A Forest Manager's Guide to Butternut

Keith Woeste, Lenny Farlee, Michael Ostry, James McKenna, and Sally Weeks

ABSTRACT

Exotic insect pests and pathogens have dramatically reduced the quantity and quality of several trees species in North America. Butternut (*Juglans cinerea* L.) is one such species. This review discusses the identification of butternut, the current status of butternut, and the nature of the threats that influence its survival, all in the context of what forest managers need to know to make difficult choices they face when managing butternut. Options for encouraging regeneration are presented, as well the current status of recovery efforts.

Keywords: butternut canker, *Juglans cinerea*, *Juglans ailantifolia*, Japanese walnut, *Juglans* × *bixbyi*, buart, hybrid invasion

Butternut (*Juglans cinerea* L.), also called white walnut or oil nut, grows over the entire northeastern quarter of the United States. Although butternut is capable of achieving a height of 110 ft with a diameter approaching 5 ft (Harlow et al. 1979), mostly much smaller trees are found today. Butternut's wood qualities once made it favorable for fine furniture, interior finishing, carving, musical instruments, and boats (Kellogg, 1919, Peterson, 1990). Butternut is now threatened, and in many parts of its range it is rare. The US Forest Service Forest Inventory and Analysis (FIA) data (USDA FIA National Program 2008) revealed that the number of butternuts across seven midwestern states decreased across all size classes by 23% from the previous survey. A survey of butternut in Wisconsin in 1992 found 92 and 27% of butternut trees were diseased and dead, respectively (Cummings-Carlson and Guthmiller 1993).

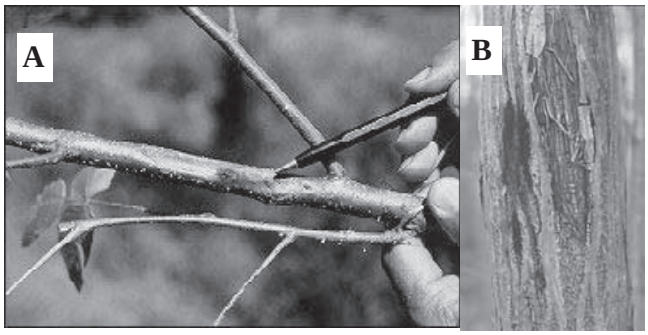

Figure 1. Symptoms of butternut canker disease on a (A) young branch and (B) main stem. Note presence of callus covering older wound.

Butternut Canker Disease

Butternut trees of all ages are killed by *Sirococcus clavigignenti-juglandacearum* (*Sc-j*), a fungus found throughout butternut's range. Although butternut is also affected by other insect pests and diseases, *Sc-j* is the most serious threat to butternut's survival (Furnier et al. 1999). Butternut canker was first reported from southwestern Wisconsin in 1967 (Renlund 1971), but *Sc-j* was most likely introduced from outside North America and probably has been present in North American forests for more than 40 years. Rain-splash is the primary means of spore dispersal (Tisserat and Kuntz 1983), but long-distance movement by insects (Katovich and Ostry 1998, Halik and Bergdahl 2002) and birds is also strongly suspected because isolated butternuts are often infected (Nicholls 1979). Young, annual cankers caused by *Sc-j* are elongated, sunken areas commonly originating at leaf scars and buds, often with an inky black center and whitish margin (Nicholls et al. 1978; Figure 1). Older, perennial branch and stem cankers are often found in bark fissures or are covered by bark and bordered by successive callus layers (Kuntz et al. 1979). Cankers can develop throughout a tree, but commonly occur on the main stem, at the base of trees, and on exposed roots (Tisserat and Kuntz 1983). As butternut canker disease progresses, cankers coalesce, eventually girdling and killing the host. *Sc-j* often kills butternuts quickly, but on occasion affected trees live as long as 30 years (Ostry et al. 1994). Epicormic branching or basal sprouts are often evident on severely affected trees, but these shoots typically succumb to the disease quickly. Black walnut and other species in the genus *Juglans* can also be infected by *Sc-j*, resulting in branch and twig dieback in some cases (Ostry et al. 1997, Ostry 1997), but so far only butternut has been seriously impacted by the fungus.

