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MODELING REGIONAL RADIOCARBON TRENDS: A CASE STUDY FROM THE EAST TEXAS WOODLAND PERIOD

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ABSTRACT. The East Texas Radiocarbon Database contributes to an analysis of tempo and place for Woodland era (~500 BC–AD 800) archaeological sites within the region. The temporal and spatial distributions of calibrated ^{14}C ages (n = 127) with a standard deviation (ΔT) of 61 from archaeological sites with Woodland components (n = 51) are useful in exploring the development and geographical continuity of the peoples in east Texas, and lead to a refinement of our current chronological understanding of the period. While analysis of summed probability distributions (SPDs) produces less than significant findings due to sample size, they are used here to illustrate the method of date combination prior to the production of site- and period-specific SPDs. Through the incorporation of this method, the number of ^{14}C dates is reduced to 85 with a ΔT of 54. The resultant data set is then subjected to statistical analyses that conclude with the separation of the east Texas Woodland period into the Early Woodland (~500 BC–AD 0), Middle Woodland (~AD 0–400), and Late Woodland (~AD 400–800) periods.

INTRODUCTION

Archaeologists have a lengthy history of tinkering with the manipulation of radiocarbon data, and have made much progress since first advocating for a more flexible method of processing data through the employment of a punch-card data retrieval system (see Taylor et al. 1968). Through the advent and acceptance of novel methodological approaches, we continue to make significant progress in our understanding and manipulation of regional cultural chronologies (Wendorf et al. 1979; Hassan 1984; Bever 2006; Bamforth and Grund 2012).

Rick's (1987) innovative explanation and subsequent employment of ^{14}C dates as data garnered acceptance and use within studies of occupational patterns and population dynamics (see Kuzmin and Keates 2005), which use the number of occupations—in lieu of the number of ^{14}C dates—as a method to view the spatial and temporal dynamics of human distribution (Straus et al. 2000). To that end, this study includes the assumptions that (1) ^{14}C dates that can be combined via the OxCal *X* test represent a single occupational episode, (2) the summed probability distribution for archaeological sites with 4 or more ^{14}C assays illustrates the discrete or diffuse nature of occupational episodes, and (3) median dates represent the age of highest probability within each date range.

Through a variety of academic, avocational, and cultural resource management pursuits, archaeologists have obtained 127 ^{14}C dates from 51 Woodland period sites across east Texas (Tables 1 and 2). The bulk of these dates were collected with the intention of exploring locally based research questions and are employed here within a discussion of macrolevel trends, using a descriptive analysis of the results from date combination, summed probability distributions, and statistics to apprise the subsequent inferences (see Bernard 2006). While the distribution of recognized Woodland sites (or components) is easily plotted spatially, this paper represents the first attempt to synthesize these combined data and illustrate the temporal relationships that exist between ^{14}C dates collected across the east Texas region over the last 40 yr.

The East Texas Radiocarbon Database (ETRD) represents a sizeable sample of dates produced within a relatively small geographic region on the southwestern border of the Woodland culture area. This research refines our current knowledge regarding the temporal complexities within the Woodland period, providing a snapshot of temporal trends extracted from an understudied sample of ^{14}C dates. The temporal and spatial distributions of calibrated ^{14}C ages are useful in exploring the development and geographic continuity of the Woodland peoples and lead to a better understanding of the current chronological framework. From these data, it is possible to establish temporal associations that correlate with site abandonment, decreases or increases in local populations, and an intensification of landscape usage throughout the Woodland period. These data are particularly helpful since paleoenvironmental models for east Texas are not able to be constructed due to the highly acidic soils (Bryant and Holloway 1985).

The inductive methodology employed here informs a regional chronology for east Texas Woodland sites (DeWalt and Pelto 1985). The goals of this article are to explore the process of ^{14}C date combination from sites with 4 or more samples (n = 11) to decrease sampling bias for statistical analysis and determine the modified summed probability distributions (see Michczyńska and Pazdur 2004; Bamforth and Grund 2012; Williams 2012), and secondly to employ the resulting median dates within a statistical analysis of regional trends.

EAST TEXAS RADIOCARBON DATABASE

Story (1990) provided the first published compendium of ^{14}C dates from east Texas, and the extensive ^{14}C database from investigations at Cooper Lake (Fields et al. 1997: Appendix B) led to Perttula's (1997, 1998) initial efforts to synthesize these data. In its current form, the ETRD is comprised of 1248 ^{14}C dates from a total of 199 archaeological sites that range in age from Paleoindian through Historic. This is a substantial increase from the 520 dates previously published (Perttula 1997; Perttula and Selden 2011), and the vast majority of the ^{14}C dates in the database are the product of cultural resource management (CRM) projects in east Texas.

METHODS OF ANALYSIS

^{14}C dates used within this research were collected from CRM reports and publications, were synthesized, then recalibrated with OxCal v 4.1.7 (Bronk Ramsey 2012) and IntCal09 (Reimer et al. 2009) (Table 1) (Perttula and Selden 2011). The completed database was analyzed using a variety of statistical processes (histograms, barplots, boxplots, kernel density, and hierarchical cluster analysis) within version 2.15.1 of R (http://www.r-project.org/), and summed probability distributions (SPDs) were produced using OxCal. Statistical calculations were made using negative numbers to represent BC and positive numbers to represent AD (Sirkin 2006).

With few exceptions where conventional ^{14}C ages were reported—to include older assays found to lack $\delta^{13}C$ dates—value estimates were made for fractionation correction as suggested by Stuiver and Reimer (1993: Table 1): –25‰ for nutshells and charcoal (C_3 plants), and –10‰ for charred maize (C_4 plants).

The Woodland sample was selected from the ETRD on the basis of median age. If the median age fell within the currently accepted temporal construct (~500 BC–AD 800) for the Woodland period (see Story 1990; Perttula and Nelson 2004; Perttula 2008a), it was included. Dates from sites found to lack geographic coordinates, with a standard deviation greater than 200 yr, or from non-archaeological contexts (i.e. geoarchaeological profile, backhoe trench, or cutbank not on a site) were removed from the sample. The remaining dates were combined and comprise the basis of the Woodland period statistical sample. Data fields from the ETRD include site name, trinomial (site number), assay number, raw age, $\delta^{13}C$, corrected ^{14}C age, 2σ age range, and median age (Table 2).

Within the distribution of Woodland ^{14}C assays (n = 127) from the ETRD, 28 sites were found to have 1 ^{14}C sample, 8 sites have 2 samples, 4 sites have 3 samples, 3 sites have 4 samples, 1 site has 5 samples, 3 sites have 6 samples, two have 7 samples, one has 9 samples, and one has 13 samples. The assays from the 11 sites with 4 or more ^{14}C dates were combined via OxCal for 2 reasons: (1)

to reduce the standard deviation and increase the accuracy of each site's temporal assignments and (2) to reduce sampling bias created by the number of samples during statistical analyses.

Once combined, a summed probability distribution (SPD) was produced for each of the 11 sites to illustrate the position of each within the period. The dates were plotted in a manner where the SPDs, the combined groups, and the individual assays that inform them can be viewed together. These efforts permit the SPD for the entirety of the Woodland period sample to be contrast with those produced for the 11 sites. This comparison demonstrates the impact that each site has upon the whole of the Woodland period ^{14}C sample, and allows for a discussion of regional trends within the temporal sample.

This method expands the scholarly impact of existing ^{14}C dates through their integration within a regional chronology. By combining and recalibrating ^{14}C dates, and producing site-specific SPDs, the most accurate temporal representation available for the Woodland period in east Texas has been developed. The investigation contrasts site-specific summed probability distributions for 11 sites against the summed probability distribution for the entirety of the Woodland period sample.

Table 1 Data sources for the 51 archaeological sites examined in this study.

Trinomial[a]	Source
41AN38	Lohse et al. 2004; Perttula et al. 2007, 2011
41AN120	Perttula 1997
41BW692	Lohse et al. 2004
41CE19	Story 1990; Davis et al. 1992; Perttula 2010a,b
41CP245	Nelson and Perttula 2006
41CP408	Sherman 2004; Perttula and Ellis 2012
41DT6	Fields et al. 1993
41DT16	Fields et al. 1993
41DT62	Fields et al. 1993
41DT141	Fields et al. 1997
41HO216	Cooper and Cooper 2005; Perttula and Nelson 2006, 2007
41HP78	Doehner and Larson 1978
41HP106	Perttula 1999
41HP137	Fields et al. 1997
41HS15	Fields and Gadus 2012
41HS16	Webb et al. 1969
41HS231	Dockall et al. 2008
41HS843	Gadus et al. 2006
41HS844	Gadus et al. 2006
41LR152	Mahoney et al. 2001, 2002
41LR164	Mahoney et al. 2001, 2002
41LR297	Bruseth et al. 2009
41MX5	Brewington et al. 1995
41NA49	Corbin 1984; Corbin et al. 1984; Corbin and Hart 1998
41NA231	Perttula 2002, 2008b
41NA236	Perttula 2000, 2002, 2008b
41NA243	Perttula 2000, 2002
41NA244	Perttula 2000, 2002
41NA248	Perttula 2000, 2002
41NA264	Perttula 2000, 2002
41NA280	Perttula 2000, 2002
41NA285	Perttula 2000, 2002, 2008b
41NA290	Perttula 2000, 2002

Table 1 Data sources for the 51 archaeological sites examined in this study. *(Continued)*

Trinomial[a]	Source
41RK170	Perttula and Nelson 2003
41RK214	Rogers and Perttula 2004; Perttula and Rogers 2007
41RK222	Rogers et al. 2001
41RK328	Cliff et al. 2004
41RK468	Dixon et al. 2009
41RK558	Dockall and Fields 2011
41SM273	Perttula and Nelson 2001, 2004
41SY41	Perttula 1997
41TT370	Kotter et al. 1993
41TT372	Barnhart et al. 1997
41TT409	Kotter et al. 1993
41TT550	Dixon et al. 1997; Perttula 1998
41TT653	Galan 1998; Perttula and Sherman 2009
41TT847	Hatfield et al. 2008
41TT865	Perttula et al. 2003; Hatfield et al. 2008
41UR77	Perttula and Ricklis 2005
41UR133	Parsons 1998
41WD495	Bruseth and Perttula 1981

[a]"Trinomial" refers to the Smithsonian trinomial numbering system where the state is indicated by a number ranging from 1 to 50, the county by 2–3 capital letters, and the site within the county is represented by a number ranging from 1 to infinity.

Table 2 ^{14}C dates for the east Texas Woodland period.[a]

Trinomial[b]	Sample nr	Raw age	δ^{13}C (‰)	Corrected ^{14}C age	1σ age range	2σ age range	Median
41AN038	Beta-236778	—	–26.2	1290 ± 40	AD 670–722 (0.43), AD 741–770 (0.25)	AD 653–783 (0.91), AD 789–812 (0.03), AD 845–856 (0.01)	722
41AN038	Beta-236790	—	–25.8	1420 ± 40	AD 604–655 (0.68)	AD 565–666 (0.95)	625
41AN038	Beta-236794	—	–24.3	1830 ± 50	AD 126–244 (0.68)	AD 70–263 (0.87), AD 278–329 (0.08)	184
41AN120	SMU-669	1744 ± 64		1744 ± 76	AD 215–401 (0.68)	AD 83–434 (0.95), AD 495–505 (0.01)	290
41BW692	UGA-13420	1270 ± 40	–24.7	1280 ± 40	AD 676–729 (0.40), AD 736–772 (0.28)	AD 657–825 (0.93), AD 841–862 (0.03)	730
41CE019	Tx-1223	1290 ± 80	—	1266 ± 90	AD 665–826 (0.61), AD 840–863 (0.07)	AD 622–972 (0.95)	767
41CE019	Tx-919	1310 ± 80	—	1286 ± 90	AD 665–820 (0.63), AD 842–860 (0.05)	AD 602–901 (0.91), AD 917–966 (0.04)	751
41CE019	Tx-105	1120 ± 90	—	1361 ± 99	AD 582–775 (0.68)	AD 436–490 (0.03), AD 510–517 (0.00), AD 530–891 (0.92)	676
41CE019	Tx-674	1420 ± 100	—	1396 ± 108	AD 542–723 (0.61), AD 740–770 (0.07)	AD 425–877 (0.95)	639
41CE019	Tx-3312	1190 ± 80	—	1431 ± 90	AD 471–477 (0.01), AD 535–683 (0.67)	AD 422–773 (0.95)	606
41CE019	—	1630 ± 40	–26.7	1600 ± 40	AD 418–466 (0.31), AD 482–533 (0.37)	AD 382–560 (0.95)	473
41CE019	Tx-3695	1400 ± 60	—	1641 ± 72	AD 337–468 (0.49), AD 479–534 (0.18)	AD 240–570 (0.95)	411
41CP245	Beta-208773	1320 ± 40	–27.5	1280 ± 40	AD 676–729 (0.40), AD 736–772 (0.28)	AD 657–825 (0.93), AD 841–862 (0.03)	730
41CP245	Beta-208775	1730 ± 40	–27.3	1690 ± 40	AD 261–280 (0.11), AD 326–410 (0.58)	AD 249–426 (0.95)	353

