ARCHAEOLOGY AND BIOARCHAEOLOGY OF THE BUCKEYE KNOLL SITE (41VT98), VICTORIA COUNTY, TEXAS

Volume 2

Final Report 2012

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Contract Nos.
DACW64-97-D-0003,
Delivery Orders 0006 and 0008

Submitted to:
U.S. Army Corps of Engineers
Galveston District

GS-10F-0445N, Order No.
DACW64-03-F-0073
ARCHAEOLOGY AND BIOARCHAEOLOGY OF THE BUCKEYE KNOLL SITE (41VT98), VICTORIA COUNTY, TEXAS

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Chapter 11

STABLE ISOTOPE AND DNA ANALYSES

Robert J. Hard
Noreen Tuross

Analytical Methods and Results
(Noreen Tuross)

Stable carbon and nitrogen isotopic measurements were made on collagen purified from the tooth samples of eight individuals. In addition, seven radiocarbon dates were obtained, and five DNA extractions and preliminary PCR reactions were done. The teeth were derived from Burials 5, 6, 8, 23, 27, 55, 71, and 74. All but one of these are ascribed to the Early Archaic cemetery component. The single exception, Burial 23, is a Late Archaic burial. A summary of the work performed is shown in Table 11-1.

Radiocarbon Ages of the Individuals

Collagen was extracted from tooth roots utilizing the decalciifying agent EDTA, washing with sodium hydroxide followed by a gelatinization process and filtering through sintered glass. The collagen had a slight yellow color and was indistinguishable from modern collagen in carbon and nitrogen content (see next section).

With the limited available data, three distinct and noncontemporaneous populations interred human remains at Buckeye Knoll. The large cluster of dates centers around 5600 years B.P. (uncalibrated). One individual is significantly older than the majority grouping, at 7570 ± 55 yrs B.P. (uncalibrated), while another single individual dates to 2120 ± 30 yrs B.P. Correcting these radiocarbon dates to allow for the observed variation in past 14C amounts was done with the OxCal program. The results are shown in Figure 11-1.

Stable Isotope Analyses

Stable isotope analyses δ13C and δ15N were performed in duplicate on the seven specified individual tooth collagens. The data are shown in Table 11-2. When these data are viewed as a function of the uncorrected age of the sample, interesting patterns are observed (Figures 11-2 and 11-3).

The heavy isotope of nitrogen is enriched in the samples as a function of age. This statement must be accompanied by two caveats. First, the trend in Figure 11-2 is controlled by two samples: the youngest and the oldest. Second, tooth type has been considered. Even with these considerations, the change of almost 3‰ in δ15N is substantial and, if confirmed with additional samples, these data would indicate a major shift in human diets or an alteration in the underlying nitrogen isotopic values in plants due to environmental change—or both. These important preliminary conclusions should be further refined with additional analyses.

The carbon isotopic values are quite scattered, but all observed values could be derived from a diet rich in estuarine fauna and/or terrestrial fauna with access to C-4 plants. The range of carbon isotopic values is surprising, as is the depletion of the most recent individual. Again, this preliminary data suggests diet and/or environmental change through the age of the Buckeye Knoll deposit. (Editor’s note: These observations are further considered in the discussion by Robert Hard in the next section of this chapter, as well as in a summary discussion in Chapter 15.)
Figure 11.1. The lower (pluses) and upper (squares) limits of the corrected radiocarbon ages in years B.C. at the 95.4 percent confidence level.

