KARREN WCISEL

White oak.

WITNESS TREES, FOSSIL POLLEN, AND OTHER INSIGHTS

How Connecticut's forests have changed from colonial to modern times

BY EDWARD K. FAISON

In 1636, the Reverend Thomas Hooker left Newtown (Cambridge), Massachusetts, with 100 followers to settle in a large, fertile river valley some 90 miles to the southwest. Following Native American trails that entered the future state of Connecticut through Woodstock, Mr. Hooker's two-week journey culminated in the founding of Hartford. This journey is fittingly celebrated as a defining moment in Connecticut history, but it also marked one of the earliest overland expeditions by European settlers into the interior of southern New England. What type of forest and landscape did Mr. Hooker and his followers encounter on their trip? If we were to retrace their steps today, how would the forest look different from its "original" counterpart? With more than 375 years elapsed and no existing firsthand natural history accounts from Mr. Hooker's expedition, these questions would seem hopelessly relegated to the realm of speculation. Remarkably, this isn't the case.

Colonial Witness Trees

Although largely ignored or unknown to foresters, ecologists, and conservationists, most Connecticut towns possess a colonial-era forest inventory in their town archives. Upon settlement, colonial towns commenced with delineation of property ownership. "Metes and bounds" surveys were the most common method. A property was typically described from a given point around its perimeter and back to the starting point with the use of physical features, distances, and directions. The most common, often the only, physical features used to mark corners in these surveys were trees.

After a town's bounds were surveyed—a process that took anywhere from a handful of years to several decades—several hundred "witness" trees had been recorded. Compiled across counties, states, and regions, witness trees offer a formidable inventory of the forest composition that greeted the first European settlers. Actually, witness tree data are arguably more comprehensive than any forest inventory we have today. Armed with these data, we can reconstruct Connecticut's original forest composition, and with reasonable accuracy assess the relative abundance of different trees that Mr. Hooker and company would have encountered on their journey from Cambridge to Hartford.

Reliability of Witness Tree Data

But are the witness tree data reliable? Can the tree identifications of the early land surveyors be trusted, and were the surveyors biased in their selection of certain tree species? These are important questions, given the large number of early land surveyors employed across Connecticut, the lack of formal botanical training of the surveyors, and the absence of a standard method for selecting trees. Despite these potential pitfalls, it is unlikely that errors or bias had an important effect on the data. Here's why. Basic natural history skills were far more common among laypeople in the colonial era than they are today; therefore, early land surveyors would probably have been familiar with the common tree types. Charles Cogbill, an ecologist and forest historian who has collected more witness tree data across the northeastern US than any other researcher, described these surveyors as "discerning naturalists." Comparisons of witness trees recorded in the midwestern United States in the 19th century with the same witness trees still standing have confirmed Dr. Cogbill's assessment that the surveyors were accurate in their identification. With respect to surveyors potentially favoring certain tree species over others, one must remember that there was an inherent guard against such bias in the surveys: Tree selection was ultimately limited to the few stems that happened to be present at a property corner.

Chestnut: The King That Never Was

Among the more fascinating aspects of studying the witness tree data is discovering that some of the conventional wisdom regarding tree abundance is not supported by the data. American chestnut (*Castanea dentata*) is often purported to have been the king of the Connecticut forest, constituting as many as half of all trees in the forest, before it succumbed to the chestnut blight in the early 1900s. But the witness trees tell a different story. Chestnut was certainly a common tree, but it was by no means the most abundant tree in the original forest, accounting for less than 10 percent of Connecticut's trees. Where does the discrepancy arise? Inferences on chestnut's "original" abundance come from early forest surveys at the beginning of the 20th century, which estimated that chestnut composed 25 to 50 percent of Connecticut's standing timber. These estimates, just before chestnut's demise to the blight, happened to coincide with the tree's historic peak in abundance—an abundance greatly inflated by 19th-century land-use practices. Intensive fuelwood cutting in Connecticut's woodlands in the late 19th and early 20th centuries created a 20- to 40-year-old forest of "sprout hardwoods," which favored the prolific stump-sprouting chestnut over less prolifically sprouting trees. It is assumed that because chestnut was so abundant at the beginning of the century, it must always have been that abundant.