Table 2 ^{14}C dates for the east Texas Woodland period.[a] *(Continued)*

Trinomial[b]	Sample nr	Raw age	$\delta^{13}C$ (‰)	Corrected ^{14}C age	1σ age range	2σ age range	Median
41CP408	Beta-184988	1930 ± 40	–25.9	1920 ± 40	AD 29–38 (0.05), AD 51–128 (0.63)	20–13 BC (0.01), 1 BC–AD 215 (0.95)	83
41DT006	Beta-51364	1270 ± 60	–26.2	1250 ± 60	AD 680–818 (0.62), AD 843–860 (0.06)	AD 657–895 (0.95), AD 927–935 (0.01)	768
41DT006	Beta-51366	1300 ± 80	–25.0	1300 ± 80	AD 649–782 (0.63), AD 790–809 (0.05)	AD 599–895 (0.95), AD 925–937 (0.01)	736
41DT006	Beta-51367	1370 ± 80	–25.5	1370 ± 80	AD 595–718 (0.59), AD 743–769 (0.10)	AD 536–876 (0.95)	663
41DT006	Beta-51368	1470 ± 80	–25.8	1460 ± 80	AD 470–478 (0.02), AD 535–660 (0.66)	AD 414–689 (0.95), AD 753–760 (0.00)	583
41DT006	Beta-51365	1790 ± 100	–26.1	1770 ± 100	AD 134–354 (0.65), AD 366–381 (0.04)	AD 27–41 (0.01), AD 48–442 (0.92), AD 455–460 (0.00), AD 484–532 (0.03)	258
41DT016	Beta-52241	1300 ± 60	–25.5	1290 ± 60	AD 663–775 (0.68)	AD 649–878 (0.95)	735
41DT016	Beta-51372	1300 ± 80	–26.0	1290 ± 80	AD 654–782 (0.60), AD 789–810 (0.06), AD 848–855 (0.02)	AD 606–897 (0.94), AD 923–941 (0.01)	744
41DT016	Beta-52242	1330 ± 70	–25.9	1310 ± 70	AD 652–776 (0.68)	AD 612–883 (0.95)	723
41DT016	Beta-52245	1520 ± 60	–24.8	1530 ± 60	AD 436–491 (0.28), AD 509–518 (0.04), AD 529–596 (0.37)	AD 416–641 (0.95)	525
41DT016	Beta-52244	1550 ± 90	–24.8	1560 ± 90	AD 415–592 (0.68)	AD 260–283 (0.02), AD 324–652 (0.94)	490
41DT016	Beta-51371	2090 ± 90	–25.7	2080 ± 90	336–331 BC (0.00), 203 BC–AD 21 (0.67)	365 BC–77 AD (0.95)	–112
41DT062	Beta-52605	1370 ± 110	–24.8	1380 ± 110	AD 556–773 (0.68)	AD 430–886 (0.95)	657
41DT141	Beta-17400	2100 ± 70	—	2100 ± 81	347–321 BC (0.06), 206–37 BC (0.58), 30–21 BC (0.02), 11–2 BC (0.02)	363 BC–AD 53 (0.95)	–134
41DT141	Beta-17401	2350 ± 70	—	2350 ± 81	733–691 BC (0.08), 662–650 BC (0.02), 545–359 BC (0.55), 276–259 BC (0.03)	761–682 BC (0.12), AD 671–347 BC (0.69), 320–206 BC (0.14)	–465
41HO216	Beta-206843	1540 ± 70	–26.5	1520 ± 70	AD 435–491 (0.25), AD 509–518 (0.04), AD 529–606 (0.40)	AD 409–651 (0.95)	534
41HP078	SMU-1978	—	–26.4	1810 ± 110	AD 81–339 (0.68)	46 BC–AD 436 (0.94), AD 490–510 (0.01), AD 517–529 (0.00)	212
41HP078	Tx-1961	2080 ± 60	—	2080 ± 72	196–20 BC (0.65), 12–1 BC (0.03)	357–285 BC (0.09), 255–249 BC (0.04), 234 BC–AD 67 (0.86)	–108
41HP106	Beta-82913	1730 ± 100	–27.6	1710 ± 100	AD 175–192 (0.03), AD 212–433 (0.65)	AD 85–547 (0.95)	325
41HP106	Beta-82914	1820 ± 90	–25.4	1810 ± 90	AD 86–106 (0.5), AD 120–264 (0.48), AD 276–332 (0.15)	AD 18–417 (0.95)	212
41HP106	Beta-82915	1820 ± 50	–24.1	1840 ± 50	AD 93–97 (0.02), AD 125–238 (0.66)	AD 62–260 (0.90), AD 282–324 (0.05)	175
41HP106	Beta-85866	1860 ± 50	–24.6	1860 ± 50	AD 86–109 (0.12), AD 117–220 (0.56)	AD 29–39 (0.01), AD 51–256 (0.93), AD 303–316 (0.01)	156
41HP106	Beta-82917	1880 ± 90	–25.9	1870 ± 90	AD 29–39 (0.02), AD 50–245 (0.66)	49 BC–AD 382 (0.95)	146
41HP106	Beta-85868	1910 ± 50	–26.2	1890 ± 50	AD 61–172 (0.61), AD 193–211 (0.07)	AD 5–240 (0.95)	118
41HP106	Beta-85867	2270 ± 50	–26.7	2250 ± 50	389–352 BC (0.23), 296–228 BC (0.40), 221–211 BC (0.05)	398–202 BC (0.95)	–287

Table 2 ^{14}C dates for the east Texas Woodland period.[a] *(Continued)*

Trinomial[b]	Sample nr	Raw age	$\delta^{13}C$ (‰)	Corrected ^{14}C age	1σ age range	2σ age range	Median
41HP137	SMU-1966	—	–25.2	1460 ± 60	AD 555–647 (0.68)	AD 434–493 (0.10), AD 507–520 (0.02), AD 527–666 (0.84)	592
41HP137	SMU-1917	—	–25.7	2090 ± 30	164–129 BC (0.26), 121–88 BC (0.25), 78–55 BC (0.17)	196–42 BC (0.95)	–112
41HS015	Beta-242049	1450 ± 40	–23.7	1470 ± 40	AD 565–635 (0.68)	AD 467–481, AD 534–665 (0.99)	594
41HS016	Tx-483	1850 ± 90	—	1850 ± 99	AD 54–259 (0.63), AD 296–321 (0.05)	AD 47–406 (0.95)	169
41HS016	Tx-481	2150 ± 100	—	2150 ± 108	359–278 BC (0.21), 259–241 BC (0.04), 236–88 BC (0.39), 78–55 BC (0.05)	402 BC–61 AD (0.95)	–194
41HS016	Tx-484	2360 ± 130	—	2360 ± 136	752–686 BC (0.11), 667–636 BC (0.05), 623–614 BC (0.01), 595–357 BC (0.45), 283–257 BC (0.04), 246–235 BC (0.02)	802–159 BC (0.95), 134–116 BC (0.01)	–480
41HS231	Beta-236382	1300 ± 40	–26.2	1280 ± 40	AD 676–729 (0.40), AD 736–772 (0.28)	AD 657–825 (0.93), AD 841–862 (0.03)	730
41HS231	Beta-236383	1290 ± 40	–25.4	1280 ± 40	AD 676–729 (0.40), AD 736–772 (0.28)	AD 657–825 (0.93), AD 841–862 (0.03)	730
41HS231	Beta-236388	1470 ± 40	–25.2	1470 ± 40	AD 565–635 (0.68)	AD 467–481 (0.01), AD 534–655 (0.94)	594
41HS843	Beta-210245	1930 ± 40	–25.3	1930 ± 40	AD 27–42 (0.10), AD 48–125 (0.58)	BC 40–AD 170 (0.92), AD 150–170 (0.02), AD 195–210 (0.01)	72
41HS844	Beta-210247	1820 ± 40	–25.6	1810 ± 40	AD 136–243 (0.68)	AD 86–109 (0.03), AD 120–264 (0.80), AD 275–334 (0.13)	201
41LR152	Beta-153588	—	–28.7	1240 ± 60	AD 688–827 (0.59), AD 840–864 (0.09)	AD 660–897 (0.94), AD 923–940 (0.02)	779
41LR164	Beta-153591	—	–21.0	2040 ± 40	106 BC–AD 17 (0.68)	BC 168–AD 30 (0.92), AD 37–52 (0.03)	–50
41LR164	Beta-153593	—	–21.2	2180 ± 40	356–286 BC (0.40), 234–177 BC (0.28)	379–154 BC (0.92), 137–114 BC (0.03)	–268
41LR164	Beta-153592	—	–20.6	2320 ± 40	412–360 BC (0.63), 274–260 BC (0.05)	514–352 BC (0.79), 295–229 BC (0.16), 220–212 BC (0.01)	–391
41LR297	Beta-239524	1290 ± 40	–25.9	1280 ± 50	AD 671–774 (0.68)	AD 656–870 (0.95)	736
41LR297	Beta-237680	1480 ± 40	–24.9	1480 ± 40	AD 550–621 (0.68)	AD 441–484 (0.06), AD 532–652 (0.90)	586
41LR297	Beta-237677	1570 ± 50	–24.9	1570 ± 50	AD 430–540 (0.68)	AD 394–600 (0.95)	489
41LR297	Beta-237678	2340 ± 50	–25.1	2340 ± 50	511–371 BC (0.68)	736–689 BC (0.05), 663–648 BC (0.01), 548–352 BC (0.80), 296–228 BC (0.07), 221–211 BC (0.01)	–417
41MX005	Beta-52709	1790 ± 90	—	1790 ± 99	AD 126–350 (0.66), AD 368–379 (0.02)	AD 2–435 (0.94), AD 491–509 (0.01), AD 518–529 (0.00)	235
41NA049	Tx-4876	1280 ± 100	—	1280 ± 108	AD 656–870 (0.68)	AD 576–984 (0.95)	760
41NA231	Beta-136806	1700 ± 40	–26.3	1680 ± 40	AD 264–276 (0.06), AD 333–415 (0.62)	AD 245–434 (0.95), AD 495–505 (0.01)	363
41NA231	Beta-204778	1970 ± 70	–25.9	1960 ± 70	42 BC–AD 90 (0.60), AD 100–124 (0.08)	159–135 BC (0.02), 116 BC–AD 221 (0.93)	37
41NA236	Beta-183857	1280 ± 60	–19.0	1380 ± 60	AD 598–688 (0.68)	AD 558–773 (0.95)	651

