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Temporal Problems and Alternatives Towards the Establishment of Paleoindian Site Chronologies in Florida and the Adjacent Coastal Southeast

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Introduction

Several Paleoindian sites have been identified in Florida that have yielded diagnostic artifacts and preserved faunal bone, but have not been radiometrically dated. There have been limitations to and new developments with the radiocarbon technique (both standard radiometric and Accelerator Mass Spectrometry AMS) that may or may not preclude its use in determining a site's temporal context. There are also alternative radiometric dating methods, generally not utilized by Florida archaeologists, which offer the potential to determine temporal context, such as Optically Stimulated Luminescence (OSL) and Uranium Thorium dating. The almost complete absence of firm temporal contexts for late Pleistocene sites in Florida and the adjacent coastal Southeast has limited a regional interpretation of Paleoindian life ways. A failure to grasp the temporal chronology of Southeastern cultures through time continues to encourage speculative answers for the most basic of questions, including which tool-making tradition came first, if some traditions coexisted together, and how long the duration of Paleoindian occupation was.

In Florida and the coastal lowlands of southeastern Alabama and southern Georgia, three diagnostic Paleoindian artifact types have been recognized, the Clovis, Suwannee, and Simpson point types (Bullen 1975). Recently, this typology has been called into question due to the diversity of forms subsumed under a Bullen type called Suwannee and as observed by inspecting his type case collection of Suwannee point specimens (Dunbar and Hemmings 2004:68). Part of the material variety that Bullen inadvertently masked within this Suwannee type appears to represent one or more distinct types that are either contemporaneous with or temporally separate from the classic Suwannee type (as redefined by Goodyear et al. 1983, Goodyear 1999) and the Clovis and Simpson types (Dunbar and Hemmings 2004). If this greater diversity of types is so, then Bullen's typology is in need of revision (for a discussion see Farr 2006), and the assemblage of types is indicative of a more materially complex and perhaps longer Paleoindian tradition in the coastal Southeast than has been previously thought. Ideally, any effort to undertake a typological revision should consider the artifacts' methods of manufacture and use, as well as the temporal placement of types in time and stratigraphic position.

Chronology and Stratigraphy of Coastal Southeast Paleoindian Sites

Since its development, radiocarbon dating (Libby et al. 1949) has been the preferred method of placing archaeological sites in temporal context (Dasovich 1996, Morlan 2004). However, the radiocarbon method has been largely ineffective in determining the age of Paleoindian sites east of the Mississippi River due to the general absence of preserved organic material capable of yielding dates (Ellis et al. 1998). This is particularly true in the coastal plain of the Southeast where the age of suspected pre-Clovis, Middle, and Late Paleoindian sites remains unconfirmed.

Florida Paleoindian sites that have eluded radiometric dating include the Wakulla Springs Lodge (8WA329), Ryan-Harley (8JE1004) Harney Flats (8HI507), Norden (8GI40) Lewis-McQuinn (8DI112), and Silver Spring (8MR192) sites (see Figure 1 for the location of Florida Paleoindian sites mentioned in this article). The only Florida site to yield a radiocarbon date from a Paleoindian level with diagnostic artifacts is the Clovis component at Sloth Hole (8JE121), an inundated site located in the Aucilla River. A carved mastodon ivory tool fragment yielded an assay of 11,050 ±50 ^{14}C BP (n=1)(Hemmings 2004), an age now believed to be one of the three oldest Clovis sites in the Americas (Waters and Stafford 2007:1124). The Sloth Hole ivory shaft fragment was carbon dated using XAD-purified collagen: a new preparation technique used to insure accurate bone dating. The stratigraphic sequence at the Page-Ladson site (8JE591) has five Paleoindian components that produced debitage, un-diagnostic tools, and butcher-marked bones. The earliest of the Paleoindian levels at Page-Ladson dated 12,245 ±32 ^{14}C BP (averaged age of seven [n=7] statically related carbon dates). Though diagnostic artifacts were recovered from displaced contexts at the Page-Ladson site, none were recovered from in place levels (Dunbar 2006b).

Another problem in the coastal Southeast is the absence of established stratigraphic positions among the different types of Paleoindian diagnostic artifacts suspected of representing different cultural manifestations through time. The Wakulla Springs Lodge, Ryan-Harley, Harney Flats, Norden, Lewis-McQuinn, and Silver Springs sites, to the extent they are now understood, all have single Paleoindian components, although many of these sites have later period Early Archaic and younger site components. Sites such as Sloth Hole and the Page-Ladson in the Aucilla have multiple Paleoindian components; nevertheless, only the Clovis component at Sloth Hole has yielded diagnostic Clovis artifacts from undisturbed, primary context.

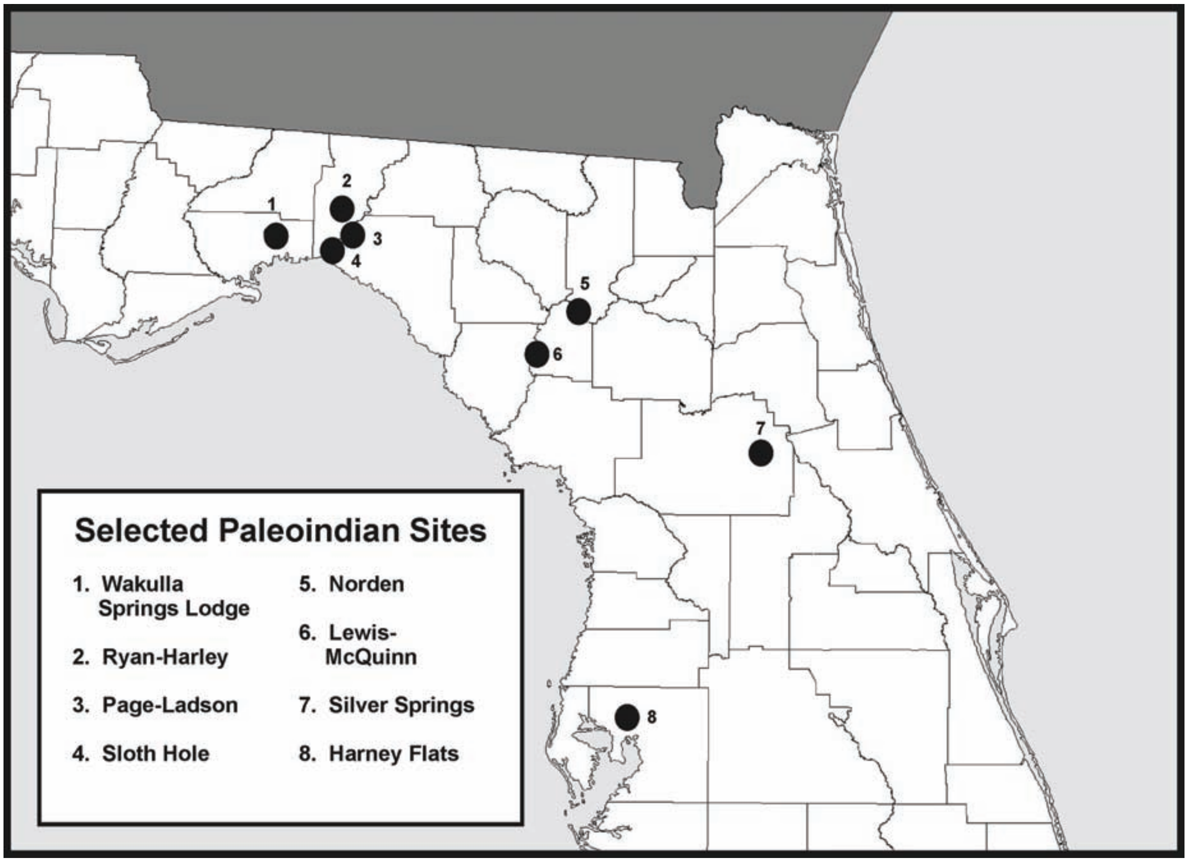

Figure 1. Site Location Map.

