Ostrya virginiana (Mill.) K. Koch — Eastern Hophornbeam

Betulaceae — Birch family

F. T. Metzger

Eastern hophornbeam *(Ostrya virginiana)*, also called American hophornbeam, hornbeam, leverwood, and "ironwood," is a small, short-lived tree scattered in the understory of hardwood forests. It has a slow to medium growth rate on a great variety of soils and produces an extremely hard wood. The tree is not large enough for commercially important lumber but is used locally. It makes an attractive landscape tree and provides wildlife with a limited amount of seed.

Habitat

Native Range

Eastern hophornbeam (fig. 1) occurs throughout most of the eastern half of the United States. The range extends from Cape Breton and Prince Edward Island west through southern Ontario, northern Michigan, to southeastern Manitoba; south into North Dakota, the Black Hills of South Dakota and northeastern Wyoming, along the Niobrara River Valley and Delta areas. It is also found in the mountains of Mexico, south to El Salvador and Honduras.

Climate

Climatic conditions vary considerably over the range of eastern hophornbeam. In the northwest corner of its range precipitation is 460 mm (18 in) annually, the frost-free season is 100 days, the mean July temperature is 16" C (60" F), and the mean January temperature is -18" C (0° F). Along the gulf coast precipitation is 1630 mm (64 in) annually, the frost-free season is 290 days, the mean July temperature is 29° C (84" F), and the mean January temperature is 13" C (56" F).

Soils and Topography

Eastern hophornbeam grows on a wide variety of soil and physiographic conditions throughout its range. It is found on soils in all of the major orders in the Eastern United States, Spodosols in the North, Alfisols in the North and Central, Mollisols in the Central, Ultisols in the South, and Entisols and Inceptisols throughout.

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Along the northernmost portion of its range, eastern hophornbeam is found on dry-mesic to xeric sites, areas with shallow soils, and bedrock outcrops on upper slopes and ridgetops *(31,53)*. Just to the south within Ontario and Quebec, it grows primarily on mesic and dry-mesic sites. In Wisconsin the species is most abundant on mesic sites usually associated with a mid-catena position, but it also occurs on dry-mesic, wet-mesic, and xeric sites *(12)*.

Mesic sites throughout the Appalachians are most favorable *(32,52)*, but the species tolerates a progressively wider range of conditions northward. In the Smokies and southern Cumberland Plateau it is limited to north slopes, protected lower slopes, ravines, and coves. It grows primarily on dry-mesic and mesic valley bottoms and lower slope positions in the highlands of New Jersey but does extend upslope to drier positions. In Massachusetts it is also found in xeric positions on ridgetops as well *(17,43)*.

From the central lowlands southward the species is associated with wet-mesic to dry-mesic sites. It is frequently found on xeric sites in northcentral Florida, however (35). Through the Ozark Plateau, Central Lowlands, and the Kentucky-Tennessee Highland Rim best development occurs on well-drained flood plains of the major rivers, ravines, coves, and lower slopes. Progressing upslope it is less abundant, becoming rare in xeric situations, and it is absent from the wettest sites as on lower flood plains, depressions, sink holes, and bogs *(45,47,49)*. In the south the species is most frequent on terraces of minor streams, common on the well-drained terraces and outwash in major bottoms, and occurs in most upland situations *(40,41)*. Originally it was limited to sites not subject to frequent wildfire in the south such as those protected by bodies of water, swamps, or bottom lands, or those that are less prone to fire such as ravines or steep bluffs along streams *(14)*.

At the westernmost extension of the species range in the Black Hills of South Dakota, the tree grows principally in mesic, deciduous streamside communities at lower elevations and to a much lesser extent on dry-mesic but deep-soiled pine sites.

