PROTECTION OF SHORTLEAF PINE FROM INSECTS AND DISEASE

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ABSTRACT

All major and potentially serious insect and disease pests of shortleaf pine are briefly presented and discussed. Major emphasis of discussion is that losses can be minimized by selection and application of appropriate pest management systems. With some pests, integrated control can be supplemented with an economic analysis to further assist selection of management options.

INTRODUCTION

As a major commercial timber species, shortleaf pine is relatively free of destructive disease and insect pests. Potentially serious growth losses and mortality, however, can be caused by several normally insignificant pests which increase following certain management activities. The two most serious pests, the southern pine beetle and littleleaf disease, are discussed in some detail. Currently available integrated pest management systems which can be easily incorporated into the management plan are introduced and discussed.

DISEASES

Nursery problems

Nursery seedlings of shortleaf pine are subject to damping off caused by *Rhizoctonia solani* Kuehn, *Fusarium oxysporum* (Schl.) em. Snyd. & Han., and *Sclerotium bataticola* (Taub.) (Hodges 1962) in soils with pH above 6 and under moist weather conditions.

Needle diseases

Foliage diseases include the needle rusts (*Coleosporium* spp.), needle casts [*Ploioderma* (*Hypoderma*) *lethale* (Dearn.) Dark. and *P. hedgcockii* (Dearn.) Dark.], and brown spot [*Scirrhia acicola* (Dearn.) Sigg.] (Hepting 1971). *Lophodermium pinastri* (Schrad. ex Hook.) Chev. is commonly observed on dead needles but is not believed to be parasitic (Boyce 1951). Witches' brooms, of apparent genetic origin, are occasionally encountered.

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Cankers

There are many stem and twig diseases but none are very damaging. Atropellis tingens Lohm. & Cash (Diller 1943) sometimes kills twigs and small branches but only produces a characteristic elongate perennial canker on larger stems and branches (Lightle and Thompson 1973). The wood beneath the canker will have a blue-black discoloration. A few trees of all ages and sizes are affected in any given stand.

Pitch canker (Fusarium moniliforme Sheld. var. subglutinans Wr. & Reink) is increasing in incidence, especially on stressed trees, and can be locally serious following insect injury. Infection results in copious resin flow and a resin-soaking of the wood under the canker face extending to the pith (Dwinell 1978). Cankers on small shoots result in dieback of the shoot. Dead needles may persist for more than a year and fade to a dull, grayish-brown color (Blakeslee et al. 1980). Cankers on large branches or on the upper portion of the main stem often do not kill the shoot until the following year, whereas cankers on larger stems usually live longer and produce copious resin flow (Blakeslee et al. 1980). These cankers, though, eventually girdle the stem.

Rust

Stem and branch infections of gall rust [Cronartium quercuum (Berk.) Miyabe ex Shirai f. sp. echinatae (Cumm.) Burds. et Snow] are occasionally encountered. Infections are usually scattered but sometimes there are extremely heavy infections on both pines and oaks, reflecting a previously favorable microenvironment for spore production and infection. In any case, this rust is not damaging except to seedlings.

Comandra blister rust (Cronartium comandrae Pk.) is a potentially serious threat that can be devastating wherever the alternate host is abundant. Shortleaf pine is quite susceptible (Berry et al. 1961). The natural range of the alternate host, Comandra umbellata subsp. umbellata Piehl, extends as far south as northern South Carolina and northern Georgia, Alabama, Mississippi and Arkansas (Piehl 1965). The rust is most destructive in plantations in the Ouachita and Ozark Plateaus of Arkansas and Missouri and in the Cumberland Plateau of eastern Tennessee. Although there is some indication that the Arkansas strain has adapted to the higher mean temperatures of the southern states (Eppstein and Tainter 1976), phenological and epidemiological studies (Dolezal and Tainter 1979) indicate that occurrence of comandra rust on shortleaf pine is dependent on close proximity of pines to infected alternate host plants and the passage of weather frontal systems which disseminate and disperse spores. Since the alternate host is an early colonizer of disturbed or mechanically prepared sites its presence is a reliable predictor of potential damage. The comandra plant also tends to maintain itself well and will even flourish if livestock grazing is allowed in older plantations.

