used to refine contrast for detection of the specimen edge. An image editing tool may be used to remove stray image content. Once the image is prepared and the point's outlined clarified, the user can process the image through the SIGGI automated expert classification system.

Once the analysis is complete, SIGGI suggests three classification types as potentially correct. Each of the three proposed types is given a numeric score. This numeric value is functionally a vector length. The vector score can be conceived as a weighted score which the query places on the "space" between the point in question and its nearest neighbors. Match scores from the spaces are weighted to determine the overall match between each record and the query (Singitham et al. 2004). The higher the vector score, the "closer" a given projectile point is to a projectile point type.

For example, Figures 5 and 6 illustrate SIGGI's analysis of a point identified as Windust C by Lohse (1985). After SIGGI processed the point, it suggested three possible types: Cascade B, Windust C, and Cascade A. Nearly identical vector lengths indicate that SIGGI finds this point to be nearly equidistant from each of the three point types. SIGGI's suggestion of the Cascade varieties instead of Windust C is in keeping with the already established similarity between three point types.

A second example demonstrating vector length relationships, shown in Figure 6, is SIGGI's analysis of a Wallula Rectangular Stemmed point, which was processed as small, triangular and complex. This figure shows that the vector score for the Wallula Rectangular Stemmed classification is almost

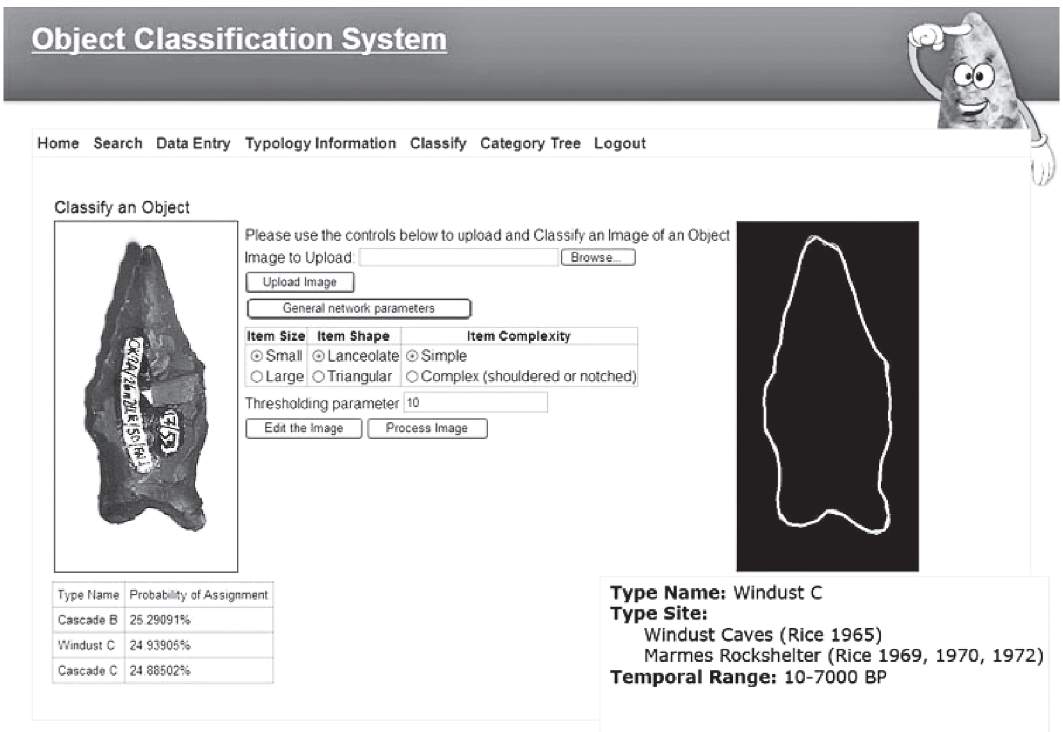


Figure 5. Screenshot of SIGGI interface showing classification of a Windust C specimen (after Lohse 1985).

three times as great as the vector scores for Rabbit Island Stemmed C and Columbia Stemmed A (28 vs. 10.3). So, SIGGI concludes that the specimen is much "closer" to the Wallula Rectangular Stemmed type than to either the Columbia Stemmed A or a Rabbit Island Stemmed C types. Previous analysis (Lohse 1985) had also identified this point as a Wallula Rectangular Stemmed.

In the discussion to follow, vector scores are reported for selected exemplar projectile point types (Figure 7).

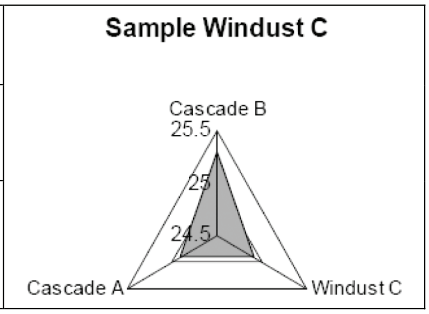
Recognized Columbia Plateau Types

In this next section, we will present type descriptions for the Southern Columbia Plateau Cultural area projectile point series, incorporating data both from Lohse (1985) and SIGGI's more recent classification of the same assemblages. Figure 8 presents a general overview of projectile point types and type series for the Southern Columbia Plateau. The chart spans the last twelve thousand years of the Holocene and presents recognized types series correlated with general morphological classes. Types and type series considered unique to the region are bolded. Projectile point type series, type variants, and individual types, prove effective in identifying these culture-historical divisions in time and space. Several type series and types in fact, probably represent robust horizon and tradition markers. Rules for inclusion of specimens, sites and assemblages in the construction of this typology are those outlined in Lohse (1994), wherein it was argued that only those diagnostic specimens from professionally excavated sites with known provenience, good dates, published results, and collections stored in professional repositories should be used.

