What's the Point:

The Transition from Dart to Bow in the Eastern Plains

By

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Abstract

Despite many years of research by professional and avocational archaeologists, many questions still surround the transition from the atlatl and dart to the bow and arrow in North America. This is an important transition, as it has many implications for how the acquisition of food changed in the past. This study documents the cadence and nature of this change, specifically focusing on 10 sites in northeastern Kansas and western Missouri. These sites are grouped into three general time periods: Early (prior to the transition), Middle/Transitional, and Late (post transition). Using David Hurst Thomas (1978) and Michael Shott's (1997) formulas , each point is classified as dart, arrow, indeterminate dart, or indeterminate arrow. The results are then compared within and across the three temporal periods, characterizing the transition. Hypotheses about any divergence from expected patterns will be examined. Also, hypotheses previously put forward to explain the transition from atlatl and dart to bow and arrow in regions of North America will be examined in light of these results.

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Chapter 1: Introduction to the Problem

The acquisition of food is one of the most important types of work done by any group of people. While the technologies used in gathering, such as baskets, are subject to decay and are only found in specific contexts (normally dry or waterlogged), the stone projectile points used in hunting are much more durable. These provide a record of the hunting technologies utilized by prehistoric peoples and the changes in these technologies over time.

The atlatl and dart had a long run as the primary hunting technology throughout the New World (Howard 1974). It was not until late in prehistory that the bow and arrow, the hunting system most associated with Native Americans by the public today, appears (Blitz 1988). From its initial introduction, whether invented or diffused from the Old World, the bow and arrow spread throughout the Americas. The atlatl did hold on in some areas, including Baja California (Massey 1961), the Arctic (Nelson 1899), and the Mayan area (Hamilton 1982); but by historic contact it was completely replaced as a functional technology in most areas. This replacement has been explained in multiple ways, from a simple superiority of technology to changes in ecology that demanded a new technology (Nassaney and Pyle 1999). The transition from atlatl and dart is not a foregone conclusion in any area, with Australia as a prime example (Churchill 1993; Cattelain 1997). As Churchill notes (1993:21), the development of any specific technological innovation is caused by specific needs rather than an inevitable technological progression. It is important to understand this point before delving into any questions relating to the transitions of technologies. Also, diffusion explains awareness of new technologies but not their adoption. Trial and error in use and selection for the most effective technology over time may explain the adoption of new technologies.

Due to their organic composition, the majority of the technounits (Oswalt 1976) of the atlatl and dart and bow and arrow systems do not normally survive archaeologically (see Baker and Kidder 1937; Frison 1991; Fenenga and Wheat 1940 for exceptions). Because of this, the entire system must usually be extrapolated from its most enduring part- the projectile point (Oswalt 1976). This project seeks to do just that.

It would be unrealistic to attempt to characterize the transition between these two technologies over a geographically diverse area. Differences in food resources, religious/ ideological systems, and many other factors will influence both when and how such a transition might take place. However, by looking at the transition in a limited geographic area, many of these variables can be controlled. This project will focus on a small area in northeast Kansas and western Missouri. This area provides similar access to resources and is small enough to discount significant cultural differences that would impact the adoption of new technologies across the sites represented. The process of this change can then be viewed from a selectionist evolutionary perspective (Dunnell 1978, 1982). If the two distinct technologies (bow and arrow and atlatl and dart) are used concurrently; the selectionist perspective assumes that the most effective or efficient one will eventually become dominant. If so, the rate and nature of this change remain issues of importance in the study of technological change. Table 1 outlines the sites that will be used and their associated radiocarbon dates. Figure 1 locates the sites on the landscape. Table 2 presents the sample numbers for each site.

Table 1: Sites and associated radiocarbon dates

Sigma Range and Median Probability dates are cal A.D., using Calib 6.1 unless otherwise noted.

Period	Site	Lab Number	C14 date	Two Sigma Range	Median Probability	Material Dated	Source
Early	14CF330	GAK-407	3600±100	2275-1689 B.C.*	1962 B.C.	charcoal	Schmits 1978
Early	14CF330	GAK-406	3500±100	2130-1536 B.C.*	1828 B.C.	charcoal	Schmits 1978
Early	14LV401	UCR-3356	1880±50	20-245	130	Unidentified annual	Logan 1993
Early	14LV401	AA36117	1775±45	131-381	255	Cucurbit rind	Logan 1993
Early	14LV401	Beta-47830	1780±60	88-397	247	unknown	Logan 1993
Early	14LV401	AA36118	1725±50	142-424	314	*Iva annua*	Adair 2003
Early	14LV401	Beta-47827	1650±80	223-592	399	unknown	Logan 1993
Early	14LV401	Beta-47827	1590±90	256-640	466	unknown	Logan 1993
Early	14LV401	Beta-47829	1580±80	261-640	478	unknown	Logan 1993
Early	14LV401	AA364120	975±40	994-1157	1086	*Zea mays*	Adair 2003
Early	14LV401	AA36119	930±45	1022-1207	1104	*Zea mays*	Adair 2003
Early	14LV401	OS-84588	600±25	1298-1407	1346	nutshell	Logan 2011
Middle	14MM26	ISGS-A1778	1610±15	407-533	463	Ceramic residue	Adair 2012
Middle	14MM26	ISGS-A1780	1585±20	427-535	486	Ceramic residue	Adair 2012
Middle	14MM26	ISGS-A1779	1515±15	442-604	559	Ceramic residue	Adair 2012
Middle	14MM26	N-1060	1160±100	660-1032	863	charcoal	Artz et al. 1975
Middle	14JN332	AA36102	1220±40	685-892	802	*Zea mays*	Adair 2003
Middle	14JN332	Beta-3320	1220±50	673-897	802	charcoal	Baugh 1991
Middle	14JN332	AA36100	1200±40	689-948	825	*Iva annua*	Adair 2003
Middle	14JN332	Beta-33220	1170±50	711-986	857	unknown	Baugh 1991
Middle	14JN332	AA36101	1165±40	722-981	865	*Zea mays*	Adair 2003
Middle	14JN332	AA39099	985±40	989-1155	1066	*Iva annus*	Adair 2003
Middle	14MM13	UGa-4088	1795±145	B.C. 99-A.D. 565	230	charcoal	Blakeslee and Rohn 1986

Table 1 (continued)

Period	**Site**	**Lab Number**	**C14 Date**	**Two Sigma Range**	**Median Probability**	**Material Dated**	**Source**
Middle	14MM13	UGa-4091	1225±75	662-970	801	Charcoal	Blakeslee and Rohn 1986
Middle	14MM13	ISGS-1785	970±15	1020-1151	1051	*Zea mays*	Adair 2012
Middle	14MM13	ISGS-1787	970±15	1020-1151	1051	Nutshell	Adair 2012
Middle	14MM13	ISGS-1786	950±15	1025-1154	1101	Nutshell	Adair 2012
Middle	14LV380	Beta-34371	900±50	1024-1223	1127	Charcoal	Logan 1990
Middle	14LV380	Beta-36365	1190±70	682-982	834	Charcoal	Logan 1990
Middle	14LV380	Beta-36366	910±50	1024-1217	1118	charcoal	Logan 1990
Middle	14LV380	AA-43407	789±39	1177-1281	1240	*Prunus* sp.	Hoard and Banks 2006
Middle	14OS314	ISGS-1760	895±20	1044-1212	1132	*Zea mays*	Adair 2012
Middle	14OS314	ISGS-1784	850±20	1158-1252	1195	*Zea mays*	Adair 2012
Middle	14DO19	Uga-4705	1075±65	778-1149	956	charcoal	Brown 1984
Middle	14DO19	Beta-19873	970±60	973-1212	1085	charcoal	Logan 1987
Middle	14DO19	ISGS-A1782	890±20	1048-1212	1159	*Zea mays*	Adair 2012
Middle	14DO19	ISGS-A1783	890±15	1048-1212	1159	Ceramic residue	Adair 2012
Middle	14DO19	ISGS-A1761	820±20	1181-1263	1228	*Zea mays*	Adair 2012
Middle	14DO19	ISGS-A1760	795±20	1216-1269	1242	*Zea mays*	Adair 2012
Late	23BN2	ISGS-1727	850±20	1158-1252	1195	Ceramic residue	Adair 2012
Late	23BN2	ISGS-1460	905±15	1042-1183	1089	Ceramic residue	Adair 2012
Late	23PL13	M-1395	920±70	886-1284	1091	unknown	Chapman 1980, Shippee 1972
Late	23PL13	HAK-590	870±80	1023-1273*	1155	Unknown	Chapman 1980, Shippee 1972

Table 1 (continued)

Period	**Site**	**Lab Number**	**C14 Date**	**Two Sigma Range**	**Median Probability**	**Material Dated**	**Source**
Late	23PL13	M-1995a	840±110	991-1387	1172	unknown	Chapman 1980, Shippee 1972
Late	23PL13	M-1398	740±100	1040-1409	1261	unknown	Chapman 1980, Shippee 1972
Late	23PL13	M-1399	720±100	1043-1421	1279	unknown	Chapman 1980, Shippee 1972

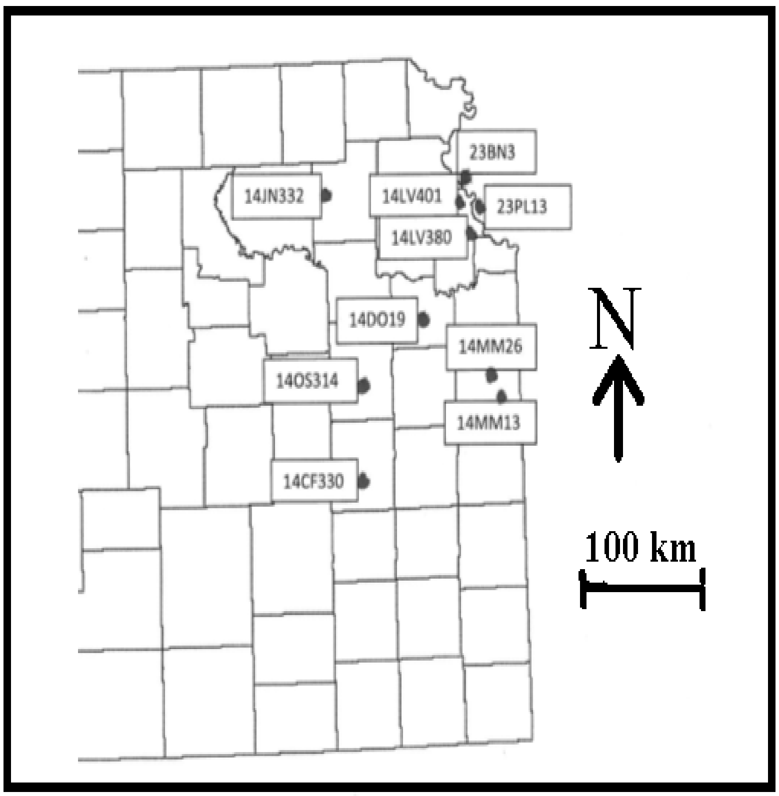

Figure 1: Map of study area with site locations.

Table 2: Point samples by site

Site	Total number of points	Number of points used	Form discards	Breakage discards
Williamson- 14CF330	32	26	4	2
Quarry Creek- 14LV401	42	27	6	9
14MM26	6	4	0	2
Avoca- 14JN332	10	7	0	3
Zacharias- 14LV380	33	22	10	1
14MM13	29	28	0	1
Hatcher-14DO19	8	5	1	2
14OS314	13	9	0	4
Cloverdale- 23BN2	71	70	0	1
Steed-Kisker- 23PL13	44	42	0	2

To reconstruct the dart to arrow technological transition it is imperative to categorize the projectile points into the technologies of which they were once a part. In general, arrows are smaller than dart points, which aids in the differentiation between the two once the transition is complete (Bergman 1994). However, it can be difficult to visually differentiate between the two technologies, especially during the period of transition (Shott 1993; Thomas 1978). This is especially true if relying on the preconception that dart points are always large and arrow points are always small. Because of this difficulty, statistical formulas are employed here to categorize the points in each sample as arrow, dart, or indeterminate, as presented by Thomas (1978) and further developed by Shott (1993 and 1997). This is done independent of typological considerations in order to avoid biases which may result from first imposing a traditional typological assignment to these artifacts.

Chapter 2: Background to the Problem

Advantages and Disadvantages of Technologies

Popular opinion holds that the bow and arrow represent an extremely effective technology for hunting and warfare. Because this technology replaced the earlier atlatl and dart system it is commonly assumed to be superior. Indeed, some early work into the transition makes such an assumption (Browne 1938, 1940). However, more recent work has vindicated the atlatl as an effective means of hunting and warfare (Shott 1993, Nassaney and Pyle 1999). Today these two modes of delivering projectiles are recognized as effective means with their own distinct advantages and disadvantages. It is important to consider these before attempting reconstruct the transition between the two. These advantages and disadvantages impact how, when, and why such a transition takes place.

The atlatl and dart system normally contains four major parts: the atlatl itself, the main dart, a foreshaft, and the stone, bone, or wood point fixed to the foreshaft with mastic such as resin and/or sinew (Van Buren 1974, Oswalt 1976). The foreshaft is not always a component of the system; however it was common as it added to the ease of use, versatility (the foreshaft can also serve as a hafted knife), and maintenance of the technology. As mentioned, all parts of the system other than the stone points are made primarily with perishable materials including wood and bone, which makes their recovery somewhat rare.

Comparisons of the atlatl and dart system with the hand thrown spear and bow and arrow have been made in recent years. The advantages over the hand thrown spear are well documented. The use of the atlatl increases the force, accuracy, and distance one can achieve (Van Buren 1974). Such factors make the atlatl an important development in hunting technology over its predecessor. The only disadvantage of the atlatl versus the hand thrown spear is the training involved in the former. It takes comparatively little training to thrown a spear by hand at close distances. More work goes into learning to effectively use an atlatl propelled dart. Even those experienced using technology, such as Browne (1940) can have difficulties using it well.

Spear thrower technology was first introduced in the Old World around 40,000 B.P. and presumably spread to the New World from there (Van Buren 1974). The long term use of the atlatl and dart speaks volumes to its effectiveness as a hunting tool across many ecosystems. This system was effectively used in all environments (Van Buren 1974). Ethnographically it has been documented primarily in open areas, such as steppe, prairie, desert, bush, and aquatic environments (Cattelain 1997). Cattelain was unable to document its use in heavily wooded, tropical areas such as New Guinea and the Amazon. It was, however, used for thousands of years in eastern North America's deciduous forests.

Atlatl darts vary in length, weight and diameter. Variation in length and weight is considerable. Cattelain (1997) indicates a range of 140-300 cm while Van Buren (1974) gives a lower range of 3-5 feet (91.4-152.4 cm). The length of the atlatl and dart add extension to the arm. Longer shafts also add to the weight of the projectile. Van Buren (1974) attributes all points greater than 20 gm. in weight to darts, spears, or knives. This may be a bit simplistic, but it provides an indication of the general weight at the end of the long shaft and foreshaft.

The accuracy of the atlatl and dart system has been a subject of discussion for many years. Browne (1940) thought the technology had poor accuracy, feeling that it was "impossible" to be accurate with the system and its "uncontrolled throw". Despite his feelings of competency with the atlatl and dart, it is notable that he had not been using one since childhood as indigenous users would. It may be impossible to fully reconstruct the true accuracy of such a technology unless it is learned from a very young age, though with considerable practice one can attain proficiency. Cattelain (1997) found that experienced, competitive atlatl throwers were only 65% as accurate as archers at targets 8-26 m away. He does not indicate whether that difference was consistent throughout that range. It may be that the atlatl became distinctly less accurate as distances increased, or it was most accurate within a specific distance or range. In the same set of observations he noted that the atlatl was difficult for beginners to learn to use. For a modern user this is indeed a downside of this technology. But an assessment of how much this learning curve would impact past societies using this technology cannot be made. It is fair to state that it would have taken some time and practice (likely as play initially, as mentioned by Churchill 1993) for young hunters to acquire the skills necessary to effectively hunt with atlatls.

The atlatl itself is a fairly simple technology to create and maintain, which is a great benefit especially for mobile hunters (Cattelain 1997). It would not take much special training to produce or repair the atlatl. The use of foreshafts also aided in production and repair time, as the main shafts would bounce back from an injured animal leaving the foreshaft and point inside. This reduced damage to the long mainshaft, but required the production of more foreshafts whose shorter length made the task more feasible and expedient.

A final disadvantage of the atlatl and dart system is a relatively slow reload time (Cattelain 1997). The attaching of extra foreshafts to mainshafts takes time. Also, the full-body action of launching an atlatl requires time to reset before the next volley can be launched, and makes it difficult for the user to remain hidden or unobserved.

The bow and arrow is commonly assumed to be the superior of the two technologies (Browne 1940). However, recent work has shown that, like the technology it often replaced, the bow and arrow has both advantages and disadvantages. There are 3 major types of bows: flat/self, composite, and compound (Hamilton 1982; Van Buren 1974). The latter two are more complicated to produce and string, requiring a skilled hand. The self or flat bow is a more simple type; though stringing it still requires a measure of skill (Hamilton 1982). The use of a larger bow or one of the latter two of these types will enable the user to create more force and therefore pierce stronger hides or armor in the case of warfare. Bow lengths vary, but tend to range from 50-100 cm in the Americas (Van Buren 1974). Longer bows have been found in Europe, up to 210 cm (Cattelain 1997). Van Buren has suggested that due to their ambush hunting style many Native American groups used bows that were considerably shorter than their European and Asian counterparts. This choice was probably related to the complexity of making the stronger bows. Since the simpler bows were effective, there was no need to replace them.

