



## Red Band Needle Blight of Pines . . .

### a tentative appraisal for California

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When a destructive needle blight first appeared in Monterey pine (*Pinus radiata*) plantations in Tanganyika (now Tanzania) in 1957 (Gibson et al. 1964), probably no one foresaw that within 10 years it would threaten the future of this and other pines around the world. No experience suggested this outcome. Since then, however, the blight has occurred in damaging form in Kenya, Uganda, Chile, England, New Zealand, and the northwest coast of North America, including the northwest coast of California.

The blight has proven to be a real catastrophe for countries such as Kenya, Chile, and New Zealand, which have thousands of acres of planted Monterey pine. The disease necessitated a major reassessment of the softwood afforestation program in Kenya (Gibson et al. 1964). In a few countries, such as Yugoslavia, from which the blight was reported in 1958 (Krstic), the forestry impact has been minimal. The disease seems to have disappeared in England after several nursery outbreaks within a 7-year period (Murray and Batco 1962; Gibson et al. 1964).

Blight was first noted in California on foliage of Monterey pine southeast of Fort Bragg in 1964, but the identity of the causal fungus was not established until 1966.<sup>1</sup> Recognition

**ABSTRACT:** Since it first appeared in Tanganyika in 1957, red band needle blight has become a major forest disease around the world. Apparently spread by high altitude winds, the blight has been found killing Monterey and other pines in California's northwest coastal counties. About 30 pine species are susceptible. Caused by the fungus *Dothistroma pini* (sexual stage *Scirrhia pini*), the disease usually damages only young trees. Climate may hold the disease in check in most of California.

**OXFORD:** 172.8 *Dothistroma pini*; 174.7 *Pinus radiata* (794) [+443.3--411]

**RETRIEVAL TERMS:** *Pinus radiata*; *Dothistroma pini*; *Scirrhia pini*; red band blight; California; high altitude dispersal; fungus attack; natural control.

of the damage potential triggered a cooperative survey for the disease by many agencies. The survey covered the coastal counties of California from Monterey County northward where the threat from the fungus appeared the most imminent. Spot checks extended the survey to parts of other counties. The survey located red band blight in three general areas, all in coastal northern California. It was principally but not entirely on Monterey pine. Some Monterey pines had apparently been killed by the disease (Calif. Forest Pest Control Action Council 1967).

What will red band blight mean for California? We can not know for certain until the disease has been thoroughly observed and studied here. But enough has been learned about it elsewhere to permit an interim appraisal of the prospects for California.

#### THE DISEASE

##### CAUSAL FUNGUS

The fungus producing the red band disease (*Scirrhia pini*) is not "new." It is similar to *Scirrhia acicola*, the causal organism of the brown spot needle disease of southern pines (Funk and

<sup>1</sup>Miller, Douglas R. *The history of Dothistroma pini in California*. Unpublished report on file in Regional Office, U.S. Forest Service, San Francisco.

Parker 1966). There is a report of its occurrence under another name as early as 1912, from the State of Georgia in southern Russia.<sup>2</sup> In North America the fungus was collected in Idaho in 1917 (Thyr and Shaw 1964), in Ohio in 1932, and in Oklahoma in 1934 (Hulbary 1941). It is probably indigenous in both Europe and North America.

Spore forms.--The fungus has a non-sexual form (*Dothistroma pini* Hulbary) as well as a sexual form (*Scirrhia pini* Funk and Parker). Both forms have been found in British Columbia (Funk and Parker 1966) and California<sup>3</sup> but not yet elsewhere. The distinctive red band character of the blight is associated with only the nonsexual form of the causal fungus, the form ordinarily seen. The spores of the nonsexual form retain their viability for a longer time than those of many other fungi (Gibson et al. 1964).

Spore liberation.--Spores of the *Dothistroma* form are liberated only in the presence of free water. They are distributed locally by a splash mechanism in droplets of water to adjoining foliage or trees (Gibson et al. 1964). Many of these droplets are in the 50 to 100μ diameter range. Because of evaporation these droplets may be very short lived. Any contained spores then become truly airborne (Amsden 1962; Gibson et al. 1964). No report on spore dispersal in the sexual (*Scirrhia*) stage has apparently been made, but there is little probability that dispersal is also by splash action. Most local dissemination of the fungus is in its *Dothistroma* form. Therefore the splash requirement for spread of this form becomes a key factor in the progress and intensification of the disease.

<sup>2</sup>Murray, J.S. *Dothistroma pini* Hulbary--Its occurrence in Europe. (Paper presented at International Union of Forestry Research Organizations, Congress, Munich, Germany, 1957. Made available to me by Fields Cobb, Jr., Dept. of Plant Pathology, Univ. of California, Berkeley.)

<sup>3</sup>Cobb, F. W., Jr., and Miller, D.R. *Hosts and geographic distribution of red band needle blight in California.* (Manuscript submitted to Journal of Forestry.)

