Conservation Assessment
for
Butternut or White walnut (Juglans cinerea) L.

USDA Forest Service, Eastern Region
2003

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This Conservation Assessment was prepared to compile the published and unpublished information on Juglans cinerea L. (butternut). This is an administrative review of existing information only and does not represent a management decision or direction by the U. S. Forest Service. Though the best scientific information available was gathered and reported in preparation of this document, then subsequently reviewed by subject experts, it is expected that new information will arise. In the spirit of continuous learning and adaptive management, if the reader has information that will assist in conserving the subject taxon, please contact the Eastern Region of the Forest Service Threatened and Endangered Species Program at 310 Wisconsin Avenue, Milwaukee, Wisconsin 53203.

Table Of Contents

EXECUTIVE SUMMARY

This Conservation Assessment provides available information regarding *Juglans cinerea* (butternut), its distribution, life history, habitat, ecology, and management practices. *Juglans cinerea* occurs throughout the central and eastern United States and southeastern Canada from New Brunswick to Minnesota, and south to Georgia and Arkansas (Gleason & Cronquist, 1991). *Juglans cinerea* tends to prefer moist, fertile soil and grows rapidly on well-drained soils on hillsides of mixed hardwood forests. At least 17 states within its range have more than 100 occurrences. As a result of butternut canker (*Sirococcus clavigignati-juglandacearum*), the species is susceptible to high mortality and high rates of infection (NatureServe, 2002). Between the years 1980 to 1994, there was a dramatic decrease in the number of live butternut trees throughout the United States. In many instances populations were down over 75 percent (Ostry et al., 1994). There is no known cure for this fungal disease (canker) and it may eliminate the species (Katovich et al., 1998).

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J. E. Juntz, Professor of Plant Pathology, University of Wisonsin-Madison.

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Michael E. Ostry, Research Plant Pathologist, North Central Research Station, St. Paul, MN.

Steven Katovich, Forest Entomologist, Northeastern Area National Forests, State and Private Forestry, St. Paul, Minnesota.

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INTRODUCTION / OBJECTIVES

The National Forest Management Act and U.S. Forest Service policy require that Forest Service lands be managed to maintain viable populations of all native plant and animal species. A viable population is one that has estimated numbers and distribution of reproductive individuals to ensure the continued existence of the species throughout its range within a given planning area. In addition to those species listed as Endangered or Threatened under the Endangered Species Act, or Species of Concern by the U.S. Fish and Wildlife Service, the Forest Service lists species that are sensitive within each region (Regional Forester Sensitive Species). A designation of "sensitive" affords some additional regulatory protection.

Juglans cinerea (butternut) is a Regional Forester Sensitive Species (RFSS) in the Eastern Region for 13 of the 16 National Forests. Butternut was the only R9 sensitive species found in every National Forest in the Eastern Region with the exception of Superior and Chippewa National Forests in Minnesota (north of natural range) and Medewin National Tallgrass Prairie in Illinois (National Forest). In Michigan, it is listed as Sensitive on the Hiawatha, Ottawa, and Huron Manistee National Forests. It is designated as a Sensitive Species on the Chequamegon-Nicolet National Forest in Wisconsin, but it is not documented on Minnesota National Forests where its statewide distribution is further east and south. Other National Forests with a RFSS listing for *Juglans cinerea* include Mark Twain in Missouri, Shawnee in Illinois, Hoosier in Indiana, Wayne in Ohio, Monongahela in West Virginia, Alleghany in Pennsylvania, Finger Lakes in New York, Green Mountain in Vermont, and White Mountain in New Hampshire.

Historically, *Juglans cinerea* was an important source of wildlife mast, especially in the northern portion of its range where black walnut did not thrive. *Juglans cinerea* does not grow in great numbers anywhere in its range (Ostry et al., 1994). According to Forest Inventory and Analysis data compiled in the 1990's, there has been a dramatic decrease of live *Juglans cinerea* trees throughout the United States since 1980 (Ostry et al., 1994). Even before 1980, it was reported that butternut had died throughout North East USA, but the cause was unknown until Kostichka, Nair, and Kuntz isolated (Koshtichka, 1982) and identified the pathogen (Nair, 1999). There is a need to maintain a viable population to preserve biodiversity in the eastern forests.

The objectives of this document are to:

1. Provide an overview of current scientific knowledge for *Juglans cinerea*.

2. Provide a summary of the distribution and status of *Juglans cinerea*, both rangewide and within the Eastern Region of the National Forests.

3. Provide the available background information needed to prepare a subsequent Conservation Strategy.

The Hiawatha National Forest in Michigan prepared this conservation assessment. We needed to rely on other forest departments in the eastern and southern states to provide us with information regarding *Juglans cinerea* for their states.

BIOLOGICAL AND GEOGRAPHICAL INFORMATION

Nomenclature and Taxonomy: (USDA Plants Database, 2001; Delaware Natural Heritage Program, 2001).

Order:	Juglandales
Family:	Juglandaceae
Scientific Name:	*Juglans cinerea* L.
Synonym:	*Wallia cinerea* (L.). Alef
USDA NRCS Plant Code:	JUCI
Common Names:	butternut, white walnut, oilnut, and lemon walnut.
Recognized hybrids:	(USDA Plants Database, 2001) *Juglans* × *quadrangulata* (= *J. cinerea* × *J. regia*) *Juglans* × *bixbi* (= *J. cinerea* × *J. ailantifolia*)

Taxonomy: The genus *Juglans* consists of about 20 species divided into four taxonomic sections. *Dioscaryon* contains the only English walnut (*J. regia*), the most widely cultivated species. *Rhysocaryon* contains black walnut (*J. nigra*). Butternut is the only member of the section *Trachycaryon*. The section *Cardiocaryon* contains the species native to Asia. Since butternut hybridizes with species in the section *Cardiocaryon* but not with black walnut, it has been suggested that butternut be included in the section *Cardiocaryon* (Fjellstrom & Parfitt, 1994).

Species Description and Life History

Juglans cinerea is a small to medium-size forest tree found in deep, moist, loamy areas throughout the East, from Canada to North Georgia and Mississippi with mostly scattered individuals (Clark, 1958). *Juglans* comes from the Latin words jovis and glans, meaning nut of Jove while *cinerea* refers to the gray color of the bark (Missouri Botanical Garden, 2002). Individual trees may attain a height of 40-60 feet and 12-24 inch diameter (maximum size 110 feet and 60 inches) (Ostry et al., 1994). The trunk often divides into an open crown of large spreading branches; gray bark, smooth on young trees, while old trunks are divided by dark fissures into lighter flat-topped ridges. Twigs can be distinguished by brown-chambered pith. Leaf scars usually have a downy line across the top, not notched; leaves alternate pinnately compound with yellowish-green leaflets, 7-17 in number. The petioles and branchlets are downy with viscid hairs, pointed, solitary or borne in drooping clusters of 3-5. Nuts with jagged shells, enclosing a sweet but oily edible kernel (Barnes & Wagner, 1981). The roots of *Juglans cinerea* exude a substance called juglone, which is allelopathic. Juglone is toxic to many other trees, ornamentals and crop plants, as well as to butternut seedlings. As a consequence, *Juglans* species are usually found as solitary trees (Pirone, 1941).

Native Americans prized butternut and had multiple traditional uses for various parts of the tree, including boiling the tree sap to make syrup beverages. Sugar may be produced from the sap of this species as in sugar maple (Van Dersal, 1938). The nuts were gathered and stored for winter. They would boil the nuts, and then use the buttery-flavored liquid to make a mush for baby food. The nuts were used in breads, cakes, soups, and relishes (Athenic Systems, 2003; Missouri Botanical Garden, 2002). The bark is used for dyeing wool a dark brown color, but is inferior to that of black walnut. Butternut has medicinal action and uses (Grieve, 1998). The inner bark of the root is the best for medicinal use and should be collected in May or June. It has a mild cathartic property like rhubarb, and may be used as a habitual laxative, as well as for dysentery and hepatic congestions. The expressed oil of the fruit removes tapeworm. The fruit when half-grown is made into pickles and when matured is a valuable part of the diet (Grieve, 1998).

SPECIES CHARACTERISTICS

Inflorescence: Monoecious, appearing at the same time as the new leaves. Staminate flowers (no petals) from previous year's growth, in yellow-greenish, drooping catkin, 6-15 cm., 1 m. length, stamens 8-12 per flower, pollen sacs 0.8-1.2 mm. Pistillate flowers on young current year's shoots with conspicuous red-fringed stigmas in a cup-shaped involucre of bracts in groups of three or five on the new growth (Collingwood & Brush, 1978). Staminate and pistillate flowers do not usually mature simultaneously on any individual tree (Wilson, 1972; Brinkman, 1974). Butternut trees flower in May or June in the Midwest and are wind pollinated.

Fruits: 1 to 3-5 husks in a bundle, ellipsoid to ovid, 2 inch long green husk, sticky-pubescent, later turning brown, 4-8 cm, aromatic, 8 ridges on a shell, an edible nut inside ripening in autumn (Neagele, 1996.) The fruit is an oblong nut, occurring singly or in clusters of 2 to 5. Nutshells may be hard to crack open and the kernels are often small. The nut is sweet, with a buttery flavor, up to 60 percent oil content at peak ripeness, and edible (Rupp, 1990). Nuts mature in September and October in the same year after pollination. Native Americans used the nuts for food.

Seed Production and Dissemination: Seed-bearing age begins when butternut is about 20 years old. From 30 to 60 years is the optimum age for seed bearing. Good crops can be expected every 2 to 3 years, with light crops during intervening years. Lack of pollination often causes low viable seed yields (Ostry et al., 1994). Upon ripening, seeds are dispersed by gravity and squirrels or other rodents (Rink, 1990). In a study done in Japan on a walnut species (*Jugulans airanthifolia*), 50.6 percent of the nuts were scattered-hoarded up to 168 m from the feed source (Tamura et al., 1999). By burying nuts in the soil, nut viability is maintained and predation by rodents is reduced (VanderWall, 2001). The buried seeds may also provide a seed bank. Seeds may also be dispersed by water in riparian situations. This may be the key to the history of its distribution in the northern Great Lakes area (Taylor, pers. comm., 2002). Although seed can remain dormant for 2 years (OMNR, 2000), in greenhouse situations cold stratification for 90-120 days at temperatures of 20 to 30 degrees Fahrenheit overcomes dormancy (Rink, 1990).

Growth and Yield: *Juglans cinerea* grows rapidly, especially as a seedling. It is considered to be a medium-sized tree, 40-60 feet high and 12-24 inches in diameter (Ostry et al., 1994).

Butternut does not usually live longer than 75 years and it is short lived in comparison to its common tree associates (Rink, 1990).

Reproduction of *Juglans cinerea* can only be sustained in stand openings or fields where shade does not impede its development. The minimum size area needed to establish and promote early development of intolerant species is about 2-3 times the height of the surrounding dominant trees. Openings that are smaller than 2 acres will have a large area that is on the edge where shading can slow the reproduction and growth (Sander, 1989). Smaller openings may need to be enlarged to allow for full growth and development of intolerant butternut trees (Ostry et al., 1994). Butternut often establishes along riparian ways and grows to maturity with less buffer area then the recommended footage. Trials are needed to determine the optimal space between trees for butternut.

The largest butternut in Michigan is located in Hillsdale County in southern Michigan. In 1989 it was 189 inches in girth, 103 feet tall (Ehrle, 1997). In Wisconsin, the Department of Natural Resources Wisconsin's Champion Trees list (2001) has a *Juglans cinerea* listed in Vernon County that has a circumference of 150 inches, a height of 63 feet, and a spread of 67.5 feet (10-3-1990 measurements). According to the Virginia Big Tree Program Big Tree List (2003), the largest *Juglans cinerea* is located in Newport News County with a circumference of 202 inches, a height of 87 feet, and has a crown of 30 feet. Butternut is also listed as a Maryland Big Tree Program State Champion for 2002 in Montgomery County with a circumference of 10 feet 4 inches, a height of 71 inches, and a crown spread of 55 feet.

Wood: *Juglans cinerea* is light brown, soft, weak, and coarse grained. Uses include furniture, cabinetwork, and interior trim (Barnes & Wagner, 1981), as well as for gunstock and paneling. At one time it was used to panel the inside of carriages (Smith, 1995). In areas where butternut is available it ranks 8th (of 28) for prime veneer and sawlogs (Peterson, 1990). There is only one other species of *Juglans* within the range of *J. cinerea, J. nigra*. *Juglans cinerea* has dark chocolate-brown pith and ovoid-oblong fruits whereas *J. nigra* has pale pith and globose fruits (Voss, 1985).

Geographical Distribution

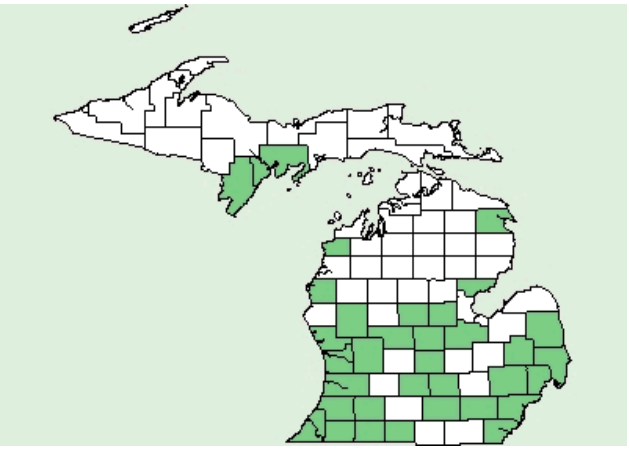
Juglans cinerea is distributed throughout the central and eastern United States and southeastern Canada. It occurs from New Brunswick throughout New England except for northern Maine, south to Maryland, Virginia, and Tennessee east to central Iowa and Missouri. The southern edge occurs in North Carolina, South Carolina, northern Georgia, northern Alabama, northern Mississippi and northeast Arkansas. Butternut occurs in Michigan, Wisconsin, southeastern Minnesota, and in to central Iowa and Missouri (Coladonato, 1991). According to Steven Katovich, Forest Entomologist, Forest Health Protection, North Central Research

Distribution of *Juglans cinerea* L. (Butternut) in North America. Flora of North America, Volume 3.

Station, in the past, populations of butternut were quite extensive in the southern three-quarters of Wisconsin. Wisconsin, Indiana, West Virginia, and Tennessee were the leading producers of butternut timber (Rink, 1990). Prior to European settlement, some populations of butternut may have been introduced into northeastern North America by the native Iroquois tribes (Wykoff, 1991). In Canada, *Juglans cinerea* is found from the St. John River Valley in southwestern New Brunswick to the lower St. Lawrence Valley, westward throughout the hardwood region of southwestern Quebec and in Ontario east and south of Georgian Bay (Department of Forestry – Canada, 1961).

Michigan

Juglans cinerea was often planted for its nut production in northern Lower Michigan. In the Lower Peninsula, butternut and black walnut (*J. nigra*) essentially overlap in distribution (Voss, 1985). It is found scattered throughout the south part of the Lower Peninsula (Smith, 1995), but it is considered rare in the southern half of the Lower Peninsula of Michigan (Barnes & Wagner, 1981). It reaches its northern range limit in the western Great Lakes region within the Upper Peninsula counties (Barnes & Wagner, 1981), and it is found in Delta and Menominee Counties (Smith, 1995).



