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Eye of the Needle: Cold Stress, Clothing, and Sewing Technology during the Younger Dryas Cold Event in North America

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This paper examines the possible underlying systemic context(s) for spurred flake gravers and eyed bone needles recovered from Paleoindian sites in North America. The idea that spurred flake gravers and eyed bone needles were closely associated is not new. Archaeologists in both Eurasia and North America have also proposed that eyed bone and ivory needles were used for manufacturing tailored skin clothing. It is suggested here that spurred flake gravers and eyed bone needles may, in fact, be the material correlates of critical non-subsistence related work carried out by women to meet the challenges of very severe winters and cold stress of the Younger Dryas Cold Event (YDCE) between 12,900–11,600 cal. B.P. It is argued here that such expediently produced flake implements and curated sewing technology including eyed needles ultimately reflect the significant ecological bottleneck(s) posed by the YDCE for Paleoindian populations. Metric attributes of both spurred flake gravers and eyed bone needles, their spatial co-occurrence in archaeological contexts, and their temporal co-occurrence within the YDCE lend empirical support for this causal argument.

Este artículo examina el contexto sistémico subyacente posible (s) de buriles escamas estimulado y agujas de hueso ojos recuperados de sitios paleoindios de América del Norte. La idea de que los buriles escamas estimulado y agujas de hueso ojos estaban estrechamente asociados no es nueva. Los arqueólogos también han propuesto tanto en Eurasia y América del Norte, que las agujas de hueso y marfil ojos fueron utilizados para la fabricación de prendas de vestir de piel a medida. Se sugiere aquí que buriles escamas estimulado y agujas de hueso ojos pueden, de hecho, el material se correlaciona de trabajo crítico no relacionado con la subsistencia que realizan las mujeres para afrontar los retos de inviernos muy severos y el estrés frío del Younger Dryas evento frío (YDCE) entre 12,900–11,600 cal aap. Aquí se argumenta que tales implementos escamas convenientemente producidos y la tecnología, incluyendo agujas de coser comisariada ojos reflejan en última instancia, el cuello de botella ecológica significativa (s) formulada por el YDCE para las poblaciones paleoindios. Atributos métricos de dos buriles estimulado escamas y agujas de hueso, sus ojos espaciales co-ocurrencia en contextos arqueológicos, y su co-ocurrencia de temporales en el YDCE prestan apoyo empírico a este argumento causal.

Archaeologists have recently devoted considerable attention to the Younger Dryas Cold Event (YDCE) and its possible impacts upon human populations in the Northern Hemisphere. These studies include Europe (Bicho et al. 2011; Jochim 2012; Jones 2009), the Middle East (Bar-Yosef 1998; Makarewicz 2012; Munro 2003), Northeast Asia (Wright and Janz 2012); and North America (Ballenger et al. 2011; Ellis et al. 2011; Goebel et al. 2011; Graf and Bigelow 2011; Holliday et al. 2011; LaBelle 2012; Lothrop et al. 2011; Meeks and Anderson 2012). A number of archaeologists have concluded that the YDCE had significant impacts upon Paleoindian populations in North America (e.g., Anderson et al. 2011; Newby et al. 2005).

Conversely, some archaeologists have concluded that this 1,300 year "cold snap" brought few, if any, consequences for prehistoric peoples of North America (e.g., Ellis et al. 2011; Eren 2009, 2012; Meltzer and Holliday 2010). For example, Meltzer and Holliday (2010:31) state that "it is likely that across most of North America south of the retreating ice sheets Paleoindians were not constantly scrambling to keep up with Younger Dryas age climate change." Eren (2012:19) concluded that "there is currently little evidence for a connection between Younger Dryas

Alan J. Osborn ■ Department of Sociology and Anthropology, University of Nebraska-Omaha, Omaha, NE 68182 (aosborn2@unomaha.edu)

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climate change and hunter-gatherer culture change." These differing views have raised important questions regarding both the geographic extent and intensity of the YDCE as well as its differential impacts upon hunter-gatherer populations throughout the Northern Hemisphere.

It is proposed here that the significance of YDCE impacts upon Paleoindian populations (e.g., Clovis, Goshen, Folsom, Gainey, Parkhill, Crowfield, Barnes, Debert, Bull Brook, Cumberland, and Redstone), as well as certain initial Early Archaic groups (e.g., Quad, Beaver Lake, and Dalton variants) has been underestimated. Winter climate during the YDCE most probably played a key role in shaping the lives and behavioral patterns of hunter-gatherers during this 13-century-long period across much of North America. Recent YDCE research suggests that much of North America experienced marked intra-annual shifts from warm summers to extremely cold winters. Such extreme seasonality in the Northern Hemisphere has no modern analogues. Many archaeologists have yet to consider the limiting effects of cold stress upon Paleoindians and initial Early Archaic populations in North America. It is suggested here that one crucial adaptive response to cold stress was the development of sewing technology designed to manufacture tailor-made skin clothing. This same adaptive response appears to have been made during the Late Glacial Maximum (LGM) and the YDCE throughout Europe and Asia by Gravetian, Solutrean, and Magdalenian populations (e.g., Soffer and Praslov 1993; Stordeur-Yedid 1979).

Responding to Cold Stress

The winter season in the Northern Hemisphere generally imposes significant ecological bottlenecks like cold stress upon plants, animals, and humans. Such bottlenecks are particularly pronounced in higher latitude and higher altitude environmental settings. Since humans are homeothermic, as well as endothermic, they must maintain a relatively constant body temperature independent of the external environment (Folk 1974:90). Consequently, humans must respond to cold stress during winter as air temperature drops below 25° C (77° F; Folk 1974; Newman 1956; Osborn 2004; So 1980), preventing heat loss and increasing rates of heat production during winter (Steegmann et al. 1983:322).

Paleoindians and initial Early Archaic groups would have required effective winter "survival suits" to reduce heat loss during extremely cold YDCE winters. Consequently, the present discussion focuses upon sewing technology used to manufacture tailored skin clothing and footwear. Eyed sewing needles were an essential implement used by hunter-gatherers at this time. The manufacture of eyed needles would have required an array of tools including gravers, burins, abraders, and perhaps bow drills. It is proposed here that these implements, as well as winter clothing, were fabricated and maintained by women in these societies. A number of previous archaeological and ethnographic studies have contributed to a better understanding of technologies developed and utilized by women (e.g., Arthur 2010; Sassaman 1992; Walthall and Holley 1997).

We cannot simply assume a priori that Paleoindian and initial Early Archaic women were responsible for this task. A number of recent studies have given increased attention to gender-based labor allocation in subsistence-based, as well as market-based, economies (Adovasio et al. 2009; Arthur 2010; Jarvenpa and Brumbach 2006; Owen 2000). We can also look to recent research on the division of labor in subsistence societies for more robust generalizations (e.g., Binford 2001; Bird 1999; Kramer and Ellison 2010; Kuhn and Stiner 2006; Waguespack 2005).

Waguespack and Surovell (2003) have argued that the Clovis hunter-gatherer diet was dominated by meat—primarily obtained from large-bodied prey, including mammoth, mastodon, and bison. We should also consider Paleoindian populations in the Great Lakes Region and the Northeast who probably relied heavily upon caribou (Jackson 1997). Interestingly, Waguespack (2005) observed that subsistence-related work (minutes per day) among hunter-gatherers is inversely related to the dietary importance of meat ($r^2 = .979$). She (2005:671) also proposed that "female participation in nonsubsistence activities increases in societies with hunting-dominated subsistence economics."

Additionally, cold and highly seasonal environments offer few foraging opportunities for women, yet such settings do require costly maintenance activities (e.g., acquiring fuel, constructing shelters, and manufacturing clothing; Kuhn and Stiner 2006:955–956). The skills required to produce tailored skin clothing were very specialized and were acquired over a long period starting in early childhood. Among the Nunamiut of the Brooks Range in Alaska, for example, women were not believed to be accomplished seamstresses until they were 35 years old (Gubser 1965:111). The fabrication of clothing is temporally and spatially compatible with a range of domestic activities, including child care, meal preparation, fire tending, and social activities (Oakes and Riewe 1998:15). We may assume, for now, that these generalizations hold for women during the YDCE.