The most celebrated attributes of the bow and arrow are it unobtrusiveness, accuracy, rapid reloading, and maneuverability (Hamilton 1982; Cattelain 1997; Van Buren 1974). One is able to shoot a bow from a standing or sitting position in any environment, including closed, dense forest. Because one can remain stationary and fire a bow it is easier to do so without being noticed. This trait is desirable for warfare and stalking prey. As noted, the atlatl was only 65% as accurate as the bow in modern competition (Cattelain 1997). However, the major advantage of the bow in accuracy comes over longer distances; if groups were ambushing prey at closer range this advantage would be lessened. The 15-20 feet that Van Buren proposes for the normal range of shots would have been well in range of a skilled atlatl thrower.

Manufacturing arrows is a trade-off between range/penetration and strength/accuracy. Most points used on arrows are less than 20 g (Van Buren 1974). This decreases the penetration potential of the system, but increases the accuracy (which appears to have been the paramount concern). This trade-off means that decisions must be made to sacrifice one or two elements of the equation at the expense of others. Also, arrows are almost always single purpose units without foreshafts, and appear to rarely have been used as knives.

The atlatl and dart appears to have held on best in aquatic contexts. Cattelain (1997) attributes this fact to the disadvantage of the bowstring. This string and required tension would be subject to moisture levels around water in ways that the atlatl, being composed of wood and sometimes bone or antler, would not. This is not to say that the bow could not be and was not used in these environments. But this issue would have to be taken into account by any hunter wishing to use this technology on the water. This factor, and perhaps the greater impact for sea mammal hunting, could at least in part account for the continued use of atlatls by Eskimo groups in marine mammal hunting up to the historic period.

General Considerations

The study of technological change in the past has not always been an element of archaeology inquiry. It has only been since the mid-1800s that archaeologists in the New and Old World have accepted that humanity's time on the planet was much longer than historical or Biblical records indicated (Grayson 1984). Discoveries of projectile points in association with extinct fauna such as at Folsom indicated that the spear throwers encountered by historic explorers in a few areas of the New World may once have dominated the hunting assemblages across much of the two continents (see Meltzer 2009 for a review of Folsom and other early finds). Once it was clear that the bow and arrow was not the only form of hunting technology present throughout human occupation of the New World, explanation of the change became a problem of interest. Throughout the last 100 years there have been multiple explanations offered for the transition from atlatl and dart to bow and arrow in North America. When attempting to describe this transition, it is important to put it in the context of these general models that have been proposed. In Chapter 5 these explanations will be evaluated using the current data, in an attempt to determine whether one or more may be used to explain the transition in the study area.

One of the oldest explanations is also one of the simplest, that the bow and arrow provides a better hunting technology. This model holds that as soon as the technology diffused from the Old World through groups in Alaska it quickly spread throughout New World groups (see Blitz 1988 for a discussion of the spread through North America). Since the atlatl and dart were presumably inferior to the bow and arrow it would presumably be quickly abandoned in favor of the new technology. In this model a rapid transition over a short period of time would be expected. As reviewed above, it has been demonstrated that both technologies have strengths and weaknesses. Most archaeologists now believe that this traditional explanation is too simplistic as an interpretation for the entire continent.

Another early explanation relates to the association between adoption of the bow and arrow and the transition to agriculture. It was long believed that these changes took place simultaneously due to a need for increased productivity in both plant and animal resources (Hall 1980). This theory is connected to the idea that the bow and arrow was a more efficient technology, but does not posit that efficiency as the sole reason for the change. The need for higher productivity was necessitated by an increase in population as groups settled into areas to farm. Corn was important to population growth, as corn can be made into a gruel that aids in weaning children off their mother's milk earlier than possible with most wild foods. Also, the need for more hands in agricultural fields, and the reduced mobility associated with agriculture, made additional children more desirable. The change associated with population growth, increased sedentism, and increased demand for protein and hides may have made the bow and arrow a more desirable weapon (Hall 1980). This theory was widely held until new radiocarbon dates indicated that the adoption of the bow and arrow and agriculture were not as closely linked as previously thought (see the regional discussion below). This makes the relationship between the two less clear. It is possible that the adoption of agriculture was a contributing factor to the adoption of the bow and arrow once agriculture was established and the transition was underway.

A related idea is that there were changes in prey selection that led to the transition to the bow and arrow. The atlatl and dart are best suited to killing medium to large sized prey (Van Buren 1974). While it is not impossible to kill a rabbit-sized small mammal with such a weapon it is considerably more difficult, and such prey was likely often taken with traps or simple throwing sticks. A bow and arrow, however, is more adaptable for killing a wide range of animals. This would increase the success of hunts in situations where the larger prey in an area are less plentiful, as the hunter could kill smaller game with the same weapon as was used for larger quarry. This is likely the situation facing hunters in new agricultural settlements. Living for an extended period of time in one place decreases the local animal population and increases the hunting range of the group, and it may take some time to adjust to related decreases in the availability of larger prey species. However, groups may not have moved quickly from mobile hunter-gatherers to settled farmers. In the Midwest, for example, people appear to have been settled on at least a seasonal basis long before the adoption of corn (McElrath et al. 2000). This indicates some resource planning knowledge prior to the more permanent settlement of areas for agriculture

Ecological change has also been identified as a motivator for the shift. There would have been differing types and abundance of game available to hunters, caused by shifting resource zones as climatic and seasonal variation impacted animal habitat. Small shifts in landscape ecology could have large impacts on resource availability, especially in more marginal areas such as the Southwest or on ecotones such as the Eastern forest and prairie border. This could have prompted changes in the toolkit, including possibly the addition and eventual dominance of the bow and arrow as a hunting technology.

Blitz (1988) has proposed a fundamentally different theory than those discussed above, that the transition was fueled by warfare. He contends that the transition happened quickly over large areas of the continent, and all within quick secession of each other in a geographic pattern. Because the bow and arrow allowed for more stealthy ambushes it was the preferred weapon for warfare, as it enabled users to better surprise their enemy and provided more rapid fire. Intergroup conflict may have increased through time as a result of population growth and competition for hunting areas. Those who did not use the bow and arrow would therefore have been at a disadvantage over their neighbors and were more likely to quickly adopt the technology. This would lead to a rapid spread over a large area in a relatively short period of time. The theory is thought to be highly applicable in the Southeast, as other indicators of violence (fortifications, violent skeletal injuries) exist in the period directly after the transition is assumed to have taken place. However, new discoveries and better dates have pushed these occurrences apart in some areas of the Southeast, not supporting the theory on a trans-regional scale. Wray and McNeish (1961) also found connections between an increase in violence and the increased use of the bow and arrow. They posited that such violence had a hastening effect on the decline of the Hopewell system. However, there does not appear to be good evidence in all regions for the level of violence predicted at the correct time which would have encouraged a rapid change in technology. Also, the correlation between increased violence and the bow and arrow, even when both are present, has not been fully demonstrated.

Timing and Rate of Change

How quickly the bow and arrow replaced the atlatl is a point of contention among researchers, and for good reason. First, not all projectile points are stone; it is possible that the first bow and arrows were completely organic and left no trace (see Knecht 1997 for examples of organic points). Exactly what is considered a point is also debated. In Europe in the Upper Paleolithic projectiles were commonly tipped with stone points made on segmented blades rather than bifacial points (Bergman 1994). It is possible, and has been argued (Odell 1988), that a similar flake technology was used for the first bow and arrows in the New World much earlier than typical chronologies place this transition. And even when the discussion is restricted to traditionally recognized projectile points there are still questions as to when the points began to tip bows and arrows (see the regional discussions). Determining the dates of first use is extremely important to the discussion of explanations for the transition; as such explanations are tied to the pace of change. Many of the proposed explanations and causes for the transition are predicated on a quick transition, lasting perhaps a few generations (100-200 years). Whether such a rapid transition truly took place is a matter of concern and will be addressed in the section on the eastern Plains in Chapter 5. A slower transition may reflect a different impetus or type of explanation and these have been less extensively explored. Regardless of the specific cause(s), the selectionist perspective posits the transition in the context of increasing dominance of the most effective all around technology as a result of selection against the less effective system.

Regional Interpretations of the Atlatl to Bow and Arrow Transition

Independent invention of the bow and arrow in multiple areas of North America is unlikely; the more likely scenario has the technology diffusing over the continent through interactions among groups (Blitz 1988).In many areas people were connected on some level by trade and movement, which would have facilitated such diffusion. Because the timing of the transition is one focus of this study it is important to consider the transition between atlatl to bow across different regions of North America, not just in the northeast Kansas area. This section will summarize current interpretations of the transition in the Midwest, Southeast, Great Plains, Southwest, and Great Basin regions of North America. These regions have some connection to the study area or have transitions proposed within a similar time frame. Understanding these regional interpretations is necessary to contextualize the transition in the study area.

Midwest

The Midwest region, as defined here, includes the area now encompassed by Ohio, Indiana, Kentucky, Illinois, and Missouri. This area was central to the Middle Woodland Hopewell complex. It is possible that the interactions among the cultural groups in the region (eg. Sassaman et al. 1990) altered how the bow and arrow system was adopted here. The trade networks that brought exotic goods into this area could also have brought in new technologies. Neighboring regions without such a system may have had a different cadence and pattern of diffusion and acceptance (McElrath et al. 2000). The decline of the Hopewell Interaction Sphere was previously correlated with the emergence of maize agriculture which may have gained importance along with the spread of the bow and arrow, according to some archaeologists (Hall 1980). However, it is unlikely that the two were linked in the decline of the Hopewell complex, as the reliance on corn agriculture apparently postdates the transition to the bow and arrow (Simon 2000). Alternative models for the Hopewell decline do not link it significantly with the spread of bow and arrow technology.

The transition from atlatl to bow and arrow in the Midwest appears to be complete about 600 A.D. (McElrath et al. 2000). There does not appear to be much research into the time span of the transition. It has been argued by Hall (1980) and Shott (1993) that the transition was connected to the greater hunting efficiency of the bow and arrow. This has been countered by Styles (2000), who found no connections to hunting efficiency evident in the fauna between sites in atlatl and dart and bow and arrow periods. However, a related model by Fortier and Jackson (2000) suggests that changes in land usage necessitated the shift in technology. They found that in the Late Woodland period there was an increased use of upland slopes for resources. In such terrain it is easier for the hunter to use the bow and arrow, since it allows a stationary posture. In contrast, the atlatl and dart, requires the user to stand and take at least one step. McElrath et al. (2000) credit warfare as a catalyst for the change. They suggest that the movement into the area was caused by conflict during to the end of the Hopewell period.

It is possible that more than one of these factors led to the adoption of the bow and arrow in the Midwest. And the highly interactive and interconnected nature of the region's Middle Woodland cultures just prior to or early during the adoption of the bow and arrow system makes multiple factors influencing the change likely. One sure thing is that the transition was concluded in the Midwest around A.D. 600, postdating the cultural transition from the

Hopewellian to the Late Woodland culture in the region, and apparently prior to the intensive widespread reliance on corn agriculture (Adair 2006).

Southeast

The long-prevailing opinion for the introduction of the bow and arrow to the Southeastern U.S. contended that the technology diffused from the north and west, replacing the atlatl and dart in the years A.D. 500-700 (Nassaney and Pyle 1999). The spread was rapid, especially when compared to the much slower diffusion of corn preceding and during this period (Nassaney and Cobb 1991). As in the Midwest and Southwest, the adoption of this technology may have been connected to the shift to corn horticulture. As Pollack and Henderson (2000) point out, there is a connection between the occurrence of early arrow points and tools with silica polish or other indicators of horticultural/agricultural activity in the region, specifically Kentucky in their case. Both shifts were seen by Nassaney and Cobb (1991) as part of a suite of changes specifically related to increased productivity. This suite includes both a heavy reliance on agriculture and the use of the bow and arrow.

As mentioned above, warfare has also been a competitive theory to explain the rapid transition to the bow and arrow in some areas of the Southeast. In some areas the bow and arrow becomes the dominant weapon around the same time as other indicators of warfare appear in the archaeological record. The correlation between the two has yet to be effectively demonstrated on a large scale.

However, these are not the only theories offered to explain the adoption of the bow and arrow in the Southeast. While Nassaney and Pyle (1999) admit that some communities did rapidly adopt the bow and arrow around A.D. 600, they also present arguments suggesting that in other communities the technology had been around for some time prior to adjacent groups adopting it. Oliver (1985) argues that a form of arrow was in use in North Carolina between 2500-2000 years B.P., at least 500 years prior to the assumed transition period mentioned previously. Sassaman et al. (1990) argue that “true” arrow points existed in South Carolina by A.D. 200, at least 300 years prior to the assumed transition. Many of the arrow points that have been recognized for periods earlier than A. D. 500 (as early as the Late Archaic in places) are unifacial flakes, not the “expected” bifacially flaked points. If, as Odell (1988) has argued, these flakes do represent projectile tips (most likely those of arrows) then we must consider an alternative view of the entrance of bow and arrow technology into the Southeast. This would indicate at least two separate explanations for adoption: a gradual adoption in which the bow and arrow was simply added to the toolkit, and a much faster adoption in which the bow and arrow quickly replaced the atlatl. This may explain different timing of adoption in subareas of the Southeast. Nassaney and Pyle (1999) do not give any definitive answer as to why this rapid adoption may have happened around A.D. 600, but they posit that changes in the social structure of the groups (increased social differentiation) and need for food storage may have impacted the need for increased efficiency in certain ecological niches. Warfare also may have had an impact on the rapid adoption of the technology, given its ability to increase the stealth, accuracy, and rate of fire.

Nassaney and Pyle also note that the atlatl and dart held on in areas of the Southeast up to historic contact, especially along the Gulf Coast. This indicates some value to the earlier technology, possibly due to the utilization of water resources in the area.

Great Plains

The Great Plains encompass a large area of the midcontinent spanning from the Canadian to Mexican borders of the U.S. Because of this fact some variation in the adoption of the bow and arrow is expected. However, even within the sub regions of Northern, Central, and Southern Plains there is some disagreement over the timing of the bow and arrow's adoption.

In the Northern Plains it has long been assumed that the technology diffused south from Athabaskan speakers in the Arctic and Subarctic (Nassaney and Pyle 1999, Blitz 1988). Perino (1968; quoted by Nassaney and Pyle) suggests that the technology had come to the region in the form of Avonlea points by around 100 A.D. However, according to Frison (1991) the technology does not make it into Wyoming until 400-1000 A.D. Whenever it diffused, there does appear to be some overlap on the Northern Plains with the atlatl and dart. This suggests that the new technology was added to the tool kit, especially for bison hunting, and did not immediately replace its predecessor (Nassaney and Pyle 1999). The replacement seems to have been gradual.

In the Central Plains there is also some discussion over when the technology was first introduced. Blitz (1988) suggests that it was not in use in the area until after A.D. 500. However, others have also suggested that the technology was known and used with the atlatl and dart from A.D 1-500. Possible arrow points have been found in Oklahoma and Kansas that date back as far as A.D. 1, but there is some possibility of mixing at these sites (Nassaney and Pyle 1999). Benn (1990; as quoted in Nassaney and Pyle 1999) states the bow and arrow was use in parts of Iowa as early as A.D. 200-450. He suggests that the transition was prompted by a need to increase food production. Johnson (1987) points to a gradual transition during the Late

Woodland period in Kansas. However, Bell (1976) points to small, corner-notched triangular points in the later pits at the Kansas City Hopewell Trowbridge site as evidence that that technology was introduced earlier than A.D. 500. This possibility could be evaluated through the study of faunal data and refined dating.

In the Southern Plains it has generally been assumed that the transition took place in A.D. 500-600 (Blitz 1988). This is in fact the time that formal ("true") arrow points entered the region. However there are unifacial points in Texas that may have tipped arrows that date back as far as B.C. 3000 (Nassaney and Pyle 1999). According to these authors there appears to be an overlap of the early formal arrow forms and dart points. There is also the suggestion, given the forms and styles of each, that the darts were prototypes for the early arrow forms.

Southwest

The timing and reasoning for the transition in the American Southwest have been debated in recent decades. Martin and Rinaldo (1951) defined what they termed the Formative period as a period of transition. These transitions included the move from pit houses to pueblos and the adoption of the bow and arrow and decline of atlatl and dart. This shift was seen in the points, with a transition from diagonally notched to side notched points (Martin and Plog 1973). It was during this period that agriculture was said to become the dominant form of food getting (Simmons 1989). Like that of the Midwest, the purposed connection in time and potential influence of these transitions is not as simple as it originally seemed.

Traditional research has placed the transition to the middle of Martin and Rinaldo's formative period, A.D. 500-600, based on preserved bows found in Arizona (Silva 1999). It is possible that this is incorrect and the transition began much earlier. Blitz (1988) has argued that the transition may have begun as early as 550 B.C. based on the presence of small, light Cienega points. These points have been proposed as arrow tips given their size and shape, especially in relation to the much heavier San Pedro dart technology preceding it (Silva 1999). If these points do represent the earliest experimentation with and use of the bow and arrow in the Southwest it would necessitate an entirely new perspective on the timing and cadence of the transition.

Great Basin

As in the other areas discussed in this section, there has been contention over the timing and length of the transition from atlatl and dart to bow and arrow in the Great Basin region. Some of this discussion is due to the amount of evidence found in caves versus open air sites. While caves can be great for the preservation of perishable artifacts, they are also candidates for palimpsests and mixing, which can impact interpretations. Webster (1980) notes the proposed evidence for early arrows in Danger Cave may be the result of mixing. However, he does indicate that the transition had an early beginning, at 3300 B.P. At Dry Cave he observed an overlap of dart and arrow points spanning 2000 years, with final replacement of the atlatl taking place at 1700 B.P.