Eastern hophornbeam grows below elevations of 910 m (3,000 ft) in the northern Appalachians but is most often found at 75 to 230 m (250 to 750 ft) in Quebec *(5)*, and at about 460 m (1,500 ft) in New York (7). Its upper elevational limit is 1520 m (5,000 ft) in the southern Appalachians, although it is more common from 850 to 980 m (2,800 to 3,200 ft). The

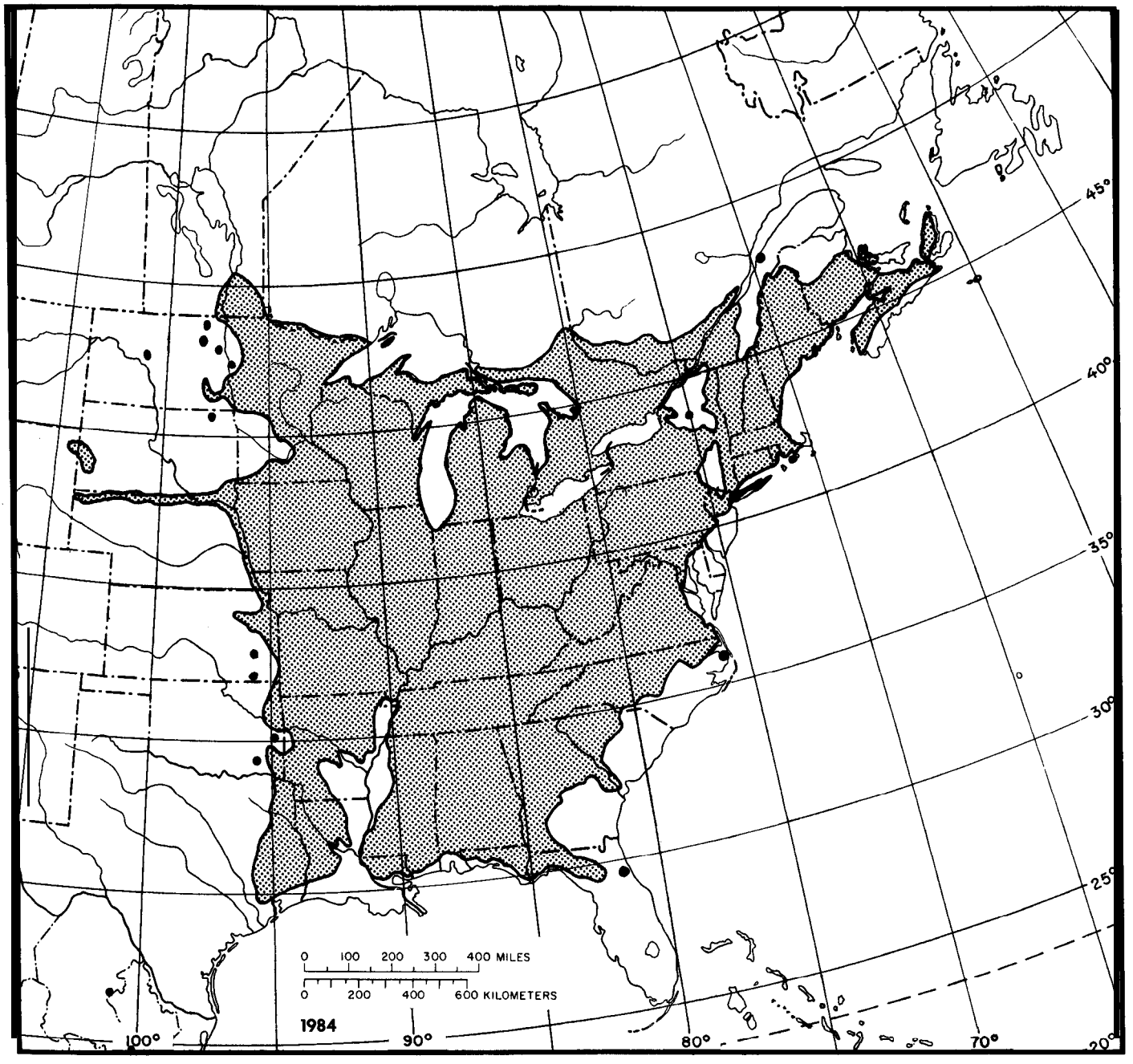

Figure *l-The native range of eastern hophornbeam.*

lowest slope position it occupies is determined by its intolerance of flooding. It was the third most flood sensitive of 39 species compared in Tennessee, where inundation 16 percent or more of the time killed all eastern hophornbeam (22). Along an Illinois stream it is limited to positions flooded less than 1 percent of the time (4).