DNA Analysis

Preliminary DNA analyses of five tooth extracts yielded no amplification products of the 9bp deletion regions of the mitochondrial genome. The extracts (Kolman and Tuross 2000) were tested for polymerase inhibition, and slight inhibition was observed in all samples. A second extraction based on a recently published technique (Rohland et al. 2004) was processed and amplification showed some promise for analytical success. Given the high input of labor and expense that full analysis would have entailed, however, it was decided by the project sponsor (U.S. Army Corps of Engineers, Galveston District) not to proceed. Janelle S. Stokes, archaeologist with the Galveston District, offered the following explanation for this decision:

During sampling for the presence of preserved DNA, initial results on human bone fragments indicated that there was no replicable DNA in the VT98 materials. Another technique was then applied that indicated additional, intensive analysis might be productive if a full DNA analysis was performed. However, further information provided by the consultant (Noreen Tuross, Harvard University) made it clear that several lengthy and costly steps would be needed to determine if this was actually the case. It was impossible to reliably

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>Procedures</th>
</tr>
</thead>
<tbody>
<tr>
<td>VT98S5B74</td>
<td>x</td>
</tr>
<tr>
<td>VT98S3B27</td>
<td>x</td>
</tr>
<tr>
<td>VT98S1B6</td>
<td>x</td>
</tr>
<tr>
<td>VT98S10B71</td>
<td>x</td>
</tr>
<tr>
<td>VT98S15B23</td>
<td>x</td>
</tr>
<tr>
<td>VT98S6B5</td>
<td>x</td>
</tr>
<tr>
<td>VT98S2B8</td>
<td>x</td>
</tr>
<tr>
<td>VT98S5B5</td>
<td>x</td>
</tr>
</tbody>
</table>
Table 11-2. Stable Carbon and Stable Nitrogen Values for Human Tooth Samples from Buckeye Knoll.

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>δ13C</th>
<th>δ15N</th>
<th>C/N</th>
</tr>
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<tbody>
<tr>
<td>41VT98S5B74</td>
<td>-15.8</td>
<td>10.9</td>
<td>2.8</td>
</tr>
<tr>
<td></td>
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<td>12.5</td>
<td>2.8</td>
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<td></td>
<td>-16.2</td>
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<td>2.8</td>
</tr>
<tr>
<td>41VT98S10B71</td>
<td>-15.6</td>
<td>11.2</td>
<td>2.8</td>
</tr>
<tr>
<td></td>
<td>-15.7</td>
<td>11.1</td>
<td>2.8</td>
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<td>2.7</td>
</tr>
<tr>
<td></td>
<td>-18.5</td>
<td>9.7</td>
<td>2.7</td>
</tr>
<tr>
<td>41VT98S6B5</td>
<td>-13.6</td>
<td>11.8</td>
<td>2.8</td>
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<tr>
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<tr>
<td>41VT98S2B8</td>
<td>-13.6</td>
<td>11.5</td>
<td>2.8</td>
</tr>
<tr>
<td></td>
<td>-13.6</td>
<td>11.6</td>
<td>2.8</td>
</tr>
</tbody>
</table>

Complete additional analyses; (3) substantial additional expenditures in this range would not be possible because the overall project cost was nearing the total Congressionally authorized limit, and (4) the treatment plan stipulated that the DNA analysis could be constrained by cost [Janelle Stokes, personal communication 2008].

Data from Buckeye Knoll: Contextual Interpretations (Robert J. Hard)

Stable 13C and 15N isotopic analyses are particularly well suited to the study of the adaptations at Buckeye Knoll, as this approach can provide data regarding the role of freshwater, marine and terrestrial aspects of the paleodiet that other techniques cannot. Noreen Tuross of Harvard University processed eight human tooth collagen samples from the site (see previous section in this chapter); seven of these dated to the Early Archaic period cemetery component and one dated to the Late Archaic period. This report considers these results within the context of stable isotope ecology of the Texas coastal plain.


Ideally, such research should include consideration of the stable isotope ecology of the plants and animals in the ancient human food web. If this is not possible, reference to relevant studies can aid in the interpretation of the human data. Biologists have ex-
Figure 11-2. Graph showing the relationship between stable nitrogen values and sample ages.

