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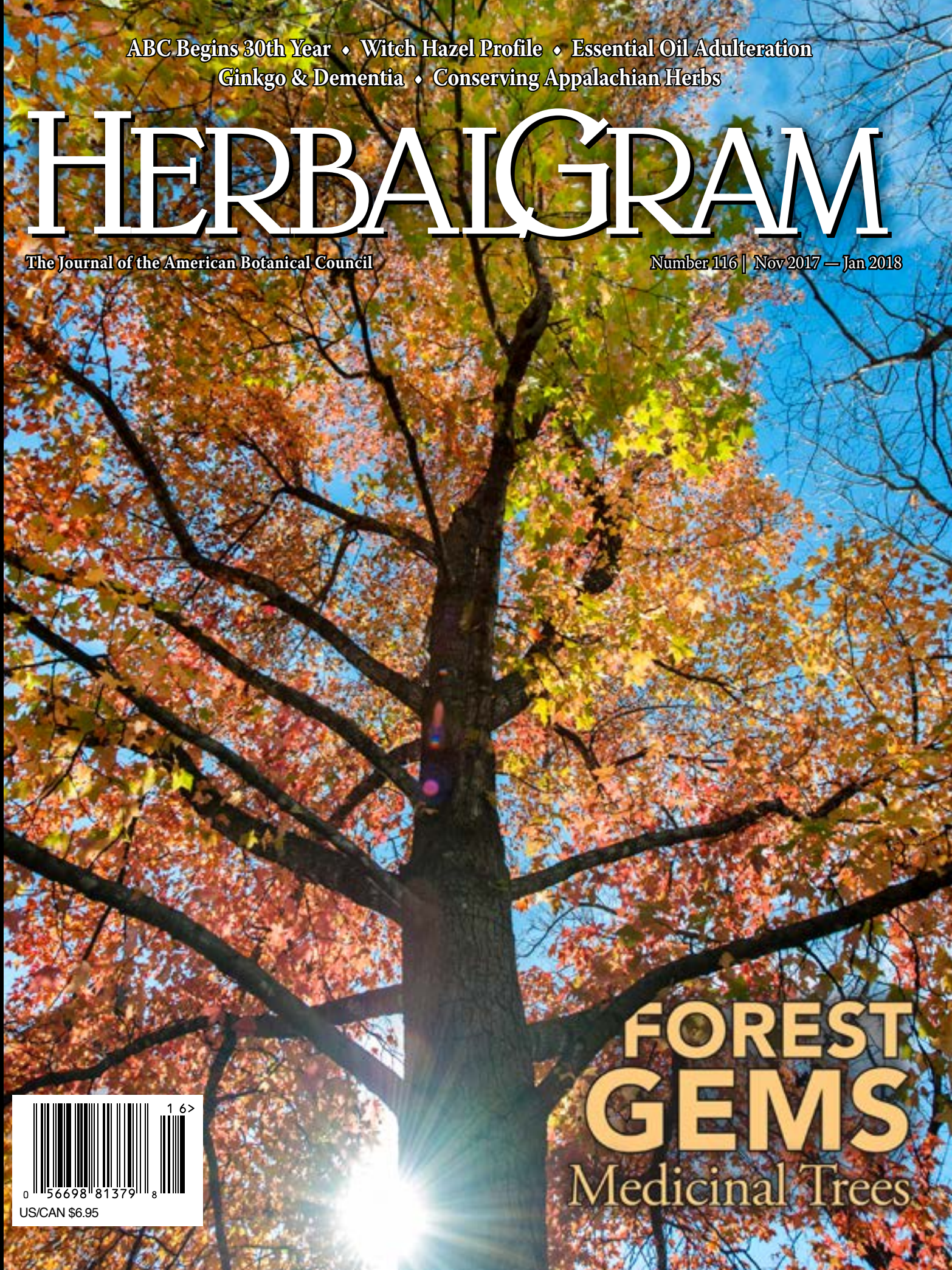

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FOREST GEMS

Exploring Medicinal Trees in American Forests

By Steven Foster

INTRODUCTION

When Odysseus returned from Troy after a 20-year absence, he found his aging father planting trees around his home. Odysseus asked, "Why, being now so far advanced in years, would you put yourself to the fatigue and labor of planting that which you are never likely to enjoy the fruits?" The old man, taking him for a stranger, replied, "I plant trees for the benefit of my son."

The benefits of many trees outlast the human lifespan. Trees have always played an important role in human affairs, one so intimate that these arborescent living giants are often taken for granted and neglected: they are just there. Trees have provided humans with shade, shelter, materials for a vast array of objects, fuel, food, medicine, and oxygen. They also provide a gift for future generations. Their uses are almost endless.

