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ADOPTION OF THE BOW IN PREHISTORIC NORTH AMERICA

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ABSTRACT

Current ecological archaeology, as often practiced, is too closed a system. The realization that introduced external factors may play a role in cultural change as potently as localized mechanisms demands increased attention to analytical boundaries and matters of scale. This article questions the utility and effectiveness of localized adaptive explanations for large-scale historical processes and, as an illustration, considers the prehistoric distribution of the bow in North America from a continental perspective. Criteria used to determine the presence of the bow in the archaeological record are briefly reviewed and a north to south chronological distribution for the initial adoption of the bow is presented.

In the popular stereotype, the bow and arrow is closely linked to the Native Americans, yet the archaeological evidence reveals a surprisingly shallow time depth for an implement that, in the historic period, was distributed from the Atlantic to the Pacific and from the Arctic to Tierra del Fuego. The bow in North America presents an interesting problem for examining the cultural implications of the distribution of a technical innovation through time and space. Although the bow has been the subject of extensive ethnographic descriptions and technical studies (Mason, 1893; Pope, 1923; Rogers, 1940; Hamilton, 1982), little effort has been made to evaluate its prehistoric development or cultural significance.

The role of technology in culture change has long been a major concern of anthropology. Diverse considerations of this fundamentally human attribute have centered on the pivotal question of technology as stimulus and consequence (Childe, 1936; White, 1949; Boserup, 1965; Hayden, 1981).

Archaeologists regularly claim that their discipline is ideally suited to unraveling technological development. Much of this effort has been directed into cost/benefit economic models of subsistence formulated within neoevolutionist and cultural ecological orientations. As an important tool, it might be expected that the bow had a major influence on cultural development in prehistoric North America. Remarkably, the bow has elicited little interest among American archaeologists beyond identification criteria and brief general comments on presumed hunting efficiency.

In this article I question the utility and effectiveness of localized adaptive explanations for large-scale historical processes and, as an illustration, consider the prehistoric distribution of the bow from a continent-wide perspective. Criteria used to determine the presence of the bow in the archaeological record are briefly reviewed and the chronological distribution surveyed. The large-scale pattern of dispersal and adoption reveals processes not directly attributable to local environmental circumstances. Instead, the rapid dissemination of the bow across major ecological boundaries is interpreted as the result of a contagious competitive advantage in intergroup conflict.

A QUESTION OF SCALE

Interpretations of technological innovations in archaeological sequences are often contrasted as independent, indigenous invention or diffusion. No doubt each played a critical developmental role in cultural evolution. Yet there has been a tendency to polarize these processes as the result of theoretical shifts in the discipline. The influential development of ecosystemic models in archeology and anthropology emphasized culture change as a gradual adaptation to new environmental variability by internal adjustment mechanisms generated by the cultural system (Flannery, 1968; Sanders and Price, 1968; Rappaport, 1968). No doubt the overwhelming dominance of an adaptionist stance in American archaeology reflects its overall methodological successes and utility. Furthermore, ecological archaeology was instrumental in expanding the research focus from the site to larger ecological zones. Because the analytical focus was a population in a localized ecosystem, however, social dynamics generated between societies were often neglected as a vital source of cultural change.

As part of this localized focus, there was also a reaction against earlier diffusionist arguments that simplistically accounted for culture change by proposing a source for an idea or innovation without consideration of the social or economic context for adoption or rejection. However, not all archaeological treatments of diffusion can be dismissed as this narrow (Tolstoy, 1972). Furthermore, anthropologists have long stressed that societies could not be considered in isolation but were linked in "web-like, net-like interconnections" with other social groups in structured and patterned relationships (Lesser, 1961). This rather hoary dialogue, cast in terms of independent invention versus diffusion, has been superseded by a broader holistic perspective. The realization that long distance interconnections are a fundamental part of the cultural equation has engendered a growing reaction against restricting analysis to local ecological and social factors. In part, this awareness directly grew out of ecologically oriented studies that revealed the necessity of expanding the scale of analysis to account for multiregional interactions (Barth, 1969). Within cultural anthropology, this reorientation has been formulated in the context of political economy and placed within the historic trajectory of the modern world system (Wolf, 1982).

These observations about cultural processes that extend beyond the boundaries of traditional units of analysis are clearly relevant to technologically simple prehistoric societies. The realization that introduced external mechanisms may be a process of cultural change as potent as localized factors demands increased attention to analytical boundaries and matters of scale. This broader conceptual framework questions the myriad of local adaptive arguments when large-scale, big-picture contexts are ignored. Things clearly look different and require radically different "explanations" depending upon the scale at which they are viewed. A more thorough interpretation will have to (re)incorporate large contexts at macroregional or continental scales. These considerations are applied to an examination of the prehistoric distribution of the bow.

