APPENDIX O

JAY CUSTER'S DELAWARE CHRONOLOGY IN REGIONAL AND GLOBAL CONTEXT

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Submitted To

U.S. DEPARTMENT OF TRANSPORTATION
Federal Highway Administration

and

DELAWARE DEPARTMENT OF STATE
Division of Historical and Cultural Affairs
Bureau of Archaeology and Historic Preservation

Prepared For

DELAWARE DEPARTMENT OF TRANSPORTATION
Division of Highways
Location and Environmental Studies Office

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Eugene E. Abbott
Director of Planning

2004

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I. INTRODUCTION

In several sweeping syntheses of Delaware prehistory, Jay Custer (1984, 1989, 1994; Custer et al. 1996) has formulated an idiosyncratic sequence of prehistoric cultural development in the state. He extends this schema beyond Delaware's borders into eastern Pennsylvania (Custer 1996). The key assumptions that underpin Custer's chronology are:

1) From the perspective of cultural ecology, human cultures are primarily adaptive structures, which respond appropriately to environmental change; therefore,

2) Episodes of culture change correspond closely to significant episodes of major climatic/environmental change (e.g., Boreal/Atlantic transition provokes Paleo-Indian to Archaic transition at 6500 bc; Atlantic /Sub-Boreal transition precipitates Archaic to Woodland I transition at 3000 bc).

3) Maize-based horticulture never replaced foraging as the subsistence base in much of Delaware before European contact; therefore, the temporal boundary defined elsewhere, dividing Archaic-stage hunter-gatherers from Woodland-stage farmers, is inappropriate for Delaware.

4) Instead, increased sedentism, as manifest in creation of large base-camps, is a more important distinction between earlier and later foragers. This development marks the beginning of Custer's Woodland I period.

5) The "Coe Axiom" (one projectile point type per period [Coe 1964:9]) is wrong: Projectile point styles often are not exclusive diagnostics of time periods or ethnic groups. For example, broadspears are tools of a specific function, added to local Late Archaic assemblages. They are contemporaneous with narrow stemmed points, part of the same cultural complex, and not markers of a new intrusive population.

Based upon these premises, Custer has divided Delaware's prehistory into four major periods:

A. PALEOINDIAN, 12,000 to 6500 bc (uncalibrated)[1]

This period, characterized by cultures with a mobile hunting adaptation, encompasses the terminal Pleistocene and the early Holocene. Elsewhere, the transition from lanceolate to side- and corner-notched projectile points at 10,000 rcbp (8000 bc, 11,400 cal BP) is generally interpreted as the divide between Paleoindian and

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[1] Dates in this report are presented variously in several formats: "BP" and "rcbp" refer to uncalibrated radiocarbon dates before present ("present" by accepted convention is AD 1950); "cal BP" refers to calibrated or calendrical years before 1950 (generally earlier than radiocarbon ages, by as much as 2,000 years at 11,000 BP [=13,000 cal BP]); and "AD" or "cal AD" and "cal BC" denote calendar ages according to standard western (Christian) usage. Because of fluctuations in atmospheric ^{14}C, the raw dates, which may be as much as 2,000 years too young, must be calibrated by reference to annual tree-rings, or, for dates older than 11,900 cal BP, by indirect correlation with other annually laminated records, such as sediment varves or ice core layers. The most recent (2003) update of the OXCAL computer program (version 3.9), developed by C. Bronk Ramsey of the Oxford Research Laboratory for Archaeology, has been used in this report to calibrate dates younger than 10,500 rcbp.

succeeding Early Archaic cultures; however, Custer observes that settlement patterns, reliance on cryptocrystalline lithic materials, and ancillary elements of the toolkit (e.g., endscrapers, gravers) display no significant changes until 6500 bc (9500 cal BP), when bifurcate points appear. Custer originally used this date (8500 rcbp) for the onset of the Holocene (Custer 1989:52), but subsequently has shifted to treating it as the boundary between early and mid-Holocene climate.

B. ARCHAIC, 6500 to 3000 bc

In response to mid-Holocene warming, mesic forests dominated by oak and hemlock expanded across the mid-Atlantic region, replacing conifers. This vegetation change at 9500 cal BP was accompanied by the extinction of grazing fauna (Custer 1989:92). The human response was a change in weaponry to forms more appropriate for hunting smaller, deciduous forest-adapted fauna—thus, the appearance of bifurcate points. The regional water-table rose, creating swamps, where plant resources were increasingly utilized by people. The necessary processing technology for this new food source was grinding stones, which now appear in the archaeological record. Efficient scheduled use of multiple resources within more confined band territories allowed greater sedentism, as manifest in the first appearance of base camps, such as Clyde Farm.

Custer (1990) has expressed some misgivings about the significance of the vegetation transition at 6500 bc. He observes that the best pollen records for this period show hemlock as more abundant than oak. Hemlock, like the spruces it replaced, produced little mast for animals or humans to feed upon, and the acidic needle litter of dense hemlock stands would discourage growth of deciduous understory plants. Thus, hemlock-dominated forests may even have supported fewer animals than the earlier spruce-dominated forests. In Virginia, Middle Archaic people camped in upland settings more often than their predecessors had. In Delmarva, the analogous extension of Middle Archaic settlement into newly formed freshwater swamps is regarded by Custer as merely a similar opportunistic expansion, not a new adaptation (Custer 1990:32,34). He recognizes nevertheless that, from Paleoindian to Middle Archaic, dependence on high-quality cryptocrystalline lithic material declines significantly, and suggests that population growth, reduced mobility, and territiorial circumscription account for this change.

C. WOODLAND I, 3000 bc to ad 1000

A period of climatic oscillation between wet and dry conditions began in 3000 bc. Custer observes that his Woodland I period is "generally correlated" with the Sub-Boreal and Sub-Atlantic climatic episodes (Custer 1994:8). During this period, foragers established large base camps. The Delmarva Adena complex (500 bc to ad 0) is a manifestation of far-flung exchange networks. Elaborate mortuary ceremonies provided a focal point for the exchange of exotic goods. A similar mortuary/exchange system is manifest later at Island Field (about ad 700-1000).

Custer emphasizes that Woodland I is a *cultural* period defined by similarities in adaptations and lifeways (Custer 1994:4); it encompasses the three *chronological* periods recognized by archaeologists working in the region (Late Archaic, Early Woodland, and Middle Woodland). Custer's period is based upon "similarities in cultural adaptations, not diagnostic lithic and ceramic artifact styles." Those adaptations are:

1) Development of estuarine and riverine adaptations stable and intensive enough to support large macroband base camps in the freshwater/saltwater interface zone and along floodplains of major drainages;

2) Population growth at single sites, or more intensive use of sites, producing sites much larger than earlier Archaic base camps;

3) Appearance of foraging and collecting adaptations (*sensu* Binford 1980) in less productive areas outside the estuarine and riverine settings;

4) Participation in long-distance exchange networks that moved both raw materials and finished artifacts;

5) Occasional participation in complex mortuary rituals that created cemeteries containing rich grave goods (Custer 1989:143-4).

Previously, Custer more succinctly stated "the common characteristics of the Woodland I adaptations to the biosocial environments that existed between 3000 BC and AD 1000 in Delaware were the emergence of a focal adaptation and the appearance of a settlement system that was centered on large macroband base camps" (Custer 1984:144, 1989:297).

D. WOODLAND II, ad 1000 to ad 1650

Woodland I mortuary/exchange systems collapsed about ad 1000. Although in many areas in the eastern woodlands, maize-based agriculture was adopted at this time, there is no evidence of significant dependence on crops in the Delaware Coastal Plain. Large base camps occupied during Woodland I continued to be used in Woodland II, and the basic foraging adaptation changed very little; however, there seems to have been an increased emphasis upon plant foods and coastal resources (Custer et al. 1996:19).

Despite some evidence of cultural continuity from Woodland I into Woodland II, Custer recognizes the possibility of major breaks in two domains:

(1) Algonquian-speaking people may have intruded into the Middle Atlantic region around the period from AD 200 to 800 (Custer 1989:310; Fiedel 1990);

(2) In southern Delaware, the period from AD 500 to 1000 is an archaeological blank. Custer fills this gap with a "hypothesized" Late Carey complex to account for perceived continuities between Woodland I into Woodland II cultures of the region but admits, "No known sites exist to be placed in this complex, and further field research will be needed to establish its validity" (Custer 1984:135; see also Custer 1989:289).

It is obviously untenable to conceive of prehistoric Delaware as an independent entity in which local cultures developed in isolation from their neighbors. In fact, Custer offers an instructive modeling exercise that underlines this reality (Custer 1990). Applying the parameters of population density and territorial mobility documented in the ethnographic literature on the Subarctic foragers of eastern Canada, he suggests that a single hypothetical Early Archaic band, centered on the Thunderbird Site in the Shenandoah Valley, would have ranged throughout a territory 150 to 500 kilometers in diameter. Transposed to Delaware as its center, the maximal territory of *a single band* would stretch from New York City to the Virginia-North Carolina border, and westward into central Pennsylvania. Clearly, in later periods, population growth, territorial packing and circumscription, and increased sedentism would have resulted in smaller habitual territories for each band or tribe. It is even possible that single social/cultural units may have become restricted to the particular physiographic zones (e.g., Piedmont Unplands, High Coastal Plain, Low Coastal Plain) that Custer (1989:25*ff*) has selected as a means to divide the Delmarva Peninsula into tractable analytical entities. On the other hand, the evidence of long-distance exchange, particularly involving Adena artifacts from Ohio, shows that later inhabitants of the Delmarva Peninsula must have had some knowledge of the cultures of faroff regions. It is therefore necessary to integrate the Delaware-specific chronology into the broader regional frameworks employed by archaeologists working beyond the state's quasi-arbitrary borders.

II. CLIMATE EPISODES

The climatic chronology to which Custer's scheme is keyed is that of Wendland and Bryson (1974) (Custer 1994:6). Carbone's thesis (Carbone 1976) is an often cited (e.g., Custer 1994:6) application of that episode chronology to the Middle Atlantic, and particularly to the Shenandoah Valley. The Wendland and Bryson episodes (Late Glacial, Pre-Boreal, Boreal, Atlantic, Sub-Boreal, Sub-Atlantic, Recent) are ultimately derived from Northern European pollen sequences (Blytt-Senander terminology).

Four major developments in ancient climate research have occurred since the publication of the Wendland and Bryson chronology. First is the extension of tree-ring-based radiocarbon calibration as far back as 11,900 cal BP (Custer could only calibrate dates back to 8000 cal BP in 1996). Second is the recovery of several ice-cores from Greenland that offer decade-scale detailed proxy records of temperature, snowfall, and wind patterns in the North Atlantic, extending from the present to 200,000 years ago. Pollen and chemical signatures in lakebed sediments from Europe and America can be tied to the dramatic climate-change events visible in the Greenland cores. Third, analyses of North Atlantic sediments have demonstrated a roughly 1,500-year recurrence of ice-rafted debris (IRD) events, which are interpreted as markers of sudden cold episodes accompanied by major reorganizations of atmospheric circulation. Fourth, a growing corpus of regional proxy records has been amassed (pollens, carbonates, midges, plant macrofossils), which shows pan-continental episodes (e.g., Hypsithermal warming) but also local variability and out-of-phase changes of climate.

The salient climate episodes for eastern North America include the following:

Onset and Termination of the Younger Dryas Cold Episode: The brief Younger Dryas Cold Episode (stadial) began at 12,950 cal BP (11,000 rcbp) and ended suddenly with warming of about 5 degrees Centigrade 50 years later at 11,570 cal BP (10,000 rcbp). This warming initiated the Holocene, which has entailed much smaller climate oscillations than the preceding Pleistocene.

Holocene cold oscillations: The sharpest of the Holocene cold oscillations occur early on; these are the Pre-Boreal Oscillation at about 11,300 cal BP, and the 8200 cal BP cold event. The latter has been attributed to the final massive draining of glacial Lake Agassiz into the North Atlantic, an event which would have disrupted thermohaline circulation. The flood event may also be related to accelerated wasting of the remnant Laurentide ice sheet between 8400 and 7900 cal BP (Shuman et al. 2002). The effects of the 8200 cal BP event may have lasted for about 400 years. The Laurentian ice shrank rapidly after 10,000 cal BP, and a lowering of the ice mass may have caused significant changes around 9000 cal BP. Between 9000 and 8000 cal BP, summer monsoon rains intensified in the present southeastern United States, causing a rise of lake levels and expansion of the range of moisture-tolerant southern pines. In the same period, the mid-continent was arid; lake levels dropped, and prairie expanded eastward. This was a period of maximum aridity in the Northeast. After the collapse of the Hudson Bay ice dome about 8200 cal BP, decreased albedo effect, along with increasing influence of the Bermuda subtropical high, resulted in more moisture in the Northeast; lake levels rose, and pines were replaced by beech and hemlock.

There appears to have been a 200-year cooling event at 10,300 cal BP (9100 rcbp) (Bjorck et al. 2001). This event has been theoretically linked to reduced solar forcing, as inferred from a beryllium-10 flux peak (i.e., more intense cosmic radiation was affecting the atmosphere as insolation weakened). Variations in solar output also seem to have been responsible for the "Bond events," cooling episodes in the North Atlantic that occurred about every 1,500 years throughout the Holocene, and probably also during the Pleistocene (Bond et al. 2001). The eight Holocene events are dated to about 11,100; 10,300; 9400; 8100; 5900; 4200; 2800; and 1400 cal BP. The modeled mechanism involves reduced solar irradiance, triggering changes in stratospheric ozone that cause cooling of the atmosphere in high northern latitudes, a slight southward shift of the northern subtropical jet stream, and decreased Northern Hadley circulation. These atmospheric changes would then lead to increased North Atlantic drift ice, cooling of the ocean surface and atmosphere above Greenland, and reduced precipitation in low latitudes (Bond et al. 2001).

Viau et al (2002) examined radiocarbon dates obtained for more than 700 pollen diagrams from across North America. These dates tend to cluster at significant discontinuities in the climate record. The major transitions identified by Viau et al. within the past 14,000 calendar years occur at 13,800; 12,900; 10,190; 8100; 6700; 4030; 2850; 1650; and 600 cal BP. Their analysis did not attach a direction (cooling or warming) to the vegetation changes observed at each transition, but it is clear that those changes were pan-continental. Four of the vegetation events correspond rather closely to Bond events (10,190=10,300; 8100=8100; 4030=4200; 2850=2800).

The Atlantic 2 event (6700 cal BP) is very broadly defined, with a large standard deviation in the radiocarbon dates. In the Midwest, this was period of transition to a warm and dry climate

The Sub-Boreal event (4030 cal BP) coincides with the beginning of neo-glaciation in the northern hemisphere. It is a cooling that follows decreasing insolation. The 2850 cal BP event is also a cooling (Sub-Atlantic), but the 1600 cal BP event (Scandic) is the beginning of the warming that culminated with the Medieval Warm Period at 1000 cal BP.

Sea Level Rise and Local Climate Oscillations in the Chesapeake Region: Apart from the hemispheric-scale climate events discussed above, there are several more localized developments (or local manifestations of the broader phenomena) that probably would have significantly affected the human inhabitants of the Mid-Atlantic region. Chesapeake Bay rapidly changed from a freshwater to a brackish body between 8200 and 7400 cal BP, coincident with local sea level rise above 18 meters below present level. This sudden saline flux was accompanied by initial appearance of oysters in the bay (Bratton et al. 2003). These developments may be a local result of a rapid global eustatic sea-level rise (Meltwater Pulse 1d) (Liu and Milliman 2003).

Frequencies of pollen and dinocysts in Chesapeake Bay sediment cores have been used to infer several relatively dry periods within the last 2,500 years: 200 BC to AD 300, AD 800 to 1200, AD 1320 to 1400, and AD 1525 to 1650 (Willard et al. 2003). Sediment cores have also provided environmental data for earlier periods (Willard et al. 1999). Early to mid-Holocene vegetation fringing the Chesapeake was diverse; oak was dominant, accompanied by abundant hickory, beech, pine, hemlock, sweetgum, and grasses. In the mid-Holocene, beech and grasses declined around 6500 cal BP (Atlantic 2 event, perhaps?), followed in the mid- to late Holocene (between ca. 4000 and 2200 cal BP) by a doubling in frequency of pine, an increase in birch, and declines in oak, hemlock, and beech. Approximately synchronous pine increases have been observed in bogs and lakes in the Appalachians and coastal plain; they indicate increased precipitation in the late Holocene that was punctuated by the previously described drought periods.

III. CLIMATE CHANGE AND CULTURE CHANGE

Custer has explicitly adopted a "cultural-ecological perspective" (Custer 1984, 1989). He stresses that people adapt not only to the biological world: "Equally important is the social environment created by the members of their own group and other neighboring societies" (Custer 1989:24). Thus, he speaks of "interaction of humans with the biosocial environment" as the proper subject of cultural ecology. Custer defines culture, following Leslie White (1949), as "human extrasomatic adaptation, emphasizing the nonbiological ways by which people adapt to all aspects of their environment." He is careful to disavow crude environmental determinism:

> The prehistoric cultures of the Delmarva Peninsula were not molded and shaped by the environment around them. However, because most prehistoric societies of the Delmarva region were composed of hunters and gatherers, the natural environment presented a series of constraints within which they had to live. At times, prehistoric cultures seemed to have achieved a dynamic equilibrium within these constraints, even though they probably never reached a long-term stasis. . . . However, as the environment changed through time, so did the constraints, which permitted the opportunity for culture change. Further, human factors, including behavioral changes such as population growth, caused prehistoric groups to exceed the bounds of the constraints, thereby necessitating further cultural change. . . . Nonetheless, even though opportunity often became necessity, environmental and culture change did not always proceed hand-in-hand through Delmarva prehistory. Furthermore, at some times the social component of these people's environment was a more important constraint upon their lifestyles than was the natural environment [Custer 1989:24-5].

When proponents of "cultural ecology" have spoken of cultural "adaptation" or "evolution," they have generally coopted the concepts and vocabulary of evolutionary biology without adequate rigor or clarity. Consider for example, in the passages quoted, the ambiguity in Custer's use of the term *extrasomatic*, and his equation of the terms *culture*, *society*, and *group* as the collective entities that somehow "adapt" to changing circumstances. It is obvious that extrasomatic means of adaptation are not inherent in human biology and thus cannot be transmitted by the same genetic mechanisms that perpetuate somatic traits. In biology, organisms adapt, physiologically and behaviorally, to their ever-changing environments, in order to survive. If they survive, they can breed and reproduce. Differential transmission of the genes that code for variants of morphology and behavior is the mechanism of evolutionary change. Darwin's inspiration came from the dismal calculations of the economist, Thomas Malthus, who realized that the finite capacity of resources put an ultimate constraint on population growth. In that sense, all living things are engaged in perpetual competition for limited resources. At the level of the individual chromosome, it is alleles that compete for phenotypic expression in the next generation of organisms. It may be argued, as Richard Dawkins (1989) has seemed to suggest, that organisms are merely the robot-like forms that genes employ for their transmission; a chicken is just an egg's way to make another egg. This aspect of biology is most stark in the case of viruses, DNA packages that coopt an organism's cells for their own replication. An alternative way to view the history of life might emphasize that genetic transfer (sex) and death evolved in the simplest early organisms as a way to ensure continuing generation of diversity in the face of a changing environment; unlike organisms essentially recreating themselves through division, sexually reproductive organisms died, which had a role in making way for those variant forms of bacteria, algae, etc., that best tracked the environment. Eggs are a chicken's way to make more and better chickens.

Darwin recognized that many traits of animals appeared impractical for sheer survival, and expensive to maintain (in terms of nutritional cost and exposure to predators)—such things as deer antlers or peacocks' tails. These features could be explained as aspects of sexual selection, as a special form of or complement to natural selection. To breed successfully, a sexually reproducing organism must gain access to a mate of opposite sex, and this also is a competitive endeavor. Generally, the choosy partner is the one who will invest more of its energy in bearing and caring for the young that may result from the sexual union—typically females among birds and mammals. A few nonhuman organisms are well known for employing extrasomatic forms of sexual advertisement, such as the bowerbird male, who lures females to the imposing and glistening nest he has constructed. Much psychological research has been devoted to the biological bases of human mating, with general agreement that humans perceive symmetrical facial features as attractive because (unconsciously) they function as an index of health and genetic fitness. The question must arise: Just how much of humans' extrasomatic apparatus functions, at some level, as a form of sexual advertisement? It has been proposed that Acheulian handaxes, which were often carefully chipped into symmetrical shapes that exceed any obvious functional requirements, may have been made by early hominin males as a display of their fitness. They signaled thereby their knowledge of the environment, their mental and social skills, and appealed to females' inherent predilection for symmetry (Kohn and Mithen 1999). Various ethnographic studies suggest that at least some of the hunting performed by human males is less significant for the procurement of protein than as a way to enhance social prestige and demonstrate fitness to potential mates; this is known as "show-off" hunting. These analyses put such archaeological phenomena as the giant, colorful, Paleoindian fluted points and the elegant bifaces that accompanied Delmarva Adena burials in a new light.

In biology, there is uncertainty about the levels at which natural selection operates. How does competitive reproduction at each progressively smaller scale redound to the benefit of the next more inclusive entity? If a behavior is conducive to the survival or expansion of the group (whether a kin group or a whole colony) but deleterious to the individual (e.g., self-sacrificing suicide to save the group, like bees stinging an intruder), how can it be passed on? This paradox is the basis of kin selection or "inclusive fitness" theories.

