PURDUE EXTENSION

FNR-421-W

Purdue University

Forestry and Natural Resources

Conservation and Management of Butternut Trees

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Introduction

Butternut (*Juglans cinerea*), also known as white walnut, is a native hardwood related to black walnut (*Juglans nigra*) and other members of the walnut family. Butternut is a medium-sized tree with alternate, pinnately compound leaves, that bears large, sharply ridged, cylindrical nuts inside sticky green hulls that earned it the nickname lemon-nut (Rink, 1990). The nuts, a preferred food of squirrels and other wildlife, were collected and eaten by Native Americans (Waugh, 1916; Hamel and Chiltoskey, 1975) and early settlers, who also valued butternut for its workable, medium brown-colored heartwood (Kellogg, 1919), and as a source of medicine (Johnson, 1884; Lawrence, 1998), dyes (Hamel and Chiltoskey, 1975), and sap sugar.

Butternut's native range extends over the entire northeastern quarter of the United States, including many states immediately west of the Mississippi River. Butternut is more cold-tolerant than black walnut, and it grows as far north as the Upper Peninsula of Michigan, New Brunswick, southern Quebec, and Ontario (Fig.1).

The butternut is now threatened everywhere by a canker disease, and in many places it is rare. The butternut is short-lived compared to many associated tree species, with a normal life span of less than 100 years. If no disturbance such as fire, wind damage, or timber harvesting occurs to create open regeneration areas near aging butternuts, they may disappear from forest stands even if they do not contract the canker disease. Conservation of native butternut populations may be enhanced with management activities designed to maintain existing trees in the best health possible, and provide opportunities for natural regeneration and planting of new butternut trees (Woeste et al., 2009).

Butternut Canker Disease

Butternut trees of all ages are killed by butternut canker disease, caused by *Sirococcus clavigignenti-juglandacearum* (*Sc-j*), a fungus found throughout butternut's range. Although butternut is affected by other pests and diseases, *Sc-j* is the most serious threat to butternut's survival (Furnier et al., 1999). Surveys from the early 1990s indicate that butternut canker disease had contributed to as much as an 80% decrease in living butternuts in some states (Cummings-Carlson and Guthmiller, 1993), and recent inventories reinforce this bleak trend. 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 longer than 40 years.

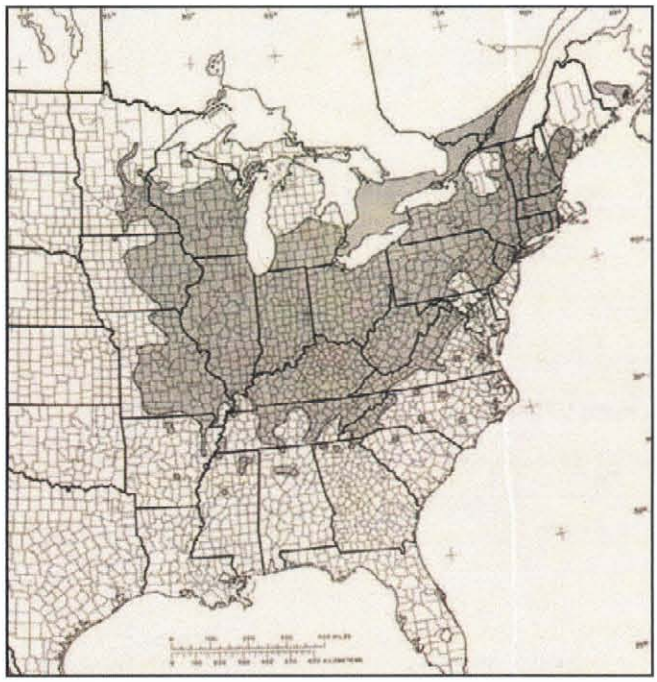

Figure 1. *Native range of butternut (*Juglans cinerea L.*).*

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

Figure 2. *Symptoms of butternut canker disease on a young branch (A) and main stem (B). Note presence of callus covering older wound.*

Photos: USDA Forest Service

(Nicholls et al., 1978; Fig. 2). Older, perennial branch and stem cankers are often found in bark fissures (Fig. 3, 4) 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 the tree, and on exposed roots (Tisserat and Kuntz, 1983). As butternut canker disease progresses, cankers coalesce, eventually girdling and killing the host tree. Butternut canker often kills butternuts quickly, but on occasion affected trees live as long as 30 years (Ostry et al., 1994). Epicormic branching or root sprouts may be evident in trees with cankers, but these shoots typically succumb quickly.