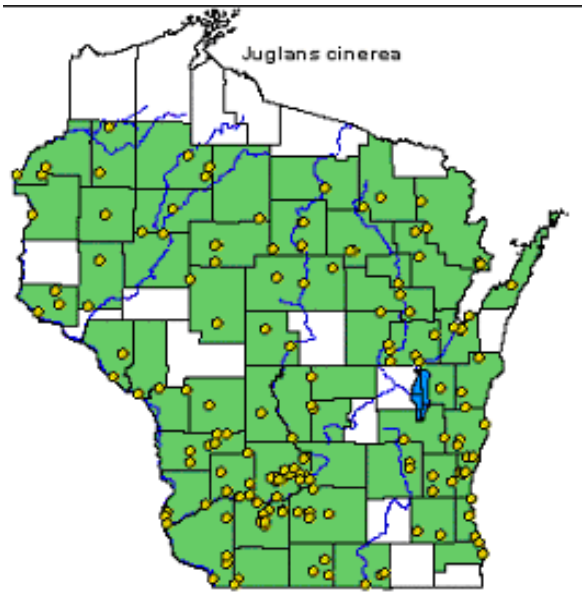
County Distribution of *Juglans cinerea* L. (Butternut) in Michigan. USDA Plants Database

In Michigan, few butternut trees are under National Forest Service management (USDA Forest Service, 1992). However, their presence is better documented on National Forests than private land. The Hiawatha National Forest Plant Atlas (1997) lists 16 plantings in Delta County and three in Schoolcraft County. In the winter of 1994, five additional butternuts were located on private property within the Rapid River Ranger District of the Hiawatha National Forest. According to Sue Trull, Forest Botanist, on the Ottawa National Norest in the western Upper Peninsula, there are two locations that were planted with butternuts and they are old homesteads. On the Huron-Manistee National Forest in Michigan's Lower Peninsula, butternut is uncommon and in rapid decline due to butternut canker disease (USDA Forest Service, 1999). Alix Cleveland, Forest Botanist, stated that most butternut trees on the Huron-Manistee National Forest are at old homestead sites. Butternut was also reported in a 1970's vegetative survey of the Huron Mountains in Marquette County, but no indication is given whether this was a natural or planted tree (Wells & Thompson, undated). According to Sylvia Taylor, Adjunct Professor of Natural Resources at University of Michigan in Ann Arbor, disease has wiped out the main stand of *Juglans cinerea* in Mackinac County (Bois Blanc Island), but isolated individuals remain.

Wisconsin

Wisconsin has the greatest number of *Juglans cinerea* stands in the United States (located across the southern three-quarters of the state), but populations are declining (Ostry et al., 1994). Wisconsin historically was a major producer of butternut and in the 1970's "select" butternut lumber was second only to walnut in economic value (Peterson, 1977).

On the Chequamegon-Nicolet National Forest, *Juglans cinerea* occurs in the following districts on upland sites: Eagle River/Florence, Great Divide, Lakewood/Laona, and Medford/Park Falls. There are more butternut trees in the Laona District than the rest of the Chequamegon-Nicolet National Forest. There is an ongoing study regard to butternut regeneration near Laona.



County Distribution of *Juglans cinerea L.* with **(Butternut) in Wisconsin**. University of Wisconsin Herbarium

According to Mark Thiesen, Forest Silviculturist for the Chequamegon-Nicolet National Forest, nearly all the butternut trees on the Forest are at their maximum age (60-75 years-old) and would be beginning to die back, even without the canker. All district silviculturists mentioned that there were some healthy trees 10 years ago, but now all mature butternut trees show signs of butternut canker. The Oconto River Seed Orchard on the Nicolet National Forest has a planting of *Juglans cinerea* (Steven Katovich pers. comm., 2001).

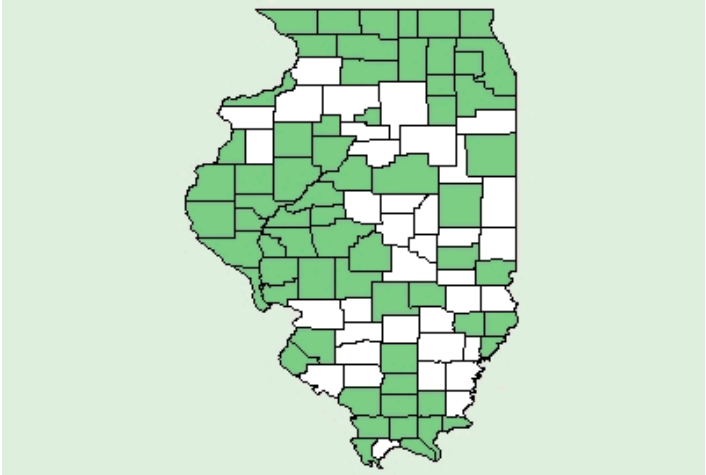
Minnesota

In Minnesota, *Juglans cinerea* has been located in 29 counties (University of Minnesota, 2001), but there are no known individuals of *J. cinerea* on the Chippewa or Superior National Forests, probably because the Forests are outside its northern limits. The nearest known site of *J. cinerea* is nine miles south of the Chippewa National Forest boundary (Ian Shackelford pers. comm., 2001). About a dozen trees of *J. cinerea* have been found in a red oak forest in Cass County, which represents the northwestern most location for this species in North America (Chippewa National Forest and Cass County Rare Plants Field Guide, 1996). Four individuals across the state exist in Natural Areas, and a couple of others exist in State Forests (University of Minnesota, 2001).

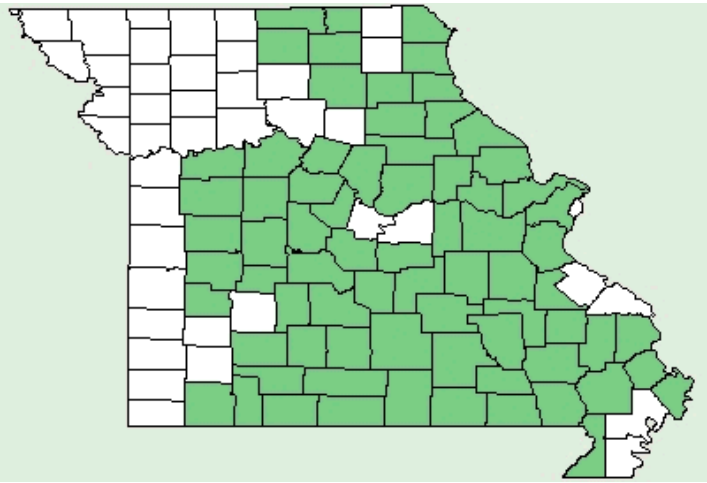
Other Midwest Region National Forests

National Forest occurrences of *Juglans cinerea* in Indiana, Illinois, and Ohio are described below with an indication of the health of the remaining trees. On the Hoosier National Forest in Indiana, there are 11 confirmed sites and one unconfirmed site. Most cites are with one or two butternut trees (Steve Olson pers. comm., 2001). However, the Hoosier National Forest has one site with 17 live trees along with 9 recently dead individuals. Of the 17 live trees, 11 trees have

50 to 90 percent live canopy. On the Shawnee National Forest in **Illinois**, *Juglans cinerea* occurs very sparingly. According to Beth Shrimp, Forest Botanist, a healthy mature tree exists here with a 15" DBH and without any cankers, along with *Liriodendron tulilifera* (tulip tree) and *Acer rubrum* (red maple) along an intermittent stream at a natural research area. On the Wayne National Forest in Ohio there are currently 22 healthy trees, 25 butternuts in some phases of disease, and 18 butternuts of unknown health (Erin Larson pers. comm., 2001).



County Distribution of *Juglans cinerea* L. (Butternut) in Illinois. USDA Plants Database



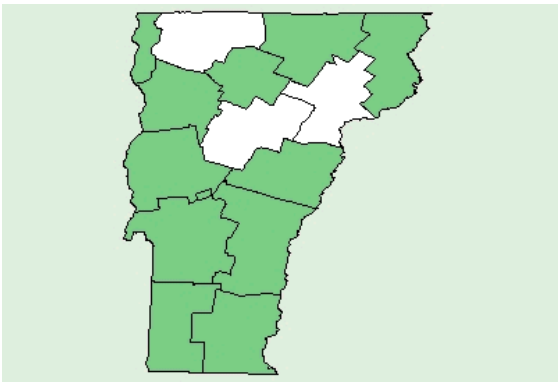
County Distribution of in *Juglans cinerea* L. (Butternut) Missouri. USDA Plants Database

Juglans cinerea occurs throughout the state of Missouri, except for the droughty western tier of counties. On the Mark Twain National Forest in **Missouri**, *J. cinerea* occurs as a scattered tree in semi riparian areas whose numbers are not known, but nuts are being collected from some of the healthy trees for replanting (Ross Melick, pers. comm., 2001).

New England States National Forests

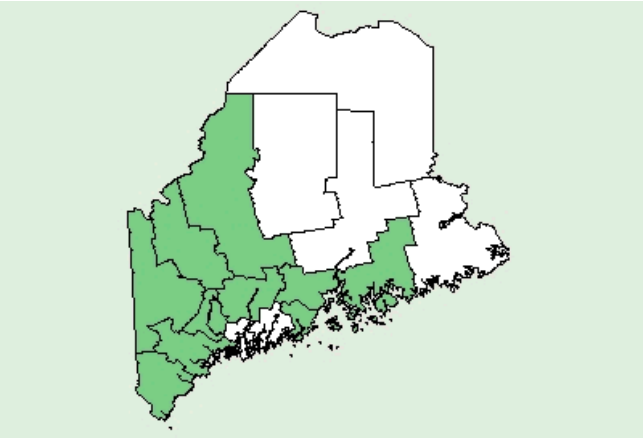
According to *Trees of New England* (Dame and Brooks, 1972), *Juglans cinerea* was previously common in Maine, Massachusetts, Rhode Island, Connecticut, and New Hampshire. Butternut was listed as frequently occurring in Vermont and often abundant throughout Maine (Dame and Brooks, 1972).

The New England states are fairly active in managing their remaining *J. cinerea* trees, especially Vermont. On the Green Mountain National

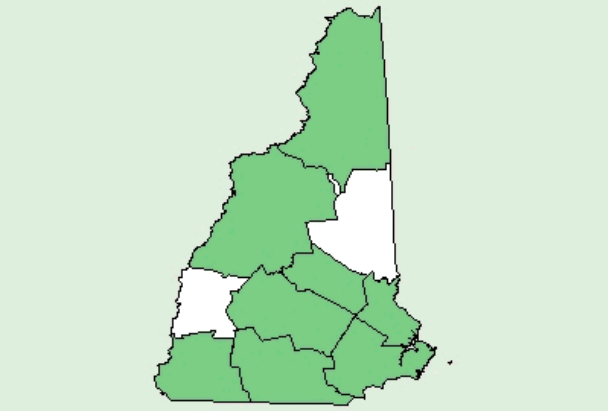


County Distribution of *Juglans cinerea* L. (Butternut) in Vermont. USDA Plants Database

Forest in Vermont there is a canker resistant butternut planting at the Rochester Ranger District (R. Burt pers. comm., 2002). The state of Vermont is working closely with the North Central Research Station by providing graft material. According to Diane Burbank, Ecologist for Green Mountain National Forest, it is estimated that butternuts are 80 percent sick and 20 percent healthy on the Green Mountain National Forest. MaryBeth Dellar, botanist at the Finger Lake National Forest in New York, stated that Green Mountain National Forest maintains a tree farm for resistant twigs from butternut canker resistant trees to be grafted to walnut. Dellar also reported the presence of butternuts mostly in hedgerows and remnants of old homesteads. On the White Mountain National Forest in New Hampshire, John Williams, Sales Design and Cruising, relayed that almost all mature trees have some evidence of canker, but here *Juglans cinerea* is regenerating and 4 to 8 inch DBH trees often appear as canker free when scattered.



County Distribution of *Juglans cinerea* L. (Butternut) in Maine. USDA Plants Database



County Distribution of *Juglans cinerea* L. Butternut) in New Hampshire. USDA Plants Database

There are twelve records of *Juglans cinerea* in five districts in the Monongehela National Forest in West Virginia (Jan Garrett pers. comm., 2001). On the Allegheny National Forest in Pennsylvania, seven trees are recorded. This estimate is probably low, as the bottomland habitat for this species has not had a recent survey (Brad Nelson pers. comm., 2001). According to Nelson, *Juglans cinerea* is neither common nor particularly rare in Pennsylvania.

ECOLOGY and HABITAT

Butternut (*Juglans cinerea*) is characteristic of moist fertile soils of lower slopes, coves, riverbanks and floodplains (Rink, 1990). Although butternut prefers rich, moist, well-drained loams, especially riverbanks and ravines (Smith, 1995), it may be found on drier rocky sites, especially those of limestone origin (Canada Department of Forestry, 1961). Butternut will tolerate drier soils than black walnut, but does not tolerate soils of over 30 percent moisture (Cogliastro et al., 1997). Butternut is more winter-hardy than black walnut (Rink, 1990), with a range that is further to the north and at higher elevations than black walnut (Grimm, 1983). Butternut's presence farther north may be related to the history of its post-glacial dispersal (Sylvia Taylor, pers. comm., 2002). In some areas, butternut occurs occasionally as a roadside

tree (NatureServe, 2002). Like other *Juglans* species, *Juglans cinerea* exhibits allelopathic tendencies. The roots exude a substance called juglone, which is toxic to many other trees and even to its own seedlings (Hepting, 1971).

Juglans cinerea is a generalist in terms of favored soil type. It grows in both loam and sandy loam soils of pH 5.9 to 7.6. On deeper soil, *Juglans cinerea* forms a taproot and wide-spreading lateral roots (Ostry et al, 1994). It does not often appear in pure stands, but it is found singly or in small groups in association with other hardwood species. It occurs in mesic hardwood forests with *Tilia americana* (basswood), *Acer saccharum* (sugar maple), *Quercus rubra* (red oak), *Quercus alba* (white oak), *Fagus grandifolia* (beech), *Ulmus americana* (American elm), *Prunus serotina* (black cherry), *Celtis occidentalis* (hackberry), *Quercus macrocarpa* (burr oak) and *Carpinus caroliniana* (blue-beech) (Barnes & Wagner, 1981).

Understory Intolerance

Juglans cinerea is a shade intolerant species. It must be in the overstory to thrive (Rink, 1990), and room must be provided for it to grow and remain in the upper canopy (Ostry et al., 1994). In a stand, young trees may withstand side competition but will not survive in shade. An important factor in regeneration success is competition from other trees and shrubs during the first 5-10 years of growth. Butternut may struggle while competing for light with aspen, raspberry, and vines. Competition and weed control, mechanical or chemical, is very important. Regeneration efforts needed for *Juglans cinerea* are similar to oak (Jane Cummings-Carlson, pers. comm., 2002). Reproduction can only be sustained in stand openings, since shade impedes its establishment. Understory intolerance is one of the reasons *J. cinerea* often grows as a riparian species, as the stream provides a natural opening.

Juglans cinerea is widely scattered in distribution. With total numbers down due to the butternut canker, butternut's chance of being in the right place to take advantage of an existing forest opening are reduced. Biology, chance, and history all play a role in gap-phase regeneration (Barnes et al., 1998). In some forests, saving butternut has become an important priority, and existing gaps are enlarged if a butternut is present (Ostry et al., 1994).

Some of the parameters affecting regeneration in a gap environment include gap size and shape, direction or compass orientation, height of the surrounding vegetation, and free-fall debris (Barnes et al., 1998; Hubbell & Foster, 1986). Open conditions may make butternut less susceptible to butternut canker, since moist conditions tend to facilitate the spread of the disease (Ostry et al., 1994). Light intensity is higher in gaps and lasts longer during the day. This leads to warmer soil during the day, but often soil temperatures are cooler at night, due to the lack of insulating cover (Hubbell & Foster, 1986). Open conditions may make butternut less susceptible to butternut canker, since moist conditions tend to facilitate the spread of the disease (Ostry et al., 1994). However, soil water content may initially be higher in gaps because of reduced root uptake competition and lower transpiration water loss (Hubbell & Foster, 1986).