Others have put the transition into a much shorter timeframe: A.D. 300-600 (Messoudi and O'Brien 2008) or 1650-1350 B.P. (Bettinger and Eerkens 1999). Much of the difference is due to debate over exactly what technologies these points represent. Bettinger and Eerkens (1999) note that there have been multiple interpretations of the typologies of this region, and the time sensitive nature of those typologies complicates matters further. These issues complicate modeling the transition, as the length of the transition is a key component in that discussion. Working within their proposed timeframe for the transition, these authors contend that the transition happened differently in California and Nevada. Those in California had less correlation between attributes and therefore more trial and error by individuals while points in Nevada showed stronger correlations and were likely produced through more direct diffusion from one source. Bettinger and Eerkens contend that this may be the result of more contact between groups in Nevada and the group from which they acquired bow and arrow technology. Their conclusions were supported by modeling and experiments done by Messoudi and O'Brien (2008). However, those authors believe that the reality may have been much more complicated and suggest that multiple interpretations may be valid and remain to be evaluated.

In many regions throughout North America, the timing of the transition from the atlatl and dart to bow and arrow has not been firmly established. Many researchers in these regions place the transition from 500-700 A.D.; however alternative hypotheses require evaluation. The cadence of the transition also remains to be established in many areas. Until we are able to explain when and how quickly this transition took place we will not be able to truly characterize what lead to the transition in regions of North America.

Chapter 3: Theory and Methodology

Evolutionary and Selectionist Archaeology: projectile technology as a case example

There are many ways to approach the study of artifacts and technologies. Cultural evolutionists of the 19th and early 20th centuries believed that technologies would progress towards the present forms in a sequential linear pattern. Once a "better" technology came along the previous form would be quickly abandoned and the newer form adopted. This simple model is not supported by archaeological and ethnographic evidence. More recent work applying Darwinian or selectionist evolution to archaeology has led to new perspectives in the study of the change in technological systems. This type of archaeology has been used to explain the transition. Therefore it is necessary to briefly describe this approach.

There are many components to evolutionary archaeology; however the focus here will be the selectionist agenda. The selectionists focus on how traits associated with artifacts or technologies are "chosen" or change in frequency through time. Much like in biological evolution, attributes that increase fitness or efficiency are more likely to be maintained. Dunnell (1982) argues that archaeology is a historical science, and it must adopt a materialist position that does not seek to predict phenomena but explain it. He has also argued for two categories of attributes; functional attributes, on which selection will act; and stylistic attributes, on which cultural forces operate (Dunnell 1978). This distinction is important. Assuming that selection has operated on all attributes of an artifact or technological system is unsupported, and may lead to erroneous assumptions about the nature of change. In this system of change copying error works much like mutation in genetics, presenting new forms. Some of these forms will be better adapted to the present situation and will be maintained through what Lyman et al. (2008) and others refer to as artifact lineages. However, if these variation or “errors” do not prove to be adaptive they are likely to occur once or at most sporadically through the lineage. Changes may also be introduced deliberately to solve specific problems. Selection will operate on these types of change in a similar way to variations caused by errors.

For many years hunting technologies were thought to follow the linear pattern. Since the bow and arrow was a “better” technology, groups would quickly adopt it and discard their atlatls and darts (Browne 1940). The continued ethnographic use of the atlatl makes this explanation unlikely and requires a new perspective. Dunnell’s (1978) two attribute system works well for projectile points. Some attributes will affect the function of the system. For example, if a point is too heavy it will not be as suitable for an arrow. Changes in projectile point hafting or stem width are likely associated with changes in overall size and weight of projectiles. The sheer variety of projectile points in the archaeological record indicates that forces can and did act on point morphology. So both stylistic and functional attributes would be present and represented throughout any technological transition. Selectionist theory predicts that traits will be selected based on their effectiveness within the allowable range of a cultural paradigm or style. There may be multiple attempts to create points that function well in the new bow and arrow system. The traits that worked would not be selected against and would remain, while those that did not work would be modified or discontinued. Initially people could use either the point styles already associated with the diffused technology or their existing dart points as models. In the latter case selection would be more likely to act. Styles that diffused into an area would be more likely to be altered in a stylistic fashion that had already been subject to selective forces.

Methodology

The analysis of the points in this study was done in three steps: a visual analysis, metric data collection, and the use of formulas to classify the point as dart or arrow. The visual analysis followed the order in which the collections were acquired, first those from the ARC, and then those for the other institutions. The middle step was done by chronological period: early (1962 B.C.-A.D. 478), middle (A.D. 463-1242), and late (A.D.1089 -1279). The sigma ranges, laboratory numbers, and materials dated for the dates from sites in each period are contained in Table 1. Figure 2 illustrates the date ranges for each sample and site by period. The final step was done in the chronological order as interpreted at that point.

Important methodological steps at the beginning of this project were the selection of sites and the selection of the points from those sites to be included in the analysis. Many of the assemblages in the middle period are small in size (see Table 2), which meant that a large number of sites was needed. Because of this, more sites were included in the middle period (six) than in the early and late periods (two each). There are only a few points from 14MM26 that can be tied to the first 200 years of the middle period. The majority of the sites fall in the middle and late portions of the middle period. This fact impacts the arguments made here about the transition during this critical time period. However, even with this limitation the sites that were included represent most of the middle period (A.D. 463-1242).

Figure 2: Radiocarbon ages for studied sites with their sigma ranges

Not all of the points recovered from each site were included in the present analysis. It was determined before the project began to limit analysis to points of the stemmed and notched type. Both Thomas (1978) and Shott (1997) included these, as well as lanceolate and triangular points, in their analysis. However, their objective was to evaluate the use of the formulas on points of known technological affiliation to determine if the formulas were useful in predicting point type. If the formulas hold for all styles of points used in prehistory they would be considered more useful. Each style of point differs in physical shape and stress points. The styles of point are fairly unique and are not easily comparable. Therefore, I choose one generalized style of point (stemmed or notched) for the analysis in order to increase the probability that the points would be correctly assigned to projectile type. For example, despite differences in exact size and shape, the points all had similar points where fractures occurred, as many tips and parts of bases were broken. Such similarities decrease the possibility that placements in technological category are due to unintended factors. In all periods that are represented in this sample, notched and stemmed points were the most abundant style, leading to a larger sample size for this study. Setting aside the lanceolate and triangular points slightly decreased the sample from some sites, but in no collection did such styles represent the majority of points. In addition, some unnotched points may represent preforms of unfinished projectile points. Table 2 includes counts of excluded points, including those too broken for inclusion and the triangular and lanceolate forms.

Visual Analysis

The project began with a visual analysis of each point. The first step was to sort the notched and stemmed points from the triangular and lanceolate varieties. The presence of excluded forms is noted (see Table 2).

This first step involved a cursory visual analysis of each point, using size and shape to determine the most likely technological category. If the point was determined too fragmentary to apply either of the formulas in part three of the methodology, it was set aside. For each site a record was kept of the number of likely dart and arrow points, as well as the number of points that were not assigned to either category (hereafter referred to as indeterminate) and the number of points in the collections excluded from this analysis due to their fragmentary condition.

The sample was roughly divided into three time periods: the “pre-transition” period (early), the transition period (middle), and the “post-transition” period (late). The early and late periods were selected to provide control for the project. These were expected to include all one type of projectile (dart or arrow), as they fall outside of the period outlined by scholars as transitional (see chapter two). Unfortunately this ideal did not match the reality, but did provide chronological control to the project (see chapter five for a further discussion).

I attempted to assemble a similar sample size for each time period. This made this first step an important key to the analysis. Because not all points represented could be used; it was important to identify those that could be included due to condition or form. The late period includes more points than the other two. One of these sites would have been sufficient, but as the other two periods included multiple sites it was important to continue that sample selection process. The abundance of points in these sites is likely due both to the nature of the bow and arrow (the use of more projectiles per individual) and the intensity or duration of occupation at the sites (site function).

Typology has the possibility to aid in this discussion. Indeed, typology is often used to classify points as dart or arrow. After consideration, however, typology was not included in this study for several reasons. The first was the condition of the points. Most of the points were no longer as they were originally created. Many were missing tips and parts of bases. Some were also likely resharpened. These alterations may impact typological assignments. Also, some of the sites included in this study were occupied for a significant period of time. It is possible that points could have been found and recycled or reused much later in time than their typology suggests. I wanted to focus on the formulas for the classification of points. Typology, however, may be helpful to confirm or question these classifications.

Metrics

Once the sample was collected and visually analyzed, metric data was collected. Each point was measured with digital calipers to the tenth of millimeter; the same instrument was used for the entire sample. Each point was measured for length (L), base width (BW), shoulder width (SW), neck width (NW), and thickness (MT). The exact areas of these measurements are visually represented in Figure 3. These measurements are the ones used by both Thomas and Shott. Thomas' formula requires a maximum width value; this was always one of the collected values (either BW or SW).

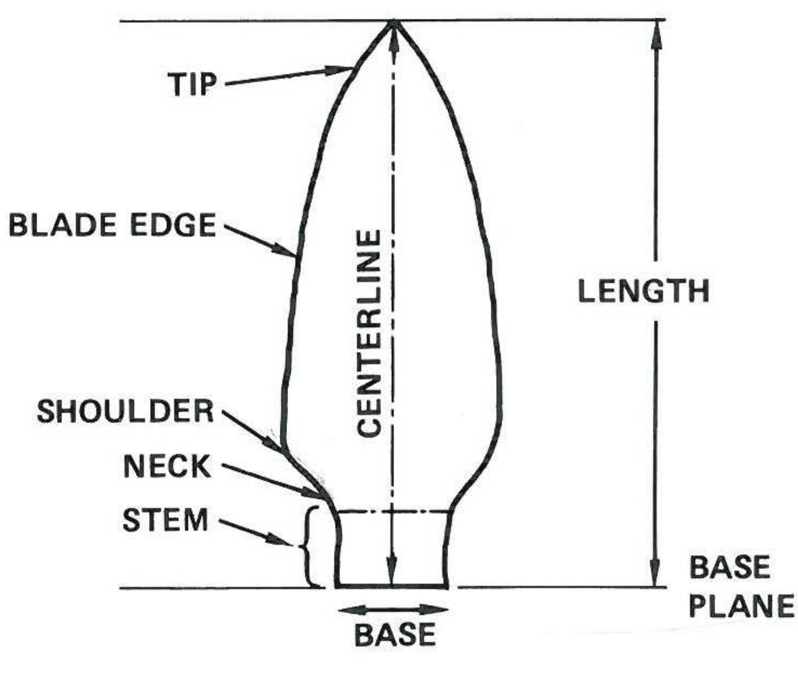

Figure 3: Measurement locations for projectile points (from Van Buren 1974)

As the measurements were recorded any breaks were noted, as these can impact the formulas used in part 3. None of the points included had any "significant" breaks, but it is still important to have information on modifications during final analysis.

During the metric analysis all of the observations were collected in a notebook. Once the collection of metric observations was completed, the data was transferred to an Excel spreadsheet (contained here as Appendix 1), including notes about the condition of points. Thomas and Shott's formulas (described below) were calculated and recorded in the same spreadsheet.

Formulas

As mentioned, a problem in study of projectile points has been the assumed accuracy of the technological assignments made by researchers. The visual assignment of point types may be acceptable at sites prior to the appearance of the bow, but categorization based solely on visual assessment is not a viable methodology. Therefore, this study uses the formulas developed by Thomas (1978) and Shott (1993; 1997) to categorize the points.

Thomas (1978) was not the first to address the problem of distinguishing between dart and arrow projectile points, see Forbis (1960); Corliss (1972); and Fenenga (1953) for earlier examples. He does, however, present a viable, tested formula to classify points. To test the formula Thomas used hafted, identifiable ethnographic and archaeological examples of darts and arrows, all drawn for museums (especially the American Museum of Natural History). The archaeological examples were all found still hafted and associated with their respective technology. This tight control of the identity of the tested sample gives strong support to the validity of the formula. The sample contained 132 arrow points and 10 dart points. It is regrettable that the dart sample was so small; but this is understandable given the rarity of intact hafted darts preserved in archaeological contexts. This is a problem that Thomas laments, but he contends that the formula is still valid. Thomas' formulas are as follows (1978: 470, parentheses and operators added for clarity):

Dart Point: C= (0.188 X length) + (1.205 X width) +(0.392 X thickness) –(0.223 X neck width) -17.552

Arrow Point: C= (0.108 X length) + (0.470 X width) + (0.864 X thickness) + (0.214 X neck width) – 7.922

To calculate each formula one multiplies length, width, thickness, and neck width (in mm) by their respective value as presented in the formula. Then, you follow the operations from left to right, finally subtracting the values in mm at the end which is not multiplied by a measurement. This gives you C, which is the designation given to the categorization of the points. Each point is evaluated using both formulas and the resulting values are compared. The higher value (either the dart formula or the arrow formula) is assumed to represent the most likely categorization. In the present study, if the difference between the values is less than 0.5; the point was categorized as indeterminate, because the differentiation between the two formulas was so small.

In Thomas' article he reports an overall success rate of 86%, with 3 darts and 17 arrows being misidentified. This is arguably an acceptable success rate, especially given the small sample of darts. Thomas also states that the arrows were typically smaller than the darts, which supports conventional wisdom. He contends that his formula provides a method to reliably separate dart and arrow points.

Shott (1993) applied Thomas' formulas to artifacts from two sites in the Ohio River Valley. He makes the important point that assumptions need to be tested, such as the validity of visually classifying dart and arrow points. Shott notes that Thomas' formulas are not ideal due to the small dart sample, but their use is vastly preferable to non-systematic classifications based on assumption or style. He applies Thomas's formulas with somewhat mixed results. The triangular points are all classified as arrows and one set of presumed dart points are also correctly identified. However, the Chesser Notched points, conventionally regarded as darts, are identified as arrows using Thomas's formula. Shott attributes this possible "misidentification" to intense resharpening during the uselife of the points.

This is an important methodological point. These formulas assume that there have been little to no changes made to the points once they are initially completed. This is an issue when points are resharpened, broken, or otherwise altered, which is especially common for dart points which sometimes have multiple functions. It is important therefore to be vigilant in the visual sorting stage of the project in this respect, as any major alterations to the points will impact the formulas. For this project any noticeable alterations were noted in the Excel sheet and taken into account during analysis. Points that were badly broken at any measurement point were excluded. In two cases the base was broken near the center. The basal measurement for these was doubled to account for the pre-breakage size. Neither point was near the indeterminate classification, so they were retained in the study sample.

Later Shott (1997) expanded on the methodology, testing multiple new formulas with the same data used by Thomas, with one notable exception. Shott, grasping the most glaring issue with Thomas' sample, updates the dart group, adding 29 new points to Thomas' original group of 10. While this does not begin to approach the number of arrow points, it does substantially increase the original sample size and enhance the results. He notes it was possible to extend the sample further, up to at least 75 artifacts, but these extras were excluded because they do not have the same level of contextual control as the selected series. Shott's position is that it is better to have a smaller reliable sample than a larger less controlled one which might introduce statistical noise to the equations.

In the course of this article Shott develops a series of formulas, combing ever smaller groups of attributes in an attempt to establish the highest classification success. He concludes that shoulder width (SW), more than any other attribute, is the most important in distinguishing the two technologies. He presents a straightforward formula using this dimension as follows (1997:95, operators added for clarity):

Dart: 1.40 X (SW) - 16.85

Arrow: .89 X (SW) - 7.22

This set of formulas, when applied to the controlled data, has a 92.4 percent success rate with arrows and a 76.9 percent success rate with darts. He points out that these results are similar to those obtained through Thomas' study, but maintains that the single variable discriminant analysis is important in separating out the technology types.

In this study Thomas's more tested formulas was the main set used. Shott's newer variable analysis was used to cross check the original formula. Thomas' analysis is well-formed but has one flaw for working with the typical archaeological record, that is, most points found are not in the same condition as the hafted points Thomas used. In my sample many of the tips and bases were broken. By adding Shott's later formulas more of the sample can be used in the analysis. While the shoulders are occasionally damaged, these breaks tend to be fairly minimal and have only slight impacts on the resulting values. The classifications were compared between the two formula sets. In most cases the two formulas resulted in the same classification. Those that did not are discussed in further detail in chapter 5.

In both Thomas's and Shott's analysis a premium was placed on getting each point into a sure technological category. In this study I examined points during the transition between the atlatl and bow and arrow technologies, and a significant problem arose. In some cases the values for dart and arrow are just too close to make a definitive classification of a particular point. For the purpose of this study, if the difference between the dart and arrow values of a particular point was less than 0.5, then the specimen was put in the indeterminate category with a notation of which value was higher. For example, Williamson site point 167 had a dart value of 14.5138 and an arrow value of 14.7418. Because the difference is 0.228 (less than 0.5), the point was classified as an indeterminate arrow (because the arrow value was larger). In a few cases one of the formula sets would classify a point to a specific technology and in the other it was indeterminate closer to a specific technology. These specimens were noted as being close. The results were then analyzed both within and across the three periods.

All points were photographed, and can be found in the following two chapters. In Chapter 4 points were organized based on Thomas's classifications. These photos provide a visual of the varieties of point styles present in each sample. In Chapter 5 points were photographed by period and classification. Points were only included in these photographs if their classification is the same for both Thomas's and Shott's formulas.