Paleoindian Period

The earliest Paleoindian archaeological cultures in the Northern Intermountain West are identified as Clovis and Folsom, characterized by use of distinctive fluted lanceolate forms dated to c. 11,500–9000 BP. These are followed by Late Paleoindian cultures marked by various unfluted lanceolate projectile points: Midland, Firstview, San Jon, Agate Basin, Hell Gap, Alberta, Frederick-Firstview, Scottsbluff, Eden, and Jimmy Allen. This idealized cultural sequence has been found in excavated contexts on the adjoining Northwestern Plains (Frison 1991:Fig.2.2; Metcalf 1987; Mulloy 1958) but Paleoindian point types are typically only

Cascade B	25.3
Windust C	24.9
Cascade A	24.9



Wallula Rectangular Stemmed	28
Rabbit Island Stemmed C	10.3
Colombia Stemmed A	10.3

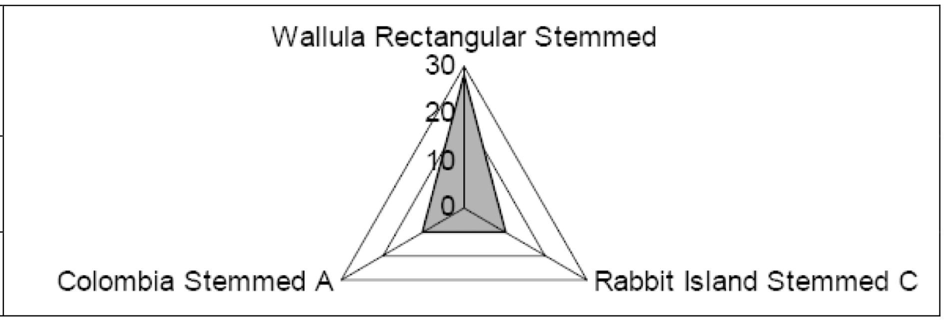


Figure 6. Vector scores generated in SIGGI classification of a Windust C specimen and a Wallula Rectangular Stemmed specimen (after Lohse 1985).

