“Mesquite Wood and Ancient Rainfall: The TxDOT EDXA Project”

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EDXA and Mesquite: and Introduction

*I am exploring the effects of modern rainfall on mesquite (Prosopis glandulosa) wood anatomy across Texas through **Ecologically Diagnostic Xylem Analysis (EDXA)**. EDXA is based on the principle that environmental moisture where a mesquite plant grows directly affects the anatomical structure of its wood.*

[“Xylem:” technical term for the tissue that transports water in vascular plants.]

Some tree species exhibit predictable variation in size (diameter) and number (density) of water transport vessels (pores) in their wood depending on local rainfall. Within species, vessel diameter tends to be higher and density lower in high rainfall regions. Conversely, in arid regions vessels tend to be smaller and more numerous (Carlquist 1977). Biological and ecological forces that drive adaptation of mesquite wood to its surrounding environment have potential as a proxy indicator for interpreting paleoenvironmental conditions from archeological remains.

Phil Dering (e.g., 2002, 2004) pioneered EDXA in Texas using mesquite wood charcoal. For millennia the iconic mesquite tree has provided indigenous peoples of Texas, the Southwest, and Mexico with food, fuel, and manufacturing materials (**Figure 1**) (Bell and Castetter 1937). Its nutritious pods are rich in sugar and protein (**Figure 2**), tools were fashioned from its wood, and the dense wood is ideal fuel for cooking and warmth. Mesquite is ideal for EDXA because of its broad distribution (**Figure 3**), ability to adapt to a wide range of annual rainfall (8 – 39 inches), and frequent occurrence as charcoal on archeological sites. Dering’s preliminary results support the potential utility of the method.

Figure 1. Roadside mesquite tree, Hamilton County.

Figure 2. Mature mesquite pods.

The TxDOT EDXA project is advancing this research by accumulating samples of modern mesquite wood from across the state to compare their microscopic anatomy with the precipitation record of their respective source locations. In theory, the general precipitation pattern in effect during the growth cycle of archeologically derived mesquite can be inferred from a morphometric baseline built from modern wood grown under known moisture conditions.

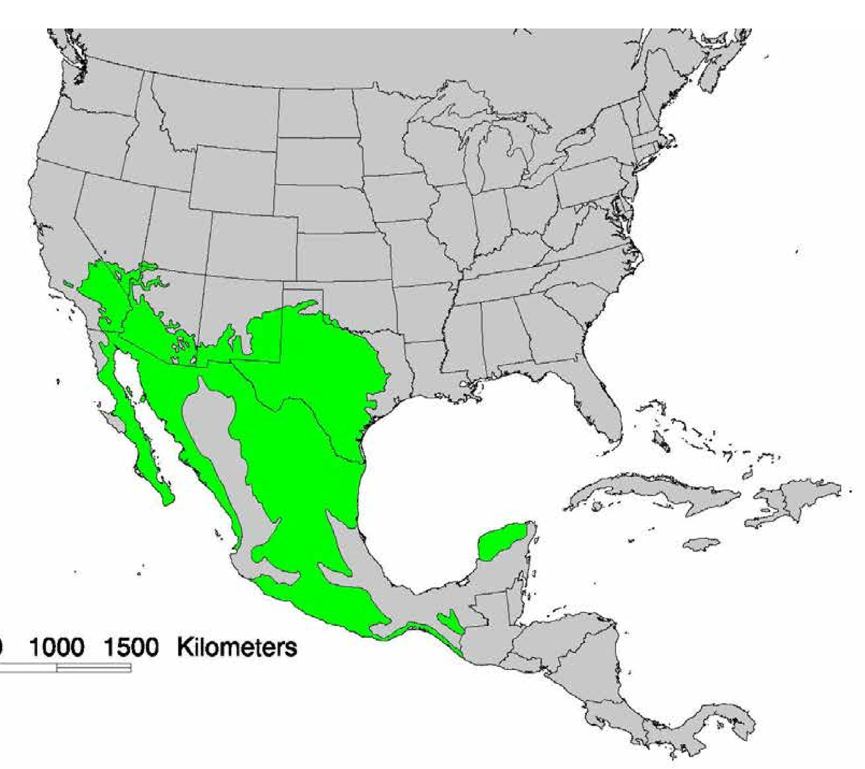

Figure 3. Mesquite distribution across southern North America.