Biological evolution is dendritic. Species evolve new traits, break apart into separate branches that no longer interbreed, and then remain mutually isolated forever. Critics of the simple unreflective importation of biological notions into anthropology often observe that, in contrast, cultural evolution is *reticulate*. Cultures can and do borrow innovative traits from one another, even merging as a result of intensive interaction. On the other hand, humans, despite their recent common ancestry (about 60,000 to 150,000 years ago) and relatively minor genetic and morphological variation across the planet, are separated into largely isolated, even mutually hostile communities by exaggerated local variations in ideology, customs, racial perceptions, and, most importantly, language. *Competition* between these culturally distinguished variant entities is an important engine of cultural evolution. In the Northeast and Middle Atlantic regions, early historic Iroquoian-speakers, Algonquian-speakers, and Siouan-speakers were frequently at war even as they shared numerous aspects of material culture, including ceramic designs. At the edges of their respective Subarctic and Arctic territories, Athapaskans and Eskimos generally tried to kill one another. Fuegian hunter-gatherers also aggressively defended their territorial boundaries, but in this case, distinct ethnic groups—Ona, Yahgan, and Alakaluf—also partitioned their habitat by pursuing different terrestrial vs. marine-based subsistence regimes. Perhaps a similar mutual avoidance, with rare social contacts, characterized the seemingly coeval users of broadspears and narrow stemmed points. Custer alludes to competition in the Early Archaic as a cause of altered settlement patterns:

> . . . . The ideal situation for a hunting and gathering group is to know of several unused productive resource locales. However, such a strategy is effective only if population densities remain low. If population densities grow to be too high, other groups may eat your "insurance policy;" therefore, it may be necessary to limit wandering ranges to some extent [Custer 1990:36-37].

Proponents of a "Darwinian" evolutionist paradigm for archaeology assert that the basic principle of "descent with modification" is as useful for our discipline as it is for biology (e.g., Dunnell 1980, Lyman and O'Brien 1998, *contra* Bamforth 2002). They do not mean this only in a metaphorical sense. In a clear programmatic statement, O'Brien et al. respond preemptively to critics who would accuse them of reductionism since, as Brew (1946) observed, "phylogenetic relationships do not exist between inanimate objects":

> Our response is that there certainly *are* phylogenetic relationships between inanimate objects; if it were otherwise, palaeontologists would be out of work. Our view . . . is that things found in the archaeological record—projectile points, ceramic pots, and the like—were once part of human phenotypes and were therefore shaped by the same evolutionary processes that shape somatic characters. This makes artifacts part and parcel of any discussion of human phylogeny. Tools do not breed, but tool makers *do* breed, and they *do* transmit

> information to other tool makers, irrespective of whether those other tool makers are lineal descendants. Cultural transmission is a different kind of transmission than what is produced intergenerationally by genes, but this is irrelevant as far as phylogeny is concerned [O'Brien et al. 2001:1117].

Based upon these assumptions, O'Brien et al. (2001) have applied cladistic analysis, a tool of biological taxonomists, to the classification of Southeastern Paleoindian points. They present a branching tree of inferred ancestral and descendant forms based upon changes in "character states." In the absence of a good corpus of associated radiocarbon dates, or even reliable stratigraphic relationships of the point varieties that emerge from their analysis, one cannot judge the real utility of the cladistic method in this case.

The mental "templates" and behaviors that define distinctive cultures must be transmitted across successive generations in much the same way that genes are passed on. Some recent discussions of cultural evolution refer to these gene-like packets of information—replicators—as "memes." Changes in artifact form are inevitable over time, because the templates or replicators change slightly in each transmission event (as in neutral genetic drift) or because certain variants are more successful within the population (often, because they enhance survival in a changing environment—a process analogous to natural selection). The spread of a beneficial mutation (or invention) through a population can be modeled in quite different ways. Perhaps a new allele or artifact type is more likely to arise in the core area of a population, where the greatest numbers of individuals and variations are concentrated and competition is thus most intense. Or maybe new variants are most likely to appear at the edge of the population's range, where competition with neighbors is most pronounced, and the environment is more variable. If a sudden catastrophic climate change decimates the core population, an opportunity may be created for a more resilient marginal population to sweep across the entire range (Snow 1981:112).

A significant change in cultural adaptation may be signaled by the appearance (whether by invention, diffusion, or intrusive replacement) of an altogether new technology (e.g., boiling stones, manos and metates, pottery, bow and arrow). However, the meaning of more subtle changes in projectile point form in the eastern woodlands is less obvious. Unlike the changes in fluted points described by O'Brien et al., these are not gradual transformations (e.g., the shift from stemmed Morrow Mountain points to side-notched Brewerton forms, or from small stemmed points to broadspear points). It is intriguing that styles seem to have a duration of about 1,500 years. Not only is this about the same periodicity as seen in North Atlantic climate events, but the moments of transition coincide so often as to raise the possibility of climatic causation (Table O-1).

Given the rare preservation of organic materials in the eastern woodlands, archaeologists generally can only study stylistic changes in lithic and ceramic artifacts. Projectile points are the favorite functional class among lithic tools for such analysis. They are numerous, their inferred functions are limited and unambiguous (missile tip or knife), and their shapes changed about every 1,500 years. Functional requirements constrained the range of possible stylistic variation; the tip had to be acute enough to penetrate a prey animal's hide, and the base had to be securely hafted in the dart or arrow shaft. In fact, most of the variability through millennia in point form is seen in the shape of the base (e.g., flutes, side and corner notches, flared stems, contracting stems), and the changes are manifestations of shifting modes of point hafting. Preferred lithic raw materials are often closely linked to particular styles (e.g., Savannah River-quartzite, Selby Bay-rhyolite, Jack's Reef-jasper). These coincident changes (style, hafting technique, material) seem to imply major disturbances of previous cultural transmission and exchange systems, particularly those involving interactions among males (the presumed makers and users of hunting weapons).

Radiocarbon dates associated with each point style are illustrated in the accompanying figures (see Attachment A). The dates have been calibrated using the OXCAL program.

Table O-1: Changes in Projectile Point Styles and Coeval Climate Episodes

Style Change	Date Rcbp (Cal BP)	Climate (Cal BP)
Fluted point to notched point	10,000 (11,500)	YD to Holocene (11,500)
Kirk-Bifurcate	8800 (10,000)	cold (10,300)
Bifurcate-Morrow Mountain	7300 (8000)	cold (8100)
Morrow Mountain-Brewerton	5700 (6700)	Atlantic 2 (6700)
Brewerton-Stemmed	4500 (5500)	cold (5900)
Stemmed-Broadspear	3700 (4200)	cold (4200)
Broadspear-EW stemmed	2700 (2800)	cold (2800)
Adena intrusion	2500 (2800-2400)	cold (2800)
EW stemmed-Selby Bay	1700	end of dry period (1650)
Selby Bay-Jack's Reef	1200	cold (1400)
Jack's Reef-triangles	900	Medieval optimum (1000)

IV. A CAUTIONARY NOTE ABOUT RADIOCARBON DATES

Some of the difficulties in using radiocarbon dates for cultural chronology are obvious and well understood. To establish 95 percent probability that the true date of a sample falls within the stated range, the 2-sigma (standard error) numbers must be used. Therefore, large sigmas of greater than 200 years allow only millennial-scale precision. Stone tools cannot be dated directly, so their close behavioral and depositional association with dated organics must be demonstrated for the age of the latter to be assigned to the former. Association within well-defined hearths or pits is optimal, but even this can be problematic. Large storage pits, in particular, are likely to accidentally incorporate earlier, disinterred artifacts within the fill.

Shott (1992) demonstrates the difficulty of interpreting radiocarbon dates, even when association appears valid, and short-lived materials (e.g., seeds, nuts) with no significant inherent age are dated. A Middle Woodland village (ca. AD 500) in Kentucky, convincingly argued to have been occupied for no more than 50 years, yielded small-sigma dates across a 600-year span. Shott reminds us that fully a third of radiocarbon dates may be inaccurate for reasons that often remain obscure. In spite of the most cautious and painstaking laboratory procedures, contamination with more recent carbon is always a possibility. Intrusive older carbon is a less frequent occurrence but must be considered a potential problem in coal-bearing regions. For example, much ink has been spilled over the possible contamination of supposed pre-Clovis samples from Meadowcroft Rockshelter (Adovasio et al. 1999; Haynes 1980; Tankersley and Munson 1992).

The cold events manifest as ice-rafting in the North Atlantic appear to correspond to solar radiation minima (Bond et al. 2001). When insolation weakens, more cosmic radiation hits the atmosphere, and thus more radiocarbon is created. Whenever ancient organisms absorbed carbon with a higher ^{14}C ratio than exists in recent reference samples, their apparent age will be reduced. Because of this process, each cold episode should be followed immediately by a jump forward in radiocarbon ages of a few hundred years. This phenomenon is seen most dramatically at the onset of the Younger Dryas (12,900 cal BP), where dates jump from about 11,200 to 10,700 rcbp (500 radiocarbon years) over the course of less than 200 calendar years (Hughen et al. 2000). Similarly, just after the 2800 cal BP cold event, radiocarbon ages fall rapidly (in about 90 years) from 2750 to 2450 rcbp. The Younger Dryas "cliff" was followed by a plateau of nearly unchanging radiocarbon dates (ca. 10,500-10,200 rcbp) from about 12,700 to 11,400 cal BP (Fiedel 1999). A similar but smaller plateau is evident after the 2800 cal BP event; between 750 and 400 cal BC, radiocarbon dates hover around 2450 rcbp (Fiedel 2001). This means that Eastern Adena manifestations cannot be dated to a more precise interval than 250 years.

As noted by Bonnichsen and Will (1999), there is a disturbing tendency for dates from eastern Paleoindian sites to come out much too late. The most obvious example is Bull Brook, Massachusetts, where charcoal-based dates are 9300±400, 6940±800, 8940±400, 7590±255, and 5440±160 rcbp. The expected age of the site is about 10,500 to 11,000 rcbp. The Whipple Paleoindian Site in New Hampshire yielded six dates, of which two are clearly much too young (8240±380 and 8180±360 rcbp) and three are probably young although their large errors barely stretch into the expected pre-10,000 rcbp range (9600±500, 9400±500, and 9700±700). Bonnichsen and Will contend that even the many seemingly accurate dates from the Debert Site in Nova Scotia, which cluster around 10,500 rcbp, may really only date the burning of dead trees, killed by Younger Dryas cold and arid conditions, rather than Paleoindian hearths. We must entertain the possibility that puzzling late radiocarbon dates for later cultural complexes might also just be dates for intrusive burnt tree roots or stumps. Roots are particularly likely to have invaded the soft and organic-rich fill of abandoned hearths and storage pits. Also, following the logic of Bonnichsen and Will, one would expect trees to have been most susceptible to forest fires in the wake of abrupt cold events. It is a plausible hypothesis that the cluster of circa 7000 to 7500 rcbp dates associated with bifurcate and Kirk Stemmed points may only reflect widespread burning of stressed vegetation after the 8200 cal BP cold event. Multiple dates from the best stratified contexts indicate that the true age of these point types is about 8200 to 8800 rcbp (9400 to 10,300 cal BP).

V. ACCEPTED CHRONOLOGY vs. THE CUSTER SEQUENCE

The accepted chronological scheme for the eastern woodlands represents an uneasy blending of environmental, adaptive, and stylistic criteria of culture change, and an ambiguous mixture of temporal periods and stages of cultural evolution. Further, it is clearly no coincidence that period boundaries tend to fall, perhaps too conveniently, at millennial disjunctions (e.g., 10,000 bp, 3000 bp, ad 0, 1000 bp).

Ironically, culture-chronology models for eastern archaeology became established only a few years before the development of radiocarbon dating, which rendered obsolete the various relative dating methods upon which these models relied. Willey and Phillips (1958:46) criticized the interchangeable use, "depending on the exigencies of the moment," of the terms "period," "culture," and "stage" in *Archeology of Eastern United States* (Griffin 1952). "Deliverance from this kind of semantic ambiguity will come when current techniques of absolute dating have reached a point of such dependability that we can place a given unit within a temporal frame, on the one hand, and in a developmental sequence, on the other, without confusing the two operations" (Griffin 1952). It was Griffin (1952) who established the period framework still used by eastern U.S. archaeologists: Paleoindian, Archaic, Early Woodland, Middle Woodland, Mississippian (including Late Woodland).

The term *Archaic* was first applied by William Ritchie in 1932, specifically to the Lamoka complex of central New York. A decade later, it was being applied more broadly to shell-midden cultures all across the east. In 1944, Ritchie conceived the Archaic as a cultural level or stage. Soon, archaeologists were lumping all non-ceramic, non-horticultural cultures under this rubric, including western American materials. The classic definition of the Archaic *stage* was formulated by Willey and Phillips (1958:107) as "the stage of migratory hunting and gathering cultures continuing into environmental conditions." They cautioned: "So far as we can tell from the meager remains characteristic of most early Archaic cultures, there is no important shift in economic and social patterns from the previous Lithic stages" (Willey and Phillips 1958:106). Acknowledging the difficulty of clearly separating their "Lithic" stage (equivalent to Paleoindian) from the Archaic in the East, Willey and Phillips (1958:112) fell back on "more tenuous criteria, such as (1) increased variety in point types and the inclusion of stemmed and corner-notched forms that are not in the lanceolate tradition and (2) increased evidence of gathering activities in the form of milling stones, mortars, cupstones, etc." Midwestern Dalton components were treated as "transitional or mixed Lithic-Archaic cultures" (Willey and Phllips 1958:113).

A 1941 conference of eastern archaeologists resulted in a definition of the Woodland cultural pattern "couched in such general terms that, as later discovered, but for the inclusion of pottery, it fitted the Archaic pattern just as well" (Willey and Phillips 1958:42). In the Willey and Phillips hemispheric "historic-developmental" stage scheme, Archaic is followed by Formative, defined "by the presence of agriculture, or any other subsistence economy of comparable effectiveness, and by the successful integration of such an economy into well-established sedentary village life" (Willey and Phillips 1958:203). Willey and Phillips classified Adena and Hopewell cultures as Formative (1958:159), even if maize cultivation was lacking (which they doubted). They appeared uncertain about the assignment of the Poverty Point culture of Louisiana (1958:156), which lacked pottery and agriculture but had impressive mounds indicative of a large, concentrated population with a stable food supply. Willey and Phillips (1958:63) also had difficulty dealing with Eastern Woodland cultures on the Hopewellian periphery: "We are semantically embarrassed at this juncture, because, if such cultures are not Formative, or at least marginal Formative, we have to call them 'Archaic,' and the term has a more restricted meaning in eastern archaeology."

Ritchie's (1965) Cultural Sequence

- I Paleoindian Hunters (ca. 7000 BC)
- II The Archaic or Hunting, Fishing, Gathering Stage (ca. 3500-1300 BC)
- III The Transitional Stage—From Stone Pots to Early Ceramics (ca. 1300-1000 BC)
- IV The Woodland Stage—Development of Ceramics, Agriculture and Village Life (ca. 1000 BC-AD 1600).

A clearly formulated and influential sequence of cultural stages for New York and adjacent regions was presented by Ritchie in 1965 (see box at right). Jennings (1974) employed a mixed stage/period strategy in his *Prehistory of North America*. Paleoindians are referred to as "Early Cultures." These are followed by the "Archaic Stage," which was transformed "in certain favored places into higher, more complex Formative cultures" by the diffusion from Mexico of horticulture, mounds, pottery, etc. (Jennings 1974:208). Thus begins a period of "Innovation and Change." Jennings (1974:212) thought that the Early Woodland in eastern North America represented "the first faint contacts with Mesoamerica." He already regarded the term *Woodland* as a remnant from earlier studies; although "of decreasing usefulness," it was necessarily used only "as a key to understanding the literature" (Jennings 1974:213). The Woodland, or "transition" as Jennings preferred to call it, was only "the Archaic complex with additions. There is no evidence of drastic cultural modifications. In effect, the Archaic ends by definition, since most scholars specify the Archaic stage as lacking in pottery" (Jennings 1974:213).

The interface of Custer's Delaware scheme with the accepted regional sequence can be seen most clearly in his Pennsylvania synthesis (Custer 1996). Again, he lumps Paleoindian and Early Archaic into the 13,000 to 6500 bc period, "Life at the End of the Ice Age." The Middle Archaic is covered in a chapter on "The Lost Years?" 6500-3000 bc (Custer thinks that this seeming hiatus is an illusion caused mainly by misdating of some stemmed point varieties). The Late Archaic (Woodland I), 3000-1000 bc, is discussed as "New Lifeways and New Environments." Early and Middle Woodland (1000 bc-ad 1000) are covered in "Cultural Development and Variation"; Late Woodland (AD 1000-1500) is "Village Life and Agriculture."

Custer (1996) distinguishes three parallel but coeval domains: cultural periods, chronological periods, and paleoenvironmental periods, as shown in Table O-2.

Table O-2: Custer's (1996) Chronology for Eastern Pennsylvania

Dates (^{14}C years)	Cultural Period	Chronological Period	Paleoenvironmental Period
13,000-6500 bc	Hunter-Gatherer I	Paleo-Indian and Early Archaic	Late Pleistocene and Early Holocene
6500-3000 bc	Hunter-Gatherer II	Middle Archaic	Middle Holocene I
3000-1000 bc	Intensive Gathering-Formative, Part I	Late Archaic	Middle Holocene II
1000 bc-ad 1000	Intensive Gathering-Formative, Part II	Early and Middle Woodland	Late Holocene
AD 1000-1500	Village Life	Late Woodland	Late Holocene

VI. CURRENT EVIDENCE ON IMPORTANT CULTURAL TRANSITIONS

A. PALEOINDIAN-EARLY ARCHAIC TRANSITION (10,000 rcbp, 11,300 cal BP)

The Paleoindian-Early Archaic boundary is recognized in three domains: climatic/biotic, stylistic, and (largely presumed) settlement pattern-social. The period boundary was originally conceived as an analogy to the Old World contrast between the Upper Paleolithic and the Mesolithic. The Paleoindians were hunters of late Pleistocene megafauna, but when the latter went extinct at the beginning of the Holocene, Archaic foragers developed a broad-spectrum subsistence pattern focused on smaller game, fish and shellfish, and plant foods.

The Pleistocene/Holocene transition was marked by a rapid warming at 10,000 rcbp (11,550 cal BP), the end of the Younger Dryas stadial. During the ensuing early Holocene, cold-adapted conifers, such as spruce, were replaced by temperate-climate-adapted trees, such as oaks, which expanded northward from refugia in the Southeast. Mast-eating fauna, such as deer and turkeys, migrated north along with the temperate forest. It is noteworthy that the Pleistocene megafauna (mammoth, mastodon, ground sloths, etc.) collapsed not at the onset of the Holocene, but more than 1,000 years earlier, at the onset of the Younger Dryas. Their extinction occurred only a few centuries after the arrival of Paleoindians (ca. 11,000 rcbp, 13,000 cal BP), a temporal coincidence that strongly suggests human predation as a major causal factor. In the absence of an adequate, well-preserved faunal record, we cannot be sure what late Paleoindians in the Middle Atlantic region were eating between 10,800 and 10,000 rcbp (12,700 and 11,500 cal BP). Was their main prey woodland caribou, or deer? In the Southeast, late Paleoindians of the Dalton complex relied upon deer and waterfowl.

The uncertainty about Younger Dryas-era subsistence means that the change in weaponry at 10,000 to 9500 rcbp, from lanceolate to side-notched (e.g., Taylor) and corner-notched (e.g., Palmer, Charleston) points, cannot be credibly explained. As Paleoindians are assumed to have already known the use of the spearthrower (atlatl), the notched points are unlikely to mark the first appearance of darts to be used with this weapon.

The presumed shift to smaller game, and perhaps initial use of nuts from the new deciduous trees, may have encouraged formation of smaller and less mobile social units. With increasing human population, fixed band territories may have been established. This should be reflected in more frequent use of local lithic resources. In fact, there is rather ambiguous evidence of major differences between Paleoindian and Early Archaic lithic preferences. True, rhyolite, quartz, and quartzite become more frequent in Early Archaic assemblages (Custer 1996:128), but high-quality cryptocrystalline stone continues in use. In Delmarva, Early Archaic points are actually more often made on exotic lithics than Paleoindian points, which were mainly chipped from local jasper pebbles (D. Lowery, personal communication 2003). The Brook Run jasper quarry, in Culpeper, Virginia, was in use at about 9900 rcbp (Voigt 2002).

Custer, it should be noted, has in some discussions (e.g., 1989:92) put the extinction of Pleistocene grazing fauna at about 8500 rcbp (9500 cal BP), coincident with the appearance of bifurcate points. However, available evidence indicates that extinction was complete some 3,000 years earlier, as Custer also observes (e.g., 1996:99, 131).