Heart rot

The only trunk rot, Phellinus (Fomes) pini (Thore ex Fr.) A. Ames (red heart), is seldom a problem in trees less than 80 years of age (Hepting 1971). It is presently a problem only in parks, urban areas, or other areas where older trees are maintained.

Root rot

Root rot caused by Heterobasidion annosum (Fr.) Bref. (Fomes annosus) is common throughout the range of shortleaf pine and some other southern pines wherever there are deep, well-drained sandy soils (Wilson 1963). Because of their high clay contents, most piedmont soils are of low hazard to annosum root rot. However, one can expect losses from annosum root rot to increase as the sand content of the surface layer of soil increases. It is not unusual to find sites with from 10-12 inches of sandy clay in the upper horizon. Stands on these sites may not exhibit appreciable mortality, but diameter and height growth of infected trees may suffer, similar to growth losses in loblolly pine (Bradford et al. 1978). The colonization of shortleaf pine stumps by H. annosum was demonstrated by Kuhlman et al. (1962). Stump colonization following thinning is the means by which H. annosum enters the stand. Subsequent thinnings on high risk sites can result in a greatly increased incidence of root rot due to this pathogen. On some sites, annosum affected stands can be confused with littleleaf disease unless root excavations are made and positive root isolations are obtained. Annosum root rot mortality on high risk sites and growth loss on low risk sites can largely be avoided if guidelines for prevention are heeded (Froelich et al. 1977). Prevention depends largely on recognizing the degree of risk, then selecting appropriate controls.

Old growth shortleaf can be found to be infected with Phaeolus (Polyporus) schweinitzii (Fr.) Pat. but this is a practical problem only in recreation areas or with some urban trees.

The most important disease of shortleaf pine is littleleaf disease (Campbell and Copeland 1954). Littleleaf disease was first recognized in 1934 in Alabama. Although the common name of the disease suggests shortleaf pine as the only host, loblolly pine is also affected when it occurs on unfavorable sites for the tree species and where the fungus involved can develop (Oak and Tainter 1985). The fungus, Phytophthora cinnamomi Rands, associated with littleleaf is an important root pathogen on many hosts, including conifers and hardwood species. It has been reported on over 100 different hosts.

Since the original report of littleleaf, the disease has been found only east of the Mississippi River in piedmont and certain contiguous mountain and upper coastal plain areas from Virginia to Mississippi. P. cinnamomi is more widely distributed than the disease, occurring in southern and western United States as well as other temperate and many tropical and subtropical regions of the world.

At one time, shortleaf pine occupied 41 million acres in southeastern United States. Although shortleaf pine is presently of less importance on federal lands, this species is still prevalent on private lands, especially on those managed by the small, nonindustrial owner. The fact that littleleaf affects trees over 20 years of age, and especially trees 30-50 years old, makes this an especially serious problem.

As is typical of many root diseases, the symptoms consist of sparse foliage, short needles, tufted upturned groups of needles and yellow foliage. Affected trees die within 3-10 years and once affected grow very little in height and diameter. Normal growth rings may be 0.5 inch in width per year and in affected trees only hundredths of an inch. Cones from infected trees are smaller and the seed less viable. Necrotic brown lesions form on large roots and many of the small roots die.

P. cinnamomi has been known as a root parasite on such hosts as chestnut, avocado, azalea, cinnamon, oak, pineapple, and chincona. At first, P. cinnamomi was difficult to obtain from diseased trees, but by using the apple as a selective medium, a correlation was found between incidence of fungus and the disease (in healthy stands, P. cinnamomi was isolated from 5% of the root samples but was recovered from 42% of the samples from littleleaf trees). When shortleaf and loblolly pine seedlings were inoculated with the fungus, reduced root and top growth resulted. P. cinnamomi apparently restricts its activities to the root system and scions from littleleaf infected trees grafted onto healthy root stock will recover completely. The fungus is present in soil to a depth of 12 inches and is most abundant in the upper 2-3 inches. There is not necessarily a positive correlation between relative abundance of P. cinnamomi and disease incidence.