This article is not born of the expertise of the forester or the taxonomic skills of the botanist; rather it is born of the curiosity of the herbalist. When botanists speak of herbs, they refer to herbaceous plants, those species without a persistent woody stem that die back to the ground each year. The botanist's tree or shrub has a woody stem or trunk. When an herbalist speaks of an "herb," he or she means any plant with fragrant, culinary, and/or medicinal qualities. This article deals with both the botanist's trees and the herbalist's herbs, which take their form as trees.

Humans came out of the forest in transit from hunter and gatherer to cultivator of plants. Once-heavily forested regions have been denuded of trees to make way for the cultivation of herbaceous plants as food.

Though humans plant trees in rows for fruits, nuts, and timber, the attitude of clearing a forest to make way for other agricultural pursuits persists in the human mind. Rather than viewing trees as temples of life, humans tend to look at them in terms of board feet for timber, cords for fuel, or as simple nuisances that prevent the soil from being pierced with a plow. This is particularly acute in tropical rain forests today. How often has this cycle been repeated in human history? How many great civilizations have bitten the dust because of arrogance?

Having inhabited the earth long before humans, trees deserve respect. Forests are often looked upon as mines. While developed countries import large quantities of exotic hardwoods, which despoils tropical rain forests, humans also clear cut American hardwoods, bulldoze them into piles, then plant pines in their place. Perhaps woodworkers should plant a North American hardwood for each piece of furniture produced.

Sassafras *Sassafras albidum*
Three-lobed leaf in autumn.
Photo ©2017 Steven Foster

Can humans afford to continue a way of thinking born of the 18th-century mind: that our fields and forest are unlimited resources? The answer is obvious. Take a stroll among the trees. Foray among the myriad human uses for trees in these personality profiles* of six trees from the eastern deciduous forest. May it help to create a greater appreciation and respect for trees as medicinal (and otherwise useful) herbs.

* Adapted from the forthcoming book *Benevolent Trees* by Steven Foster.

Sweetgum *Liquidambar styraciflua* backlit at sunset.
Photo ©2017 Steven Foster

BLACK WALNUT – *JUGLANS NIGRA*

From the stocks of Revolutionary War muskets to the rich veneer of the finest Victorian furniture, the American black walnut (*Juglans nigra*, Juglandaceae) has been the most venerated of American hardwoods since European settlers first set foot on North American shores. The wood was exported to England as early as 1610, with live fruits introduced by 1656. John Parkinson described the species in his herbal *Theatrum Botanicum* in 1640. When colonists first started harvesting the tree, it was abundant, but today, it is more scarce through much of its natural range than it once was.[1]

The black walnut grows in rich bottomlands and fertile hillsides from western Massachusetts and southern Ontario to South Dakota, Illinois, Indiana, Arkansas, and Texas, eastward to western Florida. It is now most abundant in the Ohio and Mississippi valleys and on the western slopes of the Appalachians.

Black Walnut *Juglans nigra* tree lit by morning sunlight.
Photo ©2017 Steven Foster

The native black walnut is one of the most important economic trees in the eastern deciduous forest as a source of both cultivated and wild nuts, dyes, wood materials, and biologically active compounds. In fact, it is the most important tree to the Ozark economy. Each year, the beginning of October marks the start of the buying season for wild black walnuts in the Midwest, where more than 200 buying and hulling stations spread across 11 states purchase upwards of 30 million pounds (more than 13.6 million kilograms) of whole walnuts. The vast majority are purchased by the Hammons Products Company in Stockton, Missouri, the world's largest processor and supplier of American black walnuts. The 2017 buying season began on October 2, with an opening price of $15 per 100 pounds after hulling.[2]

Hullers remove the green outer pericarp of the fruit. If picking up whole walnut fruits, one should be aware that the green husks can cause contact dermatitis, and that the husks' juglone content — a natural allelopathic naphthoquinone that thwarts competing plant species beneath a walnut tree — will stain clothing and skin orange-brown to black. Juglone and extracts of walnut hulls have potential as broad-spectrum biocides or bio-herbicides.[3]

Black Walnut *Juglans nigra*
Whole fruits on tree.
Photo ©2017 Steven Foster

The green outer husk itself is commonly discarded by commercial walnut hullers, but an unknown percentage of the dried pericarp is sold in the botanical trade. The use of the American species seems to have mirrored that of the English walnut (*J. regia*). Traditional uses of black walnut for treating intestinal parasites, for example, stem from the historical use of English walnut for similar purposes. As noted by R.E. Griffith (1847), "The rind of the unripe fruit is said to remove ringworm and tetter [eczema]; and a decoction has been given as a vermifuge with some success."[4] Culbreth (1906) reiterated similar uses.[5] Ethnobotanist James A. Duke, PhD, (1989) recognized the continuation of this traditional use. Black walnut was never official in the *United States Pharmacopeia* (USP).[6]

The husk contains potentially useful phenolic compounds with antimicrobial and antioxidant activity. In 2016, Wenzel et al. developed a supercritical fluid carbon dioxide extraction method with an ethanol modifier that unlocked the potential to concentrate antioxidants from walnut husks.[7]