B. EARLY ARCHAIC-MIDDLE ARCHAIC

Until recently, the bifurcate points dated circa 8500 rcbp were classified as Early Archaic. The tendency since the early 1990s is to regard them as the first manifestation of the Middle Archaic, although some authors still classify bifurcates as Early Archaic (e.g., Kimball 1996). Clearly, whether the bifurcate complex is seen as the tail end of a cultural continuum or as a new phenomenon, some distinctive elements are present. Dependence on blade tools decreases while bipolar flaking increases. The first groundstone axes appear. In Tennessee, there is a shift in the use of nuts from acorns to hickory and chestnut, presumably reflecting a change in forest composition (Kimball 1996). Bifurcate settlement patterns differ noticeably from earlier Kirk patterns: in some areas, sites become concentrated on certain landforms; in others, bifurcate-makers expanded into zones not previously utilized. Bifurcate point-makers made more use of diverse, locally available lithic materials and conducted the first systematic quarrying of South Mountain rhyolite.

The ostensibly quite sharp stylistic break between bifurcates and Morrow Mountain/Stark points might provoke some hesitation about lumping these types together in a single Middle Archaic period, but one can view bifurcate-Kanawha to Stanly/Neville to Morrow Mountain/Stark as an evolutionary sequence.

C. MIDDLE ARCHAIC-LATE ARCHAIC

The exact date of the Middle Archaic/Late Archaic transition is rather vague: some authors place it at 6000 rcbp, some at 5000 rcbp. Late Archaic is often viewed as a time of explosive population growth, as indicated by diagnostic point frequencies, numbers of sites, and numbers of dates. However, this apparent growth spurt actually occurs well after the supposed initiation of the period, with most dates (e.g., for Lamoka in New York) in the 4500 to 4000 rcbp range. Some diagnostic point types are alternately regarded as Middle or Late Archaic markers (e.g., Brewerton, Otter Creek), even though there are few radiocarbon dates.

D. LATE ARCHAIC-TRANSITIONAL-EARLY WOODLAND

Early Woodland was formerly thought to denote a more far-ranging cultural transformation involving a package of innovations: pottery, agriculture, sedentary villages, mound construction, and elaborate mortuary rituals (Adena complex). Even as early as 1958, however, Willey and Phillips recognized that these disparate traits were not so neatly bundled together in the Eastern Woodlands, where one finds Archaic cultures with mounds (Poverty Point) or pottery (Stallings Island) and Woodland cultures without mounds, agriculture, or large villages.

The now-traditional marker of the onset of Early Woodland is the first appearance of pottery, set at 3000 rcbp. Of course, in the Southeast, the first fiber-tempered pottery is much earlier, circa 4500 rcbp. Soapstone bowls appear centuries after ceramics in the Southeast but precede ceramic technology in the Middle Atlantic and Northeast. The first pottery—Marcey Creek ware—imitates the stone vessels' flat-based tub-like form and even contains crushed steatite as temper. Assemblages that contain stone vessels, circa 3500 to 3000 rcbp, are thus "transitional" between Late Archaic and Early Woodland.

E. EARLY WOODLAND-MIDDLE WOODLAND

The distinction between Early Woodland and Middle Woodland began in Midwestern archaeology, where it denoted the temporal divide at circa 2200 rcbp between Adena (Early) and Hopewell (Middle) (Griffin 1952, 1967). In the East, where Adena exists only as a brief intrusive episode or not at all, and Hopewell influence is minimal, different criteria had to be employed to create an analogous disjuncture. In various areas, archaeologists have fastened upon localized ceramic style changes as the transition marker. This has inevitably created temporal disconformities between regions. In the Chesapeake region, the shift from cord-marking (Accokeek) to net-marking (Popes Creek) demarcates Middle Woodland onset at circa 2500 rcbp. This creates an inter-regional problem because intrusive Delmarva Adena becomes Middle Woodland in this area, while in the Adena heartland in the Ohio River Valley it has long been classified as Early Woodland. In the Northeast, the transition is from Vinette I cordmarked ware to the more elaborately decorated (dentate, rocker-stamped) Point Peninsula pottery types. However, there has been an evident tension between the desire to put the temporal boundary at AD 0 and the recognition that there is a data gap of several centuries prior to appearance of the later ceramics circa AD 200 to 300 (Fiedel 2001). In eastern Pennsylvania, Custer places the Early/Middle transition either at AD 200 or AD 0 (Custer 1996:224, 253), based upon ceramic style changes (from Vinette I to Vinette II-like ware on the Lower Delaware, and from net-marked to dentate shell-tempered ware [Abbott Zoned] on the Middle and Upper Delaware).

F. MIDDLE WOODLAND-LATE WOODLAND

In the Midwest, Late Woodland is the period after the Hopewell decline. In many areas, Late Woodland cultures are superseded by or continue alongside Mississippian mound-building cultures after AD 1000. In the East, it is generally accepted that the Middle/Late transition is demarcated by the widespread adoption of maize horticulture. This subsistence change is accompanied by a major change in settlement pattern to large, permanently occupied villages, sometimes protected by palisades. At about the same time or slightly earlier (ca. AD 800), notched projectile points are replaced everywhere by triangular points, which signals the introduction of the bow and arrow. This may also be an indicator (along with the palisades) of intensified warfare. Ceramic styles also change significantly, with the appearance of collared vessels and incised decorations.

Although most of these ancillary cultural developments are evident in the Late Woodland archaeological record of the Middle Atlantic and Northeastern coastal plains (e.g., the Slaughter Creek Complex in Delmarva), the evidence of agriculture is generally very scarce (Custer 1989:329). It has even been suggested that native peoples along the East Coast only began intensively cultivating maize in response to European contact in the seventeenth century. However, the archaeological record stands in sharp contradiction to European explorers' descriptions of extensive cornfields. One might speculate that preservation is an issue, but Custer notes that items smaller than corn cobs were recovered from old excavations, so if corn was present, it should have been reported (Custer 1989:329). Custer observes marked continuities from Woodland I to Woodland II settlement pattern, but the major change is disruption of Woodland I trade networks and the cessation of elaborate mortuary rituals.

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ATTACHMENT A

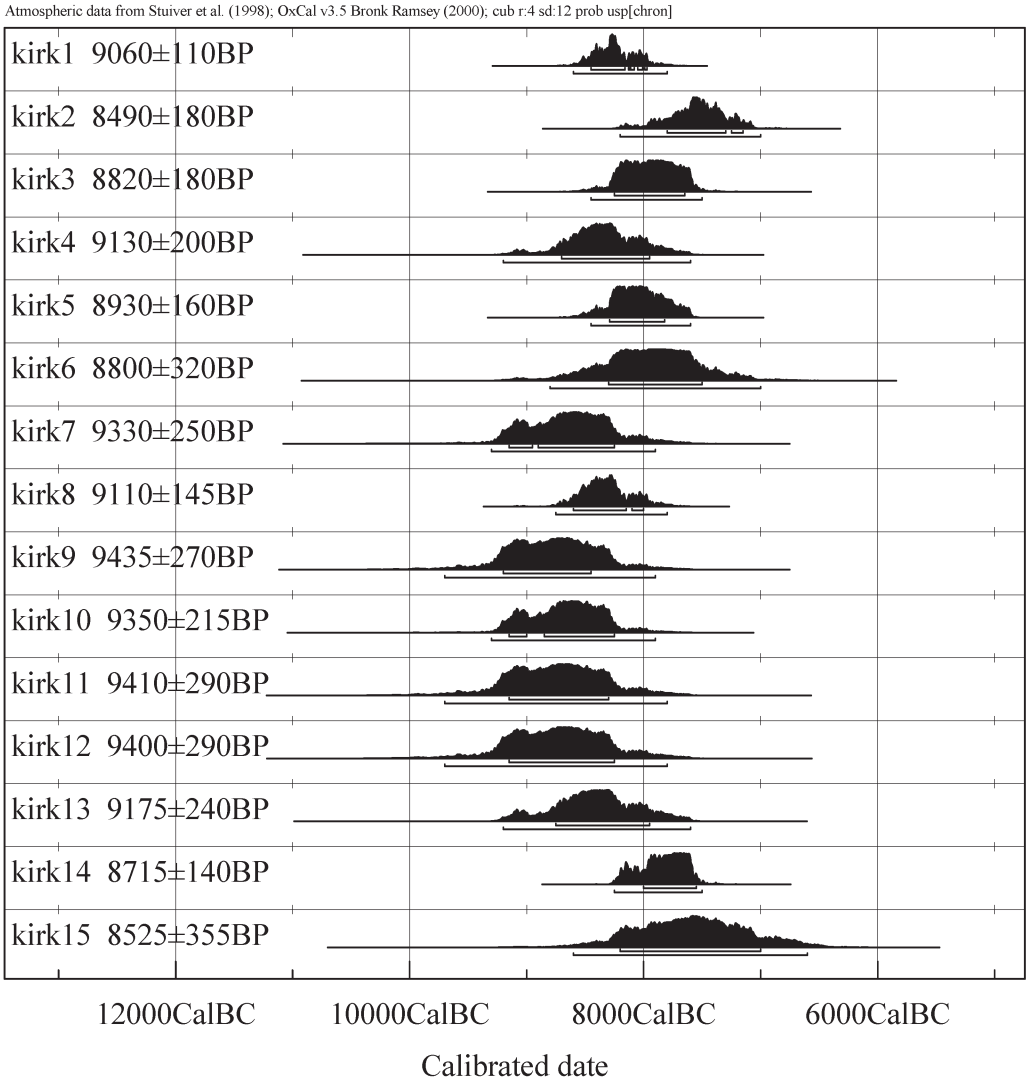


FIGURE O-1: Calibrated Radiocarbon Dates Associated with Kirk Corner-Notched Points

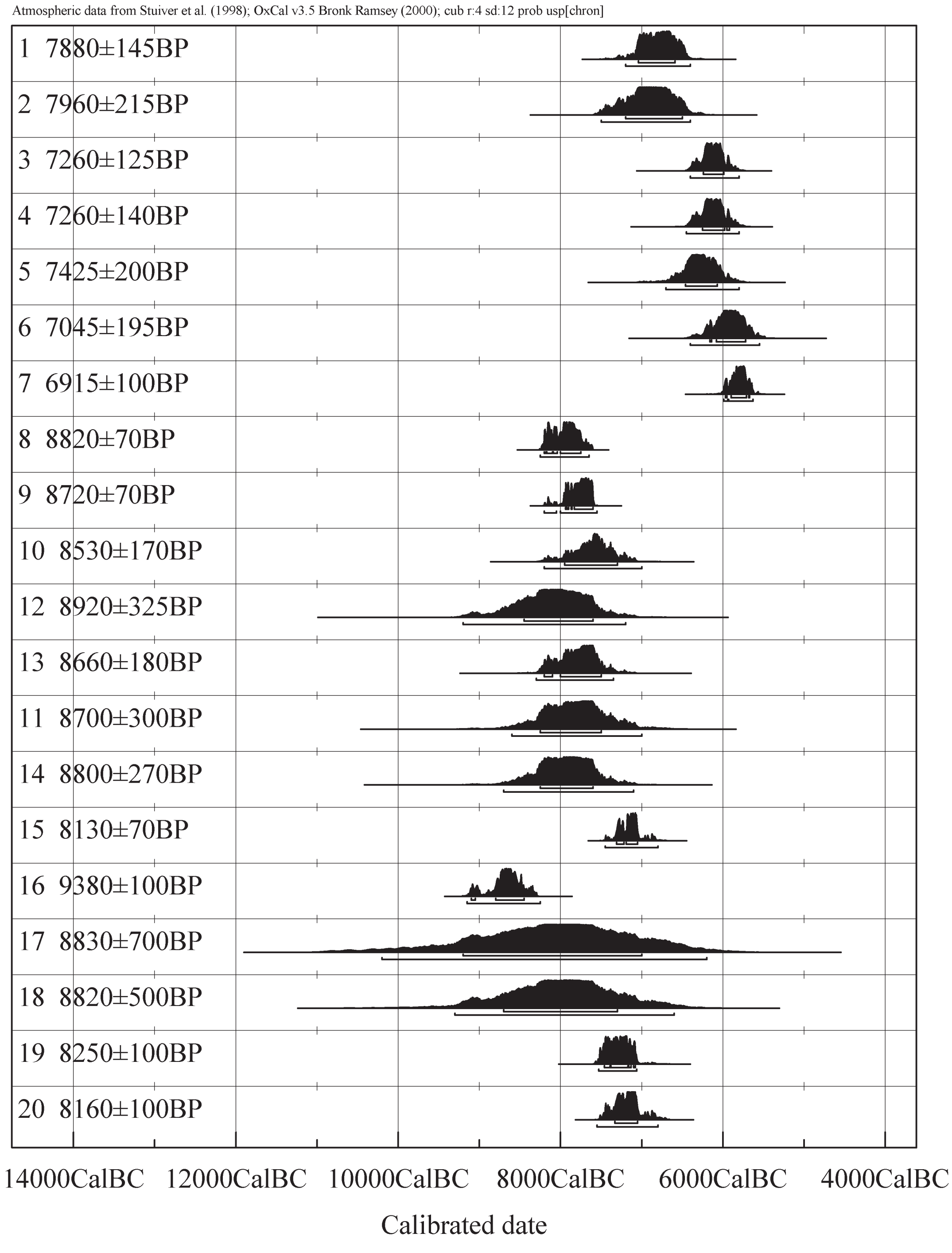


FIGURE O-2: Calibrated Radiocarbon Dates Associated with Bifurcate Points

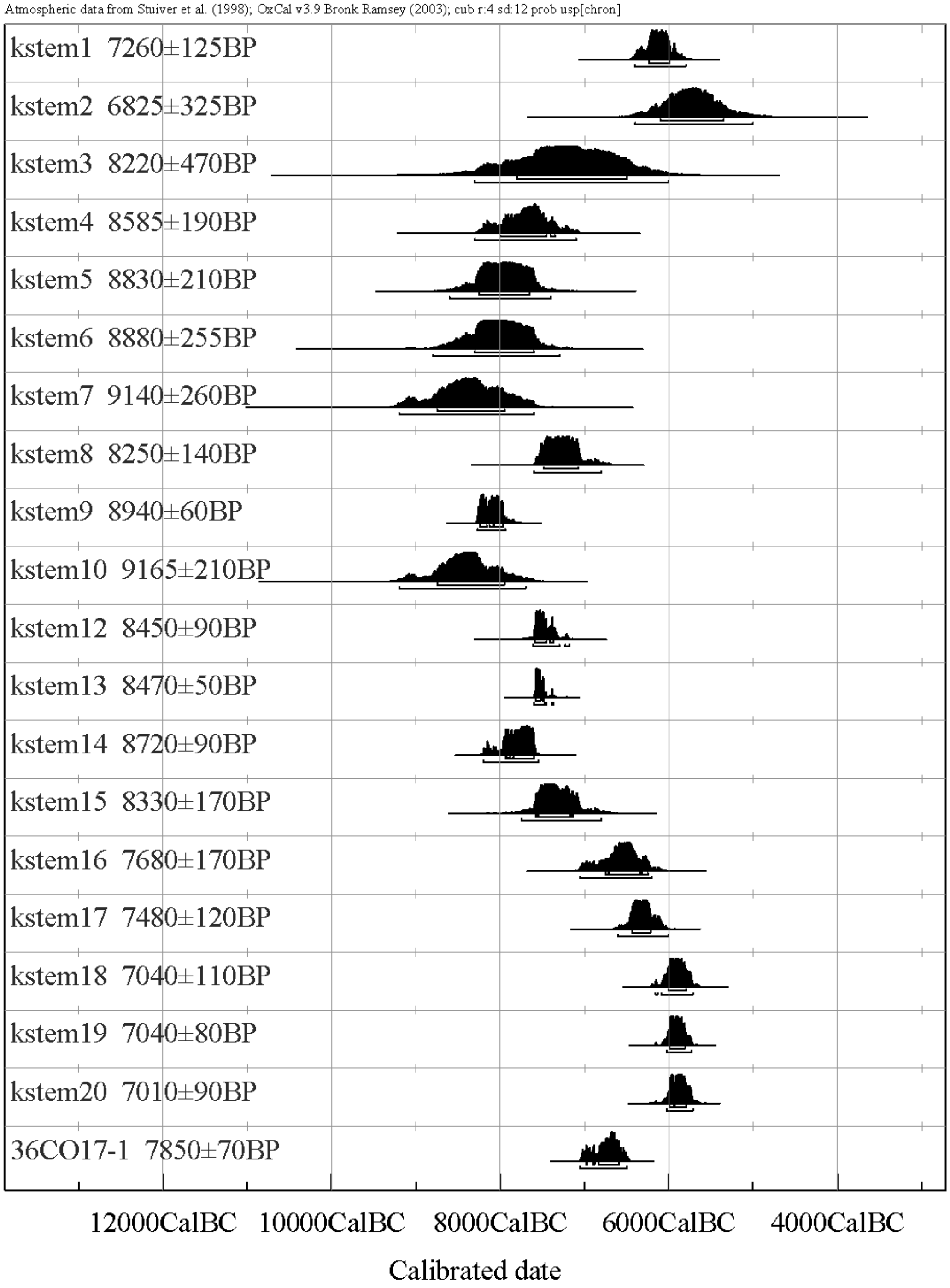


FIGURE O-3a: Calibrated Radiocarbon Dates Associated with Kirk Stemmed Points

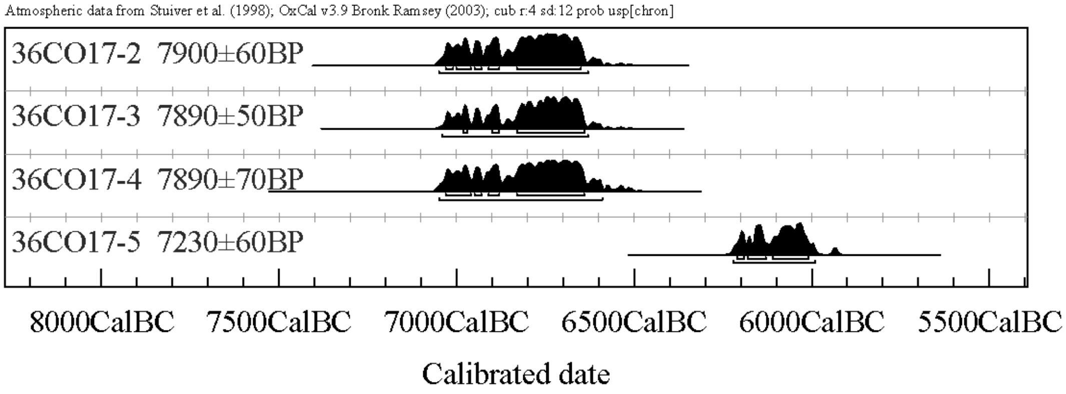


FIGURE O-3b: Calibrated Radiocarbon Dates Associated with Kirk Stemmed Points

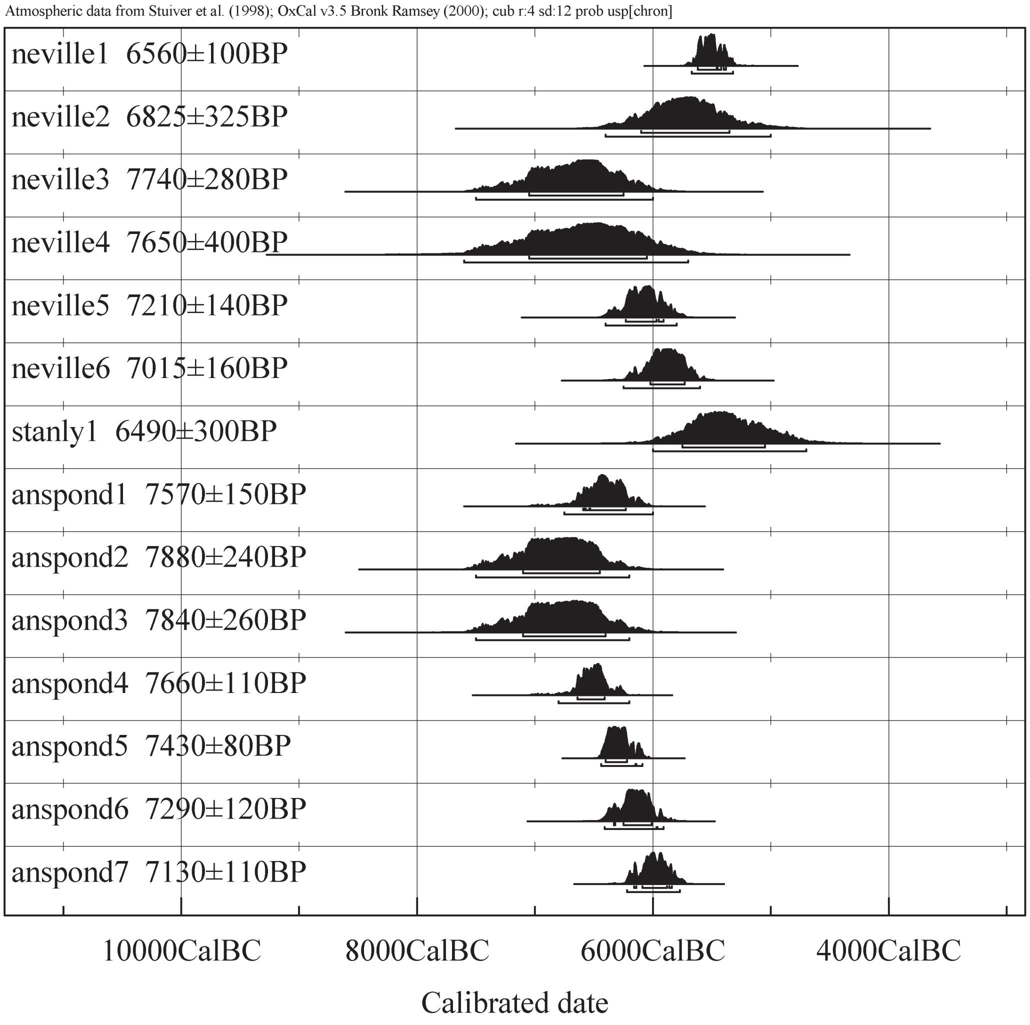


FIGURE O-4: Calibrated Radiocarbon Dates Associated with Neville and Stanly Points

