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The age of the Dalton culture: a Bayesian analysis of the radiocarbon data

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ABSTRACT
Since a radiocarbon chronology of the Dalton culture in the Southeast was first proposed, several new sites have been dated. I propose a new chronology based on radiocarbon dates from sites in the Dalton Heartland and its eastern periphery using Bayesian statistical models in OxCal and an analysis of the associated diagnostic projectile points. The analyses indicate that the Dalton culture probably evolved from the Clovis or Gainey phenomena about 12,680 cal BP (ca. 10,700 BP) and lasted at least until ca. 10,400 cal BP (ca. 9,200 BP), if not several centuries later. I propose early and late Dalton phases that follow changes in how Dalton points were made and resharpened. It appears that the people living to the east of the Heartland followed a different trajectory of projectile point evolution. There, notched points appear about 11,500 cal BP, while in the Heartland, true notched points do not appear in large numbers until the Graham Cave point over 2,000 years later. The chronologies demonstrate that early, coeval, region-wide cultural changes may not have been the norm. They also raise interesting questions about how people in the Heartland and its eastern periphery interacted.

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Dalton, a middle-to-late Paleoindian, and maybe Early Archaic, culture, is perhaps the first post-Clovis, regional, cultural historical phenomenon with wide influence in southeastern North America well beyond its heartland (Figure 1). It appears to have affected behaviors throughout much of the East and perhaps to the Southwest and into the Plains, where the presence of diagnostic artifacts and artifact attributes has been noted (Goodyear 1999; Johnson 1989). Like all cultures in the Southeast from the late Pleistocene and early Holocene, evidence is limited almost exclusively to stone tools. But we can confidently infer that Dalton is associated with the first cemetery (Morse 1997) and earliest extensive use of rockshelters and caves east of the Plains (Ahler 1971; DeJarnette 1962; Shippee 1966; Walthall 1998), hypertrophic ceremonial blades (Morse 1997; Walthall and Koldehoff 1998), and wood-working tools like adzes (Goodyear 1974; Morse and Goodyear 1973; Yerkes and Koldehoff 2018), among other innovations. The Dalton influence is best seen in changes to the design, manufacture, and resharpening of projectile points or knives, which I refer to generically as points. Dalton point makers apparently figured out (or adopted from others) how to shrink the size of the point haft, as measured by the lateral length of grinding on the point base, thereby relatively increasing the useable blade length. As the hafts shrank in size, they were often slightly indented, or waisted, in an apparent attempt to improve attachment to a handle or shaft. Some display a boxy basal shape (Gramly 2008). Blades were usually resharpened with an alternative beveling technique or serrations and sometimes modified to create drills or awls, while the boxy base shape remained unchanged (Goodyear 1974).

Here, I revisit the chronological position of Dalton in the Southeast using the OxCal Bayesian modeling tools (Bronk Ramsey 2009a), evaluate sites with ^{14}C dates associated with Dalton components, and propose separate culture histories for the Dalton Heartland (Koldehoff and Walthall 2009) and its eastern peripheral region (Figure 1; Tables 1 and 2). I propose early and late Dalton phases in the Heartland that coincide with the appearance of two varieties of Dalton points. Over thirty-five years ago, Goodyear (1982) first rigorously addressed the age of Dalton, although others have weighed in with their estimates (Kay 1983; O'Brien and Wood 1998; Ray and Lopinot 2005). Goodyear (1982) reviewed dates from four sites but concluded that only two ^{14}C dates from Rodgers Shelter (23BE125) were reliable, which he concluded were from cultural features (hearths) and properly associated only with Dalton points. The other dated sites – Stanfield-Worley (1CT125) in northern Alabama (DeJarnette 1962), and Arnold Research (23CY64) and Graham Cave (23MT2) in Missouri (Chapman 1952; Klippel 1991; Logan 1952; Shippee 1966) – contained mixed

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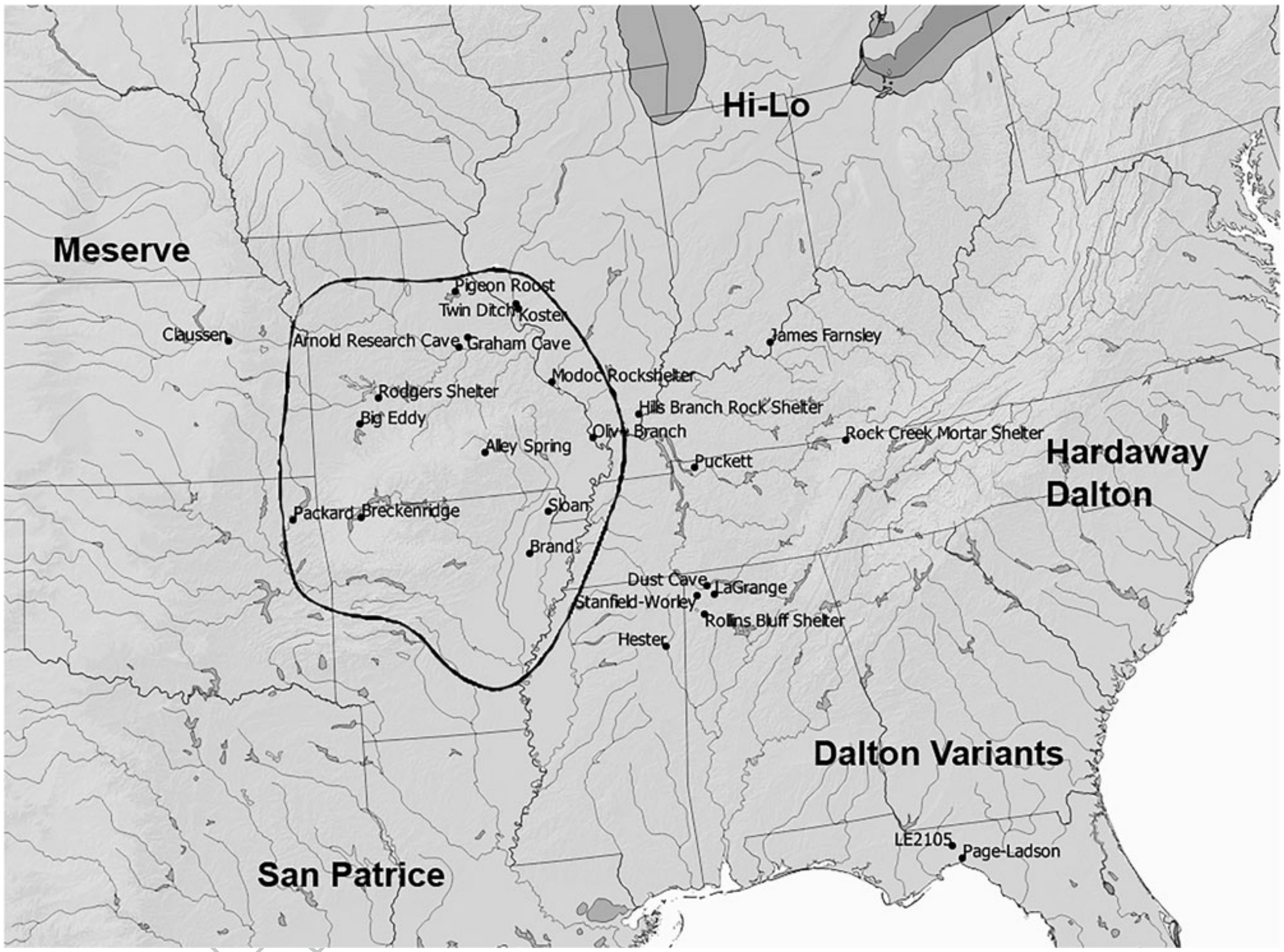

AQ10 **Figure 1.** Sites mentioned in the text, and Dalton Heartland outlined. The location of likely Dalton variants outside the Heartland indicated. Sites to the east of the Heartland are in the Eastern Periphery. Created by the author.

deposits, mainly Dalton and early side notched points, which he determined unreliably dated Dalton (Goodyear 1982:385, 387). He concluded Dalton lasted from about 10,500 to 9,900 BP (ca. 12,470–11,280 cal BP). Others have extended Dalton on the early end to about 10,700 BP (ca. 12,680 cal BP) based largely on the lack of any other expected post-Clovis point in the Heartland to match the pattern seen to the east and west (e.g., O'Brien and Wood 1998:80). On the younger end, short-chronologists, such as Ray and Lopinot (2005:283) propose that Dalton lasted until about 9800 BP (ca. 11,220 cal BP) based on dates from the Big Eddy site (23CE426) in Missouri, whereas long-chronologists extend it to about 9500 BP (ca. 10,740 cal BP; Morse and Morse 1983:42; Wyckoff 1985) or as late as 9200 BP (ca. 10,400 cal BP; Gramly 2002, 2008; Kay 1983; Wyckoff and Bartlett 1995).

Since Goodyear's 1982 article, Dalton points and Dalton variants have also been dated (Table 1) at sites in Missouri, Oklahoma, Kansas, Illinois, Tennessee, Alabama, and Arkansas. In addition, we have a better understanding of the appearance of eastern Early Archaic side-notched points (ESN), which employed a distinctly different approach to hafting technology than Dalton, but one that appears to seamlessly evolve from the short, waisted hafts of local Dalton variants (Thulman 2019).

Using sites with dated Dalton, Beaver Lake, ESN, and Graham Cave components, I evaluate two Bayesian culture history models of the transition from Paleoindian lanceolate to Early Archaic notched points in the Heartland and the Eastern Periphery regions using high quality ^{14}C samples. Each ^{14}C sample is evaluated and scored for quality as described below. Sites and ^{14}C dates evaluated for the models are listed in Tables 1 and 2 and organized by region. All models were run in OxCal 4.3 (Bronk Ramsey 2009a), and the OxCal codes and detailed results are in the Supplemental Material.

The Dalton cultural tradition

Dalton is recognized as one of myriad southeastern traditions developing out of Clovis (Lothrop et al. 2016; Morse et al. 1996), such as Cumberland (Tune 2016), Barnes (Lothrop et al. 2016), Redstone (Goodyear 2006), and Suwannee and Simpson (Pevny et al. 2018).

Presently, the consensus is that Dalton points evolved from Clovis or Gainey points in the Dalton Heartland (Bradley 1997; Morse et al. 1996; O'Brien and Wood 1998), which is in the midcontinent Mississippi River Valley, including northern Arkansas and most of Missouri (Figure 1; Koldehoff and Walthall 2009; Walthall and Koldehoff 1998), although this is not a universally held position (McElrath and Emerson 2012). Sites in Figure 1 to the east of the Heartland are termed the Eastern Periphery in this analysis. Walthall and Koldehoff (1998) envision people in the Heartland tied together in part through exchange of hypertrophic Sloan points and a north-south transport of lithic raw materials (Koldehoff and Walthall 2009:140).