## HOSTS

The red band disease has been reported on about 30 species, varieties, or hybrids of pines. Of these the following species are native in California:

Monterey pine (*P. radiata*)  
Western white pine (*P. monticola*)  
Ponderosa pine (*P. ponderosa*)  
Lodgepole pine (*P. contorta*)  
Bishop pine (*P. muricata*)  
Knobcone pine (*P. attenuata*)  
Torrey pine (*P. torreyana*)  
Limber pine (*P. flexilis*)  
Monterey x knobcone hybrid (*P. attenuata*).

Light infection by the fungus has recently been reported (Dubin and Walper 1967) on Douglas-fir (*Pseudotsuga menziesii*) in Chile but presents no problem.

In addition to the native species, four introduced pines reported elsewhere as hosts of the fungus are planted to some extent in California as shade and ornamental trees or for Christmas trees:

Canary Island pine (*P. canariensis*)  
Aleppo pine (*P. halepensis*)  
Scotch pine (*P. sylvestris*)  
Austrian pine (*P. nigra austriaca*).

These native and introduced pines differ widely in susceptibility to the red band disease. Monterey pine has shown itself to be highly susceptible. World-wide it has suffered more damage from *Dothistroma* than any other pine. Limited evidence indicates that the Monterey x knobcone hybrid is even more susceptible than Monterey pine. Because of their location and habitats, two of the native pines in the host list, Torrey pine and limber pine, are not likely to contract the disease within their natural range in California.

For wide-ranging species comprised of many geographical races, such as ponderosa and lodgepole pines, the fact that the disease has been found on trees of one race does not mean that

all races of the species will be susceptible. For example, ponderosa pine has been found infected in interior British Columbia; and in Idaho, Kansas, and Nebraska (Parker and Collis 1966; Peterson 1967; Rogerson 1953, 1954; Thyr and Shaw 1964). But this species has remained uninfected in Kenya (Gibson et al. 1964) under conditions of concentrated exposure to the fungus. Individual tree resistance has also been noted in ponderosa pine. Peterson (1967) reports that some ponderosa and Austrian pines remained uninfected by the fungus through three seasons in Nebraska. The strong probability of forms of the causal fungus with differing degrees of virulence or of host affinities should not be overlooked (Thyr and Shaw 1964).

Gibson et al. (1964) reported that some species of Mexican pines, including Mexican weeping pine (*P. patula*), did not contract the disease in Kenya's highlands although under infection conditions highly favorable for the causal fungus.

#### AGE SUSCEPTIBILITY

The disease usually damages only young trees--especially young planted trees. The upper age limit for susceptibility seems to be influenced by climatic and site conditions. In Kenya, where environmental conditions are very favorable for the rapid growth of Monterey pine, the oldest of this species attacked was 14 years (Gibson et al. 1964). In New Zealand, Monterey pine plantings older than 16 years have not been affected.<sup>4</sup> In contrast, Peterson reports (1967) finding the disease in 30- to 32-year-old Austrian and ponderosa pine plantations in Nebraska, and Parker and Collis (1966) found the disease affecting the lower branches of 31-year-old ponderosa pine in British Columbia, although the greatest damage there was to trees less than 10 years old.

<sup>4</sup>Shaw, C. Gardner. *Dothistroma pini*--History and international significance. Western Int. Forest Disease Work Conf. Proc., Kelowna, B.C., 5 pp. 1965.

Newly emerged needles of pine at first will resist infection but become susceptible by midsummer (Peterson 1967). Among older needles little difference in susceptibility, regardless of age, has been noted (Parker and Collis 1966).

#### CLIMATIC INFLUENCES

Practically all spread of the causal fungus from tree to tree takes place through the splash dispersal of spores of the *Dothistroma* stage. Thus not only the occurrence of rain but also its amount and distribution over the active season for the fungus are of utmost importance in intensification of the disease. There are indications that fog or mist may sometimes take the place of rain if it is heavy enough to cause moisture to condense on the foliage. In addition, fog or mist must persist long enough to allow the dispersed spores of the fungus to infect the foliage.

Several investigations have noted the relationship of incidence of needle blight to climatic factors. Rogerson (1953, 1954) was probably the first to call attention to the importance of rain in affecting the incidence of the disease. He noted that during the rain-deficient year of 1952 in Kansas there was no new development of *Dothistroma* needle blight, whereas during the wet year of 1951, incidence of the disease increased markedly. After 7 years of observations of the disease in England, Murray and Batco (1962) found that severe outbreaks were associated with wet conditions in early summer. No disease developed in the dry summers of 1955 and 1959, as compared with severe outbreaks in years of abundant summer rainfall: 1954, 1956, and 1960. In Kenya (Gibson et al. 1964) and Tanzania (Hocking 1966) a general relationship has been shown to exist between rainfall and blight. From his studies in Tanzania, Hocking (1966) concluded that "there exists a critical level of rainfall--below which

its effect on initiating infection is very small, and above which optimal conditions for infection occur over wide spectra of both rainfall and inoculum potential, once the disease is established.<sup>5</sup> This critical level may differ in different regions or even localities, however, depending on the extent to which seasonal rainfall patterns may be favorable or unfavorable for the development of the fungus.

