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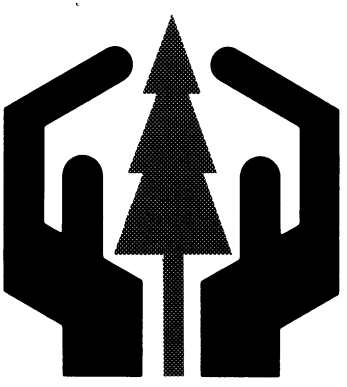
Integrated Pest Management Handbook

Managing Piedmont Forests To Reduce Losses From the Littleleaf Disease–Southern Pine Beetle Complex



Contents

In 1980, the Forest Service and the Cooperative State Research Service of the U.S. Department of Agriculture initiated the Integrated Pest Management Research, Development, and Applications Program for Bark Beetles of Southern Pines. This research/applications effort concentrates on pine bark beetles and associated tree diseases in the South. This is one in a series of Integrated Pest Management handbooks.

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Acknowledgments

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Managing Piedmont Forests To Reduce Losses From the Littleleaf Disease—Southern Pine Beetle Complex

R. P. Belanger, R. L. Hedden, and F. H. Tainter[1]

Introduction

The Piedmont is a geographic region located between the Appalachian Mountains and the Coastal Plain of the southern United States. This strip of rolling flat hills extends 1,000 miles from New York State, through Pennsylvania, Virginia, the Carolinas, Georgia, and into Alabama (fig. 1). At one time or another, most of this land—an estimated 85,000 square miles—was cleared and intensively cultivated for agricultural row crops. Exploitation and neglect of the land depleted the fertility of the soil and led to serious erosion. Wars and depressions forced migration from farms and widespread land abandonment, and forests quickly reclaimed the fields. Of the major species, loblolly and shortleaf pine occupied much of the southern portion of the

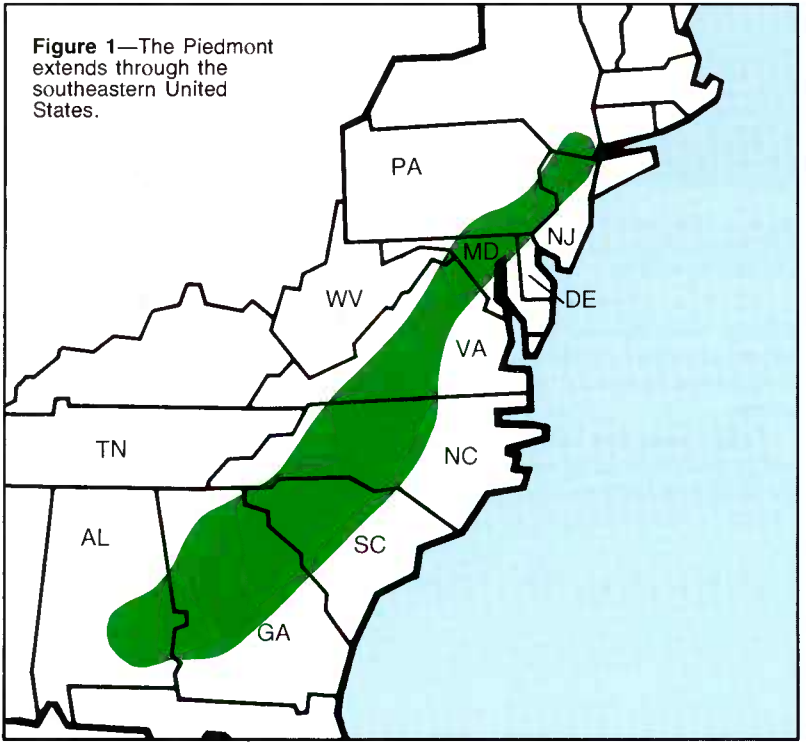

Figure 1—The Piedmont extends through the southeastern United States.

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Figure 2—Many Piedmont forests originated from natural seeding.

Piedmont while shortleaf and Virginia pine and associated hardwoods reforested the central and northern sections.

Today, more than half the Piedmont is in some stage of reforestation (fig. 2). Forest lands are concentrated mainly in the central and southern portions of the region. Farmlands in the northernmost States remain in cultivation. Approximately half the forest acreage is in natural and planted pines while the other half is composed of hardwoods. The pine component contributes significantly to the economy and ecology of the region. Yet the potential productivity of this resource is often reduced significantly because of damage by two pests: littleleaf disease and the southern pine beetle (SPB) (*Dendroctonus frontalis* Zimmermann). Losses to these two pests commonly exceed $150 million a year.

