Chapter 15.

Advances in the Control and Management of the

Southern Pine Bark Beetles

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Abstract—*Management of members of the southern pine bark beetle guild, which consists of five species, is a continually evolving process. A number of management strategies and tactics have remained fairly constant over time as new ones are being added. These basic practices include doing nothing, direct control, and indirect control. This chapter focuses primarily on the latter two. Emphasis is given to recent and possible future management strategies that may become part of our overall programs. The World Wide Web will play a key role in the distribution of information about the management of the southern pine bark beetles.*

INTRODUCTION

Five species make up the guild of insects known as the southern pine bark beetles. They include the southern pine beetle (SPB) (*Dendroctonus frontalis* Zimmermann), black turpentine beetle (BTB) [*D. terebrans* (Olivier)], small southern pine engraver (fourspined engraver) [*Ips avulsus* (Eichhoff)], fivespined engraver [*I. grandicollis* (Eichhoff)], and the sixspined engraver [*I. calligraphus* (Germar)] (fig. 15.1). The SPB was responsible, in presettlement forests, for periodic perturbations that maintained uneven-aged forests and a diversity of plant species. These outbreaks were beneficial events in normally functioning southern pine ecosystems. However, the SPB is now viewed as a pest because an economic value is placed on pine and because intensive management of pine forests has caused beetle populations to interfere with efforts to achieve management objectives (Nebeker 2003).

Because of its history, aggressive behavior, and reproductive potential, SPB causes more concern than the other bark beetles of the Southeastern United States. Although *Ips* spp. have been associated with tree mortality, they are generally considered a less-aggressive species. *Ips* prefer host material that is stressed due to a moisture deficit, slash from harvesting operations, or windthrown material. It is essential to recognize that not just one species kills our pines. However, during periods of drought, as in 1999 and 2000, *Ips* beetles attacked and killed considerable areas of pine. These events increased public awareness of the impact *Ips* can have. During that same period, SPB populations were low across the region, especially west of the Mississippi River, where they were at record lows with zero or near zero attacks reported. The reason for this apparent anomaly is unknown. One could hypothesize that SPB populations were so low because *Ips* populations displaced them during tree colonization. Another possibility is that the drought altered suitable habitat for SPB population development by limiting or changing resource availability. The question as to why the SPB population has been at such a low level during this period remains unanswered at this point. Further efforts are needed to understand the dynamics of insect biology during suboutbreak periods.

SURVEY AND DETECTION

Foresters and entomologists have long relied on ground observations, aerial surveys, and aerial photography to locate southern pine bark beetle infestations. Some progress has been made in this area over the past decade. For example, SPB spots can now be detected remotely (Carter and others 1998). Carter and others (1998) indicate that individual trees with foliage ranging from yellow to brown and classified as heavily damaged by the SPB were easily located in 675- and 698-nm reflectance images. Statistically, mild chlorosis in recently infested pines was detected by a normalized difference vegetation index (NDVI) derived from 840- and 698-nm imagery. However, this was not easily resolved visually in the NDVI images. Detection of infestations

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now depends entirely on the capability to detect small decreases in leaf chlorophyll content. Thus, it is expected that the increased reflectance near 700 nm that is characteristic of early, damage-induced chlorosis would be resolved more easily in pine plantations, which are even aged and have low species diversity. Interest in these methods will increase as technology improves and satellites with high-image resolution enter commercial service.

Global positioning systems (GPS) have increased the efficiency with which SPB spots can be located on the ground. Capturing the GPS locations of spots during aerial surveys has made it easier for ground crews to locate and evaluate infestations. The use of GPS also helps workers determine whether they are observing new infestations or infestations that were identified previously. This is helpful when one is trying to determine the total number of spots detected during the year.

