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Steven A. Katovich
USDA Forest Service

Michael E. Ostry
USDA Forest Service

INSECTS ASSOCIATED WITH BUTTERNUT AND BUTTERNUT CANKER IN MINNESOTA AND WISCONSIN

Steven A. Katovich[1] and Michael E. Ostry[2]

ABSTRACT

Butternut, *Juglans cinerea*, is being killed throughout its native range in North America by the fungus *Sirococcus clavigignenti-juglandacearum*. In addition to rain splashed spores, it is thought that the fungus may have spread over long distances to infect widely scattered butternut by insect vectors. During surveys in 1995 and 1996 we found several insect species in close association with diseased butternut trees, and spores of *S. clavigignenti-juglandacearum* were isolated in pure culture from the bodies of some of these insects. Potential insect vectors were species in the coleopteran genera *Eubulus* (Curculionidae), *Laemophlaeus* (Laemophloeidae), and *Glischrochilus* (Nitidulidae). Because several insect species become contaminated with fungal spores, further study is needed to determine if any of these insects might transmit the fungus to healthy trees and thereby infect them.

Butternut, *Juglans cinerea* L. is being killed throughout North America by the fungus *Sirococcus clavigignenti-juglandacearum* Nair, Kostichka, and Kuntz. Trees are killed by multiple branch and trunk cankers that girdle the tree. The origin of this fungus is unknown, but there is growing evidence that it may be an introduced pathogen (Ostry 1997).

Butternut trees tend to grow in small isolated groves or as scattered individuals in mixed hardwood forests. Despite the isolated nature of butternut, butternut canker has become prevalent across the eastern United States and Canada (Innes and Rainville 1996). In North America, the disease was first reported in 1967 on butternut trees in southwestern Wisconsin (Wisconsin Conservation Department 1967). A recent Wisconsin survey revealed that 91 percent of the live butternut in all age classes throughout the state were diseased (Carlson 1993). In 1978 butternut canker had not been reported in Vermont (Anderson and LaMadeleine 1978), but recently was reported in every county in Vermont with 94 percent of trees cankered (Bergdahl et al. 1996).

The conidia of *S. clavigignenti-juglandacearum* are dispersed during periods of rain and can travel at least 45 m from infected trees (Nicholls 1979, Tisserat and Kuntz 1983). Long distance dispersal is not well documented. Insect vectors may be involved in carrying the fungus between widely dispersed trees. There have only been limited studies on insects associated with butternut. We conducted a survey in western Wisconsin and eastern Min-

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[1]USDA Forest Service, Northeastern Area, Forest Health Protection, 1992 Folwell Avenue, St. Paul, MN 55108.

[2]USDA Forest Service, North Central Forest Experiment Station, 1992 Folwell Avenue, St. Paul, MN 55108.

nesota to detect insects associated with butternut trees that may vector the pathogen.

MATERIALS AND METHODS

Four locations, two in Minnesota (M1 and M2) and two in Wisconsin (W1 and W2) (Table 1) were surveyed at 10–14 day intervals between 1 April and 30 September in 1995 and 1996. Two sites, M1 and W1, were selected because logging or windthrow allowed access to recently dead boles and branches of butternut trees. The two other sites, M2 and W2, were selected because of an abundance of open-grown butternut trees that provided easy access for observing and collecting insects within tree crowns. Present on all four sites were standing dead and declining butternut trees resulting from cankers caused by *S. clavigignenti-juglandacearum*.

In addition to the four sites described above, additional insect collections were made at several other sites in both Minnesota and Wisconsin that contained butternut trees. On these sites, bark, wood and foliage were collected and all insects encountered on butternut trees were collected and identified. Their location on the tree and any association with infected portions of trees were recorded.

During each visit, branches and boles of butternut trees in various stages of decline and decay were dissected and any insects encountered were collected for identification. Notes were then taken on any insects found in association with cankers or in direct contact with conidia of *S. clavigignenti-juglandacearum*. Insect collections from foliage, twigs and branches were made during each visit by hand-picking, sweeping the foliage, using pole pruners and by vigorously shaking branches over a white drop cloth.

Table 1. Descriptions of the four major areas surveyed for insects associated with butternut trees and butternut canker in Minnesota and Wisconsin, 1995–1996.