Outbreaks of the SPB in the Piedmont are cyclic in nature, sometimes widespread in distribution, and often spectacular to witness. Losses caused by littleleaf are more subtle, resulting from a gradual decline in stand vigor, reductions in tree growth, and scattered mortality over time. Collectively, they are the most serious forest pests affecting conifers in the Piedmont. Synergistic interactions between the site, fungus, host trees, and the beetle can compound losses. This handbook provides guidelines for recognizing potential littleleaf disease–southern pine beetle problems, describes how the two pests interact, and recommends management practices to reduce losses in the Piedmont.

Recognizing Symptoms

Foresters and landowners should first determine whether littleleaf disease and/or the SPB are already a problem on their lands. Symptoms associated with each of these pests can be easily identified in the field and indicate a need for evaluating the extent of the problems and making management decisions.

Littleleaf Disease

Littleleaf disease rarely affects trees younger than 20 years of age and becomes increasingly severe in older trees. Symptoms of littleleaf (fig. 3) are similar to those commonly associated with nutrient deficiencies. In initial stages, there is a slight yellowing of the needles with a tendency for needle elongation and shoot growth to be less than normal. The reduction in crown vigor is reflected by a decline in tree growth.

In later stages, crowns of trees have sparse and tufted foliage resulting from the annual reduction in needle and twig growth. Foliage of severely damaged trees is a yellow-green color especially visible during fall and winter. Stressed trees produce heavy cone crops consisting entirely of undersized cones with a high percentage of infertile seeds. At this point, tree growth has all but ceased.

The typical diseased tree dies within 6 years after initial symptoms become evident; however, some may survive for up to 15 years. Decline and mortality occur sooner for shortleaf pine than for loblolly pine.

Southern Pine Beetle

The southern pine beetle attacks all species of pines, but prefers shortleaf and pitch pines in the Piedmont. Most forest landowners are familiar with the symptoms of SPB infestation (Thatcher and Connor 1985). The first obvious symptom of attack is a fading of the tree crown from green to yellow. In advanced stages of infestation (fig. 4), crown foliage turns completely red or brown. On closer examination, popcorn-size lumps of pitch (pitch tubes) may be visible at tree heights up to 60 feet. Examination of the inner bark will disclose small S-shaped tunnels (egg galleries) made by SPB adults. These galleries are filled with a sawdust-like material (frass) left behind by the feeding adult beetles.

Figure 3—The shortleaf pine in the center shows characteristic symptoms of littleleaf disease.

Figure 4—Shortleaf pine killed by southern pine beetles.

This feeding girdles the pine. Blue-stain fungi, introduced by the beetle, penetrate into the sapwood and cut off the normal flow of moisture and nutrients through the tree. The combined effects of beetle feeding and fungal penetration lead to the death of the tree.

Guidelines are available to detect SPB spots (infestations) from the air and ground (Billings and Pase 1979; Billings and Doggett 1980; Billings and Ward 1984). Ground checks can also be used to determine whether stands are being damaged by littleleaf disease. Forest managers and landowners may not be familiar with the interactions of the two pests and methods of evaluating problem sites for the likelihood of littleleaf and/or SPB occurrence (risk), chance of SPB spot growth (hazard), and potential for timber loss. Yet, this information is important for selecting appropriate management strategies and practices for minimizing losses caused by both pests.

Littleleaf Disease-Southern Pine Beetle Interactions

Soil, tree, and stand conditions have to be considered collectively and sequentially in understanding littleleaf-SPB interactions. Littleleaf disease results from the gradual killing of functional feeder roots by the parasitic soil fungus *Phytophthora cinnamomi* Rands and *Pythium* spp. There is a close association between the occurrence of littleleaf disease and certain soil characteristics. Littleleaf is most common and severe on sites that are heavily eroded and contain a high percentage of heavy, plastic clays in the surface soil (fig. 5). Clay soils limit aeration, bind nutrients to soil particles, and contribute to extremes in soil moisture available to plants. These conditions restrict root development and, in turn, contribute to the onset of root diseases. Diseased roots cause physiological stress and a reduction in growth, particularly during periods of drought or excess rainfall.

It is important to note that SPB attacks are most closely associated with potential littleleaf sites. The actual presence of diseased trees does, however, further complicate the problem. "Locus" trees — those first attacked and preferred by the SPB — appear to be dominant and codominant trees with root systems in the beginning stages of decline. Trees in advanced stages of decline are seldom killed by the SPB. It appears that moisture and nutrient supply in these trees may be unsuitable for beetle brood production.

