TREE-RING DATING OF HISTORIC BUILDINGS IN ARKANSAS

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ABSTRACT

Twenty-four historic log and frame buildings in Arkansas have been dated by dendrochronology. The derived historic chronologies, ranging from A.D. 1598 to 1911, have improved and extended existing modern tree-ring chronologies for the state. Dated species are southern yellow pine (*Pinus* sp.), white oak (*Quercus* sp.), eastern red cedar (*Juniperus virginiana* L.), and baldcypress (*Taxodium distichum* L. Rich).

Three chronological studies integrating tree-ring, architectural, and documentary evidence offer examples of the relationship between tree-ring dates and historic records and demonstrate significant contributions which dendrochronology can make in the management of historic properties. Historic tree-ring collections should prove important in developing long term tree-ring chronologies in the eastern United States, due to widespread exploitation of living trees, the lower average age for many eastern species, and the availability of high quality tree-ring records in early historic structures.

Vingt-quatre constructions en bois et rondins situées dans l'Arkansas ont été datées dendrochronologiquement. Les chronologies qui en résultent s'etendent de 1598 à 1911. Elles ont permis d'améliorer et d'allonger les séries déjà obtenues dans l'Etat. Les espèces analysées sont: le "yellow pine" (*Pinus* sp.), le "white oak" (*Quercus* sp.); le "red cedar" oriental (*Juniperus virginiana* L.) et le cyprès chauve (*Taxodium distichum* L. Rich).

Trois études chronologiques intégrant des arguments dendrochronologiques, architecturaux et écrits, constituent des exemples des relations qui peuvent exister entre des dendrodatations et des documents historiques. Elles démontrent l'importante contribution que peut apporter la dendrochronologie dans la gestion des propriétés historiques. Etant donné l'importance des exploitations forestières, l'âge relativement bas de nombreuses espèces d'arbres et la possibilité d'obtenir des séries dendrochronologiques de haute valeur dans des structures historiques anciennes, ces dernières auront un rôle important à jouer pour développer de longues chronologies dans l'Est des Etats-Unis.

In Arkansas wurden 24 historische Block- und Fachwerkhäuser dendrochronologisch datiert. Mit den daraus erstellten Jahrringchronologien, die von 1598 bis 1911 reichen, konnten die bestehenden rezenten Chronologien dieses Landes verbessert und verlängert werden. Die Holzarten sind Yellow-Pine, Weißeiche, Bleistiftzeder und Sumpfzypresse.

Drei Untersuchungen zu chronologischen Fragen, die dendrochronologische und architektonische Befunde sowie archivalische Zeugnisse auswerteten, zeigen beispielhaft die Beziehungen zwischen dendrochronologischen Daten und historischen Aufzeichnungen und belegen den wichtigen Beitrag, den die Dendrochronologie für die Behandlung historischer Denkmale zu liefern vermag. Auch beim Aufbau langer Jahrringchronologien für die östlichen U.S. wird sich das Sammeln historischen Jahrringmaterials als wichtig erweisen, insbesondere wegen der weitgehend durchgeführten Exploitation lebender Bäume, dem niedrigen Durchschnittsalter vieler östlicher Baumarten und der Notwendigkeit von genauen Jahrringdaten für die frühe Geschichte.

INTRODUCTION

The development of long term tree-ring chronologies in the Midwest and eastern United States has been slowed by a lack of long-lived species and by widespread land clearing and timber exploitation since the 19th century. Fortunately, however, many old-growth trees cut from the virgin forests remain as structural timbers in historic buildings (e.g., Figures 1 and 2). These historic log and frame buildings are still fairly

Figure 1. A large collection of eastern red cedar logs in the Lancaster Barn. Six cutting dates between 1854 and 1867 indicate that this barn was built in part with re-used timbers following the Civil War.

Figure 2. Two white oak log pens of the Jacob King Cabin. Three cutting dates indicate that construction on the front pen began after the growing season of 1888.

abundant and have been recognized for some time as important potential sources of wood for the extension of modern tree-ring chronologies (Willey 1937, Hawley 1941, Schulman 1942). If enough modern chronologies can be extended to the 15th or 16th century it may then be possible to date the considerable wood and charcoal collections from prehistoric archaeological sites in the eastern United States.

Previous tree-ring research with living trees in the eastern United States has established the dendrochronological suitability of a variety of species, including pines, oaks, cedar, spruce, hemlock, beech, baldcypress, ash, and maple (e.g., Lyon 1936, Hawley 1941, Schulman 1942, Bell 1951, Fritts 1962, Estes 1970, Weakley 1971, Bowers 1973, Charton and Harmon 1973, Cleaveland 1975, Cook and Jacoby 1977, DeWitt and Ames 1978). While these studies have left little doubt that historic wood collections should be equally suitable for tree-ring dating, the extent and potential contributions of historic tree-ring dating in the East have not been examined in any detail.

The availability of modern tree-ring chronologies and numerous 19th century buildings make Arkansas an ideal location for historic tree-ring dating. This study examines the tree-ring dating potential of historic log and frame buildings primarily in the Ozark and Ouachita highlands of Arkansas. In addition, the chronological analyses of three houses are reviewed as specific examples of the interpretation of tree-ring dates from historic buildings and the potential role of dendrochronology in the management of historic properties.

HISTORIC BACKGROUND

The widespread exploitation of the great virgin forests of eastern North America is a sadly familiar American legacy (Lillard 1947, Smith 1976). Many European settlers saw the wilderness as a threat to safety and economic development and systematically cleared the forests and depleted the game, frequently at the expense of the Native Americans. In spite of the pervasive negative attitude of settlers toward the virgin forests (Hutslar 1972: 30-31), inaccessibility preserved many of the upland forests in Arkansas until the late 19th century, when railroads and new markets brought the rapid commerical exploitation of this resource. Commercial cutting began somewhat earlier in the lowland baldcypress and hardwood forests of the lower Mississippi Valley of eastern Arkansas, however, because of the greater accessibility by river (Moore 1967: 74).

Today undisturbed forests are extremely rare in Arkansas and elsewhere in the eastern United States. Nevertheless, the destruction of the native forests was not complete and small tracts of undisturbed or lightly disturbed forests have been fortuitously preserved in many eastern states (Waggoner 1975, Shepard and Boggess n.d.).

At the same time, a significant percentage of the timber cut from the virgin forests is still preserved in historic structures. Since the early settlers usually relied on local raw materials for construction, structural timbers in historic buildings should provide the basis for many regional tree-ring chronologies. In areas which have been extensively cleared or which lack undisturbed forests, historic buildings offer the only hope for the development of high quality tree-ring chronologies in the absence of significant archaeological or subfossil collections. Where undisturbed forests have been preserved, historic chronologies may improve the sample size and extend the length of modern tree-ring chronologies. Since modern chronologies from the eastern United States tend to be shorter than chronologies from the West, the potential role for historic chronologies in improving and extending modern chronologies takes on added significance.

In addition to the potential contributions to eastern dendrochronology, tree-ring dating of historic buildings can make important contributions to our knowledge of the history of early American buildings and settlements. The original construction dates of many historic structures may be accurately determined through the tree-ring dating of building timbers. The dating of structures within meaningful geographic or cultural areas may also help document the temporal and spatial distribution of settlements, construction techniques, and architectural styles.

Although detailed historic records are widely available in most areas, specific buildings or settlements of historic interest all too often lack even a minimum of documentation. Tree-ring dating may provide fundamental information for these poorly documented settlements. The historical interpretation of even well documented buildings may be significantly improved with the addition of tree-ring evidence (e.g., the Wolf House), and tree-ring dates may also be used as a fully independent check on the accuracy of historic documents referring to dated buildings.

Finally, the use of tree-ring dates from historic buildings and sites is subject to the same potential sources of error facing the interpretation of any tree-ring date derived from an artifact of human activity, i.e., the use of deadwood, stockpiling, or reuse of timbers; applying construction dates to non-construction remains; subsequent replacement with fresh timbers; and using non-construction dates (e.g., from firewood) to date construction (Bannister 1962). There is reason to believe, however, that most tree-ring cutting dates from historic log buildings in the East closely reflect actual construction dates. This is primarily because green wood was easier to work than thoroughly seasoned wood (Glassie 1974: 194, Hutslar 1972: 65, 75), although the immediate need for shelter may have been a factor as well. Nevertheless, when cutting dates do not accurately reflect the actual date of construction there is frequently objective dendrochronological or architectural evidence to that effect (Bannister 1962, Dean 1969). Dendrochronological evidence might appear in a spread of cutting dates or dating clusters, while architectural evidence might include old mortises, old paint, abutments and additions, or different construction techniques. With the introduction of saw mills, frame construction, and commerical marketing of lumber, however, the potential for a significant lag between the cutting date and the date of actual construction probably increases. Even in these cases, when subsequent replacement can be ruled out, cutting dates from structural elements will always establish the absolute maximum age for the building.

MATERIALS AND METHODS

Tree-ring specimens were collected from 32 historic buildings in Arkansas (Figure 3) between 1976 and 1978 as part of my thesis research (Stahle 1978a) and under contract with state and private agencies (Stahle n.d., 1978b). The five species identified in the collections are southern yellow pine (all probably *Pinus echinata* Mill. based on the species distribution), white oak (probably both *Quercus alba* L. and *Q. stellata* Wangenh., and possibly others), eastern red cedar (*Juniperus virginiana* L.), baldcypress (*Taxodium distichum* L. Rich.), and blackgum (*Nyssa sylvatica* Marsh.). White oak, pine, baldcypress, and cedar appear to be the species most commonly used in historic construction in Arkansas.

The collections consist primarily of cores 10 mm in diameter extracted with an electric drill and a Henson coring kit. Cross sections were cut whenever a structure was in ruin and occasionally at old door and window openings or at the corner notches of log buildings. The collecting procedure began with a thorough inspection of the construction timbers. When conditions permitted, sound specimens with the most annual rings, sensitivity, and bark or bark indicators were deliberately selected for collection. The specimens were extracted near the basal end of the log to obtain the oldest sequences possible. Detailed notes were recorded on the condition and architectural associations of the timbers sampled. Particular attention was paid to evidence for reuse or subsequent replacement.