Table 2 ^{14}C dates for the east Texas Woodland period.[a] *(Continued)*

Trinomial[b]	Sample nr	Raw age	$\delta^{13}C$ (‰)	Corrected ^{14}C age	1σ age range	2σ age range	Median
41NA236	Beta-203667	1410 ± 90	–24.6	1420 ± 90	AD 537–689 (0.67), AD 753–760 (0.01)	AD 420–778 (0.95)	615
41NA236	Beta-204783	1470 ± 40	–24.7	1470 ± 40	AD 565–635 (0.68)	AD 467–481 (0.01), AD 534–655 (0.94)	594
41NA236	Beta-203666	1560 ± 40	–24.8	1560 ± 40	AD 434–495 (0.42), AD 504–543 (0.26)	AD 415–585 (0.95)	492
41NA236	Beta-204782	1830 ± 40	–24.8	1830 ± 40	AD 134–230 (0.68)	AD 80–258 (0.93), AD 300–318 (0.03)	182
41NA236	Beta-203669	1850 ± 90	–24.9	1850 ± 90	AD 61–256 (0.66)	39 BC–AD 385 (0.95)	169
41NA236	Beta-151097	1920 ± 40	–25.4	1910 ± 40	AD 31–37 (0.03), AD 52–132 (0.66)	AD 5–216 (0.95)	95
41NA236	Beta-203668	2000 ± 60	–24.6	2010 ± 60	91–70 BC (0.07), 60 BC–AD 65 (0.61)	174 BC–AD 90 (0.93), AD 100–124 (0.03)	–19
41NA236	Beta-151098	2370 ± 40	–24.7	2370 ± 40	510–436 BC (0.43), 426–393 BC (0.26)	735–690 BC (0.07), 663–649 BC (0.01), 546–382 BC (0.87)	–463
41NA243	Beta-154853	1770 ± 70	–26.2	1750 ± 70	AD 215–391 (0.68)	AD 86–106 (0.01), AD 121–428 (0.94)	285
41NA243	Beta-154854	2350 ± 60	–25.3	2350 ± 60	702–696 BC (0.01), 538–369 BC (0.67)	752–686 BC (0.10), 668–637 BC (0.03), 622–614 BC (0.00), 595–352 BC (0.74), 296–228 BC (0.07), 221–211 BC (0.01)	–454
41NA244	Beta-151102	1820 ± 40	–23.6	1840 ± 40	AD 130–226 (0.68)	AD 75–255 (0.95), AD 305–313 (0.01)	174
41NA248	Beta-151104	1670 ± 40	–26.0	1650 ± 40	AD 338–434 (0.65), AD 495–504 (0.03)	AD 260–284 (0.05), AD 323–520 (0.90)	400
41NA264	Beta-151105	2370 ± 110	–26.7	2340 ± 100	733–691 BC (0.08), 662–650 BC (0.02), 545–353 BC (0.47), 293–230 BC (0.11), 219–213 (0.01)	767–198 BC (0.95)	–451
41NA280	Beta-151107	1950 ± 40	–24.8	1950 ± 40	AD 3–85 (0.66), AD 110–115 (0.02)	41 BC–AD 129 (0.95)	50
41NA285	Beta-221421	1250 ± 40	–25.5	1240 ± 40	AD 690–752 (0.36), AD 761–783 (0.12), AD 788–815 (0.13), AD 844–859 (0.06)	AD 680–882 (0.95)	772
41NA285	Beta-201990	1240 ± 40	–23.9	1260 ± 40	AD 680–779 (0.68)	AD 668–870 (0.95)	744
41NA285	Beta-204786	1340 ± 40	–25.6	1330 ± 40	AD 652–695 (0.50), AD 701–707 (0.04), AD 748–765 (0.14)	AD 643–774 (0.95)	686
41NA285	Beta-221420	1560 ± 40	–23.2	1590 ± 40	AD 425–468 (0.30), AD 480–534 (0.40)	AD 392–562 (0.95)	480
41NA285	Beta-151112	2100 ± 40	–25.7	2090 ± 40	166–54 BC (0.68)	338–330 BC (0.01), 204 BC–AD 2 (0.95)	–113
41NA285	Beta-201989	2170 ± 40	–26.1	2150 ± 40	351–299 BC (0.24), 228–223 BC (0.02), 210–151 BC (0.32), 140–112 BC (0.11)	359–277 BC (0.30), 260–87 BC (0.62), 78–55 BC (0.04)	–196
41NA290	Beta-151116	1380 ± 40	–24.5	1390 ± 40	AD 617–665 (0.68)	AD 573–688 (0.95)	644
41RK170	Beta-166761	2110 ± 40	–24.0	2130 ± 40	342–326 BC (0.06), 204–94 BC (0.62)	355–290 BC (0.16), 232–46 BC (0.79)	–163
41RK214	B-107402**	1130 ± 50	–18.4	1240 ± 50	AD 689–753 (0.33), AD 760–822 (0.27), AD 842–861 (0.08)	AD 669–890 (0.95)	775
41RK214	Beta-81680	1810 ± 60	–23.4	1830 ± 60	AD 88–103 (0.05), AD 122–251 (0.63)	AD 55–343 (0.95)	186

Table 2 ^{14}C dates for the east Texas Woodland period.[a] *(Continued)*

Trinomial[b]	Sample nr	Raw age	$\delta^{13}C$ (‰)	Corrected ^{14}C age	1σ age range	2σ age range	Median
41RK222	Beta-60093	1400 ± 70	–24.3	1410 ± 70	AD 568–671 (0.68)	AD 439–486 (0.04), AD 532–730 (0.87), AD 735–772 (0.05)	626
41RK222	Beta-60094	1840 ± 100	–24.8	1840 ± 100	AD 64–260 (0.60), AD 284–323 (0.09)	44 BC–AD 410 (0.95)	180
41RK222	Beta-72776	1880 ± 80	–26.5	1850 ± 80	AD 70–250 (0.68)	20–13 BC (0.00), AD 1–382 (0.95)	168
41RK222	Beta-72770	1840 ± 60	–23.2	1870 ± 60	AD 78–217 (0.68)	AD 3–259 (0.93), AD 295–322 (0.02)	145
41RK222	Beta-72778	1860 ± 45	–22.0	1905 ± 50	AD 26–139 (0.62), AD 158–166 (0.02), AD 196–209 (0.04)	19–14 BC (0.01), AD 1–235 (0.95)	102
41RK222	Beta-72771	1980 ± 100	–24.6	1990 ± 100	151–140 BC (0.02), 112 BC–AD 126 (0.66)	351–298 BC (0.03), 228–222 BC (0.00), 211 BC–AD 242 (0.92)	–4
41RK328	—	—	—	1610 ± 40	AD 408–465 (0.35), AD 482–533 (0.33)	AD 348–369 (0.03), AD 379–547 (0.93)	463
41RK468	Beta-239710	2150 ± 40	–26.5	2130 ± 40	342–326 BC (0.06), 204–94 BC (0.62)	355–290 BC (0.16), 232–46 BC (0.79)	–163
41RK558	Beta-278035	1280 ± 40	–25.9	1270 ± 40	AD 682–774 (0.68)	AD 662–830 (0.89), AD 836–869 (0.06)	737
41SM273	Beta-157990	1270 ± 40	–25.7	1260 ± 40	AD 680–779 (0.68)	AD 668–870 (0.95)	744
41SM273	Beta-173089	1310 ± 40	–26.0	1290 ± 40	AD 670–722 (0.43), AD 741–770 (0.25)	AD 653–783 (0.91), AD 789–812 (0.03), AD 845–856 (0.01)	722
41SM273	Beta-154860	1400 ± 60	–25.0	1400 ± 60	AD 588–673 (0.68)	AD 540–721 (0.91), AD 741–770 (0.04)	634
41SM273	Beta-157989	1490 ± 70	–25.7	1480 ± 70	AD 469–479 (0.03), AD 534–650 (0.65)	AD 427–661 (0.95)	571
41SM273	Beta-173091	1520 ± 40	–24.9	1520 ± 40	AD 442–484 (0.19), AD 532–601 (0.49)	AD 430–617 (0.95)	546
41SM273	Beta-154857	1550 ± 80	–26.0	1530 ± 80	AD 433–497 (0.27), AD 503–599 (0.42)	AD 353–367 (0.01), AD 381–657 (0.95)	519
41SM273	Beta-173092	1590 ± 90	–25.9	1570 ± 90	AD 405–590 (0.68)	AD 259–295 (0.03), AD 322–648 (0.92)	482
41SM273	Beta-173095	1640 ± 40	–26.9	1610 ± 40	AD 408–465 (0.35), AD 482–533 (0.33)	AD 348–369 (0.03), AD 379–547 (0.93)	463
41SM273	Beta-173090	1680 ± 40	–24.4	1690 ± 40	AD 261–280 (0.11), AD 326–410 (0.58)	AD 249–426 (0.95)	353
41SM273	Beta-157991	1710 ± 40	–24.9	1710 ± 40	AD 259–296 (0.23), AD 322–388 (0.45)	AD 241–415 (0.95)	332
41SM273	Beta-182401	1710 ± 40	–25.1	1710 ± 40	AD 259–296 (0.23), AD 322–388 (0.45)	AD 241–415 (0.95)	332
41SM273	Beta-173097	1720 ± 40	–25.1	1720 ± 40	AD 257–300 (0.28), AD 318–382 (0.40)	AD 235–414 (0.95)	321
41SM273	Beta-182402	1810 ± 40	–25.0	1810 ± 40	AD 136–243 (0.68)	AD 86–109 (0.03), AD 120–264 (0.80), AD 275–334 (0.13)	201
41SY041	Beta-97897	960 ± 70	–6.0	1270 ± 70	AD 664–782 (0.58), AD 789–810 (0.08), AD 848–855 (0.02)	AD 645–896 (0.94), AD 924–938 (0.01)	755
41TT370	Beta-48882	2140 ± 100	—	2140 ± 100	356–286 BC (0.18), 234–50 BC (0.50)	394 BC–AD 29 (0.95), AD 39–50 (0.01)	–183
41TT372	Beta-70994	1290 ± 50	–26.4	1270 ± 50	AD 670–778 (0.68)	AD 660–875 (0.95)	744
41TT372	Beta-71006	1330 ± 60	–26.1	1310 ± 60	AD 657–728 (0.46), AD 736–772 (0.22)	AD 635–876 (0.95)	718
41TT372	Beta-71000	1420 ± 60	–26.8	1390 ± 60	AD 595–682 (0.68)	AD 545–724 (0.89), AD 739–771 (0.06)	643

Table 2 ^{14}C dates for the east Texas Woodland period.[a] *(Continued)*

Trinomial[b]	Sample nr	Raw age	δ^{13}C (‰)	Corrected ^{14}C age	1σ age range	2σ age range	Median
41TT372	Beta-70995	1800 ± 60	–25.3	1800 ± 60	AD 131–259 (0.58), AD 295–322 (0.10)	AD 81–382 (0.95)	220
41TT409	Beta-64984	1730 ± 60	–30.4	1640 ± 60	AD 340–442 (0.47), AD 454–461 (0.02), AD 484–533 (0.19)	AD 255–548 (0.95)	413
41TT409	Beta-64985	1710 ± 60	–25.5	1700 ± 60	AD 257–302 (0.21), AD 316–410 (0.47)	AD 172–193 (0.01), AD 211–465 (0.90), AD 482–533 (0.05)	340
41TT550	Beta-70989	2080 ± 60	–27.0	2050 ± 60	162–131 BC (0.12), 119 BC–AD 5 (0.56)	342–327 BC (0.01), 204 BC–AD 74 (0.94)	–70
41TT653	Beta-117272	1870 ± 50	–23.2	1900 ± 50	AD 29–38 (0.03), AD 51–140 (0.54), AD 151–170 (0.06), AD 194–210 (0.05)	AD 3–236 (0.95)	107
41TT847	Beta-242371	1360 ± 40	–26.6	1330 ± 40	AD 652–695 (0.50), AD 701–707 (0.04), AD 748–765 (0.14)	AD 645–772 (1.00)	686
41TT865	Beta-242373	2180 ± 40	–26.9	2150 ± 40	351–299 BC (0.24), 228–223 BC (0.02), 210–151 BC (0.32), 140–112 BC (0.11)	358–277 BC (0.31), 259–87 BC (0.65), 78–55 BC (0.04)	–196
41UR077	Beta-166910	1480 ± 50	–25.5	1470 ± 50	AD 558–640 (0.68)	AD 460–480, AD 520–660	589
41UR077	UGA-12983	1830 ± 40	–24.4	1840 ± 40	AD 130–226 (0.68)	AD 75–255 (0.95), AD 305–313 (0.01)	174
41UR077	UGA-12984	1840 ± 40	–24.8	1840 ± 40	AD 130–226 (0.68)	AD 75–255 (0.95), AD 305–313 (0.01)	174
41UR077	UGA-12971	2190 ± 40	–25.1	2190 ± 40	358–281 BC (0.42), 258–243 BC (0.06), 236–197 BC (0.20)	383–164 BC (0.95), 128–122 BC (0.01)	–278
41UR133	Beta-117743	—	—	2250 ± 60	391–350 BC (0.21), 304–209 BC (0.47)	406–170 BC (0.95)	–288
41WD495	Tx-3045	1760 ± 50	—	1760 ± 64	AD 180–187 (0.02), AD 214–382 (0.66)	AD 93–97 (0.00), AD 125–417 (0.95)	275

[a]Missing values in the Sample nr, Raw age, and δ^{13}C columns were not reported in technical reports.
[b]"Trinomial" refers to the Smithsonian trinomial numbering system where the state is indicated by a number ranging from 1 to 50, the county by 2–3 capitals, and the site within the county is represented by a number ranging from 1 to infinity.

To facilitate the statistical analysis, median ages were used to calculate the frequency of samples within each of the 5 major river basins in east Texas, and that information was used to inform a discussion of the average median age of Woodland sites in each river basin. To conclude the statistical analysis, a kernel density plot was created to explore potential populations within the sample of median ages.

Subsequent modifications include the addition of the North American Datum, UTM zone, UTM northing, UTM easting, and river basin. The river basins used in the analysis are the Red River basin (RRB), Sulphur River basin (SRB), Cypress Creek basin (CCB), Sabine River basin (SaRB), and the Neches River basin (NRB), as currently defined by the Texas Natural Resources Information System (TNRIS 2012) (Figure 1).