Younger Dryas Cold Event

The Younger Dryas Cold Event (12,940–11,640 cal. B.P.) was "one of the largest of the abrupt climate changes that have occurred frequently over most of the last 100,000 years" (Mayle and Cwynar 1995:129). The YDCE was an extreme Heinrich cold event characterized by pronounced seasonality driven by extremely cold, dry winters that impacted large portions of the Northern Hemisphere (Broecker et al. 2010). This very abrupt, short-term environmental shift involved the oceans, atmosphere, and ecosphere (Shuman et al. 2009). Heinrich events are characterized by abrupt pulses of iceberg "armadas" that were discharged from the ice shelves bordering the glacial ice in the Northern Hemisphere (Alvarez-Solas et al. 2010; Broecker 1994). The YDCE began and ended very abruptly and lasted only 1,300 ± 70 years (Alley 2000:213; Peteet 2000). This brief return to glacial conditions is evidenced in the Greenland ice cores (Dye 3, GRIP, and GISP2), sea floor sediment cores, ^{14}C coral sequences, chemical tracers in benthic foraminifera, freshwater midges, speleothem sequences, buried ice wedges, pollen and macrofossil records, tree rings, and stable isotopes in soil and water. High resolution climate records are, however, rare for portions of the Northern Hemisphere (Ballenger et al. 2011:511).

Geographical Range

Recent paleoenvironmental research has revealed that the climate during the YDCE in the Northern Hemisphere was quite complex (Anderson 1997). Significantly, plant and animal communities of the YDCE have no modern analogues. There were continental-scale, extensive changes in plant communities across North America during the YDCE that involved much more than shifts in ecotonal boundaries (Shuman et al. 2002:1784). Yu and Wright (2001:354) describe the widespread, synchronous shifts in climate across North America during the YDCE. Yet such change was not uniform. Brown (2006:234) states, "We do not yet know enough about the geographic distribution of the Younger Dryas signal to discuss whether its seemingly mosaic pattern is genuine, or an artifact of inadequate sampling."

Recent research reveals that the "signal" for the YDCE has been detected over a vast portion of North America, including Ontario (Yu and Eicher 1998); northwestern Ohio (Campbell et al. 2011); northern Illinois (Gonzales and Grimm 2009); Missouri (Denniston et al. 2001); the Northern and Southern Rocky Mountains (Brunelle 2007; Reasoner and Jodry 2000); Grand Canyon, Arizona (Wurster et al. 2008); Klamath Mountains, Oregon (Vacco et al. 2005); western and north-central Washington (Heusser 1977; Thornburg 2006); Vancouver, British Columbia (Mathewes et al. 1993; McKay et al. 2004); Kodiak Island (Hajdas et al. 1998); and Barrow, Alaska (Meyer et al. 2010). Peteet (1993a, 1993b) emphasized that the atmospheric response was very rapid and quite widespread. Importantly, the North Atlantic and North Pacific regions were teleconnected via atmospheric forcing (Mikolajewicz et al. 1997; Peteet et al. 1997). Although winters became more severe across much of North America during the YDCE, Kneller and Peteet (1999:140–143) have found that arboreal pollen profiles from Brown's Pond in central Appalachia suggest that there was a warmer climate during the Younger Dryas in the southeastern region of North America between northern Florida and northern Virginia (29°N and 41°N lat.). In the American Southwest, however, some proxy data suggests that YDCE winters may have been wetter and/or cooler ca. 12,900 cal. B.P. Currently, there is no consensus about the YDCE climate of this region (Ballenger et al. 2011).

Seasonality

Measures of mean annual temperature can mask pronounced seasonal extremes. Flückiger et al.

(2008:634) also state that paleoclimate models "confirm the strong dominance of winter versus summer temperature changes during abrupt glacial climate events" in Europe, Greenland, and the North Atlantic region. Many environmental proxies, such as pollen, macrobotanical remains, stable carbon isotopes (C_3/C_4 vegetation), and beetle assemblages, tell us little about winter climatic conditions. Broecker (2006:211) describes the disparities in measurements of mean annual cooling during the YDCE over Greenland based on isotopic versus geological measurements of cooling. This paradox was recently resolved once it was found that YDCE cooling based upon geological evidence reflected summer temperatures (degrees below present-day means), and nitrogen and argon isotopes reflected cooling driven by extremely cold winters. Meyer et al. (2010) have recently made use of stable isotopes and ice wedges to examine severe winter climate during the YDCE in northern Alaska.

Winters were significantly colder across North America, if not much of the entire Northern Hemisphere (Anderson 1997; Borisova 1997; Brand and McCarthy 2005; Broecker et al. 1988; Kennett 1990; Peteet, 2000; Shuman et al. 2002; Yu and Wright 2001:360). Borisova (1997:104) states, "In the greater part of North America the winter temperature was sufficiently colder than at present. The deviation tends to increase from the south to the north, reaching 8–9° C [14.4–16.2° F] in the inner continental area taken up by the Laurentide ice sheet." In eastern North America, temperatures dropped from 3 to 20° C (5.4 to 36° F); this range may reflect seasonal extremes (Peteet 2000:1360). In the Great Lakes region ca. 13,000 B.P., mean January temperature was ca. -20° C (-4° F) (Shane and Anderson 1993). Shuman et al. (2002:1786) describe the pronounced seasonality of the Midwest, where "Colder-than-previous winters (about -10° C) [14° F] coincided with warmer-than-previous summers (> 23° C) [73° F]." Importantly, winter severity would be expected to increase significantly in upland and mountainous regions, including the Appalachian Mountain system of the East and the Southern High Plains and Rocky Mountains of the West.

Interestingly, temperatures during the growing season throughout much of the Northern Hemisphere were warmer than present-day temperatures (Rind et al. 1986). During the YDCE, the earth was tilted toward the sun during the perihelion, or the point at which earth's orbit brings it closest to the sun, so that summer insolation was high (Anderson et al. 2007; Björck et al. 2002; Webb et al. 2004). Once again, we find that such seasonal extremes have no modern equivalent in North America. Also, it was quite windy and dry during the Younger Dryas (Alley 2000; Brauer et al. 2008; Denton et al. 2005). Denton et al. (2005:1178) discuss the significance of windborne dust during Heinrich events in the Northern Hemisphere.

Significance of Skin Clothing and Footwear

Archaeologists have given little attention to prehistoric clothing until quite recently (e.g., Adovasio et al. 2009; Gillian 2007a, 2007b; Hoffecker 2002; Soffer et al. 2000). In high latitude settings, very low air temperatures and wind require that humans make use of layered fur and skin clothing and footwear. Wind chill temperatures play a significant role in determining certain aspects of winter clothing (Aiello and Wheeler 2003; Gilligan 2007a, 2007b). Consequently, clothing becomes as significant and essential to human life as food itself.

Such clothing must be tailor-made for each person based upon age, sex, body size, and body shape. The nature of such skin clothing and footwear for Arctic peoples has been discussed in rich detail by a number of investigators (e.g., Buijs 1997; Buijs and Oosten 1997; Hall et al. 1994; Hatt 1969 [1914]; Issenman 2000 [1997]; Klokkernes 2007; Oakes 1991; Oakes and Riewe 1995, 1998, 2007; Riewe 1975; Stefánsson 1955; Stenton 1991). Select aspects of winter skin clothing for Arctic peoples have been summarized by Osborn (2004).

Throughout the Arctic, the caribou or reindeer skins were most preferred for winter clothing because they provided excellent insulation, were very durable, and were lightweight. A complete winter outfit weighed 3.0–4.5 kg (Stefánsson 1955). Yet, reindeer or caribou guard hairs are also brittle and shed relatively easily so winter outfits were usually replaced each fall (Hatt 1969 [1914]).

