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DISCOVERY OF A CLOVIS POINT AT THE SONYA HOWARD MAMMOTH SITE, COLLIN COUNTY, TEXAS

Wilson W. Crook, III

Introduction

The extended drought over the last several years has significantly affected the lakes along the East Fork of the Trinity, with both Lake Lavon (Collin County) and Lake Ray Hubbard (Rockwall and Dallas Counties) now being well below conservation levels (National Weather Service, 2014). During 2005-06, Lake Lavon resident Ms. Sonya Howard discovered a number of large fossilized bones exposed by the drop in the lake level. She eventually located the source of the material that was eroding out of a shallow bank above the current level of the lake. In the summer of 2008, Ms. Howard requested that I visit the site and confirm the discovery as well as the site's geology. This I did in July and August of 2008 and in the process of the evaluation, discovered four worked flakes in association with the bones of a Colombian mammoth (Crook et al. 2011). A date on the mammoth bones was attempted (Beta – 247853) but they proved to be too heavily mineralized and no bone collagen was present.

In the summer of 2013, I revisited the site primarily to take photographs and observe how the location had been affected by the current drought. Lake levels were down 15-20' from 2008 but no substantial new bone material had been exposed. Only a few fragments of mammoth bone were found as Ms. Howard had effectively excavated the majority of the fossil. Wave action had washed up and concentrated large amounts of shell and rock forming a berm near the current water level. This berm had been cross-cut by a number of small channels where the occasional rainfall had drained into the lake. In one of these small drainage channels, a single complete Clovis point was discovered. This paper serves to record the discovery and place it into context with other Clovis age finds in the north central Texas area.

Artifact Description and Analysis

The Sonya Howard mammoth site (41COL267) lies in south central Collin County along the edge of Lake Lavon. The site is south of the community of Branch on a peninsula adjacent to a small re-entrant of the lake that follows the channel of the now submerged Ticky Creek. Trees that originally lined Ticky Creek are currently exposed and the old original pathway of the creek is now clearly visible. Elevation at the site is approximately 493' above mean sea level. A description of the site and its geology can be found in Crook et al (2011).

The Clovis point was discovered within a 30 cm wide drainage gulley that had formed cross-cutting the shell and rock berm at the lake edge (Figure 1). The point was exposed on the surface parallel with the drainage channel with the tip of the point oriented away from the lake and point's base closest to the lake margin.

Figure 1. Shell and rock berm formed by wave action at the Sonya Howard mammoth site (41COL267). Lake Lavon margin is immediately to the right. The Clovis point was discovered in the small gulley in the foreground of the photo.

The Clovis point is undamaged and unusually large, having a length of 124.8 mm. This is considerably longer than the state mean (65.0 mm) as reported in the Texas Clovis Fluted Point Survey of 408 specimens (Beaver and Meltzer 2007). Research at the Gault site, Pavo Real and other sites indicates that Clovis points are continually used, re-sharpened (and/or re-based) and then reused (Collins 1998; Bradley et al. 2010). However, once a Clovis point reaches a length of 50-70 mm it is frequently discarded (Michael B. Collins, personal communication, 2008). The two Clovis points found at the nearby Brushy Creek site (41HU74) in Hunt County have lengths of 61.4 mm and 51.1 mm, respectively, and both showed signs of having been re-tipped or re-based (Crook et al. 2009). In this regard, the Sonya Howard site point is unusual and is likely at or near its original construction length. A photo of the point is presented in Figure 2.

Figure 2. Clovis point from the Sonya Howard mammoth site. Note the reddish coloration near the distal end potentially from heat treating of the chert. XRF analysis demonstrates the chert is from the Fort Hood area, Bell and Coryell counties.

Fluting is present on both the obverse and reverse faces of the point, although the length of the flutes (32.1mm and 29.2 mm, respectively) are relatively short compared to the overall length of the point. Similarly, lateral grinding (31.9 mm on left edge, 37.4 mm on right edge) is only 25-30 percent the length of the point. Basal depth is only 2.5 mm with weak grinding. A complete compilation of all the point's physical characteristics, as submitted to the Texas Clovis Fluted Point Survey, is listed in Table 1.

Table 1. Clovis Point Measurements, Sonya Howard Mammoth Site (41COL267), Collin County, Texas

Clovis Point	**Measurements (mm)**
Maximum Length	124.8
Maximum Width	35.0
Basal Width	30.2
Distance from Maximum Width to Base	53.7
Maximum Blade Thickness	9.3
Distance from Maximum Thickness to Base	53.7
Basal Depth	2.5
Thickness at Flute	6.5
Obverse Flute Length	32.1
Obverse Flute Width	16.8
Reverse Flute Length	29.2
Reverse Flute Width	17.0
Length of Grinding Left Lateral Edge	31.9
Length of Grinding Right Lateral edge	37.4
Basal Grinding	Weak
Weight (grams)	49.3 gm
Breaks	None
UV Fluorescence	Yellow-Orange
Material	Chert*

* Color matches Fort Hood Gray-Brown-Green Mottled; X-Ray Fluorescence analysis confirms the source as Fort Hood chert.

The point is constructed from a gray to light olive-brown chert (5Y 6/1 to 2.5Y 5/3-5/4). The chert fluoresces a brilliant yellow-orange color under both short and long-wave UV radiation. This is very similar to the so-called “Gray-Brown-Green Mottled” variety of Edwards chert as described by Dickens (1995) from the Fort Hood Military Reservation in Bell and Coryell counties. The point has an overall waxy sheen and there are areas of reddish coloration near the tip that could be signs of heat treatment (see Figure 2).

The point was subjected to a trace element geochemical analysis using a portable X-Ray Fluorescence spectrometer (pXRF) in order to attempt to determine its provenance. The analysis was conducted using a Bruker Tracer III-SD handheld energy-dispersive X-Ray Fluorescence spectrometer equipped with a rhodium target X-Ray tube and a silicon drift detector with a resolution of ca. 145 eV FWHM (Full Width at Half Maximum) at 100,000 cps over an area of 10 mm^2. Data was collected using a suite of Bruker pXRF software and processed running

Bruker's empirical calibration software add-on. Analysis was conducted during 2013 at the laboratory of the Gault School of Archeological Research located at Texas State University in San Marcos.

The Sonya Howard Clovis point was measured at 40keV, 55µA, using a 0.3 mm aluminum / 0.02 titanium filter in the X-Ray path, and a 60 second live-count time. Peak intensities for Kα and Lα peaks of 17 trace elements were calculated as ratios to the Compton peak of rhodium and converted to parts-per-million (ppm).

Provenance analysis of the trace element data collected from the artifact was conducted using a database of geologic samples from the Edwards Plateau obtained by the Gault School of Archeological Research. A total of 464 geologic samples from 4 major geographic regions of the Edwards Plateau (Gault area, Fort Hood, Callahan Divide, Leon Creek) were collected and analyzed using the same method described above. A statistical analysis based on the methodology developed by Speer (2014) was conducted on both the geologic database as well as the Sonya Howard Clovis point. Statistical analysis of the trace element signature from the Clovis point indicates a match with the Fort Hood region at a 95 percent confidence level. This result confirms the visual and UV observation of the artifact that had previously suggested a Fort Hood origin for the chert.

Conclusions

It is uncertain if the Clovis point originally was in direct association with the mammoth bones. Clearly the point's presence in the small drainage channel indicates that it likely originated up dip of its discovery location. This is precisely where the largest pieces of the mammoth were recovered in situ (Crook et al. 2011). The point's large size and undamaged condition also suggest that it could have been imbedded in the mammoth and thus preserved intact with subsequent burial. During the initial excavation of one of the animal's shoulder blades and vertebrae, four small worked flakes of Alibates dolomite were recovered. These were assumed to have been part of the butchering of the mammoth; the point therefore could have been part of its kill.

Clovis points are extremely rare in north central Texas, with a single point recovered from the Lewisville site (41DN72) in Denton County (Crook and Harris 1957), a broken point from the Aubrey site (41DN479) also in Denton County (Ferring 2001), and two complete but highly used points from the Brushy Creek site (41HU74) in Hunt County (Crook et al 2009). The Clovis point found at the Sonya Howard site marks the first reported Clovis occurrence for Collin County (David Meltzer, personal communication, 2013). Its location, midway between the four sites, poses an interesting question as to whether they might be related.

The composition of the Sonya Howard point also shows a potential correlation, at least to the Brushy Creek site 18 km to the east. XRF analysis on the chert artifacts from Brushy Creek has shown a large number are constructed of Edwards Plateau chert, mostly from the eastern part of the Plateau including the area in and around the Gault site in Bell County and the Fort Hood region (Crook and Williams 2013). Paleoindian hunters, especially Clovis people, are well-documented to have traveled extensive distances to access unique and/or high quality work material (Bradley et al. 2010). In fact, one of the salient characteristics of Clovis stone assemblages is the wide variation seen in the stone material used and the long distances that separate the archeological site and the geologic provenance of the source material (Kilby 2008).

Both the Sonya Howard and Brushy Creek site assemblages strongly reinforce this character trait.

Acknowledgments

I would like to thank the Gault School of Archeological Research located at Texas State University for access to their portable X-Ray Fluorescence unit. In particular, I would like to specifically thank Mr. Thomas J. Williams for his performance of the XRF analysis and subsequent canonical discriminant analysis of the data that led to the determination of the Fort Hood provenance for the Sonya Howard Clovis point.

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TWO NEW RADIOCARBONDATES FROM THE UPPER FARMERSVILLE SITE (41COL34), COLLIN COUNTY, TEXAS

Wilson W. Crook, III and Mark D. Hughston

Introduction

During the summers of 1973-75, the authors conducted several focused excavations on the so-called "Wylie rim-and-pit" structures that occur in many of the larger Late Prehistoric sites along the East Fork of the Trinity and its tributaries in Collin and Rockwall Counties, Texas (Crook and Hughston 2008). In particular, in May, 1973 we coordinated a salvage excavation on part of the rim as well as within the interior of the pit structure at the Upper Farmersville site (41COL34) in north-central Collin County. During this work, two significant features were discovered; an apparent trash pit was found in the rim of the pit and a large hearth was uncovered near the center of the pit structure.

Subsequent excavation of the features showed the trash pit to contain the remains of a large shell-tempered plain ceramic bowl that had apparently fallen apart during firing and had been discarded. Associated with the fragments of the bowl was a single Ellis dart point made from light gray quartzite, a broken piece of turtle shell with a well-made incising point on one end, and a small piece of limestone that had been hollowed out on one side and filled with a gray-colored ochre. The entire pit containing these artifacts was filled with charred vegetable matter, from which the remains of hackberry, pecan and other burned shells were recovered (Crook and Hughston 2009).

Reconstruction of the shell-tempered bowl showed the vessel to be consistent with type Nocona Plain as defined in Suhm and Krieger (1954) and Suhm and Jelks (1962). The reconstructed bowl was placed on exhibit in the Heard Museum of Natural Science in McKinney, Texas, one of the primary sponsors of the excavations at the Upper Farmersville site (Crook and Hughston 1986). The remaining materials were carefully labeled and stored for future study. All the burned vegetable matter was stored in aluminum foil and sealed in a glass container for possible future radiocarbon dating. These materials were then curated in the basement storage rooms of the Heard Museum.

Excavation of the hearth feature from the center of the pit revealed a number of large pieces of fire-cracked sandstone, five pieces of Cretaceous fossil oyster shell, broken fragments of more recent pelecypod shells, and the broken base of a large chert biface. The hearth contained a significant amount of charcoal, all of which was carefully removed, sealed in aluminum foil, and stored in sealed glass containers for possible future radiocarbon dating. All of the excavated materials from the hearth were stored together in the basement storage at the Heard Museum.

In March of 2014, the senior author approached the Heard Museum about being able to photograph, record and re-study the collections from 1973-75. This was graciously allowed by the Museum staff and virtually all of the authors' previously excavated materials were found intact and still sealed. In particular, a split of the preserved vegetable matter from the trash pit and the charcoal from the hearth feature was sent to Beta Analytical for radiometric dating. This has now yielded two new radiocarbon dates, the first from the Upper Farmersville site.

In addition, detailed photographs and measurements were taken of the artifacts found associated with the two features. Both the gray ochre-stained paint pot from the trash pit and the broken chert biface from the hearth feature were taken to the laboratory of the Gault School of Archeological Research at Texas State University and subjected to X-Ray Fluorescence (XRF) analysis. This analysis confirmed the presence of the mineral galena, PbS, as the source of the gray-colored ochre in the paint pot. The chert from which the biface was constructed was shown to have originated from the Edwards Plateau. This paper describes the artifacts recovered from the two features as well as places the two new radiocarbon dates in relationship with previously published age dates from sites along the East Fork.

The Upper Farmersville Site (41COL34)

The Upper Farmersville site is located in North-Central Collin County about 8 km (5 miles) northwest of the town of Farmersville. The site lies on either side of Farm Road 2756 immediately west of the confluence of Pilot Grove and Indian Creeks. The original landowners, the Warren Dugger family, cultivated the section of land north of the road leaving the smaller southern part of the site largely undisturbed. This untouched southern portion of the site contained remnants of a large Wylie Phase "rim-and-pit structure". The authors began a study of the site in 1971 and continued periodic work until the mid-1970's, with a special emphasis on the undisturbed portion of the site south of Farm Road 2756 (Crook 1984a, 2009; Crook and Hughston 1986, 2009). Enlargement of the Lavon Reservoir in 1979 was believed to result in the raising of Pilot Grove Creek and the subsequent inundation of most of the site. As a result, a significant portion of the remaining southern part of the site was removed as fill material for the construction of a new elevated portion of Farm Road 2756. Only a small remnant of the southernmost portion of the rim-and-pit structure now remains after road construction (Figure 1).

The Upper Farmersville site is one of the largest Late Prehistoric occupations along the East Fork and is well-known for having produced an abundance of unique artifacts, many of which were likely the product of exchange. Some of these artifacts include a complete Sanders Engraved water bottle (Harris 1936, 1948), eight socketed bison scapula hoes (Harris 1945), an exotic boatstone made from Arkansas diorite (Harris 1960), a unique bone harpoon (Crook 1984b), a juvenile burial with 12 attendant pieces of grave furniture (Crook 1984a), and a large cache of unusually-shaped arrow points made from exotic cherts (Crook 2009). Coupled with large amount if imported pottery, these artifacts suggest that the Upper Farmersville site was a major local entrepot for trade, especially with the Caddo peoples to the east (Crook 2014a).

Feature 1 - Trash Pit in the Pit Rim

Two backhoe trenches at right angles to each other were put through the southern and the western parts of the rim of the pit structure at Upper Farmersville, intersecting near the center of the pit. At a depth of 10-15 cm, the southern trench exposed several large pieces of plain, shell-tempered pottery. While broken, the pieces were close to their original fit, forming one side of a large bowl. Backhoe trenching was terminated on the rim and replaced by a careful excavation with trowel and brush.

Figure 1. Remnant part of the Rim-and-Pit Structure, Upper Farmersville (41COL34) Site, Collin County, Texas. The original rim structure (from the tree to the right of the telephone pole) curved toward the position of the photographer with the trash pit discussed herein being located in the right foreground of the photo.

The pottery sherds that had been initially exposed by the backhoe were found to be part of a largely complete, shell-tempered plain vessel that had collapsed on top of itself when placed into the rim. The sherds on the upper side were found to be well-fired to over-fired; some even containing a bubbly, frothy texture from having partially melted during the firing process. Underneath these sherds was the backside of the vessel, much of which was completely under-fired. Many of these fragments were extremely friable, still having a soft clay texture. As a result, a complete reconstruction was impossible. However, enough of the base and one side of the vessel were present to make a partial reconstruction and estimate its overall dimensions. These are presented in Figures 2 and 3 as well as Table 1 below. Overall, the vessel is characteristic of type Nocona Plain as described in Suhm and Krieger (1954) and Suhm and Jelks (1962).

Excavation of the area containing the bowl revealed a small pit, approximately 1.0 x 0.6 meters that had been partially filled with burned vegetable material. In addition to the 33 sherds that were identified as being part of the Nocona Plain bowl, other artifacts found in the trash pit included 5 shell-tempered sherds (type Nocona Plain) that were clearly in terms of color and texture from a different ceramic vessel, one Ellis dart point made from light-gray quartzite, an ovoid (66.5 mm x 34.3 mm) piece of local Austin Chalk limestone that had been hollowed out on one side and used as a paint pot for powdered galena (PbS) ochre, and a fragment of turtle shell that had a well-defined point on one end. The latter, shown in Figure 4, may have been used for incising pottery. Based on the above collection of unassociated artifacts, the presence of a failed pottery vessel that appears to have been discarded, coupled with the presence of burned vegetable matter, led us to conclude that the feature was likely a trash pit.

Figure 2. Side view of the plain shell-tempered jar from trash pit at the Upper Farmersville site, Collin County, Texas.

Figure 3. Upper view of the same vessel; note the over-fired frothy condition of the sherds near the base on the far side.

Table 1. Nocona Plain Bowl from Rim of the Pit Structure
Upper Farmersville Site (41COL34), Collin County, Texas

Major Attributes	Measurements / Observations
Ceramic Type	Nocona Plain
Vessel Type	Large Bowl
Color	Highly Mottled; Very Pale Brown (10YR8/3) to Light Gray to Gray (10YR7/2-6/1) to Grayish-Brown (10YR5/2) to Dark Gray (10YR4/1)
Fire Mottling	Yes; extensive
Temper	Shell
Paste	Coarse; Tan to Gray
Surface Finish	Poorly smoothed and uneven
Height	129.9+ mm
Base	Flat, 110.5 mm
Body	Gently Sloped Outward
Basal Thickness	9.5 mm
Wall Thickness	4.5-5.0 mm (Rim) to 7.0-8.5 mm (Sides)
Max. Diameter Orifice	247.4 mm
Diameter Base of Rim	110.5 mm
Rim Type	Lip rounded and flush with wall
Body Decoration	None
Rim Decoration	None
Reconstruction	Partial (9 sherds); 24 unfitted additional sherds into four wall pieces (165 x 186 mm; 124 x 111 mm; 90.5 x 115 mm; 79.4 x 86.2 mm) and one rim section (32 x 64 mm)
Occurrence	Trash pit located in rim of large rim-and-pit structure; bowl associated with charred vegetable matter, limestone paint pot, turtle shell engraving tool, Ellis dart point
Date	AD 1300 +/- 30 (650 +/- 30 BP)

Feature 2 – Hearth Inside the Pit Structure

Near the estimated depocenter of the rim-and-pit structure, one of the backhoe trenches intersected the side of a hearth. This feature was subsequently excavated and shown to be approximately 1 x 1.5 meters in aerial extent. The hearth was exposed 10 cm below the present surface and extended to a depth of 40 cm.

Figure 4. Possible pottery incising tool found in the trash pit in the rim of the pit structure at the Upper Farmersville (41COL34) site, Collin County, Texas. Dimensions of the tool are 42 x 10.5 mm.

Portions of the edges of the hearth were lined with hardened clay daub, some of which retained wattle impressions (Figure 5). Similar hearth construction was reported by Lynott (1975a, 1975b) from the Sister Grove Creek site (41COL36). Stephenson also noted wattle and daub in some of the hearth features excavated from the pit structure at Hogge Bridge (41COL1) (Stephenson 1952), and daub was found in one hearth excavated by the Dallas Archeological Society at the Branch site (41COL9) (R. K. Harris, personal communication, 1973).

At the base of the hearth were a large number of rectangular shaped pieces of coarse-grained sandstone. A number of these rocks either had cracks developed in them and/or had broken into fragments. All were a deep red-brown color from intense heating (Figure 6). Fire-cracked rock, often sandstone, is a common element in hearths along the East Fork. Hearths filled with fire-cracked rock have been found at Branch (Harris 1965), Sister Grove Creek (Lynott 1975), Hogge Bridge (Stephenson 1952), Upper Rockwall (Ross 1966), Glen Hill (Ross 1966), Lower Rockwall (Lorrain and Hoffrichter 1968), and Gilkey Hill (Crook 2011; Todd and Skinner 2006; Todd et al., 2011). The rectangular nature of many of the sandstone blocks may give a hint as to their source. Sandstone does not crop out in Collin County, the bedrock being either Austin Chalk (limestone) or the Taylor Marl (Ozan Formation) of Upper Cretaceous age. However, in central Rockwall County, prominent NNE-SSW trending dikes of sandstone from the Wolfe City Formation were exposed in a number of locations (Paige 1909; Martin and Denton 1932). While most exposures are now covered by human development, original descriptions of the dikes indicate the sandstone was tabular in nature with regular fracturing due to having been squeezed up through fissures in the overlying Cretaceous limestone strata (Martin and Denton 1932). As a result, flat, tabular blocks for use in earth ovens could have been easily obtained. Black and Thoms (2014) have shown that earth ovens best retain heat when lined with silica-rich rocks (sandstone being an especially good heat element) with a bed of coals on top and then buried during the cooking process. This technique appears to have been extensively practiced all across the East Fork.

Figure 5. Pieces of daub found lining the hearth feature. Wattle impressions can be seen in the piece in the top row right.

Other elements found in the hearth feature included five pieces of fossil oyster shell (Figure 7), a number of broken fragments of more modern pelecypod shells, and the broken base of a large chert biface (Figure 8). Both the fossil and freshwater pelecypod shells showed blackening on the exterior of the shells from having been exposed to fire. Two of the fossil shells were of unidentifiable fragments; the other three (see Figure 7 bottom row) could be generally classified as belonging to both *Ostrea sp*. and *Crassostrea sp.*, both common oysters from the Upper Cretaceous Gulf Series. Why fossil oysters would have been in a Late Prehistoric earth oven is unknown; they could have either served as heating elements themselves and/or may have been used as food holders. The more recent pelecypods were largely fragmented making identification difficult. However, two species, *Amblema picata* and *Lampsilis hydiana*, both common constituents of the invertebrate fauna of the East Fork, were identified (Harold Laughlin, personal communication, 1973).

Figure 6. Fire-cracked sandstone from the hearth feature excavated at the Upper Farmersville (41COL34) site, Collin County, Texas. Note the tabular nature of the sandstone and the intense red coloration from exposure to heat.

Figure 7. Fossil Cretaceous oyster shells (*Ostrea sp*. and *Crassostrea sp.*) recovered from the hearth feature.

Figure 8. Broken base of chert biface recovered from the hearth feature. XRF analysis shows it to be constructed from Edwards chert.

The remaining artifact recovered from the hearth was the base of an ovoid-shaped biface (see Figure 8). The biface was constructed of a white to light-gray colored chert (N 9/0 – N 8/0), 49.8 mm (remaining length) by 53.4 mm wide. Maximum thickness is 6.5 mm. The artifact fluoresces a bright yellow-orange under both short and long-wave UV radiation. Analysis by X-Ray Fluorescence shows it to be composed of almost pure silica with minor traces of iron. Based on source models developed for Texas cherts at the laboratory of the Gault School of Archeological Research, the biface is made from Edwards chert (Tom Williams, personal communication, 2014).

Radiocarbon Dating

As mentioned above, both the trash pit and the hearth were filled with coarse and fine-grained charred vegetable matter. Examination of this material under 20-60x revealed the presence of some burned seeds and nuts amongst the unidentifiable charred material. These seeds included hackberry along with pieces of pecan and walnut shells (Harold Laughlin, personal communication, 1973).