Figure 11-3. Graph showing the relationship between stable carbon values and sample ages.
Chapter 11: Stable Isotope Analyses


Since excellent reviews of stable isotope methods and applications are readily accessible, only a synopsis of the principles of human dietary isotope studies is provided here (e.g., Ambrose and Harrison 1997; Schoeninger and Moore 1992; Schwarz and Schoeninger 1991). The stable isotopes $^{13}$C and $^{15}$N have different reaction rates, known as fractionations, than their lighter, more common cousins $^{12}$C and $^{14}$N. With fractionations, the ratios between the scarcer, heavier isotope and the lighter, abundant isotope change (e.g. $^{13}$C to $^{12}$C) as carbon and nitrogen move from the environment through plants and their consumers. Some groups of plants and animals incorporate heavy isotopes into their tissues at different rates. These ratios are recorded in living tissue, including human and animal bone found on archaeological sites. Laboratory analysis of bone or teeth measures the ratios of $^{13}$C to $^{12}$C and $^{15}$N to $^{14}$N and these ratios are compared to the ratios in laboratory standard materials. These ratios of the sample relative to the standard are symbolized with the "δ" (delta) sign and are measured in permil (‰) or parts per thousand. The ratios, as they are recorded in human bone and teeth, allow identification of some food groups that tend to have somewhat unique isotopic ratios. As discussed below, some of the identifiable food groups include: terrestrial C₄ plants, terrestrial C₃ animals, terrestrial C₄ plants (including maize), C₃ plant grazers (e.g. bison), freshwater fish and marine (or estuarine) fish.

In bone and teeth, both the collagen and apatite compounds can be analyzed. In this study only tooth collagen was analyzed so apatite will not be discussed further. Ingested protein contains the essential amino acids that build the collagen carbon molecules; therefore collagen δ¹³C values usually reflect the protein component of the diet (Schwarz 2000). Collagen δ¹³C fractionates so that it is estimated to be 5‰ greater than the δ¹³C value of the dietary protein source, assuming protein intake is adequate (Katzenberg 2000; Schwarz 2000; van der Merwe and Vogel 1978). Therefore, if human δ¹³C collagen measured -20‰, the ingested dietary protein would be -25‰.

Three groups of plants with different photosynthetic pathways fractionate δ¹³C at varying rates. Most trees, shrubs and forbs belong to the C₄ group and have a global mean δ¹³C value of about -27‰ (O’Leary 1988:334). Warm-season grasses and some forbs belong to the C₃ group, as does maize, and these plants have a mean δ¹³C value of -13.1‰ (O’Leary 1988:334). Maize consumers can be distinguished from non-maize consumers, assuming there are no other significant C₃ or CAM (Crasulacean Acid Metabolism) plants in the diet. Bison that graze on C₄ grasses have more positive values than do deer that feed on C₃ plants. CAM plants, including arid-land succulents such as agave and cacti, can fluctuate between C₃-like and C₄-like values. Prickly pear, the principal CAM plant on the south Texas coastal plain, has C₃-like values (Bouton et al. 1998). Flesh tends to be 2‰ less than collagen, so for example, deer bone collagen with a δ¹³C value of -19‰ indicates that deer meat is -21‰.

Nitrogen isotope ratios (δ¹⁵N) are potentially more complex, since trophic level, temperature, nitrogen source, and plant and animal physiology can affect collagen nitrogen isotope ratios (e.g. Ambrose 1991; Minagawa and Wada 1984). The δ¹⁵N value of atmospheric nitrogen (N₂), the primary standard, delineates the arbitrary zero point of the nitrogen isotope scale (δ¹⁴N=0‰). For each trophic-level increase from plants to herbivores to carnivores in both terrestrial and aquatic environments there is a 3 to 4‰ gain in δ¹⁵N values (Ambrose 1991; Minagawa and Wada 1984; Schoeninger and DeNiro 1984). Drought-tolerant herbivores can have more elevated δ¹⁵N values (Ambrose 1993; Sealy et al. 1987). Unlike δ¹³C values, the δ¹⁵N values of flesh and collagen are the same.

