Wildly ADAPTABLE Trees

A look at Minnesota's forests today tells which species have successfully adapted to changes on the landscape.

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&
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IMAGINE YOURSELF strolling through a lush, layered forest of towering centuries-old red and white pine trees. An occasional giant sugar maple and yellow birch splash bursts of vibrant red and yellow in the deep green canvas surrounding you. A soft carpet of needle and leaf litter cushions your steps as you wind through huge, downed logs draped in chartreuse moss. The rhythmic drumming of a woodpecker accompanies the melodic flute of a thrush and the sweet song of a warbler. The air feels alive as you inhale the rich, earthy smells of decaying organic matter.

These were the wild forests that European settlers found when they arrived in Minnesota 150 years ago. At that time, forests covered about half the state, or almost 32 million acres. Today, forests cover roughly one-third of Minnesota, and they have lost

Photography by Welby Smith

WHITE PINE STAND

some of their wild character. The giant elders of the forests are mostly gone, removed by loggers in the early days of settlement. Less than 4 percent of the original forests remain untouched. The forests of today are simpler, with fewer age classes of trees, less structural diversity, and a different proportion of species in the forest community.

At the time of settlement, the most common tree species was tamarack *(Larix laricina),* trembling aspen *(Populus tremuloides)* was second, followed by bur oak *(Quercus macrocarpa),* then paper birch *(Betula papyrifera).* How do we know this history? Between the years 1847 and 1908, a government-sponsored project enlisted dozens of survey crews to create the Public Land Survey of Minnesota.

The land survey created a statewide grid of 1-mile-square sections with the corners of each section actually marked on the ground. To help relocate the corners, the surveyors selected nearby trees as *bearing trees.* Typically, each corner had four bearing trees. For each tree the surveyor recorded the species name, the diameter of the trunk, distance to the corner, and its azimuth, or bearing, from the corner (hence the phrase *bearing tree*). Each surveyor recorded these data in field notebooks, which are archived by the Minnesota Historical Society. When added together, the field data described a total of 352,896 bearing trees—a gold mine of natural history for ecologists today.

The difference between the tree species that are still abundant today, like trembling aspen, and those that have fared less well, like bur oak, is a matter of adaptation. Those that were, by chance, pre-adapted to the effects of logging have flourished, while those that required the ancient process of fire and flooding have not fared as well. The adaptive strategies of tree species are as unique as their leaves and bark, and understanding those strategies provides insight into a tree's evolutionary history.

ASPEN CATKINS

Most *Populous* Poplar

Ecologists have determined that trembling aspen has now become the most abundant tree in Minnesota. There are about 3.5 billion aspens in Minnesota today. And this success happened at the expense of red pine and white pine.

With little thought of conservation, early timber companies cut the biggest straight pines. The harvesting process left discarded branches and broken limbs, termed *slash,* covering large parts of the landscape. When the slash dried, it fueled devastating fires that left nothing standing. The raging fires burned the pine seeds on the

ground before they could sprout. And there were few standing pines left to spread new seeds.

But trembling aspen was adapted to these conditions. Fire actually stimulates dormant buds on the roots of aspen to sprout new stems, or suckers. In fact, a single root system can sprout dozens or perhaps hundreds of new stems. Each stem appears to be an individual tree, but actually they are all connected to a single existing root system.

With no competition to impede it, aspen spreads rapidly using its long invasive roots and suckering ability to quickly revegetate the charred landscape. Current forest management practices and demand for wood pulp will assure the continued existence of aspen in Minnesota, but effects of climate change could shrink its range and abundance.

Grow Fast, *Die* Young

COTTONWOOD CATKINS

THE FLOOD PLAINS of large rivers in southern Minnesota were once the exclusive realm of tall cottonwoods *(Populus deltoides* var. *occidentalis)*, silver maples *(Acer saccharinum)*, and black willows *(Salix nigra)*. Few other species could survive the scouring torrents of spring floodwater and the destructive forces of ice floes. The cottonwood's response to this flood-prone environment is a classic study in tree adaptation.