Chapter 4: Regional and Site Backgrounds

Regional Background

Geographic and ecological contexts are important to any archaeological question, as such factors impacted past groups just as they do groups today. Eastern Kansas and western Missouri are on the eastern edge of a geographic area known as the Great Plains or Central Plains. The climate of this area has varied over time, but the effects of these changes were presumably felt in generally comparable ways across the study area. There is also a similar history of the groups who took up residence in this area. This section will discuss these factors as well as a brief description of the physical landscape.

Climate and Ecology

This area includes a mix of tall grass prairies, savannas, and oak/hickory forests (Mandel 2006a). The exact extent of these ecological areas has varied over time (King and Graham 1981). In the mid-Holocene the short grass prairies of central and western Kansas spread east due to the dry, warm conditions. By the time of occupation at Williamson (3600 rcybp) short grass prairies were replaced in the east by mixed and tall grass prairies and forests extended their reach (Wright 1971).

The variety of landscapes and ecological zones provided prehistoric inhabitants of the area with diverse plant and animal resources. For example, bison tend to be most plentiful in the short grass plains to the west of the study area (Graham and Lundelius 1984). Big bluestem grasses would be available in the prairie but not the forests, and acorns and hickory nuts in the forests but not the prairie. These zones are typically in a mosaic pattern in this area of the state, so each set of resources is generally in close proximity to the others (Mandel 2006a). This means that inhabitants would not have to travel far to obtain each set of resources, especially if they had access to water transport. This patterning of diverse resources makes the area a prime region for settlement.

Physical Landscapes

A popular image of Kansas sees it and surrounding states as having limited topographic relief and ecological diversity. In fact, there is a pattern of gentle decline from high points in western Kansas east to the Missouri border. As Mandel (2006b) outlines, the study area lies within two physical landscapes: the Glaciated Region and the Osage Cuestas.

The Glaciated Region lies in the northeast corner of Kansas, and includes Leavenworth and Jackson Counties (sites 14LV401, 14LV 380, 14JN332). As Mandel (2006b) notes, this area was covered early in the Pleistocene by glaciers, leaving plains and gently rolling hills with glacial tills. Within the study area, that portion closest to the Missouri River has the greatest amount of topographic variation, with stream valleys cutting through the upland areas. The bedrock of the area (on both the Missouri and Kansas sides of the Missouri River) is Pennsylvanian and Mississippian in age and some of this limestone contain chert which is well suited to flitnapping and was widely used prehistorically (Stein 2006). The glacial tills also include lithic materials from further north that was deposited during glaciation (Mandel 2006b).

The remaining sites are contained in the Osage Cuestas south of the Kansas River (Mandel 2006b, Buchanan 2010). The general landscape (uplands and lowlands) and resources of this area are similar to the Glacial Region, with the noted absence of glacial activity and the resulting till. The area contains alternating layers of Pennsylvanian-aged soft shale and harder limestone. The differential erosion of these has created uplands areas with limestone bedrock and lowland areas with underlying shale. The limestone is quite similar to that underlying the Glacial Region, and therefore contains some of the same chert good for making stone tools (Stein 2006). The area has a general upward slope toward the northwest area of the region. This is interrupted in some places by the east to southeast flowing streams throughout the region (Mandel 2006b).

Regional Chronology

The chronology of this area generally follows the chronology of the Great Plains and midcontinent regions of North America. As outlined in Hoard and Banks (2006), the culture history begins with the Paleoindian period and continues to the present. The chronology represented in my study is somewhat shorter, spanning only the Late Archaic through Early/Middle Ceramic periods (c.a. 3500-5000 rcybp). This section will outline only these periods, with references to other periods as pertinent.

The Archaic period (9,000-2,000 B.P.) existed throughout the Plains. This period is characterized by subsistence strategies based on wild resources (Wedel 1986; Blackmar and Hofman 2006). This often required movement across the landscape in a seasonal round, acquiring resources as they became available. The first site, 14CF330, dates to the later portion of this period.

Following the Archaic is the Plains Woodland or Early Ceramic Period (Logan 2006; Johnson and Johnson 1975). It is this period that encompasses most of the sites in my study, including one date for an early period site (14LV401) and all of the middle/transitional period sites. The terminology for the period varies, but here will here be referred to as the Plains Woodland. This term is a reference to the sequence used throughout much of Eastern North

America; as the archaeological record shows more similarities to this period than to portions of the western Plains or regions to the west (Wedel 1986). As presented by Logan (2006), the Plains Woodland is further divided into three stages: Early (2000 B.C- A.D.1), Middle (A.D. 1-500) and Late (A.D. 500-1000). The Early period is not represented in my sample, due to the lack of well-dated assemblages.

The Middle Woodland in my sample is represented by 14LV401. This period is marked by the influence of Hopewell the area by what has been designated the Kansas City Hopewell variant (Logan 1993, 2006; Johnson 1976). This distinctive culture has similarities and potential connections to the Havana Hopewell to the east. Similarities in pottery and subsistence practices link the Kansas City Hopewell with similar cultural practitioners in the Illinois River Valley (Johnson and Johnson 1975). It has been argued that sites such as Trowbridge and Quarry Creek were permanent or semi-permanent and that smaller, sites in the area were used for specific tasks (Logan 2006, Johnson 1976). These sites occur across the area along both the Missouri and Kansas Rivers and their tributaries, providing access to wild resources and water transport. There is also evidence of horticultural plants which suggests gardening (Logan 2006). Some exotic goods have been found in area graves, but not in the quantity of their Illinois or Ohio counterparts (Logan 2006).

Around A.D. 500 the Middle Woodland transition to the Late Woodland occurs. This later period encompasses most of the middle period/ transitional sites in my study. Recent dates for 14DO19 and 14OS314 place those sites just outside the transitional period. The Kansas City Hopewell sequence, the hallmark of the local Middle Woodland, had long been thought to continue until about A.D. 750 (Johnson 1976). Recent redating has pushed this transition earlier, with the cultural components waning at the beginning of the Late Woodland and absent from the record after about A.D. 600 (Logan 2006). The Late period is marked by the emergence of fairly plain, utilitarian ceramics and the emergence of corn and the bow and arrow as the presumed dominant forms of subsistence and weaponry. Logan (2006) states that both of these may have been a response to population growth and associated resource stress. By the end of the Late Woodland both of these transitions are reported to be complete. The validity of this argument for the bow and arrow will be tested in the next chapter.

Immediately following the Late Woodland in the area is the Steed-Kisker phase of the Central Plains tradition, beginning at A.D. 1100 (Roper and Adair 2011). The final two sites in my study (23BN2 and 23PL13) represent this phase. By this time corn agriculture is dominant, though a wide variety of wild foods have also been found at sites dating to this period (Roper 2006). Roper also notes that the sites continue to be located along major waterways. Sites normally contain 2-12 earth lodges which indicate well-established communities in the area.

Site Backgrounds

Here I present basic information about the individual sites in my study including location, age, and basic background. As mentioned, all sites are located in a small area of eastern Kansas and western Missouri. They are presented in chronological order beginning with the earliest and listed in Table 1 and Figure 1.

Early Period

Williamson- 14CF330

Williamson is a multicomponent site located in the Osage Prairie Plain on Eagle Creek in Coffey County, Kansas (Schmits 1987). Excavations were conducted by the Kansas State Historical Society in 1983. It is well stratified, with four distinct stratigraphic units (I-IV). Unit II contains an El Dorado phase Late Archaic occupation. Unit III contains later Plains Woodland and Plains Village materials. Units I and IV did not contain cultural materials. Unit II was the main component of the site, dating to median ages of 1962 B.C. and 1828 B.C. The Late Archaic component indicates a sizable occupation, with twenty-one hearths, two pits, two human burials, and one dog burial. Unit III only contained a few usable points; because of this and the temporal distance between the two occupations only points from Unit II were included. The points in this sample are illustrated in Figure 4.

Figure 4: Williamson site points. Darts (top row), indeterminate dart (second row), indeterminate arrow (third row), arrows (fourth row), used only in Shott (bottom row)

Quarry Creek: 14LV401

The Quarry Creek site is a Kansas City Hopewell site at the confluence of two tributaries of the Missouri River in Leavenworth County, Kansas (Logan 1993). The site was intensively investigated by the 1991 field school from the University of Kansas and Kansas State (Logan 1993). These investigations revealed a large site with 9 features and a large number of artifacts similar to those on other Hopewell sites. There are currently 10 radiocarbon dates for the site. Seven of these dates cluster in the Kansas City Hopewell period, with median probabilities ranging from A.D. 130-478. Three other dates (A.D. 1004, 1086, 1346) have recently been obtained indicating a later occupation of the site. The points for this site are presented in Figure 5. The points classified as indeterminate arrows and arrows look similar to darts. These similarities will be discussed in Chapter 5.

Figure 5: Quarry Creek site points. Darts (top two rows), indeterminate dart (third row), indeterminate arrows (fourth row), arrows (bottom row)

Middle Period

14MM26

The 14MM26 site is a multicomponent site located at the confluence of the Little Bull and Big Bull Creeks in the Hillsdale Reservoir area (Artz et al. 1975). There are two components at the site: Component A which is Late Woodland and Component B which is terminal Middle Woodland. These are well separated and Component B was discovered at the very end of the field season in 1970 by a crew from the University of Kansas. The site included a house, multiple pit features, and artifacts. The points are well documented as to their original location on the site. The points in this sample come from both components, which span the transitional period. There are four dates associated with the site. Component B has four associated dates, A.D. 463, 486, 559, and 863 (Adair 2012). There is some overlap between this component's age and the occupations at Quarry Creek. The sample for this site is included in Figure 6.

Figure 6: 14MM26 site points. Darts (top row) and arrow (bottom row)

Avoca: 14JN332

The Avoca site is a Grasshopper Falls phase Plains Village site on an alluvial terrace overlooking Cross Creek in Jackson County, Kansas (Baugh 1991). It was located during a survey associated with the Cross Creek Watershed Project and was excavated to mitigate impact prior to development. It is a large site, including houses, pits, other cultural features, and artifacts. There are seven radiocarbon dates for the site, generally clustering from A.D. 802-865. There is one outlying date of A.D. 1066. The points for this sample are illustrated in Figure 7.

Figure 7: Avoca site points. Darts (top row) and arrows (bottom row)

Stiles: 14MM13

The Stiles site is a multicomponent site on a terrace within the Hillsdale Lake area in Miami County, Kansas (Rohn and Daniel 1984). The site was first identified in 1965 by Wilfred Husted during a survey of the area by the Smithsonian RBS. It was later investigated as part of the Hillsdale project by Wichita State University. The site includes components attributed to the Plains Woodland, Pomona, and Historic time periods. The two later periods are primarily represented by finds in the plow zone and on the surface. The Plains Woodland component was primarily in situ, and includes a house and multiple pit features with artifacts. Most of the projectile points are associated with the Woodland period. There are at least four points in the 65 recovered from the site that are likely from the later periods based on typology. These points were identified and were removed from the sample. Dates of A.D. 230 and 801 were obtained for the site by Rohn and Daniel (1984). The large difference was attributed to the old wood effect and the investigators put more stock in the later date as being representative of the actual Woodland occupation of the site (Blakeslee and Rohn 1984). More recent dates by Adair are slightly later than the Blakeslee and Rohn date at A.D. 1051, 1051, and 1101 (Adair 2012). The points for this site are illustrated in Figure 8.

Figure 8: Stiles site points. Darts (top two rows), indeterminate arrow (third row), arrows (bottom row)

Zacharias site: 14LV380

The Zacharias site is a multicomponent site in Leavenworth County, Kansas (Logan 2006). This site contains pottery indicating a Grasshopper Falls (my Middle Period) component as well as a later Steed-Kisker (my Late Period) component. Four dates are available for the site:

A.D. 834, 1118, 1127, and 1240. There is no formal report on this site so projectile points have not been assigned to specific components. Assignment is made difficult by the lack of stratigraphic separation between the two components. Indeed, it has been argued that evidence at the site indicates a continuous occupation. These factors impact the relative chronological placement of this sample. A continuous occupation during the period of transition should record that transition and its result. Due to this the site was placed in my Middle Period. The points for this site are illustrated in Figure 9.

Figure 9: Zacharias site points. Dart (top row left), indeterminate dart (top row right), arrows (bottom two rows)

Hatcher site: 14DO19

The Hatcher site is situated in the Clinton Lake Reservoir area in Douglas County, and was originally investigated by Johnson in 1966 and 1967 (Johnson 1968). The site is divided into four areas. Area A contains an intact Clinton phase Woodland component including two house structures. Six dates have been obtained for the site. Area A has dates of A.D. 1228 and 1242, Area C has dates of A.D. 1159 (2 dates), and there are two dates (A.D. 956 and 1085) for which provenience was not given. Points came from all areas of the site. The points for this site are illustrated in Figure 10.

Figure 10: Hatcher site points. Darts (top row) and arrows (bottom row)

Harsch: 14OS314

The Harsch site, 14OS314, is single component site located at a bend in Stevens Creek in Osage County, Kansas (Smith and Birkby 1962). The site contains two houses which were defined by the presence of large concentrations of daub at or near the surface. Many of the artifacts were found at the surface or in the plow zone; owing to many years of disturbance and a fairly shallow depth (house floors were estimated to lie 8-9 inches below surface). There are two available dates, A.D. 1132 and 1195, which support a single occupation of the site. The points for this site are illustrated in Figure 11.

Figure 11: Harsch site points. Darts (top row) and arrows (bottom row)

Late Period

Cloverdale: 23BN2

The Cloverdale site is located on a ridge and floodplain about 58 km north of the Steed-Kisker site in Buchanan County, Missouri (Shippee 1972). The site has been assigned to the Steed-Kisker phase. There is one house associated with the site, located on the ridge overlooking the Missouri River Valley. There is an earlier occupation of the site, but the points included in this sample are only from the later phase. Dates of A.D. 1089 (Adair 2012) and A.D. 1195 (Roper and Adair 2011) have been obtained for the site. This date is at the beginning of the Steed-Kisker phase, and slightly earlier than the later dates of the final two transitional sites.

Steed-Kisker: 23PL13

The type site for the Steed-Kisker phase of the Central Plains Tradition is located about five miles from Kansas in the Missouri River Valley in Platte County, Missouri (Wedel 1943). One of the requirements for sites of this phase is the presence of only arrow points. The site is well dated, with dates of A.D. 1091, 1155, 1172, 1261, and 1279.

Chapter 5: Analysis and Results

Early period

The Williamson site (14CF330) is the earliest site in the group, but when both Thomas and Shott's formulas are applied the results do not follow expectations. As a Late Archaic period site my expectation was that the assemblage should contain only dart points. This is not the case. The classification breakdown for both formulas is as follows (Table 3):

Table 3: Williamson classification of projectile points as dart or arrow

Formula	Dart	Arrow	Indeterminate Dart	Indeterminate Arrow	Unable to use
Thomas	7 (33%)	8 (38%)	1 (5%)	4 (19%)	1 (5%)
Shott	9 (43%)	8 (38%)	3 (14%)	1 (5%)	0 (0%)

The two formulas agree on the majority of the points in this sample (13 of 20 points). This difference is not statistically significant (p=0.5999). In four cases the point was classified as a dart or arrow in one formula and indeterminate trending toward the same in the other. In four cases points were classified entirely differently. Artifact 694 has a broken base which likely influenced the Thomas formula, but did not have an effect on Shott's. The other three have no obvious reason for the disagreement; this may simply reflect the expected error range of both formulas. There is no absolute means to determine which classification is correct. One point could not be used in Thomas's formulas because of breakage. The use of both formulas allowed for the inclusion of this point, as Shott's formula enabled inclusion of the specimen.

I noted in the initial visual inspection that many of the points were small, possibly due to resharpening, material choice, form, and/or stylistic considerations. Many of the points may have been classified as arrow and indeterminate arrow due to this, even though it was expected that this site would contain only darts. However, fewer points are classified as arrows in the Quarry Creek assemblage. This diminishes the hypothesis that the arrow was in sustained use prior to the generally assumed transition (my middle period). It is more likely that small or retouched points were lost or discarded at Williamson. These may or may not have been used as arrow points.

Mixing between components of the site seems unlikely, but can never be entirely ruled out. Williamson does contain multiple components dating to different periods. However, these components were well separated vertically at the site. Each artifact was individually labeled with its artifact number and area, so lab mix-ups are unlikely. Therefore I do not believe that mixing can explain these patterns. However one point matches well with those from later sites and is likely in the sample due to some post-depositional process.

The Quarry Creek site generally conforms to the expectations of a Kansas City Hopewell age site. The majority of points are classified in the dart category with a few assigned to the arrow and indeterminate arrow categories (see Table 4). There is some disagreement between the two formulas, with six of the points classified differently and one being close (an arrow and indeterminate arrow). The difference between the formulas is not statistically significant ($p=0.7395$). Many of the disagreements involve points that Shott's formula indicated as darts and Thomas's indicated as indeterminate arrows. While this is problematic, the fact that points are classified as indeterminate indicates potential overlap and possible concordance, especially when two broken artifacts are considered.

