# THE NEED FOR SILVICULTURAL PRACTICES AND COLLECTION OF BUTTERNUT GERMPLASM FOR SPECIES CONSERVATION

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ABSTRACT.—Butternut is a short-lived tree and is declining in numbers for a variety of reasons ranging from changing land use to aging forest stands, seed predation and lack of suitable conditions for reproduction. However, the major reason for the dramatic decrease in butternut populations throughout its range in North America is the lethal canker disease caused by the fungus *Sirococcus clavigignenti-juglandacearum* that is believed to be an exotic pathogen. The fungus has killed up to 80 percent of the trees in some states and is threatening butternut's survival as a viable species in North America.

There is a critical need for additional collections of butternut (*Juglans cinerea* L.) from throughout its range in the eastern United States and the development of silvicultural practices targeted at butternut regeneration. Butternut is being killed throughout its range in North America by the fungus *Sirococcus clavigignenti-juglandacearum*. Diseased trees are eventually overwhelmed by multiple branch and stem cankers. First observed in 1967 in southwestern Wisconsin, the disease is now affecting over 90 percent of the living trees and has killed up to 80 percent of the trees in some states and is threatening butternut's survival as a viable species (Ostry 1998). Eastern black walnut (*J. nigra* L.) and heartnut (*J. ailantifolia* var. *cordiformis* Carr.) are other natural hosts but not severely damaged (Ostry and Pijut 2000). The potential host range among *Juglans* species is cause for concern outside of North America as well (Nair 1999).

The fungus was described as a new species in 1979 and evidence thus far strongly suggests that this pathogen is an exotic from an unknown origin outside of North America (Furnier and others 1999). The fungus can become airborne and dispersed long distances during rain (Tisserat and Kuntz 1983) and can be seedborne on butternut and eastern black walnut (Innes 1998). Insects (Bergdahl and Halik 1998, Katovich and Ostry 1998) and perhaps birds are also probably involved in the long distance spread of the fungus explaining how the pathogen has been able to move rather quickly throughout the widely scattered populations of butternut in the United States and Canada.

Butternut is a small- to medium-size tree seldom exceeding 75 years of age and is shade intolerant. It commonly grows on rich loamy soils as well as on drier rocky soils of limestone origin (Rink 1990). While not occurring in pure stands, butternut can be locally abundant in mixed hardwood forests and often grows as a riparian species. Butternut has never been a major commercially important species, however, it is valued for its wood for furniture, paneling, specialty products, and carving, its flavorful nuts, wildlife mast, and for its contribution to forest diversity. Its value is increasing as mature trees are becoming increasingly scarce and the disease, if present, is killing regeneration.

## KEY DATES IN THE BUTTERNUT CANKER HISTORY

To our knowledge, there are no written records or evidence based on many dissections and aging of cankers on diseased trees in the field that indicates the presence of the disease in the Lake States prior to the early 1960's, however, evidence from trees in the southern portion of its range suggests that the disease has been present in North America earlier than the 1960s. Rapid spread of the pathogen was documented in Wisconsin using permanent plots

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that indicated that from its original presence in western Wisconsin in 1976 the fungus had moved throughout the range of butternut in the state by 1992.

It was not until 1979 that the fungus was proved to be a new species never before recorded on any host species (Nair and others 1979) and efforts to determine its origin have not been successful. In Canada, the disease was first reported from Quebec in 1990, Ontario in 1992, and from New Brunswick in 1998. In 1992 Minnesota enacted a moratorium on the harvest of healthy butternut on state lands. This was followed by harvest restrictions on healthy butternut on federal lands by the USDA Forest Service in 1993. Butternut is a Regional Forester Sensitive Species in the Eastern Region on 13 of the 16 National Forests and is listed as a sensitive species or a species of concern in most states in which butternut is a common component of hardwood forests. Management guidelines have been put in place to conserve butternut in several of those states.

## THE NEED FOR CONSERVATION STRATEGIES

Conservation assessments for butternut are being prepared in the United States and Canada. Criteria for determining the need for conservation strategies for species at risk include the following: the species is naturally rare; there is an uncertain viable seed source; its range is decreasing; its habitat is in demand for other uses; poor regeneration after usual forest practices; loss due to hybridization; demand for species for special purposes; and there is a serious threat from disease (Loo 1998). Butternut meets all these criteria.

In order to improve prospects for the recovery of butternut there are several key issues that must be addressed. First, increased cooperation among researchers, landowners, and resource managers is needed to identify and retain selected healthy butternut wherever they occur. Second, we must increase the collection of scionwood from healthy trees that may have disease resistance to preserve genetic diversity within butternut across its range while it is still possible. Third, develop a greater understanding of the specialized habitat and site requirements of butternut so that we can favor natural and artificial regeneration. Fourth, develop practical butternut management prescriptions that can be implemented by landowners and managers.