Legal Status and Certification Issues

Butternut is not currently a federally protected species under the Endangered Species Act (ESA). It is listed by the federal government as a species of special concern, meaning it could be under consideration for ESA listing, but there is insufficient supporting information to list it at this time. Canada has listed butternut as an endangered species as of November 2003. NatureServe, a nonprofit organization of natural heritage programs, provides a global conservation status listing of G4 for butternut, meaning the species is

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Table 1. State and province conservation status of butternut according to NatureServe (2007).

United States: Alabama (S1), Arkansas (S3), Connecticut (SNR), Delaware (S3), District of Columbia (S1), Georgia (S2), Illinois (S2), Indiana (S3), Iowa (SU), Kentucky (S3), Maine (SNR), Maryland (S2S3), Massachusetts (S4?), Michigan (S3), Minnesota (S3), Mississippi (S2), Missouri (S2), New Hampshire (S3), New Jersey (S3S4), New York (S4), North Carolina (S2S3), Ohio (S3), Pennsylvania (S4), Rhode Island (SU), Tennessee (S3), Vermont (SU), Virginia (S3?), West Virginia (S3), and Wisconsin (S3?)
Canada: Manitoba (SNA), New Brunswick (S3), Ontario (S3?), Prince Edward Island (SNA), Quebec (S3S4)

S1, critically imperiled; S2, imperiled; S3, vulnerable; S4, apparently secure; SNA/SNR/SU, not ranked or under review.

considered apparently secure from extinction. They note (NatureServe 2007) the species is in rapid decline, and its conservation status should be reevaluated frequently. Some states have highlighted butternut's status by giving it a special designation beyond its status in NatureServe (Table 1); Arkansas, Georgia, Kentucky, Massachusetts, Ohio, Tennessee, New York, Minnesota, West Virginia, and Wisconsin have officially listed butternut as a species of special concern, threatened, or vulnerable or placed it on a watch or special inventory list. Some federal and state agencies have established management policies aimed at retaining butternut on public lands. This includes Minnesota and nearly all the national forests within butternut's range.

The decline of butternut and its listing as a species of concern may have implications for management, particularly within the framework of forest certification. Principles and indicators for conformity with sustainable management practices in these systems generally include statements on retaining biological diversity and protecting rare, threatened, or endangered species. Although butternut is not officially listed in the United States, its declining population and the increased incidence of canker indicate the need for management to sustain local populations. This issue should be considered when decisions on the management of butternut are made within the context of certification systems. The onsite maintenance of locally adapted genes should be one of the main objectives of forest management, whether or not regeneration is required (Rajora and Mosseler 2001).

Management Implications of Butternut Canker Disease

Butternut trees of good vigor and in a competitive crown position may be better able to delay mortality due to canker, but there is currently no practical method for preventing butternut canker of forest trees (Schultz 2003). Healthy trees should be retained as a seed source whenever possible. Guidelines developed by Ostry et al. (1994) suggest retention of all trees with more than 70% live crown and less than 20% of the combined circumference of the bole and root flares affected by cankers and all trees with at least 50% live crown and no cankers on the bole or root flares. When evaluating the live crown and extent of crown dieback, consider only those limbs in the upper and outer portion of the crown. Interior and lower branches can be considered as having died from shading. Butternut trees with crown damage due to causes other than canker should be evaluated based on their potential for surviving until the next stand entry. Low-vigor butternut trees may have value as habitat, as a source of nuts, or for wood products. Severely affected butternut trees have little chance of survival, so they can be salvaged for any remaining wood value. Even small amounts of butternut wood could have value if marketed to woodcarvers and turners, custom furniture manufacturers, or as specialty veneer. Stained or "spalted" wood from damaged or recently dead trees is sought by carvers and turners for its aesthetic qualities.