Site #	County	Site description
Minnesota		
M1	Olmsted	Farm woodlot, 50–60 yr old trees. Butternut canker prevalent. Windthrow and single tree harvesting occurred in 1995. Associated trees; *Tilia americana*, *Quercus* sp., and *Fraxinus americana*.
M2	Goodhue	State Forest, 30–40 yr old trees. Butternut canker prevalent. Stand poorly stocked with large crowned butternut trees scattered throughout. Associated trees; *Juglans nigra, Quercus sp.*
Wisconsin		
W1	Menominee	School Forest, 50–60 year old trees. Butternut canker prevalent. Stand thinned in 1995. Stand well stocked with tall mature trees. Associated trees; *Carya cordiformis, Populus tremuloides, Quercus rubra*, and *Tilia americana*.
W2	St. Croix	State Park, 20–50 year old trees. Butternut canker prevalent. Many open grown trees with large crowns accessible from the ground. Associated trees; *Acer saccharinum, Populus tremuloides, Quercus* sp., and *Robinia pseudoacacia*.

At sites M1 and W1, collections of branches and the main stems of butternut trees cut or damaged by wind in the winter of 1994–95 were made every 14 days between 15 April and 1 September, 1995. Approximately 1-m-long sections of fine branches (< 2.5 cm diam.), medium branches (2.5 cm – 7.5 cm diam.) and larger branches or main stem (> 7.5 cm diam.) were collected. This material was placed in screened containers and kept in a greenhouse. Insects emerging from the material were collected and identified. In addition, 30.5 cm wide sticky bands (Tanglefoot®) were maintained on three recently killed (girdled or storm damaged) and three living butternut trees at each site. The sticky bands were placed at a height of 2 m on the trunk.

The relative frequency at which each insect species was collected on butternut trees was defined as common (present at all four sites during both years), occasional (found both years but not at all sites or found only one year but at all sites), or rare (found one year only and not at all sites).

Attempts to isolate *S. clavigignenti-juglandacearum* from selected insects were made by collecting individual insects in gel caps, freezing them, and then placing the insects onto potato dextrose agar and incubating them at 20° C.

RESULTS AND DISCUSSION

Overall, 87 insect species were identified (Table 2), representing 7 orders and 37 families. The most commonly collected order was Coleoptera with 16 families and 58 species. Other orders collected were Thysanoptera, 3 species; Hemiptera, 1 species; Homoptera, 7 species; Diptera, 3 species; Lepidoptera, 9 species; and Hymenoptera, 6 species.

Most species were consistently collected in or near the same location on trees, specifically under or on bark, and on or in twigs, foliage or reproductive structures. On infected trees, *S. clavigignenti-juglandacearum* forms hyphal pegs under the bark of recently killed twigs, branches and the main stem where conidia are produced (Ostry 1997). These pegs break open the bark, exposing the sticky conidia. Presumably, insects that spend time under the bark are more likely to encounter conidia than those that only visit the outer bark surface or those that tunnel in wood where the fungus does not sporulate.

Insects that are found on foliage and live twigs would not normally encounter hyphal pegs. Often, the first cankers on newly infected trees develop on small branches in the upper crown. Therefore, insects that visit both dead or dying branches where hyphal pegs and conidia are formed and also visit the upper-crown portions of trees may be likely vectors of this pathogen.

Insects found associated with bark. Most Coleoptera species were encountered on or under bark of dead or declining trees. A number of species were reared from bark or wood samples. The most abundant and commonly encountered species were *Eubulus parochus* and *Cossonus platalae* (Curculionidae). *Sirococcus clavigignenti-juglandacearum* was previously isolated from both *E. parochus* and *C. platalae* (Halik and Bergdahl, 1996). Adults of *E. parochus* were very abundant on the bark of declining and recently killed trees. Larvae and pupae developed under the bark of recently dead material. Positive isolations were obtained from 2 of 38 *E. parochus* adults (Table 3). The two positive individuals were collected under the bark in association with hyphal pegs. The other 36 specimens were collected on the outer bark surface. *Cossonus platalae* adults were only found in large numbers under bark that sloughed off very easily, indicating that the bark had been dead for

Table 2. Insect species found in association with butternut trees. Relative frequency is listed either as common (C), occasional (O), or rare (R). Common species were present at all four sites during both years; occasional species were found both years but not at all sites or found only one year but at all sites; and rare species were found one year only and not at all sites. Stages collected were adult (A), immature (I), and pupa (P). The notes include the plant part where the insect was most frequently observed or collected.