Animal skins for winter clothing had to be obtained within a very short window of time. Historically, in late spring and early summer the skins of caribou were riddled with botfly holes (Kelsall 1968:269–74). During the summer, fur was still relatively thin and provided less insulation. Yet the skins had to be procured early enough in the fall to allow ample time for hide processing and the manufacture of adequate winter parkas, pants, gloves, and boots. The skins of adult animals are thick and heavy and were usually not used for clothing unless more preferred skins were not available (Hatt 1969:8 [1914]).

McGhee (2001: 59–60) states, "The most unremitting summer task faced by women, however, was the preparation of skins, sewing of new clothes, and repair of old." Caribou hides required arduous processing aimed at removing all subcutaneous fat and tissue from the interior surface of the hide. Hall et al. (1994:18–19) state that five caribou skins were required to make a coat (parka), pants, boots, and mitts for one individual. An adult female expended approximately 525 hours to produce complete winter outfits for a family of five individuals (or about 105 hours per outfit; Issenman 2000:95).

Manufacture of winter clothing was so crucial to Arctic life that sewing was given ritual significance (Oakes and Riewe 1998:18). Perhaps, more importantly, the actual process of making winter clothing was carried out in special "sewing camps" and was subject to strict rules (Balikci 1970:55). Taboos related to the "sewing period" and the fabrication of winter clothing functioned to focus the group's undivided attention on this critical activity. We would not expect that clothing manufacture by YDCE hunter-gatherers would have been any less significant.

Eyed Bone Needles

Eyed bone needles have been recovered from a number of archaeological sites throughout Europe, Russia, and North America (Flenniken 1978; Hoffman 2002; Storduer-Yedid 1979). The presence of these small, delicate artifacts has been equated with the production of tailored skin clothing that was very well suited for surviving severe winters in higher latitude settings (Gilligan 2007a, 2007b). Many eyed bone needles have been recovered from Magdalenian sites in Western Europe dating to the YDCE (Stordeur-Yedid 1979). As mentioned, eyed needles of bone, ivory, and copper were also essential implements for making warm, waterproof winter boots in such settings. During the YDCE, winter apparel would have been necessary in the mid-latitudes of North America.

Eyed bone needles have been recovered from Paleoindian sites in Alaska, Washington, Idaho, Nevada, Wyoming, Colorado, Texas, Nebraska, and Missouri (Figure 1). Eyed bone needles from Paleoindian contexts in North America date between 12,660–10,310 cal. B.P. (Table 1). These bone implements appear to be quite rare in the archaeological record after the YDCE. Based upon the published literature, few, if any, eyed bone needles have been recovered from archaeological contexts outside of the Arctic region after the Paleoindian and initial Early Archaic periods. Skin clothing for ethnographically-documented groups living outside the Arctic appears not to have been made using eyed needles but, instead, was sewn using bone awls and a "pierce and lace" method (Hatt 1969 [1914]).

Needle Manufacture

Eyed needles were made from bone, ivory, and, in rare cases, native copper (McGhee 1972, 2001). We do know that Unangan women of the Aleutian Islands were observed making bone needles by Russian explorers (e.g., Merck 1980:77, 173, 203). We find that sewing needles were made from bird bone (goose, sea gull, albatross), red fox tibiae, caribou fibulae and metatarsals, bison scapulae, and assorted bones of bear, reindeer, and fish (Balikci 1970; Hoffman 2002; Issenman, 2000:14; Murdoch 1892; Oakes and Riewe 1998). The Caribou and Belcher Islander Inuit made eyed sewing needles from walrus ivory (Oakes and Riewe 1995:30).

Perhaps the most widely used method for making bone needles involved the "groove and snap" technique (Clark and Thompson 1953). Hoffman (2002:156) states, "This technique involves incising long parallel grooves into a bone 'Core' and then prying or snapping out the linear blank." Archaeological and ethnographic records reveal that the eyes in bone, ivory, and antler needles were created either by drilling with a bow drill or gouging with burins (Borziyak 1993; Hoffman 2002). Oakes and Riewe (2007:26) propose that needles

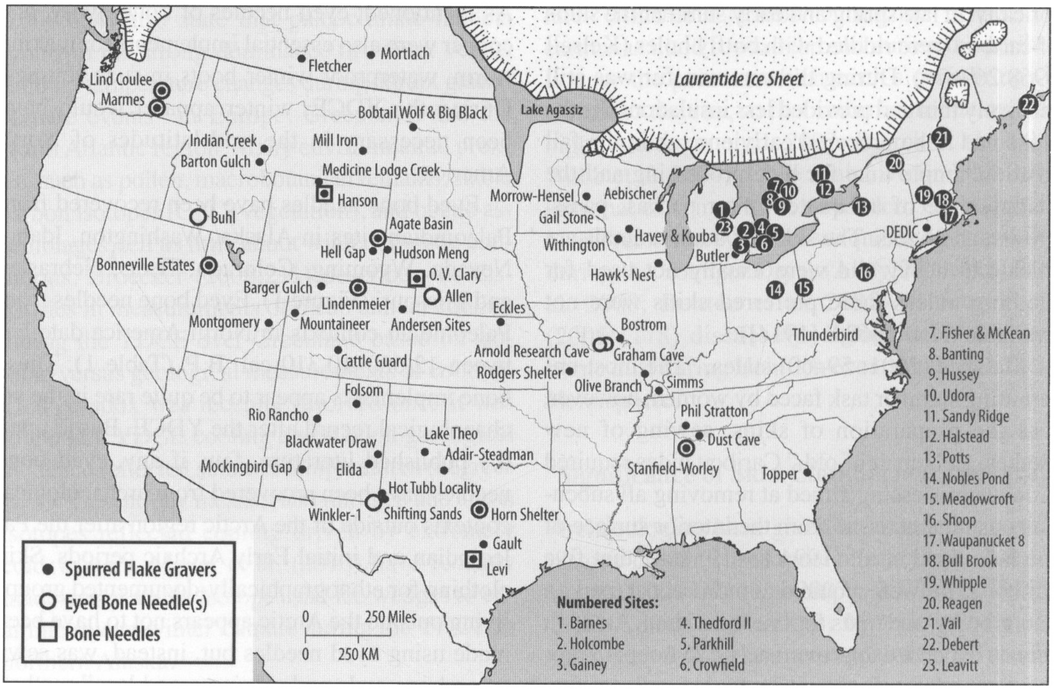

Figure 1. Paleoindian sites with spurred flake gravers and eyed bone needles.

made using gouged slits created smaller eyes than those that were drilled. An elongated eye within a groove or channel also allows the needle and thread to pass through the materials without widening the hole. Issenman (1997:41) points out that Dorset groups gouged eyes in needles that exhibited lenticular or lozenge-shaped cross sections. It also appears that eyes were completed through use of both gouging and drilling (Stordeur-Yedid 1979). Merck (1980:77) mentions that bone needles made by the Unangan women were smoothed and sharpened with abraders made from "spongy volcanic rock."

Murdoch (1892:318–319) described historic eyed bone needles from Pt. Barrow, Alaska, that ranged in length from 45.72–63.5 mm. Two com-

Table 1. Eyed Bone Needles Recovered from Paleoindian Contexts.

Site	Location	Age Estimate (cal. B.P.)	Reference
Broken Mammoth	Alaska	11,800–11,000	Holmes 1996
Marmes Rockshelter	Washington	11,500	Root and Gustafson 2004
Lind Coulee	Washington	12,300–11,200	Irwin and Moody 1978; Lyman 2013
Buhl Burial	Idaho	12,660	Green et al. 1998
Agate Basin	Wyoming	12,764–11,938	Frison 1991
Medicine Lodge Creek	Wyoming	10,700*	Frison and Walker 2007
Barton Gulch	Montana	11,190	Davis 1993
Lindenmeier	Colorado	12,558	Wilmsen and Roberts 1983
Allen Site	Nebraska	12,250–11,980	Bamforth 2007
Bonneville Estates	Nevada	12,752-11,661	Goebel et al. 2011
Graham Cave	Missouri	12,865–11,233	Chapman 1952; Logan 1952
Arnold Research Cave	Missouri	11,172–10,239	Shippee 1966
Horn Shelter	Texas	10,310	Young et al. 1987
Winkler-1	Texas	11,000	Blaine and Wendorf 1972

*Based upon two calibrated age estimates from 20–22 ft level, Area 2 (Frison and Walker 2007:34, Figure 3.1).