Butternut and Butternut Hybrids

Butternut is relatively easy to distinguish from other native species. Nevertheless, butternut can be difficult to identify because although butternut does not hybridize with black walnut, butternut hybridizes with at least two exotic species. Hybrids of butternut and Persian or English walnut (*Juglans regia* L.) are known as *Juglans* × *quadrangulata* (Carr.) Rehd. (pro sp.); they form spontaneously but are uncommon, probably because *J.* × *quadrangulata* trees produce few fruit. *Juglans* × *bixbyi* Rehd. is the hybrid of butternut and Japanese walnut (*Juglans ailantifolia* Carr.; USDA Agricultural Research Service National Genetic Resources Program). Heartnuts are a horticultural variety of *J. ailantifolia*, a species first introduced into the United States about 1860 and widely planted in the following 70 years (Crane et al. 1937). Japanese walnut blooms at about the same time as butternut, and the two species hybridize easily; the resulting buart (pronounced *bew*-art) hybrid bears nuts that greatly resemble butternuts (Table 2; Figure 2). Buarts are also known as butterjaps and buartnuts. Unlike most *Juglans* hybrids, buarts are highly fruitful and able to cross with other hybrids, both parental species, and may even self-pollinate, producing trees with confusing combinations of traits. Over the past 70 years, many productive hybrids of unknown provenance have been propagated and dispersed as butternuts, compounding the confusion. The authors have observed that in some places, buart hybrids or their offspring are virtually the only "butternuts" to be found. The prevalence of buartnuts is well known among nut growers in eastern North America but little recognized by taxonomists, silviculturists, dendrologists, and professional forest managers. No single trait distinguishes butternut from hybrids, but hybrids can usually be recognized using multiple characteristics (Ross-Davis et al. 2008b; Table 2; Figure 3). Our ability to distinguish hybrids from pure butternuts has improved considerably with the development of DNA-based markers associated with the parental species (Ross-Davis et al. 2008b). These markers are already being used to identify nonhybrid trees in National Forests for use in establishing seed orchards and to further butternut breeding efforts by the US Forest Service and public cooperating institutions.

Management Implications of Butternut Hybrids

Determining whether a tree growing in a forest is a hybrid is often impossible unless twigs or seeds can be examined, so in most cases, forest managers will probably manage butternuts using the retention guidelines described previously. Even when managers suspect a tree may be a hybrid based on its morphology or location near an old homestead (Table 2), they may choose to retain it for sale (although the commercial qualities of the wood of hybrid trees still have to be determined) or as a food source for wildlife. Landowners who choose to favor native species or who must favor native species for reasons of certification should remove hybrids if they are known to be present. Japanese walnuts (and presumably hybrids) have been considered invasive in some habitats (Froude 2002). If hybrids are permitted to invade forests, they could "pollute" the gene pool of native butternut by continued hybridizing, reducing the ability of

Table 2. Summary of characteristics distinguishing pure butternut from hybrid butternuts.

Characteristics	Butternut	Butternut hybrids
Habitat	Forests	Parks, forest edges, farmyards, urban areas, planted trees, and orchards
1-yr Twigs		
Current-year stem	Olive green changing to red-brown near terminal, glossy, and few hairs except immediately beneath terminal buds	Bright green to copper brown or tan, often densely covered with russet or tan hairs, especially near terminal buds; pale green near terminal bud
Terminal bud	Beige in color; longer and narrower than hybrids, and the outer, fleshy scales more tightly compact	Pale green to tan or yellowish in color, wider and squatter than *J. cinerea;* outer fleshy scales more divergent than butternut and often deciduous
Lateral bud	Vegetative buds are elongated (sometimes stalked) and somewhat angular, creamy white to beige in color	Vegetative buds are rounded and green to greenish brown in color
Lenticels	Small, round, abundant, evenly distributed, and sometimes elongating horizontally across the branch (perpendicular to the stem axis)	Large, often elongating laterally down the branch (parallel to the stem axis) on 1-yr wood, patchy distribution; on 3- and 4-yr wood, lenticels often form a diamond pattern as they become stretched both transversely and longitudinally
Leaf scar	Top edge almost always straight or slightly convex; scar usually compact	Top edge almost always notched; often with large, exaggerated lobes
Pith	Dark brown	Dark brown, medium brown, or even light brown
Mature tree		
Bark	Varies from light grey and platy to dark grey and diamond patterned in mature trees; in older trees, fissures between bark ridges may be shallow or deep but are consistently dark grey in color	Silvery or light grey, rarely darker; fissures between bark ridges moderate to shallow in depth and often tan to pinkish-tan in color
Leaf senescence	Leaves yellow and brown by early midautumn, dehiscing in early to mid autumn	Leaves often green until late autumn, dehiscing in late autumn or may freeze green on the tree
Catkins	5–12 cm in length at peak pollen shed	13–26 cm in length at peak pollen shed
Nut Clusters	One or two nuts per terminal in most clusters, sometimes three to five, rarely more	Usually three to five per cluster, sometimes as many as seven

