The Southern Pine Beetle Prevention Initiative: Working for Healthier Forests

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ABSTRACT

The southern pine beetle (SPB) is the most destructive forest pest in the South. After a recent SPB outbreak, the US Forest Service (Forest Health Protection and Southern Research Station [SRS]) received SPB Initiative (SPBI) funding to focus more resources on proactive SPB prevention work. This funding is being used for on-the-ground accomplishments, landowner education, and research and development. Since 2003, on-the-ground accomplishments have totaled over 500,000 ac of thinning and restoration work on state, private, and national forestland. The SRS (SRS Research Work Unit 4552) has worked, internally and externally, on projects addressing (1) the risks and costs of SPB, (2) preventing and controlling SPB outbreaks, and (3) recovery from SPB outbreaks. Much work has been accomplished through the SPBI and will hopefully have a long-lasting impact. This article describes the history, current practices, and the accomplishments for the first 6 years of the SPBI.

Keywords: bark beetles, forest management, cost-share incentives

The southern pine beetle (SPB; *Dendroctonus frontalis* Zimmerman; Fig. 1) is the most destructive insect pest of pines throughout the South, ranging from New Jersey to Florida and west to Texas and Oklahoma (Thatcher and Barry 1982, Clarke and Nowak 2008). The SPB can also be found in Arizona, Mexico, and parts of Central America (Thatcher and Barry 1982, Clarke and Nowak 2008). Although all southern pines may serve as hosts for SPB, loblolly pine (*Pinus taeda* L.) and shortleaf pine (*Pinus echinata* Mill.) are considered most susceptible (Thatcher and Barry 1982, Clarke and Nowak 2008). From 1999 to 2003, SPBs caused unprecedented damage to pine forests in Alabama, Florida, Georgia, Kentucky, North Carolina, South Carolina, and Tennessee (Coulson et al. 2004, Nowak 2004). Almost a million acres on private farms and forests, industry lands, state lands, national forests, and other federal lands were affected (Nowak 2004). The estimated $1 billion in economic losses severely impacted the natural resource base that supports the South's tourism and wood-based manufacturing industries. In addition, SPBs destroyed forests that served as habitat for threatened and endangered species, such as the red-cockaded woodpecker (*Picoides borealis* [Vieillot]). In the aftermath of large infestations (Fig. 2A), dead and downed trees (Fig. 2B) provide abundant fuel for wildfires and pose additional threats to transportation corridors and public safety (Coulson and Stephen 2006). These factors and a renewed desire for more proactive management leading to healthier forests contributed to the creation of the SPB Prevention and Restoration Program administered by the US Forest Service.

In July of 2001, the National Association of State Foresters issued a Policy Statement titled "*Southern Pine Beetle: A Time for Action to Protect the South's Forests*," which included a proposal by the US Forest Service for a comprehensive strategy to deal with current and future SPB infestations in the southern United States. (National Association of State Foresters 2002). The strategy consisted of seven components: (1) continued suppression using current methods, (2) mitigation of future epidemics by making existing forests more resistant, (3) restoration of forests impacted by SPBs, (4) assistance to communities affected by SPB epi-

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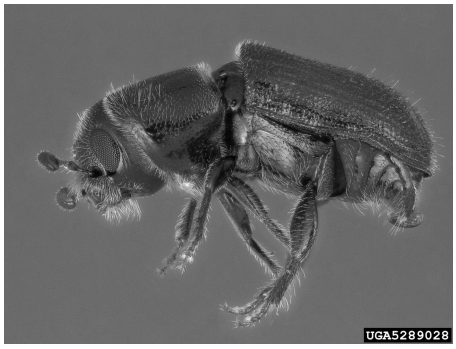

Figure 1. Southern pine beetle. (Photo by Erich G. Vallery [US Forest Service], Bugwood.org.)

