Fraxinus americana L. White Ash

Oleaceae Olive family

Richard C. Schlesinger

White ash ***(Fraxinus americana),*** also called Biltmore ash or Biltmore white ash, is the most common and useful native ash but is never a dominant species in the forest. It grows best on rich, moist, well-drained soils to medium size. Because white ash wood is tough, strong, and highly resistant to shock, it is particularly sought for handles, oars, and baseball bats. The winged seeds provide food for many kinds of birds.

Habitat

Native Range

White ash (figs. 1, 2) grows naturally from Cape Breton Island, Nova Scotia, to northern Florida in the east, and to eastern Minnesota south to eastern Texas at the western edge of its range (7).

Climate

The climate varies greatly within the natural range of this species. The length of the frost-free period is from 90 to 270 days. Mean January temperatures range from -14" C (7" F) to 12° C (54° F) and the mean annual minimum temperatures range from -34" C (-30" F) to -5" C (23" F). Mean July temperatures range from 18" C (64" F) to 27" C (81° F). The average annual precipitation is between 760 and 1520 mm (30 and 60 in), and the snowfall is from 0 to 250 cm (100 in).

Soils and Topography

White ash has demanding soil fertility and soil moisture requirements. These requirements may be provided by soils derived from a variety of parent materials-limestone, basalt, shale, alluvium, and fine glacial till. A large number of soil types may support white ash, many of which are included in the Hapludalfs and Fragiudalfs of the order Alfisols, Haplorthods and Fragiorthods of the order Spodosols, and Dystrochrepts and Fragiochrepts of the order Inceptisols *(11).*

White ash grows most commonly on fertile soils with a high nitrogen content and a moderate to high calcium content. Nutrient culture results show that an absence of nitrogen reduces seedling dry weight by 38 percent compared to seedlings grown in complete nutrient solution, and that calcium is the second most important macroelement, followed by sulfur (3). Its pH tolerance varies from 5.0 to 7.5.

Soil moisture is an important factor affecting local distribution. Best growth occurs on moderately well drained soils, including areas underlain by compacted glacial till; light textured, well drained, glacial drift; and sandy to clay loam soils in which roots can penetrate to a depth of 40 cm (16 in) or more. Although rarely found in swamps, white ash is intermediately tolerant of temporary flooding.

White ash is found in various topographic situations. It grows from near sea level in the southeastern Coastal Plain to about 1050 m (3,450 ft) in the Cumberland Mountains and up to 600 m (1,970 ft) in New York's Adirondack Mountains. In the hilly and mountainous areas of the Northeast, it grows on the mesophytic lower and middle slopes, usually stopping short of both the dry, oak-pine ridgetops and the cold, spruce-fir mountain tops. In the Coastal Plain, white ash usually is limited to the slightly elevated ridges in the floodplains of major streams. In the Central States it is most common on slopes along major streams, less common in upland situations, and rarely found in the flat bottoms of major streams or in depressions *(16).*

Associated Forest Cover

White ash is a major component in the forest cover type White Pine-Northern Red Oak-Red Maple (Society of American Foresters Type 20) and is a common associate in 25 other forest cover types *(4):*

19 Gray Birch-Red Maple
21 Eastern White Pine
22 White Pine-Hemlock
23 Eastern Hemlock
24 Hemlock-Yellow Birch
25 Sugar Maple-Beech-Yellow Birch
26 Sugar Maple-Basswood
27 Sugar Maple
28 Black Cherry-Maple
33 Red Spruce-Balsam Fir
39 Black Ash-American Elm-Red Maple
42 Bur Oak
52 White Oak-Black Oak-Northern Red Oak
53 White Oak
55 Northern Red Oak
57 Yellow-Poplar