All specimens were mounted and surfaced according to standard techniques (Stokes and Smiley 1968). The Douglass method of crossdating (Douglass 1941, Stokes

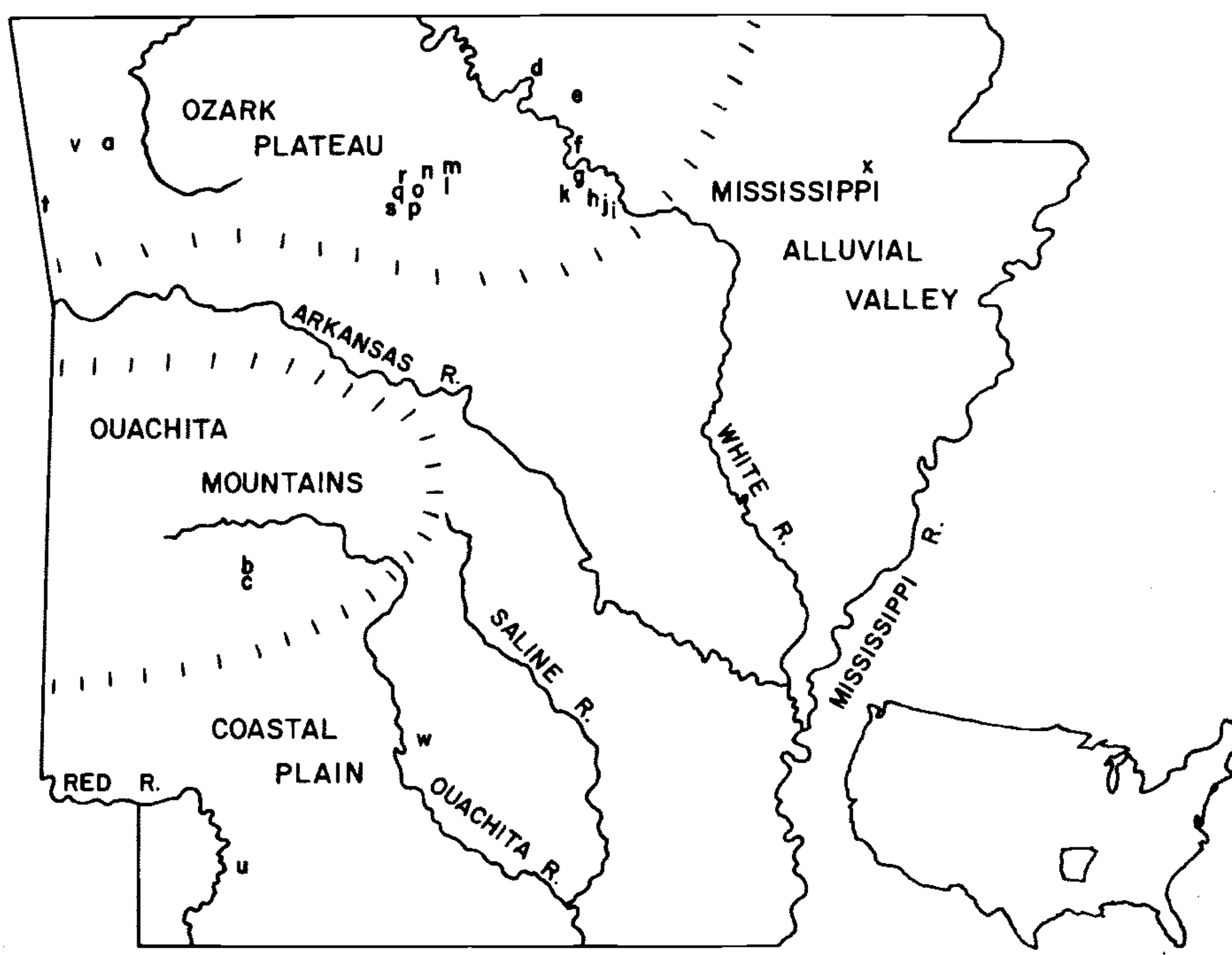


Figure 3. Locations of 32 historic tree-ring collection sites in Arkansas. The dated structures are listed in Figure 4.

a. Ridge House
b. Collier Cabin
c. McLean House
   McLean Storage Cabin
   McLean Caretaker Cabin
d. Wolf House
e. Trimble House
f. Mt. Olive Group:
   E. Jeffrey House
   E. Jeffrey Outbuilding
   A. C. Jeffrey Smokehouse
   Daniel House
g. Lancaster Cabin and Barn
h. Monroe Barn
i. Copeland House
j. Chitwood Barn
k. King Cabin
l. Horton House
m. Jackson Cabin
n. Steen House
o. Hendrix Cabin
p. Hardin Cabin
q. Ruff Barn
r. Magness Barn, north
   Magness Barn, south
s. Drury House
t. Dutch Mills Ruin
u. Lafayette County Jail
v. Borden House
w. Shaddock Barn
   Everett Barn
x. "Loch Bee Post Office"

and Smiley 1968) was used exclusively to date the specimens. All historic chronologies were absolutely dated against modern white oak and shortleaf pine chronologies from the Ozark and Ouachita Mountains. The modern chronologies were compiled by the University of Arizona Laboratory of Tree-Ring Research and made available through the International Tree-Ring Data Bank. The collectors of the modern chronologies include R. E. Bell, E. Schulman, E. T. Estes, C. W. Stockton, J. Harsha, and M. Ames. The entire historic collection was then submitted to the Laboratory of Tree-Ring Research for an independent check of the crossdating (Douglass 1934). The dating of all structures reported herein has been confirmed.

Eleven historic tree-ring collections of four species were selected for derivation of standardized tree-ring chronologies. The criteria used to select these chronologies included species, sample size, total length, and the quality of crossdating. The specimens were measured to .01 mm on a Bannister Incremental Measuring Machine and the measurements were randomly checked to assure accuracy. The computer programs RWLST and INDXA, developed at the Laboratory of Tree-Ring Research, were used to convert raw ring widths into tree-ring indices and to calculate the statistical parameters of the 11 historic chronologies. These standardized chronologies are on file with the International Tree-Ring Data Bank in Tucson.

RESULTS

The many specimens and sites dated during this research demonstrate that historic buildings may be routinely dated and can produce high quality tree-ring chronologies in Arkansas and no doubt elsewhere in the eastern United States. A total of 231 tree-ring specimens have been dated, or 50% of the specimens that were surfaced and analyzed (Table 1). Twenty-four of the 32 historic buildings sampled were dated, for a site dating percentage of 75%. Cutting dates from these buildings range from 1825 to 1911 and comprise 61% of all dated specimens. The collection sites are located in Figure 3 and a chronological summary of the dated sites is presented in Figure 4.

Two tree-ring dating regions were observed in the highlands of Arkansas. The pine and oak chronologies in the Arkansas Ozarks are generally distinct from chronologies of the same species in the Ouachita Mountains. Although most long term trends and certain individual years show correspondence between the two regions, crossdating is normally stronger within each area. The Mississippi Valley and the Gulf Coastal Plain are poorly represented in these collections and may constitute distinct dating regions as well. Particularly sensitive chronologies, however, may crossdate over the entire state and among different species.

The 11 historic chronologies selected for ring width standardization are plotted in Figure 5. Selected statistical characteristics for these chronologies are listed in Table 2 and may be used to compare the relative dendroclimatic potential of the four species (Fritts and Shatz 1975). DeWitt and Ames (1978) compiled a standardized set of 39 modern chronologies from eastern North America listing statistical summaries for three well represented species, the entire 39 chronology set, and a 102 chronology set from western North America. These summaries offer a convenient comparative framework and are included with summaries for the historic chronologies in Table 3. Finally, four historic collections were sufficiently replicated to allow analysis of variance. These results and a cross-correlation analysis are listed in Table 4.

On the whole, the average ring width for most historic specimens systematically decreased as the tree aged. This typical age trend was usually well approximated by the negative exponential and straight trend lines which were used exclusively to derive