Splits of the recovered carbon material from both features were sent to Beta Analytic, Inc. for radiocarbon dating. After pretreatment, 21 grams of charcoal was recovered from the trash pit sample (Feature 1; Beta – 376327) and 799 milligrams of charcoal from the heart (Feature 2; Beta – 376328). Most of the material collected from both samples turned out to be sediment but there was enough for a conventional radiometric dating for Feature 1 and for Accelerator Mass Spectrometry (AMS) dating of the carbon from Feature 2.

Radiocarbon analysis results indicate both samples date to the Late Prehistoric period that is consistent with the major occupation of the site. Conventional radiocarbon age on Feature 1 was 650 +/- 30 BP with a two sigma calibration of A.D. 1280 to 1325 (Table 2). The AMS date on Feature 2 was 580 +/- 30 BP with a two sigma calibration of A.D. 1345 to 1395 (Table 2).

Table 2. Radiometric Data from Two Features from Upper Farmersville (41COL34)

Sample	**Conventional Radiocarbon Age**	**Intercept**	**2 Sigma Calibration**	**1 Sigma Calibration**	**^{13}C / ^{12}C**
41COL34 – F1 (Beta-376327)	650 +/- 30 BP	A.D. 1295	A.D. 1280-1325	A.D. 1290-1310	-26.0
41COL34 – F2 (Beta-376328)	580 +/- 30 BP	A.D. 1370	A.D. 1345-1395	A.D. 1360-1385	-27.9

Conclusions

The excavation of the two features described above at the Upper Farmersville site yielded an extraordinary number of significant results. First and foremost, two new radiocarbon dates were obtained; the first dates for the Upper Farmersville site. The radiocarbon dates of A.D. 1300 +/- 30 and A.D. 1370 +/- 30 obtained from the trash pit and the hearth are consistent with dates obtained from other East Fork sites, in particular Sister Grove Creek (TX2036, TX2039) and Upper Rockwall (TX320) (see Table 3 below).

Both the trash pit and the hearth were uncovered at a depth of 10-15 cm below the present surface. Based on excavations in undisturbed strata elsewhere at the Upper Farmersville site (Crook 2009; Crook and Hughston 2009), this represents the upper third of the occupation at the site. Radiocarbon dates from the Sister Grove Creek and Upper Rockwall sites, both of which have near identical stratigraphy to Upper Farmersville, indicate a Late Prehistoric occupation that spans the period from approximately A.D. 800-900 to A.D. 1500-1600, with suggested peaks (based on frequency of radiocarbon dates) at A.D. 1000-1150 and A.D. 1250-1400 (Lynott 1978). The dates obtained from Upper Farmersville of A.D. 1300 +/- 30 and A.D. 1370 +/- 30 fit well within this observed occupational range.

Secondly, a radiocarbon date on material in association with the artifacts recovered from the trash pit also serves to effectively date those objects as well. A date of A.D. 1300 +/- 30 for the Nocona Plain bowl matches the estimated age of the type as initially put forth by Suhm and Krieger (1952). Moreover, as the ceramic vessel appears to have been discarded after a failed attempt at firing, the vessel also gives the only verifiable evidence that the Late Prehistoric peoples of the East Fork manufactured at least some of their own pottery (Crook and Hughston 1986). The worked turtle shell incising tool may also have been used in the subsequent decoration of some locally made ceramics.

Table 3. Radiocarbon / Collagen Dates From East Fork Late Prehistoric Sites

Site	Sample Reference Number	Corrected Radiocarbon Date (A.D.)	Comments
Hogge Bridge (41COL1)	TX1928	1000 ± 70	Charcoal in association with fire-cracked rock from large hearth inside rim-and-pit structure
Upper Farmersville (41COL34)	Beta-376327	1300 ± 30	Trash Pit – charcoal from pit within pit rim; associated with Nocona Plain bowl
Upper Farmersville (41COL34)	Beta-376328	1370 ± 30	Charcoal from hearth near middle of rim-and-pit structure
Sister Grove Creek (41COL36)	TX2033	1590 ± 70	Feature 5 – charcoal in association with fire-cracked rock in a hearth from the central part of the rim-and-pit structure
Sister Grove Creek (41COL36)	TX2034	980 ± 200	Feature 6 – charcoal from a hearth in the southern part of the rim-and-pit structure
Sister Grove Creek (41COL36)	TX2036	1380 ± 80	Feature 7 – charcoal from a hearth in the northern part of the rim-and-pit structure
Sister Grove Creek (41COL36)	TX2037	980 ± 70	Feature 8 – charcoal from a suspected hearth at the base of the rim-and-pit structure
Sister Grove Creek (41COL36)	TX2038	950 ± 240	Feature 10 charcoal from a hearth in the eastern end of the rim-and-pit structure
Sister Grove Creek (41COL36)	TX2039	1330 ± 80	Feature 11 – charcoal from a hearth outside the rim-and-pit structure
Sister Grove Creek (41COL36)	TX2040	1160 ± 90	Feature 15 – charcoal from a burial located outside the rim-and-pit structure
Sister Grove Creek (41COL36)	SMU233	1160 ± 60	Feature 15 – collagen and apatite date from human bone from the burial
Sister Grove Creek (41COL36)	SMU239	1160 ± 45	Feature 15 – collagen and apatite date from human bone from the burial
Upper Rockwall (41RW2)	TX320	1330 ± 120	Burial 1 – charcoal from grave fill within rim-and-pit structure
Upper Rockwall (41RW2)	TX315	1020 ± 90	Charcoal from burned zone inside rim-and-pit structure

The occurrence of galena at the Upper Farmersville site marks the third known occurrence of the mineral from sites along the East Fork and the first occurrence of where the mineral has been powdered for use as a pigment. Naturally occurring galena is exceedingly rare in Texas, found only in the Shafter mining district in Presidio County and the Pavitte mine in Burnet County. In both occurrences, galena occurs as vein material in association with silver, copper and traces amounts of gold (Sellards 1934). In fact, both mines were exploited for silver rather than galena. X-Ray Fluorescence analysis on the Upper Farmersville artifact shows it to be very close to stoichiometric PbS with little to no associated trace elements. This is more characteristic of galena from the Picher Field in the so-called Tri-State area of northeast Oklahoma-southeast Kansas-southwest Missouri (McKnight and Fischer 1970). While some galena from the Tri-State district has recoverable amounts of silver, many assays should only trace amounts with even less of copper, gold and other metals (McKnight and Fischer 1970).

Galena is well-known as a high value trade item throughout the Upper Mississippi River Valley (Walthall 1981). Powdered and mixed with animal fat, galena made a unique silver-gray pigment that could not be duplicated by the more common earth pigments such as red and yellow ochre (Walthall, 1981). Five hundred pounds of powdered galena and over one thousand pounds of unworked galena ore was reportedly found in the major burial chamber of Craig Mound at Spiro (Brown 1976; La Vere 2007). Galena was also one of the items believed to have been traded from Spiro to its immediate network in exchange for other high value items.

Schambach (1995), Bruseth et al. (1995) and others have postulated that major sites along the Red River in Texas, such as the Sanders site (41LR2), could have served as a Spiroan entrepots for trade. It is intriguing that the lead ochre paint pot described above comes from one of the largest sites along the East Fork. It is probable that Upper Farmersville, along with other major sites like Branch, Upper Rockwall and Lower Rockwall, served as centers of trade between the East Fork and the peoples east of the region, thus serving as the principal entrepots for the East Fork. Perttula (1992, 2002) has noted that trade between the Caddo peoples of East Texas and those in the surrounding regions notably increased in the A.D. 1300-1400 timeframe. The artifacts as well as the corresponding age date for the materials from the trash pit strongly support this observation.

Lastly, the radiocarbon date of A.D. 1370 +/- 30 from the hearth feature located inside the rim-and-pit structure demonstrates that use of the pit was more or less contemporaneous with the age of the artifacts from the trash pit. Other artifacts found in the rim of the pit structure at the Upper Farmersville site, such as a complete miniature Killough Pinched jar (Crook 2014b), also correspond well with this time period. Excavation of the hearth showed it to contain the remains of an earth oven as has been found elsewhere in sites along the East Fork, notably at the Sister Grove Creek site (Lynott 1975a). The lack of discovery of any other feature inside the pit, such as post holes, reinforces the conclusion that these structures were likely used for some form of communal feasting activities.

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A NEAR COMPLETE SHELL-TEMPERED VESSEL FROM THE SISTER GROVE CREEK SITE (41COL36), COLLIN COUNTY, TEXAS

Wilson W. Crook, III

Introduction

A near complete and reconstructed shell-tempered vessel has been recovered by the author from the Sister Grove Creek site (41COL36) in Collin County, in north central Texas. The vessel is of an un-named type, but is similar to shell-tempered vessels from East Texas along the Red River and from southeastern Oklahoma. The vessel has prominent lip notching on the rim as well as two curved strap handles, the first known occurrence of these forms in any of the Late Prehistoric sites along the East Fork. This paper discusses the find and the character of the reconstructed vessel, and puts on record further evidence of contact between the Caddo and Late Prehistoric populations living in the upper Trinity River basin.

Sister Grove Creek Site (41COL36)

During the early 1970s, Mark Lynott (1975a, 1975b) led a major excavation of the rim-and-pit structure at the Sister Grove Creek site (41COL36) on the East Fork of the Trinity River. Following completion of Lynott's work at the site, an expansion of Lake Lavon inundated the site. The site has remained under the lake until recently. The extended drought over the last several years has significantly affected the lakes along the East Fork of the Trinity with both Lake Lavon (Collin County) and Lake Ray Hubbard (Rockwall and Dallas Counties) now being well below conservation levels (National Weather Service 2014). As a result, many archeological sites that had been inundated by the lakes back in the 1960's and 1970's have been re-exposed. One of these is the Sister Grove site (41COL36).

In order to take advantage of the current situation, the author visited Sister Grove Creek in early 2014 to take photographs of the site and its major feature, the rim-and-pit structure. Over 40 years of wave action has severely deflated the site with most of its original stratigraphy now no longer intact. In particular, the upper gray-black soil horizon that contained the site's cultural materials has now mostly been eroded away along with the northern rim of the rim-and-pit structure. On one site visitation following a strong rain, a number of large, freshly broken pottery sherds were discovered over a 3 x 3 meter area immediately north of the pit structure. Visual inspection showed all the sherds to be of the same type and thus likely from a single ceramic vessel. With the chance of recovering a near-complete pottery vessel from an East Fork site, the author carefully searched the area. A test excavation showed that virtually no depth component of the site remained. A total of 20 sherds were recovered in the immediate area of the initial surface discovery. Subsequent reconstruction of the vessel showed it to be about 90 percent complete, and of an un-named plain shell-tempered ceramic type.

Shell-Tempered Vessel

The recovered sherds were carefully cleaned using water and a firm brush and then hardened in a weak solution of Muriatic acid (HCl). Individual sherds were then measured and viewed under a binocular microscope prior to reconstruction. Due to the combination of both the size of the sherds and fresh breaks, reconstruction was relatively easy with 19 of the 20 sherds being able to be refitted (Figures 1 and 2).

Figure 1. Shell-tempered jar with strap handle from the Sister Grove Creek site.

Figure 2. Top view of vessel; note the prominent lip notching around the rim.

The vessel is a small jar, 95.5 mm in height. It has a rounded base (approximately 71.2 mm across) with a gently rounded body that slopes inward near the base of the rim and then flares outward (see Figure 1). Two strap handles were once present, one having probably been broken during use given the weathered nature of the break. The remaining handle is curved, with a length is 21.8 mm and a width is 20.0 mm; thickness of the handle is 4.0 mm. The vessel is plain with no exterior decoration other than prominent lip notching every 7-8 mm around the edges of the rim (see Figure 2).

Wall thickness of the vessel varies from 5.0 mm near the rim to 6.0-6.8 mm in the main part of the body to 7.5 mm at the base. These thickness data suggest that the vessel appears to have been built from the base upwards to the rim (cf. Krause 2007). It is tempered with shell and finely-crushed grog and has a compact clay paste. The color of the vessel is quite variable, primarily due to extensive fire mottling, ranging from very pale brown (10YR 7/4), gray-brown (10Y 3/1), greenish-gray (5GY 5/1), to gray-brown (2.5Y 5/2). Cores of the sherds are darker than the surfaces, suggesting the vessel was fired in a low oxygen or reducing environment, and then pulled from the fire to cool. Both the interior and exterior surfaces of the jar are highly smoothed, almost polished in surface treatment.

Plain shell-tempered ceramics from Caddo sites along the Red River have generally not been named as most shell-tempered vessels are almost always decorated (Timothy K. Perttula, personal communication, 2014). Plain shell-tempered pottery from the Lake Texoma area (Haley's Point site, 34MA15) have been described as Woodward Plain, *var. Haley's Point*, but it has not been described as having strap handles or lip notching (Rohn 1998). The Woodward Plain type as defined is similar to the vessel described herein but again, the presence of handles and lip notching on the Sister Grove Creek specimen is unique (Freeman and Buck 1960).

The vessel's dimensions have been three-dimensionally scanned and recorded by Dr. Zac Selden for the prehistoric ceramic data base at the Center for Regional Heritage Research (CRHR) at Stephen F. Austin University. The one sherd that could not be fitted into the reconstruction of the vessel has been submitted for Instrumental Neutron Activation Analysis (INAA) in order to hopefully ascertain its provenance in the future.

Conclusions

Fresh water mussel shell was used by the ancestral Caddo as a temper in the manufacture of ceramic vessels after ca. A.D. 1300 (Perttula et al. 2011). This is generally contemporaneous with shell-tempered usage in parts of the Southern Plains, especially by the peoples of the Henrietta phase located immediately to the west of the East Fork (Suhm and Jelks 1962). The introduction of shell temper was quite variable across the Caddo area, its use being negligible in some area until the sixteenth and seventeenth centuries (Kelley 2012). However, once adopted, shell became one of the dominant tempers used, especially in utilitarian vessels.

Based on stylistic analysis of shell-tempered pottery across the Caddo area, Perttula et al. (2012) concluded that use of shell as a temper was centered in three areas: (1) the middle Red River, below the Great Bend of the Red River in northwest Louisiana, and (3) in the Ouachita River basin in southwestern Arkansas. The occurrence of shell-tempered wares outside these three regions thus constitutes evidence for trade / exchange of ceramics. Selden et al. (2014) tested this observation by conducting neutron activation analysis on 88 shell-tempered sherds from 26 Caddo sites. The results of their analysis demonstrated that shell-tempered pottery manufacture was limited to three distinct geographic areas of the Red River basin; one in southeastern Oklahoma, a second in northwestern Louisiana, and a third in the middle of the Red River basin in southeastern Oklahoma and northeastern Texas.

Ceramic trade between the Caddo peoples and the aboriginal inhabitants of the East Fork of the Trinity has been well-established (Crook and Hughston 2008; Crook 2014). This includes a one vessel of Foster trailed Incised, *var. Foster* that is known to originate in the Red River basin of northeast Texas, southeast Oklahoma, southwest Arkansas and northwest Louisiana (Kelley 1997). The presence of a Foster Trailed Incised, *var. Foster* vessel in a Late Prehistoric site on the East Fork of the Trinity clearly indicates trade between an East Fork aboriginal group and one of the Red River Caddo groups, probably the prehistoric ancestors of the Kadohadacho (Crook 2007; Crook and Perttula 2008). Caddo pottery was widely traded across Texas and surrounding states (Perttula 2002; Perttula et al. 2002) in prehistoric and historic times, especially after about A.D. 1400, when there were apparently periodic contacts and interaction between several different and non-Caddo aboriginal groups and southern Caddo groups.

Shell-tempered pottery is one of the defining characteristics of the Late Prehistoric along the East Fork, comprising nearly 50 percent of all ceramics recovered (Crook and Hughston 2008). However, while this pottery is exclusively plain ware, it is considerably thicker (wall thicknesses >10 mm and bases of 15-20 mm) and from flat-bottomed bowls and jars, consistent with Henrietta phase type Nocona Plain (Suhm and Jelks 1962). No other shell-tempered pottery like the vessel described in this paper has previously been found.

In his excavation of the Sister Grove Creek site, Lynott (1975a) obtained seven radiocarbon dates on charcoal and two dates from collagen and apatite from human bone. Charcoal from Feature 5, a hearth from near the center of the central rim-and-pit structure, yielded an uncorrected radiocarbon date of 360 $\pm$ 70 B.P. (A.D. 1590 $\pm$ 70); its calibrated age range is AD 1469-1614 (CAL PAL Online Radiocarbon Calibration, accessed October 19, 2007). The discovery of a un-named shell-tempered utilitarian vessel of a type known to be most common in Caddo sites between A.D. 1400-1600 corroborates this calibrated radiocarbon date and further establishes that the Late Prehistoric inhabitants of the East Fork were in contact with various Caddo groups to the east and northeast.

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WOODLAND AND LATE PREHISTORIC CERAMICS FROM THE MIDDLE TRINITY RIVER BASIN, HOUSTON AND MADISON COUNTIES, TEXAS

Timothy K. Perttula

Introduction

Aboriginal groups in the middle Trinity River basin began to manufacture and use ceramic vessels sometime after ca. 2500 years ago (Fields 1993, 2004). In this article, I discuss the stylistic and technological character of the aboriginal ceramic wares in this part of the basin as seen in a large sample of sites from the Eastham State Prison Farm and Ferguson Prison Unit on the Trinity River (Figure 1). The ceramic sherds recovered during survey investigations from more than 30 sites found on the two prisons (see Perttula et al. 2015) also provide insights into the native history of this part of East Texas.

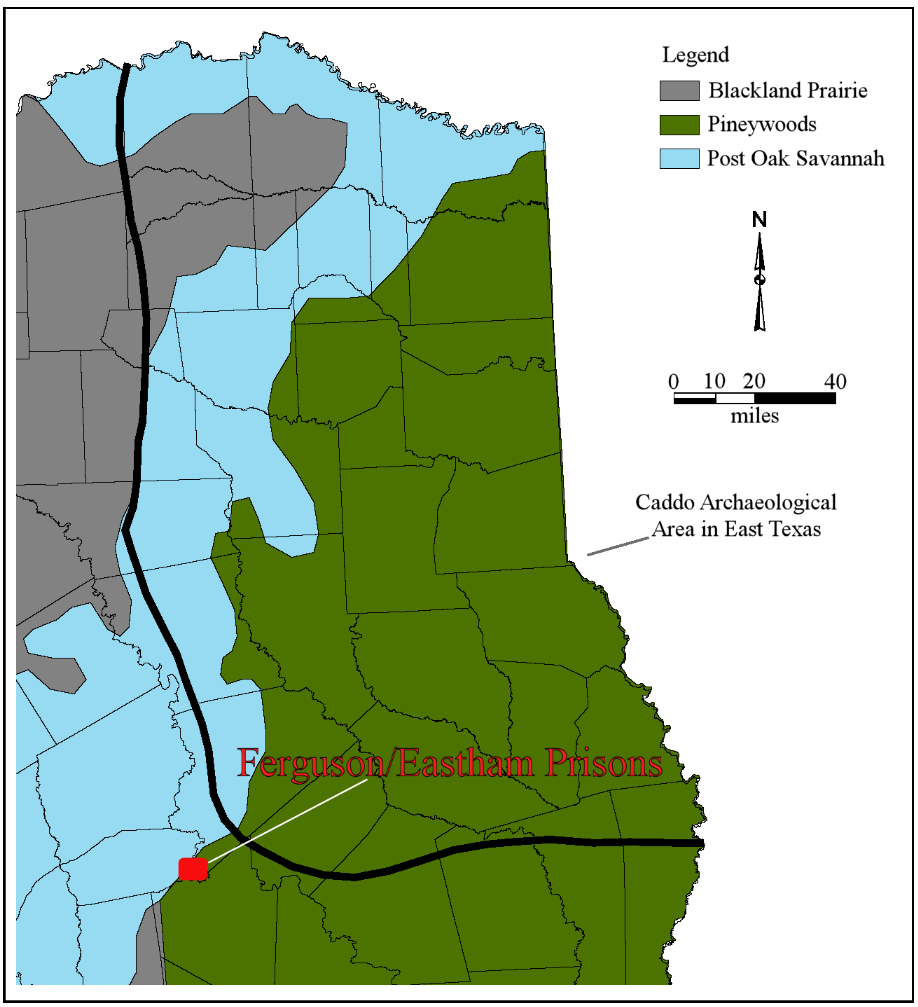

Figure 1. The location of the Eastham State Prison Farm and Ferguson Prison Unit in East Texas.

Setting and Cultural Context

The Ferguson Prison Unit and Adjacent Eastham State Prison Farm lands are in the middle part of the Trinity River basin, along the boundaries of both the Post Oak Savanna and Pineywoods in East Texas (see Figure 1; see also Diggs et al. 2006:Figure 2). The headwaters of the Trinity River originate in the Blackland Prairie well to the north. The Blackland Prairie is a zone of tall grass prairie and clayey soils, with a riparian deciduous forest of oak, hickory, and other tree species. The Post Oak Savanna to the east and south of the Blackland Prairie is a narrow southwest-northeast trending woodland that marks an ecotone between the more xeric Blackland Prairie to the west and the more mesic Pineywoods to the east and southeast. The woodlands in the Post Oak Savanna consist of broadleaf deciduous forests, primarily including several species of oak as well as hickory and pecan. Small areas of tall grass prairie were present in this physiographic province, as well as in the Pineywoods.

With few exceptions in the last 2000 years of the prehistoric era, this part of the state of Texas was first settled by mobile hunter-gatherers and foragers, and remained an area lived in by residentially mobile hunter-gatherer populations until the time of European contact (Story 1990; Fields 2004; Ricklis 2004; Foster 2008). By around 2500 to 1150 years ago, during the Woodland period, however, prehistoric Native Americans began to settle down in small hamlets and camps throughout the region. These Native Americans made plain sandy paste pottery and used first Gary and Kent dart points for hunting and other tasks, and then replaced them with early stemmed arrow points about 1250 years ago. Story (1990:Figure 39) includes such sites within an inland Mossy Grove culture or tradition.

Sites of the Woodland period are quite common in this part of the Trinity River basin. Excavations at several occupation sites to the south at Lake Livingston on the Trinity River—such as Jones Hill (41PK8) and Burris 1 (41PK88)—suggest that the intensity of prehistoric use of this part of the basin began to increase about this time, as certain sites are known that contain features and burials indicative of lengthier and more intensive settlement (Story 1990).

Through time, the Native American groups became less mobile, and developed distinctive territories within which diverse settlement and subsistence patterns began to fully develop (see Gadus et al. 2002). Caddo farmers lived farther to the east in the East Texas Pineywoods (Perttula 2004, 2008; Story 1990), beginning in the Neches River basin in the eastern half of Houston County, although possible Prairie Caddo groups would have used and/or settled in prairie-savanna habitats (see Shafer 2006). Small contemporaneous settlements (with middens and occasionally small cemeteries) are also known in the middle stretches of the Trinity River basin, dating to both earlier (ca. A.D. 800-1400) and later (after A.D. 1400) portions of the Late Prehistoric period. In terms of their material culture, these sites are characterized by a variety of stemmed arrow points, the continued manufacture of plain sandy paste pottery (Story 1990:275), and decorated non-sandy paste pottery having affiliations with Caddo pottery from the eastern and northeastern parts of Houston County (Story 1990:275 and Table 58). These Late Prehistoric sites in the middle Trinity River basin tend to occur on low terrace remnants, terraces, and floodplain rises, and upland landforms were not apparently as intensively used.