Dalton points or their variants are found throughout the Southeast from the Plains to the southern Atlantic coast (Anderson et al. 2015; Anderson and Sassaman 1996) and possibly to the Great Lakes (Ellis et al. 1998) and Texas (Jennings 2008). The variety of Dalton tool assemblages in the Heartland has not been found elsewhere (Johnson 1989; Morse et al. 1996:328), and many regions outside the Heartland show Dalton influence but do not include a full complement of Dalton tools and tool attributes. The regional distinctions and similarities have long been familiar (e.g., Ensor 1987; Johnson 1989). Local manifestations are most often recognized by the presence of woodworking tools and point morphologies, especially short hafts, alternative beveling on resharpened blades, and the repurposing of exhausted knives into other tools. Goodyear (1999:441) recognized "considerable regionalization" of Dalton throughout the Southeast and a few Dalton point varieties (Figure 1): Hardaway (Coe 1964; Daniel 1998), Colbert (Cambron and Hulse 1975), Nuckolls, Greenbriar (Bullen 1975; Cambron and Hulse 1975), Sloan (Morse 1997), and Holland (Wyckoff and Bartlett 1995). To the southwest, Golondrina, Plainview (Justice 1987), and San Patrice (Jennings 2008, 2010) points have been linked to Dalton points. Archaeologists do not always agree on what constitutes a Dalton variant. For example, Meserve in the Plains (Goodyear 1982; Myers and Lambert 1983) and Hi-Lo in the Great Lakes region may also be Dalton variants (Ellis et al. 1998). The degree of variation in point morphology outside the Heartland is not reflected in the Heartland, although to my eye and others (e.g., Ray 2016), there is variability in point shape in the Heartland (e.g., Gramly 2002), which Ray (1998:168–172) thinks may represent temporal design changes. Whether this represents functional, local, or temporal variation has not been determined, but I agree with Ray and propose a temporal change in point shape and other attributes that coincide with early and late Dalton phases.

The number of Dalton variants indicates the extent of influence and acceptance of at least some behaviors we attribute to Dalton, but the disagreements about whether Meserve and Hi-Lo points should be considered Dalton variants illustrates the difficulty in deciding whether to include a point as a member of the Dalton extended family. For example, Hi-Lo points have short, incurvate bases and beveled blades, but their makers did not adopt robust woodworking tools, such as adzes (Koldehoff and Walthall 2009:145). If beveled blades are enough, then Hi-Lo is in; if not, it is excluded. Figure 1 shows the likely extent of Dalton influence.

The greatest impact of Dalton was to the east of the Heartland, where most variants are found. It also appears that people making Dalton points and coincident points to the west like Folsom and Packard (an Agate Basin-like point [Ray 1998]) did not mix (Wyckoff and Bartlett 1995:36, 62). But several eastern sites, such as Stanfield-Worley, LaGrange Rock Shelter (1Q90), and Rollins Bluff Shelter (1FR323) in northern Alabama, may tell a different story. These and other sites have strata with both Dalton variants and ESN points. How we interpret these sites with mixed assemblages affects how we understand the Dalton chronology.

The Dalton chronology

When Goodyear (1982) evaluated the Dalton chronology, he rejected the three sites with mixed components, apparently believing that different point types in a stratum could not be properly associated with the same date. This conception of culture history derives from an assumption that point types evolved sequentially across the early Southeast and would not properly be present in the same stratum, which is common among southeastern archaeologists (e.g., Anderson et al. 1996: Figure 1.2). Lopinot and Ray (2010:120–121) describe a version of this interpretation as One Point-One Culture, although they use it as a heuristic for interpreting the archaeological record. A model of sequential evolution would posit a short transition between lanceolate and notched points at the start of the Holocene (ca. 11,500 cal BP), during which myriad transitional varieties may have been made, but in about a century, lanceolate points stop being made and notched points are the most numerous form after about 11,500 cal BP (ca. 10,000 BP). The apparently sudden appearance of notched points in southern Indiana, northern Alabama, and north Florida at about 11,500 cal BP supports this view (Pevny et al. 2018). A common assumption about the culture history of the late Pleistocene and early Holocene epochs in the Southeast is that cultural change, mainly in the guise of changes in point shapes, generally moved in lockstep across the region as lanceolate shapes morphed into side notched, corner notched, and finally bifurcate points (e.g., Anderson and Sassaman 1996). It is possible, as I argue later, that the transition to notching was not accomplished uniformly across the region at the same time. There is an argument to be made that in the Dalton Heartland, notching was not adopted until after ca. 10,200 cal BP (ca. 9000 BP) with the adoption of the Graham Cave point.

The sequential evolution hypothesis can constrain our thinking and lead to dismissal of mixed sites that do not meet the received view. For example, Goodyear (1999:440) dismisses the Dalton date at the Packard site (34MY66; Wyckoff 1989), because the site "deviates from the rest of the southeastern United States stratigraphic sequence, suggest[ing] that it was redeposited." Ray and Lopinot (2005:283) conclude two Dalton points are out of position at Big Eddy, because, in large part, they were in levels dated as young as 10,350 cal BP (ca. 9200 BP), which are several centuries after they assume Dalton ended. It may be the case that the younger components associated with Dalton points should be rejected, but not because they do not meet expectations. If we discard the assumption of sequential, region-wide culture history, the chronology of Dalton and our understanding of changes during this time become more complex, and perhaps more accurate. Once we accept the possibility of coincident occupations, the question is not whether there would be mixed sites but what kind of social interactions produced them.

I do not reject the proposition that mixed sites can be explained with nonanthropogenic processes, such as artifact accumulation over time on a stable surface, deflation, or bioturbation. Several sites considered here seem clearly to have mixed strata caused by accumulation on a stable surface or deflation (e.g., Pigeon Roost Creek [23MN732]; O'Brien and Warren 2009) or not-well-understood geological processes (e.g., Alley Mill [23SH83/159]; Ray and Mandel 2015). My point is simply that the better practice when using ^{14}C dates as data is to not reject a date simply because it does not meet expectations.

Variation in Dalton points

There appears to be at least three general categories of Dalton points in the Heartland: a straight-sided lanceolate point, a box-based point, and a point with a long, serrated blade. The first two are most common and are further explored here (Figure 2). Straight-sided Dalton points have no beveled or serrated blades, and the length of the base, as measured by the length of lateral grinding, is longer. Box-based points have beveled or serrated blades and are resharpened in the haft, leaving a shorter, box-shaped base (Gramly 2002, 2008) and sometimes modified into new tools (Goodyear 1974). Table 3 lists the straight-sided, box-based, and indeterminate Dalton, and ESN points found in the Dalton components of the sites in Tables 1 and 2.

More than these three Dalton point varieties have been described, but most generally can be lumped into the straight-sided or box-based groups. For example, at Rodgers Shelter, Kay (1982:494–500, Figure 11.32) identified and illustrated four Dalton categories: Categories 10 (fluted lanceolate), 21 (Dalton-like), 22 (Dalton), and 23 (unfluted Plainview). I agree with Ray's (1998:171–172; O'Brien and Wood 1998:83–86) conclusion that all these are Dalton variants, although Kay believes Category 23 is clearly not a Dalton (Marvin Kay, personal communication 2018). Categories 10 and 23 are straight-sided with no beveling or serration of the blades. Categories 21 and 22 points are box-based with beveled or serrated blades.

In the Periphery sites (Table 2, Figure 1), all Dalton variants have short basal lengths (Figure 2). No Periphery site reports describe or illustrate a straight-sided Dalton. The Periphery Dalton variants could be described as box-based, such as Colbert and Nuckolls Daltons, or trapezoid based with slightly flaring ears, such as Greenbrier Daltons (Figure 2(g–j); DeJarnette et al. 1962). The Dalton variant from Dust Cave (1LU496) has a flaring base (Figure 2(f); Driskell 1994:Figure 9; Sherwood et al. 2004:Figure 8) and looks like a final stage Dalton point from the Brand site (3PO139) in Arkansas (Goodyear 1974:Figure 11(s–w)). At LaGrange, four Greenbriers and one Colbert Dalton were recovered from "deep stratigraphic context" (DeJarnette and Knight 1976:38–43, Plate XI). At Rollins Shelter, two Greenbriers, four Colberts, and one "Dalton-Big Sandy" were recovered (Stowe 1970:102, Plate 17, Table 13). At Puckett (40SW228), two Greenbriers were recovered, one with a beveled blade (Norton and Broster 1993:Figure 3). At Stanfield-Worley, 10 Colbert, seven Greenbrier, and six Nuckolls Daltons were recovered from Zone D (DeJarnette et al. 1962).

Almost invariably, at Heartland sites with dated Dalton components, the straight-sided points are found in the early components (Table 3). At Rodgers Shelter, four of the straight-sided points (Categories 10 and 23) were found in the lowest cultural level 10, one in level 9, and one in the Middle Archaic-age level 7 (Kay 1982:Table 11.1). Six Category 22 (box-based Daltons) were found in level 10 and one in level 8. Category 21 points are box-based Daltons in all respects, except they were found in Middle Archaic levels (two in level 7 and one each in levels 5 and 6; Kay 1982:499). In

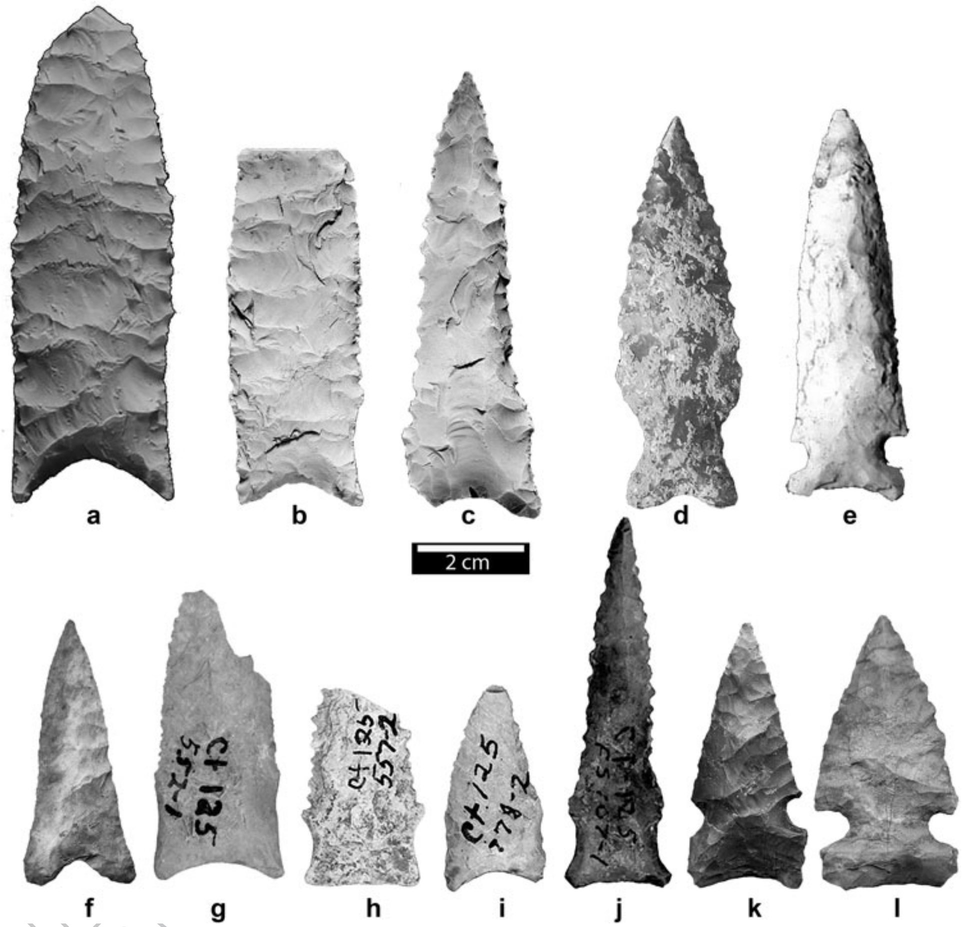

Figure 2. Heartland points (a–e): Early (a) and late (b–c) Daltons from Big Eddy, (d) point from Breckenridge site, (e) Graham Cave from the Graham Cave site. Eastern Periphery points (f–l): (f) Dalton variant from Dust Cave, (g–j) Dalton variants from Stanfield-Worley, (k–l) ESNs from Dust Cave. Points a–d courtesy of Marvin Kay, point e from 23GR120 courtesy of Professor Michael Fuller, St. Louis Community College. Other images by author.

