Datability of Pecan Tree Rings

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Abstract. Analyses of stem cross sections of 97 pecan [*Carya illinoensis* (Wangenh.) K. Koch] and 22 post oak (*Quercus stellata* Wangenh.) trees from seven sites showed tree rings were sensitive to the environment and were datable by tree, among trees within a site, among sites, and between species. Pecan had well-defined annual growth rings averaging from 1.25 to 3.36 mm in width and that varied synchronously among trees. Pecan had a mean sensitivity of about 0.3 compared to 0.4 for post oak, indicating a smaller but adequate response of pecan to reflect climatic variations and to use pecan tree rings in other dendrological studies.

Variation in the width of tree rings has been useful in the reconstruction of various environmental factors affecting tree growth (Cook and Kairiukstis, 1990). Factors that have been of most interest in past research include rainfall and temperature. The annual production of xylem growth and the sensitivity of that growth to some environmental events provide the basis for the use of tree rings for reconstruction of these events. Not all woody species produce datable tree-ring sequences, nor do all species provide correlatable information between ring growth and events of interest (Fritts, 1971). Therefore, a new candidate species considered for tree-ring analysis must exhibit datability and environmental sensitivity of the ring series as a starting point for further studies. Datability of the Junglandaceae genera has not been reported previously in the literature, and pecan is proposed here as a useful species.

The pecan is a riparian species and the most important horticultural plant native to the United States (Brison, 1974). Native pecan distribution is widespread, from Illinois, down the Mississippi River Valley on the east to the headwaters of the San Saba River in Texas on the west, and extending south into Mexico (Little, 1971). Nuts from the wild trees were used by native Americans and later prized by explorers and settlers (Brison, 1974). The lat-

ter often left the wild pecan when they developed land for grazing or crop production to preserve their periodic nut production. Some 80% of the 18 million kg of annual Texas pecan production from 1960 to 1980 was produced by such trees, demonstrating that the practice is still widespread and encompasses great expanses in the indigenous range of the tree (Harris, 1983). The addition of this species to those available for tree-ring analyses would be of benefit to science and agriculture. Horticultural events of interest, for example, that might be made accessible for study would include effects of pruning and thinning orchards and groves on tree growth; correlations of nut yield with xylem growth; irrigation; confirmation of frost damage at specific times in the past; and defoliation due to arthropods, disease, or weather. We tested the datability and environmental sensitivity to determine whether pecan tree rings would be suitable for such investigations.

Materials and Methods

Preliminary inspection of 5-mm cores from pecan stems extracted with an increment borer indicated that individual rings were not uniform in width around the tree, and this was confirmed by examination of pecan stumps. Thus, formal studies were conducted using stem cross sections for ring analyses. This procedure minimized confusion due to circuit variability, but limited the availability of samples to sites where trees were being cut down for reasons unassociated with this study. Although the preferred methodological approach would have been to obtain pecan cross sections using site characteristics proven to be especially sensitive to stress for other species (Fritts, 1971), such as differences in elevation, steep terrain, or crowded conditions, our opportunistic approach was pursued as a workable alternative.

Cross sections of naturally occurring pecan in eastern Texas were obtained at every opportunity from 1975 to 1978. Cross sections of post oak were also taken in Seguin, Texas, for comparison with pecan. The native pecan trees were located on flood plains and the post oak was a typical upland site. Previous work in dendrochronology has emphasized the importance of site characteristics to enhance the environmental signal(s) that limit the growth of the tree. Tree rings of post oak are annual and environmentally sensitive, and closely fit the criteria of 1) dependence on precipitation as the major water source; 2) relatively coarse soil profiles ensuring low water retention; and 3) growing on slope exposures with a uniform influx of solar radiation (Cook and Kairiukstis, 1990). Thus, the post oak provided a climatologically sensitive ring series that served as a dating control for the more riparian pecan.