Figure 2. Butternut seeds (upper row). Hybrid seeds are in the bottom row (B). Grid = 1 cm^2.

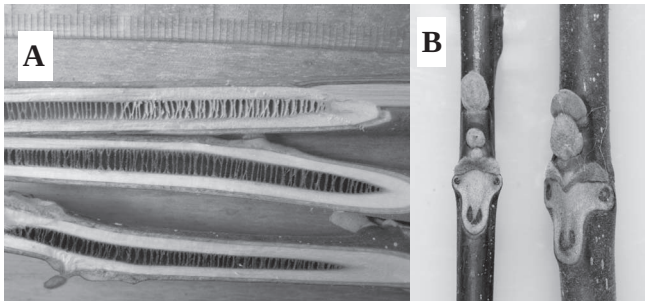

Figure 3. Branch traits that distinguish butternut from hybrids. (A) Pith color of Japanese walnut (upper), hybrid tree (middle), and butternut (lower); (B) leaf scar, dormant buds, and lenticels of butternut (left) and a hybrid (right) (see Table 2 for additional details).

butternut to reproduce as an identifiable species (Mooney and Cleland 2001). Because some Asian walnuts can also hybridize with black walnut, the process of hybrid invasion could begin to affect the quality of black walnut as well (Wilson and Corneil 1979)

Butternut Regeneration

Many butternut trees are nearing the end of their life expectancy and regeneration is generally not adequate to maintain even the existing, greatly diminished population. Additional factors that have contributed to poor regeneration include a shortage of suitable sites for regeneration (Schultz 2003, Thompson et al. 2006), irregular seed bearing, seed predation by animals, and a limited seed bank because butternut seeds do not survive more than 2 years in the soil. We have observed that butternut is now most often found on woodland edges, abandoned crop fields or pastures, cutover areas, steep slopes where there is light exposure due to terrain or blowdown, fence rows, riparian areas, and road cuts, perhaps indicating that butternut regenerates best on sites with high levels of disturbance. Recent FIA data report that 39% of live butternuts are in overstocked or fully stocked forests with poor prospects of supporting regeneration (USDA FIA National Program 2008). Because there are no published studies concerning methods for natural regeneration of butternut, a commonsense approach seems advised. Butternut is shade intolerant, so it must be in the upper canopy or on a forest edge to survive, grow, and bear fruit, and it needs full sunlight to regenerate (Ostry et al. 2003). Openings to encourage natural

regeneration of butternut might be accomplished with group selection or patch clearcuts that are near seed sources and of adequate size (generally two to three times local tree height) to provide full sunlight to seedlings (Murphy et al. 1993). Soil disturbance in the opening may contribute to seeding success. In openings where butternut is not among the fastest growing trees, thinning or crop tree release will be needed to assure butternut's survival and vigor as the stand develops. Protection from deer may be necessary to assure regeneration because butternut leaves and twigs are preferred by white-tailed deer (Van Dersal 1938), and bucks may also use young trees for antler rubbing. Burning to increase oak regeneration may suppress butternut, because it typically does not sprout following a top-killing fire (Clark1965).