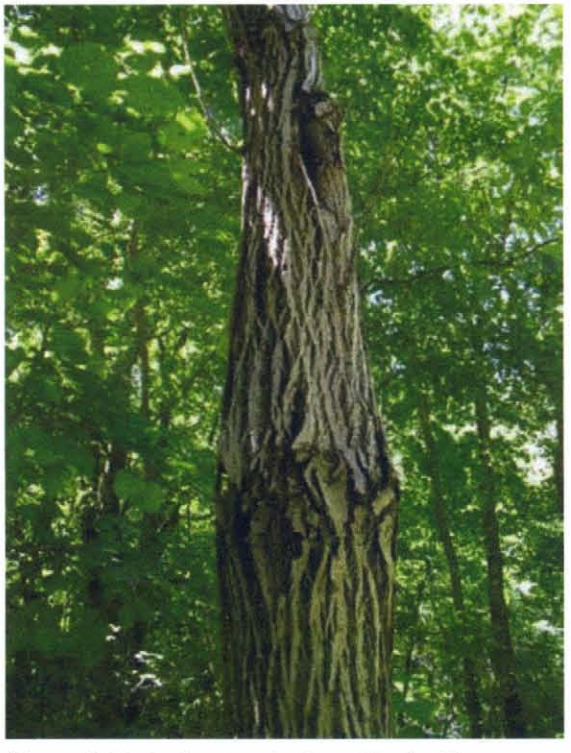

Figure 3. *Typical mature butternut bark with some canker damage.*

Photo: Lenny Farlee, HTIRC, Purdue University

Figure 4. *Butternut canker disease damage creating bark cracks and death of bark and branches at branch crotches.*

Photo: Lenny Farlee, HTIRC, Purdue University

Management Implications of Butternut Canker Disease

Aside from basic practices that promote tree health, little can be done to control the spread 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 infection, but there is currently no practical method for preventing butternut canker infection of forest trees (Schultz, 2003), and the disease is ultimately fatal. Rain-splash is the primary vector of fungal spore dispersal (Tisserat and Kuntz, 1983), but long-distance movement by insects and birds is strongly suspected (Nichols, 1979). Even apparently isolated butternuts may be exposed to *Sc-j,* because species commonly associated with butternuts in natural stands, including hickory, cherry, and oak species, may serve as reservoirs of the canker fungus (Ostry and Moore, 2007). Black walnut and other *Juglans* species can also be infected, resulting in limb dieback in rare cases, but so far only butternut has been seriously impacted by the fungus. Due to their increasing rarity, all butternut trees encountered should be evaluated for retention. A tree retention guide developed by Ostry, Mielke, and Skilling (1994) provides guidance for decision making in the field:

- Retain 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.
- Retain 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 period of management activity. Erring on the side of retention is recommended to maintain as many butternuts as long as possible.
- Harvesting healthy trees or trees producing seed reduces the chances of having butternut regeneration and eliminates trees that may have increased resistance to the disease. Retain these trees and consider thinning out neighboring trees competing directly with the crown of the butternut, particularly if the crown is becoming overtopped or "pinched" by neighboring trees.
- Trees killed by the canker disease or not meeting the retention guidelines may be salvaged to recover any useable wood and possibly decrease the quantity of the canker fungus inoculum. Trees that die may be left as wildlife habitat or removed, depending on the landowner objectives.