Figure 2. Pine forest after southern pine beetle outbreak. (Photos by Ronald Billings, Texas Forest Service.)

demics to protect jobs and to develop the infrastructure necessary to employ effective SPB control and prevention techniques, (5) funding for implementing the program, (6) funding for education of forest landowners and the public, and (7) conducting research to support suppression, prevention, and restoration activities.

Two years later, the US Forest Service and the Southern Group of State Foresters developed a program that very closely followed the recommendations given in 2001. The US Forest Service Forest Health Protection (FHP) unit and the Southern Research Station (SRS) have been funded through SPB Initiative (SPBI) funds to cooperatively focus more on SPB prevention work. FHP has developed the SPB Prevention and Restoration Program and is working with 12 national forests and all 13 states in the southern region. The SRS Research Unit 4552 ("Insects, diseases, and invasive plants of southern forests") is working to enhance our basic understanding of SPBs, its population dynamics, and the best management strategies for preventing and suppressing outbreaks.

The SPB Prevention Initiative

Funding for the SPBI has totaled $73 million since 2003, making it one of the larger federal bark beetle prevention programs in the history of forest health management. Of the total SPBI funding, FHP has allocated nearly $70 million to state forestry agencies and national forests during federal fiscal years 2003–2008 through the SPB Prevention and Restoration Program (Fig. 3). State forestry agencies have received about $48 million of this funding to implement the program. These state cooperative funds are leveraged through a 50% cost share so that each federal dollar is matched by a state or private dollar. State forestry agency funds are being used to manage nonindustrial private forests (NIPF) and state-owned land, educate landowners about the impacts of SPB and the need to maintain healthy forests to prevent SPB infestations, and to develop and use SPB hazard-rating systems. In addition, FHP has allocated $20.5 million (of the $73 million of SPBI) to 12 national forests to thin high-hazard pine stands and restore forests previously impacted by SPBs, including all the necessary environmental assessment work. In the past 6 years, SRS-4552 has awarded and managed over 60 cooperative agreements totaling over $3 million to increase our understanding of the SPB and our ability to reduce its negative impacts.

Program Implementation

There are three basic fund allocation streams for program funding: on-the-ground accomplishments, landowner education, and research and development. Funds are allocated and prioritized based on past performance and SPB risk. Risk, in this case, is defined as forested areas where the SPB has caused large amounts of tree mortality in the past and/or is expected to cause large outbreaks in the future, and based on

amount of high-hazard host type (typically overstocked monocultures of pine). Although, on a regional basis, SPB populations have declined since 2003, outbreaks occur within individual states, and epidemic populations are expected again (especially based on the numerous high-hazard stands that remain as estimated by the 2006 National Insect and Disease Risk Map [Krist et al. 2007]). According to Krist et al. (2007), there are currently 8.4 million ac of pine forests in the South that are at risk of having 25% or more of the standing live basal area (BA) greater than 1 in. in diameter killed by SPBs in the next 15 years. The impact of future outbreaks in these high-hazard stands can be significantly reduced through healthy forest management.