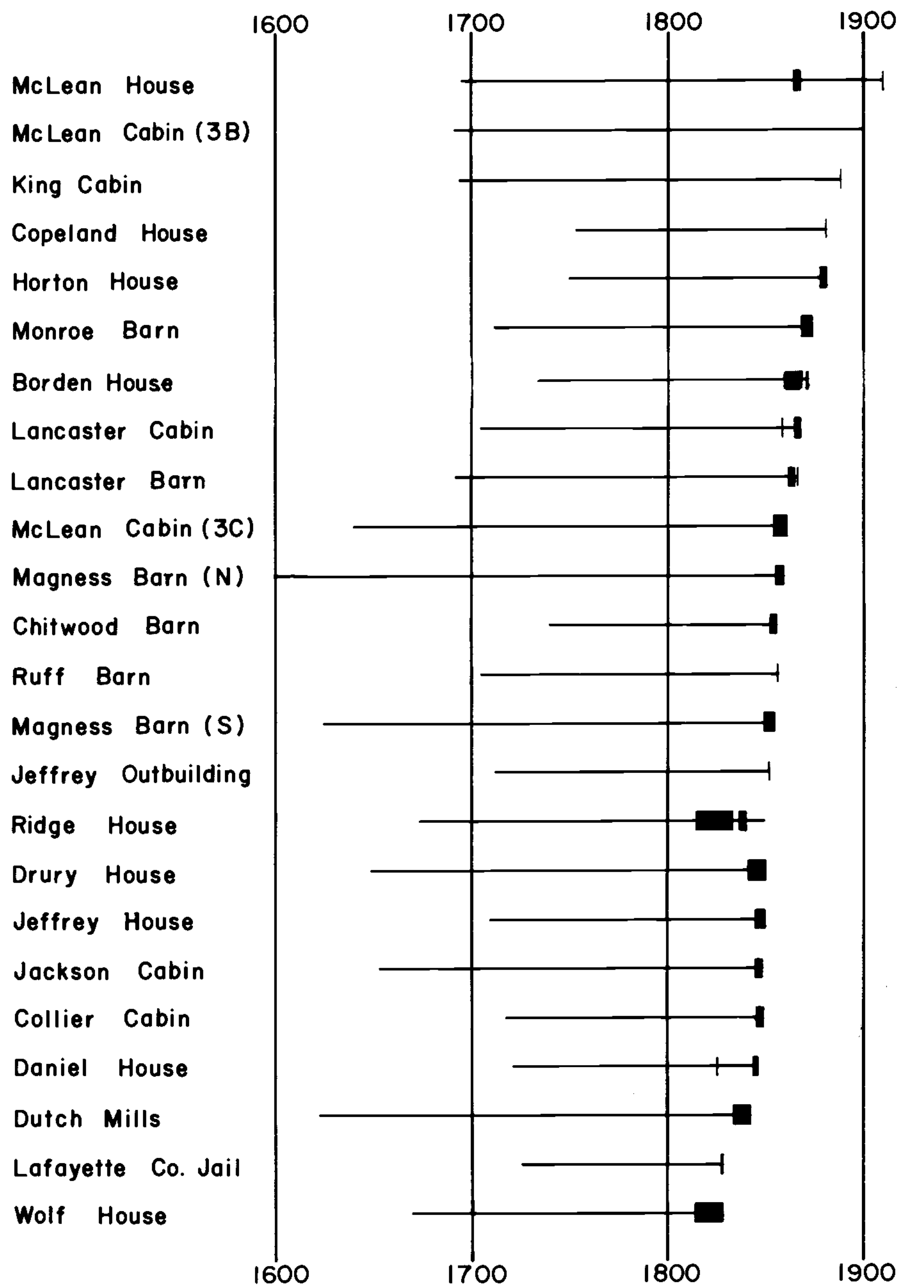


Figure 4. Chronological summary of 24 dated historic buildings from Arkansas. Horizontal lines indicate the total length of the derived chronology. Narrow vertical lines indicate single cutting dates, wide vertical bars indicate clusters of cutting dates.

Table 1. Summary of dated tree-ring specimens.

Species	Number	Dated Specimens	Dating %
southern yellow pine	209	101	48
white oak	174	87	50
eastern red cedar	71	38	53
baldcypress	6	5	83
blackgum	2	0	—
other	1	0	—
TOTAL	463	231	50%

the historic tree-ring indices. This contrasts with the disturbed ring series observed in many living trees in Arkansas which frequently display one or more growth releases due to lumbering or other artificial stand disturbance (Estes 1970: 306-308). The general absence of artificial growth disturbances in the tree-ring records from early historic buildings is a valuable asset of this material.

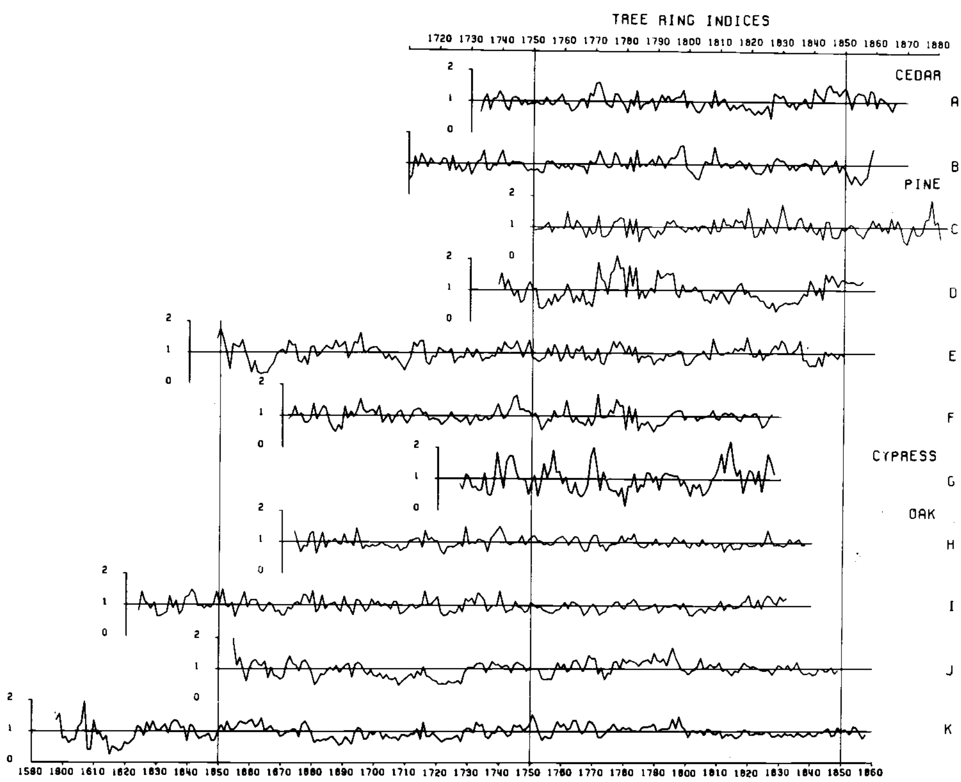


Figure 5. Crossdating among eleven standardized tree-ring chronologies of four species from historic buildings in Arkansas. The statistical characteristics of these chronologies are presented in Table 2. A. Lancaster Barns, B. Mt. Olive Group, C. Horton House, D. Chitwood Barn, E. Drury House, F. Wolf House, G. Lafayette County Jail, H. Ridge House, I. Dutch Mills Ruin, J. Jackson Cabin, K. Magness Barns (A,B = eastern red cedar; C-F = southern yellow pine; G = baldcypress; H-K = white oak).

The earliest inner dates for modern tree-ring chronologies in Arkansas are A.D. 1666 for shortleaf pine and A.D. 1642 for white oak, although most modern chronologies extend only as far as the 18th century. The chronologies derived from historic buildings provide modest extensions of the modern chronologies and significantly improve the sample size of specimens dating to the 17th, 18th, and 19th centuries.

White oak chronologies from ten structures average 196 years in length and together cover the period A.D. 1597-1900. White oak can be a difficult species to date simply due to complacency and the complex ring structure of the wood. Tyloses in the earlywood vessels tend to reduce the sharp contrast between annual rings, while wood rays may disrupt the rings and make it difficult to follow specific rings around the circumference of a specimen. These problems of ring identification are most severe in the narrow, complacent rings of old-growth specimens.

In spite of the complicated ring structure white oak specimens may usually be crossdated when at least 100 rings are present. Specimens with fewer rings may occasionally be dated, depending on the sensitivity of the series and the sample size of the collection. Especially wide rings in white oak may be as helpful in crossdating as narrow rings (Figure 6). Locally absent and false rings are extremely rare.

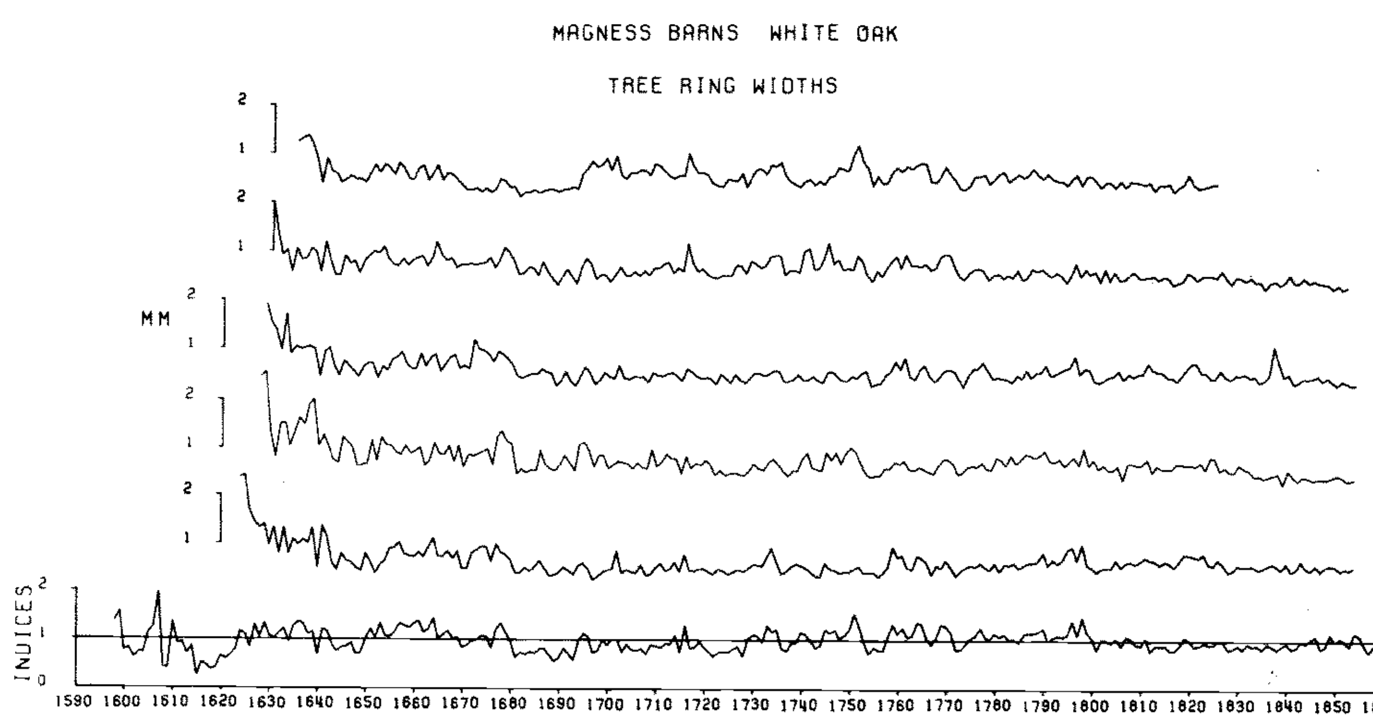


Figure 6. Crossdating among five white oak specimens (658112, -081, -051, -021, -091 from the top) and the mean index chronology (lower plot) from the Magness Barns.