The basic principles outlined above apply to aquatic environments, but there are some important differences. Basal carbon sources in aquatic ecosystems may have different δ¹³C values than atmospheric carbon; particularly in marine ecosystems where dissolved inorganic carbon is the primary source (Katzenberg 2000; Pate 1994). Freshwater plants obtain carbon, not only from atmospheric CO₂ but from the water and associated sources with more variable δ¹³C values than terrestrial C₃ plants (Jepsen 1999; Katzenberg 2000). A foodweb study of Brazos River isotope ecology found the δ¹³C values of freshwater plants range from -18% to -25% (Jepsen 1999).

In Texas estuarine settings, seagrass meadows are common in shallow water (~2 m) and have C₄ values, while in offshore environments, algae, with values intermediate between C₃ and C₄ plants, dominate the base of the foodweb (Fry and Parker 1979). Fish from seagrass meadows in some Texas shallow bays yield
mean δ13C flesh values from -8.3 to -15.5‰ (mean -12.1‰) while offshore fish have more negative values, -14.8 to -19.2‰ (mean -17.5‰) (Fry and Parker 1979:502). The role of seagrass versus algae as the basal producer for any particular Texas estuarine environment or fish species can vary. Texas saltmarsh fish (including several species of ancient economic value) yield more negative flesh values, from -13 to -20‰ (Winemiller et al. 2006). The lifecycle of some species involves movement from offshore to nearshore settings, exposing them to both seagrass- and algae-dominated niches. Humans feeding on nearshore fish from seagrass environments may have elevated δ13C values that overlap with the values resulting from a diet of C4 plants, while fish from algae-dominated settings should have δ13C values that are intermediate between that of C3 and C4 plants. However, a marine diet should have distinctive elevated δ15N values.

A Texas saltmarsh yielded 15N values from aquatic plants that ranged from 0.7 to 6.5‰, generally higher than the range of most terrestrial plants (Winemiller et al. 2006). Marine and freshwater fish tend to have elevated δ15N values reflecting more trophic levels (e.g. aquatic plants, zooplankton and invertebrates, fish, piscivorous fish) than in most terrestrial herbivore species.

Methods

As noted, CEI submitted teeth from eight individuals to Noreen Tuross for δ13C and δ15N analyses, 14C dating, and DNA screening. Using a stable mass spectrometer, analyses of δ13C and δ15N were performed on pairs of duplicate samples for the eight teeth (see Table 11-2). The difference between the measurements is negligible, indicating high measurement consistency. The ratio of elemental carbon to nitrogen was measured and the values are 2.7 to 2.8 for all samples, thus indicating the carbon and nitrogen in the collagen are well preserved (see Table 11-2). Table 11-3 lists these samples again, along with the results of the associated radiocarbon dates. The "OC" dates are from the tooth collagen Tuross extracted. The "Beta" dates are from bone collagen from that particular burial.

Results

Table 11-3 reports the paired values and the mean of each pair. The mean δ13C value of the seven Early Archaic period samples is -15.6‰ and the mean δ15N value is 11.51‰. The δ13C values are more variable, ranging from -13.7‰ to -17.6‰, while the δ15N values range from 10.9‰ to 12.55‰. The single Late Archaic period sample (Burial 23) reflects a notable decline in both δ13C and δ15N values, with values of -18.3‰ and 9.7‰. All values are plotted in Figure 11-4, including the mean and standard deviation of the δ13C and δ15N values. The Early Archaic period samples have both elevated δ13C and δ15N values and the δ15N value suggests a substantial reliance on aquatic species. The δ13C value suggests freshwater resources dominate over marine species, but marine (or estuarine) resources are isotopically visible (see below). The two individuals with -13‰ to -14‰ δ13C values (Burials 5 and 8) indicate they had a different diet, one that includes notably more estuarine C4 resources than the other five Early Archaic period individuals. The single Late Archaic value (Burial 23) suggests a decline in use of aquatic species, particularly in marine resources since there is a decline in both δ15N and δ13C values, a trend that can be accounted for if C4 plant resources were replacing lost estuarine resources.