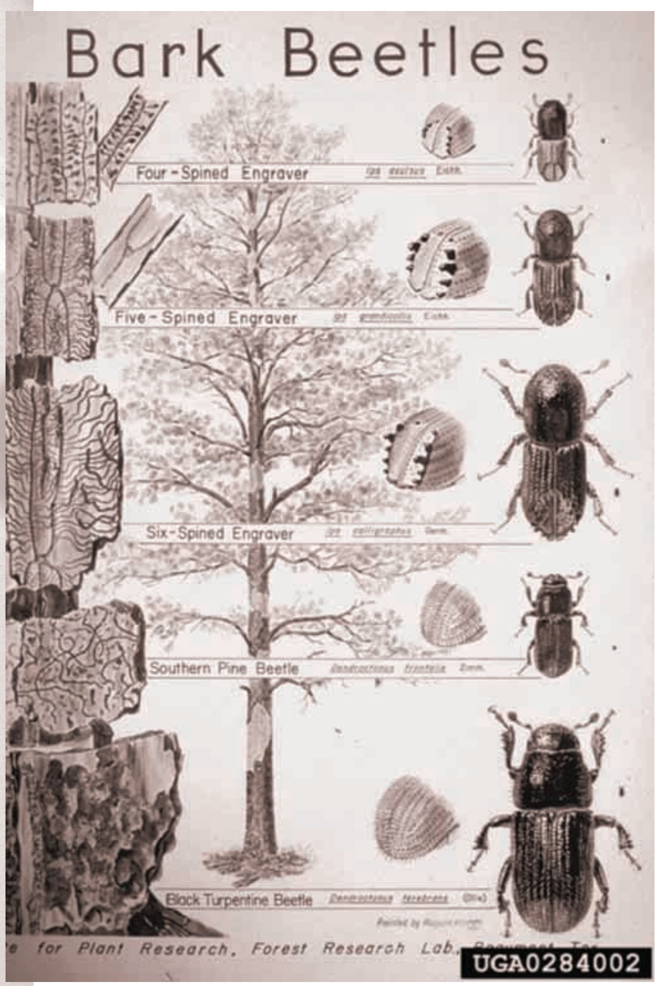

Figure 15.1—Diagram of adults, gallery patterns, and attack sites of the southern pine bark beetle guild (*Ips vulsus*, *I. grandicollis*, *I. calligraphus*, *Dendroctonus frontalis*, and *D. terebrans*). Painting by Richard Kleifoth in 1964, Southern Forest Research Institute, Jasper, TX; photo by Dr. Ronald Billings in 1981, Texas Forest Service, Lufkin, TX.

The use of aerial videography is a relatively new technology. Current uses include aerial surveys to detect SPB spots and the development of hazard ratings for the SPB. Matthews (1998) states that aerial videography at 1,000 feet aboveground level (AGL) proved to be adequate for SPB hazard rating. Because of the resolution limits of video, missions must be flown at about 1,000 feet AGL if individual trees in dense forests are to be detected. There is an added convenience in that the video can be analyzed in an office or laboratory; traditional spotters located spots on sketch maps while flying 500 to 1,000 feet AGL.

Oliveria observed that electronic sketch-mapping has been developed to assist in plotting the locations of infestations during aerial surveys.[2] Selected backdrops (maps or aerial photos) of the survey area can be loaded into a laptop computer. The computer is linked to an onboard GPS system and a touch-sensitive screen. During the survey flight, the computer uses the GPS to display the proper backdrop while indicating the plane's location relative to the ground. The spotter plots observed infestations by touching their locations on the display screen. The data are downloaded into a Geographic Information System (GIS) Program, and maps with spot coordinates are produced.

MANAGEMENT

Integrated pest management (IPM), integrated forest pest management (IFPM), forest health protection (FHP), forest health (FH), and forest resource protection (FRP) have slightly different philosophies, but they all have the goal of protecting and sustaining forest resources (Nebeker 2003). Ecosystem management also has much to offer, but sometimes fails to include consideration of pest problems (Boyce and Haney 1997). Continuing changes in our society and individual views of how forest resources are to be utilized or not utilized directly impact management options. For example, some view certain forest conditions as threatening or unhealthy, while others see the same conditions as healthy or just the natural course of events. The potential for forest fire can be seen in this way. These differing points of view are based on individual

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or organizational agendas (Allen 1994, Boyce and Haney 1997). Reconciling different points of view is one of the most difficult tasks we face in the protection of our natural resources.