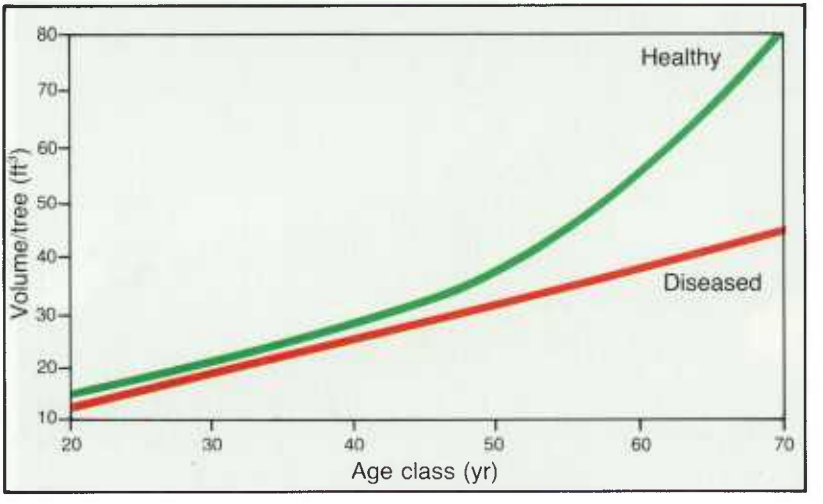
Southern pine beetle infestations occur as two distinct events: initial attack and population growth or spot spread of infestations. The insects first attack stressed trees. After the initial attack, individual spot growth is related to the number of beetles within the area, the presence of nearby newly attacked (attractive) trees, and the density of pines in the stand (fig. 6).

Figure 5—Soil conditions can be used to evaluate potential littleleaf sites. (Photo courtesy of Clemson University.)

Losses caused by littleleaf–SPB interactions are greatest in shortleaf pine stands. Shortleaf has the widest range of all the southern pines and grows on a wide variety of soils. The growth, yield, and quality of shortleaf pine stands can be excellent on good sites. However, susceptibility to littleleaf increases as site quality declines. Symptoms of growth decline become evident at approximately 25 to 30 years of age. Decrease in vigor is closely associated with increases in stand susceptibility to SPB attack. Loblolly pine, although more resistant than shortleaf pine, is not immune to littleleaf–SPB problems. Symptoms are similar to those on shortleaf pine (fig. 7), but usually are expressed later in the life of the stand. By this time, growth loss on high-hazard littleleaf sites can be substantial. The littleleaf–SPB complex could become a serious problem throughout the Piedmont where natural stands and plantations of loblolly pine are growing into mature and overmature age classes. Methods are available, however, that enable forest managers to evaluate the extent of the problem in both shortleaf and loblolly pine stands.

Figure 6—More trees are killed in overstocked pine stands in years when beetle populations are high than at any other time.

Figure 7—Loblolly pine is by no means immune to littleleaf disease. Differences in volume between healthy and diseased trees are greatest in mature stands.



Rating the relative susceptibility of pine stands to littleleaf and SPB problems provides information that can be used to identify current or future hazard conditions, set priorities for management actions, and assess loss potential. The systems used to evaluate potential littleleaf and SPB problems in the Piedmont place heavy emphasis on site and soil conditions. These are important but neglected variables in assessing pest problems.

Littleleaf Disease

The most efficient way to evaluate a site for littleleaf hazard is to consider its history. A site with no previous history of littleleaf is a low-hazard site. Sites with a history of littleleaf are high hazard (Anderson and Mistretta 1982). When mature and overmature shortleaf or loblolly pine are not present on the site, the rating system based on soil characteristics (Campbell and Copeland 1954) can be used (table 1). Soil characteristics are rated numerically and the scores totaled. Those sites totaling 75 or higher are expected to be free of littleleaf; scores of 51 to 74 indicate light to moderate hazard; a score of 50 or lower indicates high littleleaf hazard.

As a general rule, sites having severely eroded soil with a firm texture, a shallow permeable layer, or strong mottling of the subsoil are potentially high hazard for littleleaf and should be evaluated more critically.

Southern Pine Beetle

The SPB risk-rating system described here has been developed specifically for Piedmont stand and site conditions (Karpinski and others 1984). It can be used in the office if suitable stand records exist or in the field by making a cruise. This system allows the user to rate a stand for the likelihood of an SPB attack, chance of spot growth, and potential for timber loss.