sum, four of five straight-sided Daltons were found in the lowest levels, and the box-based Daltons were found in the lowest and higher levels. At Big Eddy, the two in situ Dalton points in the early component are indeterminant but likely straight-sided. The out of context point assigned to the early component is straight-sided (Figure 2(a); Ray 1998:Figure 8.37). Straight-sided Daltons with unbeveled blades, which Gramly (2002, 2008) describes as akin to Beaver Lake points, are found in the lowest dated level at Olive Branch (11AX267).

In contrast, the box-based Daltons are almost always in the later components (Table 3). Rodgers Shelter is a possible exception, although the precise positions of these Dalton points are not clear from the reports, and the two earliest ^{14}C dates are difficult to interpret because the error ranges (±650 and 330 years) are large enough to span the early and late Dalton phases (see below). Thus, it is not possible to know when the box-based Daltons from the deeper levels at Rodgers Shelter first appear. Regardless, even at sites with problematic dates, such as Alley Mill, Arnold Research Cave, Graham Cave, Twin Ditch (11GE146), and Olive Branch, the box-based points are in strata dated younger than ca. 11,500 cal BP. For the Periphery sites, all the Dalton variant dates are younger than ca. 11,500 cal BP, except at Dust Cave, where the single Dalton variant (Figure 2(f)) is dated between ca. 12,040 and 11,260 cal BP (Thulman 2017).

The introduction of ESN points in the east

ESN points are locally variant in shape but have several shared characteristics: they are truly notched and usually beveled when resharpened (Figure 2(k–l)). Four sites have produced dated early Holocene strata for notched points east of the Mississippi River: an unnamed notched point from James Farnsley (12HR520) in Indiana (Stafford and Cantin 2009); Big Sandy side notched points from Dust Cave in Alabama (Sherwood et al. 2004; Thulman 2017); Bolen side and corner notched points from Page-Ladson (8JE591) Unit C (Carter and

Table 1. Sites and ^{14}C dates used in the heartland analysis.

Site, Sample No.[a]	Material and Context[b]	^{14}C Age (BP)	$\delta^{13}C$ (‰)[c]	Associated Diagnostic[d]	Total Score[e]	Sample Type	Sample Context	Diagnostic Context	Lab Info	Bayesian Context	Model Use[f]	References
Alley Mill												
ISGS-A1436	Charred Juglandaceae fragment, 63 cm	7805 ± 25	NR	BB Dalton, EA points	5	2	1	2	0	0		Ray and Mandel (2015:Table 3)
ISGS-A1435	Charred walnut shell fragment, 83 cm	9940 ± 30	NR	BB Dalton, EA points	5	2	1	2	0	0		Ray and Mandel (2015:Table 3)
ISGS-A1443	WCh, 94 cm	8555 ± 25	NR	BB Dalton, EA points	4	1	1	2	0	0		Ray and Mandel (2015:Table 3)
Arnold Research Cave												
M-1495	Ch, 54–60 in	8120 ± 350	NR	None	2	1	0	0	0	1		Crane and Griffin (1968:69)
M-1496	Ch, 54–60 in	8190 ± 400	NR	Dalton, 2 notched points	5	1	2	1	0	1		Crane and Griffin (1968:69); O'Brien and Wood 1998:76-78; Shippee (1966:35)
M-1497	Ch, 60–65 in., basal level	9130 ± 300	NR	Lanceolate point	3	1	0	1	0	1		Crane and Griffin (1968:69); O'Brien and Wood 1998:76–78; Shippee (1966:35)
Big Eddy												
AA-56604	CW, 160–170	7300 ± 50	−25.2	Hidden Valley	8	1	2	1	1	3	Bracket Graham Cave	Ray and Lopinot (2005:Table 6.1)
AA-29019	CW, 190–192 cm	8190 ± 60	−25.0	Rice Lobed	8	1	2	1	1	3	Bracket Graham Cave	Ray and Lopinot (2005:Table 6.1)
AA-60623	CNS, 208–219	8230 ± 55	−25.2	Graham Cave	9	2	2	1	1	3	Graham Cave	Ray and Lopinot (2005:Table 6.1)
Beta-112982	WCh, 2Btb5/3Ab, possible root burn	9190 ± 90	−25.0	None	5	1	0	0	1	3		Hajic et al. (1998:Table 7.1)
AA-56598	CW, 274 cm	9200 ± 50	−24.6	BB Dalton	9	1	2	2	1	3	Late Dalton	Ray and Lopinot (2005:Table 6.1)
AA-27479	CW, Stratum 3Ab (near top)	9525 ± 65	−23.7	BB Dalton, Scottsbluff	9	1	2	2	1	3	Late Dalton	Ray and Lopinot (2005:Table 6.1)
TX-9329	Soil humates	9450 ± 61	−17.9	None	X							Hajic et al. (1998:Table 7.1)
AA-26653	Ch, Stratum 3Ab	10185 ± 75	−26.2	SS & Unk Dalton, San Patrice	8	1	2	1	1	3	Early Dalton	Hajic et al. (1998:Table 7.1)
AA-27488	WCh, Stratum 3Ab	10470 ± 80	−24.8	SS & Unk Dalton	8	1	2	1	1	3	Early Dalton	Hajic et al. (1998:Table 7.1)
TX-9325	Soil humates, 3Ab (near bottom)	10336 ± 110	−17.8	SS & Unk Dalton	X							Hajic et al. (1998:Table 7.1)
AA-29022	Ch, Stratum 3Ab	10430 ± 70	−25.6	SS & Unk Dalton	8	1	2	1	1	3	Early Dalton	Hajic et al. (1998:Table 7.1)
AA-27480	WCh, Stratum 3Ab	10340 ± 100	−24.7	SS & Unk Dalton	8	1	2	1	1	3	Early Dalton	Hajic et al. (1998:Table 7.1)
AA-27487	WCh, Stratum 3Ab	10400 ± 75	−23.9	SS & Unk Dalton	8	1	2	1	1	3	Early Dalton	Hajic et al. (1998:Table 7.1)
Breckenridge												
Beta-410496	Ch, Hearth	8720 ± 30	−27.7	Breckenridge	8	1	4	2	1	1	Breckenridge	Hilliard et al. (2015)
Beta-420705	Ch, Hearth	8790 ± 30	−24.8	Breckenridge	8	1	4	2	1	1	Breckenridge	Hilliard (2016)
Beta-420706	Ch, Hearth	8810 ± 30	−26.3	Breckenridge	8	1	4	2	1	1	Breckenridge	Hilliard (2016)
Graham Cave												
M-130	Bone and Ch, Zone IV Hearth	9700 ± 500	NR	Dalton, others	X							Crane (1956)
M-131	Bone and Ch, Zone IV Hearth	8830 ± 300	NR	Dalton, others	X							Crane (1956)
M-1889	Ch, Ash lens, Original floor, 66.5-69 in.	9290 ± 300	NR	fragments of fluted points	5	1	2	2	0	1		Crane and Griffin (1968:84); Klippel (1971:65)
M-1928	Ch, Original floor, 66.5–69 in. or 51–54 in.	9470 ± 400	NR	fragments of fluted points	5	1	2	2	0	1		Crane and Griffin (1968:85); Klippel (1971:65)

Koster												
ISGS-783	WC & NS dispersed in and around hearth	8230 ± 120	−26.0	MA1	7	1	3	0	1	2	Bracket Graham Cave	Wiant et al. (2009:Table 9.4, 9.5); Liu et al. (1992)
ISGS-336	CW & NS, Fea. 262b&c	8220 ± 75	NR	MA1	4	1	1	0	0	2		Wiant et al. (2009:Table 9.4, 9.5); Liu et al. (1986)
ISGS-337	CW & NS, Fea. 288c	8130 ± 75	NR	MA1	4	1	1	0	0	2		Wiant et al. (2009:Table 9.4, 9.5); Liu et al. (1986)
ISGS-923	WC & NS dispersed in and around hearth	7920 ± 150	−25.1	MA1	7	1	3	0	1	2	Bracket Graham Cave	Wiant et al. (2009:Table 9.4, 9.5); Liu et al. (1992)
ISGS-229	CW, Horizon 9	7910 ± 100	NR	MA1	4	1	1	0	0	2		Wiant et al. (2009:Table 9.4, 9.5); Coleman and Liu (1975)
ISGS-316	CW & NS, Fea. 2007b	7800 ± 160	NR	MA1	4	1	1	0	0	2		Wiant et al. (2009:Table 9.4, 9.5); Liu et al. (1986)
ISGS-303	CW & NS, Fea. 2010a	7670 ± 110	NR	MA1	4	1	1	0	0	2		Wiant et al. (2009:Table 9.4, 9.5); Liu et al. (1986)
ISGS-210	CW, Horizon sub-8	7630 ± 210	NR	MA1	4	1	1	0	0	2		Wiant et al. (2009:Table 9.4, 9.5); Coleman and Liu (1975)
ISGS-1065	WC & NS, dog burial	8130 ± 90	−25.5	EA2	7	1	1	2	1	2	Graham Cave	Wiant et al. (2009:Table 9.4, 9.5); Liu et al. (1992)
ISGS-230	CW, Horizon 11	8430 ± 90	NR	EA2	6	1	1	2	0	2	Graham Cave	Wiant et al. (2009:Table 9.4, 9.5); Coleman and Liu (1975)
ISGS-231	CW, Horizon 11	8430 ± 100	NR	EA2	6	1	1	2	0	2	Graham Cave	Wiant et al. (2009:Table 9.4, 9.5); Coleman and Liu (1975)
ISGS-292	CW & NS, Fea. 2025a	8445 ± 75	NR	EA2	6	1	1	2	0	2	Graham Cave	Wiant et al. (2009:Table 9.4, 9.5); Liu et al. (1986)
ISGS-1762	Ch, dog burial	8470 ± 110	NR	EA2	6	1	1	2	0	2	Graham Cave	Wiant et al. (2009:Table 9.4, 9.5); Morey and Wiant (1992:225)
ISGS-236	CW, Horizon 11	8480 ± 110	NR	EA2	6	1	1	2	0	2	Graham Cave	Wiant et al. (2009:Table 9.4, 9.5); Coleman and Liu (1975)
ISGS-328	CW & NS, Fea. 2062a&b	8730 ± 90	NR	EA2	6	1	1	2	0	2	Graham Cave	Wiant et al. (2009:Table 9.4, 9.5); Liu et al. (1986)
Modoc Rock Shelte												
L-381C	WCh /CNS	7000 ± 170	NR	MAR2	6	1	1	1	0	3	Bracket Sequence	Ahler and Koldehoff (2009: Tables 8.1, 8.2)
ISGS-831	WCh /CNS	7130 ± 180	NR	MAR2	6	1	1	1	0	3	Bracket Sequence	Ahler and Koldehoff (2009: Tables 8.1, 8.2)
ISGS-840	WCh /CNS	7230 ± 140	NR	MAR2	6	1	1	1	0	3	Bracket Sequence	Ahler and Koldehoff (2009: Tables 8.1, 8.2)
L-406A	organics from burned bone	7200 ± 200	NR	MAR2	X							Ahler and Koldehoff (2009: Tables 8.1, 8.2)
ISGS-1485	WCh	7200 ± 160	NR	MAR2	6	1	1	1	0	3	Bracket Sequence	Ahler and Koldehoff (2009: Tables 8.1, 8.2)
ISGS-1386	CNS	7210 ± 70	NR	MAR2	6	1	1	1	0	3	Bracket Sequence	Ahler and Koldehoff (2009: Tables 8.1, 8.2)
ISGS-1991	WCh /CNS	7260 ± 90	NR	MAR2	6	1	1	1	0	3	Bracket Sequence	Ahler and Koldehoff (2009: Tables 8.1, 8.2)
ISGS-813	WCh /CNS	7580 ± 190	NR	MAR1	6	1	1	1	0	3	Bracket Graham Cave	Ahler and Koldehoff (2009: Tables 8.1, 8.2)
ISGS-815	WCh	7830 ± 230	NR	MAR1	6	1	1	1	0	3	Bracket Graham Cave	Ahler and Koldehoff (2009: Tables 8.1, 8.2)
ISGS-1383	WCh /CNS	7760 ± 70	NR	MAR1	6	1	1	1	0	3	Bracket Graham Cave	Ahler and Koldehoff (2009: Tables 8.1, 8.2)