Both *ex situ* (conservation of planted seedlings or in clonal archives, seed banks, etc.) and *in situ* (conservation within protected areas of natural occurrence) conservation strategies are needed and warranted for butternut (McIlwrick and others 2000). Each strategy has its advantages and disadvantages. Several efforts to conserve butternut are underway in the United States and Canada. Brief summaries of two examples from the north central region representing *in situ* and *ex situ* projects follow.

## CLONAL ARCHIVES

High mortality of butternut in all age classes and lack of adequate regeneration, both resulting from multiple stress agents, aging of the resource, changing land uses, and butternut canker all contribute to the need to conserve individual trees exhibiting superior qualities among populations of butternut outside (*ex situ*) of the natural stands where they are found.

Over the years, very few selected butternut cultivars were described and only a few have survived and are available for propagation on a limited basis. All of these trees were selected for their superior nut qualities but they do not represent the geographical range or diversity of the species and their resistance to butternut canker is unknown.

Since 1992 we have established five butternut clonal archives located in Minnesota, Wisconsin, Illinois, New York, and Vermont consisting of trees selected from 14 states on the basis of their phenotypic resistance to butternut canker in the field. The scionwood, collected from these trees that exhibit disease resistance were grafted onto black walnut rootstock and the grafted trees were established in replicated plantings. These trees will be screened for their level of disease resistance and genetic typing will be used to examine genetic variation among the trees and eventually the patterns of inheritance of disease resistance. In spite of high disease incidence among the surrounding trees, many of the trees we have collected scionwood from have remained disease-free for over 10 years, providing encouraging evidence that disease resistance does exist in butternut populations.

The shortcoming of this effort thus far is that there has been little investigation of the genetics of butternut. Lacking is an adequate study of the genetic structure and diversity of butternut across its range. This information is critical to designing an effective conservation strategy and is needed to guide us in determining what germplasm, how many genotypes, and where in its range we put our collection emphasis. Only a limited amount of resistance screening has been carried out owing to a lack of an efficient screening technique so we do not know the level of resistance or the mechanisms of resistance of the phenotypes collected thus far.

We have detected two different bark phenotypes among the butternut we have studied: a light gray, shallow fissured type most often associated with cankered trees and a dark gray, deeply fissured type often associated with healthy trees. In addition, there are intermediate types. In one 40-acre woodlot of the 544 butternut examined, 92 were disease-free, 67 (73 percent) of them being the dark-deep bark phenotype. Of the 452 diseased or killed butternut, 93 (21 percent) were the dark-deep phenotype and 310 (69 percent) were the light-shallow phenotype. Our research goal is to determine if this bark trait may be valuable in identifying potentially resistant trees and if it may be an identifiable heritable trait that could be used in selection and breeding.

**REGENERATION STUDY**

Conservation of individuals or populations of butternut within its natural habitat (*in situ*) is preferable to removing individual genotypes to collections located distant to their origins, however, this is not always feasible if trees cannot be protected. Throughout its range individual healthy butternut occasionally can be found growing alongside severely diseased trees. Silviculture, intended or not, can affect genetic change in a species. Guidelines to retain trees that may have disease resistance have been proposed (Ostry and others 1994). No specific silvicultural practices have been developed for butternut; however, butternut is closely related to black walnut so many management recommendations are similar for both species.

In 1993, on the Nicolet National Forest in Wisconsin, we established what we believe to be the only large-scale study designed to conserve and regenerate butternut according to the suggested guidelines. Our objectives were to determine the validity of the tree retention guidelines and to develop stand conditions to successfully regenerate butternut naturally and by planting.

A pending 160-acre sale unit in a northern hardwood stand on the Laona Ranger District containing 15 square feet basal area (BA) of butternut presented us with a unique opportunity to apply the guidelines. The 1938 air photos show numerous roads and grades through a moderately stocked hardwood stand, perhaps 20 to 30 years old. It seems that this area was never plowed. The site is habitat type AH (*Acer*/*Hydrophyllum*), a rich mesic type.

In the 1970s to the early 1980s, there were two timber sales in the area. Records are not complete, but these sales typically involved heavy American elm (*Ulmus americana*) and trembling aspen (*Populus tremuloides*) cutting. In 1994 through 1997 the Old Town Road sale resulted in the current administrative study.

In June 1993 marking crews were trained in the identification of butternut canker and in applying the marking guide. The marking guide was designed to increase seed production and to conserve any butternut that may have disease resistance and those trees that were likely to survive the 15 years between stand entries.

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 cankers were retained. In addition, all trees with at least 50 percent live crown and no cankers on the bole or root flares were retained. Dead butternut and trees of poor vigor were marked for harvest. A total of 1,165 butternut in the stand was marked; 43 percent reserved and 57 percent cut. Various pre-harvest habitat and plant data were collected. Several large, healthy butternut were marked for scionwood collection to be included in the clonal archives.