THE IDENTIFICATION PROBLEM

The proposition that the cultural implications of a prehistoric technological development such as the bow can be evaluated assumes that it can be identified in the archaeological record, but differential preservation presents an immediate problem. Only rarely have organic portions of bows and arrows been preserved. For this reason the major burden of identification has focused on the stone arrow tip, only one part of the complete weapon. Traditionally, archaeological assessment of the presence or absence of the bow and arrow has been based on functional interpretations of projectile point size.

How valid is the critical assumption that large, heavy projectile points were used to tip atlatl darts while small, light points represent arrowheads? Can arrowheads be distinguished from atlatl dart tips? Various measurements have been applied to archaeological samples of projectile points in efforts to address these problems. An extensive examination of North American arrow specimens by Hamilton (1982:27) revealed that arrow shaft diameter limits the thickness of the point base which can be mounted into the notched or split shaft end. Haft area thickness of actual mounted arrow point specimens was generally no more than 3/16 of an inch. The size of the hafting area, the portion of the projectile point bound to the shaft, has been assumed to correlate with shaft diameter (Corliss, 1972; Forbis, 1960; Wyckoff, 1964). After observing that gross weight, rather than measurements such as length, thickness, or width produced the strongest bimodal distribution, Fenenga (1953) concluded that weight differences best documented dart and arrow points. However, experimenters with bow and atlatl reproductions have claimed that both large and small projectile points prove adequate when used with either weapon (Brown, 1938, 1940; Evans, 1957; Fenenga, 1953). While the range of point sizes used in experiments may present no physical constraints, these studies may have no direct relevance to the actual pattern observed archaeologically.

In a rigorous attempt to resolve this size-function problem, Thomas (1978) analyzed an ethnographic and archaeological sample of 142 stone-tipped arrows and atlatl darts. He found that larger arrows tended to have larger arrowheads, but that atlatl dart foreshaft size had no significant effect on atlatl dart tip size. However, arrow foreshafts were found to be significantly smaller than atlatl foreshafts. More importantly, arrowheads were significantly smaller than atlatl dart tips and these two classes could be separated with a discriminant function analysis. Through the use of a classification equation that used length, width, thickness and neck width measurements, a method was devised to separate arrowheads from atlatl dart points with an accuracy of 86 percent (Thomas, 1978:471).

While Thomas' study is not directly applicable to the mass of unsystematized data on the bow in prehistoric North America to be reviewed below, it does support the traditional view that arrowheads tend to be smaller and lighter than atlatl dart tips. Presently, there are no middle range studies of either an ethnographic or archaeological nature that directly challenge this size-function generalization. Therefore, one may tentatively accept the widespread dominance of small projectile points in late prehistoric North America as evidence of the bow and arrow.

CHRONOLOGICAL APPEARANCE OF THE BOW

The bow has considerable antiquity in the Old World. The oldest evidence appears first in Africa around 11,000 B.C in the form of microblades used as compound barbs on arrows (Clark, 1970:156-157). Mesolithic rock art depictions of hunters with bows are widespread in Africa and the Mediterranean region (Lewis-Williams, 1981; Oakley, 1972:68). Temperate and northern latitude hunters of Mesolithic Europe and Asia utilized the bow, as indicated by microblades mounted on arrows and preserved bow specimens (Clark, 1970:92-94); Oakley, 1972:70). Unfortunately, the chronology of the bow in northeast Asia, the presumed source for diffusion into the New World, is presently uncertain. To chart the initial appearance of the bow across North America, the available evidence has been summarized by region.

Arctic

The earliest evidence of the bow and arrow in North America is in the Arctic. A prepared core and microblade technology characterizes a number of local Alaskan complexes grouped into the Paleoarctic Tradition from 9000 to 6000 B.C. (Dumond, 1978:47-51). This technology derives from similar complexes in northeastern Asia with Old World Mesolithic techniques (MacNeish, 1959; West, 1981). After 6000 B.C. in interior Alaska and northwestern Canada, the microblade technology is infused with an Archaic technology of more southerly origins to form the Northern Archaic Tradition (Dumond, 1978:57). These microblades may have paralleled Mesolithic usage as arrow barbs but there is no direct evidence; and a series of lanceolate, leaf-shaped, side-notched, and stemmed large points were used throughout this long sequence. While bow technology may have occurred in these early traditions, clear evidence appears only after 3000 B.C.