The Expanded Southern Pine Beetle Research and Application Program and the IFPM Program were administered by the U.S. Department of Agriculture Forest Service (Forest Service) out of Pineville, LA, during the 1970s and 1980s. These programs provided an opportunity to gain a great deal of new information concerning the SPB, as well as for *Ips* and BTB. The technology transfer efforts associated with these programs provided a structure for getting pest management information into the hands of users as quickly as possible. Efforts such as these have shown that communication and distribution of information are critical for control and management purposes.

Recently an extremely useful tool for the management of bark beetles has been evolving on the World Wide Web (WWW). Financial resources have become a limiting factor in providing printed material for distribution, and the Web has developed into an outstanding addition to that end. The Web site (http://whizlab.isis.vt.edu/servlet/sf/spbicc/) of the Southern Pine Beetle Internet Control Center (SPBICC) has become a source for SPB information, control strategies, research, and other ongoing activities. This site also supports communication among persons whose work involves southern pine bark beetles. For example, CONTACT _Con-49F8B1C38C Steve Clark (U.S. Department of Agriculture Forest Service, Lufkin, TX) has summarized an IPM Program for the SPB that can be accessed on the SPBICC at http://whizlab.isis.vt.edu/servlet/sf/spbicc/page.html?name=spb_IPM. This program draws together currently available approaches and new investigations. Appropriate links are included to provide additional information about the various control and management options. Information about SPB activity is posted on the SPBICC site as it becomes available. Another site, http://bugwood.org/, contains valuable information about bark beetles and related insects. It also presents a wealth of related information about FH and FHP issues. One can also refer to numerous Web sites at universities, follow the appropriate links, and find needed information. An example of a university site having links to useful sites is http://msstate.edu/~nebekers/. The WWW has become an extremely useful tool for communication and technology transfer. With such information, informed decisions can be made and appropriate strategies can be followed.

We have, for a number of years, recognized various management strategies and tactics that are available when dealing with bark beetles. One option is to do nothing. If we take this approach, we can expect history to be repeated: we can expect periodic outbreaks as a result of population fluctuations, and we can expect that the amount of pine mortality in our forests will reflect past trends. However, with increases in acreage of host type, we might predict proportional increases in bark beetle activity and tree mortality.

Prevention is another management strategy we are beginning to understand. To prevent losses to southern pine bark beetles, we must follow a few guiding principles (Nebeker and Hedden 1984). These principles include (1) matching the tree species to the right site—trees planted on the wrong sites seldom have the vigor necessary to deter or withstand attack; (2) controlling stand density—if a stand's basal area exceeds the site index, then the stand should be thinned to the appropriate level; (3) promptly salvaging all lightning-struck, logging-damaged, diseased, and high-risk trees, and harvesting overmature trees when pest activity is low; (4) planting trees only in their natural range—planting pines outside their range and offsite causes additional stress that increases their susceptibility to attack; (5) minimizing site and stand disturbances—exercising care in use of heavy equipment, road layout, culvert location, and other construction projects since changes in drainage result in tree stress; and (6) harvesting all mature trees at, or shortly after, rotation age. The use of good silvicultural practices reduces the likelihood of insect attack. Good silviculture can reduce losses from SPB (Belanger and Malac 1980).

Hazard rating and thinning have tremendous practical value but have not been fully utilized. Hazard-rating systems have been developed for most subregions of the South (Mason and others 1985). They identify the combinations of site and stand conditions commonly associated with SPB infestations. They also identify the conditions under which SPB is most likely to occur and where the greatest amount of damage would be expected. Hazard ratings do not predict when, or if, an attack will occur, but they do provide information that managers should find useful in identifying and ranking locations or stands that warrant consideration for increased surveillance, preventive treatment, accelerated suppression action, or postdamage appraisal (Hicks and others 1987). Most hazard-rating systems include variables that can be altered silviculturally.

High-hazard stands can be converted to medium-hazard or low-hazard stands through silvicultural treatments that alter parameters such as stand density, basal area, or radial growth.