A consistent feature evident in many historic white oak specimens is the decreasing ring width and variability as the tree aged. Juvenile and mature growth are much more variable and generally crossdate better than the frequently narrow and complacent old-growth portion of the specimen. This decreasing ring width and variability with increasing age is apparent in the plotted white oak chronologies (Figure 5h-k) and in the decreasing values of mean sensitivity and standard deviation and the decreasing correlation of all series calculated for the 20-year means of four standardized white oak chronologies (Stahle 1978a).

The white oak chronologies also have the least favorable statistics of the four historic species (Tables 2 and 3). Nevertheless, the historic white oak statistics closely resemble the average statistics for 16 modern white oak chronologies (Table 3). Also, the average percent variance attributed to the chronology (in Table 4) is 36% for the historic group compared with 31% for a group of 12 modern white oak chronologies (DeWitt and Ames 1978: 13). Estes (1970), however, examined a variety of chronology statistics for white oak, black oak (*Quercus velutina* Lamb.), and shortleaf pine in the central Mississippi Valley and found black oak to be the most climatically sensitive of the three species. Unfortunately, black oak was rarely used in the construction of historic buildings in Arkansas.

The southern yellow pine chronologies derived from eight historic buildings average 166 years in length and together cover the period A.D. 1648-1911. Locally absent or missing rings were occasionally encountered in the dated pine specimens but were easily recognized when crossdating controls were adequate. False rings in pine occurred in both the earlywood and latewood but were readily identified by the classic features of false rings (e.g., obscure outer boundary, discontinuity around the circumference, and interruptions by resin ducts [Stokes and Smiley 1968]). Although the quality of crossdating in pine varies considerably, specimens with as few as 50 rings have been dated.

A pine signature from the Ozarks in the 1780s was the most reliable ring width pattern observed (Figures 5a-g and 7). Narrow rings consistently occur at 1780, 1782, 1784, and 1789 in most dated pine and cedar specimens from the Ozarks. This pattern

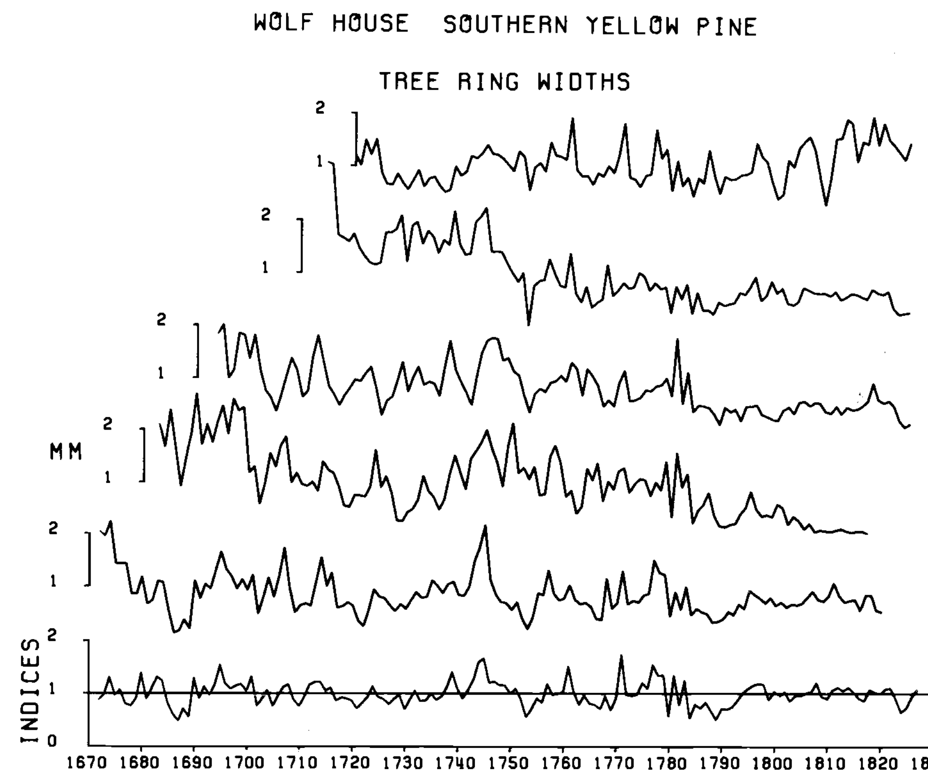


Figure 7. Crossdating among five southern yellow pine specimens (656041, -031, -051, -062, -071 from the top) and the mean index chronology (lower plot) from the Jacob Wolf House.

was essential to the accurate dating of several structures. It also occurs in the Lafayette County Jail baldcypress specimens and with some modification in the pine specimens from the Ouachita Mountains.

Five red cedar buildings along the White River in northern Arkansas were dated and together cover the period A.D. 1692-1867. These historic red cedar chronologies average 152 years in length. Because no modern red cedar chronologies were locally available the historic cedar collections were dated against both modern and historic pine chronologies from the Ozarks. Most historic cedar specimens show some visual crossdating with Bell's (1951) modern red cedar chronology some 180 miles north in Jefferson County, Missouri.

Eastern red cedar can be a difficult species to crossdate. False rings and poor circuit uniformity may render individual specimens or entire samples undatable. Locally absent rings were occasionally encountered in the historic specimens dated but were readily identified through crossdating. False rings are particularly common in the juvenile growth of red cedar (Weakley 1971: 11). As a result, chronological coverage prior to many suspected false rings was often too poor for a solution through

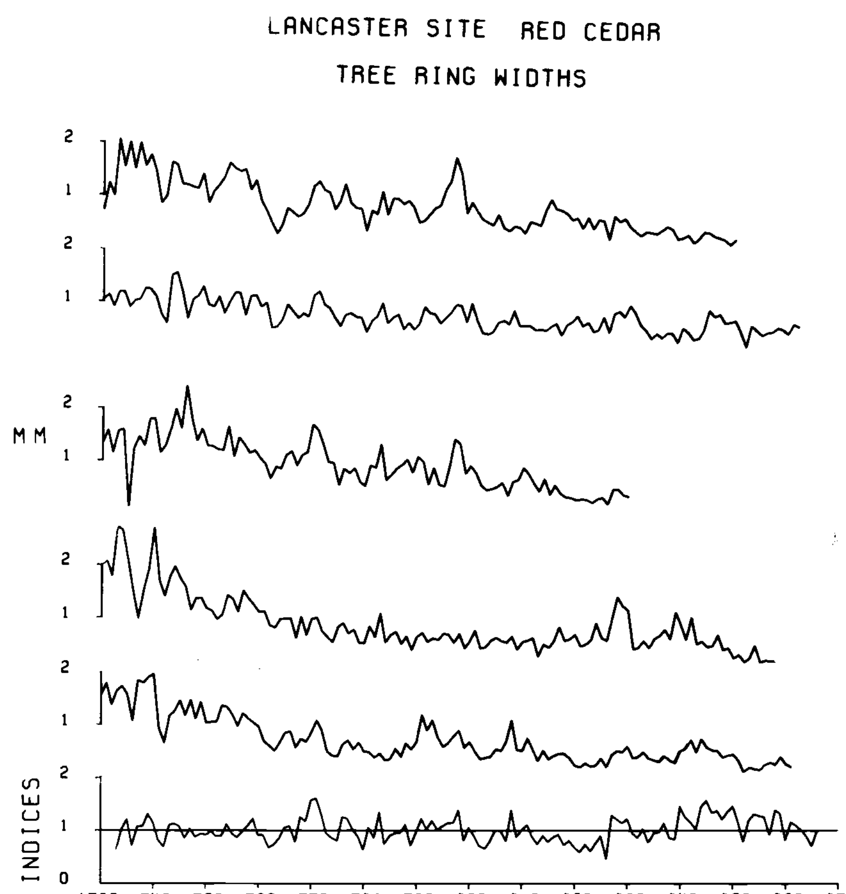


Figure 8. Crossdating among five eastern red cedar specimens (660031, -081, -041, -021, -071 from the top) and the mean index chronology (lower plot) from the Lancaster Cabin and Barn.

crossdating. In these cases simple ring counts were used for the undated sequence inside the problem ring(s). Fortunately, however, good specimens free of false rings and uniformity problems commonly occur in historic buildings in Arkansas and may frequently be dated (Figures 5a, b and 8).

The average chronology statistics for four measured historic pine chronologies (Table 3) are slightly higher but still well within the range of variation typical for modern shortleaf pine chronologies (DeWitt and Ames 1978: 10). The statistics for the two measured red cedar chronologies approximate the average modern and historic pine statistics (Table 3), as might be expected on the basis of the good crossdating among the two species. The relatively low mean correlation among trees and the high percent variance attributed to the cores for a single replicated red cedar chronology (Table 4) suggests the poor circuit uniformity which is obvious upon visual examination of many red cedar cross sections.

A single baldcypress chronology dating from A.D. 1726 to 1828 was derived from the Lafayette County log jail in southwestern Arkansas (Figure 5g). Since the two modern baldcypress chronologies previously available for Arkansas do not extend beyond the 19th century they did not provide enough overlap to date the Lafayette jail. Nevertheless, it was possible to date the structure because of good internal crossdating (Figure 9) and good agreement with upland chronologies available for other species elsewhere in Arkansas.