Materials and Methods

Plants parts are delicate compared to most archeological remains, and aside from exceptional sites (e.g., dry rock shelters) evidence of past plant use is often in the form of charcoal. Plant preservation in open sites requires exposure to 250 – 500°C (482 – 932°F) temperatures with minimal oxygen, resulting in carbonization and rendering them resistant to biological deterioration. A specialist can often identify charcoal fragments to at least the genus level.

So far, 121 samples have been collected from 66 counties (**Figure 4**). Many are from TxDOT right-of-way, but numerous contributions from private land have been donated by the interested public. Since archaeological mesquite wood is usually found as charcoal, modern samples are charred for comparability to ancient specimens. Samples are tightly sealed in heavy duty aluminum foil (to minimize oxygen exposure), and fully carbonized in the coals of an open fire (**Figure 5**).

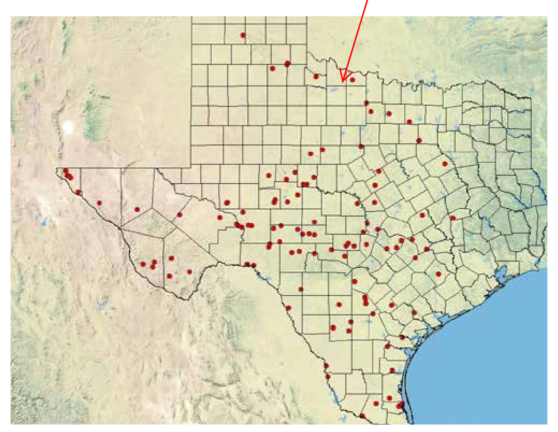

Figure 4. Mesquite wood samples for the present study, as of October August 2018

Figure 5. Carbonizing samples.

Each sample is snapped to expose a fresh, clean transverse plane (**Figures 6, 7**), and examined at 150X using a Dino-Lite USB digital microscope. Using DinoCapture 2.0 software, a 4 mm² square is superimposed on the exposed face (**Figure 8**). The following indices are calculated from the vessels within the square:

- **Mean vessel diameter:** sum of all vessel diameters divided by total vessel count;
- **Vessel density:** mean number of vessels per mm²;
- **Vulnerability index:** mean vessel diameter divided by vessel density.

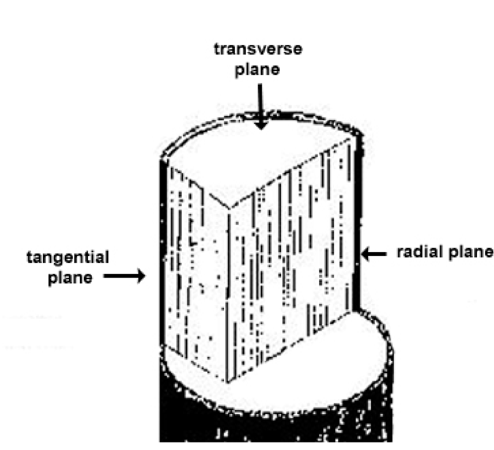

Figure 6. Three planes of section in wood; EDXA utilizes the transverse plane.

A low vulnerability index indicates smaller but denser vessels (predicted to indicate aridity); a high vulnerability index reflects fewer but larger vessels (predicted to indicate high moisture) (Carlquist 1977; Dering 2000, 2004). These predictions will be tested by comparing the indices against the modern rainfall record of the sample source locations, but first a more general pilot study was performed.

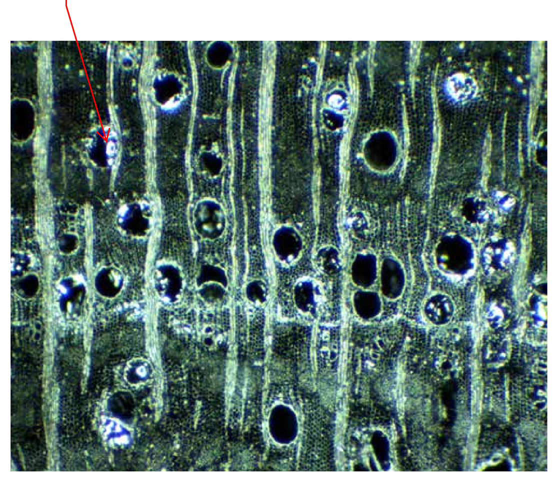

Figure 7. Transverse plane of mesquite wood charcoal (45x).