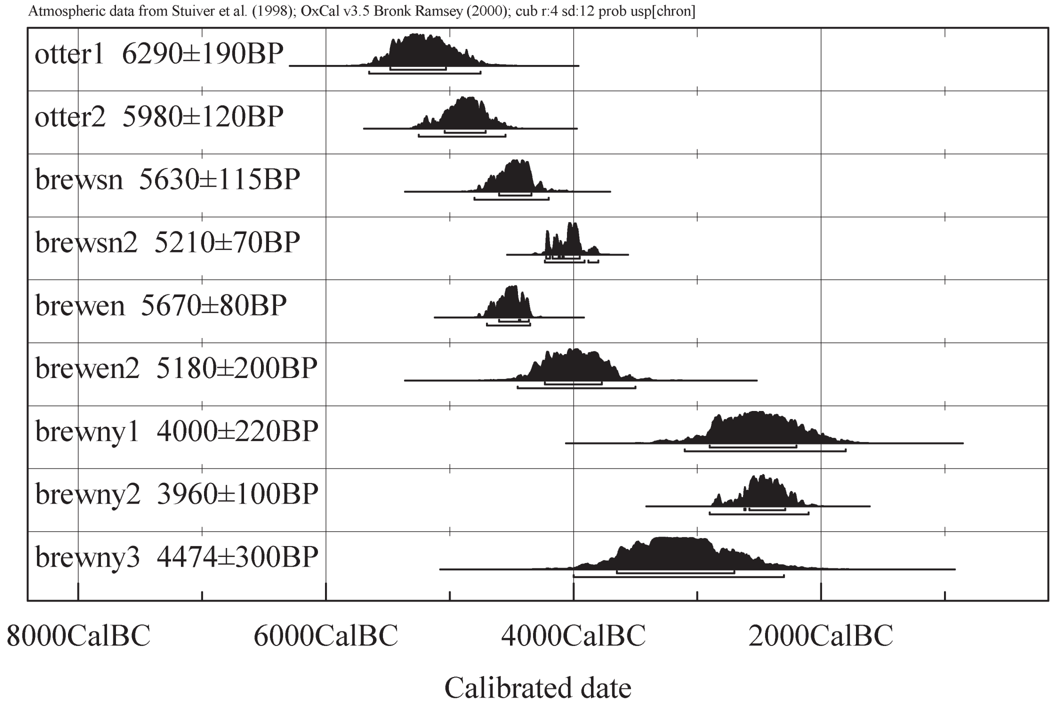


FIGURE O-5: Calibrated Radiocarbon Dates Associated with Otter Creek and Brewerton Points

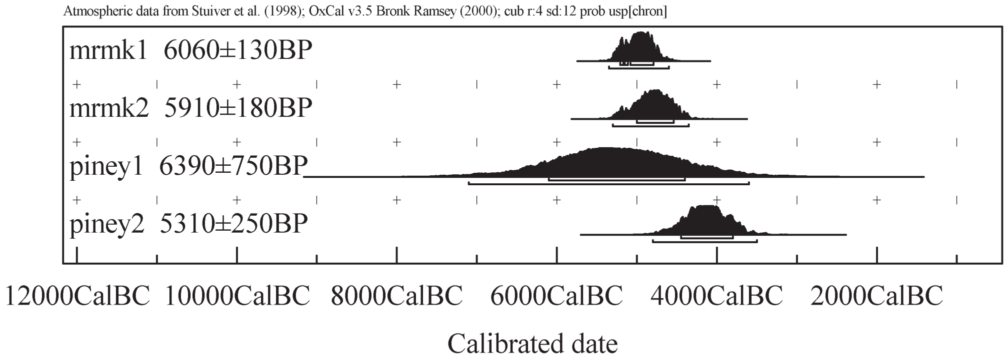


FIGURE O-6: Calibrated Radiocarbon Dates Associated with Early Narrow Stemmed Points (Merrimack and Piney Island types)

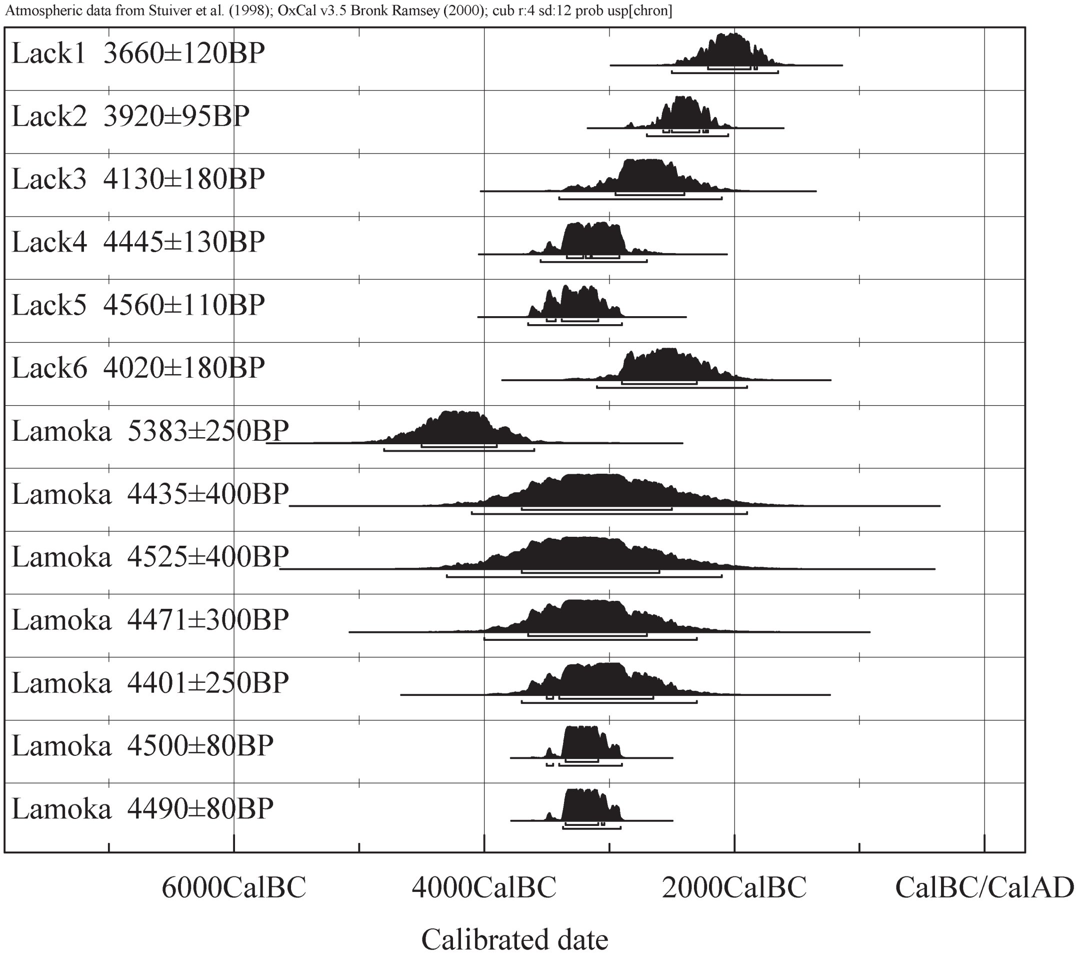


FIGURE O-7: Calibrated Radiocarbon Dates Associated with Lackawaxen and Lamoka Points

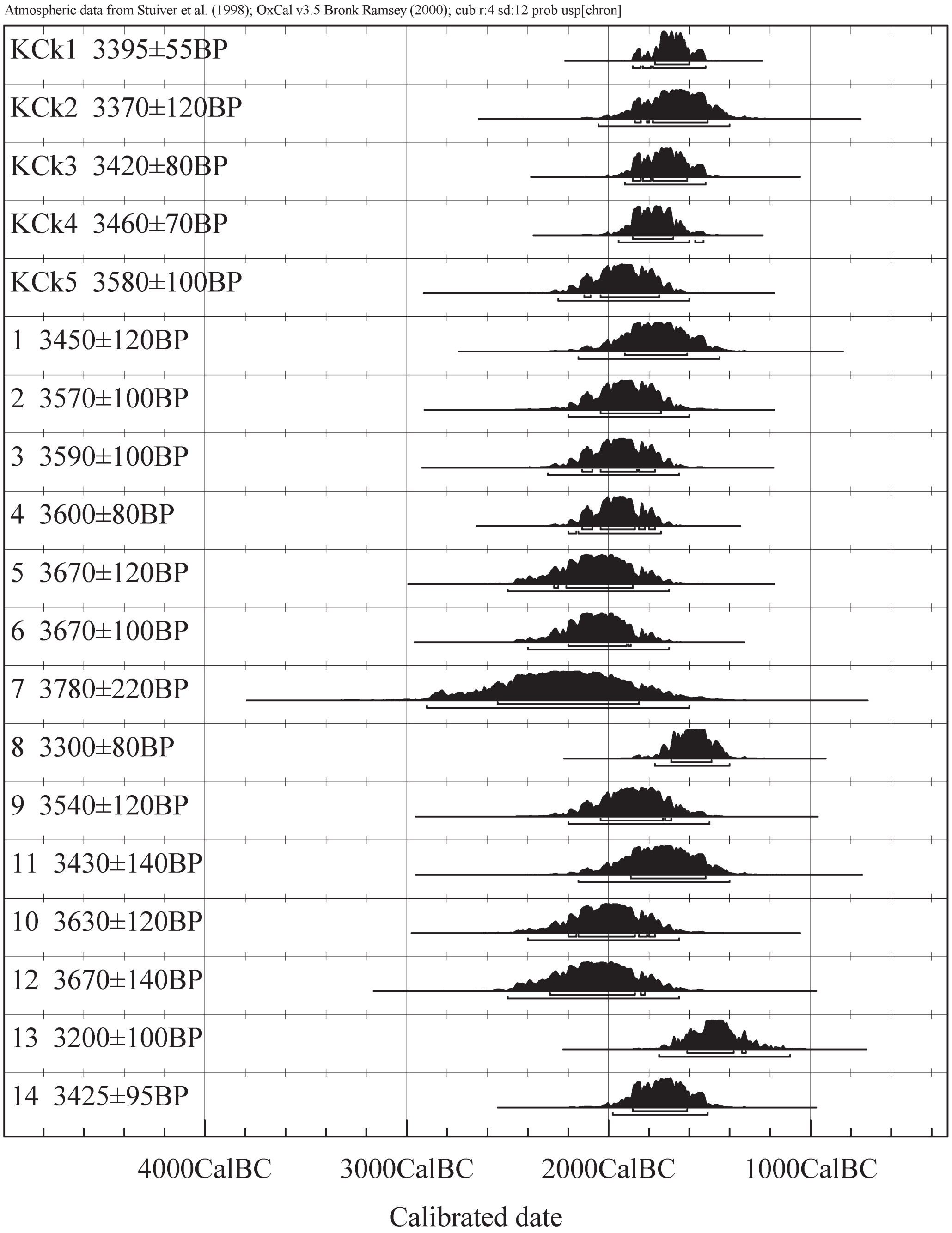


FIGURE O-8: Calibrated Radiocarbon Dates Associated with Susquehanna and Perkiomen Broadspear Points

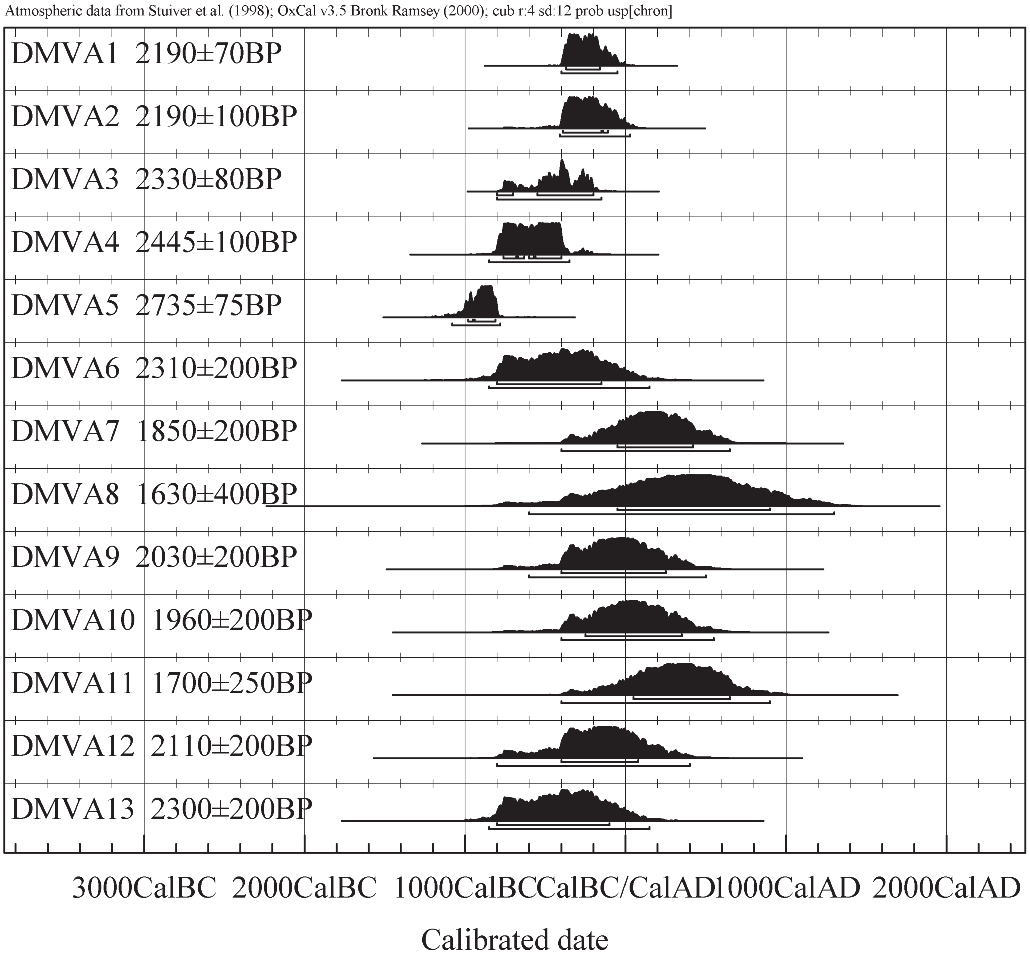


FIGURE O-9: Calibrated Radiocarbon Dates for Delmarva Adena Sites

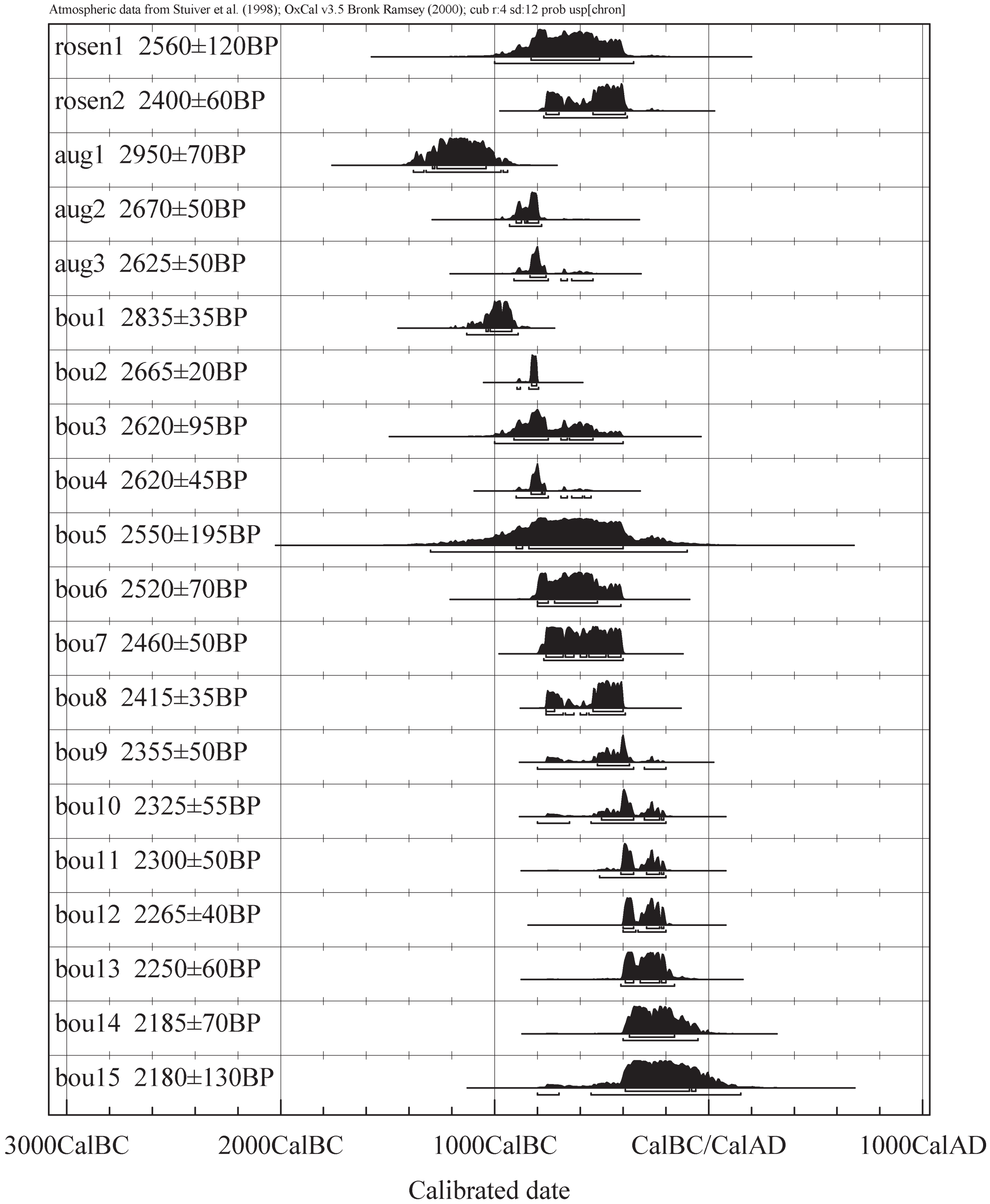


FIGURE O-10a: Calibrated Radiocarbon Dates for Northeastern Adena Sites (Rosenkrans NJ, Augustine NB, Boucher VT)

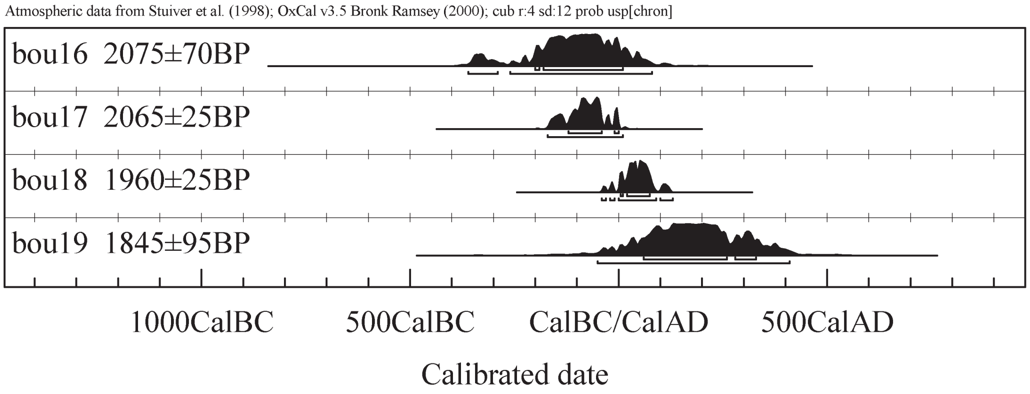


FIGURE O-10b: Calibrated Radiocarbon Dates for Northeastern Adena Sites (Rosenkrans NJ, Augustine NB, Boucher VT)

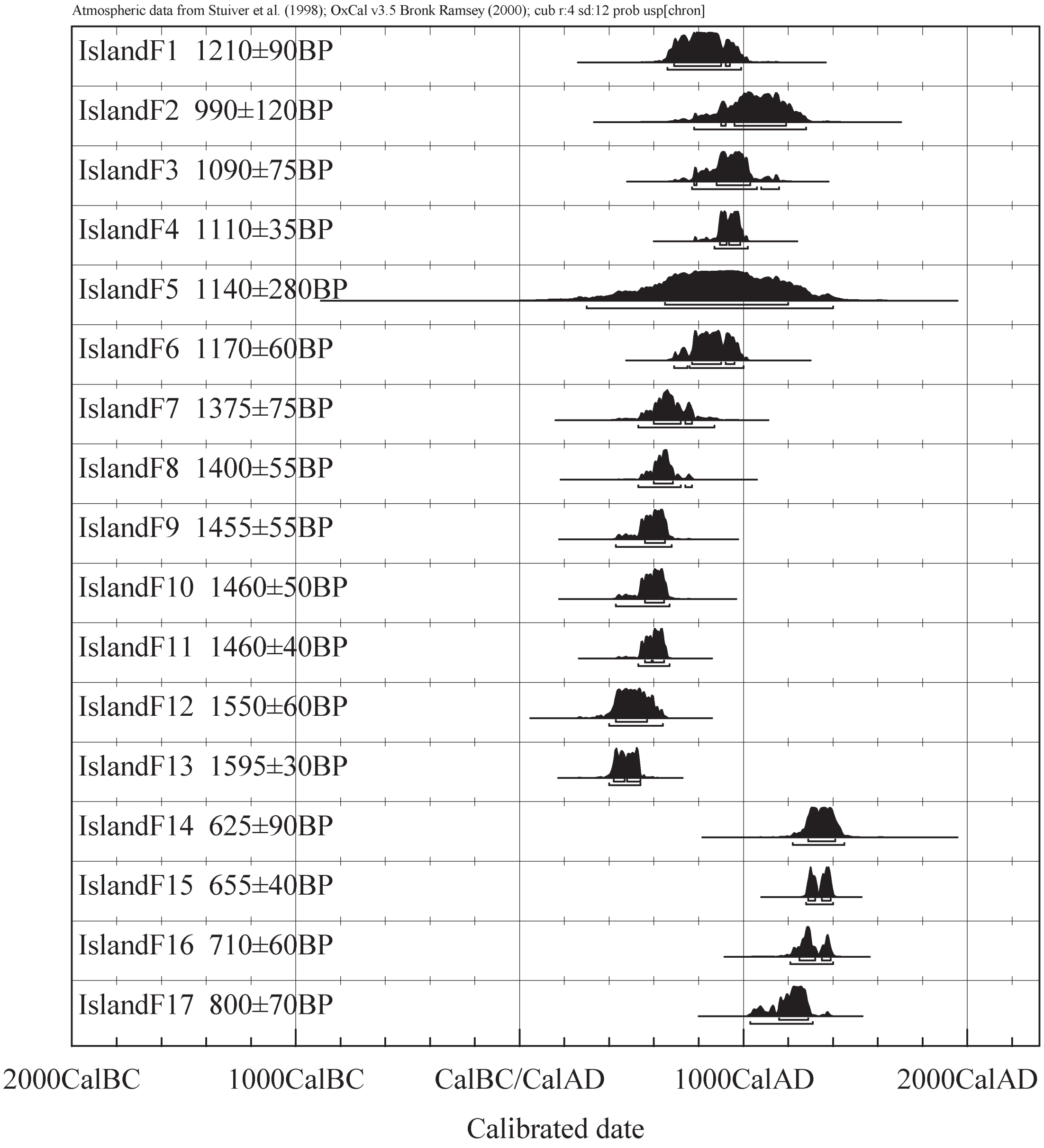


FIGURE O-11: Calibrated Radiocarbon Dates from Island Field Site.

