Silvicultural Options to Reduce Pine Susceptibility to Attack by a Newly Detected Invasive Species, *Sirex noctilio*

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ABSTRACT

A nonnative woodwasp of Eurasian origin, *Sirex noctilio* F., was detected recently in Oswego, New York, infesting Scots, red, and white pine. *S. noctilio* has caused periodic widespread losses of pine timber resources in several Southern Hemisphere countries and may cause significant damage in pure even-aged stands and overstocked plantations in North America. However, stand management and biological control programs have successfully managed *S. noctilio* populations in other countries and similar programs are being developed for North America. Until the primary biological control agent, *Beddingia siricidicola*, a parasitic nematode, is established in North America, forest owners will have to rely solely on silvicultural treatments to reduce the susceptibility of at-risk pine stands to *S. noctilio* attack. Silvicultural treatments including precommercial thinning, promoting optimal growing conditions for pines on a given site, reducing numbers of susceptible hosts, and consistent monitoring of stands are suggested activities to help protect pine stands from invasion by *S. noctilio*.

Keywords: *Sirex noctilio*, Siricidae, integrated pest management, invasive species, *Pinus*, silviculture

The recent introduction of an invasive woodwasp, *Sirex noctilio* F. (Hymenoptera: Siricidae), into North America has garnered much attention from the forest health community. The initial *S. noctilio* detection was from a New York Department of Agriculture and Markets Cooperative Agricultural Pest Survey monitoring trap placed in Fulton, New York. One adult female *S. noctilio* was collected in September 2004 and was subsequently identified as the exotic woodwasp. Ground surveys concentrated around the initial detection trap and surrounding areas located *S. noctilio*–infested trees in Oswego, New York. During 2005 and 2006, population delimitation efforts using traps were undertaken and resulted in positive catches in 25 New York counties concentrated in central and western New York, two north-central Pennsylvania counties, and sites throughout southern Ontario.

Although it still is unknown what levels of tree mortality will be seen in North America, *S. noctilio* has caused large losses of pine resources in countries including Australia (Haugen 1990), New Zealand (Rawlings 1955), and Brazil (Iede et al. 1998). Several North American pine species (e.g., loblolly pine [*Pinus taeda* L.] and Monterey pine [*P. radiata* D. Don]) are grown commercially throughout the Southern Hemisphere and large outbreaks of *S. noctilio* have occurred in forests dominated by these trees. Based on its ability to colonize North American pine species and other factors, *S. noctilio* has been rated as a high-risk species for North American forests (Haugen 1999). Although *S. noctilio* has caused significant losses in even-aged plantation settings throughout the Southern Hemisphere, many North American pine ecosystems are distinctly different and have more in common with Eurasian forests where the species is innocuous. It is likely that *S. noctilio* damage will vary by region, forest composition, and intensity of historic silvicultural treatments. However, pine stands that have not been managed intensively (i.e., dense stands with no follow-up treatments since stand establishment) in North America are likely at risk to *S. noctilio* introductions and damage.

Confirmed North American *S. noctilio* hosts include jack (*Pinus banksiana* Lamb), loblolly, lodgepole (*Pinus contorta* Dougl.), longleaf (*Pinus palustris* Mill.), Monterey, ponderosa (*Pinus ponderosa* Laws.), shortleaf (*Pinus echinata* Mill), and slash (*Pinus elliottii* Engelm.) pines (Haugen 1999). However, most North American hard pines are likely susceptible to *S. noctilio* infestation. In North America, *S. noctilio* has been found in Scots pine (*Pinus sylvestris* L.), an exotic species in North America, red pine (*Pinus resinosa* Ait.), and white pine (*Pinus strobus* L.), a soft pine.

Successful integrated pest management plans have been developed and implemented for *S. noctilio* in intensively managed pine plantations in Australia (Haugen 1990, Haugen et al. 1990). These plans rely on the combination of a biological control agent, *Beddingia* (*Deladenus*) *siricidicola* and silvicultural treatments of at-risk pine stands. *B. siricidicola* is a parasitic nematode first identified from New Zealand (Zondag 1969). This nematode has two life cycles consisting of a mycetophagous (i.e., fungi-feeding) free-living cycle that feeds on *S. noctilio*'s symbiotic fungi, *Amylostereum areolatum* (Fries), and a parasitic cycle that attacks developing woodwasp larvae effectively sterilizing female woodwasps (Bedding 1972). Techniques to culture and establish this nematode in *S. noctilio* populations have been developed (Bedding and Akhurst 1974, Bedding and Iede 2005). Parasitoid species, some native to

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North America, also have been introduced into Southern Hemisphere *S. noctilio* populations as biological control agents (Taylor 1976).

