Forest Insect
& Disease
Leaflet
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Forest Service
U.S. Department
of Agriculture

Fusiform Rust of Southern Pines

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Fusiform rust, caused by the fungus *Cronartium fusiforme* Hedg. & Hunt ex Cumm., is distributed in the Southern United States from Maryland to Florida and west to Texas and southern Arkansas. Infections by the fungus, which develops at or near the point of infection, result in tapered, spindle-shaped swells, called galls, on branches and stems of pines. (see photo).

While the disease attacks several southern pine species, it is especially damaging on slash pine (*Pinus elliottii* var. *elliottii Englem.*) and loblolly pine (*Pinus taeda* L.) and severely limits their management in high-hazard areas. Mortality is heaviest on trees less than 10 years old, but the galls and resulting cankers deform older trees, reducing growth and weakening the stems until breakage in windstorms becomes likely. Annual losses from this disease are estimated at 562 million board feet of sawtimber and 194 million cubic feet of growth stock.

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Stumpage losses are valued at $28 million annually.

Fusiform rust can be minimized by planting resistant varieties and applying approved silvicultural and chemical measures of control.

Hosts

The fungus that causes fusiform rust requires an alternation of hosts to complete its life cycle. Part of the cycle is spent in the living tissue of pine stems and branches, and the remainder in the green leaves of several species of oak.

Although slash and loblolly pine are the most susceptible and the most commercially important hosts, pitch pine (*P. rigida* Mill.) and pond pine (*P. serotina* Michx.) are also

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Figure 1.—Young slash pine plantation with heavy incidence of lower bole infection.

attacked. Longleaf pine (*P. palustris* Mill.) is relatively resistant. Although shortleaf pine (*P. echinata* Mill.) seems to be highly resistant, it is sometimes infected with a similar but usually less damaging rust caused by *Cronartium quercuum* (Berk.) Miyabe ex Shirai, which produces globose galls. This disease, eastern gall rust, occasionally also occurs on loblolly and slash pine.

Black oak as a group is more susceptible to fusiform rust than white oak. The effect of the disease on oak hosts is slight, although severe infections may cause defoliation. The most susceptible species are water, willow, and laurel oaks, followed by bluejack, blackjack, southern red, and turkey oaks. Other oak and pine species have been infected by artificial inoculation.

Distribution

The fusiform rust fungus is widely distributed throughout the Gulf and South Atlantic States (figs. 2-3). Incidence has increased dramatically in frequency and severity over the past 50 years. Southwide surveys made during the last 5 years have delineated geographic variation patterns in rust incidence. Rust incidence was the highest for both loblolly and slash in Georgia, Alabama, South Carolina, and Mississippi. Louisiana has a low incidence for loblolly and a higher incidence for slash, while Florida has a high incidence for loblolly and a lower incidence for slash pine. Incidence is the lowest in Arkansas, Virginia,

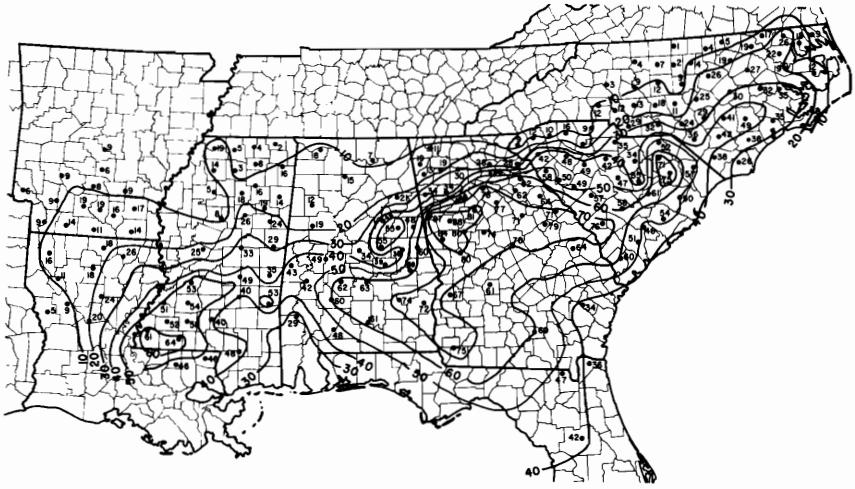

Figure 2.—Distribution and incidence of trees infected with fusiform rust in 8- to 12-year-old loblolly pine plantations.