The establishment of a radiometric chronology for Paleoindian sites in the coastal Southeast is fundamental to archaeological and paleontological interpretation, a factor that is presently limited by temporal uncertainty. This is particularly apparent when site data are compared to data from the desert Southwest. Southwestern Paleoindian cultural traditions (including their respective diagnostic artifact assemblages) have long been referenced to chronostratigraphy and geoclimate data (Antevs 1954, 1962a, 1962b, Berry and Berry 1968, Bryan 1950, Bryan and Albritton 1943, Haynes 1971, 1982, 1991). The investigations of karst, wetland, and inundated sites in the Southeast have begun to provide regional chronologies (Carr 1987, Clausen et al. 1979, Cockrell and Murphy 1978, Collins et al. 1994, Doran and Dickel 1988, Driskell 1994, 1996, Hemmings 1999, 2004, Hoffman 1983, Walker 1998) and the Page-Ladson site is the first well-dated stratigraphic sequence to yield a regional chronostratigraphy and geoclimate reconstruction for the coastal Southeast (Dunbar 2002, 2006a, 2006b, 2006c). Thus, the compelling research questions for the coastal Southeast become: 1) where do the various manifestations of Paleoindian culture fit in time (for instance, Clovis before Suwannee or the other way around)? 2) What are the material manifestations of these adaptations (artifacts, dietary patterns, resource choices, land use preferences etc.)? 3) Did more than one tool-making tradition and/or distinctly different group of people coexist concurrently (i.e. Clovis and Suwannee) or did one culture develop from an earlier one (i.e. Clovis, the ancestor, gave way to Suwannee, the offspring) or possibly replace an existing group or fill a cultural lacuna[1].

In order to fully appreciate our need to more firmly establish these temporal contexts, one needs to look no further than the problems related to the interpretations of the Suwannee point-making, Paleoindian culture. The Clovis and Suwannee tool kits are similar but also differ in many respects. Waisted Clovis points display the diagnostic Clovis manufacture techniques of fluted and overshot flaking, while the Waisted Suwannee points seldom display this fluting or overshot flaking technique. Nevertheless, a small population of Suwannee points do display single or multiple fluting on one or both sides as well as overshot flaking as a method of thinning blade thickness; morphological features first recognized by Dunbar et al. (2005) at the Ryan-Harley site and further documented by Dunbar and Hemmings (2004) on other Suwannee point specimens. The distal tips of Clovis points tend to be broad with rounded tips when viewed dorsal or ventrally, but in lateral view they are thinned for sharpness across the tip. The tips on waisted Suwannee points differ and come to a shape-pointed tip (acute) when viewed dorsally or ventrally, but are not thinned laterally for sharpness across the tip. Waisted Clovis and Suwannee points have similar blade width to hafting waist dimensions. The similarities and differences between the waisted forms of Clovis and Suwannee as well as similarities in other parts of their stone tool kits are considered evidence that Clovis is the likely ancestor of Suwannee (Dunbar and Hemmings 2004).

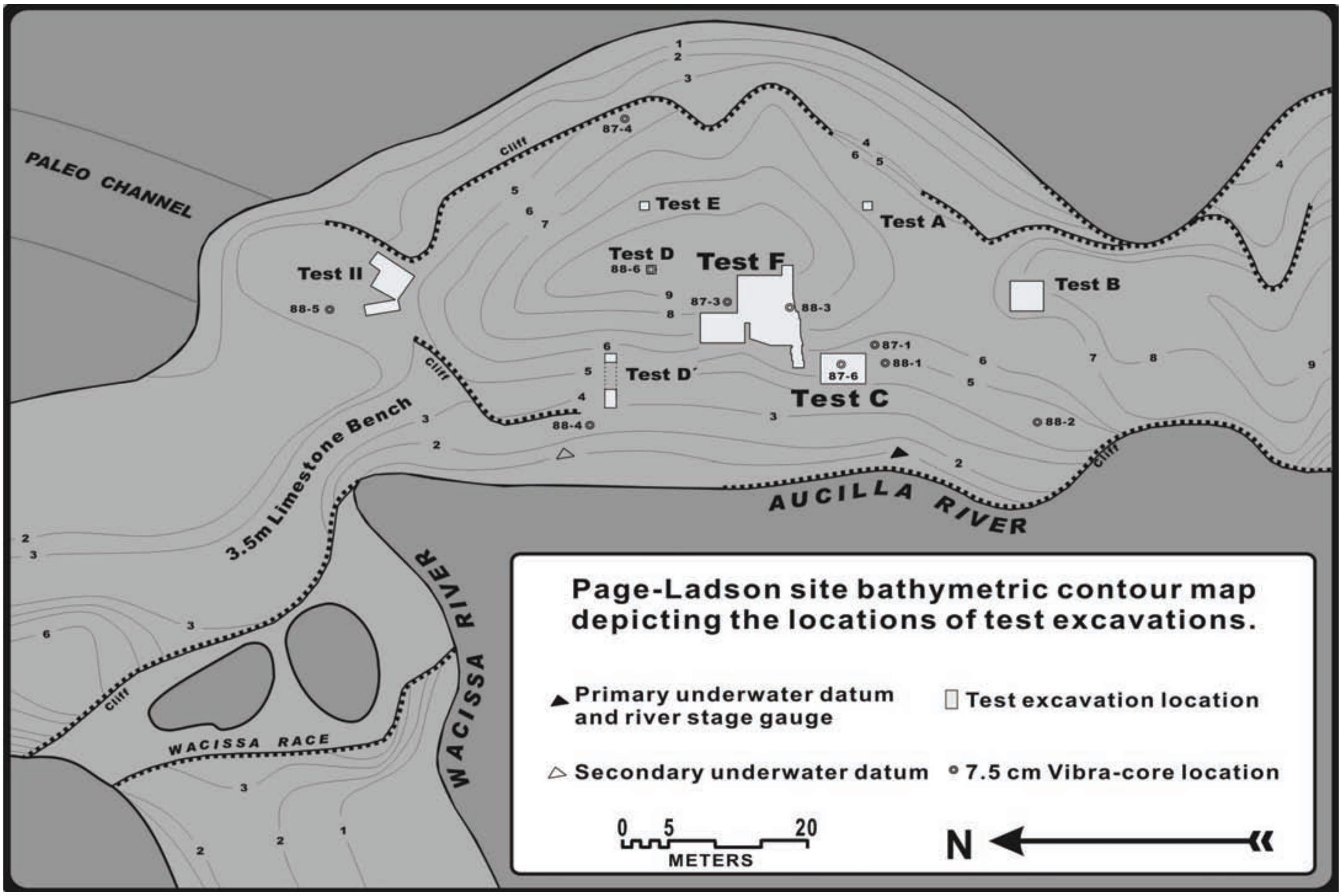

Figure 2. Map depicting the Page-Ladson Site Excavations.

With that said, Dennis Stanford correctly pointed out that both Suwannee and Simpson point sites remain undated and hypothesized "that when dated, they may be slightly older than Clovis" (Stanford 1991:9). I tend to go along with the traditional thought of southeastern archaeologists (Bullen 1975, Ellis et al. 1998 Goodyear 1999) and assume a post-Clovis age for the Suwannee tool kit; however, this viewpoint introduces a different set of issues. If Suwannee points are post-Clovis, they are also associated with extinct late Pleistocene species, including horse and tapir at two Florida sites, the Ryan-Harley site (Dunbar et al. 2005) and the Norden site (Dunbar and Vojnovski 2007). Elsewhere, North American Pleistocene megafauna are believed to have become extinct before the end of Clovis time (Haynes 2005:120-125 and Figure 5). During Clovis time, the region west of the Mississippi River experienced the "Clovis drought," which is one of the factors attributed to megafaunal extinction prior to the onset of the Younger Dryas[2] (Haynes 1984, 1991, 1993, 2006, Haynes et al. 1999). But such an extinction event may not have taken place in the Southeast if Suwannee point-making people are truly Middle Paleoindian. The stratigraphic integrity of the Ryan-Harley site has been verified (Balsillie et al. 2006), therefore the only other alternative would be that Stanford (1991) is correct and that Suwannee points are either contemporary with or are older than Clovis. Either way, the resolution of this temporal enigma invigorates Paleoindian research in the coastal Southeast and promises to provide heretofore-undiscovered revelations.