Ceramic Sherd Assemblages in Sites in Houston County

Topp (41HO183)

The ceramic sherds (n=84) from the Topp site are mainly from sandy paste Goose Creek Plain, *var. unspecified* vessels (cf. Aten and Bollich 2011; Story 1990). These sherds include a rim with a direct profile and a rounded lip; about 15 percent of the sherds have been smoothed on either the interior and/or exterior surfaces, probably to lower their permeability and increase their hearing effectiveness (see Rice 1996:148). One sandy paste sherd is from a Goose Creek Incised vessel that has diagonal incised lines on the upper body and rim of a jar (see Perttula and Prikryl 1997:Figure 9a).

The Goose Creek Plain have thin walls (mean thickness ranging between 5.8-6.2 mm), and they were fired under a variety of conditions, and most likely under low temperatures. More than 64 percent of the sherds were fired in a reducing or low oxygen environment (see Teltser 1993:Figure 2), most having been reduced and then cooled in a high oxygen environment. A few sherds (15 percent) were fired in an oxidizing environment, and the remainder (20.7 percent) of the Goose Creek Plain sherds are from vessels that were incompletely oxidized during firing.

Both grog-tempered and bone-grog-tempered sherds (n=31) were also found at the site. These sherds are from vessels with thicker body walls (mean thickness ranging from 7.1-7.2 mm), and the vessels were primarily fired in a reducing environment (69.6 percent); 13 percent had been smoothed on interior and/or exterior surfaces. Several of these were decorated with incised (n=5), brushed (n=2), grooved (n=1), and appliqued (n=1) decorative elements (Perttula and Prikryl 1997:Figure 9c-d, f-g). The incised sherds have parallel, horizontal, or diagonal decorative elements, and one has opposed incised triangles. The brushed sherds have light parallel brushing on the exterior surface, and are probably from cooking jars. Brushed vessels are characteristic of many post-A.D. 1300 Caddo ceramic assemblages in East Texas (see Perttula 2015). The grooved sherd is a rim with broad and horizontal ridges and shallow grooves. Comparable grooved sherds from Lindsay Grooved vessels are known in post-A.D. 1650 Caddo sites in the Angelina-Neches river basins in East Texas (Marceaux 2011; Perttula 2015). The appliqued body sherd has a single appliqued node.

41HO184

There is a sample of 66 ceramic sherds from 41HO184 (Perttula and Prikryl 1997:Table 6). More than 83 percent of the sherds are from Goose Creek Plain, var. unspecified vessels; they have unsmoothed surfaces and thin walls. These sherds are from vessels that have been mainly fired under reducing or low oxygen conditions, and then cooled in a high oxygen environment.

The bone- and grog-tempered pottery sherds (10.6 percent of the sherd assemblage) are also plain and unsmoothed, and probably from bowls. These sherds are from vessels that were principally fired in a reducing environment. The grog-tempered ceramic sherds from the site comprise only 6 percent (n=4) of the 41HO184 ceramic assemblage. Two of the grog-tempered sherds have decorations. The first decorated body sherd has multiple, broad, and parallel incised lines (probably on the upper body and rim), and the interior surface is smoothed; the sherd is likely from a jar. The second decorated grog-tempered sherd has multiple, parallel, fine line incisions (see Perttula and Prikryl 1997:Figure 9h).

Young Spot (41HO185)

The one aboriginal ceramic sherd from the Young Spot site found by Perttula et al. (2015) is a plain bone-tempered body sherd (6.7 mm in thickness). It is from a vessel that was fired and cooled in a reducing or low oxygen environment. This bone-tempered sherd is probably also associated with the Woodland period component earlier recognized by Perttula and Prikryl (1997). This component had two Goose Creek Plain, *var. unspecified* body sherds from thin (mean thickness of 5.6 mm) bowls and jars and one Goose Creek Incised sherd with wide diagonal incised lines on what is likely the upper portion of the vessel rim (Perttula and Prikryl 1997:40).

Swine Island (41HO190)

All three ceramic sherds from the site are from Goose Creek Plain, *var. unspecified* vessels; this includes one rim (20-40 cm bs) (Figure 2a) and two body sherds. The sherds come from the same depths as an arrow point fragment, which suggests that if the sherds and arrow point are associated, the occupation took place during the latter part of the Woodland period, ca. A.D. 700-800.

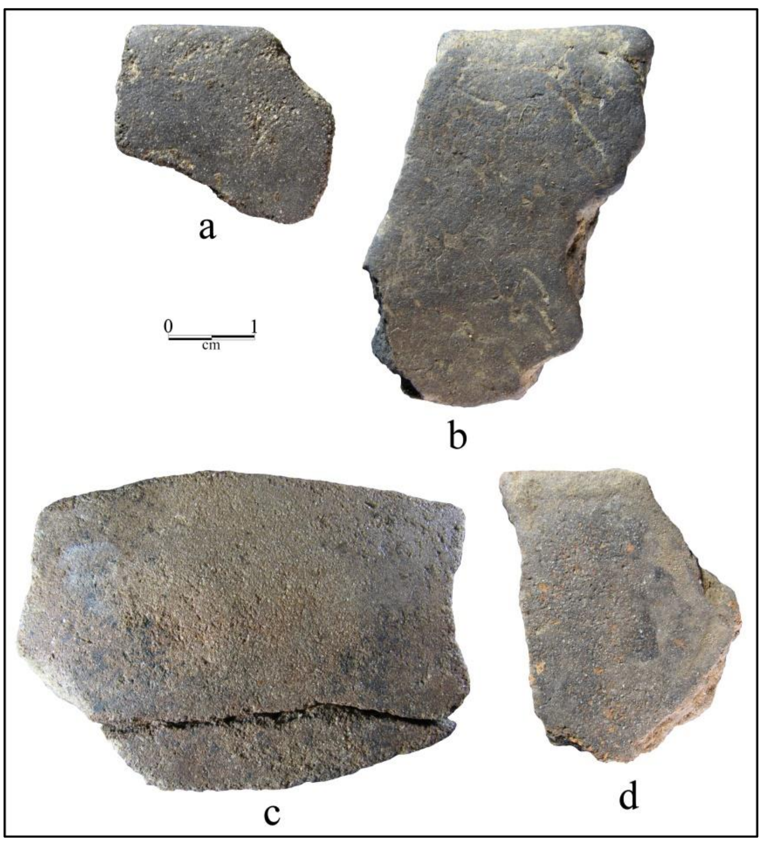

Figure 2. Plain rim sherds from Eastham State Prison Farm sites: a, Goose Creek Plain, 41HO190, ST 2655, 20-40 cm bs; b, 41HO268, ST 85, 60-80 cm bs; c, 41HO268, ST 101, 60-80 cm bs; d, 41HO312, ST 3052, 60-80 cm bs.

Dancing Snakes (41HO268)

Three ceramic sherds thought to be from a post-A.D. 1300 component (Moore 2010:Appendix VI), were found between 30-50 cm bs at the Dancing Snakes site during 2010 investigations. They included a plain bone-tempered body sherd; a sandy pastebone-tempered body sherd with fingernail punctations; and a grog-tempered sandy paste body sherd with incised lines. The ceramic sherds found during renewed investigations in 2014 (Perttula et al. 2015) belong to two different wares, a tempered ware (tempered with grog and/or bone, n=7 sherds) and a sandy paste ware, Goose Creek Plain, *var. unspecified* (n=8 sherds).

The tempered ceramic ware likely date after ca. A.D. 900, while the sandy paste ware sherds most likely date prior to A.D. 900, and they may in fact date as early as ca. 500 B.C. (Ellis 2013). The tempered ceramic wares include one rim and six body sherds recovered between 0-20 cm bs (n=1), 20-40 cm bs (n=1), 40-60 cm bs (n=3), and 60-80 cm bs (n=2). These sherds are tempered with grog and bone (n=1) and grog (n=6). Two of the grog-tempered body sherds are decorated with either a row of crescent-shaped punctations (Figure 3a) or a single fingernail punctation. About 71 percent of the sherds are from vessels fired in a reducing environment, one is from a vessel that was fired in an oxidizing environment, and the other sherd was from a vessel with sooting/smudging. The one rim sherd (60-80 cm bs) is from a jar with an everted profile and a rounded lip; it is 6.7 mm thick. The mean thickness of the body sherds is 6.3 mm.

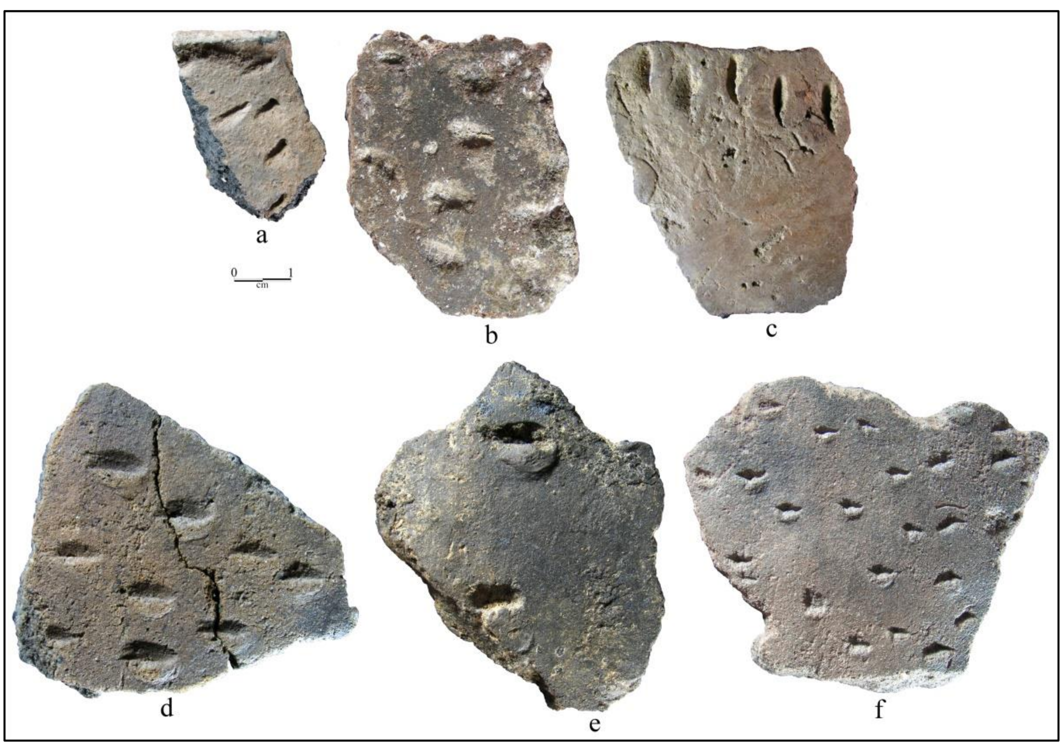

Figure 3. Decorated ceramic sherds from Eastham State Prison Farm sites: a, punctated, 41HO268, ST 100, 60-80 cm bs; b, punctated, 41HO273, ST 121, 40-60 cm bs; c, punctated, 41HO282, from the cut bank; d, punctated, 41HO292, ST 263, 40-60 cm bs; e, punctated, 41HO312, ST 3045, 20-40 cm bs; f, punctated, 41HO314, ST 3178, 60-80 cm bs.

The sandy paste Goose Creek Plain sherds (three rim sherds and five body sherds) were recovered between 40-100 cm bs (see Figure 2b-c), with 63 percent found from 40-60 cm bs in association with midden deposits, animal bone, and mussel shell fragments; the vertical distribution of the tempered and sandy paste wares overlap between 40-80 cm bs. The rims have direct profiles and rounded lips, with a mean thickness of 5.3 mm. Most of the sherds are from vessels fired in a reducing environment (75 percent), but one is from a vessel that was incompletely oxidized during firing, and the other is from a vessel with sooting/smudging. The body sherds range in thickness from 6.2-8.1 mm, with a mean thickness of 7.0 mm.

Garden Lake (41HO269)

The aboriginal ceramic sherds found in the shovel testing at the Garden Lake site include a possible ceramic bead fragment in one shovel test (0-20 cm bs). It has a 4.9 mm opening and is 14.0 mm in diameter. The fragment has no obvious temper. Ceramic beads are not common occurrences in East Texas sites, but Girard (2014) and Walters and Perttula (2015) have noted ceramic beads in ca. A.D. 800-1050, ca. A.D. 1200-1400, and ca. A.D. 1430-1550+ Caddo sites in the upper parts of the Sabine River, Sulphur River, and Big Cypress Creek basins.
Three of the sherds are from Goose Creek Plain, *var. unspecified* vessels; they are body sherds found between 0-60 cm bs. They are from vessels that were fired and cooled in a reducing environments. Vessel body wall thicknesses range from 4.7-6.5 mm, with a mean thickness of 5.53 mm. The other two plain body sherds are tempered with bone. One is from another vessel fired and cooled in a reducing environment; it has 5.0 mm thick body walls. The other bone-tempered sherd has a sandy paste, and is from a vessel that was fired in a reducing environment and cooled in the open air. The body wall is 5.8 mm thick.

Roundup #1 (41HO273)

The one aboriginal ceramic sherd from the Roundup site is from 40-60 cm bs in a shovel test. It is a bone-tempered sandy paste body sherd (9.1 mm in thickness) with rows of fingernail punctates (see Figure 3b). A similar sherd was recovered at the Cliff Base site (see below).

Lick Mine (41HO281)

Artifacts documented from the shovel testing at the Lick Mine site by Perttula and Nelson (2013) include three plain sherds. The three were found between 0-40 cm bs. Two were plain sandy paste sherds (i.e., Goose Creek Plain, *var. unspecified*), while the other was tempered with bone and crushed hematite pieces. The sandy paste sherds from the Lick Mine site suggest that the occupation dates to the Woodland period, when plain sandy paste pottery in the Trinity River basin began to be made around 2100 years ago (Fields 2004; Perttula and Ellis 2013) and continued to be made until after ca. A.D. 900-1000.

G. Robbins (41HO282)

The prehistoric artifacts noted at the G. Robbins site indicates that its principal occupation was during the Woodland period (ca. 500 B.C.-A.D. 800) (Perttula and Nelson 2014). This is indicated by the recovery of Goose Creek Plain, *var. unspecified* body sherds and Gary points. In these initial investigations, the Goose Creek Plain sherds were recovered from 70-80 cm bs and 80-103 cm bs in two different shovel tests, suggesting the component is buried in the sandy alluvial sediments.

In more recent work at the site by Perttula et al. (2015), prehistoric ceramic sherds were found between 0-100 cm bs, but were concentrated between 40-60 cm bs and 80-100 cm bs, and were found as well on the eroded surface of the stream cut bank area. The ceramic sherds (n=30) in the artifact assemblage from the G. Robbins site are from the cut bank area and 17 different shovel tests.

The majority of the sherds are from Woodland period Goose Creek Plain, *var. unspecified* body and base sherds (n=23, 77 percent of the sherd assemblage); there is also one plain bone-tempered sandy paste body sherd that may also be part of the Woodland period ceramic assemblage at the site. The other 20 percent of the sherds are from grog- (n=4), grog-bone- (n=1), and bone-tempered (n=1) wares that are likely from one or more post-A.D. 800 Late Prehistoric occupations at the G. Robbins site. Two of these sherds are decorated, one with a row of fingernail punctations (grog-tempered) (see Figure 3c) and the other a parallel brushed-incised body sherd (grog-bone-tempered). If the decoration of utility ware vessels in neighboring East Texas Caddo sites is any indication, sherds from brushed utility ware vessels, particularly jars, are a distinctive characteristic of both Middle (ca. A.D. 1200-1400), Late (ca. A.D. 1400-1680), and Historic Caddo period (ca. A.D. 1680-1830) sites in much of East Texas. It also appears to be the case that the relative proportions of brushed utility wares increase through time in those areas where brushed vessels were made and used, such that sherds with brushing marks may comprise as much as 90 percent of all the decorated sherds in some post-A.D. 1400 East Texas ceramic assemblages (Perttula 2015). This suggests that the brushed sherd from the G. Robbins site may be part of a post-A.D. 1200 ceramic assemblage. Based on their occurrence in shovel tests, sandy paste sherds have been found from 0-100 cm bs, and are most common from 80-100 cm bs. The one bone-sandy paste sherd is from 0-20 cm bs, while the grog, bone, and grog-bone-tempered sherds are from 40-60 cm bs in the shovel tests.

The bone-tempered sandy paste body sherd is only 4.8 mm in thickness; it is from a vessel that was fired and cooled in a reducing or low oxygen environment. The bone-tempered body sherd is 4.9 mm in thickness and is also from a vessel fired and cooled in a reducing environment. The grog-bone-tempered body sherd is thicker—7.6 mm—and is from a vessel fired in a reducing environment, but cooled in the open air. The grog-tempered sherds include a rim (7.4 mm), a base (11.2 mm), and two body sherds (mean thickness of 6.0 mm). The rim is from a vessel that was fired and cooled in a reducing environment, but the base and body sherds are from vessels fired in a reducing environment and cooled in the open air.

The Goose Creek Plain, *var. unspecified* sherds from the G. Robbins site include 22 body sherds and one base sherd (8.4 mm thick). The mean thickness of the body sherds is 6.21 mm. These sherds are from vessels fired in a number of different ways, including firing and cooling in an oxidizing or high oxygen environment (n=3, 13 percent); incompletely oxidized during firing (n=6, 26 percent); fired and cooled in a reducing environment (n=5, 22 percent); and fired in a reducing environment and cooled in the open air (n=8, 35 percent). One sherd (4 percent) has multiple oxidized and reduced bands visible in the sherd core, suggesting it is from a vessel that has been refired or deliberately smudged/sooted.

Red Bean (41HO290)

The ceramic sherds from the Red Bean site include one grog-tempered sherd (20-40 cm bs) and four Goose Creek Plain, *var. unspecified* rim and body sherds from 40-100 cm bs. The grog-tempered sherd is only 2.1 mm thick (and fired in an oxidizing environment), and may be from a Early Caddo style long-stemmed Red River pipe bowl (cf. Hoffman 1967). The one Goose Creek Plain sandy paste rim (80-100 cm bs) has a direct rim profile and a rounded lip, and is 3.8 mm thick; it is from a vessel that was fired in an oxidizing environment. The three body sherds are from three different vessels, two fired in a reducing environment and the other incompletely oxidized during firing. Body wall thickness ranges from 4.6-6.2 mm, with a mean thickness of 5.6 mm.

Double Pond (41HO291)

The six ceramic body sherds from this site are from Goose Creek Plain, *var. unspecified* sandy paste vessels. These sherds are from at least four vessels that were fired either in a reducing environment (n=4 sherds) or were incompletely oxidized during firing (n=2). Body wall thickness of the sherds ranges from 4.3-6.1 mm, with a mean thickness of 5.37 mm.

Cliff Base (41HO292)

One of the sherds is a bone-tempered sandy paste body sherd with no decoration (20-40 cm bs), while the other is a sandy paste body sherd with rows of fingernail punctations (40-60 cm bs), what I have dubbed Goose Creek Punctated (see Figure 3d). The co-occurrence of sandy paste sherds and a Steiner arrow point in the archeological deposits here suggests the occupation of the Cliff Base site postdates ca. A.D. 700, when arrow points began to be made in East Texas (Shafer and Walters 2010), but the occupation probably ended before ca. A.D. 900.

Piney Grove (41HO294)

The three ceramic sherds (found from 40-80 cm bs) are Goose Creek Plain, *var. unspecified* body sherds of Woodland period age. They are from vessels either fired in a reducing or low oxygen environment or a vessel incompletely oxidized during firing. Body wall thickness ranges from 4.6-7.0 mm, with a mean thickness of 6.1 mm.

Pipe Junction (41HO295)

The five sherds from four shovel tests at the Pipe Junction site are body sherds from Goose Creek Plain, *var. unspecified* vessels. Such vessels were made as early as ca. A.D. 100 in the region, if not earlier, until after ca. A.D. 900 (Perttula and Ellis 2013:116-120). Four of the sherds are from vessels fired in a reducing environment, while the other may have been deliberately smudged or sooted during firing. The body sherds range from 4.9-7.9 mm in thickness, with a mean thickness of 6.5 mm.

Blue Lake (41HO297)

Two sherds of aboriginal pottery of Woodland period age were recovered from 20-40 cm bs and 80-100 cm bs in the shovel testing at the Blue Lake site. Both are body sherds of Goose Creek Plain, *var. unspecified*, with body wall thicknesses that range from 5.9-6.5 mm. One sherd has been sooted/smudged on one vessel surface, and the other is from a vessel that was fired and cooled in a reducing environment.

A02 Road Cut (41HO298)

A single Goose Creek Plain, *var. unspecified* body sherd came from 20-40 cm bs in a shovel test. This indicates that the archeological deposits at the A02 Road Cut site likely date to Woodland period times, when such pottery was being made in parts of East Texas (see Ellis 2013; Perttula and Ellis 2013). The sherd was incompletely oxidized during firing and has 6.4 mm thick body walls.

Clay Pit (41HO299)

All 17 of the aboriginal ceramic sherds are from subsurface contexts at the Clay Pit site. They include plain sandy paste Goose Creek Plain, *var. unspecified* body sherds (n=8), plain bone-tempered body sherds (n=5), one plain grog-tempered sandy paste body sherd, and plain grog-tempered body sherds (n=3) (Table 1). There is no apparent stratigraphic difference in depth between the four different wares, with the possible exception that the grog-tempered sherds (with or without a sandy paste) occur slightly higher in the deposits and therefore may possibly be younger in age/manufacture than the sandy paste or bone-tempered wares at the Clay Pit site: namely with the sandy paste sherds found from 0-60 cm bs, the bone-tempered wares from 0-60 cm bs, the grog-tempered sandy paste sherds from 0-20 cm bs, and the grog-tempered sherds occurring from 0-40 cm bs.

All but three of the sandy paste sherds are from vessels fired in a reducing or low oxygen environment (see Table 1). Two of the sandy paste sherds were from vessels fired in a high oxygen environment, and another has been sooted/smudged, leaving a dark lens along one vessel surface.

The thinnest body walls occur in the grog-tempered body sherds (3.9-5.1 mm) and the bone-tempered body sherds (4.1-5.3 mm); the latter are likely therefore not from thick-walled Cooper Boneware vessels (cf. Schambach 1998). The one grog-tempered sandy paste sherd is 6.4 mm in body wall thickness, while the sandy paste Goose Creek Plain, *var. unspecified* body sherds range from 4.5-6.5 mm in thickness; the mean thickness of the sandy paste sherds is 5.9 mm.

One fine screen special sample from a 35 x 35 cm unit from the Clay Pit site had six plain body sherds (n=2 in the 0-20 cm level and n=4 in the 20-40 cm level). Three of the sherds are from sandy paste Goose Creek Plain, *var. unspecified* vessels, two others are grog-tempered with a sandy paste, and one sherd is bone-tempered. The sherds are from vessels fired and cooled in a reducing environment (n=3); fired in a reducing environment and cooled in the open air (n=1); incompletely oxidized during firing (n=1); and sooted/smudged (n=1). Vessel wall thickness ranges from 4.9-7.9 mm for the sherds, with a mean thickness of 6.42 mm.