Butternut's wood qualities make it favorable for fine furniture, carving, turnings, and similar decorative uses. When it was more abundant, the wood was mainly used for interior finishing, including furniture and paneling, for boxes and crates, mill work, musical instruments, and boats (Kellogg, 1919). Butternut veneer was highly valued (Peterson, 1990), and although butternut is capable of achieving a height of 100 feet with a diameter approaching 3 feet, only much smaller trees are commonly found today. Because of its scarcity, butternut wood is now considered a specialty item, sought for its soft, easily worked nature; patterned grain; light cinnamon color; and satin-like polishing capability (Cassens, 2006).

As the available volume of butternut wood decreases, markets may be limited to custom, specialty, and novelty uses instead of larger, commercial production. Even small amounts of butternut wood could have value if marketed to woodcarvers and turners, custom furniture manufacturers, or as specialty lumber or veneer. Stained or "spalted" wood from damaged or recently dead trees is sought by carvers and turners for its aesthetic qualities.

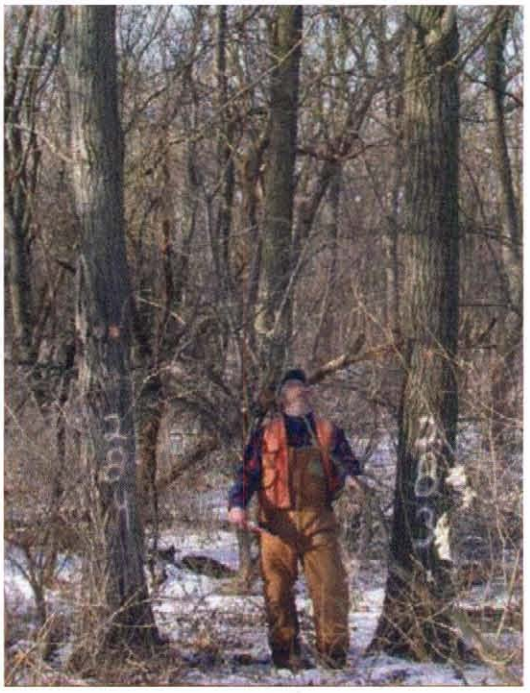

Figure 5. *Typical bark for butternut on the left and dark-barked butternut on the right. Some dark-barked trees have demonstrated greater apparent resistance to canker disease.*

Photo: James McKenna, HTIRC, Purdue University

Management Implications of Butternut Hybrids

Some apparent butternuts are actually hybrids. Butternuts freely hybridize with at least two exotic species, Persian or English walnut (*Juglans regia*), to form *Juglans* × *quadrangulata*, and Japanese walnut (*Juglans ailantifolia*), to form *Juglans* × *bixbyi*, commonly called buarts) (USDA, ARS National Genetic Resources Program). Japanese hybrids are far more common than Persian hybrids in most of the United States, and in some places, these hybrids or their offspring are virtually the only "butternuts" to be found. Information on field identification of hybrids and butternuts is available in the publication *Identification of Butternuts and Butternut Hybrids,* FNR-420-W.

Although nuts from hybrids can be a valuable food source for both humans and wildlife, hybrid trees present some issues to consider in butternut conservation. For example, landowners who choose to favor native species may not prefer to plant hybrids because it is unknown if hybrids can fully replace the ecological services provided by butternuts. The suitability of hybrid trees as a source of timber is unknown. Hybrid trees have wood that is similar in appearance to butternut wood, but additional information on wood characteristics is not available at this time.