Order Family	Species	Relative Frequency	Stages Collected	Notes
THYSANOPTERA				
Thripidae	*Catinathrips* sp.	O	A	On foliage
	Taenothrips inconsequens (Uzel)	O	A	On foliage
	Thrips pallicornis Hood	O	A	On foliage
HEMIPTERA				
Tingidae	*Corythuca juglandis* (Fitch)	C	A,I	On foliage
HOMOPTERA				
Cercopidae	*Clastoptera obtusa* (Say)	O	A	On foliage
Cicadellidae	*Xestocephalus piceus* Osb.	O	A	On foliage
Coccidae	*Parthenolecanium corni* (Bouche)	C	A	On twigs
Flatidae	*Metcalfa pruinosa* Say	C	A	On foliage & twigs
Membracidae	*Ceresa bubalis* (Fab.)	R	A	On twigs
	Enchenopa binotata (Say)	R	A	On twigs
	Telamona monticola (Fab.)	R	A	On twigs & small branches
COLEOPTERA				
Anobiidae	*Ptilinus thoracicus* (Rand.)	C	A	Tunneling in wood, no bark
Buprestidae	*Agrilus juglandis* Knull	C	A	Reared from bark of dead & declining trees
	Agrilus masculinus Horn	R	A	Reared from dead branches
	Agrilus obsoletoguttatus Gory	R	A	Reared from bark of dead branches
	Chrysobothris azurea LeConte	R	A	On bark of declining trees
	Dicerca divaricata (Say)	R	A	On bark of declining trees
Carabidae	*Bembidion patruele* Dejean	R	A	Under dead bark
Cerambycidae	*Amniscus macula* (Say)	C	A	Reared from dead branches
	Catagenus rufus (Fab.)	R	A	Reared from dead branches
	Cyrtophorus verrucosus (Oliver)	R	A	On bark of declining trees

	Eupogonius submartys (LeConte)	R	A	Reared from dead branches
	Gaurotes cyanipennis (Say)	C	A	On bark of dead & declining trees
	Graphisurus fasciatus (DeGeer)	R	A	Reared from dead branches
	Hyperplatys aspersa (Say)	C	A	Reared from dead branches
	Hyperplatys maculata Haldeman	C	A	Reared from dead branches
	Leptostylus transversus transversus Gryllenhal	C	A	Reared from dead branches
	Microgoes oculatus (LeConte)	C	A	On bark of dead & declining trees
	Sternidius alpha misellus LeConte	C	A	Reared from dead small diameter branches
	Urgleptes querci (Fitch)	C	A	Reared from dead small diameter branches
Chrysomelidae	*Paria quadriguttata* LeConte	O	A	Under dead bark
Cleridae	*Enoclerus nigripes nigripes* (Say)	O	A	On bark of dead & declining trees
	Zenodosus sanguineus (Say)	O	A	On bark of dead trees
Cucujidae	*Brontes dubius* Fab.	O	A	Under dead bark
	Cucujus clavipes Fab.	O	A	Under dead bark
Curculionidae	*Acoptus suturalis* LeConte	C	A	bark of dead & declining trees
	Barypeithes pellucidus (Boheman)	R	A	On foliage
	Cimberis sp.	O	A	Under dead bark
	Conotrachelus juglandis LeConte	C	A,I	Adults on foliage, larvae mining twigs
	Cossonus platalae Say	C	A	Under bark of dead and decaying trees
	Eubulus parochus (Hbst.)	C	A,I,P	On bark of dead & declining trees, reared from dead branches
	Polydrusus flavipes DeGeer	R	A	On foliage
Erotylidae	*Ischyrus quadripunctatus quadripunctatus* (Oliv.)	R	A	On foliage
Histeridae	*Hololepta fossularis* Say	O	A	Under dead bark
	Platysoma sp.	R	A	Under dead bark
Laemophilidae	*Laemophlaeus biguttatus* (Say)	C	A	Under dead bark
	Laemophlaeus fasciatus Melsh.	C	A	Under dead bark