Table 4: Quarry Creek classification of projectile points as dart or arrow

Formula	Dart	Arrow	Indeterminate Dart	Indeterminate Arrow	Unable to use
Thomas	18 (64%)	4 (14%)	1 (4%)	3 (11%)	2 (7%)
Shott	27 (96%)	0 (0%)	0 (0%)	1 (4%)	0 (0%)

Overall the Early Period sites do not provide the control for which the project aimed. However, it does provide a frame of reference and more importantly, it highlights a few of the biggest issues with the methodology. This remains valuable information for comparing with the middle period. It is unlikely that these classification issues will be limited to the early period. These results also suggest that there may have been earlier experimentation with the bow and arrow during the Late Archaic. This could be investigated with other Late Archaic sites. This does not invalidate the conclusions of the transition to be discussed during the middle and late period. The possible experimentation does not appear from my sample to have continued into Kansas City Hopewell times (based on Shott's formula), and therefore can be approached as separate from the later transition.

Middle Period

Overall the middle period sites had a combination of arrow and dart technologies. Somewhat surprisingly, only two points over the entire sample were put into the indeterminate category using Thomas's formulas. This implies that the arrow forms present are actually arrows, and are not dart type/style points used as arrows. There is the possibility that dart points used as arrows, which are arguably short-lived chronologically, may have existed. The assemblage representing the early portion of the middle period was quite small (3 points from 14MM26), so it is difficult to draw any conclusions based on such a small sample. The adoption of new technologies can potentially occur over the space of one or two generations, so this gap is significant. Unfortunately, no other components of the appropriate age, preservation, and with sufficient artifacts were available for this study to help fill the gap. This is a void that can hopefully be filled in the future.

14MM26 has overall agreement between the two formulas, with more darts than arrows (see Table 5). Only one artifact, 7088, is classified differently by the two formulas. This difference is not statistically significant (p=0.7458). There is no obvious reason for this, and like some of the points discussed previously this may be an indication of the error rate incumbent in the method. Three of these points are associated with the earlier occupation and are expected to be darts. The more recently obtained dates for this site primarily cluster during the transition from the early to middle period at A.D. 463-559. The overlap in those early dates explains why 14MM26 more closely resembles Quarry Creek than the other sites in the middle period.

Table 5: 14MM26 classification of projectile points as dart or arrow

Formula	Dart	Arrow	Indeterminate Dart	Indeterminate Arrow	Unable to use
Thomas	3 (75%)	1 (25%)	0 (0%)	0 (0%)	0 (0%)
Shott	4 (100%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)

Avoca (14JN332) has complete agreement between the two formulas over the designation of technologies (see Table 6). This increases the confidence that the point classifications are correct. This site assemblage is dominated by arrows, with 2.5 times more arrows than darts. This is a strong indication for a shift away from darts to arrows, but the sample size is small (n=7).

Table 6: Avoca classification of projectile points as dart or arrow

Formula	Dart	Arrow	Indeterminate Dart	Indeterminate Arrow	Unable to use
Thomas	2 (29%)	5 (71%)	0 (0%)	0 (0%)	0 (0%)
Shott	2 (29%)	5 (71%)	0 (0%)	0 (0%)	0 (0%)

Zacharias (14LV380) continues the trend of increasing arrows from the previous site (see Table 7). In this sample there are two points not classified the same by both formulas. One point, 4588, is identified as a dart in Shott's method but indeterminate dart in Thomas'. There is no obvious reason for this. However, in Thomas' formula there was only a 0.3304 difference between the values, trending towards dart (dart 18.0352 and arrow 17.7048). The difference between the two formulas (p=0.7458) is not statistically significant.

Table 7: Zacharias classification of projectile points as dart or arrow

Formula	Dart	Arrow	Indeterminate Dart	Indeterminate Arrow	Unable to use
Thomas	1 (4%)	22 (92%)	1 (4%)	0 (0%)	0 (0%)
Shott	3 (12.5%)	21 (87.5%)	0 (0%)	0 (0%)	0 (0%)

Stiles (14MM13) shows significant differences between the two formula sets (see Table 8). Two of those differences are close and nearly match, with darts and indeterminate darts classified in both. The differences between the two formulas are not statistically significant (p=0.7273). In two more cases, points are classified as darts in one and indeterminate arrows in the other. The final two are simply classified as different technologies. One of these had a broken distal end that likely impacted Thomas' formula enough to contradict Shott's formula, for which the measurement was unaffected. The second difference of opinion has no discernible cause, and it may simply reflect the error ranges of the methods.

This site diverges from the previous trend, with nearly an even representation of darts and arrows. The assemblage is much larger than Avoca (24 points versus 7) and does not contain a later component like Zacharias. These factors may make the assemblage more representative of the period. The assemblage does have a strong co-occurrence of the two types of points, indicating that both technologies were in use, presumably concurrently, at the site.

Table 8: Stiles classification of projectile points as dart or arrow

Formula	Dart	Arrow	Indeterminate Dart	Indeterminate Arrow	Unable to use
Thomas	16 (55%)	12 (41%)	0 (0%)	1 (3%)	0 (0%)
Shott	12 (41%)	14 (48%)	2 (7%)	1 (3%)	0 (0%)

The Hatcher site (14DO19) has more artifacts classified as arrows than darts (see Table 9). There is one difference between the two formulas; artifact 733 is identified using Thomas formula as a dart, but using Shott's formula as an indeterminate arrow. This difference is not statistically significant (p=0.8223). There is nothing to indicate an error in the more attribute-heavy Thomas formula. In that instance the dart formula yields a value of 6.8238 and the arrow formula yields a value of 2.228, a difference of 4.5958. This is a firm classification. Given this, the Thomas designation of dart is more likely to be correct. Both formulas indicate a slightly larger number of arrows than darts. The difference is not as great as in some of the other sites, and may reflect the small size of the Hatcher site sample (n=9).

Table 9 Hatcher classification of projectile points as dart or arrow

Formula	Dart	Arrow	Indeterminate Dart	Indeterminate Arrow	Unable to use
Thomas	2 (40%)	3 (60%)	0 (0%)	0 (0%)	0 (0%)
Shott	1 (20%)	3 (60%)	0 (0%)	1 (20%)	0 (0%)

The final site in the middle period, Harsch (14OS314), consistently has more points classified as arrows than darts. This sample, shown in Table 9, includes 2 darts and 7 arrows according to both formula sets, with no variance between the two formulas. As with all of the other sites in this period there is a mix of technologies.

Table 10: Harsch classification of projectile points as dart or arrow

Formula	Dart	Arrow	Indeterminate Dart	Indeterminate Arrow	Unable to use
Thomas	2 (22%)	7 (78%)	0 (0%)	0 (0%)	0 (0%)
Shott	2 (22%)	7 (78%)	0 (0%)	0 (0%)	0 (0%)

Late Period

Both of the post-transitional sites, Cloverdale (23BN2) and Steed-Kisker (23PL13) conform to the expectations of that time period, that the technological system for this period is based on the bow and arrow. There is some overlap between the dates of these sites and the latest dates on the late transitional sites. This may be indicative of a difference in the timing of the transition between the Late Woodland adaptations (which had a mix of technologies) and the Steed-Kisker phase (in which the bow and arrow was the sole hunting technology).

The Cloverdale sample follows the expected trend (see Table 11); however, it does exhibit one interesting difference between the Thomas and Shott formulas- two points (0731 and 0751) are in the indeterminate arrow category. This difference is not statistically significant (p=0.7838). There are no visible alterations to the artifacts to explain this. But even in the indeterminate category the fact that they are classified close to the arrows supports the rest of the sample.

Table 11: Cloverdale classification of projectile points as dart or arrow

Formula	Dart	Arrow	Indeterminate Dart	Indeterminate Arrow	Unable to use
Thomas	0 (0%)	68 (97%)	0 (0%)	2 (3%)	0(0%)
Shott	0 (0%)	70 (100%)	0 (0%)	0 (0%)	0 (0%)

The Steed-Kisker sample has agreement between the formulas, these projectile points are all classified as arrows (see Table 12). This follows expectations and supports the correspondence of the methods.

Table 12: Steed-Kisker classification of projectile points as dart or arrow

Formula	Dart	Arrow	Indeterminate Dart	Indeterminate Arrow	Unable to use
Thomas	0 (0%)	42 (100%)	0 (0%)	0 (0%)	0 (0%)
Shott	0 (0%)	42 (100%)	0 (0%)	0 (0%)	0 (0%)

Period Comparisons

The study sample data generally conform to expectations: the early period includes mostly dart points, the middle period is mixed but apparently includes an increasing use of arrows, and during the late period the arrow is apparently the only point form (see Figures 12, 13 and 14 and Table 13). There were a few surprises, however, and these may highlight questions for future research.

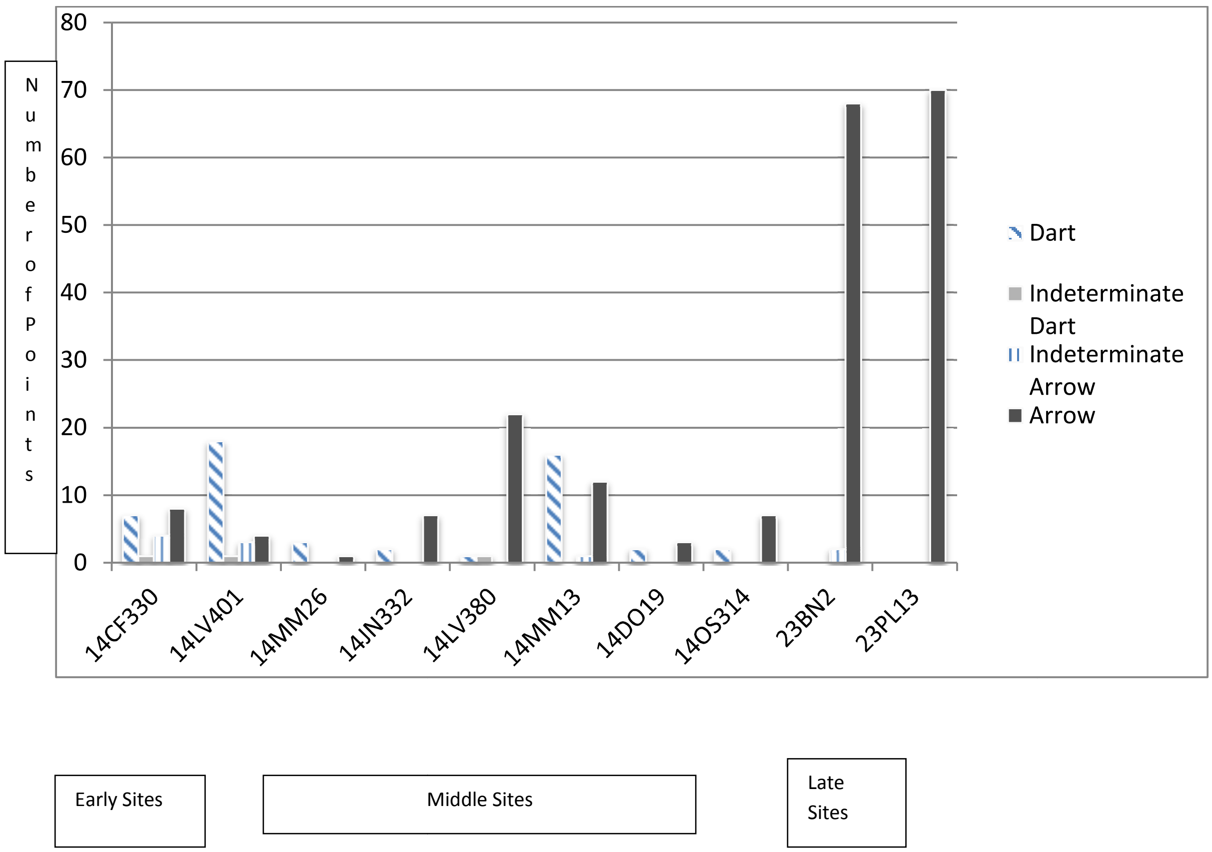

Figure 12: Graph of trends in number of points (Thomas formula)

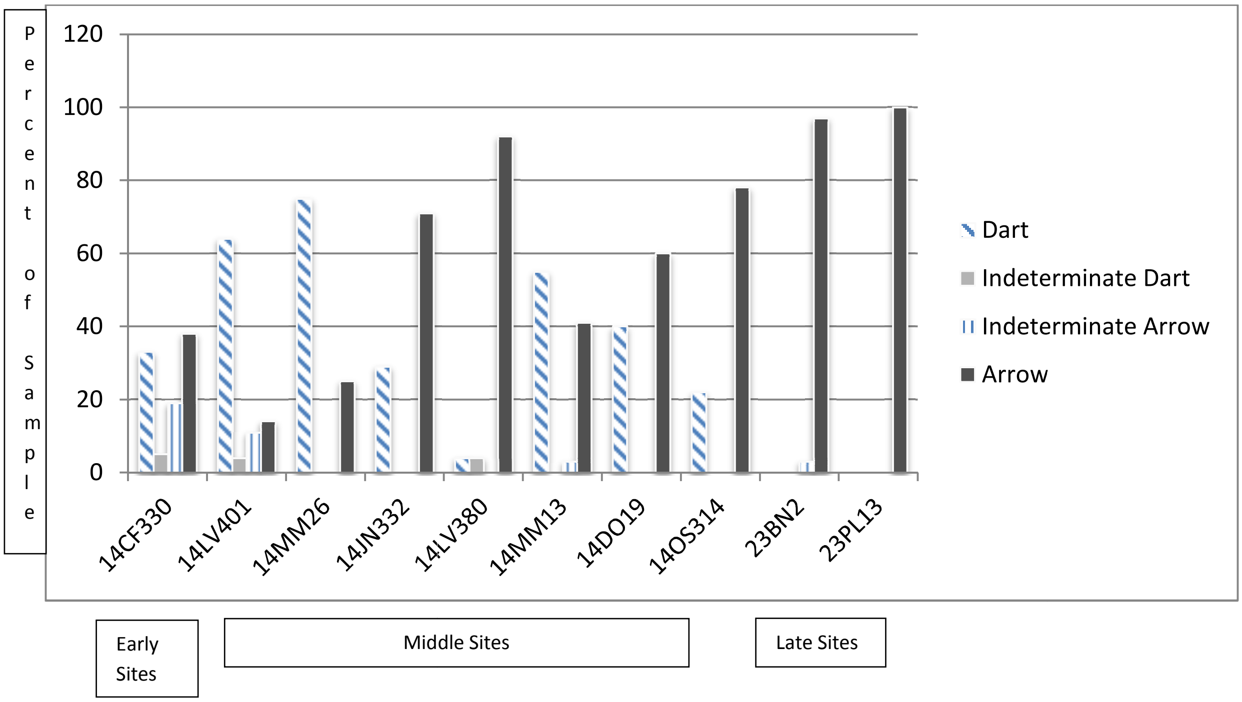

Figure 13: Percentages of each technology by site (Thomas Formula)

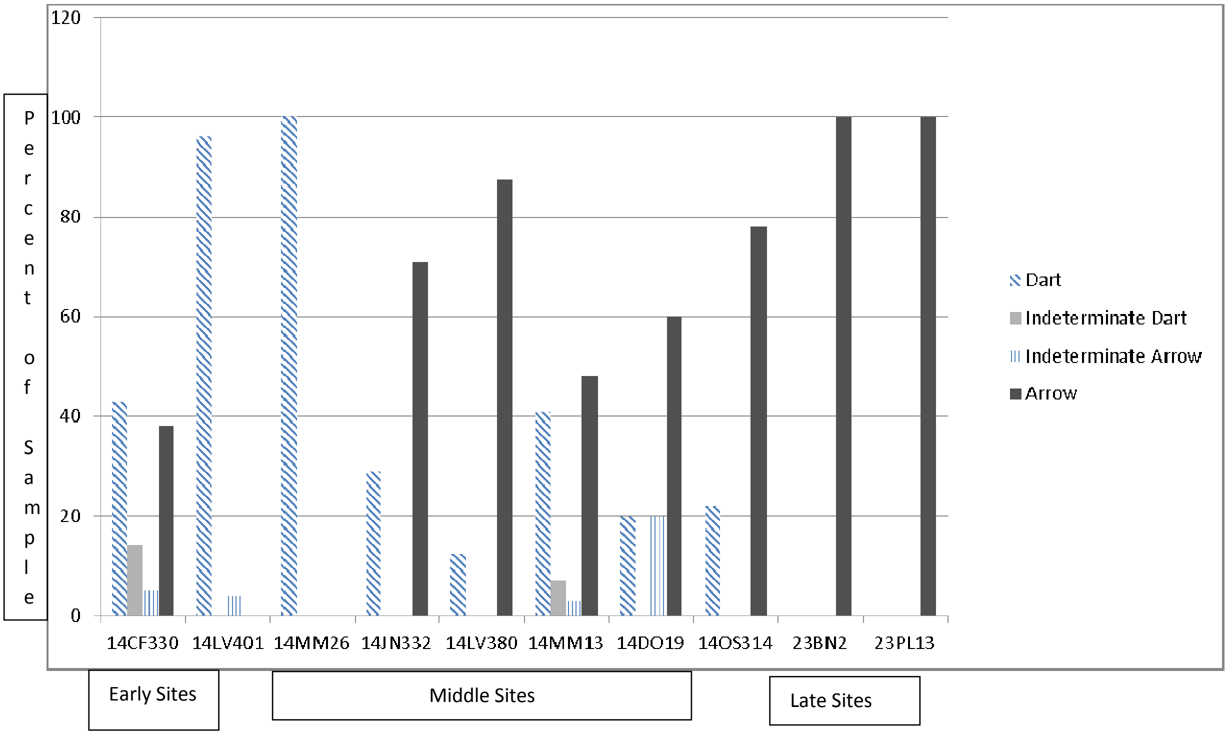

Figure 14: Percentages of each technology by site (Shott Formula)

The three previous figures illustrate some of the main findings of this study. Darts typically compose the majority of the earlier sites, including both early period sites and 14MM26, the earliest middle period site. The other five middle period sites contain a mix of darts and arrow, though the amounts and percentages of each vary by site. Finally, there is a jump in both numbers of and percentages (21% and 23%) of arrows between 14OS314 and 23BN2.