Discussion and Conclusions

Comparative data allow the stable isotope study for Buckeye Knoll to be placed within the context of human isotopic ecology of the Texas coastal plain. Hard and Katzenberg (2007) measured δ13C and δ15N collagen values for 168 faunal samples from 29 taxa from three prehistoric and four historic sites on the Texas coastal plain. Figure 11-5 summarizes the data for 75 of these faunal samples including the four faunal categories (bison, terrestrial mammals, riverine fish, and estuarine fish) that are representative of the most important human dietary items, plus the three plant categories (C3 plants, C4 plants and CAM plants) that are isotopically recognizable. The points on the Figure 11-5 are the mean collagen values and the error bars represent ± values at a 90-percent confidence interval, with outliers removed. Further details are found in Hard and Katzenberg (2007). The Buckeye Knoll Early Archaic mean value (with its 90-percent confidence level error bars) and the single Buckeye Knoll Late Archaic collagen value (again with 90-percent confidence bars) are also plotted on Figure 11-5.

The C3 and C4 plant values were derived from the herbivore collagen values from Hard and Katzenberg (2007). CAM plant values, primarily prickly pear in this region, were derived from Boutton et al. (1998:Table 1) and Boutton (personal communication 2006). C3 terrestrial mammals represent collagen from white-tail deer, cottontail rabbit, opossum, and raccoon, all of which feed on C3 plants or their consumers (n=17). This group has negative δ13C values and intermediate δ15N collagen values. The riverine fish group repre-
Table 11-3. Stable Isotope and AMS-Derived Chronometric Data Obtained on Samples of Human Tooth Collagen from Buckeye Knoll.

<table>
<thead>
<tr>
<th>Period</th>
<th>Burial No.</th>
<th>δ^13C pairs</th>
<th>δ^12C</th>
<th>δ^15N pairs</th>
<th>δ^15N</th>
<th>C/N pairs</th>
<th>2-Sigma Cal. (yrs. B.P.)</th>
<th>C14 Lab No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early Archaic</td>
<td>74</td>
<td>-15.8/-15.9</td>
<td>-15.85</td>
<td>10.9/10.9</td>
<td>10.90</td>
<td>2.8/2.8</td>
<td>6670-6580</td>
<td>OC-44622</td>
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<td>27</td>
<td>-16.2/-16.2</td>
<td>-16.20</td>
<td>12.5/12.6</td>
<td>12.55</td>
<td>2.8/2.8</td>
<td>6640-6410</td>
<td>Beta-157424</td>
</tr>
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<td></td>
<td>6</td>
<td>-16.3/-16.2</td>
<td>-16.25</td>
<td>11.5/11.5</td>
<td>11.50</td>
<td>2.8/2.8</td>
<td>6300-6220</td>
<td>OC-44624</td>
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<td>-15.6/-15.7</td>
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<td>11.2/11.1</td>
<td>11.15</td>
<td>2.8/2.8</td>
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<td>OC-44625</td>
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<td>-13.70</td>
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<td>11.80</td>
<td>2.8/2.8</td>
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<td>—</td>
<td>0.55</td>
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<td>-18.30</td>
<td>9.7/9.7</td>
<td>9.70</td>
<td>2.7</td>
<td>2130-2050</td>
<td>OC-44626</td>
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</tbody>
</table>
Figure 11.4. Graphic plotting of stable isotope values for the Early Archaic and Late Archaic burials from Buckeye Knoll.

sents freshwater species that include bowfin, catfish, flathead catfish, and gar (n=37), all with elevated δ¹⁵N values since fish tend to feed at higher trophic levels and have more diverse δ¹⁵N sources than terrestrial species. Such fish also tend to have depleted δ¹³C values that are similar to terrestrial plant C₃ values.