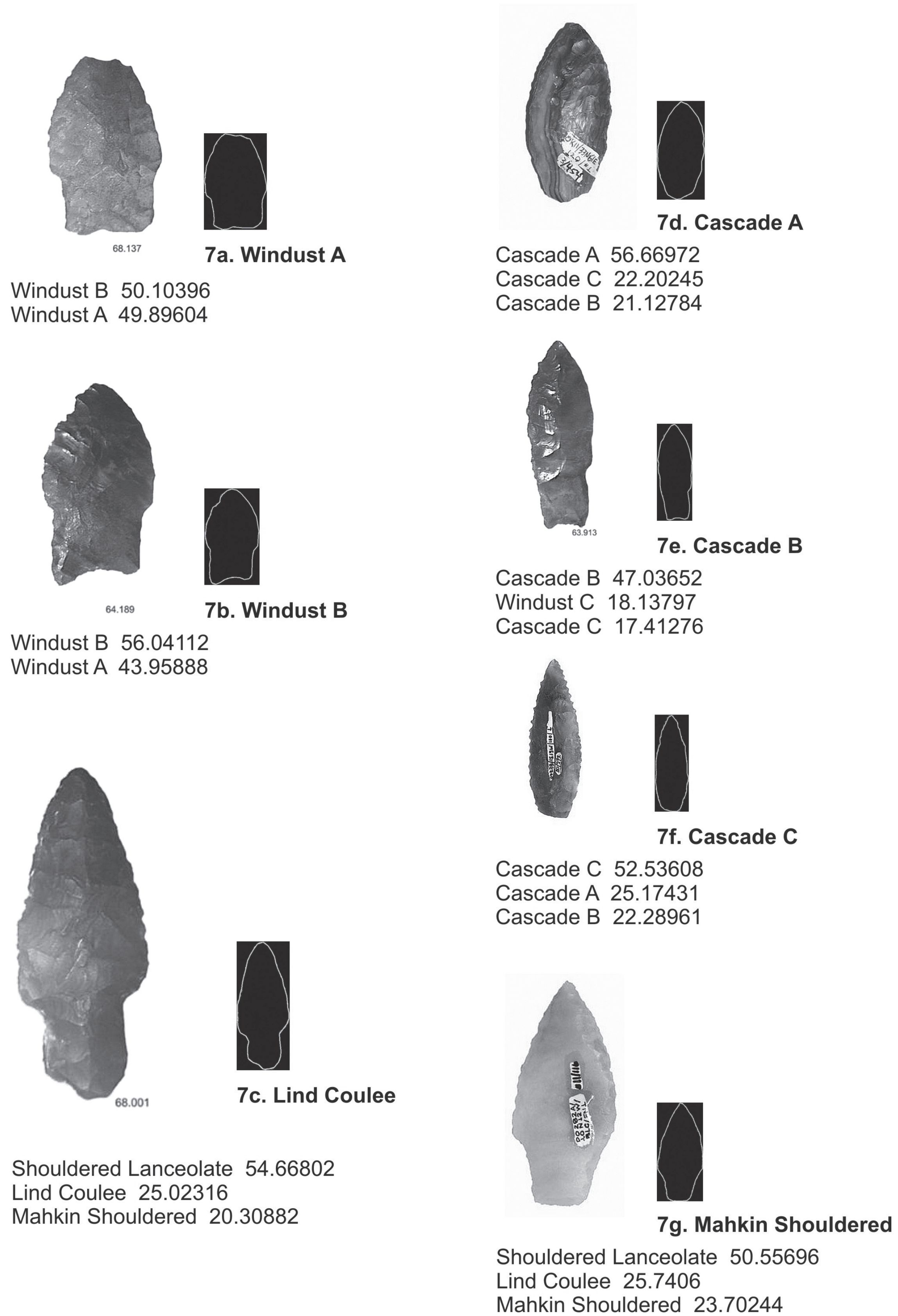


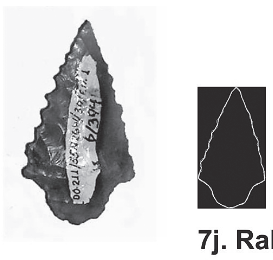
Figure 7. Examples of named projectile point types from the Southern Columbia Plateau.

7h. Cold Springs S-n

Cold Springs Sn 33.27889
Columbia C-n A 16.85796
Nespelem Bar 12.90345

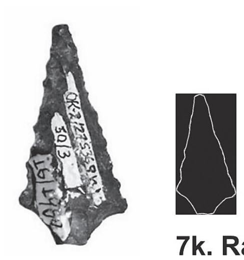
7i. Nespelem Bar

Nespelem Bar 27.40165
Rabbit Island Stem A 19.41543
Columbia C-n 10.69941



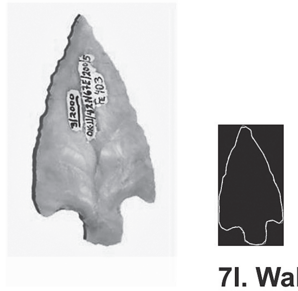
7j. Rabbit Island A

Rabbit Island A 31.15669
Nespelem Bar 11.52536
Cold Springs S-n 11.4694



7k. Rabbit Island B

Rabbit Island Stem B 19.69573
Rabbit Island Stem C 11.47345
Wallula R-Stem 11.4718

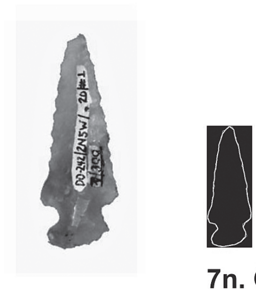


7l. Wallula Rect-Stem

Wallula R-Stem 27.86804
Rabbit Island C 10.30795
Rabbit Island B 10.30401

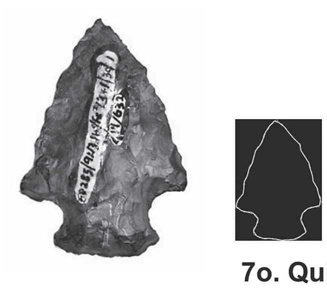
7m. Columbia C-n A

Columbia C-n A 14.60788
Cold Springs S-n 14.49156
Quilomene Bar C-n 14.22186



7n. Columbia C-n B

Columbia C-n B 21.84119
Wallula R-Stem 14.29629
Rabbit Island Stem B 12.9975



7o. Quilomene Bar C-n

Quilomene Bar C-n 27.49496
Nespelem Bar 15.03861
Columbia C-n A 14.42634

Figure 7 continued.