Across a vast area from northwestern Alaska to Greenland, the Arctic Small Tool Tradition encompasses a number of local and regionally specific artifact complexes. These complexes share a core and microblade technology used in the production of lanceolate, side and triangular end blades that were inserted into slotted antler foreshafts. One of the earliest of these regional manifestations is the Denbigh Flint Complex, known from Onion Portage in northwestern Alaska. Found there were narrow, long microblades and ". . . tiny bipointed end and side blades for inserting into antler arrow and spear heads . . ." (Anderson, 1984:84). MacNeish (1958:93) identified this complex, which he estimated to date from 9000 B.C. to 3000 B.C., as the earliest evidence of the bow in the New World. Recent area syntheses date this complex from ca. 3000 to 1600 B.C. (Anderson, 1984). After 1600 B.C., the microblades no longer occur, but are replaced by antler and chipped stone projectile points. These Arctic sites are identified with a tundra and seasonal sea mammal hunting economy (Anderson, 1984:83).

Initial dates for the bow appear progressively later from west to east across the Arctic. In the central Canadian Arctic, definite evidence of the bow occurs in the Pre-Dorset period, ca. 2500 to 800 B.C. (Harp, 1978; Maxwell, 1984). Antler bow braces and handle fragments of small, recurved composite bows have been found along with thin triangular points (Maxwell, 1984:361). These sites exhibit evidence of seasonal exploitation of both coastal and interior tundra resources. South, along the western shores of Hudson's Bay, Nash (1969:77) equates Pre-Dorset with the Arctic Small Tool Tradition sites in which small triangular points are present. These northern Manitoba sites date 1500 B.C. to 800 B.C. and suggest an economy that exploited both interior and Bay resources (Nash, 1970). Interestingly, evidence for the bow disappears in early Dorset, ca. 800 B.C. to A.D. 300, but reappears in the latter part of the sequence. During this apparent hiatus, the climate is thought to have become colder, and there is evidence that winter caribou hunting, in which the bow would have played an important role, was abandoned in favor of increased coastal settlement that emphasized sea-ice hunting (Maxwell, 1984:364-365).

Subarctic

South of the tundra in the interior boreal forests of the Northwest Territories, northern Saskatchewan, Quebec and Labrador, is a huge area still too poorly known archaeologically to adequately assess when the bow first appeared. The southern extent of the Arctic Small Tool Tradition is presently unclear. In interior Alaska and northwestern Canada, contemporary and analogous complexes representative of boreal forest hunting societies are found (Dixon, 1985).

Much of the Canadian Shield has a widely distributed tool complex known as the Shield Archaic that is characterized by several forms of large, heavy projectile points. However, there is no evidence of the bow in the southern Shield region until the beginning of the Terminal Woodland period at ca. 600 A.D. (Wright, 1981:95). Bone, antler, and wooden artifacts preserved on Archaic sites in southern North America have failed to reveal multiple slotted arrow shafts, a principle bow indicator in Arctic and Old World Mesolithic contexts. This is consistent with the evidence that microblade arrow barbs were replaced by small bifacial arrowpoints prior to bow diffusion south of the boreal forests. In southeastern Manitoba, near the interface of the boreal forest with a prairie environment to the west and deciduous forests to the southeast, MacNeish (1958:92-93) documents a "radical" shift from broad corner-notched and contracting-stemmed points to small triangular points at ca. 500 A.D.

In the western Subarctic, there is a similar shift to smaller points in the late prehistoric periods. "Tapered-stem" points that are widely distributed from northwestern Alaska through British Columbia are replaced by smaller side-notched points, particularly in Alberta and British Columbia (Clark, 1981:118). The chronology is vague but when radiocarbon dates are available, the transition appears to be after 500 A.D. (Dumond, 1978:83).

Plains

In the Northern Plains of Saskatchewan and Alberta, small side-notched Avonlea projectile points thought to represent arrow tips appear by 200 A.D. or slightly earlier. Kehoe (1966:839) associates these points with the southerly movement of Athabascan speakers onto the northern plains, where they readily altered their Caribou hunting pattern to take advantage of bison. Farther south in Montana and Wyoming, the shift to smaller projectile points occurred later than in the north. The earliest radiocarbon dates for Avonlea points, 1600-1000 B.P., are from the Wardell site in western Wyoming (Frison, 1978:69). Several styles of small, thin corner-notched and side-notched points together with ceramics of a proposed Algonquin affiliation are widespread in the region by A.D. 500. Southward through the central and southern plains, similar small notched and unnotched triangular points are not present until after 500 A.D. (Wedel, 1978:206; Lehmer, 1971). In southern Texas, estimates for the appearance of the bow vary from A.D. 500 to 600 in the upper coastal plain (Aten, 1984:81) to perhaps as late as A.D. 1200 in extreme lower Texas and the Rio Grande Valley (Hester, 1977).