^{14}C Date Combination

The date combination process assumes that if all assays collected at a particular site draw carbon from the same reservoir, then they should have the same underlying F^{14}C value and can be combined prior to calibration (Bronk Ramsey 2008). The measurements have Gaussian uncertainty distribu-

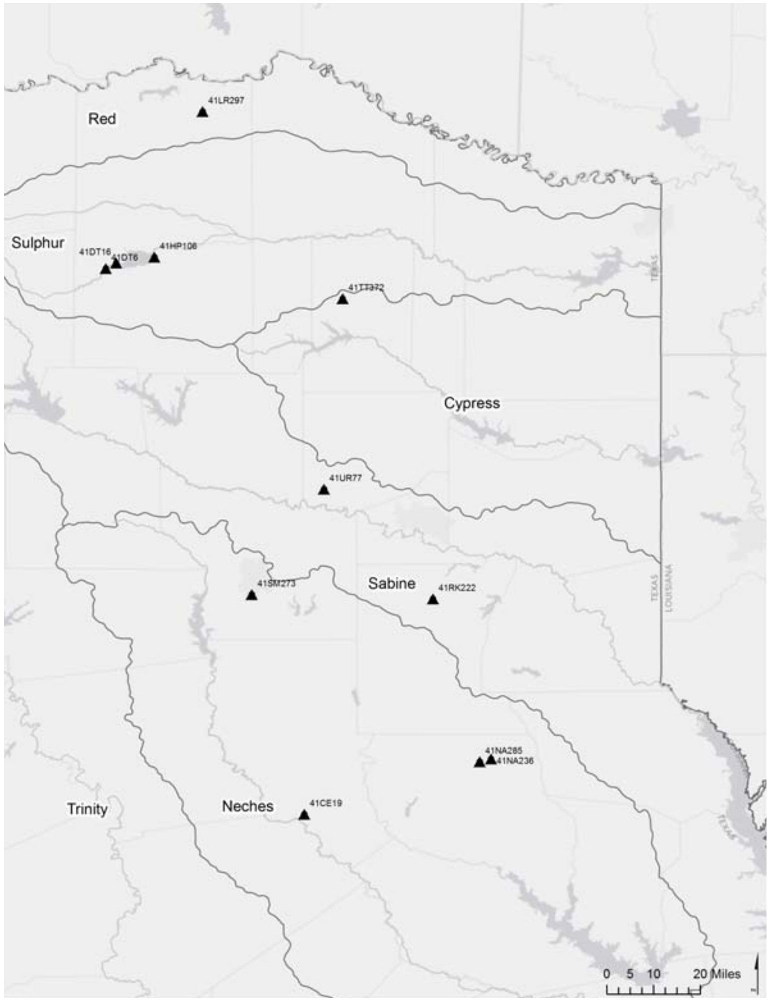

Figure 1 Map of east Texas river basins and the 11 Woodland period sites with 4 or more ^{14}C dates.

tions, and χ^2 was used to test the assumption that all ratios are the same to reveal whether compelling evidence exists—at the 95% confidence level—that dates cannot be related to the same event (Bronk Ramsey 2008). Each site-specific figure provides the SPDs, calibrated age range for combined assays, and all dates utilized to inform these results.

Although ^{14}C determinations are most often represented in the form $A \pm E$ where A is the ^{14}C estimate (BP) and E represents the standard deviation, the method of date combination can be used to create a new ^{14}C determination from multiple assays often with the ancillary benefit of a decrease in the standard deviation (Ward and Wilson 1978). To test whether a series of ^{14}C determinations are consistent, the pooled mean is calculated by way of A_p, where

$$A_p = \left(\sum_{1}^{n} A_i / E_i^2\right) / \left(\sum_{1}^{n} 1 / E_i^2\right) \quad (1)$$

followed by the test statistic, *T*, where

$$T = \sum_{1}^{n} (A_i - A_p)^2 / E_i^2 \tag{2}$$

the latter of which illustrates a χ^2 distribution on n–1 degrees of freedom under the null hypothesis (see Clark 1975:252; Ward and Wilson 1978:21).

Provided that the ^{14}C determinations are found not to be significantly different, they can then be combined with the pooled age as A_p given by *i*, and the variance given by

$$V(A_p) = \left(\sum_{1}^{n} 1/E_i^2\right)^{-1} \tag{3}$$

(Ward and Wilson 1978:21), which is a process accessible in OxCal by way of the R_Combine function. Once combined with R_Combine, a new date range, standard deviation, and median age is provided for the combined samples (Figure 2). Within the framework of this study, the new date range replaces the combined dates and was employed within the revised SPD, while the new median date was used for statistical analyses.

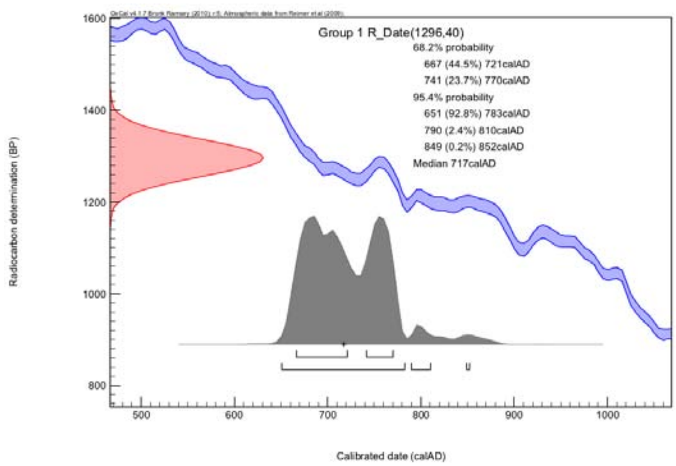

Figure 2 Calibrated results from the R_Combine function for 41DT16 Group 1

Calibration Curve

Conventional ^{14}C dates used within the framework of this study were recalibrated using IntCal09 (Figure 3). The curve serves as the basis for date calibration and can aid the process of archaeological interpretation by highlighting temporal zones with reversals and plateaus. Within the span of time assigned to the east Texas Woodland period (500 BC–AD 800), the curve can be seen to have 3 notable reversals of varying degrees (370–220 BC, AD 240–340, and AD 680–780). There are also 3 plateaus within the curve (500–420 BC, AD 140–210, and AD 430–540). While this does not produce clues regarding human behaviors, it does help to clarify why—even after combination—some date ranges have longer spans of probability for the calibrated date range.

Figure 3 IntCal09 ^{14}C calibration curve for the east Texas Woodland period

THE WOODLAND SAMPLE

The Woodland sites with 4 or more ^{14}C assays include George C Davis (41CE19), Tick (41DT6), Spike (41DT16), Hurricane Hill (41HP106), Stallings Ranch (41LR297), Naconiche Creek (41NA236), Boyette (41NA285), Herman Ballew (41RK222), Broadway (41SM273), 41TT372, and 41UR77. The number of ^{14}C samples from each site is heavily biased by the variable mitigation strategies and research designs used in archaeological practice. The ^{14}C samples from these sites are refined through date combination, where the results of date combination replaced the original assays, and then incorporated with the remaining 42 samples used in this analysis.

41CE19 (George C Davis Site)

The Woodland period ^{14}C dates for the George C Davis site (n = 7) have been combined into 2 groups (Figure 4). Group 1 consists of Tx-1223, -919, -105, -674, and -3312. Group 2 comprises Tx-3695 and a reported conventional ^{14}C age with an assay number that was not reported. The 2σ age ranges for the groups, AD 358–544 for Group 2 and AD 616–773 for Group 1, indicate a possible occupational hiatus of 72 ^{14}C yr. Occupation periods for the 2 ^{14}C groups span 186 and 157 cal ^{14}C yr, respectively.

41DT6 (Tick Site)

All ^{14}C dates from the Tick site (n = 5) were unable to be combined via the OxCal X test (Figure 5). Only 3 assays (Beta-51364, -51366, and -51367) were combined into Group 1, leaving the remaining assays (Beta-51368 and -51365) to populate the balance of the summed probability distribution. This site represents the singular example of overlapping occupations between AD 660–667, and the ^{14}C assays indicate a continuous, but probably episodic, occupation of 831 cal ^{14}C yr.

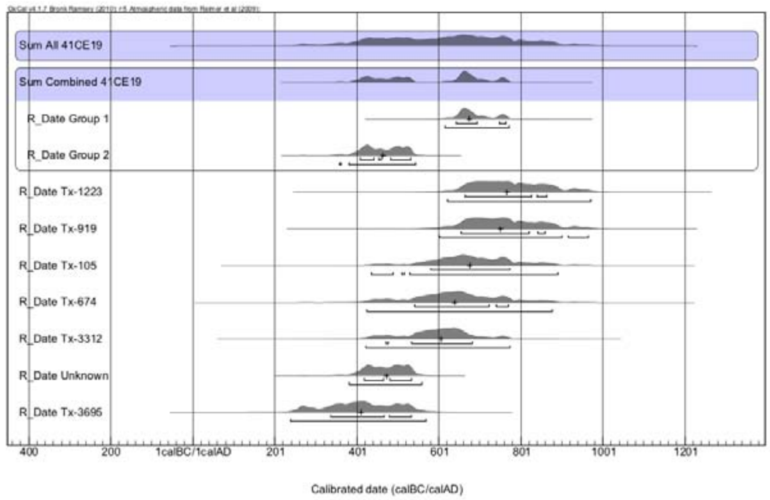

Figure 4 Combined 1σ and 2σ date ranges with median age illustrated, normal and combined summed probability distribution for ^{14}C dates from the George C Davis site (41CE19).

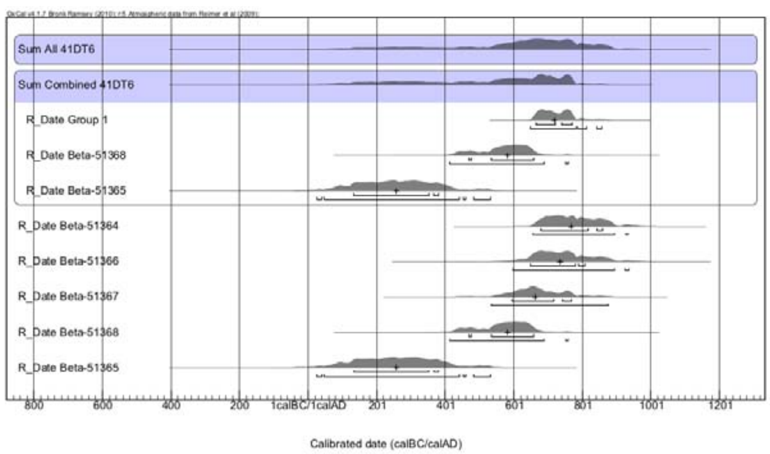

Figure 5 Combined 1σ and 2σ date ranges with median age illustrated, normal and combined summed probability distribution for ^{14}C dates from the Tick site (41DT6).

41DT16 (Spike Site)

There are 6 ^{14}C assays from the Spike site, 3 of which were combined, resulting in a final sample of 3 ^{14}C ages. Group 1 consists of Beta-52245 and -52244, and Group 2 includes Beta-52242, -52241, and -51372 (Figure 6). Beta-51371 was not able to be combined with the 2 other groups. Beta-51371 ranges from 336 BC–AD 21, the Group 2 range is AD 434–574, and Group 1 ranges from AD 667–770, indicating a temporal hiatus of 413 cal ^{14}C yr between Beta-51371 and Group 2, and 93 cal ^{14}C yr between Group 2 and Group 1. Occupational periods span 357, 140, and 103 cal ^{14}C yr, respectively.

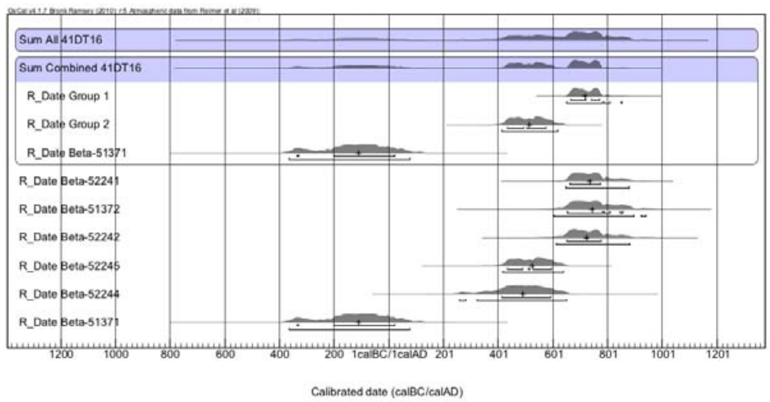

Figure 6 Combined 1σ and 2σ date ranges with median age illustrated, normal and combined summed probability distribution for ^{14}C dates from the Spike site (41DT16).

41HP106 (Hurricane Hill Site)

There are 7 ^{14}C dates from the Woodland period occupation at the Hurricane Hill site. Six of these (Beta-82913, -82914, -82915, -85866, -82917, and -85868) comprise Group 1, while a single and much earlier assay (Beta-85867) was unable to be combined with the other dates (Figure 7). The Beta-85867 date ranges from 398–202 BC and Group 1 dates indicate an occupation ranging from AD 85–235; there is a temporal hiatus of 287 cal ^{14}C yr between the 2 occupations. Occupational periods span 150 and 196 cal ^{14}C yr, respectively.