The marine fish category (n=16) represents drum, freshwater drum and gar (the latter two live in both freshwater and estuarine environments and can tolerate saline waters); the samples in this study yielded marine values and were so classified (Hard and Katzenberg 2007). This sample yielded mean flesh δ¹³C values of -12.01‰ (std dev = 2.7‰) and mean δ¹⁵N flesh values of 9.0‰ (std dev = 2.1‰). Estuarine species linked to C₄ seagrasses tend to have values similar to these. However, fish in estuarine settings can have more negative δ¹³C values than this archaeofaunal sample if they are from foodwebs controlled by filamentous algae and C₃ plants rather than seagrass meadows (Fry 2006:120-131; Fry and Parker 1979). For example, Winemiller et al. (2006) found that Matagorda Bay mullet, black drum, red drum, sea trout, gar and sea catfish, all important estuarine resources in ancient times, had mean δ¹³C values on the order of 6‰ more negative than the mean values in our study. Once these modern values are corrected for changes due to fossil fuel inputs, the difference remains about 4‰ to 5‰ more negative. The most likely explanation is that the archaeofaunal samples represent foodwebs dominated by C₄ seagrass meadows since the modern samples are from algal foodwebs (Winemiller et al. 2006).

The modern fish samples also yielded mean δ¹⁵N values about 3‰ more positive than archaeological fish samples, even though some species were the same (Winemiller et al. 2006; Hard and Katzenberg 2007). This difference may be due to modern pollution and/or variability in estuarine plant δ¹⁵N values (Fry 2006; Pate 1994). In addition, estuarine gastropods and mollusks can also have widely varying isotopic values (Fry 2006:126; Winemiller et al. 2006). These issues
Bison (n=5), due to their status as grazers in an environment where C$_4$ grasses dominate, have elevated $\delta^{13}$C values and relatively low $\delta^{15}$N values. Figure 11-5 gives a rough idea of the isotopic relationships between potential food sources and collagen values from Buckeye Knoll. It is clear these elevated values suggest substantial inputs of freshwater fish.

The Figure 11-5 collagen values should be corrected for fractionation in order to better estimate diet. Animal $\delta^{13}$C flesh values are 2% more negative than collagen values, but $\delta^{15}$N flesh values are assumed to be equal to the $6^{15}$N collagen (Ambrose 2000:Table 12.2; Newsome et al. 2004:1106; Schwarz and Schoeninger 1991:301; Tieszen 1994:273). Figure 11-5 plots these calculated flesh values of the animal groups.

The isotope value of the human diet is estimated to be 3 to 6% less than the $6^{13}$C collagen value due to fractionation during collagen production; in this study 5% is used (Ambrose 1993; DeNiro and Epstein 1978; Katzenberg et al. 2000; Newsome 2004:1105; Schwarz 2000; Vogel 1978). The diet is estimated to be 3% less than the $6^{15}$N value of collagen due to trophic fractionation effects (e.g. Ambrose 1993, 2000; Newsome 2004:1105). Collagen $6^{13}$C values, under most conditions, tend to be controlled by protein intake rather than whole diet (Ambrose 1993). Therefore, the Early Archaic period component of Buckeye Knoll, with a mean $6^{13}$C collagen value of -15.6%, indicates these individuals consumed protein with a lifetime average of $6^{13}$C value of -20.6% (-15.6% –
5.0\(^\circ\)). The $\delta^{15}N$ value of 11.6\(^\circ\) indicates a diet with an average $\delta^{15}N$ value of 8.6\(^\circ\) (11.6\(^\circ\) - 3\(^\circ\)). Figure 11-5 displays the resource flesh values and the human dietary values for the Buckeye Knoll individuals.