(*Continued*)

Table 1. Continued.

Site, Sample No.[a]	Material and Context[b]	^{14}C Age (BP)	δ^{13}C (‰)[c]	Associated Diagnostic[d]	Total Score[e]	Sample Type	Sample Context	Diagnostic Context	Lab Info	Bayesian Context	Model Use[f]	References
ISGS-1344	WCh /CNS	7750 ± 130	NR	MAR1	6	1	1	1	0	3	Bracket Graham Cave	Ahler and Koldehoff (2009: Tables 8.1, 8.2)
ISGS-830	WCh	8010 ± 140	NR	EAR2	6	1	1	1	0	3	Graham Cave	Ahler and Koldehoff (2009: Tables 8.1, 8.2)
ISGS-1299	WCh	8030 ± 220	NR	EAR2	6	1	1	1	0	3	Graham Cave	Ahler and Koldehoff (2009: Tables 8.1, 8.2)
ISGS-808	WCh	8270 ± 80	NR	EAR2	6	1	1	1	0	3	Graham Cave	Ahler and Koldehoff (2009: Tables 8.1, 8.2)
ISGS-1374	WCh /CNS	8530 ± 120	NR	EAR2	6	1	1	1	0	3	Graham Cave	Ahler and Koldehoff (2009: Tables 8.1, 8.2)
ISGS-1375	WCh	8430 ± 70	NR	EAR2	6	1	1	1	0	3	Graham Cave	Ahler and Koldehoff (2009: Tables 8.1, 8.2)
ISGS-1333	WCh	8350 ± 100	NR	EAR2	6	1	1	1	0	3	Graham Cave	Ahler and Koldehoff (2009: Tables 8.1, 8.2)
ISGS-1376	WCh	8190 ± 110	NR	EAR2	6	1	1	1	0	3	Graham Cave	Ahler and Koldehoff (2009: Tables 8.1, 8.2)
ISGS-1352	WCh	8150 ± 90	NR	EAR2	6	1	1	1	0	3	Graham Cave	Ahler and Koldehoff (2009: Tables 8.1, 8.2)
ISGS-1381	WCh	8100 ± 130	NR	EAR2	6	1	1	1	0	3	Graham Cave	Ahler and Koldehoff (2009: Tables 8.1, 8.2)
ISGS-1994	WCh /CNS	8240 ± 80	NR	EAR2	6	1	1	1	0	3	Graham Cave	Ahler and Koldehoff (2009: Tables 8.1, 8.2)
ISGS-1382	WCh	8000 ± 80	NR	EAR2	6	1	1	1	0	3	Graham Cave	Ahler and Koldehoff (2009: Tables 8.1, 8.2)
ISGS-797	WCh /CNS	8680 ± 150	NR	EAR1	6	1	1	1	0	3	Bracket Sequence	Ahler and Koldehoff (2009: Tables 8.1, 8.2)
ISGS-780	WCh	8710 ± 140	NR	EAR1	6	1	1	1	0	3	Bracket Sequence	Ahler and Koldehoff (2009: Tables 8.1, 8.2)
ISGS-747	WCh /CNS	8890 ± 140	NR	EAR1	6	1	1	1	0	3	Bracket Sequence	Ahler and Koldehoff (2009: Tables 8.1, 8.2)
ISGS-740	WCh	8920 ± 220	NR	EAR1	6	1	1	1	0	3	Bracket Sequence	Ahler and Koldehoff (2009: Tables 8.1, 8.2)
Olive Branch												
AA-4805	Ch (scattered), Rock Platform	9975 ± 125	NR	SS Dalton	4	1	1	1	0	1		Gramly (2002:Table 4)
Beta-32366	Ch, Split	9115 ± 100	NR	BB Dalton	4	1	1	1	0	1		Gramly (2002:Table 4)
Beta-124214	Ch, The Dalton Trash dump	9180 ± 50	NR	BB Dalton	4	1	1	1	0	1		Gramly (2002:Table 4)
Beta-140578	Ch (saved from Beta-124214)	9190 ± 60	NR	BB Dalton	4	1	1	1	0	1		Gramly (2002:Table 4)
Beta-182618	Collagen, Dalton latrine	9080 ± 50	NR	BB Dalton	X							Gramly (2008:50)
Packard												
AA-3119	WCh, 259 cm, above Packard stratum	9630 ± 100	−25	BB Dalton	6	1	1	2	0	2	Late Dalton	Wyckoff (1989:25)
NZ-478	Ch stained soil, Scattered in same hearth	9416 ± 193	NR	Packard/ESN	X							Wyckoff (1989:25)
AA-3116	Bark Ch, Scattered in same hearth	9880 ± 90	−25	Packard/ESN	8	1	3	2	0	2	Bracket Late Dalton	Wyckoff (1989:25)
AA-3117	Bark Ch, Scattered in same hearth	9830 ± 70	−25	Packard/ESN	8	1	3	2	0	2	Bracket Late Dalton	Wyckoff (1989:25)
AA-3118	Bark Ch, Scattered in same hearth	9770 ± 80	−25	Packard/ESN	8	1	3	2	0	2	Bracket Late Dalton	Wyckoff (1989:25)
Pigeon Roost												
TX-3289	Ch, Dispersed	8500 ± 220	NR	Dalton, Graham Cave, others	5	1	1	1	0	2		O'Brien and Warren (1985); O'Brien and Wood (1998)

Rodgers Shelter												
A-0274	Ch, Stratum 1C (upper), 5.4 m	9216 ± 73	−26	BB Daltons	8	1	2	2	1	2	Late Dalton	Marvin Kay, personal communication 2017
A-0273	Ch, Stratum 1C (upper), 5.6 m	9094 ± 63	−26	BB Daltons	8	1	2	2	1	2	Late Dalton	Marvin Kay, personal communication 2017
A-0311	Ch, Stratum 1C (middle), 6.25 m	9290 ± 56	−26	BB Daltons	8	1	2	2	1	2	Late Dalton	Marvin Kay, personal communication 2017
A-0312	Ch, Stratum 1C (lower), 7.1 m	8941 ± 53	−26	BB Daltons	8	1	2	2	1	2	Late Dalton	Marvin Kay, personal communication 2017
A-0313	Ch, Stratum 1B (bottom), 8.75 m	9941 ± 53	−26	Daltons	8	1	2	2	1	2	Early Dalton	Marvin Kay, personal communication 2017
M-2333	CW, Stratum 1B (bottom), 8.9 m, hearth	10200 ± 330	NR	SS & BB Daltons	7	1	3	1	0	2	Early Dalton	Crane and Griffin (1972:159)
ISGS-48	CW, Stratum 1B (bottom), 8.5 m	10530 ± 650	NR	SS & BB Daltons	6	1	2	1	0	2	Early Dalton	Coleman (1972:154)
Twin Ditch												
Beta-38000	Ch, Horizon 2	9510 ± 100	NR	Thebes, BB & Unk Dalton	2	1	0	0	0	1		Wiant et al. (2009:242, Table 9.4)
Beta-38001	Ch, Horizon 2	9390 ± 100	NR	Thebes, BB & Unk Dalton	2	1	0	0	0	1		Wiant et al. (2009:242, Table 9.4)
Beta-37999	Ch, Horizon 2	9310 ± 100	NR	Thebes, BB & Unk Dalton	2	1	0	0	0	1		Wiant et al. (2009:242, Table 9.4)
Beta-47002	Ch, Horizon 2	9200 ± 70	NR	Thebes, BB & Unk Dalton	2	1	0	0	0	1		Wiant et al. (2009:242, Table 9.4)
Beta-47005	Ch, Horizon 2	9130 ± 70	NR	Thebes, BB & Unk Dalton	2	1	0	0	0	1		Wiant et al. (2009:242, Table 9.4)
Beta-47003	Ch, Horizon 2	9120 ± 70	NR	Thebes, BB & Unk Dalton	2	1	0	0	0	1		Wiant et al. (2009:242, Table 9.4)
Beta-38002	Ch, Horizon 2	8900 ± 100	NR	Thebes, BB & Unk Dalton	2	1	0	0	0	1		Wiant et al. (2009:242, Table 9.4)
Beta-47004	Ch, Horizon 2	8740 ± 70	NR	Thebes, BB & Unk Dalton	2	1	0	0	0	1		Wiant et al. (2009:242, Table 9.4)

[a]Laboratory codes: ISGS = Illinois State Geologic Survey; M = University of Michigan; Beta = Beta Analytic Laboratory; A = Arizona; TX = Texas; NZ = Rafter Radiocarbon Lab; AA = Arizona AMS; L = Lamont-Doherty.
[b]Material and context codes: W = wood; WCh = wood charcoal; Ch = charcoal; CW = charred wood; CNS = charred nut shell; CM = charred material; CW & NS = carbonized wood and nutshell; NS = nutshell; F or Fea. = feature.
[c]$\delta^{13}C$ values given where available. NR = not reported.
[d]Diagnostics associated with each date are listed. BB = box-based; SS = straight-sided; Unk = unknown; ESN = early side notched; EAR1 = Early Archaic 1, EAR2 = Early Archaic 2, MAR1 = Middle Archaic 1, MAR2 = Middle Archaic 2 (as defined in Ahler and Koldehoff 2009); EA2 = Early Archaic 2, MA1 = Middle Archaic 1 (as defined in Wiant et al. 2009).
[e]Total Score for sample quality; X = sample did not meet minimum criteria for evaluation. Criteria for individual scores that make up the Total Score (Sample Type, Sample Context, Diagnostic Context, Lab Information, and Bayesian Context) are explained in Table 4.
[f]Model Use for each date used in the Heartland models to date the diagnostics of interest.