Three variables are used to evaluate the risk of spot occurrence and the potential for loss (fig. 8):

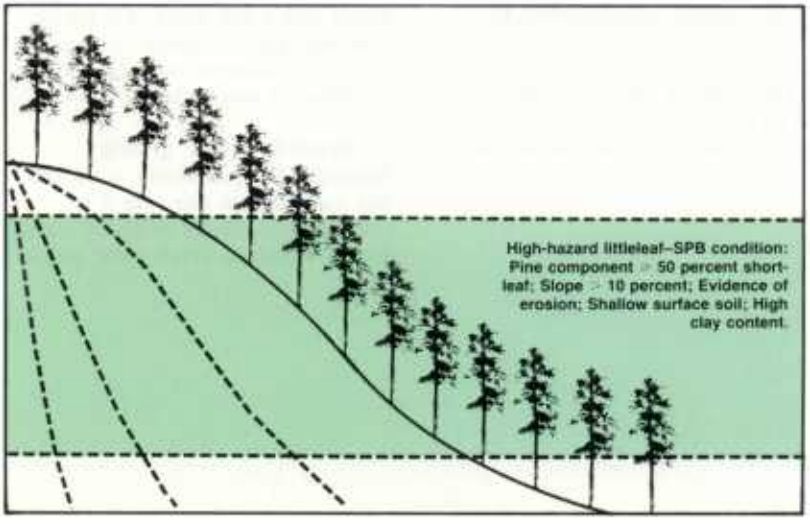


Figure 8—Characteristics of high hazard littleleaf disease–southern pine beetle stands in the Piedmont (after Karpinski and others 1984).

- **Pine component**—Shortleaf pine is among the most susceptible species to SPB attack. Stands with 50 percent or more shortleaf pine have been shown to be very susceptible to SPB. The percentage of shortleaf pine in a stand can be determined by making visual estimates, conducting a cruise, or using appropriate stand records.

- **Slope**—In the Piedmont, more than 60 percent of all SPB infestations occur in areas where slopes exceed 10 percent. On such sites, erosion is a common cause of stress and may make trees more susceptible to SPB.

- **Clay content**—Clay soils are often associated with steep slopes or a history of sheet erosion. Littleleaf disease commonly occurs on these sites, stressing trees, and thus making them more susceptible to SPB attack. Any uncertainty about the identification of soil type or clay content in a stand can be resolved by a field visit. Pine stands growing on soils with at least 28 percent clay content are susceptible to SPB.

Determining spot occurrence (risk)—The following tabulation shows the procedure that can be used to determine the risk class for SPB spot occurrence in a stand:

Spot Occurrence

(Select line with your combination)

Shortleaf component ≥ 50%	Slope ≥ 10%	Clay content ≥ 28%	Risk class
Yes	Yes	Yes	High
Yes	No	Yes	High
No	Yes	Yes	High
Yes	Yes	No	Moderate
No	No	Yes	Moderate
Yes	No	No	Low
No	Yes	No	Low
No	No	No	Low

Each risk class is assigned a numerical value (see the tabulation below). These values will be used in conjunction with others determined from "spot growth" on p. 11 to estimate potential loss.

Risk class	Risk value
High	3
Moderate	2
Low	1

Stands with a low risk value (1) are the least susceptible to attack by SPB. Stands with a risk value of 3 are the most susceptible to attack, whereas those with moderate value (2) are intermediate in susceptibility.

Predicting spot growth (hazard)—The probability of an SPB spot increasing in size once it is established is directly related to stand density. Stands in which basal area is

more than 120 square feet per acre are highly susceptible to spot growth. In dense stands, trees are close together, allowing dispersing beetles to find a new host easily. Pine basal area can be approximated using conventional approaches. The following tabulation shows how to determine the possibility of spot growth (hazard). Each hazard class is assigned a numerical value for purposes of estimating potential loss.

Spot Growth

Pine basal area (sq. ft./acre)	Hazard	
	Class	Value
More than 120	High	3
90–120	Moderate	2
Less than 90	Low	1

Estimating potential loss— Potential loss depends on the risk of an SPB spot becoming established in a stand plus the hazard of the spot growing once it is established. To determine potential loss, simply add risk value to hazard value:

Potential loss value = Risk value + Hazard value

Potential loss values can be used to determine the need for cultural treatments. Stands with loss values of 5 to 6 should be scheduled for silvicultural treatments first. Potential pest problems are greatly reduced in stands with loss values of 2 or 3.

When applying this rating system in the field, measurements should be made at several points. Then the risk, hazard, and potential loss calculated for each point should be averaged for the stand. When appropriate stand records exist, rating the stands in the office will yield a good estimate. If possible, ratings should be made when SPB populations are low, so that attention can be given to applying necessary cultural treatments to prevent losses rather than reacting to infestations when they may be too numerous to control or considerable loss has already occurred.