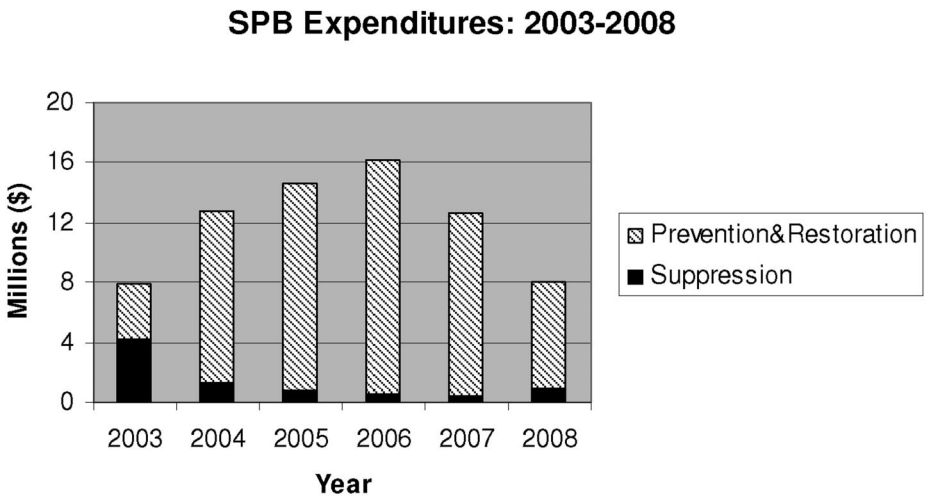

Figure 3. Forest Health Protection southern pine beetle (SPB) prevention and suppression funds by year allocated to 12 national forests and 13 southern states.

On-the-Ground Accomplishments. Although new strategies to combat exotic invasive insects must be developed rapidly (Hain 2006), integrated pest management techniques for bark beetles have been available for some time (Clarke 2003, Fettig et al. 2007). Forest managers and forest health specialists commonly believe that the most effective method of managing SPBs is through preventing outbreak populations and creating forest conditions that lessen impacts once outbreaks occur (Thatcher et al. 1980, Belanger et al. 1993, Clarke 2003). Stand structure is thought to be one of the most critical factors in determining the chances of spot initiation and the rate of spot expansion within a stand. Thinning is the preferred forest management tool used to attain desired stand structures, and it is widely recommended that stands with a BA greater than 120 ft^2/ac should be thinned below 80 ft^2/ac (Belanger and Malac 1980). Planting the appropriate tree species for the site at proper densities and maintaining a vigorously growing stand through timely thinning represents the best strategy for reducing the impact of bark beetles (Clarke 2003). Unfortunately, these management practices are often not followed for a variety of reasons, including the prevalence of poor local market conditions for southern yellow pine, landowner objectives or lack thereof, rapid changes in landownership patterns, and resistance by forest managers to change current practices.

A major focus of the SPB Prevention Program is to distribute a high percentage of the funding to NIPF landowners for on-the-ground accomplishments through cost-share dollars (Table 1). Cost-share incentives increase the amount of work accomplished by sharing the financial responsibility with landowners and by giving state foresters and private forestry consultants the opportunity to discuss healthy forest management options with landowners. Often, cost-share incentives lead to additional acres treated beyond the cost-share plan. Since the beginning of the program in 2003, nearly 40% of the cooperative forest health funding has been obligated to landowners to accomplish thinning and restoration work (Table 1). This work has led to the treatment of about 400,000 ac by nearly 6,000 landowners in 10 states.

A good example of how the cost-share program works at the individual state level is provided by the Florida Division of Forestry (FDOF). The FDOF cost-share program for NIPFs includes precommercial pine thinning, first pulpwood thinning, and prescribed burning. The FDOF encourages planting species that are less susceptible to SPB (i.e., longleaf, *Pinus palustris* Mill., and slash pine, *Pinus elliottii* Englem.) on appropriate sites but does not cost share any regeneration treatments on NIPF lands. Cost-share rates for precommercial thinning and prescribed burning are 50% of the cost, not to exceed $50 and $8/ac, respectively. The FDOF pays a flat rate of $50/ac for a first pulpwood thinning. Since 2003, the FDOF has completed or approved contracts for more than 300 landowners totaling more than 30,000 ac, and they have also funded thinning and restoration treatments on more than 6,500 ac of state land.

Precommercial and First Thinning. Thinning is the preferred practice for reducing a forest stand's susceptibility to SPBs and thus constitutes the predominant strategy of prevention efforts (Fig. 4). It is well documented that thinning stands to a threshold of about 80 ft^2/ac of BA decreases the frequency and severity of SPB infestations (Belanger and Malac 1980; Nebeker 1981; Nebeker and Hodges 1983, 1985; Nebeker et al. 1983; Brown et al. 1987, Fettig et al. 2007). Thinning reduces intraspecific competition and provides trees with enhanced ability to ward off SPB attacks via increased resin flow. SPB spots are unlikely to grow in stands that have an intertree distance greater than 20 ft (Gara and Coster 1968), and reducing stand density through thinning will likely disrupt SPB pheromone communication by increasing the amount of air flow within the stand (Thistle et al. 2004, 2005).