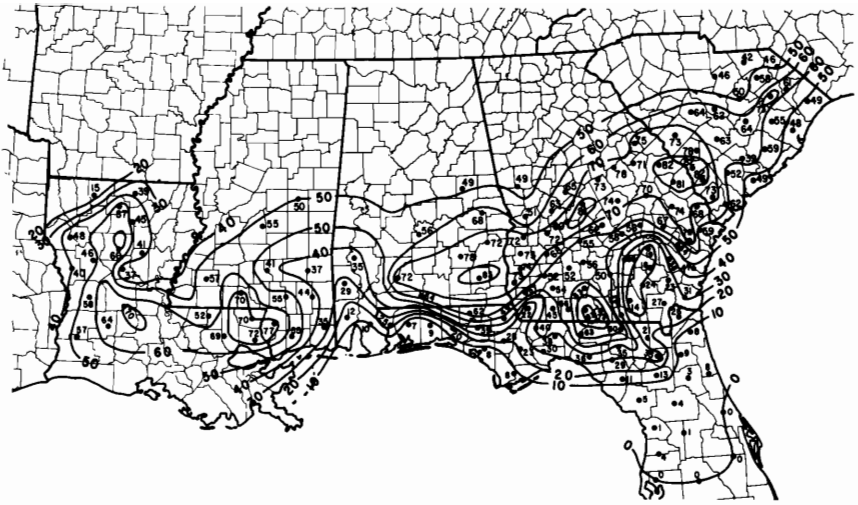

Figure 3.—Distribution and incidence of trees infected with fusiform rust in 8- to 12-year-old slash pine plantations.

Texas, and North Carolina. A ridge of high incidence extends northeast to southwest through the central portion of the South; infection usually decreases to the north and south of this ridge. The incidence patterns and gradients for both loblolly and slash are very similar.

Presence of similar patterns in incidence and gradients indicates that climate may be a large factor in determining degree of rust incidence. However, the discontinuity between the two high-incidence areas suggests that other factors such as oak host present, seed sources, planting and silvicultural practices, and genetic mutations of the rust may be involved.

Life Cycle

The disease has five spore forms, which are produced in succession (fig. 4). It takes 2 years or more to complete the life cycle. From late February to early April, the fusiform galls on infected pines produce enormous numbers of orange aeciospores. These are carried by the wind and air currents to oak leaves. When they are deposited on young oak leaves, the spores germinate and cause localized infections. In 7 to 10 days, the rust fungus produces a small pustule that bears orange urediosphores on the lower surface of the leaf (fig. 5). These urediospores can cause infections on the same leaf or on other oak leaves and are often referred to as the repeating stage of the fungus. After about a week, brown, hairlike structures, or telia, appear on the lower surface of the leaf but not necessarily associated with the uredial pustules (fig. 6). Depending on the severity of infection, each leaf may have a few to several hundred telia. Each telium is made up of several hundred teliospores, which may remain viable until early June.

When conditions are favorable—temperatures between 60° and 80° F (15° and 27° C) and relative humidity between 97 and 100 percent for 4 or more hours—the teliospores germinate; each produces three to four basidiospores (sporidia). The basi-