Preventive Cultural Treatments

Appropriate management practices can reduce or prevent losses occurring on problem littleleaf–SPB sites (fig. 9). Preventive and direct control methods are intended to increase the productivity of susceptible stands (Belanger and Malac 1980). A prime concern is to manage soil and stand conditions associated with the littleleaf–SPB complex in a manner that will minimize potential pest losses.

Stand Establishment

Planting or natural seeding is used to establish pine forests in the Piedmont. While planting offers the best opportunity to control species composition, seedling quality, stocking, and culture of the stand, natural regeneration has the advantage of low establishment costs. Although the choice of natural or artificial regeneration is frequently decided by owner objectives, methods of preparing and regenerating problem areas are usually determined by soil and stand conditions specific to each site. The following considerations should be kept in mind in developing plans for regenerating high-risk littleleaf–SPB sites:

Regeneration methods should favor species most resistant to littleleaf disease and SPB problems. Probability of losses from these forest

Figure 9—Silvicultural practices recommended to reduce the impact of pests in Piedmont forests.

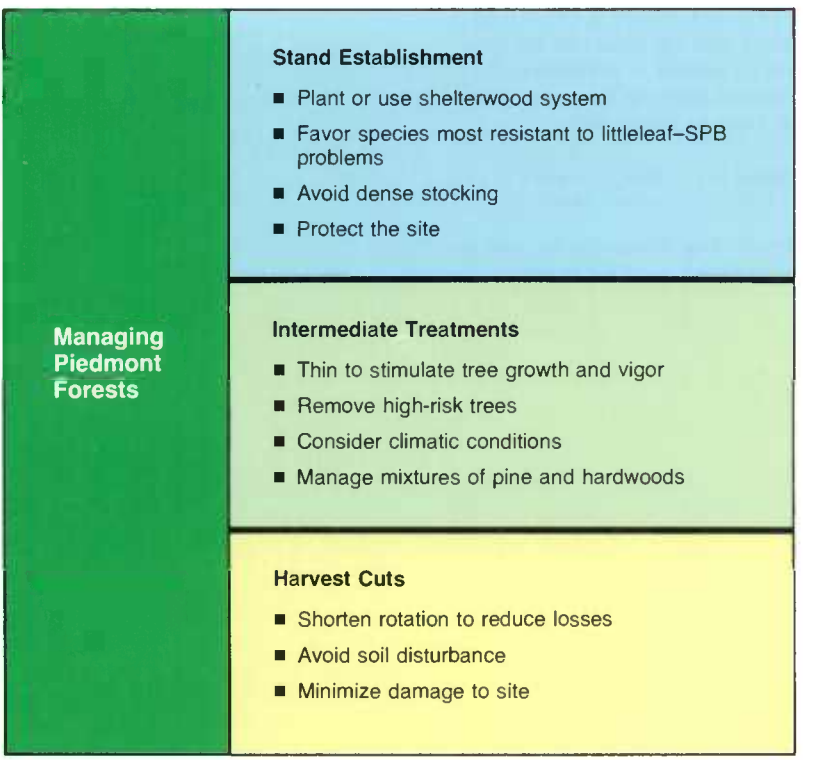


Figure 10—Subsoiling is one method of improving compacted soils in the Piedmont.

pests is likely to be high in pure stands of shortleaf pine. Thus, loblolly pine is recommended for most sites in the Piedmont. In addition to being less susceptible to littleleaf–SPB, loblolly grows well on a wide range of soil types and can be managed for multiple owner objectives.

Virginia and pitch pines commonly occur in natural stands in the northern Piedmont. Virginia pine is highly resistant to pest problems and can be managed to produce high yields of wood fiber on poor sites. However, natural pruning in Virginia pine is extremely slow; therefore, the species is not recommended for owners who wish to produce quality sawtimber. Pitch pine, although resistant to littleleaf disease, is highly susceptible to SPB.

The potential productivity of high-risk littleleaf–SPB sites is generally poor. The site index[2] for pest-prone stands surveyed in Georgia averaged 72 compared with 87 for healthy old-field plantations and about 76 for healthy natural stands. Proper management can rehabilitate problem sites in the Piedmont. These are eroded sites that have shallow surface soils and firm textured clays. Such sites have a high erosion potential, are poorly aerated, and restrict root development. Soils become excessively wet during rainy periods and extremely dry during periods of deficient rainfall. Trees growing on these sites are subject to varying periods of severe physiological stress.