Temperature, as well as rainfall, influences infection by the blight fungus. Hocking and Etheridge (1967) report that a weekly mean temperature of at least 65°F. in Tanzania is necessary for large disease increases. It follows that both climatic elements must be favorable to produce a heightened disease incidence.

#### EFFECTS

Red band blight directly killed young Monterey pines, according to reports, in East Africa (Gibson et al. 1964), North America (Parker and Collis 1966), and South America (Dubin and Staley 1966). Other reported victims were Bishop pines in British Columbia (Parker and Collis 1966), and Monterey x knobcone hybrids in California<sup>5</sup> and Chile.<sup>6</sup> These reports demonstrate that the blight can be very destructive to susceptible hosts in locations favorable to the causal fungus. Several susceptible tree species are grown for Christmas trees in California. Disfiguration alone by the red band blight would make them unsalable. Even aside from the mortality caused, the red band disease has jeopardized the future of susceptible pine species for general forestry purposes in various parts of the world.

#### MEANS OF GLOBAL SPREAD

The speed with which the red band blight became established in new centers around the world is probably unparalleled in the history of tree

diseases. The rate of spread is especially noteworthy because the causal fungus is not recognized as unusually well adapted for wind dissemination, as are the grain rusts, for example. Heretofore nearly all noteworthy outbreaks of serious tree diseases in parts of the world previously free of them has been through the transport of infected material by man (Smith et al. 1933). Examples include chestnut blight, white pine blister rust, and Dutch elm disease. So far, however, there is no evidence that man has been responsible for the transport of the red band blight fungus.

This is not to say that man's activities have played no part in the spread of the disease. Man set the stage by planting hundreds of thousands of acres of the highly susceptible Monterey pine. The very limited native range of this species restricted the genetic diversification and development of geographic races normally found in widely ranging species. The response of Monterey pine to biotic interactions is accordingly quite uniform, accounting for its uniform susceptibility to the blight.

When spores of *Dothistroma* lodged on pines on the southeast slopes of the Abedare Mountains, Kenya, in 1960 they came in initial contact with extensive young plantations of susceptible Monterey pines growing in a year-round equable climate and watered by frequent, well-spaced rains normally aggregating more than 70 inches per year. Under these conditions the fungus remained active 10 months of the year, with progressive waves of spore production and infection. An explosive intensification and spread of the disease resulted. Within 3 years the fungus was established in all of the major softwood-producing areas of Kenya and was already killing many young pines (Gibson et al. 1964).

Gibson et al. (1964) explored the capability of the fungus for long distance spread in moving air currents under the conditions prevailing in the highlands of Kenya. They found that at

<sup>5</sup>Op. cit. (see footnote 1)

<sup>6</sup>Personal communication from J. Kummerow, May 1967.

8,000 feet and above, where the heavily infected plantations are located, spores of the *Dothistroma* stage of the fungus maintained their viability for days. Mountain mists trapped at tree top level over an infected Monterey pine plantation yielded as many as 130 *Dothistroma* spores per ml. of condensed mist. From these and other findings Gibson et al. concluded that long distance transport of the fungus in the air was entirely possible. It may be pointed out that air turbulence might well carry airborne spores originating near the 8,000-foot level to much higher elevations in the atmosphere, where rapidly moving upper air currents might carry them for very great distances.

Transport of spores of the fungus by high level upper air currents seems the only plausible explanation to account for the unprecedented global spread of the red band blight that has taken place within the last decade.

#### OUTLOOK

The red band blight has already demonstrated that it can damage young trees of susceptible pine species, such as Monterey pine or the Monterey x knobcone hybrid, in the wetter parts of the north coast region of California. In view of the connection between abundant rainfall and incidence of the disease, it may be significant that all infection centers found to date in the survey for the disease have been within zones with a normal annual rainfall of 50 to 80 inches (Sprague 1941, (Unnumbered fig. p. 795)).

Pine species known to be very susceptible to the red band fungus are likely to be heavily damaged by it when planted in the high rainfall zones of the northwest California coast. Under these conditions the growing of such species there cannot be recommended. But California is well known for wide differences in climate that may exist within relatively short distances. For most of the State the summer dry season is sufficiently pronounced to

preclude any appreciable development of the disease even if the fungus should establish itself on scattered needles.

The unusual frequency of spring rains in 1967 should have favored an increase in the disease. But, as Hocking and Etheridge (1967) have pointed out, such an increase requires both favorable moisture conditions and temperature levels. Temperatures in April and May 1967 at two locations on the north coast near where red band disease appeared before 1967 were much below normal and did not come near the 65°F. level specified by Hocking and Etheridge as a minimum for pronounced blight increases. At other points in the State, however, temperatures may have been more favorable. Thus the planned continuance of surveys for the disease for a year or two seems particularly important.

If the blight does become established in young trees during a climatically abnormal season, in an area where natural control normally exists, the fact that the fungus is sensitive to copper sprays (Gibson et al. 1964; Peterson 1967) is encouraging. Spraying probably could prevent serious damage under California weather conditions until climatic patterns become normal and natural biotic control is reestablished.

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