Apparently the fungus is widespread throughout the South, but the disease develops primarily in clay soils where internal soil drainage is poor. Infection of the host occurs when roots are most active, probably in spring and fall with very little infection during the summer. Throughout the year, roots of diseased trees contain less than one half of the starch and sugar found in healthy roots. Soils that are poorly drained, severely eroded, shallow in depth, highly variable as to porosity, permeability, compactness, or plasticity and usually low in fertility are likely littleleaf sites.

Diseased foliage contains approximately 1/3 to 1/2 the normal amount of nitrogen. If the trees are in the early or intermediate stages of littleleaf, the addition of nitrogen reduces symptoms. The addition of large quantities of organic matter low in nitrogen and mechanical injury of the roots will result in increased symptoms. These facts indicate that littleleaf is the result of the failure of the roots to absorb nitrogen even though this nutrient is present in adequate amounts in the soil.

The fungus is able to spread for short distances through the soil by means of swimming zoospores. Another kind of spore, the thick-walled oospore, enables the fungus to survive unfavorable conditions, such as when the soil is dry. P. cinnamomi also produces chlamydospores in soil and root exudates stimulate their germination. The fungus penetrates epidermal cells directly and also invades the host roots through wounds.

For management of existing stands that have some littleleaf symptoms, the following cutting practices have been recommended to minimize overall losses (Campbell et al. 1953):

1. If only an occasional tree is diseased, cut lightly at 10-year intervals.

2. If 10-25% of the stand is diseased, cut at 6-year intervals, removing all diseased trees.

3. If over 25% of the trees are diseased, clear cut as soon as the stand is merchantable.

Predicting littleleaf risk can be done for existing or future stands using two methods. In the first rating system, on-site evaluations are made of erosion class and internal drainage characteristics of the soil, and a 100-point system used to classify risk (Campbell and Copeland 1954). The second rating system utilizes the identified associations of some soil series with different amounts of littleleaf (Campbell and Copeland 1954). Internal drainage characteristics for these soils were summarized from published Soil Conservation Service (SCS) descriptions and extended to previously unrated piedmont soils (Oak 1985). Though more general than the point system, the soil system does not require on-site evaluation but can be applied using existing SCS county survey maps. Soil types which are high hazard for littleleaf disease are characterized by the SCS as having mostly clay subsoils with moderately slow to slow permeability about 12 inches below the surface.

Using this information hazard maps may be prepared identifying high hazard sites which the forest manager can use to provide treatments before actual growth losses occur. On U.S. Forest Service lands in the piedmont, stand hazard ratings and other important stand information are maintained and updated using a computerized data management system and are used for short- and long-range planning purposes. Hazard ratings are used in the compartment prescription process when priorities are established for harvesting, thinning, regeneration planning, stand conversions, timber stand improvement, and possible fertilization. They are also valuable for setting priorities in reconnaisance and salvage activities during attacks by southern pine beetle. An overview of the interrelationship in the piedmont between littleleaf disease and the southern pine beetle is provided by Belanger et al. (1986).

INSECTS

Sawflies

Several species of spring- and summer-feeding pine sawflies (*Neodiprion* spp.) can cause locally serious damage to shortleaf pine. Sawflies receive their name from the saw-toothed ovipositor which the female uses for cutting slits in the needles in which to lay eggs. The damage is done by the larvae as they feed on the foliage. Some sawfly larvae are gregarious and as they consume all of the foliage tissues, the defoliation can be impressive. Attack is usually restricted to trees less than about 15 feet tall.