The hard inner shell encasing the walnut kernel or meat is not discarded, but is valuable as an industrial abrasive. It is sold in a variety of grades and six standard particle sizes as a soft, reusable abrasive for blast-cleaning and polishing soft metals, fiberglass, plastics, wood, and stone. As a tumble polish, it is used for jewelry, ink pens, and surface preparation for painting, among other purposes. In the oil industry, it is used to make and maintain seals. For water filtration, black walnut hull particles are used in the separation of small-particle solid contaminants suspended in water.[8]

Within the green outer layers lies the inner pericarp, or the hard shell surrounding what humans and squirrels eventually hope to reach: the kernel or walnut itself. Native groups throughout the tree's range prized the kernels as food, and they were eaten plain, sweetened with honey, and cooked in soups.[9] James Mooney (1932) wrote that it was taboo for pregnant women to eat walnuts for fear that the child's nose would be overly broad.[10] Nutrient-dense black walnuts are high in lipids, protein, fiber, vitamins, and minerals, as well as phenolic compounds and phytosterols. They are a rich source of fatty acids including oleic acid, omega-6 linoleic acid, and omega-3 alpha-linolenic acid, among others.[11]

Black Walnut *Juglans nigra* green outer pericarp, which turns black upon drying, is sold dried in the botanical trade. Photo ©2017 Steven Foster

In 1837, the Legislature of Massachusetts initiated a study of the woody plants of the state by George B. Emerson, a distinguished Boston schoolmaster. This culminated in the publication of *A Report of the Trees and Shrubs Growing Naturally in Massachusetts* (1846), which appeared in four more editions by 1906. In summarizing the value of the walnut, Emerson wrote: "It thus unites almost all the qualities desirable in a tree … beauty, gracefulness, and richness of foliage, in every period of its growth; bark and husks which may be employed in an important art; fruit valuable as food; wood unsurpassed in durability for use, or in elegance of ornament."[12]

DOGWOOD – *CORNUS FLORIDA*

No tree in the eastern deciduous forest heralds spring's arrival with greater surety than the flowering dogwood (*Cornus florida*, Cornaceae). In a range extending from Maine to Florida and west to Minnesota and Texas, native groups marked the beginning of the anticipated renascent season with the blooming dogwood. For indigenous peoples and European settlers alike, the unfurling of the venerable dogwood blooms indicated the proper time for planting corn.[3]

Dogwood has sometimes been called boxwood, referring to the similar qualities between it and the European boxwood (*Buxus sempervirens*, Buxaceae). Because it wears slowly and is very hard, dogwood was used to make mill wheel cogs and the small parts of other wooden machinery that was susceptible to wear. Forks, spoons, rulers, chisel and hammer handles, mallet heads, and wooden vices are just a few implements the 19th-century woodworker made from this durable material. Weavers have long used shuttles and bobbins made from this wood.[12]

Chewing sticks, the forerunners of toothbrushes, were known for helping maintain white teeth. Dogwood twigs are chief among the chewing sticks in North America. William P.C. Barton (1786-1856), physician and medical botanist, observed in his *Vegetable Materia Medica of the United States*:

Dogwood *Cornus florida* flower cluster surrounded by the white leaflike bracts, which are commonly referred to as "dogwood flowers." Photo ©2017 Steven Foster

> The wood of the *Cornus florida* is much used by Dentists, in the insertion of artificial teeth; and the young branches stripped of their bark, and rubbed with their ends against the teeth, render them extremely white. The creole negroes who inhabit Norfolk in Virginia in great numbers, are in the constant practice of substituting the dogwood twigs, for a West Indian shrub in cleansing their teeth. The striking whiteness of these, which I have frequently observed, is a proof of the efficacy of the practice. The application of the juice of these twigs to the gums, is also useful in preserving them hard and sound.[13]

Barton's more famous uncle, colonial physician Benjamin Smith Barton, also extolled the value of flowering dogwood. "The ripe fruit, or berries, infused in spirit or brandy, make an agreeable bitter," he wrote. "Our Indians employ an infusion of the flowers for intermittents [fevers]. The same infusion has been recommended by some in flatulent cholic. I have used it as a tea."[14]

Historically, physicians in North America held dogwood bark in high esteem as a potential antimalarial. Dogwood's inner bark became a preferred indigenous alternative to the high-priced and often-adulterated Peruvian bark, Jesuit's bark, or cinchona (*Cinchona* spp., Rubiaceae), the chief source of the drug quinine.[15] Dogwood bark, preferably that of the root, was substituted for cinchona in the treatment of intermittent fevers (a telltale symptom of malaria). Primarily used in the form of powdered bark or tincture, dogwood's effects were also considered astringent, tonic, and antiseptic. The bark was most often used after being cured for a year, because the fresh bark tends to irritate the stomach and bowels. During the American Civil War (1861-1865), in the South, dogwood was used almost exclusively over cinchona due to lack of availability of the latter.[16] From 1820 through 1894, the inner bark of the flowering dogwood was an official remedy in the USP.