Range of Climatic Conditions

Climatic conditions within the native range of *Juglans cinerea* vary widely. Mean annual temperature ranges from 16 degrees Celsius (60 degrees Fahrenheit) in Alabama to 4 degrees

Celsius (40 degrees Fahrenheit) in New Brunswick, within an average maximum of 41 degrees Celsius (105 degrees Fahrenheit) and a minimum of –34 degrees Celsius (-30 degrees Fahrenheit). The frost-free period is 210 days in the southern part and 105 days in the north (Rink, 1990).

HABITAT

Wisconsin

In Wisconsin, *Juglans cinerea* is a component of the southern Wisconsin hardwood forest (Curtis, 1971). These forests are the densest forests in the state, dominated by sugar maple, basswood, white ash, slippery elm, American elm, and ironwood. Black walnut (*J. nigra*), butternut (*J. cinerea*), yellow-bud hickory (*Carya cordiformis*), and large-toothed aspen (*Populus grandidentata*) are also present. Butternut is also widely scattered in the oak-hickory forests of southern Wisconsin (Jane Cummings-Carlson, pers. comm., 2002). However, Curtis (1971) found that butternut, black walnut, white oak (*Quercus alba*), and American elm (*Ulmus americana*) were totally lacking in the seedling classes.

In northwestern Wisconsin, Braun (1972) described a streamside community dominated by *Acer saccharinum* (silver maple), with a mixed stand of *Fraxinus americana* (white ash) and *F. nigra* (black ash), and scattered individuals of *Quercus macrocarpa* (bur oak) and butternut. Favored habitats include northern lowland forest, northern upland forest, southern lowland forest, and southern upland forest (University of Wisconsin, 2001). During the early 1900's, butternut quickly colonized farm fields and pastures when agricultural activities were abandoned (Katovich et al., 1998).

Michigan

Smith (1995) states that *Juglans cinerea* is not common in the state, rare at the northern limits and becoming more frequent and larger in size in the southern counties. In the southern counties it may be found in stands of basswood, elm, tulip poplar, hickory, cherry, oak, and maple whereas in the north its associates include yellow birch and white pine. According to Barnes and Wagner (1981), in Michigan, butternut habitat characteristics include moist, fertile soils of lower slopes, coves, and riverbanks and floodplains. It may also grow on dry, rocky soils derived from limestone. *Juglans cinerea* occurs singly in mesic hardwood forests with basswood, sugar maple, red oak, white oak, beech, American elm, black cherry, hackberry, bur oak, and bluebeech.

New England

In New England, butternut is typically found along roadsides, in rich woods and river valleys, on fertile moist hillsides, and on mountain slopes (Dame & Brooks, 1972).

Appalachian Mountains

Juglans cinerea is found along with several hardwood species such as beech/sugar maple, sugar maple/basswood, yellow poplar/white and red oak, and river birch/sycamore (Rink, 1990). In

the southern and eastern sections of the Adirondacks at low elevation (400 to 700 feet), forests species include *Quercus alba, Q. rubra, Q. prinus* (chestnut oak), and *Tilia Americana. Fraxinus* species, *Juglans cinerea, Acer rubrum, Acer saccharum,* and *Fagus grandifolia* differ from the less varied hardwood forests (Braun, 1972) because cutting has modified this region. In addition, there is some mixed mesophytic forest in the valleys and lower eastern slopes that are dominated by *Acer saccharum, Fagus grandifolia,* and *Quercus rubra* (Braun, 1972).

Canada

In Canada, *Juglans cinerea* is found near the St. Lawrence Forest Region and the western section of the Acadian Forest region (McIlwrick et al., 2000). Ontario accounts for 60 to 70 percent of the Canadian distribution (Nielsen, unpublished 2001). In southern Ontario, it occurs throughout the entire Carolinian Floral Zone and along the length of the Niagara Escarpment (McIlwrick et al, 2000). A few characteristically southern species reach their northern limits in southern Ontario: sycamore, butternut, and bitternut hickory (Braun, 1972). In Quebec, butternut is found mostly in young stands along with bitternut hickory (*Carya cordiformis*), white ash (*Fraxinus americana*), black cherry (*Prunus serotina),* white elm (*Ulmus americana*), and red elm (*Ulmus rubra*) (Doyon et al., 1998). On Manitoulin Island in northern Lake Huron, *Juglans cinerea* was planted in gardens and along roadsides (Morton & Venn, 1984). Manitoulin Island has similar habitat to Bois Blanc Island, where butternut occurs naturally along a very old beach ridge in the center of the island among old-growth northern hardwoods (Sylvia Taylor, pers. comm., 2002).

CONSERVATION STATUS

Currently, the official Conservation Status of *Juglans cinerea* L. with respect to federal and state agencies is:

Federal:	**U.S. Fish and Wildlife Service:**	Not Listed
	Federal Status:	No Status
	National Heritage Status Rank:	N3 N4 (29 Jan 1998) (NatureServe, 2002)

The Nature Conservancy lists these rankings as:

3 = species rare or uncommon

4 = species is globally or nationally widespread, abundant, or apparently secure, but with cause for long–term concern.

Juglans cinerea L. is listed as a Regional Forester Sensitive Species in 13 of the 16 U.S. Forest Service, Region 9 National Forests: Mark Twain (MO), Shawnee (IL), Hoosier (IN), Wayne (OH), Monongahela (WV), Allegheny (PA), Finger Lakes (NY), Green Mountain (VT), White Mountain (NH), Hiawatha (MI), Huron Manistee (MI), Ottawa (MI), and Chequamegon Nicolet (WI). Butternut is likely to occur on the Chippewa National Forest in Minnesota, and currently is a "Forest Sensitive" species (Chippewa National Forest and Cass County Rare Plants Field Guide, 1996).

In 1993, "the harvest of butternut trees was restricted on National Forests in Region 8 and Region 9 to protect potentially valuable genetic material" (Katovich et al., 1998).

Sylvia Taylor, adjunct professor at the University of Michigan and former DNR biologist, feels field assessments and the existing published knowledge on butternut emphasizes the need for it's listing under both the State and Federal Endangered Species acts.

State Status Ranks: (NatureServe, 2002)

ALABAMA	S1	**MISSOURI**	S2
RKANSAS	S3	**NEW HAMPSHIRE**	S1S2
CONNECTICUT	SR	**NEW JERSEY**	S3S4
DELAWARE	S3	**NEW YORK**	S4
GEORGIA	S1S2	**NORTH CAROLINA**	S2S3
ILLINOIS	S2	**NORTH DAKOTA**	SR
INDIANA	S3	**OHIO**	S3
IOWA	SU	**PENNSYLVANIA**	S4
KANSAS	SR	**RHODE ISLAND**	SU
KENTUCKY	S3	**SOUTH CAROLINA**	S?
MAINE	SU	**TENNESSEE**	S2S3
MARYLAND	S2S3	**VERMONT**	SU
MASSACHUSETTS	S4?	**VIRGINIA**	S3?
MICHIGAN	S3	**WEST VIRGINIA**	S3
MINNESOTA	S3	**WISCONSIN**	S3?
MISSISSIPPI	S2	**District of Columbia**	S1

Of the states that are included in the range of distribution for *Juglans cinerea* L., only three have any type of listing regarding status (USDA Plants Database, 2003):

Kentucky	Kentucky State Nature Preserves Commission. 2000. Endangered, Threatened, and Special Concern species (http://www.kynaturepreserves.org/etsquery.asp) Kentucky State Nature Preserves Commission. State Status: Special Concern
Tennessee	Tennessee Natural Heritage Program. 2002. Rare Plant List (http://www.state.tn.us/environment/nh/data.php) Department of Environment and Conservation. State Status: Threatened
New York	Department of Environmental Conservation. 2000. Protected Native Plants (http://www.dec.state.ny.us/website/dlf/privland/forprot/pnp/index.html) Division of Land and Forests. State Status: Exploitably Vulnerable

Canada: **National Heritage Status Rank:** N3N4 (11Aug2000) (NatureServe, 2002)

Canadian Province Heritage Status Rank: (NatureServe, 2002)

MANITOBA	SE	**PRINCE EDWARD ISLAND**	SE
NEW BRUNSWICK	SR	**QUEBEC**	S4
ONTARIO	S4?		

Global: **Global Rank:** G3 G4 (22 Dec 1997) (NatureServe, 2002)
Global Heritage Status Rank Reasons: More than 100 occurrences from at least 17 states within the range of the species; however, the abundance and condition are both in rapid decline due to butternut canker disease, with no known remedy. High mortality, higher rates of infection, and rapid loss of the remaining uninfected trees to timber cutting are factors.

Definition of Ranks

S1 = Extremely rare; typically 5 or fewer known occurrences in the state; or only a few remaining individuals; may be especially vulnerable to extirpation.
S2 = Very rare; typically between 6 and 20 known occurrences; may susceptible to becoming extirpated.
S, N, or G 3 = Rare to uncommon; typically 21 to 50 known occurrences; S3 ranked species are not yet susceptible to becoming extirpated in the state but may be if additional populations are destroyed.
S, N, or G 4 = Common, apparently secure under present conditions; typically 51 or more known occurrences, but may be fewer with many large populations; usually not susceptible to immediate threats.
SU = Status uncertain, a species thought to be uncommon in the state, but there is inadequate data to determine rarity. Also includes uncommon species of uncertain nativity in the state and of questionable taxonomic standing.
SR = Reported from the state, but without persuasive documentation that would provide a basis for either accepting or rejecting the species.
SE = Believed to be expatiated from former region.
S? = Species has not yet been ranked (NatureServe, 2002).

POPULATION VIABILITY AND FRAGILITY

Viability

The abundance of *Juglans cinerea* trees in their native range is rapidly declining due to butternut canker disease, with no known remedy. High rates of infection and subsequent high mortality have resulted in the species recent decline (NatureServe, 2002). Since the pathogen was identified as a new species of *Sirococcus* (Nair et al., 1979), its threat to this valuable species forced federal and state governments to undertake surveys for this serious disease. Michigan and Wisconsin surveys indicated a dramatic decrease in the number of healthy *Juglans cinerea* trees by 84 percent in Michigan and 91 percent in Wisconsin. Ostry (1995) concluded from earlier

reports of infection that "viable populations of butternut are probably no longer present in the southern portions of its range." Schlarbaum et al. (1997) reported that 77 percent of butternut trees in the southeastern United States are now dead. *Juglans cinerea* is now listed as a threatened, sensitive, rare, and highly valuable forest species of the United States. (Kuntz & Prey, 1978; Kuntz et al., 1979; Ostry, 1997a; Ostry et al., 1994).

Fragility

Juglans cinerea seedlings are intolerant to shade and do not easily become established under a closed canopy. It is not easily transplanted because of a deep tap root (Smith, 1995). In addition, the seedlings are sensitive to juglone. Juglone is exuded into the soil via the roots of *Juglans* species. When a parent tree dies, it is unlikely to be readily replaced at the same location due to an accumulation of juglone in the soil, even when viable nuts are left (Hepting, 1971).

Another issue that might lead to the fragile nature of *Juglans cinerea* is its lack of genetic diversity. The lack of genetic diversity could limit butternut's ability to develop resistance to the butternut canker. However, non-infected butternut trees have been found among severely cankered, dying, and dead butternuts. Selections of these individuals have survived repeated inoculations with the pathogen in greenhouse and nursery studies (Tisserat, 1982; Tisserat and Kuntz, 1982). In a Canadian study (Morin et al., 2000), genetic diversity estimates for butternut were low with values much below those estimated for black walnut or other boreal tree species. The average observed heterozygosity was 0.028, indicating a low genetic diversity. These findings may point to limited adaptive genetic diversity and difficulty coping with drastic environmental changes. The exact biological or biogeographical cause for the lower level of genetic diversity remains unclear (Morin et al., 2000).

PRIMARY THREAT

Butternut canker caused by *Sirococcus clavigignenti-juglandacearum* Nair, Kostichka, and Kuntz is the primary threat to *Juglans cinerea* survival. Widespread dying of butternut was first reported in Wisconsin in 1967 (Renlund, 1971). The number and extent of the diseased areas and the determination of canker age by ring count indicated that the disease had been active for several years (Kuntz et al., 1977). Since then, the pathogen was identified as a new species of *Sirococcus*, *Sirococcus clavigignenti-juglandacearum* (Nair et al., 1979). Additional studies on this disease have been undertaken. Butternut canker kills trees of all ages. Young saplings may be quickly killed. Older trees are killed over a period of time by multiple, coalescing cankers that either progressively kill the crown or eventually girdle the stem (Ostry, 1997a).

Symptoms of Butternut Canker and Host Parasite Interactions

The butternut canker affects trees of all ages, sizes, and on all soil types (USDA Forest Service, 1978). Young butternut cankers commonly originate at leaf scars (fig. 1), buds, lenticels, bark wounds, including insect wound and natural bark cracks, and they are often with an inky black center and whitish margin (Nicholls et al., 1978). Early symptoms of the disease are elliptical to fusiform cankers involving the bark and underlying wood of twigs, branches (fig. 2), and stems (Kuntz et al., 1979). Branch cankers usually occur first in the lower crown, and then stem

Figures 1-6: *Young incipient butternut canker at leaf scars (fig 1). Infection at bark cracks and above branch crotch (fig 2). Basal canker (fig. 3). Infected butternut showing the presence of hyphal pegs which lift and rupture the bark (fig 4). Open, shredded, calloused butternut canker (figs. 5 and 6). (Photo images courtesy V. M. G. Nair).*

cankers (bole of a tree) develop from spores washing down from branch cankers (Nicholls et al., 1978). Cankers can commonly occur at the base of trees (fig. 3) and exposed buttress roots (Tisserat & Kuntz, 1983). Cankers of different ages and sizes commonly occur on the same tree.

Initially, only the outer bark is affected, but soon the underlying wood is invaded. After several weeks, masses of black hyphal pegs with pycnidia arise from the mycelial stroma, which loosen and rupture the outer bark (Nair, 1999) (fig. 4). The bark cells become thin and rapidly disintegrate leaving only a dark brown, gummy residue that gives rise to a brownish/black exudate in the spring. By summer, sooty black patches remain. Older cankers on trunks are large and open or partly covered by shredded bark, frequently bordered by callus, vertically oriented, and perennial (Kuntz et al, 1979) (figs. 5 and 6).

During host-parasite interaction, the fungus penetrates host cells at leaf scars. It then penetrates phloem parenchyma cells and in between the phloem fiber elements. Later they penetrate uni- and multi- xylem ray cells and parenchyma (Nair, 1999). Some stem cankers have progressed for many years (at least 13 years) as evidenced by differences in annual ring counts. Cankers eventually coalesce to girdle and kill trees by preventing the nutrient flow through the tree (Kuntz et al., 1979). It may take over 30 years for a butternut tree to die, but death usually follows infection. Sprouts, if they develop, are also infected and killed usually within the first few years (Ostry et al., 1994).