Program guidelines set targets to thin down to at least 450 stems/ac for precommercial thinning and to a BA of 80 ft^2/ac ($\pm$15%) for first thinnings. In the first 4 years of the program, 200,750 ac were treated under program guidelines and there are an additional 55,000 ac scheduled for treatment in 2008. Thinning is best accomplished during periods when SPB populations are low. Fortuitously, SPB populations have been relatively low regionally since the inception of the program. This respite from wide-scale outbreaks has provided a window of opportunity to get as many acres thinned as possible.

The Texas Forest Service (TFS) provides an excellent example of how a cost-share incentive for thinning can work effectively (Billings et al. 2006). Since 2003, the TFS has signed up over 700 landowners to thin (precommercial and first) more than

Table 1. Southern Pine Beetle Prevention and Restoration Program state cost-share programs at a glance.

State	Total funding (2003–2008) ($)	Accomplished and planned acres[a]	Obligated cost-share funding (2003–2007) ($)	Cost-shared acres treated	No. of landowners	Cost-share program	First thinning	Precommercial thinning	Prescribed burning	Restoration planting
Alabama	4,500,000	29,548	948,129	22,548	366	Y	Y	Y	N	Y
Arkansas	3,600,000	41,519	1,455,612	26,519	519	Y	Y	Y	Y	Y
Florida	3,400,000	59,341	1,180,438	49,341	441	Y	Y	Y	Y	N
Georgia	6,750,000	150,931	3,680,000	126,931	1,694	Y	N	Y	Y	Y
Kentucky	1,100,000	500	0	0	0	N	N	N	N	N
Louisiana	950,000	20,293	304,395	20,293	189	Y	N	Y	Y	N
Mississippi	1,724,619	5,000	0	0	0	Y	Y	Y	N	N
North Carolina	10,325,000	40,302	1,961,848	25,302	640	Y	N	Y	N	N
Oklahoma	200,000	2,500	0	0	0	Y	N	Y	N	N
South Carolina	6,275,000	33,970	1,427,275	25,970	400	Y	N	Y	Y	Y
Tennessee	4,400,000	41,186	2,853,806	38,686	733	Y	N	Y	N	Y
Texas	5,750,000	68,812	2,935,297	50,812	706	Y	Y	Y	N	N
Virginia	2,275,000	20,958	774,225	14,958	304	Y	N	Y	N	Y
ALL States	51,249,619	514,860	17,521,025	401,360	5,992	—	—	—	—	—

Note: Funding and total accomplishments include 2003–2008 numbers.
[a] Include approximately 111,000 ac planned for treatment in 2008 and work completed on state-owned forest that was not part of landowner cost-share program.
N, no; Y, yes.

Figure 4. Stand thinned as part of the Southern Pine Beetle (SPB) Prevention and Restoration Program in an effort to lessen the impact of the SPB. (Photo by Ronald Billings, Texas Forest Service.)