Several recent studies have analyzed possible antiplasmodial compounds from dogwood. Graziose et al. (2012) at Rutgers University looked at the dried powdered bark extracted with 95% ethanol and found that antiplasmodial-guided fractionation revealed eight compounds with moderate in vitro antiplasmodial activity, none of which were effective enough to explain the historical use of flowering dogwood as an antimalarial remedy. However, they did show that several compounds possessed promising in vitro activity against *Leishmania* parasites.[17]

Flowering **Dogwood** *Cornus florida* tree in full bloom.
Photo ©2017 Steven Foster

Dogwood *Cornus florida* in autumn.
Its bright red fruit is unpalatable to humans, but commonly eaten by birds and other wildlife.
Photo ©2017 Steven Foster

A new iridoid glucoside (cornusoside A), four new iridoid aglycones (cornolactones A–D), and 10 known compounds were isolated from *C. florida* leaves collected at the University of Mississippi. The *Cornus* genus is a rich source of iridoid glucosides with potential antidiabetic, antioxidant, anti-inflammatory, anti-amnesic, and immunosuppressive activities.[18] In addition, cyanidin 3-*O*-galactoside and cyanidin 3-*O*-glucoside are the first biologically active anthocyanins from dogwood fresh fruits to have been quantified.[19]

The white robe of dogwoods in bloom makes it one of the fairest trees of North American forests. However, for four decades, once-abundant populations of the fair dogwood have been decimated by a disease known as dogwood anthracnose. The disease is caused by *Discula destructiva*, a fungus first identified in 1991 and thought to have originated with kousa dogwood (*C. kousa*) horticultural stock from Asia.[20] Widely planted in North American horticulture, the Asian kousa dogwood produces fruits that are not eaten by North American song birds. With the extensive mortality of *C. florida,* many birds and mammals throughout eastern North America are deprived of an important fall food source.[21]

SASSAFRAS – *SASSAFRAS ALBIDUM*

"That sassafras tea was a very common beverage in my boyhood days," wrote Eclectic pharmacist John Uri Lloyd in 1911, "may be shown by the following incident: I was traveling up the Ohio River on one of the palatial steamers of other days, and the waiter asked a Kentuckian at my side who ordered tea, 'what kind of tea' he wanted. 'Store tea,' he answered, 'I kin get plenty of sassafras at home.'"[22]

Perhaps no other tree holds such an important place in American history. One of the first natural products from the New World, sassafras (*Sassafras albidum*, Lauraceae) exports rivaled those of tobacco (*Nicotiana tabacum*, Solanaceae). As a salubrious tea and a traditional "blood thinner," sassafras' fame is unsurpassed. Sassafras has also been used as a controversial "health food." The sassafras story is one of fact, fallacy, and fortune — a story that has yet to end.

The dried leaves of sassafras were used by native groups and subsequently by Cajun settlers as a soup base. The leaves are powdered, then sifted to remove stringy fibers. These dried and powdered leaves, which are very mucilaginous and give soup a ropy consistency, are the base of the traditional southern American dishes gumbo filé or gumbo zab and are added at the end of preparation as a thickener. Agricultural chemist and inventor George Washington Carver, DSc, PhD, of peanut (*Arachis hypogaea*, Fabaceae) and sweet potato (*Ipomoea batatas*, Convolvulaceae) fame, said of sassafras leaf powder: "It can be cooked with the soup, etc., or put in a salt shaker and placed on the table to be used at will, like salt and pepper. It is most wholesome and appetizing."[23]

Sassafras tends to be more shrub-like in the northern part of its range, typically growing up to 30 feet tall with a trunk up to a foot in diameter. However, George B. Emerson (1846) described a sassafras tree in Cambridge, Massachusetts, that was more than 60 feet tall and three feet in diameter. "It was felled and its roots dug up, to allow a stone wall to run in a right line," he lamented. "Such pieces of barbarism are still but too common. A tree so beautiful and lofty, of such rare dimensions, such an ornament to a bare hillside, sacrificed to the straightness of a wall!"[24]

Sassafras *Sassafras albidum* inner bark oxidizing, turning cinnamon brown in color. Damage from beavers exposes the lighter wood beneath.
Photo ©2017 Steven Foster

Sassafras *Sassafras albidum* leaves, which are typically oval, mitten-shaped, and three-lobed, turning color in autumn. Photo ©2017 Steven Foster

Sassafras *Sassafras albidum* leaves emerging in spring. The leaves are commonly enjoyed by wild food foragers and enthusiasts. Photo ©2017 Steven Foster