Table 13: Technologies by period with Thomas and Shott formulas

Technology Classification	Early Period-Thomas (1962 B.C.-A.D. 478)	Middle Period-Thomas (A.D. 463-1242)	Late Period-Thomas (A.D. 1089-1279)	Early Period-Shott (1962 B.C.-A.D.478)	Middle Period-Shott (A.D. 463-1242)	Late Period- Shott (A.D. 1089-1279)
Dart	25 (54%)	26 (33%)	0 (0%)	36 (16%)	24 (31%)	0 (0%)
Indeterminate Dart	2 (4%)	1 (1%)	0 (0%)	3 (6%)	2 (2.5%)	0 (0%)
Indeterminate Arrow	7 (15%)	1 (1%)	2 (2%)	2 (4%)	2 (2.5%)	0 (0%)
Arrow	12 (26%)	50 (64%)	110 (98%)	8 (16%)	50 (64%)	112 (100%)
Totals	46	78	112	49	78	112

There is some difference in how each formula identified the points. However, P-values from T-tests are not statistically significant for the early (0.3249) middle (0.1747) and late (0.4089) periods.

When Williamson and Quarry Creek are combined the total data provide a window into the period early in the transition from atlatl to bow and arrow. One dart point and one arrow can be added to the totals in Table 13. These two points were too fragmentary to utilize Thomas' formulas, but were intact enough in the shoulder to use Shott's formulas. With these the 29:14 ratio of confirmed darts to arrows suggests that darts dominated arrows by more than 2:1 in this period. These two sets of points are illustrated in Figure 15. This is supported by the large size of some of the points, as these are less likely to be misidentified. This pattern remains in the beginning of the middle period, as a similar ratio is found at 14MM26 (3:1 in Thomas' formula and 4:0 in Shott's). It is important to remember that some of the points identified as arrows were the appropriate size to function in either system. Even so, it is likely that at least some of these points may have functioned solely as arrows. Given that many of the arrows were from the Williamson sample this would indicate a much earlier use of the bow and arrow system than previously argued. This is a difficult position to defend given that the Quarry Creek assemblage was not similar. It is possible that these sites represent distinct groups that adopted the bow and arrow at different rates. But to truly defend such an early introduction and partial adoption of bow and arrow technology more sites dating directly before, during, and after Williamson need to be analyzed. This is especially important given that roughly 20 percent of known dart points were incorrectly classified by Thomas in his original study (1978). Therefore, this interpretation for the early introduction of the bow and arrow will not be argued for this particular sample at this time. The pattern may represent some experimentation with the bow and arrow in the Late Archaic, issues with the formulas, the use of very small dart points suitable for use on arrows, intense re-use of points or any combination of these factors. And as previously mentioned, any experimentation with or adoption of the bow and arrow apparently does not continue in the later sample and therefore does not impact the discussion of the later shift.

Figure 15: Early period darts and arrows. Top, Early Darts (Top) Early Arrows (Bottom)

There are nine points in the early period which are classified as indeterminate. These points were either designed small or were simply resharpened to their small size. Either way, the impact on what enters the record is the same (assuming small points are not further reduced through resharpening). It is important to remember that what we recover may not be what the artifact looked like during most of its functional life (Rondeau 1996). We should not assume that all or most tools represent new or fairly new tools. It is likely that the points classified as indeterminate, including those that are closer to arrows, were reworked at least once, reducing size in such a way that the formulas may not accurately identify the original form. Such reduction through resharpening events can be difficult to recognize macroscopically. It is possible that under a microscope some or even all of these points would show evidence of such events. It is possible that one arrow point might be intrusive despite the general control of the Williamson site. It is very different in form and likely function than the others in the sample.

In conclusion, the Early Period sample shows some divergence from the expectation of a total reliance on dart technology. However, the majority of points are classified as darts, especially when the indeterminate points are excluded from the sample. The early period is a reference point to compare the transitional period, but could itself represent a period of transition.

The middle period diverges from the early period in a number of ways. While certain trends through time were visible one trend stands out when the sites are combined: arrows are almost twice as prevalent as darts (26 darts to 50 arrows). The darts and arrows are illustrated in Figure 16. This, along with the fact that every sample had at least one representative of each technology, indicates that while the dart held on as a viable hunting technology throughout the transitional period, the arrow became increasingly popular and dominant. This is not unexpected. New technologies, if they are successful, tend to spread quickly though some segments of society may tend to hold on to the older, more traditional forms of technology. It is possible, if not likely, that some segments of society (especially the young) were more likely to adapt to the use of the new technology than their older relatives. This can be seen today with many technological innovations in our own society. Younger people also may have had an advantage in that a smaller amount of people relied on them for provisioning or protection. This is speculative, but may have influenced the rate of transition between the two technologies.

Figure 16: Middle period darts and arrows. Middle period darts (Top) Middle period arrows (Bottom)

It is also important to note that into ethnohistoric times a version of the atlatl was being used in religious ceremonies (Hall 1980). This implies that in the past the technology may have had a ritual as well as practical function. This is possibly one reason that atlatls appear to continue in use for so long. If ritual significance was imbued in their hunting weaponry it is possible that people may simply add a new technological form (in this case the bow and arrow) into their more traditional and sacred ways of hunting. This model has some humanistic appeal over simply abandoning the traditional technology. If so, this transition may relate not only to a change in food getting technology but a change in ritual life as well. Conversely, it is possible that as the atlatl was phased out as a hunting technology it was incorporated into religious ritual. Either way, it is important to recognize and consider the broader systemic impact of such a significant technological change.

As mentioned, only two of the 78 points in the middle period were classified as indeterminate. This implies that the points used in the two systems were fairly distinct from each other. The visual analysis supports this statement and unlike, the Williamson sample, most points appeared to clearly belong to one category. This may counter the suggestions that dart points were simply being modified for use in the new system. If that were the case we might expect a higher percentage of the sample to be classified in the indeterminate category.

The late period, as noted, follows the expectation of being solely arrows (a sample of which is illustrated in Figure 17). Only two of the 112 points in this period are not definitely categorized as arrows. These two indeterminate points visually conform to the expectation of arrows. It is likely that are just large arrow points that read as indeterminate in Thomas's formula, even though they were identified as arrows using Shott's formula. Therefore, it is argued that the entire sample from this period represents arrows. This indicates that shortly after A.D. 1000 all individuals were using bow and arrow technology.

Figure 17: Some late period arrows

The transition from atlatl to bow and arrow was apparently an extended process followed by an abrupt change about A.D. 1000. It appears from the current sample to have taken hundreds of years to complete the transition. This may simply reflect the longevity of the atlatl and dart as hunting systems in the New World. The atlatl was adaptable enough to last through the extinction of the megafauna and the subsequent environmental and food supply changes during thousands of years of the Holocene. Therefore it is reasonable to assume that any technology that replaced it would have needed some selective advantage and might not take total hold of the weaponry technological niche quickly.

There is one important point about the two technologies that must be discussed: fewer darts are assumed to have been carried (and produced) by individual hunters than arrows. One of the often discussed advantages of the bow and arrow system is the ability to carry numerous arrows along with the bow (Hamilton 1982). Because of the size of the atlatl and darts it is cumbersome to carry more than a couple of extra darts (though more foreshafts likely were carried). This key difference between the two technological systems has the potential to greatly impact the resulting archaeological record and its analysis. Assuming that an equal intensity of use of these two systems should result in an equal amount of dart points and arrow points would be unrealistic in light of these facts. There is no established ratio of the number of arrows versus darts used or needed that can be simply projected into the past. Therefore we cannot assume that there were twice as many people using the new technology simply because there are twice as many arrow points as dart points. It is, however, valid to contend that there were likely an increasing number of people using the bow and arrow than the atlatl and dart.

The small size of many of the Middle Period site samples is a drawback to characterizing exactly how the transition in weaponry happened. Many of the sites of this time period in the study area do not have long-term occupations that would produce a large sample of projectile points. Taken as a whole the transitional sites provide information about the length and character of the atlatl and dart to bow and arrow transition.

Applying General Theories

As discussed in Chapter 2, various theories have been presented to explain what drove the transition from the atlatl and dart to bow and arrow in specific regions of North America. The following section will examine each of these theories given the evidence presented in this chapter.

The first theory presented indicated that the bow and arrow was simply a better, more efficient technology. Groups would therefore quickly abandon their previous technologies for the bow and arrow soon after they were introduced to it. Given the period of mixed assemblages, continuing at least 500 years, we are able to dismiss this theory as an explanation for the evidence in the study area. The persistence of the atlatl and dart in these assemblages indicates that both technologies had their place in the toolkit for a prolonged period before replacement. If the bow and arrow were simply better it is unlikely that such a pattern would persist in the archaeological record.

Agriculture, another often argued motivator of the transition, does not appear to necessarily have a causal relationship with the transition based on evidence from these sites. The paleoethnobotanical data for this group of sites varies in its completeness, which makes the precise patterns of corn use on these sites difficult to track. Generally during this period domestic crops did gain importance in the diet during this period. So while the introduction of agriculture and the documented shift to the bow and arrow are both taking place through parts of the same time frame, it is too simplistic to argue causation of one with the other.

Warfare, which appears to have had some impact in parts of the Southeast, does not appear to have much of an impact here. The site reports do not indicate any trends towards fortifications during the transition. This is important, since it is possible that groups would focus on the defense of their settlements before worrying about changing their weaponry. Also, this theory indicates that the transition should happen quickly. As presented, the transition appears to be too gradual to provide support for this model as a sole or driving cause throughout the transition. However, warfare may have played a part in the completion of the transition around A.D. 1000.

The final two explanations presented in Chapter 2, changes in prey selection and ecological change, have more potential than the previous three. Unfortunately, the necessary supporting evidence is not such that either, or both, of these can be evaluated as a major influence spurring on the transition.

To confirm the hypothesis of changes in prey selection with this technological change a systematic and detailed study would need to be made of the fauna material recovered from all sites (the amount and quality of these data for the sites varies). Available data do not indicate that any major prey species were no longer acquired or that new species suddenly took a central role. Further work could indicate whether changes in prey selection happened over the period of transition. During this period there is a general trend towards increasing sedentism and a decrease in prey size. So at present this hypothesis cannot be dismissed or confirmed as a major or contributing factor to this transition.

The final proposal, ecological change, also cannot be confirmed or dismissed with the available evidence. It would require a very fine scaled paleoecological record. Some proxy measures, such as botanical or faunal remains, could be used to partially reconstruct such changes. However such a study is not available at this time and therefore no confirmation or dismissal can be made. Logically, however, this theory best fits the evidence of a gradual change between the two technologies. As the ecological environment altered around them (either due to environmental and/ or cultural factors) groups would seek to adapt to those changes. The bow and arrow may have been somehow better suited to dealing with those changes, so some in these communities began to use the bow and arrow to their advantage. The ecological change may not have been very rapid if correlated with this transition, given the more than 500 year transition period evident in the current data. A rapid change should also be more apparent in other parts of the archaeological record. If large prey decreased in availability focus would have shifted more toward small and medium sized prey. Such a change might necessitate changes in the weapons used in hunting. This change might also appear archaeologically as a change in prey selection. However well this may fit the model, there is simply not evidence to support a claim that ecological changes sparked or selected for the transition from the atlatl and dart to the bow and arrow. The transition may simply reflect the diffusion and gradual adoption of a new technology with a variety of important advantages.

Chapter 6: Conclusions and Further Research

This study suggests that the transition from the atlatl and dart to the bow and arrow was gradual in eastern Kansas and western Missouri. For a period of more than 500 years both technologies remained in use as groups appear to concurrently use their atlatls alongside bows and arrows. This transition was not standardized across the study area. While all middle period sites did contain both technologies, the proportions in each varied. The small sample size of many of the sites probably impacted these figures. This gradual transition indicates that there was no dramatic pressure to quickly adopt the new technology. There was undoubtedly some kind of selective pressure, or the transition may not have happened at all. But this worked at a varying pace across the region. Stiles (14MM13) with almost equal numbers of points classified as darts and arrows, stands out in this respect. It is important to remember, however, that individuals would likely use many more arrow points than dart points. Because more arrows than darts would be used by individuals, there is no one-to-one correlation of people using each technology.

It is impossible to reconstruct the number of atlatls and bows in use at any given site or point in time, other than in relative terms. These components were occupied for significant periods of time, from weeks to months to years. This fact creates an archaeological record that does not record a snapshot of the group at a single moment. Rather, these sites record the use of the atlatl and bow throughout their occupation. It is therefore more prudent to speak of the presence and absence and the relative abundance of these technologies.

This project has illuminated several areas that would benefit from future research. The early period, originally designated as a control, produced some interesting results from the Williamson site. Because there were only two sites in the early period, it was not possible to determine if those results were anomalous or indicative of an earlier than expected introduction of the bow and arrow. Expanding the early period set to include additional well dated Late Archaic assemblages and Middle Archaic assemblages would provide firmer information on this problem.

It would also be interesting to add to the collection of sites in the transition period. By expanding the study area, perhaps more could be learned about the nature of the transition, especially if those sites contained large and well dated assemblages of points. It would also be interesting to study a set of sites from elsewhere in the Plains to compare the record for the transition from atlatl to bow.

A typological study of the points would permit more to be said about how forms were chosen for early arrow points. As discussed in Chapter 3, it is possible that either local or exotic artifact lineages were used to model the new arrow points. While the Shott and Thomas formulas can be used to categorize the points by technology, they do not give us insight into how these points were created or designed. In visual examination it appeared that some points were typologically similar in the early and middle period. Their similarities could be better understood by using a typological analysis.

Documenting the transition and rate of change between two technologies is just the first step. Explaining the transition from atlatl and dart to bow and arrow is of great importance for understanding the people of this period in prehistory. While models to explain the transition have been presented, the situation is complicated and more than one factor was probably involved during the time of this transition. Evaluating the fauna and flora from each site to determine the diet and ecological background would aid in placing the transition in context. It would also necessitate documenting the local environmental conditions and changes across the study area throughout the time of interest.

It is difficult to designate what prompted this transition, but it is unlikely that there was a single cause. A few of the general theories, notably agriculture and changes in prey selection, were likely contributing factors. However these forces did not operate in a vacuum. The transition from atlatl and dart to bow and arrow was likely just one part of a suite of changes that took place in this area from A.D. 500-1200.