One of the reasons that chestnut was not the king of the original southern New England forest is that the tree's abundance varied tremendously with topography and soil. It grew well in sloping, elevated terrain such as the western uplands of Connecticut, where it constituted as much as 14 to 16 percent of trees in the towns of Redding and Kent in the 1700s. Chestnut was less common in flat areas such as the northern Connecticut Valley towns of Enfield and Suffield (where it made up only 1 to 4 percent of all trees), and it was rare on the sandy coastal plain of eastern and southeastern Massachusetts. Chestnut is completely absent from the witness tree data in the original eastern Massachusetts towns of Cambridge, Sudbury, Framingham, Hopkinton, and Grafton. In other words, for the first one-third of Mr. Hooker's journey from Cambridge to Hartford, there is a good chance that his company saw few if any American chestnut trees. Not until Sutton, Massachusetts, would Mr. Hooker have begun to encounter chestnuts regularly. From Woodstock to Hartford, chestnut would have been a common tree in the forest.

The Dominant White Oak

If American chestnut was not the king of Connecticut's original forest, then which tree was? The answer, interestingly enough, is Connecticut's state tree: white oak (*Quercus alba*). Connecticut's choice of white oak as the state tree in 1947 came about because a majestic white oak happened to be the tree in which Connecticut's charter was hidden from the British in 1687. Little did Connecticut's legislators know just how appropriate their choice was, for white oak composed approximately one-third of all trees in Connecticut's pre-colonial forests. From Woodstock to Hartford, Mr. Hooker's company would have traversed forests in which almost 40 percent of the standing trees were white oak, more than white oak's eight closest non-oak competitors—chestnut, hickory (*Carya spp.*), pine (*Pinus spp.*), ash (*Fraxinus spp.*), maple (*Acer spp.*), birch (*Betula spp.*), hemlock (*Tsuga spp.*), and beech (*Fagus spp.*)—combined. What made white oak so successful? It appears that white oak was not the best-adapted tree with respect to any single trait in the Connecticut environment of 1600, but white oak succeeded because it did several things really well.

Longevity. The first thing white oak did well was to live a long time—up to 600 years, which is considerably longer than most trees. Before European settlement, southern New England was a landscape in which natural disturbances such as hurricanes and tornadoes were infrequent, and forest cutting, clearance, and burning by Native Americans were generally limited to areas near settlements—and in the case of fire generally burned only the understory and not the overstory trees. In such a setting, old forests would have been the norm, and long-lived trees would have been selected for. Observations by Henry Thoreau on perhaps the last uncut forest in eastern Massachusetts support the notion of original forests being dominated by old white oaks.

> [in this uncut forest] there may be a thousand acres of old oak wood. The large wood is chiefly oak, and that white oak, though black, red, and scarlet oak are also common . . .
>
> Seeing this I can realize how this country appeared when it was discovered . . . We have but a faint conception of a full grown oak forest stretching uninterrupted for miles, consisting of sturdy trees from one to three and even four feet in diameter, whose interlacing branches form a complete and uninterrupted canopy
> —*Journal entries November 9–10, 1860*

Despite white oak's longevity, hemlock (*Tsuga canadensis*) and black gum (*Nyssa sylvatica*) are even longer-lived, reaching more than 900 and almost 700 years respectively. Hemlock, however, was only a minor tree (2 percent) and black gum was rare (less than 1 percent) in the pre-colonial forests of Connecticut. Not surprisingly, these trees had other serious limitations. Black gum is close to its northern range limit in southern New England. Trees at their range limits are typically less competitive than are trees within the heart of their range. The former are therefore often limited to extreme sites, and black gum is no exception: It is mostly a swamp tree in Connecticut. Hemlock was limited by other factors. First, the tree is particular about where it grows, preferring cool, moist microclimates. Hemlock is also susceptible to several natural disturbances including fire, drought, and insect attack and has experienced severe declines over the millennia from the latter two disturbances.