The sale unit was divided into three equally-sized blocks each sub-divided into the following treatments: one 5 acre clearcut; two 1 acre clearcuts; eight 2 acre blocks with two cut to 60 square feet BA, two cut to 30 square feet BA, two clearcuts, and two no-cut controls. Selection cut buffers separated all treatment blocks. One block was to be direct seeded, one to be planted, and one to be a natural regeneration control. The stand was harvested according to the prescription from 1994 to 1997. Direct seeding was done in the fall of 1995. Butternut seedlings, 2-0 stock from the same seed crop as the direct seeding, were planted in tree shelters in 1998. The pattern for both the direct seeding and the planting was to place a row in each of the cardinal directions from the center of the plot. Regeneration surveys were made in 1999 and 2001.

Early observations have revealed that recruitment of new butternut regeneration continued from 1999 to 2001 but approximately 60 percent of the seedlings are infected and the regeneration is not uniform throughout the site. Stocking from direct seeding and planting 2-0 stock both appear unsatisfactory. Hardwood sprouts and heavy shrub growth are outcompeting much of the butternut regeneration.

Mortality of planted seedlings has been high but is not known to be associated with cankers. Not unexpectedly, few of the infected stumps have sprouted and the majority of those sprouts are infected. Canker-related mortality of reserve trees continues but trees in the intermediate cut blocks, in the no-cut controls and in the buffers look to be more vigorous than those in the clearcut blocks. Previously tagged healthy trees, those selected for the clonal archive, remain healthy.

Butternut is widely recognized as shade intolerant. As expected, the more severe cutting treatments produced a more favorable seedling environment, but not with the consistency one would hope for. At this time, the reserve trees that are serving as the seed source seem to be in better health in the moderate thinning treatments, and the seedlings are growing more vigorously in the heavier thinning or clearcut treatments. Therefore, we speculate that there should be two prescriptions for stands where butternut is of concern, one to release the mature trees and promote seed production, and one that would provide optimum conditions for the seedlings in the new stand.

Wisconsin's pre-harvest white-tailed deer herd in the year 2000 was estimated at over 1.7 million. That year's harvest of over 618,000 established an all time record for any state. Even at that, the 2001 herd was estimated at more than 1.6 million. The butternut study area is in a deer management unit that has been fairly stable and consistently closer to goal than many others in the Northern Forest. However, deer have impacted the butternut regeneration in two ways, by browsing and antler rubbing. Unless it is suppressed by shade or affected by cankers or repeated browsing, butternut will quickly grow out of the browse zone. Annual height growth over 3 feet is common. While the frequency of browsed seedlings can be high, the majority of them are not seriously damaged.

Deer browse may be a net asset by controlling the competing trees and brush. Deer tend to use salient saplings to rub the velvet off their antlers as they harden. This behavior also has some role in mating and territorial dominance. Butternut tends to occupy open areas in stands where deer activity is high and may account for the high incidence of damage observed, however, based on observations deer may preferentially select butternut seedlings for unknown reasons. This damage may be as significant as that caused by browsing.

The most frequently observed seed dispersing animals are red squirrels and chipmunks. Grey squirrels are present, but not in the numbers that they might be found in nearby oak (*Quercus* L.) dominated stands.

Bitternut hickory (*Carya cordiformis* (Wangenh.) K. Koch) is an indicator species for the forest type in this study area, and is present within the stand. The stand developing in the clearcut blocks includes a considerable number of seed origin basswood as well as stump sprouts. There is an interesting contrast in the stump sprouts. In the clearcuts, the sprouts are able to grow out of browse height, while in the lighter cuts they are suppressed and heavily browsed with corresponding high levels of sprout mortality. White ash (*Fraxinus americana* L.) and hard maple (*Acer saccharum* Marsh.) will continue as the dominant species, ash being favored in the more open treatments, maple in the more closed canopy. Gone from the clearcut blocks are the elm and yellow birch (*Betula alleghaniensis* Britton).

## FUTURE OUTLOOK

Although butternut is an excellent candidate for the application of gene conservation and restoration techniques, we are lacking the knowledge in many critical areas in the biology of both the host and pathogen to efficiently and successfully employ them at this time. However, there is still justification to immediately begin to build the framework of a restoration program and initiate collections of potentially valuable germplasm in the wake of the rapid decline in the resource.

Butternut canker is another example of a disease that is currently having negative impacts on forest ecosystems, and perhaps other impacts that may not be obvious for years to come. Considering not only butternut canker, but also several other diseases that are affecting our hardwood forests such as oak wilt, oak decline, dogwood anthracnose, Dutch elm disease, and a number of insect pests and environmental stresses, it is obvious that we have to address multiple issues in the management of our hardwood forests.

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