Host Range of the Pathogen

Recent research studies using artificial inoculations have revealed that the butternut canker pathogen can attack other highly valuable species of Juglandaeae. These include black walnut (*Juglans nigra*), Japanese walnut (*J. ailantifolia*), Persian walnut (*J. regia*), and heartnut (*J.*

ailantifolia var. *cordiformis*), as well as various hybrids of the species. Both seedlings and 10 to 20 year old field planted trees of all above-mentioned species proved to be susceptible (Fiderspiel and Nair, 1982; Gabka, 1996). In addition, black walnuts growing in a mixed stand of diseased butternuts have been found infected naturally (Prey & Kuntz, 1982). However, heartnut, Japanese walnut, and hybrids between them and butternut exhibited greater resistance to the pathogen by developing smaller cankers (Gabka, 1996; Nair, 1999). Artificial inoculations of one-year-old seedlings of shagbark hickory (*Carya ovata*), an unrelated species to *Juglans*, proved susceptible to this pathogen by developing cankers (Ostry, unpublished data). This wide host range of the pathogen, including butternut, black walnut, Persian walnut, Japanese walnut, and heartnut has attracted concern because they are all economically important and highly valuable species that support many wood-using and nut-processing industries, both nationally and internationally.

TRANSMISSION AND SPREAD OF BUTTERNUT CANKER

Wind and Rain Borne Transmission

Butternut canker is transmitted from tree-to-tree by pycnidiospores carried by wind (45 meters) and in small droplets of splashing rain, or aerosols during rainfall up to 40 m from a cankered tree (Tisserat & Kuntz, 1983). Conidia require free water for release from a gelatinous matrix and are released from pycnidia during periods of rain or high humidity (Cree, 1995). The fungus can survive and sporulate on dead trees for at least 20 months (Tisserat & Kuntz, 1984). Spores are produced throughout the growing season and are extruded either in sticky masses or as fine, hair-like cirri (Tisserat & Kuntz, 1982). Once airborne, the spores can survive and be dispersed long distances during weather conditions of cool temperatures and overcast skies (Tisserat & Kuntz, 1983). Relative humidity of 95-100 percent greatly aids in successful infection (Nair, 1999). Cankers resulting from natural infection have been found over 100 m from the nearest cankered tree (Tissart & Kuntz, 1983).

Seed Borne Transmission

The fungus is also internally seed-borne (Orchard, 1984). The fungus can survive in infected nut-meats of seed stratified at 4°C for up to 18 months. Seedlings that emerge from infected seeds develop basal lesions, stem cankers, fungal stroma, pycnidia and hyphal pegs and quickly die (Orchard, 1984). This internally seed borne condition of the pathogen could partially explain the lack of butternut regeneration (Nair, 1999). This internal seed borne infection could lead to transmission of butternut canker to disease-free areas in a country and also internationally. Butternut canker was identified on nursery seedlings in Quebec, far away from any native butternut trees (Gaston LaFlamme, pers. comm., 2003 with V.M.G. Nair and A. Prey). The seeds for planting had been selected throughout the range of butternut in Quebec where the disease had been detected in several natural strands (Ostry, 1998b).

Insect Transmission Possibilities

The role of insects in long-distance transmission has not yet been confirmed. However, Katovich and Ostry initiated a study in the spring of 1995 and 1996 to examine the potential role of insects in butternut canker's dissemination. Several plots were established in Minnesota and

Wisconsin to monitor insect activity in infected butternut trees. On recently dead branches of butternut, a group of beetles were commonly found under the bark in association with stromatal pegs and pycnidia produced by butternut canker fungus (Katovich and Ostry, 1998).

Spread of Butternut Canker

Widespread dying of *Juglans cinerea* was first reported for the United States in southwestern Wisconsin in 1967 (Renlund, 1971). Butternut dieback was mapped for Grant County, Wisconsin in 1970, and sampled in other Wisconsin counties to determine the extent of the dieback. In 1967, the butternut canker was limited to three southwestern counties (Katovich et al., 1998).

A survey done in 1978 reported canker dieback from 12 states, especially severe was the Midwest area. North and South Carolina reported that the disease had essentially eliminated their *Juglans cinerea* stands. In 1978, New England states were still mostly unaffected and New Hampshire and Vermont did not report cankered trees (Anderson & LaMadeleine, 1978). By 1983, the butternut canker had spread throughout the southwestern portion of Wisconsin (19 counties) and also included two central counties (Prey & Kuntz, 1982).

It was not until 1979 that the casual fungus was isolated in pure culture and identified as *Sirococcus clavigignenti-juglandacearum* (Nair et al., 1979). Between 1980 and 1994, a dramatic decrease in the number of live butternuts throughout the United States was documented (Ostry et al., 1994). In Michigan, there was an 84 percent decrease in butternut during this period. A 1993 Wisconsin Department of Natural Resources survey indicated that 91 percent of the live butternut trees in all age classes in Wisconsin were diseased, and 27 percent of the surveyed trees had died (USDA Forest Service, 1993). By 1996, the butternut canker was known from almost the entire state, including most eastern counties north to the Door Peninsula (Katovich et al., 1998). By 1993, the disease had spread to central coastal Maine and Vermont (USDA Forest Service, 1993). By 1996, the butternut canker was reported from every county in Vermont with 94 percent of the trees cankered (Bergdahl et al., 1996).

In Canada, the butternut canker was first collected in Quebec in 1990 (Innes et al., 1996, see Nielsen draft 2001), and then in Ontario in 1991 (Davis et al., 1992, see Nielsen draft 2001). Since then, it has been reported in numerous locations (Fleguel, 1996; Harrison & Hurley, 1998, see Morin et al., 2000). The forest Insect and Disease Survey (FIDS) unit of the Canadian Forest Service sampled 30 locations in southwestern Ontario in 1992. The canker was present at 22 out of 30 locations. Twenty-seven percent of the butternut trees were killed by the disease in the Cambridge District (Davis et al., 1992 see Nielsen draft 2001). The health of *Juglans cinerea* in Canada is not yet as severely affected as in the United States. Yet, the spread of the butternut canker is worrisome since the canker was not known until 1991 in Ontario (Davis et al., 1992; Morin et al., 2000). In Quebec, the disease has been detected on trees in several neutral stands, in a plantation, and even in seedlings in a forest tree nursery (Ostry, 1998b). By 1997, the butternut canker was found for the first time in New Brunswick (Harrison & Hurley, 1998). The Field Guide to Tree Diseases in Ontario (Davis & Meyer, 1997, see Nielsen draft 2001) has assigned the most serious damage rating of "1" to butternut canker or "capable of causing serious injury or death to living trees." Currently in Canada, a team of researchers (Ontario

Ministry of Natural Resources, 2000) is working to assess viability and develop a Conservation Plan (Ostry, pers. comm., 2002).

OTHER THREATS

The most serious insect pest to *Juglans cinerea* is *Conotrachelus juglandis* LeConte (butternut curculio). Feeding by larvae and adults causes severe damage to the nuts, young stems, leaf petioles, and branches of butternut (Johnson & Lyon, 1988, see Pijut, 1997). Butternut wooly sawfly, *Eriocampa juglandis*, feeds on butternut, black walnut and hickory. It is not considered a serious pest, although it sometimes becomes locally abundant. The larvae have white heads with black eyespots, and their smooth green bodies are covered with wool-like waxy material. When full grown, they are ¾ inch long (Minnesota DNR, 2000). Other insect pests include borers, lace bugs, caterpillars, and bark beetles (Missouri Botanical Garden, 2001). Results from a Quebec, Canada study done in 1980 (Maufette & Lechhowicz, 2000), reported that gypsy moth pupae were found to be disproportionately abundant on host species, which included *Juglans cinerea*.

Historically, butternut was subject to periodic damage from general hardwood defoliating insects and fungal pathogens, though none are known to have been of major importance (Katovich, et al., 1998). Foliage diseases include (*Gnomonia leptostyla* and *Cercospora juglandis*). They are sometimes found on butternut leaflets, especially in the southern portion of its range. *Gnomonica leptostyla* cause anthracnose and can be heavy enough to blight most of the leaf and cause it to drop prematurely (Hepting, 1971). The dying portions of the tree are often rapidly colonized by a secondary invading fungus, *Melanconis juglandis* (Nicholls et al., 1978) weakening the tree even further.

Juglans cinerea is wind-firm, but easily storm damaged (Van Dersal, 1938). Heavy winds and ice often break butternut's brittle branches. Broken branches may provide an entrance for fungi (Smith, 1995). *Juglans cinerea* is being eliminated from the forest by natural causes of old age, root disease, and weather damage, along with changing land use (Ostry, 1997a). In addition, butternut is very susceptible to fire damage (Van Dersal, 1938; Clark, 1965).

Natural reproduction of *Juglans cinerea* is often scarce because of periodic low seed production, consumption of seed by animals, lack of stump sprouts, and the absence of necessary site conditions for seedling establishment and survival (Ostry, 1997a). Squirrels and rodents can be aggressive consumers of butternut seed (Ostry et al., 1994).

CONTROL STRATEGIES FOR BUTTERNUT CANKER

Management Strategies

There is no known control for butternut canker. Cultural controls, such as preventing movement of infected logs into regions where the canker is not present, might reduce the incidence and spread of the canker. If resistant *Juglans cinerea* can be found and propagated, as stated previously by Tissrat and Kuntz (1982), this resistant stock could be used to restore forests (Ostry et al., 1994).

Butternut cankers eventually girdle and kill severely affected trees. Severely infected trees can be harvested early to salvage the quality and value of the wood. Care needs to be exercised in evaluating trees for butternut cankers so that trees with dead branches are not automatically considered diseased. Trees free of canker, or those able to overcome infection, need to be retained for reproduction. Resistant seedlings, when available, should be planted in these managed stands (Ostry et al., 1994).

Resistant specimens should be protected. Healthy trees throughout the range (whether or not resistance is known) should be conserved where possible. The Minnesota DNR placed a moratorium on the harvest of healthy butternut in 1992 (USDA Forest Service, 1992). Since 1993, Wisconsin DNR has placed a moratorium on the harvest of healthy butternut on state-owned land (Cummings-Carlson, pers. comm., 2002). In March 1994, harvest restrictions were placed on remaining healthy butternut on National Forests (Ostry et al., 1994). There are no effective or practical management techniques known that completely protect *Juglans cinerea* from butternut canker (Biosource, 1999). Fungicide control, for example, does not appear practical except in nurseries and plantations (Nicholls et al., 1978).

Genotypes and Clonal Plantings

Replicated plantings have been established at several sites to conserve selected butternut genotypes (individual trees) in protected areas and to facilitate the further propagation of these trees for research and breeding. Clonal archive plantings were established at Rosemount, MN (1992, 1995, 1996); Oconto River Seed Orchard, Nicolet National Forest, WI (1993); Carbondale, IL (1994); Saratoga Springs, NY (1995); and Green Mountain National Forest, VT (1995). Accessions from 13 states are included. Most trees represented are from healthy butternut, but few cankered trees were collected to serve as controls in the screening tests. The plantings at Rosemount have yielded a good seed crop from resistant parent trees (Ostry, 2001).

Grafting of Butternut on Black Walnut

Foresters at Saratoga Springs, New York are cooperating with the U.S. Forest Service, North Central Research Station in St. Paul, Minnesota to assist with the recovery of *Juglans cinerea.* Scion shoots taken from healthy *Juglans cinerea* are sent to Minnesota for grafting to more resistant and readily available black walnut trees. *Juglans cinerea* grafts are returned to the State Department of Conservation nursery at Saratoga Springs where seedlings are propagated for redistribution throughout New York and part of Vermont as well as other states (Birmingham & Cooper, 1995).

Silvicultural Practices

In 1993, a study was designed in the Chequamegon Nicolet National Forest, Laona Ranger District, to examine what silvicultural practices and site factors would produce conditions for successful *Juglans cinerea* regeneration (Ostry, 2001). The site consisted of 160 acres and was harvested from 1994-1997. Butternut seedlings were planted in tree shelters in 1999. Early results have revealed poor survival of planted seedlings. Approximately 60 percent of the natural regeneration is already cankered. This study was not conclusive at the time and further

research is needed (Ostry, 2001). The Hiawatha National Forest has begun a program to nursery-raise *Juglans cinerea* to supplement natural forest sites.

Hybrids and Species Resistance and Susceptibility

Initially, *Juglans cinerea* was thought to be the only natural host of butternut canker, although other *Juglans* species could be infected in greenhouse experiments. By 1981, a few small branch and stem cankers were detected in black walnut (*J. nigra*) that was growing in mixed stands with severely infected butternuts (Prey & Kuntz, 1982). In the spring of 1996, two 20-year-old black walnuts growing near a butternut plantation in southeastern Minnesota exhibited branch dieback (Ostry et al., 1997). By 1997, the first report of branch dieback was observed throughout the crown of a 25-year-old heartnut, (*J. ailantifolia* var. *cordiformis*) a variety of Japanese walnut in central Iowa (Ostry, 1997b).

Using artificial inoculations, Orchard et al. (1982) assessed the relative susceptibility of several commercially valuable *Juglans* species and hybrids to the butternut canker. *Juglans cinerea* was the most susceptible. The Asian species (*J. ailantifolia* (Japanese walnut) and *J. ailantifolia* var. *cordiformis* (heartnut) show the highest levels of resistance in greenhouse trials (Orchard et al., 1982). Nair and Gabka studied the varying degrees of resistance exhibited by heartnut, Japanese walnut, black walnut, Persian walnut, and butternut to the butternut canker pathogen (Nair, 1999). Although none of these species were immune to the pathogen, the heartnut and Japanese walnut exhibited more resistance to the pathogen attack than black walnut, Persian walnut or butternut. Cankers produced on heartnut and Japanese walnuts were smaller. This may be due to the presence of a very thick periderm (35 to 45 cells thick) compared to a 7 to 12 cell thick periderm in other species. This thick periderm may be acting as a barrier to pathogen penetration (Gabka, 1996; Nair, 1999). In addition, this may be the reason that cankers produced on heartnut and Japanese walnut have the ability to restrict canker development by sealing the wound with callus layers, as was reported by Fiderspiel and Nair (1982).

Nair (1999) conducted additional studies of resistance due to the production of phenolics. In black walnut, it appears that the phenolic production and production of tyloses with phenolic contents in xylem vessels take place in response to wounding and recognition of the pathogen. This condition partially explains the hypersensitive reaction exhibited by the rapid death of the infected twigs of black walnut as was reported by Orchard, Kuntz and Kessler (1982). This condition may also be responsible for the presence of apparently healthy black walnuts in mixed stands of diseased butternuts.

In more resistant heartnuts, the resistance may be due to (a) its thick periderm acting as a barrier to fungal penetration, or (b) phytoalexins produced in living cells under pathogen attack as well as in cells adjacent to them, or both. In addition, phytoalexins were produced immediately upon wounding, before the wound became colonized by the pathogen (Nair, 1999). In comparison, highly susceptible butternuts and Persian walnuts, exhibited cell maceration associated with mycelial penetration of phloem and xylem cells. In addition, they also exhibited loss of birifrigence of cell walls under polarized light, which indicated hydrolysis of cellulose in addition to pectin and lignin due to the presence of hyphae in the middle lamella (Nair, 1999).

So, resistance to the butternut canker pathogen may be due to a combination of resistant factors present in resistant host species at varying degrees, such as:

(a) the presence of thick periderm which act as a barrier to fungal penetration,
(b) the presence of "pre-infectional phenolics" found in healthy cells which resist the invasion of the pathogen, and:
(c) the production of phytoalexins under pathogen attack. All these factors alone or in combination can offer protection to the host against the invasion of the butternut canker pathogen (Bell, 1981; Dixon et al., 1983; Nicholson & Hammerschmidt, 1992; Nair, 1999).