Table 2. Metric Dimensions (mm) of Historic and Paleoindian Eyed Bone Needles.

Site	Length (mm)	Shaft Diameter (mm)	Eye Inside Diameter (mm)	Reference
Pt. Barrow, AL	45.72–63.50 55 (mean)	-	-	Murdoch 1892:318–319
Lind Coulee, WA	-	2.05	0.90	Flenniken 1978:63, Table 1
Marmes Rockshelter, WA	51.90	1.50	0.90	Root and Gustafson 2004
Buhl Burial, ID	31.00	2.00	0.80	Green et al. 1998
Winkler-1, TX	13.34*	1.07	0.75	Blaine and Wendorf 1972:50
Mean	41.45	1.65	0.84	

*fragment

plete eyed bone needles from Marmes Rockshelter in Oregon and the Buhl burial in Idaho were 52 mm and 31 mm in length, respectively (Table 2). Their diameters range from .19–2.0 mm and the eyes range in diameter from .2–.8 mm. Balikci (1970:13) states, "These bone needles broke frequently, to the annoyance of the seamstress, and they were quickly and gladly replaced by needles of metal when metal came into use." Inuit women kept their delicate sewing needles in decorated bone or ivory needle cases or small leather bags that they wore around their necks (e.g., Birket-Smith 1929:I:248; Murdoch 1892:320–322, Figures 327–328).

Spurred Flake Gravers

Archaeologists have used the term "graver" to include a diverse array of chipped stone tools that exhibit points or projections. Consequently, one can find references to "gravers" from Paleoindian, Archaic, and Woodland contexts, but it must be emphasized here that not all gravers are the same. For example, gravers were recovered from the Dash Reeves Site, a Middle Woodland village, in the American Bottom of western Illinois; however, these implements are actually "truncated burins" (Fortier 2001:168). For this reason, it is important to examine photographs and line drawings that accompany the references to "gravers" in the archaeological literature.

This study focuses specifically upon flake gravers that possess one or more very small spurs along the flake margin. These expedient tools-to-make-tools will be referred to here as "spurred flake gravers." Spurs were created between two concavities along the flake margin that were formed by minute unifacial retouch or crushing (Figure 2; Nero 1957:303). Spurred flake gravers were not used as drills in a rotary fashion but were instead used to cut or gouge narrow grooves in bone, antler, and perhaps ivory. Spurred flake gravers are found almost exclusively in Paleoindian and initial Early Archaic contexts (ca. 12,300–9,000 B.P.; Irwin and Wormington 1970; Judge 1973; MacDonald 1968; Mason 1981; Rogers 1985).

Importantly, spurred flake gravers should not be confused with spurred endscrapers. Spurred endscrapers, too, have been considered by many archaeologists to be a "diagnostic" Paleoindian implement (Shott 1995:59). Many Paleoindian endscrapers exhibit spur-like elements at one or both corners of the scraper bit (see Judge 1973:94–95, Figures 11–12; MacDonald 1968:185, Plate XIII). Although these spurs have been considered by some archaeologists to have been deliberate, functional elements, Shott (1995:60) has proposed that they represent "an incidental consequence of resharpening the tool." Most so-called spurred scrapers simply appear to be examples of scrapers that have been completely exhausted as a result of repeated resharpening.

Spurred flake gravers, in fact, have been variously referred to as "gravers" (Roberts 1935b; Wormington 1957), "spurs" (Irwin and Wormington 1970), "spur perforators" (Irwin-Williams et al. 1973), "spurred gravers", "denticulate gravers" (Keenlyside 1991), "compass-coring-coronet gravers" (MacDonald 1968), "three-pronged gravers" (Frison 1991), "piercers or micro piercers" (Deller and Ellis 1984, 1992a, 1992b; Ellis and Deller 1988), and "cutters" (Gramly 1982). More detailed graver typologies have been proposed by Boast (1983), Irwin and Wormington (1970), and Wright (1940).

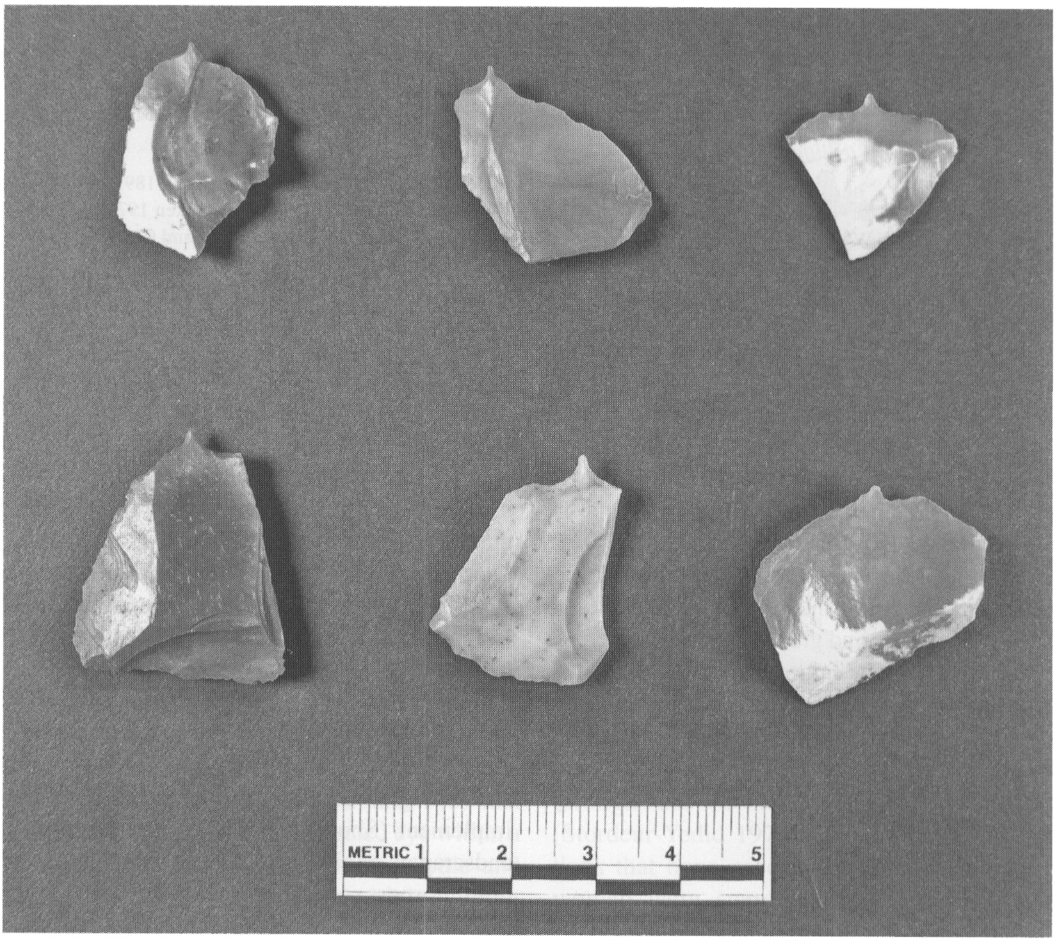

Figure 2. Spurred flake gravers from Paleoindian sites in Yuma County, Colorado.

Spurred flake gravers have been found across North America in Nova Scotia, Ontario, Maine, Vermont, New Hampshire, New York, Massachusetts, Pennsylvania, Virginia, South Carolina, Kentucky, Alabama, Ohio, Michigan, Wisconsin, Illinois, Missouri, Nebraska, Texas, New Mexico, Arizona, Colorado, Nevada, Wyoming, Montana, Saskatchewan, and Alaska (Figure 1). It is interesting to note that a majority of sites with spurred flake gravers appear in the Northeast above 44°N latitude near the ice sheet during the YDCE and in the West from the Southern High Plains northward along the Front Range of the Rocky Mountains. We would expect that YDCE winters in these regions would have been quite severe given the lapse rate that involves decreased temperatures relative to increased latitude and altitude.