Sand Flats (41HO303)

The four ceramic body sherds from the site (in three different shovel tests) are from Goose Creek Plain, *var. unspecified* vessels with body wall thicknesses that range from 5.3-7.1 mm. The mean body wall thickness is 6.08 mm. All four of the sherds are from vessels that were fired in a reducing environment; 75 percent are from vessels that were then cooled in the open air.

Table 1. Plain aboriginal ceramic sherds from the shovel testing at the Clay Pit site (41HO299).

Ware Provenience ST # and cm bs	Firing Condition	Thickness (mm)
sandy paste, Goose Creek Plain, *var. unspecified*		
ST 1474, 20-40 (2)	fired and cooled in an oxidizing environment	5.6, 5.7
ST 1476, 0-20	sooted/smudged	5.5
ST 1491, 40-60	fired in a reducing environment and cooled in the open air	6.4
ST 1508, 0-20	fired in a reducing environment and Cooled in the open air	6.5
ST 1509, 0-20 (2)	fired and cooled in a reducing environment; fired in a reducing environment and cooled in the open air	6.5, 6.4
ST 1512, 20-40	fired in a reducing environment and cooled in the open air	4.5
bone-tempered		
ST 1473, 40-60	fired in a reducing environment and cooled in the open air	4.5
ST 1509, 0-20	fired in a reducing environment and cooled in the open air	4.1
ST 1509, 20-40 (2)	fired and cooled in a reducing environment; fired in a reducing environment and cooled in the open air	5.1, 5.1
ST 1513, 20-35	fired in a reducing environment and Cooled in the open air	5.3
grog-tempered, sandy paste		
ST 1509, 0-20	fired in a reducing environment and cooled in the open air	6.4
grog-tempered		
ST 1509, 20-40 (2)	fired and cooled in a reducing	3.9, 4.1

environment		
ST 1513, 0-20	fired in a reducing environment and cooled in the open air	5.1

Eggshell (41HO304)

The two ceramic sherds from the Eggshell site are plain body sherds. One sherd is from a bone-tempered vessel (0-20 cm bs), while the other is from a sandy paste Goose Creek Plain, *var. unspecified* vessel (60-80 cm bs). Body wall thickness ranges from 3.8-5.9 mm. The bone-tempered sherd is from a vessel that was fired and cooled in a reducing environment, and the sandy paste sherd is from a vessel fired and cooled in an oxidizing environment. Both sherds are likely of Woodland period manufacture (cf. Ellis 2013).

Disposal Creek (41HO312)

The three ceramic sherds from the Disposal Creek site have grog temper and a sandy paste; they are from 20-40 cm (n=2) and 60-80 cm bs (n=1). It is suspected that these sherds are from a ca. A.D. 800-1100 occupation, based on the use of grog temper as well as the continued use of a sandy paste; tempered vessels are not noted in pre-A.D. 800 ceramic vessels in this part of East Texas, and sandy paste vessels became much less frequent after ca. A.D. 800-1100 in the same region. Two of the three sherds are from vessels fired and cooled in a reducing environment and the other is from a vessel fired in a reducing environment but cooled in the open air. The one rim sherd (60-80 cm bs) is plain and has a direct rim and a rounded lip (see Figure 2d); it is 7.1 mm thick. The two body sherds (20-40 cm bs) range from 7.4-8.3 mm in thickness. One body sherd is plain and the other has a row of fingernail punctates (see Figure 3e). There is preserved organic residue on this body sherd.

Cimmaron (41HO313)

The two ceramic sherds (0-40 cm bs) are from Goose Creek Plain, *var. unspecified* vessels. One is a body sherd (5.0 mm in thickness) and the other is a rim (5.7 mm in thickness) with a direct profile and a rounded lip. The body sherd is from a vessel that was fired in a reducing environment and cooled in the open air, while the rim sherd is from an incompletely oxidized vessel with sooting/smudging on both interior and exterior walls.

Playa Lake (41HO314)

Eight ceramic sherds were recovered in the shovel testing at the Playa Lake site, all body sherds. Six of the body sherds are from Goose Creek Plain, *var. unspecified* sandy paste vessels, while one plain body sherd (80-100 cm bs) has a sandy paste with bits of grog temper added to the paste. The other sandy paste body sherd (Goose Creek Punctated) has rows of small tool punctations (see Figure 3f). These sherds are from vessels that were fired in a reducing environment and cooled in the open air (n=3), incompletely oxidized (n=3), fired and cooled in a reducing environment (n=1); two sherds (20-60 cm bs) have been smudged or sooted. The body walls range from 5.2-8.1 mm in thickness, with a mean thickness of 6.71 mm.

Green House Orchard (41HO320)

A single Goose Creek Plain, *var. unspecified* body sherd (20-25 cm bs) from the site indicates it was occupied at some point during the Woodland period. This sherd is from a vessel that was incompletely oxidized during firing; it has a 6.5 mm thick body wall.

Melton Creek (41HO337)

The Goose Creek Plain, *var. unspecified* body sherd is from a vessel that was incompletely oxidized during firing. The sherd is 5.8 mm thick.

Red Lock (41HO339)

Two of the shovel tests at the site have Goose Creek Plain, *var. unspecified* sandy paste body sherds. Both sherds are from vessels fired and cooled in a low or reduced oxygen environment; body wall thickness ranges from 4.8-5.9 mm.

Wright Creek (41HO341)

There are two Goose Creek Plain, *var. unspecified* body sherds between 20-60 cm bs in the fine screen sample. One sherd is from a vessel that was fired and cooled in a reducing or low oxygen environment, while the other is from a vessel that has been sooted or smudged. Vessel wall thickness ranges from 5.7-6.0 mm.

Boneyard (41HO345)

The one ceramic sherd is a Woodland period Goose Creek Plain, *var. unspecified* sandy paste base sherd. The sherd is from a vessel fired in a reducing environment and cooled in the open air; it is 7.6 mm in thickness.

Gordiano (41HO346)

A single Goose Creek Plain, *var. unspecified* body sherd was found between 60-80 cm bs. The sherd is from a vessel that was fired and cooled in a high oxygen environment; body wall thickness is 6.9 mm.

Ceramic Sherd Assemblages in Sites in Madison County

Vondra Road (41MA42)

Including two sherds from the surface by a dirt road, there are 18 aboriginal ceramic sherds from the Vondra Road archeological deposits. The sherds include the following wares:

• Goose Creek Plain, *var. unspecified* sandy paste rim (n=1) and body (n=15) sherds;
• plain grog-tempered and sandy paste body sherd (n=1); and
• plain grog-tempered body sherd (n=1)

The Goose Creek Plain, *var. unspecified* sherds are from five shovel tests and two 35 x 35 cm fine screen sample units. By depth, they occur from 0-20 cm bs (n=4), 20-40 cm bs (n=5), 40-60 cm bs (n=4), and 60-80 cm bs (n=2), indicating their use throughout the Woodland period occupation of the site; one body sherd is from the surface of the site. The one plain rim has a direct profile and a rounded lip, with 7.5 mm thick walls (Figure 4a). It is from a vessel that was fired and cooled in a reducing environment. The Goose Creek Plain body sherds are from vessels fired and cooled in an oxidizing environment (27 percent); incompletely oxidized during firing (20 percent); fired and cooled in a reducing environment (20 percent); and fired in a reducing environment and cooled in the open air (33 percent). Mean body wall thickness is 7.13, with a range from 5.1-8.9 mm.

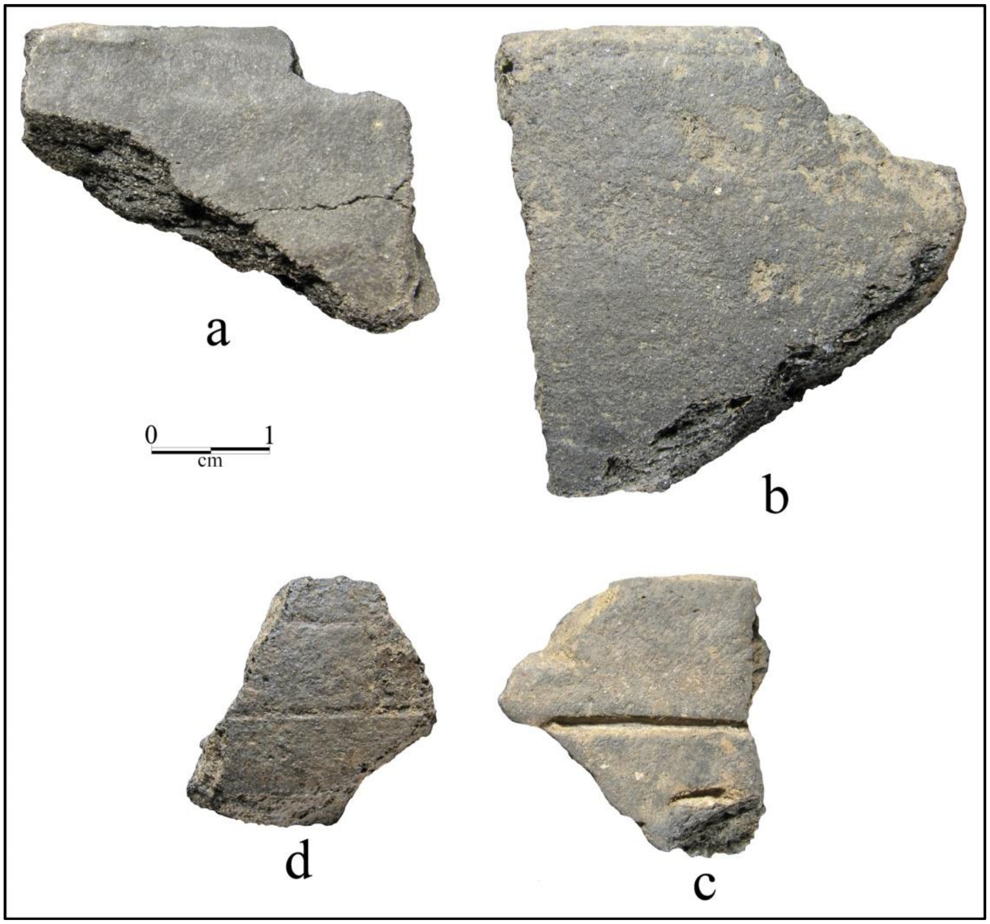

Figure 4. Aboriginal ceramic sherds from Ferguson Prison unit sites: a, Goose Creek Plain rim, 41MA42, ST 6015-SS, 20-40 cm bs; b, Goose Creek Plain rim, 41MA58, ST 5942, 20-40 cm bs; c, Weches Fingernail Impressed rim sherd, 41MA58, ST 5941, 40-60 cm bs; d, incised sandy paste body sherd, 41MA58, ST 5941, 40-60 cm bs.

The grog-tempered and sandy paste body sherd was found on the surface of the site. It has 7.9 mm thick body walls, and is from a vessel fired in a reducing environment and cooled in the open air. The one grog-tempered body sherd (40-60 cm bs) has 4.8 mm thick body walls. It is from a vessel that was fired and cooled in a reducing environment.

Salt Branch (41MA58)

The 23 ceramic sherds found at the Salt Branch site include sherds from vessels with grog temper (n=1), grog temper and a sandy paste (n=2), bone temper and a sandy paste (n=5), sandy paste Goose Creek Plain, *var. unspecified* sherds (n=14), and Goose Creek Incised, *var. unspecified* (n=1). The variety in ceramic sherd temper and paste represented in the site sample suggests that the site may have been occupied in both pre-A.D. 800 Woodland and ca. A.D. 900-1200 periods.

Two of the sherds are from rims with direct profiles and rounded lips: a grog-tempered Weches Fingernail Impressed sherd (6.5 mm in thickness, 40-60 cm bs) (see Figure 4c) and a plain bone-tempered sandy paste sherd (5.9 mm in thickness, 20-40 cm bs) (see Figure 4b). There are 18 plain body sherds and three base sherds: one Goose Creek Plain (9.0 mm thick, 0-20 cm bs), grog-tempered and sandy paste (9.4 mm in thickness, 20-40 cm bs), and bone-tempered and sandy paste (9.5 mm in thickness, 20-40 cm bs). The mean thickness of the body sherds is 7.6 mm (grog-tempered and sandy paste); 6.6 mm (bone-tempered and sandy paste); 6.82 mm (Goose Creek Plain, *var. unspecified*); and 5.4 mm (Goose Creek Incised, *var. unspecified*).

Three of the sherds are from decorated vessels: the previously mentioned grog-tempered rim (40-60 cm bs) from a Weches Fingernail Impressed vessel with a horizontal incised line above a fingernail punctation (see Figure 4c); a bone-tempered sandy paste vessel with a straight incised line (40-60 cm bs); and a Goose Creek Incised vessel with parallel incised lines (40-60 cm bs) (see Figure 4d).

The grog-tempered and grog-tempered sandy paste sherds are from vessels fired in reducing environments (n=2) or were incompletely oxidized during firing (n=1). The bone-tempered sandy paste sherds are from vessels all fired in a reducing environment, as is the one Goose Creek Incised vessel sherd. The Goose Creek Plain, *var. unspecified* sherds are from vessels fired in an oxidizing environment (29 percent), fired in a reducing environment (64 percent), and one sherd is from a sooted or smudged vessel.

Sagar (41MA61)

There are nine Goose Creek Plain, *var. unspecified* body sherds in the Woodland period archeological deposits at the Sagar site. These are from 0-20 cm bs (n=3), 20-40 cm bs (n=3), and 40-60 cm bs (n=3). The sherds have a mean body wall thickness of 6.41 mm, with a range from 5.8-7.3 mm. About 78 percent of the sherds are from vessels fired in a reducing environment, while the remainder may be from vessels that were deliberately sooted or smudged during firing; both of these sherds are from 40-60 cm bs.

Pine Curve (41MA62)

The three body sherds of Goose Creek Plain, *var. unspecified* from 0-40 cm bs in are from different vessels fired in a reducing environment. Body wall thickness ranges from 5.8-7.9 mm, with a mean of 6.53 mm.

Renegade Bull (41MA67)

All four of the ceramic sherds from the site are Goose Creek Plain, *var. unspecified* body sherds. They are from vessels fired in either oxidizing (n=1) or reducing (n=3) environments, and have a mean body wall thickness of 6.78 mm (range 6.3-7.6 mm).

Dove Pond (41MA72)

Aboriginal ceramic sherds (n=20) are relatively abundant in the archeological deposits at the Dove Pond site. All the sherds are body sherds from sandy paste Goose Creek Plain, *var. unspecified* vessels. They come from 0-20 cm bs (n=2), 20-40 cm bs (n=8), and 40-57 cm bs (n=10). The mean body wall thickness of these vessels is 5.96 mm, with a range of 4.0-8.0 mm. The sherds are from vessels fired in several different ways: fired and cooled in an oxidizing environment (10 percent); incompletely oxidized during firing (15 percent); fired and cooled in a reducing environment (20 percent); fired in a reducing environment and cooled in the open air (50 percent); and smudged/sooted during firing (5 percent).

Summary and Conclusions

Based on the various projects conducted on the two prisons in the middle Trinity River basin, not just including the 2014 survey, a total of 34 sites have sherds from aboriginally-manufactured ceramic vessels: 28 sites on the Eastham State Prison Farm and six sites on the Ferguson Prison Unit. Sample size ranges from one sherd (six sites) to as many as 84 sherds (at only one site: the Topp site [41HO183]) (Table 2); the mean number of sherds per site is 10.9 (range 1-84) and the total number of sherds is 369.

The majority of the sherds are from Woodland period sandy paste Goose Creek Plain, Goose Creek Incised, and Goose Creek Punctated vessels, as these sherds comprise approximately 75 percent of the overall sherd assemblage (see Table 2). The proportion of sandy paste sherds in the overall sherd assemblage is higher on the sites on the west side of the Trinity River, on the Ferguson Prison Unit, at 86 percent, compared to 71 percent on sites on the Eastham State Prison Farm on the east side of the river. At the local scale, this suggests that the Woodland period use of sites was more intensive on the west side of the Trinity River.

About 5.4 percent of the sherds are from sandy paste vessels that are tempered with either burned bone (2.4 percent) or grog (3.0 percent, i.e., crushed pottery sherds). These sherds may be part of

Late Woodland period ceramic assemblages (ca. A.D. 700-900) or post-A.D. 900 sandy paste vessels where two kinds of tempers were added to the paste during vessel manufacture.

The bone- and grog-tempered sherds from vessels made after ca. A.D. 900 comprise 20 percent of the sherd assemblage from the two prisons (see Table 2). Almost all of these sherds are from sites on the east side of the river—where they account for 24 percent of the sherds on Eastham State Prison Farm sites—compared to only 2.6 percent of the sherds from sites on the west side of the river on the Ferguson Prison Unit. The later aboriginal occupants of this part of the middle Trinity River basin clearly preferred to settle on the alluvial terraces along the east side of the Trinity River valley.

Only 7.3 percent of the ceramic sherds are from the decorated portions of sandy paste and tempered vessels (Table 3). The sandy paste wares have only six decorated sherds (2.2 percent of the sandy paste sherds), including three Goose Creek Incised and three Goose Creek Punctated sherds. Goose Creek Punctated includes fingernail punctated sherds on vessels with a sandy paste or with a sandy-bone tempered paste. The other 21 decorated sherds are from vessels with either grog or bone in the paste; these decorated sherds represent 25 percent of the tempered wares in the 34 sites with ceramics on the two prisons.

Many of these decorated sherds have incised elements (n=8, 30 percent of decorated sherds from tempered wares), followed by fingernail punctated (19 percent), brushed and brushed-incised (11 percent), incised-punctated (4.8 percent), grooved (4.8 percent), appliqued (4.8 percent), and tool punctated (4.8 percent). These decorated sherds are from vessels manufactured after ca. A.D. 900, and includes one Weches Fingernail Impressed rim (see Suhm and Jelks 1962:Plate 77) sherd from 41MA58.

Table 2. Ceramic assemblages on prehistoric sites on the Eastham State Prison Farm and Ferguson Prison Unit.

Site	GCP	GCI/ GCp	bone/SP	grog/SP	grog	bone	N
41HO183	52	1/-	-	-	23	8	84
41HO184	55	-	-	-	4	7	66
41HO185	2	1/-	-	-	-	1	4
41HO190	3	-	-	-	-	-	3
41HO268	9	-	1	1	7	3	21
41HO269	3	-	1	-	-	1	5
41HO273	-	-/1	-	-	-	-	1
41HO281	2	-	-	-	-	1	3
41HO282	25	- 1	-	4	2	3	2
41HO290	4	-	-	-	-	-	4
41HO291	6	-	-	-	-	-	6
41HO292	-	-/1	1	-	-	-	2
41HO294	3	-	-	-	-	-	3
41HO295	5	-	-	-	-	-	5
41HO297	2	-	-	-	-	-	2
41HO298	1	-	-	-	-	-	1
41HO299	11	-	-	3	3	6	23

41HO303	4	-	-		-		-	-	4	
41HO304	1	-	-		-		-	1	2	
41HO312	-	-	-		3		-	-	3	
41HO313	2	-	-		-		-	-	2	
41HO314	6	-/1	-		1		-	-	8	
41HO320	1	-	-		-		-	-	1	
41HO337	1	-	-		-		-	-	1	
41HO339	2	-	-		-		-	-	2	
41HO341	2	-	-		-		-	-	2	
41HO345	1	-	-		-		-	-	1	
41HO346	1	-	-		-		-	-	1	
Subtotal, ESPF sites	204	2/3	4		8		41	30	292	
41MA42	16	-	-		1		1	-	18	
41MA58	14	1/-	5		2		1	-	23	
41MA61	9	-	-		-		-	-	9	
41MA62	3	-	-		-		-	-	3	
41MA67	4	-	-		-		-	-	4	
41MA72	20	-	-		-		-	-	20	
Subtotal, FPU sites	66	1/-	5		3		2	-	77	
Totals		270	3/3	9		11		43	30	369

GCP=Goose Creek Plain, *var. unspecified*; GCI=Goose Creek Incised; GCp=Goose Creek Punctated; SP=sandy paste

Table 3. Decorated sherds in the grog- and bone-tempered wares as well as the sandy paste ware.

Site				Decorated Methods						N
GCI GCp	I	I-P	Gr	B	A	fP	tP			
41HO183	1	-	4	-	1	2	1	-	-	9
41HO184	-	-	2	-	-	-	-	-	-	2
41HO285	1	-	-	-	-	-	-	-	-	1
41HO268	-	-	1	-	-	-	-	2	1	4
41HO273	-	1	-	-	-	-	-	-	-	1
41HO282	-	-	-	-	-	1*	-	1	-	2
41HO292	-	1	-	-	-	-	-	-	-	1
41HO312	-	-	-	-	-	-	-	1	-	1
41HO314	-	1	-	-	-	-	-	-	-	1
Subtotal, ESPF sites	2	3	7	-	1	3	1	4	1	24

41MA58	1	-	1	1	-	-	-	-	-	3
Totals	3	3	8	1	1	3	1	4	1	27

*brushed-incised
GCI=Goose Creek Incised; GCp=Goose Creek Punctated; I=incised; I-P=incised-punctated; Gr=grooved; B=brushed; A=appliqued; fP=fingernail punctated; tP=tool punctated

Based on the brushed, brushed-incised, and grooved ceramics, only two sites on the Eastham State Prison Farm were occupied after ca. A.D. 1200, and perhaps also then occupied after the mid-17th century, namely at the Topps (41HO183) and G. Robbins (41HO282) sites (see Table 3). Sherds from brushed and brushed-incised utility ware vessels, particularly jars, are a distinctive characteristic of both Middle, Late, and Historic Caddo sites in much of East Texas. It also appears to be the case that the relative proportions of brushed utility wares increase through time in those areas where brushed vessels were made and used, such that sherds with brushing marks may comprise as much as 90 percent of all the decorated sherds in some post-A.D. 1400 East Texas ceramic assemblages. Utility ware jar sherds with grooved decorative elements (i.e., from Lindsey Grooved vessels, see Marceaux 2011) are distributed in two clusters of Caddo sites in the upper Neches and Angelina river basins (Perttula 2015:Figure 8).

These sites all date after ca. A.D. 1680 to ca. A.D. 1750 and are historic Caddo sites associated with the Allen phase. One grooved sherd from the Gilbert site (41RA13) on the upper Sabine River basin likely represents part of a vessel that was manufactured in one or the other of the two identified spatial clusters. There are also a few grooved sherds from ca. A.D. 900-1300 contexts at three sites in the Neches, Red, and Sabine River basins, most notably at the George C. Davis site (41CE19). These grooved sherds are not related either stylistically or temporally with Lindsey Grooved wares, and are likely from Crenshaw Fluted vessels with deep vertical grooves or flutes.

In addition to sherds from ceramic vessels, there are other ceramic artifacts in the assemblages from the Eastham State Prison Farm sites. This includes a possible ceramic bead from the Garden Lake site (41HO269) and a pipe stem from a long-stemmed Red River style pipe from the Red Bean site (41HO290).

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AN OCCURRENCE OF SHELL, TURQUOISE, AND OBSIDIAN AT THE BRANCH SITE (41COL9), COLLIN COUNTY, TEXAS

Wilson W. Crook, III

Introduction

The extended drought over the last several years has significantly affected the lakes along the East Fork of the Trinity with both Lake Lavon (Collin County) and Lake Ray Hubbard (Rockwall and Dallas Counties) now being well below conservation levels (National Weather Service 2014). As a result, many archeological sites that had been inundated by the lakes back in the 1960's and 1970's have been re-exposed. One of these is the Branch site (41COL9), a large Late Prehistoric occupation in central Collin County.