Choosing Seed Trees, Harvesting, and Handling Seeds

Seeds or seedlings used for regeneration should be locally adapted and as genetically diverse as possible. Studies of black walnut showed that trees separated by over a mile can pollinate one another, so even isolated trees can bear a crop, and even relatively small butternut populations contain a considerable amount of genetic diversity (Ross-Davis et al. 2008a). The potential for inbreeding depression is present in butternut because trees are often highly dispersed and they can self-pollinate. Although there is no evidence yet that seed gathered from isolated trees or a small number of individuals is inbred, it is always a good policy to gather seeds from as many mother trees as possible, rather than a large number of seeds from a single tree. If managers wish to avoid hybrids, caution is warranted in the collection and distribution of butternut seed because we have observed that this has been a common method for unknowingly dispersing hybrids. Clusters of forest-grown butternuts that are not near former home sites are most likely to produce pure butternut seed, although they may bear crops only sporadically and harvesting from them is often difficult.

Butternut seeds, like walnuts, become mature toward the end of summer and may be harvested from early September through October. Butternut fruits (the sticky, green husk with the single seed inside) are indehiscent, like the fruits of black walnut. This means the seed will remain inside the fruit until it is mechanically opened or the husk decays. The seeds are fully mature once the husk becomes soft and yields when pressed with a finger. At this stage, and over the next few weeks as further ripening occurs, the peduncle (the stem connecting the cluster of fruits to the branch) begins to senesce, and the fruits fall to the ground. We discard the earliest seeds that fall, because they are typically infested with insect larvae or they may have shriveled kernels. Butternuts, like walnuts, should be harvested once 50% of the fruits are ripe—after the first 10% of the fruits have fallen. The predation of seeds by squirrels begins as butternuts mature, and one must be diligent to out-compete squirrels. If possible, gather butternuts before they fall to the ground; shake or knock them down with a long pole, by tossing a throw bag with a line attached over limbs, or, when trees are readily accessible and the number of trees warrants such an expense, by using a tractor mounted tree shaker. A tree climber equipped with a pole can effectively knock nuts to the ground if trees are large or too remote to be routinely checked for fallen nuts.

Storing and Planting Seeds

Procedures for postharvest seed handling, storage, and planting are much like those for black walnut (Rink 1988), but some important points will be highlighted here. Once seeds are collected, protect them from direct sunlight and keep them as cool as possible. There is no need to remove the green husk, but the husks should be given enough ventilation to prevent molding. Butternut husk tissue is rich in nitrogen, and if many fruits are piled up, the husk tissue will compost and produce heat that could reduce the viability of the seed. Composting can be avoided by holding the bulked fruits in a refrigerator or by separating them into smaller batches. There are many ways to remove butternut husks; if the husk tissue has naturally deteriorated, the remaining husk can be removed with a garden hose and/or high-pressure wash. If the husks are still firm, a walnut husking machine can be used. A simple method to husk seeds is to place them on a concrete or firm gravel surface and run over them with the front wheels of a light or midsized tractor or other vehicle. The remaining broken husk tissue can be rinsed off with pressurized water. Within 3 days of husking, prepare them for stratification by immersing them for 3–12 hours, preferably in gently flowing water. Seeds that float are usually not viable. Butternut seeds require 120 days of moist chilling (stratification) between 32 and 40° F before they will germinate. Stratify the viable seeds by arranging them in single layers in a box or a plastic bag. Cover each layer with a moist medium such as peat moss, sphagnum, or sand to a depth that fully covers the seed. For refrigerated storage, the medium should not be wet but only damp so that water can not be squeezed out by hand. If you have chosen to keep the husks on your seed, the stratification medium should be drier than it would need to be for husked seed. Once a box or bag is filled, keep the package covered with plastic to retain moisture, but make a few small holes in the plastic to allow air to pass through, because stratifying seeds require oxygen for respiration. Butternuts can be stratified outdoors using a technique known as "pit storage," which was devised for black walnut (Rink 1988). For pit storage, choose a site with good drainage to ensure the seed will not be flooded. The easiest way to plant butternut is to direct-seed them in the fall. The main problem with pit storage and direct seeding is predation by squirrels.