Burning, chopping, and the use of suitable herbicides are recommended practices for regenerating high-risk littleleaf–SPB sites. Mechanical site preparation should be avoided on slopes greater than 10 percent. Preplanting practices that scarify and expose the soil contribute to erosion and reduction of litter and organic matter considered essential for improving the site.

Long periods of time are normally required to improve soil conditions. Where special values are involved, this process can be accelerated by subsoiling and the addition of sewage sludge (fig. 10). Subsoiling breaks any hardpan that may exist and increases water percolation.

[2]The average height in feet of dominant and codominant loblolly pine trees at age 50.

Figure 11—Thinning reduces the probability of southern pine beetle attack and spot growth.

Sewage sludge acts as a slow-release fertilizer and produces a grass cover that protects the soil surface. Studies have shown that subsoiling results in better tree growth than disking and that sewage sludge is superior to inorganic fertilizers (Berry 1985). These are expensive methods but show promise as a means of improving problem soils in the Piedmont. Caution: potential users should obtain guidelines from States regulating the application of sewage sludge.

Poor stocking is another characteristic of littleleaf-SPB sites. Most mortality in these stressed stands occurs during stand establishment and late in the rotation. Planting to achieve a stocking level of 500 to 600 seedlings per acre at the end of the first year is recommended for plantations. Stocking levels may vary depending on site quality and management objectives. Overstocking will increase the probability of attack and spot growth by the SPB; understocking will reduce the potential productivity of the site.

The shelterwood method can be used to regenerate pines on littleleaf-SPB sites (Society of American Foresters 1981). Stands are usually harvested by the two-cut method. The first cut removes all but 20 to 30 mature seedbearing trees per acre. Parent trees should be healthy, 10 inches or greater in diameter, and well distributed over the area. (Healthy trees may incorporate genetic resistance in the future stand.) The final removal cut should be made as soon as reproduction is established.

The seed tree method is not recommended for high-risk Piedmont stands. Conditions on these severe sites are unfavorable for seed production, seed germination, and seedling establishment. There is also the possibility of losing seed trees to lightning, wind, and ice storms. Deterioration of root systems by littleleaf disease further increases the susceptibility of the residual seed trees to storm damage.

Intermediate Cuttings

Intermediate cuttings can be made as the stands develop and mature to reduce losses and to increase the amount and value of residual timber on littleleaf-SPB sites.

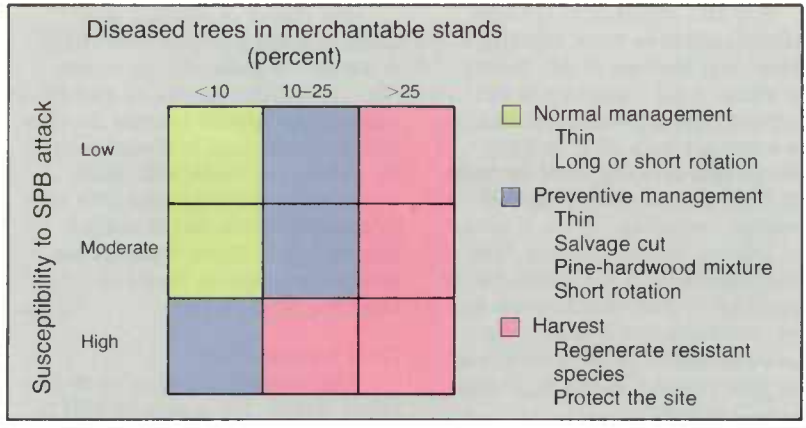


Figure 12—Guidelines for managing littleleaf disease-southern pine beetle stands.

Thinning stimulates growth and vigor in young stands and reduces the probability of SPB spot occurrence and growth (fig. 11). Salvage cutting may be used to minimize losses from littleleaf disease and bark beetles in mature stands. The most important factors to consider in selecting stands for intermediate cutting are (1) the percentage of diseased trees in the stand and (2) susceptibility to SPB attack.

Stands that are low to moderate risk for SPB and contain only a small percentage of littleleaf trees can be managed utilizing prudent silvicultural strategies and long rotation harvesting schedules (fig. 12). For high-risk littleleaf-SPB sites, a combination of adequate spacing, salvage-sanitation cutting, and harvest rotations of 25 to 35 years will minimize timber losses. Stands with high levels of littleleaf disease should be harvested and regenerated as soon as practical. Such stands deteriorate rapidly and require frequent salvage cuttings to utilize dead and diseased timber. Clearcutting followed by planting with loblolly or Virginia pine is also recommended for high-risk SPB stands with moderate levels of littleleaf disease.