Spurred flake gravers are small, delicate, and expediently made implements (Maika 2010). The mean spur length for 367 spurred flake gravers is 2.65 mm (Table 3). Spur length ranges from 2.0–6.0 mm. The spur lengths at the Lindenmeier site range between 1.5–2.0 mm and were 1.0–1.5 mm wide at the base (Roberts 1935a:26). More detailed measurements were taken on 51 spurred flake gravers in the Andersen collection at the University of Nebraska State Museum. Spur lengths range from .5–4.5 mm (mean = 2.01 mm) in length and from .9–7.5 mm (mean = 3.02 mm) in basal width. Their thicknesses range from .5–4.0 mm (mean = 1.41 mm). The spurs always exhibit a plano-convex cross section (see Figure 3). Spurs are frequently placed along the flake edge at the juncture of two adjacent, dorsal surface flake scars.

Function(s)

Archaeologists have proposed that gravers were used to engrave designs on bone, antler, and/or

Table 3. Mean Spur Length (mm) of Paleoindian Gravers.

Site	Location	Mean Spur Length (mm)	n	Comments	Reference
Andersen	NE Colorado	2.0	51	Single and multiple	
Banting	Ontario	3.0	1	Single	Storck 1979
Banting	Ontario	4.0	1	Single	Storck 1979
Banting	Ontario	4.0	7	Single and double	Storck 1979
Hussey	Ontario	3.0	1	Single	Storck 1979
Hussey	Ontario	2.0	1	Single	Storck 1979
Thedford II	Ontario	2.27	36	Single and multiple	Deller and Ellis 1992a
Fisher	Ontario	2.0	81		Storck 1997
Havey	Wisconsin	2.4			Ritzenthaler 1967
Lindenmeier, Hanson and Agate Basin	Colorado and Wyoming	2.6	65	Single	Boast 1983
Lindenmeier, Hanson and Agate Basin	Colorado and Wyoming	2.0	32	Multiple	Boast 1983
Debert	Nova Scotia	2.5	91	Single and multiple	MacDonald 1966
Total		2.65	367		

ivory tool hafts, needle cases, and bone disks (Table 4). However, Wright (1940:65) states, "Many of the gravers found are too small and lack the necessary strength for engraving hard substances." MacDonald (1968:100) states, "They are much too delicate to have been used for extensive work on bone or antler other than for scratching the surface."

Storck (1997:117) proposed that coronet or compass-coring gravers had been used to pierce animal hides. Wendorf and Hester (1962) assumed that gravers recovered from Folsom kill sites must have been utilized as butchering tools. Both Frison and Stanford, like Wendorf and Hester, proffered that spurred flake gravers had been used for butchering animals— particularly to sever tendons and ligaments in the joints of larger mammals (see Boast 1983:15–16; cf. Frison 1984:298). It should be noted that few, if any, spurred flake gravers have been recovered from Clovis or Folsom kill sites.

It has also been argued that gravers were used to manufacture and repair hunting implements (Boast 1983; Kornfeld 2009:256). In this regard, Rasic (2011:153–154) points out that spurred flake gravers were absent in Sluiceway sites in eastern Beringia, thought to represent locations where hunting weapons were repaired. Roberts (1935) and Tomenchuk and Storck (1997) proposed that coronet or compass-coring gravers had been used to scribe circular designs or to cut disks from bone, antler, calcite, shell, and nephrite. Several archaeologists have suggested that the needle-like spurs on gravers were utilized to create tattoos (MacDonald 1968; Painter 1985; Roberts 1935b).

One of the most interesting ideas regarding the function of spurred flake gravers was offered by Henry T. Irwin (Irwin and Wormington 1970:30). Based upon unpublished experiments, he proposed that the fine, delicate points or spurs on flakes were used to drill or engrave the eyes in Paleoindian bone sewing needles (Figure 3). Regarding the spurred flake gravers found at the Lindenmeier site, Roberts (1935a:26) stated that "small, almost microscopic, flakes have been broken away from the point...such as to suggest that it was caused by a scratching or gouging movement of the implement rather than by a rotary twist such as is used in drilling." Similarly, Mason (1981:88) stated, "Certainly the smaller gravers could have been used to gouge out the eyes in bone needles."

Testing the Causal Linkage

More than four decades ago, Irwin and Wormington (1970:30) stated that, "Through experimentation, Irwin has demonstrated that spurs could have served in the production of eyed bone needles of the type used by early hunters." Irwin had worked at both Lind Coulee and Agate Basin, where eyed needles had been recovered from early deposits,

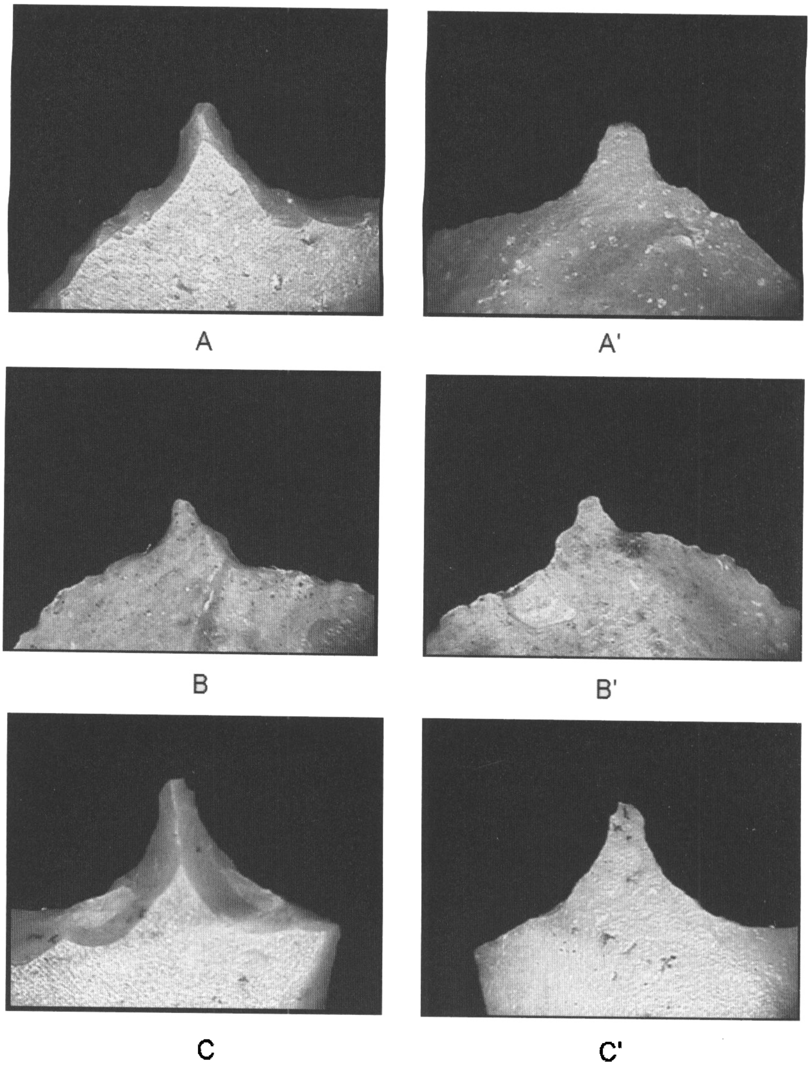

Figure 3. Microphotographs of dorsal and ventral surfaces of spurred flake gravers, A-C (30×).

and was aware that they had been found at the Lindenmeier site along with a number of spurred flake gravers. Archaeologists working in Europe and the Ukraine have also suggested that eyed bone needles and burins from Upper Paleolithic contexts reflected the manufacture of tailored skin clothing. In North America, archaeologists have proposed alternative functions for the spurred flake gravers found in Paleoindian contexts. It is important to ask at this point how Irwin's functional argument linking spurred flake gravers and needles might be strengthened.