Sassafras albidum is a member of the laurel family (Lauraceae). The North American *S. albidum* is one of three known species in the genus.[25] The other two are East Asian natives. *Sassafras tzumu* is indigenous to Anhui, Fujian, Guangdong, Guizhou, Hubei, Hunan, Jiangsu, Sichuan, Yunnan, and Zhejiang provinces and the Guangxi autonomous region in China, and it contains approximately 1% essential oil with safrole as the primary component. *Sassafras randaiense* is found on high mountains in broad-leaved evergreen forests in central and southern Taiwan. All three species are very closely related.[26]

The first detailed record of sassafras and its healing properties comes from writings of the Spanish physician Nicolás Monardes of Seville (1574). Monardes' records come not from personal experience or travels to the Americas, but accounts from travelers and government records. Prior to 1574, sassafras had, for some years, been imported into Spain from its Florida expeditions. The remaining French settlers from the French Huguenot immigrants who settled Florida from 1562-1564 are said to have recommended sassafras to the Spaniards to treat fevers, unwholesome drinking water, and other diseases arising from the swamp miasma. The French first learned of the virtues of sassafras from the native groups of the Florida peninsula.[27]

Sassafras was one of the first exports from American shores. The Spaniards and French imported sassafras, or fennel wood, as it was known, to the European continent before the English did. It was well known in Germany by the 1580s. As early as 1585, a publication from Walter Raleigh's second excursion to America deemed sassafras a "merchantable commodity." In June 1603, an English merchant, Martin Pring, arrived on the American coast and sailed south until he found a suitable place to collect sassafras. He loaded two ships' holds with bark and root, then set sail for England with his cache. By 1610, the root fetched a price better than 50 pounds sterling per ton. The 1618 *London Pharmacopoeia* proclaimed sassafras imports to be equal to those of tobacco.[28]

One reason for its European popularity was its supposed ability to cure syphilis. As American physician and botanist Jacob Bigelow noted in 1818:

> The bark and wood of the sassafras were formerly much celebrated in the cure of various complaints, particularly syphilis, rheumatism, and dropsy. Its reputation, however, as a specific in those diseases, particularly the first, has fallen into deserved oblivion, while it is now recognized only with regard to its general properties, which are those of a warm stimulant and diaphoretic.[28]

The most well-known use for sassafras oil was in the flavoring industry in which it was used to flavor root beer, candies, and chewing gum. The chief chemical constituent of sassafras oil, safrole, comprises 80-90% of the weight of the oil and is responsible for the characteristic flavor of sassafras. Safrole is found in the essential oils of at least 70 other plants, including some common culinary herbs, such as basil (*Ocimum basilicum*, Lamiaceae), nutmeg (*Myristica fragrans*, Myristicaceae), and star anise (*Illicium verum*, Illiciaceae).

Resulting from studies conducted on the effects of safrole administered by injection in rats, a ruling published in the *Federal Register* on December 3, 1960, prohibited the further use of safrole in foods. Laboratory tests conducted by the US Food and Drug Administration (FDA) found safrole to cause liver cancer in rats. At this point, the beverage industry voluntarily withdrew safrole as a flavoring agent for root beer and related products.

According to Arthur O. Tucker, PhD, safrole is a pre-hepatocarcinogen in humans (and dogs). It requires metabolic activation to become a carcinogen, but by itself, safrole is not highly carcinogenic. The leaves contain no or only trace amounts of safrole, by most reports, which is mostly concentrated in the essential oil of the root bark. Safrole shares some chemical similarities (and odors) with trans-Anethole found in anise (*Pimpinella anisum*, Apiaceae) and estragole found in tarragon (*Artemisia dracunculus*, Asteraceae), basil, and fennel (*Foeniculum vulgare*, Apiaceae), for example.[29]

In 1974, the FDA expanded and clarified the earlier law to include the sale of sassafras root, bark, and leaves for the purpose of making an herbal tea. The FDA argued that the water used to make tea was a "food" and that the purpose of making sassafras tea was to extract safrole, the banned flavoring agent, into water. The FDA thereby attempted to define a substance used to make herbal tea as a "food additive," subject to the Delaney Amendment of the Food and Drug Act, which says essentially that any substance that causes cancer (including in experiments on animals) cannot be added to food.[30]

Subsequently, the FDA seized a supply of a California herb company's sassafras and attempted to take them to court for selling it as an herbal tea. The usual delays of such a court case resulted in the sassafras' becoming moldy in the warehouse, and by the time the case finally came to trial (three years later), the moldy sassafras was no longer fit for human consumption, and it was destroyed. In protest of the FDA's action, a token handful of sassafras was tossed into Boston Harbor from the Boston Tea Party Ships and Museum at a gathering of the then-fledgling, now-defunct Herb Trade Association in July 1978.

The case of sassafras' safety or potential to cause cancer has never been satisfactorily resolved. Is there actually safrole left in a cup of sassafras tea after it has simmered uncovered on low heat? Some believe the FDA simply picked on sassafras as a way to apply food additive regulations to the then-emerging herb industry of the 1970s. Herbs used for food purposes were regulated under food additive laws at the time. If one ever went into an herb shop and saw a package of sassafras labeled "not for food use," that label results from FDA regulations, rather than any inherent problem with that particular lot of sassafras. It is legal to sell sassafras bark or leaves if they are "safrole-free."