Ecological versatility. In addition to being long-lived, white oak is among the most drought- and fire-tolerant trees and is not particularly susceptible to insect attacks. Drought tolerance would have been particularly important in the early colonial period, as the climate was notably drier than today and included three severe and lengthy droughts, one of which centered around the year 1635. White oak is also adapted to a range of soil and topographic conditions. Unlike chestnut's relatively specific topographical and substrate requirements, white oak was far more versatile in where it could grow. It dominated the low-lying, sandy outwash soils of outer Cape Cod buffeted by wind and salt spray, the fine-grained and fertile glacial lake deposits of the Connecticut Valley, and the moist, cool slopes of the western uplands of Connecticut. Only in the coldest parts of Connecticut—the towns of Norfolk, Colebrook, and Hartland—and northward into the Berkshires did white oak relinquish its dominance to the more cold-tolerant beech.

Still, white oak is not the most ecologically versatile tree in this region. That distinction belongs to red maple (*Acer rubrum*). Red maple grows well in most of the conditions that white oak does, but red maple also thrives in swamps and floodplains where white oak does not venture, and red maple tolerates colder temperatures than does white oak. Yet, red maple accounted for less than 4 percent of the trees in Connecticut's original forest. Its limitations: a relatively short lifespan—only half as long as white oak—and a greater susceptibility to repeated fire and drought than white oak.

Fall germination and the passenger pigeon. A third thing white oak did well was to produce an acorn that germinated in the fall instead of the spring. Each spring, as red and black oak acorns and chestnuts were coming out of winter dormancy and preparing to germinate, 3 to 5 billion passenger pigeons (*Ectopistes migratorius*)— migrating north from their wintering grounds—would descend into their core northeastern nesting area (which included Connecticut) and feast on beechnuts, acorns, and chestnuts. Although some seed dispersal undoubtedly occurred, the pigeon's gizzard generally destroyed the seeds without dispersing them. Alexander Wilson in 1832 calculated that one large flock of pigeons could consume more than 17 million bushels of nuts per day. Because white oak germinated in the fall, the acorns became small seedlings by the time the pigeons arrived in the spring and were useless to the mast-eating birds. Indeed, it was no coincidence that Connecticut's charter oak was a white oak.

So as Mr. Hooker's company passed through the Woodstock Drumlin field, over the Tolland Range, across the Bolton ridge, and into the Connecticut Valley, they were undoubtedly passing through primarily white-oak dominated forests of large, old trees across much of the uplands. Oaks, in total, would have composed almost 7 of every 10 trees. Hickory and chestnut would have been the most common associate trees, constituting about 9 percent and 8 percent of the standing timber respectively. During the day, large flocks of passenger pigeons were undoubtedly seen overhead or nesting in the canopies. White-tailed deer (*Odocoileus virginianus*) would have been the most common large mammal, an occasional cougar (*Puma concolor*) may have prowled near the company's herd of domestic cattle, and at twilight, the howls of wolves (*Canis lupus*) were undoubtedly heard. In wetter areas along streams and rivers and in swamps, white oak and its associates would have been replaced by red maple, white pine (*Pinus strobus*), yellow birch (*Betula alleghaniensis*), and hemlock.

Semi-Open or Forested?

> *The Newtown Pilgrims struck out into the almost pathless woods . . . Only a few miles from their place of brief habitation, and they were in a wilderness marked only by signs of Indian trails.*
>
> George Leon Walker, 1891, *in Thomas Hooker: Preacher, Founder, Democrat*

A lingering question about the original southern New England landscape is how much of it was actually forested. In other words, could much of Mr. Hooker and company's 1636 journey through the "wilderness" actually have been through open fields and savannahs? A number of accounts from early settlers and explorers mention the presence of sizable open areas in southern New England, particularly near the coast and along major river valleys, either cleared and planted or burned by American Indians. Did early explorers and settlers highlight, or even exaggerate, anomalous large openings in an otherwise wooded landscape (to paint an optimistic picture for potential European colonization), or did their observations of large openings actually reflect a predominant landscape condition of openness? Opinions regarding this question vary greatly among ecologists and environmental historians. Many believe the southern New England landscape was predominantly forested, but others believe it was semi-open—perhaps half woodland and half grassland—or even predominantly open. Which position is closer to the truth? A quantitative, independent assessment using pollen analysis provides an answer.

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Passenger pigeon.