First, we can examine the correspondence between the dimensions of graver spurs and the eyes of bone needles. The mean diameter of Paleoindian eyed bone needles equals 1.65 mm (Table 2). The mean inside eye diameter of Paleoindian bone needles from western North America equals .84 mm (Table 2). The eye of the Buhl burial needle "was carefully gouged with a hand-held perforator and was not drilled" (Green et al. 1998:451). As mentioned, graver spurs are quite small and delicate. The mean length of 357 graver spurs equals 2.65 mm, their basal width averages 3.02 mm, and their medial thickness is 1.41 mm (Table 4). Thus, graver spurs were small enough to gouge an eye .9 mm wide and .85 mm deep (halfway through the needle from both sides).

Table 4. Proposed Functions for Spurred Gravers.

Proposed Function	Reference
Engraving designs in bone, antler, ivory	MacDonald 1968; Nero 1957; Roberts 1935b; Wright 1940
Piercing hides	Storck 1997
Butchering; severing tendons	Frison 1984; Wendorf and Hester 1962
Maintenance of hunting implements	Boast 1983; Kornfeld 2009
Scribing circles; cutting disks of bone, antler, shell, and stone	Roberts 1935b; Tomenchuk and Storck 1997
Tattooing	MacDonald 1968; Painter 1985; Roberts 1935b; Wright 1940
Engraving or gouging eyes in bone/ivory needles	Irwin and Wormington 1970; Mason 1981

Second, we would expect to observe relatively tight spatial clustering of spurred flake gravers and eyed bone needles within residential sites that exhibit little or no post-depositional disturbance. Such a congruent spatial distribution would be most apparent in those locations that served as "sewing camps." As mentioned, bone needles were fragile and apparently broke often. McGhee (2001:41) has mentioned that bone needle fragments are quite common in Paleo-Eskimo sites in Arctic settings. Longer proximal fragments were apparently resharpened when possible (McGhee 1979:103).

One of the few Paleoindian sites to contain both spurred flake gravers and preserved eyed bone needles is the Lindenmeier site in northeastern Colorado. Both spurred flake gravers (*n* = 74) and bone needles (*n* = 24 fragments) were recovered during excavations between 1934 and 1940 (Roberts 1935a, 1935b; Wilmsen and Roberts 1984 [1978]). All bone needle fragments were recovered from contiguous Units G and H (Area II). Twenty bone needle fragments were clustered in the central portion of Unit H and a number of contiguous, "indeterminate" 5-x-5-ft excavation units to the south (Wilmsen and Roberts 1978:134, Figure 131). The density of gravers or "tips" is highest within Unit H (ca. 2.9 gravers/10 m^2). Graver density in the remaining units (e.g., Unit A and Unit B) ranges between 1.47/m^2 and 2.17/m^2, respectively.

Third, if spurred flake gravers were used to finish eyed bone needles, we would expect to observe that these expedient flake tools and curated sewing implements would be temporally coincident and would be restricted to Paleoindian and initial Early Archaic archaeological contexts that date to the YDCE (12,940–11,640 cal. B.P.). In order to evaluate this expectation, a database of North American sites with spurred flake gravers was compiled from published articles, site reports, monographs, online search engines, and databases (e.g., JSTOR (c)2000–2013 ITHAKA). Searches for spurred flake gravers and eyed bone needles were conducted regardless of time period or cultural affiliation. This database consists of 77 archaeological localities that contained more than 2,148 spurred flake gravers (Table 5).

Twenty-three sites had been dated based on 50 radiocarbon determinations. Radiometric assays that were originally presented as radiocarbon years before present (RCYBP) were calibrated using CalPal-2007$^{\text{online}}$ (Danzeglocke et al. 2010). Forty (80 percent) of the 50 radiometric dates ($\pm 1\ \delta$) fall within the YDCE between 12,940 and 11,640 cal. B.P. (Figure 4). Twenty-eight sites (Table 6) had been assigned relative dates based upon established projectile point chronologies, including Clovis, Goshen, Folsom, Parkhill, Crowfield, Barnes, Debert, Bull Brook, Cumberland, Redstone, Quad, Beaver Lake, and Dalton variants (e.g., Bradley et al. 2008; Frison 1991; Meeks and Anderson 2012). Finally, we find that 12 of the 14 archaeological occurrences of eyed bone needles fall within the YDCE (Table 1).

Discussion

The systemic implications of YDCE climate change, cold stress, and related adaptive responses of Paleoindian and initial Early Archaic populations are far reaching. Tailored skin clothing and winter footwear would have been essential for survival. Acquiring and processing suitable animal skins for winter clothing had to have been accomplished during a brief window of time in the fall. Failure to provide each individual in the group with a winter "survival suit" would have meant certain death. These conditions would have placed very significant constraints upon hunter-gatherers

Table 5. Radiometric Age Estimates for Paleoindian Sites Containing Spurred Flake Gravers.

Site	Location	C14 B.P. ± 1 δ	cal B.P.	cal B.P. +1 δ	cal B.P. -1 δ	Reference
Agate Basin	Wyoming	10,780 ± 120	12,770	12,870	12,670	Frison 1991:25, Table 2.1
Agate Basin	Wyoming	10,375 ± 700	11,938	12,842	11,034	Frison 1991:25, Table 2.1
Aubrey	Texas	11,590 ± 93	13,477	13,614	13,340	Ferring 1994
Aubrey	Texas	11,542 ± 111	13,431	13,573	13,289	Ferring 1994
Barger Gulch	Colorado	10,770 ± 70	12,754	12,823	12,685	Mayer et al. 2005; Surovell et al. 2001
Barger Gulch	Colorado	10,470 ± 40	12,408	12,575	12,241	Mayer et al. 2005; Surovell et al. 2001
Blackwater Draw	New Mexico	8873 ± 45	10,010	10,120	9900	Alexander 1963
Blackwater Draw	New Mexico	10,264 ± 219	12,010	12,440	11,580	Alexander 1963
Blackwater Draw	New Mexico	10,377 ± 156	12,240	12,550	11,930	Alexander 1963
Blackwater Draw	New Mexico	10,823 ± 103	12,830	12,900	12,760	Alexander 1963
Mockingbird Gap	New Mexico	10,285 ± 115	12,102	12,391	11,813	Huckell et al. 2008
Bobtail Wolf	North Dakota	9990 ± 60	11,477	11,610	11,343	Root 2000
Bobtail Wolf	North Dakota	9300 ± 60	10,486	10,575	10,397	Root 2000
Bull Brook	Massachusetts	10,410 ± 60	12,338	12,518	12,158	Robinson et al. 2009
Bull Brook	Massachusetts	10,380 ± 60	12,308	12,494	12,122	Robinson et al. 2009
Carter/Kerr-McGee	Wyoming	10,400 ± 600	12,000	12,770	11,230	Frison 1984
Clary Ranch	Nebraska	9040 ± 35	10,219	10,234	10,204	May et al. 2008
Debert	Nova Scotia	10,600 ± 47	12,575	12,688	12,462	Wilson and Burns 1999:232
Dust Cave	Alabama	9990 ± 140	11,566	11,807	11,325	Sherwood et al. 2004
Dust Cave	Alabama	10,310 ± 230	12,054	12,475	11,632	Sherwood et al. 2004
Dust Cave	Alabama	10,390 ± 80	12,171	12,508	11,659	Sherwood et al. 2004
Dust Cave	Alabama	10,490 ± 360	12,310	12,683	12,112	Sherwood et al. 2004
Hanson	Wyoming	10,700 ± 670	12,236	13,106	11,366	Frison and Bradley 1980; Ingbar 1992
Hanson	Wyoming	10,080 ± 330	11,764	12,294	11,234	Frison and Bradley 1980; Ingbar 1992
Hanson	Wyoming	10,300 ± 150	12,105	12,439	11,771	Frison and Bradley 1980; Ingbar 1992
Hanson	Wyoming	9970 ± 340	11,581	12,143	11,019	Frison and Bradley 1980; Ingbar 1992
Hedden	Maine	10,500 ± 60	12,432	12,682	12,416	Spiess et al. 1998
Hedden	Maine	10,590 ± 60	12,549	12,682	12,416	Spiess et al. 1998
Hell Gap	Wyoming	10,850 ± 550	12,550	12,910	10,962	Larson, Kornfeld , and Frison 2009
Hell Gap	Wyoming	9050 ± 160	10,166	10,405	9927	Larson, Kornfeld , and Frison 2009
Horner Site	Wyoming	9390 ± 75	10,621	10,713	10,529	Frison and Todd 1987
Horner Site	Wyoming	9875 ± 85	11,371	11,502	11,240	Frison and Todd 1987
Horner Site	Wyoming	10,060 ± 220	11,721	12,104	11,338	Frison and Todd 1987