Appendix: Data Table

Site	Artifact number	Level	Piece Plot Cooridinates	Feature	Field #	Length	Base Width	Neck Width	Shoulder Width	Thickness	Max width	NOTES	Thomas dart	Thomas arrow	MLT	Shott dart	Shott arrow	MLT2	AGREE?
14CF330	694				167	47.2	10.4	11.3	21.2	6	21.2	BROKEN BASE	14.5138	14.7418	I-A	12.83	11.648	D	N
14CF330	132				139	64.7	28.8	25.2	45.8	12.9	45.8	SNYDER	49.2378	37.13	D	47.27	33.542	D	Y
14CF330	9.8		6N 7W 6.5BD 5.5BS		179	52.9	14.9	13.8	21.3	9.1	21.3		18.5495	18.6178	I-A	12.97	11.737	D	N
14CF330	696		0N 1W 5.15BD 6.95BS			32.3	13	12.4	18.8	5.8	18.8		10.6828	12.0672	A	9.47	9.512	I-A	C
14CF330	1002		6N 1.8W 4.15BD 2.15BS		318	31	11.4	6.6	10.3	2.9	11.4		1.678	4.702	A	-2.43	1.947	A	Y
14CF330	900				173	40.6	16.2	13.1	28.9	6.6	28.9	DIST. FROM E WALL	24.5712	18.5516	D	23.61	18.501	D	Y
14CF330	711		3S 1.1W 6.3BD 5.25BS		168	51.9	10.8	11.4	17.8	5.9	17.8		13.4248	13.5864	I-A	8.07	8.622	A	C
14CF330	904		4N 4.1W 5.25BD 4.25BS		180	59.3	14.2	11.4	22.8	7.1	22.8		21.3114	17.7724	D	15.07	13.072	D	Y
14CF330	989		2.3N 0E 5BD 4BS		219	47.2	10.9	9.2	17	6.5	17		12.303	12.7504	I-A	6.95	7.91	A	C
14CF330	937		1.7N 2E 4BS		200	43.8	14.4	11.6	19.3	8.1	19.3		14.5273	15.3602	A	10.17	9.957	I-D	N
14CF330	284		6.6N 7.7W 4.1BD 3.1BS		154	43	12.2	9.2	15.2	5.3	15.2		8.874	10.414	A	4.43	6.308	A	Y
14CF330	609		3-3.5BS		161	37.7	15.7	12.2	16	7	12.2	BROKEN DISTAL END	4.26	10.5424	A	5.55	7.02	A	Y
14CF330	173		1.5N 1W 5BD 4BS		141	65.1		10.3	17.5	8.1		BROKEN AT NECK			X	7.65	8.355	A	X
14CF330	286				146	38.5	14.4	11.8	23.4	6.3	23.4		17.7212	15.2024	D	15.91	13.606	D	Y
14CF330	110		0N 7.6W 4.4BD 3.4BS		101	54.2	14	12.8	22.1	6.5	22.1		18.9617	16.6738	D	14.09	12.449	D	Y
14CF330	924		0N 2.85W 5.45BD 4.5BS		201	26.6	8.1	6.7	14.7	5	14.7		5.6282	7.6136	A	3.73	5.863	A	Y
14CF330	265		4.2N 2.1E 3.9BD 2.9BS		119	31.5	13.9	10.8	17.6	5.5	17.6		9.3256	10.8152	A	7.79	8.444	A	Y
14CF330	925				202	49.6	12.5	13.7	19.8	5.9	19.8		14.8895	14.7702	I-D	10.87	10.402	I-D	Y
14CF330	907		3.5N 6W 4.5BD 3.5BS		194	38.7	10.8	8	18.9	6.6	18.9		13.3013	12.555	D	9.61	9.601	I-D	C
14CF330	1030		3.6N 3.4E 5.6BD 3.6BS		327	33.3	23.9	20.4	22.8	5.6	23.9		15.1539	16.1114	A	15.07	13.072	D	N
14CF330	170		3.4S 3W 3BD 2BS		113	43	17.3	16.5	26.4	5.5	26.4		20.8205	17.413	D	20.11	16.276	D	Y
14LV401	4135-91		87.2N 150.06E	5		69	28.7	20.5	26.5	8.7	28.7		28.8424	24.9228	D	20.25	16.365	D	Y
14LV401	1989/91	1	80.09N 168.76E 98.23D			71.1	24.6	17.5	32.8	10.6	32.8		35.5915	28.0762	D	29.07	21.972	D	Y
14LV401	1246-91	6	99.82N 172.99E 97.65D			44.9	15.8	14.7	22.9	4.6	22.9		17.0088	14.8104	D	15.21	13.161	D	Y
14LV401	1486/91	3	79.56N 169.92E 97.99D		370	62.5	13.1	19.3	25.6	10.6	25.6	Base broken	24.8973	24.1486	D	18.99	15.564	D	Y
14LV401	2334/91	5	89.0N 160.35E 95.27D		925	45.8	25.4	20.6	22.6	8.3	25.4		20.3252	20.542	I-A	14.79	12.894	D	N
14LV401	3213-91	5	91N 168E 98.23D			34.8	18.6	17.9	26.3	8.9	26.3	BROKEN DISTAL END	20.179	19.7176	I-A	19.97	16.187	D	N
14LV401	3860-91		90-91.3N 144E 98.12D			21.1	20.2	16.9	25.7	6.8	25.7		16.2802	15.9276	I-D	19.13	15.653	D	C
14LV401	2850-91	1			1100	45.6	26	19.3	29.4	19.3	29.4	SURFACE	29.7095	31.6262	A	24.31	18.946	D	N
14LV401	3559-9	2	90.15N 143.76E 99.36D		530	65.6	22.6	17.5	24.3	8.7	24.3		23.5702	21.8456	I-A	17.17	14.407	D	N
14LV401	2189/91	5	87N 160E 98.41-98.31D		818	42.9	20.8	16.8	18.5	6.6	20.8		14.418	15.7848	A	9.05	9.245	I-A	C
14LV401	1972/91	5	79.23N 168.53E 97.99D			36.5			24	7		BASE AND 1 NOTCH MISSING			X	16.75	14.14	D	X
14LV401	3945-9	1	88N 161E 98.8D			34.4	21.1	18.3	25.7	10.4	25.7	TIP MISSING	19.8796	20.774	A	19.13	15.653	D	N
14LV401	2728/91	3	85.66N 168.62E 98.13D			60.9	25.1	18.8	25.7	9.5	25.7		24.3973	22.9654	D	19.13	15.653	D	Y
14LV401	4278/91	4	84.98N 168.13E 97.42	7	W1055	49.7	16.7		27.3	9.3		PREFORM- ONLY 1 NOTCH			X	21.37	17.077	D	X
14LV401	2340-91	1	81.65N 168.91E 98.10D		738	48.5	28.9	21.6	30.2	7.7	30.2		26.1586	22.7852	D	25.43	19.658	D	Y
14LV401	0648/91		93.30N 168.60E			60.2	28.1	22.2	27.5	7.3	28.1	SURFACE	25.5371	22.8446	D	21.65	17.255	D	Y
14LV401	3520-91	3	97.75N 130.93E 99.17		1095	60.3	27.5	21.2	31	8.2	31	TIP MISSING	29.6262	24.782	D	26.55	20.37	D	Y
14LV401	4249/91	3	84.37N 168.99E 97.47D	7	1015	55.5	28.1	22.1	29.2	7	29.2		25.8837	22.5734	D	24.03	18.768	D	Y
14LV401	2305/91	1	88.31N 160.95E 98.4D		877	53.7	23.7	19.7	30.8	6.8	30.8		27.9301	22.4446	D	26.27	20.192	D	Y
14LV401	4181/97	1	84.55N 168.45E 97.82D	7	906	66.7	23.9	17	28.1	7.5	28.1		27.9971	22.6066	D	22.49	17.789	D	Y
14LV401	0798/91	4	95.96N 151.84E 98.52D		159	53.2	23.8	18	22.9	8.6	23.8		20.4858	20.292	D	15.21	13.161	D	Y
14LV401	3192/91	4	91.18N 168.39E 98.28D		746	42	27.2	19.7	29.7	8.3	29.7	MISSING TIP	24.993	21.96	D	24.73	19.213	D	Y
14LV401	4002-9	4	88.24N 161.39E 98.42D		991	63	26.8	22	25.3	8.9	26.8		25.1688	23.8756	D	18.57	15.297	D	Y
14LV401	1655/91	4	93.92N 168.27E 98.26D		536	38.2	23.6	24.7	31.6	13.8	24.7	MISSING DISTAL END	19.2946	25.0216	A	27.39	20.904	D	N
14LV401	1830-91	4	87.58N 161.78E 98.40D		673	38.7	16.4	17.5	32.1	8.1	32.1	MISSING DISTAL END	27.6768	22.088	D	28.09	21.349	D	Y
14LV401	3111-91	3	90.75N 168.57E 98.37D		574A	46.1	26.2	20.5	28.5	7.4	28.5	BROKEN TP	23.7866	21.2324	D	23.05	18.145	D	Y
14LV401	3854-91	4	91.21N 144.78E 99.04D		836	53.5	18.8	20.2	32.2	7.5	32.2		29.7424	23.7928	D	28.23	21.438	D	Y
14LV401	4236/91	3	84.27N 168.42E 97.55D	7	957	49.6	26.3	20.3	28.1	6.4	28.1		23.6152	20.5156	D	22.49	17.789	D	Y

14LV380	27588	3	273.18N 207.18E 100.70D		19.3	5.6	5.1	8	2.6	8	BROKEN BASE	-4.4017	1.2602	A	-5.65	-0.1	A	Y
14LV380	238088	3	275N 207E		20.4	1.9	4.4	8.8	3.4	8.8		-2.7612	2.2964	A	-4.53	0.612	A	Y
14LV380	20388		273N 203E 100.595D		22.2	6.7	4.5	10.7	3.3	10.7		-0.1948	3.3188	A	-1.87	2.303	A	Y
14LV380	58288		288N 183E		24.7	12	6.4	10.2	2.4	12	SURFACE	1.0652	3.8288	A	-2.57	1.858	A	Y
14LV380	20889		290.76N 183.11E 100.8D		25.4	7.3	4.5	9.8	3.7	9.8		-0.5209	3.587	A	-3.13	1.502	A	Y
14LV380	34289		237.96N 173.49E 100.87D		17.6	8.1	7.6	8.6	2.2	8.6		-4.7126	1.548	A	-4.81	0.434	A	Y
14LV380	111589	2	293N 180E 100.9D		17.6	12	6.3	8.2	2.6	12		-0.1689	3.2134	A	-5.37	0.078	A	Y
14LV380	55988			559	14.3	11.8	7.7	9	2.4	11.8	SURFACE	-1.4209	2.8898	A	-4.25	0.79	A	Y
14LV380	125189	2	292N 182E 100.9D		21.9	10.9	5.5	9.2	1.9	10.9		-0.782	2.3848	A	-3.97	0.968	A	Y
14LV380	57688			576	27.6	12.3	8.7	10.4	3.1	12.3	SURFACE	1.7334	5.38	A	-2.29	2.036	A	Y
14LV380	52788		276.69N 205.91E 100.49D		42.3	15.4	16.6	21.6	6.8	21.6	UNFINISHED	15.3922	16.226	A	13.39	12.004	D	N
14LV380	217088		276N 205E		23	12.6	5.9	9.6	2.3	12.6	SURFACE	1.5409	3.7338	A	-3.41	1.324	A	Y
14LV380	4288		274.04N 208.42E 100.55D	42	36.1	16.2	13.6	24.6	5.1	24.6	TIP AND ONE EAR MISSIN	17.8442	14.8556	D	17.59	14.674	D	Y
14LV380	44089		236.21N 173.11E 100.74D	440	15	8.9	4.5	6.9	1.1	8.9		-4.5798	-0.2056	A	-7.19	-1.079	A	Y
14LV380	250288	1	291N 183E		19.9	10.3	5.2	8.8	4.2	10.3		-0.9125	3.8098	A	-4.53	0.612	A	Y
14LV380	125289	2	292N 182E 100.90D		13.3	11.4	7.2	8.6	2.1	11.4		-2.097	2.2276	A	-4.81	0.434	A	Y
14LV380	268788	3	296N 183E		21.2	13.7	5.7	8.6	3.4	13.7		3.0038	4.964	A	-4.81	0.434	A	Y
14LV380	58188		280N 208E	581	19.8	13	6.7	11.6	2.9	13	BROKEN TIP	1.4781	4.2658	A	-0.61	3.104	A	Y
14LV380	149489		273N 215E		17.7	10.7	6.7	8.9	3.2	10.7	SURFACE	-1.5706	3.2172	A	-4.39	0.701	A	Y
14LV380	226888	2	276N 206E		19.4	6.2	6.9	15.3	3.9	15.3	DISTAL END BROKEN	4.5218	6.2104	A	4.57	6.397	A	Y
14LV380	120488	1	272N 227E		17.9	9.9	6	6.6	2.9	9.9		-2.4585	2.4538	A	-7.61	-1.346	A	Y
14LV380					24.2	11.3	8.5	12.6	5.3	12.6	SURFACE, NEAR AREA 4	2.3627	7.0118	A	0.79	3.994	A	Y
14LV380	233388	2	274N 207E		22.7	12.4	7	8	3.2	12.4		1.351	4.6204	A	-5.65	-0.1	A	Y
14LV380	4588	4	274.09N 208.24E 100.51D		40.7	21.6	17.8	24.2	7	24.2		18.0352	17.7048	I-D	17.03	14.318	D	C
14DO19	733				20.6	19	16	18.2	3	19		6.8238	2.228	D	8.63	8.978	I-A	N
14DO19	726				20.4	6.4	6	12.8	3.7	12.8	BASE BROKEN AT MIDPOI	1.8196	4.778	A	1.07	4.172	A	Y
14DO19	639				30	19.1	13.6	17.8	6	19.1		10.4227	12.3894	A	8.07	8.622	A	Y
14DO19	733				43.6	11.9	12.9	24.9	7.5	24.9		20.7126	17.7304	D	18.01	14.941	D	Y
14DO19	732				21.8	8.1	7.3	15.2	2.4	15.2		4.1753	5.2122	A	4.43	6.308	A	Y
14MM26	7088				41.3	16.9	13.4	21.5	9.3	21.5		16.7773	17.5462	A	13.25	11.915	D	N
14MM26	17120			13	42.6	20.9	18.6	27.2	8.4	27.2	BROKEN TIP AND ONE EA	22.3778	20.7008	D	21.23	16.988	D	Y
14MM26	17078			84	35.5	21.3	16.2	24.9	5.1	24.9		17.5131	15.4882	D	18.01	14.941	D	Y
14MM26	17078			79	42.9	18.6	15.2	24.5	6.6	24.5		19.2333	17.1814	D	17.45	14.585	D	Y
14OS314	185				29.1	15.1	7.6	11.4	3.8	15.1		5.9091	7.2274	A	-0.89	2.926	A	Y
14OS314	5				60.4	21	12.6	29.9	8.6	29.9		30.3941	22.781	D	25.01	19.391	D	Y
14OS314	159				19.7	10.7	6.1	8.2	2	10.7		-1.5312	2.268	A	-5.37	0.078	A	Y
14OS314	164				18.9	10.7	7.6	10.3	2.1	10.7		-1.9769	2.589	A	-2.43	1.947	A	Y
14OS314	168				19.7	5.1	4.7	9.9	2.2	9.9		-2.1046	1.7652	A	-2.99	1.591	A	Y
14OS314	10				16.4	11	5.7	8.3	2.2	11		-1.6225	2.1398	A	-5.23	0.167	A	Y
14OS314	132				21.5	14.5	7.9	11.8	3.1	14.5		3.416	5.584	A	-0.33	3.282	A	Y
14OS314	6				24	8.3	6.5	10.3	4.3	10.3		-0.3924	4.6172	A	-2.43	1.947	A	Y
14OS314	47				35.9	13.9	12.9	23.1	6.4	23.1		16.6648	15.1024	D	15.49	13.339	D	Y
14JN332	5175			175	27.2	8.8	4.6	10.9	4.6	10.9		1.4735	5.0974	A	-1.59	2.481	A	Y
14JN332	4782				27.1	11.5	5.9	10.7	2.8	11.5	SURFACE	1.1822	4.0916	A	-1.87	2.303	A	Y
14JN332	2999				53.1	32.6	23.3	43.4	7.7	43.4	SNYDER'S POINT, TIP BRC	42.5503	29.8498	D	43.91	31.406	D	Y
14JN332	3873				29.4	24.8	18.1	29.5	6.7	29.5	SURFACE	22.1128	18.7804	D	24.45	19.035	D	Y
14JN332	1109	0-10CM			18.1	9.4	5.7	11.4	2.7	11.4	BROKEN TIP	-0.6249	2.9434	A	-0.89	2.926	A	Y
14JN332	4174				19.8	7.8	6.1	11.4	3	11.4		-0.2769	3.4718	A	-0.89	2.926	A	Y
14JN332	5277	10-20CM		136	22.8	11.4	7.7	11.3	4.3	11.4		0.4399	5.2614	A	-1.03	2.837	A	Y