Although *B. siricidicola* has been successful at reducing *S. noctilio* populations in other countries and will be an integral component of a management plan in North America, silvicultural treatments of at-risk pine stands also are recommended for protecting commercial pine forests. Typically, overstocked commercial pine stands have been impacted by *S. noctilio* at greater levels than thinned commercial stands (McKimm and Walls 1980, Neumann et al. 1987). *S. noctilio* populations begin building in stressed and suppressed trees and eventually begin colonizing larger trees as the infestation progresses (McKimm and Walls 1980). As stand conditions change because of *S. noctilio*– caused tree mortality and more resources are available for the remaining trees, resistance to attack increases (Madden 1975). Fortunately, northeastern forests are made up of a mosaic of forest types, with pine species distributed throughout the landscape and large blocks of pure even-aged stands less common. Natural mixed stands likely will not suffer large losses from *S. noctilio* attacks, but overstocked pine plantations or fire-regenerated (e.g., jack pine) stands that are overstocked are highly susceptible. Abandoned Scots pine Christmas tree plantations that are common throughout the northeast also are at risk of *S. noctilio* colonization. It is unknown how effective *B. siricidicola* will be in North America, therefore, at this point it is suggested that silvicultural options focused on increasing stand vigor be considered for at-risk pine stands. Based on experiences from other countries growing North American pine species, silvicultural treatments are important tools for reducing the impact of *S. noctilio* in a pine stand (McKimm and Walls 1980, Neumann et al. 1987, Neumann and Marks 1990).

S. noctilio poses a serious threat to North American pine forests and it is prudent that forest managers begin to evaluate the health of pine stands under their stewardship. This document outlines general recommendations for reducing the susceptibility of pine stands to *S. noctilio* infestation.

Reducing Stand Susceptibility

Past experience with *S. noctilio* in other countries suggests that an integrated approach that incorporates monitoring and silvicultural treatments can be effective at reducing the susceptibility of pine stands to attack. Effective monitoring is critical and will allow for the earliest possible detection of an infestation. Silvicultural treatments that promote the growth of healthy vigorous trees that are less susceptible to attack are desired (Madden 1968).

Monitoring

Monitoring pine stands for unexpected or excessive mortality is critical to successfully managing for *S. noctilio*. Two forms of monitoring should be implemented in or near areas where *S. noctilio* populations are active. Annual stand examinations should occur in areas where infestations are known to exist. Characteristics of *S. noctilio* attack include fading crowns, resin beads and/or resin dripping down the bole, and round exit holes approximately 3–10 mm in diameter. Round exit holes can be caused by native insects, but if higher than normal levels of mortality are seen in a stand and trees have numerous round exit holes, *S. noctilio* could be the cause. *S. noctilio* adults are active from early July into mid-October and may be seen in a stand or on a tree bole, while signs of attack can be seen throughout the year. Conduct walk-through surveys of pine or pine-dominated stands and look for symptoms of *S. noctilio* infestations. Also, look at any trees that have recently died or downed material and determine if *S. noctilio* may have been the cause. Look carefully at the smaller suppressed or damaged trees in a stand because *S. noctilio* often concentrates attacks on these trees.

The second form of monitoring for *S. noctilio* includes the use of traps or trap trees. Lindgren funnel traps and intercept panel traps can be used in combination with synthetic lures to detect the presence of *S. noctilio*. Trap trees have been effective in other countries as a *S. noctilio* monitoring tool (Neumann et al. 1982, Haugen 1990, Haugen et al. 1990).

Several considerations arise if *S. noctilio* is detected in a pine stand. First, the current condition of the stand (i.e., stocking levels, number of suppressed trees, and tree species present) and landowner objectives should be evaluated. If the stand has been well managed or if pine is not the dominant tree species present, landowners may decide against action. However, if a pine stand has been designated for timber production and growing conditions are stressful for individual trees, silvicultural options should be considered. The current level and future potential of *S. noctilio* activity should be assessed in a stand. If stand conditions are poor and individual tree growth is compromised, silvicultural options may be a viable option for increasing stand vigor.

Stand Management

A possible key to reducing tree mortality caused by *S. noctilio* and other insects is to increase tree vigor by reducing stand stress (e.g., Mitchell et al. [1983]). *S. noctilio* is attracted to suppressed trees (Morgan and Stewart 1966, Hall 1968, Madden 1968, Madden 1975) and reduction of this material from a forest stand should limit potential host trees. This can be done with a combination of practices that will allow for active harvesting of forest products, while simultaneously reducing the susceptibility of stands.