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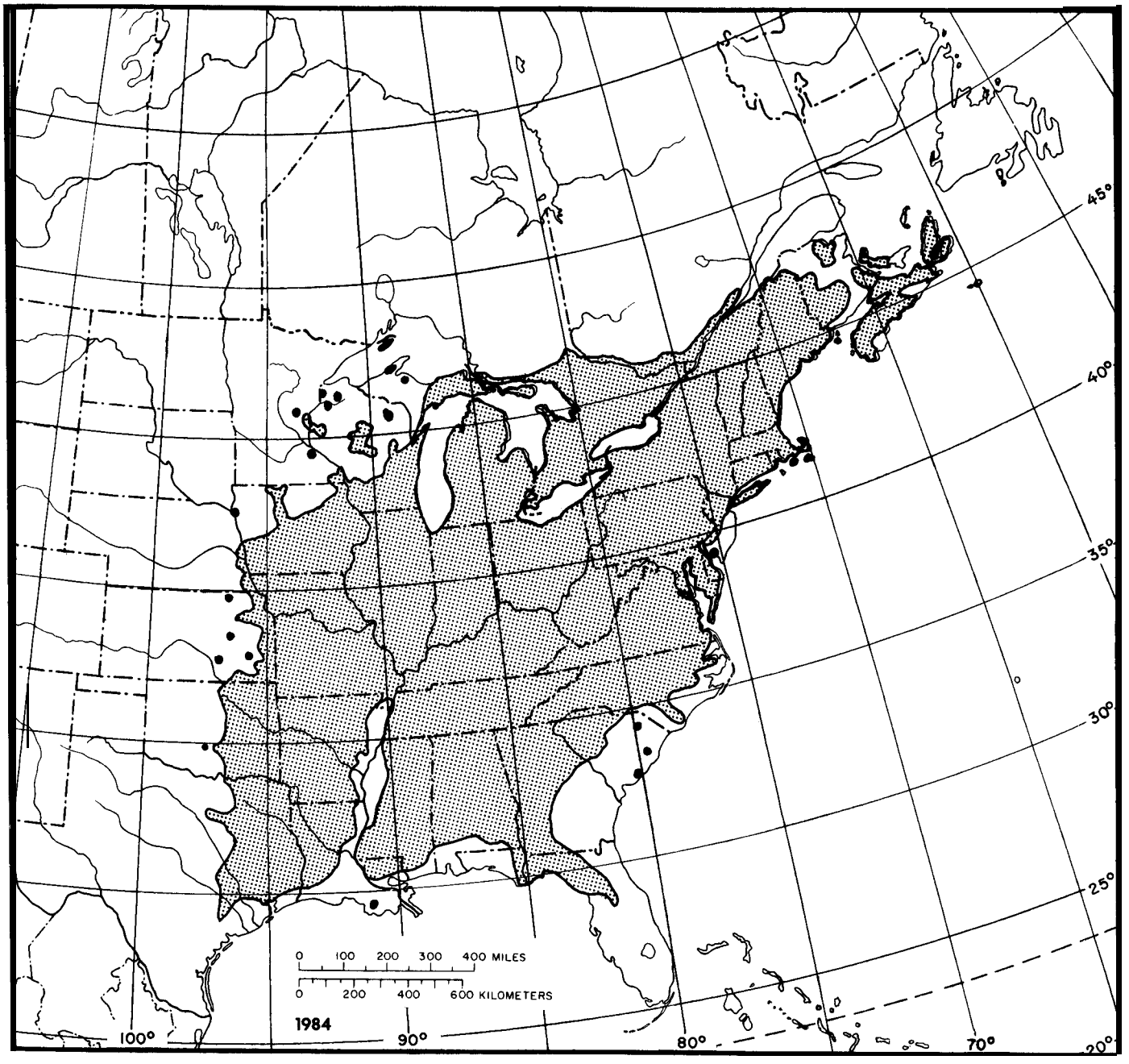

Figure 1--The ***native range*** *of white ash.*

Figure 2—*A 60-year-old white ash 36 cm (14 in) in d.b.h.*

58 Yellow-Poplar-Eastern Hemlock
59 Yellow-Poplar-White Oak-Northern Red Oak
60 Beech-Sugar Maple
63 Cottonwood
64 Sassafras-Persimmon
80 Loblolly Pine-Shortleaf Pine
82 Loblolly Pine-Hardwood
87 Sweetgum-Yellow-Poplar
91 Swamp Chestnut Oak-Cherrybark Oak

