

Tree Rings and Ancient Forest Relics

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Centuries-old trees persist in thousands of forest remnants across the United States. Small and weathered, they preserve, in a fragmentary pattern, one stratum of our presettlement forest ecology and biodiversity.

It is widely believed that the ancient forests of the eastern United States have been completely destroyed by successive waves of European settlement, commercial logging, agricultural development, and urban sprawl. However, the search for presettlement forests in North America by specialists in tree-ring analysis has produced surprising findings. Tree-ring research suggests that literally thousands of ancient forests survive throughout the United States. These forest relics are often small and unimpressive but nevertheless preserve centuries-old trees.

Forest distribution and productivity in presettlement North America was dictated by climate, topography, and soil fertility, and included marginal stands as well as the majestic. Marion Clawson has estimated that the contiguous United States were covered with some 950 million acres of forest just prior to European settlement, but that this total included an estimated 100 million acres of noncommercial forests. Dendrochronologists have dated thousands of trees in more than four-hundred ancient forest sites located in all forty-eight contiguous states except Delaware and Rhode Island (Cook et al. 1996). These records of tree growth extend hundreds to thousands of years into prehistory and are particularly useful for estimating past climate change. These relics

emphasize that the disturbance waves unleashed following European settlement were largely driven by economic motives, and the commercially valuable stands of ancient timber were indeed decimated. For the few surviving examples of magnificent marketable timber, we owe a debt of gratitude to individual landowners and to the early state and federal preserves such as Adirondack State Park and Great Smoky Mountains National Park. But forest disturbance often bypassed stands of remarkably old trees found on noncommercial sites. These for-



This map locates most of the tree-ring chronologies developed from ancient forest sites in the United States. Undisturbed or relatively undisturbed ancient forests with trees dating from at least A.D. 1700 to 1979 were present at most of these locations at the time of sampling (mainly from the 1970s through the 1990s), but the size of these forests varies tremendously from less than one acre to thousands of acres. The true distribution of surviving ancient forests in the United States is of course much greater because only a small fraction of the ancient forests actually known have been sampled for tree-ring analysis.

ests, sometimes described as "decrepit" and "overmature," do not fit the stereotype of "the forest primeval" as cathedral forest and have largely failed to interest forest scientists, managers, or advocates. Nonetheless these are authentic examples of one part of the primeval forest mosaic and deserve to endure.

Tree-Ring Study of Ancient American Forests

For nearly a century, tree-ring experts have specialized in the location of ancient forests and in the biological and ecological processes that drive their growth, longevity, and sensitivity to climatic variations. American work began with Andrew E. Douglass in the semiarid Southwest. Douglass discovered that the width of annual growth rings in living Ponderosa pines (*Pinus ponderosa*) could be synchronized for centuries across the entire Colorado Plateau. Douglass developed the technique of crossdating, the fundamental tool for tree-ring dating. In many species, annual ring series form unique, nonrepetitive patterns of wide and narrow rings that can be compared and synchronized among hundreds of trees in a given region. Using the outermost ring in living trees as the known datum in time, exact calendar years can be assigned to every cross-synchronized growth ring, whether in living or long-dead trees.

Douglass also demonstrated that climatic fluctuations were responsible for most of the interannual variations in tree growth quantified in these tree-ring chronologies. Today, tree-ring

analysis is widely used to date the construction of ancient buildings, prehistoric volcanic eruptions and earthquakes, to document the presettlement fire ecology of forests, to recon-



*The exact age of trees can be readily and harmlessly determined by using a Swedish increment borer to extract a small-diameter core from bark to pith and then carefully polishing the core to reveal the minute anatomy of the annual growth rings. The author is seen here coring a 300-year-old eastern red cedar (*Juniperus virginiana*) in Elk River, Kansas. In most cases, tree-ring data provide the best information on the maximum longevity for tree species.*



This canopy of a pondcypress (*Taxodium distichum* var. *nutans*) at Topsail Hills, Florida, typifies the flat-topped crowns reduced to a few heavy, craggy limbs often found in cypress trees of great age.

struct past climate fluctuations, and to study the carbon budget of the earth. With a remarkable degree of precision, it can test theories of anthropogenic climate change.