Cottonwoods reproduce only by seed, but a single tree can produce up to 48 million seeds each year. Seeds are released in late May just as spring floodwaters are receding. Newly exposed sand and silt make an ideal seedbed, allowing the seeds to germinate almost immediately and grow as much as 2.5 feet by autumn of the first year.

Although flooding is easily tolerated, shade is not. So the young cottonwood must grow tall and fast to keep ahead of competitors. In Minnesota a cottonwood can grow to a height of 120 feet in less than 60 years—it is said to be the fastest growing tree in North America—but it pays the price. Few cottonwoods live past 100 years, and those that do survive long suffer broken limbs, decayed cores, and scarred trunks.

Dams, levees, and channel straightening conducted in the early 20th century tamed rivers and streams, turning torrents into placid pools and flood plains into prime

agricultural land. Cottonwood, as a species, is still common in Minnesota, but it is usually seen as single specimens or small groves at the edge of a stream or marsh. It may never again dominate large tracts of forest.

BUR OAK

Growth by Fire

ANOTHER fascinating story of adaptation of a species to a dynamic natural system is bur oak *(Quercus macrocarpa)* in oak savanna. Savannas, native plant communities with a mosaic of trees and prairie grasses, developed where prairie met forest. Most tree species could not get a foothold in the prairies due to frequent wildfires, but bur oaks devised a strategy to withstand fire. An acorn quickly sends down a taproot that can reach 4.5 feet deep by the end of the first year. Because energy is directed to the root system, the above-ground stem may be only 6 inches tall.

When the next fire sweeps over the surface, the stem might be killed, but the oversized root system will easily survive. The root system can sprout a new stem that grows faster and taller than the previous one, allowing the young oak

to make some headway before the next fire. If this sequence repeats often enough, the oak could develop into a shrublike "grub"—a 2- to 10-foot-tall tree that looks like a bush above ground but harbors a deep and vast root system that is centuries old.

These oak grubs are rarely seen anymore. Their savanna habitats have been reduced to small fragments that are isolated from the fire that sustained them. As few as 12 to 15 years without fire is enough for a grub to grow into a tree with thick fire-resistant bark. When deprived of fire, savannas will succeed into a forest community and lose their characteristic savanna flora. Bur oak need sunlight for their acorns to sprout and grow, so they fail to reproduce in shaded forests and the next generation of forest trees will not include bur oak.

Acorn Synchronicity. Oaks give us another mystery to ponder. The oak seed is an acorn, and in some years oak trees produce a lot of acorns. Other years, they produce practically none at all. Following a particularly large acorn crop, oaks usually have two to four years with little or no acorn production.

This pattern is typically synchronized within each oak species over large geographic areas, with each species being on a different cycle. Bur oak seems to be on a two-year cycle, with good acorn crops statewide in 1994, 1996, 1998, 2000, and 2002, and poor crops in the intervening years. White oak and northern red oak appear to be on a three-year cycle and had good crops statewide in 1994, 1997, and 2000. The cycles of all oak species seemed to converge in 2000 with an extraordinary combined crop of acorns throughout Minnesota and much of the Midwest. Predictably, 2001 was

BUR OAK ACORNS

a poor year for acorn production, and no species produced an abundant crop.

The acorn crop is called *mast,* and this phenomenon is called *mast-fruiting.* It has been suggested that weather conditions control the synchronicity of mast-fruiting. But the cyclical aspect is likely inherent within each species and is apparently an evolved survival strategy. The survival benefits of mast-fruiting are not known, but it is often speculated that in years of little or no acorn production, populations of seed predators (such as squirrels and deer) may decline. With fewer seed predators in years of large mast production, the predators are easily satiated, allowing large numbers of acorns to survive and germinate.

