Spore Deposition of *Heterobasidion annosum* in Thinned Coastal Western Hemlock Stands in Oregon and Washington

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ABSTRACT

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Deposition of spores of *Heterobasidion annosum* was studied in both commercially and precommercially thinned stands of western hemlock (*Tsuga heterophylla*) at five coastal locations in Washington and Oregon. Petri plates containing selective medium were exposed at approximately monthly intervals from April 1981 to June 1982. Average spore deposition rates were higher in precommercially than commercially thinned stands, with the highest average rate (19,557/m^2/hr) occurring at Seaside, OR. The maximum spore deposition rate was 44,353/m^2/hr in a precommercially thinned stand at Tillamook, OR. Deposition rates in precommercially thinned stands were higher at the southern sites (Cathlamet, Seaside, and Tillamook) than the northern sites (Sekiu and Hoquiam). This trend did not occur in commercially thinned stands. Deposition rates were, in general, highest in autumn and spring and lowest in winter and summer.

Additional key words: root disease

Heterobasidion annosum (Fr.) Bref. (*Fomes annosus* (Fr.) Cke.) causes root and butt rot of western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) in Oregon, Washington, British Columbia, and Alaska (3,13,16). The fungus, dispersed as airborne basidiospores, colonizes freshly cut stump surfaces or wounds created during thinning. Mycelium spreads to adjacent trees through root contacts. *H. annosum* also produces conidia, but their role in nature is not yet known.

Because young western hemlock stands are generally overstocked, forest managers wish to thin them early, often precommercially; however, if *H. annosum* enters the stand early, it may cause considerable decay. Chavez et al (1) showed that incidence of infection increased from 8% at the time of precommercial thinning (age 15 yr) to 90% at 26 yr in western hemlock at Clallam Bay, WA. Only incipient decay was present at 26 yr. Incidence of infection was lower (60%) in a 26-yr-old unthinned stand at Clallam Bay adjacent to the precommercially thinned stand of Chavez et al (1; R. L. Edmonds, *personal communication*). Losses in commercially thinned stands have been low (3). If a high incidence of incipient decay indicates considerable future advanced decay, it may be preferable to delay thinning.

Deposition of spores of *H. annosum* has been studied in the U.S. Pacific Northwest and Canada (2,9,10,12), but spore loads in precommercially and commercially thinned stands have not been compared. This could be important with respect to forest management because infection has been directly related to the number of airborne basidiospores (14,15). This study was initiated to determine relative amounts of inoculum (spore deposition rates) in precommercially and commercially thinned western hemlock stands in coastal Oregon and Washington on a seasonal basis.

MATERIALS AND METHODS

Rates of deposition of spores of *H. annosum* were determined in five commercially and precommercially

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Table 1. Characteristics of precommercially and commercially thinned stands of western hemlock in which spore deposition of *Heterobasidion annosum* was studied

Site	Thinning type	Establishment year	Thinning year	Postthinning stand density (trees/ha)	Postthinning avg. tree diam. (cm) at 1.4 m[a]	Comments
Sekiu, WA	P[b]	1952	1980	613	···	
	C	1929	1980	509	···	Also includes Sitka spruce
Hoquiam, WA	P	1960	1980	815	14.0	
	C	1947	1979	1,110	···	Strip thinning, strips 15 m wide, 30 m between strips
Cathlamet, WA	P	1961	1974	740	22.4	
	C	1934	1979	403	40.1	
Seaside, OR	P	1962	1977	731	26.4	Also includes Douglas-fir, Sitka spruce, and grand fir
	C	1938	1980	348	39.2	Also includes Sitka spruce
Tillamook, OR	P	1961	1980	667	13.7	
	C	1936	1980	667	42.9	

[a] Immediately after thinning.
[b] P = precommercial thinning and C = commercial thinning.