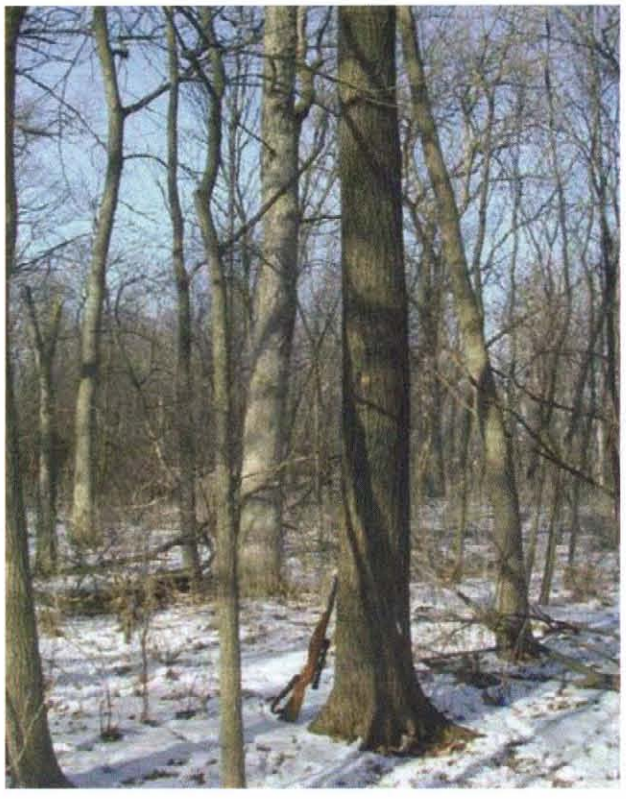

Figure 6. *Dark-barked butternut demonstrating apparent resistance to the canker disease. The rifle pictured is used to shoot small stems out of the crown. This scion wood will be used to create grafted seed orchard and test plantings, continuing the search for butternut canker resistance in native butternut populations.*

Photo: James McKenna, HTIRC, Purdue University

If hybrids are permitted to invade forests or are widely propagated in the range of butternuts, they could "pollute" the gene pool of native butternuts by continued hybridizing, reducing the ability of butternuts to reproduce as an identifiable species (Mooney and Cleland, 2001). A recent study has verified the natural hybridization occurring between Japanese walnut and butternut trees and has found first- and second-generation hybrids, as well as more complex backcrosses in the native range of American butternuts (Hoban et al., 2009).

Hybrids are frequently planted because they are typically more resistant than butternuts to canker, and they are often highly vigorous trees that produce large numbers of nuts. Hybrids are also commonly misidentified or incorrectly advertised as butternuts by seed and tree seedling vendors, resulting in an unintentional proliferation of hybrids in place of butternuts.

Hybrids may also provide opportunities to conserve butternuts. If the effort to select and propagate canker-resistant butternuts fails, hybrids may offer a source of disease resistance or tolerance, and may be the only viable means to retain butternuts in the landscape. An example of using hybridization with an exotic tree species to salvage a native species is the effort to produce an American chestnut (*Castanea dentata*) that has resistance to chestnut blight. The American chestnut breeding program makes use of blight resistance from Chinese chestnut (*Castanea mollissima*). By repeatedly crossing resistant hybrid trees back to American chestnuts, the resulting hybrids are bred to be nearly identical to the American species. This method of hybrid breeding was pursued as it became clear that no pure American chestnuts had high levels of resistance to chestnut blight. Screening of butternuts and hybrids has begun with the goal of identifying disease-resistant trees, but it is too early to know if trees with high canker resistance will be found among the native butternuts. Care should be taken to conserve native butternut populations where they still exist and encourage conservation of the species until more is known about the place native butternuts or hybrids will play in disease resistance and management of the species.

Legal and Population Status

The 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 the butternut as an endangered species as of November 2003. NatureServe, a non-profit organization of natural heritage programs, provides a global conservation status listing for butternuts of G4, meaning the species is considered apparently secure from extinction. They note the species is in rapid decline, and its conservation status should be reevaluated frequently. State and province conservation status listings are provided in Table 1. Some federal and state land-holding agencies have established management policies aimed at retaining butternut on their properties. This includes several national forests in the range of butternut.