SLIPPERY ELM – *ULMUS RUBRA*

When the coming of spring is still a hopeful thought, the russet downy buds of slippery elm (*Ulmus rubra*, Ulmaceae) unfold inconspicuous petalless blooms, then set mature seeds, before most trees leaf out. The slippery elm, or red elm, is the only one of the five or six species of North American elms with rough, hairy twigs and fuzzy red buds. The silky yellow wafer-like fruits seen on the tree from about late March into June are oval in shape and roughly one-half to one inch broad. Unlike the fruits of other elm species native to North America, the margins of slippery elm's fruits are entire or smooth-edged. Other species have a hairy fringe on the fruit's margins.

Ulmus is the old classical Latin name for elm trees.

Slippery Elm *Ulmus rubra* leaves in summer.
Photo ©2017 Steven Foster

Rubra, meaning "red," refers to the rust color of the buds. "Elm" is the ancient name from Anglo-Saxon, Celtic, Gothic, and Teutonic dialects, remaining unchanged in modern English. Although *U. rubra* is the Latin name found in current botanical manuals, many herb books list slippery elm under its old superseded Latin name, *U. fulva*.

Slippery elm occurs in a variety of soils, from dry upland types to moist, limey stream banks. The tree ranges from Maine through the St. Lawrence Valley to the Dakotas, south to Texas and east to Florida. Like American elm (*U. americana*), slippery elm is also susceptible to Dutch elm disease (from the fungus *Ophiostoma ulmi*, formerly *Ceratocystis ulmi*).[31] Charles Sprague Sargent, the first director of the Arnold Arboretum of Harvard University, described slippery elm as a handsome, shapely, fast-growing tree in cultivation. However, in 1895, he warned, "in public parks and streets its use is to be avoided, for once its identity is established, it usually falls prey to boys eager to devour the inner bark of the branches."[32]

The inner bark, which is tawny- or buff-white in color, is the "slippery" or mucilaginous medicinal and edible portion of the tree. In *Materia Medica Americana Potissimum Regni Vegetabilis* (1787), one of the first works devoted to American medicinal plants, Johann David Schoepf referred to it as "salve bark."[33] European settlers

Slippery Elm *Ulmus rubra* shredded inner bark, as found in commerce. Photo ©2017 Steven Foster

Slippery Elm *Ulmus rubra* early blooms flowering in March in Arkansas. Photo ©2017 Steven Foster

were taught by indigenous groups to make an infusion by soaking the shredded inner bark in cold water, and this was used as a domestic remedy for fevers with diarrhea, and bowel afflictions. The inner bark was widely used as a poultice for skin diseases and was commonly known to many. The powdered inner bark makes a gel-like substance, similar to that of arrowroot (*Maranta arundinacea*, Marantaceae), when stirred into warm water. The polymath Constantine Samuel Rafinesque, writing in his *Medical Flora or, Manual of the Medical Botany of the United States of North America* (1830), considered that preparation useful for urinary and bowel complaints, as well as sore throat, pneumonia, pleurisy, inflammation of the stomach and bowels, and herpes. It was also valued as a nutritive, taken as a small spoonful with an equal amount of sugar dissolved in water. Externally, he suggested that it allays inflammation and provides speedy healing for ulcers, burns, skin eruption, sores, scabs, and to extract the ball in the case of musket ball wounds.[34]

In 1853, Thomas Meehan complained that the slippery elm specimen at Bartram's Garden outside of Philadelphia, although 50 feet high and more than five feet in circumference, was nearly dead "owing to the bark having been almost entirely stolen off for medicinal purposes."[35] In 2007, *HerbalGram* reported on the theft of slippery elm bark from the Daniel Boone National Forest in Kentucky, illegally stripped from the trees by poachers.[36]

Slippery elm is an FDA-approved nonprescription (over-the-counter [OTC]) demulcent drug ingredient used for temporary relief of minor discomfort, protection of irritated mucous membranes in the mouth, and for sore throat. The product is a lozenge formed from agar or other water-soluble gum base that contains 10-15% of slippery elm bark. Unfortunately, both the FDA OTC drug monograph as well as the ingredient-defining monograph in the USP call the ingredient "elm bark" rather than "slippery elm bark," the name by which it is has widely been known in the botanical trade and literature for more than 200 years.[36]

SWEETGUM – *LIQUIDAMBAR STYRACIFLUA*

Fresh beaver activity marked a trail for a fall hike. A small dam under construction made hiking difficult in a water-soaked thicket. Fortunately, the beaver left a collection of neatly carved "walking sticks" along the creek's edge. Nearby stood a stand of old sweetgums girdled by a beaver. The source of the genus name for the tree, *Liquidambar*, was in strong evidence. At the top of the girdled scars were oozing drops of "liquid amber," moving like glaciers from the tree's veins. It is this gum resin that provides the tree's product of commerce.

