

The Incidence and Impact of *Heterobasidion annosum* on Pine and Incense-Cedar in California Forests¹

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Abstract: Approximately 12.5 percent of California commercial forest land is infested with *Heterobasidion annosum*, resulting in annual losses of approximately 111 million board feet. The east side of the Sierra Nevada/Cascade Crest in northeastern California is most severely affected, with about 20 percent of the land out of production because of annosus root disease. In Yosemite Valley, 158 annosus root disease centers were identified. These centers are enlarging at an average rate of 0.67 m/yr. The most important impact of annosus root disease in recreation areas appears to be hazard and the loss of vegetative cover.

Annosus root disease, which is caused by *Heterobasidion annosum* (Fr.) Brev., is locally a very serious problem in California forests. Its effects are particularly noticeable in pine, and the primary impact of the disease is tree mortality. Forest managers and forest pest specialists are continually aware of its presence in the forest. Evidence for this is the number of biological evaluations requested by forest managers and performed by forest pest specialists in Region Five of the National Forest System. Of 152 biological evaluations conducted during the years 1984 through 1988 at the request of forest managers, 32 percent identified *H. annosum* as a primary or secondary cause of tree mortality.

This paper presents our current knowledge of the incidence and impacts of annosus root disease on pine and incense-cedar trees growing on commercial forest land and in recreation areas in California.

¹Presented at the Symposium on Research and Management of Annosus Root Disease in Western North America, April 18-21, 1989, Monterey, California.

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PINE ON COMMERCIAL FOREST LAND

Of about 16 million acres of commercial forest land in California, about 812,626 hectares (2,008,000 acres), or 12.6 percent, are infested with root disease. About 99.6 percent of this disease is annosus root disease. Approximately 566,572 hectares (1.4 million acres) of ponderosa pine (*Pinus ponderosae* Laws.) and Jeffrey pine (*Pinus jeffreyi* Grev. and Balf.) are affected; the remaining affected area (242,817 hectares [0.6 million acres]) is in true fir (Table 1) (Anonymous 1988). The area of the state where these tree species are most severely affected is northeastern California on the east side of the Sierra Nevada/Cascade crest.

Of about 826.2 million board feet (MMBF) (137.7 million cubic feet [MMCF]) of estimated annual mortality from all causes on commercial forest land in California in 1976 (Smith 1984), about 118.8 MMBF (19.8 MMCF), or 14.4 percent, is due to root disease. Of this, about 111 MMBF (18.5 MMCF), or 93.4 percent, is annosus root disease. Pine accounts for approximately 60 MMBF (10 MMCF) of annosus-caused mortality; fir accounts for 51 MMBF (8.5 MMCF) (Table 1) (Anonymous 1988). A biological evaluation conducted by Kliejunas (1986) indicated that some stands of eastside pine have up to 50 percent of stumps infected, with about 20 percent of the land out of production because of annosus root disease.

PINE AND INCENSE-CEDAR IN RECREATION AREAS

More extensive information on the incidence and impacts of annosus root disease in California recreation areas has been provided by a continuing cooperative study begun in 1970 in Yosemite National Park. Yosemite Valley is one of the most heavily used areas in the National Park system. Between 1935 and 1977, 16,000 hazardous tree situations were dealt with in the park (Anonymous 1977), including three fatalities. As it became increasingly evident that *H. annosum* was involved in these hazardous tree incidents, an evaluation of the root disease situation was undertaken jointly by the University of California, the U.S. Department of the Interior, Park Service, and the U.S. Department of Agriculture, Forest Service.

Objectives of the study were: 1) to determine the numbers, sizes, and locations of H. annosum infection centers within the developed sites in Yosemite Valley; 2) to estimate the rate of pathogen spread and tree mortality in infection centers and the resulting vegetation changes occurring within these centers; 3) to estimate the hazards the infected trees pose to park visitors; and 4) to develop management options aimed at reducing stand damage and hazard. Preliminary information has been published (Anonymous 1977, Felix and others 1973, Parmeter and others 1978, Parmeter and others 1979).

In 1970, developed sites of Yosemite Valley were surveyed for H. annosum by systematically traversing stands, reviewing records of hazardous tree incidents, examining aerial photographs, and observing stands of trees from the valley rim. Dead trees, and declining trees associated with stumps, windthrows, or stand openings containing stumps were investigated. Any localized area of tree mortality was considered to be an annosus center if one or more trees or stumps yielded the fungus. Centers were confirmed by finding sporophores in stumps or by isolating the fungus. A similar survey of undeveloped Yosemite Valley sites was made in 1975. Additional centers were noted by investigating windthrows, deliberately uprooted trees, and random mortality in developed sites. Most centers appeared to be single-tree centers, or to consist of at most two or three trees.

Incidence

Within the developed sites of Yosemite Valley, 102 annosus root disease centers including both ponderosa pine and incense-cedar (Calocedrus decurrens) were identified, representing about 140-150 loci of infection. An additional 56 centers of infection were confirmed in undeveloped sites.