Great Basin

In the Great Basin and Intermontane West, there are various conflicting interpretations of when bow technology first appears. Excavations of deeply stratified sites from Idaho to California reveal a similar sequence of large Desert Archaic points—Elko, Pinto, Humbolt types in the lowest levels—followed by a stratigraphic co-occurrence with the smaller Rose Spring-Eastgate projectile point complex. In the uppermost levels, small Desert Side Notched and Cottonwood triangular points become predominant. The sequence is thought to represent gradual transition from large dart points to small arrow points, with an intermediate time period during which both the atlatl and the bow were in use. The size overlap may be due to the multiple use of Elko points as knives (Aikens and Madsen, 1986:160). Archaeological examples of arrow and bow fragments appear to be late in the sequence (Jennings, 1957:189).

Great Basin projectile neck widths, presumed to correlate with shaft diameter, exhibit a constant size range until a sharp reduction between A.D. 1-500 (Corliss, 1972). This change and a significant overall size reduction is interpreted as an indicator of the bow. Investigators are unanimous in their acceptance of Desert Side Notched and Cottonwood types as arrowheads. These small triangular points appear in the eastern Basin from 800-1200 A.D. and predominate throughout the Great Basin and Intermontane West after A.D. 1300 in association with the Numic tradition (Holmes, 1986:107).

However, significant size reduction begins with the earlier Rose Springs-Eastgate types (Rosegate) and the chronology is controversial. Rosegate is given a 1 A.D. dateline in the eastern Basin (Aikens and Madsen, 1986:160) and a 500 A.D. dateline in the western Basin (Elston, 1986:145). Some investigators accept a 500 A.D. initial appearance (Lanning, 1963; Hester, 1973; Madsen and Berry, 1975). Earlier claims for the bow based on these point types at Danger Cave (Jennings, 1957) and Hogup Cave (Aikens, 1970) are ambiguous due to questions about the stratigraphic integrity of the deposits (Hester, 1973; Webster, 1980). Other early Rosegate dates include Dirty Shame Rockshelter (Aikens, 1976) and Cowboy Cave in northern Colorado, both ca. 300–450 A.D. (Holmes, 1986:106). Perhaps the oldest dated Rosegate component is at Dry Creek Rockshelter in western Idaho where strata with these points produced a range from 586 B.C. to 36 A.D. (Webster, 1980). Dates for the bow as indicated by either Rosegate or Desert side-notched are consistently more recent in a northwest to southwest progression. If Rosegate is considered an arrowpoint, the earlier dates and the other sequences together with comparable early dates in the adjacent Northern Plains region would date the appearance of the bow in the Great Basin and Intermontane West at ca. 200 A.D.

The Pacific Northwest and California

As is the case in the Great Basin, portions of the Pacific Northwest are characterized by archaeological sequences with long continuities of similar tool types that make a sensitive chronological order difficult to construct. For instance, for the Columbia Plateau, Aikens (1978:167) discusses the Harder phase where ". . . both the atlatl and dart and bow and arrow were in use." The dates for this "phase" bracket an 1800 year time span. Similarly, on the Lower Columbia River and in the Klamath Lake region, there is an intermediate period during which the bow and atlatl are assumed to co-occur on the basis of projectile point size differences and the presence of atlatl weights, but the chronology is obscure (Cressman, 1956; 1960).

In California, the situation is somewhat clearer. During Late Horizon Phase I, after 500 A.D. in the Central Valley region, the bow and arrow is suggested by a shift from large, heavy projectile points to small, serrated side-notched points and the presence of arrow shaft straighteners (Moratto, 1984:183; Elsasser, 1978:43-57). Similar evidence in the Sierra Nevada indicates the bow is present after 500 A.D. (Moratto, 1984:338).

Southwest

In contrast to other regions of the American West, the initial appearance of the bow in the Southwest is relatively unambiguous. The bow and arrow replaced the atlatl during the Basketmaker III period dated between A.D. 575 to 750 (Cordell, 1979:134, 1984:102; Plog, 1979:114). Lipe (1978:369) concludes that the bow is present by the latter part of Basketmaker III at ca. 700 A.D. Even earlier evidence occurs in the form of archaeological arrows preserved in Basketmaker cave sites in northeastern Arizona between A.D. 500 and 600 (Morris, 1980:146). Although a Mexican origin for the bow had at one time been entertained, diffusion from the Great Basin appears more likely (Woodbury and Zubrow, 1979:55).

