CHAPTER 4

Southern Forest Insects

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Between 1998 and 2008, five Evaluation Monitoring (EM) projects under the national Forest Health Monitoring (FHM) Program of the Forest Service, U.S. Department of Agriculture, studied insects of the Southern United States. The projects reflected expanded survey efforts related to various nonnative bark and ambrosia beetles. Two of the projects conducted preliminary surveys of the Southeast to determine the occurrence of exotic ambrosia beetles, and two projects addressed mortality surveys and survey methodology for the nonnative redbay ambrosia beetle and associated laurel wilt fungus. The fifth project investigated risk of initial hemlock woolly adelgid (HWA) infestations to hemlock stands in the Southern Appalachian Mountains region. The emphases of these projects reflect the growing impacts that nonnative insects are having on southern forested ecosystems. The first four projects discussed increased our knowledge of the extent and distribution of nonnative bark/ambrosia beetles, improved detection methods, helped to focus current and future survey efforts, and formed the basis for impact studies. The last project focused on identifying areas at risk of initial HWA infestations, and the site variables that are important in modeling which areas may be at greatest risk.

Projects SO-EM-00-01 and SO-EM-01-02: Exotic Ambrosia Beetle Survey of the Southeastern United States, 2000–2001

The purpose of these projects was to conduct preliminary and follow-up surveys in the Southeast to detect and confirm the distribution of exotic ambrosia beetles in the region. Information from these 2 years was used as a baseline for current and future surveys and has helped form the basis for impact studies. Ethanol was used as the attractant in Lindgren-funnel traps. One 250 ml Nalgene® bottle was used per trap. Ethanol (75 to 95 percent) was released from the bottle through a cotton wick placed through a hole in a closed top and was replenished as needed. Nine States (27 trapping sites) participated in this survey in 2000. Ten States (28 trapping sites) participated in 2001. The trap catches were collected weekly for 8 weeks and sent to Dr. Robert Rabaglia for identification and tally.

Previous to the 2000 survey, 150 species of scolytids had been recorded in the nine States in the region (species occurring only in southern Florida and south or west Texas were not included). During the 2000 survey, 48 species were identified from the 8,273 specimens collected. The exotic ambrosia beetle (*Xyleborus pelliculosus),* collected in Tennessee, was the first record of this species in the southeast. During the 2001 survey, 52 species were identified from the 5,358 specimens collected. Eleven species were collected in 2001 that were not collected in 2000, whereas seven species that were collected in 2000 were not collected in 2001. Four of the species collected for the first time in 2001 were ambrosia beetles that are native to the region.

Collection of such a large percentage (90 percent) of ambrosia beetles indicates that these species are likely to have an impact on tree health, even if the impact is only on dying or weakened trees. Infrequent reports implicate several of these ambrosia beetles in attacks on healthy trees.

During the 2001 survey, 5,358 scolytids were collected. Ambrosia beetles accounted for 4,880 of these specimens (91 percent). The most common species was *Xyleborinus saxeseni*, accounting for 57 percent (3,043) of all specimens. As in the 2000 survey, this exotic ambrosia beetle was found in every State and dominated most trap samples. A native of Europe, it has been in North America for over 100 years and occurs throughout most of the United States. It is often found attacking weakened, injured, or dying trees as well as fresh-cut logs (Solomon 1995).

Members of the tribe Xyleborini made up 71 percent of the species collected. This is the most common and often most damaging group of ambrosia beetles worldwide. In the United States, there are currently 34 species of xyleborines; 14 of these are exotics. Within this tribe five

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different genera were collected: *Ambrosiodmus, Euwallacea, Xyleborus, Xyleborinus,* and *Xylosandrus*. The three species of *Xylosandrus* are potentially the most damaging (Wood 1977). *Xylosandrus compactus* (Eichhoff), an aggressive primary borer in twigs of a wide variety of hosts, has been reported killing twigs of dogwood along the Gulf Coast and from Florida through the Carolinas. *Xylosandrus germanus* (Blandford) and *X. crassiusculus* (Motschulsky) both breed in branches and stems of weakened hosts, and there is concern that these species are attacking and killing nursery stock and young trees that are only slightly stressed; in 2001, there were reports from Richmond, VA, that *X. crassiusculus* was aggressively attacking landscape trees.