To estimate the rate of center enlargement, historical maps of areas where annosus root

disease centers have since been identified were examined. Measurements on ten mapped plots coincident with older vegetation maps gave an average annual radial enlargement of 0.67 m (2.2 ft) (Table 2). At this rate, centers could be expected to reach 0.20 hectares (0.5 acre) in about 38 years and 0.40 hectares (1 acre) by 54 years. It appears that continued monitoring for perhaps another 20 years will be necessary to develop needed refinement of spread rate estimates.

Impact

Potential impacts to recreation areas caused by annosus root disease include growth loss, mortality, loss of vegetative cover, and hazard. To estimate annosus root disease-caused growth loss, growth for the past 20 years was measured on 44 pines which had been uprooted and examined for disease. No correlation was found between growth patterns and root disease (Table 3).

Estimates of mortality caused by annosus root disease were made from 67 disease centers mapped in 1971 and monitored from 1972 through 1980. Annual losses of both pine and cedar during this period averaged about 78 trees. This mortality varied greatly by year. For example, high mortality occurred during 1978 and 1979, coincident with a period of drought and epidemic bark beetle activity. Extrapolation from these figures, and from DBH and volume records for recent timber salvage sales in the valley, indicates that over 1-1/3 MMBF of timber have been lost on 85 mapped centers, or about 16 thousand board feet (MBF) per center.

In addition to losses of timber volume, recreational areas are impacted by a loss of vegetative cover and the creation of large openings. Large areas (up to 0.2 hectare [1/2 acre]) have been virtually denuded within 30-40 years by single loci of infection. Since most

Table 1--Annual mortality caused by Heterobasidion annosum in pine and fir trees in California

Host	Area infested	Losses to mortality	Value of dead timber
	<u>hectares</u>	<u>MBF</u>	<u>dollars</u>
Pine	566,572	60	\$7,838,500
Fir	242,817	51	\$1,804,124
Total	809,389	111	\$9,642,624

Table 2--Enlargement calculations for tree disease centers caused by Heterobasidion annosum coincident with areas in Yosemite Valley for which there are old vegetation maps

Center	Early map	Recent map ¹	Years	Infection Center Enlargement
	<u>year</u>	<u>year</u>	<u>no.</u>	<u>avg. m/yr</u>
UR 9	1937	1983	46	0.64
UR Oak	1937	1971	34	0.70
UR Oak	1937	1983	46	0.73
Juniper	1948	1971	23	0.70
Juniper	1948	1977	29	0.76
Juniper	1948	1980	32	0.73
Tent	1948	1964	16	0.79
6-4	1950	1971	21	0.43
6-4	1950	1978	28	0.61
6-5	1950	1978	28	0.52
6-2	1950	1983	33	0.55
LP-41	1950	1976	26	0.91
LP-6	1966	1983	17	0.35
LP-17	1966	1976	10	<u>0.64</u>
			Average =	0.67

¹Date of recent map depends on the years in which significant center enlargement occurred.

Table 3--Radial growth of pines infected with Heterobasidion annosum

Root disease	Average growth 1958-1978	Trees examined
<u>pct</u>	<u>centimeters</u>	<u>no.</u>
0	2.41 ± 0.39	10
1 - 25	1.33 ± 1.19	8
26 - 50	0.70 ± 0.57	7
51 - 75	1.07 ± 0.53	5
76 - 100	1.24 ± 0.67	14

annosus root disease centers are small, losses in the future will probably accelerate. If most of the 140-150 loci reach 0.20 hectares in the next 30 years, many of the existing camping and housing developments will be without forest cover. If the estimate of 140-150 loci is far too low, then most of the cabin and campground cover in the valley will be lost within the next 20-40 years. Attempts to revegetate large openings in campgrounds with native hardwoods in southern California have cost the Forest Service \$24,710/hectare (\$10,000/acre) and up. Treatment of fresh stumps with borax is required in Forest Service public recreational areas, at a cost of about \$65.00/100 MBF removed³. Region 5 spent about \$9,000 in 1987 for stump treatment.

Equal in importance to the loss of vegetative cover in recreation areas is the hazard (due to falling of trees whose roots are weakened by annosus root disease) to recreationists and facilities. Although pines are usually killed by annosus root disease before the root systems are extensively decayed, incense-cedar usually has extensive decay of the roots and butt before the tree dies; therefore, it is likely to fail while still living. Annosus root disease centers open up the stand; this reduces the protection from wind afforded by surrounding trees, and thereby further increases the chances of windthrow. The manager of the forest recreation area is legally responsible for the reasonable safety of visitors, and he must have the means to reduce hazard in root disease-infested stands. Otherwise, removal either of the forest or the people and facilities must be considered. How this dilemma is being addressed in Yosemite National Park is discussed by West (1989).

³Unpublished data available at the Big Bear Ranger District of the San Bernardino National Forest, Fawnskin, California.

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