Yet another factor regarding the Paleoindian occupation of Florida and the adjacent coastal plain is its unique late Pleistocene faunal assemblage. Though many land mammals, including mastodon and mammoths, occupied geographic regions throughout ice-free North America, the southeastern coastal plain, particularly Florida, also had a significant assemblage of South American-immigrant or Neotropical fauna (Webb et al. 2004). Furthermore, Florida makes up most of the geographic faunal area specified as the Chlamythere–Glyptodont[3] province of North America. It is a faunal province that is "distinct from the rest of the Southeast [during the Pleistocene], but during the Holocene [after the late Pleistocene extinction], Florida's faunas clustered with others from the Southeast" (FAUNMAP Working Group 1996:1603) because most if not all of the Neotropical fauna became extinct or retreat from this province by the Holocene (ibid: 1604-1605). Neotropical species in the Florida Pleistocene not only included the giant armadillo and glyptodont; they also include the jaguar, tapir, capybara, ground sloths, and opossum. It may or may not be a coincidence, but the distribution of waisted and fishtailed Paleoindian projectile points (recurvate forms) appears to perfectly mirror the Pleistocene distribution of Neotropical fauna from Florida to South America. Two recent studies suggest the Clovis tool making tradition, which includes the waisted Clovis type in North America, was the likely progenitor of subsequent waisted and fishtailed point types in Central and South America (Faught 2006, Ranere 2006). By default this becomes part of the temporal origins issue and supports the need to determine the actual age of Simpson and Suwannee Paleoindian sites.

Some Important Aspects of River-Basin and Upland Stratigraphy

The Page-Ladson site is located in a sediment-filled sinkhole in the center channel of the Half Mile Rise section of the Aucilla River (Figure 2). The Paleoindian components of this site are deeply inundated, being some 8 to 10 m below present sea level. Due to the sinkhole's low-lying elevation, its 7 m plus section includes stratigraphic units that have outstanding organic preservation; preservation that has yielded 48 radiocarbon assays taken from samples collected by hand during controlled excavation. The sinkhole's stratigraphic units included the following: calcitic silts, silts that were rich in freshwater fauna, primarily snail shells; still-water deposited peat including wood-rich peat, and colluvium mixed with freshwater pond deposits (Dunbar 2006a, Kendrick 2006).

Many Paleoindian river basin sites are located in much shallower water or are elevated above the water table during times of low-river stage conditions. The Suwannee point component at the Ryan-Harley site is located about 1 m below low-river stage and about 10 m above sea level (Figure 3). The Norden site in the Santa Fe River basin (Figure 3) and Lewis-McQuinn site in the Suwannee River basin (Figure 3) are located in the floodplain and are about 1 m above the low river stage. These three sites contain stone artifacts as well as bone preserved in the river basin's predominately alkaline sedimentary environments. The ability to radiocarbon date these sites has been hindered by the mineralized nature of the faunal bone samples submitted for dating. Of the samples of bone from the Ryan-Harley and Norden campsites, none had surviving bone collagen and were therefore not datable. In addition, none of these sites have produced preserved botanical material, although it is possible a fire hearth feature may one day yield charcoal for radiocarbon dating (Dunbar et al. 2005, Dunbar and Vojnovski 2007). Typical floodplain sediment sequences are dominated by levels of calcitic silts, sands, lags, and freshwater limestone, all of which are conducive for good faunal bone preservation.

Sites overlooking river basins are well above the floodplain in upland settings. These include sites such as Wakulla Springs Lodge (Jones and Tesar 2000, 2004), Silver Springs (Hemmings 1975, Neill 1958), and Harney Flats (Daniel and Wisenbaker 1987), all sites that are buried in eolian (wind blown) sand. Unfortunately none of these sites are known to have organic preservation including bone, therefore radiocarbon dating has not been possible. The preservation of stone artifacts, while often generally good, is nonetheless degraded by an outer rind of patina resulting from the accumulated effects of wet-dry cycles in the sediment column through time. Nevertheless, the Wakulla Springs Lodge site is particularly noteworthy because it is the only documented Simpson point site in the Southeast known to have stratigraphic integrity (Figure 4).

In the coastal Southeast, organic preservation appears to be a function of elevation above or below the present water table as well as the alkalinity (karst) or acidity (generally upland non-karst) of a site's sediment column. Outstanding organic preservation is found in deeply inundated sites. Good preservation of bone and perhaps charcoal is found in wetland, river basin, and cave and sinkhole sites. The environments least conducive for organic preservation include upland and other open-air sites where humates increase sediment acidity and alternating wet-dry conditions facilitates the decomposition of organic materials to humates.

Another consideration of stratigraphy relates to the completeness of the Page-Ladson site stratigraphic column. The deep part of the sinkhole at the Page-Ladson site is now some 10 m below modern sea level. The Page-Ladson site sinkhole acted as a sediment trap during the late Pleistocene and accumulated an almost uninterrupted sedimentary record from the late glacial maximum until the early Holocene (Figure 5). The extent of the sediment-fill is limited horizontally to the confines of the sinkhole. The stratigraphic units in the Page-Ladson stratigraphic column are representative of the local environments of deposition and contain the well preserved organic material needed to radiocarbon date the units and levels within the units (Figure 5).

In comparison, the shallower sections of the Aucilla channel have a less complete stratigraphic sequence of deposits due to differing deposition versus erosion potentials. Similar to other sections of the lower Aucilla River, the Half Mile Rise section has an entrenched limestone channel that carries very little sediment load (Yon 1966). The river does not have terraced valleys nor does it have levee or floodplain deposits, in part due to the lack of particulate sediment load and the underground nature of karst drainage channels. The lower Aucilla River is best described as a labyrinth of underground channels slowly emerging on the land's surface due to the processes of karstification and collapse.

Karst sections of other rivers, such as the Wacissa, Wakulla, Suwannee, and Santa Fe, do have wide flood basins in many areas; however, their floodplain sediment fills are atypical compared to non-karst rivers in the Southeast. Karst river sections also carry very little sediment load, (Puri et al. 1967, Vernon 1951) and as a result often discharge almost transparent groundwater, particularly during elevated potentiometric surface intervals with low rainfall, when tannins of organic origin lend little or no dark staining to the water column. Such conditions are, and have in the past been, conducive for the deposition of calcitic silts, shelly silts, and freshwater limestone over broad floodplain expanses. This is because the potentiometric surface periodically filled these basins across the extent of their margins. Sedimentation of this type is responsible for the preservation of incorporated faunal bone. Although the calcitic floodplain sediments are wide-ranging horizontally, they also are interrupted vertically by numerous unconformable contacts between levels of disparate ages. Therefore, sediment fills of karst floodplains are much