Great Lakes and Northeastern Woodlands

From the Great Lakes region across eastern Ontario, southwestern Quebec into New York, two projectile point styles have been suggested as representative of bow technology. Levanna points first appear ca. 600-700 A.D. but only become common between A.D. 900 to 1350 (Mason, 1981:272-273; Ritchie, 1971:31-32). There is a chronological trend for equilateral Levanna points to become smaller in size, which may indicate a developmental continuum with the small isosceles triangular points that succeeds them (Mason, 1981:298, 329). These small, sometimes side-notched triangular points are present in the western New York Owasco tradition by ca. 1000 A.D. and become ubiquitous throughout the Great Lakes and Northeast until historic times (Ritchie, 1971).

However, earlier claims for the bow and arrow have been made for the Brewerton complex in New York and New England (MacNeish, 1958:93). Dates for this complex, which include the types Brewerton Eared-Triangular and Brewerton Eared-Notched, range between 2980 and 1723 B.C. (Ritchie, 1980:91; Dincauze, 1976:126). These dates are contemporary with or slightly precede a so-called Small Point Complex, characterized by a number of local types such as Squibnocket and Beekman triangles (Ritchie, 1969; Funk, 1971:121, 127; Dincauze, 1976:114, 126). These artifact complexes are local expressions of a widespread regional adaptation recently referred to as the Mast Forest Archaic (Snow, 1980). While it is possible that these points represent the use of the bow, atlatl weights and large, heavy projectile points co-occur in these components, an indication that they may have tipped fletched dart points (Christenson, 1986:121). The complete predominance of small projectile points pan-regionally is a post-500 A.D. phenomenon.

Midwest and Southeast

Around 700 A.D., small triangular points, along with the more locally variable small triangular notched forms, make a sudden dramatic appearance throughout most of the Eastern Woodlands, from the Plains to the Atlantic seaboard and south to the Gulf of Mexico. These widespread forms include morphologically distinctive variations: Madison (Perino, 1968:52); Hamilton (Bell, 1960:54); Pinellas (Bullen, 1975:8); Guntersville (Cambron and Hulse, 1975); and Dallas (Lewis and Kneberg, 1970) are some examples. Throughout this area, archaeologists have interpreted these small points as evidence for the initial appearance of the bow and arrow (Griffin, 1978:254). In Illinois these points appear between 600 and 700 A.D. (Fowler and Hall, 1978:560-561; Kelley, et al., 1984:122) and by 800 A.D. in the Arkansas portion of the Central Mississippi Valley (Morse and Morse, 1980:210). Between 700 and 800 A.D. morphologically similar triangular points become predominant in local sequences on the Cumberland Plateau (Faulkner, 1968; Kneberg, 1956); Mid-Atlantic (Kinsey, 1972); Carolina Piedmont (Coe, 1964); Gulf Coastal Plain (Ensor, 1981; Dickens, 1971) and Florida (Bullen, 1975).

A number of general conclusions seem warranted from this survey: (1) Except for rare occurrences of archaeological bow and arrows, the change from large to small projectile points is the main criterion archaeologists have used for judging the appearance of the bow.