Figure 11-6 now allows a clearer image of diet at Buckeye Knoll. If the Buckeye Knoll values were centered on any particular resource it would suggest that 100 percent of the diet was from that resource. The Early Archaic component, with a $\delta^{13}C$ dietary protein value of -20.6\(^\circ\) is consistent with protein sources from both $C_3$ terrestrial animals and freshwater resources. The $\delta^{15}N$ value falls between that of those two groups suggesting that terrestrial animals and freshwater resources are contributing substantially to the diet. One diet scenario that would account for the Buckeye Knoll values is a diet that is a mix of only freshwater and terrestrial animals. However, this is highly unlikely given the available plant resources and the human need for carbohydrates (e.g. Speth and Spielmann 1983). A more likely scenario is that, along with substantial freshwater resources and some terrestrial animals, the Early Archaic populations were also using $C_4$ plant resources. However, a diet of freshwater fish, terrestrial animals and $C_3$ plants would yield $\delta^{13}C$ and $\delta^{15}N$ values lower than the Buckeye Knoll values. However, if marine resources were added then the elevated isotopic values of such resources would offset the negative values of $C_3$ plants, thus accounting for the measured isotopic values of the Early Archaic component. The most likely diet that accounts for the Early Archaic isotope values is one that is dominated by freshwater resources, but with terrestrial animals, estuarine resources, and $C_3$ plants each contributing to the diet. It is difficult to make a more explicit estimate of dietary source contributions, particularly with the uncertainty of estuarine source values. None to only slight levels of bison, CAM or $C_4$ plants were likely being used in the Early Archaic period.

The $\delta^{13}C$ value of the dietary protein from the single Late Archaic individual is -23.1\(^\circ\) and the
dietary δ15N is 6.7‰, representing a decline in both values compared with that of the Early Archaic period. Notice on Figure 11-5, the Late Archaic data point represents a clear increase in C₄ plant resources and a drop in aquatic resource use. Marine resource use notably declined and freshwater resource use declined somewhat but still remained important. This individual’s diet was made up of substantial levels of freshwater resources, C₄ plant resources, and C₃ terrestrial animal resources, with marine resources playing a negligible role or being completely absent. Given that this is only a single individual, it is unknown if this is typical of the Late Archaic period for the area.

Comparisons with Other Sites

Hard and Katzenberg (2007) included analysis of nine prehistoric cemeteries in three ecological zones: the Coastal Zone, the Riverine-Savanna Zone and the Inland Zone (Figure 11-7). The Coastal Zone covers a strip of land about 50 km wide extending from the shoreline inland. It includes the coastline, bays, estuaries, and river mouths. Extending westward from the western boundary of the Coastal Zone, to about 200 ft amsl, is the Riverine-Savanna Zone. The land in this zone is flat to gently rolling and the rivers are sinuous, with wide floodplains, swamps, sloughs, and oxbow lakes where freshwater aquatic resources are abundant. The Riverine-Savanna Zone measures about 30-70 km east-west but extends an additional 30-100 km farther inland following the 200-ft contour along the low-lying floodplains. This zone is attractive to spawning fish in the spring and forms resource-rich zones that Hall (1998, 2000) describes as “natural catfish farms.” The Inland Zone extends west from the Riverine-Savanna Zone to the edge of Edwards Plateau. This flat to hilly land rises from the 200-ft contour to about 1,000 ft in the vicinity of San Antonio.

Human bone samples from three prehistoric Coastal Zone cemeteries were included in the study: Cayo del Oso (41NU2), Mitchell Ridge (41GV66), and Harris County Boys School Cemetery (41HR80). All are largely Late Archaic to Late Prehistoric in age. The five mortuary sites from the Riverine-Savanna Zone are Morhiss (41VT1), Ernest Witte (41AU36), Bowser (41FB3), Crestmont (41WH39), and Loma Sandia (41LK28). The one site in the Inland Zone was Olmos Dam (41BX1). Bone preservation at Loma Sandia was poor, so valid results were obtained for only one sample from this site, although 37 samples from the locale were processed.

Figure 11-8 shows the dietary values (collagen corrected for fractionation, see above) for the sites in the Texas coastal plain study, as well as the Buckeye Knoll data. Three prehistoric cemeteries in the Riverine-Savanna Zone, Ernest Witte (AU36), Bowser (FB3) and Crestmont (WH39), overlap with mean δ13C dietary values ranging from -23.9‰ to -24.1‰. The δ15N dietary values are sharply elevated and range from 7.6‰ to 8.1‰. These values represent substantial dependence on freshwater resources with C₄ plant and animal resources present as well. In contrast to the Early Archaic period diet at Buckeye Knoll, marine resource use does not appear to be isotopically visible in these Riverine-Savanna sites during the Middle and Late Archaic periods.