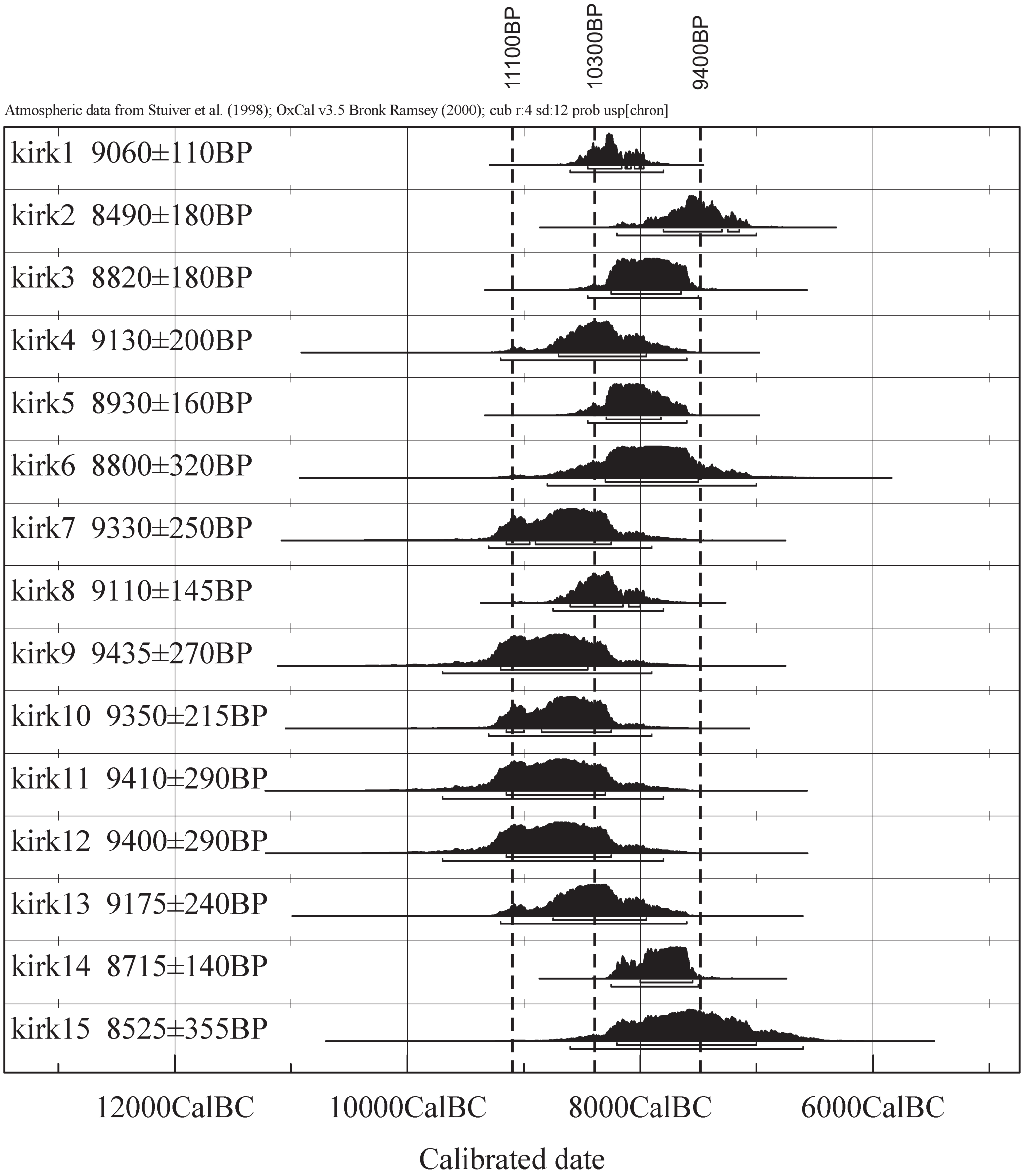


FIGURE O-12: Kirk Corner-Notched Dates and Contemporaneous Climate Episodes

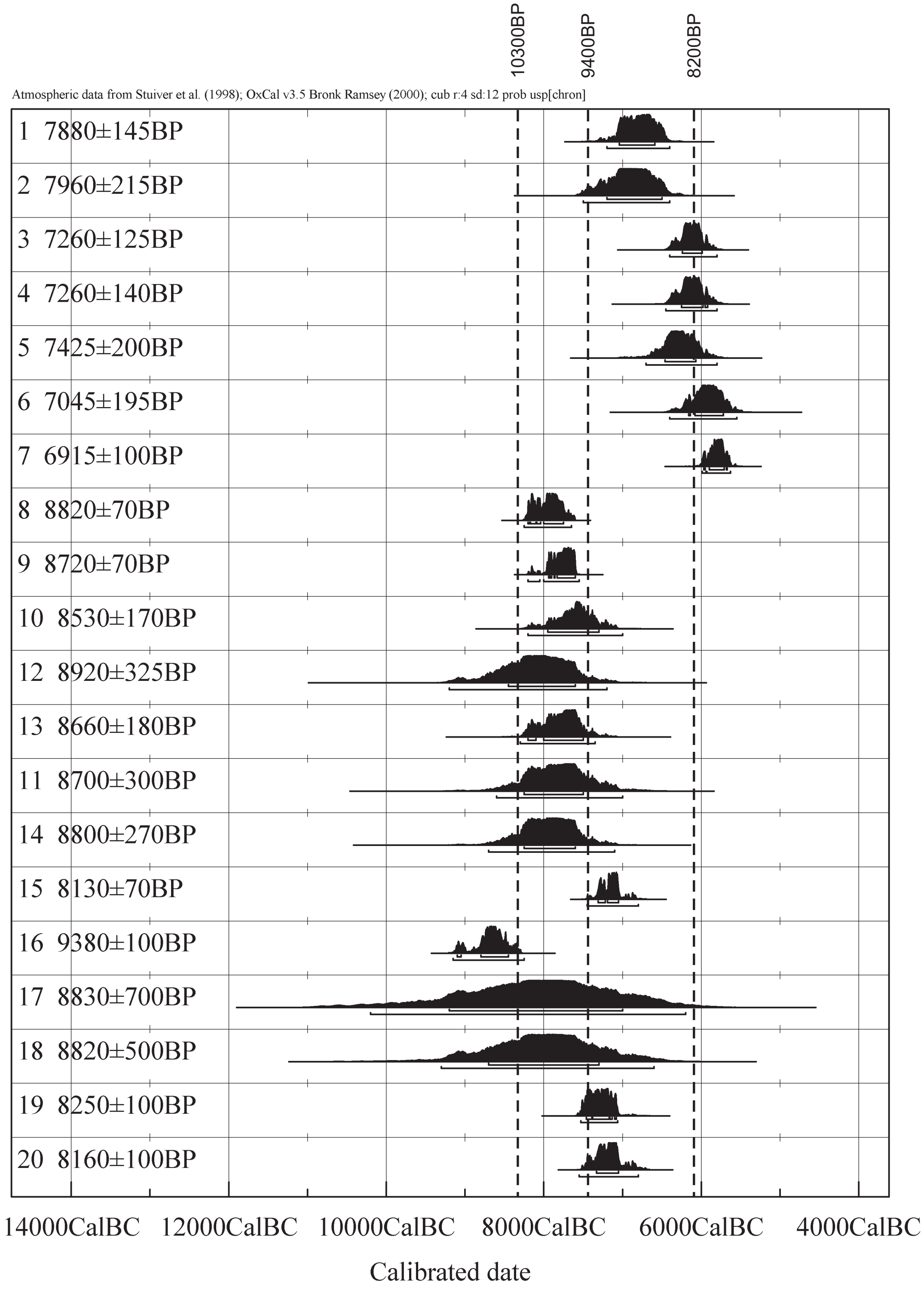

Atmospheric data from Stuiver et al. (1998); OxCal v3.5 Bronk Ramsey (2000); cub r:4 sd:12 prob usp[chron]

FIGURE O-13: Bifurcate Dates and Contemporaneous Climate Episodes

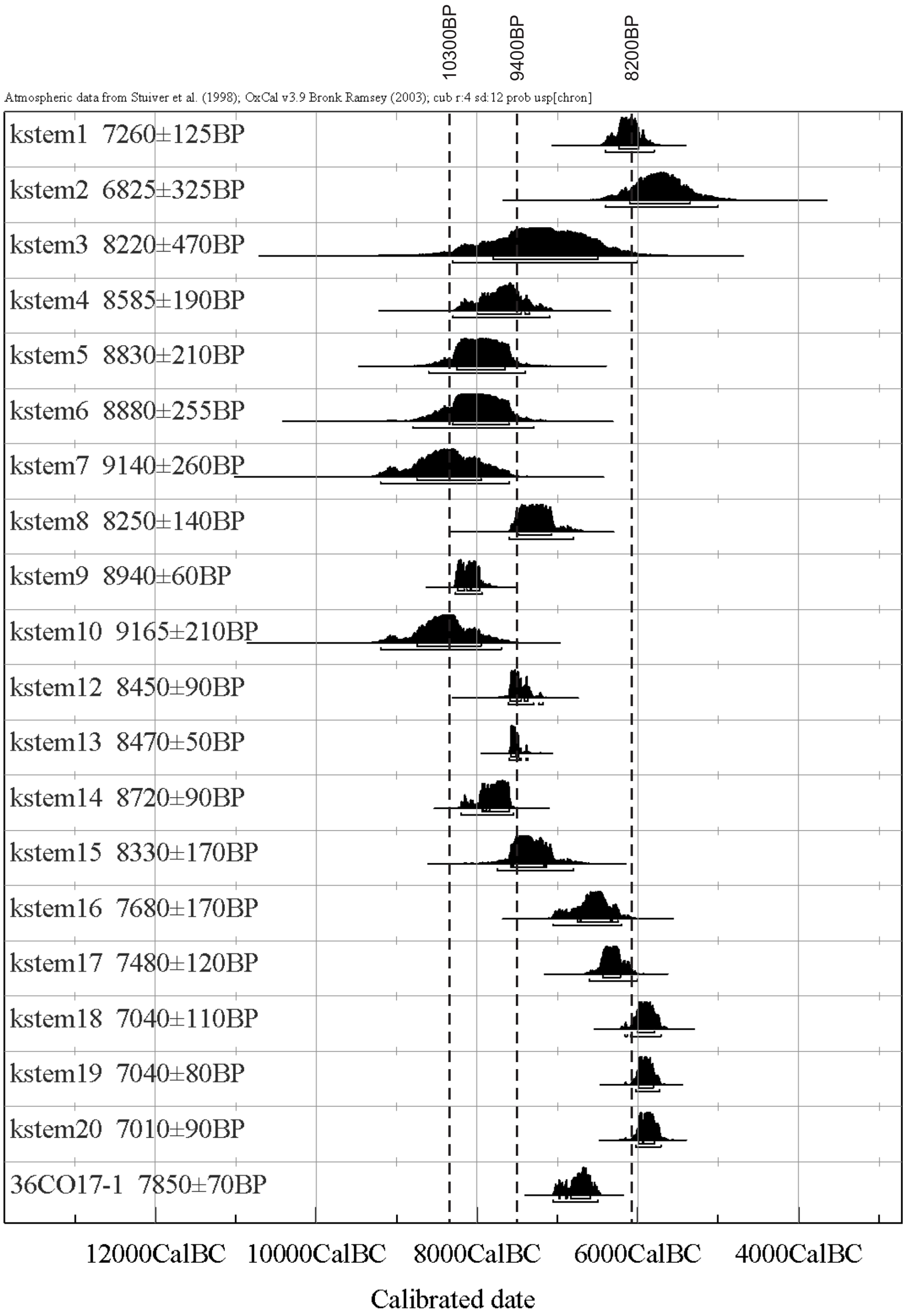


FIGURE O-14a: Kirk Stemmed Dates and Contemporaneous Climate Episodes

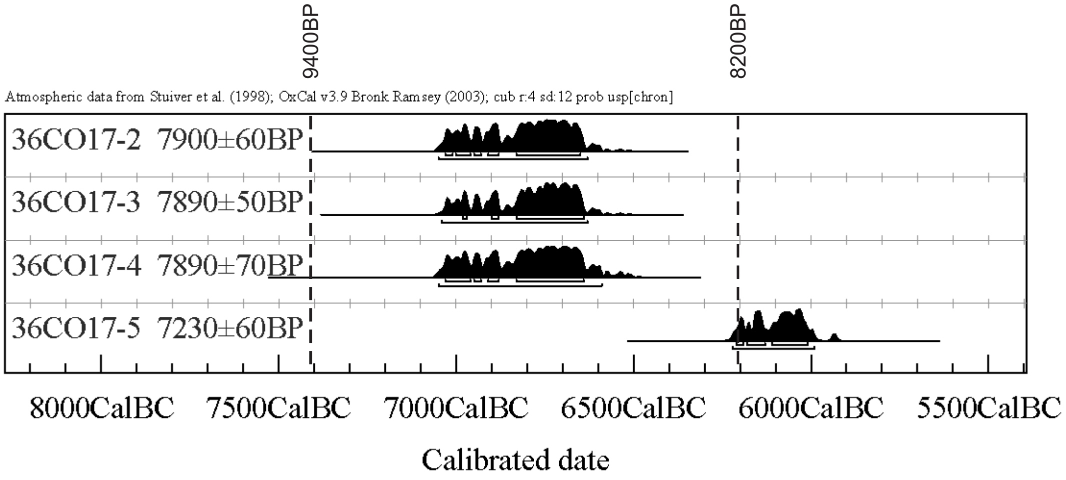


FIGURE O-14b: Kirk Stemmed Dates and Contemporaneous Climate Episodes

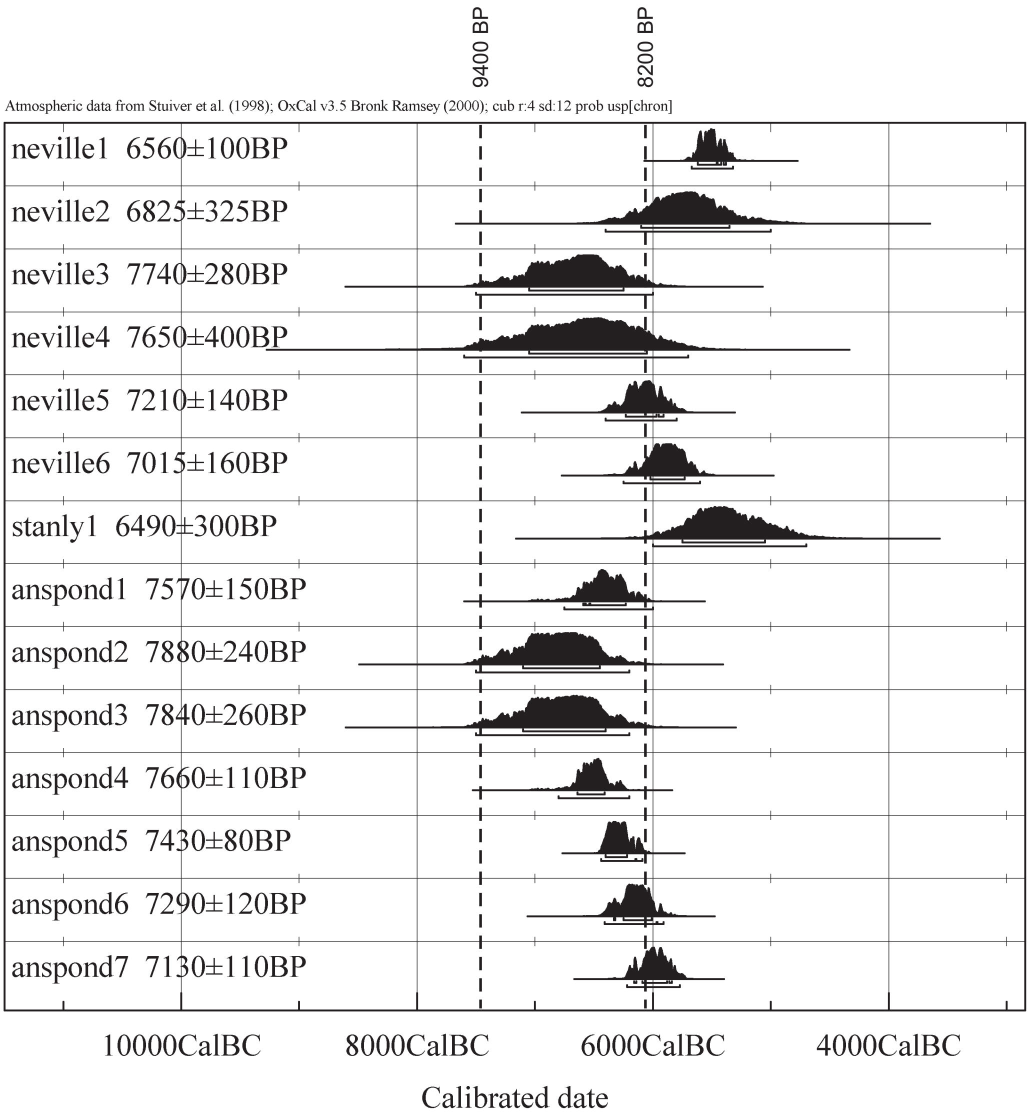


FIGURE O-15: Neville and Stanly Dates and Contemporaneous Climate Episodes

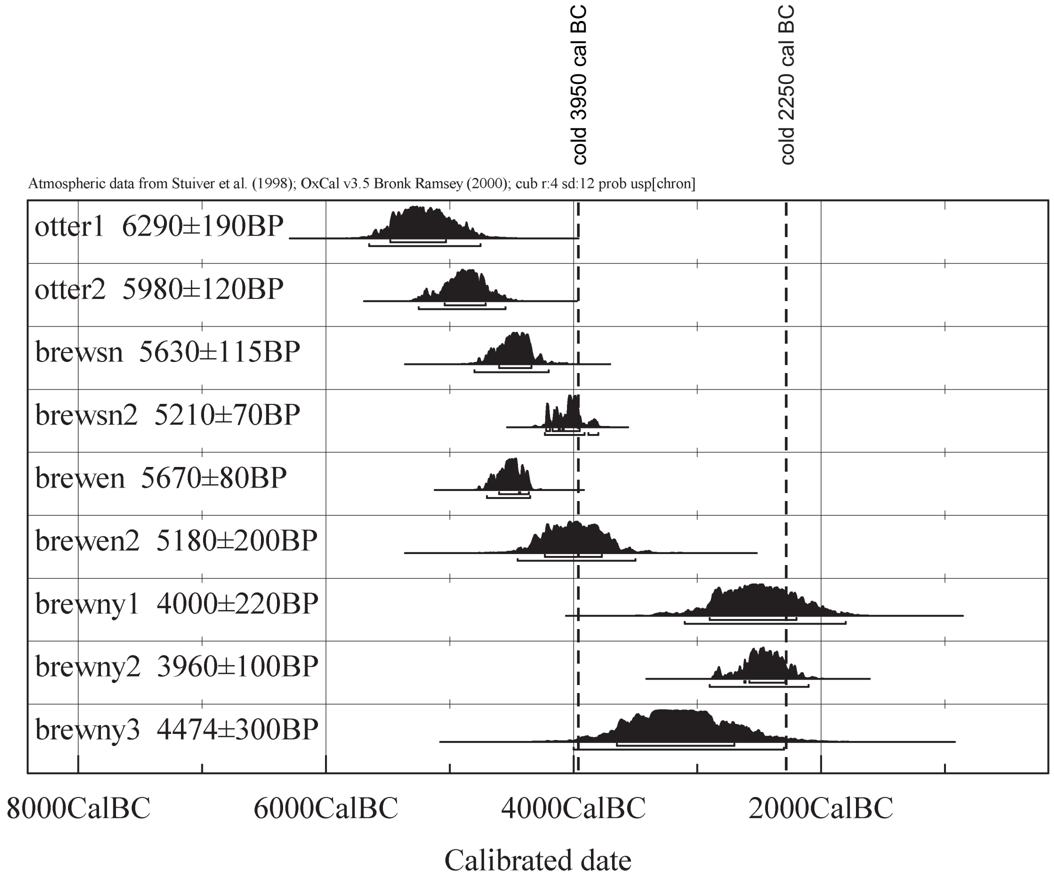


FIGURE O-16: Otter Creek and Brewerton Dates and Contemporaneous Climate Episodes