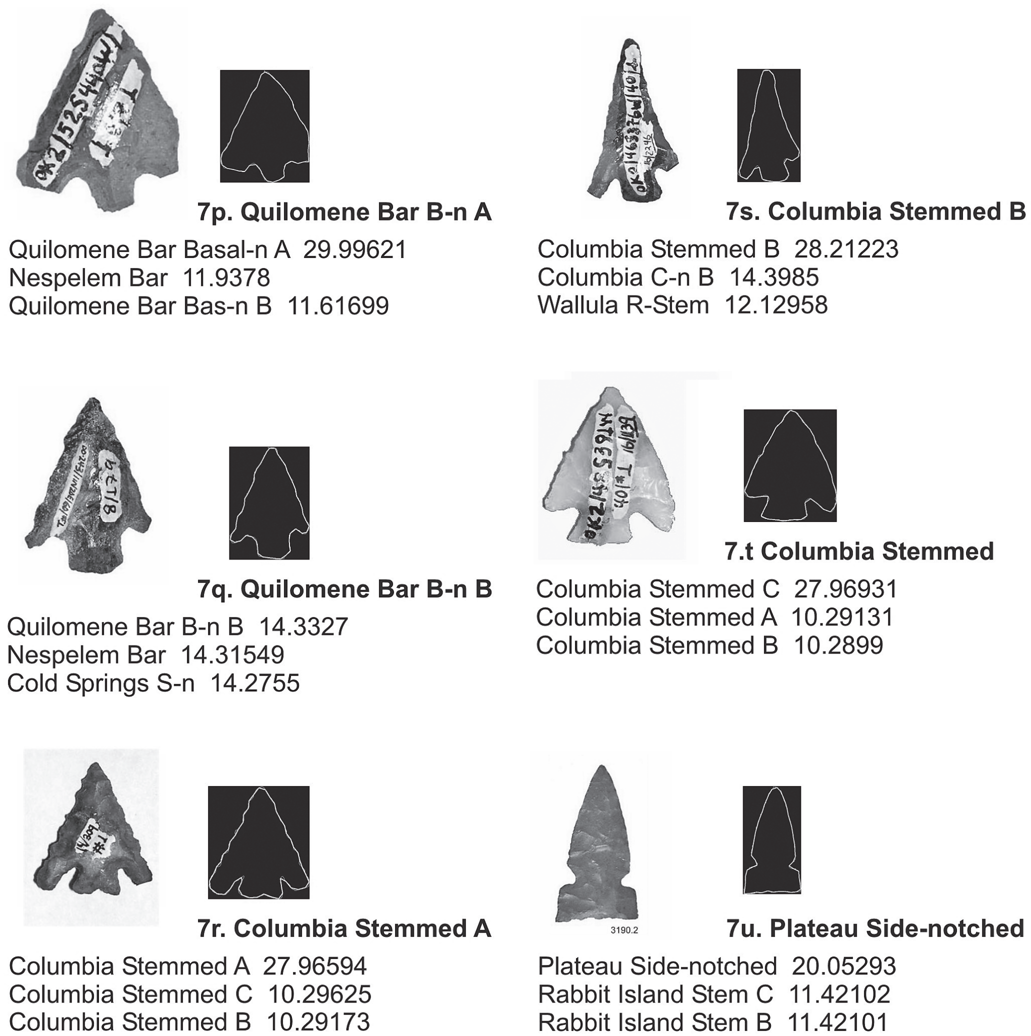


Figure 7 continued.

found as surface finds on the Columbia Plateau and the majority held in private collections. Unique find contexts have been preserved at the Richey-Roberts Clovis Cache near Wenatchee (Mehringer 1988; Mehringer and Voit 1990), at the Lind Coulee site in the Walla Walla Basin (Daugherty 1956a,b), at the Haskett Sentinel Gap site on the Middle Columbia River, and at the Haskett Locality sites on the Snake River Plain (Butler 1965a,b, 1967).

Ames et al. (1998) refer to this Paleoindian Period as Period I, dating c. 11,500–7000 BP. A Subperiod IA corresponds to Clovis and a Subperiod IB is described as "post-Clovis" (Ames et al. 1998). It is assumed that prehistoric populations in these periods lived at very low densities, emphasizing high mobility hunting and gathering strategies focused on a wide range of plant and animal species. These Paleoinidan cultures used large lanceolate and shouldered lanceolate projectile points. The end of Period I is marked by use of small, foliate Cascade projectile points. Butler dubbed this latter assemblage, including Cascade projectile points and edge-ground cobbles, the "Old Cordilleran Culture" (1961, 1962, 1965b). More recently, researchers applied the Old Cordilleran concept to a range of early assemblages with lanceolate projectile points and bifaces, bone tools, and a generalized hunter-gatherer economy. Daugherty (1962) referred to the Old Cordilleran Culture as an areal tradition within the "Intermontane Western Tradition."

Fluted lanceolate projectile points and Plano series projectile points are lightly represented in the Columbia Plateau region. Lind Coulee and Haskett types are clearly members of the larger Plano series.

More intriguing is the Windust type series, now dated in a broad range from c. 11,000–8500 BP (Davis and Sisson 1998; Green et al. 1998). A number of researchers have compared Windust point types to forms indicative of the broader "Western Pluvial Lake Tradition" or "Western Stemmed Tradition" (Ames 1988). On the Columbia Plateau, Clovis and Folsom are poorly represented in secure archaeological contexts and the Windust type series or Windust Phase is often the earliest assemblage present.

Clovis. Clovis projectile points are found as surface finds throughout the Northern Intermountain West (cf. Titmus and Woods 1991; Yohe and Woods 2002). Secure archaeological contexts for Clovis on the Southern Columbia Plateau include the Simon Cache on the Snake River Plain (Butler 1963) and the Richey-Roberts Cache in the Walla Walla Basin (Gramley 1993; Mehringer 1988; Mehringer and Voit 1990). For discussions of early occupations in British Columbia see Rousseau (1993) and Carlson (1991). Type Site: Blackwater Draw (Hester 1972); Naco-Lehner-Murray Springs, southeastern Arizona (Haury, Antevs and Lance 1953; Haury, Sayles and Wasley 1969; Haynes and Hemming 1968). Temporal Range: c. 12,000–11,000 BP.

Windust Series. Windust series projectile points include stemmed and unstemmed lanceolate forms with straight and indented bases. Lohse (1985, 1995) identified three variants: Windust A, shouldered with a straight base (Figure 7a); Windust B, shouldered with a concave base (Figure 7b); and Windust C, a lanceolate point with a markedly concave base. H. Rice (1965) referred to the Windust C variant as "Farrington Basal-notched." Type Site: Windust Caves (Rice 1965); Marmes Rockshelter (Rice 1972). Temporal Range: c. 13,000–9000 BP.