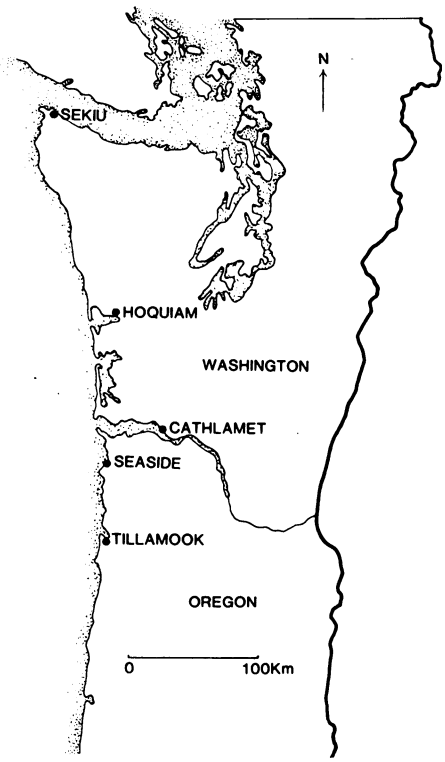

Fig. 1. Sites where spore deposition by *Heterobasidion annosum* was studied in Oregon and Washington.

thinned western hemlock stands in western Oregon and Washington. Locations of these sites are shown in Figure 1 and stand characteristics are shown in Table 1.

Five plastic petri plates (100 mm diam.) containing selective medium for *H. annosum* (7) amended with rose bengal (300 μg/g) were exposed at stump height in each stand approximately monthly from April 1981 to June 1982. Plates were exposed on stumps for 1 hr during daylight (0635–1638 hours), with the exception of a 3-hr exposure at Sekiu on 8 July 1981.

Plates were then mailed to the laboratory at the University of Washington, incubated for 10 days at 25 C, and examined under a dissecting microscope for the presence of conidial colonies (*Oedocephalum* stage). Deposition rates were calculated with the assumption that each colony resulted from one spore. Data were analyzed using analysis of variance and the Student-Newman-Keuls test for significance.

Table 2. Average rates of deposition of spores of *Heterobasidion annosum* (± standard deviation) based on monthly samples in precommercially and commercially thinned western hemlock stands in Washington and Oregon from April 1981 to June 1982

Site	Spore deposition rate (no./m^2/hr)[x]	
	P[y]	C[y]
Sekiu, WA	7,152 (5,909) a	3,931 (3,495) a
Hoquiam, WA	1,707 (1,189) a	2,022 (1,397) a
Cathlamet, WA	11,568 (9,544) a	3,091 (3,964) b
Seaside, OR	19,557 (13,549) a[z]	2,414 (2,900) b
Tillamook, OR	13,331 (12,335) a	2,845 (3,808) b

[x] Values followed by a different letter indicate that precommercial is higher than commercial thinning ($P<0.05$).
[y] Thinning type: P = precommercial and C = commercial.
[z] Seaside higher than other precommercially thinned sites ($P<0.01$).

RESULTS AND DISCUSSION

Average rates of spore deposition were 3.7–8.1 times higher in precommercially than in commercially thinned stands at Cathlamet, WA, and Seaside and Tillamook, OR (Table 2). Differences at Sekiu and Hoquiam, WA, were not significant although the average rate at Sekiu was 1.8 times higher. The highest average rate in precommercially thinned stands occurred at Seaside, OR (19,557/m^2/hr). Generally, rates were higher at the southern locations (Cathlamet, Seaside, and Tillamook) than at the northern locations (Sekiu and Hoquiam), although only the Seaside deposition rate was significantly higher. This trend did not occur in commercially thinned stands, where the highest average spore deposition rate was 3,931/m^2/hr at Sekiu, WA (Table 2), and there were no significant differences among stands.

In general, rates of spore deposition were highest in autumn and spring and lowest in summer and winter in precommercially thinned stands (Fig. 2). Patterns were similar in commercially thinned stands, except at Seaside, OR, where the highest rate occurred in winter (Fig. 2).

The maximum rate of spore deposition in this study was 44,383/m^2/hr in a precommercially thinned stand at Tillamook, OR, on 15 October 1981 (Fig. 2). Rishbeth (11) found similar high rates (28,000/m^2/hr) in a pine stand in England. The highest rate in a commercially thinned stand was 13,468/m^2/hr on 24 April 1981 at Tillamook, OR (Fig. 2). In British Columbia, the highest rate noted was 5,500/m^2/hr (9) and a previous study in Washington (2) revealed very low deposition rates (3–70/m^2/hr), but in this stand, no sporophores were observed. Low deposition rates were also noted in