Table 2. Sites and ^{14}C dates used in the eastern periphery analysis.

Site, Sample No.[a]	Material and Context[b]	^{14}C Age (BP)	$\delta^{13}C$ (‰)[c]	Associated Diagnostic[d]	Total Score[e]	Sample Type	Sample Context	Diagnostic Context	Lab Info	Bayesian Context	Model Use[f]	References
Claussen												
ISGS-A0479	Ch, Akb3, below hearth	9225 ± 30	−24.2	Dalton	8	1	2	2	1	2	Western Periphery	Mandel et al. (2006); Mandel (2008)
ISGS-A0480	Ch, Akb3, below hearth	9225 ± 35	−25.5	Dalton	8	1	2	2	1	2	Western Periphery	Mandel et al. (2006); Mandel (2008)
ISGS-4684	Ch, Akb3, hearth	8800 ± 150	−24.8	None	8	1	4	0	1	2	Western Periphery	Mandel et al. (2006); Mandel (2008)
Dust Cave												
Beta-81603	CM, Zone Y	10590 ± 60	−26.2	Sterile	6	1	1	0	1	3	Bracket Sequence	Sherwood et al. (2004); Thulman (2017)
Beta-100506	CM, Zone U	10370 ± 180	−25.0	Beaver Lake/Quad	7	1	1	1	1	3	Beaver Lake	Sherwood et al. (2004); Thulman (2017)
Beta-81613	CM, Zone U	10490 ± 60	−25.0	Beaver Lake/Quad	7	1	1	1	1	3	Beaver Lake	Sherwood et al. (2004); Thulman (2017)
Beta-40680	Ch, Zone U	10345 ± 80	−25.0	Beaver Lake/Quad	7	1	1	1	1	3	Beaver Lake	Sherwood et al. (2004); Thulman (2017)
Beta-133790	CM, Zone U	10310 ± 60	−26.1	Beaver Lake/Quad	7	1	1	1	1	3	Beaver Lake	Sherwood et al. (2004); Thulman (2017)
Beta-81599	CM, Zone U	10500 ± 60	−26.2	Beaver Lake/Quad	7	1	1	1	1	3	Beaver Lake	Sherwood et al. (2004); Thulman (2017)
Beta-65179	Ch stained soil, Zone U	10390 ± 80	−25.0	Beaver Lake/Quad	X							Sherwood et al. (2004); Thulman (2017)
Beta-65181	Ch stained soil, Zone U	10310 ± 230	−25.0	Beaver Lake/Quad	X							Sherwood et al. (2004); Thulman (2017)
Beta-81609	Organic soil, Zone U	10340 ± 130	−25.0	Beaver Lake/Quad	X							Sherwood et al. (2004); Thulman (2017)
Beta-133791	CM, Zone T	10100 ± 50	−26.6	Dalton Variant	7	1	1	1	1	3	Dalton Variant	Sherwood et al. (2004); Thulman (2017)
Beta-81611	Organic soil, Zone T	9890 ± 70	−25.0	Dalton Variant	X							Sherwood et al. (2004); Thulman (2017)
Beta-40681	Ch, Zone T	10490 ± 360	−25.0	Dalton Variant	7	1	1	1	1	3	Dalton Variant	Sherwood et al. (2004); Thulman (2017)
Beta-147132	CM, Zone T	10010 ± 40	−25.5	Dalton Variant	7	1	1	1	1	3	Dalton Variant	Sherwood et al. (2004); Thulman (2017)
Beta-133788	CM, Zone T	9950 ± 50	−25.0	Dalton Variant	7	1	1	1	1	3	Dalton Variant	Sherwood et al. (2004); Thulman (2017)
Beta-41063	Ch, Zone T	10330 ± 120	−25.0	Dalton Variant	7	1	1	1	1	3	Dalton Variant	Sherwood et al. (2004); Thulman (2017)
Beta-147135	CM, Zone T	10140 ± 40	−24.6	Dalton Variant	7	1	1	1	1	3	Dalton Variant	Sherwood et al. (2004); Thulman (2017)
Beta-65177	Ch stained soil, Zone T	9990 ± 140	−25.0	Dalton Variant	X							Sherwood et al. (2004); Thulman (2017)
Beta-81610	CM, Zone T	10070 ± 70	−25.0	Dalton Variant	7	1	1	1	1	3	Dalton Variant	Sherwood et al. (2004); Thulman (2017)
Beta-81606	Organic soil, Zone R	9720 ± 70	−25.0	ESN	X							Sherwood et al. (2004); Thulman (2017)
Beta-81602	CM, Zone R	10070 ± 60	−26.0	ESN	7	1	1	1	1	3	ESN	Sherwood et al. (2004); Thulman (2017)
Beta-190498	NS, Zone Q	8880 ± 40	−26.2	Mixed	6	2	0	0	1	3	Bracket Sequence	Homsey (2010); Thulman (2017)

Hills Branch Rock Shelter												
Beta-141573	WCh, Unit 2, flecks	9130 ± 200	−25	Dalton Variants, KCN	4	1	0	2	1	0		Wagner and Butler (2000:58)
Beta 152942	NS & WCh, F300, surface hearth, Main Block	10370 ± 190	NR	unknown point type	10	1	3	3	0	3	Bracket Sequence	Stafford and Cantin 2009a: Table 10.1; 2009b
ISGS 4898	NS Ch, F306, surface hearth, Main Block	10100 ± 100	NR	ESN	9	2	3	1	0	3	ESN	Stafford and Cantin 2009a: Table 10.1; 2009b
ISGS 4897	Ch flecks, F311, surface hearth, Main Block	9700 ± 100	NR	ESN	8	1	3	1	0	3	ESN	Stafford and Cantin 2009a: Table 10.1; 2009b
No Numbers	W, split sample, averaged, F313, large surface hearth	9955 ± 86	NR	ESN	11	1	4	3	0	3	ESN	Stafford and Cantin 2009a:291; 2009b
ISGS 4835	Ch flecks, FWT-15, surface hearth, Western Terrace	10090 ± 120	NR	ESN	8	1	3	1	0	3	ESN	Stafford and Cantin 2009a: Table 10.1; 2009b
Beta 13574	Ch flecking, F35, heating facility, Western Terrace	10020 ± 100	NR	ESN	6	1	1	1	0	3	ESN	Stafford and Cantin 2009a: Table 10.1; 2009b
Beta 153586	No information	9680 ± 170	NR	ESN	4	0	0	1	0	3		Stafford and Cantin 2009a: Table 10.1
Beta 153512	Ch scattered, F298, surface hearth, Main Block	9490 ± 60	NR	St. Charles/ Thebes	8	1	3	1	0	3	Bracket ESN	Stafford and Cantin 2009a: Table 10.1; 2009b
ISGS 4837	No information	9420 ± 100	NR	KCN	4	0	0	1	0	3	Bracket Sequence	Stafford and Cantin 2009a: Table 10.1
ISGS 4834	NS Ch, F98, surface hearth, Main Block	9350 ± 80	NR	KCN	9	2	3	1	0	3	Bracket Sequence	Stafford and Cantin 2009a: Table 10.1; 2009b
ISGS 5035	Ch, hearth, Main Block	8780 ± 80	NR	KCN	8	1	3	1	0	3	Bracket Sequence	Stafford and Cantin 2009a: Table 10.1; 2009b
ISGS 5046	Ch, surface hearth, Main Block	8900 ± 120	NR	KCN	8	1	3	1	0	3	Bracket Sequence	Stafford and Cantin 2009a: Table 10.1; 2009b
ISGS 5040	Ch, surface hearth, Main Block	8810 ± 120	NR	KCN	8	1	3	1	0	3	Bracket Sequence	Stafford and Cantin 2009a: Table 10.1; 2009b
ISGS 4838	Ch, F103, pit, Main Block	8740 ± 100	NR	KCN	8	1	3	1	0	3	Bracket Sequence	Stafford and Cantin 2009a: Table 10.1; 2009b
Beta 206921	Ch, F205, surface hearth, Main Block	9260 ± 40	NR	KCN	8	1	3	1	0	3	Bracket Sequence	Stafford and Cantin 2009b
Beta 218528	Ch, F213, pit feature, Main Block	9200 ± 60	NR	KCN	6	1	1	1	0	3	Bracket Sequence	Stafford and Cantin 2009b
LaGrange Shelter												
Beta-205457	Hickory NS, Zone E, below Dalton	9910 ± 50	−25.7	None	3	2	0	0	1	0		
Puckett												
Beta-48045	Ch (scattered), Lvl 5, Test Unit 1	9790 ± 160	NR	Dalton Variant	4	1	1	2	0	0		Hollenbach (2005:89)
Rock Creek Mortar Shelter												
Beta-370146	WCh, Trench, L7, Stratum 7	9530 ± 50	NR	Greenbriar Dalton, others	4	1	2	0	0	1		Norton and Broster (1993:47)
Beta-370147	WCh, Trench Unit 10, L6, Stratum 7	9890 ± 50	NR	Greenbriar Dalton, others	4	1	2	0	0	1		
Beta-373685	WCh, Trench L6, Stratum 7	9390 ± 40	NR	Greenbriar Dalton, others	4	1	2	0	0	1		Franklin et al. (2016:69–70)
Beta-205463	NS, Zone E	10000 ± 50	−26.3	Dalton Variants, ESN	4	2	1	0	1	0		Franklin et al. (2016:69-70)
Stanfield-Worley Bluff Shelter												
M-1348	Ch, Zone D, 1 in below top	9040 ± 400	NR	Dalton Variants, ESN	4	1	2	0	0	1		
M-1347	Ch, Zone D, 4 in below top	9340 ± 400	NR	Dalton Variants, ESN	4	1	2	0	0	1		Hollenbach (2005:82)

(*Continued*)

Table 2. Continued.