Butternut seedlings are available from nurseries most years, although catalog listings are limited because of small inventories, and cost may fluctuate considerably. It is hard to be certain of the identity of purchased butternut seeds and seedlings because nurseries and seed brokers often do not know the sources of their butternut seed. In fact, hybrid trees attract seed collectors because hybrids look like butternuts, often grow close to roads, are highly vigorous, high yielding, and have greater resistance to canker (Orchard et al. 1982). So, if you are concerned whether you receive pure butternuts versus hybrids, ask the vendor if the sources of the seed are known to be butternuts. Planted butternuts will grow best on well-drained, rich, loamy soils found on stream terraces or sites with similar soil characteristics, but it may also grow well on rocky, drier soils and slopes (Goodrich 1838, Johnston 1851, Rink 1990, Cogliastro et al. 1997). Once established, butternut's growth is comparable with black walnut on abandoned farmland; butternut survival on stony, littoral sites was comparable with bur oak, and butternut's survival was comparable with red oak on dry-mesic moraines, mesic moraines, and morainic ridges (Cogliastro et al. 1997).

Butternut Recovery and Restoration

Despite the widespread and severe decline in butternut populations, some butternut trees remain healthy or nearly disease free. An

Figure 4. Light and dark-barked butternut (far left and right, respectively) growing in the woods near the Oconto River Seed Orchard in northern Wisconsin. (Photo credit: Douglass Jacobs)

illustrated guide for disease assessment and for identifying potentially resistant trees is now available (Forest Gene Conservation Association 2008). Dozens of candidate resistant trees have been identified, usually as long-term survivors in stands affected by canker. Often, these trees have evidence of callused or "healed" cankers that are usually visible as raised areas where the stem appears to bulge (Forest Gene Conservation Association 2008). A large number of candidate resistant trees have an unusual, darkly colored bark that is similar in appearance to the bark of black walnut; few of the candidate resistant trees have the silvery or light-colored bark often associated with butternut (Figure 4; Ross-Davis et al. 2008b). Collections of these candidate trees (usually by graft propagation) represent a promising start toward the breeding of canker-resistant butternuts, but each tree will have to be evaluated using inoculation trials (Ostry and Moore 2007) to quantify its level of disease resistance, and whether the candidate trees are butternuts or hybrids will have to be determined (Ross-Davis et al. 2008b). Ultimately, the most resistant trees are expected to become part of a seed orchard that would provide planting stock of regionally adapted, genetically diverse, disease-resistant butternuts. Research is also underway to identify the best sites for restoration plantings (Thompson et al. 2006).

Prospects for Butternut

Butternut, like American chestnut, American elm, American beech, and ash species, is being killed by an exotic organism. The prospects for butternut, however, may not be as dire as those for some of these other species, and there are good reasons for optimism. The genetic diversity of butternut probably remains high in places where it is growing, and wild populations continue to regenerate in some locations. Sustainable management of butternut in these locations is a critical and necessary component of forest genetic resource conservation (Rajora and Mosseler 2001). Evidence suggests that occasional butternut trees may have resistance to the disease, and many of these have been propagated. Disease resistance screening methods to evaluate these candidate trees have been developed and are being refined. Some planted butternuts have remained canker free long enough to flower and produce seeds, indicating that it should be possible to grow butternut on some sites even in the presence of the disease. Several butternut seed orchards have been established, and they can be expected to produce thousands of seeds in the near future. Expansion of these orchards by grafting and further testing of the parent trees and progeny from these orchards for disease resistance should permit the production and distribution of improved butternut seeds to nurseries within the next 20 years. Silvicultural systems for restoring butternut in the southern part of its range are already being tested by researchers at the University of Tennessee. The impact of climate and land-use change, the nature and extent of hybridization with Japanese walnut, and quantifying the types and levels of disease resistance in butternut remain research challenges, but we believe that over the long term, butternut can be maintained and restored to many eastern landscapes.

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