Atkinson and others (1990) and Wood (1977) pointed out the preponderance of east-Asian xyleborines in eastern North America. All of these exotic species have inbred polygyny as their mating system. Newly matured females mate with siblings before emerging from host trees. With a skewed female to male ratio of at least 10 to 1, individual females, which are also polyphagus, are able to quickly establish new populations.

The fungal associates of ambrosia beetles have been well documented (Roeper 1996), but few studies have investigated the impacts and aggressiveness of these fungi (Anderson and Hoffard 1978, Kessler 1974). In a new environment, the host-beetle-fungus interaction can change and negatively affect the susceptible host tree.

The increasing rate of establishment of exotic ambrosia beetles should be of concern. Of the 10 species collected in the 2001 survey, five have been reported for the first time in the Southeast in the past 10 years. Most of these new introductions are from Asia, and in this study, eight of the 11 exotics were from Asia.

During the 2 years covered by these projects, numerous new State records were documented. The distribution of ambrosia beetles, and in particular exotic ambrosia beetles in the southeast, is now better known.

Project SO-EM-06-01 Redbay Mortality Survey in the Coastal Region of Georgia; Project SO-EM-06-02: Redbay Mortality Survey in the Southeastern Coastal Region of South Carolina

Laurel wilt (LW), caused by the fungus *Raffaelea lauricola*, is a new disease of plants in the Lauraceae family in the United States that is vectored by an introduced Asian ambrosia beetle, *Xyleborus glabratus* (Fraedrich and others 2008, Harrington and others 2008). Since the capture of the first *X. glabratus* in a monitoring trap near the Port of Savannah in 2002 and the first reports of dying redbay trees (*Persea borbonia*) in 2003 and 2004, this disease has spread rapidly through the abundant redbay in the maritime and coastal plain forests northward into South Carolina and south into Florida, killing most of the redbay trees in its path. Other plants in the laurel family known to be susceptible to varying degrees include: sassafras (*Sassafras albidum*), avocado (*Persea americana*), pondspice (*Litsea aestivalis*), and pondberry (*Lindera melissifolia*), the latter two on Federal lists as threatened and endangered species, respectively (Fraedrich and others 2008).

This exotic disease episode is particularly noteworthy because it is caused by a previously unknown pathogen vectored by an ambrosia beetle that was not expected to be a serious threat to forests or wood products in the United States. Yet in under 10 years, it has essentially eliminated redbay from a large portion of the South Atlantic Coastal Plain and maritime forests. This disease will likely continue to expand throughout coastal plain forests from Virginia to Texas and is a threat to the avocado industry in south Florida and elsewhere. Ambrosia beetles generally attack dead and dying hosts and do not vector important diseases. The redbay ambrosia beetle is not known to be an important pest in its native range in Southeast Asia, but was known to be associated with members of the Lauraceae (laurel) family (Rabaglia 2003). However, the unique association between insect, pathogen and host in which *X. glabratus* conveys the *R. lauricola* fungus into highly susceptible redbay trees has proven to be exceptionally fatal. The fungus spreads through the vascular system, blocking water transport, and causes redbay trees to wilt and die within months after initial infection.

Although redbay is a species of minor importance for forest products, it plays an important ecological role. Various birds and animals feed on its fruit and one species of butterfly, the Palamedes swallowtail, feeds almost exclusively on its foliage during the larval stage (Coder 2007). This new disease may eventually become much more widely distributed if it continues to spread in sassafras, which is found in much of the eastern half of the United States. There are many additional genera and species in the laurel family, concentrated mainly in the tropical and subtropical areas in Central and South America, which may also be susceptible to LW disease. Thus, it is important to document the advance of this disease both in geographic distribution and species affected; this was the main purpose of both of these EM projects. Parallel surveys have also been carried out in Florida, although these surveys were supported outside of FHM EM.