Reproduction weevils

First year plantings of shortleaf pine may be seriously attacked by two reproduction weevils, *Hylobius pales* (Herbst) and *Pachylobius picivorus* (Germ.), the pales and pitch eating weevils. Only the adults cause tree injury. They eat areas of bark and phloem and may girdle the twig or seedling or weaken the seedling, predisposing it to drought.

Damage only occurs where pines were present in previous stands. Reproduction weevils are not a problem in old-fields or in aerially-seeded plantations. Nor are they a problem in stands harvested and site-prepared before July since overwintering adults and their broods will have migrated from the areas before fall or winter planting. High hazard sites are those which were previously in pine and have been harvested after June 30 or have been site-prepared in late summer or early fall. Weevils are attracted to volatiles released from pines damaged during these operations. Adults initially feed on the inner bark of fresh stumps or coniferous logging debris. When this material is no longer available, the weevils feed on pine seedlings or the inner bark of twigs of larger trees.

If the weevils are attracted into an area early in the spring or summer year, they will lay eggs and disperse to other areas before fall. If attracted into an area in fall, they will lay eggs but will stay on the site until the next spring. It is this combination of overwintering parent adults and emerging brood adults that accounts for the heavy damage in newly regenerated plantations.

Management of reproduction weevil populations consists of three alternatives: (1) harvest before June 30, (2) delay regeneration one year, or (3) the use of insecticides. If planting is delayed one year, all weevils will have migrated from the area and no damage will occur. The economic loss associated with the loss of one year of growth, however, may be unacceptable. A variety of insecticides and treatments are available and are effective against a given anticipated level of attack. Under extremely heavy weevil populations, however, even insecticide-treated seedlings may be killed (Cade et al. 1981).

Tip moth

The Nantucket pine tip moth [*Rhyacionia frustrana* (Comst.)] is a serious pest of young plantation-grown shortleaf pines. Tip moths infest developing shoots and buds. Adults emerge in spring and females lay eggs for the first generation. Larvae tunnel in the twig and eventually into the base of the bud. There are 2 to 4 generations per year, 5 to 6 in the extreme south.

Attacks are concentrated in the upper portion of trees less than 15 feet in height. Preferential attack of the leading terminal shoot leads to growth response by the host as either a whorl of adventitious buds forming just below the killed bud, or a lateral branch assuming dominance and becoming the new leader. Damage may result as a severe stem deformity, more knots in the wood, more compression wood, and some amount of growth loss. The net effect is to delay crown closure.

In unthinned stands, growth of tip moth attacked trees nearly catches up in volume growth by rotation age. In thinned stands, however, the growth differences are carried throughout the rotation.

High hazard sites for tip moth are those that have been mechanically site prepared, and they are even higher in hazard if they have had herbaceous weed control. Pine tip moths are attracted to the higher nutritional value of more vigorous trees and, thus, high populations result. There also appears to be a relationship between high populations of tip moth and incidence of pitch canker fungus. Several insecticides and correct timing of their application are effective but may not be cost-effective.

Bark beetles

The southern pine beetle (SPB) (Dendroctonus frontalis Zimm.) is the most destructive insect pest of shortleaf pine. It is greatly feared because great epidemics may develop with concurrent heavy mortality. Attacked trees are colonized with blue stain fungi, followed by wood decay fungi and the wood rapidly deteriorates. Beetle attack may shift management expectations significantly for the stand and incur actual control and salvage costs. In addition, substantial degrade may occur in the salvaged logs.

In general, SPB infestations are associated with adverse conditions, such as lightning or other injury, moisture extremes, excessive stand density or stocking levels, slow growth rate, and diseases such as annosum root rot and littleleaf.

Stand risk rating is one of the first steps toward minimizing losses to this pest. Different systems are available for different geographic areas (the mountains, piedmont, and coastal plain) and for different landowners (USDA Forest Service, private industry, and the small private landowner).