USDA Forest Service Forest Inventory and Analysis data revealed the number of butternuts across seven Midwestern states decreased across all size classes by 23% from the previous survey period (USDA 2008). A survey of butternuts in Wisconsin in 1992 found 92% and 27% of butternut trees were diseased and dead, respectively (Carlson and Guthmiller 1993). Regeneration of butternuts has been particularly poor. Because the butternut is a short-lived species that requires full sunlight to

Table 1. *State and Province Conservation Status of Butternut (NatureServe 2009).*

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

Key: S1: Critically Imperiled, S2: Imperiled, S3: Vulnerable, S4: Apparently Secure, SNR/SU: Not Ranked/Under Review.

regenerate, even uninfected butternut populations in fully stocked forests may be at risk if no disturbance occurs to allow for new regeneration before the current trees die. Recent USDA Forest Service Forest Inventory and Analysis data report that 39% of live butternuts are in overstocked or fully stocked forests with poor prospects of supporting regeneration. The decline of the butternut and its listing as a species of special concern may have implications for properties in forest management certification systems, like Tree Farm group certification, Forest Stewardship Council, and Sustainable Forestry Initiative enrolled lands. 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 by the United States, its declining numbers and the increased incidence of canker infection indicate a possibility of future listing as a state or federally endangered species, and the need for management to sustain local populations. This issue should be considered when making decisions on the management of stands containing butternut within the context of certification systems.

Butternut Regeneration

Whenever possible, healthy butternuts or butternuts still producing seed should be retained in stands to provide seed for natural regeneration, planting, and future research (Schultz, 2003). Butternuts are shade-intolerant, so must be in the main canopy to survive and grow, and they need full sunlight to regenerate. Unfortunately, natural reproduction of butternuts is often poor because of a shortage of suitable sites for regeneration (Schultz, 2003; Thompson et al, 2006). Butternut trees are often diseased or over-mature and bear seeds irregularly, and animals often consume the few seeds that are available. Natural regeneration of butternuts takes place in forest openings, abandoned pastures or crop fields, and other disturbed areas that are near seed sources and of adequate size (generally an opening diameter of two to three times local tree height) to provide full sunlight to seedlings. Some soil disturbance may also be beneficial to butternut seedling establishment. Butternut leaves are reportedly preferred by white tailed deer (Van Dersal, 1938), and deer may also use butternuts for antler rubbing, so protection from deer may enhance regeneration success.

Butternuts grow in widely scattered clusters on rich, loamy soils and on stream terraces; they can also compete on rocky, drier soils, and slopes (Goodrich, 1838; Johnston, 1851; Rink, 1990). Historical records indicate that butternuts were once much more common than they are today (Johnson, 1884; Larsen, 1942) and that they may be able to occupy more habitats than those on which they are currently found. Butternuts grow best on deep, well-drained soils associated with stream benches, floodplains, or moist lower slopes and coves. Natural regeneration and planted trees should be examined carefully for signs of infection, because the seeds of butternuts can be infected with the canker fungus, leading to infection of the seedlings (Orchard, 1984).

Butternuts can compete with many commonly planted hardwoods on abandoned farmland or planting areas (Cogliastro et al., 1997). However, in plantings where butternuts are not among the fastest growing trees, thinning or crop tree release will be needed to maintain butternuts' survival and vigor as the stand develops. Burning is not recommended as a management tool for butternuts, because they typically do not sprout following a top-killing fire (Clark, 1965). Butternuts, like black walnuts, produce a compound called juglone, which is selectively toxic (allelopathic) to some plant species, including several conifers and tomatoes.

If butternut trees are being grown for reforestation and timber production, there are several important issues to consider in management:

- Currently no butternut is proven to be canker resistant, so the risk of tree mortality remains high. Some selections have demonstrated promising characteristics, but more testing is required to confirm disease resistance

or tolerance in these trees and their offspring. Hybrids have also demonstrated varying degrees of canker resistance, and several hybrid families are being evaluated for disease resistance and growth characteristics.