Samples were taken to the Tree Ring Research Laboratory, Univ. of Arizona, Tucson, and prepared and analyzed using standard techniques (Fritts, 1971). After dating the samples according to the techniques described by Stokes and Smiley (1964), ring width measurements (to the nearest 0.01 mm) were obtained from several radii from each cross section to obtain a mean width for each ring. Comparisons were made between radii of the same tree, between trees of the same site, and between trees from other collection sites. These comparisons constitute cross-dating, which is the most important principle of dendrochronology (Fritts, 1976). In this technique, ring patterns are matched between trees and the correlation of each ring with a calendar year. The last-formed ring was the last growth period, generally the year the tree was cut down. Once all samples from the given site were dated, mean ring width indices were constructed for that site.

In deriving indices, the measured ring series for each sample (tree) were subjected to a standardization procedure (Fritts, 1976). This process minimizes the age trend exhibited in each sample resulting from the change in ring width associated with increasing age of the tree (Fritts, 1976). On relatively arid sites, this trend generally is exponentially linear, with decreasing values toward the outer rings. Since this trend can be influenced by factors other than increasing age, the trends of individual trees may vary from the linear mode. Standardization procedures are used so that each tree within the site grouping is comparable to all other samples. Indices for each ring are then averaged with all other indices from each of the trees within the site. Standard statistical procedures (Cook and Kairiukstis, 1990) were used to analyze these data. These methods identified 97 pecan and 22 oak cross sections from seven sites for further analysis (Table 1).

Results and Discussion

Growth rings were well defined, varied in width from year to year, and exhibited synchronicity in variability within and between species through time (Fig. 1).

The tree rings available for analysis grew

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from 1790 to 1978 (Table 1). The site indices in common for all samples were calculated for 1903 through 1973 (Fig. 1). The correspondence of years with low index values for post oak and pecan show that stresses at these times operated similarly on both species (Fig. 1). The higher variation evident in post oak indicates a greater sensitivity to stress, as expected in an upland species more exposed to drought than the riparian pecan. Cross-dating was also evident when a direct comparison was made between any two or other combinations of sites (data not shown).

Cross-datability among trees, sites, and species was further analyzed (Table 1) using all data for each site to calculate the 1) mean index value, which indicates how close the standardization procedure fit the trend line to the actual mean (1.00 indicates an exact fit), and 2) mean sensitivity, which measures variability around the mean (the higher the value, the more variability). Both species had mean index values near 1, showing that intrasite and interyear trend lines fit the actual means well (Table 1). Post oak showed higher sensitivity (0.411), as expected for a species subjected to the greatest stress, due to variation in environmental changes influencing growth. The pecan mean sensitivity (range = 0.260 to 0.331), however, was well within the range to indicate confidence in the cross-dating and compared favorably with previously published indexes for trees and sites in the arid southwestern United States (Stokes et al., 1973). Two rings were absent in the pecan database (<0.1%) and 14 in the post oak database (0.57%). The percentage of absent rings is a factor that indicates the degree of sensitivity to the environment and, when numerous, increases the complexity of cross-dating. The low percentage of absent rings was sufficient to indicate sensitivity, but not numerous enough to confound the analysis. In all three values, for all sites, the data were suitable for accurately dating time series. The mean ring widths (Table 1) show site variations observed in pecans we studied.

Pecan rings were datable, and we conclude that they were formed annually and were sensitive to the environment within a site, between sites, and across species. The utility of these rings in examining specific cause-and-effect relationships remains to be investigated.

Table 1. Tree rings examined from cross sections of tree stems for sensitivity to the environment.

Texas location latitude/longitude (°)	Species	Samples (no.)	Calendar years	Mean index value	Mean sensitivity	Mean ring width (mm)
29.7/98.2	Post oak	22	1790–1978	0.945	0.411	1.32
31.4/98.1	Pecan	8	1898–1976	0.996	0.265	3.36
29.7/98.2		14	1885–1977	1.024	0.298	2.22
29.3/97.3		26	1903–1973	1.000	0.260	3.07
30.5/97.5		7	1851–1975	0.996	0.329	2.61
30.5/97.3		32	1873–1978	0.919	0.278	1.25
30.5/99.7		10	1884–1977	0.960	0.331	2.53

Fig. 1. Tree-ring indices from post oak (one site, solid line) compared to pecan (pooled from six sites, dotted line) show correspondence between species in response to climate through time.

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