Over 40 years of wave action has severely deflated the site with most of its original stratigraphy now no longer intact. In particular, the upper gray-black soil horizon that contained the site's cultural materials has now mostly been eroded away along with the site's major surface features, including the once prominent rim-and-pit structure. With erosion of the topsoil, lithic, bone and ceramic artifacts have been exposed on the surface of an impermeable yellow sandy clay that originally formed the underlying soil horizon at the site. While the precise placement of the rim-and-pit structure can no longer be seen, its location can be fairly accurately inferred from previous excavation notes by both Robert L. Stephenson (1952) and the Dallas Archeological Society (Harris 1965), as well as a past excavation conducted by the author (Crook 2007).

The rim-and-pit structure at the Branch site was originally oblong in shape, 18 by 15 meters in size, oriented north-south. Starting in late 2012, a number of shell and stone beads, a single small turquoise pendant, and nine lithic artifacts of obsidian began to be exposed in the area of the southern rim of the pit. The writer tested the area where the artifacts were found and confirmed that there is no real depth component left at the site. However, many of the artifacts are so small that any wind or rain can easily cover and then re-expose them.

Most of the artifacts appear to have a clear Puebloan connection. Analysis by X-Ray Fluorescence (XRF) confirms a New Mexico and/or other Western U.S. origin for both the obsidian and the turquoise. This paper serves to document these new discoveries and further strengthen the already established Puebloan area-to-East Fork network that has been previously noted by Lorrain and Hoffrichter (1968), McIntyre and McGregor (1982), Jurney and Young (1996), Crook (1985, 2013), and Crook and Hughston (2008, 2009).

Artifact Description

The first artifacts discovered in the area of the southern rim were a small cache of beads, including 3 perforated *Olivella* shells, three small shell beads, a single very small turquoise bead, and a larger bead also made from turquoise. Dimensions of the cache were only 20 x 20 cm with the *Olivella* shells on top of the other 5 beads. Figure 1 shows the eight artifacts from the cache.

Figure 1. Contents of the small bead cache found near the southern rim of the rim-and-pit structure at the Branch site (41COL9), Collin County, Texas. L to R: Three small shell and one turquoise bead, three perforated *Olivella* shells, and a larger turquoise bead.

Four obsidian arrow points were found on the surface within 30 cm of the cache. While not in direct association with the beads, their close proximity coupled with the fact that they were constructed from a toolstone not native to the area, strongly suggests that they were also originally part of the cache.

In December, 2013 another group of shell beads was discovered about three meters west of where the original bead-arrow point cache was located. A total of nine small (4-7 mm) shell beads were found over an area of 0.5 x 2 meters. The area was marked and returns to the site in January and February of 2014 recovered eight additional shell beads, a single bead made from a yellow-tan limestone, and another obsidian arrow point - all from the same area. Additional trips to the Branch site in May and August of 2014 produced three more shell beads of the same construction as the first 17, plus three worked pieces of obsidian, five additional obsidian arrow points, and a small (16 x 10 mm) turquoise pendant. In addition, a broken shaped sherd of an as yet unidentified Puebloan black-on-white ceramic was found to the east of the pit structure near the center of the site.

Measurements of the 23 small shell beads are tabulated in Table 1. As can be seen in the table, the three beads found in the original cache (Beads #1-3) are considerably smaller than the other 20, supporting the conclusion that they are potentially of a different origin. Of the other 20 shell beads (Beads #4-23), 19 have a very similar appearance being small and more tubular than tabular in shape. Outside diameters vary from 4 to almost 7 millimeters, with a perforation diameter of typically between 1.7-2.1 millimeters. Thickness varies but averages around 3.0 mm (2.6 when the three cache beads are factored in). Bead #23 is noticeably different, being much larger and more tabular in shape than the others (Figure 2).

Table 1. Branch Shell Bead Measurements

Artifact	Material	Outside Diameter (mm)	Perforation Diameter (mm)	Thickness (mm)
Bead 1 (cache)	Shell	1.9	0.9	0.8
Bead 2 (cache)	Shell	2.2	1.1	0.8
Bead 3 (cache)	Shell	3.9	1.5	0.6
Bead 4	Shell	3.9	1.1	2.0
Bead 5	Shell	4.1	1.5	2.0
Bead 6	Shell	4.1	1.2	3.5
Bead 7	Shell	5.0	1.9	3.3
Bead 8	Shell	5.1	1.7	2.3
Bead 9	Shell	5.1	1.9	2.4
Bead 10	Shell	5.2	1.8	4.0
Bead 11	Shell	5.3	1.9	3.0
Bead 12	Shell	5.8	1.9	2.8
Bead 13	Shell	5.9	1.9	3.1
Bead 14	Shell	5.9	2.0	3.0
Bead 15	Shell	6.0	2.1	2.1
Bead 16	Shell	6.0	1.9	2.1
Bead 17	Shell	6.0	2.0	4.0
Bead 18	Shell	6.1	1.9	3.1
Bead 19	Shell	6.5	1.9	2.4
Bead 20	Shell	6.8	2.0	3.0
Bead 21	Shell	6.8	2.0	3.5
Bead 22	Shell	6.8	2.0	3.8
Bead 23	Shell	8.4	2.8	2.0
Average		*5.3*	*1.8*	*2.6*

The three *Olivella* shell beads found in the original cache (Beads #24-26) have a similar shape and appearance (see Figure 1). Length of the shells ranges between 10.2 and 15.0 mm, with widths between 5.4 and 6.8 mm. As is characteristic of *Olivella* shells beads, the tops of the shells have been ground off in order to create an orifice to string the beads (Kozuch 2002; Hoard and Chaney 2010). Measurements of the three beads are shown in Table 2. Given the relative wide widths of the shells relative to the lengths, they have been tentatively identified as belonging to *Olivella dama* (Kozuch 2002; Hoard and Chaney 2010).

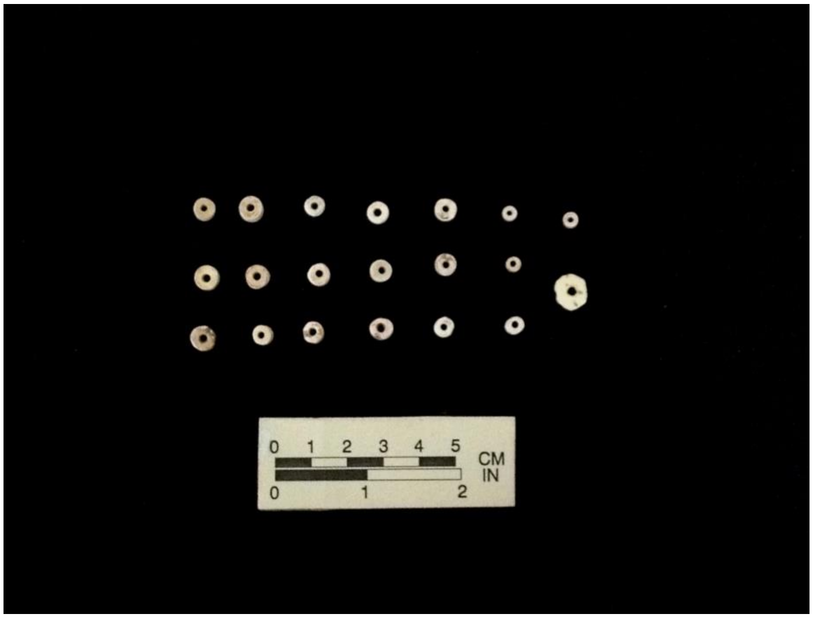

Figure 2. The 20 shell beads (Beads #4-23) recovered from near the southern rim of the rim-and-pit structure at the Branch site (41COL9), Collin County, Texas. Note the similarity in size and construction of most of the beads; Bead #23 (lower right hand side) is noticeably different in shape.

Table 2. Branch *Olivella* Shell Bead Measurements

Artifact	Material	Length (mm)	Width (mm)	Thickness (mm)
Bead 24 (cache)	*Olivella dama*	10.2	6.4	5.0
Bead 25 (cache)	*Olivella dama*	11.0	5.9	5.0
Bead 26 (cache)	*Olivella dama*	15.0	6.8	6.0
Average		*12.1*	*6.4*	*5.3*

Measurements of the three stone beads (Beads #27-29), including the two turquoise beads found in the original cache (see Figure 1) plus the limestone bead found in association with the 20 shell beads from the southern rim area, are shown in Table 3. As can be seen in the measurements, all three are very different in terms of diameter and thickness and are probably the result of three very independent constructions. The small turquoise bead (Bead #27), both in size and shape, is very similar to the three shell beads that were found with it in the cache described above.

A small ovoid shaped turquoise pendant was found in the same immediate area as the 20 shell beads described above (see Figure 2) and in direct association with Beads #21-23 (see Table 1). The pendant is 15.9 mm in length, 10.0 mm along the base and 7.1 mm at the top end near the single perforation. Thickness of the artifact is a uniform 2.5 mm. Diameter of the perforation is 1.5 mm.

Table 3. Branch Stone Bead Measurements

Artifact	Material	Outside Diameter (mm)	Inside Diameter (mm)	Thickness (mm)
Bead 27 (cache)	Turquoise	2.2	1.2	0.8
Bead 28	Turquoise	12.0	2.4	5.5
Bead 29	Limestone	8.5	3.0	6.2
Average		*7.6*	*2.2*	*4.2*

The pendant is very pale blue (5B 8/2) to very pale green (10G 8/2) on the obverse face (Figure 3) and bluish white (5B 9/1) to grayish yellow (5Y 8/4) on the reverse face. The latter was the face exposed on the surface when the artifact was discovered. As the color of turquoise is known to be affected by prolonged exposure to light, this may account for the color difference between the two sides.

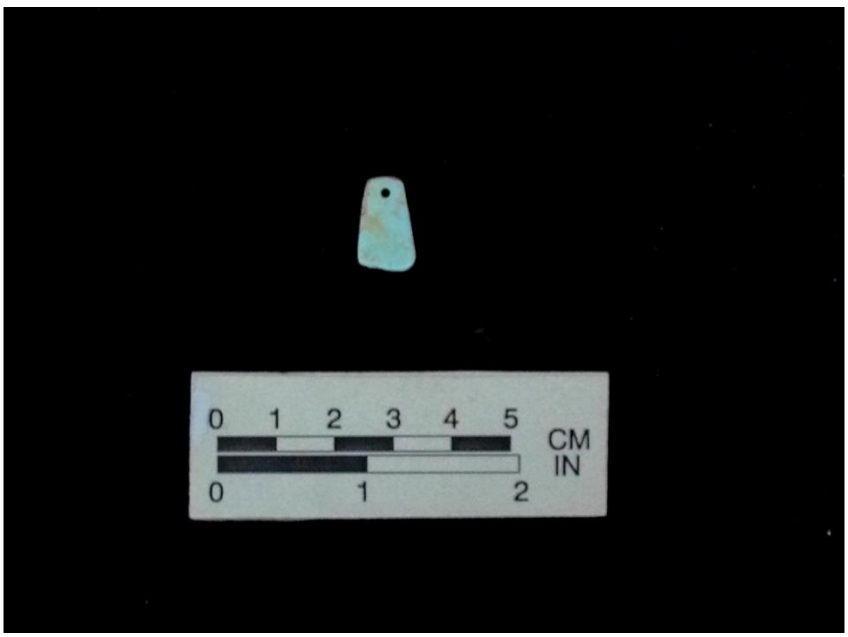

Figure 3. Turquoise pendant recovered from near the southern rim of the rim-and-pit structure at the Branch site (41COL9), Collin County, Texas.

In addition to the four obsidian arrow points found near the 2012 bead cache, five additional obsidian arrow points and three worked flakes of obsidian were recovered. One of the points was found near the bead concentration in the southern pit rim area; the other arrow points along with the three worked obsidian flakes were found elsewhere over the main part of the Branch site. Six of the nine arrow points and the three worked flakes can be seen in Figure 4. Interestingly, with the exception of one tri-notched triangular arrow point from the bead cache area (a point type common to sites of the Pueblo II through Pueblo IV periods), all of the remaining points are of types typical to North Central Texas (Alba, Catahoula). This suggests that the aboriginal inhabitants of the Branch site may have procured either unworked obsidian nodules or large flakes and subsequently manufactured the arrow points locally in styles they were familiar with as opposed to trading for completed points.

Figure 4. Branch site obsidian artifacts (Top Row, right; Middle Row, all 5 points; Bottom Row, all 3 worked flakes). Note with the exception of the tri-notched point on the Top Row, the Branch obsidian points are of the Alba (Middle Row, first two points) and the Catahoula (Middle Row, last 3 points) type. The first three points on the Top Row are from the Upper Farmersville site.

X-Ray Fluorescence Analysis

The obsidian and turquoise artifacts were subjected to a trace element geochemical analysis using a portable X-Ray Fluorescence spectrometer (pXRF) in order to attempt to determine their provenance. The analysis was conducted using a Bruker Tracer III-SD handheld energy-dispersive X-Ray Fluorescence spectrometer equipped with a rhodium target X-Ray tube and a silicon drift detector with a resolution of ca. 145 eV FWHM (Full Width at Half Maximum) at 100,000 cps over an area of 10 mm^2. Data was collected using a suite of Bruker pXRF software and processed running Bruker's empirical calibration software add-on. Analyses were conducted in September, 2012 and in April and December of 2014 at the laboratory of the Gault School of Archeological Research located at Texas State University in San Marcos.

The obsidian and turquoise artifacts were measured at 40keV, 36.2µA, using a 0.3 mm aluminum / 0.15 copper filter (0.02 titanium filter for turquoise) in the X-Ray path, and a 300 second live-count time. For the obsidian samples, peak intensities for Kα peaks of manganese (Mn), iron (Fe), zinc (Zn), gallium (Ga), rubidium (Rb), strontium (Sr), yttrium (Zr), niobium (Nb) and barium (Ba) and the Lα peak for thorium (Th) were calculated as ratios to the Compton peak of rhodium and converted to parts-per-million (ppm). For the turquoise artifacts, analytical focus was on potential source distinguishing elements, primarily copper (Cu), iron (Fe), zinc (Zn), phosphorus (P), arsenic (As) and silica (Si).

Artifact provenance analysis using X-Ray Fluorescence (XRF) was pioneered using obsidian from the western United States (Shackley 2005). This is due to the fact that most obsidians can be distinguished by looking at a suite of only seven to nine elements, and sometimes even less (Glascock et al. 1999; Glascock and Ferguson 2012; Shackley 2009, 2013). Duff et al (2012) found that for some northern New Mexico sources in and around the Jemez Caldera, a bivariate plot of rubidium vs zirconium coupled with a plot of yttrium vs zirconium was enough to distinguish the obsidian source. This is due in part to the relatively short periods of time between eruptions in the area and thus the geochemistry of the associated volcanic glass reflects the differentiated composition of the remaining magma (Gardner et al. 1986; Shackley 2005, 2013).

XRF analyses of the nine obsidian arrow points from the Branch site are presented in Table 4. The four points found near the bead cache are listed as 41COL9 – 1 through 4. The fifth point found in the same general area is designated as artifact 41COL9-5. The last four points, 41COL9-6 through 421COL9-9, were found in the main part of the site, 40 meters east of the other five.

The five points from the general area of the southern pit rim (see Figure 4, Top Row far right and Middle Row first four points) all have a fairly similar trace element geochemical signature, characterized by very high iron content and high levels of rubidium, yttrium and zirconium. Based on published reference samples, the closest matches lie in eastern Oregon (Burns Butte, Chickahominy, and Cougar Mountain) and southwestern Idaho (Timber Butte). While this appears to represent an extremely long distance from North Central Texas, similar occurrences of Pacific Northwest obsidian have been found in the Great Plains (Hoard et al. 2008) and north central New Mexico (Shackley 2005).

The other four obsidian arrow points (Table 4 - 41COL9-6 through 412COL9-9) have a distinctly different trace element geochemistry being relatively depleted in rubidium, yttrium and zirconium. Using the bivariate plot analysis proposed by Duff et al. (2012), the obsidian in these arrow points fall within the established ranges for locations within the Jemez Caldera, namely for Valles Rhyolite and Cerrro Toledo (Gardner et al. 1986; Baugh and Nelson 1987; Shackley 2013). Likewise, XRF analysis of the three worked pieces of obsidian from the Branch site corresponds to another eruption within the Jemez Caldera (“Cerro del Medio”) (Table 5) (Duff et al. 2012; Shackley 2013). All three of these areas have a well-established history of producing high quality artifact glass that was procured as large nodules eroding from the rim of the dome (Church 2000). Valles Rhyolite obsidian does not occur in secondary alluvial sources because it erodes within the Jemez Caldera (Goff 2009; Freeman 2014).

Table 4. X-Ray Fluorescence Trace Element Analysis of Obsidian Arrow Points from Branch Site (41COL9), Collin County, Texas

Artifact	Mn (ppm)	Fe (ppm)	Rb (ppm)	Sr (ppm)	Y (ppm)	Zr (ppm)	Nb (ppm)	Ba (ppm)	Probable Source
41COL9-4 Side-Notched Triangle point	914	7,942	9,377	759	2,327	2,880	2,502	1,287	Timber Butte, Idaho
41COL9-1 Alba-like point	1,285	37,823	12,085	1	4,276	47,178	2,601	1,502	Burns Butte, Oregon
41COL9-3 Alba-like point	331	30,086	9,473	2,114	3,012	27,171	2,867	3,016	Chickahominy, Oregon
41COL9-2 Catahoula-like point	246	15,157	10,914	1,376	1,222	6,234	709	1,787	Cougar Mtn., Oregon
41COL9-5 Catahoula-like point	1,214	35,969	11,998	17	4,244	45,799	2,685	1,456	Burns Butte, Oregon
41COL9-6 Catahoula-like point	417	8,011	166	3	44	172	55	35	Valles Rhyolite, New Mexico
41COL9-7 Alba-like point	643	8.974	226	0	68	190	99	25	Cerro Toledo, New Mexico
41COL9-8 Alba-like point	404	8,083	167	4	45	176	55	33	Valles Rhyolite, New Mexico
41COL9-9 Alba-like point	629	8,669	217	0	65	182	99	22	Cerro Toledo, New Mexico

Lastly, the turquoise pendant and one of the turquoise beads were also subjected to X-Ray Fluorescence analysis. Mineralogically, turquoise is a hydrous basic copper aluminum phosphate with a stoichiometric composition of $CuAl_6(PO_4)_4(OH)_8 \cdot nH_2O$. However, there is wide variance in composition, notably in the substitution for the aluminum cation site and for phosphorus. In fact, turquoise forms a solid solution series with chalcosiderite, which is the iron equivalent of turquoise (Palache et al. 1951). As such, archeologists have tried with limited success to use trace element chemistry to determine turquoise sources.

Table 5. X-Ray Fluorescence Trace Element Analysis Obsidian Scrapers from Branch Site (41COL9), Collin County, Texas

Artifact	Mn (ppm)	Fe (ppm)	Rb (ppm)	Sr (ppm)	Y (ppm)	Zr (ppm)	Nb (ppm)	Ba (ppm)	Probable Source
41COL9-10 Side Scraper	386	7,032	142	3	40	151	49	28	Valles Rhyolite, New Mexico
41COL9-11 Worked Flake	479	7,355	150	4	45	165	51	35	Valles Rhyolite, New Mexico
41COL9-12 Side Scraper	405	7,112	141	4	39	158	49	38	Valles Rhyolite, New Mexico

Recently, Hull et al. (2014) have devised an analytical methodology using isotope ratios of hydrogen ($^{2}H/^{1}H$) and copper ($^{65}Cu/^{63}Cu$) and a secondary ion mass spectrometer (SIMS) to try and determine turquoise sources. The methodology has been partially successful (54 percent of 74 artifacts were identified as to original source area) but is expensive and in part destructive to the sample. As a result, a less destructive analysis was attempted using X-Ray Fluorescence. The Los Cerrillos area, located 30 km south of Santa Fe, is the oldest established turquoise mining district in North America. Ten areas in and around Turquoise Hill have been recognized as having prehistoric mining activity dating back to ca. A.D. 1000 (Disbrow and Stoll 1957). Los Cerrillos or Turquoise Hill turquoise comes in a variety of colors ranging from tan and khaki-green to a rich blue-green to various shades of light blue and even white (so-called "bone turquoise"). While the chemistry of these color variations changes with regard to both copper and iron content, Los Cerrillos turquoise is known to contain a consistent trace percentage of silica (Palache et al. 1951; Disbrow and Stoll 1957).

Using this known chemical marker, the pendant (see Figure 3) and the large turquoise bead (see Figure 1) were analyzed using the same methodology described above (the small bead found in the cache was too small to be placed effectively over the XRF stage). To aid in the analysis, the author purchased several well-documented specimens of Los Cerrillos turquoise to use as reference type specimens. The Charles Lewis Tiffany company of New York purchased the mines of Turquoise Hill and mined the area for gem quality turquoise from 1892-1922 (Jeff Cathrow, personal communication, 2014). While the mines are now played out and abandoned, a small amount of this authenticated material remains available on the market. Analysis of the two Branch turquoise artifacts showed a general geochemical similarity to type Los Cerrillos material but the variation in chemistry of the mineral samples made it impossible to positively identify Los Cerrillos as the source. However, given the close proximity of the Los Cerrillos mines to the Jemez Caldera where a number of the Branch obsidian artifacts were sourced, it is possible that they are the source for the turquoise found at the site.

Discussion

The presence of exotic materials in East Fork sites broaches the subject of interregional exchange and potentially provides insights into the social and economic relationships between groups (Baugh 1998). An established trade between the Puebloan Southwest and East Texas has long been recognized (Krieger 1946). Strategic resources in this exchange have been thought to be bison hides (robes), meat, turquoise and textiles from the Plains; bow wood and salt from East Texas (Creel 1991). Evidence of this trade has been recorded from several Caddo sites in East Texas and Arkansas (Housewright 1946; Hayes 1955; Prikryl 1990; Jurney and Young 1996; Early 1978) and from Toyah sites in Central Texas (Speth and Newlander 2012). These include items such as turquoise beads and pendants, worked flakes of obsidian, and various Puebloan ceramics. Turquoise has been recovered from five Caddo sites including Sanders (41LR2), Goss Farm (41FN12), Holdeman (41RR11), Hatchel (41BW3), and Sam Kaufman (41RR16), but it always represents a very minor component of the site's total artifact assemblage, with usually only a few pieces reported per site. In this regard, the East Fork sites and Branch in particular, are unique given the number and variety of Puebloan materials recovered to date. For example, only three obsidian points and seven worked flakes along with a few pieces of *Olivella* shell and no Puebloan ceramics are known from the entire Late Prehistoric Toyah phase of Central Texas

(Kibler 2012). Moreover, based on dates from the Puebloan ceramics found in East Fork sites, this exchange seems to have been over an extended timeframe (ca. A.D. 900 to 1550+).

