Armillaria root disease: A major impediment to sustainable management of southern Interior ecosystems

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INTRODUCTION

Armillaria ostoyae (Romagn.) Herink has a circumpolar distribution in the northern hemisphere where it causes Armillaria root disease of conifers (Kile et al. 1991). In British Columbia, the fungus occurs south of a line between McBride and Bella Coola, and in the Interior it is found in most biogeoclimatic subzones, except those that are very dry and above the elevational limit. Within its range, it attacks all species of trees, many shrubs, and some herbs. Tree mortality usually begins 5–7 years after stand establishment and can continue throughout a rotation.

In managed forests infested by Armillaria root disease, the stump and root system of cut trees have an essential role in disease development. In thinned (Cruickshank et al. 1997), selectively cut (Shaw et al. 1976), and clearcut (Woods 1994) stands, the stump and root system of cut, infected trees can be colonized and become inoculum. Inoculum is woody substrate containing *A. ostoyae*, and inoculum potential is a measure of the fungus' energy. Increases in the amount and potential of inoculum put residual trees and regeneration at risk from Armillaria root disease.

Some results are reported here from two studies on the epidemiology of Armillaria root disease, one on juvenile stands and the other on mature stands, parts of which had been selectively cut. These studies had the following objectives.

- To determine the incidence of trees with above-ground symptoms and below-ground infection at sites in the dry, moist, and wet climatic regions.
- To observe the host–pathogen interaction at infections; that is, to observe whether the fungus was advancing (progressive) or had been stopped (callused).
- To measure the effects of selective cutting in mature stands on below-ground incidence of infected trees and on merchantable volume in five tree-condition classes.

METHODS

Five sites with 12–24-year-old plantations, or naturally regenerated stands, were selected from among candidates in each of the dry, moist, and wet climatic regions of the Nelson Forest Region. Plots (0.01 ha) were centred on trees killed by *A. ostoyae* more than 5 years or less than 2 years previously, or where there were no symptomatic trees. In two mature stands approximately 100 years old (one in the IDFdm2, the other in the ICHmw2), five plots of 0.04 ha were located in parts of the stands that were undisturbed

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or had been selectively cut 30 and 13 years previously, respectively. Merchantable volumes in five tree-condition classes were determined using the Ministry of Forests cruise compilation program. All trees in plots were examined for above-ground symptoms of Armillaria root disease before being removed from the soil by an excavator. Root systems were examined for infections, and infections were classified as callused or progressive. Data were analyzed using the SAS statistical package, including logistic regression, ANOVA, Student Neuman-Keuls test, and *t*-tests.

RESULTS AND DISCUSSION

In juvenile stands, significant differences were found in the percentage of trees with below-ground infection among climatic regions ($p < 0.0001$), with values for dry region sites being significantly lower than those in the moist and wet regions. Below-ground incidence was significantly greater ($p < 0001$) in plots centred on a dead tree than in asymptomatic plots. Significant differences ($p = 0.01$) were evident among climatic regions in the percentage of trees with below-ground infection that showed above-ground symptoms. In the dry region, 51% of trees infected below ground were detected compared to 28% and 23% in the moist and wet regions, respectively. The probability of a tree being infected below ground increases with DBH and is higher in the moist climatic region than in the wet or dry regions (Figure 1).

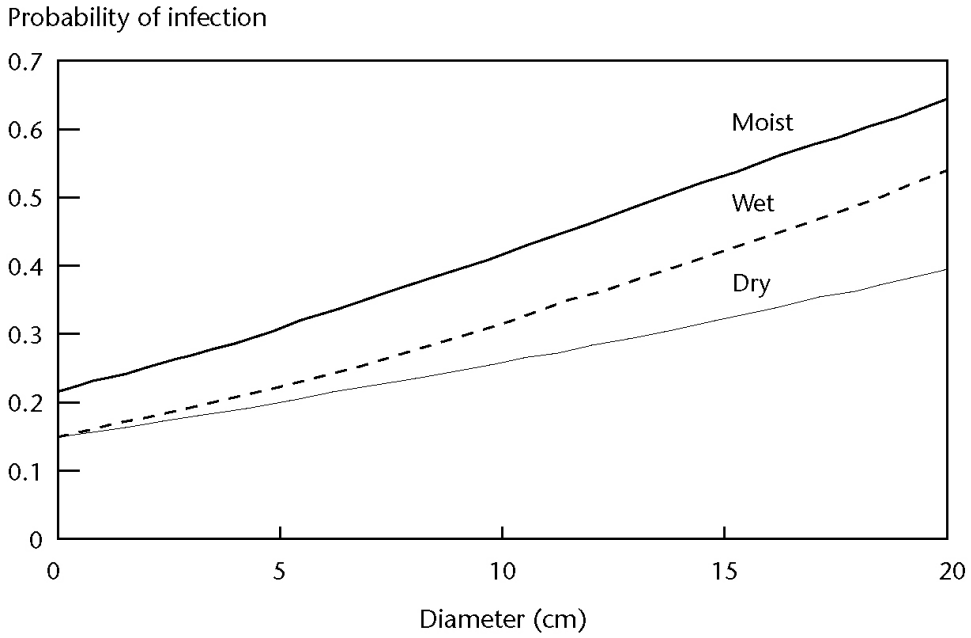

FIGURE 1 *Probability of below-ground infection on juvenile coniferous trees up to 20 cm DBH at sites in the dry, moist, and wet climatic regions.*

In the moist and wet regions, about 55% of infected trees had at least one progressive infection compared to 78% in the dry region; on more than 80% of these trees in all climatic regions, the progressive infection was at or within 50 cm of the root collar. Therefore, many infected trees are at risk of being killed by *A. ostoyae* in the future. Although it is encouraging that about 45% of infected trees have stopped the spread of the fungus, the disease has not become quiescent. Cruickshank et al. (1997) showed that cutting of infected trees during thinning resulted in colonization of the stump and spread

of *A. ostoyae* to adjacent crop trees via root contacts. Thinning could increase the proportion of infected trees in juvenile stands and result in mortality.