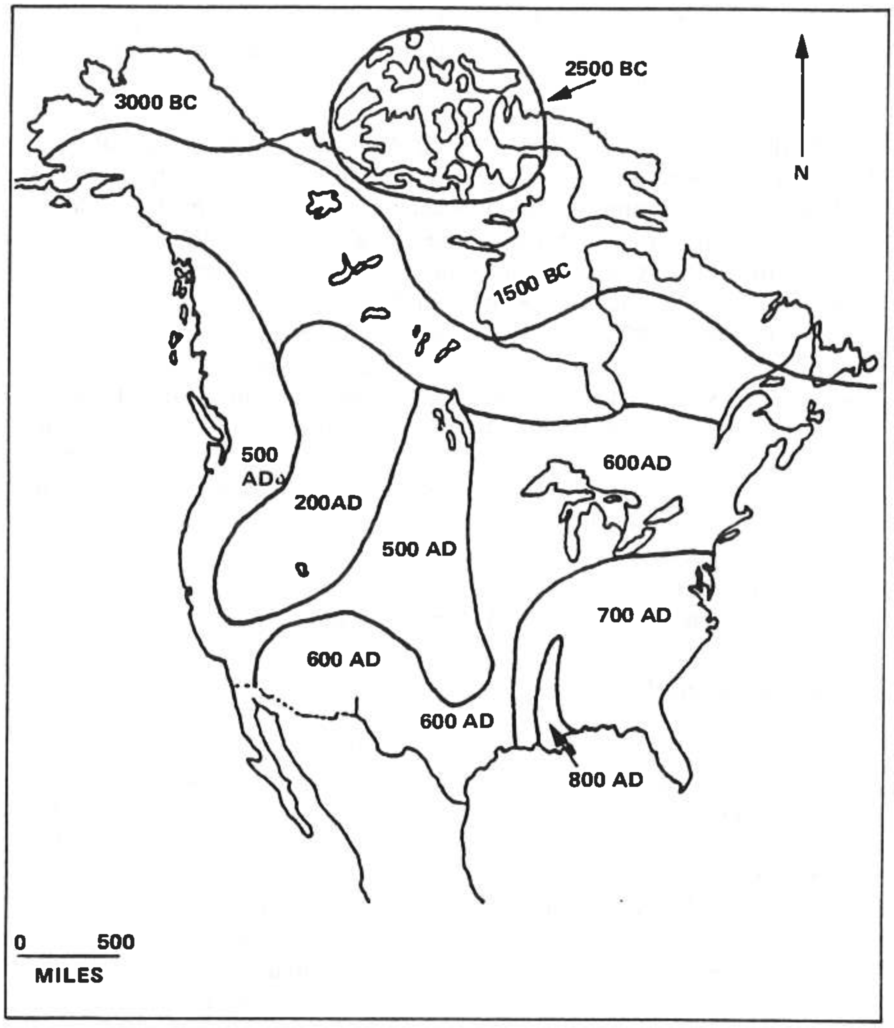

Figure 1. Estimated chronology for the adoption of the bow in North America.

(2) Even though the initial occurrence of the bow in most regions must be expressed in relatively large units of time, there is a clear chronological trend north to south (Figure 1). This trend implies diffusion rather than multiple episodes of independent invention. While movements of people may have played a limited role, the rapidity of the spread over great distances indicates a secondary diffusion process.

(3) While the bow was used for many centuries in the Arctic prior to its diffusion to the south, morphologically similar small triangular and triangular notched points took only a few centuries to be introduced over much of the continent south of the boreal forest.

(4) Beginning at least as early as A.D. 200 in some areas but intensifying after A.D. 500 over all of the continent south of the boreal forests, there is a reduction in the overall size of projectile points through time. In those regions that show gradual transitions (the co-occurrence of large, heavy points with small, triangular points) such as the Great Basin and Intermontane West, the presence of the atlatl can also be demonstrated. In those areas that show relatively sudden shifts to predominantly small points, such as the Southwest, Plains, Midwest and Southeast, evidence for the atlatl rapidly disappears from the archaeological record.

EFFICIENCY AND SUBSISTENCE

The large scale pattern of bow distribution reveals that the adoption was rapid and persuasive. Introduced cultural elements will have multiple social, ideological and technological impacts. No doubt the bow had implications beyond technology, as did the spearthrower (Hall, 1977), but its functional value as a tool will be considered first. To what extent can this dissemination process be related to the bow's greater technological efficiency and its potential utility in 1) subsistence economy and 2) intergroup competition?

First, the implicit assumption that the bow is a technological advance over the atlatl must be addressed. Is this indeed the case? Both ethnographic and experimental observations provide a means to assess the comparative efficiencies of the bow and atlatl. Most ethnographic examples of atlatl hunting discuss an ambush technique at very close range. Such a method appears to reflect limits on the atlatl's range and accuracy. An observer of the Arunta atlatl hunters of Australia commented "it takes an exceptionally good man to kill or disable at more than twenty yards" (Spencer and Gillen, 1927:16). In certain situations, the atlatl may have specific advantages over the bow. Kellar (1955) notes atlatl use by canoe-based hunters such as various Eskimo groups and peoples located in central Mexico. The bow was also known to these hunters. He suggests that the need for a free hand to maneuver and detrimental effects of moisture on bow strings favored use of the atlatl for this type of hunting.

Yet it seems clear that in purely physical and mechanical terms, the bow has the advantage of increased range and accuracy over the atlatl. Modern experimenters with various types of atlatls report highly variable distance and impact measurements which are difficult to evaluate and relate to the archaeological record (Hill, 1948; Howard, 1974; Raymond, 1986). Nevertheless, extensive measurements of distance, velocity, and accuracy by a variety of traditional bow types indicates that the bow's performance is far superior to the atlatl (Pope, 1923; Brown, 1940).