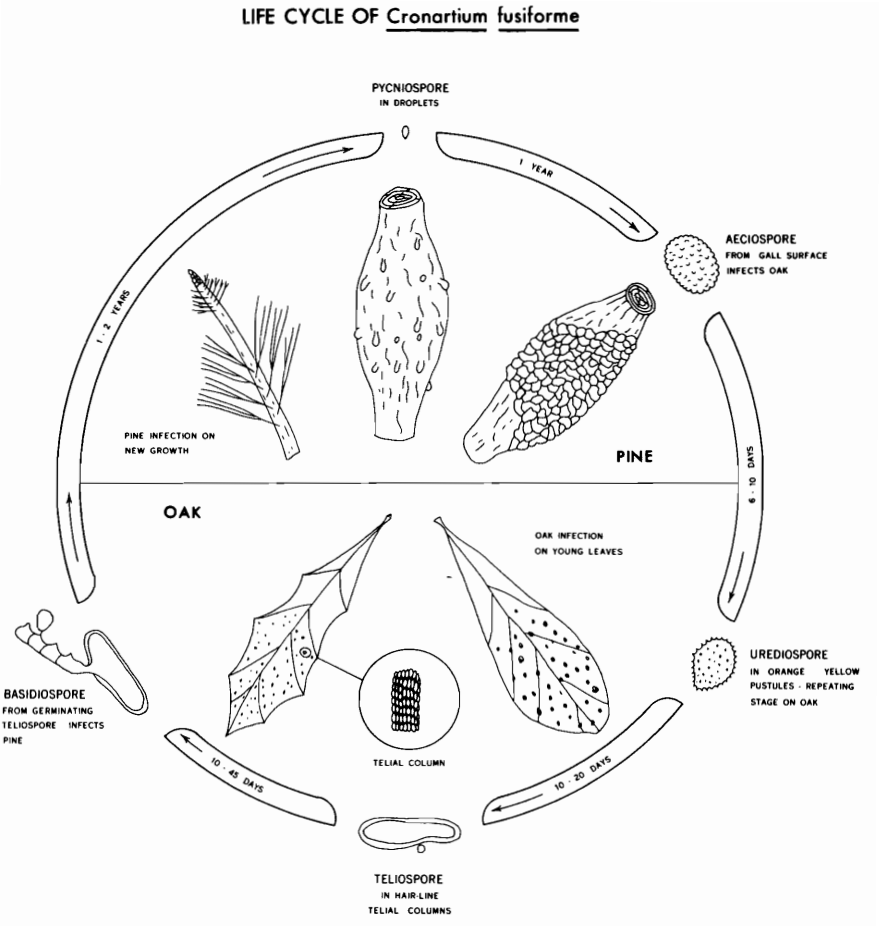

Figure 4.—Schematic diagram of the lifecycle of fusiform rust.

diospores are carried by air currents to susceptible pine hosts. Infection occurs on cotyledons, on needles, or on succulent bark tissues. Sporidia are very sensitive to adverse conditions and quickly lose their germinative capacity. Once the host is successfully infected, the developing fungus grows through the host tissue into the branch or stem. In 4 to 6 months, a gall or swelling begins to form. If the disease does not kill the pine host during the first few months after infection, drops of orange fluid containing pycniospores appear on the gall surface. Occasionally, pycniospores occur during the year of infection; more often they appear from October to January of the following year. Aeciospores are produced on the gall during the next spring, thus completing the life cycle.

In oaks, only the leaves are affected, and the fungus is usually inactivated or killed when temperatures exceed 85° F (29° C) for several days. The oaks are free of the disease in winter, when they cast their

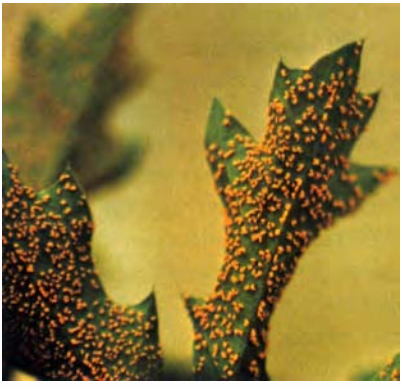

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Figure 5.—Urediospores are found on oak leaves and are the repeating stage of the fungus.

leaves. In pines, however, the fungus persists until the infected tissues are killed; aeciospores can be produced for many years in succession.