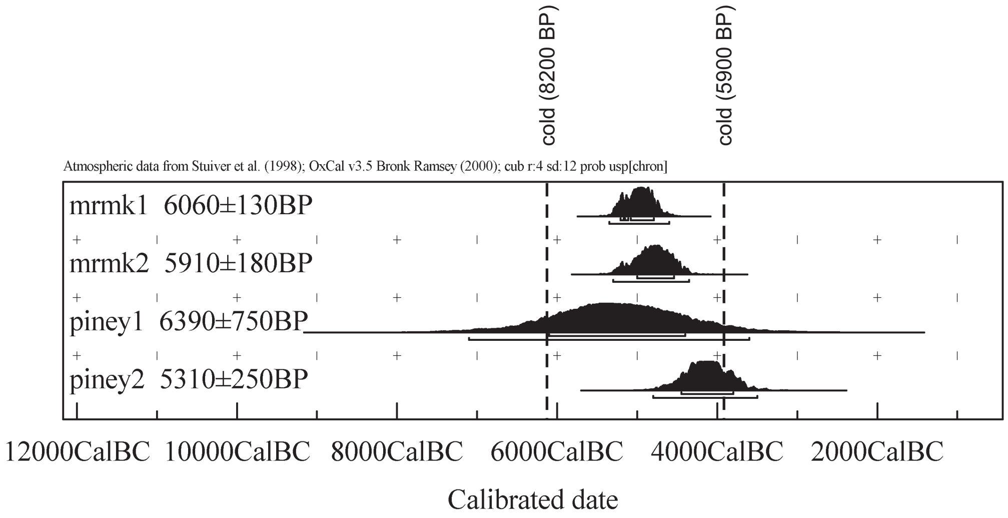


FIGURE O-17: Merrimack and Piney Island Dates and Contemporaneous Climate Episodes

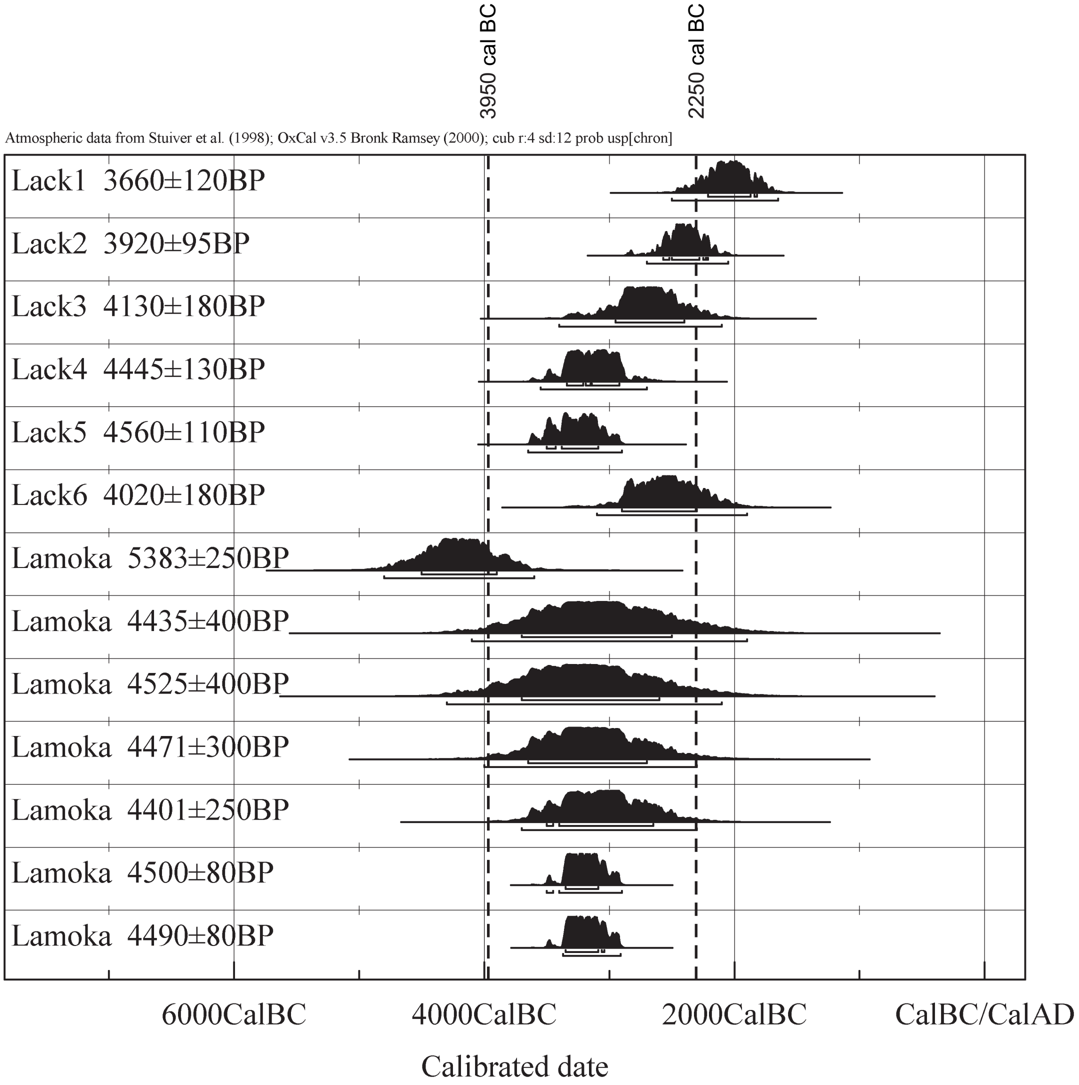


FIGURE O-18: Lackawaxen and Lamoka Dates and Contemporaneous Climate Episodes

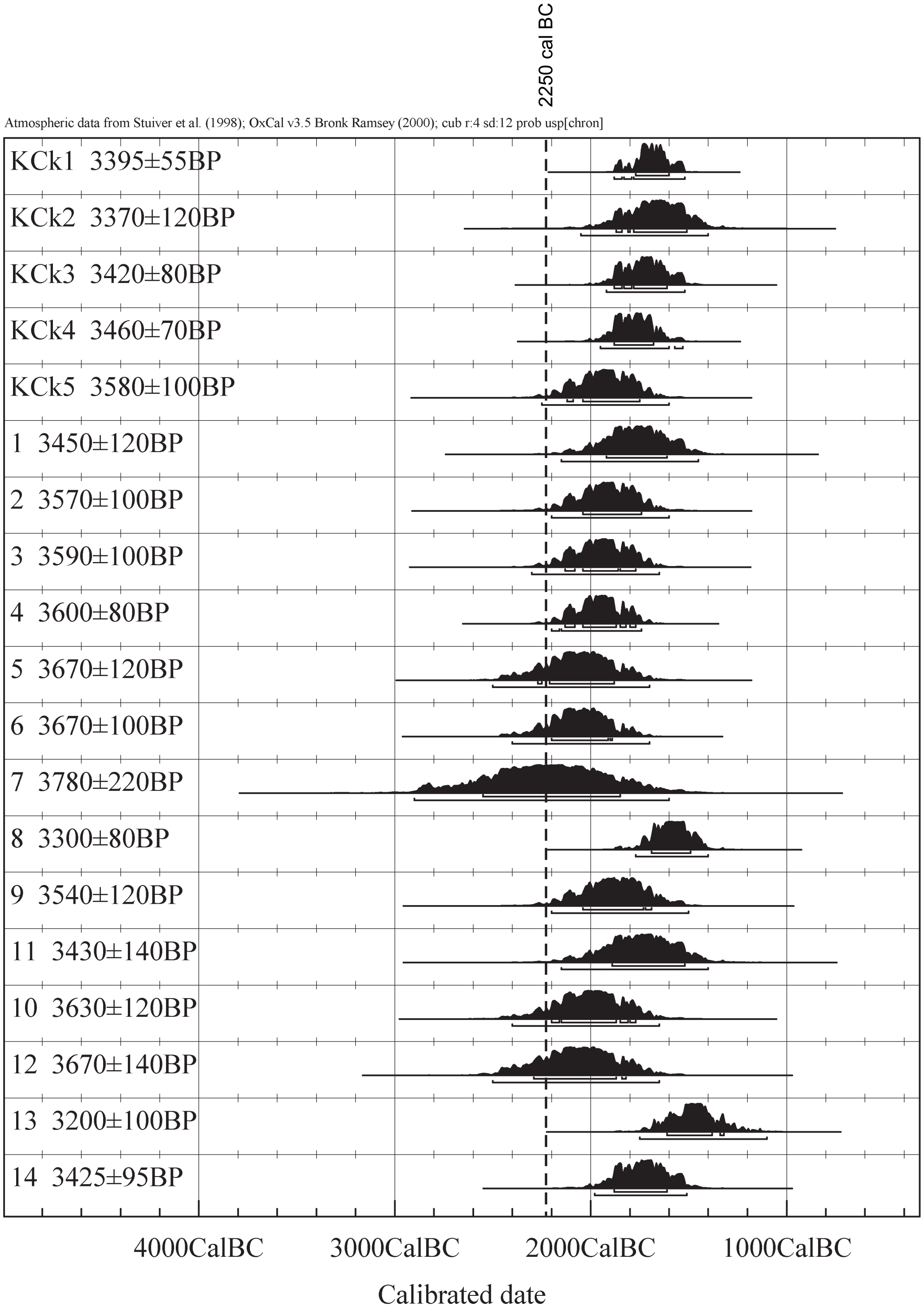


FIGURE O-19: Susquehanna and Perkiomen Broadspear Dates and Contemporaneous Climate Episodes