Baldcypress is a lowland and swamp grown species in the redwood family (taxodiaceae) (Harlow and Harrar 1937) and has only recently been used for tree-ring dating. However, the species is known to attain great age. Mattoon (1915) stated that baldcypress 400 to 600 years old were common, and that trees 600 to 900 years old were occasionally present in most virgin cypress forests. Bowers (1973, 1975) reported the crossdating of baldcypress and compiled a chronology (1800-1972) consisting of 10 trees from several widely dispersed sites in northeastern Arkansas. Munson is developing a 400-year modern baldcypress chronology for southern Illinois (Patrick Munson, personal communication) and Phipps is developing cypress chronologies in the Dismal Swamp of southern Virginia (Richard Phipps, personal communication). I compiled two short baldcypress chronologies in south-central Arkansas (1850-1977) and reviewed some of the evidence indicating that baldcypress produces annual rings (Stahle n.d.).

The annual rings of baldcypress are distinct with conspicuous latewood, inconspicuous rays, and no resin canals (Panshin and de Zeeuw 1970: 487-488). False rings and resin bands (non-annual) have been previously reported for baldcypress (Beaufait and Nelson 1957), but are usually easy to recognize when a proper surface has been prepared on the specimen (Stokes and Smiley 1968: 41, 46). The ring growth of baldcypress, however, has a tendency to be erratic. The width of the annual rings may be highly irregular around the circumference of the tree, particularly in the vicinity of the basal swell. Locally absent and missing rings appear to be more common in baldcypress than in the other three species examined. Some specimens approach hyper-sensitivity and cannot be crossdated. Severely depressed growth which may persist for several decades has also been observed in some long baldcypress ring series and may present problems for dating due to locally absent and missing rings. Nevertheless, the unaffected ring series on either side of the depressed growth may provide datable series.

In spite of the problems with erratic and depressed growth the crossdating of baldcypress can be excellent. Cypress specimens from the Lafayette County jail show a high degree of internal crossdating and the derived chronology corresponds well with

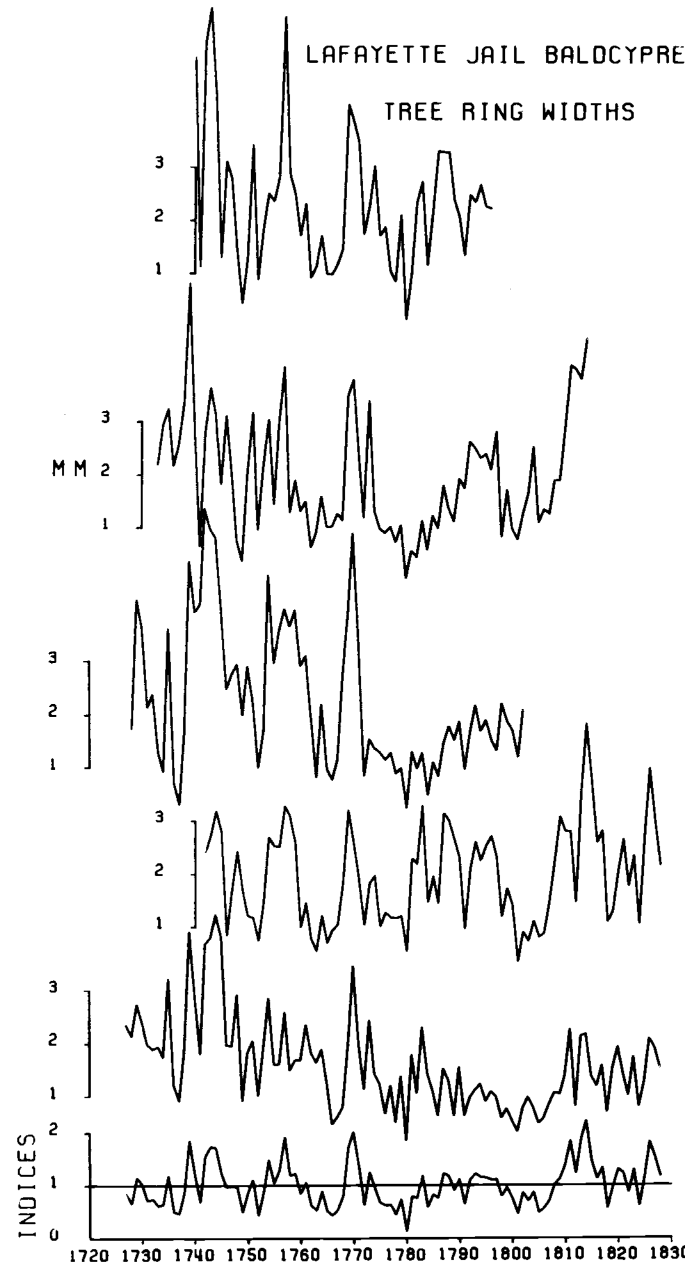


Figure 9. Crossdating among five baldcypress specimens (028311, -161, -231, -151, -041 from the top) and the mean index chronology (lower plot) from the Lafayette County Jail.

pine, oak, and cedar chronologies throughout Arkansas (Figure 5). The Dallas County living cypress (Stahle n.d.) crossdate with an upland white oak chronology some 80 miles to the west.

It is also apparent from Table 2 that the single historic cypress chronology, although consisting of only five specimens and 102 years, has the most favorable statistics of the 11 historic chronologies measured with the highest mean sensitivity, standard deviation, and mean correlation among trees. These baldcypress statistics are well above the averages for all other eastern species and are more similar to arid-site chronologies from western North America (Table 3). Furthermore, the baldcypress statistics Bowers (1973) and I (n.d.) reported are generally consistent with the Lafayette jail cypress data. Although great significance cannot be attached to this limited baldcypress data it does suggest an important dendroclimatic potential for this species.

The average chronology statistics for both the historic and modern chronologies examined from the eastern United States, with the possible exception of baldycpress,

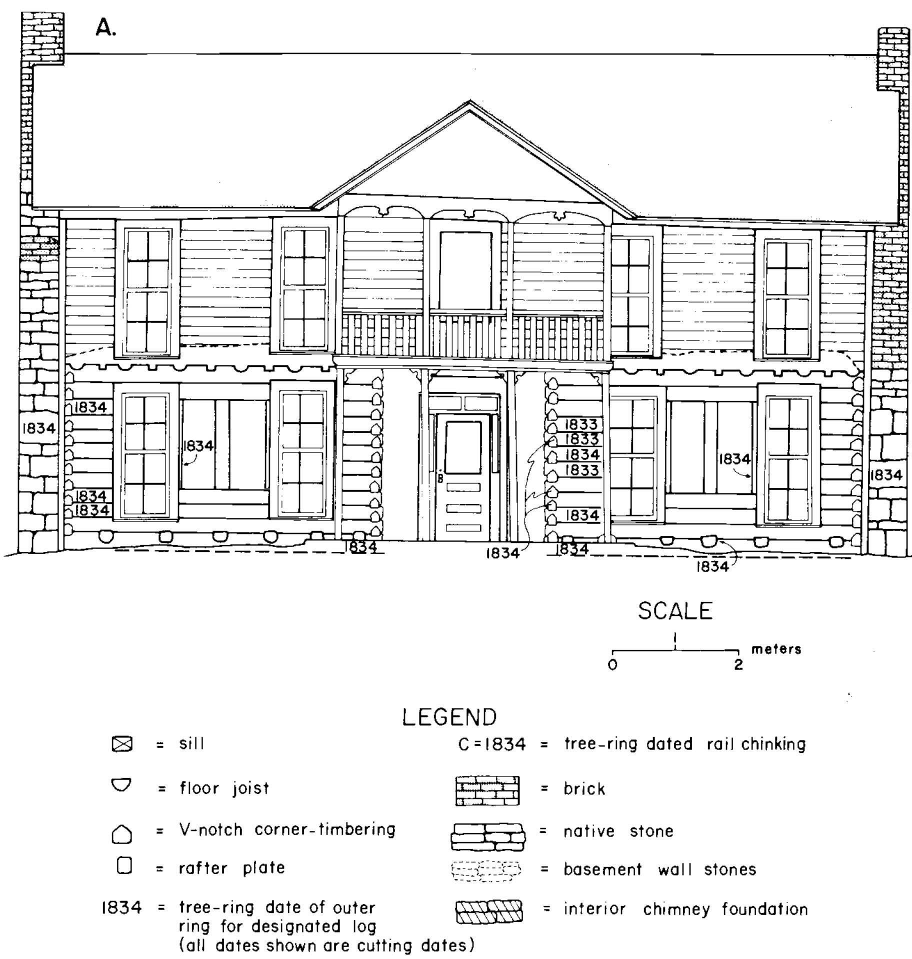
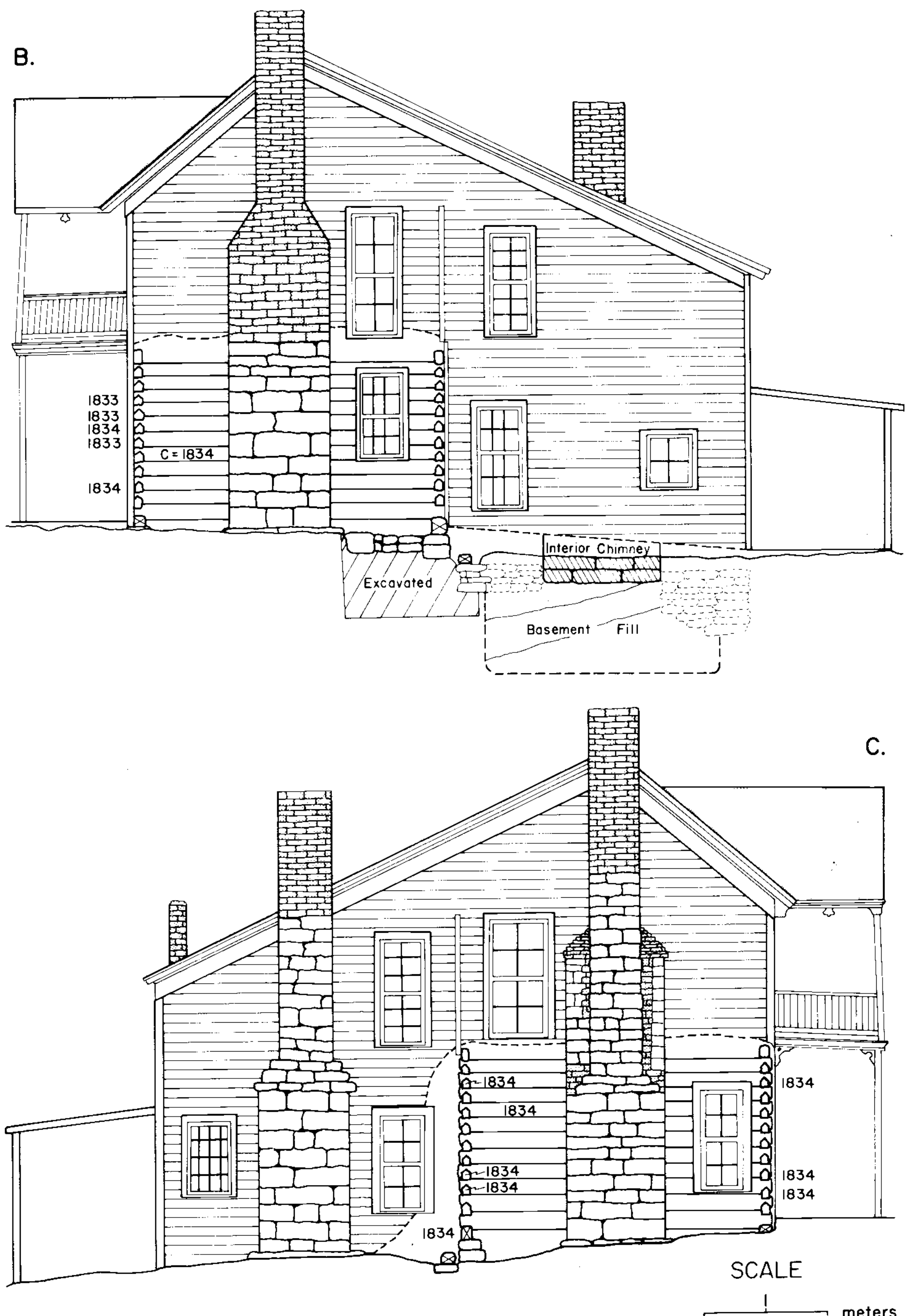