Lind Coulee. The Lind Coulee projectile point is a large shouldered lanceolate form with elongate stem and sloping to squared shoulders (Figure 7c). It is a distinctive Late Plano series point indicative of the Columbia Plateau. Type Site: Lind Coulee (Daugherty 1956). Temporal Range: c. 10,000–9000 BP.

Haskett. The Haskett type is a large, elongate lanceolate projectile point with a relatively thick cross-section and bulbous distal end. The Haskett point is very similar to other Late Paleoindian or Plano forms but appears distinctive of the lower Southern Columbia Plateau. Type Site: Haskett Locality (Butler 1964, 1967). Temporal Range: c. 8500–7000 BP.

Archaic Period

The shift from Late Paleoindian to the Early Archaic Period (c. 8000-5000 BP) is marked by continuation of the Shouldered Lanceolate morphological series as the Mahkin Shouldered type, and by introduction of the Cascade Series of small, finely made, lenticular, lanceolate projectile points. Lohse (1985, 1995) identified three principal variants. These are followed over the course of the Archaic Period by introduction four basic morphological series: side-notched triangular (Cold Springs Side-notched and Plateau Side-notched), corner-removed triangular (Nespelem Bar, Rabbit Island Springs Series, Wallula Rectangular-stemmed), corner-notched triangular (Columbia Corner-notched Series, Quilomene Bar Corner-notched), and basal-notched triangular (Quilomene Bar Series and Columbia Stemmed Series).

Cascade Series. Cascade Series projectile points include three variants: Cascade A, a broad lanceolate projectile point with a rounded to convex base (Figure 7d); Cascade B, a slender lanceolate projectile point with a concave base (Figure 7e); Cascade C, a slender, smaller lanceolate projectile point, often with serrated margins (Figure 7f) (Lohse 1985, 1995). Type Site: Indian Wells (Butler 1961); Marmes Rockshelter (Rice 1972). Temporal Range: c. 8000–5000 BP.

Mahkin Shouldered. This is a broad category of shouldered lanceolate projectile point with variable size, cross-section and flaking pattern, which spans a broad range of time (Figure 7g). Lohse (1985) defined this type to highlight a classification category that needs greater resolution as to type variants indicative of temporal period and also clarification of whether this a style of projectile point or a multi-purpose projectile point/biface. Type Site: Windust Caves (H. Rice1965); Marmes Rockshelter (D. Rice 1969, 1972); 45-OK-11 (Lohse 1984). Temporal Range: c. 8000–2500 BP.

Cold Springs Side-notched. These are large side-notched triangular projectile points with straight to concave bases (Figure 7h), first occurring in association with Cascade Series projectile points in Late Cascade assemblages (Leonhardy and Rice 1970) dating c. 6000-4000 BP. Type Site: Cold Springs (Shiner 1961). Temporal Range: c. 6000–4000 BP.

Nespelem Bar. The Nespelem Bar type was also named by Lohse (1985) as a classification category in need of clarification. This is a slightly shouldered triangular projectile point with variable basal morphology (Figure 7i). Researchers in the past included it with the Rabbit Island Series but it is distinctive and a clearly earlier triangular form. Type Site: 45-OK-11 (Lohse 1984); 45-OK-258 (Jaehnig 1985). Temporal Range: c. 5000–3000 BP.

Rabbit Island Stemmed Seies. This distinctive projectile point seems to be unique to the Columbia Plateau and clearly marks the Middle Archaic. Lohse (1985) identified two variants: Rabbit Island Stemmed A, a thin triangular projectile point with square shoulders and well defined straight to contracting stems, often with serrated blade margins (Figure 7j); Rabbit Island Stemmed B, a smaller, thinner triangular point with square shoulders, straight to incurvate lateral margins, sharply contracting stems, and often serrated blade margins (Figure 7k). Type Site: Shalkop Site (Swanson 1962); Sunset Creek Site (Nelson 1969) Temporal Range: Rabbit Island Stemmed A, c. 4000–2000 BP; Rabbit Island Stemmed B, c. 3000–1500 BP.

Wallula Rectangular Stemmed. This is a small, corner-notched triangular projectile point with square shoulders and straight, elongate stems (Figure 7l). The straight stem is distinctive and distinguishes this form from the Columbia Corner-notched series. It may represent a late development within the general Rabbit Island Stemmed series. Type Site: Sunset Creek (Nelson 1969), Wanapum Dam (Greengo 1982). Temporal Range: c. 2000–1500 BP.

Columbia Corner-notched Series. Columbia Corner-notched projectile points constitute a general series that can be broken into an earlier larger form (Columbia Corner-notched A) (Figure 7m) and a later smaller form (Columbia Corner-notched B) (Figure 7n) (Lohse 1985, 1995). Both have well developed corner notches, convex to straight lateral margins, and straight to expanding stems. This series resembles large corner-notched points of comparable age found across the Northern Intermountain West. Type Site: Marmes Rockshelter (Rice 1969, 1972), Granite Point Locality (Leonhardy and Rice 1970), Sunset Creek (Nelson 1969). Temporal Range: Columbia Corner-notched A (c. 5000–2500 BP), Columbia Corner-notched B (c. 2000–150 BP).