- Select planting sites with good fertility and moisture availability for best tree health and productivity. Sites suitable for black walnut should also be good butternut sites.
- Butternuts tend to have a broadly branching form when open-grown, so close spacing between trees and/or the use of competitive nurse trees such as white pine are recommended to force development of a straight, single stem for high-quality wood products. Side-shading can encourage single-stem development, but butternuts must have access to overhead sunlight to maintain growth and vigor. Pruning can also be used to maintain a single stem, but pruning may increase the risk of canker infection. Coppicing (cutting the main stem to encourage re-sprouting) may also result in improved stem form on the resulting sprouts, but, similar to pruning, may increase risk of canker infection.
- Butternuts should be part of a diverse mixture of tree species appropriate for the site being planted and the objectives of the landowner. Planting butternuts may become increasingly important to maintain representative populations on the landscape as existing trees die in locations where natural regeneration will not occur.
- Placing group selection or clear-cut harvests near butternut trees producing seed may provide opportunities for some natural regeneration in these open areas. Field experiments which left butternuts in openings as seed trees resulted in rapid death of the seed trees after the harvest (Ostry, 2009), so arrange openings to have seed-bearing butternuts near, but not in, the opening.
- Direct seeding butternuts into openings using collected seed, or depending on wildlife to move seed to openings may be desirable to conserve existing trees while providing for regeneration.

Butternut seedlings may be obtained in most years from public and private forest tree nurseries. Contact your state forestry seedling nursery to inquire if they have butternut trees. They may grow small lots from year to year but not formally list butternuts in their catalogs. In addition, a number of private nurseries offer butternut seedlings, and there are commercial seed companies that will sell seeds directly to landowners. The availability and cost of seedlings may fluctuate widely. Because hybrids look like butternuts, often grow close to roads, are highly vigorous, produce abundant nut crops, and have greater resistance to canker (Orchard et al., 1982), it is much easier to gather hybrid seeds than butternuts. Consequently, hybrid trees attract seed collectors. Sometimes nurseries buy "butternut" seeds from brokers or collectors who do not distinguish true butternut seed sources from hybrids. Some nurseries will inform their customers that the seedlings they sell are interspecies hybrids. In many cases, the nursery cannot confirm the seed source as a true butternut or hybrid, so unless the identity of the seed trees are known, or you do the collection yourself, it is difficult to know if you have butternut or hybrid seedlings. *Identification of Butternuts and Butternut Hybrids,* FNR-420-W, provides an outline and photos of tree and nut characteristics that may help you separate pure butternuts from hybrid trees.

Choosing Seed Trees, Obtaining and Handling Seeds

The best sources of seed are clusters of forest-grown butternuts. Trees growing away from edges, towns, homes or old farm sites are most likely to be butternuts and not hybrids, and they are most likely to be pollinated by other butternuts. Researchers at the Hardwood Tree Improvement and Regeneration Center have determined that butternut populations that have been affected by canker can still contain a considerable amount of genetic diversity. Gather seeds from as many mother trees as possible rather than focusing on obtaining a large number of seeds from a single tree.

Butternut seeds become mature toward the end of summer and may be harvested from the middle of September through October. Butternut fruits (the sticky, green hull with the single butternut seed inside) are indehiscent, like the fruits of black walnut. This means the butternut seed will remain inside the fruit until it is mechanically opened or the hull decays. The seeds (butternuts) are fully mature once the hull 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 green fruits (each with a single seed inside) fall to the ground. The earliest seeds that fall should be discarded, as they are typically infested with worms, or have shriveled kernels.

Butternuts, like walnuts, are harvested once 50% of the fruits are ripe (yield to finger pressure)—about the time the first 10% of the fruits have fallen. Predation of seeds by squirrels begins as butternuts mature, and one must be diligent to out-compete squirrels. Do not wait until the fruits fall to the ground to gather the seeds; shake or

knock down butternut fruits by using a long pole or by tossing a throw bag with a line attached over limbs. If trees are large and too isolated and remote to be routinely checked for fallen nuts, a tree climber equipped with a pole can knock nuts to the ground effectively. Work carefully to limit injury to the trees, which may encourage canker infection, and be aware that trees may have limbs weakened by disease that may suddenly break.