50,000 ac of young pine stands susceptible to SPB infestations. Special emphasis is placed on reducing SPB hazard through thinning cost shares in counties that the TFS has identified as moderate to high hazard for SPBs. These practices are limited to $8,500/landowner per year or $17,000/year for trusts and partnerships. The TFS cost-share program pays 50% of the costs for precommercial thinning up to $75/ac, plus up to $10/ac for any consulting forester fees. For the first thinning of merchantable pulpwood stands, approved landowners receive a flat $50/ac and up to $10/ac for consulting forester fees, in addition to any profits made on the sale of the harvested pulpwood. As of May 1, 2007, cost-share rates increased to $80/ac for first thinning of targeted stands in 10 counties within southeast Texas and $100/ac for private forest stands within 5 mi of a national forest in Texas. These increased rates are designed to increase thinning of beetle-prone stands in counties where SPB activity has historically been high, yet current pulpwood prices are below the state average. Annual maximum fees in these situations also have been increased to $10,000 and $20,000/year for individuals and partnerships or trusts, respectively. In the case of pulpwood stands, the cost-share match is provided by multiplying the tons of pulpwood harvested by $18/tn, the average statewide cost in Texas to cut and remove the pulpwood. Thus, thinned pulpwood tracts must yield at least 3–6 tn of harvested wood per acre to match the $50–100 of cost shares per acre paid to the landowner.

Restoration. Restoration is one of the main cost-share incentive forest management treatments because thousands of acres were impacted by SPBs in the last major outbreak. Restoration efforts include replanting lower-density stands on SPB-impacted sites and planting less susceptible species such as longleaf pine on appropriate sites (Fig. 5). Program guidelines set a maximum planting density of 550 stems/ac (approximately 8 × 10-ft spacing) for all pine species. This is a lower density than has been used historically when and where maximizing timber production is the overriding priority. Past planting densities reflected higher anticipated seedling loss because of poorer seedling storage, handling, and planting practices as well as less genetically improved planting stock compared with what is commonly seen today. With many plantings realizing 90% seedling survival or better (Creighton 2007a, Fox et al. 2007), those that exceed 550 trees/ac can often quickly

Figure 5. Stand planted with longleaf pine, a less susceptible species to southern pine beetle (SPB), as part of the SPB Prevention and Restoration Program.

become overstocked because of volunteer pines that seed in naturally (Scrivani 2007).

A recent Virginia Department of Forestry (VDOF) study concludes that low-density (less than 350 trees/ac) planted stands of loblolly pine are healthier, have less intraspecific competition, are more vigorous, and are less susceptible to bark beetles and other pests (Bowman et al. 2005, Creighton 2007a). In addition, lower density plantings usually preclude the need to perform a precommercial thinning (in the absence of extensive natural reseeding) and provide landowners with longer time periods to thin before live crown ratios start to decrease (Clarke 2003). It was shown that planting on a 9 × 14-ft (346 trees/ac) or 10 × 14-ft (311 trees/ac) spacing, likewise, eliminates the need to remove rows for roads (allowing for a true selective thinning; Bowman et al. 2005, Creighton 2007a). However, the authors caution that planting fewer trees per acre greatly increases the importance of ensuring that seedlings are planted correctly. In the first 4 years of the program, 72,753 ac were planted southwide under program guidelines and an additional 20,000 ac were scheduled for planting southwide in 2008.

The VDOF is also actively involved in restoring longleaf pine to southeast Virginia via the cost-share program and is cooperating with the Virginia Department of Conservation and Recreation–Division of Natural Heritage to reestablish longleaf pine native to Virginia on private land, state forests, and state natural area preserves. Early results from a test comparing Virginia longleaf pine with provenances collected from North Carolina, South Carolina, Mississippi, Alabama, Georgia, and Florida show that Virginia longleaf seedlings generally have lower mortality, less time spent in the grass stage, and greater average height than the other strains (Creighton 2007b, Lojewski 2008). Private landowners who reestablish longleaf on their property are eligible for 60% cost sharing, not to exceed $10,000/landowner per year. This money can be used for site preparation, planting, and burning costs.