Reconstructing Regional Landscapes with Pollen Analysis

Palynology involves identifying and quantifying fossil pollen from wetland sediments to reconstruct changes in plant communities over centuries and millennia. Here's how it works. When pollen is released from plants and lands on a pond or lake, the grains sink to the bottom and are incorporated year after year into the accumulating sediments. These layers of sediment remain largely undisturbed and therefore act as a natural archive of the surrounding landscape's vegetation. By extracting a sediment "core" and identifying and counting different pollen grains in these sediments, researchers can calculate the relative abundance of each pollen type and display these data alongside the corresponding age of the sediment (determined by radiocarbon and other dating methods).

Tom Webb, a paleoecologist from Brown University, examined the fossil pollen from a large number of ponds in the midwestern United States and determined the percentage of open field pollen types that corresponded to certain vegetation types (i.e., prairie, forest, or a mix of both). For example, ponds within a prairie landscape collected at least 20 percent "prairie forb" pollen (a combination of four types of weedy, open field plants) in its sediments, ponds within a mosaic of woodland, and prairie vegetation collected 5 percent to 20 percent forb pollen, and ponds surrounded by predominantly forest vegetation collected less than 5 percent forb pollen. What do Connecticut and inland Massachusetts ponds show? Forb percentages that occur in sediments just before European arrival are less than 4 percent and in most cases less than 2 percent. After widespread European settlement, forb levels reach 5 percent to 20 percent, revealing the mosaic of open and forested land that characterized the 18th- and 19th-century agricultural landscape when 30 percent to 70 percent of Connecticut was open field. In 1636, Mr. Hooker almost certainly encountered a landscape more diverse than just a "pathless woods"—likely passing agricultural fields, clearings, and burns near Nipmuc settlements in what became Grafton and Dudley, Massachusetts, and in Woodstock, Connecticut; beaver (*Castor canadensis*) meadows and other open wetlands near streams; and perhaps recent blowdowns from the great colonial hurricane of 1635 that tracked through Rhode Island and southeastern Massachusetts. Even the intact oak forests were probably relatively open with widely dispersed trees, given their advanced age and the droughty climate of the time period. But the paleoecological evidence is unequivocal: The original landscape of interior southern New England was predominantly a forested landscape.

Landscape Change After Three Centuries

Were a traveler to retrace Mr. Hooker's steps in 2014, without a doubt the most dramatic change she would see are the extensive paved roads and residential and industrial development dissecting the landscape. Accompanying this development is the fragmentation and overall diminishment of the forest, relative to that which occurred in the early 17th century. Although forest cover has rebounded dramatically since approximately 70 percent of Connecticut was cleared during the agricultural peak in the mid-19th century, recent deforestation has left only about 55 percent of the state in forest today, far lower than the estimated 90 percent in 1630.

Loss of Important Species

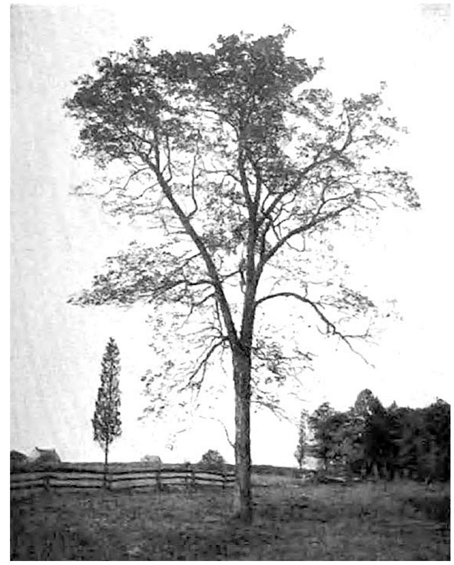
Although chestnut was considerably less abundant in the pre-colonial forests of Connecticut than is generally believed, the demise of chestnut to the Asian chestnut blight (*Cryphonectria parasitica*) in the early 20th century is certainly the most dramatic change in Connecticut's forest composition from 1636 to 2014. The chestnut fungus attacks the stem of larger trees but not the root systems, causing the tree to resprout, only to be killed again by the blight before reaching reproductive age. In contrast to the towering chestnuts that Mr. Hooker and company would have passed in 1636, a traveler today would see chestnut trees in miniature.