Site, Sample No.[a]	Material and Context[b]	^{14}C Age (BP)	δ^{13}C ($^0/_{00}$)[c]	Associated Diagnostic[d]	Total Score[e]	Sample Type	Sample Context	Diagnostic Context	Lab Info	Bayesian Context	Model Use[f]	References
M-1346	Ch, Zone D, 10 in below top	9440 ± 400	NR	Dalton Variants, ESN	4	1	2	0	0	1		
M-1152	Ch, Zone D, vertical random	9640 ± 450	NR	Dalton Variants, ESN	4	1	2	0	0	1		Goldman-Finn (1997:Table 3)
M-1153	Ch, Zone D, vertical random	8920 ± 400	NR	Dalton Variants, ESN	4	1	2	0	0	1		Goldman-Finn (1997:Table 3)

[a]Laboratory codes: ISGS = Illinois State Geologic Survey; M = University of Michigan; Beta = Beta Analytic Laboratory.
[b]Material and context codes: W = wood; WCh = wood charcoal; Ch = charcoal; CNS = charred nut shell; CM = charred material; NS = nutshell; F or Fea. = feature.
[c]δ13C values given where available. NR = not reported.
[d]Diagnostics associated with each date are listed. ESN = early side notched; KCN = Kirk corner notched.
[e]Total Score for sample quality; X = sample did not meet minimum criteria for evaluation. Criteria for individual scores that make up the Total Score (Sample Type, Sample Context, Diagnostic Context, Lab Information, and Bayesian Context) are explained in Table 4.
[f]Model Use for each date used in the Periphery models to date the diagnostics of interest.

Dunbar 2006); and 8LE2105 (Goodwin et al. 2013) in Florida. I use only Dust Cave and James Farnsley in this analysis, because they are close to the Heartland; the Florida sites are essentially contemporaneous, but at least 600 km distant.

The first true notched points in the Heartland are Graham Cave points (Figure 2(e)) and perhaps the point associated with the dated hearth at the Breckenridge site (3CR2) Figure 2(d); Hilliard et al. 2015; Hilliard 2016). There is some dispute as how that point should be characterized (Kay 2012:239; Ray 2016:49–50), and it may represent a local variant. Here I treat it as a notched or almost-notched point intermediate between box-based Dalton and Graham Cave. Cache River notched points (Ray 2016) are directly dated only at the Packard site and contemporaneous with Packard points (Wyckoff 1989). They are also found in the Heartland in undated but relative positions above the box-based Dalton components at Olive Branch (Gramly 2002, 2008). The dated components with Graham Cave points used in the Heartland model include Big Eddy, and Koster (11GE4; Wiant et al. 1983) and Modoc Shelter (11R5; Ahler and Koldehoff 2009) in Illinois.

The Dalton and ESN sites and dates considered in the analyses

In his analysis, Goodyear (1982) presented a detailed, thoughtful, and reasonable exercise in what is now commonly called radiocarbon hygiene (e.g., Graf 2009; Pettitt et al. 2003). He concluded the best samples were taken from cultural features, like hearths, associated only with Dalton points. Unfortunately, it appears no Dalton sites meet this strict criterion. Granted that plucking charcoal out of a stratum that contains artifacts of interest may not be ideal, but it is certainly not uncommon. Most sites with long Paleoindian and Early Archaic chronologies, such as Big Eddy, Dust Cave, Modoc, and Koster, rely on non-hearth dates for the age of strata in which artifacts were found. As long as diagnostic points are properly associated with a stratum, they will be accurately, albeit usually less precisely, dated.

Table 4 summarizes the criteria used to evaluate sites and score ^{14}C sample quality. These criteria are different from others (e.g., Graf 2009), because the Bayesian models do not need to cull otherwise accurate dates to increase precision (Hamilton and Krus 2018). Several sites were rejected for not meeting minimum criteria, such as Alley Mill, which produced mixed cultural material and dates out of stratigraphic order, and Puckett, which had only a 1 m^2 test pit. Samples were scored for Sample Type (for example, bone, charcoal, humates), Sample Context (for example, dispersed charcoal, hearth

Table 3. Distributions of straight-sided, box-based, local variant, and indeterminate daltons in early and late components at the sites.

Site	State	Straight-sided	Box-based	Local Variant	Indeterminate	ESN[a]
Rodgers Shelter	MO	5 Early, 1 Late	6 Early, 5 Late			
Big Eddy	MO	3[b] Early	2 Late			1 Younger
Alley Mill	MO		17 Late		4 Late	2 Coeval
Graham Cave	MO				19 Late	48 Younger, 2 Coeval
Arnold Research	MO		3 Late			1 Older
Pigeon Roost	MO		3 Late			3 Coeval
Olive Branch	IL	26 Early	>250 Late			1 between Early & Late
Twin Ditch	IL		1 Late		1 Late	20 Coeval
Packard	OK		3 Late		1 Late	1 Older
Claussen	KS		1* Late			
Rollins Shelter	AL			7 Late		7 Younger
LaGrange Shelter	AL			5 Late		16 Coeval
Dust Cave	AL			1 Late		43 Younger
Stanfield-Worley	AL			24 Late		46 Coeval
Puckett	TN			2 Late		
Rock Creek Mortar Shelter TN1 Late				1 Late		
Hills Branch Rock Shelter	IL			4 Late		3 Coeval

[a]ESN points, if present, are listed as older, coeval, or younger than Dalton points.
[b]One point out of context but attributed to a component.

charcoal, one of several samples in the same cultural stratum), Diagnostic Context (for example, diagnostic in dated stratum or associated with a particular sample), whether the δ^{13}C results were reported, and Bayesian Context. The last criterion, which concerns the sample's value in the Bayesian model, is described in more detail below. Samples had to achieve a minimum score of 6 to be used.

Table 4. Sample evaluation scoring criteria (I–V) and criteria for site rejection.

I. Sample type:
  Rejected. Soil humates; charcoal stained soil; organic soil; ash lens.
  0. Bone or collagen pretreatment not explained; organics from burned bone; bone and wood; not reported.
  1. Wood charcoal; unidentified charcoal; charred wood; wood and nutshell; bark charcoal; charred material.
  2. Nutshell.
II. Sample Context:
  0. Not reported, unclear, or ambiguous cultural association or sample location.
  1. Dispersed or single sample in cultural stratum or feature.
  2. One of several single samples in a cultural stratum or feature; dispersed samples around hearth.
  3. Dispersed samples in hearth.
  4. Single sample in hearth.
III. Diagnostic Context
  0. No diagnostic in association, unclear, or not known; diagnostics mixed from widely different time periods.
  1. Diagnostic association assumed because of date and context.
  2. Diagnostic in dated stratum.
  3. Diagnostic in association with sample.
IV. Laboratory Reporting:
  0. δ^{13}C not reported.
  1. δ^{13}C reported and acceptable.
V. Bayesian context:
  0. Single sample in stratum or unbracketed phase.
  1. One of several samples in single phase or stratum.
  2. Sample in stratum or phase bracketed either above or below, but not both.
  3. Sample in stratum or phase bracketed above and below; sample in initial or terminal stratum in sequence of three or more phases.
Site Evaluation Criteria:
  Rejected: Dates in site stratigraphy not in order and cannot be resolved; cultural material mixed and cannot be resolved; no cultural material associated with dates; small excavation.

The sites are divided into Dalton Heartland and Periphery regions (Figure 1, Tables 1 and 2). The following site descriptions are limited to pertinent data, but some sites are complex, which affects interpretation of the sample and artifact associations. Some samples are not associated with a diagnostic artifact but were used in the Bayesian models, as explained below. All bone samples were rejected, because they were either taken before sophisticated pretreatment protocols were developed or the protocol for purifying the sample was not described. All humic acid and charcoal or organic stained soil samples were rejected. All charcoal (except nutshell charcoal) was treated with OxCal's charcoal outlier protocol (Bronk Ramsey 2009b).

Heartland sites

Alley spring, Missouri

Two excavations (Lynott et al. 2006; Ray and Mandel 2015) revealed two Dalton middens adjacent to the foundation of an historic mill. The stratigraphy, artifact concentrations, and ^{14}C dates are difficult to reconcile, and two dates are not in expected stratigraphic order. The site was rejected.

Arnold research cave, Missouri

Deposits in the cave were greatly disturbed by historic activities (O'Brien and Wood 1998; Shippee 1966). Goodyear (1982:385) rejected the site, because two "side-notched points" were associated with Dalton points. One date (M-1497) from the basal level was associated with a "lanceolate point" (Crane and Griffin 1968). No samples met the minimum score.

Big Eddy, Missouri

The site appears to have two Dalton components. The older, which is above a dated Gainey point fragment

(Ray 1998), is accepted by the excavators, but the younger is rejected, because they conclude the two Dalton points are displaced (Ray 1998; Ray and Lopinot 2005:283). The site has a dated Graham Cave component. The site was used to date the early and late Dalton and Graham Cave phases.

Breckenridge Shelter, Arkansas

The site was originally excavated in the early 1960s (Wood 1963). In 2012 the site was revisited and a hearth with an associated point was dated (Figure 2(d); Hillard 2016; Hillard et al. 2015). There is disagreement whether the associated point is a Breckenridge or a later form transitional to a Graham Cave side notched (Ray 2016:49–50). The site was used as a transitional phase between the late Dalton and Graham Cave phases.

Graham Cave, Missouri

Dalton points were mainly excavated from deepest levels of this cave, but Graham Cave and other point types were also recovered (Klippel 1971; Logan 1952), leading Goodyear (1982) to reject the site. Chapman (1952:97) illustrates and discusses the Dalton points, which he states were found throughout all levels. Crane (1956) and Crane and Griffin (1968:84–85) discuss the ^{14}C sample distributions and state the two earliest dates (M-1928, M-1900) were at the bottom of the deposit and associated with "fragments of modified fluted blades, fluted blades reworked into drills." These "blades" are likely Dalton points. However, Klippel (1971) states sample M-1928 is from a higher elevation but within the same lowest level. The two dates did not score high enough, and the site was not used.

Koster, Illinois

The Koster ^{14}C dates relied on here are from Wiant and colleagues (1983; Wiant et al. 2009). The Graham Cave component is Early Archaic 2 (EA2), which produced seven dates. The site was used to date Graham Cave.

Modoc Rockshelter, Illinois

The Modoc ^{14}C dates relied on here are from Ahler and Koldehoff (2009). The Graham Cave component is Early Archaic 2 (EAR2), and the site was used to date that phase.

Rodgers Shelter, Missouri

The site was excavated and reevaluated several times from the 1950s to 1970s (Ahler 1971; Chapman 1952; Crane 1956; Crane and Griffin 1968, 1972; Kay 1982; Klippel 1971; Logan 1952; O'Brien and Wood 1998; Wood and McMillan 1976). The shelter stratigraphy is complex (O'Brien and Wood 1998), but the site is critical for understanding Dalton. Kay (personal communication, 2018) collected charcoal for five new dates above the Dalton hearths, but within the Dalton zone and below the Graham Cave component. The site was modeled with early and late Dalton phases.

Olive Branch, Illinois

This large Dalton site at the eastern edge of the Heartland produced an intact early Dalton component and younger box-based Dalton components. Although not an ideal site, the early Dalton component was isolated from the overlying "bioturbated main mass of Dalton remains" (Gramly 2002:73). The site reports are difficult to decipher, and the components were dated with dispersed charcoal in association with diagnostic points (Gramly 2002, 2008). All samples scored below 6, and the site was not used.