It should be noted that none of these exotic items found in East Fork sites were really necessities for the aboriginal inhabitants of the East Fork. For example, the East Fork peoples did not need Puebloan ceramics, since they made their own serviceable shell- and sandy paste-tempered plain pottery. The same can be said for the obsidian artifacts as well as the shell beads. Nor can it be said that the exotic items found in East Fork sites were associated with the exchange of food, at least not where exchange was a major source of food. Instead there seems over time to have been an increasing desire to obtain more prestige items, of which clearly Puebloan ceramics, obsidian, shell and turquoise would have been near the top of the list (Brown et al. 1990; Bradley 1999; Perttula 2002; Trubitt 2000, 2003).

The artifacts found at the Branch site indicates that exchange items included ceramics, completed beads and pendants, exotic toolstone (both as completed points and as raw toolstone), and possibly raw material for beads including turquoise, red coral and *Olivella* shell (Crook 1985, 2013). XRF analysis shows that all of the worked flakes of obsidian and four of the arrow points originate from sources in and around the Jemez Caldera in north central New Mexico. The other arrow points are made from obsidian that comes from the Pacific Northwest (eastern Oregon, southwestern Idaho). While this seems like an extremely long distance for trade to have occurred, Pacific Northwest obsidian has been found in both north central New Mexico and the Great Plains (Duff et al. 2012; Hoard et al. 2008). Obsidian from Choke Canyon (Texas) and Oklahoma has been sourced to Idaho (Baugh 1998). XRF analysis also suggests that the turquoise found at the Branch site came from the deposits in the Los Cerrillos area, also of north central New Mexico and only 130 km from the obsidian sources of the Jemez Caldera.

Further evidence of long-distance trade can be seen in the three *Olivella dama* shell beads. Two species of *Olivella* shells have been identified in archeological sites across North America: *Olivella nivea,* which comes from the Atlantic and the Gulf of Mexico, and *Olivella dama*, which originates along the Pacific coast and in Baja California (Kozuch 2002; Hoard and Chaney 2010). The latter is characterized by a greater width-to-length ratio of the shell. Based on measurements of the Branch beads coupled with comparisons of the reference collections at the Texas Archeological Research Laboratory and the Houston Museum of Natural Science, it appears the Branch specimens are of *Olivella dama* and thus probably originate from Baja California.

Jurney (1995) postulates that one reason East Texas may have been a destination for trade with the Puebloan Southwest is the presence of bois d'arc. Native bois d'arc stands are prominent within the range of the Late Prehistoric of the East Fork and its tributaries, being widespread in the northern part of the region and gradually thinning toward the south (Bush 2014). The southernmost sites along the East Fork are near the southern end of this stand, almost as if the presence of bois d'arc delineated the Late Prehistoric occupation (Jurney 1995; Crook and Hughston 2008).

Crook and Hughston (2007, 2008) have demonstrated that the inhabitants of the East Fork made extensive use of bois d'arc, even to the extent of crafting a specialized stone tool (the "East Fork Biface") for working the hard wood. It is entirely plausible that some of this production could have been used in periodic trade in addition to local use. As such, it is likely that the Branch site represents a major entrepot for trade into the region.

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THE INTERVENTION OF HUMAN MODIFICATION ON PLANT AND TREE SPECIES IN THE LANDSCAPE OF THE LBJ NATIONAL GRASSLANDS

Brett Lang

Project Description

Landscape modification occurs both naturally and through human interaction. The question examined with this applied thesis is how plant and tree species are affected by land altered for the supposed benefit of private land owners. The project looks at how plants and trees in the LBJ National Grasslands have been impacted by man-made changes to the region. The larger LBJ National Grasslands administrative boundary in north central Wise County includes approximately 20,000 acres of 78 federally owned grassland units surrounded by privately owned lands (United States Department of Agriculture 2011).

The LBJ National Grasslands are located within the Western Cross Timbers ecoregion with the Grand Prairie ecoregion to the west and the Blackland Prairie ecoregion to the east (Griffith, et al 2007:vi Figure 2). Prior to becoming the national grasslands the plots were originally bought by the government during the Dust Bowl Era in the 1930s (Hurt 1985:248). Currently, the few anthropogenic modifications largely consist of measures to control erosion (Personal communication with Austin Sewell). The soils vary from sandy loams in the Western Cross Timbers to clays in both the Grand and Blackland Prairies. The variation in soil types allows for different types of plant and tree species to flourish (Natural Resources Conservation Service N.D.). Some of the surrounding privately owned land, including farm and ranch land, can be compared with land modification through human intervention resulting in terracing, plowing and clearing of land for agriculture or grazing. The result of man-made landscape changes, such as agricultural fields, can change which plants and tree species will develop (Dyksterhuis 1948:342 Table 3).

Research questions:

1. How do private landowners and Forest Service employees in and around the LBJ National Grasslands classify the changes to the landscape in the past and present?
   A. What are their views on plant and tree species conservation?
2. How are environmental impacts different on public and privately owned lands?
   A. Do current land modification practices hinder the chance for successful biodiversity conservation on public and private lands?
3. How will land modification in the future affect the different types of soils, along with plants and trees in privately owned lands?
   A. Can conservation methods be introduced that will maximize flora biodiversity?

4. Using historical and modern data, can land modification in the future be anticipated and how will it affect the different types of soils, along with plants and trees in privately owned lands?

Context of Work

The LBJ National Grasslands located in north central Wise County is surrounded by Montague and Cooke counties north, Denton County east, Tarrant and Parker counties south and Jack County to the west. Within the larger administrative boundary covering roughly 115 thousand acres are 78 federally owned lands encompassing approximately 20 thousand acres, or units, intended for wildlife or grazing surrounded by privately owned lands. Figure 1 shows the location of the grasslands and the adjacent counties.

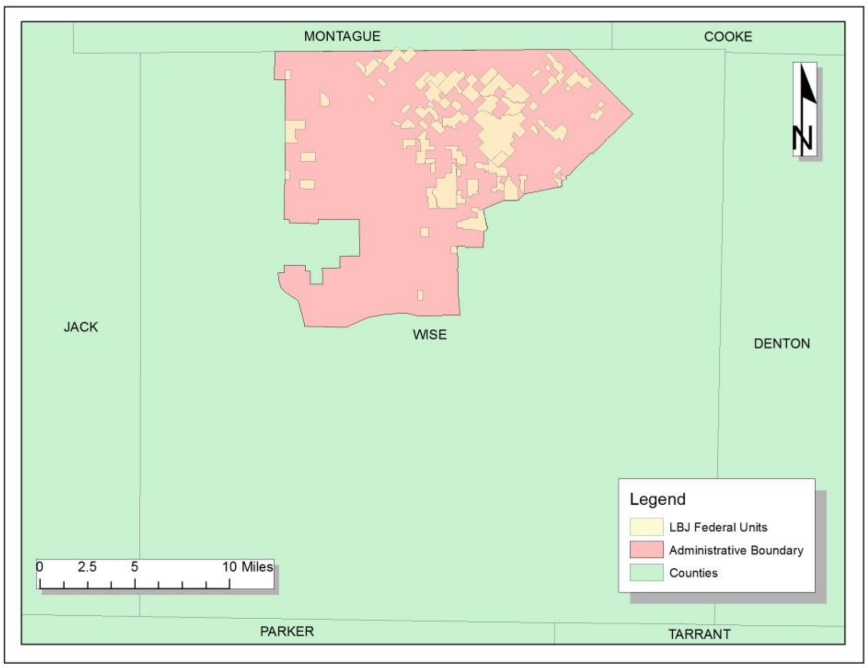

Figure 1. Location of the LBJ National Grasslands

Land use and the corresponding modification, along with the effects on the plants and trees within the overall environment entails a number of important discussion points. First, the historical background comprises information on the national grasslands formation, use of fire and ethnographic accounts ranging from the 16th to the 20th Centuries. Second, the vegetation data for the Western Cross Timbers with two sources from the 1940s and 1950s, and three later sources from 1990 to 2007 deliberated. Lastly, plant and tree biodiversity research and study results from various locations in Minnesota, Texas and Kansas follow the plant and tree species information and listing.

Historical Background

The historical background of the research project area cannot be explained without discussing the formation of the national grasslands themselves. The LBJ National grasslands were 1 of 19 formed on June 20, 1960 from 22 former New Deal Land Utilization (L-U) projects in eleven western states. Land Utilization projects were experiments run by the federal government employing land use reform to restore eroded grasslands and agriculture during the Dust Bowl Era. In 1942 the acres of crop land in the United States numbered 415 million, with 76 million not suitable based on safety and profitability (Hurt 1985:246,Lewis 1989:161,Unknown author 1942:576). The steps leading up the formation of the national grasslands involved a number of different policies and agencies. The initial policy, the 1929 Agricultural Marketing Act and the Federal Farm Board, decided which lands deemed submarginal based on erosion would be removed from cultivation. Next, the Land Use Planning Committee listed submarginal lands to purchase for L-U projects in 1932. A year later, the Federal Emergency Relief Administration (FERA) was established to buy submarginal lands, with dollars from the Public Works Administration. Power then transferred to the newly formed Soil Conservation Service (SCS) under Title III of the Bankhead-Jones Farm Tenant Act of 1938. The SCS was responsible for erosional control methods with land use changes including listing, furrows, terracing, strip cropping, and artificial seeding. The SCS remained in control until 1953 when the Forest Service, the current manager, took over the responsibilities of the L-U projects (Hurt 1985:248,249,258). The L-U projects shrank from nearly ten million to four million acres with the selling of six million to various states and colleges in 1958. Finally two years later in 1960 the remaining four million acres became the national grasslands (West 1990:89).

The Dust Bowl Era and the environmental problems that ensued greatly influenced the formation of the National Grasslands within the United States. Agriculture spread rapidly by European settlement removing native prairie grasses and trees in North Texas covering the Fort Worth, Eastern and Western Cross Timbers, and Blackland Prairie ecoregions. The number of farms steadily increased in the United States from 1.5 million in 1900 to 6.25 million by 1930, along with the acreage cultivated corresponded accordingly with 177 million in 1880 to 413 million by 1931 (Brown 1936:338). The loss of native prairie grasslands to agriculture or animal grazing caused erosion due to the loss of top soil, with the Blackland Prairie experiencing the highest loss. By 1915 it was estimated that the destruction of the original Blackland Prairie was nearly 100 percent due to agriculture plowing and the expansion of settlers in the 19th Century. The formation of the SCS under the direction of President Roosevelt’s New Deal attempted to reduce the environmental impact of the Dust Bowl Era (Hurt 1985:248,249; Diggs Jr., et al. 1990:34,37).

The role of the Forest Service expanded over time since its conception early in the twentieth century. The National Forest Service (NFS) established in 1905 provided good quality water and timber intended for the Nation by Congress under the United States Department of Agriculture. The management powers of the Forest Service expanded within the national grasslands, along with Congress authorizing further management of sustained yields of renewable sources such as water, wood, wildlife, and recreation. Other areas of management included wilderness, minerals, grazing, fish, and wildlife. In 2006 the Forest Service managed 155 forests, 20 grasslands, and 222 research or experimental forests covering 192 million acres of public land handled by roughly 30 thousand employees (National Forest Service 2006:36).

Fire Use

The use of fire assisted in shaping the history, landscape and vegetation within the Western Cross Timbers and LBJ National Grasslands region. Prior to the large settlement of farmers in the area ranchers did set fires on their rangelands. The recollection of the ranchers indicated that during drier seasons fires frequently burned off the tall grasses and the limbs off trees allowing a rider on horseback to move through the forest easily. European settlers attributed to vegetation change by overgrazing and utilizing “patch farming” practices. Patch farmers built structures and fences making fire dangerous for them, thus they suppressed fire (Dyksterhuis 1948:333). Fire suppression of Cross Timbers vegetation often established the quick return of understory vines and brush, post oaks and blackjack oaks including areas previously grasslands. The Fort Worth Nature Center tested the hypothesis by reduced burning and the post oaks and blackjack oaks did reappear rapidly. At a separate location within the nature center areas were burned with oaks disappearing and grasses reestablishing themselves (Francaviglia 2000:Kindle Edition). The Crosstimbers Trail at the Nature Center contains a post oak and blackjack oak forest as it might have appeared in the 1800s with old growth forests.

Ethnographic accounts

The historical background, ethnographic accounts, discusses the inhabitants of the LBJ National Grasslands region, and Wise County, largely from the European settler’s point of view. Accounts of the early indigenous Native American groups from the 16th and 17th Centuries in North Texas offer the least reliable ethnographic accounts. According to Dr. Bascope with the Botanical Research Institute of Texas the original inhabitants, the time frame not specified, were probably nomadic gatherers/hunters based on sparse archaeological data, but very little evidence has been found to properly describe how they lived or used the land. The most commonly associated North Texas tribes including the Caddo, Wichita, Apache, and Comanche arrived later most likely as seasonal hunters (Personal communication with Dr. Bascope 4-15-13). A myth that Native Americans were stewards of the land and lived in a pristine environment exists. Evidence from vague ethno-historical accounts, field surveys and archaeology sites states that in 1492 the landscape modified by Native Americans included the expansion of forests, grasslands, and building of mounds widespread before large European settlement. The way the land appeared in 1750 was more pristine, or less humanized, when compared to 1492 due to the population decrease of the Native Americans (Denevan 1992:370).

Beginning in the 18th Century information about Native Americans became more reliable and accurate. The primary source for the time period around the American Revolution came from Juan Agustín de Morfi, a Franciscan monk, famous orator, and theology professor. The work of Morfi has endured due to the 1932 translation by Carlos Eduardo Castañeda where large numbers of passages describe the daily lives of Texas Indians. The account includes passages detailing how the indigenous groups managed or modified the land (Skeels and Lowndes 1972:24,25). One such account talks about the Wichita, labeled as the Quitzels Nation, Indians territory in North Texas:

> Eighteen leagues north of the abandoned Bucareli was situated a pueblo of the Quitzels Nation, their numbers being 20 armed at the most. They possess a very beautiful valley where they cultivate the land, and maintain their horse herds. Nearby are many salt beds, where they can freely supply their wants. The main

body of this nation united with the Cadognoches (Skeels and Lowndes 1972:32).

Later in the 19th Century historical accounts portrayed a more accurate relationship between people and their interaction with the environment. In present day Tarrant County an account from De Shields about Birds Fort in 1841 tells how the settlers did not bring a large enough supply of provisions based on the environment when they discovered that the Indians burned much of the ground surface. According to the account because of the burning no wild game could be located, resulting in a wagon sent back to restock the settlers (Baker and Cage 1962:10). Another account from John Peter Smith details that in 1853 "there were indians of the Caddo, Waco, and Ionian tribes scattered throughout this section. Their camp fires could be seen dotting the prairies at night in every direction around Fort Worth" (Baker and Cage 1962:14).

Vegetation Sources

Sources for vegetation in the past and relative present examined the plant and tree species within the LBJ National Grasslands and the surrounding ecoregions. Problems occur when attempting to determine which species are native and those introduced into the grasslands and forested regions. It is important to note that the Soil Conservation Service (SCS) after 1937 experimented with different grasses for the reseeding of the highly eroded areas. It was determined that in harder soils blue grama (Bouteloua gracilis), sideoats grama (Bouteloua curtipendula) and buffalograss (Buchloe dactyloides) were best suited for harder soils. In sandier soils blue grama, sand lovegrass (Eragrostis trichodes), sideoats grama, little bluestem (Schizachyrium scoparium) and sand bluestem (Andropogon hallii) demonstrated better characteristics for prairie restoration (Hurt 1985:254).

Dyksterhuis in 1948 described the vegetation in the Western Cross Timbers using four coverage categories in which includes the location of the LBJ National Grasslands: Quercus-Smilax, Quercus-Prosopis, Prosopis, and Old-field (Dyksterhuis:342). The Quercus-Smilax coverage found on gentle to rolling terrain contained large numbers of post oak (Quercus stellate), blackjack oak (Quercus marilandica) at 25.8 percent of the total. saw greenbrier (Smilax bona-nox) made up the second largest percentage at 10.4 percent, followed with sideoats grama, texas winter grass (Stipa leucotricha) at 3.7 and 3.6 percent, hairy grama (Bouteloua hirsuta) at 2.7 percent, coralberry (Symphoricorpos orbiculatus) at 0.2 percent. Undescribed forbs represented 19.5 percent of the total for the coverage area. Quercus-Prosopis found in areas of the roughest terrain with reddish prairie soils were the next coverage. Present again was post oak and Blackjack oak, at 11.7 percent, along with buffalograss at 12 percent. Threeawns (Arista spp) runs in at 6.6 percent, hairy grama at 2.8 percent, texas grama (Bouteloua rigidiseta) at 0.5 percent, blue grama at 0.3 percent, western wheatgrass (Agropyon smithii) at 0.2 percent, buckley (Triodia pilosa) at 0.3 percent. The unidentified forbs were at a higher percentage again of the overall total at 19.8 percent (Dyksterhuis 1948:342).

The other two coverage types set forth by Dyksterhuis, Prosopis and Old-field, differed from Quercus-Smilax and Quercus-Prosopis. The chief difference being that post and blackjack oak were marginally represented. The Prosopis coverage type was located in areas of flat to gentle terrain with buffalograss having been the most abundant at 20.1 percent and little barley (Horeum pusillum) next at 14.1 percent. Other vegetation included texas wintergrass present again representing 8.3 percent, hairy grama at 3.8 percent, texas grama and blue grama again at 0.8 and 0.4 percent, along with buckley at 0.3 percent. The non-described forbs are rated large in percentage at 12 percent, but unidentified again. The last coverage, Old-field, is associated with cultivated, cleared, or abandoned lands noted by the near absence of post and blackjack oaks. The highest plant percentage assigned went to western or cuman ragweed (Ambrosia psilostachya) at 6.8 percent, followed by walter (Festuca octoflora) at 5.8 percent, and threeawns at 3.7 percent (Dyksterhuis 1948:342).

In 1950 Frank Blair observed and recorded the biotic provinces of Texas describing the various plants, trees and animals for each. A total of six biotic provinces were described: Chihuahuan, Kansan, Balconian, Tamaulipan, Texan, and Austroriparian (Blair Figure 1:98). In the LBJ National Grasslands, the two provinces represented in the research area and surrounding region are the Texan and Kansan extending from Oklahoma into Texas. Plant species documented by Blair in the Kansan Province were threeawns, sideoats grama, and blue grama. The Texan province contained western wheatgrass, buckley and texas wintergrass, along with post oak, blackjack oak, and hickory (Caya buckleyi). The Kansan biotic province consisted of broomweed (Gaillardia texana), gaillardia (Gaillardia puchella), hairy grama, sideoats grama, blue grama, along with the absence of hickory (carya spp),post oak and blackjack oak (1950:100-102). Dyksterhuis and Blair described the same plant and tree species for the Western Cross Timbers.

A later source of vegetation types came from Steve L. Orzell who inventoried the National Forests and Grasslands in Texas for his Master's thesis in 1990. The LBJ National Grasslands were one of the areas inventoried and comparable with the earlier sources from Dyksterhuis and Blair. Three tasks assigned by Orzell were to: 1) compile a list of sensitive plants, 2) identify plant communities and classification and 3) make land management recommendations (Orzell 1990:1,2). A large quantity of plant species are part of earlier lists by Dyksterhuis and Blair including threeawns, hairy grama, sideoats grama, texas grama, saw greenbriar, silver bluestem (Bothriochloa sacchariodes), western ragweed, coralberry, post oak, blackjack oak and cedar elm (Ulmus crassifolia). Species listed only by Ortiz are shumard red oak (Quercus shumardii), texas live oak (Quercus fusiformis), eastern red cedar (Juniperus virginiana), and sugarberry (Celtis laevigata). One significant difference between Orzell, Dyksterhuis and Blair is a better description of forbs by Orzell including broomweed (Gutierrezia dracuncuioides), fragrant sumac (Rhus aromatica), mountain pink (Centarium beyrichii), and compact prairie clover (Dalea compact var. pubescens), prairie clover. The possibility exists that these and other forb types could have been present in the earlier Dyksterhuis and Blair accounts but just not described.

A second later source of plant and tree identifications comes from Diggs, et al in 1999 covering North Central Texas incorporating an area of approximately 40,000 square miles and fifty counties. The vegetation areas described are the Blackland prairie, Eastern Cross timbers, Western Cross timbers, Fort Worth prairie, Lampasas Cut plain and Red River areas (Diggs Jr., et al. 1999:3). The vegetation zone applicable to the current research is the Western Cross timbers zone. The grasses recorded by all three previous sources and Diggs, et al included hairy grama and sideoats grama, and those by only Dyksterhuis are tall dropseed (Sporobolus asper), switch grass (Panicum virgatum), and canada wildrye (Elymus canadensis). Texas wintergrass is recorded in the early sources from Dyksterhuis and Blair, but not Ortiz. Post oak and blackjack oak trees are represented in all three previous sources, along with hackberry (Celtis spp) and cedar elm recorded in both early and later sources. Trees new to the overall inventory included honey mesquite (Prosopis glandulosa), pecan (Carya illinoinensis) and juniper (Juniperus spp).

A third modern source comes from a 2007 report presented to the Texas Commission on Environmental Quality (TCEQ) that determined the vegetation, geology and topography in Texas. In the Westerns Cross Timbers ecosystem, a section of the larger Grand Prairie, the plants and trees in the Upland forest included post oak, blackjack oak, cedar elm, black hickory (Carya texana), live oak, eastern red cedar and sumac (Rhus spp). The riparian forest adjacent to waterways in the east contained pecan, Black willow (Salix nigra), eastern cottonwood (Populus deltoides), sycamore (Platanus spp) and boxelder (Acer negundo) vegetation. The western riparian forest had honey mesquite, hackberry and little walnut (Juglans microcarpa). The relatively undisturbed areas were composed of big bluestem (Andropogon gerardii), little bluestem, yellow indiangrass (Sorghastrum nutans), switchgrass and sideoats grama. The understory is listed as buffalograss, purple threeawn (Aristida purpurea), curlymesquite (Hilaria belangeri), honey mesquite and lotebush (Ziziphus obtusifolia). The grazed sections populated with understory shrubs and vines included persimmon (Diospyrus spp), sassafras (Sassafras spp), greenbriar (Smilax spp) and virginia creeper (Parthenocissus quinquefolia).

Biodiversity

Biodiversity studies vary from one region to another based on factors such as lands use, ecosystem function, scale, soil types and seed types (LaCroix and Abbadie 1998, Polley, et al, 2005). Studies in the LBJ National Grasslands related to biodiversity included inventories of the vegetation (Orzell 1990) and witness tree data from GLO records (Jurney, et al 1989). Links between biodiversity and ecosystems usually focus on the nutritional impact in relation to energy flows, species richness impacts, and sustainability (LaCroix and Abbadie 1998). Patch to patch biodiversity and disturbance regimes including land use changes of land abandonment, along with habitat fragmentation with clear cutting and urbanization as examples offer improved analysis attributes. Another common problem is properly assigning the correct scale that best represents the link between the biodiversity and ecosystem, and a variety of temporal spatial and times scales. Historical disturbances, manmade and natural, must also be considered since they affect current biodiversity; ignoring this factor can lead to misunderstandings of the environmental conditions. Finally the environmental factors influencing the overall processes of ecology have to be examined, and not just the nutritional or reproductive scopes (LaCroix and Abbadie 1998:189-191).