Role of the Butternut Canker Pathogen and Host Species for the Development of Further Resistance to the Host

Butternuts are highly susceptible to *Sirococcus clavigignenti-juglandacearum* (Nair et al., 1979). It is suggested that the *Juglans cinerea* and the pathogen have not co-evolved, hence, the pathogen may most likely be able to produce genotypes to attack resistant genotypes if found (Furnier et al., 1999). Since the sexual stage of the pathogen is unknown, the production of new races is unlikely. *Sirococcus* is pathogenic to pine. Whether or not the butternut canker pathogen is a product of mutation from the *Sirococcus* pathogen on pine is unknown. As the butternut canker pathogen is not reported from anywhere in the world except the United States and recently in Canada (Nair & Kuntz, pers. comm., 2002), the possibility still exists.

Recently, Ostry (2001) had detected two butternut bark phenotypes in a 40-acre wood lot in southern Wisconsin; a light gray shallow fissured type associated with cankered trees, and a dark gray deep-fissured type associated with healthy trees. Of the 544 butternut examined, 92 were disease free; 67 (73 percent) were of the dark, deep-fissured bark phenotype; and 310 of the 452 diseased butternut (69 percent) were of the light, shallow phenotype.

At present, there are no known cultivars or varieties of butternut with proven resistance to butternut canker. However, Orchard (1984) has shown that with butternut seedlings from open-pollinated parents, though all seedlings were infected, when inoculated with spores in growth chambers the canker development was greater on seedlings from diseased parents. This suggests resistance to butternut canker may be heritable (Prey et al., 1996).

National and International Quarantine Regulations

Butternut canker pathogen has a wide host range covering five *Juglans* species and one unrelated *Carya* (hickory) species. All of these species are economically important and highly valuable trees, which support many wood using and nut producing industries worldwide. In addition, the pathogen is internally seed borne and could spread by the infected seeds and seedlings in nursery stock. National and international quarantine regulations against the import of butternut canker pathogen are warranted (Nair, 1999).

STEWARDSHIP

Stewardship Needs

Before the spread of butternut canker, *Juglans cinerea* regenerated more frequently from trunk sprouts. Now, due to the death of diseased parent trees, these sprouts often die in less than a year. Canker often affects nuts from diseased trees and seedlings from such infected nuts will die off shortly after emerging (Prey et al., 1996). *Juglans cinerea* is a shade-intolerant species. Its natural propagation can be assisted by managing forests to create disturbance conditions (e.g. canopy gaps, openings, soil disturbance) needed for colonization and establishment of new individuals (Ostry et al., 1994).

Criteria have been developed to assist land managers and woodland owners interested in identifying butternut that may have disease resistance and may be valuable for tree improvement efforts (Ostry, et al., 1994). Presence of all healthy (non-infected) trees should be tracked. Resistant trees, which are of the greatest importance for conservation of the species, should be most actively sought and identified. At present, *Juglans cinerea* trees are being permanently tagged, measured, and their location mapped. Information on their health and the health of adjacent butternut are noted (Ostry, 1997a). Protecting butternut scion wood will involve establishing partnerships as "the majority of butternut is growing on privately-held forests" (Ostry, 1995). The cooperation of these landowners in research, management, and restoration is essential.

Sanitation to remove recently killed or severely infected trees, due to butternut canker, may reduce the inoculum in local areas (Prey et al., 1996). Fungicides have been tested in the laboratory with some success, but they have not been applied to trees in the field and would only be practical in nurseries or plantations of high value (Nicholls, 1979).

A USDA Forest Service (1993) publication for the northeast area lists the following suggested steps to conserve *Juglans cinerea*:

1) Define the problem.
2) Define what is the value of a healthy tree for resistance testing.
3) Manage (protect) trees of value, and collect fruit and scions from healthy trees.
4) Establish gene banks and test sites.
5) Test for resistance to butternut canker pathogen.
6) Propagate and re-introduce canker resistant seedlings.

Re-establishment

Ostry et al. (1994) cited the primary need for *Juglans cinerea* conservation is the identification of canker resistant strains of *Juglans cinerea*, development of effective methods of propagation along with silvicultural methods for their regeneration, and reintroduction back into the species previous habitat. Genetic improvement to develop resistance in butternut is justified if individual trees exhibiting disease resistance can be found and propagated. Interspecific

breeding with other more resistant *Juglans* species, such as Japanese walnut or heartnut, may yield resistant hybrid trees for reforestation (Prey et al., 1996). Healthy butternut should be retained in stands for seed production and clonally propagated for tree improvement research.

The conservation of remaining healthy *Juglans cinerea* depends on a coordinated approach using both *in situ* and *ex situ* efforts. *In situ* conservation refers to the conservation of genetic material within the area of natural occurrence. This is usually the preferred method of conservation since the genetic structure remains intact. *Ex situ* conservation includes such methods as seed banks, tissue banks, clonal orchards and arboreta (McIlwrick et al., 2000).

Seed banks are useful for short-term regeneration. Seed collection and storage is relatively easy and cost effective (McIlwrick et al., 2000). Seeds of *Juglans cinerea* have a dormant embryo, but dormancy can be broken by fall sowing or by moist (in sand) pre-chilling of seeds at 34 to 41^{o} F (1 to 5 ^{o}C) for 3 to 4 months (Brinkman, 1974). Recalcitrant seeds are desiccation-sensitive and may only be stored at near freezing temperatures (3^{o}C to –3^{o}C). A seed of nut trees such as butternut cannot tolerate drying (moisture content below 30%) and are sensitive to temperatures below –40^{o}C (Wang et al., 1993, see McIlwrick et al., 2000). Satisfactory storage of *Juglans cinerea* seed can be obtained for at least two years if stored in closed containers at 80 to 90% humidity and +5 to 0^{o}C (Wang et al., 1993, see McIlwrick et al., 2000).

Ex situ conservation could lead to the loss of genetic diversity due to inbreeding and genetic drift which can greatly reduce the average fitness and genetic variation of a population (Lande, 1988; Mosseler, 1995), but this depends on how many parents contributed to the seed and how large is the planting (McIlwrick et al., 2000). Methods of asexual propagation of *Juglans cinerea* include grafting, rooting, and budding. "Grafting is the most successful method, however, problems exist due to winter injury and incompatibility between scion and rootstock" (Ostry pers. comm., 2001).

Selected *Juglans cinerea* is grafted onto seedling rootstock, usually black walnut since this rootstock is more often available. Nursery trees need to enter dormancy before being lifted. Seedlings can be placed in cold storage at 34-36^{o}F (1 to 2^{o}C) for several months. Roots must be kept moist, but not wet, during storage (Ostry & Pijut, 2000).

Propagation methods for *Juglans cinerea*

As per Pijut and Moore (2002), in 1999 and 2000, hardwood cuttings (mature tissue) were collected March (dormancy), April (bud break), and May (branches flushed out). Cuttings were dipped in treatment solution, placed in a peat/perlite mixture and misted for 5 seconds every 18 minutes on a greenhouse bench with bottom heat maintained at 27 °C. Rooting success did not vary by growth stage in 1999 ($P>0.45$) or 2000 ($P> 0.85$). No difference was found by date of collection ($P> 0.40$) when data was pooled across years. The greatest rooting success was with 62mM K-IBA (22.2%) and 74 mM IBA (27.8%) when hardwood cuttings were collected when the branches had flushed (mis-May). Softwood cuttings (wood consisting of soft, immature tissue) were collected at specific growth stages: early June (current season's first flush of new growth, mid to late June (softwood growth 40 cm or greater, early July (shoots beginning to become lignified), and late July (shoots starting to set bud). Softwood cutting have uniformly higher number of roots produced than do hardwood cuttings. In 1999, the fourth

sample growth stage was significantly lower ($P< 0.003$) from the others in rooting success, whereas the first three sample growth stages did not differ ($P>0.95$). The greatest rooting success of 76.9% (62 mM K-IBA) and 87.5% (74 mM IBA) was achieved when softwood cuttings were taken in June. Cuttings from the current season's first flush of new growth (20.7 cm) and shoots beginning to become lignified (23.2 cm) development stages had shorter roots than the softwood growth 40 cm or greater development stage (33.5 cm). There was no difference in root length from cuttings from the first, third, and fourth sample development stages. Mean root length was similar for all treatments and controls (Pijut & Moore, 2002). Over a 3-year period, softwood cuttings taken from mid-June through early July averaged 50 percent success. Both hardwood and softwood cuttings successfully acclimated from the mist bed and initiated new growth (Ostry, 2001).

Although still mostly experimental, progress has been made for developing techniques for in vitro culture for five *Juglans* spp. and hybrids have been very successful over the past 10 years (Pijut, 1997). Pijut (1997) has demonstrated micro propagation of butternut by axillary bud culture. Microshoots (1.5 to 2 cm long) with three axillary buds were excised from the original explant and used in rooting experiments. Cultures were incubated at 26^{o}C under an 18-h photoperiod. Highest rooting frequency (75 percent) occurred on microshoots pulsed on half-strength MS containing 2.5 *u*M IBA for 7 days in darkness. Weekly transfer of butternut nodal explants to fresh culture medium was necessary to maintain optimum growth and limit the buildup of phytotoxic exudates (Pijut, 1997). Immature cotyledonary tissue of *Juglans cinerea* was found to be amenable to somatic embryogenesis. However, germination of somatic embryos and plant survival were at a low frequency. If maturation and germination techniques can be improved, then the potential could exist for genetic improvement and multiplication of butternut (Pijut, 1997).

Conservation Efforts

Juglans cinerea scion wood was collected in 14 states from superior, healthy trees that appeared to have resistance to the butternut canker (Ostry, 1997a). Grafts were outplanted in clonal orchards for screening disease resistance beginning in 1992. Artificial inoculation techniques are being developed to rapidly screen butternut clones for disease resistance. Over 800 trees from nearly 60 clones are established in replicated plantings in Illinois, Wisconsin, and Minnesota (Ostry & Skilling, 1994). In 1995, two additional clonal orchards were established in Vermont and New York (Ostry, 1997a). Success rate has varied from 0-85 percent among the various accessions (Ostry, 1997a). There are now nearly 200 genotypes represented in the combined orchards, which will be challenged by the fungus in various tests to determine their level of disease resistance (Ostry, 1997a). The objectives of these plantings are to serve as a clone bank to:

1. Preserve potentially valuable butternut genotypes.

2. Provide a source of easily obtained scion wood for disease research and possible re-establishment.

3. Allow *in situ* (within area of natural occurrence) evaluation for traits such as growth, stem form, flowering, and disease resistance (Ostry, 1997a).

Conservation efforts have focused on determining pathogenicity among isolates, development of rapid screening and efficient propagation techniques, and breeding for disease resistance by outplanting grafts in clonal orchards (Ostry, 1995).

Beginning in 1992, *Juglans cinerea* seed was collected in the Great Smoky Mountains National Park and from Tennessee and North Carolina (Ostry, 1997a). Seedlings were planted in test plantings to evaluate their disease resistance. Clonal propagation of selected trees for a breeding orchard is planned.

USDA Forest Service (1993) described a "Butternut Coalition" whose purpose is to restore butternut across its range and across ownership. Partnerships are being developed between the federal government, state government agencies, conservation groups, and industry and private landowners. Research objectives of this partnership (Ostry, 2001) are:

1. Conserve butternut trees that may have resistance to the canker by grafting branch wood (scions) onto black walnut rootstock.

2. Establish replicated clonal plantings of these trees for further research and breeding.

3. Determine the differences in tree phenotypes related to genetic resistance

4. Develop laboratory and field techniques to screen for canker resistance.

In southern Ontario, the Science and Technology Transfer Unit of the Ontario Ministry of Natural Resources initiated a butternut conservation and recovery project. This project consists of a literature review, field surveys for identification of potentially resistant individuals, and grafting and archiving of potentially resistant individuals, along with maintenance of potentially resistant individuals on which to base a screening program and set up a butternut recovery program (Nielsen draft 2001).

Tree Retention Guidelines (70-20-50 rule)

A major objective of the tree retention guidelines is to create conditions within a stand that will result in the establishment of natural regeneration (Ostry et al., 1994).

- The guideline recommends retaining all trees with more than 70 percent live crown and less than 20 percent of the combined circumference of the bole and root flares affected by the canker.
- It also recommends retaining all trees with at least 50 percent live crown, and no cankers in bole or root flare. Only the branches in the outer and upper crown should be considered when rating dieback.
- Dead *Juglans cinerea*, as well as butternut of poor vigor, may be cut.

Guidelines for Selecting Potentially Resistant Trees

Trees that are either disease-free or that have been able to inhibit canker expansion may have value in future tree improvement and should be retained in the stand. Listed are the requirements of candidate trees for retention as resistant stock: (Ostry et al., 1994).

- A healthy tree within 100 feet of a diseased tree in a stand with high incidence of the disease so as to have had a reasonable chance of exposure to the canker and develop resistance.
- At least 10 inches DBH (diameter at breast height) and must be free of cankers.
- Manager/landowner are encouraged to allow collection of scion wood and seed from the tree for several years.

SUMMARY

Juglans cinerea L. occurs in central and eastern United States and southeastern Canada. Butternut is a shade intolerant species that requires an open area for establishment. Riparian areas are a favored habitat, often found on riverbanks. When it is found in the forest, it usually grows as a single tree or very scattered in occurrences. *Juglans cinerea* is highly susceptible to the fungus *Sirococcus clavigignati-juglandacearum* Nair, Kostichka, and Kuntz, which causes branch and stem canker. This canker will eventually girdle infected trees. The butternut canker has spread rapidly throughout the range of *Juglans cinerea*. By the 1990's, 91 percent of the butternuts were diseased in Wisconsin. Historically, Wisconsin had the most commercial butternut trees in the United States. Initially, healthy butternut trees were cut to salvage the wood before its lumber became worthless due to the canker. Now many National Forests have policies to identify and protect the stock of remaining healthy trees. In Michigan's Upper Peninsula, *Juglans cinerea* is at the northernmost limit of its range. All these factors put butternut under considerable negative pressure, with continued viability at risk throughout its range. There is no known cure for this fungal disease, and it may eliminate the species (Katovich, et al., 1998). The best hope for preservation of *Juglans cinerea* is identification of resistant strains and preserving sites of healthy trees for seed source and grafting material, followed by propagation and restoration.

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APPENDICES

APPENDIX A

Juglans cinerea L. Element Occurrence Records

Michigan

Ottawa National Forest:

Location: Iron County, Michigan
Ownership: Ottawa National Forest
Abundance: One tree
Habitat: The one butternut tree is part of an old homestead site. It is located in a large opening on the south end. Nearby are several apple trees, elm, and basswood. Open, dry site.
Associated species: *Poa compressa, Rubus ideaus, Phleum pratense, Agropyron repens, Berberis thunbergii*. A rock wall is on the west side approximately 100 feet from tree. A house foundation is located several hundred feet SE of the tree.
Comments: Last visited on October 21, 1999.
Source of Information: Ottawa National Forest.

Location: Houghton County, Michigan
Ownership: Ottawa National Forest
Abundance: One tree
Habitat: One butternut tree at old abandoned homestead, in a 40-acre clearing. Hilltop, wet with springs. Moist, open site. Grassy opening, with one maple tree nearby. Associated species: *Festuca pratensis, Dactylis glomerata, Hieracium caespitosum, Phleum pratense, Agropyron repens, Plantago lanceolata, Chrysanthemum leucanthemum, Aster macrophyllus, Aster ciliolatus, Solidage canadense, Solidago altissima, Oenothera biennis, Satureja vulgaris, Argimonia striata*, and *Fragaria virginiana*. Main (older) trunk is dead and fallen. The three suckers are doing well. A large population of *Polygonum caespitosum* (Japanese knotweed) within 40 feet.
Comments: Last visited on September 4, 1998.
Source of Information: Ottawa National Forest.