Quilomene Bar Series. Quilomene Bar series projectile points are large, thick corner-notched and basal-notched triangular forms, morphologically similar to Columbia Corner-notched specimens and later Columbia Stemmed Series specimens but much more massive in character. Lohse (1985, 1995) breaks these into three significant variants: Quilomene Bar Corner-notched (Figure 7o), Quilomene Bar Basal-notched A (Figure 7p), and Quilomene Bar Basal-notched B (Figure 7q). Type Site: Marmes Rockshelter (Rice 1969, 1972), Sunset Creek Site (Nelson 1969), Wanapum Dam (Greengo 1982). Temporal Range: Quilomene Bar Corner-notched (c. 3000–2000 BP), Quilomene Bar Basal-notched A (c. 2000–1500 BP), and Quilomene Bar Basal-notched B (c. 2500–1500 BP).

Columbia Stemmed Series. These are delicate triangular projectile points with long symmetrical barbs, thin, narrow, straight to expanding stems, and straight to incurvate blade margins. Lohse (1985, 1995) identifies three variants: Columbia Stemmed A Figure 7r), Columbia Stemmed B (Figure 7s), and Columbia Stemmed C (Figure 7t). Type Site: Sunset Creek (Nelson 1969), Wanapum Dam (Greengo 1982). Temporal Range: c. 2000–150 BP.

Plateau Side-notched. The Plateau Side-notched designates a large, highly variable series of small side-notched points with straight to concave bases, marking the late prehistoric period (Figure 7u). Type Site: Not identified. Temporal Range: c.1500-200 BP.

Conclusions

The current Southern Columbia Plateau projectile point sequence has focused on obtaining authenticated data in an effort to produce a "clean" set that reproduces exactly the classification published by Lohse (1985). Data collected are stored in an image database with attached descriptive fields. SIGGI is, in a sense, Lohse's virtual brain. SIGGI can "think" like Lohse, but as the project expands, SIGGI will also interact with other researchers, i.e., SIGGI will be educated by the larger community. This reflective activity is one of the more important aspects of the project. Obviously, certain kinds of things can be classified in proscribed ways, but our research focuses on identifying WHY things should be classified in certain ways. By watching SIGGI make classifications, researchers hope to gain a better understanding of why archaeologists make classifications and how these classifications might be continually improved as research methodology improves.

SIGGI has successfully incorporated the original database used by Lohse (1985) in development of the Rufus Woods Lake classification, and has been effective in producing results comparable to or exceeding those attained in the original analysis. The vast majority of specimens are assigned with high statistical probabilities of group membership, indicated as a vector length. Perhaps most interesting are instances where SIGGI has had difficulty in assigning specimens to one category or another. Difficulties in assignment may indicate where classifications need to be revised. The continuous addition of new data to the master database may well significantly alter or expand past classifications. This is the area where we will make gains in understanding how core types were distributed across regions temporally and spatially. Constant incorporation of new data in the AI system will inevitably result in increasingly refined classifications, and may allow us to approach research questions of ethnicity and cultural interactions over broader areas and regions. This is just the area archaeologists would like to push the data to understand behaviors of prehistoric cultures.

The SIGGI classification system aspires to create a heritage database of stone projectile point types using a trainable AI interface. It is expected that new authenticated data will be added continuously and that type assignments will be re-run as these data are entered. The result will be a master comparative data set that will allow incorporation of new finds and which will produce the possibility of typological refinement with each and every auto-classification run. Eventually, projectile point collections from surrounding regions will be added and the neural agent trained to emulate classification systems across the broader region. If successful, this may produce the data structure called for by so many researchers who attempt to construct detailed culture-historical sequences in synthesizing the vast archaeological data set to assess behavioral research questions (e.g., Ames et al. 1998; Chatters 1995).

Improved Resolution in Culture-Historical Sequences

Figures 2 and 8 suggest a strong directionality in projectile point design over time. As Lohse (1985, 1995) points out, the underlying design factor is probably the change in projectile propulsion over time, from throwing stick to bow and arrow, with a markedly corresponding decrease in projectile shaft diameter and mass (cf. Flenniken and Raymond 1986 for provisos in analysis; Hutchings 1997; Hutching and Bruchert 1997). This diminution in point size is accompanied by changes in basic projectile point morphology. Earlier simple lanceolate forms become shouldered, and then lanceolate evolve to triangular forms, which move from side-notched, to corner-removed, to corner-notched and basal-notched. There is no clear hard and fast functional correlate for these shifts in point morphology, and so, they are arguably best thought of as stylistic shifts reflecting conceptual templates of prehistoric artisans (cf. Close 1978; Conkey and Hastorf 1990; Dunnell 1978). Different types and type series are indicative of prehistoric idealizations or cultural templates that can be used to create a sound temporal and spatial structure to define and integrate local, regional and areal cultural chronologies (cf. Andrefsky 2004).

Prehistoric artisans produced projectile point types within closely constrained functional and stylistic templates. These master templates constitute core types. We depict these templates as concept maps (Figures 3 and 4), which date archaeological materials and reflect prehistoric design templates. To be able to classify projectile points we only need to understand the grammar of production and not the parameters of effective design and use. We can effectively employ this concept by use of schema theory.