The Morhiss site (VT1) population represents multiple periods, as existing site data do not allow the burials to be sorted temporally. In Figure 11-8, the Morhiss data plot between the Early Archaic Buckeye Knoll data and the Late Archaic Buckeye Knoll individual. The Morhiss site has a mean δ13C value that is more positive than the other three Riverine-Savanna sites, suggesting that some of the Morhiss population, like the Early Archaic Buckeye Knoll population, may have been utilizing some of the marine resources that were available 38 km to the south.

Radiocarbon dating at Morhiss has identified three individuals belonging to the Early Archaic period, two to the Middle Archaic period and two to the Late Archaic period, and these are plotted on Figure 11-9 along with those of unknown temporal affiliation (Hard and Katzenberg 2007). The three Early Archaic Morhiss individuals and the one Middle Archaic Morhiss individual are similar to the Buckeye Knoll Early Archaic sample. The other Middle Archaic individual from Morhiss, plus one of the Late Archaic individuals from that site, cluster with the Buckeye Knoll Late Archaic individual. Most of the unknown affiliates from Morhiss fall in or near this late cluster. This cluster of Late Archaic and unknown period individuals indicates a decline in aquatic resource use. The contribution of marine resources declined to lower levels and may have been slight to none. Freshwater resource use declined from Early Archaic levels but remained an important part of the diet. Note that the single Late Archaic individual from Morhiss, on the far right of Figure 11-9, has a sharply elevated δ13C value. This person likely came from a coastal environment as its δ13C value is similar to individuals from the Cayo del Oso site (NU2).

On Figure 11-8, the three Coastal Zones sites—Cayo del Oso (NU2), Harris County Boys School
Figure 11-7. Map showing Coastal, Riverine, and Inland Resource Zones on the Texas coastal plain, plus locations of sites referenced in the text.
Figure 11-8. Stable isotope values from collagen (corrected for fractionation) from Buckeye Knoll and other sites on the Texas coastal plain.

(HR80), and Mitchell Ridge (GV66)—show elevated $\delta^{15}N$ values, but more variability in the $\delta^{13}C$ dietary values. The Cayo del Oso individuals are the most enriched, with mean $\delta^{13}C$ and $\delta^{15}N$ dietary values of -14.7% and 8.5%, respectively, indicating a diet with a substantial contribution of marine resources and little to no use of freshwater resources. The Harris County Boys School and Mitchell Ridge individuals reflect various mixtures of marine and freshwater resources, combined with terrestrial resources. Improved baseline estuarine source data would allow a better resolution of this issue. The individuals from the single Inland Zone site, Olmos Dam (BX1), have lighter mean isotopic values that reflect a focus on inland, C$_3$ plant and animal resources, although minor use of freshwater aquatic resources likely occurred (see Figure 11-8).
Figure 11.9. Plotting of the stable isotope data from Early, Middle, and Late Archaic burials from the Buckeye Knoll and Morhiss (41VT1) sites.

Conclusions

The Early Archaic individuals from Buckeye Knoll reflect a very early focus on freshwater aquatic resources combined with terrestrial C₃ plants, terrestrial C₁ animals and estuarine resources. This diverse pattern reflects a wider mix of resources and perhaps a greater level of mobility than the pattern that had emerged by the Middle Archaic period and continued into the Late Archaic period, in which hunters and gatherers in Riverine-Savanna settings (Morhiss, Ernest Witte, Crestmont, and Bowser) appear to have made little or no use of coastal resources, despite their proximity. The single Late Archaic individual from Buckeye Knoll is consistent with that pattern. Future work will need to consider the ramifications of these important cultural changes, as well improve baseline estuarine resource data.