Thinning, like hazard rating, has often been overlooked as a method of reducing the amount of suitable habitat for the SPB during periods of low populations. Thinning has the potential of affecting the overall population dynamics of the SPB when applied over the landscape. Numerous studies have indicated that thinning is useful in reducing the susceptibility and suitability of stands to SPB attack (Brown and others 1987; Nebeker and Hedden 1984; Nebeker and Hodges 1983, 1985; Nebeker and others 1985). Traugott (2000) indicated that it is important to thin at the appropriate time for the following reasons: (1) to retain high-quality trees, (2) to receive an intermediate income, (3) to enhance wildlife habitat, and (4) to maintain the health and vigor of the stand and, thus, reduce the severity of losses caused by southern pine bark beetles.

In 2001, the Forest Service allocated funds to cooperating State agencies for southern pine bark beetle prevention work. Prior to this, funds had been allocated only for suppression. The move to initiate prevention efforts came as a result of Forest Service efforts to develop nationwide risk maps and to utilize these maps in setting priorities for addressing problems associated with changing FH conditions. FHP (Forest Service) strives to reduce impacts of insects and diseases by implementing pest suppression and prevention projects on national forests and on other Federal, State, and tribal lands. SPB risk can be reduced by early detection and rapid control of spots, which reduces additional mortality caused by spot growth. Thinning helps maintain vigorous, healthy stands resulting in a reduction of habitat for attack and spot growth. It is hoped that practitioners of FRP will welcome this movement toward prevention rather than relying only on suppression strategies and tactics.

Under circumstances in which prevention is not the management strategy of choice, there are other options. They include both direct and indirect methods of control and management that are available or evolving. Direct control measures result in immediate mortality to the bark beetle population. There are four basic direct control tactics: (1) salvage—infested trees and an appropriate buffer strip (uninfested trees) are sold, cut, and removed; (2) cut and leave—infested trees are felled toward the center of the spot to allow for maximum exposure of the infested portion of the bole to the sun; (3) cut, pile, and burn—infested trees are felled, pushed into a pile, and burned; and (4) cut and spray—trees are felled, and their boles are sprayed with an approved insecticide. It appears, however, that it may not be possible to use insecticides to control pine bark beetles in the future. Only lindane and chlorpyrifos are now registered for use in forest operations. Lindane is registered but is not presently available with a label for forestry use. Existing supplies of lindane are disappearing, or have disappeared, and the product will be discontinued within the next few years. However, the manufacturer of a chlorpyrifos-based compound has consented to maintain a forestry registration and is reregistering its product. The manufacturer will not initiate production of the forestry-labeled product until they can determine that there is a demand for it. Also, chlorpyrifos is now a restricted-use pesticide and can be purchased and applied only by certified applicators or persons under their supervision. Other compounds, such as bifenthrin, are being studied as possible alternatives. Direct control tactics other than insecticides will be recommended when immediate mortality to the bark beetle population is the goal. Cut, pile, and burn methods will have limited use because of their cost and the problems associated with smoke.

New approaches to managing bark beetles are always being investigated. For example, verbenone, an antiaggregation compound, has been registered in North Carolina, South Carolina, Mississippi, and Georgia and can be used to suppress SPB. Specialized training is necessary to ensure that the product is used correctly. A Web site, http://everest.ento.vt.edu/~salom/Workshop/workshop.html, has been established for those interested in following this effort. Other strategies and tactics are also being investigated to suppress bark beetle populations by the use of various compounds that have been found to repel or attract bark beetles, but have not yet been registered for use.

BIOLOGICAL CONTROL

Consideration of biological control in relation to the southern pine bark beetles has largely been ignored, especially in relation to intensive pine plantation management systems. Pine trees grown in a monoculture usually create a forest that has less plant and animal diversity than a natural pine forest. In such settings plant diversity is low, and nectar sources for the parasites of bark beetles are limited. Hence, the community of SPB natural enemies is potentially reduced in pine plantations and is therefore less likely to be effective against SPB populations in such settings. In addition, direct control techniques recommended for controlling bark beetles are aimed at killing or disrupting the colonization process, and these techniques also damage natural enemy communities.