Table 2. Continued

Order Family	Species	Relative Frequency	Stages Collected	Notes
	Laemophlaeus testareus (Fab.)	C	A	Under dead bark
Monotomidae	*Bactridium* sp.	C	A	Under dead bark
Nitidulidae	*Glischrochilus confluentus* (Say)	C	A	Under dead bark
	Glischrochilus fasciatus (Oliv.)	C	A	Under dead bark & visiting bleeding cankers
	Glischrochilus quadrisignatus (Say)	C	A	Under dead bark & visiting bleeding cankers
	Glischrochilus sanguinolentus (Oliv.)	R	A	Under dead bark
	Prometopia sexmaculata (Say)	R	A	Under dead bark
Phalacridae	*Phalacrus politus* Melsh.	O	A	Under dead bark
Scolytidae	*Hylesinus aculeatus* Say	R	A	On bark of dead trees
	Monarthrum mali (Fitch)	C	A	Reared from dead branches
	Phloeotribus dentifrons Blackman	R	A	On foliage
	Pityopthorus lautus Eichoff	R	A	On foliage
	Trypodendron betulae Swaine	R	A	On bark of dead & declining trees
	Xyleborus sayi (Hopkins)	O	A,I,P	Under dead bark
	Xyloterinus politus Say	R	A	On bark of declining trees
Staphylinidae	*Charhyphus picipennis* LeConte	C	A	Under dead bark
	Lordithon sp.	O	A	Under dead bark
	Neobisnius sp.	O	A	Under dead bark
	Ontholestes cingulatus Grav.	R	A	On bark of declining tree
	Philonthus sp.	O	A	Under dead bark
	Sepedophilus sp.	O	A	Under dead bark
	Siagonium sp.	O	A	Under dead bark
LEPIDOPTERA				
Arctiidae	*Hyphantria cunea* (Drury)	O	I	On foliage
	Lophocampa caryae (Harris)	O	I	On foliage
Lymantriidae	*Orgyia leucostigma* (J.E. Smith)	O	I	On foliage
Noctuidae	*Acronicta americana* (Harris)	R	I	On foliage

Notodontidae	*Datana ministra* (Drury)	O	I	On foliage
	Schizura concinna (J.E. Smith)	R	I	On foliage
Pyralidae	*Acrobasis demotella* Grote	C	I	Mining buds & shoots
	Acrobasis juglandis (Le Baron)	C	I	Mining buds & shoots
Tortricidae	*Gretchena bolliana* Sling.	O	I	On foliage & buds
DIPTERA				
Lonchaeidae	*Lonchaea* sp.	O	A	Reared from dead branches
Syrphidae	*Lejota aerea* (Loew)	O	A	Reared from dead branches
Tephritidae	*Rhagoletis suavis* (Loew)	C	A,I	Reared from nut husks
HYMENOPTERA				
Braconidae	*Cenocoelius ashmeadii* Dalla Torre	R	A	On bark of dead trees
	Ipobracon sp.	O	A	On bark of declining trees
Formicidae	*Camponotus pennsylvanicus* (DeGeer)	C	A,I	In decaying wood
Ichneumonidae	*Dolichomitus pterelas* (Say)	R	A	Reared from dead branches
Sphecidae	*Pison frigidum* Smith	R	A	Reared from dead branches
Tenthredinidae	*Macrophya* sp.	R	L	On foliage

Table 3. Coleoptera that were used for isolation attempts for *Siroccocus clavigignenti-juglandacearum*. The insects were collected either on the outer bark, at bleeding cankers, or under the bark of canker killed trees. Insects under the bark were either found in direct contact with hyphal pegs or were collected in locations that did not have hyphal pegs.

Family Species	On outer bark	At bleeding cankers	Under bark hyphal pegs present	Under bark no hyphal pegs	Isolation attempted # of insects	Isolation success
Cerambycidae						
Gaurotes cyanipennis	X				2	Negative
Cyrtophorus verrucosus	X				1	Negative
Cucujidae						
Brontes dubius				X	2	Negative
Cucujus clavipes				X	3	Negative
Curculionidae						
Cossonus platalae				X	33	Negative
Eubulus parochus			X		2	Positive
Eubulus parochus	X				36	Negative
Laemophloeidae						
Laemophlaeus biguttatus			X		9	Positive
Laemophlaeus fasciatus			X		13	Positive
Laemophlaeus testareus			X		20	Positive
Monotomidae						
Bactridium sp.			X		1	Positive
Nitidulidae						
Glischrochilus confluentus				X	1	Negative
Glischrochilus quadrisignatus				X	15	Positive
Glischrochilus quadrisignatus		X			2	Negative

a long period of time. *Sirococcus clavigignenti-juglandacearum* formed hyphal pegs under bark that was still tightly adhered to the wood and therefore *C. platalae* adults were not found in association with hyphal pegs or conidia. In our study, a positive isolation was not obtained from any of the 33 *C. platalae* adults tested (Table 3).