Packard, Oklahoma

On the western edge of the Heartland, the site produced dated sequential Packard and Dalton components (Wyckoff 1985, 1989). The Dalton ^{14}C sample is not from a feature, but its age is essentially immediately after the Packard deposits, providing a tight limiting age for Dalton. In other words, the Dalton point can be no earlier than 9630 ± 100 BP. The site was used to date the late Dalton phase.

Pigeon Roost Creek, Missouri

The site produced a variety of points from Dalton through Late Woodland. A single date was initially assigned to the Dalton component (O'Brien and Warren 2009) but later reassigned to Graham Cave (O'Brien and Wood 1998). The proper association is unclear, so the site was not used.

Twin Ditch, Illinois

The site is on the eastern edge of the Heartland. A distinct Thebes-point Horizon 2 was excavated and dated. The horizon produced eight ^{14}C dates, 18 Thebes, two St. Charles, two Daltons, and 26 Dalton-type adzes in at least two occupations (Morrow 1989, 1996; Wiant et al. 2009). It is not clear which dates are associated with the Daltons. The site was not used.

Periphery sites

Claussen, Kansas

A distinctive Horizon 2 at Claussen (14WB322) was excavated on the bank of a tributary to the Kansas River and produced a dated hearth and two deeper charcoal samples. A box-based Dalton point was recovered that had been displaced from the lowest portion of

Horizon 2, from which the charcoal samples were found (Mandel 2008; Mandel et al. 2006). This high-quality site was not used, because it is on the western periphery of the Heartland.

Dust Cave, Alabama

Two Paleoindian and one ESN components were excavated (Sherwood et al. 2004; Thulman 2017). One Dalton variant was recovered from the younger Paleoindian component (Figure 2(f); Driskell 1994). The site was used to date the Beaver Lake, Dalton variant, and ESN phases.

Hills Branch Rock Shelter, Illinois

The lowest levels produced four Dalton variants and Early Archaic Kirk corner notch points. Wagner and Butler (2000:169) infer the Dalton points were deflated as sediments in the rock shelter eroded. The site was not used.

Lagrange Shelter, Alabama

Dalton artifacts were recovered from Zone D; Early Archaic artifacts were recovered from near the top of Zone D (DeJarnette and Knight 1976). Zones E and C were dated by Hollenbach (2005). The site was not used.

Puckett, Tennessee

Two Dalton variants were recovered from a midden with flakes and charcoal flecks in level 5 of a 1×1 m^2 Test Unit 1 (Norton and Broster 1993). The excavation was small, and it is not clear the midden flecks are properly associated with the Dalton variant component. The site was not used.

Rock Creek Mortar Shelter, Tennessee

A reworked Greenbrier Dalton was recovered in Stratum 7 in spatial association with three pieces of charcoal ranging from 9390 ± 40 to 10,566 ± 33 BP. The excavators state the association should be viewed cautiously (Franklin et al. 2016). The site was not used.

Rollins Bluff Shelter, Alabama

Dalton variants clustered in Zone E, and ESN points were in upper Zone E and Zone D (Hollenbach 2009; Stowe 1970). Whereas it is arguable that Hollenbach's (2009) date from Zone E is likely associated with the Dalton material, the organization of the excavation report (Stowe 1970) did not clearly distinguish the artifact loci. The site was not used.

Stanfield-Worley Bluff Shelter, Alabama

Zone D, the lowest, was capped by a generally sterile Zone C. Zone D contained Dalton variants and ESN points (DeJarnette 1962; Goldman-Finn 1997). It is not clear whether the artifacts in Zone D are properly associated with the ^{14}C dates. Goldman-Finn (1997) identified some areas in Zone D that indicated a possible, but inconclusive, vertical separation of Dalton and ESN material. The site was not used.

Bayesian analysis of radiocarbon dates

Bayesian statistical analysis of ^{14}C dates has been described as the fourth radiocarbon revolution, because it better associates single but individually-linked ^{14}C dates with archaeological data (Pollard and Bray 2007:249). In this work, ^{14}C dates are not treated as independent data but related to one another by being sequential (earlier or later) or associated (found in the same stratum or feature). These relationships increase precision without sacrificing accuracy by constraining individual date calibrations (Hamilton and Krus 2018). In OxCal, associated dates in a single stratum are modeled as *phases*, which are constrained on the early and late ends by *boundaries*, which are undated events that fall outside the range of the ^{14}C dates. Boundaries are needed for statistical reasons but also justified archaeologically, because it is highly unlikely that we would ever date the first or last event in a phase or sequence (Bronk Ramsey 2017). OxCal offers different boundary configurations that affect how one phase transitions to the next. Here I used the *uniform boundary*, which assumes the diagnostic phases transition abruptly (Bronk Ramsey 2009a).

A Bayesian analysis is most often applied to individual site chronologies, but OxCal has protocols for creating new chronologies from several geographically distant sites through cross-referencing calibrated ages (Bronk Ramsey 2009a). The culture histories for the Heartland and Periphery were modeled as sequential phases of diagnostic points using cross-referenced individual dates and boundaries (Bronk Ramsey 2009a). The Heartland was modeled as sequential early Dalton, late Dalton, Breckenridge site, and Graham Cave phases. The Periphery was modeled as sequential Beaver Lake, Dalton variant, and ESN phases. I ran each model using acceptable sites and samples with scores of 6 and above. Table 5 lists the dates and boundaries cross-referenced to the diagnostic phases in each model.

The cross-referenced models

An artifact closely associated with a dated hearth meets the gold standard of high quality ^{14}C samples, but it appears no Daltons are unambiguously associated with a dated hearth. Goodyear (1982) used only the two

Table 5. Cross-referenced boundaries and individual calibrated dates used in the heartland and periphery models.

Heartland	Periphery
Early Dalton	*Beaver Lake*
Big Eddy, EB Early Dalton Phase	Dust Cave, EB Beaver Lake Phase
Big Eddy, TB Early-Late Dalton Phases	
Rodgers Shelter, EB Early Dalton Phase	*Dalton Variant*
	Dust Cave, TB Beaver Lake-Dalton Variant Phases
Late Dalton	Dust Cave, TB Dalton Variant-ESN Phases
Packard, Date AA-3119	
Rodgers Shelter, TB Early-Late Dalton Phases	*ESN*
Big Eddy, LB Late Dalton Phase	Dust Cave, Date Beta-81602
	James Farnsley, EB ESN
Breckenridge Site	James Farnsley, TB ESN-St. Charles
Breckenridge, EB Breckenridge	
Breckenridge, LB Breckenridge	
Graham Cave	
Koster, EB EAR2	
Koster, TB MAR1/EAR2	
Modoc Shelter, EB EAR1	
Modoc Shelter, LB EAR1/EAR2	
Big Eddy, Date AA-60623	

Notes: Phase names in italics. EB = Early Boundary; TB = Transition Boundary; LB = Late Boundary; ESN = Early Side Notched.

earliest dates from Rodgers Shelter (M-2332 and ISGS-485), the samples of which he asserted came from hearths with closely associated diagnostics, but whether they were in fact is unclear. Crane and Griffin (1972:159) state the sample for M-2332 was "[c]arbonized wood from the deepest hearth discovered at the site," and although "cultural debris was scattered around hearth (chert, bone)," no diagnostic artifacts were present. "Hearths just above this location contained Dalton cultural materials" (Crane and Griffin 1972:159); "just above" was not quantified. Sample ISGS-48 was apparently not from a hearth but was "[c]arbonized wood from alluvial clay near the base of Stratum 1 in the Rodgers sequence" (Coleman 1972:154). Further, that sample was composed of two pieces of wood (7799 and 8259) from loci separated by about 1 m in depth,

Table 6. Start and end calibrated dates before present in the cultural history model of heartland and eastern periphery phases at 68.2 and 95.4% likelihoods.

	68.2% likelihood		95.4% likelihood	
Phase Boundaries	Start	End	Start	End
Heartland Phases				
Early Dalton Start	12,578	12,160	13,172	12,052
Early-Late Dalton	12,227	11,239	12,322	11,138
Late Dalton-Breckenridge	10,096	9700	10,773	9647
Breckenridge-Graham Cave	9745	9612	9828	9573
Graham Cave End	9340	9082	9400	8856
Eastern Periphery Phases				
Beaver Lake Start	12,853	12,338	13,730	12,160
Beaver Lake-Dalton Variant	12,454	11,949	12,537	11,700
Dalton-ESN	11,570	11,390	11,674	11,325
ESN End	11,469	11,174	11,582	10,856

although apparently both were from depositional Unit B2 (Ahler 1976:Figures 8.2, 8.7). Regardless, I agree that Goodyear's (1982:387) conclusion that these samples are "validly associated with Dalton" is sound, although they dated the early Dalton stratum at Rodgers Shelter, rather than specific artifacts. Marvin Kay analyzed five additional samples from Rodgers Shelter that he attributes to the Dalton component (Table 1). One sample (A-0313) is from the level containing the two early samples, but whether all four younger dates were closely associated with Dalton artifacts is less clear to me.

For the Heartland early Dalton phase, I cross-referenced three boundaries: the early and late boundaries for the early Dalton phase from Big Eddy and the early boundary for the early Dalton phase from Rodgers Shelter. Because five of six straight-sided points were in the deepest levels and half of the box-based points were in the lower levels at Rodgers Shelter (Table 3), the early boundary date would be a better estimate of the early phase than the transition boundary between the early and late Dalton phases. That transition boundary was cross-referenced in the Heartland late Dalton phase. The late Dalton phase also includes the cross-referenced boundary of the late Dalton phase from Big Eddy and the single late Dalton date from Packard. The Breckenridge site phase uses cross-referenced boundaries for that phase. The Graham Cave phase uses cross-referenced boundaries from Koster Unit EAR2 and Modoc Rock Shelter Strata Group EAR1 and one cross-referenced date from Big Eddy.

In the Periphery, the Beaver Lake phase is modeled with the cross-referenced early boundary for Unit U at Dust Cave. The Dalton horizon is less well-dated than in the Heartland. Although only one Dalton variant was excavated from Unit T at Dust Cave, it is the least ambiguous Dalton variant component in the Periphery and the early and later boundaries from that unit (Sherwood et al. 2004) are cross-referenced in the Periphery Dalton variant phase. The other Periphery sites with Dalton components have problematic post-depositional histories (Hills Branch Rock Shelter; 11PP508), small excavations (Puckett), equifinal interpretations of mixed Dalton and ESN artifacts (Rollins Bluff Shelter, Stanfield-Worley), or poor ^{14}C associations (Rock Creek Mortar Shelter; 40PT209). The start of the ESN phase is modeled with cross-referenced boundaries for the ESN unit from James Farnsley and the single date from Unit R at Dust Cave.