Some of the primary associates of white ash include eastern white pine *(Pinus strobus),* northern red oak *(Quercus rubra),* white oak *(Q. alba),* sugar maple *(Acer saccharum),* red maple *(A. rubrum), yellow* birch *(Betula alleghaniensis),* American beech *(Fagus grandifolia),* black cherry *(Prunus serotina),* American basswood *(Tilia americana),* eastern hemlock *(Tsuga canadensis),* American elm *(Ulmus americana),* and yellow-poplar *(Liriodendron tulipifera).* Understory shrubs and small trees frequently found growing with ash are downy serviceberry *(Amelanchier arborea),* pawpaw *(Asimina triloba),* American hornbeam *(Carpinus caroliniana),* flowering dogwood *(Cornus florida),* witch-hazel *(Hamamelis virginiana),* eastern hophornbeam *(Ostrya virginiana),* and mapleleaf viburnum *(Viburnum acerifolium).*

Life History

Reproduction and Early Growth

Flowering and Fruiting-White ash is dioecious; flowers appear with or just before the leaves in April and May. A good seed crop is produced about every third year. The time between the first noticeable enlargement of the male flower buds until shedding is 2 to 3 weeks. Pollen shedding from an individual tree usually takes 3 or 4 days. The pollen is carried by wind as far as 100 m (328 ft) from the point of dispersion.

Female buds are completely open a few days after they begin to swell. Exposed flowers remain receptive for about 1 week, but once the stigmas discolor, the period of receptivity is past. Abundant seed crops are borne by about half of the flowering trees.

Good seeds are produced in all parts of the crown. Almost 99 percent of the fruits (samaras) contain one seed, about 1 percent contain two, and a very small percent have twin embryos. Vigorous trees may first flower when only 8 to 10 cm (3 to 4 in) in d.b.h., but white ash is usually 20 to 25 cm (8 to 10 in) in d.b.h. before it flowers abundantly.

Seed Production and Dissemination-The seed is dispersed by wind up to 140 m (460 ft) from the parent tree. White ash seed has a very pronounced dormancy. Although the embryo is completely developed morphologically at the time of seedfall (September to December), the physiological state of the endosperm and embryo inhibit germination. Seeds must be stratified under moist conditions for 2 or 3 months before they will germinate, and the average laboratory germination is 54 percent. The minimum seed-bearing age is 20 years (14).

Seedling Development-Germination is epigeal. Natural regeneration from seeds will occur if the soil, humus, or leaf litter is wet in the spring. Under experimental conditions, seedlings developed best in 45 percent of full sunlight *(8).* Thus silvicultural systems that can provide sunlight, such as shelterwood or clearcutting, have been recommended for white ash.

Photoperiodic response appears to vary with geographic location. North Carolina seedlings showed no growth response to a 14.5-hour daylength. In a Massachusetts test, however, northern seedlings

ceased height growth and dropped their leaves well before the first frost, while southern seedlings continued height growth until late autumn.

Vegetative buds begin to enlarge in April or May. Height growth is 90 percent complete in 30 days, and 100 percent complete in 60 days. Diameter growth generally continues until August.

Young white ash exhibits strong apical dominance. Thrifty open-grown seedlings 2 m (6.6 ft) tall often have only two or three pairs of lateral branches, and sometimes none. If the terminal bud is removed, apical dominance is altered and new branches develop from the uppermost pair of lateral buds. Generally one of these grows faster than the other and soon assumes apical control.

Vegetative Reproduction-Stumps of freshly cut seedling and sapling white ash sprout readily. Usually only one or two stems are produced. This species can be propagated by conventional methods of budding, grafting, or layering. Even open field and bench grafting of unpotted stock are highly successful. Diploid, tetraploid, and hexaploid white ash have all been successfully grafted on diploid stock.

Sapling and Pole Stages to Maturity

Growth and Yield-Depending on the amount of root competition, a field-grown white ash tree in full sunlight may take from 3 to 15 years to become 1.5 m (5 ft) tall. By then, its root system is usually well established and white ash is able to grow rapidly even if surrounded by weeds. Post-juvenile growth rates of dominant and codominant trees in unthinned, even-aged stands in central Massachusetts are as follows:

Age	D.b.h.		Height	
yr	*cm*	*in*	*m*	*ft*
20	10	4	12	39
30	18	7	17	56
40	25	10	21	69
50	30	12	23	75
60	36	14	25	82
70	43	17	27	89

Yield tables are not available for white ash in pure stands. However, for plantations in Canada ranging in age from 20 to 38 years, the growth of the dominant and codominant trees averaged 3 to 5 mm (0.1 to 0.2 in) per year in diameter and 0.2 to 0.8 m (0.7 to 2.6 ft) in height *(13)*. In mixed Appalachian hardwood stands, diameter growth ranged from 3 to 8 mm (0.1 to 0.3 in) per year, depending on site quality and individual tree variation.