Prescribed Burning. Prescribed burning is a forest management tool commonly used in southern pine forests to reduce understory competition. It can be used to treat large areas at a relatively low cost relative to mechanical treatments (McNab 1977). Still, limited literature exists on the relationships between prescribed burning and bark beetles in the eastern United States, including SPBs. Prescribed fire to reduce competition may influence the stand's microenvironment and help lead to the disruption of the pheromone plume in the stand, as discussed by Thistle et al. (2004, 2005). However, Cameron and Billings (1988) found that prescribed burns in pine plantations less than 10 years of age were associated with increased incidence of SPB infestations in East Texas. Other studies have looked at the influences of prescribed fire on subsequent activity of bark beetles (Santoro et al. 2001, Sullivan et al. 2003). Boyle et al. (2004) as part of a larger National Fire and Fire Surrogate Study, looked at the effects of prescribed burning and thinning on SPBs caused tree mortality and resin flow. The authors did not show significant differences related to treatment in SPBs caused mortality. Additional studies are needed to understand the complex interactions between prescribed fire and bark beetle activity.

In the first 5 years of the program, about 120,000 ac were prescription burned on state and private lands. There will be an estimated 33,000 ac treated under this practice in 2007. Prescribed burning is also a standard site preparation treatment for establishing and propagating fire-dependent species such as longleaf pine. The value of prescribed burning for directly reducing SPB hazard remains unclear; therefore, some southern forestry agencies do not include this practice among the cost-share eligible treatments for SPB prevention.

National Forests. Nearly 95,000 ac of SPB prevention practices have been completed on National Forest System lands since 2003, and there are an additional 12,000 ac planned to be treated in 2008. This figure is in addition to prevention work being completed on state and private forestlands. The work includes restoration of areas impacted by the most recent SPB outbreak, especially shortleaf and table mountain pine (*Pinus pungens* Lamb.) stands in eastern Tennessee and western North Carolina, and both precommercial and first thinning in high forest health priority areas. There has been considerable effort to integrate SPB prevention work with other national forest objectives, including fire-hazard reduction, red-cockaded woodpecker habitat protection, and timber stand improvement.

Treatment Area Prioritization. To maximize the impact of this program on a regional scale, significant efforts have been made to target areas where medium and high-hazard stands are most concentrated. For example, Florida, North Carolina, and Texas use hazard maps to preferentially treat stands only in areas considered high hazard and have experienced significant SPB outbreaks in the past. Other states prioritize based simply on need and areas that have experienced past SPB outbreaks. However, there are attempts to improve this process for all the states involved. A regional 30-m resolution SPB hazard map has been devel-

oped with the intent to prioritize prevention treatments in areas with the largest quantity of high-hazard stands. These maps will help forest managers select areas of the state that should be a priority and individual stands within the larger areas that need to be targeted first. This targeted approach will help ensure the program goal of having regional impact, not only helping individual landowners. A regional impact is possible if the SPB Prevention Program goal of 2 million ac in 15 years is reached, relative to the 8.4 million ac determined to be at risk according to the 2006 National Insect and Disease Risk Map (Krist et al. 2007).

Landowner Education. Many landowners in the South are unaware of SPBs as a source of timber loss or have little interest in limiting SPB impact (Molnar et al. 2003, Mayfield et al. 2006). Sixty-six percent of the forestland east of the Mississippi is considered NIPF and the average parcel size is 17 ac (Molnar et al. 2003). About 60% of the landowners with less than 15 ac are slightly aware to unaware that SPBs are a source of timber loss, about 50% have slight or no interest in limiting SPB impacts, and 82% do not have a forest management plan (Molnar et al. 2003). Larger forest landowners (100 ac) were more likely to have management plans and to have implemented forest management practices (Mayfield et al. 2006). Those who cited discouragements to managing their forestland frequently stated that they did not know where to get help and did not know what management practices to apply.