Indian Creek	Montana	10,420 ± 170	12,360	12,520	12,200	Davis and Baumler 2000
Levi Shelter	Texas	9300 ± 160	10,541	10,757	10,325	Alexander 1963
Lindenmeier	Colorado	10,780 ± 135	12,758	12,898	12,558	Frison 1991:25, Table 2.1
Meadowcroft	Pennsylvania	13,270 ± 340	13279	14,242	11,316	Adovasio et al. 1982
Meadowcroft	Pennsylvania	16,175 ± 975	19,550	19,661	19,439	Adovasio et al. 1982
Medicine Lodge Creek	Wyoming	9030 ± 350	10,149	10,507	9791	Frison and Walker 2007
Medicine Lodge Creek	Wyoming	9940 ± 350	11,528	12,109	10,946	Frison and Walker 2007
Mesa Site	Alaska	10,260 ± 110	12,055	12,341	11,769	Kunz, Bever & Adkins 2003
Mesa Site	Alaska	9855 ± 150	11,355	11,605	11,105	Kunz, Bever & Adkins 2003
Mockingbird Gap	New Mexico	11,870 ± 230	13,884	14,231	13,537	Huckell et al. 2008
Mountaineer	Colorado	10,440 ± 50	12,370	12,543	12,197	Stiger 2006:331, Table 1.
Mountaineer	Colorado	10,295 ± 50	12,151	12,342	11,962	Stiger 2006:331, Table 1.
Mountaineer	Colorado	10,380 ± 30	12,315	12,486	12,144	Stiger 2006:331, Table 1.
Mountaineer	Colorado	10,445 ± 25	12,381	12,543	12,219	Stiger 2006:331, Table 1.
Murray Springs	Arizona	10, 900 ± 50	12,851	12,932	12,770	Haynes and Huckell 2007:239
Rodgers Shelter	Missouri	10,200 ± 330	11,896	12,419	11,373	Goodyear 1982
Rodgers Shelter	Missouri	10,536 ± 650	12,141	12,664	11,618	Goodyear 1982
Stanfield-Worley	Alabama	9640 ± 450	11,120	11,805	10,435	DeJarnette et al. 1962
Thunderbird	Virginia	9900 ± 340	11,470	12,040	10,900	Gardner 1974
Vail	Maine	10,300 ± 90	12,142	12,396	11,888	Gramly and Rutledge 1981; Spiess et al. 1998
Vail	Maine	11,120 ± 180	13,036	13,221	12,851	Gramly and Rutledge 1981; Spiess et al. 1998
Whipple	New Hampshire	9550 ± 320	10,910	11,363	10,457	Curran 1984:38, Figure 5d
Whipple	New Hampshire	11,050 ± 300	12,993	13,272	12,714	Curran 1984:38, Figure 5d
Whipple	New Hampshire	10,250 ± 260	11,969	12,431	11,507	Curran 1984:38, Figure 5d

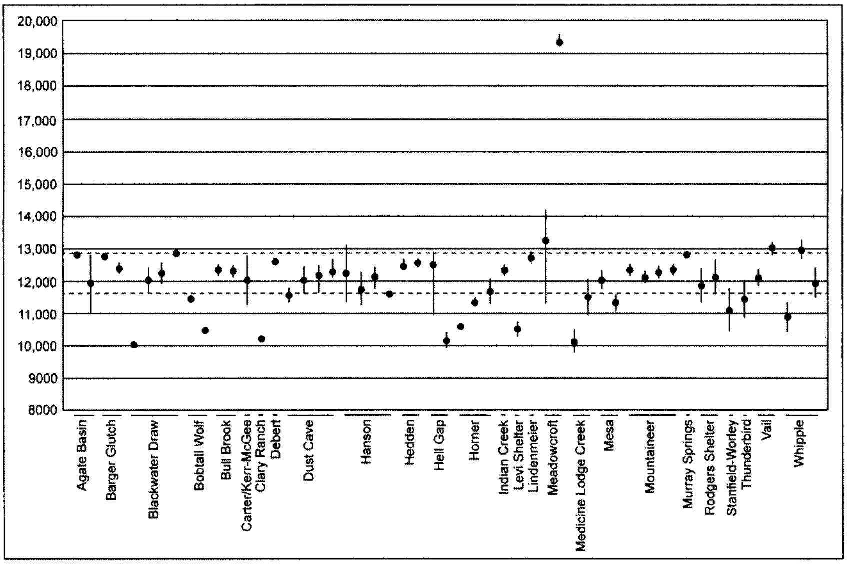

Figure 4. Radiometric dates for Paleoindian sites in North America with spurred flake gravers.

during the YDCE. We might then expect to observe a range of past behavioral responses to such stress in the archaeological record.

For example, Balicki (1970) described the large late summer-early fall "sewing camps" that were established by the Netsilik for the primary purpose of making winter skin clothing. Among the Copper Inuit, we find that aggregations comprised of 45–50 people formed in late autumn (November) for two to four weeks in "finishing camps," where women devoted their full attention to making new winter outfits from caribou hides (Damas 1984:399). During late fall, the Copper Inuit relied upon cached food and instituted taboos to insure that other activities did not interfere with the critical "sewing period" (Damas 1984:399). Women and men would have been sure to gear up for such critical periods and to have amassed plenty of cached food, fuel, well-prepared animal skins, needles, sinew, thimbles, awls, and so forth.

Archaeologists might then expect to observe evidence for such late fall aggregations, hide preparation, and winter clothing manufacture. Previous studies of Paleoindian land use have not mentioned the possibility of identifying such sewing camps or spatially discrete components within residential sites that reflect sewing activities, such as bone and ivory needles, needle "blanks," needle fragments, grooved stone abraders (sandstone or pumice), needle cases, sinew combs, women's cutting knives, and discarded or cached sewing boards (tablets of wood, bone or stone) used for cutting out skin clothing. Paleoindian sites that warrant further investigation in this regard include Lindenmeier in the West and Bull Brook, Debert, Fisher, Nobles Pond, Parkhill, Udora, and Vail in the Northeast. As mentioned, spatial data from the Lindenmeier site in Area II may reflect such sewing camp activities.

In addition, archaeologists might expect to observe evidence for "gearing up" activities associated with these fall hunting and processing camps. For example, Ritzenthaler (1967a, 1967b) has documented a cache of 87 flake gravers that was discovered in a plowed field at the Kouba site in Dane County, Wisconsin. They were found in a small cluster and perhaps they were "originally in a bag or some sort of receptacle" (Ritzenthaler 1967b:262). Such "stockpiles" of essential raw materials and tools to make tools would have served to reduce risk during such critical periods during the annual round. Spurred flake gravers were probably very expedient tools and perhaps were useful for graving the eye in one or two bone needles before they became dull and were discarded. Fresh gravers could then be used to quickly refurbish broken, slightly damaged bone or ivory needles. Multiple spur gravers would have pro-

Table 6. Relative Age Estimates for PaleoIndian/Early Archaic Sites Containing Spurred Flake Gravers.