Storing and Planting Seeds

Once seeds are collected, they should be removed from direct sunlight and kept as cool as possible. There is no need to remove the green hull from the seed, but the hulls should be given enough ventilation to prevent molding or composting the seed. Problems can be avoided by holding bulked fruit in a refrigerator or by separating fruits into smaller batches. Air dry butternut fruits (with the seed inside) for a couple of weeks before fall planting, or if spring planting is preferred, air dry the fruits and place them in a cooler for later stratification. If a large quantity of seed will be collected for spring sowing, and if refrigerated space is limited, butternut hulls may be removed to decrease the volume to be stored.

There are many ways to remove butternut hulls. If the hull tissue has naturally deteriorated, the remaining hull can be removed with a garden hose and/or high-pressure wash. If the hulls are still firm, a walnut hulling machine can be used. A simple method to hull seeds is to place them on a concrete or firm gravel surface and run over them with the front wheels of a light or mid-sized tractor or other vehicle. The remaining broken hull tissue can be rinsed off with pressurized water.

Butternut and walnut seeds require 120 days of moist chilling (stratification) between 32 and 40 degrees F before they will germinate. To begin stratifying butternuts, soak the seeds in water for 3–12 hours and then let them air dry for a few hours. Arrange the seeds in single layers in a box or a plastic bag and cover each layer with a moist medium such as peat moss, sphagnum, or sand to a depth that fully covers the seed. For refrigerator storage, the medium should be only so damp that water cannot be squeezed out by hand. Once a box or bag is filled, keep the package covered with plastic to retain the moisture, but poke a few small holes through the plastic to allow air to pass through, since stratifying seeds require oxygen for respiration.

Stratification can be accomplished outdoors utilizing a technique known as "pit storage." For pit storage, choose a site with good drainage to ensure the seed will not be flooded. Dig a pit and line the bottom with coarse sand. Place on the sand a single layer of butternuts covered with a layer of sand or chopped straw; continue layering seed and stratification medium until the hole is filled, or, if necessary, fill the remainder of the pit with chopped straw and cover with hardware cloth to keep rodents out. Rain and snow melt will keep the seeds moist until they can be dug for planting when the ground thaws in the spring.

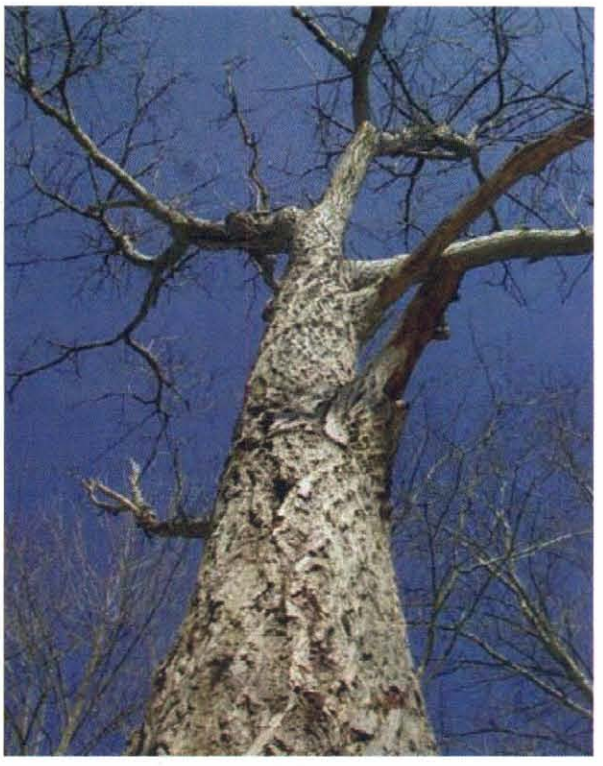

Figure 7. *Typical crown and stem form of a forest-grown butternut. Note lower branches killed by shading. Open-grown trees tend to have trunks that fork much closer to the ground and wide, spreading crowns.*

Photo: James McKenna, HTIRC, Purdue University

The easiest way to plant butternuts is to direct-seed in the fall. The main problem with this simple method is predation by squirrels. If squirrels are likely to be a problem, seek advice from a wildlife specialist for appropriate control techniques. Butternut seed should be planted between one and two inches deep with a layer of straw or sawdust mulch up to one inch thick placed over the planting bed. Remove mulch in the spring if it has compacted or crusted to the point that seedling emergence could be hindered (Bonner and Karrfalt, 2008).