Rooting Habit-White ash generally forms a taproot that in turn branches into a few large roots that grow downward. From these vertical roots, single lateral branches develop at intervals. Intraspecific grafting is common. The distribution of roots is strongly influenced by soil type. On a loamy sand, most of the roots, both large and small, were in the A horizon. On a fine sandy loam, the majority of the fine roots were in the B_1 horizon, and the large roots equally in the A and B_1.

Knowledge of mycorrhizal associations is limited. *Gyrodon merulioides* has been reported on white ash. Seedlings inoculated with the endomycorrhizal fungi *Glomus mosseae* and G. *fasciculatus* grew markedly better than nonmycorrhizal controls *(12)*.

Reaction to Competition-White ash is a pioneer species that establishes itself on fertile abandoned fields in several parts of the country. In the Southeast, much of the abandoned agricultural land is incapable of supporting white ash. On such sites, white ash establishes itself only after some site protection and improvement has been accomplished by pines. However, pioneer ash often do not develop into good timber trees unless other hardwoods or pines are also present to provide competition and reduce branchiness.

Open-grown trees commonly remain single stemmed and fine branched until they are 9 to 12 m (30 to 40 ft) tall, although old specimens can become as broad crowned as an elm. With even slight crowding, the single-stemmed characteristic can easily be maintained throughout a rotation. Shade-killed branches drop quickly-small ones within a year or two and larger ones within 4 or 5 years *(16)*.

Uninjured terminal buds suppress the growth of all lateral buds on the current year's growth, and they suppress the growth of other laterals to such an extent that each internode has only one pair of branches that persist more than a few years. Even the strongest lateral branches grow only half as fast as the terminal except on old, open-grown trees. Little or no epicormic branching occurs on the boles of released trees. The branches of dominant trees emerge from the bole at about a 35° angle from the vertical, whereas the branches of intermediate trees emerge at about a 55" angle (16).

When young, white ash is a shade-tolerant tree. Seedlings can survive under a canopy with less than 3 percent of full sunlight but grow little under these conditions. Seedlings that receive sufficient sunlight grow rapidly. With increasing age, white ash becomes less tolerant of shade and is classed overall as intolerant. The decrease in shade tolerance with increasing age is reflected in the fact that young white

ash is abundant in the understory of northern hardwood stands, but few grow into the overstory unless provided with light from above.

Despite its low shade tolerance, white ash is characteristic of intermediate as well as early stages of natural plant succession. Throughout its range it is a minor but constant component of both the understory and overstory of mature forests on suitable soils. It owes its position in the final overstory to its ability to persist for a few years in moderately dense shade and to respond quickly to openings in the canopy created by death or other causes.

White ash can be maintained more easily in a dense stand than can some of its more shade-intolerant associates, such as northern red oak. In contrast, dominant or codominant white ash responds readily to thinning and within a few years will increase its crown area to take full advantage of any reasonable release *(16)*.

Damaging Agents--Ash decline (also called ash dieback) is the most serious problem affecting white ash. Especially prevalent in the northeastern part of the tree's range, this disease complex occurs from the Great Plains to the Atlantic coast between 39 and 45 degrees north latitude *(10)*. The disease, ash yellows, caused by mycoplasma-like organisms (MLO), has been found associated with most of the dying trees where ash decline is conspicuous (9). However, since not all dying trees are infected with MLO, ash decline is thought to result from multiple causes. Drought-weakened trees may be invaded by canker-causing, branch-girdling fungi such as ***Fusicoccum*** spp. and ***Cytophoma pruinosa.*** Additional stresses that may be involved in the etiology of ash decline are air pollution, leaf-spotting fungi, and viruses. Control recommendations are based primarily on maintaining good tree vigor (6).

Air pollution damages white ash. It is rated as sensitive to ozone and is severely injured by stack gases from soft coal consumption and from industrial processes, both of which emit sulfur dioxide.