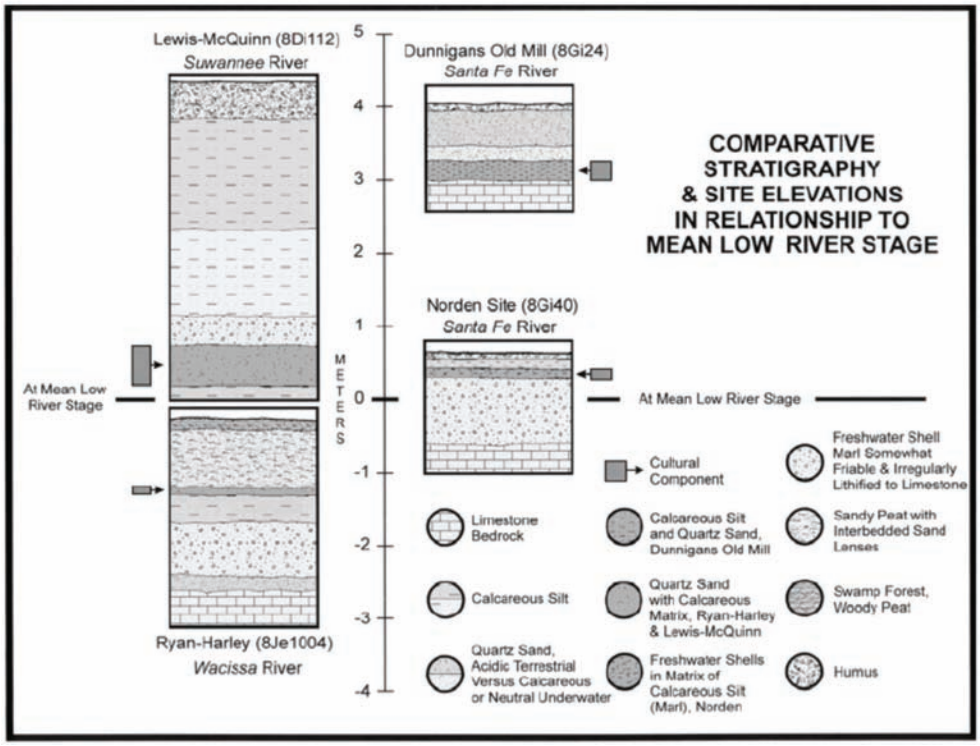

Figure 3. Stratigraphic profiles of karst river basin Paleoindian sites.

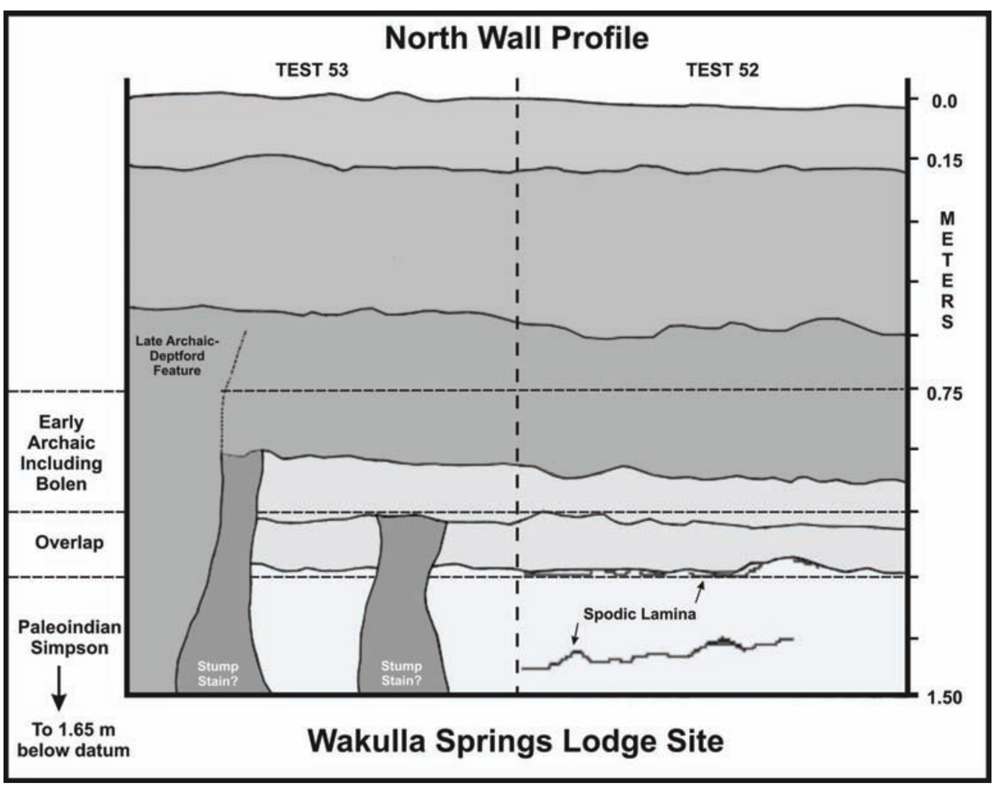

Figure 4. A stratigraphic profile at the Wakulla Springs Lodge site depicting the Simpson point Paleoindian stratum.

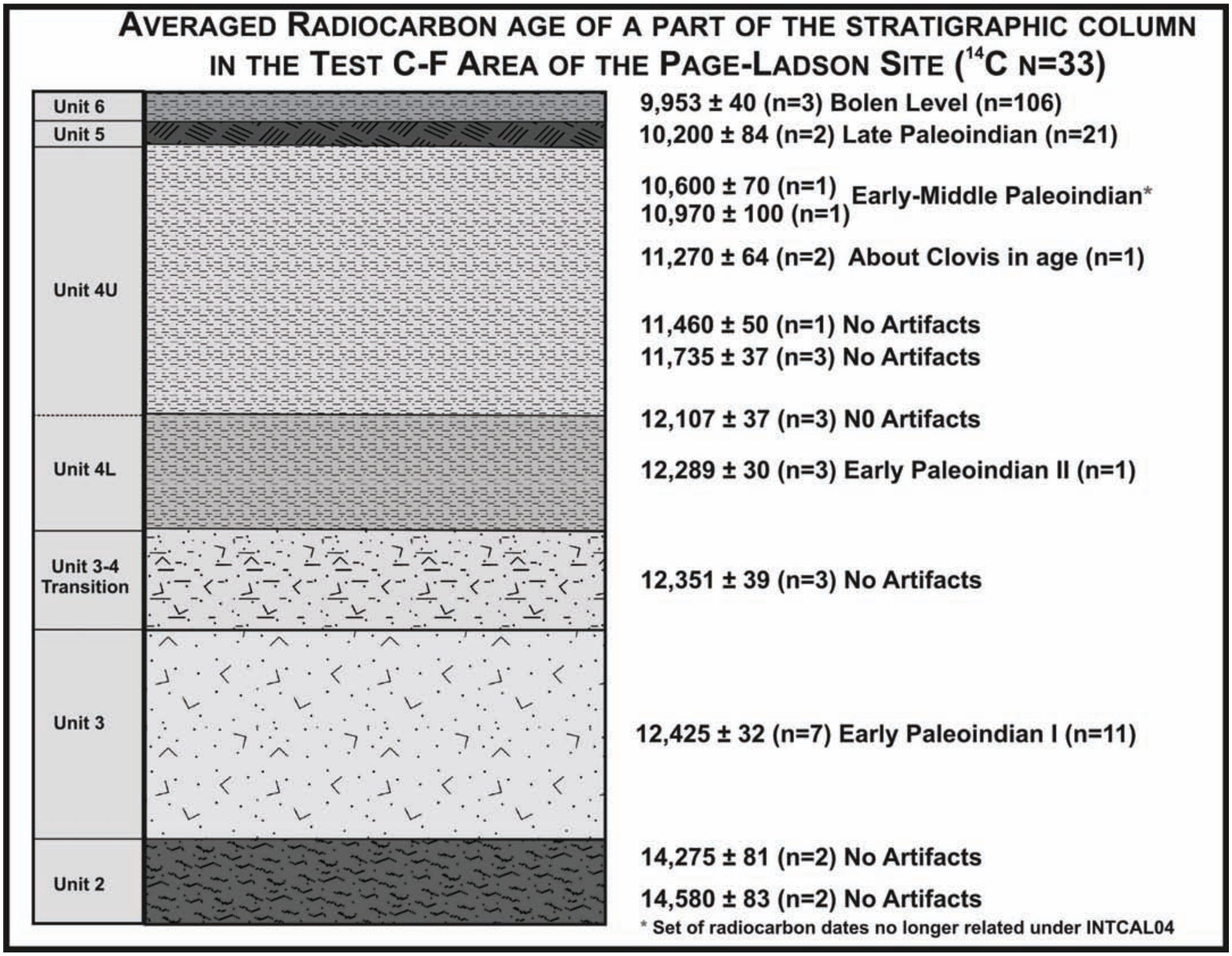

Figure 5. Showing the Page-Ladson site stratigraphic profile.

less complete compared to the sediment fills that are held in sinkholes like that at the Page-Ladson site. Karst floodplain sediment fills also have the potential to contain many more Paleoindian sites, the most significant of which are Paleoindian campsites, which are more likely to occur in floodplains than in sinkholes. The challenge in future research will be to attempt to understand when and under what conditions the floodplain sediments were formed as well as determine to what degree elevation differences and inter-basin sequences are alike or dissimilar.