Frequency and intensity of thinning—Thinning is most effective and economical as an SPB prevention technique when management uses 35+ year rotations to produce sawtimber and veneer. Stands should initially be thinned at the onset of root and crown competition. This occurs in pine plantations at approximately 10 to 15 years of age, but may start even earlier in dense natural stands. Thinning is not recommended for pulpwood stands being managed on 20- or 25-year rotations. Growth in these stands is generally good and fairly high stocking is needed to get full production from the site.

Intensity of cutting will depend upon the age of the stand, total stand density, site index, and management objectives. In the Piedmont, basal areas of 80 to 100 feet^2 per acre are recommended to reduce the potential for SPB problems. The risk of beetle outbreaks will increase considerably when stand density exceeds 100 feet^2 per acre.

It is also important to consider climatic conditions when selecting a method and intensity of cut. Severe ice storms occur frequently in the Piedmont, and pulpwood-size stands are extremely vulnerable to glaze damage after thinning. Tree mortality and stand decline result from bole breakage, uprooting, severe leaning, and bending beyond recovery. The damaging effects of ice storms can be minimized by early and frequent thinning. No more than a third of the basal area should be removed at each cut. Row thinning should be avoided as much as possible.

Other considerations—Intermediate cuttings should remove all trees with symptoms of littleleaf disease, and those highly susceptible to SPB attack should be cut next. These include trees that are damaged or weakened or with crowns that are overtopped or surrounded by taller trees. Taller (dominant and codominant) trees are then cut to obtain the desired spacing. The residual stand should contain healthy trees that are free to grow.

Intermediate cuttings will not completely eliminate stand stress or associated SPB problems on littleleaf sites. Losses are still apt to occur toward the end of the rotation period. However, the magnitude of damage is less than for untreated stands being grown for the same product.

The impact of southern pine beetle is greatest in pure pine stands. A mixture of pines and hardwoods (fig. 13) reduces the risk of spot occurrence and growth because the continuity among pines is disrupted by the intervening hardwoods. Hardwoods also benefit littleleaf–SPB sites by building humus and increasing nutrient levels. These measures are slow but progressive means of amending problem sites.

Final Harvest Cuts

The susceptibility of pines to littleleaf disease and associated SPB attack increases with age. Volume and value losses are greatest in dense pure stands 30 years or older. High-risk stands seldom respond to intermediate cuttings and should be replaced with the most resistant pine species or a mixture of species suited to the area. In managed stands, final harvest should be timed to occur before the growth and vigor of the stand starts to decline. Maintaining a healthy, free-to-grow stand of established pines and shortening rotation lengths are effective means of reducing losses resulting from littleleaf and SPB attack.