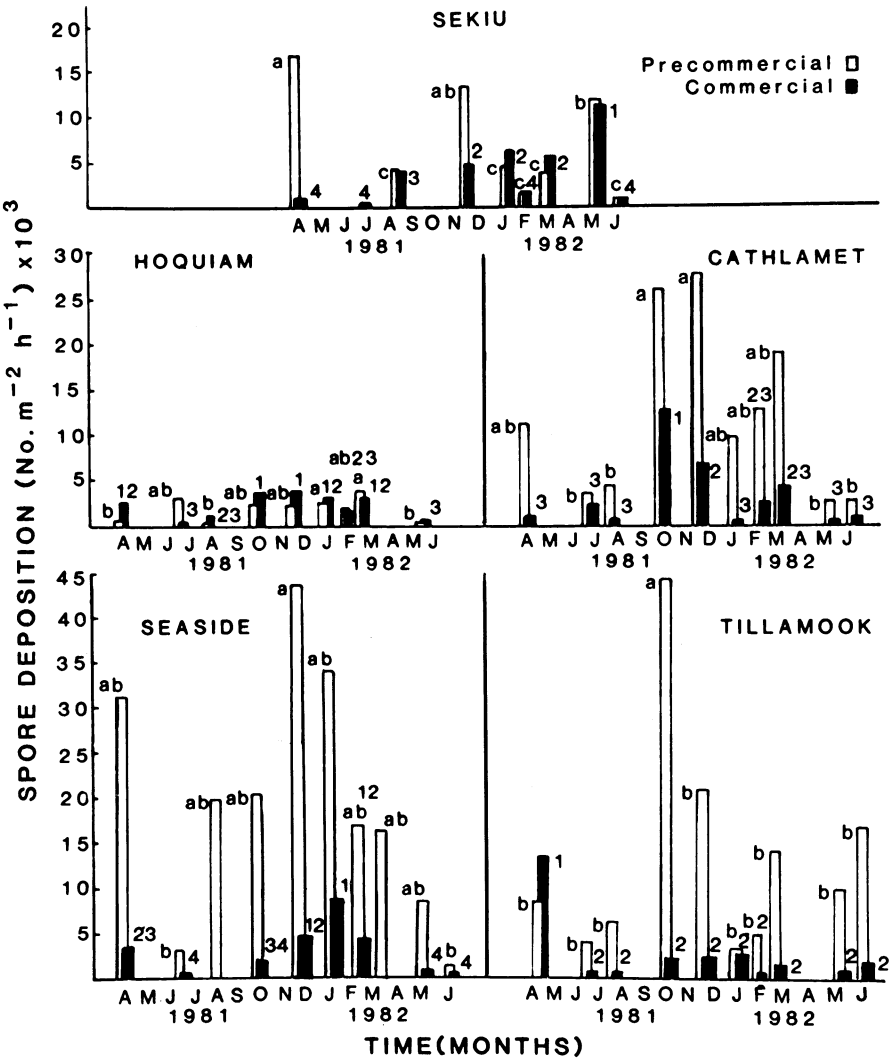

Fig. 2. Rates of deposition of spores of *Heterobasidion annosum* in precommercially and commercially thinned western hemlock stands near Sekiu, Hoquiam, and Cathlamet, WA, and Seaside and Tillamook, OR, from April 1981 to June 1982. In precommercially thinned stands, monthly values with different letters in each site are different, $P<0.05$. In commercially thinned stands monthly values with different numbers are different, $P<0.05$.

California (3–796/m^2/hr) (4).

All data in this study were obtained during daytime hours (0635–1638 hours). A number of studies (2,5,6,14) have indicated that more spores are deposited at night than during the day. Leslie (8), however, found that this tends to be seasonal in Washington. She observed that there was generally no significant difference between day (0600–1700 hours) and night (1700–0600 hours) deposition in autumn and winter, but in some months during spring and summer, night deposition was significantly greater. Thus, during periods of high spore deposition, daytime deposition rates may reflect deposition rates throughout entire 24-hr periods.

The high spore deposition rates in autumn and spring are typical for *H. annosum* in this area. Morrison and Johnson (9) found the highest rates in British Columbia at this time of year and lowest rates in summer and winter.

It appears that viable spore deposition rates are generally higher in precommercially than in commercially thinned stands in coastal Oregon and Washington. If rates of infection of stumps and logging sears are directly related to spore deposition rates, there is a smaller chance of infection in stands commercially thinned than in those precommercially thinned.

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