Upland Paleoindian sites, with the exception of cave sites or other sites located in karst features with alkaline sediments, represent a different sedimentary environment altogether. Most upland Paleoindian sites are located in acidic, sandy, or clayey sediments where long-term organic preservation is unlikely. However, the frequent occurrence of upland eolian sand deposits in Florida offers the potential for temporal evaluation if a site's archaeological components have accumulated without subsequent episodes of erosion and are stratigraphically separated from one another by sufficient thickness of sediment accumulation.

Upland sites, such as the Harney Flats site in south-central Florida, have accumulations of eolian sands; however, and for what ever reason, the thickness of the sand deposit that hold Suwannee point component is not actually separated from the early Holocene, Bolen point component. Thus, the Suwannee and Bolen components were found to occur in same apparent level, whereas the younger site components were completely separated from this early level and from one another by much thicker sediment accumulations in upper stratigraphic levels (Daniel and Wisenbaker 1987).

In northern Florida the Wakulla Springs Lodge site has an overlap zone where Paleoindian Simpson and Early Archaic Bolen artifacts occur on the same stratigraphic level. Fortunately, there is a level below the overlap zone where Simpson artifacts occur in a discrete level (Jones and Tesar 2004). Archaeological sites with good site component separation are ideal candidates for temporal placement.

Potential for Radiometric Dating River-Basin and adjacent Upland Stratigraphies

Karst river-basin stratigraphy

In the wetland and shallow-water archaeological sites thus far encountered, collagen has not been preserved in bone samples that would otherwise be dateable using the radiocarbon method. Similarly, fire hearth features with charcoal, which could also provide a means for radiocarbon dating, have yet to be identified. It is the reason that sites such as they Ryan-Harley site remain undated. The types of material available for dating include faunal bone, teeth (including ivory), lithic artifacts, heat exploded lithic artifact fragments, and sediment matrix.

The Suwannee-point stratum at the Ryan-Harley site is composed of point bar sand mixed with lesser amounts of much finer eolian sand (Balsillie et al. 2006) (Figures 3 and 6). Directly above the Suwannee level are organic-rich sediments with lenses of unconsolidated sand. Below the Suwannee-point stratum is a consolidated, silty sand and below that a level of freshwater shell with minor inclusions of calcitic silt and small fossil bones.

At the Norden site, the Suwannee-point stratum appears to consist of a silty, sandy level mixed with calcitic shell-rich level that rests below it (Figures 3 and 7). The lower shell-rich level appears to be about 1 m thick, below which is limestone bedrock. Above the Suwannee level is a level of calcitic silt followed by an upper humus level.

At the Lewis-McQuinn site the Paleoindian level yielded a fragment of an unfluted Clovis-like base. The Paleoindian level consists of sand that is partly lithified by calcium carbonate that has leached from a freshwater, shell-rich silt level above it. Below and above these levels are levels of calcitic silt (Figure 3). The Lewis-McQuinn site is unique in that it appears to be buried below river-levee deposits and is in or very near an abandoned paleo-channel (Figure 8).

Potential means of dating the river-basin sites

Radiocarbon**.** Should bone with surviving collagen or charcoal be recovered from one of these sites, the standard radiometric or, more likely, the AMS radiocarbon method would be utilized to secured age evaluations. Charcoal from a fire pit would represent a find of major significance because it is better suited for radiocarbon dating without elaborate pretreatment. A point of caution related to selection of charcoal or any other samples for dating is one association with the cultural deposit. Are you dating the cultural deposit or something else that is not be related to the cultural deposit? Thus, sample selection from early sites becomes very important. For example, one of the selection criteria for choosing samples to date at the Cactus Hill site in Virginia included charcoal identification. A sample of white pine charcoal was selected from the suspected pre-Clovis level because it represented a species that existed locally during the colder intervals of the late glacial recession, but that had receded away from the Virginia coastal lowlands into the Appalachian Mountains, presumably after the Pleniglacial and prior to or during the Allerød[4]. The white pine sample yielded an age of 15,070 ±70 ^{14}C BP (Beta-81590) and reinvigorated the pre-Clovis controversy in the Eastern North America (McAvoy and McAvoy 1997). Subsequent radiocarbon dates from the pre-Clovis level at Cactus Hill include 16,670 ±730 ^{14}C BP ^{14}C BP (Beta-81590) and 16,940 ±50 ^{14}C BP (Beta-97708) (Feathers et al. 2006). Calibrated to calendar years before present, these radiocarbon dates indicate Cactus Hill was occupied around 18,200 to 20,200 Cal BP.

A recent caution has been expressed about using the radiocarbon method to date collagen from Pleistocene bone (George et al. 2005). Bone is composed of collagen (organic fibers) and apatite (inorganic, nano-sized mineral hydroxyapatite). It is the organic, collagen, fraction in bone that is used for radiocarbon dating; however, it can be contaminated by intrusive, postmortem organic residue. The utilization of standard pretreatment procedures for radiocarbon samples has shown that it is not uncommon for the samples to yield age determinations that are too young. For example, two samples of mastodon bones recovered from the pre-Clovis, Monte Verde site in Chile provided two dates that were obviously separated in time by about 5,000 radiocarbon years (6550 ± 160 ^{14}C BP [BETA-7824] versus 11,990 ± 200 ^{14}C BP [TX-3769])(ibid: 767). Because both of the dated samples came from the same mastodon femur (they refit together along a fracture line), their age evaluations were obviously considered problematic. One of the samples was recovered from undisturbed stratigraphic context while the other came from displaced context in an adjacent stream. Both samples used the collagen fraction of the bone to obtain dates. A recent effort to re-date both bone samples used two alternative techniques to obtain radiocarbon assays. The two techniques are related to the specialized pre-treatment and preparation of samples for dating and are more complex compared to the extraction of the bone collagen fraction for dating. The first technique dated a sample of the total amino acids while the second dated a sample of ultrafiltered gelatin from both specimens. The resulting four dates were statistically identical (12,510 ± 60 ^{14}C BP to 12,450 ± 60 ^{14}C BP) (George et al. 2005:770) and yield an average radiocarbon age of 12,460 ±30 ^{14}C BP (n=4), an age that agrees with other radiocarbon dates from the pre-Clovis, El Jobo point component at Monte Verde site in South America.

A final thought about the radiocarbon method relates to the calibration of radiocarbon years to calendar years BP or BC. There are several radiocarbon calibration programs available for use over the World Wide Web, by download, or provided by the radiocarbon laboratories themselves. The intent here is not to discuss the different programs and datasets, but to compare an example of the results derived from four calibration programs using three different datasets processing the same radiocarbon date (averaged date derived from seven statistically related radiocarbon dates from Unit 3, the oldest cultural level at the Page-Ladson site) (Table 1).These ages are statistically derived and are based on three reconstructed datasets of calendar year tables.