Figure 10. Three views of the Sarah Ridge House, Fayetteville, Arkansas, showing the original double-pen log house (dogtrot) and the location of dated tree-ring specimens inside the present structure. *A*, south elevation; *B*, east elevation; *C*, west elevation. Note that the interior chimney intrudes the basement wall and overlies the fill in the east elevation, and the two building episodes in the chimneys of the west elevation.

are well below the averages for arid-site chronologies from western North America (Table 3). DeWitt and Ames (1978: 15-16) point out, however, that the amount of climatic information from eastern tree-ring chronologies can be considerably improved to a level comparable with western chronologies by increasing the sample size to the vicinity of 40 trees. Since many historic log buildings in the East easily contain 40 or



more individual logs with long ring records generally free of artificial disturbances, these structures should yield high quality tree-ring chronologies suitable for climatic analysis.

Chronological Analysis of Three Dated Houses

Aside from the purely chronological applications, tree-ring dating can significantly improve the accuracy and detail of historic interpretations of early American buildings and settlements. The following three houses offer specific examples of the interpretation of tree-ring dates from historic buildings. The Ridge House analysis illustrates the interpretation of sequential tree-ring dates from distinct structural

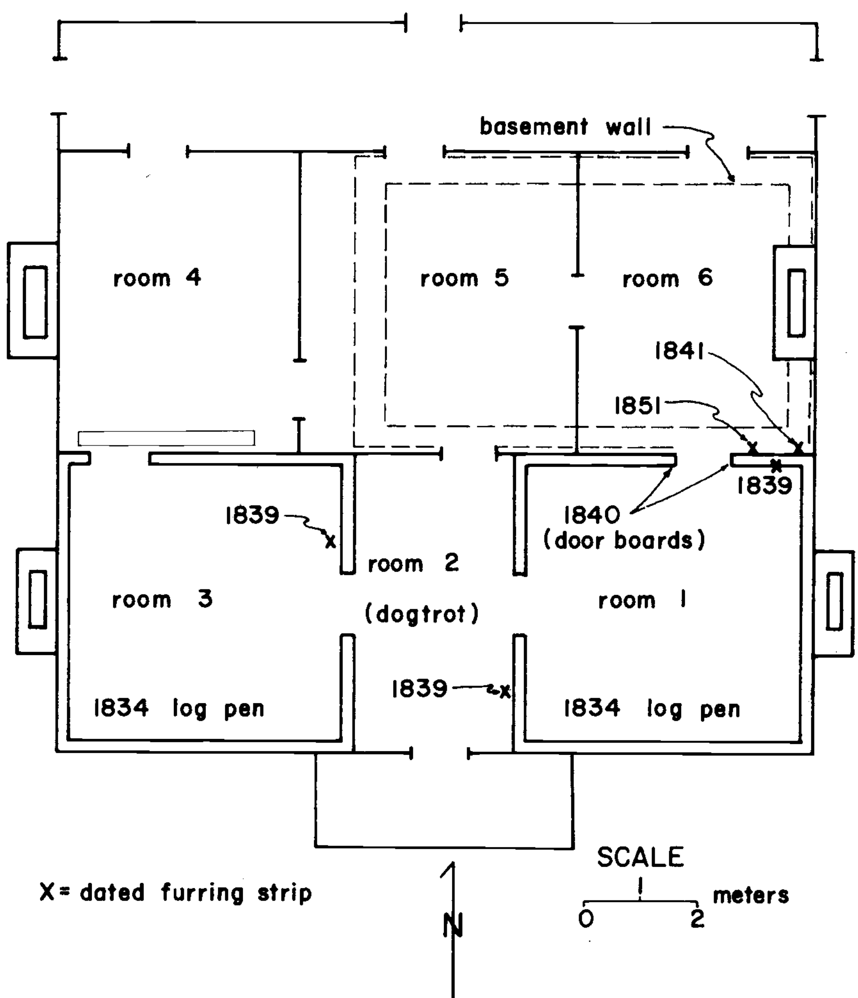


Figure 11. Plan view of the Sarah Ridge House (ground floor) showing the location of dated furring strips and door boards, and the association of the basement with the original double-pen log house. All dates shown are cutting dates except 1841 (non-cutting date) and 1851 (probable cutting date).

elements and the agreement of the derived dates with the available documentary records. The Wolf House illustrates the interpretation of dating clusters and the re-evaluation of documentary records in light of the tree-ring dates. The Borden House is an example of the tree-ring dating of milled lumber from a frame building and demonstrates the important contribution dendrochronology can make to the management of historic properties.

Ridge House

The Sarah B. N. Ridge House in Fayetteville, Arkansas, is a two-story salt-box style house on the National Register of Historic Places (Figures 10 and 11). Sarah Ridge was married to John Ridge, the son of a noted Cherokee chief. Her husband and father-in-law were instrumental in signing the Treaty of Removal in 1835 which led to the Trail of Tears and the removal of the Cherokee people to the Indian Territories west of the Mississippi River (Wilkins 1970). Mrs. Ridge moved her family to Fayetteville in 1839 or 1840 following the assassination of her husband and father-in-law by opposing factions of the Cherokee Nation. At that time she purchased the single floor, double-pen log house (dogtrot) which still stands inside the present two-story house (Volume B, Records of the Washington County Chancery Court, pp. 276-277).

Although they are not specific, the available documents indicate that Mrs. Ridge made several improvements on her house between 1840 and her death sometime in the late 1850s. The comparison of the 30 tree-ring dates from various structural timbers with the available documentary records, however, provides new evidence on the original construction and subsequent remodeling of the Ridge House (Figures 10 and 11).

Twenty-three cutting dates document the beginning of construction on the log dogtrot at 1833 and 1834 although the builder, M. H. Clark, did not obtain official title to the property until 1836 (Deed Book A, Washington County, Arkansas, pp. 345-346). Three cutting dates at 1839 from furring strips and one at 1840 on a door board indicate that the interior walls of the dogtrot were plastered, and the north door in room one (Figure 11) was built during or soon after 1840. The plaster walls indicate that the dogtrot was enclosed at this time, and the new door suggests that a rear addition was also added which probably included the large basement. This remodeling episode coincides with the purchase and "improvement" of the Clark property by Mrs. Ridge in 1840 (Donat 1973; First Probate Book, Benton County, Arkansas, Chancery Court). Two additional tree-ring dates at 1841 (non-cutting date) and 1851 (probable cutting date) from furring strips associated with the interior wall plaster of the rear addition (room 6, Figure 11) probably coincide with the 1853-1854 repairs referred to in a letter by Mrs. Ridge (Lemke 1951). The second-floor addition over the dogtrot was added in 1877 by a subsequent owner, Sheriff Pettigrew (*Fayetteville Democrat,* October 6, 1877, p. 3, col. 3).

Although the three tree-ring dated building episodes coincide with the available documentary references concerning the Ridge House, the documents alone do not specifically identify the type or extent of construction that took place. With the architectural associations of tree-ring dated timbers, however, it is possible to identify the results of early construction and remodeling at the Ridge House and to relate these events to the nonspecific recorded history of the building.