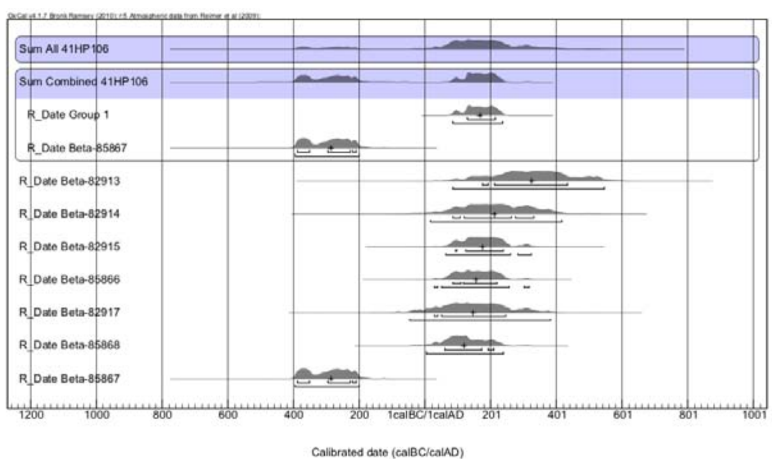

Figure 7 Combined 1σ and 2σ date ranges with median age illustrated, normal and combined summed probability distribution for ^{14}C dates from the Hurricane Hill site (41HP106).

41LR297 (Stallings Ranch Site)

Only 2 of the ^{14}C dates from the Stallings Ranch site ($n = 4$) were combined. The assays with the latest (Beta-239524) and the earliest (Beta-237678) calibrated age ranges are plotted individually, and Group 1 consists of Beta-237680 and -237677 (Figure 8). There are 3 possible occupations at Stallings Ranch, the first (Beta-237678) ranging from 736–211 BC, with a peak distribution at 400 BC, Group 1 from AD 432–619, and AD 656–870 for Beta-239524. This indicates a 643 cal ^{14}C yr hiatus between the first and second occupations, and a 37 cal ^{14}C yr hiatus between the second and third. Occupational periods span 525, 187, and 214 cal ^{14}C yr, respectively.

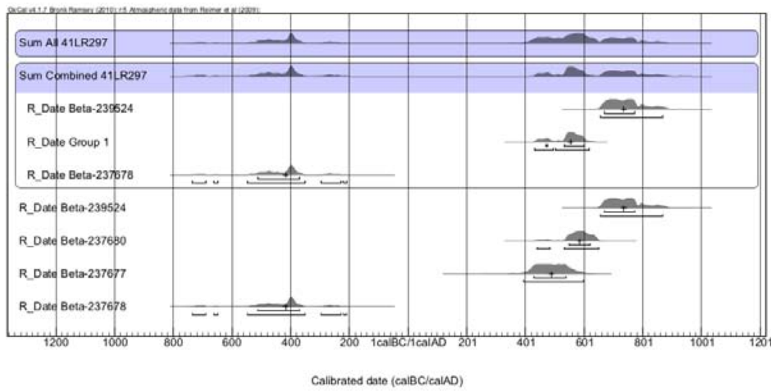

Figure 8 Combined 1σ and 2σ date ranges with median age illustrated, normal and combined summed probability distribution for ^{14}C dates from the Stallings Ranch site (41LR297).

41NA236 (Naconiche Creek Site)

The ^{14}C dates from the Naconiche Creek site (n = 9) were combined into 2 groups, excluding only a single and older assay (Beta-151098) (Figure 9). Group 1 encompasses the Beta-183857, -203667, -204783, and -203666 samples. Group 2 consists of the samples Beta-204782, -203669, -151097, and -203668. Beta-151098 spans the period from 735–382 BC, Group 2 ranges from AD 56–214, and Group 1 extends from AD 541–636, indicating an occupational hiatus of 438 cal ^{14}C yr between the first and second occupations, and 327 cal ^{14}C yr between the second and third occupations. Occupational periods span 353, 158, and 95 cal ^{14}C yr, respectively.

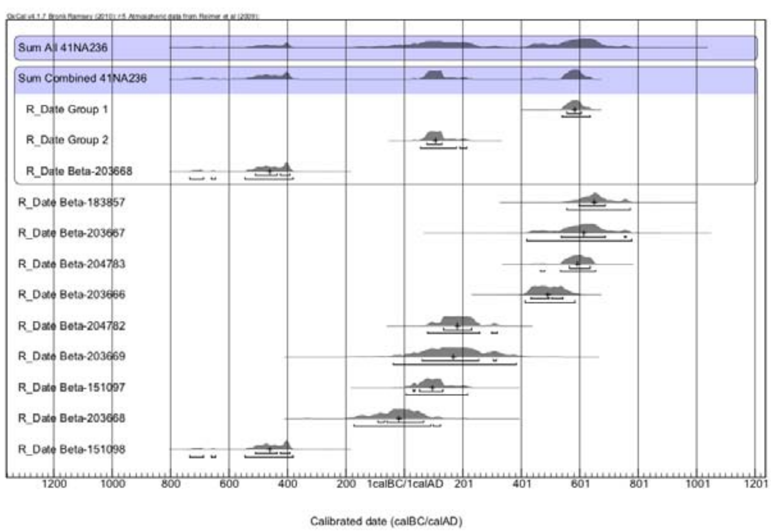

Figure 9 Combined 1σ and 2σ date ranges with median age illustrated, normal and combined summed probability distribution for ^{14}C dates from the Naconiche Creek site (41NA236).

41NA285 (Boyette Site)

^{14}C dates from the Boyette site (*n* = 6) were combined into 2 groups with a single uncombined exception (Beta-221420) (Figure 10). Group 1 comprises 3 assays (Beta-221421, -201990, and -204786), while Group 2 consists of 2 assays (Beta-151112 and -201989). Group 2 dates from 197–107 BC, Beta-221420 dates from AD 425–534, and Group 1 ranges from AD 685–770, indicating a temporal hiatus of 532 cal ^{14}C yr between Group 2 and Beta-221420, and 151 cal ^{14}C yr between Beta-221420 and Group 1. Occupational periods span 90, 109, and 85 cal ^{14}C yr, respectively.

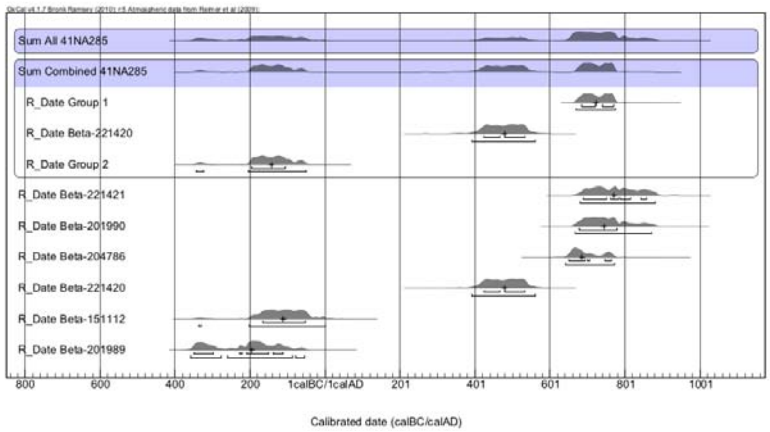

Figure 10 Combined 1σ and 2σ date ranges with median age illustrated, normal and combined summed probability distribution for ^{14}C dates from the Boyette site (41NA285).

41RK222 (Herman Ballew Site)

The ^{14}C dates from the Herman Ballew site (*n* = 6) were combined into 1 group (*n* = 5), excluding only a single and younger assay (Beta-60093) (Figure 11). Group 1 consists of Beta-60094, -72776, -72770, -72778, and -72771. The 2σ age range for Group 1 is AD 54–221, and AD 439–772 is the calibrated age range for the Beta-60093 assay. This indicates a possible hiatus of 218 cal ^{14}C yr between occupations. Occupational periods span 167 and 333 cal ^{14}C yr, respectively.

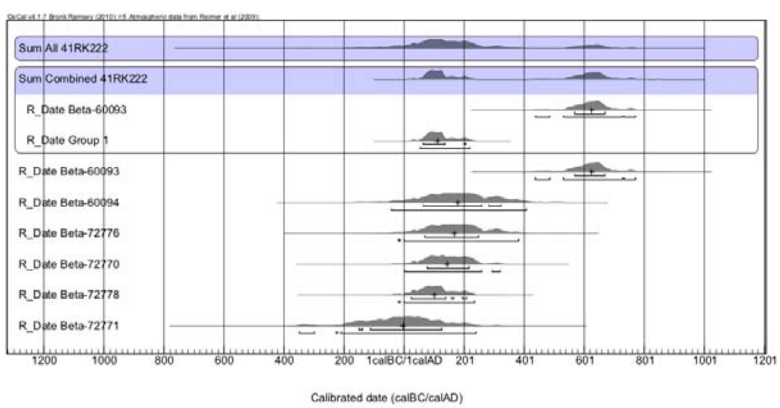

Figure 11 Combined 1σ and 2σ date ranges with median age illustrated, normal and combined summed probability distribution for ^{14}C dates from the Herman Ballew site (41RK222).

41SM273 (Broadway Site)

The 13 ^{14}C dates from the Woodland period occupation at the Broadway site were combined into 3 groups (Figure 12). Group 1 consists of 2 assays (Beta-157990 and -173089), Group 2 has 6 assays (Beta-154860, -157989, -173091, -154857, -173092, and -173095), and Group 3 has 5 assays (Beta-173090, -157991, -182401, -173097, and -182402). Group 3 dates from AD 257–344, Group 2 has an age range from AD 442–574, and Group 1 dates from AD 685–771, indicating a temporal hiatus of 98 cal ^{14}C yr between Group 3 and Group 2, and 111 cal ^{14}C yr between Group 2 and Group 1. Occupational periods span 87, 132, and 86 cal ^{14}C yr, respectively.

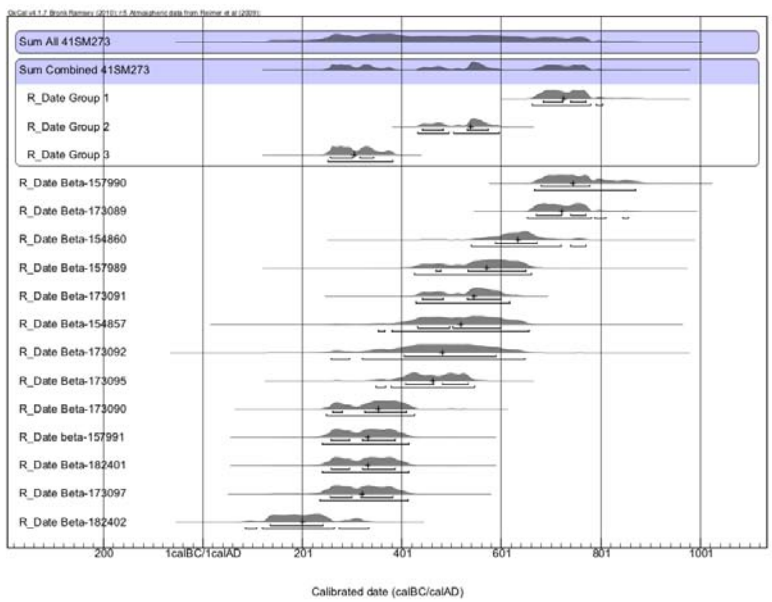

Figure 12 Combined 1σ and 2σ date ranges with median age illustrated, normal and combined summed probability distribution for ^{14}C dates from the Broadway site (41SM273).

41TT372

^{14}C dates for 41TT372 ($n = 4$) were combined into a single group ($n = 3$), excluding 1 earlier assay (Beta-70995) (Figure 13). Group 1 consists of Beta-70994, -71006, and -71000. The early assay (Beta-70995) ranges from AD 131–322, and Group 1 dates from AD 659–765, indicating a temporal hiatus of 337 cal ^{14}C yr between occupations. Occupational periods span 191 and 106 cal ^{14}C yr, respectively.

41UR77

^{14}C dates from 41UR77 ($n = 4$) were combined into a single group with 2 dates, and there are 2 younger and older exclusions (Beta-166910 and UGA-12971, respectively) that could not be grouped (Figure 14). Group 1 consists of UGA-12983 and UGA-12984. The 2σ age range for UGA-12971 is 358–197 BC, for Group 1 it is AD 133–215, and for Beta-166910 the age range is AD 558–640. This indicates a temporal hiatus of 330 cal ^{14}C yr between the first and second occupations, and 343 cal ^{14}C yr between the second and third occupations. Occupational periods span 161, 82, and 82 cal ^{14}C yr, respectively.

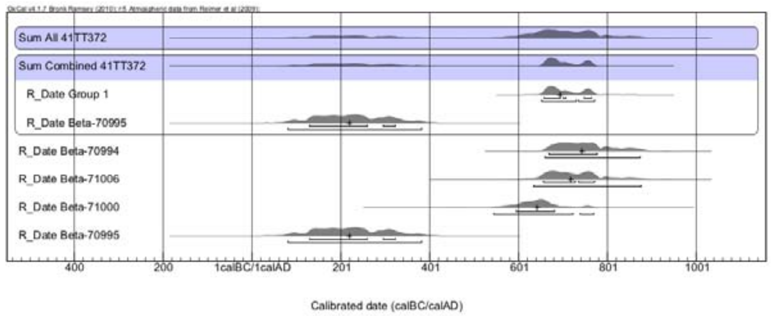

Figure 13 Combined 1σ and 2σ date ranges with median age illustrated, normal and combined summed probability distribution for ^{14}C dates from 41TT372.