Surface soils on sites occupied by eastern hophornbeam include a full range of textures and moisture-drainage classes. Best development of the species is associated with soils that are in loam or loam-modified textural classes and on somewhat poorly drained to well-drained soils. Surface soil pH ranges from 4.2 to 7.6 in the northern half of its range

(10,26). In the mid-South the pH range is narrower—from 4.6 to 5.6 (8). Nevertheless, the species does occur on sites with shallow soils over limestone or soils with limestone fragments at various locations throughout its range.

The calcium content of the foliage of eastern hophornbeam is high in comparison to other species on the same site. Concentrations frequently exceed 2 percent on the basis of ovendry leaf weight *(2,11)*. Nitrogen concentrations range from moderate to high in comparison to the other species on the site, but concentrations of phosphorus and potassium are usually low.

Associated Forest Cover

Eastern hophornbeam is a minor member of most forest communities where it is present. It rarely attains a codominant or dominant crown position in mature stands and is not a commercial species. In the following forest cover types it is only a subordinate species (Society of American Foresters) *(18)*:

Boreal and Northern Forest Region

16 Aspen
20 White Pine-Northern Red Oak-Red Maple
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
60 Beech-Sugar Maple

Central Forest Region

42 Bur Oak
52 White Oak-Black Oak-Northern Red Oak
55 Northern Red Oak
110 Black Oak

Southern Forest Region *(30)*

82 Loblolly Pine-Hardwood
87 Sweetgum-Yellow-Poplar
91 Swamp Chestnut Oak-Cherrybark Oak

It probably occurs in other types but is omitted from their descriptions, particularly in the South where the types are complex.

The species occurs in all nine forest regions Braun recognizes in the eastern deciduous forest formation (6). One plant association based on the species, in which eastern hophornbeam is second in importance to sugar maple, is recognized in Quebec as the ***Ostryo-Aceratum saccaharai*** association that occurs on dry knoll tops ***(31).***

From the northern part of its range to Missouri, Tennessee, and Maryland, eastern hophornbeam reaches its greatest abundance in hardwood communities dominated by sugar maple *(Acer saccharum),* American beech *(Fagus grandifolia),* or both. It may be the second most important species in some stands. Occasionally, it is abundant in stands dominated by eastern hemlock ***(Tsuga canadensis)*** and northern red oak ***(Quercus rubra).*** In aspen stands, it is a member of a northern hardwood understory reclaiming the site. In the central United States the species is frequently an important subcanopy component of stands dominated by white oak ***(Quercus alba)***, black oak *(Q. velutina)*, northern red oak, scarlet oak *(Q. **coccinea),*** and southern red oak *(Q. **falcata).***

The species named in the northern forest types plus white ash ***(Fraxinus americana)*** and American elm *(Ulmus **americana)*** are eastern hophornbeam's most frequent associates in the North. Progressing southward, the following species are added as associates: bitternut ***(Carya cordiformis),*** shagbark *(C. **ouata),*** and pignut *(C. glabra)*, hickories; sweetgum ***(Liquidambar styraciflua)***; blackgum *(Nyssa sylvatica)*; yellow-poplar ***(Liriodendron tulipifera);*** slippery elm *(Ulmus **rubra);*** sassafras ***(Sassafras albidum);*** and flowering dogwood *(Cornus florida)*.

The extremely species-rich mixed mesophytic forests of the Cumberland Mountains and plateau have minor amounts of eastern hophornbeam.