14MM13	369-1					40.5	16.2	10.5	21.3	5.9	21.3		15.6998	13.8076	D	12.97	11.737	D	Y
14MM13	302-1					43	17.2	11	24.1	4.6	24.1		18.9227	14.3774	D	16.89	14.229	D	Y
14MM13	191-1					42.2	21.3	15.6	26.6	5.8	26.6	BROKEN TIP	21.2294	17.4872	D	20.39	16.454	D	Y
14MM13	324-1					33.8	17.6	14.6	25.4	5.7	25.4	BROKEN DISTAL END	18.388	15.7156	D	18.71	15.386	D	Y
14MM13	159-1					29.4	23	15.9	30.4	5.9	30.4	BROKEN DISTAL END	23.3743	18.0414	D	25.71	19.836	D	Y
14MM13	250-1					73.4	19.2	18	23.8	8.4	23.8		24.205	22.3008	D	16.47	13.962	D	Y
14MM13	184-1					75.3	11.2	11.2	24.7	5.7	24.7	ONE EAR BROKEN, BW LII	26.1047	19.141	D	17.73	14.763	D	Y
14MM13	171-4					48	14.5	14.2	27.3	6.7	27.3		23.8283	18.9206	D	21.37	17.077	D	Y
14MM13	400-1					60	23.6	17.5	26.8	6.7	26.8		24.7459	20.6878	D	20.67	16.632	D	Y
14MM13	143-3					53.3	30.2	21.6	39.6	8.2	39.6		38.584	28.1536	D	38.59	28.024	D	Y
14MM13	143-2					41.3	29.1	20	36.7	8.8	36.7	BROKEN TIP	33.4255	25.6706	D	34.53	25.443	D	Y
14MM13	182-1					65.1	19.5	11.7	18.5	6.3	19.5		18.0448	16.2208	D	9.05	9.245	I-A	N
14MM13	112-10					36.2	12.7	7.3	17.8	3	17.8		10.2507	8.5078	D	8.07	8.622	A	N
14MM13	321-8					40.9	10	8.4	15.6	5.4	15.6		9.1788	10.2904	A	4.99	6.664	A	Y
14MM13	159-1					33.3	13	10.1	19.7	5	19.7		12.1546	11.4148	D	10.73	10.313	I-D	C
14MM13	278/2					23.4	11.1	9.1	19.4	4.1	19.4	BROKEN DISTAL END	9.8021	9.213	D	10.31	10.046	I-D	C
14MM13	163-6					17.9	8.7	6.3	8	2.3	8.7		-4.2066	1.4356	A	-5.65	-0.1	A	Y
14MM13	285-2					23.8	11.1	5.3	11.8	3.9	11.8		1.4883	4.6982	A	-0.33	3.282	A	Y
14MM13	285-1					26.3	14	7.9	14.8	4.9	14.8		5.3855	7.7986	A	3.87	5.952	A	Y
14MM13	134-2					21.4	15.7	7.7	11.6	2.7	15.7		4.731	5.7488	A	-0.61	3.104	A	Y
14MM13	346-1					25.9	7.2	4	9.3	2.6	9.3		-1.3491	2.3486	A	-3.83	1.057	A	Y
14MM13	207-1					25.8	7.7	5	12.9	3	12.9		2.9039	4.5894	A	1.21	4.261	A	Y
14MM13	178-2			7		20	8.8	4.1	11.5	2.2	11.5		0.0136	2.4212	A	-0.75	3.015	A	Y
14MM13	278-1					13.2	11.1	5.4	9.5	2.1	11.1	BROKEN TIP	-2.0759	1.6906	A	-3.55	1.235	A	Y
14MM13	270-1					14.1	9.2	4.7	10.9	2.8	10.9	BROKEN TIP	-1.7172	2.1488	A	-1.59	2.481	A	Y
14MM13	248-1					22.5	8.4	4.8	17.3	3.2	17.3	BROKEN DISTAL END	7.7085	6.431	D	7.37	8.177	A	N
14MM13	122-3					18.1	10.6	8.6	14.4	3.8	14.4	BROKEN TIP	2.7746	5.9244	A	3.31	5.596	A	Y
14MM13	173-2					20.6	12.3	12.1	21.3	5.3	21.3		11.3666	11.4824	I-A	12.97	11.737	D	N
14MM13	247					18.2	5.1	5.4	13.1	3	13.1		1.6269	3.9482	A	1.49	4.439	A	Y
23BN2	0287/89					18.1	11	7.3	10.4	2.7	11	Broken tip	-1.4637	3.0978	A	-2.29	2.036	A	Y
23BN2	0742/89					24.2	14	8.8	10.7	4.7	14		3.7476	7.2156	A	-1.87	2.303	A	Y
23BN2	0722/89					18.7	12	7.1	8.2	3.1	12		0.0555	3.9354	A	-5.37	0.078	A	Y
23BN2	0693/89					19.6	9.3	7.2	9.7	3.2	9.7		-2.5299	3.0594	A	-3.27	1.413	A	Y
23BN2	0280/89					18.4	7.4	4.4	12	3.4	12	BROKEN TIP	0.7188	3.5844	A	-0.05	3.46	A	Y
23BN2	0273/89					21.2	13.9	7.4	10.8	3.5	13.9		2.9049	5.5082	A	-1.73	2.392	A	Y
23BN2	0686/89					22	9.5	5.1	7.5	2.4	9.5		-2.165	2.084	A	-6.35	-0.545	A	Y
23BN2	0270/89					22	11.1	8.1	9.7	2	11.1		-1.0628	3.1324	A	-3.27	1.413	A	Y
23BN2	0723/89					20.1	10.4	8.1	9.1	2.6	10.4		-2.0283	3.1166	A	-4.11	0.879	A	Y
23BN2	0283/83					17.1	15.1	8.4	11.5	3.5	15.1		3.3571	5.8434	A	-0.75	3.015	A	Y
23BN2	0701/89					22.2	11.7	6.9	9.2	2.3	11.7		0.083	3.4384	A	-3.97	0.968	A	Y
23BN2	0748/89					22	12	9.7	11.8	2.8	12	BROKEN TIP	-0.0215	4.589	A	-0.33	3.282	A	Y
23BN2	0272/89					20.4	14.1	7.3	9.8	2.2	14.1		2.5082	4.3712	A	-3.13	1.502	A	Y
23BN2	0265/89					18.2	13.9	8.6	9.2	3.6	13.9		2.1125	5.5274	A	-3.97	0.968	A	Y
23BN2	0263/89					18.9	13	8.5	9.8	3.5	13		1.1427	5.0722	A	-3.13	1.502	A	Y
23BN2	0261/89					22.5	5.2	5.1	10.1	4	10.1		-0.7208	3.8024	A	-2.71	1.769	A	Y
23BN2	0724/89					22.3	12.5	8.1	10.7	2.9	12.5		1.0334	4.6004	A	-1.87	2.303	A	Y
23BN2	0747/89					27	14.8	8.5	11.5	2.3	14.8		4.3641	5.7562	A	-0.75	3.015	A	Y
23BN2	0267/89					22.1	14.2	5.9	9.3	3.3	14.2		3.6917	5.2526	A	-3.83	1.057	A	Y
23BN2	0279/89					16.9	13.3	7	10.5	1.8	13.3	TIP MISSING	0.7963	3.2074	A	-2.15	2.125	A	Y
23BN2	0264/89					18.7	13.2	7.1	8.6	3.5	13.2		1.6583	4.845	A	-4.81	0.434	A	Y

23BN2	0292/89					15.3	12.6	8.4	10.4	2.3	12.6	TIP MISSING	-0.4642	3.4372	A	-2.29	2.036	A	Y
23BN2	0741/89					24.6	14.1	6.6	10	2.6	14.1		3.6107	5.0206	A	-2.85	1.68	A	Y
23BN2	0793/89					24.8	10.3	6.1	11.1	3.3	11.1		0.4192	4.13	A	-1.31	2.659	A	Y
23BN2	0699/89					15.5	7	5.9	13.6	4	13.6		2.0023	4.8626	A	2.19	4.884	A	Y
23BN2	0734/89					20.9	12.7	8.1	10.4	3.1	12.7		1.0896	4.716	A	-2.29	2.036	A	Y
23BN2	0738/89					25.9	11.8	7.1	9.7	2.5	11.8		0.9329	4.1006	A	-3.27	1.413	A	Y
23BN2	0746/89					24.6	16.2	7.3	10.3	3.4	16.2		6.2987	6.8486	A	-2.43	1.947	A	Y
23BN2	0700/89					16.4	13.7	6.4	7	2.8	13.7		1.7101	4.077	A	-7.05	-0.99	A	Y
23BN2	0739/89					23.5	12.3	7.2	9.5	3.6	12.3		1.4931	5.0482	A	-3.55	1.235	A	Y
23BN2	0288/89					17.2	10.7	6.4	9.5	2.7	10.7		-1.7937	2.667	A	-3.55	1.235	A	Y
23BN2	0685/89					23	11.1	7.3	9.2	2.6	11.1		-0.4612	3.5876	A	-3.97	0.968	A	Y
23BN2	0690/89					16	12.5	6.8	7.9	3.1	12.5		0.2173	3.8146	A	-5.79	-0.189	A	Y
23BN2	0725/89					21.6	12	5.4	8.7	2.7	12		0.823	3.5392	A	-4.67	0.523	A	Y
23BN2	0277/89					24.7	11.8	7.4	9.1	4.1	11.8		1.2676	5.4176	A	-4.11	0.879	A	Y
23BN2	0737/89					20.7	11.9	7.4	11.4	2.5	11.9		0.0089	3.6502	A	-0.89	2.926	A	Y
23BN2	0684/89					18.9	11.3	6.5	9.2	2.2	11.3		-0.9694	2.722	A	-3.97	0.968	A	Y
23BN2	0730/89					21.7	11.9	7.2	10.2	2.7	11.9		0.3199	3.8882	A	-2.57	1.858	A	Y
23BN2	0719/89					20.5	12.8	8.1	9.9	3	12.8		1.0957	4.6334	A	-2.99	1.591	A	Y
23BN2	0688/89					16.5	8.8	4.9	10.6	2.9	10.6		-1.6329	2.3962	A	-2.01	2.214	A	Y
23BN2	0745/89					26.3	13.3	6.8	9.6	3.3	13.3		3.1961	5.4758	A	-3.41	1.324	A	Y
23BN2	0751/89					26.1	16.8	8.3	12	3.2	16.8		7.0023	7.3338	I-A	-0.05	3.46	A	C
23BN2	0740/89					24	11.8	8	9.7	3.6	11.8		0.8062	5.0384	A	-3.27	1.413	A	Y
23BN2	0744/89					21.1	15.4	7.4	10.7	3.2	15.4		4.576	5.9432	A	-1.87	2.303	A	Y
23BN2	0732/89					24.7	11.6	8.2	10.6	3.4	11.6		0.5738	4.89	A	-2.01	2.214	A	Y
23BN2	0698/89					20.3	11.1	7.2	9.3	3.2	11.1		-0.7113	3.793	A	-3.83	1.057	A	Y
23BN2	0696/89					15.3	13.8	6.9	9.4	2.8	13.8		1.5123	4.1122	A	-3.69	1.146	A	Y
23BN2	0262/89					26.7	9	7.4	14.4	3	14.4		4.3454	5.9052	A	3.31	5.596	A	Y
23BN2	0682/89					11.5	11.8	5.7		2.1		DISTAL END BROKEN			X	-16.85	-7.22	X	X
23BN2	0697/89					21.8	6.2	5.7	9.9	2.9	9.9		-1.6584	2.8108	A	-2.99	1.591	A	Y
23BN2	0694/89					20.4	5.8	5.6	9.8	2.4	9.8		-2.2158	2.1592	A	-3.13	1.502	A	Y
23BN2	0750/89					17.8	17	8.5	15.4	3.3	17		5.6775	6.6606	A	4.71	6.486	A	Y
23BN2	0291/89					13.9	12.2	6.6	9.4	2.9	12.2	TIP BROKEN	-0.5728	3.2312	A	-3.69	1.146	A	Y
23BN2	0293/89					17.2	7.4	4.5	15.2	3.8	15.2	TIP BROKEN	4.4837	5.3258	A	4.43	6.308	A	Y
23BN2	0727/89					22.9	12.7	8.3	8.9	3.4	12.7		1.5386	5.234	A	-4.39	0.701	A	Y
23BN2	0687/89					15.8	13.2	8	8.6	2.8	13.2		0.638	4.1196	A	-4.81	0.434	A	Y
23BN2	0733/89					21.7	11.5	8.3	13.3	2.4	13.3		1.644	4.5224	A	1.77	4.617	A	Y
23BN2	0735/89					19.5	14.4	8.8	9.6	3	14.4		2.6796	5.4272	A	-3.41	1.324	A	Y
23BN2	0268/89					20.3	11.3	5.7	9.4	2.9	11.3	TIP AND ONE EAR BROKE	-0.2534	3.3068	A	-3.69	1.146	A	Y
23BN2	0736/89					20.7	13.8	7.3	9.9	3.1	13.8		2.5559	5.0402	A	-2.99	1.591	A	Y
23BN2	0720/89					23.8	13.6	6.2	9.7	3.5	13.6		3.2998	5.3912	A	-3.27	1.413	A	Y
23BN2	0721/89					23.7	10.1	5.1	9.9	2.5	10.1		-1.0832	2.636	A	-2.99	1.591	A	Y
23BN2	0282/89					16.1	12.2	8.6	11	3	12.2	BROKEN TIP	-0.566	3.9832	A	-1.45	2.57	A	Y
23BN2	0689/89					15.5	11.7	7.4	9.4	1.9	11.7		-1.4449	2.4762	A	-3.69	1.146	A	Y
23BN2	0729/89					21.4	12.7	9.4	11	2.4	12.7		0.6193	4.4434	A	-1.45	2.57	A	Y
23BN2	0731/89					23.3	16.3	6.2	11	3.3	16.3		6.3809	6.4334	I-A	-1.45	2.57	A	C
23BN2	0286/89					21.4	14.1	9.9	12.9	3.5	14.1	RESHARPENING ON ONE	2.626	6.1588	A	1.21	4.261	A	Y
23BN2	0692/89					17	12.7	7.3	9.6	3.4	12.7		0.6524	4.3828	A	-3.41	1.324	A	Y
23BN2	0278/89					21.4	5.3	7.1	10.9	3.1	10.9	BROKEN CORNER AND BA	-0.7624	3.71	A	-1.59	2.481	A	Y
23BN2	0294/89					16	11.1	9.1	12.1	3.9	12.1	BROKEN DISTAL END AND	-0.464	4.81	A	0.09	3.549	A	Y
23BN2	0728/89					21.2	13.4	7.1	10.7	2.4	13.4		1.9381	4.2586	A	-1.87	2.303	A	Y

23PL13	A					34.3	7.8	6.9	15.1	5.1	15.1		7.5524	8.7624	A	4.29	6.219	A	Y
23PL13	B					19.7	12.5	7.5	6.9	2.4	12.5		0.4824	3.7592	A	-7.19	-1.079	A	Y
23PL13	C					32.7	8.1	6.9	9.5	4.3	9.5		0.19	5.2664	A	-3.55	1.235	A	Y
23PL13	D					27.4	14.7	8.7	11.8	4.4	14.7		5.0974	7.6096	A	-0.33	3.282	A	Y
23PL13	G					17.9	11.2	6.5	8.3	3.3	11.2		-0.8467	3.5174	A	-5.23	0.167	A	Y
23PL13	L					19.5	12.8	6.9	8.4	3.3	12.8		1.2929	4.5278	A	-5.09	0.256	A	Y
23PL13	K					15.7	12.5	4.5	6.8	2.7	12.5		0.517	2.9444	A	-7.33	-1.168	A	Y
23PL13	J					29.9	12.9	7.5	8.8	3.4	12.9		3.274	5.9128	A	-4.53	0.612	A	Y
23PL13	N					17.2	14.1	7.7	10.5	3.5	14.1	TIP MISSING	2.327	5.2344	A	-2.15	2.125	A	Y
23PL13	I					16.4	11.3	5.7	7.9	1.9	11.3		-1.3786	2.0216	A	-5.79	-0.189	A	Y
23PL13	H					20.8	16	8.3	8.6	3.4	16		5.1203	6.5582	A	-4.81	0.434	A	Y
23PL13	E					16.2	13.7	7	8.1	3.7	13.7		1.8915	4.9614	A	-5.51	-0.011	A	Y
23PL13	F					18.6	12.1	8.3	10.8	2.4	12.1	BROKEN TIP	-0.3848	3.6236	A	-1.73	2.392	A	Y
23PL13	M					8.5	13.3	7.3		2.6		BROKEN DISTAL END	-16.5627	-3.1954	A	-16.85	-7.22	X	X
23PL13	1988-0004					21.4	10.6	5.4	9	2.8	10.6		-0.8624	2.946	A	-4.25	0.79	A	Y
23PL13	1988-0001					26.8	12.7	6.5	10	2.9	12.7		2.4772	4.838	A	-2.85	1.68	A	Y
23PL13	1988-0003					31.2	13.8	7.5	10.3	3.4	13.8		4.6029	6.4762	A	-2.43	1.947	A	Y
23PL13	T					14.5	12	7.4	8.8	2.8	12		-0.9186	3.2868	A	-4.53	0.612	A	Y
23PL13	Y					26.5	12.2	8	11.4	3.4	12.2	ONE EAR MISSING	1.6798	5.3236	A	-0.89	2.926	A	Y
23PL13	Z					18.4	11.6	7.6	8.5	3	11.6		-0.6336	3.7356	A	-4.95	0.345	A	Y
23PL13	X					21.1	13.7	6.4	9.3	3.1	13.7		2.7113	4.8438	A	-3.83	1.057	A	Y
23PL13	U					20.2	12.1	6	10.7	3	12.1		0.6641	3.8226	A	-1.87	2.303	A	Y
23PL13	V					20.2	14	6.3	9.6	2.8	14		2.8083	4.607	A	-3.41	1.324	A	Y
23PL13	W					16.3	13.9	7.8	9.5	2.6	13.9		1.5417	4.287	A	-3.55	1.235	A	Y
23PL13	S					16.9	10.4	5.5	6.3	2	10.4		-2.2853	1.6962	A	-8.03	-1.613	A	Y
23PL13	Q					23.8	13.3	8.4	11	4	13.3		2.6437	6.153	A	-1.45	2.57	A	Y
23PL13	R					21.7	13.7	7.1	9.6	2.7	13.7		2.5112	4.7128	A	-3.41	1.324	A	Y
23PL13	P					16.3	11.8	7.5	10.1	2.9	11.8		-0.8043	3.495	A	-2.71	1.769	A	Y
23PL13	O					26.2	14.4	8.6	11.5	3	14.4		3.9838	6.108	A	-0.75	3.015	A	Y
23PL13	CC					27.4	12.2	7.3	11.5	2.8	12.2		1.7699	4.7526	A	-0.75	3.015	A	Y
23PL13	AA					19.9	10.4	5.3	7.3	3.1	10.4		-1.2455	2.9278	A	-6.63	-0.723	A	Y
23PL13	FF					22	13.4	8.2	11	3	13.4		2.0784	5.0988	A	-1.45	2.57	A	Y
23PL13	EE					15.4	11.4	5.4	6.7	2.1	11.4		-1.3008	2.0692	A	-7.47	-1.257	A	Y
23PL13	BB					20	12.2	6.6	9	2.4	12.2		0.378	3.458	A	-4.25	0.79	A	Y
23PL13	GG					18.4	14.4	9.7	15	3.9	15	BROKEN DISTAL END	3.3479	6.5606	A	4.15	6.13	A	Y
23PL13	DD					12.4	14.5	6.4	10.1	2.8	14.5	BROKEN DISTAL END	1.9221	4.021	A	-2.71	1.769	A	Y
23PL13	HH					25.4	13.6	6.8	11	2.7	13.6		3.1532	5.0012	A	-1.45	2.57	A	Y
23PL13	1988-0005					16.8	10.8	5.3	8.3	8.9	10.8		0.9273	7.7922	A	-5.23	0.167	A	Y
23PL13	II					26.9	13.6	6.2	9.9	3.2	13.6		3.765	5.4668	A	-2.99	1.591	A	Y
23PL13	1988-0002					23.2	12.3	5.8	8	3	12.3		1.5137	4.1978	A	-5.65	-0.1	A	Y
23PL13	KK					18	11.9	5.9	8	2.3	11.9		-0.2426	2.8648	A	-5.65	-0.1	A	Y
23PL13	JJ					19	12.4	7.1	9.8	3.6	12.4		0.7899	4.5878	A	-3.13	1.502	A	Y
23PL13						24.1	12.2	7.2	10.3	2.5	12.2		1.0542	1.034	A	-2.43	1.947	A	Y

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