Two leaf spot fungi, ***Mycosphaerella effigurata*** and ***M. fraxinicola,*** are common in nurseries and in the forest and cause premature defoliation of white ash. Anthracnose ***(Gloeosporium aridum)*** also causes premature defoliation and is most serious following exceptionally wet springs. An ash strain of tobacco ringspot virus causes chlorotic areas on the leaves and has been associated with ash dieback.

A rust ***(Puccinia peridermiospora)*** distorts petioles and small twigs. Cankers caused by ***Nectria galligena*** may cause branches to break but are rarely found on main stems. Heartwood rots may be caused by ***Perenniporia fraxinophilus, Phellinus igniarius, Pleurotus ostreatus, Tyromyces spraguei,*** and ***Laetiporus sulphureus.*** These organisms usually enter through wounds or broken branches, mainly on older trees.

Of 26 species of nematodes reported from the roots or root zones of white ash, only one, ***Meloidogyne ovalis,*** has been associated with root injury. However, nematodes can be vectors for the ringspot virus *(5)*.

Of the insect pests, the oystershell scale ***(Lepidosaphes ulmi)*** is the most serious. Severe infestations cause yellowing of the leaves, and if prolonged, may kill some trees. The cottony maple scale ***(Pulvinaria innumerabilis)*** also attacks white ash.

The brownheaded ash sawfly ***(Tomostethus multicinctus)*** and the blackheaded ash sawfly ***(Tethida cordigera)*** are defoliators that are of concern mainly on ornamental trees. The forest tent caterpillar ***(Malacosoma disstria)*** and the green fruitworm ***(Lithophane antennata)*** feed on forest trees and occasionally cause complete defoliation within small geographic areas. The larvae of sphingid moths—***Sphinx chersis*** (the great ash sphinx), S. ***kalmiae,*** and ***Ceratomia undulosa-feed*** on the leaves of white ash, as does the notched-wing geometer ***(Ennomos magnaria).*** The larvae of two leaf roller moths, ***Sparganothis dilutocostana*** and S. ***folgidipenna,*** also feed on ash.

The ash bark beetle ***(Leperisinus aculeatus)*** may cause slight injury when the adults bore into the bark to hibernate. The ash borer ***(Podosesia syringae)*** may seriously damage young shade and shelterbelt trees. The ash and privet borer ***(Tylonotus bimaculatus)*** attacks and kills branches, especially on older trees. Both the red-headed ash borer ***(Neoclytus acuminatus)*** and the banded ash borer (N. ***caprea)*** colonize cut logs and dead or dying trees *(1)*.

White ash seedlings are easily damaged or destroyed by deer and cattle browsing. Rabbits, beaver, and porcupine occasionally use the bark of young trees for food.

Special Uses

One of the earliest reported uses of white ash was as a snake bite preventive. Ash leaves in a hunter's pocket or boots were "proved" to be offensive to rattlesnakes and thereby provided protection from them. Seeds of white ash are eaten by the wood duck, bob white, purple finch, pine grosbeak, and fox squirrel. White ash is used in yard, street, and roadside plantings and also has been planted on strip mines with some success.

Genetics

Population Differences

White ash contains several phenotypic variants of leaf form that appear to be genetically controlled even though they are randomly distributed throughout the natural range. Chief among these are g-leaflet, narrow-leaflet, blunt-leaflet, ascidiate leaflet, partially pubescent, purple-keyed, and crinkle-leaf forms. A purple leaf variant is vegetatively propagated and grown as an ornamental.

White ash is a polyploid species. Diploids (2n=46) occur throughout the species range but most tetraploids (2n=92) are found south of latitude 35" N and hexaploids (2n=138) are concentrated between latitude 35" and 40" N. Although three ecotypes were previously recognized on the basis of seedling morphology and ploidy level *(15),* recent work has shown that the variation in several traits is closely related to latitude. This clonal variation and the strong effects of ploidy level on several other traits indicate that ecotypes probably do not exist in white ash (2).

Hybrids

White ash and Texas ash *(Fraxinus texensis* (Gray) Sarg.) intergrade in Texas. The pumpkin ash *(Fraxinus profunda* (Bush) Bush) behaves in many respects as if it were a true breeding hexaploid derivative of a cross between tetraploid white ash and diploid green ash *(Fraxinus pennsylvanica* Marsh.). However, attempts have failed to artificially cross the two species. It is likely that natural hybridization between white ash and other species is extremely rare *(16).*

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