Within the Piedmont and Coastal Plains of the South the species grows in the southern mixed hardwood and in loblolly *(Pinus **taeda)*** and shortleaf *(P. **echinata)*** pine-dominated forests. Although typically a minor component of southern mixed hardwood stands, it is occasionally the second most abundant species *(35,36)*. In these forests it is associated with many trees including American beech, southern magnolia ***(Magnolia grandiflora)***, white oak, loblolly pine, and shortleaf pine; and with many understory species including flowering dogwood, American holly *(Ilex **opaca),*** American hornbeam ***(Carpinus caroliniana),*** tree sparkleberry *(Vaccinium **arboreum),*** eastern redbud ***(Cercis canadensis),*** and pawpaw ***(Asimina triloba).*** Other associated trees include blackgum; sweetgum; yellow-poplar; southern red laurel ***(Quercus laurifolia),*** water *(Q. **nigra),*** swamp chestnut *(Q. **michauxii),*** post *(Q. stellata)*, black, cherrybark *(Q. **falcata*** var. ***pagodifolia),*** shumard *(Q. **shumardii),*** and scarlet oaks; mockernut *(Carya **tomentosa),*** sand ***(C. pallida),*** pignut, and bitternut hickories; American basswood *(Tilia **americana);*** red *(Acer rubrum)* and Florida ***(A. barbatum)*** maples; winged *(Ulmus alata)* and slippery elms; and white and green *(Fraxinus pennsylvanica)* ashes.

Shrubs that occur with eastern hophornbeam in the north include mountain maple *(Acer **spicatum),***

roundleaf dogwood *(Cornus rugosa),* American hazel *(Corylus americana),* beaked hazel *(Corylus cornuta),* dwarf bush-honeysuckle *(Diervilla lonicera),* Atlantic leatherwood *(Dirca palustris),* witch-hazel *(Hamamelis virginiana), fly* honeysuckle *(Lonicera canadensis),* American elder *(Sambucus canadensis),* redberry elder *(Sambucus pubens),* American yew *(Taxus canadensis),* mapleleaf viburnum *(Viburnum acerifolium),* and hobblebush *(Viburnum alnifolium).* In the South its associated shrub species include devils-walkingstick *(Aralia spinosa),* St. Andrews cross *(Ascyrum hypericoides),* smallflower pawpaw *(Asimina parviflora),* beautyberry *(Callicarpa americana),* fringetree *(Chionanthus virginicus),* strawberry-bush *(Euonymus americanus),* oakleaf hydrangea *(Hydrangea quercifolia),* southern bayberry *(Myrica cerifera),* woolly azalea *(Rhododendron viscosum tomentosum),* greenbriers *(Smilax* spp.), sweetleaf *(Symplocus tinctoria),* and *Vaccinium* spp.

Life History

Reproduction and Early Growth

Flowering and Fruiting-Eastern hophornbeam is monoecious; from 1 to 3 staminate catkins develop at the end of branches late in the summer that precede pistillate flower development. Pollen forms, matures, and is shed in spring. It is wind disseminated. Solitary pistillate catkins first appear with the beginning of leaf development, and full bloom occurs about a month later. In the southeast, flowering occurs between March 25 and April 16, and in the north, between mid-May and mid-June *(21).*

Seed Production and Dissemination-The fruits complete development during the summer and are ripe by the end of August in Michigan and as late as October in the South. The hoplike strobile begins to break up immediately after ripening and the seeds are dispersed throughout the fall and into early winter. Seeds should be collected when the strobiles are a pale greenish brown and before they dry enough to shatter. Seeds are light-about 66,000 cleaned seeds per kilogram (30,000/lb). The nuts are 7 mm (0.3 in) long and are enclosed in an inflated sac about 20 mm (0.8 in) long that provides buoyancy and improved dispersal by the wind. Birds provide a secondary means of seed dispersal. Trees begin to be fruitful at age 25. Seed production in northern hardwood stands has averaged 124,000/ha (50,000/acre) *(19,21,37).*

Seedling Development-Seeds usually germinate in the spring the year after they are shed. Germination is epigeal. The seeds have a form of internal dormancy that requires stratification to overcome. Potential germination is 85 to 90 percent but germination capacity is only 27 to 65 percent *(44).*