Butternut Recovery and Restoration

Research teams in the Northern Research Station of the USDA Forest Service have focused on the pathology of butternut canker disease, the conservation genetics of butternuts, the identification of butternut habitat, and the propagation of butternut seed orchards to supply seeds

Figure 8. *Fungal inoculation and subsequent canker development on butternuts. Inoculated trees will be monitored to determine the ability of selected trees to resist infection and spread of the canker fungus.*
Photo: Lenny Farlee, HTIRC, Purdue University

for National Forests. Outreach to landowners in 2008 was designed to sample and conserve the remaining genetic diversity of butternuts. As a result, seeds and scion wood from about 200 distinct sources from across the species' range were added to a permanent collection.

Over the past 25 years or so, dozens of candidate resistant trees have been identified, usually as long-term survivors. These are trees that continue to survive in areas strongly affected by canker. Often these trees have evidence of callused or "healed" cankers, and some have an unusual darkly colored bark much like that of black walnut (Fig. 5, 6). Collections of these candidate trees (often by graft propagation) represent a promising start toward the breeding of canker-resistant butternuts, but a number of important hurdles remain. Molecular methods for determining if the candidate trees are butternuts or interspecies hybrids are currently under development (Ross-Davis et al., 2008), and many of the candidate trees will need to be tested if they are to be used in a breeding strategy that aims to return pure butternuts to the landscape.

A method to inoculate trees to test their resistance to the fungus that causes butternut canker has been developed (Ostry and Moore, 2008) (Fig. 8), and techniques for mass-propagating resistant individuals have also been developed (Pijut and Moore, 2002). A region-wide butternut health survey is underway in the Northeastern United States, including a program to train other scientists to assess butternut's status. In Canada, where the butternut is officially listed as endangered, a national recovery strategy for butternut is under development. Some parts of that strategy are already taking shape. The Canadian Forest Service is funding research into methods for long-term, cryogenic storage of butternut embryos and buds with the goal of maintaining the genetic diversity of the species until mechanisms for controlling the spread of the disease can be found. Groups in Ontario and New Brunswick have focused on assessment of the current threat and the development of strategic plans for butternut recovery, education, and fundraising; developing diseased tree assessment guidelines; developing butternut management practices to promote natural regeneration; and locating vigorous surviving butternut trees for seed collection.

This publication is an adaptation and expansion of an article that appeared in the *Northern Journal of Applied Forestry*: Woeste, K., L. Farlee, M. Ostry, J. McKenna, S. Weeks. 2009. A Forest Manager's Guide to Butternut. *Northern Journal of Applied Forestry*. 26(1): 9-14.

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Additional Resources

Detailed information on the life-history, range, identification and a variety of other characteristics of butternuts is readily available in printed and digital format.

Several research and management documents for butternuts are accessible from the USDA Forest Service Northern Research Station: http://nrs.fs.fed.us/

The USDA Forest Service Conservation Assessment for butternut is available at www.fs.fed.us/r9/wildlife/tes/ca-overview/docs/plant_Juglans_cinera-Butternut.pdf.

The Fire Effects Information System (FEIS) provides an index of information for butternut at www.fs.fed.us/database/feis/plants/tree/jugcin/all.html.

The USDA NRCS PLANTS Database also provides a butternut plant profile at http://plants.usda.gov/.

The biological characteristics (silvics) of butternut can be found at www.na.fs.fed.us/spfo/pubs/silvics_manual/Volume_2/juglans/cinerea.htm.

Identification of Butternut and Butternut Hybrids, FNR-420-W, provides field identification information.

In addition to these information sources, many states within the range of butternut will have information available through forestry, conservation, and botanical survey organizations.

Acknowledgements

The authors wish to thank Janet Eger and Dan Shaver for their very helpful expert review of this document.

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