Hiawatha National Forest:

Location: Delta County, Michigan
Record Number: 02-58-83
Ownership: Hiawatha National Forest
Legal: T41N R18W S36, SWSE
Quad: Cooks
Source Data: Gerdes, General File 1993

Location: Delta County, Michigan
Record Number: 01-37-83
Ownership: Hiawatha National Forest
Legal: T40N R21W S15, SESE
Quad: RR-SE
Source Data: Gerdes, General File 1993

Location: Schoolcraft County, Michigan
Record Number: 02-32-83
Ownership: Hiawatha National Forest
Legal: T41N R17W S31, NE1/4 NE1/2 NW1/4
Quad: Cooks
Source Data: General File 1994

Location: Delta County, Michigan
Record Number: 01-31-83
Ownership: Hiawatha National Forest
Legal: T39N R21W S08, SE1/4 SE1/4 NE1/4 NE1/4
Quad: RR-SW
Source Data: General File 1994

Location: Delta County, Michigan
Record Number: 02-60-10
Ownership: Hiawatha National Forest
Legal: T41N R19W S23, NESE SENE
Quad: Garden NW
Source Data: Deb Leblanc 1994, General File 6 94.

Location: Schoolcraft County, Michigan
Record Number: 02-77-83
Ownership: Hiawatha National Forest
Legal: T41N R17W S31, NE1/4 NE1/4 WW1/4
Quad: Cooks
Source Data: HIA TES Report 1995

Location: Schoolcraft County, Michigan
Record Number: 02-78-83
Ownership: Hiawatha National Forest
Legal: T41N R18W S36, NW1/4 NE1/4 SE1/4
Quad: Cooks
Source Data: HIA TES Report 1995

Location: Delta County, Michigan
Record Number: 01-59-83
Ownership: Hiawatha National Forest
Legal: T41N R21W S19, C
Quad: RR-NW
Source Data: Gerdes, Hiawatha 1995 Report

Location: Delta County, Michigan
Record Number: 01-60-83
Ownership: Hiawatha National Forest
Legal: T41N R21W S19, NWNW
Quad: RR-NW
Source Data: Gerdes, Hiawatha 1995, Juglans

Location: Delta County, Michigan
Record Number: 01-61-83
Ownership: Hiawatha National Forest
Legal: T41N R21W S19, E1/2
Quad: Garden NW
Source Data: Hiawatha 1995 Report

Location: Delta County, Michigan
Record Number: 01-40-83
Ownership: Hiawatha National Forest
Legal: T39N R22W S11, SESE
Quad: RR-SW
Source Data: Gerdes 1994, Jaunzems 1995, General File

Location: Delta County, Michigan
Record Number: 01-42-83
Ownership: Hiawatha National Forest
Legal: T41N R21W S27, NE1/4 SE1/4 NE1/4
Quad: RR-NW
Source Data: HIA Report 1995

Location: Delta County, Michigan
Record Number: 01-43-83
Ownership: Hiawatha National Forest
Legal: T40N R21W S17, NE1/4 SE1/4 NE1/4
Quad: RR-SW
Source Data: HIA Report 1995

Location: Delta County, Michigan
Record Number: 01-44-83
Ownership: Hiawatha National Forest
Legal: T40N R21W S17, NE1/4 SE1/4 SE1/4
Quad: RR-SW
Source Data: HIA Report 1995

Location: Delta County, Michigan
Record Number: 01-45-83
Ownership: Hiawatha National Forest
Legal: T39N R21W S11, SE1/4 NE1/4
Quad: RR-SE
Source Data: HIA Report 1995, Juglans

Location: Delta County, Michigan
Record Number: 01-56-83
Ownership: Hiawatha National Forest
Legal: T40N R21W S14, NWNW
Quad: RR-SE
Source Data: Gerdes, HIA Report 1995, Juglans

Location: Delta County, Michigan
Record Number: 01-57-83
Ownership: Hiawatha National Forest
Legal: T39N R21W S03
Quad: RR-SW
Source Data: Gerdes, HIA Report 1995

Location: Delta County, Michigan
Record Number: 01-58-83
Ownership: Hiawatha National Forest
Legal: T40N R21W S29, E1/2
Quad: RR-SW
Source Data: Gerdes, HIA Report 1995

Location: Delta County, Michigan
Record Number: 01-62-83
Ownership: Hiawatha National Forest
Legal: T39N R22W S14, W1/2 NE
Quad: RR-SW
Source Data: Jaunzems 1996

The Michigan Botanist
1993. Vol. 32. Pp. 269-273. Peter Fritsch.
Vascular plant species new to Hillsdale County, Michigan.

Location: Hillsdale County, Michigan.
Record Number:
Ownership: Scouting camp based just south of the Michigan-Ohio border.
Legal: T9S R3W, 8 km SE of Camden.
Habitat: Floodplain and adjacent rich woods on the St. Joseph River.

Minnesota

University of Minnesota Herbarium:

Location: Washington County, Minnesota
Access Number: 584012
Special Area: Stillwater Wildlife Area
Legal: T30N R20W

Location: Le Sueur County, Minnesota
Access Number: 679031
Special Area: Ottawa Bluffs Preserve [TNC]
Legal: T110N R26W

Location: Houston County, Minnesota
Access Number: 747125
Special Area: Caledonia Oaks [TNC]
Legal: T102N R05W

Location: Goodhue County, Minnesota
Access Number: 747301
Special Area: Grace Nature Preserve [TNC]
Legal: T109N R18W

Location: Houston County, Minnesota
Access Number: 747226
Special Area: Caledonia Oaks [TNC]
Legal: T102N R05W

Location: Rice County, Minnesota
Access Number: 747153
Special Area: Cannon River Trout Lily SNA
Legal: T110N R20W

Location: Dakota County, Minnesota
Access Number: 334566
Special Area:
Legal: T N

Location: Brown County, Minnesota
Access Number: 97139
Special Area:
Legal: T110N R32W

Location: Wright County, Minnesota
Access Number: 745091
Special Area:
Legal: T122N R25W

Location: Wright County, Minnesota
Access Number: 745002
Special Area:
Legal: T120N R25W

Location: Rice County, Minnesota
Access Number: 265399
Special Area:
Legal: T N

Location: Morrison County, Minnesota
Access Number: 448577
Special Area:
Legal: T N

Location: Blue Earth County, Minnesota
Access Number: 97140
Special Area:
Legal: T N

Location: Chisago County, Minnesota
Access Number: 730339
Special Area: Wild River SP
Legal: T36N R21W

Location: Pine County, Minnesota
Access Number: 729672
Special Area: St. Croix SP
Legal: T41N R17W

Location: Mower County, Minnesota
Access Number: 781837
Special Area: Lake Louise SP
Legal: T101N R14W

Location: Pine County, Minnesota
Access Number: 729874
Special Area: Kettle River SNA / Sandstone NWR
Legal: T41N R20W

Location: Winona County, Minnesota
Access Number: 264254
Special Area:
Legal: T N

Location: Sherburne / Wright County, Minnesota
Access Number: 728725
Special Area: Mississippi River Islands SNA
Legal: T N

Location: Houston County, Minnesota
Access Number: 97129
Special Area: Dorer Memorial Hardwood SF
Legal: T N

Location: Le Sueur County, Minnesota
Access Number: 97132
Special Area:
Legal: T109N R24W

Location: Blue Earth County, Minnesota
Access Number: 97137
Special Area:
Legal: T N

Location: Winona County, Minnesota
Access Number: 97134
Special Area:
Legal:

Location: Hennepin County, Minnesota
Access Number: 97136
Special Area: Minnehaha Falls Park
Legal: T28N R23W

Location: Sherburne County, Minnesota
Access Number: 721194
Special Area: Clear Lake SNA
Legal: T34N R30W

Location: Anoka County, Minnesota
Access Number: 722490
Special Area: Boot Lake SNA
Legal: T33N R22W

Location: St. Louis County, Minnesota
Access Number: 347280
Special Area:
Legal: T N

Location: Chisago County, Minnesota
Access Number: 370350
Special Area:
Legal: T N

Location: Sherburne County, Minnesota
Access Number: 808519
Special Area:
Legal: T34N R26W

Location: Anoka County, Minnesota
Access Number: 802777
Special Area: Lamprey Pass Wildlife Area
Legal: T32N R22W

Location: Dakota / Hennepin / Ramsey County, Minnesota
Access Number: 97130
Special Area: Fort Snelling Reservation
Legal: T28N R23W

Location: Winona County, Minnesota
Access Number: 97141
Special Area:
Legal:

Location: Fillmore County, Minnesota
Access Number: 370271
Special Area:
Legal: T103N R10W

Location: Carver County, Minnesota
Access Number: 97133
Special Area:
Legal: T N

Location: Isanti County, Minnesota
Access Number: 586390
Special Area: Cedar Creek Natural History Area
Legal: T34N R23W

Location: Crow Wing County, Minnesota
Access Number: 616750
Special Area: Crow Wing Natural Area
Legal: T44N R28W

Location: Washington County, Minnesota
Access Number: 436971
Special Area:
Legal: T30N R20W

Location: Hennepin County, Minnesota
Access Number: 288574
Special Area: Minnehaha Falls Park
Legal: T28N R23W

Location: Brown County, Minnesota
Access Number: 595447
Special Area:
Legal: T110N R30W

Location: McLeod County, Minnesota
Access Number: 97131
Special Area:
Legal: T N

Location: Crow Wing County, Minnesota
Access Number: 97135
Special Area:
Legal: T44N R28W

Location: Hennepin County, Minnesota
Access Number: 97138
Special Area:
Legal: T N

Location: Pine County, Minnesota
Access Number: 828387
Special Area: Chengwatana SF
Legal: T38N R20W

Location: Fillmore County, Minnesota
Access Number: 834881
Special Area: Forestville SP
Legal: T102N R12W

Location: Morrison County, Minnesota
Access Number: 836135
Special Area: Camp Ripley Military Reservation
Legal: T131N R30W

Location: Aitkin County, Minnesota
Access Number: 519973
Special Area:
Legal: T46N R27W

Location: Dodge County, Minnesota
Access Number: 514710
Special Area:
Legal: T105N R16W

Location: Cass County, Minnesota
Access Number: 457185
Special Area: Land O'Lakes SF
Legal: T139N R27W

Location: Washington County, Minnesota
Access Number: 430002
Special Area:
Legal: T31N R20W

Location: Kanabec County, Minnesota
Access Number: 475592
Special Area: Mille Lacs Wildlife Area
Legal: T40N R25W

Wisconsin

Wisconsin State Herbarium

Location: Wisconsin
Access Number: v0053817WIS
Habitat:
Collector: Schutte, J. H.
Coll. No.: s.n.
Date:

Location: Dane County, Wisconsin
Access Number: v0053832WIS
Habitat:
Collector: Hale, T. J.
Coll. No.: s.n.
Date:

Location: Dane County, Wisconsin
Access Number: v0053834WIS
Habitat:
Collector: Chase, W. H.
Coll. No.: s.n.
Date: Coll. May 1877. BER

Location: Dane County, Wisconsin
Access Number: v0053836WIS
Habitat: Previously logged mesic woods; NE-facing slope; silty loam soil.
Collector: Daniel, R.
Coll. No.: 58
Date:

Location: Milwaukee County, Wisconsin
Access Number: v0053870WIS
Habitat:
Collector: Lapham, I. A.
Coll. No.: s.n.
Date: Coll. July 1867. BER

Location: Milwaukee County, Wisconsin
Access Number: v0053872WIS
Habitat:
Collector: Lapham, I. A.
Coll. No.: s.n.
Date:

Location: Sauk County, Wisconsin
Access Number: v0053973WIS
Habitat: Open second growth woods.
Collector: Iltis, Hugh H.
Coll. No.: s.n.
Date: Coll. Nov. 1963. BER

Location: Iowa County, Wisconsin
Access Number: v0073771WIS
Habitat: Oak wood and hillside
Collector: Lord, L.
Coll. No.: s.n.
Date: April 1957

Location: Dane County, Wisconsin
Access Number: v0053829WIS
Habitat:
Collector: Kremers, Edward
Coll. No.: s.n.
Date: 5/27/1888

Location: Dane County, Wisconsin
Access Number: v0053830WIS
Habitat:
Collector: Kremers, Edward
Coll. No.: s.n.
Date: 5/27/1888

Location: Dane County, Wisconsin
Access Number: v0053833WIS
Habitat:
Collector: Cheney, L. S.
Coll. No.: s.n.
Date: 5/25/1891

Location: Rock County, Wisconsin
Access Number: v0053962WIS
Habitat:
Collector: Olds, G. B.
Coll. No.: s.n.
Date: 6/5/1893

Location: Dunn County, Wisconsin
Access Number: v0053839WIS
Habitat:
Collector: Weinzirl, John
Coll. No.: s.n.
Date: 6/24/1893

Location: Racine County, Wisconsin
Access Number: v0053883WIS
Habitat:
Collector: Heddle, J. R.
Coll. No.: 203
Date: 5/19/1906

Location: Sheboygan County, Wisconsin
Access Number: v0053980WIS
Habitat:
Collector: Cottam, Grant
Coll. No.: s.n.
Date: 5/25/1914

Location: Barron County, Wisconsin
Access Number: v0053819WIS
Habitat:
Collector: Goessl, Chas.
Coll. No.: 6832
Date: 5/28/1917

Location: Crawford County, Wisconsin
Access Number: v0053828WIS
Habitat:
Collector: Smith, Huron, H.
Coll. No.: 7616
Date: 7/24/1922

Location: Grant County, Wisconsin
Access Number: v0053843WIS
Habitat:
Collector: Smith, Huron, H.
Coll. No.: 7655
Date: 7/27/1922

Location: Sauk County, Wisconsin
Access Number: v0053967WIS
Habitat: Baraboo Bluffs
Collector: Smith, Huron H.
Coll. No.: 8175
Date: 8/9/1922

Location: Vernon County, Wisconsin
Access Number: v0053991WIS
Habitat:
Collector: Hansen, H. P.
Coll. No.: 291
Date: 9/15/1929

Location: Columbia County, Wisconsin
Access Number: v0053826WIS
Habitat:
Collector: Fernholz, D. L.
Coll. No.: s.n.
Date: 9/9/1930

Location: Marathon County, Wisconsin
Access Number: v0053865WIS
Habitat:
Collector: Fassett, N. C.
Coll. No.: 14068
Date: 5/21/1932

Location: Dodge County, Wisconsin
Access Number: v0053838WIS
Habitat: Limestone bluff
Collector: Fassett, N. C.
Coll. No.: 15244
Date: 7/4/1932

Location: Fond du Lac County, Wisconsin
Access Number: v0053840WIS
Habitat:
Collector: Fassett, N. C.
Coll. No.: 18410
Date: 7/13/1934

Location: Wood County, Wisconsin
Access Number: v0053995WIS
Habitat:
Collector: Fassett, N. C.
Coll. No.: 22660
Date: 9/19/1934

Location: Wood County, Wisconsin
Access Number: v0053996WIS
Habitat:
Collector: Fassett, N. C.
Coll. No.: 22660
Date: 9/19/1934

Location: Trempealeau County, Wisconsin
Access Number: v0053986WIS
Habitat:
Collector: Fassett, N. C.
Coll. No.: s.n.
Date: 6/1/1935

Location: Trempealeau County, Wisconsin
Access Number: v0053987WIS
Habitat: Pollen slide.
Collector: Fassett, N. C.
Coll. No.: s.n.
Date: 6/1/1935

Location: Polk County, Wisconsin
Access Number: v0053881WIS
Habitat: Woods. Occasional. BER
Collector: Pohl, Richard W.
Coll. No.: 440
Date: 7/3/1936

Location: Marinette County, Wisconsin
Access Number: v0053866WIS
Habitat: Woods.
Collector: Fassett, N. C.
Coll. No.: 20458
Date: 9/14/1937