New *Tree* Discoveries

Of about 20,000 tree species in the world, 92 are considered native to Minnesota There are an additional 131 shrub species and 12 species of woody vines native to Minnesota. The rarer ones can be difficult to find, even when we know they are out there. Occasionally a species entirely new to Minnesota is discovered. While doing research for the upcoming book *Trees and Shrubs of Minnesota*, I made several such discoveries, including two species of hawthorn (*Crataegus* spp.) that were discovered while teasing apart the 12 species in this particularly perplexing group.

Welby Smith, *DNR botanist*

KENTUCKY COFFEE TREE SEEDPODS

Adaptations of a Different Era

WHEN deprived of natural pollinators or seed dispersal agents, some highly specialized tree species will likely suffer. The native but enigmatic Kentucky coffee tree *(Gymnocladus dioica)* has perhaps outlived its seed disperser. An inhabitant of river valleys in southern Minnesota, the Kentucky coffee tree is the last to leaf out in the spring and one of the first to drop its leaves in the fall. In fact, because this species has no leaves for at least seven months of the year, healthy trees are often mistaken for dead. The leaf itself is the largest of any tree in northern climates, nearly 3 feet long with as many as 100 individual leaflets.

The tree's large, strangely shaped seedpods are another mystery. No animal that currently shares its habitat is known to eat them or to disperse the seeds they carry within. The pods simply fall from the tree and rot where they land. One theory holds that the animal evolved to disperse the seeds may have become extinct near the end of the Pleistocene Epoch about 13,000 years ago, when many large North American mammal species became extinct. This could explain why Kentucky coffee trees have become so scarce and why the surviving populations are now so isolated and scattered.

Minnesota's *Rarest* Tree

EASTERN HEMLOCK *(Tsuga canadensis)*, one of Minnesota's most imperiled trees, has been unable to keep up with environmental changes. It was rare even before the era of unrestrained logging and slash fires, but its future in Minnesota is even more tenuous now.

The state's largest reported hemlock stand, nearly 5,000 trees of all sizes, was near the town of Paupores in St. Louis County. In 1912, about 8,000 hemlock railroad ties were cut from this stand. To protect the remaining trees, a state park was proposed for the site. The Moose Lake–Cloquet fire of 1918 intervened, destroying all but a few individual trees, which eventually died.

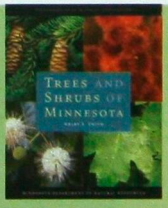
Currently there are around 10 known hemlock stands in Minnesota. The largest consists of 14 mature trees and fewer than 50 juveniles and seedlings. Other sites may have only a few trees, with little if any reproduction.

Eastern hemlock is a species of stable, old-growth forests. Reproduction takes place only where there is deep shade and moist, undisturbed forest soils. When forests are cut, sunlight warms and dries the soil, giving the advantage to other tree species. This may be one reason hemlock didn't fare well in Minnesota during the logging and land clearing in the early part of the 20th century. Predation by deer and porcupine may have contributed to the decline.

The future might not look much better for hemlock in Minnesota. We know it needs a moist climate, especially in autumn, and some climate change predictions posit that Minnesota may get warmer and drier in the years to come. But other forecasts suggest a warmer and wetter climate, which would be more hospitable to hemlock.

The composition of Minnesota's future forests, in an era of global warming, will largely depend on each species' adaptations. Trees evolved exquisite adaptations over millennia. But the climate changes that trees face today are happening quickly, perhaps within only one or two tree generations, far too quickly for trees to change their strategy. It will be the most rapid, large-scale change to Minnesota's forests since logging and settlement, when grand stands of towering pines fell and were replaced by legions of aspens.

EASTERN HEMLOCK CONES



New Resource

Learn more about Minnesota's native trees in Trees and Shrubs of Minnesota, *by DNR botanist Welby Smith, just published by University of Minnesota Press and available in bookstores and online.*

www.mndnr.gov/magazine

Test your tree smarts with an online quiz.