American sweetgum (*Liquidambar styraciflua*, Hamamelidaceae; or separated into the smaller family Altingiaceae) is one of four or five species historically placed in the genus, depending on the taxonomic treatment. Two species are native to China (*L. formosana* and *L. acalycina*), and another species (*L. orientalis*) is native to the western Mediterranean region, particularly Greece and Turkey. American sweetgum grows from Connecticut, west to Arkansas and beyond, then south to Guatemala, Honduras, and Nicaragua, with the Central American populations about 500 miles disjunct from the southernmost temperate forest populations.[31,37] The genera *Altingia*, *Semiliquidambar*, and *Liquidambar*, all of which are in the small family Altingiaceae, have recently been nested within the genus *Liquidambar*, which combined contains 15 total species. The genus is of interest to plant geographers because of the intercontinental disjunction in temperate North America, West Asia, and montane areas of subtropical Asia and Mexico.[38]

The balsamic oleoresin known as American styrax or storax is the consistency of honey when fresh, but hardens to a soft amber-like substance upon exposure to air. It has an aromatic, balsamic fragrance and a mild, pleasant flavor, slightly bitter and warm. The color is more or less transparent yellow, becoming cloudy and darker upon aging. It

Sweetgum *Liquidambar styraciflua* leaves, which are typically five-lobed, in autumn. Photo ©2017 Steven Foster

Sweetgum *Liquidambar styraciflua* leaves, which contain an essential oil not currently traded in essential oil markets.
Photo ©2017 Steven Foster

Sweetgum *Liquidambar styraciflua* leaves turn a variety of colors in autumn.
Photo ©2017 Steven Foster

makes a good chewing gum, known to many school boys a hundred years ago throughout the tree's range. Storax is the subject of an official monograph in the USP, with *L. orientalis* and *L. styraciflua* listed as the source species.[39]

Early American naturalists, including Mark Catesby, recognized the usefulness of the gum. In *The Natural history of Carolina, Florida and the Bahama Islands* (1743), Catesby wrote:

> From between the Wood and the Bark of this Tree issues a fragrant Gum, which trickles from the wounded Trees, and by the Heat of the Sun congeals into transparent resinous Drops, which the Indians chew, esteeming it a Preservative of their Teeth: The Bark is also of singular use to them for covering their houses, which has frequently given me an opportunity of gathering the gum from Trees strip'd of their Bark, one of which would yield an Hat full of Gum. This Gum smells so like the Balsam of Tolu, that it is not easy to distinguish them.[40]

In his *Collections for an Essay Towards a Materia Medica of the United States* (1801), Benjamin Smith Barton described some of the tree's uses:

> The gum-resin which exudes from the Sweet-gum or maple-leaved Liquidambar-Tree, the Liquidambar Styraciflua of Linnaeus, deserves to be mentioned. The storax of the shops is thought to be the produce of this tree: but perhaps this point is not yet quite ascertained. I am informed that the produce of our tree has been used, with advantage, in diarrhea. Some of our southern Indians mix the dried leaves with tobacco, for smoking.[41]

American sweetgum was sometimes found in early American pharmacies, mainly as a substitute for or adulterant of the Asian storax, which is derived from oriental sweetgum (*L. orientalis*). Both were considered to have the same properties, but the American sweetgum was little used by American physicians.

The leaves of the tree have five to seven deep, sharply-pointed lobes, similar to maple leaves. The prominent lower veins exude a sweet fragrance when bruised or broken. In autumn, the leaves turn a deep crimson red, yellow, or dull purple. Wyllie and Brophy (1989) identified terpinen-4-ol as the major component of sweetgum leaf essential oil, coupled with a low content of 1,8-cineole, suggesting it to be of similar chemical composition to commercially viable Australian tea tree (*Melaleuca alternifolia*, Myrtaceae) oil.[42]

Tulip Tree *Liriodendron tulipifera* showing typical flowers and iconic saddle-shaped leaves.
Photo ©2017 Steven Foster

In 2010, Martin et al. showed that sweetgum contains significant quantities of shikimic acid, which is a medicinal compound used as a precursor in the manufacture of the anti-influenza drug oseltamivir (Tamiflu). Star anise from Asia is the current primary source of shikimic acid, but supply shortages in 2005 prompted a search for other sources. Sweetgum, considered a weed tree in southern pine plantations, yields upwards of 1.7 mg/g of shikimic acid.[43]