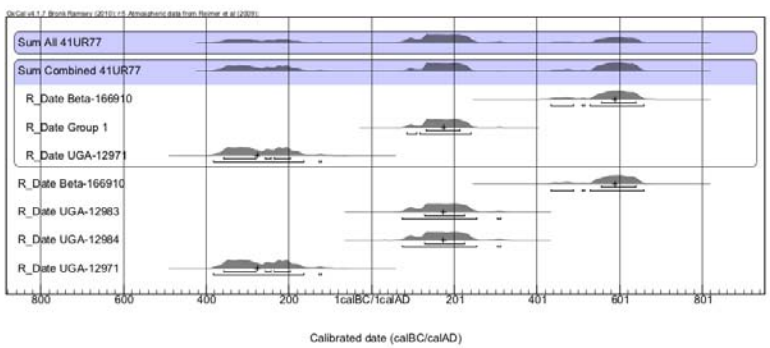

Figure 14 Combined 1σ and 2σ date ranges with median age illustrated, normal and combined summed probability distribution for ^{14}C dates from 41UR77.

RESULTS

Through the date combination (R_Combine) process, the number of assays decreased from 127 to 85, which lowered the standard deviation for the combined group while reducing the number of median ages to be used in the statistical analysis. Summed probability distributions were then produced for each site with 4 or more dates to better illustrate when diffuse and discrete periods of occupation can be identified.

The SPD for the whole of the Woodland period was created using the revised (i.e. combined from sites with 4 ^{14}C assays) sample of 85 ^{14}C dates from 51 archaeological sites in east Texas (Figure 15). This representation of these data is not biased by sites with larger numbers of samples due to the date combination process. While not discussed here, those sites with <4 ^{14}C assays that conformed to methodological constraints were included in the Woodland SPD.

Temporal Considerations

Incorporating these results into a revised Woodland sample reduces the number of ^{14}C assays from 127 to 85. The final sample represents Woodland components from 51 archaeological sites in the Red River (n = 7 dates), Sulphur River (n = 20), Cypress Creek (n = 10), Sabine River (n = 20), and Neches River (n = 26) basins (Figure 16). The sample was sorted by median age, illustrating that the dates for Woodland period sites—when ordered by appearance—are oldest in the Red River basin (AD 134), followed by Cypress Creek (AD 202), Sulphur (AD 251), Sabine River (AD 296), and Neches River basins (AD 312) (Figure 16).

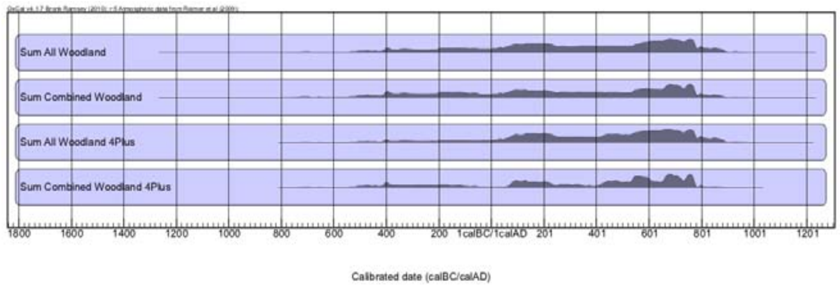

Figure 15 Summed probability distributions contrasting all and combined dates from the entirety of the sample, and from those sites with 4 ^{14}C dates.

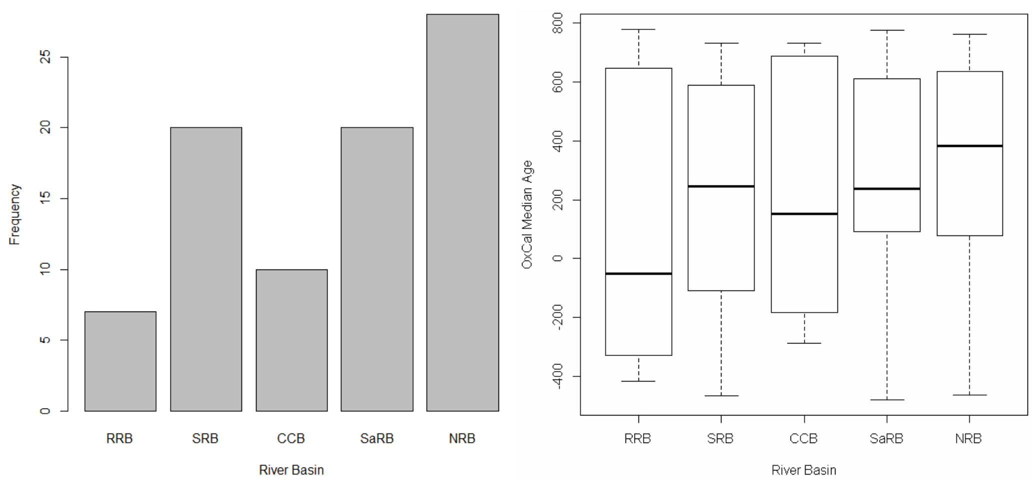

Figure 16 Frequency of samples (left) and boxplot of median ages (right) by river basin

A summed probability distribution was calculated for the entirety of the Woodland period, and illustrates the temporal placement of Woodland components from key sites in east Texas (Figure 17). Although the number of sites is small, they highlight a possible temporal hiatus of nearly 400 yr in the Red River basin, and another of nearly 200 yr in the Cypress Creek basin, both of which appear here on the basis of data from 1 site in each river basin. The remaining peaks correlate with populations from the kernel density plot, and they illustrate a small peak in the Red River basin around 400 BC followed by slight increases in the dates from the Sulphur, Cypress, and Sabine basins around 200 BC. This is prior to a 200-yr peak in dates from the Sulphur and Sabine River basins for AD 50–220, after which a marked increase occurs in the number of dated Woodland sites for the Sulphur, Cypress, Sabine, and Neches River basins from AD 600–800.

The temporal character of Woodland occupations from the 11 sites has been dissected and then reassembled to illustrate the temporal range of occupations and hiatuses for each (Table 3). The diversity of occupational length within the sample ranges from an average of 95–831 cal ^{14}C yr, with breaks of 0–382 cal ^{14}C yr. Of the 11 sites, 1 may have been continually—if episodically—occupied (41DT6), 4 have 2 discretely dated occupational events (41HP106, 41TT372, 41RK222, and 41CE19), and 6 have 3 discretely dated occupational events (41LR297, 41DT16, 41UR77, 41NA236, 41NA285, and 41SM273).

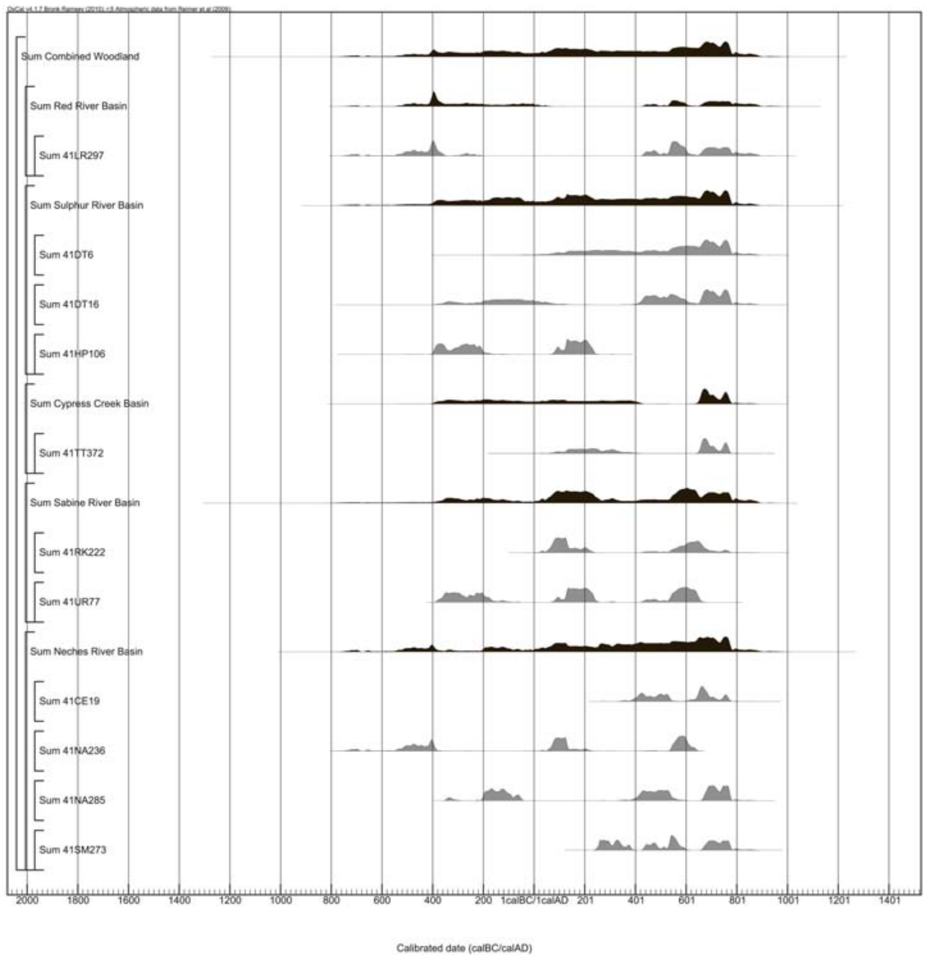

Figure 17 Summed probability distributions illustrating the impact of the 11 sites on the whole of the period, and upon the associated river basin.

Table 3 Occupations and hiatuses by river basin for sites with 4 ^{14}C dates.[a]

River Basin	Site	O(1)	H(1)	O(2)	H(2)	O(3)	AOL	AHL
Red	41LR297	525	643	187	37	214	309	340
Sulphur	41DT6	831	—	—	—	—	831	0
	41DT16	357	413	140	93	103	200	253
	41HP106	150	287	196	—	—	173	287
Cypress	41TT372	191	337	106	—	—	149	337
Sabine	41RK222	167	218	333	—	—	250	218
	41UR77	161	330	82	343	82	108	337
Neches	41CE19	186	72	157	—	—	172	72
	41NA236	353	436	158	327	95	202	382
	41NA285	90	532	109	151	85	95	342
	41SM273	87	98	132	111	86	102	105

[a]O = occupation; H = hiatus; AOL = average occupation length; AHL = average hiatus length.

Spatial Considerations

It has become increasingly apparent that there was no preference for river basin or natural region by this prehistoric population as they began to intensify upon the landscape within the Post Oak Savannah, Blackland Prairie, and Pineywoods of east Texas. In fact, Woodland period populations settled in all 3 natural regions within the Red, Sulphur, Cypress Creek, Sabine, and Neches River basins. While the great majority of Woodland sites fall within the Austroriparian biotic province (Blair 1950:98), some sites—those in the western Red River and Sulphur River basins—occur within the Texan biotic province. The western boundary of the Austroriparian is limited by moisture (Blair 1950:99), and rainfall amounts range from 44 inches on the western margin of the province to 56 inches on the eastern border of Texas (Window on State Government 2012). While this region boasts the highest annual rainfall for the state, it lies within the Region of Summer Drought as characteristically defined by Carr (1967:17), where he notes that,

> "[o]ne abnormal climatologic occurrence which would have deleterious effects on East Texas would be the loss in April and May of the generous rainfalls which occur there during these months and again in November and December. These are the two peak rainfall periods before and after the summer-drought months. The loss of peak rainfalls during these months could result in a year-long drought—not merely a summer drought."

This cyclical pattern produces a winter surplus and summer deficiency of water for the region (see Carr 1967: Figure 7), and may be a factor in the geographic location of Woodland-period settlements. While impossible to determine from the record of ^{14}C dates alone, shifts in residential strategies of these semi-nomadic to semi-sedentary populations may have much to do with the variability in rainfall, since seasonal shortcomings could have caused a dramatic shift in the availability of regionally important ecological resources.

Another consideration of residential strategies is trade. This is defined by Perttula and Bruseth (1990:95) as "the movement of objects or materials to be used in the production of objects back and forth between different groups." Archaeologically, participation in extra-local trade follows—virtually entirely—500 BC and continues to mature through the entirety of the Woodland period before fluorescing during the Caddo period in east Texas (~800–1680) (Perttula and Bruseth 1990).

Through the analysis of median dates by way of kernel density and hierarchical cluster analysis, Woodland period median dates were found to encompass 3 potential divisions (Figure 18). Although the small sample size prevents these results from achieving the appropriate level of significance—750 by Michczyńska and Pazdur (2004) and 500 by Williams (2012)—they do warrant mention here.

These temporal trends were manifest within the geographic boundaries for east Texas Woodland populations of the Fourche Maline (Schambach 1998, 2002), Mill Creek (Perttula and Nelson 2004), and Mossy Grove (Story 1990) culture areas, and appear to support Schambach's (1998:128) hypothesis that the Caddo culture developed "in situ in the Trans-Mississippi South." However, this observation appears true for all 3 currently defined culture areas in east Texas and is not limited to the Fourche Maline.