Location: Waukesha County, Wisconsin
Access Number: v0053992WIS
Habitat: Oak - hard maple - elm woods. Heavy loam. Common, growing to big healthy trees. BER
Collector: Cook, Chester C.
Coll. No.: C47
Date: 7/21/1938

Location: Waukesha County, Wisconsin
Access Number: v0053993WIS
Habitat: Assoc. with, oak hard maple, elm. Common, large tree. BER
Collector: Parenteau, Robert E.
Coll. No.: 5
Date: 7/21/1938

Location: Ozaukee County, Wisconsin
Access Number: v0008836WIS
Habitat: Lake Michigan area, sandy lake shore. Cherry, Ash. Butternut was growing next to the lake shore and a very few grew in the ash groves.
Collector: Cook, Chester C.
Coll. No.: C81
Date: 7/27/1938

Location: Sheboygan County, Wisconsin
Access Number: v0053981WIS
Habitat: Woods. Heavy loam. Scattered throughout woods, 2 very good ones along road. BER
Collector: Cook, Chester C.
Coll. No.: C122
Date: 8/10/1938

Location: Columbia County, Wisconsin
Access Number: v0053827WIS
Habitat: Gravel with a poor soil top. Scattered throughout - a large tree. Fruits plentiful - leaves dropped in most cases. BER
Collector: Cook, Chester C.
Coll. No.: C280
Date: 9/19/1938

Location: Milwaukee County, Wisconsin
Access Number: v0053871WIS
Habitat: Corner of pasture.
Collector: Shinners, L. H.
Coll. No.: 1147
Date: 7/16/1939

Location: Waushara County, Wisconsin
Access Number: v0053994WIS
Habitat:
Collector: Partch, Max
Coll. No.: s.n.
Date: 6/6/1940

Location: Outagamie County, Wisconsin
Access Number: v0053877WIS
Habitat: High land.
Collector: Basehart, Harry
Coll. No.: 29
Date: 9/11/1941

Location: Sawyer County, Wisconsin
Access Number: v0053977WIS
Habitat: Maple hardwoods.
Collector: Plant Ecology Laboratory
Coll. No.: s.n.
Date: 7/28/1950

Location: Clark County, Wisconsin
Access Number: v0053825WIS
Habitat: 40 acres of maple-basswood.
Collector: Bergseng, Margaret Schmidt
Coll. No.: s.n.
Date: 5/26/1951

Location: Lincoln County, Wisconsin
Access Number: v0048952WIS
Habitat: Deciduous woods along Wisconsin River.
Collector: Seymour, Frank C.
Coll. No.: 12533
Date: 6/5/1951

Location: Lincoln County, Wisconsin
Access Number: v0048954WIS
Habitat: Rich deciduous woods.
Collector: Seymour, Frank C.
Coll. No.: 12590
Date: 6/26/1951

Location: Lincoln County, Wisconsin
Access Number: v0048953WIS
Habitat: In a grove of trees.
Collector: Seymour, Frank C.
Coll. No.: 12767
Date: 7/9/1951

Location: Lincoln County, Wisconsin
Access Number: v0048951WIS
Habitat: Common fairly in southern part of county.
Collector: Peroutky, J. W.
Coll. No.: 5
Date: 6/1/1956

Location: LaCrosse County, Wisconsin
Access Number: v0053860WIS
Habitat: Rich, N-facing wooded sandstone ridge (Tilia, Carya, Betula papyr., many ferns).
Collector: Iltis, Hugh H.
Coll. No.: 5974
Date: 6/14/1956

Location: LaCrosse County, Wisconsin
Access Number: v0053859WIS
Habitat: Moist woods along a creek. Small tree. BER
Collector: Hartley, Thomas G.
Coll. No.: 3087
Date: 9/7/1956

Location: Vernon County, Wisconsin
Access Number: v0053990WIS
Habitat: N-facing slope near river, with Tsuga canadensis.
Collector: Gale, Harriet
Coll. No.: s.n.
Date: 6/17/1957

Location: Buffalo County, Wisconsin
Access Number: v0053820WIS
Habitat: Steep WSW-facing deciduous woods (Quercus alba, Q. rubra, Tilia americana, Betula papyrifera, Populus tremuloides, Osmunda claytoniana very abundant).
Collector: Iltis, Hugh H.
Coll. No.: 9156
Date: 6/26/1957

Location: Burnett County, Wisconsin
Access Number: v0053822WIS
Habitat: Wooded roadside.
Collector: Greene, H. C.
Coll. No.: s.n.
Date: 7/16/1957

Location: Grant County, Wisconsin
Access Number: v0053846WIS
Habitat: Dry upland mixed oakwoods (Quercus alba, Q. rubra, Q. velutina, Acer saccharum, Fraxinus, Tilia) on topof NW-facing bluffs overlooking Mississippi River.
Collector: Iltis, Hugh H.
Coll. No.: 10193
Date: 8/28/1957

Location: Grant County, Wisconsin
Access Number: v0053848WIS
Habitat: Upland mesic mixed oak woods above steep, N-facing moist cliffs and talus slopes.
Collector: Iltis, Hugh H.
Coll. No.: 10349
Date: 9/17/1957

Location: Grant County, Wisconsin
Access Number: v0053849WIS
Habitat: Steep, N-facing moist cliffs and talus slopes in dense maple-basswood forest with understory of Taxus canadensis.
Collector: Iltis, Hugh H.
Coll. No.: 10362
Date: 9/17/1957

Location: Iowa County, Wisconsin
Access Number: v0053853WIS
Habitat: Mixed-hardwood canyon bottom with moist-soil openings along meandering creek.
Collector: Adamson, W.
Coll. No.: 44
Date: 5/13/1958

Location: Iowa County, Wisconsin
Access Number: v0053854WIS
Habitat: Mixed-hardwood canyon bottom with moist-soil openings along meandering creek.
Collector: Adamson, W.
Coll. No.: 44
Date: 5/13/1958

Location: Dane County, Wisconsin
Access Number: v0053831WIS
Habitat: Near the roadside.
Collector: Stopple, Fred J.
Coll. No.: s.n.
Date: 5/15/1958

Location: Lafayette County, Wisconsin
Access Number: v0053862WIS
Habitat: Steep, damp, densely wooded limestone slope, NNE-facing, above river. Maple-basswood and older oaks, Taxus on cliff!
Collector: Iltis, Hugh, H.
Coll. No.: 10588
Date: 5/30/1958

Location: Sauk County, Wisconsin
Access Number: v0053966WIS
Habitat: E-facing slope of maple-basswood-white pine woods. Tree ca. 50 ft. high. BER
Collector: Koeppen, Robert
Coll. No.: 517
Date: 7/19/1958

Location: Sauk County, Wisconsin
Access Number: v0053971WIS
Habitat: Edge of fields and roadside. S slope of Baraboo Hills.
Collector: Peters, Ralph F.
Coll. No.: 52
Date: 9/14/1958

Location: Vernon County, Wisconsin
Access Number: v0053989WIS
Habitat: Grazed bluffs.
Collector: Melchert, T.
Coll. No.: s.n.
Date: 9/20/1958

Location: Sauk County, Wisconsin
Access Number: v0053968WIS
Habitat: Base of S-facing goat prairie with Carya, Poa, and Andropogon.
Collector: Freriks, J.
Coll. No.: s.n.
Date: 5/19/1960

Location: Iowa County, Wisconsin
Access Number: v0053855WIS
Habitat: N slope of meadow between farmhouse and road. Flowering twigs collected on 5 May. BER
Collector: Likens, G.
Coll. No.: 61
Date: 5/19/1960

Location: Iowa County, Wisconsin
Access Number: v0053857WIS
Habitat: N slope of meadow between farmhouse and road. Flowering twigs collected on 5 May. BER
Collector: Likens, G.
Coll. No.: 61
Date: 5/19/1960

Location: Chippewa County, Wisconsin
Access Number: v0053823WIS
Habitat: Roadside, sandy loam. Tree 25 ft tall. BER
Collector: Ebert, T. A.
Coll. No.: s.n.
Date: 8/23/1960

Location: Sauk County, Wisconsin
Access Number: v0053972WIS
Habitat: Rich woods with Acer rubrum, Tilia americana, Quercus alba. At base of S slope at fringe of woods. Frequent. BER
Collector: Keune, Steve
Coll. No.: s.n.
Date: 5/21/1961

Location: Langlade County, Wisconsin
Access Number: v0053863WIS
Habitat: Woods of sugar maple and ironwood; abundant maple seedlings; Erythronium, Allium, Hydrophyllum, and abundant Viola canadensis. Large trees. BER
Collector: Schlising, Robert A.
Coll.No.: 1991
Date: 6/17/1961

Location: Sauk County, Wisconsin
Access Number: v0053965WIS
Habitat:
Collector: Ream, Catherine H.
Coll. No.: s.n.
Date: 5/19/1962

Location: Richland County, Wisconsin
Access Number: v0053888WIS
Habitat:
Collector: Nielsen, Ulla
Coll. No.: s.n.
Date: 5/24/1962

Location: Marquette County, Wisconsin
Access Number: v0053867WIS
Habitat: N-facing wooded bluff above creek. Collecting event: Flora of the old bed of glacial Lake Wisconsin and the adjacent terminal moraine.
Collector: Sorensen, Paul D.
Coll. No.: 1629
Date: 6/25/1962

Location: Marquette County, Wisconsin
Access Number: v0053868WIS
Habitat: N-facing wooded bluff above creek. Collecting event: Flora of the old bed of glacial Lake Wisconsin and the adjacent terminal moraine.
Collector: Sorensen, Paul D.
Coll. No.: 1629
Date: 6/25/1962

Location: Marathon County, Wisconsin
Access Number: v0053864WIS
Habitat: Wooded rocky draws and slopes of dells with Tsuga canadensis on N-side (s-facing).
Collector: Iltis, Hugh H.
Coll. No.: 20813
Date: 9/5/1962

Location: Sauk County, Wisconsin
Access Number: v0053970WIS
Habitat:
Collector: Voight, P. W.
Coll. No.: s.n.
Date: 5/18/1963

Location: Iowa County, Wisconsin
Access Number: v0054523WIS
Habitat: Wet forest; river bottom; Acer- Ulmus - Populus - Salix with Symplocarpus and Caltha.
Collector: Lewis, D.W.
Coll. No.: 31
Date: 5/18/1963

Location: Sauk County, Wisconsin
Access Number: voo69383WIS
Habitat: Upland oak - maple woods.
Collector: Gordon, Richard
Coll. No.: s.n.
Date: 5/26/1963

Location: Richland County, Wisconsin
Access Number: v0053884WIS
Habitat: Open second growth woods.
Collector: Milfred, Clarence J.
Coll. No.: 17
Date: 6/1/1963

Location: Clark County, Wisconsin
Access Number: v0053824WIS
Habitat: Butternut woods. On silt loam soil.
Collector: Purchase, J. E.
Coll. No.: 501-64
Date: 7/7/1964

Location: Waupaca County, Wisconsin
Access Number: v0069384WIS
Habitat: Site moist - mesic in character, soil sandy loam. Large solitary tree rooting near base of hillside.
Collector: Mauritz, J. G.
Coll. No.: 1031
Date: 8/6/1964

Location: Iowa County, Wisconsin
Access Number: v0069386WIS
Habitat: In woods, mainly on the lower land.
Collector: Dravnicks, B.
Coll. No.: 14
Date: 5/25/1965

Location: Crawford County, Wisconsin
Access Number: v0069385WIS
Habitat: Shaded west facing hillside – borders.
Collector: Teynor, Larry
Coll. No.: s.n.
Date: 5/30/1965

Location: Richland County, Wisconsin
Access Number: v0053887WIS
Habitat: River bluff.
Collector: Force
Coll. No.: s.n.
Date: 6/2/1965

Location: Columbia County, Wisconsin
Access Number: v0073770WIS
Habitat: On road. Sticky petioles and leaflets. Occasional.
Collector: Barnes, Wm. J.
Coll. No.: 98
Date: 6/3/1966

Location: Green County, Wisconsin
Access Number: v0053850WIS
Habitat: Top of prairie behind woods.
Collector: Medler, John
Coll. No.: s.n.
Date: 6/26/1966

Location: Milwaukee County, Wisconsin
Access Number: v0048957WIS
Habitat: Growing near shed in open space in an old farm yard. Tree about 40 feet high.
Collector: Schendel, Jon D.
Coll. No.: 8
Date: 10/5/1966

Location: Iowa County, Wisconsin
Access Number: v0053858WIS
Habitat: Old woodlot woods, with Quercus, Populus, Carya.
Collector: Thorn, N.
Coll. No.: s.n.
Date: 5/27/1967

Location: Rock County, Wisconsin
Access Number: v0053964WIS
Habitat: Limestone outcroppings along creek. Several large trees. BER
Collector: Musselman, Lytton J.
Coll. No.: 1683
Date: 1/26/1968

Location: Green County, Wisconsin
Access Number: v0053851WIS
Habitat: Base of bluff along river. E-facing sandstone slope.
Collector: Musselman, Lytton J.
Coll. No.: 1781
Date: 4/29/1968

Location: Sauk County, Wisconsin
Access Number: v0053969WIS
Habitat: Rich oak-hickory woods.
Collector: Curtis, T.
Coll. No.: s.n.
Date: 5/31/1968

Location: Sheboygan County, Wisconsin
Access Number: v0053979WIS
Habitat: Beech-sugar maple woods with Tilia, Ulmus, Ostrya, Carpinus, Quercus sp.. A rich understory. On N slope with silt loam soil.
Collector: Heidel, David
Coll. No.: 672
Date: 6/6/1968

Location: Waukesha County, Wisconsin
Access Number: v0073774WIS
Habitat: In an upland forest.
Collector: Sellers
Coll. No.: s.n.
Date: 5/28/1969

Location: Sauk County, Wisconsin
Access Number: v0073772WIS
Habitat: Open field with Rhus typhina, Rhus glabra, Ribes allegheniense.
Collector: Eckstein, Ron
Coll. No.: s.n.
Date: 6/1/1969

Location: Rock County, Wisconsin
Access Number: v0053963WIS
Habitat: Limestone area. Mesic red oak-sugar maple woods with some Ostrya and basswood; parts heavily grazed.
Collector: Rice, W.
Coll. No.: 370
Date: 6/14/1969

Location: Sauk County, Wisconsin
Access Number: v0073773WIS
Habitat: Top of hillside, sandy rich soil, Quercus alba, Rhubus, Acer rubrum.
Collector: Simon, H.
Coll. No.: s.n.
Date: 5/8/1971

Location: Dane County, Wisconsin
Access Number: v0053835WIS
Habitat: Forested hillside.
Collector: Guth, J.
Coll. No.: s.n.
Date: 5/14/1972

Location: Iowa County, Wisconsin
Access Number: v0053856WIS
Habitat: Valley floor, moist soil.
Collector: Monthey
Coll. No.: s.n.
Date: 5/17/1972

Location: Grant County, Wisconsin
Access Number: v0053844WIS
Habitat: Woods and woods edges with Pyrus malus and Ulmus Americana, also flowering stem coll. 20May1972. BER
Collector: Lonsdorf, Charles
Coll. No.: 241
Date: 5/22/1972

Location: Lafayette County, Wisconsin
Access Number: v0053861WIS
Habitat: Heavily wooded N-facing slope above river, with Quercus alba, Q. borealis, Tilia americana, Acer saccharum. Occasional small tree. BER
Collector: Hansen, Bruce
Coll. No.: 1191
Date: 7/18/1972