Acoptus suturalis was another weevil that was commonly observed, as an adult, on the outer bark of dead and declining trees, and *Cimberis* sp. were small weevils that were occasionally collected, though always in close association with hyphal pegs. No fungal isolation attempts were made on these species.

Cerambycidae were very abundant in this study with 12 species identified and 8 species being considered common (Table 2). Halik and Bergdahl (1996) isolated *S. clavigignenti-juglandacearum* from adult *Amniscus macula* which were commonly reared from dead branches in our survey. We did not attempt fungal isolations from this cerambycid. Limited isolation attempts were negative from two adult *Gaurotes cyanipennis,* which was very common, and one adult *Cyrtophorus verrucosus* (Table 3). These adults were collected on the outer bark of heavily infected butternut trees. Cerambycidae collected in this survey used butternut as a larval host and therefore, they developed and pupated under the bark. However, none of the larvae were observed in direct association with *S. clavigignenti-juglandacearum* hyphal pegs or conidia. Limited isolation attempts were negative for 4 cerambycid larvae collected under the bark of a dead butternut branch with cankers.

Seven species of Scolytidae and one species of Anobiidae were collected. The only commonly encountered species were *Monarthrum mali* (Scolytidae) an ambrosia beetle, and *Ptilinus thoracicus* (Anobiidae) a powderpost beetle. The only scolytid that was observed developing galleries under the bark was *Xyleborus sayi.* The other species were either collected via sticky bands on the outer bark or on the foliage.

A number of other beetle species were consistently collected under the bark of dead and dying butternut trees. Many of these were found in close association with the hyphal pegs and conidia of *S. clavigignenti-juglandacearum.* These included *Laemophlaeus biguttatus, L. fasciatus* and *L. testareus* (Laemophilidae). *Laemophlaeus biguttatus* has previously been reported feeding on the conidia of a *Hypoxylon sp.* fungus on oak (Lawrence 1977). In our study, pure cultures of *S. clavigignenti-juglandacearum* were isolated from the bodies of all three *Laemophlaeus* species. The fungus was also isolated from a single specimen of *Bactridium* sp. (Monotomidae). This species was commonly collected in association with hyphal pegs. *Hololepta fossularis* and *Platysoma* sp. (Histeridae), *Phalacrus politus* (Phalacridae) and several species of Staphylinidae were also collected in association with the hyphal pegs of *S. clavigignenti-juglandacearum,* however, isolations were not attempted.

Nitidulids have been implicated in vectoring *Ceratocystis fagacearum,* the fungus responsible for the oak wilt disease (Dorsey and Leach 1956). In our survey, several nitidulid species were commonly found in association with fungal pegs under the bark of dead and declining butternut trees (Table 2). Isolations of *S. clavigignenti-juglandacearum* were attempted on two of the most commonly encountered species, *Glischrochilus confluentus* and *G. quadrisignatus.* A positive isolation was obtained from 15 *G. quadrisagnatus* adults collected under bark where no hyphal pegs were observed. Negative isolations were obtained from two adults that were collected while apparently feeding at "bleeding" cankers. The single isolation attempt from a *G. confluentus* adult collected under bark was negative.

Buprestidae were not commonly encountered during our 2-year survey.

Agrilus juglandis adults were reared from bark of live and dead butternut but were never abundant. *Agrilus juglandis* larval galleries were located in the outer bark and did not penetrate to the phloem where the fungus sporulated.

Brontes dubius and *Cucujes claviceps* (Cucujidae) were occasionally collected under the bark of dead butternut. Attempts to isolate *S. clavigignenti-juglandacearum* from these two species were negative, though only five specimens were sampled.

Enoclerus nigripes nigripes and *Zenodosus sanguineus* (Cleridae) were occasionally collected on the outer bark of recently dead and declining trees. Both of these clerids are predators that would have developed as larvae and pupated under bark, though not necessarily under the bark of butternut trees.

Paria quadriguttata, a chrysomelid leaf beetle, was collected occasionally under bark flaps, though it was not observed in direct contact with hyphal pegs. This species was not observed feeding on butternut leaves during this study.