Information is scarce on the relation of germination and seedling establishment to the environment. The occurrence of reproduction on a variety of sites in undisturbed forests indicates its ability to become established on various seedbeds, soils, and moisture regimes under dense shade. Conversely, the ecesis of the species into old fields demonstrates its ability to become established in the open in competition with a heavy cover of grasses and forbs. Mechanical scarification to expose mineral soil seedbeds in an Ontario partially cut sugar maple stand had no effect on eastern hophornbeam abundance after 10 years *(50).*

Seedlings have the potential for unusually fast juvenile height growth *(27,48,54).* In Pennsylvania eastern hophornbeam was 2.1 m (7 ft) tall 5 years after a partial harvest of the overstory. In Michigan, the species averaged 3.4 m (11 ft) tall 10 years after an improvement cut and 5.9 m (19.5 ft) tall 20 years after the cut.

Advance reproduction of eastern hophornbeam is aggressive when released by overstory cutting, a trait that makes its proportion in the reproduced stand similar to that in the original stand regardless of the cutting method (53). Its position in the new stand may even be improved if new reproduction of eastern hophornbeam becomes established, as is likely, or if mortality increases among the other species. Increases have occurred after clearcutting and seed-tree and selection cuttings in West Virginia Appalachian hardwood stands on better sites (48). Similarly, the species proportion of the basal area stocking in northern hardwood stands in Wisconsin increased after strip clearcutting and after a shelterwood removal *(21).* Greater increases in the species relative abundance have occurred when northern hardwood stands less than 40 years old are clearcut because little advance reproduction of other species is present at this time *(28).*

The species' response to fire apparently is related to the severity of the fire. Areas burned severely enough to kill almost the entire overstory in 21 white oak-scarlet oak stands in Rhode Island contained no eastern hophornbeam 5 to 51 years later. In unburned stands the species made up 10 percent of the understory stems (9). After a prescribed burn of a clearcut aspen stand, eastern hophornbeam remained constant, because new sprouting equalled mortality during the 5 years following the burn *(39).* Accidental fires in two sugar maple stands in New

York resulted in increased sugar maple and eastern hophornbeam stocking because of sprouting (46). The initial incidence of fire in the Big Woods of Minnesota converted the forest to a thicket of basswood and eastern hophornbeam (13). Subsequent fires converted them to a bur oak savanna.

Vegetative Reproduction-Stump sprouting is common on cut, burned, or injured trees. The proportion of stumps sprouting increases with stump height. Only 17 percent of the stumps cut at ground line sprouted, whereas 40 percent of stumps cut at a height of 15 cm (6 in) sprouted and between 80 and 90 percent of stumps cut at a height of more than 30 cm (12 in) sprouted *(15).* Sprouts arose from dormant adventitious buds on the stump and no root suckering occurred.

After fires, 62 percent of the top-killed stems in New York (46) and 100 percent of those in Minnesota sprouted (39). Number of sprouts per clump averaged 4.4 in New York and 32 in Minnesota. Height growth of the Minnesota sprouts averaged 2.4 m (7.9 ft) after 5 years, which is about average for the other species measured. Height growth of eastern hophornbeam sprouts in an Allegheny hardwood stand exceeded that of other sprouting species (27).

Sapling and Pole Stages to Maturity

Growth and Yield-Eastern hophornbeam trees are normally less than 30 cm (12 in) in d.b.h. and less than 12 m (40 ft) tall, except in east Texas and south Arkansas where they may reach a height of from 15 to 18 m (50 to 60 ft). Occasionally they reach saw log size. The largest tree is 91 cm (36 in) in d.b.h., 22 m (73 ft) tall, and has a crown spread of 27 m (88 ft). It was found in 1976 in Michigan.

The slow growth and small size of the species earn it the title "weed" throughout its range, especially in some areas in the South where it is considered the number one weed species. Eastern hophornbeam usually is discriminated against in stands managed for timber. Silviculturally, more interest has been given to eradicating it than to improving its growth.

Girdling is effective in eradicating the species, killing the tree within 2 years. Herbicides (especially 2,4,5-T, and Tordon 101) applied by mist blowing, tree injection, or spraying at the tree base, on cut stumps, or in frills have also been successful.