Under schema theory, stone projectile points represent individual knappers' renditions of cultural idealizations concerning how these artifacts should be made as styles or templates shift over time. These knappers were building on standard templates reflecting cultural norms on how things should be done. The point types we view today were the result of these individuals performing accepted sets or scripts of actions to achieve their goal. So, these scripts represent collective norms or cultural schemata, which we can interpret as representing knapping traditions and cultural or ethnic idealizations in the past (cf. Boeda et al. 1990; Dobres and Hoffman 1994; Edmonds 1990).

These projectile point types, because they exist in groupings or associations clustered areally and temporally, can be classified statistically, and envisioned as centroids or norms within larger distributions of related forms. We can assume that variation will be found within these defined types, and that analysts may be able to identify ranges or production within these norms represent discrete social modes of expression in different areas and times. Figure 1 shows these distinctions semantically as six basic morphological types and twenty-five historical or cultural types. Figure 8 displays these cultural types as morphological clusters changing over time.

Our classifications will depend upon imposition of consistent, explicit rules for characterizing basic design. In this paper, following Lohse (1985, 1995), we have chosen to characterize these ranges in form based on simple description of outline. Part of this exercise is characterization of symmetry as reflecting the relative rigor of strict design parameters. We grasp the grammar of prehistoric makers by portraying past cultural templates as manipulating basic variables of two-dimensional shape, symmetry and surface reduction (cf. Chippindale 1992).

Six basic morphological classes of stone projectile point forms can be identified for the 11,500 radiocarbon year span of documented human occupation on the Columbia Plateau. This sequence shows a linear progression from large lanceolate to smaller, more elaborate triangular forms. Within these groupings, researchers have recognized distinctive types series, type variants and individual types demarcating more discrete areal and temporal distributions. It is assumed that enhanced sample sizes submitted to more analytical rigor as in use of refined multivariate statistical analysis as part of artificial intelligence applications or automated

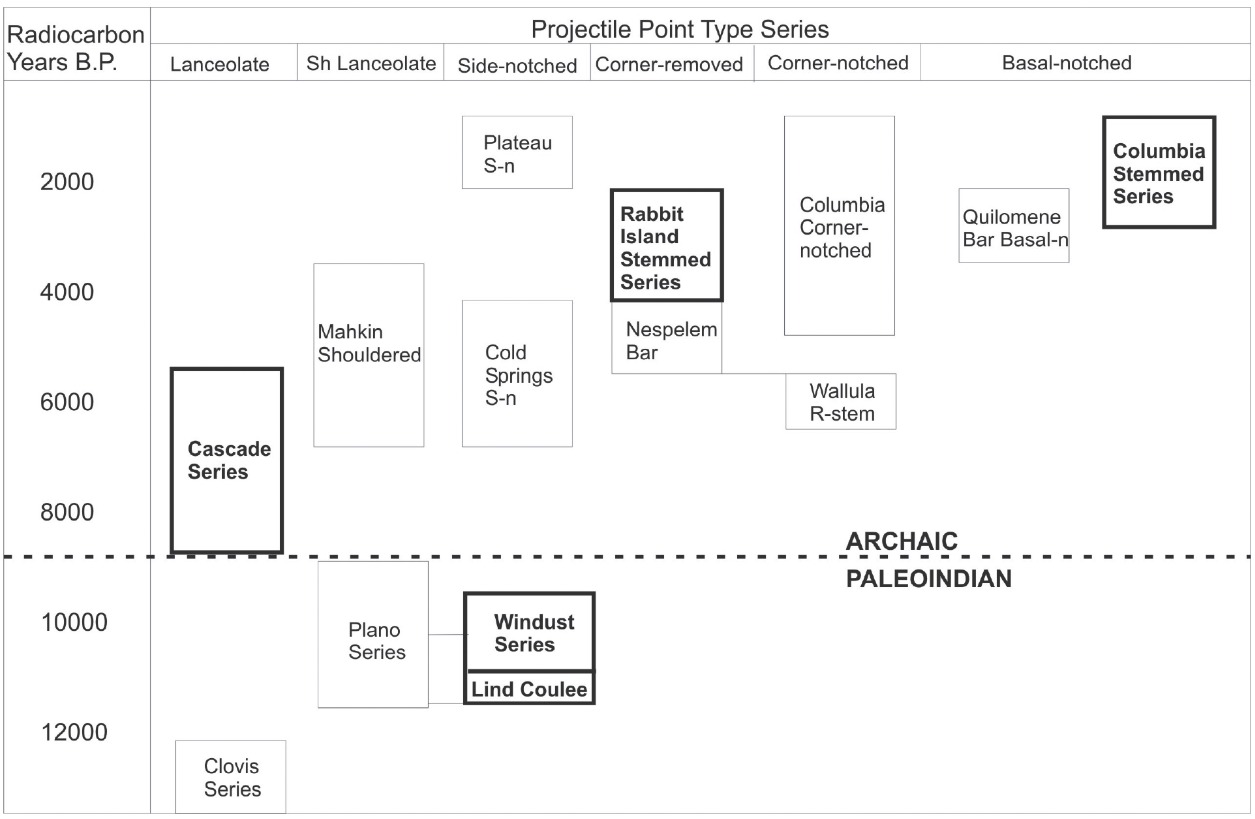


Figure 8. Projectile point type series. Series distinctive for the Southern Columbia Plateau are shown in bold.

classifications of tens of thousands of points from controlled collections from across archaeological regions will result in finer and finer discrimination of cultural styles or templates indicative of separate cultural traditions, ethnic groups, areal associations and finer periods of time (cf. Lohse 1994, 1995; Lohse, Sammons et al. 2005; Lohse, Shou et al. 2004).