Figure 8. Sample 11 (Crockett County, 100x) data collection using Dino-Capture 2.0 software; vessel measurements / counts are collected within the 4 mm² red square.

Pilot Study: East to West

Mean annual precipitation generally decreases from about 56 inches in the forests of east Texas to about eight inches in the desert west (**Figure 9**). Given this precipitation gradient one could hypothesize the following changes in mesquite wood anatomy from east to west:

- decreasing vulnerability indices
- decreasing vessel sizes
- increasing vessel densities

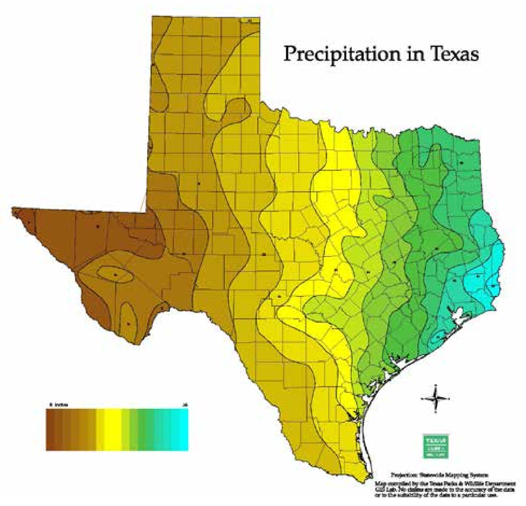

Figure 9. Mean annual precipitation in Texas, showing diminishing gradient from east to west.

Vessel measurements were obtained from 23 samples along a transect spanning 16 counties from El Paso, along the I-10 corridor, across the Hill Country and Edwards Plateau, and east to Colorado County (**Figure 10, Table 1**). Two additional outlying samples from Motley and Brewster Counties were also included.

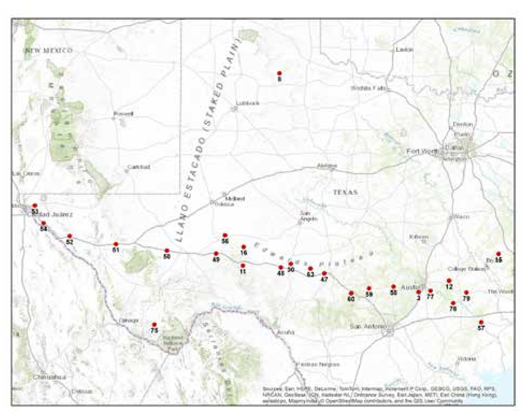

Figure 10. Samples selected for pilot study (n = 25).

Results indicate a lack of correlation between broad scale shifts in rainfall and vessel patterns among the widely spaced, individual samples along the gradient (**Table 1**). However, samples from the opposite extremes are distinctly dissimilar (**Figure 11**). Sample 53 (El Paso County) clearly has more vessels than Sample 57 (Colorado County); mean pore diameter is relatively similar between the two, but the respective vulnerability indices are consistent with EDXA expectations (lower in the drier west, higher in the wetter east).

Sample #	Mean Vessel Diameter (mm)	Vessel Density (x/mm2)	Vulnerability Index	Landform	County	County Mean Annual Precipitation (mm)
57	0.079	17.50	0.0045	upland	Colorado	1136
15	0.081	13.00	0.0062	upland	Madison	1118
79	0.093	19.25	0.0048	depression (wet)	Fayette	1024
78	0.092	14.25	0.0065	upland		
12	0.079	18.75	0.0042	sandy rise	Lee	915
77	0.095	9.00	0.0106	upland	Travis	855
3	0.091	9.25	0.0098	upland		
58	0.061	26.00	0.0023	upland	Blanco	883
59	0.088	28.00	0.0031	upland	Gillespie	804
60	0.081	15.50	0.0052	upland	Kerr	828
47	0.072	16.50	0.0044	upland	Kimble	593
63	0.092	31.25	0.0029	upland	Sutton	569
30	0.099	29.50	0.0034	upland		
48	0.066	21.00	0.0031	upland		
8	0.061	30.50	0.0020	drainage	Motley	582
16	0.055	56.50	0.0010	upland	Crockett	481
11	0.075	30.00	0.0025	upland		
56	0.047	25.00	0.0019	upland	Upton	367
49	0.076	27.75	0.0027	upland	Pecos	357
50	0.074	37.75	0.0020	plain		
75	0.077	38.50	0.0020	sandy terrace	Brewster	437
51	0.056	28.75	0.0019	ditch margin	Culberson	304
52	0.068	15.25	0.0045	alluvial fan	Hudspeth	303
54	0.073	26.75	0.0027	basin, coppice dune	El Paso	240
53	0.078	23.75	0.0033	basin, coppice dune		

