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DISTRIBUTION OF FOMES ANNOSUS IN NATURAL FORESTS OF CALIFORNIA

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Worldwide in distribution and the causal agent of a root and butt rot, Fomes annosus (Fr.) Cke. is one of the most important pathogens of conifers in the temperate climatic zone. This disease is particularly severe in coniferous plantations of Europe. In eastern and southern United States, observations from systematic disease surveys during the past two decades suggest that annosus root rot is becoming increasingly significant as a limiting factor in the intensive management of conifer plantations. This suggestion, first advanced by Hepting and Downs (7) and by Campbell and Hepting (3), has been substantiated by recent reports (4, 5, 9, 11, 12) that show the disease is continuing to build up in thinned plantations and cutover natural stands. Losses are expected to be even greater in second and subsequent rotations and thinnings.

Conifer forests throughout western North America consist mostly of virgin stands and young-growth cutover stands restocked primarily by natural regeneration. Plantation forestry in the West is still in its infancy. Artificial regeneration there is primarily directed toward reclaiming large brush fields and forests destroyed by fires. Few of these plantings have reached the age of closure and therefore have not yet had a first thinning.

F. annosus is probably indigenous to the coniferous forests of western North America. It occurs in British Columbia (6) as a common cause of decay in the roots and butt of Douglas-fir, firs, Sitka spruce, western hemlock, and western red cedar. It is common as a root parasite throughout Idaho, Utah, and the adjoining Intermountain areas, principally on western white pine, western hemlock, and true firs. And in southern Idaho, the fungus causes death of trees of all ages from seedlings to overmature in ponderosa pine stands after partial cutting (J. W. Kimmey, personal communication).

In California, the pathogen is widely distributed throughout the State (Fig. 1)². It has been reported in all of the National Forests in both the Sierra Nevada and the Coast Range and in 28 of the State's 58 counties (Table 1)². The fungus was first recorded in 1909, by E. P. Meinecke, in an office report. He found the disease while examining a grove of P. radiata that had been turned into a park at Monterey, California. He reported that many trees had died since the establishment of the park, but he was not able to verify if this was also the case before normal conditions were upset. In 1914 Meinecke (8) reported that "although at present F. annosus apparently is somewhat rare in California, surveys may prove it to be more prevalent." Since then the disease has been recorded with increasing frequency in California. Although F. annosus has been considered of relatively little importance in the past, accumulated evidence now shows that it may well be one of the most important conifer disease problems in the State.

The organism can cause extensive damage under California conditions. Since 1934, when Olson (10) found it associated with dead and dying pines on the Lassen National Forest and demonstrated its pathogenicity to Jeffrey and ponderosa pines, there has been a slow but steady increase in the number of detection reports which associate F. annosus with tree mortality. Some of these reports note only slight damage in the loss of one to a few trees, but others show rather substantial losses involving the death of several hundred trees over rather large areas. In 1942, W. W. Wagener (personal communication) surveyed about 10,000 Pinus jeffreyii that had been treated for bark beetle attack on the Cleveland National Forest in San Diego County. He found that root killing by pathogenic fungi -- principally F. annosus -- was involved in the death of an estimated 70% of these pines. Wagener and Cave (14) reported infestations with large losses in the Mt. Laguna area (San Diego County) and Hat Creek Drainage (Shasta County). In recent years large losses have occurred at the Institute of Forest Genetics in Placerville, El Dorado County, where 26 species of pines, 3 varieties, and 1 pine hybrid were attacked and killed by F. annosus (1, 13). At Boggs Mountain State Forest, Lake County, a survey (2) of five sections of land revealed more than 60 F. annosus infection centers involving the death of nearly 800 trees. Infection centers ranged in size from 1 to 62 attacked trees.

Figure 1 and Table 1 represent only general areas within counties where the disease has been discovered. They do not show the number of infection centers within these areas. For example, Table 1 shows 13 areas have been found in Lassen County. However, one of these,

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²Figure 1 and Table 1 were compiled primarily from unpublished detection reports gathered in California from 1909 through 1965.