It was A. E. Douglass' longtime colleague Edmund Schulman who suggested the concept of "longevity under adversity," used by dendrochronologists to locate ancient trees worldwide. He had found that the oldest conifers tend to grow under the most adverse ecological conditions, such as the arid lower forest border in the western United States or the cold windswept forests at the subalpine treeline. For instance, the oldest known continuously living organisms on earth, the bristlecone pine (*Pinus longaeva*) of California's Inyo National Forest, are found at 9,000 feet above Death Valley in the rainshadow of the Sierra Nevada, one of the most hyperarid forest sites on earth. The steep dolomite slopes receive an average of only five to ten inches of precipitation annually. Bristlecone growth can be as slow as one radial inch

per century and individuals as old as 5,000 years have been identified.

External Attributes of Ancient Trees

Based on analysis of thousands of ancient trees throughout the world, dendrochronologists have described a suite of external physical attributes often associated with ancient conifers and hardwoods (Schulman 1956, Stahl and Hehr 1984, Swetnam and Brown 1992). Experienced dendrochronologists can often identify ancient trees visually and can readily segregate individuals into approximate age categories. These external attributes are not precise or infallible, of course, and microscopic analysis of the annual growth rings is the only way to obtain certain age evidence.

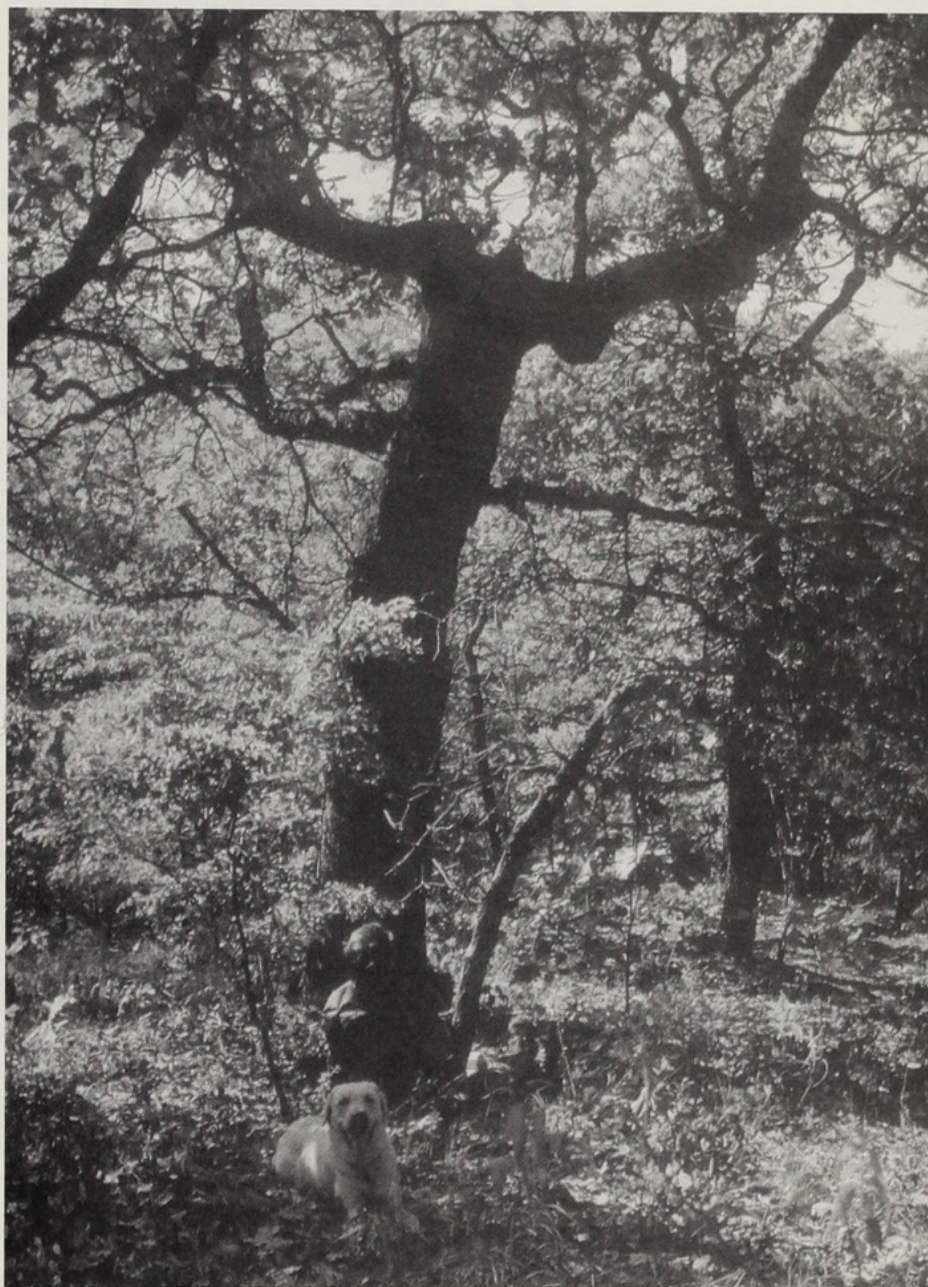
Perhaps the most reliable attribute associated with great age in trees is a pronounced longitudinal twist to the stem, which is also evident as spiral grain in the wood of ancient trees. Other attributes include crown dieback (also referred