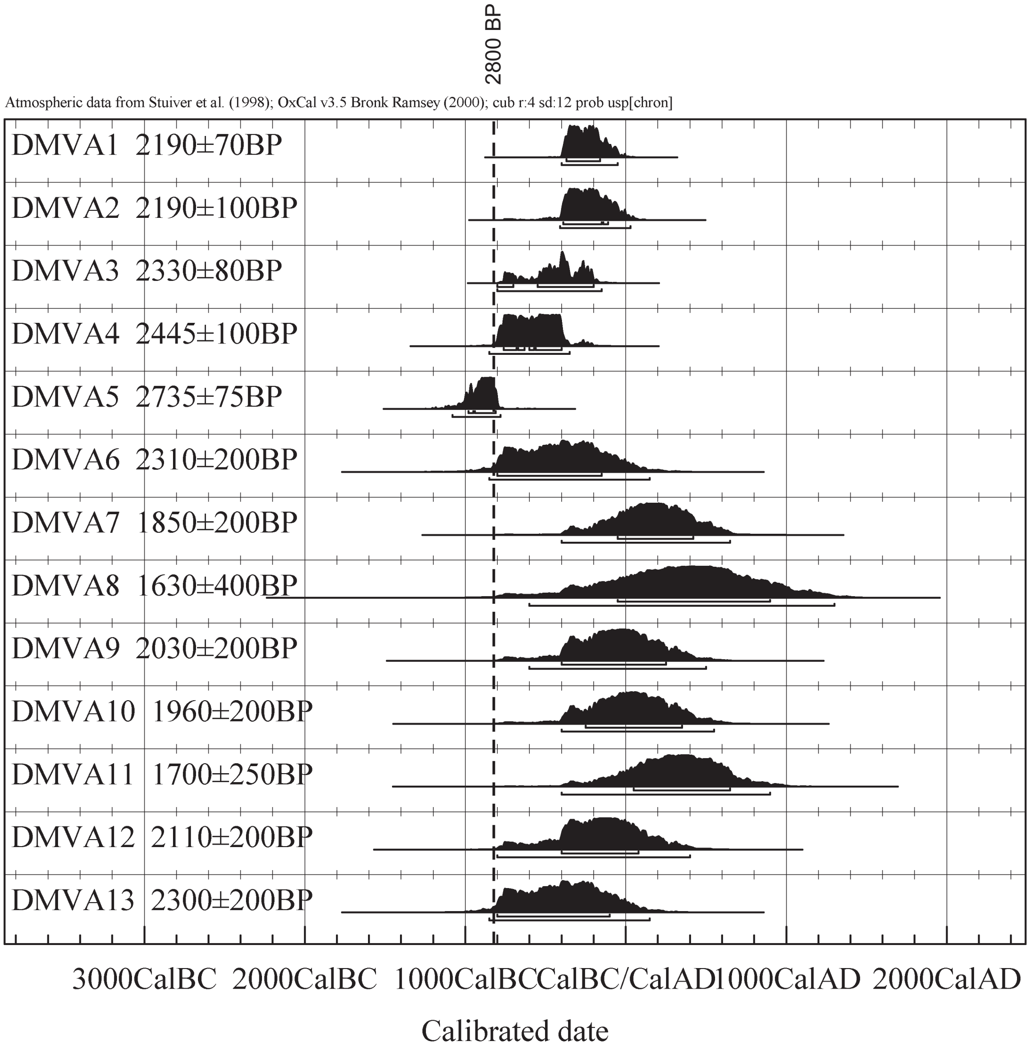


FIGURE O-20: Delmarva Adena Dates and Contemporaneous Climate Episodes

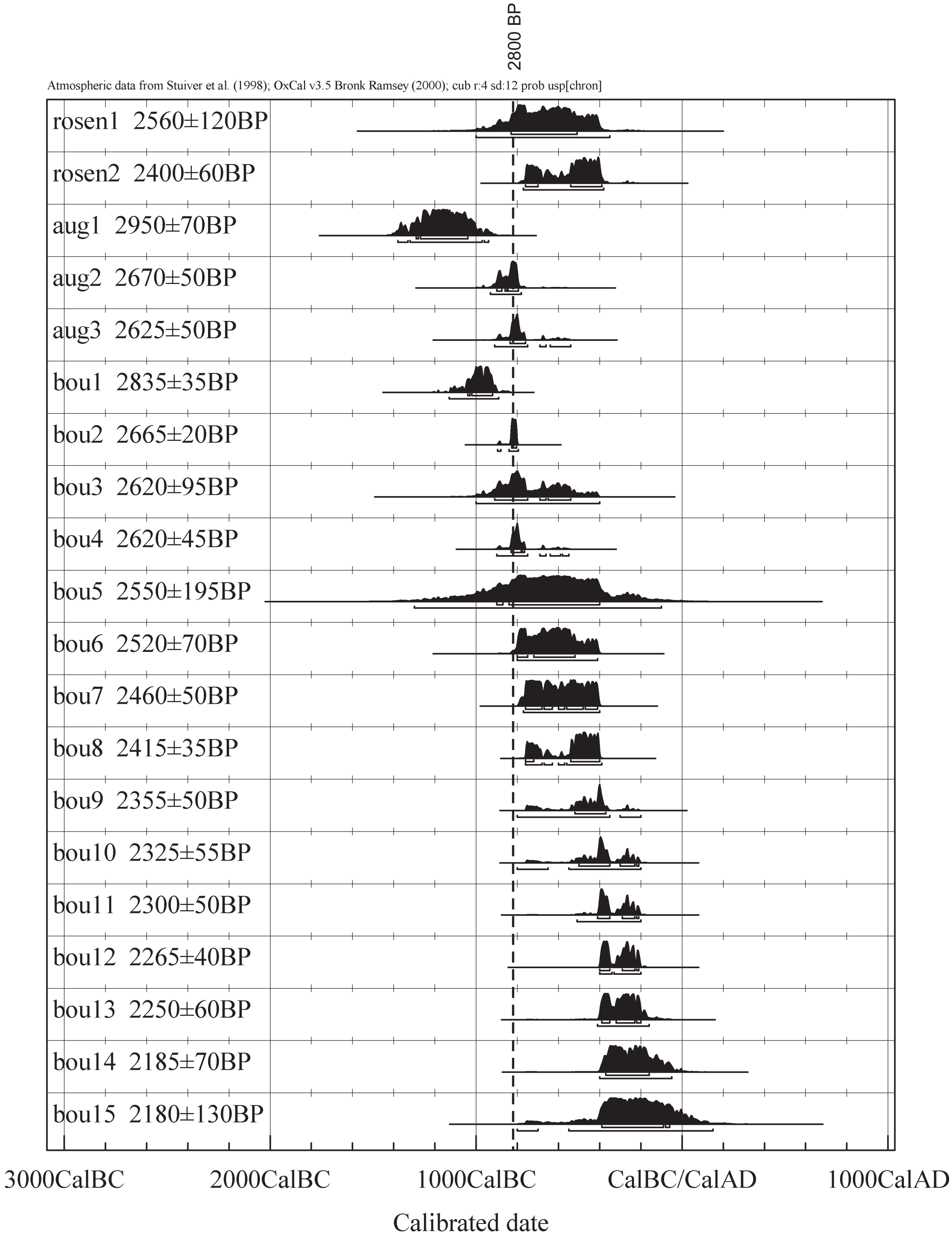


FIGURE O-21a: Northeastern Adena Dates and Contemporaneous Climate Episodes

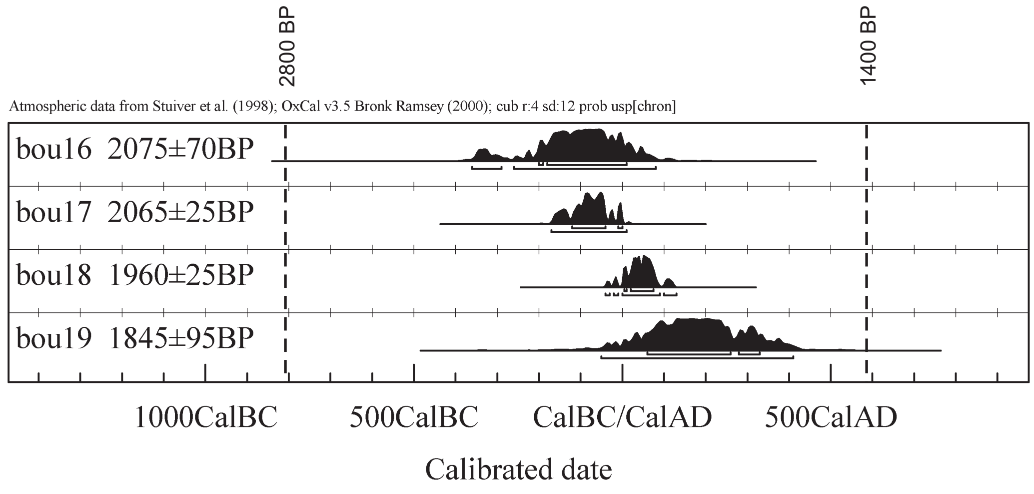


FIGURE O-21b: Northeastern Adena Dates and Contemporaneous Climate Episodes

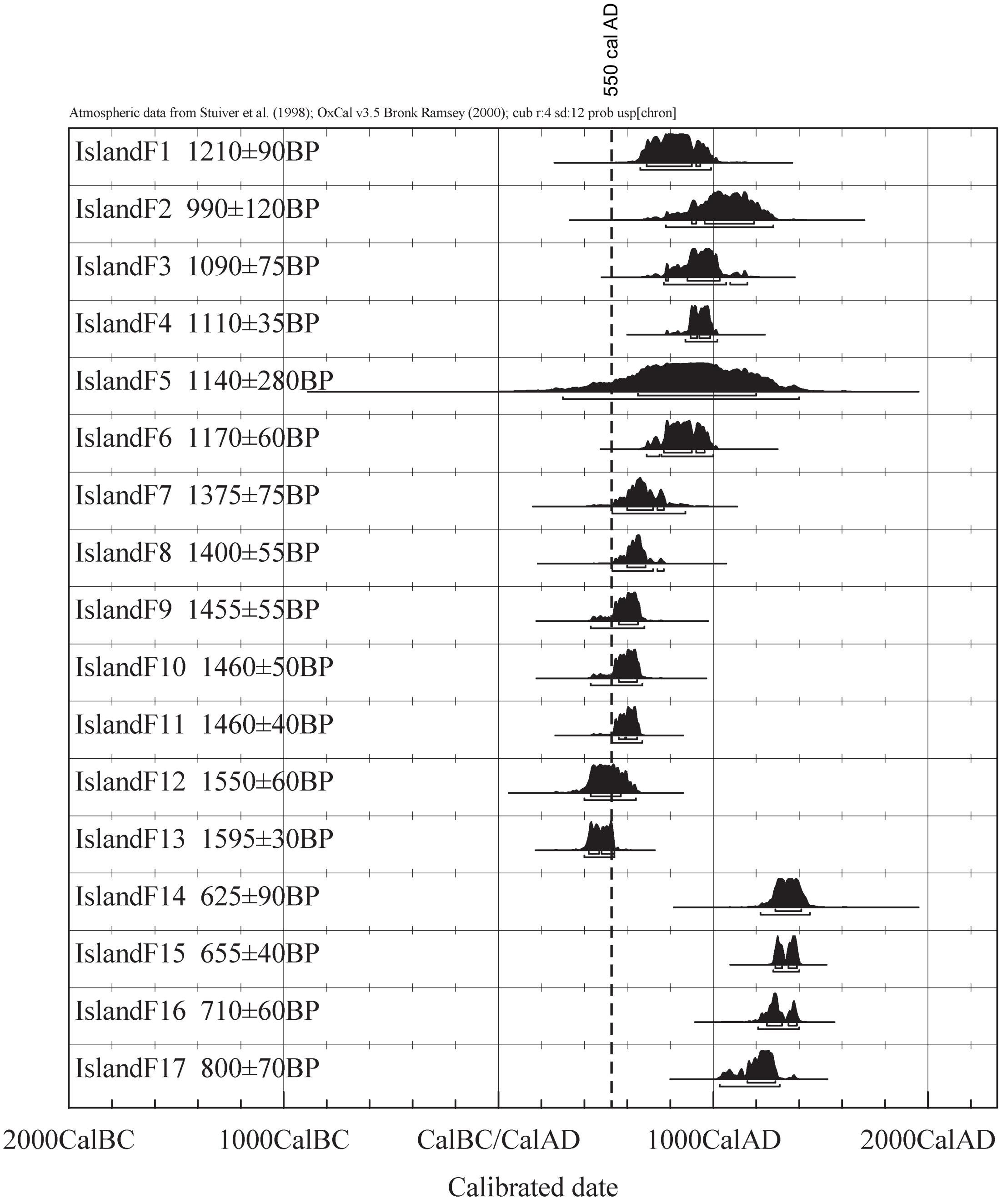
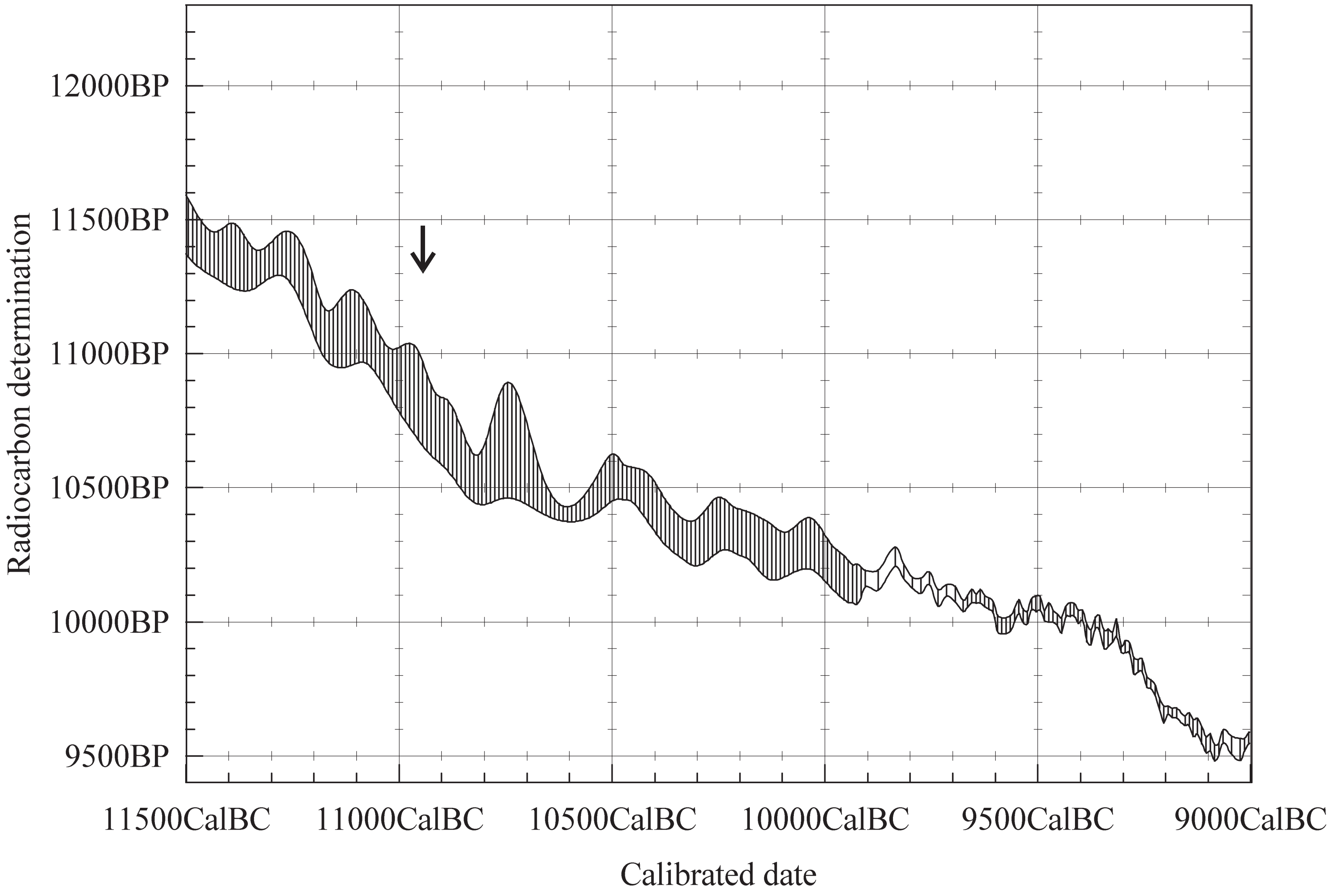


FIGURE O-22: Island Field Dates and Contemporaneous Climate Episodes



Atmospheric data from Stuiver et al. (1998); OxCal v3.5 Bronk Ramsey (2000); cub r:4 sd:12 prob usp[chron]

FIGURE O-23a: Radiocarbon Calibration Curve from 11,500 cal BC to 1500 cal AD with Cold Episodes and Plateau Effects Indicated

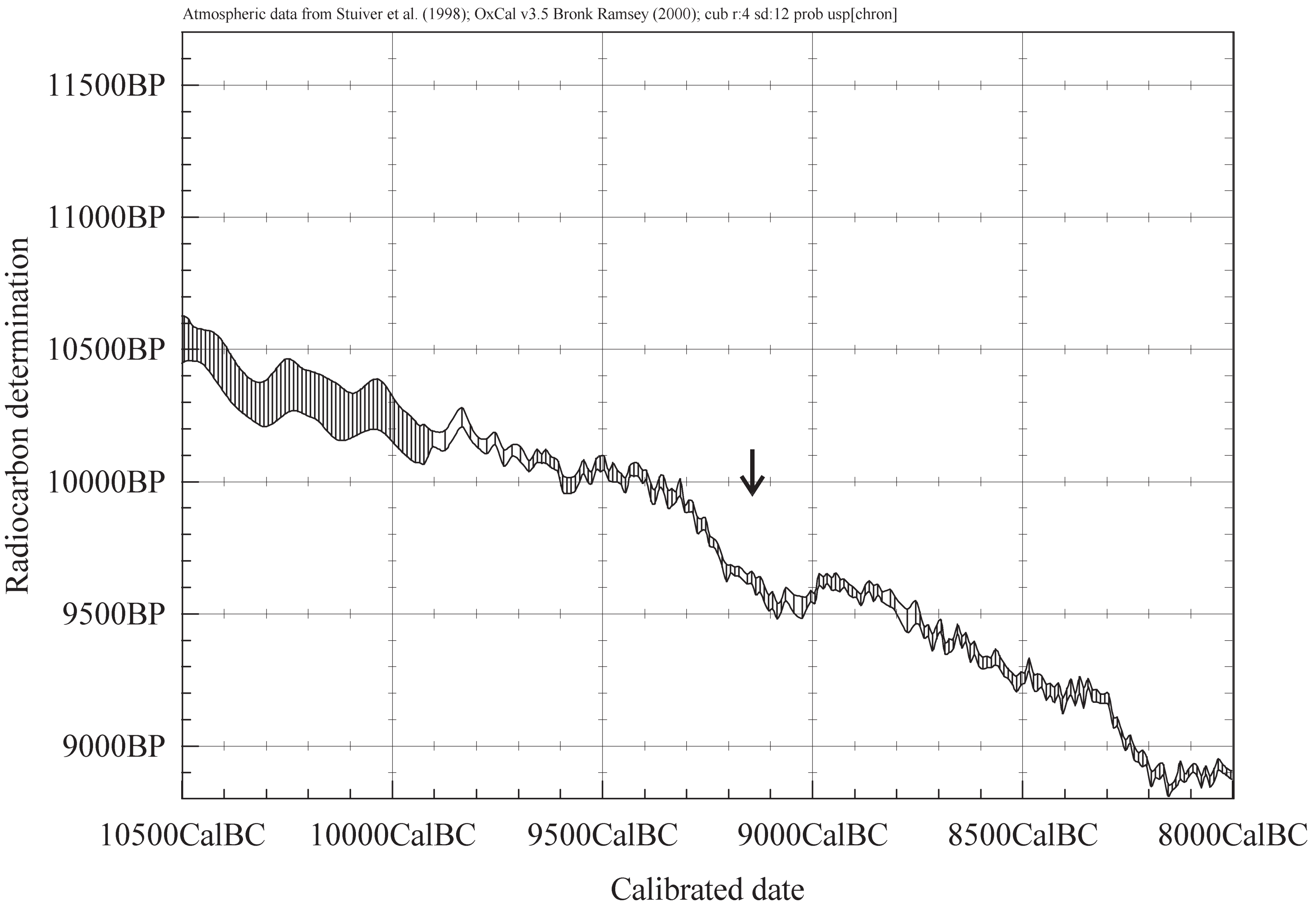


FIGURE O-23b: Radiocarbon Calibration Curve from 11,500 cal BC to 1500 cal AD with Cold Episodes and Plateau Effects Indicated

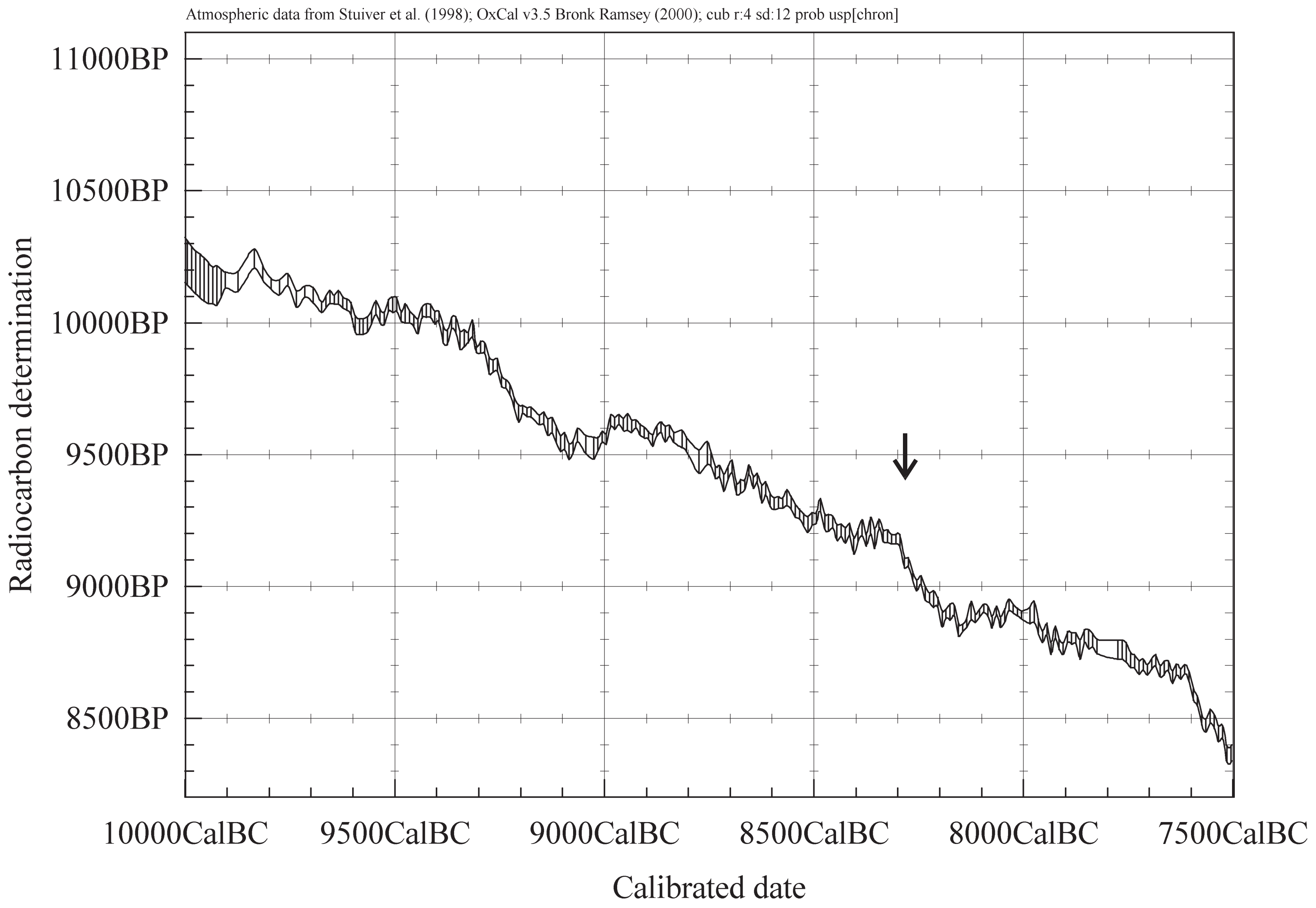

Atmospheric data from Stuiver et al. (1998); OxCal v3.5 Bronk Ramsey (2000); cub r:4 sd:12 prob usp[chron]

FIGURE O-23c: Radiocarbon Calibration Curve from 11,500 cal BC to 1500 cal AD with Cold Episodes and Plateau Effects Indicated

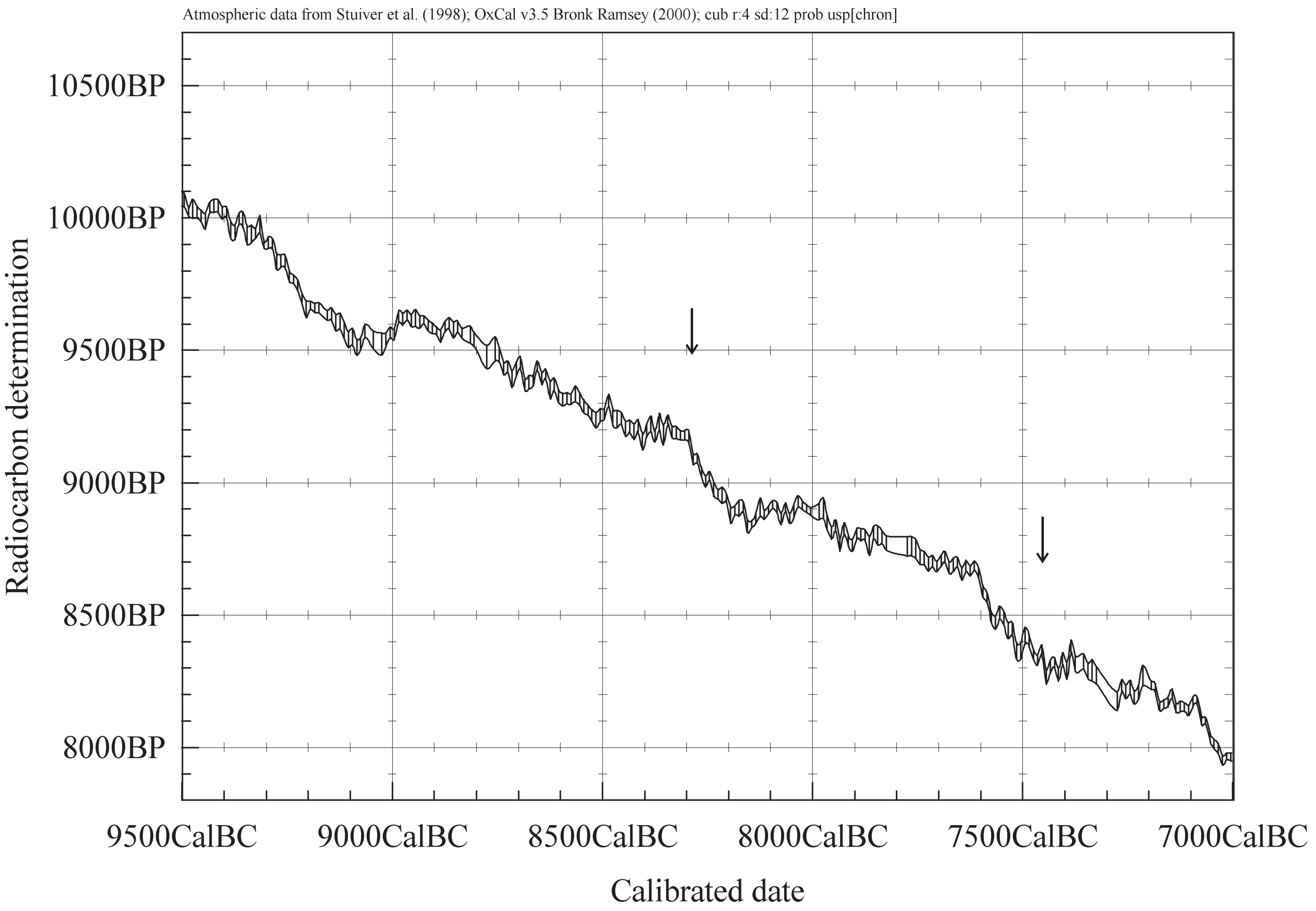


FIGURE O-23d: Radiocarbon Calibration Curve from 11,500 cal BC to 1500 cal AD with Cold Episodes and Plateau Effects Indicated

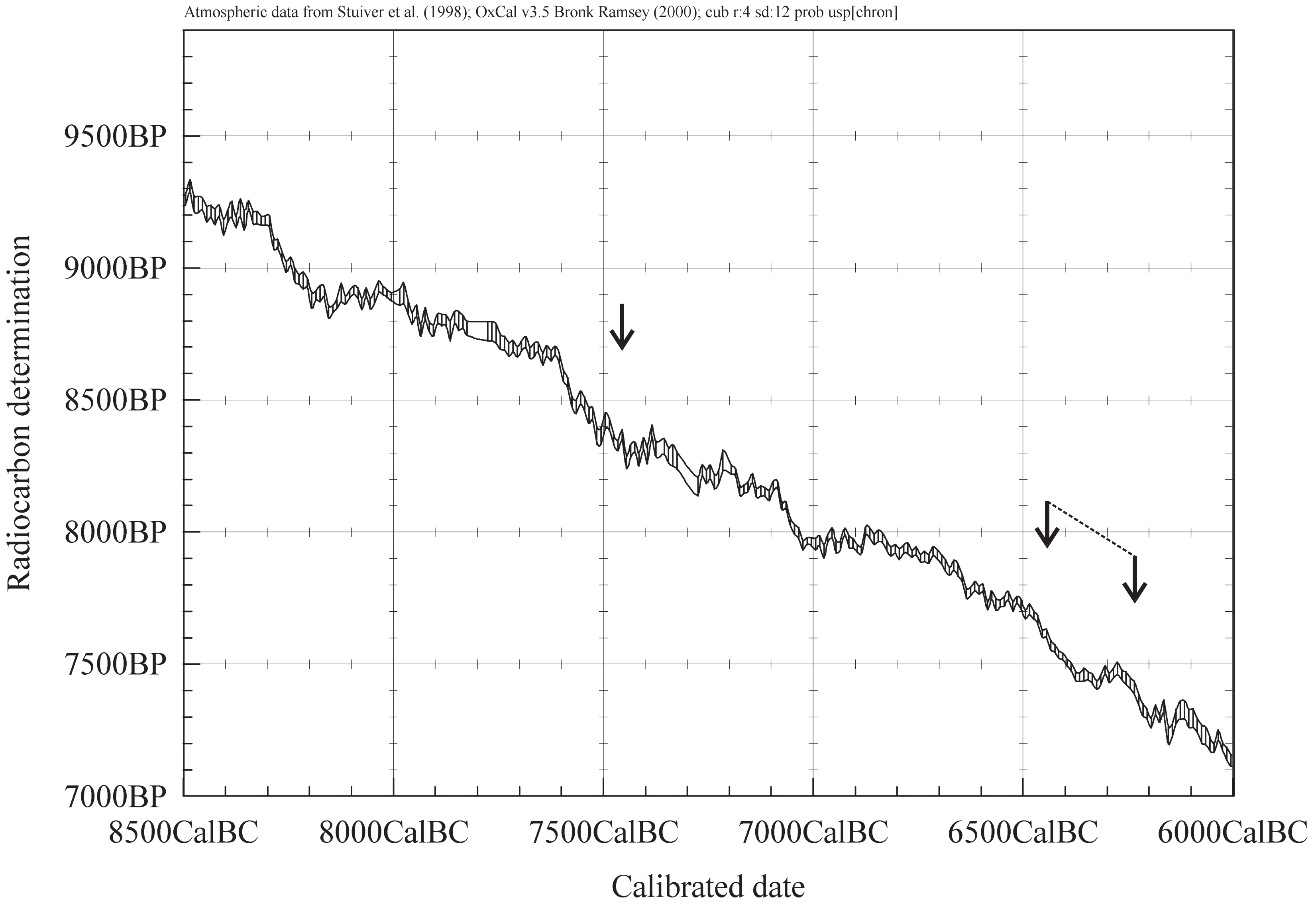


FIGURE O-23e: Radiocarbon Calibration Curve from 11,500 cal BC to 1500 cal AD with Cold Episodes and Plateau Effects Indicated