To track the geographic distribution and rate of spread of the disease in a more comprehensive and systematic fashion, surveys were conducted in Georgia and South Carolina in 2006/2007 (2006 survey) and 2007/2008 (2007 survey). The objectives of the surveys included the following:

1. Systematically document the distribution of LW disease on a grid pattern over the area known to be infected and beyond the apparent advancing front.
2. Determine the severity of infection within the range of distribution of the disease.
3. Document the rate and direction of spread and elucidate possible causes of varying rates of spread in Georgia.
4. Investigate the symptoms and incidence of LW disease in sassafras and other species in the laurel family in Georgia.
5. Lay the foundation for future monitoring projects.

Via these projects, over 400 plots have been evaluated for LW-caused mortality to redbay, sassafras, and other susceptible species. Many new affected areas/counties were documented, the severity of mortality was recorded according to standardized damage classes, effective survey methods were identified and enhanced, and information was gained regarding the rate and means of spread and possible future expansion of this devastating disease. To view the current distribution, visit: http://www.fs.fed.us/r8/foresthealth/laurelwilt/dist_map.shtml.

Project SO-EM-03-01: Early Warning System for Hemlock Woolly Adelgid in the Southern Appalachians

This project was also funded in 2003. The principle investigators include Frank Koch, Heather Cheshire, and Hugh Devine from North Carolina State University. The goals of this project were to develop a protocol for mapping hemlock stands, and to develop a model for predicting areas at greatest risk to initial HWA infestations in the Southern Appalachian Mountains.

The Great Smoky Mountains National Park served as the study area for this project. The technique for mapping hemlock forest stands used selected Landsat 7 and ASTER multispectral images acquired of the west and east sides of the park during leaf on and leaf off periods between 2000 and 2003. A 15-m resolution was used and the images were geometrically corrected using polynomial equations as well as topographically normalized. Evergreen and non-evergreen maps were then created from the winter images, and non-evergreen areas were eventually masked out from the summer images. Stratified random sample points collected from the masked images were compared to a vegetation map (derived from an aerial photograph) of the park and used in creating a “training” dataset to construct a decision-rules-based “expert” classifier. The expert classifier was then used to create output hemlock maps from the western and eastern study areas that included hemlock, non-hemlock evergreen and non-evergreen map layers. Field surveys and or aerial photographs were then used to assess the accuracy of the generated maps and resulted in better than 85 percent accuracy in the eastern study area, and 69 percent in the western study area.

The risk to initial HWA infestations was assessed by using GIS technology to calculate values for a suite of site related variables on 56 infested and 45 noninfested sites within the park. Some of the variables included: elevation; aspect; geology; vegetation type; disturbance history; and proximity to roads, trails, and streams. Resulting logistic regression equations using four variables—proximity to trails, elevation, slope, and aspect—correctly classified 83 percent of the input sample and 75 percent of the sites set aside for testing. Other procedures also used proximity to roads as an additional variable and had similar results indicating that between 16 to 38 percent of hemlock areas in the Great Smoky Mountains National Park are at risk to early HWA infestation. Areas near roads and trailheads are at high risk.

Summary of Key Findings

- Greatly increased knowledge was obtained about the number of species, rate of introduction, distribution, and abundance of exotic bark and ambrosia beetles in southeastern forests. Numerous new State records of exotic ambrosia and bark beetles were documented.
- Over 400 plots were evaluated for LW-caused mortality to redbay, sassafras, and other susceptible species, and produced the following results:
  - Many new affected areas/counties were documented.
  - The severity of mortality was recorded according to standardized damage classes.
  - Effective survey methods were identified and enhanced.
  - Insights were gained regarding the rate and means of spread and possible future expansion of this devastating disease.
- A protocol was developed for mapping hemlock stands and models for predicting the areas at greatest risk to initial HWA infestations in the Southern Appalachian Mountains region. Models including proximity to roads indicated that between 16 to 38 percent of hemlock areas in the Great Smokey Mountains National park are at risk to early HWA infestation.