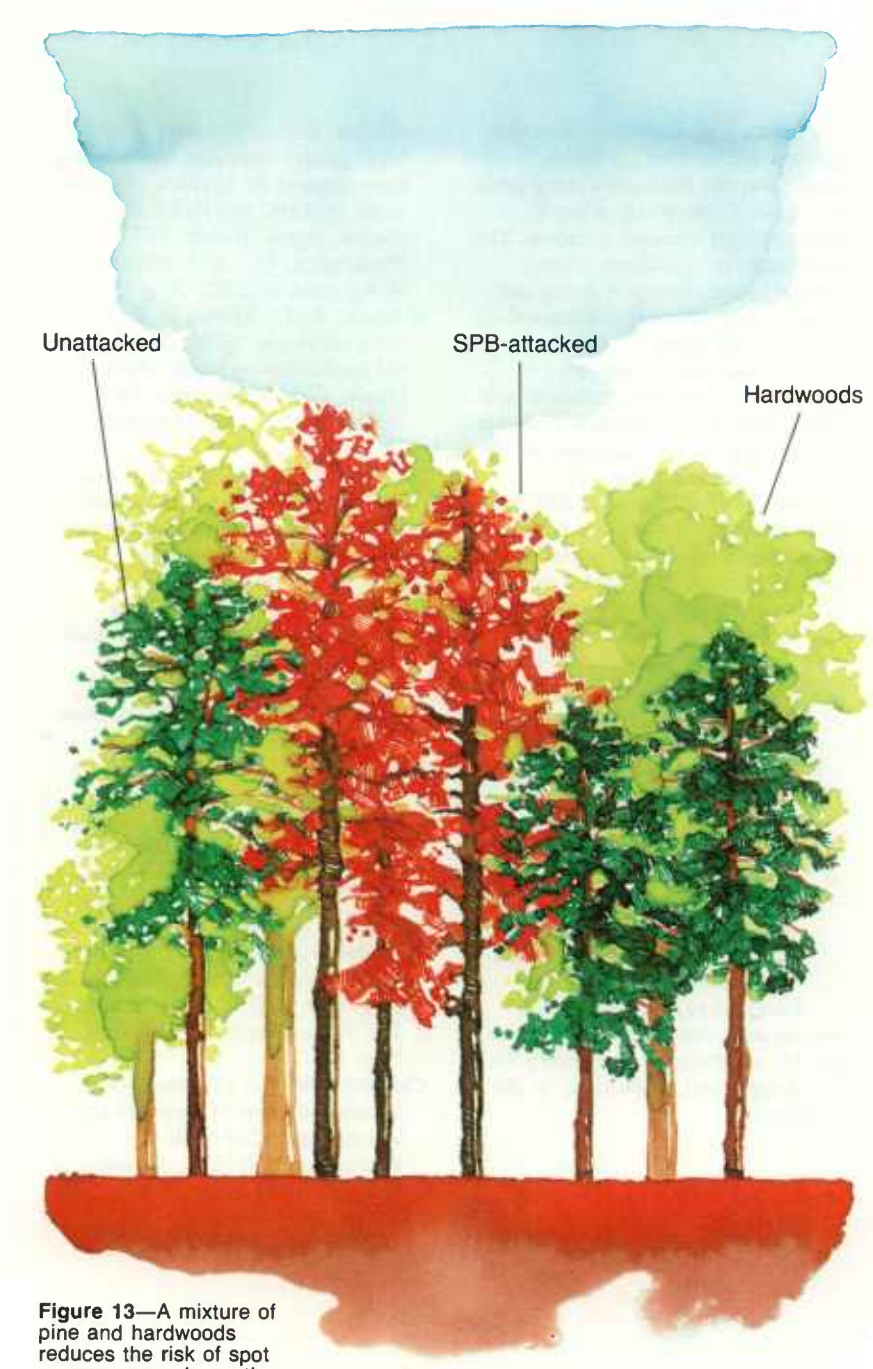


Figure 13—A mixture of pine and hardwoods reduces the risk of spot occurrence and growth by disrupting continuity between host trees.

Summary

Forest conditions and ownership patterns are extremely variable throughout the Piedmont. Some lands are cultured intensively whereas others receive minimal attention. This wide range of conditions favors multiple pests; however, losses are greatest from littleleaf disease and southern pine beetle.

Site and stand conditions favorable to these two pests are well understood. Means are now available to rate sites for the likelihood of littleleaf occurrence using soil characteristics. The risk of SPB spot occurrence and growth can be determined based on site and stand conditions. Strategies have been developed to compensate for these pests and the risk they pose on high-hazard sites:

1. Regenerate stands using more resistant species, proper site preparation techniques, and stocking control.
2. Use thinning and salvage cutting to maintain stand vigor and reduce the susceptibility or severity of losses in young stands.
3. Reduce volume losses in older stands by intermediate cuttings and, where necessary, shorten the rotation.

Recognizing, evaluating, and treating high-risk littleleaf–SPB sites provide a significant opportunity for increasing forest productivity in the Piedmont.

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Table 1—*Numerical system for field-rating sites for littleleaf disease hazard based on soil characteristics (after Campbell and Copeland 1954)*[1]

Soil characteristics	Score
Erosion:	
Slight—Depth of A horizon not seriously changed, less than 25 percent removed	40
Moderate—25 to 75 percent of A horizon lost, shallow gullies may be present	30
Severe—All of A horizon lost, often some of B gone, shallow gullies common	20
Rough gullied land—Soil profile has been destroyed except in small areas between gullies	10
Subsoil consistency (when moist):	
Very friable—Crushes under gentle pressure, coheres when pressed	32
Friable—Crushes under gentle to moderate pressure, coheres when pressed	24
Firm—Crushes with moderate pressure, but resists	16
Very firm—Crushes under strong pressure, barely crushes between thumb and forefinger	8
Extremely firm—Cannot be crushed between thumb and forefinger	0
Depth to zone of greatly reduced permeability:	
24 to 36 inches (61 to 90 cm)	15
18 to 23 inches (46 to 60 cm)	12
12 to 17 inches (30 to 45 cm)	9
6 to 11 inches (15 to 29 cm)	3
Subsoil mottling (grays and browns):	
None	13
Slight	9
Moderate	5
Strong	1

[1]High-hazard soils score 0 to 50 points; moderate-hazard soils score 51 to 74 points; and low-hazard soils score 75 to 100 points.