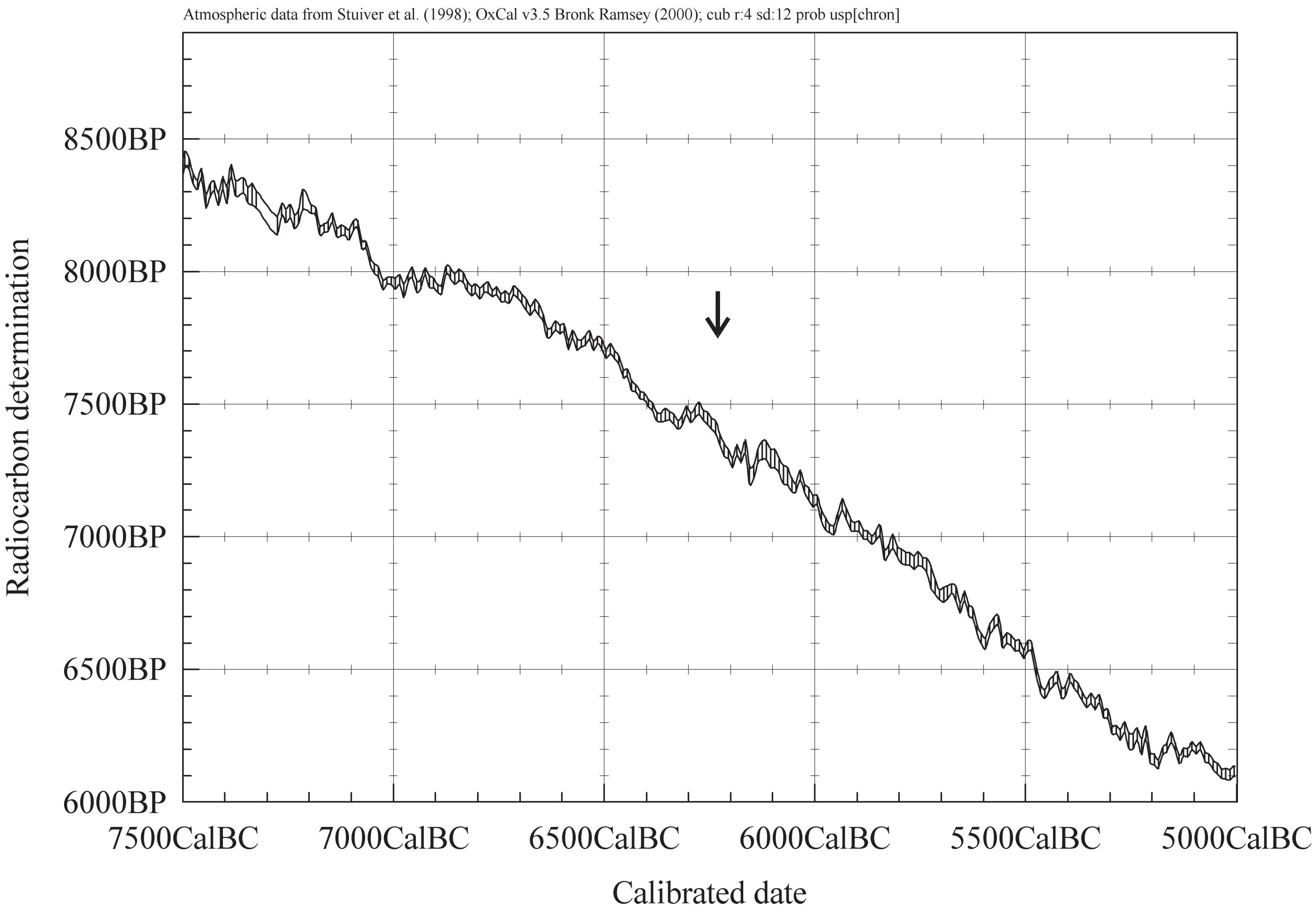
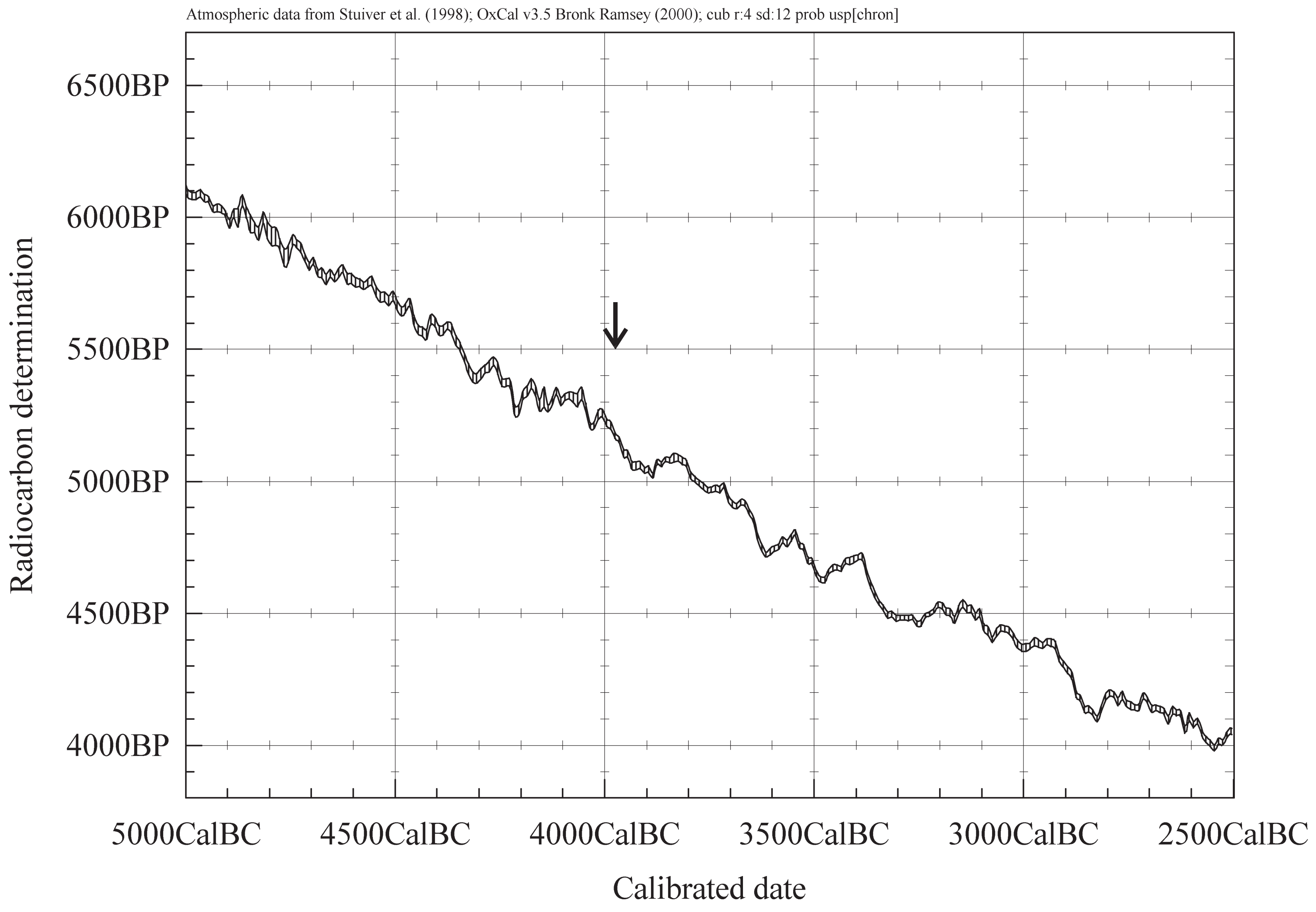


FIGURE O-23f: Radiocarbon Calibration Curve from 11,500 cal BC to 1500 cal AD with Cold Episodes and Plateau Effects Indicated



Atmospheric data from Stuiver et al. (1998); OxCal v3.5 Bronk Ramsey (2000); cub r:4 sd:12 prob usp[chron]

FIGURE O-23g: Radiocarbon Calibration Curve from 11,500 cal BC to 1500 cal AD with Cold Episodes and Plateau Effects Indicated

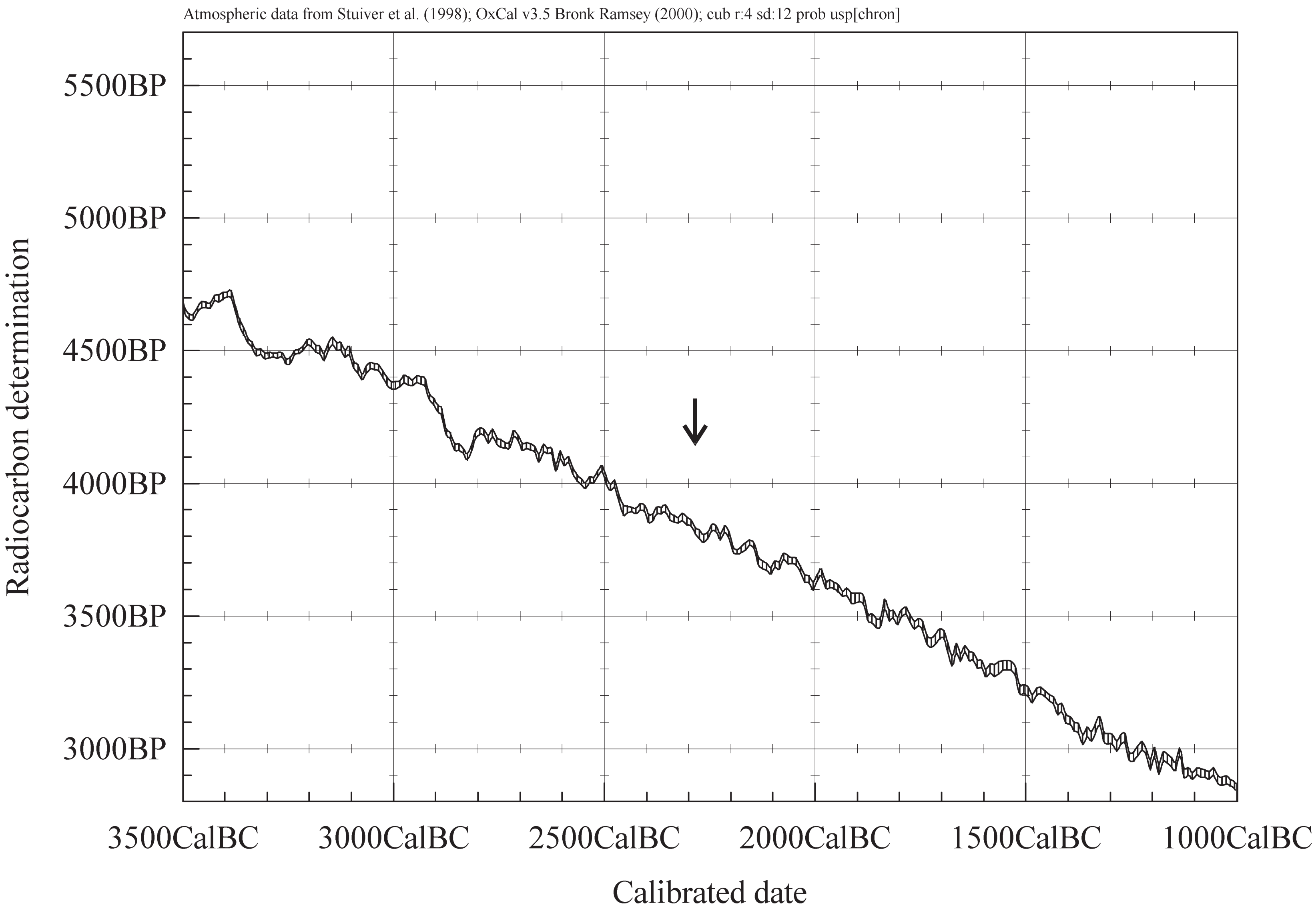

Atmospheric data from Stuiver et al. (1998); OxCal v3.5 Bronk Ramsey (2000); cub r:4 sd:12 prob usp[chron]

FIGURE O-23h: Radiocarbon Calibration Curve from 11,500 cal BC to 1500 cal AD with Cold Episodes and Plateau Effects Indicated

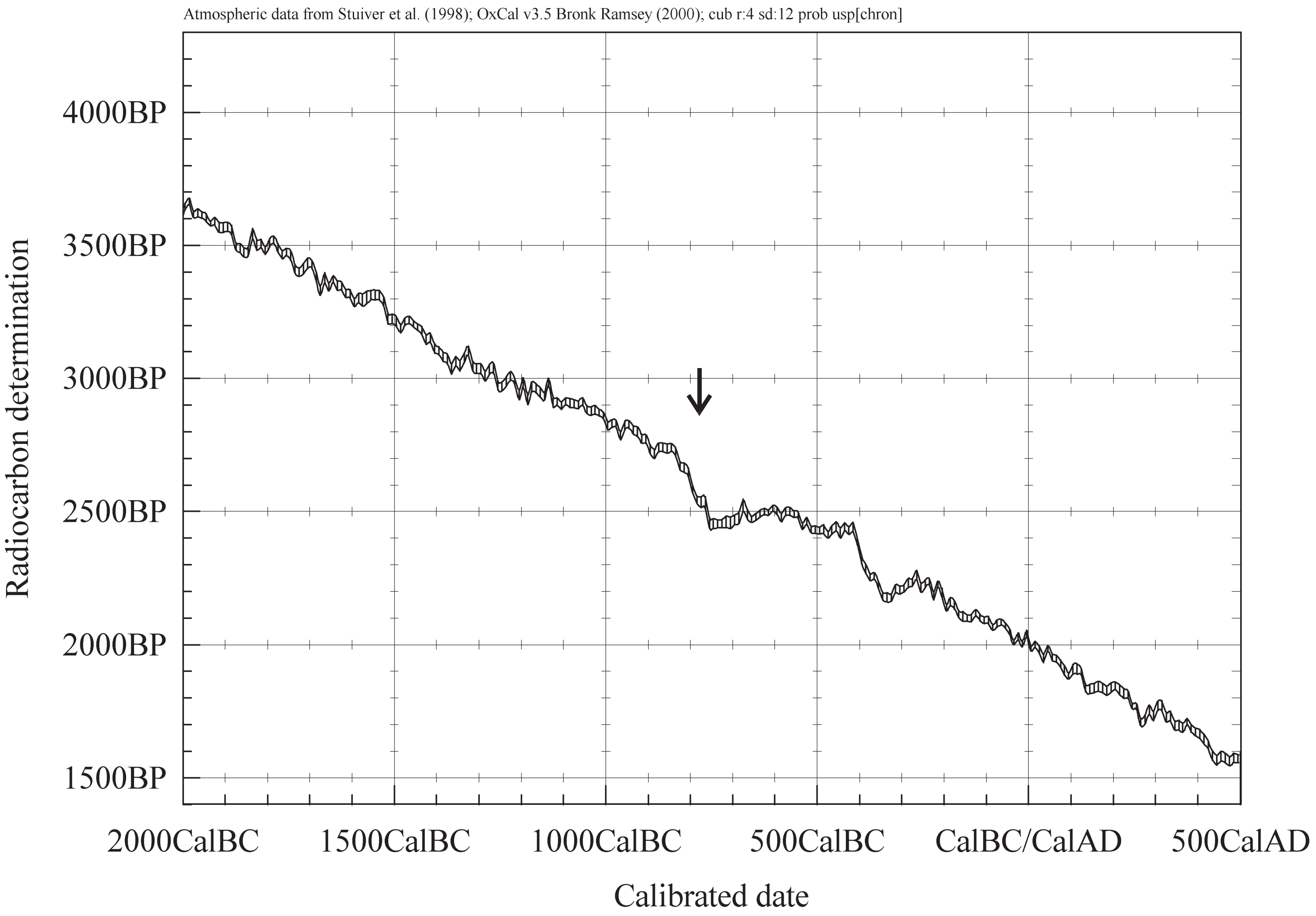


FIGURE O-23i: Radiocarbon Calibration Curve from 11,500 cal BC to 1500 cal AD with Cold Episodes and Plateau Effects Indicated

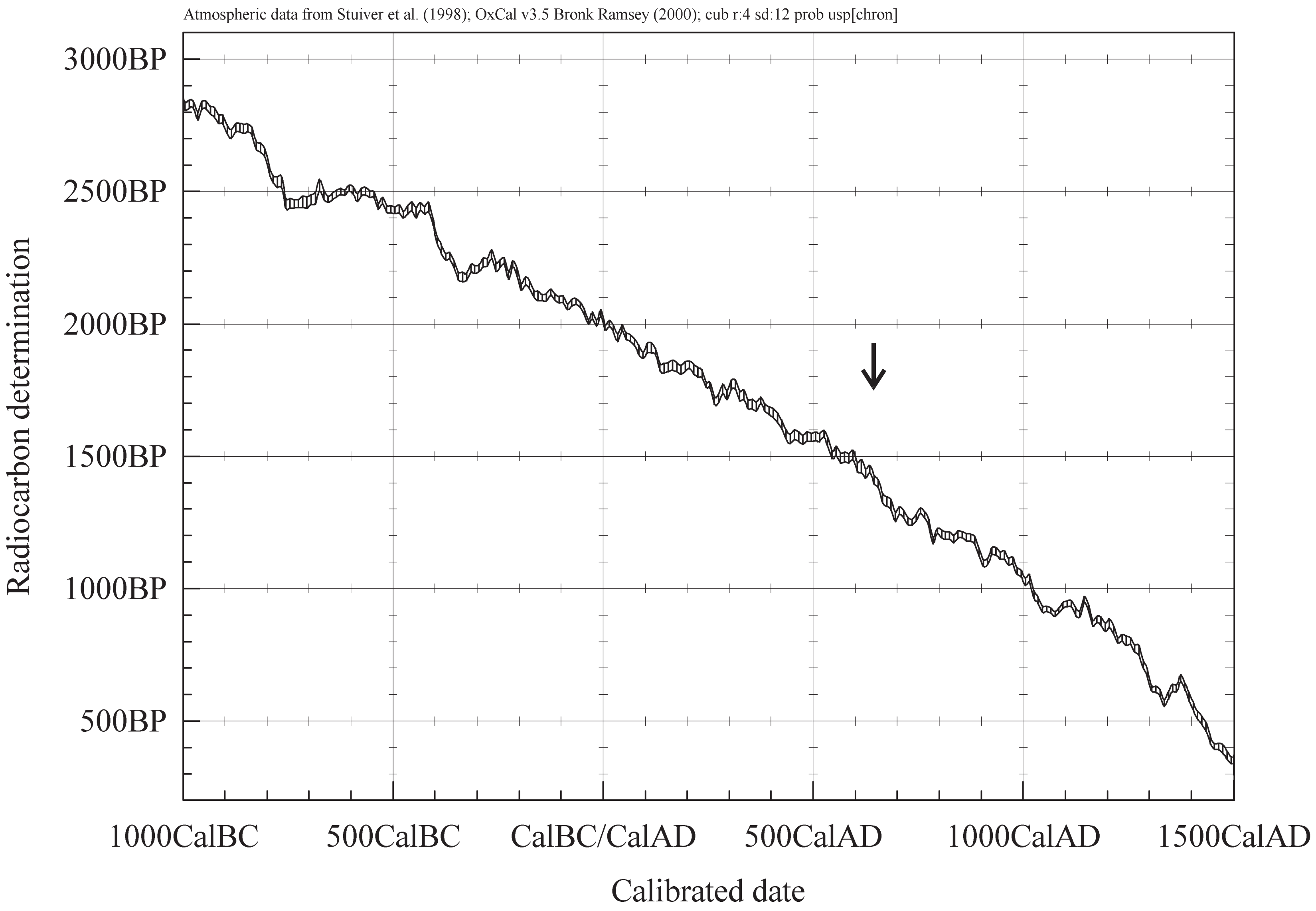


FIGURE O-23j: Radiocarbon Calibration Curve from 11,500 cal BC to 1500 cal AD with Cold Episodes and Plateau Effects Indicated