The demonstrated occupational episodes represent the cultural antecedents of the later prehistoric and protohistoric Caddo populations (~AD 800–1680) and the shift from a hunter-gatherer and horticultural economy to one dominated by agriculture within greater east Texas. While lacking in detailed temporal correlations with the material culture of the different Woodland culture areas, the 11 sites surveyed within this study illustrate a significant increase in site use during the period of AD 400–800.

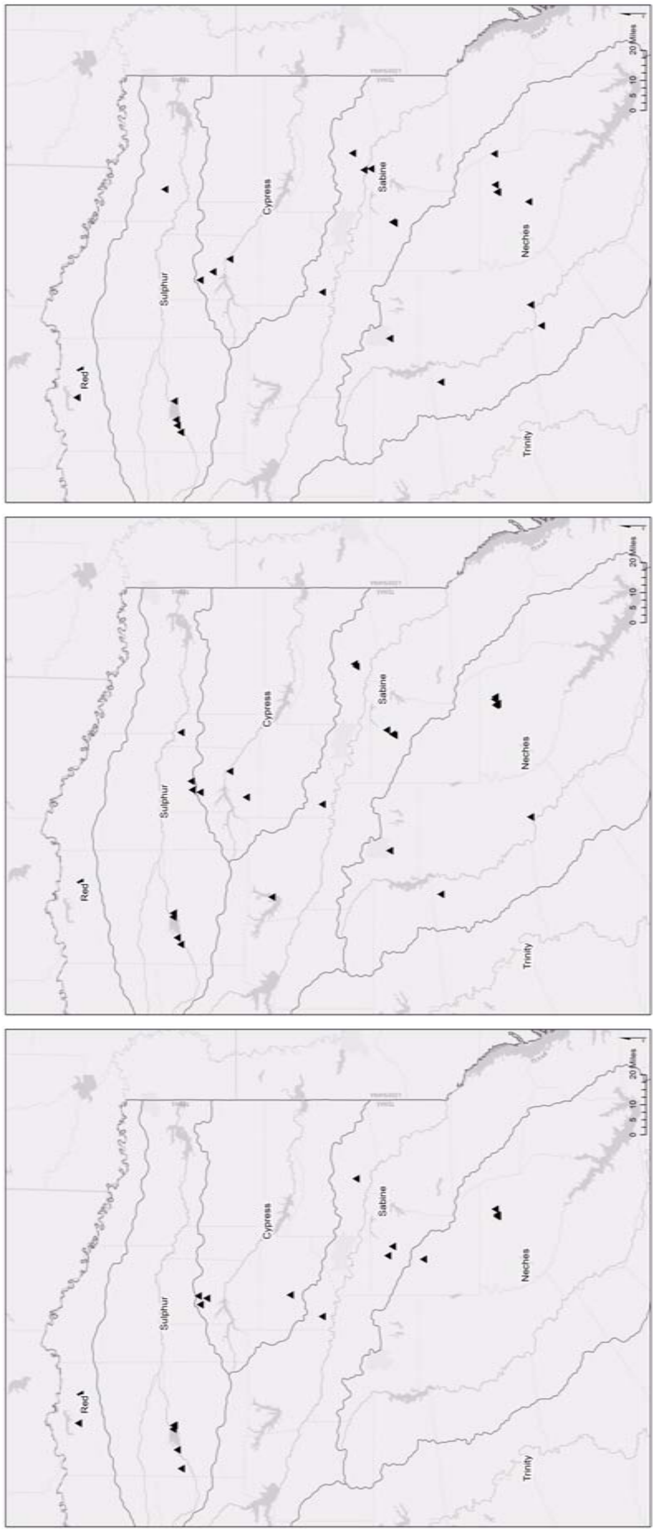

Figure 18 From left to right, Early Woodland (500 BC–AD 0), Middle Woodland (AD 0–400), and Late Woodland (AD 400–800) archaeological sites

The temporal distribution of occupational episodes for Woodland sites in east Texas (see Figure 17) increased exponentially after AD 400 and the associated hiatuses decreased in both frequency and duration. Prior to AD 400, only 13 occupational episodes occurred throughout an 800 cal ^{14}C yr period, while the number of occupational episodes increased to 16 during the last 400 cal ^{14}C yr of the Woodland period. This trend is indicative not only of a larger population, but possibly a more sedentary lifestyle, which may temporally demonstrate the cultural shift from hunter-gatherer to agriculturalist.

DISCUSSION

Due to depositional and contextual issues and the wide variety of mitigation strategies and research designs employed throughout the region, the western boundary of the Eastern Woodlands remains one of the least well-known and explored periods in the greater Southeast. This can be seen plainly when the number of components from Woodland period sites is contrast against the much more robust representation of ^{14}C dates from the Caddo period. The fact that only 127 of the 1248 ^{14}C samples in the East Texas Radiocarbon Database are representative of this period speaks to the need for further research.

These results present a significant advancement in the manner by which ^{14}C assays may be manipulated for use within summed probability distributions. At the regional and sometimes local scale, most archaeologists have encountered at least 1 very well-dated site. These sites, while often incredibly informative at the microscale, are fairly detrimental to macrolevel analyses due to the amount of bias they introduce. Through incorporation of date combination to studies of summed probability distribution, the amount of site-specific sample bias can be reduced.

Although not essential to this analysis due to sample size, consideration should be given to taphonomic loss (see Surovell and Brantingham 2007; Surovell et al. 2009; Peros et al. 2010) and land-use patterns (see Grove 2008, 2009, 2011) once the sample size threshold is surpassed. When coupled with the method of date combination, these tools can further clarify much of the ambiguity encountered as we continue to move forward with our analyses of these data at the regional scale.

SUMMARY AND CONCLUSION

Regionally, statistical nuances within the data appear to illustrate the likelihood of 3 temporal divisions and an increase in occupational episodes post ~AD 400. While more research needs to be completed to reveal the nature of the cultural shift from hunter-gatherer/part-time horticulturist to a more agriculturalist lifestyle, this investigation illustrates those sites with temporal components that would likely be more fruitful than others within the framework of that endeavor.

Subsequent efforts to refine the chronology of the material culture from these different components should take the form of case studies from specific Woodland period sites where artifacts were recovered in association with ^{14}C samples. As that effort expands, our knowledge of the temporal and spatial distributions of specific artifact classes, types, and assemblages can be enhanced. We are quickly approaching an era where typological assignments can be associated with ^{14}C samples in this same manner, but significant advances in correlating these data with specific aspects of archaeological assemblages still need to be made as we progress in our analyses of the Woodland period of east Texas.

This analysis represents only a small sample of ^{14}C dates from the ETRD, which remains a large and understudied amalgam of ^{14}C dates that is available for use within current cultural resource management endeavors. Through the systematic employment of this methodological approach, it is plausible that similar analyses would strengthen the arguments presented here (i.e. shorter hiatuses during the later and better-understood Caddo period, and longer hiatuses ranging from the Archaic through Paleoindian periods), providing a productive medium through which dialogues regarding the material culture of east Texas can continue to be developed.

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REFERENCES

Bamforth DB, Grund B. 2012. Radiocarbon calibration curves, summed probability distributions, and early Paleoindian population trends in North America. *Journal of Archaeological Science* 39(6):1768–74.

Barnhart E, Dixon B, Kotter S, Nash M, Reese-Taylor K, Skokan E, Taylor R. 1997. *Data Recovery Excavations at Site 41 TT372 in the Tankersley Creek Watershed, Monticello B-2 Surface Mine, Titus County, Texas*. Document No. 940608. Espey Huston & Associates, Inc., Austin.

Bernard HR. 2006. *Research Methods in Anthropology: Qualitative and Quantitative Approaches*. New York: AltaMira Press.

Bever MR. 2006. Too little, too late? The radiocarbon chronology of Alaska and the peopling of the New World. *American Antiquity* 71(4):595–620.

Blair WF. 1950. The biotic provinces of Texas. *The Texas Journal of Science* 2(1):93–113.

Bronk Ramsey C. 2008. Radiocarbon dating: revolutions in understanding. *Archaeometry* 50(2):249–75.

Bronk Ramsey C. 2012. OxCal 4.1.7/ORAU. Electronic resource. URL: https://c14.arch.ox.ac.uk/login/login.php?Location=/oxcal/OxCal.html. Accessed January 2012.

Brewington RL, Dockall JE, Shafer HJ. 1995. *Archaeology of 41MX5: A Late Prehistoric Caddoan Hamlet in Morris County, Texas*. Report of Investigations No. 1. Center for Environmental Archaeology, Texas A&M University, College Station.

Bruseth JE, Perttula TK. 1981. *Prehistoric Settlement Patterns at Lake Fork Reservoir.* Texas Antiquities Permit Series, Report No. 2. Austin: Texas Antiquities Committee; Dallas: Southern Methodist University.

Bruseth J, Durst J, Proctor R, Banks L, Sykes G, Pierson B. 2009. Investigations at the Gene and Ruth Ann Stallings Ranch Site (41LR297). *Bulletin of the Texas Archeological Society* 80:195–205.

Bryant VM, Holloway RG. 1985. A Late Quaternary paleoenvironmental record of Texas: an overview of the pollen evidence. In: Bryant VM, Holloway RG, editors. *Pollen Records of Late Quaternary North American Sediments*. Dallas: American Association of Stratigraphic Palynologists Foundation. p 39–70.

Carr JT. 1967. *The Climate and Physiography of Texas*. Report 53, Texas Water Development Board.

Clark RM. 1975. A calibration curve for radiocarbon dates. *Antiquity* 49(196):251–66.

Cliff MB, Sills EC, Acuna L, Dering P. 2004. *Results of National Register Investigations Conducted on Site 41RK328, Rusk County, Texas*. Document No. 040010. PBS&J, Dallas.

Cooper JH, Cooper ES. 2005. *Archaeological Investigations of 291 Acres at Mission Tejas State Park, Houston County, Texas*. Report of Investigations No. 2004-06. C-Dimensions, Plano.

Corbin JE. 1984. *An Archaeological Assessment of a Portion of the Washington Square Mound Site (41NA49), Nacogdoches County, Texas*. Archaeological Investigations No. 1. Stephen F Austin State University, Nacogdoches.

Corbin JE, Hart JP. 1998. The Washington Square Mound Site: A Middle Caddo mound complex in south central East Texas. *Bulletin of the Texas Archeological Society* 69:47–78.

Corbin JE, Kisling DC, Oakes S, Hart JP. 1984. *Archaeological Investigations of the Washington Square Mound Site (41NA49), Nacogdoches County, Texas*. Papers in Anthropology No. 5. Stephen F. Austin State University, Nacogdoches.

Davis MW, Earls AC, Tomka MSF. 1992. *1987 Archeological Excavations at the George C. Davis Site (41CE19), Caddoan Mounds State Historical Park, Cherokee County, Texas*. Technical Report No. 1. Texas Parks and Wildlife Department, Austin.

DeWalt BR, Pelto PJ. 1985. *Micro and Macro Levels of Analysis in Anthropology: Issues in Theory and Research*. London: Westview Press.

Dixon B, Kotter S, Taylor R. 1997. *Data Recovery Excavations at the Mockingbird Site (41TT550): The Archaic and Early Caddo Components*. Document No. 970735. Espey, Huston & Associates, Inc., Austin.

Dixon B, Smith C, Loftus S, Shipp J, Ellis L, Shortes R, Harris B, Rogers R, Wallace C, Nash M. 2009. *Intensive Cultural Resources Survey of the Proposed South Henderson Deposit First 5-Year Area and Ancillary Properties, Rusk County, Texas*. Document No. 080138. PBS&J, Austin.

Dockall JE Fields RC. 2011. *National Register Testing of Three Sites in the Sabine Mine's South Hallsville No. 1 Mine-Rusk Permit, Rusk County, Texas*. Report of Investigations No. 162. Prewitt and Associates, Inc., Austin.

Dockall J, Katauskas S, Fields R. 2008. *National Register Testing of Four Sites in the Sabine Mine's Area M, Harrison County, Texas*. Report of Investigations No. 157. Prewitt and Associates, Inc., Austin.

Doehner K, Larson RE. 1978. *Archaeological Research at Cooper Lake, Northeast Texas, 1974–75*. Research Report No. 108. Archaeology Research Program, Southern Methodist University, Dallas.

Fields RC, Gadus EF, editors. 2012. *Archeology of the Nadaco Caddo: The View from the Pine Tree Mound Site (41HS15), Harrison County, Texas*. Report of Investigations No. 164. Prewitt and Associates, Inc., Austin.

Fields RC, Blake ME, Kibler KW. 1997. *Synthesis of the Prehistoric and Historic Archeology of Cooper Lake, Delta and Hopkins Counties, Texas*. Report of Investigations No. 104. Prewitt and Associates, Inc., Austin.