Radiation Exposure, OSL Dating. Age determination using the Optically Stimulated Luminescence (OSL) method has been refined over the past decade or so and has virtually replaced Thermoluminescence (TL) as a means to date sediment samples. Age determinations derived from OSL method are considered to be in calendar years BP, therefore OSL dates

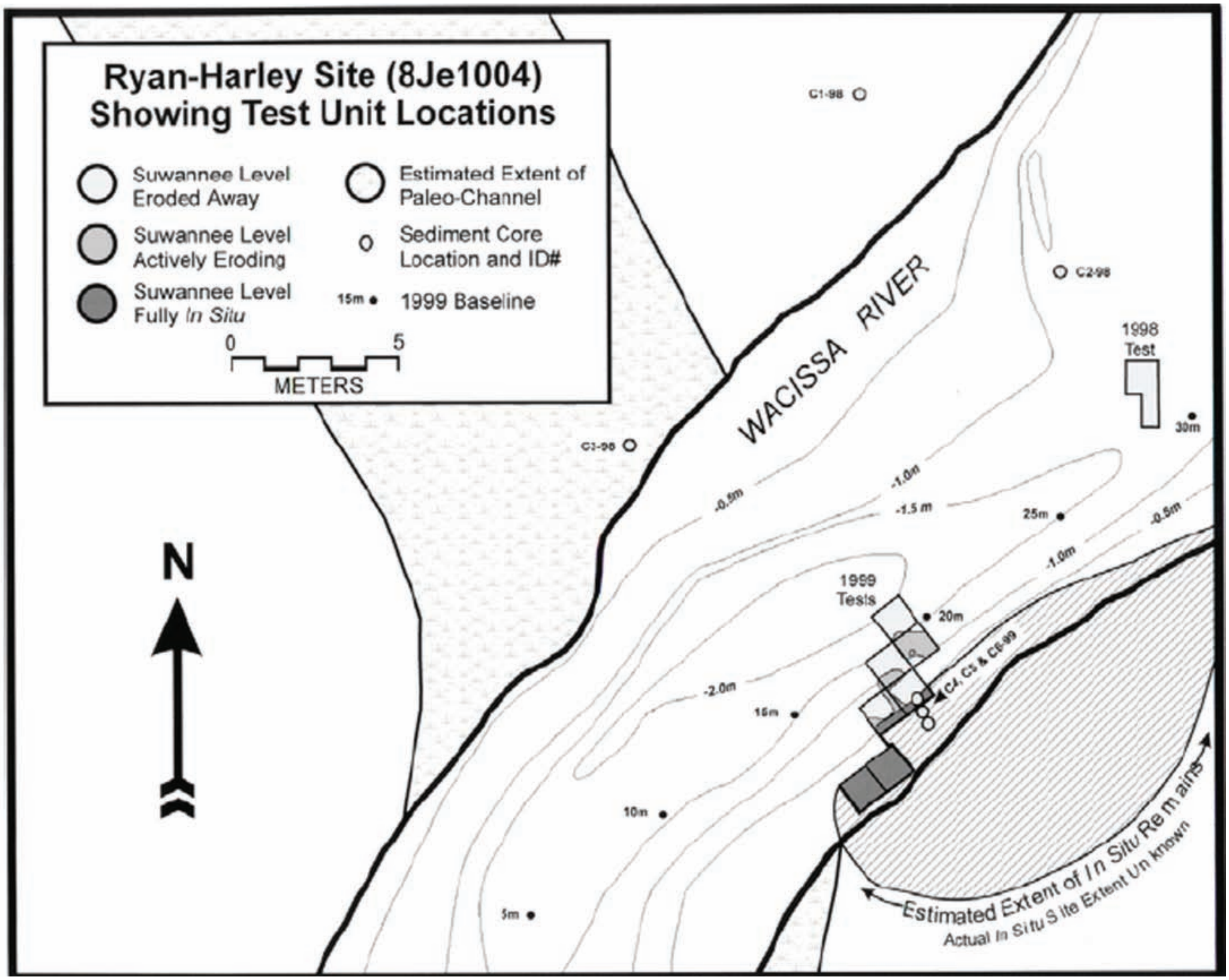

Figure 6. Ryan-Harley site plan-view map.

do not require calibration like that of the radiocarbon method. OSL dating has become a major Quaternary dating tool despite it's thus far ~3% to ~10% standard deviation in ± years cal BP. Perhaps the most important advancements in OSL dating includes the use of high-powered blue-green LEDs to release the trapped electrons in quartz, and the development of the single aliquot regeneration (SAR) method of obtaining repeated measurements from a single sample. "Another significant advance has been the ability to obtain OSL measurements from a single grain" of quartz sand (Walker 2005:99).

An important OSL success story has recently been accomplished on the pre-Clovis level at the Cactus Hill site in Virginia. Wagner and McAvoy (2004) investigated the stratigraphic integrity of the Cactus Hill site, particularly as it related to the Paleoindian Clovis and pre-Clovis levels. Their investigation determined that the Clovis and pre-Clovis levels had accumulated as a result of incremental eolian sand accumulation that contained no evidence of post-depositional disturbance. In other words, Cactus Hill contained a sediment sequence ideal for OSL dating, and that is exactly what Feathers et al. (2006) accomplished. Taking thirteen OSL samples from various levels of the site, they derived OSL dates from the pre-Clovis level that ranged in age from 17,000 Cal BP to 20,000 Cal BP, an age range in complete agreement with the calibrated (to calendar years BP) radiocarbon dates from the same level (Feathers et al. 2006:182-185).

The potential to use luminescence dating on fluvial deposits was once thought impractical due to problems related to partial zeroing[5]. However by the mid 1990s, with the increased use of OSL as a means of dating, this method brought with it a greater potential for dating river-basin sediments (Prescott and Robertson 1997). A recent landmark study employed OSL dating to determine the age of three Pleistocene braided channel beds in the Mississippi River basin. OSL dating was conducted on several samples from each of the braided channel deposits and yielded ages that were consistent with the first Pleniglacial[6]modern mode event, Meltwater Pulse IA and Meltwater Pulse IB[7]. These OSL age