Conceptual Spaces: The Geometry of Projectile Point Classification

Conceptual spaces serve as a framework for knowledge representation. These consist of quality dimensions derived from the perceptions of experts. Following Gardenfors (2004:10), representation of information can be based on simple geometrical structures, with similarities between structures modeled as conceptual forms (see also Gardenfors 2000). Measures of similarity between objects can be described as distances; the smaller the distance, the closer the representation values. Similarities can then be shown as the relative distances between object representations as points in space. The epistemological role of conceptual spaces is as a tool in sorting out these similarity relations. This model is shown in Figures 3 and 4, which depict known projectile point types as lanceolate and triangular forms in space defined based on the intersections of presence or absence of shoulders.

Quality dimensions represent various qualities of the stone projectile points. The dimensions form a framework used to assign properties to the points and to specify relations between the points. The coordinates of a particular measurement in the conceptual space represents the intersection of pertinent dimensions. Gardenfors (2004:11) argues that the dimensions are to be understood literally. It is assumed that each of the quality dimensions represents geometrical structures, and may represent topological orderings.

Some quality dimensions may have only a discrete structure that serves to divide objects into disjointed classes. Nodes may represent different types as in projectile points, and the space may be defined based on the intersection of defined dimensions. The distance between two nodes can be measured by the length of the path that connects them. This construction represents a geometric structure, and serves to depict the relationship of Type A to B as more closely related than Type B to D.

Construction of archaeological typologies represents two different uses of quality dimensions: phenomenal as allusion to the perceptions of archaeological experts and scientific as dimensions drawn from theory. The measurements are descriptions of data but the distinctions drawn and the associations made are products of implicit and explicit applied expertise.

The classifications performed by SIGGI follow explicit rules within a dynamic, thoughtful matching of shapes by a neural agent. Behind the type assignments is a comprehensive database containing relevant provenience information. SIGGI classifies in moments, defined as best fits within a specific data context. Adding more data will substantiate or revise prior assignments as group centroids move in n-dimensional space. That classificatory space can be depicted variably as conceptual spaces drawn abstractly within specified dimensions.

Implications

The SIGGI Southern Columbia Plateau project illustrates fundamentals of database design, user interface design, and relational database design. SIGGI operates on multiple levels, from development of an explicit, statistically based, online classification system with attached database, to use of a neural agent to augment archaeological training in classification, to observation of the artificial agent to study the character and effectiveness of archaeological thinking. Anthropologists and archaeologists are beginning to join cognitive psychologists and learning theorists in the use of artificial intelligence systems to explore human thought and behavior (e.g., Baylor 2002; Conte and Castelfranchi 1995; Cumming 1998; Doran 2000a,b; Gonzalez and DesJardins 2002; Russell and Norvig 1995; Woolridge and Jennings 1998; Woolridge, Muller and Tambe 1996), and the SIGGI Southern Columbia Plateau projectile point classification is part of this trend.

There are examples of successful neural networks applied to classifications in archaeology (e.g., van den Dries 1998). We need to expand on these prototypes and authenticate their potential. Obvious productive spinoffs from this research include: (1) training of an online neural classification system capable of accurately identifying archaeological artifacts (SIGGI in this sense constitutes a highly interactive user interface sitting atop a secure database); (2) creation of new theoretical and methodological frameworks to accelerate effective information design; (SIGGI offers advantages in teaching and insights into how we conceive of our study domains); and (3) further development of artificial intelligence systems linked to giant heritage databases that are constantly maintained and revised to ensure secure storage, organization and transfer of our archaeological heritage.

Construction of large databases supervised by intelligent agents is a completely attainable, realistic projection not just for archaeology but for all data rich disciplines (e.g., Egenhofer 2002). This is a major break from past practice in archaeology where laborious searches in libraries and archives for hard-to-find publications and "gray literature" are the norm; where tedious and time-consuming requests are made of overworked archive and collections managers to hand-relate various hard copy finder's guides in order to find and pull specimens from cabinet drawers and storage boxes (cf. Huggett 1995; Lock 1995; Lock and Brown 2000; Madsen 2001; Stewart 1996). The vision that information can be accessed through a central portal and seamlessly indexed and sorted, dependent upon researcher interest and creative motivation, constitutes a paradigm shift in archaeological information management and dissemination. An affirmation of technology has taken place and is driving significant changes in the infrastructure of scientific research (cf. Dreyfus 2001). Use of the Internet for delivery of scientific information not only speeds access but forces changes in the social organization of scholarship and the authentication of information (cf. Fulda 2000; Lamprell et al. 1995; van Leusen et al. 1996). SIGGI, like other new kinds of interfaces, will sit atop a large heritage database, ensuring that users have virtually seamless interaction with data.

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