The region's largest wild canid has also shrunk. Instead of the deep howls of wolves likely heard by Mr. Hooker and company, our 2014 traveler would hear higher-pitched, more yappy howls from the eastern coyote (*Canis latrans "var"*), half the size of its larger cousin. With bounty hunting eliminating the gray wolf from southern New England by the 19th century, the smaller coyote moved into the region from the Great Plains in the 20th century, acquired some wolf DNA along the way, and partially filled the ecological niche left by the wolf.

But perhaps the most dramatic (and tragic) change experienced by the modern-day traveler with respect to changes in flora or fauna would be the skies and tree canopies devoid of passenger pigeons—hunted to extinction by the late 19th century. Whereas Mr. Hooker and company would have potentially passed beneath roosting or nesting pigeon flocks that were hundreds or even thousands of acres in size, a traveler today wouldn't see anything even remotely comparable in the avian world.

Alien Forest Pathogens

Unlike the chestnut blight that eliminated chestnut from the canopy in a few decades, other introduced forest pathogens arriving in the late 19th and early 20th centuries such as beech bark disease, Dutch elm disease, and white pine blister rust have had far less serious effects on their hosts in the intervening years. Neither beech, white pine, nor elm has changed significantly in abundance in Connecticut when one compares the witness tree data to the U.S. Forests Service's Forest Inventory and Analysis data (covering trees with stems greater than 5 inches in diameter). Hemlock may be the most surprising story of all. Despite over a quarter century of exposure to the hemlock woolly adelgid (*Adelges tsugae*), approximately 1 in every 15 trees in Connecticut today is a hemlock compared with about 1 in every 60 during the colonial period. Hemlock has suffered significant declines in the past 25 years from the woolly adelgid, but other factors—perhaps increased precipitation, the loss of chestnut (which once occupied an ecological niche similar to the hemlock's today), and fewer fires—have greatly increased this tree in Connecticut since colonial times.



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Hickory 1920.

Alien Trees

Although alien shrubs and herbs have proliferated in Connecticut's forest understories, the same cannot be said for alien trees. Less than 0.3 percent of Connecticut's standing timber is alien to the United States. These species include Norway maple (*Acer platanoides*), Norway spruce (*Picea abies*), tree of heaven (*Ailanthus altissima*), and apple (*Malus spp.*). In general, a traveler in the 2014 forest would encounter very much the same tree species that Mr. Hooker observed in 1636. The size (for example, chestnut) and the frequency at which these trees occur today relative to 1636, however, is another matter.

The Decline of Oak and the Rise of Maple

Although overshadowed by the loss of American chestnut, white oak—the true original king of the forest—has declined sixfold in modern times—reduced from 1 of every 3 trees to 1 of every 20 today. Although still locally abundant in some areas, white oak has generally faded into the background in our hardwood forests. Oaks, in general, are no longer the most abundant trees. Whereas almost 70 percent of the trees that Mr. Hooker and his followers passed from Woodstock to Hartford would have been oaks, today oaks would number closer to 25 percent. Replacing the oaks have been red maple and to a lesser extent black birch (*Betula lenta*). Maples in total have increased from less than 4 percent of all trees in Connecticut's original forest to about 32 percent of all trees today, and most of those are red maple. Red maple *alone* is more abundant than all oaks combined. The larger oaks do, however, maintain a greater cross sectional (basal) area than maples do across the state.

Why the proliferation of red maple? Recall that red maple is the most ecologically versatile tree in our forest. In contrast to Connecticut's original old-growth forests, today's southern New England forests are on average only 80 to 100 years old, well within the 150–300-year lifespan of red maple. These forests owe much of their origin to the intensive logging that occurred in the early 20th century, but before they were logged, many of these forests grew up on abandoned agricultural fields. Again, the observations of Henry Thoreau provide insights into the increase in maple and birch:

> The new woodlands, i.e. forests that spring up where there were no trees before, are pine, birch, or maple . . . But oaks, are not seen springing up thus . . . They form a sprout-land, or stand amid the stumps of a recent pine lot. (October 19, 1860)