Fields RC, Gadus EF, Klement LW, Bousman CB, McLerran JB. 1993. *Excavations at the Tick, Spike, Johns Creek, and Peerless Bottoms Sites, Cooper Lake Project, Delta & Hopkins Counties, Texas*. Report of Investigations No. 91. Prewitt and Associates, Inc., Austin.

Gadus EF, Fields RC, McWilliams JK, Dockall J, Wilder MC. 2006. *National Register Testing of Seven Prehistoric Sites in the Sabine Mine's Area Q, Harrison County, Texas*. Report of Investigations, No. 147. Prewitt and Associates, Inc., Austin.

Galan V. 1998. Excavations at 41TT653, the Ear Spool Site. *CRM News & Views* 10(2):21–5. Archaeology Division, Texas Historical Commission, Austin.

Grove M. 2008 The evolution of hominin group size and land use: an archaeological perspective [unpublished PhD dissertation]. University of London.

Grove M. 2009. Hunter-gatherer movement patterns: causes and constraints. *Journal of Anthropological Archaeology* 28(2):222–33.

Grove M. 2011. A spatio-temporal kernel method for mapping changes in prehistoric land-use patterns. *Archaeometry* 53(5):1012–30.

Hassan FA. 1984. Radiocarbon chronology of predynastic Dagada settlements, Upper Egypt. *Current Anthropology* 25(5):681–3.

Hatfield V, Kibler KW, Fields RC. 2008. *Interim Report on Eligibility Testing at 41TT6, 41TT846, 41TT847, 41TT851, 41TT852, 41TT853, 41TT854, 41TT858, 41TT862, 41TT865, and 41TT866, U.S. Highway 271 Mount Pleasant Relief Route, Titus County, Texas*. Prewitt and Associates, Inc., Austin.

Kotter SM, Rogers R, Taylor R, Reese-Taylor K, Glander WE. 1993. *Archaeological Investigations within the Monticello B-2 First Five Year Disturbance Area, Titus County, Texas*. Document No. 920013. Espey, Huston & Associates, Inc., Austin.

Kuzmin YV, Keates SG. 2005. Dates are not just data: Paleolithic settlement patterns in Siberia derived from radiocarbon records. *American Antiquity* 70(4):773–89.

Lohse JC, with contributions by T. K. Perttula and R. A. Ricklis. 2004. *Interim Report on Archaeological Testing at 41AN38 and 41AN159, Anderson County, Texas*. Coastal Environments, Inc., Corpus Christi.

Mahoney R, Crawford C, Mauldin R, Nordt L, Perttula T, Reyna S. 2001. *Camp Maxey III, Archaeological Testing of 23 Prehistoric Sites, Lamar County, Texas*. Archaeological Survey Report No. 314. Center for Archaeological Research, The University of Texas at San Antonio.

Mahoney RB, Tomka SA, Weston J, Mauldin R. 2002. *Camp Maxey IV: Archaeological Testing of Six Sites, Lamar County, Texas*. Archaeological Survey Report No. 326. Center for Archaeological Research, The University of Texas at San Antonio.

Michczyńska DJ, Pazdur A. 2004. Shape analysis of cumulative probability density function of radiocarbon dates set in the study of climate change in the Late Glacial and Holocene. *Radiocarbon* 46(2):733–44.

Nelson B, Perttula TK. 2006a. Archaeological investigations at the Polk Estates Site (41CP245), Camp County, Texas. *Journal of Northeast Texas Archaeology* 24:1–83.

Parsons M. 1998. 41UR133: a Late Caddo hamlet at Lake Gilmer. Division of Antiquities Protection, Texas Historical Commission, Austin. *Cultural Resource Management News & Views* 10(1):16–9.

Peros MC, Munoz SE, Gajewski K, Viau AE. 2010. Prehistoric demography of North America inferred from radiocarbon data. *Journal of Archaeological Science* 37(3):656–64.

Perttula TK. 1997. A compendium of radiocarbon and oxidizable carbon ratio dates from archaeological sites in east Texas, with a discussion of the age and dating of select components and phases. *Radiocarbon* 39(3): 305–42.

Perttula TK. 1998. Radiocarbon and oxidizable carbon ratio dates from archaeological sites in east Texas, part II. *Journal of Northeast Texas Archaeology* 11:66–90.

Perttula TK. 1999. Current archeological investigations at the Pilgrim's Pride Site (41CP304) in Camp County, Texas. *Caddoan Archeology* 10(2):7–18.

Perttula TK. 2000. Functional and stylistic analyses of ceramic vessels from mortuary features at a 15th and 16th century Caddo site in northeast Texas. *Midcontinental Journal of Archaeology* 25(1):101–51.

Perttula TK, editor. 2002. *Archeological Investigations at the Proposed Lake Naconiche, Nacogdoches County, Texas*. Report of Investigations No. 42. Archeological and Environmental Consultants, LLC, Austin.

Perttula TK. 2008a. Analysis of the historic Caddo ceramics from 41NA223 in downtown Nacogdoches, Nacogdoches County, Texas. *Journal of Northeast Texas Archaeology* 28:35–50.

Perttula TK, editor. 2008b. *Lake Naconiche Archeology, Nacogdoches County, Texas: Results of the Data Recovery Excavations at Five Prehistoric Archeological Sites*. Report of Investigations No. 60. Archeological & Environmental Consultants, LLC, Austin.

Perttula TK. 2010a. *Recent Archeological Survey Investigations at Caddo Mounds State Historic Site (George C. Davis Site, 41CE19)*. Letter Report No. 242. Archeological & Environmental Consultants, LLC, Austin.

Perttula TK. 2010b. Analysis of prehistoric artifacts from 2003 excavations at the George C. Davis Site (41CE19), Cherokee County, Texas. *Journal of Northeast Texas Archaeology* 33:63–7.

Perttula TK, Bruseth JE. 1990. Trade and exchange in eastern Texas, 1100 BC – A.D. 800. *Louisiana Archaeology* 17:93–121.

Perttula TK, Ellis LW. 2012. *The Hickory Hill Site (41CP408): Archeological Investigations at a Middle Caddo Site in the Little Cypress Creek Basin in East Texas*. Atkins Group, Austin.

Perttula TK, Nelson B. 2001. *Archeological Test Excavations at the Prestonwood (41SM272) and Broadway (41SM273) Sites along the City of Tyler-Lake Palestine WTP Project, Smith County, Texas*. Report of Investigations No. 43. Archeological and Environmental Consultants, LLC, Austin.

Perttula TK, Nelson B. 2003. *The Nawi haia ina Site (41RK170): Archeological Investigations in the City of Henderson's Southside Wastewater Treatment Plant, Rusk County, Texas*. Report of Investigations No. 51. Archeological & Environmental Consultants, LLC, Austin.

Perttula TK, Nelson B. 2004. *Woodland and Caddo Archeology at the Broadway or Kanduts'ah Kuhnihdahahdisa' Site (41SM273) on the City of Tyler-Lake Palestine WTP Project, Smith County, Texas*. Report of Investigations No. 50. Archeological & Environmental Consultants, LLC, Austin.

Perttula TK, Nelson B. 2006. *Test Excavations at Three Caddo Sites at Mission Tejas State Park, Houston County, Texas*. Report of Investigations No. 76. Archeological & Environmental Consultants, LLC, Austin.

Perttula TK, Nelson B. 2007. Documentation of a collection of archaeological materials from the Millsey Williamson Site (41RK3), a historic Nadaco Caddo settlement. *Journal of Northeast Texas Archaeology* 26: 120–7.

Perttula TK, Ricklis RA. 2005. *Archeological Testing at 41UR77 on Big Sandy Creek, Upshur County, Texas*. Archeological Studies Program, Report No. 71. Texas Department of Transportation, Environmental Affairs Division, Austin.

Perttula TK, Rogers R. 2007. The evolution of a Caddo community in northeastern Texas: the Oak Hill Village Site (41RK214), Rusk County, Texas. *American Antiquity* 72(1):71–94.

Perttula TK, Selden Jr RS. 2011. East Texas Radiocarbon Database. Electronic resource. http://counciloftexas-archeologists.org/?page_id=27. Accessed July 2012.

Perttula TK, Sherman DL. 2009. *Data Recovery Investigations at the Ear Spool Site (41TT653), Titus County, Texas*. Document No. 070205. PBS&J, Austin.

Perttula TK, Nelson B, Schniebs L. 2003. Titus Phase archeology at the S. Stockade Site (41TT865) on Tankersley Creek, Titus County, Texas. *Caddoan Archeology Journal* 13(1):7–15.

Perttula TK, Nelson B, Walters M, Schniebs L. 2007. Archaeological investigations of the Lang Pasture (41AN38) midden deposits on private property west of the SH 155 Right-of-Way, Anderson County, Texas. *Caddo Archeology Journal* 16:27–36.

Perttula TK, Kelley DB, Ricklis RA, assemblers and editors. 2011. *Archeological Investigations at the Lang Pasture Site (41AN38) in the Upper Neches River Basin of East Texas*. Report No. 129. Texas Department of Transportation, Archeological Studies Program, Environmental Affairs Division, Austin.

Reimer PJ, Baillie MGL, Bard E, Bayliss A, Beck JW, Blackwell PG, Bronk Ramsey C, Buck CE, Burr GS, Edwards RL, Friedrich M, Grootes PM, Guilderson TP, Hajdas I, Heaton TJ, Hogg AG, Hughen KA, Kaiser KF, Kromer B, McCormac FG, Manning SW, Reimer RW, Richards DA, Southon JR, Talamo S, Turney CSM, van der Plicht J, Weyhenmeyer CE. 2009. IntCal09 and Marine09 radiocarbon age calibration curves, 0–50,000 years cal BP. *Radiocarbon* 51(4): 1111–50.

Rick JW. 1987. Dates as data: an examination of the Peruvian preceramic radiocarbon record. *American Antiquity* 52(1):55–73.

Rogers R, Perttula TK. 2004. *The Oak Hill Village (41RK214), Rusk County, Texas*. Document No. 030083. PBS&J, Austin.

Rogers R, Nash MA, Perttula TK. 2001. *Excavations at the Herman Ballew Site (41RK222), Rusk County, Texas*. Document No. 000021. PBS&J, Inc., Austin.

Schambach FF. 1998. *Pre-Caddoan Cultures in the Trans-Mississippi South: A Beginning Sequence*. Research Series No. 53. Arkansas Archeological Survey, Fayetteville.

Schambach FF. 2002. Fourche Maline: a Woodland period culture of the Trans-Mississippi South. In: Anderson DG, Mainfort Jr RC, editors. *The Woodland Southeast*. Tuscaloosa: University of Alabama Press. p 91–112.

Sherman DL. 2004. *National Register Testing of Site 41CP408: A Middle Caddoan Farmstead, Camp County, Texas*. Document No. 040031. PBS&J, Austin.

Sirkin RM. 2006. *Statistics for the Social Sciences*. Thousand Oaks: Sage.

Story DA. 1990. Radiocarbon assays. In: Story DA, Guy JA, Burnett BA, Freeman MD, Rose JC, Steele DG, Olive BW, Reinhard KJ. *The Archeology and Bioarcheology of the Gulf Coastal Plain*. Research Series No. 38. Arkansas Archeological Survey, Fayetteville. p 658–735.

Straus LG, Bicho N, Winegardner AC. 2000. The Upper Palaeolithic settlement of Iberia: first generation maps. *Antiquity* 74(285):553–66.

Stuiver M, Reimer PJ. 1993. *CALIB User's Guide Rev 3.0.3A for Macintosh computers*. Quaternary Research Center, University of Washington, Seattle.

Surovell TA, Brantingham PJ. 2007. A note on the use of temporal frequency distributions in studies of prehistoric demography. *Journal of Archaeological Science* 34(9):1868–77.

Surovell TA, Byrd Finley J, Smith GM, Brantingham PJ, Kelley R. 2009. Correcting temporal frequency distributions for taphonomic bias. *Journal of Archaeological Science* 36(8):1715–24.

Taylor RE, Berger R, Dimsdale B. 1968. Electronic data processing for radiocarbon dates. *American Antiquity* 33(2):180–4.

Texas Natural Resources Information System. 2012. Data search and download. URL: http://www.tnris.org/. Accessed January 2012.

Ward GK, Wilson SR. 1978. Procedures for comparing and combining radiocarbon age determinations: a critique. *Archaeometry* 20(1):19–31.

Webb CH, Murphey FE, Ellis WG, Green HR. 1969. The Resch Site, 41HS16, Harrison County, Texas. *Bulletin of the Texas Archeological Society* 40:3–106.

Wendorf F, Schild R, Haas H. 1979. A new radiocarbon chronology for prehistoric sites in Nubia. *Journal of Field Archaeology* 6(2):219–23.

Williams AN. 2012. The use of summed radiocarbon probability distributions in archaeology: a review of methods. *Journal of Archaeological Science* 39(3):578–89.

Window on State Government. 2012. Water. Electronic resource. URL: http://www.window.state.tx.us/specialrpt/tif/water.html. Accessed July 2012.