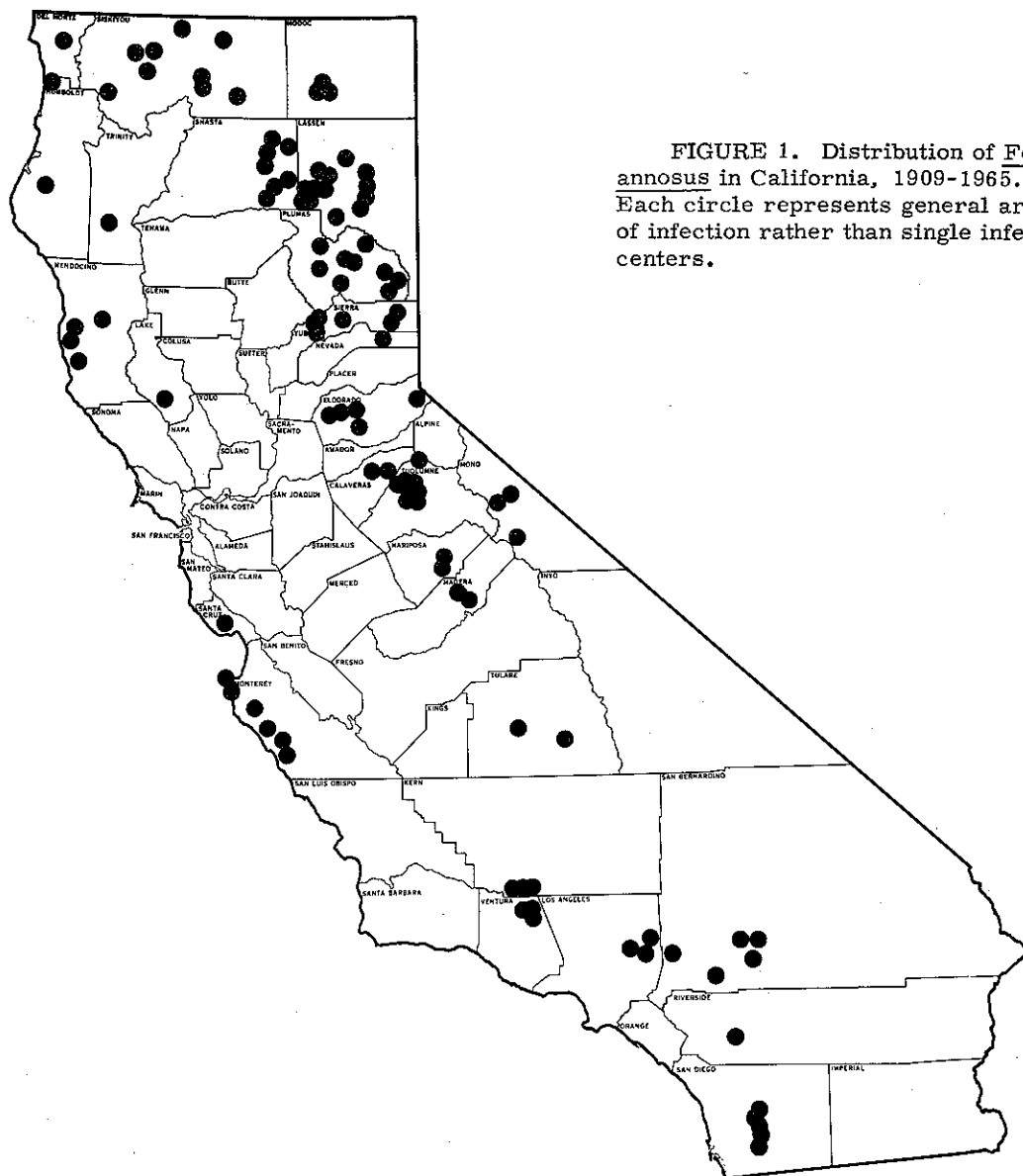


FIGURE 1. Distribution of *Fomes annosus* in California, 1909-1965. Each circle represents general areas of infection rather than single infection centers.

Blacks Mountain Experimental Forest, has more than 100 separate infection centers with several hundred dead and dying trees. One of the three areas listed in Ventura County, Alamo Mountain, was reported in 1965 as having 21 separate infection centers.

DISCUSSION

As yet no systematic survey has been conducted on a statewide basis in California to determine the distribution and impact of the fungus as a primary pathogen. Although *F. annosus* is considered to be indigenous to western North America, it is only within recent years that the importance of this disease has been clearly recognized. And the intensity of the disease in California is probably even greater than our present reports indicate.

Three major factors hamper the undertaking of an adequate systematic survey: erratic production of sporophores, diversity of host species and symptoms, and bark beetle infestations.

In most areas of the world the presence of sporophores is the principal method by which the fungus is detected in the field. Observations to date in California indicate that only during an occasional year are sporophores found with any frequency. Sporophores also appear to be more numerous in some areas of the Coast Range that have milder winters than in the lower elevations of the Sierra Nevada. Even at times and in places where sporophores are found with some frequency, they are small and usually hidden beneath a thick carpet of duff or buried in mineral soil where they are formed in channels left by decaying roots. At times they also develop on stumps in and beneath the bark where moisture conditions remain favorable for longer periods of time. Because of the erratic production of sporophores and their hidden nature, detection by this means is not practical. The more difficult method of using host symptoms complemented by laboratory culture has proved to be the only reliable means of identification.