Wolf House

The Jacob Wolf House in Norfork, Arkansas, is a large two-story log house also on the National Register of Historic Places. The age and historical significance of the Wolf House, however, has been the subject of considerable disagreement. The Wolf House is frequently described as the oldest standing structure in Arkansas or as the oldest house in the Ozarks (*The Ozark Mountaineer* 1961). Shiras (1939: 61) believed the house was built ca. 1809 by Indians under Wolf's supervision. More recent studies, however, found that Wolf did not move to Arkansas until sometime in the early 1820s. Documents show that Wolf entered a claim on the Wolf House property on November

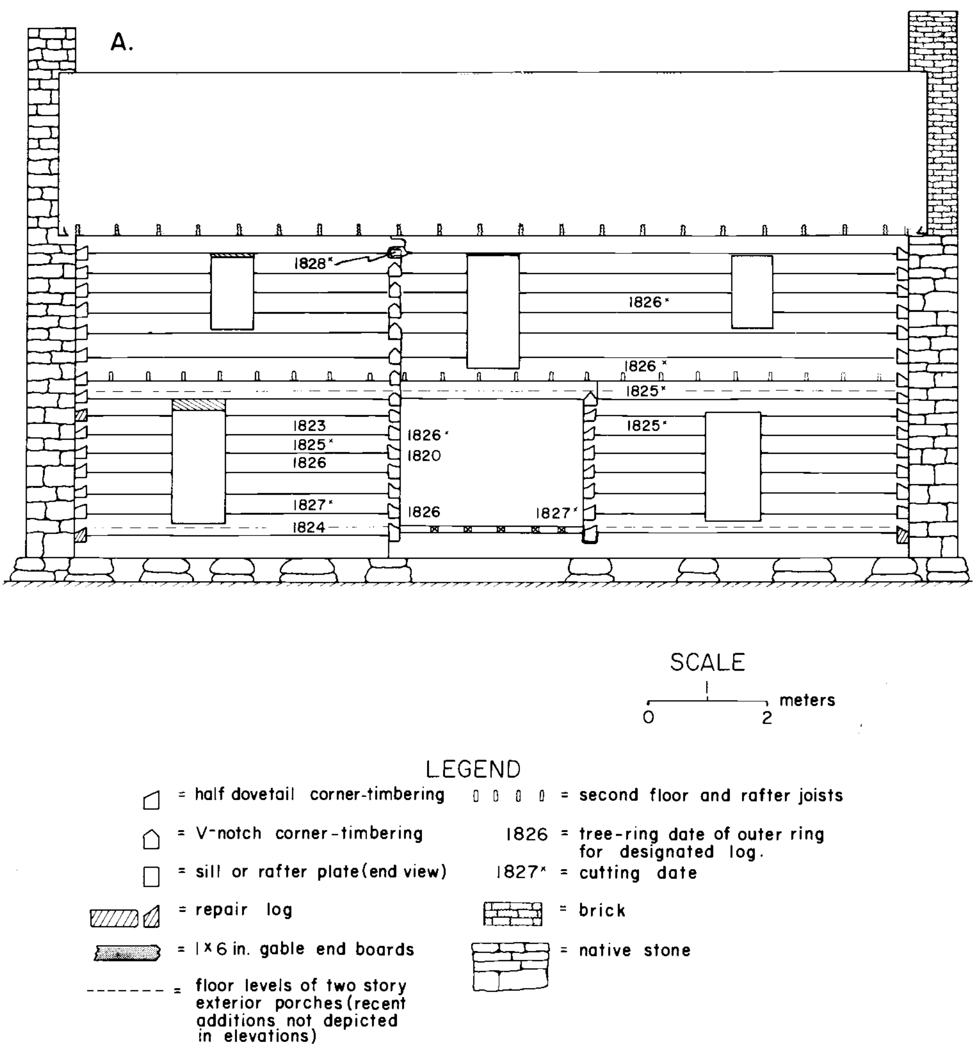


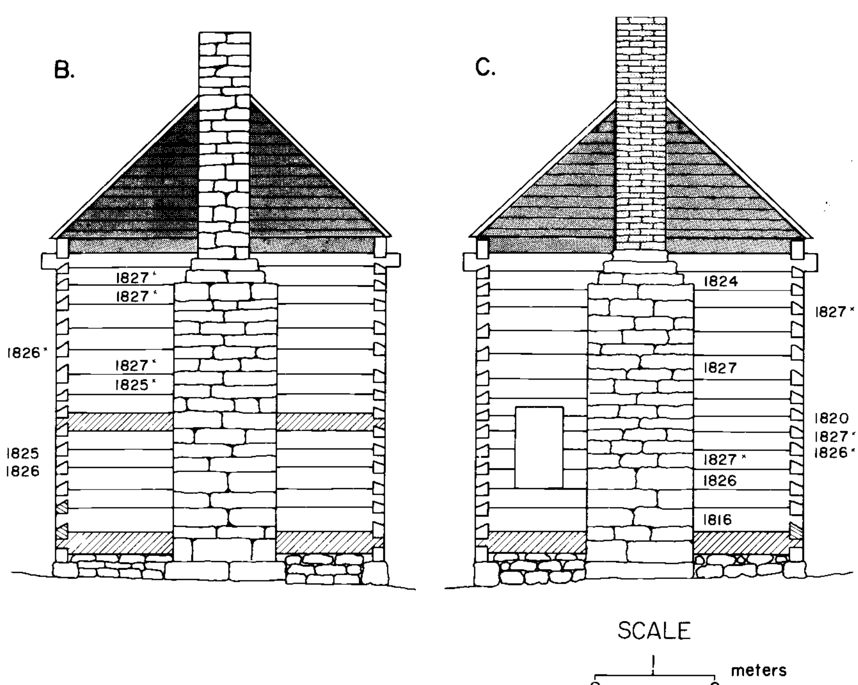
Figure 12. Three views of the Jacob Wolf House, Norfork, Arkansas. *A,* west elevation; *B,* north elevation; *C,* south elevation. Note the distribution of 1827 cutting dates and the single 1828 cutting date in the second-floor partition wall (west elevation).

15, 1824 (Baker 1978), and patented this land July 20, 1825 (Bearss and Carroll 1965). On October 27, 1825, the Arkansas Territorial Legislature created Izard County and designated the home of Jacob Wolf as the seat of justice (Bearss and Carrol 1965). On the basis of these records Bearss and Carroll (1965) reasonably concluded that the Wolf House was built ca. 1825 and served as the first courthouse for Izard County.

Re-evaluation of the documentary evidence in light of the 30 tree-ring dates derived from the Wolf House (Figure 12), however, implies a different interpretation of the early history of the Wolf House and Izard County. The tree-ring dates also offer some insight into Jacob Wolf's personal plans for the development of his property.

Three dating clusters and 18 cutting dates document tree-cutting activity both during and after the growing seasons of 1825, 1826, and 1827. But the Wolf House was not erected before late 1827 at the earliest because at least one 1827 cutting date was obtained from all four rooms of the house (Figure 12). A single cutting date after the growing season of 1828 suggests that the Wolf House was not actually assembled or completed until that year or soon thereafter. This date, however, is from the top wall log in the upstairs partition wall (Figure 12) and might have been a repair log used in 1828 or sometime thereafter. But since there is no architectural evidence suggesting replacement, I suspect that the substantial Wolf House was not finally completed until late 1828, when Wolf found it necessary to cut at least one additional log to complete the structure.

Although Wolf claimed the property in 1824 and the Territorial Legislature designated Wolf's home as the first courthouse for Izard County in 1825, the existing house was not standing before 1827 at the earliest. This conflict suggests that the Wolf family resided in another structure between 1824 and 1827 or 1828. This may have been the home of a relative or neighbor or, more likely, some sort of temporary dwell-



ing erected by Wolf on his property. Technically, it was this temporary home and not the existing house that was the first Izard County courthouse. Archaeological evidence for this postulated temporary dwelling may still exist in the immediate vicinity of the present Wolf House.

From a different perspective, the tree-ring and documentary evidence suggest that Jacob Wolf had well-formulated plans to construct the large two-story log house as early as the summer of 1825, before his home was designated as the Izard County courthouse. Three cutting dates with incomplete terminal rings indicate that Wolf began cutting trees to use in building the existing house during the spring or summer of 1825. In addition, the three dating clusters indicate significant tree cutting activity in 1825, 1826, and 1827. Assuming the logs were cut by Wolf or members of his household, which seems likely considering the frontier conditions, the cutting dates and dating clusters document a considerable amount of labor between 1825 and 1828 and may be seen as evidence for Wolf's long range plans to build the large log house. The logs were then stockpiled until actual construction on the house began in late 1827, 1828, or soon thereafter. Upon completion the Wolf House did finally serve as the courthouse for Izard County until the county seat was moved to Livingston's Mill in 1835 (Baker 1978).

Borden House

The Archibald Borden House is a two-story frame building on the site of the 1862 Civil War battle of Prairie Grove, Arkansas. The Borden House is depicted on a battlefield map drawn in 1863 (Logan 1957). Primary sources indicate that the Borden house held Confederate sharpshooters upstairs and wounded soldiers in the cellar (Joseph Cavanaugh, personal communication). The available architectural and documentary evidence, however, does not prove that the existing house was the structure actually present during the battle. The exact age of the Borden House became an important question when the Prairie Grove Battlefield State Park was buying the property and considering the restoration of the building. Consequently, an attempt was made to verify the association of the existing structure with the Civil War battle by dating it with dendrochronology.

The Borden House is a post and beam or balloon frame building. The sills, posts, and beams of the superstructure are hewn oak. Circular sawn 2 x 4 inch pine studs are mortised directly into the oak sills, beams, and rafter plates at two-foot intervals to frame the walls of the house. Architectural evidence, however, proves that the oak timbers and the (southern yellow) pine studs are contemporaneous (Stahle 1978b).

The oak superstructure consists of very young trees unsuitable for tree-ring dating. A surprising percentage of the pine studs and other framing materials, however, possess thin strips of bark along one edge (i.e., the waney edge) and an adequate number of annual rings for dating. Furthermore, it was possible to lengthen and improve the specimen depth of the pine chronology from the Borden House by sampling studs without bark which were instead sawn from the interior of the tree. The outer rings of the studs without bark (and in some cases without sapwood) frequently overlapped and matched with the inner rings of the studs with bark to provide a longer and more reliable ring record. By extending the Borden House composite in this manner, a 143-year chronolgy (1730-1872) was developed and was absolutely dated against modern shortleaf pine chronologies from elsewhere in Arkansas.