Research has discovered that supplemental feeding of SPB parasitoids increases their egg production and longevity (Stephen and Browne 1999). This suggests that providing food for parasitoids can increase parasitism of SPB. A new product has been developed for application to boles and crowns of pines infested with SPB (Stephen and Browne 2000). The use of this new product should conserve and promote parasitoid populations and increase their effectiveness.

It is important to maintain communities of natural enemies. Simple things, such as not cutting trees vacated (used and abandoned) by SPB when implementing direct control tactics is a good strategy. Many of the natural enemies do not complete their life cycle until after the SPB has vacated the tree. Vacated trees also provide nesting habitat for woodpeckers that prey on bark beetles. Our society has emphasized and will continue to emphasize the need for protecting the environment and the need for increasing species diversity whenever possible. Hence, there is a need to expand our efforts in the area of biological control, concentrating on methods that increase biodiversity without harming the environment. It may be possible in the future to plant flowers in or near pine stands to provide nectar that will increase the life span of adult parasites associated with the southern pine bark beetle guild.

As we learn more about the nutritional requirements of the natural enemies of SPB, we must also understand their population dynamics. Progress has been made in this area. For example, it has been hypothesized (Turchin and others 1999) that SPB outbreaks are controlled by a delayed density-dependent response from natural enemies. Augmenting natural populations of predators, parasitoids, and competitors may accelerate the decline of SPB epidemics. In addition, mass-rearing techniques are being developed for one of the key predators of the SPB, the checkered clerid beetle [*Thanasimus dubius* (F.)].[3] Releasing a mass-reared predator would be another option in attempting to manage bark beetle populations.

Recently, new mortality agents have been discovered in association with the SPB. Sikorowski and others (1996) were the first to discover and describe virus and viruslike particles in SPB adults from Mississippi and Georgia. It is believed that this is the first record of viruses associated with SPB and *Dendroctonus* (Coleoptera: Scolytidae) in general. Sikorowski and others (1996) hypothesize that viruses associated with SPB may be an important means of naturally controlling SPB populations and useful in explaining population cycles. Future research will examine this hypothesis.

CONCLUSIONS

It is anticipated that there will be major advances in survey and detection in the future. These advances will involve the use of remotely sensed data obtained from satellites and various other platforms. High-resolution imaging systems are in place or are planned, and accompanying techniques to identify key features on the landscape, such as SPB spots, will become another part of our detection system. Processing imagery of large landscapes will become automated and increase our efficiency in identifying the boundaries of infestations.

FRP of the future will be aimed more and more at prevention. Initial steps have already been taken through the development of hazard- and risk-rating systems. These systems identify areas that are likely to be attacked by bark beetles. This information then becomes part of the decisionmaking process by identifying the areas that should be treated first to reduce the hazard. Hazard-rating information can then be used in connection with other criteria specified in a forest management plan to make a final decision. Hazard-rating systems provide various options for reducing hazard through silvicultural means and become part of a prevention management program. Various decision-support systems that can help us deal with southern pine bark beetles can be accessed through the SPBICC.

We may soon be unable to use any insecticides in our forests. At present, there is effectively only one insecticide labeled for forest uses, and there are no new insecticides on the horizon. Hence we will be dependent on the other direct tactics, such as salvage or cut-and-leave operations, when trying to suppress southern pine bark beetle populations. The practicality of salvage

[3] Personal communication. 2002. John D. Reeve, Assistant Professor, Department of Zoology, Southern Illinois University, Carbondale, IL 62901–6501.

and cut-and-leave tactics is limited by the difficulty or impossibility of finding markets for salvaged trees. Because of these limitations, more and more emphasis will be placed on prevention tactics.

There is hope that new approaches may prove useful. These include the use of antiaggregation compounds that disrupt the bark beetle colonization process. The WWW will be a useful tool for distributing information concerning this approach and other developments in the management of bark beetle populations. New paradigms will influence our decisionmaking process, especially as our understanding of ecological processes improves and helps us to identify and document the key factors regulating bark beetle populations.

We stand at an interesting point in history, one at which we have become much more aware of the environment around us. We have an increased desire to participate in resource management processes that limit adverse environmental change. Such processes include efforts to restore and rehabilitate forests and to conserve our natural resources.

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