Table 1. Distribution of *Fomes annosus* in California, by county.

| County | No. areas within county ^a | Period of reports | Hosts reported |
|----------------|--------------------------------------|-------------------|---|
| Calaveras | 2 | 1965 | <i>Pinus ponderosa</i> |
| Del Norte | 1 | 1918 | <i>Tsuga heterophylla</i> |
| El Dorado | 5 | 1944-1965 | <i>Abies concolor</i> <i>Pseudotsuga menziesii</i> <i>A. bracteata</i> 26 spp. of <i>Pinus</i> |
| Humboldt | 2 | 1923-1950 | <i>Sequoia sempervirens</i> |
| Kern | 3 | 1943-1965 | <i>P. jeffreyi</i> <i>P. monophylla</i> |
| Lake | 1 | 1963 | <i>Arctostaphylos</i> spp. <i>P. ponderosa</i> <i>P. lambertiana</i> |
| Lassen | 13 | 1914-1965 | <i>P. jeffreyi</i> <i>P. ponderosa</i> <i>A. concolor</i> <i>A. magnifica</i> <i>Artemisia tridentata</i> |
| Los Angeles | 3 | 1945-1965 | <i>P. jeffreyi</i> |
| Madera | 2 | 1963-1964 | <i>P. ponderosa</i> |
| Mariposa | 2 | 1942-1961 | <i>P. lambertiana</i> <i>P. contorta</i> <i>P. ponderosa</i> <i>Libocedrus decurrens</i> |
| Mendocino | 4 | 1964 | <i>P. ponderosa</i> |
| Modoc | 3 | 1965 | <i>P. ponderosa</i> |
| Mono | 3 | 1963-1964 | <i>P. jeffreyi</i> |
| Monterey | 6 | 1909-1963 | <i>P. radiata</i> <i>P. contorta</i> <i>P. coulteri</i> <i>Leptospermum laevigatum</i> |
| Nevada | 1 | 1916 | <i>A. magnifica</i> |
| Plumas | 7 | 1919-1964 | <i>P. jeffreyi</i> <i>P. ponderosa</i> <i>A. concolor</i> <i>A. magnifica</i> |
| Riverside | 1 | 1942 | <i>P. jeffreyi</i> |
| San Bernardino | 5 | 1942-1965 | <i>P. jeffreyi</i> <i>P. ponderosa</i> |
| San Diego | 5 | 1941-1944 | <i>P. jeffreyi</i> <i>P. coulteri</i> |
| Santa Cruz | 1 | 1956 | <i>P. ponderosa</i> |
| Shasta | 7 | 1942-1965 | <i>P. jeffreyi</i> <i>P. lambertiana</i> <i>P. ponderosa</i> |
| Sierra | 3 | 1914 | <i>A. magnifica</i> |

Table 1. (Continued)

| County | No. areas within county ^a | Period of reports | Hosts reported |
|----------|--------------------------------------|-------------------|---|
| Siskiyou | 9 | 1943-1964 | A. concolor P. ponderosa P. jeffreyi A. magnifica Arbutus menziesii P. attenuata x radiata |
| Trinity | 1 | 1964 | P. ponderosa |
| Tulare | 2 | 1910-1965 | P. contorta P. lambertiana |
| Tuolumne | 8 | 1939-1965 | A. concolor A. magnifica P. ponderosa P. lambertiana |
| Ventura | 3 | 1964-1965 | P. ponderosa P. jeffreyi |
| Yuba | 3 | 1964-1965 | P. ponderosa P. jeffreyi |

^aIndicates number of areas rather than number of infection centers within an area.

The forest flora of California includes about 55 species of conifers, many of which occur in mixed stands. As a result of such a diversity of coniferous host species and of physiographic differences found throughout the State, symptomatology and disease development are somewhat different from that reported to occur in other areas. In California, on both native and introduced species of pine, the fungus often invades and kills the cambium rapidly, the tree dies, and then a slow decay of the root and butt occurs. In true firs and other non-pine conifers, the fungus seldom attacks and kills the cambial tissues of the root. Instead it causes a chronic decay condition, with almost no detectable top symptoms, which the hosts appear to tolerate for a number of years.

Detection is further aggravated by the problem of bark beetles that attack coniferous forests of the western States -- especially California. In the later stages of root disease, infected trees are often invaded by bark beetles and appear superficially as if they had been killed by bark beetles alone; thus many trees infected with *F. annosus* are reported as bark-beetle-killed trees. Because of this insect problem, the sanitation cutting system has been adopted. Infected trees that show signs of decline are removed without giving full consideration to the cause of decline. Consequently many undetected centers of fungus infection are left in the stumps and roots.

Experience in Europe and the eastern United States shows that this disease can become more severe as forest management and utilization are increased. In California the observation that the greatest losses have been associated with stumps left from thinnings and harvest cuttings indicates that increased forest management there also is contributing to an increased incidence of the disease. The widespread distribution of the fungus in the State (Fig. 1, Table 1) makes it apparent that future damage will be directly related to intensified silvicultural practices. Proper recognition in future forest management plans must be given to such potential disease problems as those caused by *F. annosus*.

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