The reduction of shaft width, projectile point size, use of fletching, and velocity differences between bow and atlatl all determine the complex aerodynamic properties of arrows and darts, which directly relates to the accuracy, killing power and range of the two weapon systems (Christenson, 1986). The greater mechanical efficiency of the bow is due to higher velocity, flatter trajectory, and greater effective range. Other observations that the bow and arrow provided advantages over the atlatl include the ability to shoot projectiles at a faster rate (Christenson, 1986:122); a bow is easier to use in wooded areas (Glassow, 1972:298); the bow requires less physical movement in use (Frison, 1978:228; Raymond, 1986;171); and a bow is back-sighted (Christenson, 1986:122).

Any evaluation of increased hunting efficiency must consider the context in which the activity is taking place. Thus, in close range ambush hunting, both bow and atlatl may be highly efficient tools. However, as the distance from hunter to prey increases, the greater accuracy and velocity of the bow would prove more advantageous. With the bow, the ratio of hits to misses would be expected to increase, especially for wary, hard-to-approach species. Perhaps this is why the bow has been used throughout the world in a wider variety of ambush, stalk, and surround hunting situations than has the atlatl.

Clearly, the bow was a significant technological improvement over the atlatl but did this change have any effect on subsistence economies that is detectable in the archaeological record? Broad spectrum subsistence economies with accelerating population densities, horticultural intensification, and increased sedentism characterized many societies in southern North America at the time of the adoption of the bow. It has been suggested that bow technology may have played a role in increased productivity in the Midwest (Brown, 1977:173; Fowler and Hall, 1978:561), Southeast (Jenkins, 1982:182), and Southwest (Glassow, 1972:298-299). Because horticultural expansion demanded more energy expenditure, it could be argued that increased efficiency was required in the hunting economy and that this was provided by the bow (Glassow, 1972:293).

There is little evidence to support a view of the bow as an adaptive necessity. In the Eastern Woodlands, there are no clear changes in faunal assemblages that correlate with bow introduction. Faunal remains indicate long-term general trends to maximize the breadth of the subsistence economy and the major focal species of earlier periods are relatively similar through Late Woodland when the bow was adopted (Muller, 1986:141; Kelley and Cross, 1984:232; Ford, 1977:178). Optimal foraging analyses of Midwestern subsistence economies estimate only slight reductions in procurement costs with bow hunting (Christenson, 1986:122). Examination of faunal remains from a number of contemporary sites in a specific area reveals frequency differences that seem to represent fluctuations and variability due to the highly localized environmental conditions in each catchment area (Kelley and Cross, 1984) rather than a specific technological change such as the bow. This observation makes any attempt to link faunal changes with the bow exceedingly insecure. For instance, it is possible that procurement efficiency may have increased without producing a detectable change in faunal assemblages, or alternatively, efficiency may have been merely maintained in areas of increased pressure on faunal resources.

COMPETITION

One can accept that the bow was attractive as an efficient implement without conceiving of this adoption as mandated by local ecosystemic necessities. If adoption of the bow and arrow is largely a response to changes in local man/land relationships, why does the distribution spread so rapidly across a wide diversity of ecosystems? Dissemination appears to be continuous over areas that must have varied considerably in population density and resource aggregation. The trend is powerful and almost certainly overrides local ecological conditions.

Rapid adoption of the bow cannot be understood in technological terms alone. The competitive context of individual and group interaction generated the principal motivations for acceptance of the bow. Relatively modest social ranking appears to characterize the organizational structure of hunting, foraging, and gardening societies in North America at the time of bow introduction. Besides age and sex distinctions, archaeological evidence suggests that personal influence within the social group was governed primarily by competitive status achievement. One important route to greater prestige widespread in North American ethnographic accounts is prowess in hunting. Assuming the bow was indeed more versatile and efficient than the spearthrower, this enhancement of individual hunting success must have been a strong incentive for adoption. Technological efficiency, while inherent in a tool's mechanical properties, must be defined and interpreted within a social context.

The bow has specific advantages in situations of intergroup conflict, which may arise under conditions of competition for resource territories. Groups confronted by hostile neighbors armed with the bow would be under significant pressure to adopt it themselves. While intergroup conflict might logically be expected in the most densely settled areas, competition over resources can arise under a wide range of demographic and environmental circumstances. To the degree that territories of even low-density, mobile groups overlapped at nodes of concentrated resources, those groups without the bow were at a critical competitive disadvantage. Furthermore, intergroup contacts may occur in spheres that overlap ecological boundaries.