TULIP TREE – *LIRIODENDRON TULIPIFERA*

Few North American trees surpass the tulip tree (*Liriodendron tulipifera*, Magnoliaceae) for its great size and long, straight trunk. This member of the magnolia family has been known as yellow poplar, white wood, canoe tree, tulip poplar, and tulip tree. The genus name, *Liriodendron*, is derived from two Greek words meaning "tree with lily-like flower." The tree's northern limit stretches to the southern extremity of Lake Champlain, though the main part of its range is in the Ohio River Basin. From Vermont in the north, its range extends south to Rhode Island, west to the southern shores of Lake Michigan, southward to Arkansas and east to northern Florida. The tree attains its greatest growth in the deep, fertile soils of river bottoms, borders of large springs, creeks, and swamps, and rich mountain embankments.[44]

During the Lower Cretaceous Period (about 65.5-145.5 million years ago), the genus *Liriodendron* was widespread across North America, Europe, and Asia. Botanists long thought that the tulip tree was the only living species of this ancient genus, but much to their surprise, a Chinese species was discovered in 1875 and named in 1903 by Charles Sprague Sargent.[45] *Liriodendron chinense*, the Chinese tulip tree, is from central China along the Yangtze River Valley in a narrow range in northern Jiangxi and western Hubei provinces.

For 300 years, since the discovery of American ginseng (*Panax quinquefolius*, Araliaceae), plant geographers have been aware of a classical pattern of plant disjunctions between eastern Asia and eastern North America. The floras of the eastern portions of both continents harbor dozens of closely related species not found elsewhere. Chief among these "disjunct" plants are trees. Upwards of 120 genera of eastern North American plants are involved in this disjunct pattern, about half of which are woody plants, including the genera *Sassafras* and *Liriodendron*.[46,47]

Tulip tree was among the early remedies to be passed along from native groups to early European settlers. Pennsylvania Germans used a decoction prepared from the bark of the tulip tree as a remedy for toothaches. The hot infusion was poured into the marrow of the toothache as an anodyne (painkiller).

In 1830, Rafinesque wrote: "The Cherokee Indians used the leaves in a poultice for sores and headache, and the ointment of the leaves for inflammation; that the seeds are laxative, and that the extract of the bark is a useful remedy for syphilitic ulcers of the nose."[48]

Native groups of North Carolina are reported to have used an ointment from the buds of the tree as a remedy for burns and scalds. Nightmares resulting from bad cookery, late suppers, and irregular hours were treated by Cherokee medicine men with a formula that included a syrup of the tulip tree, when the preferred remedy, rattlesnake fern (*Botrychium virginianum,* Ophioglossaceae) was unavailable. The bark of the Chinese tulip tree has also been used to break fevers.[49]

In Schoepf's *Materia Medica Americana*, he recognized the bark, root, leaves, and seed of the tulip tree as remedies. The bark and root were used in tincture form for fevers and rheumatism. The seeds were used as a very mild laxative. The fresh leaves were used in ointments for gangrene and inflammation.[50]

The bark, like that of dogwood, was used to some extent as a substitute for cinchona to treat malarial fevers. A physician, J.T. Young, addressed a letter to Governor Clayton of Delaware in 1792, expressing his belief in the value of the bark in intermittent fevers and as a sure cure for worms. Later, during the Civil War, tulip tree was one of the remedies used in Confederate hospitals as a substitute for cinchona. In Confederate hospitals, a compound fluidextract for the treatment of malaria was prepared from the barks of the tulip tree, dogwood, and black willow (*Salix nigra*, Salicaceae).[46]

Francis Peyre Porcher (1863), in his *Resources of Southern Fields and Forests*, noted:

> The powdered bark in syrup is given to children who are liable to convulsions and worms, to promote their expulsion, and to strengthen the tone of the digestive organs. The bark should be pulverized and bottled. We have employed a strong infusion of the bark and root of this plant as an anti-intermittent, among a number of negroes and are much pleased with its efficiency.[51]

American physicians used the bark as a stimulant tonic, with diaphoretic qualities. In addition to being substituted for cinchona, it was also used as a gentle stimulant of the digestive system, gout, and externally as a wash in chronic rheumatism. It was also used as a domestic remedy for some intestinal disorders such as diarrhea and dysentery, as well as colic and worms. Though little used by the established medical profession, the bark was an official remedy of the USP from 1830 to 1880.[46]

This relic of ancient forests, though today serving primarily as an ornamental tree, provided inhabitants of this continent with material and medicine for centuries. At least 17 compounds from the bark, stems, and leaves (including lignans, aporphine alkaloids, coumarins, sesquiterpenes, cyclitols, phytosterols, and benzenoids), some with antioxidant, cancer chemopreventive, and tyrosinase-inhibiting activities, have been identified.[52] Hidden in its chemical secrets may be important compounds from which future products could be derived. HG

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Chinese Tulip Tree *Liriodendron chinense*, the only other species in the genus *Liriodendron*. Photo ©2017 Steven Foster

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Tulip Tree *Liriodendron tulipifera* explored by a queen eastern yellowjacket (*Vespula maculifrons*). Photo ©2017 Steven Foster

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