Site	Location	Affiliation	Estimated Age Range (cal B.P.)	Reference
Aebischer	Wisconsin	Early Paleoindian	~12,900–12,200	Loebel 2005; Mason 1988
Banting	Ontario	Parkhill	~12,632–12,337	Storck 1979
Barnes	Michigan	Parkhill	~12,632–12,337	Wright and Roosa 1977
Black Mountain	Colorado	Folsom	~12,900–12,800	Jodry et al. 1996
Bostrom	Illinois	Clovis, Gainey, Holcombe	~12,900–11,600	Tankersley, Koldehoff and Hajic 1993
Butler	Michigan	Gainey/Parkhill	~12,900–12,337	Simons and Wright 1992
Cattle Guard	Colorado	Folsom	~12,900–12,800	Jodry and Stanford 1992
Cliche-Rancourt	Quebec	Early Paleoindian	~12,500–12,200	Chapdelaine 2012
Crowfield	Ontario	Crowfield	~12,457–11,482	Deller and Ellis 1984
Culloden	Ontario	Gainey	~12,900–12,200	Ellis and Deller 1991
DEDIC (Sugarloaf)	Massachusetts	Early Paleoindian	~12,900–12,200	Spiess et al. 1998
Eckles	Kansas	Clovis	~12,900–12,550	Holen 1998
Devisscher Paleo-Indian II	Michigan	Early Paleoindian	~12,900–12,200	Fitting et al. 1966:49–50
Elida	New Mexico	Folsom	~12,900–12,800	Hester 1962; Meltzer et al. 2006
Fischer	Ontario	Parkhill	~12,632–12,337	Deller and Ellis 1992:82
Fletcher	Alberta	Paleoindian	~12,910–7846	Forbis 1968
Gail Stone	Wisconsin	Early Paleoindian	~12,900–12,200	Hill et al. 1999
Gault	Texas	Clovis	~12,900–12,550	Collins 1996–2003
Halstead	Ontario	Gainey	~12,900–12,200	Jackson 1998:88, Table 22
Havey	Wisconsin	Early Paleoindian	~12,900–12,200	Nero 1957
Hawk's Nest	Illinois	Early Paleoindian	~12,900–12,200	Loebel 2005:236
Holcombe	Michigan	Holcombe	~11,800–11,600	Fitting et al. 1966:49–50
Hot Tubb Locality	Texas	Folsom	~12,900–12,800	Meltzer et al. 2006
Hussey	Ontario	Crowfield	~12,200–11,600	Storck 1979
Kouba	Wisconsin	Early Paleoindian	~ 12,900–12,200	Ritzenthaler 1967a, 1967b
Lake Theo	Texas	Folsom	~12,900–12,800	Harrison and Killenn 1978
Leavitt	Michigan	Parkhill	~12,632–12,337	Shott 1993
McLeod	Ontario	Parkhill	~12,632–12,337	Muller 1999
Morlach	Saskatchewan	Folsom	~12,900–12,800	Howard 1939:277–279
Morrow-Hensel	Wisconsin	Parkhill/Gainey	~12,323–12,337	Hensel et al. 1999
Nobles Pond	Ohio	Gainey	~12,900–12,200	Gramly and Summers 1986; Seeman 1994
Paleo-II-W	Michigan	Early Paleoindian	~12,900–12,200	Fitting et al. 1966:49–50
Paleo-II-W-A	Michigan	Early Paleoindian	~12,900–12,200	Fitting et al. 1966:49–50
Parkhill	Ontario	Parkhill	~12,632–12,337	Wilson and Burns 1999:232
Pavo Real	Texas	Folsom	~12,900–12,800	Meltzer et al. 2006
Phil Stratten	Kentucky	Early Paleoindian	~12,900–12,200	Gramly 2005
Potts	New York	Gainey	~12,900–12,200	Gramly and Lothrop 1984
Sandy Ridge	Ontario	Parkhill	~12,632–12,337	Jackson 1998:88, Table 22
Shifting Sands	Texas	Folsom	~12,900–12,800	Hoffman et al. 1990; Meltzer et al. 2006
Stewart's Cattle Guard	Colorado	Folsom	~12,900–12,800	Meltzer et al. 2006
Thedford	Ontario	Parkhill	~12,632–12,337	Deller and Ellis 1992a:70–71
Udora	Ontario	Gainey	~12,900–12,200	Storck and Spiess 1994:122
West Mesa	New Mexico	Folsom	~12,900–12,800	Meltzer et al. 2006
Winkler-1	Texas	Folsom	~12,900–12,800	Meltzer et al. 2006

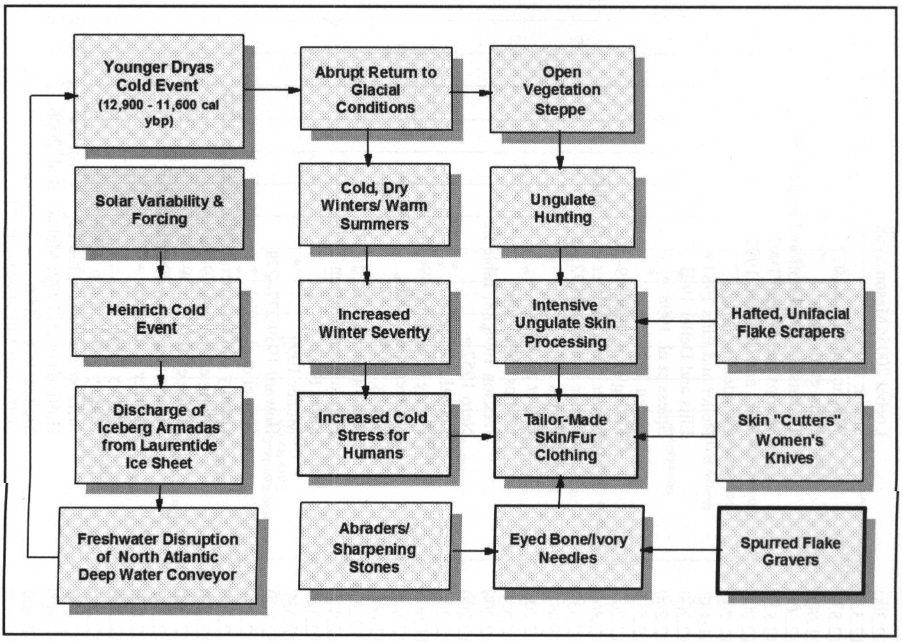

Figure 5. Systemic context for spurred flake gravers and eyed sewing needles in YDCE hunter-gatherer technology.

vided several fresh spurs for use during the brief time available during the critical "sewing period."

Conclusions

If the YDCE did, in fact, bring about a marked increase in winter severity, archaeologists have an opportunity to investigate a range of prehistoric behavioral and technological responses to abrupt climate change. In the case of Paleoindian and initial Early Archaic adaptive responses, we have an opportunity to examine the critical role that women played in the manufacture and use of a range of facilities and implements, such as gravers, needles, and tools to make tools, as well as the manufacture of clothing and footwear.

This study has placed two distinctive Paleoindian implements—spurred flake gravers and eyed bone needles—in a broader systemic context (Figure 5). It is proposed here that both gravers and needles were essential components of Paleoindian and initial Early Archaic technology that enabled hunter-gatherers to adapt to the rigors of YDCE winters. We have found that the causal linkage between expediently made spurred flake gravers and curated eyed bone sewing needles is strengthened by three independent lines of empirical evidence. First, metrical data for graver spurs and bone needles is congruent and supports the feasibility of using gravers for gouging the eyes in sewing needles. Second, the spatial distribution of spurred flake gravers and eyed bone needles at the Folsom-age Lindenmeier site in northern Colorado co-occur in relatively high densities within Area II (Wilmsen and Roberts 1984:134, Figures 131 and 164–165). And finally, both relative and absolute dates for archaeological sites containing spurred flake gravers, as well as eyed bone sewing needles, occur predominantly within the YDCE (12,900–11,600 cal. B.P.).

We can anticipate that future paleoclimate research will continue to delineate the geographical extent and environmental impacts of the YDCE across North America. The YDCE was characterized by abrupt and extreme changes not only in climatic conditions, but also in the structure, composition, and dynamics of ecological communities. None of these conditions have modern analogues. Quite possibly, then, archaeologists have yet to understand fully the abrupt and pronounced environmental changes brought about by the YDCE, as well as the various behavioral strategies developed by Paleoindian and initial Early Archaic populations in North America. Perhaps spurred flake gravers and eyed bone needles might serve as archaeological proxies reflecting the harsh realities of YDCE winters. Such seemingly insignificant stone and bone artifacts may prove to be very significant material correlates of the crucial role played by women in adapting to cold stress during the extreme winters of the YDCE across the North American continent.

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