In undisturbed parts of the two mature stands, below-ground incidence of infected trees was 10% at the dry site and 80% at the moist site. At the dry site, 27% of trees with below-ground infection showed above-ground symptoms compared to 15% at the moist site. The probability of a tree being infected below ground increased with DBH (Figure 2), as it did in the juvenile stands.

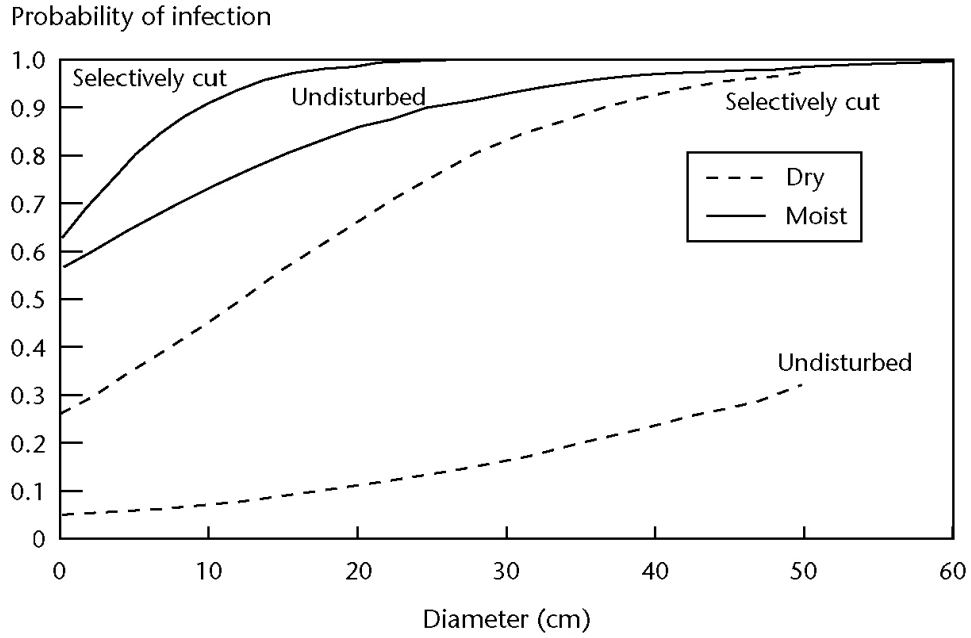

FIGURE 2 *Probability of below-ground infection on mature conifers in undisturbed and selectively cut parts of stands in the dry and moist climatic regions.*

Selective cutting significantly increased the probability of infection at the dry site ($p = 0.0001$), but not at the moist site ($p = 0.91$). At the dry site, about 95% of infected trees had one or more progressive infections compared to 75–80% at the moist site; differences between undisturbed and selectively cut plots were not significant. At the dry and moist sites, 55% and 100%, respectively, of the stumps created by the selective cut were colonized by *A. ostoyae*. In selectively cut plots at both sites, a significant decrease was evident in the percentage of merchantable volume in the uninfected condition class compared to that in undisturbed plots. Increases also occurred in the percentage of volume in the *A. ostoyae*-killed, -threatened, and non-threatened classes.

In summary:

- Climate affects incidence of infected trees, symptom expression, and host response.
- Only one-quarter to one-half of infected trees at dry sites and one-sixth to one-quarter at moist sites show above-ground symptoms.
- Probability of infection by *A. ostoyae* increases with increasing DBH.
- Pre-commercial thinning may increase inoculum to a level that results in killing of crop trees.
- Selective cutting increases the amount and potential of *A. ostoyae* inoculum resulting in an increase in incidence of infected trees and mortality. The increases are greater in the dry region. Damage may not become obvious until 20–30 years after harvest.

Is Armillaria root disease a threat to sustainable management in the southern Interior? The results of

these studies suggest that this is the case. The threat can be reduced by modifying practices to minimize the amount of inoculum created or by mechanical removal of potential inoculum during thinning and selective harvesting.

REFERENCES

Cruickshank, M.G., D.J. Morrison, and Z.K. Punja. 1997. Incidence of Armillaria species in precommercial thinning stumps and spread of *Armillaria ostoyae* to adjacent Douglas-fir trees. Canadian Journal of Forestry Research 27:481–90.

Kile, G.A., G.I. McDonald, and J.W. Byler. 1991. Ecology and disease in natural forests. *In* Armillaria root disease. C.G. Shaw and G.A. Kile (editors). U.S. Department of Agriculture Forest Service, Washington, DC. Handbook No. 691. pp. 102–21.

Shaw, C.G., L.F. Roth, L. Rolph, and J. Hunt. 1976. Dynamics of pine and pathogen as they relate to damage in a forest attacked by Armillaria. Plant Disease Reporter 60:214–8.

Woods, A.J. 1994. The behaviour and impacts of *Armillaria ostoyae* in mature stands and plantations in the Shuswap region of British Columbia. MSc thesis. University of British Columbia, Vancouver, B.C.

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