Outside of the LBJ National Grasslands area studies in other grasslands include experimentation and plant and tree species observations. A study conducted in the Blackland Prairie ecosystem east of the LBJ National Grasslands examined biodiversity (Polley et al. 2005). Observations at three locations compared remnant plots with replanted restoration grasses to observe the rate of biodiversity that occurred in each at different spatial scales. Restored tallgrass prairies were implemented by placing seed hay from remnant fields into previously cultivated fields. The results demonstrated that in all the different time scales the remnant grasslands had the highest biodiversity, species composition, and richness. Resource partitioning improvements in the remnant grasslands also contained more functional groups with fewer species per group than compared to the restored prairie grasslands. The overall results were consistent with previous studies that local processes such as seed dispersal and resource partitioning help to improve the overall biodiversity (Polley, et al. 2005:480-481,485-486). The difference between the LBJ National Grasslands and this study is primarily the soil types. Despite the soil difference, the information gained along with the biodiversity results could be similar, since both areas could experience similar drought conditions. One problem lies in that the LBJ grasslands have already been reseeded during L-U projects in the 1930's and 1940's, so determining native versus exotic, remnant or not, provides a greater challenge.

Research Design

Data Collection

A collection of both quantitative and qualitative information comprised the data for the research project. Quantitative data sources used in conjunction with the Geographic Information System (GIS) analysis using the ArcGIS software program 10.1 with environmental information gathered from public websites (www.tnris.org, www.water.usgs.gov), Bruce Hunter with the Center for Spatial Analysis and Mapping, and the Associate Director of the Institute of Applied Sciences at the University of North Texas in Denton. Archaeological sites within the study area were provided by the Texas Historical Commission at www.atlas.thc.state.tx.us/texsite/texsite-main.asp. In order to expand the understanding of the local private land owners and professionals working within the LBJ National Grasslands interviews were conducted with them. Questions asked of the willing participants interviews included what plants and trees they considered native, non-native, how the landscape looked in the past, how they envision the landscape in the future, and how long they have lived on the land, and potential threats to the environment.

Data Analysis

As with the data collection different methods of analysis for the collected data were required of the quantitative GIS shapefiles and qualitative interviews from local participants. ArcGIS allowed for the layering of multiple components forming an analysis, along with the ease of removing or adding elements. The analysis section investigated layers looking for patterns within the environmental setting in the LBJ National Grasslands. Additionally, a predictive model using ArcGIS's "fuzzy logic" based on specific criteria examines how the grassland/herbaceous gridcode coverage could look like in the future. The qualitative part of the research relied on interviews from private landowners and environmental professionals working for governmental agencies within the larger administrative boundary and the 78 federally owned grassland units. The participants were each assigned a letter designation to provide anonymity. Information obtained from the interviews was then transcribed using Microsoft Word 2010 allowing for manual coding based on the research questions for the project. As with the ArcGIS analysis, once all the ethnographic data was coded the search for patterns of agreement or disagreement among the participants formulated the final results.

Research Results

GIS Data

Soils

A number of soil types exist within the administrative boundary of the LBJ National Grasslands. The soil types, were classified into groups based on the description from the Soil Survey of Wise County, Texas (Ressel 1989:iv). The groups were loams, gullied soils, stony loams, eroded loams, flooded loams, stony clays, clays, flooded clays and quarry soils. The top three groupings were loams comprised of 25 soils, eroded loams with five soils, and flooded loams with four different soil types. Some of the soils include Arents loamy (Ar), Keeter very fine sandy loam with 1-6 percent slopes (KtC), Truce fine sandy loam with 2-5 percent slopes (TuC3) and frequently flooded Pulexas (Pu). In many cases certain soil groupings are associated with specific topographic terrains and settings. The loams and stony clays are commonly located on upland ridges, hilltops, terraces and some slopes. The flooded loams and flooded clays groupings are observed along the creeks and tributaries with two main creeks traversing the national grasslands from north to south, the Big Sandy Creek to the west and Denton Creek to the east.

Geology

Geology of the research area consists of ten underlying rock types with one type the most prominent. Antler sand (Ka) from the early Cretaceous period comprises the largest area covering 88.5 percent of the LBJ grasslands administrative boundary with Alluvium (Qal) from the Holocene period, the second largest, at 5.42 percent. The eight remaining rock types, all under three percent of the total, include Pennsylvanian fine grained clastic Jasper Creek Shale at 2.21 percent, along with early Cretaceous Goodland limestone and Walnut clay undivided at 1.75 percent. Antler sand is the principal geology type for the research area with no real comparison for changes in plant and tree species over time available based solely on geology.

Land cover

National Land Cover Databases (NLCD) provided information on how land use changed throughout time to determine areas affected by human landscape modification. The data collected labeled as gridcodes fell under multiple categories ranging from open waters to high intensity development. The national grasslands contain 22 gridcodes with open waters, high intensity developed, deciduous forest, and pasture/hay as examples of the types of land use categories. Three different NLCD data sets were downloaded corresponding to the years of 1992, 2001 and 2006. Not all of the gridcodes require an explanation of change from 1992 to 2006 due to the values not changing overtime. Predominately the greatest change in the landscape occurred between the years 1992 and 2001.

Several of the gridcodes have noticeably changed just since 1992 including open waters, low intensity developed and high intensity developed landscapes. Open waters, gridcode 11, any open area with less than 25 percent cover, soil or vegetation, decreased with a loss of 642 acres or 45 percent. Low intensity development, gridcode 22, increased dramatically from 1992 to 2001 with only slight upward change in 2006 with a 74 percent increase encompassing a gain of 1196 acres. Low intensity development includes a combination of constructed materials, such as single-family housing, and vegetation with 20 to 49 percent surface cover. A majority of the development occurred along US Highways 81/287 and 380, county roads, farm to market roads and private roads. High intensity development, grid code 24, rose from 4 to 29 acres from 1992 to 2001 and maintained the same acreage in 2006 with an 87 percent gain. The city of Alvord had the greatest percentage of high intensity development, along with scattered sections adjacent to low intensity developed land. Figures 2 and 3 show the illustrated gridcodes and how they have changed over time.

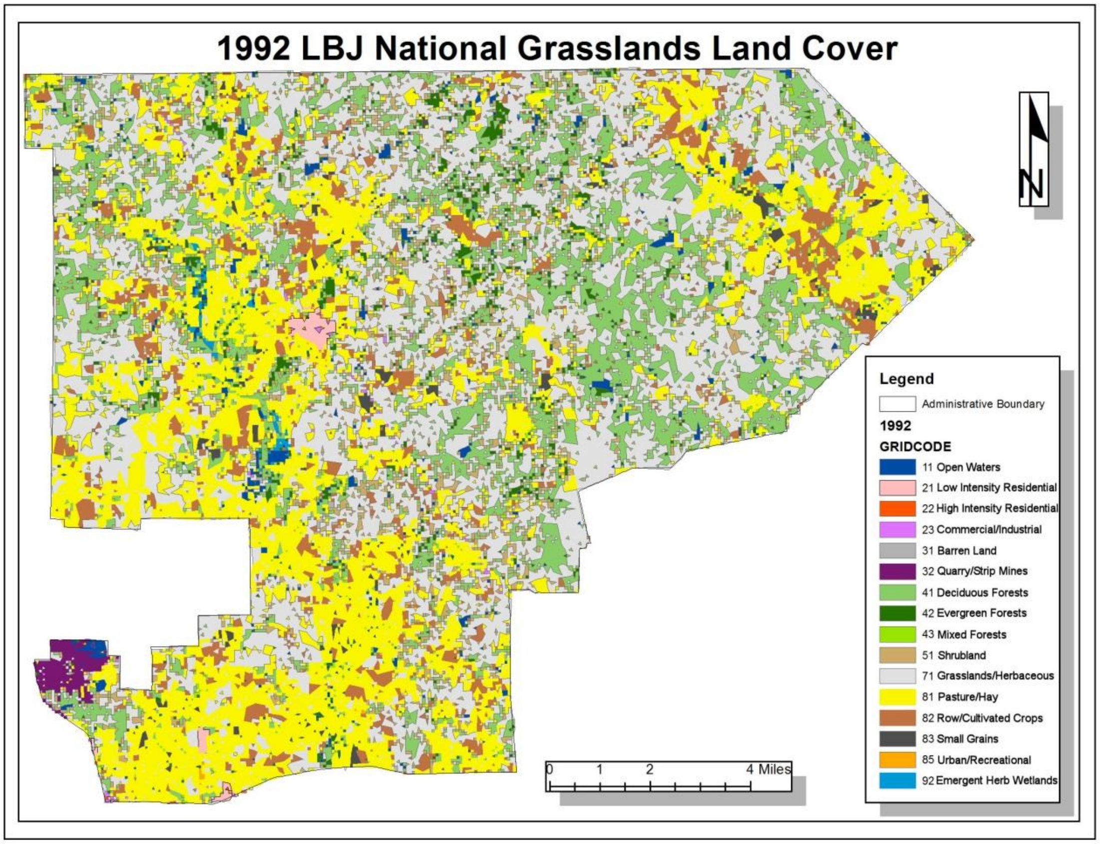

Figure 2. 1992 LBJ National Grasslands land cover gridcodes

GIS data showed barren land, deciduous forest and evergreen forest were areas of significant change. Barren land, gridcode 31, rose 89 percent from 88 acres in 1992 to 684 in 2001 and finally 768 by 2006. Areas with bedrock, sand dunes, strip mines, gravel pits and other earthen material where vegetation is less than 15 percent constitutes barren land. The size of the plotted changes range from 1.4 to 476.1 acres and are scattered throughout the national grasslands administrative boundary. Deciduous forests, gridcode 41, are defined as areas dominated with trees larger than five meters tall, greater than 20 percent vegetation cover and where the leaves drop in the fall on 75 percent of the trees. Deciduous forests increased from 19,608 acres in 1992 to the highest in 2001 with 24,640 acres in 2001 before dropping off slightly to 24,429 by 2006 with an overall average of 20 percent increase. At the same time evergreen forests, gridcode 42, decreased from 2580 to 205 acres from 1992 to 2006, with the greatest loss by 2001 with 97 percent average over time. The difference between deciduous and evergreen forests lies in that evergreens maintain at least 75 percent of leaves year round.

Additional gridcodes representing significant land use changes include grasslands/herbaceous and pasture/hay. Grasslands/herbaceous, gridcode 71, are areas with 80 percent or greater grass and herbaceous vegetation used for grazing but not intensely managed.

Grasslands/herbaceous increased to 61,755 acres in 2001 from the previous number of 43,904 acres gaining incrementally to 61,946 by 2006 by 29 percent. Locations where grasses and grass-legume combinations are greater than 20 percent of total vegetation and utilized for either livestock grazing or hay crops comprise gridcode 81 pasture/hay. The 1992 database listed 30,466 acres of pasture/hay; however by 2001 the total lowered to 14,062 acres and 14,035 by 2006 for a loss of 54 percent overall.

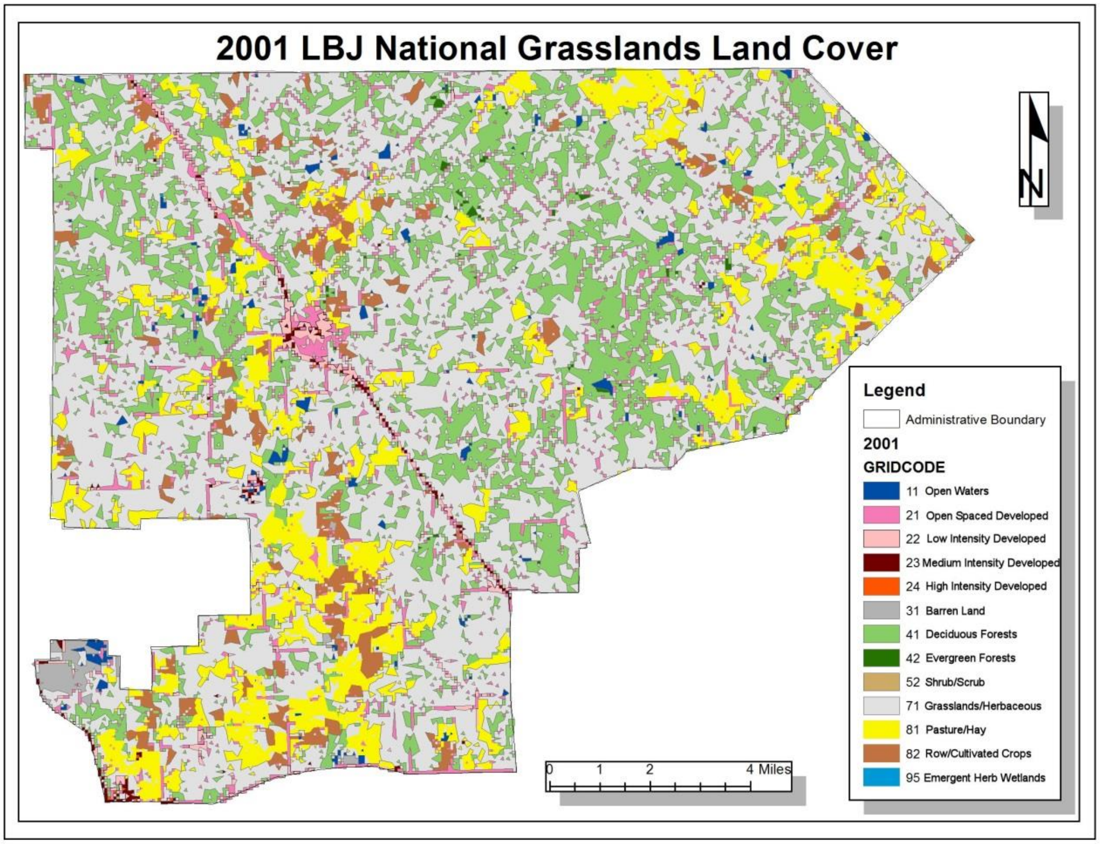

Figure 3. 2001 LBJ National Grasslands land cover gridcodes

Another loss of acreage comes from row/cultivation crops covering greater than 20 percent of the ground including all lands actively tilled and used for the production of annual crops such as corn, vegetables, cotton and soybeans. In addition perennial woody crops like orchards and vineyards fall under the same definition. Row/cultivated crops in 1992 covered 7707 acres and reduced to 4587 acres by 2001 and then slightly rose back up to 4626 acres five years later. It is possible that the reduction in acreage for both the pasture/hay and row/cultivation crop grid codes could account for the increase in the acreage of the grasslands/herbaceous areas. The 2001 NLCD data also shows that open space development, along with low intensity and medium intensity development adjacent to county and farm to market roads contributed to the expanded grasslands/herbaceous vegetation.

Archaeology Sites

Multiple historic, prehistoric and multi-component archaeological sites are recorded throughout the LBJ National Grasslands. Multi-component sites contain both prehistoric and historic artifacts in a single site. A total of 60 sites are located within the boundaries of the LBJ National Grasslands according to the Texas Archaeological Site Atlas (TASA). The sites are comprised primarily of prehistoric lithic scatters and buried settings, along with historical farmsteads and a lime kiln (TASA N.D., Accessed 12-16-14). The prehistoric time frame includes the period before European settlement during the 1840's. TASA records designate the Middle Archaic period as the earliest time frame for the research area based on one Carrollton point found at site 41WS108. The Late Archaic, Late Prehistoric I and II, Historic Native American and Historic Anglo-American time periods (Table 3) cover the remaining sites because of no diagnostic materials recovered (Prikryl 1990:49).

Table 3. North Central Texas archaeology chronology

Historic European/American	110 B.P. to Present	A.D. 1840 to Present
Historic Native American	250 to 110 B.P.	A.D. 1700 to 1850
Late Prehistoric II	750 to 250 B.P.	A.D. 1200 to 1700
Late Prehistoric I	1250 to 750 B.P.	A.D. 700 to 1200
Late Archaic	3500 to 1250 B.P.	1550 B.C. to A.D. 700
Middle Archaic	6000 to 3500 B.P.	4050 to 1550 B.C.
Early Archaic	8500 to 6000 B.P.	6550 to 4050 B.C.
Paleoindian	Pre 8500 B.P.	Pre 6550 B.C.

A correlation exists between the soil types and archaeological site locations. All of the site locations are observed on loamy soil settings specifically loams, eroded loams, flooded loams, gullied soils and stony loams. Loams have the most even distribution with 15 prehistoric, 15 historic and four multi-component sites, but this is not surprising since loams cover the greatest acreage within the national grasslands. Eroded loams are the least distributive with historical sites predominant at 15 total along with two multi-component and one prehistoric location. Gullied soils are also represented in all three site types with much smaller numbers though, two for prehistoric, one for historic and one for multi-component. Two prehistoric and one unidentified site type are located in flooded loams, and lastly stony loams only have two prehistoric sites recorded.

The time period with the greatest number of sites lies within the Historic Anglo-American timeframe. According to the TASA website 34 out of the 60 sites are historic with all but one a homestead or farmstead. The farmsteads range in condition from nothing left but artifact scatters on the surface to buildings left standing such as houses and out buildings. In other cases just a foundation is left to determine the location of a historic site. The remaining historical archaeological site was a lime kiln built into the already eroded side of a gully (TASA N.D., Accessed 12-16-14). Historic sites are often located on ridges and hilltops in uplands where the soils consisted of loams, eroded loams, flooded loams, gullied soils and stony loams.

Prehistoric sites make up the second largest number for the LBJ National Grasslands administrative boundary. Prehistoric sites, 19 in number, describe lithic scatters or quarries with unknown time frames due to lithic chert, not diagnostic points, found on surfaces or in shovel tests. There is one exception where one site, 41WS108, does have a diagnostic chert point allowing for a specific time frame to be assigned, which is the Archaic period. The single chert point designates the earliest time frame based on the artifacts recovered from all of the sites in the research area (TASA N.D., Accessed 12-16-14). The soil groups associated with prehistoric sites are loams, eroded loams, flooded loams, gullied soils and stony loams at various elevations just like the historic sites. Figure 10 shows the number of sites, however due to proprietary reasons the locations cannot be shown in order to prevent looting.

The multi-component sites having both prehistoric and historic elements in one location comprise the third largest grouping of sites. Seven sites were recorded from the 1980s to the present with lithic scatters and farmsteads the most common site types. As with the previous historic and prehistoric sites not enough information was available to determine a specific time frame for either both components. The artifacts recovered were from the surface and subsurface, with the historical often on the surface only (TASA N.D., Accessed 12-16-14). Soil associations for multi component sites are limited to loams, eroded loams and gullied soils often near creeks on uplands or slight slopes.

The degree of modification on the landscape varies according to the site type described in TASA. Prehistoric sites often display the least environmental disturbance due to the perceived short duration the locations were occupied in the past. Most of the prehistoric sites were surface sites not requiring much alteration of the land. An example is a quarry where people of the past gathered lithic material on the surface or just below the surface for tools used in conjunction with hunting or cooking. Other prehistoric sites are buried, as those located on the banks of waterways where sediment builds up as time passes due to periodic flooding.

Historic sites associated with agriculture and ranching are thought to be more destructive towards the natural environment, because farming and ranching typically involve much larger scale land clearing. Landscape change included cutting down forested areas of post oaks and blackjack oaks in order to have more acreage for cultivation fields. Lime kilns required large amounts of wood to turn limestone into lime, sometimes as much as one cord per furnace load. In historic times lime was invaluable for the production of concrete, mortar, plaster and stone construction materials. Additional sources for lime included softening water, reducing butter acids, making tortillas, tanning leather, killing termites and weevils and whitewashing (Smith 2010, Accessed 1-27-15). The Penobscot Marine Museum in Maine studied line kilns and determined that a typical kiln required 1000 cords of wood per year if ran continuously (N.D., Accessed 1-1-15). The measurement for a cord of wood is four feet tall by four feet wide by eight feet deep, or 128 cubic feet total. The clearing of the forested areas within the LBJ National Grasslands in the late 1800’s could include the operation of lime kilns. According to Patmos (2005:1), an estimate of 50 trees five foot in diameter would be required to produce one cord of wood. The diameter of post oak and blackjack oak tends to be half that size or smaller requiring even more deforestation to operate a typical lime kiln.

An archaeological example of environmental land use mismanagement comes from the largest pre-European settlement in North America mound building complex, Cahokia, in present day western Illinois. The complex flourished from the 10th century and continued for approximately 350 years adjacent to the Illinois, Missouri and Mississippi Rivers. Environmental degradation over time from deforestation for agricultural fields to feed an expanded population eventually caused erosion, runoff and downstream flooding during the important growing seasons. A series of wooden palisade walls constructed provided protection around the central part of the city; however this action required deforestation on a large scale. Archaeological evidence shows that the palisade wall was rebuilt three times during the habitation of Cahokia. In the end social and economic culture clashed resulting in declining crop production for the local farmers was believed to lead to the abandonment of Cahokia (Wood 2003:255,259).

Ethnographic Data

Semi-structured interviews from private landowners and environmental professionals within and around the LBJ National Grasslands provided information on how plant and tree species potentially changed over time due to human intervention. A total of 11 interviewees agreed to participate in the research project with eight private landowners and three environmental professionals working within and around the project area. The resulting data delivered land use patterns past and present, perceived native vegetation, perceived introduced vegetation, fire use and environmental factors.

Land use past and present

Private land owners often provided information on land use past and present because of first hand or family knowledge of the area. Five of the eight land owners have lived, or their families have, within the LBJ National Grasslands from 42 to 70 years with the remaining three land owners unknown or less than a year. Sometimes the data was non-determinant with Participant D listing how long they lived in the area as “all my life”, which could mean 42 plus years or less than one. The three environmental professionals also supplied information on land use with knowledge of the past and present, but how long they have lived in the research area was not obtained.

Cattle grazing and hay production represent the main economic activities in the LBJ National Grasslands. Presently, cattle grazing dominates the landscape among the private land owners, but this is only determined by the small number of those interviewed. Two of the participants, A and B, own ranches with 600 and 676 acres respectively used for cattle grazing with limited hay production for cattle. The number of acres owned decreased for the remaining participants with 163, 160, 80, 57, 15 and 6. Cattle grazing is the most common land use with the exception of Participant F who grows hay for cattle. Participant C’s family originally farmed the land over a century ago, however switched to mostly cattle grazing with limited farming. In addition a section of the land was a portion of the original Homestead Act land grant. The switch from agriculture to grazing was due to the erosion of the topsoil from poor farming methods.

Participants described land use changes in both the past and present. Participant B provided strong background information for the research area with firsthand accounts and recollections of conversations with his father. Farming was the common land use earlier in twentieth century with cotton, corn, and wheat often planted, and according to his father “if it’s not in timbers it was farmed”. Of the acreage currently owned by him and his wife 240 out of 600 previously belonged to his father and mother, and before that eight families had been raised on the same property. Many of the eight families raised on the 240 acres lived in barrack like structures, most likely as tenant farmers. The continuous farming of the land caused the topsoil to erode, and in conjunction with a long drought in the 1930s, especially 1934, assisted in the formation of the Dust Bowl Era.

Information about the cotton industry comes from Roger L. Dixon who planted and sold cotton for 60 years starting around 1910. The cotton industry lasted for 80 years beginning during the reconstruction period after the Civil War and extended to 10 years after World War II. In 1912 cotton was king in Bowie, north of the LBJ National Grasslands, due to the sandy soil and then recently plowed up top soils. A low point in production occurred in 1929 when the stock market crashed and an extended drought in West Texas and Oklahoma caused the cotton crops to completely fail two years in a row (2009:i,14,37).