Utilization of Project Results

The survey methods developed and honed via the first four projects above have been used to standardize nonnative bark/ambrosia beetle detection surveys and LW surveys. The trapping protocols refined by the exotic ambrosia beetle survey projects have been used in the national Bark Beetle

Early Detection and Rapid Response Program (of the Forest Health Protection Program, Forest Service). The exotic ambrosia beetle survey projects raised awareness among land managers regarding the number and impacts of nonnative bark/ambrosia beetles occurring on their lands. Similarly, the LW survey projects educated land managers and the general public about the spread and impact of LW. The LW survey methods developed by these projects are used by Federal, State, and private land managers to measure the spread and impacts of LW as it moves into new areas.

Suggestions for Further Investigation

Future work on exotic bark and ambrosia beetles should include expanded monitoring of forested areas near high-risk sites for new introductions. New detection methods and introduction risk assessments could be evaluated and improved to increase the efficiency and effectiveness of detecting new exotic bark and ambrosia beetles. Evaluation studies should be conducted to determine the aggressiveness of new exotic bark and ambrosia beetle species, the pathogenicity of their fungal associates, and ultimately, their impact on the long-term health of forests in the southeast.

Mortality of various species (redbay, sassafras, avocado, pondspice, pondberry, etc.) due to LW should continue to be documented and measured. Lessons learned and survey methods developed should be used as a starting point in evaluating future tree mortality caused by nonnative species. In addition, the following areas should be explored: improved detection and evaluation techniques for LW, possible use of remote sensing methods, better traps/lures, and more efficient visual surveys.

Literature Cited

Anderson, R.L.; Hoffard, W.H. 1978. Fusarium canker-ambrosia beetle complex on tulip poplar in Ohio. Plant Disease. Rep. 62:751.

Atkinson, T.H.; Rabaglia, R.J.; Bright, D.E. 1990. Newly detected exotic species of Xyleborus (Coleoptera: Scolytidae), with a revised key to species in eastern North America. Canadian Entomologist. 122: 93-104.

Coder, K, D. 2007. Taxonomy and identification:Redbay (Persea bobonia). University of Georgia Warnell School of Forestry & Natural Resources Outreach publication WSFNR07-2 10 pp.

Fraedrich, S.W.; Harrington,T.C.; Rabaglia, R.J. [and others]. 2008. A fungal symbiont of the redbay ambrosia beetle causes a lethal wilt in redbay and other Lauraceae in the Southeastern United States. Plant Disease. 92: 215-224.

Harrington, T.C.; Fraedrich, S.W.; Aghayeva, D.N. 2008. Raffaelea lauricola , a new ambrosia beetle symbiont and pathogen on the Lauraceae. Mycotaxon. 104: 399-404.

Kessler, K.J., Jr. 1974. An apparent symbiosis between Fusarium fungi and ambrosia beetles causes canker on black walnut stems. Plant Disease. Rep. 58: 1044-1047.

Rabaglia, R.J. 2003. Pest Data Sheet: Xyleborus glabratus. Pest Reports—The Exotic Forest Pest Information System for North America (ExFor). http://www.spfnic.fs.fed.us/exfor. [Date accessed: unknown].

Roeper, R.A. 1996. Ambrosia beetles of the continental United States and Canada and status of knowledge of their associated primary symbiotic fungi. Michigan Entomology Society Newsletter. 41:12-14.

Solomon, J.D. 1995. Guide to the insect borers of North American broadleaf trees and shrubs. Agric. Handbook 706. Washington, DC: U.S. Department of Agriculture Forest Service. 735 p.

Wood, S.L. 1977. Introduced and exported American Scolytidae (Coleoptera). Great Basin Naturalist. 37: 67-74.