Table 1. Results of the pilot study (from east to west).

Discussion

In spite of the challenges, the distinct vessel patterning between the El Paso and Colorado County samples examined in the pilot study along with the results of Dering’s (2002, 2004) earlier EDXA experiments remain intriguing. Dering (2002) recommends the following stages to further develop the method:

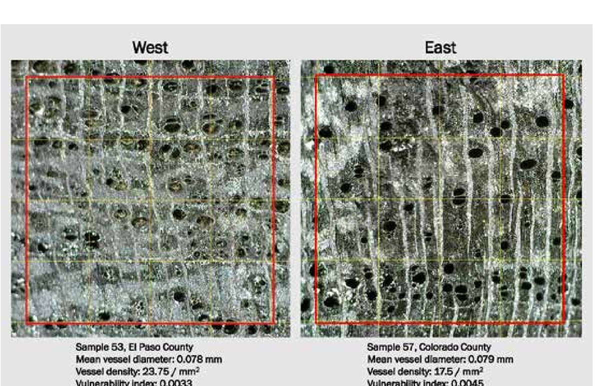

Figure 11. Comparison of samples from opposite extremes of the rainfall gradient.

1. “Establish a large modern reference dataset from each major precipitation regime [in Texas], including samples from most landforms in the region.
2. Subject the data set to statistical analysis to establish the variability of mesquite xylem anatomy within a given precipitation regime.
3. In all possible situations pair the xylem analysis of a piece of wood charcoal with AMS dates to provide an accurate temporal context.”

The TxDOT EDXA project is presently executing stage one and the overall results of the pilot study emphasize the need to pursue stage two. Rigorous exploration of multiple variables is clearly necessary before EDXA is established as a viable proxy method for paleoenvironmental reconstruction.

Possible relevant variables:

- **Scale:** rain falling directly on the tree is more influential than the mean annual rainfall for the county; more precise precipitation records should be considered.
- **Immediate physical setting:** different landforms or soil types allow for differential access to or retention of ground moisture.
- **Sample size:** a single plant is not likely representative of a larger population in a given area; variability may tend to average out with a larger sample of individuals (as Dering’s [2002] previous findings suggest).

Conclusion

Precipitation fills streams, provides potable water, and regulates the abundance and distribution of plant and animal resources on which past peoples depended. In some parts of Texas sufficient and well-timed rainfall made farming a viable alternative to hunting and gathering. Reconstructing past regional rainfall patterns is vital for understanding prehistoric human adaptations. As this project progresses and if EDXA proves viable, its application to radiocarbon dated archeological specimens would potentially help clarify past precipitation conditions across time and space.

Request for Contributions

Mesquite wood contributions are welcome for this ongoing study. Samples are notably absent from northwest Texas, but additional samples from regions already covered will only enhance the data. Obtain proper permission to collect samples on private land.

Guidelines:

- Samples should be at least three inches long, and between 1.5 and 3 inches in diameter (**Figure 12**);
- either fresh or dead wood is acceptable, but source location is crucial;
- GPS coordinate of source location;
- notes on setting (landform, nearby water sources, etc.);
- photograph tree and setting, if possible;
- mail to:
  Kevin Hanselka
  Texas Department of Transportation
  Environmental Affairs Division
  125 E. 11th Street
  Austin, TX 78701
- email notes, GPS points, photos to: **Kevin.Hanselka@txdot.gov**;
- Questions? Call TxDOT archeologist Kevin Hanselka: **512-416-2639**.

Figure 12. Ideal size range of samples; contributions welcome!

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