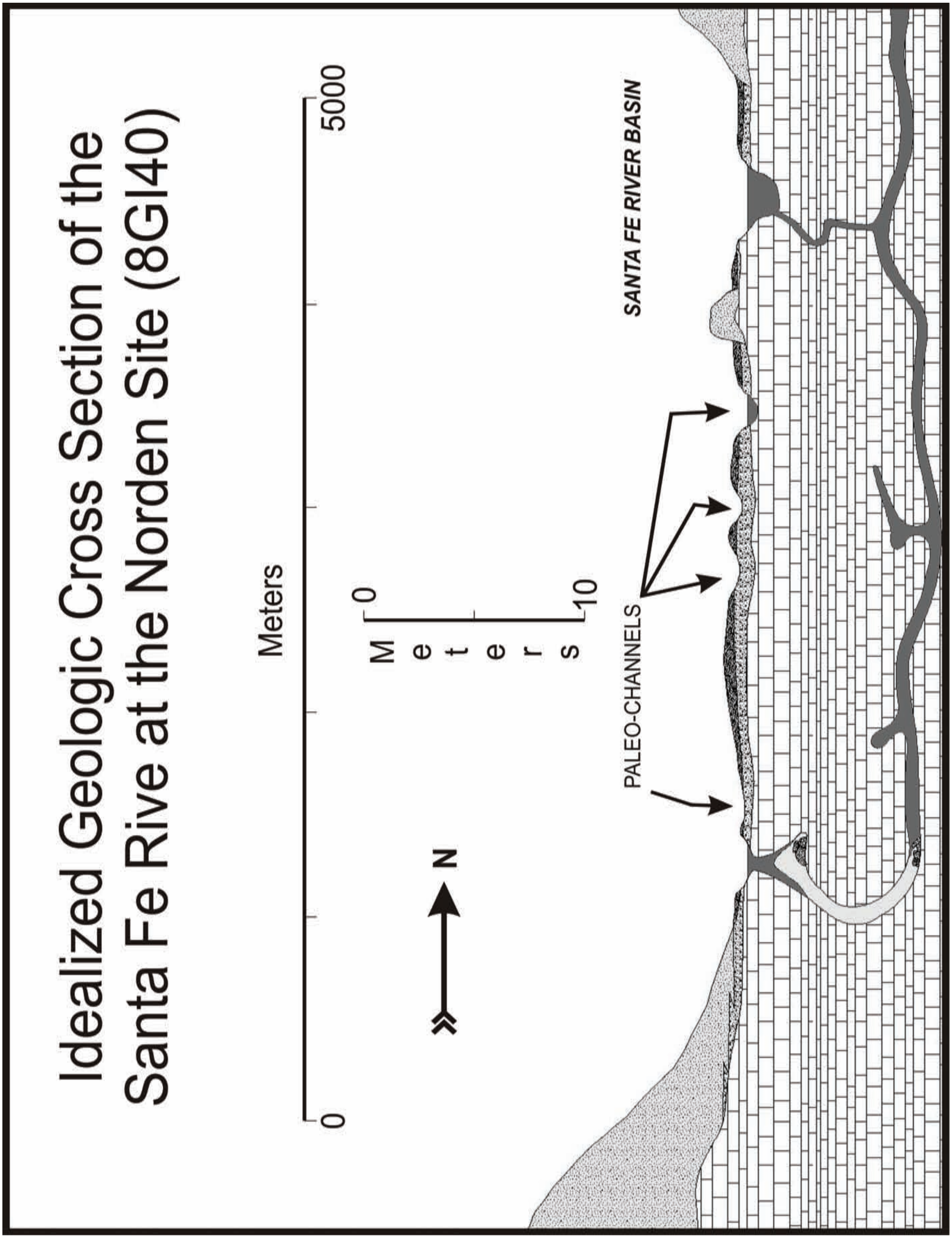

Figure 7. Norden site area, cross section.

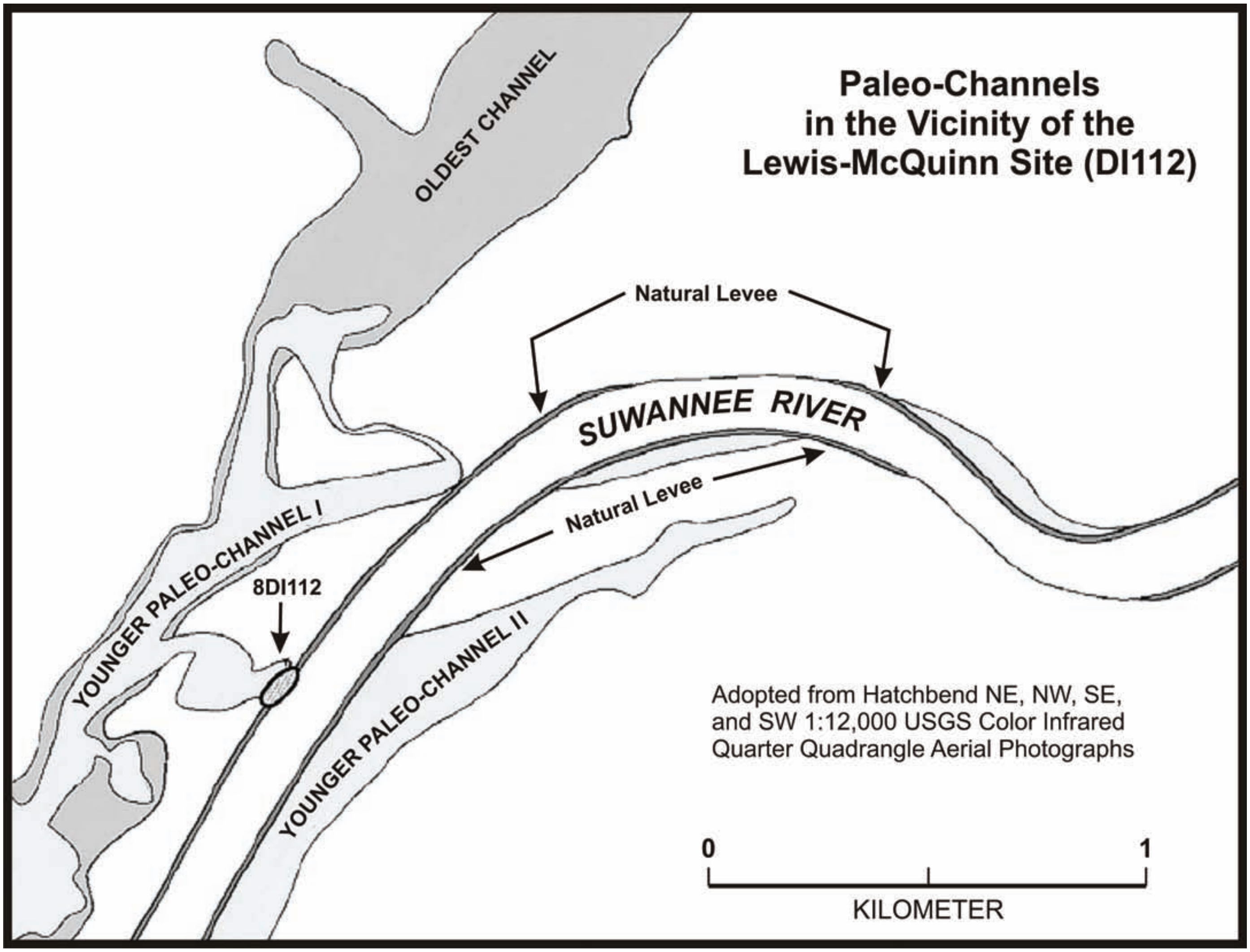

Figure 8. Plan view map of the Lewis-McQuinn site.

evaluations were in general agreement with other geologic investigations (Rittenour et al. 2003) and is touted as a leading example of a successful effort to OSL date fluvial sediments (Walker 2005).

Because OSL dating relies on quartz sand exposure to sunlight in order to set its radiometric clock, the turbid water of the Pleistocene Mississippi River is clearly an extreme test of the OSL technique. The karst sections of rivers in Florida should present a much more favorable scenario for OSL dating. Because the Ryan-Harley and Norden sites are Paleoindian camps they are significant not only archaeologically, but also for their potential to be OSL dated. During site occupation, the ground's surface was subjected to human foot traffic as well as other culturally generated ground disturbing activity. The effects of this activity helped expose the sites' sediment to daylight and increased the likelihood for it to be zeroed (fully bleached). At the Ryan-Harley site part of the sand is eolian and part is fluvial in origin. The selection of eolian versus fluvial sand grains might yield the best sand grains for dating.

<u>Long-lived Radioactive Isotopes, Uranium-Series Dating.</u> Among the types of materials that the Uranium-series method can date is calcium carbonate sediment and organisms that secrete carbonate to form exoskeletons. U-series disequilibrium dating can be used in two ways to determine age based on the U-series decay chain. These are the daughter deficient (DD) and the daughter excess (DE) methods (Walker 2005).

The DD method measures ^{230}Th/^{234}U ratios and works on the principal that uranium is soluble in water whereas thorium, the daughter, is not. Organisms such as corals and mollusks uptake uranium in their shells; however, there is little or no uptake of thorium. This makes the decay (daughter) isotope deficient and thus allows dating. The DD method also can be used on speleothems and travertines. The DD method applied to precipitated carbonate in speleothems, and travertines determines the age of its precipitation and solidification.

The DE method differs from DD because in some carbonates it is the daughter isotope that is present in excess concentration. The deficiency of the parent isotope can be due to the precipitation of the daughter but not the parent or the preferential leaching of the parent, which causes the disequilibrium state. Lakebed and seabed sediment often have

Radiocarbon Age		Calendar Age		Calibration version
Mean age	std dev ± ^{14}C years BP	Mean age	std dev ± Cal BP	
12,425	32 (n=7)	14,315	102	LDEO/Fairbanks0107 (1 sigma) 68%
		14,421	167	Calib/Intcal04 (1 sigma) 68%
		14,488	310	Calib/Intcal04 (2 sigma) 95%
		14,690	130	CalPal/05-SFCP (1 sigma) 68%
		14,690	260	CalPal/05-SFCP (2 sigma) 95%
		14,420	170	OxCal/Intcal04 (1 sigma) 68%
		14,500	350	OxCal/Intcal04 (2 sigma) 95%

Table 1. Radiocarbon to Calendar Year Age Calibrations Using Different Programs and Datasets (Chiu et al. 2007, Ramsey 2001, Reimer et al. 2004, Weninger et al. 2005).

carbonate sediments that can be dated in this manner.