The necessity for increased hunting efficiency in the face of demographic stress on the local resource base has been offered as the primary adaptive context for adoption of the bow but the causal "arrow" might well be the other way around. That is, local environmental demands need not be the stimulus for the change. Instead, the technical advantages of the bow may have permitted new possibilities of resource exploitation and territory expansion, and yet resulted from external introduction. Groups armed with the bow could expand their resource territories at the expense of those without it. Territory expansion, together with an increased productive capacity may have precipitated demographic change rather than have been a response to it.

It is relevant to note that in the Eastern Woodlands archaeologists have suggested that bow warfare may have disrupted exchange and led to the Hopewell "decline" (Ford, 1974:403; Chapman and Chapman, 1964:58), but it is now clear that the bow appeared too late for this exact scenario. However, the paradox of Late Woodland population increase and dispersal attended by a decline in regional exchange may be a result of technological change. Ceramic efficiency, intensification of starchy seeds, and the bow perhaps led to greater economic independence and intergroup autonomy (Muller, 1986:148).

Not only does the chain-reaction mechanism of competitive advantage adequately fit the bow's distribution pattern, but there are indications that the nature of intergroup conflict was strongly affected. Archaeological evidence for increased intergroup conflict indicated by small projectile points lodged in human bone, group burials of such individuals, and the appearance of fortified communities or placement of sites into defensive positions, closely correlates with or follows soon after bow introduction into many areas of North America. Single and group burials with embedded arrowpoints are found in the Late Woodland Midwest (Perino, 1973; Kelly et al., 1984:127; Christenson, 1986:122; Cook, 1984); Northeast (Ritchie, 1969:294, 318); and Southeast (Hill, 1981).

In an atmosphere of increased sedentism and horticultural intensification that characterized several regions of North America at the time of the bow's introduction, a group wishing to protect their food surpluses and avoid being dislodged from favorable localities needed to build fortifications or seek defensive positions. In the Anazasi and Mogollon areas of the Southwest, the appearance of the bow about 600 A.D. coincides with shifts in site placement to defensive positions on bluffs and mesas (Plog, 1979:126; Cordell, 1984:224; Lipe, 1978:382; Martin, 1979:65); villages enclosed by stockades (Plog, 1979:126; Cordell, 1979:136); and burned dwellings with skeletons indicating violent death (Cordell, 1979:136). In the Northeast, evidence of fortification has been found ca. A.D. 800 in the Lake Erie area (Griffin, 1978:254). In the Plains, Midwest and Southeast, definite evidence of palisades and defensive works occur at A.D. 900-1000, one to three centuries after the bow had been in use. This indicates that the bow did not immediately necessitate fortified communities, which must be understood as a response to additional demographic, social and economic changes. However, those fortifications that do appear have specific design layouts, such as bastions and constricted entrances, that are a direct response to bow warfare (Larson, 1972; Lafferty, 1973).

CONCLUSIONS

In both intent and execution the spirit of this inquiry has been exploratory rather than definitive. My main purpose is to reiterate that conclusions about interrelationships between technological innovations and human behavior, or any other complex phenomena, are shaped by the scale with which they are measured. In this case, a continent-wide perspective reveals a north to south chronological distribution for the initial adoption of the bow. Multiple episodes of independent invention or extensive movements of people are rejected as explanations in favor of a secondary diffusion process.

The large-scale pattern suggests that this technological change is not to be explained by highly localized ecological conditions, but rather by a historical process of intergroup contact and competition. For those who adopted it, the bow as a weapon conferred a competitive advantage over groups who retained the atlatl and a rapid process of dissemination and technological replacement occurred. No doubt local aspects of this dissemination were mediated in part by demographic and ecological factors, but the entire distribution, spread, and adoption phenomenon cannot be reduced to the local level. The overwhelming characteristic of the spread is a rapid cross-cutting of local ecological conditions.

One kind of stimulus that runs through the course of cultural evolution is the external constraints and opportunities repeatedly introduced into social groups as open systems. Accessibility to a technology is one such constraint/opportunity. The decision to accept a technological innovation into the local economy is predicated on its availability. In this case, had the bow been unavailable, the character of subsequent cultural development may have been quite different. The incorporation of the bow into North American societies is best understood as the result of competitive social relations rather than a gradual, passive unfolding of environmental pressures.

Archaeologists should not hesitate to incorporate large-scale diffusionary events into their interpretive frameworks. This decision will demand a reconsideration of the more narrow "determinisms" in many ecological arguments. Some of the causal factors promoted as explanations in ecological archaeology may be only local rates or fluctuations, minor perturbations compared to patterns revealed at a larger scale. To avoid this limitation, a true cultural ecology and a more holistic archaeology will have to integrate localized, continental and global perspectives.

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