The larvae of two Diptera species, *Lonchae* sp. (Lonchaeidae) and *Lejota aerea* (Syrphidae) were occasionally collected under the bark of dead butternut trees. They were not observed however, in close association with hyphal pegs of *S. clavigignenti-juglandacearum*.

Carpenter ants, *Camponotus pennsylvanicus* (Formicidae) were common anywhere wood decay had begun. Four Hymenopteran parasites were collected. *Cenocoelis ashmeadii* (Braconidae) and *Dolichomitus pterelas* (Ichneumonidae) were reared from dead branch material. *Ipobracon* sp. (Braconidae) and *Pison frigidum* (Sphecidae) were collected flying around and landing on the bark of recently dead and declining trees.

Insects found associated with twigs, foliage and reproductive structures. Only one Coleoptera species, *Conotrachelus juglandis* (Curculionidae), was commonly observed in the upper parts of tree crowns. *Conotrachelus juglandis* larvae tunneled into twigs in the upper crowns of trees and adults were collected on foliage by sweeping or shaking branches over a sheet. *Conotrachelus juglandis* create open-wounds on branches and twigs in the crowns of trees that could serve as entry points for fungal spores, however, it is not clear how they might acquire conidia of *S. clavigignenti-juglandacearum*.

Seven species of Homoptera were collected on small branches, twigs and foliage. Only two however, were commonly encountered, *Parthenolecanium corni* (Coccidae) and *Metcalfa pruinosa* (Flatidae). *Parthenolecanium corni* were very abundant in 1995, but no association between newly formed cankers and the location of scales was obvious. *Metcalfa pruinosa* were observed feeding on butternut twigs. *Clastoptera obtusa* (Cercopidae) was only collected as adults. No spittle masses were observed.

Both adult and immature *Corythuca juglandis* (Hemiptera) were commonly collected on foliage. Three thrip species (Thysanoptera) were collected on leaves though there was no evidence of feeding or oviposition. Leaf feeding Lepidoptera were not commonly collected. Several small Noctuidae and Geometridae larvae were collected but could not be identified further. The most common Lepidoptera were shoot and bud miners, *Acrobasis demotella* and *A. juglandis* (Pyralidae), and *Gretchena bolliana* (Tortricidae). *Acrobasis demotella* and *A. juglandis* are common on black walnut, *Juglans nigra*, in the Lake States (Martinat and Wallner, 1980). One sawfly (Hymenoptera: Tenthredinidae) *Macrophya* sp., was found feeding on foliage, but only two individuals were observed.

Larvae of *Rhagoletis suavis* (Diptera: Tephritidae) were commonly encountered infesting the husks of nuts that had dropped to the ground.

SUMMARY

Leach (1940) stated that in order for an insect to be an effective vector it must be consistently associated with diseased plants in a way that is conducive to contamination with the pathogen and it must visit healthy plants under conditions suitable for transmission of the pathogen. This survey found a number of insect species that occur in close association with hyphal pegs or conidia of *S. clavigignenti-juglandacearum* as well as a number of species that occur under the bark of diseased butternut. Any of these species may become contaminated with *S. clavigignenti-juglandacearum.* However, it is still unclear if any of these insects would then visit healthy butternut trees and serve as efficient vectors.

The nitidulid species are one group that we found, at times, in close association with the fungus that would likely visit fresh wounds on butternut trees. A number of other Coleoptera species do spend time under the bark of dead and declining trees and therefore could contact *S. clavigignenti-juglandacearum.* Several of these insects are very mobile and may visit healthy butternut trees to feed as adults on twigs, including many of the Cerambycidae. Three species of *Laemophlaeus* were regularly found in association with hyphal pegs of *S. clavigignenti-juglandacearum* and all three species had positive fungal isolations obtained from individuals. These three species would be potential vectors if they could be found visiting healthy trees. *Eubulus parochus,* because of its abundance on recently killed and declining trees and because it does spend part of its life cycle under bark, is another potential vector.

Efforts are underway in the United States and Canada to conserve butternut and to restore this species to areas where it was once more common than today in order to maintain diversity in the eastern North American forests. There is some evidence that resistance to the canker does exist, but at this time there are no known resistant butternut selections available for planting. There is a need to more fully understand the potential risk of insects in reintroducing the pathogen into potential planting areas, stands where butternut can be regenerated, or into areas where healthy butternut trees still exist. In addition, insects may have the potential to introduce this fungus into plantations of other susceptible *Juglans* species.

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