The culture history models are illustrated with probability density functions for the cross-referenced dates and boundaries for the diagnostic phases (Figure 3). Table 6 lists the dates of each boundary for the 68.2 and 95.4% likelihoods, which correspond to the one

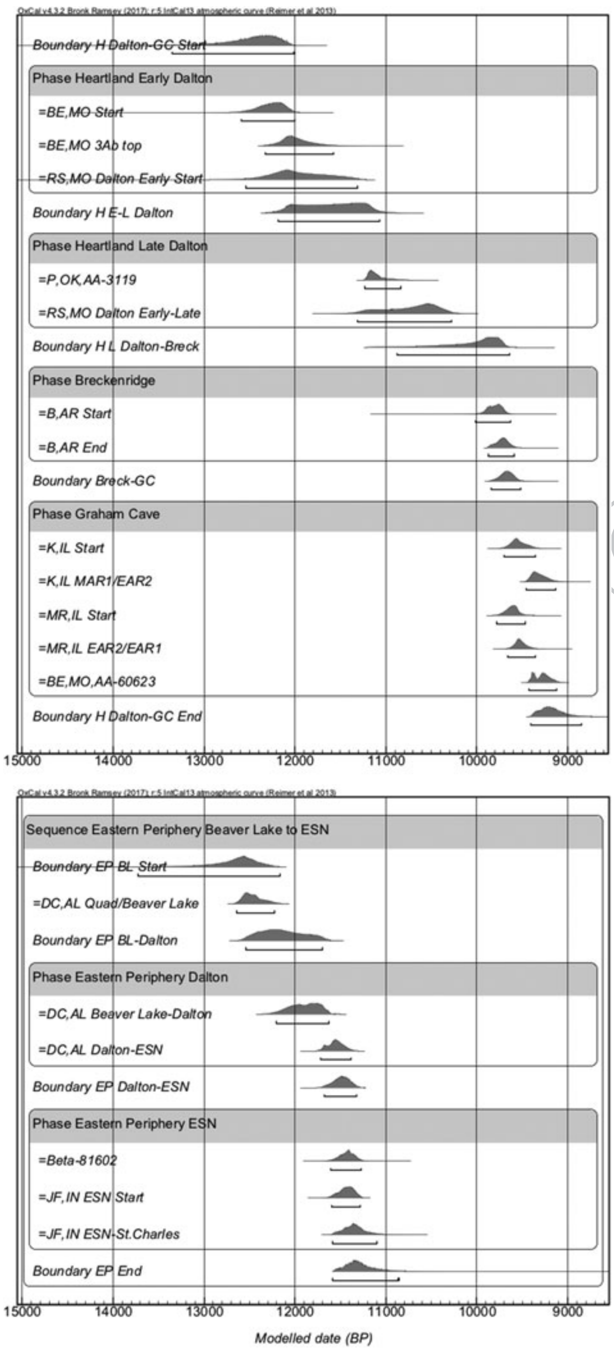

Figure 3. Probability density functions of the phases in the Heartland and Eastern Periphery models. Created by the author in OxCal.

and two-sigma errors in traditional statistics. These dates bracket the uncertainty in the calibrations. For example, the transition boundary between the early and late Dalton phases in the Heartland model could be as long as about 1,200 years (from 12,322 to 11,138 cal BP, at the 95.4% *likelihood*), but probably about 1,000 years (from 12,227 to 11,239 cal BP, at the 68.2% *likelihood*). OxCal produces an A-model index to help evaluate the strength of the model. If the A-model index is above 60, the model is adequate; below 60 and the model is suspect, usually because there are too many individual dates that are outliers (Bronk Ramsey 2009b). However, when outlier protocols are employed, the effects of outlier dates on the overall model are down weighted. In that case, the A-model index is no longer a good measure of model adequacy (Bronk Ramsey 2014). Both models in this analysis incorporated the charcoal outlier protocol, and the Periphery model also incorporated the general outlier protocol. Three runs of the Heartland and Periphery models produced A-model indices ranging from 81.5 to 82.4 and 43.5 to 45, respectively, which indicates the models are adequate and stable.

Discussion

The detailed culture history model results (Supplemental Figures 1 and 2) are not very precise and should not be over-interpreted (Table 6, Figure 3). For example, the conventional wisdom is that Dalton started soon after the end of Clovis in the Heartland and Beaver Lake followed Cumberland in the Periphery, but Figure 3 and Table 5 show them potentially starting at about the same time or earlier than Clovis (ca. 11,500 BP, 13,350 cal BP) at the 95.4% likelihood. This is due to few ^{14}C data for the early end of the sequences and no early bracketing dates. However, the data are sufficient to conclude that the sequential chronologies of the point sequences in the Heartland and Eastern Periphery are different.

The results support an early Dalton phase in the Heartland consisting of straight-sided Dalton points. The lower numbers of these points comport with what has been inferred for the rest of the Southeast, where Cumberland and Redstone points are few in number, perhaps due to a post-Clovis population decline (Anderson et al. 2011). The Beaver Lake phase in the Eastern Periphery is contemporaneous with the Heartland early Dalton phase. Whereas both Beaver Lake and straight-sided Daltons are not beveled, not serrated, and have longer hafts (as measured by the length of lateral grinding) than later types, whether Beaver Lake should be considered a straight-sided Dalton variant (e.g., Gramly 2002:71) is beyond the scope of this article.

The late Dalton phase in the Heartland is also supported. First, the ages from the late Dalton phases at Rodgers Shelter and Packard are appropriately associated with box-based Dalton points. The ^{14}C samples from Rodgers Shelter and Packard date strata with box-based Daltons and are bracketed by deeper, earlier-dated strata. None of the dates in the other Heartland sites with box-based Daltons (Graham Cave, Big Eddy, Arnold Research Cave, Olive Branch, and Alley

Mill) conflict with the presence of a late Dalton phase (Table 3). Further, the Heartland has no ubiquitous notched point form until the Graham Cave type appears, which leaves at least a 1,000-calendar-year gap in the Heartland without a point type if the late Dalton phase is not accepted.

The Heartland Late Dalton phase marks significant changes in the Dalton point base and blade designs, which occurred no earlier than 12,322 cal BP, but probably between 12,227 and 11,239 cal BP. The same changes are seen in the Periphery Dalton variants, which occurred no earlier than 12,537 cal BP, but probably between 12,454 and 11,949 cal BP. Blade beveling as a resharpening technique is also a hallmark of ESN in the Eastern Periphery and in Florida (Pevny et al. 2018). There was a relative explosion in the number of points at that time. Based on my review of these and other site reports and large point collections, many more box-based Daltons and Dalton variants have been found than straight-sided Daltons or Beaver Lakes (e.g., Gramly 2002, 2008; Kay 1982). Whether the Late Dalton design changes were introduced into or derived from the Heartland cannot be determined from these data. The implications of the Breckenridge point need more research. Is it a transitional form, regional variant, or representative of a very late Dalton form?

The model indicates the late Heartland Dalton phase ends no later than 9647 cal BP, but probably between 10,096 and 9700 cal BP. This should also be viewed with caution, because the calibration curve is flatter at this time (making the calibration less precise) and only the three dates from a single hearth at the Breckenridge site bracket the end of the late Dalton phase. Nevertheless, a late end for the late Dalton phase is supported by the two high-quality dates at the Claussen site (about 10,500–10,270 cal BP) and the latest date likely associated with Dalton at Rodgers Shelter (about 10,220–9910 cal BP). The late end for the phase is also supported by lower quality dates from Olive Branch (scores of 4, as late as 9940 cal BP at 95.4% *likelihood*) and Graham Cave (scores of 5, as late as 9625 cal BP at 95.4% *likelihood*).

For the Eastern Periphery, the Beaver Lake and Dalton variant phases are discussed above. The model results indicate the ESN tradition in the Eastern Periphery started no earlier than 11,671 cal BP, probably between 11,570 and 11,390 cal BP. This means the Heartland Late Dalton and Periphery ESN phases overlapped for at least several centuries. The interesting anthropological question is what happened at sites that were occupied by ESN point makers at the same time the late Dalton phase was occurring in the Heartland. These data indicate that there was at least the opportunity for ongoing interaction between people using late Daltons on the eastern edge of the Heartland and people using ESN points on the western edge of the Eastern Periphery.

Were Dalton variants and ESN points made at the same time in the same places? Several Periphery sites show a clear stratigraphic separation between Dalton variants and ESN. At the Hester site (22MO569) in northeast Mississippi (Brookes 1979:52), the box-based Dalton component was clearly below the ESN Big Sandy component. The same relationship existed at Rollins Bluff Shelter, where ESN Big Sandys were found above the lower Dalton variants (Stowe 1970:102–103), Dust Cave (Sherwood et al. 2004), and, perhaps, at Stanfield-Worley (Goldman-Finn 1997:10). In contrast, at LaGrange Shelter, Hills Branch Rockshelter, and Rock Creek Mortar Shelter, Dalton variants and ESN points were found together in Holocene-aged contexts.

LaGrange may answer the question. Zone D produced ESN and Dalton variants, and the underlying Zone E produced sparse cultural material (DeJarnette and Knight 1976:9, 39–44). Hollenbach (2005:88) dated a hickory shell from Zone E at 9910 ± 50 BP, which is an appropriate limiting early date for the Dalton variants at the site. Because that age is approximately the same as the start of the Periphery ESN phase, it is fair to infer that Dalton variants and ESN were contemporaneous at the site, and by extension in the Eastern Periphery.

Contemporaneity should be uncontroversial, because even the early chronologists propose that Dalton in the Heartland lasted 100–200 ^{14}C years after ESN points were being made in the Eastern Periphery. If the dates from Stanfield-Worley, LaGrange, Puckett, and Twin Ditch correctly date their Dalton variant assemblages, then the interaction between late Dalton and ESN and subsequent groups in and near the edge of the Periphery lasted at most about 2,000 calendar years, probably about 900 calendar years. Given the overlap of the late Dalton and ESN phases, the sites with sequential Dalton variant and ESN components like Hester, Dust Cave, and Rollins may represent the early end of the Dalton variant phase in the Periphery, whereas the mixed sites and Puckett were occupied during the overlap.

Conclusion

The Bayesian models of these quality ^{14}C data establish refined culture histories for the late Paleoindian and Early Archaic periods in the Heartland and Eastern Periphery. Together with the diagnostic stone tools, the dates present interesting questions of social interaction, agency, and artifact evolution and stasis. What were the Heartland and Periphery group interactions? Did they occupy the same sites sequentially or coincidently? Why did groups in the Heartland stay with the Dalton hafting technology for another 1,600–2,000 calendar years after it was abandoned in the Eastern Periphery?

This work does not upend previous work on the chronology of Dalton. It supports Jack Ray's intuition that box-based Daltons may represent a temporal change in basal design, and Marvin Kay's inference that the Dalton phase lasted until about 9600 cal BP. However, it provides some interpretive rigor to the ^{14}C data of the transition from late Paleoindian to the Early Archaic periods in the Heartland and Periphery. How applicable will the culture histories be outside the Heartland and Periphery? I suspect each region in the Southeast and elsewhere should be examined separately; the notion of pan-regional social change should not be taken as the norm.

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Data availability statement

Digital and physical data on which this research is based can be obtained by contacting the author.

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No potential conflict of interest was reported by the author.

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