Two problems with employing U-series dating are that it assumes closed-system behavior when it may not exist and samples may be contaminated by the inclusion of detrital sediment in the otherwise carbonate matrix. Open-system behavior is caused if there is post-mortem migration of radionuclides into and out of the mollusk shells (Schwarcz and Gascoyne 1984). When needed, the correction factor(s) for open-system behavior requires a detailed knowledge of the processes that caused the post-mortem isotope disequilibrium (Walker 2005).

The inclusion of detrital materials, such as eolian or water transported sediment (that also contain nuclides) in carbonate sediments can cause a problem. If the detrital sediment carries daughter isotopes they will generate dates older than the true age. On the other hand, if the detrital sediment has ^{234}U and ^{238}U, it will lead to age evaluations that are too young. The effect of detrital contamination can be corrected by measuring the ^{232}Th, which is an isotope present in detrital sediment, not carbonate; thus, the ^{232}Th/Th^{230} ratio can be used to correct for the detrital additions of ^{232}Th. The method for conducting this correction is referred to as the isochron technique (Walker 2005).

The dating of shell can be problematic if the post-mortem, open-system behavior is detected and the processes that caused the post-mortem disequilibrium cannot be determined. The dating of calcitic sediments has greater promise, although post-depositional leaching or recrystallization also may pose problems.

The problem of water-transported detrital contamination may be negligible in river basins like the Wacissa and Santa Fe, since both have little or no particulate sediment load. There may be more of a potential problem with eolian-sediment contamination, however, and as mentioned, that can be corrected. The deposition of karst basin calcitic-sediments appears to be of biologic rather than precipitated origin. Although it has not been demonstrated, the process appears to have something to do with aquatic plants and/or algae assimilating (fixing) the dissolved calcium carbonate from the water column. As a result of its death and decomposition, aquatic vegetation appears responsible for the formation of calcitic sediment, which is left behind as a residue. Presumably these calcitic sediments formed in slow-moving, relatively shallow riverine environments. Many of these environments also support freshwater mollusks and upon death their shells are also preserved in calcitic sediments.

Conclusions

Work at the Page-Ladson site has yielded the first complete late Pleistocene chronostratigraphic and geoclimatic reconstruction in the coastal Southeast. This reconstruction was possible due to the nearly complete, fully datable stratigraphic section preserved in a sinkhole that is now situated several meters below present sea level. Deeply recessed sinkhole sites offer more complete, late Pleistocene stratigraphic sections, but they also are limited in size horizontally and have not been correlated with contemporaneous river basin and upland stratigraphic sequences. The Page-Ladson site investigation recognized five levels containing Paleoindian artifacts, but none of the artifacts recovered from these levels represent diagnostic tool types. Although the chronostratigraphy and geoclimate data have been reconstructed from the site's stratigraphic profile, it has not given us the information needed to understand the temporal placement of the different types of diagnostic, Paleoindian artifacts. In all likelihood the answers will come from sites located in river basins and upland sites, which are single component or have clear stratigraphic separation of their cultural components. Therefore, it becomes imperative that future research on Paleoindian sites be undertaken with budgets that allow for their placement in time and that allows for the battery of cooperative studies necessary to firmly understand these sites. Only when this is accomplished will we be able to more completely understand the complexity of these artifact typologies, their sequence of evolutionary development, and where they fit into the chronostratigraphy and paleoclimate of late Pleistocene Florida. In this way the Southeast has lagged behind the archaeological data developed from Paleoindian sites in the desert Southwest.

In the desert Southwest, the geoarchaeological understanding of the arroyo sediment sequences has been a vital key, which led geoarchaeologists to develop the *Clovis First Hypothesis*. With advanced methods of radiocarbon, OSL, and U-series dating, we now have the means to determine the age of river basin and upland deep sand sites. The utilization of these radiometric dating methods will revolutionize our understanding of Paleoindian cultural activity and more completely refine the geoarchaeological reconstruction of the coastal Southeast. With strong evidence of pre-Clovis human activity in the Southeast, the need for multi-disciplinary research, including geologic dating and sediment analyses, becomes essential to achieving this goal.

One final thought before closing. Today it makes no sense for someone living in Florida to rely on a long-term weather forecast from New Mexico or Arizona. Yet that is what has taken place in North American Paleoindian Archaeology. It is wonderful that researchers in the Southwest have accomplished so much compared to other regions of this country, driven in part by the development of nuclear technology with offshoot research relating to radiometric dating capability. It is also true that preservation of organic remains, the stuff needed for radiocarbon dating, has more commonly been found in Paleoindian sites west of the Mississippi River than in sites east of that national divide. However, with the advent of OSL and advances in Uranium-series dating methods, we need no longer rely on radiocarbon as the only means of dating a site. Therefore, the purpose of this article is not to compare the Southeast to the Southwest; rather it is to call for well-planned research to include whatever radiometric dating method it takes to understand the dynamic late Pleistocene contexts of the Southeast. These contexts include time, habitat, climate, resources, and the cultural and material adaptations made by Paleoindian peoples that took place during the late glacial recession.

Notes

[1] An example of cultural replacement or the filling of a void left by a cultural lacuna (abandonment or absence of another people already occupying the landscape) has been hypothesized by Keith Ashley (2003:282-283) for the lower St. Johns River, Mill Cove Complex area at the Early to Middle Mississippian temporal boundary. This temporal boundary is placed at 1250 AD, which coincides with a climatic transition from a warmer climatic cycle to a cooler one widely recognized as the Little Ice Age (Fagan 2000).

[2] **Younger Dryas** – an interval of late-glacial time, from about 13,000 to 11,600 Cal BP (11,000 to 10,000 14C BP) during which the climate in the northern latitudes of the northern hemisphere deteriorated and returned to glacial maximum-like cold conditions. In the desert Southwest, large Pleistocene animals such as the horse, mammoth, and others except for the Bison, had become extinct prior to its onset.

[3] **Chlamythere-Glyptodont** – Chlamythere - the giant armadillo and the Glyptodont - a Pleistocene, thicker-shelled relative of the giant armadillo.

[4] **Allerød** - a warm (modern-mode) interval of late glacial time from about 12,300 to 11,000 14C BP.

[5] **Zeroing** (also called bleaching) – has to do with the zeroing of the luminescence clock caused by quartz sand being exposed to direct sunlight.

[6] **Pleniglacial** - a term of European origin used to identify the generally colder interval of time from the peak of the late glacial maximum ~18,500 14C BP until about ~13,000 14C BP, after which (during the Allerød) the recession of the continental glaciers became more common than their advances. With that said, there was one interval of sub-modern warming conditions during the Pleniglacial from about 17,000 to 15,000 14C BP, which is within the time-range that the pre-Clovis, Cactus Hill site in Virginia appears to have been occupied.

[7] **Meltwater Pulse (MWP) MWP-1A and MWP-1B** – represent two times that meltwater from the Laurentide ice sheet in Canada was routed down the Mississippi River to the Gulf of Mexico. MWP-1A took place from about 12,700 to 12,600 14C BP and MWP-1B from about 10,000 to 9,900 14C BP. The occurrence of meltwater in the Gulf of Mexico caused the Bermuda High pressure area to center over Florida causing severe and prolonged drought conditions. During meltwater pulse intervals to the Gulf of Mexico, inland water tables in Florida fell many meters and the climate was arid. Conversely, the desert Southwest experienced relatively moderate climatic conditions; as the climate in the eastern Gulf shifted to dry, in the western Gulf it shifted to moderate to wet conditions. It was not until aftermath of MWP-1A beginning around 11,700 ^{14}C BP and lasting to 11,000 ^{14}C BP that the Clovis drought took place in the desert Southwest and the extinction of mega-mammals took place. Conversely, in the Southeast after MWP-1A the climate was moderated and inland water tables rebounded. Rivers such as the Aucilla River resumed flow after MWP-1A. The only other evidence of cessations of channel flow conditions in the Aucilla River took place during the late glacial maximum and again during MWP-1B.

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