to as a spike top, stag top, or dead top); a reduced canopy often restricted to a few heavy, craggy limbs; branch stubs and other bark-covered knobs on the stem; hollow voids or heart rot; partial exposure of massive roots and root collar; leaning stems; heavy lichen and moss growth on stems; thin and patchy bark; strip bark in conifers; wind-sculpted bark or exposed wood; flat-topped crowns; fire or lightning scars; and size—not absolute size, but size relative to other trees of the same species growing on similar sites.

The Network of Long Tree-Ring Chronologies in the United States

On my first collecting trip in northwest Arkansas, I was surprised at how easily ancient forest remnants could be located in the heavily cutover eastern United States. We found 250-to-300-year-old post oak (*Quercus stellata*) dominating a narrow, but largely undisturbed corridor of forest winding around the dry upper slopes of Wedington Mountain. At first I believed that this was just a lucky find, but the hundreds of ancient post oak discoveries we have made since in Arkansas, Missouri, southeastern Kansas, Oklahoma, and Texas clearly demonstrate that this particular forest type has often been left uncut.

Ancient hardwood stands have been found on steep and dry upland sites throughout the eastern deciduous forest, among them chestnut oak (*Quercus prinus*) along the Blue Ridge Parkway and white oak (*Q. alba*) on ravine slopes near the western limit of upland deciduous forests in Illinois and Iowa. A variety of ancient conifers have also been found, including northern white



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cedar (*Thuja occidentalis*) over 1,000 years old on the Niagara Escarpment and pitch pine (*Pinus rigida*) up to 450 years old in the Schawangunk Mountains only sixty-five miles from Manhattan.

Noncommercial stands are not restricted to dry upland sites; they include an interesting variety of bottomland and swamp forests. Relatively undisturbed old-growth timber in the East includes the pine pocosins of the Carolinas,



This *Pinus rigida* near Mohonk Lake, New York, is in the 450-year age range and is the oldest pitch pine yet discovered.

the pitch pine bogs of New Jersey, and a few scattered northern white cedar bogs and wetlands. None of these wetland forests support particularly large trees, but some are surprisingly old and undisturbed in spite of their unimpressive size.

The many baldcypress (*Taxodium distichum*) swamps with trees from 500 to over 1,500 years

old are certainly among the most notable ancient forests left in eastern North America. The natural range of baldcypress was restricted to excessively wet forests and swamps in the southeastern United States. This habitat contrasts vividly with the adverse upland sites usually associated with longevity in trees, but the specific environmental stresses responsible for slow growth and longevity can vary dramatically among species and forest types. For baldcypress and other wet-site species, these environmental stresses include excessive moisture and acidic, nutrient-poor swamp waters.

Bottomland hardwood forests along many southern streams have also been heavily exploited for timber and cleared for farmland, but again not all bottomland hardwood species produce quality lumber and some species tend to be restricted to the lowest and wettest positions, which are poorly suited for agriculture. The best example might be overcup oak (*Quercus lyrata*), which can achieve impressive size, but its lumber is often twisted, defective, and prone to

rot. We have occasionally found 200-to-350-year-old overcup oak growing on slightly higher positions in or adjacent to ancient cypress swamps. Small tracts of marketable timber of a variety of species have also survived in a few areas surrounded by noncommercial forests or rough, inaccessible terrain.*

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* These can include beech (*Fagus grandifolia*), post oak, white oak, chestnut oak, chinkapin oak (*Quercus muehlenbergii*), blackjack oak (*Q. marilandica*), Texas live oak (*Q. virginiana* var. *fusiformis*), shin oak (*Q. mohriana*), overcup oak, swamp chestnut oak (*Q. michauxii*), black gum (*Nyssa sylvatica*), tupelo gum (*N. aquatica*), ashe juniper (*Juniperus ashei*), eastern red cedar (*J. virginiana*), pitch pine (*Pinus rigida*), table mountain pine (*P. pungens*), jack pine (*P. banksiana*), yellow poplar (*Liriodendron tulipifera*), eastern hemlock (*Tsuga canadensis*), baldcypress, and pondcypress (*Taxodium distichum* var. *nutans*).