Old galls may develop into open-faced cankers when the pine tissues are killed at the margin of the gall. These cankers are often invaded by insects and wood-rotting fungi, which further reduce the tree's value and make it susceptible to windbreakage.

Control

In nurseries and seed orchards, where values are high, the damage caused by fusiform rust may be reduced by spraying the trees with fungicides. In plantations or natural stands, where spraying is not economically feasible, other steps can be taken.

Land managers should use longleaf and shortleaf pine for slash or loblolly pine planting sites with histories of severe rust infection or an abundance of oaks nearby.

Where local experience shows that rust hazard is moderate, satisfactory stocking can be attained by using closer spacing than usual in planting. Moderate mortality will then not lead to understocking. In addition, closer spacing helps to create a natural pruning of infected branches, thus reducing the chances that the rust will reach the trunk.

In young plantations, pruning branches with rust galls less than 15 inches from the stem will reduce the likelihood of trunk infections. Pruning is useless on trees that already have a trunk gall or canker. Moreover, new infections sometimes occur even after pruning. Sometimes it is possible to save a high-value tree with a small, newly developed trunk gall. Carefully remove the

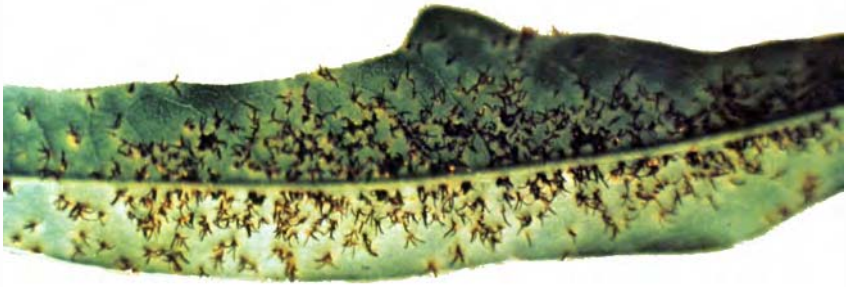

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Figure 6.—Brown hairline telia are found on the underside of oak leaves.

bark and some of the wood around the gall, and apply tree wound paint.

In general, any cultural practice that stimulates growth of either pine host will increase rust infection. Attempts to improve the growth rate of pine plantations by cultivation and fertilization were found to cause a substantial increase in rust. The cultured trees break dormancy earlier than other pines, have tissues in a succulent stage for longer periods of time, and develop larger areas of succulent tissues.

Trees with trunk cankers should be salvaged in thinning, provided their removal does not open the stand more than is silviculturally desirable. Diseased trees are not a direct risk to the surrounding healthy ones, since spores that infect pines come only from oak leaves. The following rule of thumb may be useful in planning the salvage of trees with trunk cankers: (a) Less than 50 percent of circumference killed—more than an even chance of salvage for 8 years; (b) 50 percent of circumference killed but no bend in stem at canker or sunken canker face—an even chance of salvage for 5 years; (c) 50 percent of circumference killed, with a bend at canker and either a normal or sunken canker face—less than even chance of salvage for 5 years.

Seed orchards have been established with rust-resistant clones of loblolly and slash pine. As seeds from these orchards become generally available, they should be given preference when establishing plantations in areas of high rust hazard.

Genetically controlled resistance offers a method of minimizing rust losses. The fusiform rust progeny testing center at Asheville, N.C., tests loblolly and slash pine seedlings

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Figure 7.—Artificially inoculated pine seedlings, 6 months after inoculation in the fusiform rust progeny testing center.

in 6 months for resistance (fig. 7). Normally, resistance testing takes from 10 to 15 years in field trials.

The Center employs an automated mechanical spray system for mass inoculation of seedlings under controlled conditions. This method uses a water-spore suspension spray technique that assures critical control and standardizations of spore density in the inoculum spray. Thus, each seedling tested is exposed to the same amount of spores at the time of inoculation.

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Revised February 1978

☆ U.S. GOVERNMENT PRINTING OFFICE: 1978 O—248-914

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