Other land modifications in the past included terracing, land clearing, construction of stock tanks and dairies. Terracing became common after the Dust Bowl Era in order to control erosion of the topsoil in planted fields and mentioned by four of the participants directly. Participant D specified that terracing was used for the watermelon and peanut crops, along with some cattle grazing. The other three participants just mentioned that terracing was used to reduce erosion after the Dust Bowl Era. Land clearing identified by four of the participants fell under clearing of invasive brush and trees, for hay fields, mesquites for pastures, and timber removal along waterways. Lastly two participants talked about stock tanks and a dairy farm constructed in an earlier unknown time period.

Environmental professionals, Participants I, J and K, provided information on the background of the LBJ National Grasslands and land use. Deep gullies formed from planting crops such as wheat, corn and cotton starting with European settlement in the late 1800s. Some gullies were deep enough in the 1930s and 1940s that they resembled “baby grand canyons”. After purchasing the land the newly formed Soil Conservation Service (SCS) in the late 1930s began planting seeds to try to return dirt back to grasslands and repairing gullies with gully plugs to stop further erosion. The Civilian Conservation Corp (CCC) in the 1940s also constructed gully plugs and other erosional control structures using small masonry bricks.

Research participant responses stated that modern land modifications still largely consist of environmental improvements. The biggest difference appears to be that private land owners and environmental professionals work together in a common interest to conserve the landscape. Improvements such as flood control dams help with water control and supply water for cattle, along with improved grasses for grazing on private lands. Environmental professionals work with private land owners to solve problems entailing grade stabilization structures, diversion terraces, grass planting and native grass restoration. In the end though environmental professionals only consult land owners on the best methods for land improvements. Overall, how much the land owner wants to spend on land improvements determines the level of landscape change. In the federally owned lands horse trails, camping locations and other recreational areas have been built. Improvements include erosional control structures, reseeding of native seeds in old fields to stabilize the soil and limited cattle grazing.

Native and introduced vegetation

Private land owners and environmental professionals described both native and introduced plants and trees in the LBJ National Grasslands. The major difference between the two groups of participants primarily resides in the level of expertise in identifying plant and tree species. Environmental professionals identified more species of vegetation, especially grasses, compared to private land owners. Similarly, what is considered native or introduced can differ slightly between the two participant groups based on the data collected during interviews and questionnaire answers. Overall more research participants identified more native species compared to those introduced.

Native plants and trees described by participants outnumber the perceived introduced vegetation. The most straight forward response came from Participant I stating that anything before white settlement is native. White settlement did not begin in Wise County and the research area as a whole until the mid-nineteenth century with the first official survey not until 1852 (Jurney, et al 1989:90 Table 8). Participants frequently identified creeks as location for native trees. Native trees identified by participants were post oak, blackjack oak, live oak, burr oak, red oak, pecan, cedar elm, water elm, redbud, texas ash, hawthorne, eastern red cedar, cottonwood, mesquite, mexican plum, mulberry, bois d' arc, and hardwoods. In smaller numbers grasses comprised lovegrass, bluestem, little bluestem, indian grass, switch grass, sideoats grama and native grasses, along with blazing star flower and sunflower and the viney greenbriar. One land owner added that more brush, mesquite and cedars are present now than in the past.

Historical sources help verify that some of the trees and plants identified by the participants are indeed native based on pre-white settlement in the county. Before the forests in the Western Cross Timbers were cleared after European settlement specific trees were used as witness trees for the Wise County surveys under the General Land Office (GLO) starting in 1852. The witness trees that correlate with the participants' native trees were cottonwood, mesquite, blackjack oak, burr oak, pin oak, post oak and elm (Jurney, et al. 1989:86 Table 6). On Cactus Hill in 1855 Mrs. D.J. Galbraith described Col W.H. Hunt's home on a hilltop where Lake Bridgeport is currently located with live oak trees and cactus of all varieties (Cates 1907:41). In 1907 a woodland belt covered two-thirds of the Western Cross Timbers, or the Upper Cross Timbers, in Wise County. Trees that are in common with the participants' choices as native included post oak, pin oak, burr oak, water oak, red oak. Black walnut, pecan, cottonwood and elm were recorded along streams, while post oak and blackjack oak located on uplands (Cates 1907:355).

Additional historical sources from the nineteenth century help to verify the participants' choices as native vegetation. Richard V. Francaviglia discussed the North American Cross Timbers providing information on nineteenth century vegetation. The publication Texas in 1840, or The Emigrant's Guide to the New Republic described the Western Cross Timbers as diverse with blackjack oak, post oak, live oak, mixed in with elm and cedar. William Kennedy was an Irish diplomat and writer who in the 1830s traveled around the United States and the Texas Republic. In 1844 Kennedy wrote Texas: Its Geography, Natural History, and Topography and included blackjack oak, white oak, post oak, holly, hickory and elm as common trees for what is now called the Western Cross Timbers (Francaviglia 2000:Kindle Edition).

Research participants more readily identified native plants and trees compared to introduced species. By far the most common grass chosen by private land owners and environmental professionals was coastal Bermuda. Continuing with grasses old world bluestem, KR bluestem, plains bluestem, bromes, thistles and seresia were mentioned more by the environmental professional participants. The number of trees described as introduced was greatly reduced compared to native types with memosa spreading in the grasslands, honey locust, black locust, and generic pine. Cedars were considered introduced by some of the participants and a bradford pear planted in one of the participant's front yard. Mesquite and honey mesquite trees were also recognized as introduced and native.

Planted cash crops not surprisingly were considered introduced by private land owners with cultivation requiring clearing of forested areas or plowing up of grassland prairies. Most of the time, the native vegetation is removed to allow for the introduced species. Crops described by the research participants included cotton, corn and wheat, along with peanuts and watermelon in the past. Both peanuts and watermelon are no longer widely grown in Wise County, because soil nutrient loss made the crops not economically viable. Early in the 20th Century Cates described the Wise County area upland sandy soils highly productive for a wide variety of crops including cotton, wheat, oats, rye, barley, sorghum, kaflie, milo maize, melons, fruits and vegetable (1907:355-357).

Environmental Factors

Land use and vegetation only account for part of the LBJ National Grasslands change, other environmental factors command attention. The first factor, control burns are examined to see how management differs from private and federally owned units within the administrative boundary of the LBJ grasslands. Second, the use of chemicals or organic methods by research participants to maintain crop and grazing lands. Third, potential damages facing the natural environment, such as prolonged drought and tree diseases. Finally how will the oil and natural gas industry effect the environment and land use in the future.

Control burns used within the LBJ National Grasslands happen only on a limited basis. Interviews concluded that private land owners concurred unanimously that control burns are rare on their properties. Participant A expanded saying that a fear of damaging their land and house often prevented them from burning, even though control fires occurred on the federally owned units immediately adjacent to their property. Environmental professionals work with private land owners recommending modifications to improve the landscape from erosion and other problems. As the population increases in Wise County the environmental professionals seldom recommend control burns.

The situation is different on the 78 federally owned units within the administrative boundary where control burns have been performed on a yearly basis since the late 1990s. Participant I expressed two different ideas relating to the annual burning schedule. The first idea considers the vegetation for wildlife, livestock and agriculture in the federal units of the national grasslands. All 78 units within the LBJ National Grasslands are assigned to one of three categories based on their environmental setting importance. The first rate category entails the most important units requiring burning first because of identified environmental issues. Second rate units are not as important and will be burned if resources allow, and third rate units are not nearly as important and often are not burned. The second idea considers public safety by setting control burns to potentially lower the risk of wildfires in the future. The Forest Service manages the control burns for wildfire prevention since it is primarily a firefighting organization.

While the environmental professionals recommended organic methods, private land owners primarily relied on chemical fertilizer. All but one of the private land owners use or used chemical means to fertilize bermuda grass, improving hay production, removing brush and killing weeds. The fertilizer Triple 15 was designated for use on coastal bermuda to keep the grass growing and improve seed. A single land owner gave the opinion of “have not” on the questionnaire, which could apply towards organic or chemical methods. Most participants agreed that cattle prefer coastal bermuda grass over native species requiring the use of chemical fertilizers. Any lapse in the use of chemicals on coastal bermuda often allows the more resilient native grasses to return in their place.

Environmental professionals share a different view on the use of chemicals to control plants and trees. Inside the grasslands federally owned units, professionals seldom used chemicals except to eradicate invasive aquatic plants, water mussel and hydrilla, largely leaving the other vegetation natural. The environmental professionals working with land owners recommend more organic methods over chemical use. Cover crops and plant combinations with mixtures of grasses to build up the soil to improve organic and biological properties of soil are pitched to land owners as a viable option.

Potential damage towards the environment as quantified by the research participants varied from unknown to drought. The potential damage with the greatest frequency was drought and the effects on the land, cattle and vegetation. The environmental professionals agreed that native species would survive better in drought conditions because they have been through previous droughts in the past. Participant A commented on previous drought conditions in 1956, believed to be the hottest, and again in 1980 when the temperature reached 113 degrees causing newborn calves to die in the fields if they could not reach shade. A study looking at records of drought were traced from 1698 to 1980 based on climatic post oak tree ring data using the June Palmer Drought Severity Index (PDSI). Data from the years of 1951 to 1956 identified those dates as one of the most severe drought periods in North Texas with the exception of the 1698 drought (Stahle and Cleaveland 1988:72).

Other potential damages detailed by private land owners and environmental professionals included disease, advancement of invasive species and the influx of people. Infestations of dutch elm disease killing elm trees and an unknown infection, a bug more than likely, drilling holes into live oaks worried one land owner. Advancement of trees such as cedars, mesquites and others onto the landscape previously more prairie like was described as potential threat. Relating to drought issues the utilization of water for non-native, or introduced, species of plants and trees concerned another land owner. Although no further details were given the belief could be because introduced vegetation requires more water in order to survive than native ones. Lastly, too many people moving to the area with overgrazing of cattle as a consequence of increased population and less acres available concerned some of the participants.

The oil and natural gas exploration and extraction activities make up the final environmental factor identified by the research participants. Five of the eleven participants did not give oil and natural activities as an environmental factor, however, those who did reply on the issue showed concern. Royalties from natural gas and other mineral rights extraction within and around the national grasslands lead to increased drilling activity in the region. One land owner expressed concern over this oil and gas activity wondering whether recent earthquakes, in an area not known for them, correlated with drilling of the Barnett Shale. Changes to the natural environment occur with oil and natural gas drilling. Construction for well pads, access roads and pipeline routes displaces large number of trees and other vegetation.

Past and future landscape visualization

In order to understand how plants and trees have changed over time in the LBJ National Grasslands views on how the landscape appeared in the past according to the participants is an important aspect. Two of the four participants who completed the questionnaire noted the landscape was the same or similar. One of the participants developed his view through conversations with people who lived in the area for many years. The remaining land owners interviewed visualized the landscape as either forested or farmed, or a combination of both. Two of the land owners observed the area heavily forested or timberland, with one stating that eventually forests changed into cotton fields. Growing cotton on forested land required clearing of the Western Cross Timbers woodlands, and the view that farming was prevalent in the past was expressed by two other participants. Another viewpoint from land owners stated that the landscape contained less underbrush and more land clearing, however for what purpose was not specified.

As expected the view of the environmental professionals followed an ecological analysis in assessing the use of the past landscape. Participant I commented on varying historical accounts describing the vegetation of the Western Cross Timbers vegetation as thick as keeping a hat on was difficult to as open to where a wagon would fit through. This description led the participant to consider widely variable scenery of post oak and blackjack oaks canopy with an herbaceous understory comprised of grass and flowers. The small branches of the post oaks when burned left a barrel like trunk and two or three thick branches above head level. Cedar trees on the other hand have the opposite effect by not returning to previously burned areas no matter how much time passes. As the area appears today grasslands covered what was not forested. Participants J and K envisioned tall grass prairies with scattered post oak forests before "we stuck the plow in the ground". Gullies formed, sometimes from cattle trails, and by 1915 most of the farmers fled due to erosional gullies greatly reducing the annual cotton production.

The question of the LBJ National Grasslands in the future in terms of the environmental setting asked of the participants and environmental professionals provided varying results. Concerns over an extended drought and potential climate change persist with the hope that the effects will not be too severe. The largest percentage of participants, six, agreed that development is the future for all of Wise County. Farmers are selling their land to developers who in turn break the land up into 5 or 10 acre ranchettes that can be used as tax breaks if the new owners keep cattle on their property. The lack of mineral rights could also help land owners decide in the future to sell their land for subdivision. Three participants expressed erosion and overgrazing of the land most likely in the future. One reason given for the erosion and overgrazing includes improper cattle grazing practices on the growing number of 5 or 10 acre ranchettes. The land is not sustainable often for the number of cattle on the ranchettes, or ranchers fails to rotate the cattle in order for the grasses to return.

Conclusions

It is impossible to cover every aspect of how plants and trees have been affected over a long period from human landscape modification within this applied thesis research. What is attempted presently investigates some of the major factors with the available information online and from limited interviews. GIS data confirmed that land use changed the most between the years of 1992 and 2001, with only minor additional changes by 2006. The loss of acreage in watered areas was the most visible change by 2006. Urbanization increased greatly between 1992 and 2001 with more people moving into the Wise County, and in the LBJ National Grasslands along the county roads, farm to market roads and private roads. Because of human expansion into the LBJ National Grasslands the advancement of barren land with little or no vegetation, less cultivated land and an increase in grassland/herbaceous landscapes transpired.

Evaluating the environmental change earlier in time has to come from early firsthand accounts, archaeological evidence and ethnographic interviews with the local participants who, or their families have, lived in the area for many years. Interviews with the research participants and environmental professionals confirmed that a long history of cattle ranching has been a mainstay activity for the area, and continues into modern times. Previously agriculture dominated with cotton, wheat, watermelons and peanuts grown for both economic and personal purposes. The resulting action, along with active cattle grazing, often restricted the growth of native species of plants and trees. The Dust Bowl Era, along with erosion and soil nutrient removal from earlier improper farming practices greatly hurt the landscape leading to federal actions attempting to restore the grasslands. Presently federal and state assistance helps land owners prevent erosion and manage their land so that cattle grazing can persist.

One last important aspect to examine is the overall environment, the plants, trees and the people living within it, further into the future. Predicting the landscape in the future through modeling often is more effective when based on multi-scales, integrated and spatially categorical aspects. Also more often the source of land use changes is because of economic opportunities by people (Veldkamp and Lambin 2001:1, Lambin, et al 2001:261). As already confirmed by some of the research participants a concern is more people moving into the administrative boundary of the LBJ National Grasslands and Wise County. The question is what kind of condition the natural landscape will be in with increased population, more 5 to 10 acre ranchettes and the possibility of eroded, overgrazed grasslands due to improper cattle grazing practices.

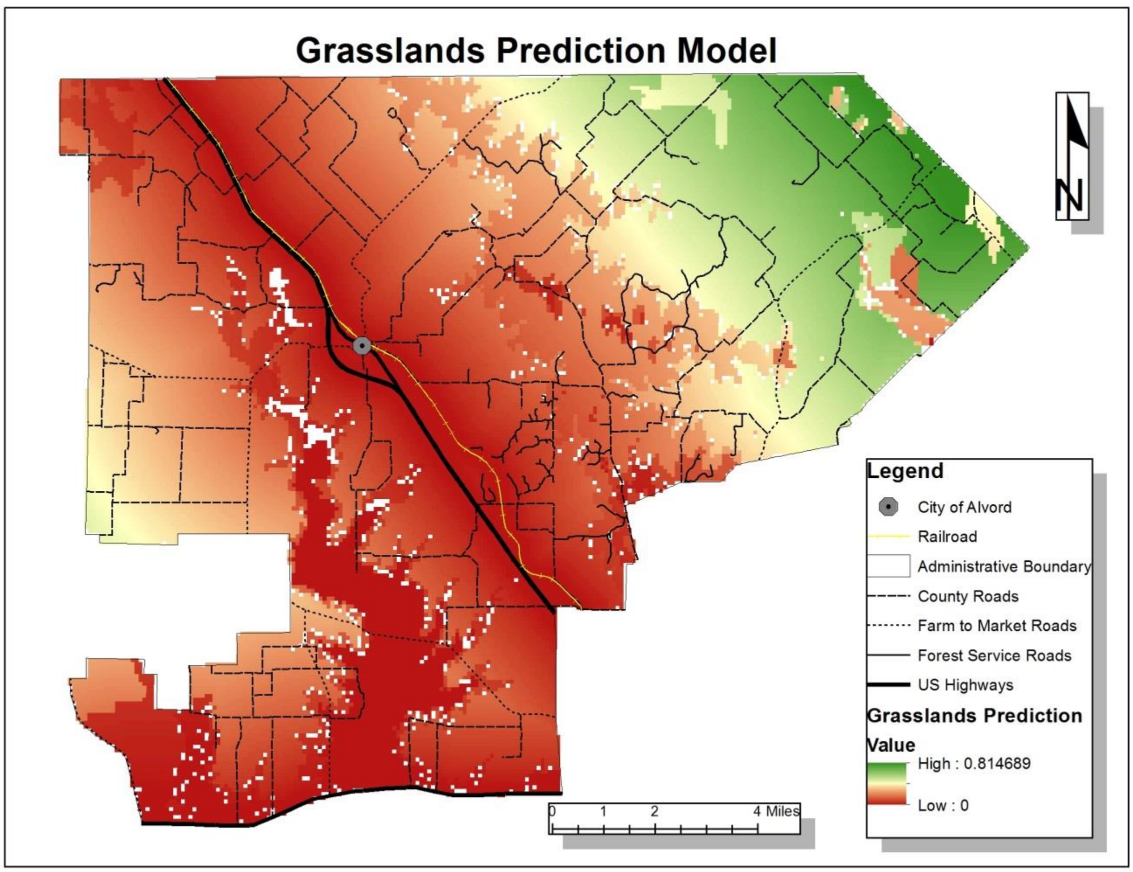

Figure 4. Prediction model for the grasslands/herbaceous gridcode

The formation of a predictive model of the LBJ National Grasslands (Figure 4), using "fuzzy logic" in ArcGIS, examined the following environmental characteristics: land use gridcode 71 (grasslands/herbaceous), the antler sand geologic formation, and human disturbance. The green area of the model represents where the GIS designated grasslands have the best potential to flourish in the future and support efficient cattle grazing. The red area depicts locations of human disturbance representing the lowest probability with a value of zero for grasslands or herbaceous locations. The decision to use the grasslands/herbaceous gridcode corresponded with the greatest acreage within the administrative boundary. The Antler sand geologic formation was used based on two factors: the greatest acreage and the widespread distribution. Human disturbance only looked at the most occupied areas within the administrative boundary, namely along the US Highways and adjacent to the railroad system. The first is US Highway 380 following the southern border heading east to west and US Highway 81/287 roughly in the middle of the administrative boundary heading from the southeast to the northwest.

In addition to the major highways the railroad system contributes to human disturbance. The railroad system in Wise County and the LBJ National Grasslands parallels US Highway 81/287 traveling southeast to the northwest. According to Cates two different railroads traversed the research area, the Fort Worth and Denver City Railroad and the Chicago, Rock Island and Gulf Railroad (1907:357). The Fort Worth and Denver City Railway Company (FW&D) originally chartered in 1873 did not begin construction until 1881 due to the financial panic of 1873. Completion of the railroad to the Texas state line occurred in 1888. The FW&D Railroad accelerated the growth of the area with the “No settlers, no trains” and using winter wheat as food for cattle promotions (Billingsley N.D.). The Chicago, Rock Island and Gulf Railway Company (CRI&G) chartered in 1902 constructed originally to extend the Rock Island system from Fort Worth to Galveston. A year later the CRI&G merged with three other subsidiaries of the Rock Island to form a 334 mile system stretching from Oklahoma to Texas (Young N.D.).

Recommendations

Variations in land use management patterns between private land owners and environmental professionals sometimes lead to erosion of the landscape. The Smiley-Woodfin grasslands in North Texas with regard to the natural landscape provided an example of how the grasslands originally looked in an area surrounded by nearly 100 percent human disturbance. The grasslands have never been plowed since the mid-1800s when European settlers first started arriving in modern Texas. The man responsible for the conservation was M.L. Smiley (1872-1953) who recognized that the area lacked sufficient fuel sources and was too far away from a water source. Lands adjacent to the grasslands farmed in the past eroded because of depleted soil. Smiley originally used the land for cattle grazing and hay production and technologies such as cutting and drying using steam powered presses. The continual use of the Smiley-Woodfin prairie grasslands for hay production makes it the state’s largest supplier of native hay. (www.atlas.thc.state.tx.us/Lamar-county.htm Accessed 12-13-14).

Examining plants and trees in the research area modified through human interaction of the landscape in the present, along with historic and prehistoric sites in the past three recommendations are put forth:

•**Adaptive and holistic cattle grazing plans for current and future land owners within the research area and surrounding Wise County**

A location in North Central Texas currently offers potential model for conservation while operating as a working cattle and sheep ranch. The 2150 acre Bear Creek Ranch in Parker County presents an opportunity to view the tallgrass prairie grasslands as close to its original form as possible under the management of the Dixon Water Foundation. The foundation promotes healthy watersheds by implementing good landscape choices through sustainable land practices at four working ranches in North and West Texas, funding annual programs for ecosystems, providing education for landowners, and raising public awareness about healthy living and watersheds. The grazing plan used at Bear Creek and the other working ranches are adaptive and holistic. A total of 22 fenced paddocks are enclosed using barbed wire and electric fences around four water stations and Bear Creek. Cattle eat the native grasses including little bluestem, big bluestem, and indian grass, while the sheep eat the weeds. Allowing cattle only the top one third of the grass containing all the nutrients conserves the native grasses and when this occurs they are moved to the next paddock. Any change in the environment is taken into account modifying the grazing plans, and every January a new plan developed (Board of the Dixon Water Foundation 2010, personal communication with Danny Parker 4-23-13).

•Expansion of partnerships between governments agencies already in place and private land owners

In the LBJ National Grasslands and surrounding area an expanded partnership between government agencies and private land owners could improve land management practices. Land management practices like those at Bear Creek Ranch could reduce overgrazing of land on privately owned lands. The higher costs to start and maintain the process compared to normal cattle grazing on privately owned land points to an important issue to overcome. Also to be effective large numbers of acreage is necessary posing a problem with small ranchettes composed of usually no more than ten acres becoming more common. Control burns on grazing lands, as done in the 78 federal units, could further assist in natural landscape preservation by providing sufficient nutrients for cattle. The continued partnership with environmental professionals from the USDA and other government agencies and private land owners in the future probably provides the greatest opportunity to reduce erosion and other land issues. The infrastructure is already in place for the partnership and further education to continue into the future. Research into how to help the programs assist more land owners is the next avenue to examine with the expected rise in population in Wise County.

•Models using ArcGIS to predict where archaeological sites and vegetation changes within Wise County could be located by examining natural characteristics and man-made landscape changes

The location of archaeological sites depends on both natural and man-made environmental conditions along with the vegetation. Understanding site variation and their impact on the environment is important. Modification of the natural environment is often more common with historic sites compared to prehistoric sites. By overlaying identified site locations on top of the soils, geology and topography of an area, potentially undiscovered sites may be identified by examining land with similar characteristics. Vegetation change prediction offers similar results by examining the same environmental information but looking at individual plant species or diverse ecosystems instead of archaeology sites. Lastly, the overlay process could work in any location, not just the research area, as long as ArcGIS data is available.

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