Information necessary to apply the system may come from a variety of sources. Risk rating may employ data obtained from aerial photographs (Mason et al. 1981) including basal area/acre, total stand height, species composition, crown closure, average tree diameter, and topographic position; or utilize readily available resource data (Lorio and Sommers 1981) such as forest type, tree size and age, stand density, and site index from continuous inventory of stand conditions. These are subjected to a sequential evaluation to determine stand risk for SPB.

Another system (Ku et al. 1980) uses field data collected in SPB attacked stands to identify unique factors that predisposed those stands to attack and includes variables of total basal area, hardwood basal area, stand age, and radial growth in last 10 years. Since the data were collected from undisturbed natural stands on upland flats, application of this system is best suited to these sites.

A system for predicting potential loss from SPB in the Gulf coastal plain of Georgia (Karpinski et al. 1984) uses the variables of landform, total basal area, and percent pine. These variables can be collected in the field in conjunction with a simple prism cruise or in the office if suitable stand records exist. This system determines risk of spot occurrence and then determines hazard of spot spread. These two can be combined to determine potential loss which is then used to determine the need for cultural treatment. A similar system is used for SPB hazard rating in the mountains of Georgia (Karpinski et al. 1984).

Two systems have been developed for the piedmont (Karpinski et al. 1984 and Belanger et al. 1981). Risk in the former is evaluated from the percentage shortleaf pine component, percent slope, and percent clay content. For the latter system, variables included proportion of shortleaf pine, radial growth, amount of clay and depth of surface soil. A land manager's model was also developed which included four variables that are easily measured or are contained in existing inventories.

The significant variables in both of these systems strongly suggest the contributing role of littleleaf disease in predisposing trees to attack by SPB, and stand treatment to reduce SPB risk may actually preempt recommended controls for littleleaf-related injury. Recent control efforts for SPB in shortleaf pine stands are aimed at minimizing initial attack of the beetle and reducing its chances of spread if a spot is initiated. This is done by identifying high risk stands and then using thinning, harvesting, or other stand manipulations to reduce the amount of wood lost. Almost no direct or chemical controls are used to reduce beetle populations.

INTEGRATING PEST MANAGEMENT INTO OVERALL FOREST MANAGEMENT

A demonstration project conducted on USDA Forest Service lands carries pest management one step further along toward integrating pest control into the overall forest management plan and, if successful, will provide a strong impetus to expanding the concept to other land management groups. This represents a natural evaluation from an early approach toward integrating the available management strategies for control of major diseases of southern pines, including shortleaf, provided by Anderson and Mistretta (1982) and later updated (Anderson et al. 1985). This latest development is outlined by Hoffard and Oak (1985) and represents the closest practical refinement yet of the integrated forest pest management concept for this tree species.

In this project major tree pests were identified on national forest districts in the piedmont of Georgia and South Carolina. These included fusiform rust, annosum root rot, pales weevil, littleleaf disease, and SPB. Best available risk rating systems were selected from those mentioned previously. Where appropriate, economic analysis of control options was provided through the IPM Decision Key (Anderson et al. 1985).

This technology was communicated to federal land managers at the district level and district personnel assisted in production of hazard maps in a form compatible with their current management methods. All appropriate data were computerized for the mapping process and to assist in long-term storage and retrieval of the data. This was accomplished by using a computerized Geographic Information System developed by Beveridge and Knapp (1984). This system allows overlaying of different data files (e.g. such as overlaying soil hazard with forest type, or age) and it can be done on the same scale as maps currently in use in ranger districts.

The hazard maps and pest related recommendations will be placed in compartment prescription files for continuing reference. Ready access of this information will ensure that pest management information will be considered in the future in formulating silvicultural strategies.

This project has thus far met with great success at the district level. District personnel recognize that some pests are causing severe losses and that preventative measures must be addressed if losses are to be minimized. Consideration of major pests and control strategies in the prescription file each 10 years ensures that potential problems will be addressed before they actually occur. Even more benefits will accrue when this concept is expanded and employed by other forest landowners.

CONCLUSION

Current and potentially serious pests of shortleaf pine can be successfully managed to minimize losses if available pest management information is considered within the overall forest management plan.

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