Thoreau recognized that old fields in eastern Massachusetts generally reverted to pine, birch, or maple. In Connecticut, red cedar (Juniperus virginiana) often colonized old fields instead of pine, but birch and maple were still the predominant hardwood colonizers rather than oaks. Light birch and maple seeds blow readily into a forest clearing, whereas heavier oak seeds are dispersed by forest animals such as blue jays (*Cyanocitta cristata*) and squirrels, which tend to avoid pastures and old fields. Oaks are prolific stump sprouters, as Thoreau alluded to, which enabled them to fare well during the late 19th–early 20th-century period of heavy cutting. But the less-heralded red maple may be at least as prolific a stump sprouter as oak. One advantage that red maple has—as chestnut once did—over oaks is that it continues to produce viable stump sprouts at relatively large stump diameters. Data from permanent forest plots at Highstead, a 150-acre preserve in Redding, Connecticut, seem to confirm this trend: Red maple exceeds all oaks combined in multiple-stem trees that originated as stump sprouts.

In addition to the effects of logging and land clearance, fires are actively suppressed today. Burning by Native Americans, even if concentrated near their settlements, almost certainly exceeded the extent of burning that occurs in our modern landscape since strict fire suppression was enacted in the early 1900s. Red maple has undoubtedly benefitted from the elimination of this disturbance, as well as from a wetter climate that is generally more conducive to maples than to oaks. With its weaknesses (longevity and enduring fire and drought) mitigated in the modern forest and its strengths (colonizing cleared land and stump sprouting) promoted, it is no surprise that the most ecologically versatile tree has become the new dominant tree in Connecticut.

Where Is Hickory?

If chestnut was the king that never was in the original forests of Connecticut, then hickory may hold a similar place in the modern forest. "Oak-hickory" forest is considered the dominant forest type across Connecticut, suggesting that hickory is the most important species next to oak. But once again, the FIA data tell a different story. Hickory is ranked sixth in abundance behind pine, hemlock, birch, maple, and oak. Again, the root of this discrepancy may be traced to the early foresters. George Nichols in 1914 reported that oak-hickory forest in Connecticut "in many sites . . . may represent the ultimate formation." This notion of oak-hickory as a "climax" forest type has survived to the present day so that now a forest with oak and even a small component of hickory is labeled oak-hickory. Ironically, the precolonial forests of Connecticut were oak–hickory, as Mr. Nichols recognized, but are believed by many to have been dominated by chestnut. Today, Connecticut's forests are often *characterized* as oak-hickory when in reality they are maple-oak-birch forests.

Tomorrow's Forests

What will the next 375 years bring? Or even the next 100 years? Higher carbon dioxide emission scenarios project that Connecticut's climate will resemble today's South Carolina climate by the end of the 21st century; lower emission scenarios over the same time period project a Connecticut climate that resembles today's northern Virginia climate. Red maple seedlings perform especially well in elevated soil temperatures, showing that this versatile tree may be especially well adapted to a warming climate, enabling it to continue to thrive in our forests. As our forests continue to age, the longer-lived oaks may slowly begin to replace red maple; however, gypsy moth outbreaks and selective logging may continue to take their toll on oaks. Black birch will undoubtedly continue to thrive into the foreseeable future, as it is relatively long-lived (as long as 360 years) and has proven to be a successful gap-replacing specialist of disease-stricken trees like hemlock and chestnut. American chestnut could rise again, as occasional flowering chestnuts have been found, and researchers continue to work to breed a blight resistant tree. Hemlock will undoubtedly continue to decline from the hemlock woolly adelgid, particularly with increasing temperatures, which favor the cold-intolerant woolly adelgid. Cougars are expanding their range eastward and could recolonize the region in the coming decades.

These forest changes depend on Connecticut's forest remaining that—a forest. In the past 25 years, the state has lost about 7 percent of its forest area to development. "Hard deforestation"—through development—is permanent, unlike the "soft" deforestation of the 18th and 19th centuries, when woodlands temporarily became fields. Slowing development is a daunting problem. We see promising indications that landowners, land trusts, communities, businesses, philanthropists, and state and federal agencies are working to preserve forests. In the past 10-15 years, partnerships of these groups have increased by a factor of six in New England. Much uncertainty remains about the dynamics of Connecticut's future forest, but we know with great certainty what we must do to keep these forests standing.

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For a list of Mr. Faison's references for this article, visit ctwoodlands.org.