Current Stands

S. noctilio caused higher rates of mortality to smaller-diameter trees than larger-diameter trees and trees above 29 cm dbh were not attacked in pine plantations in Australia (Neumann and Minko 1981). Smaller-diameter suppressed trees also were the first trees to be attacked by *S. noctilio* in a *Pinus radiata* plantation in Tasmania (Madden 1975). In unthinned stands, an average of 77 and 63% tree mortality occurred in severe (defined as more than 65% cumulative mortality over an 8-year period) and moderate–severe (40 – 64% cumulative damage) damage classes, respectively (McKimm and Walls 1980, Neumann et al. 1987). No mortality in the severe and moderate–severe damage classes was recorded for thinned stands (Neumann et al. 1987). Similar attack patterns are likely to occur in many North American pine stands. Consequently, pine stand management, especially in pure, even-aged stands, should focus on removing suppressed trees and maintaining vigorously growing trees. An aggressive precommercial and commercial thinning program with stand entries at approximate 10-year intervals using a thin from below strategy should be planned. To promote optimal growth of pine, maintain a 40 –50% live crown ratio on residual trees. Thinnings performed on a regular basis maintain individual trees that are in a vigorous condition with strong defensive capabilities (Waring and Pitman 1985).

Silvicultural recommendations often are site-specific and may vary by region, but some general prescriptions can be followed. Basal area for red pine is best maintained at 100 ft^2/ac (or slightly lower) for optimal individual tree growth and vigor (Benzie 1977a, Gilmore and Palik 2006). For previously unthinned white pine, basal areas less than 150 ft^2/ac would promote optimal individual tree growth and vigor (Lancaster and Leak 1978). Stocking levels below 125 ft^2/ac of basal area can be used for previously managed stands of white pine (Leak and Lamson 1999). For jack pine, optimal stand density would be between 110 and 140 ft^2/ac for optimal individual tree growth (Benzie 1977b). Note that these basal areas are general guidelines and modifications may be made according to professional experience and individual landowner objectives. However, to maximize individual tree growth and vigor, lower basal areas are suggested. In addition, removal of potential host trees exhibiting poor health and low vigor during each thinning are suggested to further reduce the risk of *S. noctilio* expansion or outbreaks.

Thinning practices are stand-level disturbances that cause stress to individual trees. It may take the stand up to a year or longer to recover from this disturbance. Therefore, the stand should be thinned before a problem is evident. When doing any stand entry, reducing damage to residual trees, carefully designing skidder trails to minimize soil compaction, and removing any unhealthy trees should be priorities. In addition, harvesting from the interior to the exterior of the stand will further minimize damage. Stand treatments should be scheduled during periods when *S. noctilio* is not active (November–April). Follow all quarantine procedures that are in place for a given locality.

Future Stands/Regeneration

Given its wide host breadth and the overstocked conditions that exist in many pine stands, *S. noctilio* likely will become established in many North American pine forests. Consequently, the potential effects of this insect should be considered when natural resource managers are concerned with pine regeneration. If populations of *S. noctilio* are present in an area, it is imperative to select the best pine species for a given site when planting. Site-specific factors can dictate what tree species will develop the best on a site and if the species can maintain vigorous growth throughout its development. Planting density will depend on ownership objectives, but tree densities and stocking levels should be regulated and maintained at levels to promote individual tree vigor throughout the life of the stand. Finally, converting off-site pine stands back to hardwoods also should be considered (Kint et al. 2006).

Conclusions

S. noctilio poses a threat to the health of many North American pine forests. However, unlike countries where *S. noctilio* causes significant economic losses in plantations, North American forests likely will vary in their susceptibility to this insect. Although pine plantations are common in some regions of North America, many noncommercial forests that contain pine are more species diverse, structurally varied, and have established populations of predators and parasitoids that likely will attack *S. noctilio*. The combination of these factors makes predicting *S. noctilio* impacts on North American forests more difficult than in the homogenous forest plantations where this insect has caused significant timber losses.

Unlike the situation with some recent invasive species, proactive forest management has reduced susceptibility of forest stands to *S. noctilio* infestation elsewhere. Although some invasive species have made it impossible to grow certain tree species in an area, growing pines still will be possible in areas where *S. noctilio* becomes established. However, forest management plans with carefully timed thinning schedules should be implemented to reduce pine stand susceptibility to *S. noctilio* attack. As biological control options become available for *S. noctilio*, they can be integrated into the management plan. The combination of biological control and forest management has kept *S. noctilio* populations below damaging levels in countries where it has been introduced and should guide management efforts in North America.

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