Location: Grant County, Wisconsin
Access Number: v0053847WIS
Habitat:
Collector: Iltis, Michael
Coll. No.: s.n.
Date: 5/18/1973

Location: Richland County, Wisconsin
Access Number: v0053885WIS
Habitat: Young woods of Quercus alba, Q. rubra, Q. macrocarpa, Carya ovata on SW-facing slope, now only lightly grazed. With Desmodium glutinosum, Xanthoxylum, Geranium maculatum, Ceanothus americanus, Festuca obtusa, Vitis aestivalis, Amphicarpaea, Carya cordiformis.
Collector: Nee, Mike
Coll. No.: 5868
Date: 6/27/1973

Location: Sauk County, Wisconsin
Access Number: v0053974WIS
Habitat: Oak woods.
Collector: Iltis, Hugh H.
Coll. No.: s.n.
Date: 6/30/1973

Location: Richland County, Wisconsin
Access Number: v0053886WIS
Habitat: Pastured slope between town road and marsh. Few trees, many weeds. Tree 30 ft. tall. BER
Collector: Nee, Mike
Coll. No.: 6130
Date: 7/11/1973

Location: Vernon County, Wisconsin
Access Number: v0053988WIS
Habitat: Moist shrubby area.
Collector: Kline, V.
Coll. No.: s.n.
Date: 7/12/1974

Location: Sawyer County, Wisconsin
Access Number: v0053976WIS
Habitat: In red oak - white pine - balsam fir woods; northern hardwoods, 14' dbh tree. BER
Collector: Iltis, Hugh H.
Coll. No.: 27686
Date: 8/13/1974

Location: Sawyer County, Wisconsin
Access Number: v0053975WIS
Habitat: Small, rich deciduous woods of Betula allegheniensis, Acer rubrum, Juglans. With Prunus virginiana, Acer spicatum, Hydrophyllum virginianum, Streptopus roseus, Asarum, Trillium grandiflorum, Mitella diphylla. Tree 6m tall, 15cm dbh. BER
Collector: Hansen, Bruce
Coll. No.: 3032
Date: 5/31/1975

Location: Outagamie County, Wisconsin
Access Number: v0053874WIS
Habitat: Formerly pastured knoll top Acer saccharum - Ulmus americana stand with ample Xanthoxylum fraxinium in the understory. 4th coll.: S. McCarthy. BER
Collector: Cochrane, Theodore S.
Coll. No.: 6448
Date: 6/11/1975

Location: Forest County, Wisconsin
Access Number: v0053842WIS
Habitat: Acer saccahrum woods, with Tilia americana, Ostrya virginiana, Aralia racemosa, Carex sprengelii, C. pensylvanica, Athyrium filix-femina, Trillium grandiflorum, Smilacina racemosa, Maianthemum canadense, Sanguinaria canadensis, Milium effusum, Sanicula marilandica, Cornus alternifolia, Streptopus rosesus. Other collectors: C.S. Keller, M. Waterway. BER
Collector: Hansen, Bruce
Coll. No.: 3540
Date: 6/28/1975

Location: Vernon County, Wisconsin
Access Number: v0048958WIS
Habitat: Abandoned farmstead, steep east exposure slope of Oak-hickory. Narrow strip of dry prairie on ridge top.
Collector: Jurewicz, Randle L.
Coll. No.: s.n.
Date: 9/15/1975

Location: Marquette County, Wisconsin
Access Number: v0053869WIS
Habitat: Farm with Fraximus sps. and Salix sps.
Collector: Dessel, John
Coll. No.: 39
Date: 5/22/1976

Location: Fond du Lac County, Wisconsin
Access Number: v0053841WIS
Habitat: Dryish, grassy open edge, with Juniperus virginiana, Carya ovata, Ulmus rubra, and Ostrya virginiana. Medium-good stand of mixed hardwoods on level ground; thin Miami silt loam overlying Niagara dolomite just back from escarpement. Acer saccharum-Quercus borealis woods w/Ulmus rubra, Ostrya virginiana, Prunus serotina, Juglans cinera, more mesic at the escarpment, w/ Betula papyrifera & Taxus canadensis, drier back away from the escarpment, w/ Quercus alba.
Collector: Cochrane, Theodore S.
Coll. No.: 7594
Date: 7/16/1976

Location: Pierce County, Wisconsin
Access Number: v0053879WIS
Habitat: Excellent bluff prairie along lower bluff slopes, w/few weeds, some rare plants, such as Psoralea esculenta, Artemisia frigida, A. dracunculoides, Muhlenbergia cuspidata, Eupatorium altissimum. Also A. caudata, Solidago nemoralis, S. rigida, S. speciosa, Equisetum hyemale, Gnaphalium obtusifolium, Euphorbia corollata, Andropogon scoparius, A. gerardii, Liatris aspera, L. cylindracea, Linum sulcatum, Eragrostis spectabilis, Helianthus rigidus, Asclepias verticillata, Bouteloua curtipendula, Petalostemum purpureum, Aster azureus, A. sericeus, A. ericoides, A. oblongifolius, Amorpha canescens, Sorghastrum nutans, Kuhnia eupatorioides, also w/ encroaching Rhus glabra, Juglans, Physocarpus opulifolius, Prunus vir., [see label] Stump sprouts. BER
Collector: Hansen, Bruce
Coll. No.: 4039
Date: 9/14/1976

Location: Pierce County, Wisconsin
Access Number: v0053880WIS
Habitat: Rank weedy streambank, with Napaea dioica, Urtica dioica, Ambrosia trifida, Acer negundo, Rhus typhina, Mattueccia struthiopteris.
Collector: Hansen, Bruce
Coll. No.: 4182
Date: 9/14/1976

Location: Pierce County, Wisconsin
Access Number: v0053878WIS
Habitat: Rank, weedy (natives mostly) river floodplain, mostly open but with clumps of Acer negundo, Salix alba, S. interior. Also Sambucus canadensis, Symphoricarpos occidentalis, Fraxinus nigra, Xanthoxylum, Prunus virginiana, Ulmus americana, U. rubra, Vitis riparia, Menispermum, Napaea dioica, Silphium perfoliatum, Bromus latiglumis, Aster lateriflorus, A. prenanthoides, Cryptotaenia, Leonurus, Scrophularia marilandica, Glechoma hederacea, Blephilia hirsuta, Teucrium, Echinocystis lobata, Artemisia serrata, Eupatorium maculatum, Verbena urticifolia, ELymus canadensis, LActuca biennis, Agastache scroph., Triosteum perfol., Veronicastrum vir., Lysimachia ciliata, Solidago altissima. Young tree. BER
Collector: Hansen, Bruce
Coll. No.: 4416
Date: 9/23/1976

Location: Outagamie County, Wisconsin
Access Number: v0053876WIS
Habitat: Woods on a rock ledge.
Collector: Petit, Alan
Coll. No.: 88
Date: 9/25/1977

Location: Outagamie County, Wisconsin
Access Number: v0053875WIS
Habitat: Thick woods.
Collector: Petit, Alan
Coll. No.: 180
Date: 6/9/1978

Location: Green County, Wisconsin
Access Number: v0053852WIS
Habitat: Rich woods with Acer and Tilia.
Collector: Toulon, Lauren
Coll. No.: s.n.
Date: 5/21/1979

Location: Richland County, Wisconsin
Access Number: v0053961WIS
Habitat: Old pasture slope at base of bluffs along Wisconsin River valley, with Ulmus americana, U. rubra, Rhus glabra, Juniperus virginiana, Prunus serotina, Xanthoxylum, Betula papyrifera, Vitis riparia. Common, invasive. Very young tree 5 m tall, 15 cm diam. Bark light gray. Male inflorescences abundant, readily falling, 1-2 from axils of last year's leaves. BER
Collector: Nee, Mike
Coll. No.: 16752
Date: 5/28/1979

Location: Shawano County, Wisconsin
Access Number: v0053978WIS
Habitat: Second growth forest, with Populus tremuloides dominant. At base of ridge with Alnus rugosa, Populus grandidentata BER Navarino Wildlife Area. Grouse Survey.
Collector: DeStefano, Stephen
Coll. No.: 322
Date: 9/12/1980

Location: Grant County, Wisconsin
Access Number: v0053845WIS
Habitat: Very steep W-facing slope of Mississippi River valley bluff, with limestone outcroppings. Much grown-up with brush and small trees, Rhus glabra, Rhamnus lanceolata, Celastrus scandens, Ulmus rubra, Juniperus virginiana, Quercus macrocarpa, Fraxinus macrocarpa, Fraxinus pennsylvnica. Once undoubtedly all prairie and still a rich flora with Onosmodium, Desmodium illinoense, Silphium laciniatum, Coreopsis palmata, Amorpha canescens, Helianthus occidentalis, Potentilla arguta. Young tree, no fruit. BER
Collector: Nee, Mike
Coll. No.: 20950
Date: 7/18/1981

Location: Oconto County, Wisconsin
Access Number: v0053873WIS
Habitat: In woods of red oak and white birch. A common tree. [with good regeneration until the early 1990's when the blight struck. In 2000 there are still a few living, sick trees and seedlings. -E.J Judziewicz]. BER
Collector: Judziewicz, Emmet J.
Coll. No.: 2411
Date: 7/26/1981

Location: Dane County, Wisconsin
Access Number: v0048956WIS
Habitat: Dry woods with Quercus spp., Ostrya, Ulmus spp. Common throughout.
Collector: French, J. B. Jr.
Coll. No.: 36
Date: 5/15/1982

Location: Richland County, Wisconsin
Access Number: v0069382WIS
Habitat: NE facing slope with (now) ungrazed woods of Quercus alba, Q. rubrum, Betula papyrifera, Ostrya virginiana, Juglans cinerea, with a few disturbed openings. Small tree. Leaves viscid.
Collector: Nee, Mike
Coll. No.: 24288
Date: 6/6/1982

Location: Adams County, Wisconsin
Access Number: v0053818WIS
Habitat: Woods edge in sandy loam, with Quercus ellipsoidalis. 30 ft. tree. Fruit: nut. BER
Collector: Hobler, E. K.
Coll. No.: 281
Date: 7/30/1987

Location: Burnett County, Wisconsin
Access Number: v0053821WIS
Habitat: Roadside with Tilia americana, Fraxinus americana.
Collector: Culbertson, Carol
Coll. No.: 75
Date: 8/2/1987

Location: Dodge County, Wisconsin
Access Number: v0053837
Habitat: Beech-maple woods. Rare. BER
Collector: Leitner, Lawrence A.
Coll. No.: 1287
Date: 7/13/1988

Location: Ozaukee County, Wisconsin
Access Number: v0048959WIS
Habitat: Rare.
Collector: Leitner, Lawrence A.
Coll. No.: 3100
Date: 10/10/1989

Location: Chippewa County, Wisconsin
Access Number: v0048955WIS
Habitat:
Collector: Thompson, Kathy L.
Coll. No.: 520
Date: 7/14/1992

Location: Taylor County, Wisconsin
Access Number: v0053982WIS
Habitat: Along little-used road at edge of mixed hardwood forest on well-drained soil. Common. Mostly young trees ca. 5 m high. BER
Collector: Fields, Douglas M.
Coll. No.: 1014
Date: 5/23/1994

Location: Taylor County, Wisconsin
Access Number: v0053983WIS
Habitat: Open river bottomland woods. With swamp white oak, silver maple, basswood, ash hawthorn. Common. BER
Collector: Fields, Douglas M.
Coll. No.: 2175
Date: 9/21/1994

Location: Taylor County, Wisconsin
Access Number: v0053984WIS
Habitat: Disturbed bottomland forest along river, with silver maple, bur oak, red maple, and ash. Fairly common. BER
Collector: Fields, Douglas M.
Coll. No.: 2375
Date: 6/21/1995

Location: Taylor County, Wisconsin
Access Number: v0053985WIS
Habitat: Rich mixed, hardwoods forest. Fairly common. BER
Collector: Fields, Douglas M.
Coll. No.: 2478
Date: 7/16/1995

Location: Price County, Wisconsin
Access Number: v0053882WIS
Habitat: With white cedar and mountain maple. S side of channel between lakes. Many large trees. BER
Collector: Fields, Douglas M.
Coll. No.: 2807
Date: 9/11/1995

Location: Iowa County, Wisconsin
Access Number: v0048950WIS
Habitat: In shady white oak, red oak, red maple woods. Sandy loam. Near woodland edge. Growing with Acer rubrum, Quercus alba, Quercus rubra, Rubus spp. St. Peter Sandstone bedrock. One individual to 3 meters.
Collector: Wernerehl, Robert
Coll. No.: 299
Date: 9/14/1995

APPENDIX B:
Contacts (*Juglans cinerea* L.)

A thank you is extended to all who responded and shared pertinent information from the various forests and locations as are listed below:

Forest Service Contacts:

Allegheny National Forest: Brad Nelson (814) 723-5150.
Chequamegon-Nicolet National Forest: Mariquita Sheehan, Plant Ecologist (715) 479-2827.
Chequamegon-Nicolet National Forest: Mark Theisen, Forest Silviculturist (715) 362-1346.
Chequamegon-Nicolet National Forest: Steven Spickerman, Plant Ecologist (715) 264-2511.
Chequamegon-Nicolet National Forest: Steve Janke, Plant Ecologist (715) 276-6333.
Chippewa National Forest: Nancy Berlin, R9 TES Detailer (218) 335-8673.
Chippewa National Forest: Ian Shackleford, Botanist. Currently works for the Ottawa National Forest (906) 932-1330.
Green Mountain National Forest: Diane Burbank, Ecologist (802) 388-4362 ext. 116.
Green Mountain National Forest: MaryBeth Deller, Botanist (802) 767-4261 ext. 524.
Green Mountain National Forest: Robert Burt. Forest Silviculturist. (802) 747-6739.
Hiawatha National Forest: Jan Schultz, Forest Plant Ecologist (906) 228-8491.
Hiawatha National Forest: Chuck Cutter, District Silverculturist, Rapid River District (906) 474-6442 ext 139.
Hoosier National Forest: Steve Olson (812) 547-7051.
Huron-Manistee: Alix Cleveland, Forest Botanist, (231) 775-2421.
Mark Twain National Forest: Ross Melick (573) 364-4621 ext. 434.
Monongahela National Forest: Jan Garrett (304) 636-1800.
Ottawa National Forest: Sue Trull, Forest Botanist (906) 932-1330.

Shawnee National Forest: Beth Shimp, Forest Botanist (618) 253-1053.
Wayne National Forest: Erin Larson (740) 753-0558.
White Mountain National Forest: Leighlan Prout, Wildlife Biologist (603) 528-8744.
White Mountain National Forest: John Williams, Sales Design and Cruising (603) 536-1315.

Regional Forest Contacts

Library Services, North Central Research Station, St. Paul, MN. Laura Hutchinson. (lhutchinson@fs.fed.us)
Steven Katovich, Forest Entomologist, Forest Health Protection, St. Paul, MN. (skatovich@fs.fed.us)
Manfred Mielke, Forest Health Monitoring, Forest Health Protection, St. Paul, MN. (mmielke@fs.fed.us)
Cathy Nielsen, Ontario Forest Research Institute at Sault Ste. Marie, Ontario, Canada. (cathy.nielsen@mnr.gov.on.ca)
Michael E. Ostry, Research Plant Pathologist, North Central Research Station, St. Paul, MN. (mostry@fs.fed.us)

Other Contacts

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V.M.G. Nair, Professor of Plant and Forest Pathology-Mycology, University of Wisconsin at Green Bay. (nairg@uwgb.edu)

Sylvia Taylor, Adjunct Associate Professor Natural Resources, University of Michigan, Ann Arbor, MI. (smtaylor@umich.edu)