A total of 22 pine specimens were dated, including 12 cutting dates at 1867 from the 2 x 4 inch framing studs, a 2 x 12 inch floor joist, a 1 x 6 inch wall board, and a 2 x

6 inch diagonal brace. A single 1872 cutting date was derived from a 1 x 4 inch plaster lathing stud associated with the interior wall plaster. These tree-ring dates seem to indicate that the framing was erected in 1867 or soon thereafter, and that the lathing studs were added in 1872 or soon thereafter when the interior walls were plastered. The evidence at hand, however, is not conclusive and the framing may not have been erected until 1872 or soon thereafter, while the lathing stud could be a later replacement.

At any rate, there is no doubt that the existing Borden House was not present during the Civil War battle at Prairie Grove. This finding had important implications for the managers of the State Park. Since the existing structure was not present during the battle, an expensive restoration could not be justified on that basis. More important to the goals of the State Park is the location of the original Borden House. Since the existing structure is known to post-date the battle, efforts are now being directed toward locating the original house site believed to be in the immediate vicinity.

At the same time, the tree-ring dating of the Borden House primarily on the basis of 2 x 4 inch framing studs represents a relatively unique application of dendrochronology. These results are very encouraging and suggest that many historic frame buildings may be suitable for tree-ring dating in Arkansas and elsewhere.

COMMENTS

The potential development of long term tree-ring chronologies in the eastern United States is more favorable than might be expected in view of the drastic historical changes that have taken place in the native forests. Small undisturbed and lightly disturbed remnants of the former virgin forests still exist in many eastern states. Federal and state agencies have recently inventoried many of these "natural areas," nominating the most nearly pristine areas for permanent federal protection (Waggoner 1975, Goodwin and Niering 1975, Lindsey and Escobar 1976, Shepard and Bogess n.d., Arkansas Natural Heritage Commission 1978). Many of these areas contain virgin and old-growth timber that should provide the basis for a fairly dense eastern chronology network. Even in areas of heavy disturbance populations of certain commercially marginal species (e.g., post oak) were left uncut and can provide perfectly suitable chronology material. Modern chronologies 200 to 300 years long should be routinely available with several hardwood and conifer species. The 39 modern chronologies compiled by DeWitt and Ames (1978) are a major contribution to the eastern chronology network and should be expanded to provide more uniform coverage.

Eastern red cedar and baldcypress have wide distribution in the eastern United States and show particular promise for the development of very long term chronologies. Although both species have been heavily exploited since European settlement, many early historic structures built with these species still remain and preserve valuable tree-ring records in their construction timbers. Furthermore, both species are capable of attaining great age and may still be recovered from isolated remnants of their former environments.

Many old-growth red cedar which may produce sensitive chronologies still exist on steep, relatively inaccessible bluffs and exposed ridges throughout the midwest and easten United States (Bell 1951, Weakley 1971). Bell (1951) located several specimens over 400 years old on cedar bluffs in Missouri and I have collected individuals 250 to 350 years old from cedar bluffs in northwest Arkansas. In addition, old stumps, dead snags, and relic ground litter of the hard and very durable red cedar can persist for many years on cedar bluffs. Red cedar has also been recovered in significant quantity from prehistoric archaeological sites in the eastern United States (Bell 1951, Hamilton 1952), and archaeological specimens have been crossdated in Illinois (Bell 1951) and South Dakota (Weakley 1971). Coupled with the red cedar specimens available in historic buildings, these sources of living and relic red cedar wood should contribute to the development of very long term tree-ring chronologies.

A similar species, ashe juniper (*Juniperus ashei*), is generally distributed from southern Missouri to Mexico and may also be suitable for tree-ring dating. Individuals up to 500 years old have been reported from southwestern Missouri (Charles Stockton, personal communication) and the north-central Arkansas Ozarks (Dwight Moore, personal communication).

Baldcypress was also a preferred building material and is very common in historic buildings throughout the southeastern United States. Although baldcypress has been efficiently harvested since the 18th century with the aid of annual and semi-annual flooding in the lower Mississippi Valley (Moore 1967: 10-11), small remnants of the once extensive cypress brakes still remain in areas with poor access to the main waterways, on protected private lands, and as cull trees in heavily timbered areas. Baldcypress is an extremely durable wood as well and has been recovered from riverine and swamp deposits throughout the South (Moore 1967: 4, Mills 1978: 18-22). Baldcypress specimens have also been excavated from prehistoric archaeological deposits (Walker 1936, Porter 1969), and subfossil baldcypress have been reported from the upper Chesapeake Bay north of the present range of the species (Bibbins 1905: 53). These historic, archaeological, and relic or subfossil wood remains provide the classic sources for the extension of both the modern baldcypress and red cedar chronologies well into prehistory.

Post oak (*Q. stellata*) should also be included among the more promising species for long term chronologies primarily because relatively undisturbed old-growth stands are still widely distributed in the Midwest. Post oak is a drought resistant species common on xeric, upland sites throughout its range, and pure stands of virgin trees still exist in the prairie transition region of central Oklahoma and Texas (Dyksterhuis 1948). Even in heavily timbered areas the frequently stunted post oak were not profitable and were often left uncut. I have dated living post oak over 250 years old in Arkansas and Harlan has dated sensitive post oak in central Texas which are 300 years old (T. P. Harlan, personal communication). Post oak samples from living stands and historic buildings in the prairie transition region should provide good chronologies for the last 300 to 400 years.

Bur oak (*Q. macrocarpa* Michx.) is another drought resistant oak and may reach ages of 300 to 400 years (Fowells 1965: 565). Bur oak is widely distributed in the Midwest and should be especially valuable for tree-ring chronologies in the northern plains.

Whatever the prospects for very long term chronologies may be, historic timbers can readily provide high quality tree-ring chronologies for the 17th, 18th, and 19th centuries in Arkansas and probably elsewhere in the East. In fact, by concentrating on certain species or areas it may very well be possible to obtain longer historic chronologies and more significant extensions than those obtained during this research. Historic tree-ring materials, therefore, still offer an important potential link between modern and archaeological tree-ring chronologies in the eastern United States.

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Table 2. Selected statistical characteristics of 11 historic tree-ring chronologies from Arkansas (species abbreviations defined in Table 3).

SITE NAME	ID	Species	N of trees	N of cores	N of years	Mean ring width (mm)	Percent missing rings	Mean sensitivity	Serial correlation	Standard deviation	Mean correlation among trees	Average standard deviation of cores	Standard error	Total chronology
Ridge House	655819	WO	22	22	165	61.2	0	.153	.253	.169	.292	.28	.065	1674-1838
Jackson Cabin	657810	WO	8	16	196	75.8	0	.158	.637	.309	.470	.30	.081	1654-1849
Magness Barns	658819	WO	15	23	261	58.5	0	.157	.447	.213	.413	.32	.058	1598-1858
Dutch Mills	659810	WO	13	26	219	68.0	0	.166	.350	.194	.325	.29	.059	1624-1842
Wolf House	656849	YP	25	27	156	93.0	.03	.194	.361	.226	.444	.36	.064	1672-1827
Chitwood Barn	661849	YP	4	4	118	89.1	0	.254	.583	.366	.563	.46	.123	1739-1856
Horton House	663849	YP	9	9	132	97.1	0	.234	.182	.236	.251	.37	.106	1750-1881
Drury House	664849	YP	9	9	202	102.7	0	.206	.511	.257	.335	.33	.097	1649-1850
Lancaster Barns	660830	RC	11	22	134	78.5	.04	.202	.384	.230	.386	.35	.078	1733-1866
Mt. Olive Group	665839	RC	10	12	150	95.2	0	.199	.405	.230	.303	.37	.090	1710-1859
Lafayette Jail	028979	BC	5	5	102	199.7	0	.363	.476	.411	.621	.48	.138	1727-1828

Table 3. Average statistical characteristics of 11 historic chronologies compared with 39 eastern and 102 western North American modern chronologies (after DeWitt and Ames 1978).

	HISTORIC[a]				MODERN[b]			HISTORIC[c]	EASTERN[d]	WESTERN[e]
Characteristic	WO	YP	RC	BC	QUAL	PIEC	PCRU	TOTAL SET	TOTAL SET	TOTAL SET
Mean Sensitivity	.158	.222	.200	.363	.157	.202	.158	.208	.175	.365
Serial Correlation	.422	.409	.394	.476	.468	.533	.540	.417	.496	.415
Standard Deviation	.221	.271	.230	.411	.213	.277	.236	.258	.238	.380
Number of Chronologies	4	4	2	1	16	9	5	11	39	102

[a]Historic chronologies stratified by species:

- WO = white oak (Quercus sp.)
- YP = southern yellow pine (Pinus sp.)
- RC = eastern red cedar (Juniperus virginiana L.)
- BC = baldcypress (Taxodium distichum L. Rich)

[b]Eastern modern chronologies stratified by species:

- QUAL = white oak (Quercus alba L.)
- PIEC = shortleaf pine (Pinus echinata Mill.)
- PCRU = red spruce (Picea rubens Sarg.)

[c]Combined set of 11 historic chronologies from Arkansas

[d]Combined set of 39 modern chronologies from eastern North America

[e]Combined set of 102 modern chronologies from western North America

Table 4. Cross-correlation and analysis of variance results for four replicated historic chronologies.

Site Name	ID	Species	XCORR and ANOVA period	Mean correlation within trees	Mean correlation between trees	Mean correlation among tree chronologies	Error of Y	Percent Variance: Chronology	Percent Variance: Trees	Percent Variance: Cores
Jackson Cabin	657810	WO	1745-1820	.700	.454	.470	.061	42	23	35
Magness Barns	658819	WO	1635-1730	.666	.392	.413	.088	38	31	30
Dutch Mills	659810	WO	1675-1815	.617	.313	.325	.056	29	32	39
Lancaster Barns	660830	RC	1755-1830	.514	.379	.386	.064	37	13	50