These studies on landownership demography and landowners' knowledge of SPB-related issues suggest an opportunity exists for enhanced education and outreach. A number of states now have well-developed landowner education programs as part of their SPB prevention programs. For example, the Georgia Forestry Commission has developed educational materials, conducted landowner workshops, and is involved in developing demonstration projects to highlight healthy forest management. Their efforts are substantial and are designed to teach people not only about SPB-related issues, but also the importance of appropriate forest stewardship. Another well-developed landowner education program is provided by the FDOF. The FDOF has developed and distributed a color brochure entitled *Manage Your Forest to Prevent Southern Pine Beetle Damage* (Mayfield et al. 2004). Their foresters have conducted landowner workshops with an emphasis on thinning as a tool for improving forest health. The FDOF also has used billboards (Fig. 6), radio spots, extensive newspaper ads, and magazine ads to promote SPB awareness and management of healthy forests. There has also been a special effort in a number of states to reach traditionally underserved and minority landowners. For instance, the Arkansas Forestry Commission (AFC) has made it a priority to reach "minority and limited resource landowners" through meetings at nontraditional meeting sites, such as churches. The AFC has held several educational meetings and has increased the cost-share rate for minority landowners to encourage their participation. The North Carolina Department of Forest Resources has helped fund a new outreach coordinator position. The coordinator works with the US Forest Service and the SPB Prevention Program to connect with landowners at SPB workshops and with local nonprofit, community-based agencies to help people without forestry backgrounds better understand the utility of forest management practices such as thinning and prescribed burning and their effectiveness for prevention of SPB infestations.

Figure 6. Billboard displayed on highways in Florida, paid for by the Florida Division of Forestry, that is part of the forest landowner southern pine beetle landowner education efforts.

Research and Development. The US Forest Service Research effort around SPBs is contained within the mission of SRS-4552. This Research Work Unit has active (internal and external) projects addressing (1) the risks and costs of SPBs, (2) preventing and controlling SPB outbreaks, and (3) recovery from SPB outbreaks. Key to the efforts of the Unit has been the development of a competitive grants program based on the critical research and development needs identified in a facilitated Cooperative State Research, Education, and Extension Service sponsored workshop (Coulson et al. 2004). The findings of this customer-driven statement of research and development priorities were used to create two competitive requests for proposals. Through peer review (including input from FHP scientists), funds were awarded to SRS, university, private company, and state forestry researchers.

These programs have been effective in making progress in strategic areas, such as the collection of historical SPB damage and outbreak data, extending the record database from 1960–1996 to 1960–2003. Progress has also been made in identifying candidate SPB resistance genes and associating them with high resin flow in loblolly pine. A computer model to simulate SPB population dynamics in stands of loblolly pine will help identify the stand characteristics that are most desirable for preventing SPB spot initiation and growth. Studies are also underway to aid in efforts to restore pine forests in areas previously impacted by SPBs including guidelines for regenerating small patches of SPB-killed forests and restoration planning and evaluation using LANDIS, a model of forest disturbance and succession.

One project that will have an immediate impact on SPB management is the development and release in March 2008 of 30-m resolution SPB stand hazard maps for each of the 13 states in the southern region (FHTET 2008). This effort, supported by the FHP and state funding, was led by members of the US Forest Service, Forest Health Technology Enterprise Team in Ft. Collins, Colorado. The resulting maps were customized for each state to better prioritize and target areas for funding through the SPB Prevention and Restoration Program, as discussed previously. The maps were developed from models that weight variables such as species composition, stand age, BA, drought index, and soil conditions to predict areas that are considered high-hazard areas for SPBs.

Summary/Conclusions

The SPBI has led to thinning and hazard reduction on more than 500,000 ac across the South, education of thousands of landowners about SPB-related issues, and numerous additions to our application and knowledge base about this insect. Accomplishments, to date, will have a long-lasting impact. This has been a welcome shift in the management of this most notable pest, from predominantly reactive (direct suppression) to that of a proactive approach (prevention). Currently, SPB activity is increasing in sev-

eral states including North Carolina, South Carolina, Georgia, Alabama, and Mississippi. This potential outbreak reminds us of the continued need for prevention work on millions of acres in the southern United States. Through the state, federal, and private cooperation outlined in this study, we will be better prepared to deal with this potential outbreak and future outbreaks than we have been previously.

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