Diameter growth rates under individual tree selection management of northern hardwoods in Wisconsin and Michigan average 12 to 13 mm (0.48 to 0.51 in) per decade for poles and saplings, respectively (21). Sugar maple, the most abundant species in these stands, averages from 3.8 to 5.0 cm (1.5 to 2.0 in) per decade for poles and saw logs. Annual ingrowth in these stands is averaging 0.2 and 3.1 trees per hectare (0.1 and 1.3/acre) into the pole and sapling classes, respectively, and exceeds mortality in all but one stand, so stocking of eastern hophornbeam is increasing. Subcanopy trees in Michigan stands average 9.9 m (32.5 ft) tall after 50 years with growth progressively declining as the trees age, the peak growth of 3.3 m (10.8 ft) occurring the first decade (54).

The biomass of trees with basal diameters ranging between 5 and 23 mm (0.2 and 0.9 in) can be estimated by the equation

$$Y = 34.3x \pm .\S$$

where Y is the total plant weight in grams and X is the basal diameter in centimeters; the equation accounts for 98 percent of the variation in weights *(16).*

Rooting Habit-No information available.

Reaction to Competition-The species typically grows in climax forests in the northern part of its range. It is classed as shade tolerant and reproduces well under full shade. Ecologists rank it high in their ratings of species climax potential *(12,51).*

In the South the composition of the climax forests has not been clearly identified. The species is associated with later seral stages that follow the pioneer pine communities. Eastern hophornbeam first appears in piedmont pine stands after they are about 90 years old and in bottom-land hardwoods after they are about 36 years old (38). Repeated harvesting of the larger, commercial species from hardwood stands that contain well-developed subcanopies of eastern hophornbeam and its allies may allow the subcanopy to dominate and prevent the reproduction of the original overstory species *(14,29).*

Damaging Agents-The most important disease problems are the trunk and butt rots. The species is one of the most defective in Ontario—defect claims 20 percent of the gross merchantable cubic foot volumes of trees more than 10 cm (4 in) d.b.h. (3). Losses are greatest in trees 95 to 140 years old and more than 18 cm (7 in) d.b.h., with cull averaging 32 percent. Brown stains cause 62 percent of the defect, while yellow-brown stringy rot, white spongy rot, and an incipient yellow rot account for most of the remaining defect. The organisms primarily responsible are ***Stereum murrayi, Phellinus igniarius,*** and ***Pholiota limonella (3).***

Throughout its range, eastern hophornbeam is browsed by white-tailed deer only incidentally. Selective deer browsing of more desirable species of reproduction increases the proportion of beech and

eastern hophornbeam, which are avoided in heavily browsed regenerated stands in New York (42). Beaver in Ohio prefer the species as food-it was the most utilized food after alder and aspen in one drainage (25).

Eastern hophornbeam is considered to be relatively free of insect and other disease problems. The species is not readily injured by cold temperatures; succulent growth was not damaged until temperatures dropped below -8" C (17" F) in Wisconsin *(1)*. It is sensitive to pollutants in the upper Ohio River Valley, where it does not grow in areas with high exposure to oxides of sulfur or nitrogen, or to chlorine or fluorine (33). Its tough, resilient branches resist wind, snow, and ice damage.

Special Uses

Buds and catkins of eastern hophornbeam are important winter food for ruffed grouse, equal to the value of aspen and birch, and the nuts are secondary food in the fall. It is a preferred food for sharp-tailed grouse and wild turkey and is eaten to a lesser extent by bobwhite, red and grey squirrels, cottontails, white-tailed deer, ring-necked pheasant, purple finch, rose-breasted grosbeak, and downy woodpeckers *(23,24)*.

The tree is not commonly used as an ornamental because of its slow growth and sensitivity to pollutants.

Genetics

One variety of the species, var. *lasia*, replaces the typical *Ostrya* in the southern half of the species' range. The forma *glandulosa* occurs in the range of the typical *Ostryu (20)*. The three are distinguished by surface features on new twigs: var. *lasia* is pubescent, forma *glandulosa* is glandular hairy, and the typical plant is glabrous or sparsely pilose. The species has eight pairs of chromosomes.

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