A Portfolio of Ancient Trees



An ancient *Quercus stellata* forest of the Ozark Plateau drawn by Richard P. Guyette, an accomplished artist and dendrochronologist. This drawing illustrates many of the external attributes typical of ancient hardwoods and gives some impression of the aesthetic qualities that distinguish these authentic presettlement forest survivors. Richard has illustrated the details of a post oak-dominated forest on the Ozark Plateau, including twisted stems, dead tops and branches, exposed root collar, hollow voids, and canopies restricted to a few heavy muscular limbs. Leaning trees, branch stubs, irregular bark texture, fire and lightning scars, and fallen logs in various stages of decay are also evident.

These weathered relics are found on steep slopes and poor soils broken by small glades and picturesque blufflines. Post oak tends to dominate these dry infertile positions in the Ozarks, but blackjack oak, black oak, northern red oak, white oak, winged elm, white ash, bitternut and mockernut hickory, serviceberry, dogwood, dryland blueberry, little bluestem, and a variety of mosses and lichens are variously present in these forest remnants. Although stunted by the adverse environment, these noble post oak trees often exceed 300 years in age.

Ancient spike-top and strip-bark *Juniperus virginiana* on a bluffline in the Missouri Ozarks drawn by R. P. Guyette. The old-growth attributes illustrated here are typical of ancient *Juniperus* trees worldwide. The classic spike top of these red cedars, particularly the massive twisted spike top at right, are virtually a universal indicator of old-growth conifers and can often be identified from a considerable distance. Notice that this spike top is free of delicate branching, which was broken off after years of exposure to wind, ice storms, perching birds, and climbing animals. The mildly intoxicating fragrance of cedarene can permeate these bluff-edge red cedar, making the collection of tree-ring samples from these high blufflines a precarious experience.



In strip-bark trees only thin filaments of living cambium connect the canopy and root systems. Strip-bark growth is a hallmark of the ancient bristlecone pine forest along Methuselah Walk in California's Inyo National Forest and is common in many other high-elevation and drought-stressed conifers. However, strip-bark growth is not common in old pines of the eastern or southern United States.

The oldest red cedars on the Ozark Plateau are often found growing on rocky pinnacles detached from the main cliff escarpment, where they may have enjoyed a measure of protection from the occasional ground fires that swept the hardwood forest floor. The oldest red cedars are 600 to over 900 years old and have been found by Richard Guyette on dolomite-derived soils along the Jack's Fork and other scenic streams in Missouri. In fact, a number of the oldest known trees of several species have been discovered on dolomite or gypsum-derived soils. Other very ancient dolomite- or gypsum-grown trees include bristlecone pine at Methuselah Walk, California (up to 5,000 years old); ancient Rocky Mountain Douglas fir at Eagle, Colorado (up to 900 years old); and northern white cedar on the Niagara Escarpment, Ontario (up to 1,000 years old).



Ancient *Taxodium distichum* typical of blackwater streams in the Carolinas, Georgia, and Florida, drawn by R. P. Guyette. Note the blunt and bent silhouette on the stout cypress in the foreground, which would be in the 800-year age class. The mature tree in the middle distance on the right would be in the 400-year age class, and the stunted and twisted tree at the right margin resembles a specific tree at Black River that is over 1,500 years old.

These nutrient-limited blackwater swamps are frequently dominated by slow-growing baldcypress in an open canopy and by Carolina ash in the understory, often to the near exclusion of other species of trees and shrubs. The canopy cypress are rarely over 60 feet tall or over 36 inches in diameter above the buttress; we have measured radial growth in some ancient blackwater cypress at less than one inch per century. The frequently broken main stem, flat-topped crowns, and recently sprouted fine branches on the stem and broken branches seen in the foreground all bear mute testimony to the pruning effects of past hurricanes in these near-coastal cypress swamps.

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Ancient noncommercial forest remnants are sometimes discounted in the debate over eastern old growth because they do not answer our desire for large as well as old trees. These relics are not our lost cathedral forests, but they are the authentic remains of our oldest forests; they represent an important part of the presettlement forest mosaic that once graced eastern North America. Their growth rings faithfully record a natural history of the virgin forest and may hold the answers to questions of environmental change we have yet to pose.

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