Fungal root disease starts at the stump

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Mention "*Armillaria* root disease" in BC's southern interior and you will probably find a diverse range of opinions about this parasite's impact on the forest. There are many reasons for this range. One is that most of the biology of this disease lies below ground and is difficult to study. As well, the disease is not associated with the huge mortality flushes that occur with other pests, such as bark beetles. Instead, damage occurs over an extended period and is less noticeable. Moreover, stands do not look "dead" even though the stand composition and structure may have been altered, and still appear "green". Additionally, disease expression and impact are strongly affected by ecosystem type, and comparisons between ecosystems can be misleading. Finally, still other opinions exist because of personal beliefs about how the forest should be managed.

This disease presents a long-term decision-making problem for managers because it may take decades for the consequences of an action to be seen. An understanding of the biology and epidemiology of the disease would help clarify the issue.

Table 1. The susceptibility of host species to *Armillaria ostoyae* in BC.

SUSCEPTIBILITY	HOST SPECIES
Susceptible	*Abies* series Douglas fir
Moderately susceptible	lodgepole pine Spruce species western hemlock western red cedar
Tolerant	western larch ponderosa pine
Resistant	aspen birch poplar

Armillaria ostoyae, *the fungus responsible for "Armillaria root disease," is widespread in southern BC.*

Successful management of the disease will occur when the amount of fungal food base (stumps) is carefully managed to a level that the ecosystem can support.

The disease and its hosts

The fungus responsible for the disease, *Armillaria ostoyae*, is widespread in southern BC and has a wide host range. The disease is most damaging in the southern interior ecosystems, while coastal forests over the age of 20 are not at risk. Vigorous trees in coastal forests tend to outgrow the fungus even though they are infected. None of the tree species are immune. However, the ability to cope with infection differs according to tree species (Table 1). Below the age of 20 years, all trees are more or less susceptible, except the deciduous species. Deciduous species can become susceptible at a later date, especially when they become over-topped by conifers.

Armillaria species are excellent stump colonizers, and few fungi can match their ability. These species are maintained in apparently healthy stands because they are in balance with the natural vegetation. One of the primary factors affecting disease is the amount of food base (stumps) the fungus occupies. The creation of stumps in these stands increases the food base available to *Armillaria* species, and tips the balance in favour of the fungus for a while. Successful management of the disease will occur when the amount of fungal food base (stumps) is carefully managed to a level that the ecosystem can support.

Stump colonization

The fungus exists in lesions on the roots of trees before they are cut. In the south-

ern interior, up to 40% of the trees in spacing-aged stands and 80% in mature stands have root lesions. Following stump creation, *Armillaria* spreads from the lesion and colonizes the stump in about two years. The fungus colonizes the nutrient-rich outer phloem and cambial tissues first, and then spreads into the heartwood.

The initial positioning on the root and rapid growth rate put the fungus in a good position to exploit the stump. Possession of the stump is critical for the fungus because it cannot live in the soil in absence of the food base. After colonizing the stump, the fungus moves onto the crop trees at root contacts and by rhizomorphs (i.e., root-like structures produced by the fungus). The greatest damage is done through root contacts between the crop tree and the stumps.

Armillaria *spreads through root contact between infected stumps and crop trees.*

Brushing and weeding create small root systems that may become food base for the fungus.

Timing and size of stumps in the stand

The timing of stump creation, and the number and location of stumps within a stand affect the development of the disease. Management methods that increase the time for root contacts to occur between susceptible crop trees and the colonized stump, reduce the number of susceptible trees exposed to the stump, or reduce the size of the stumps to affect the level of the disease. Also, creation of stumps at regular intervals keeps the fungus in a vigorous state.

Of course, any stand with a high level of mortality prior to management activities can be expected to have high mortality in the residual stand, regardless of the management system used, unless the stumps are removed. Given the size and location of stumps, and the timing of stump creation relative to the crop trees, we can make some predictions about the effects of stand tending and harvest practices on disease.

Brushing and weeding

Brushing and weeding create small root systems that may become food base for the fungus. Removing the woody shrubs and deciduous species also allows greater root-to-root contact between conifers because the roots no longer act as a physical barrier. Brushing and weeding should only be done where necessary to get sufficient regeneration established, and then only in a small area around the tree.

Precommercial thinning

The stumps created by precommercial thinning are smaller than those left by other operations, but the large number of stumps scattered throughout the stand often results in unacceptable post-spacing mortality. Thinning in stands that show a moderate to high number of diseased trees and that contain a large proportion of susceptible species should not be done. If both a precommercial and a commercial thinning are planned in one rotation, then the effects on the fungal food base are compounded.

Commercial thinning

In commercially thinned stands, the stumps are in root contact with the remaining crop trees. The fungus moves across the root contacts when its energy level is at maximum. Transfer of the fungus from the stump to tree occurs in the second or third year. The stumps are also created uniformly across the site, maximizing the contact between stumps and crop trees. In this way, disease is favoured in space and in time.

Commercial thinning, where the largest trees are removed in favour of a smaller diameter class, is most likely to favour the disease. This system leaves the largest stumps in contact with the smallest trees. Commercial thinning stands where the smallest trees are cut will likely have less disease because the stumps

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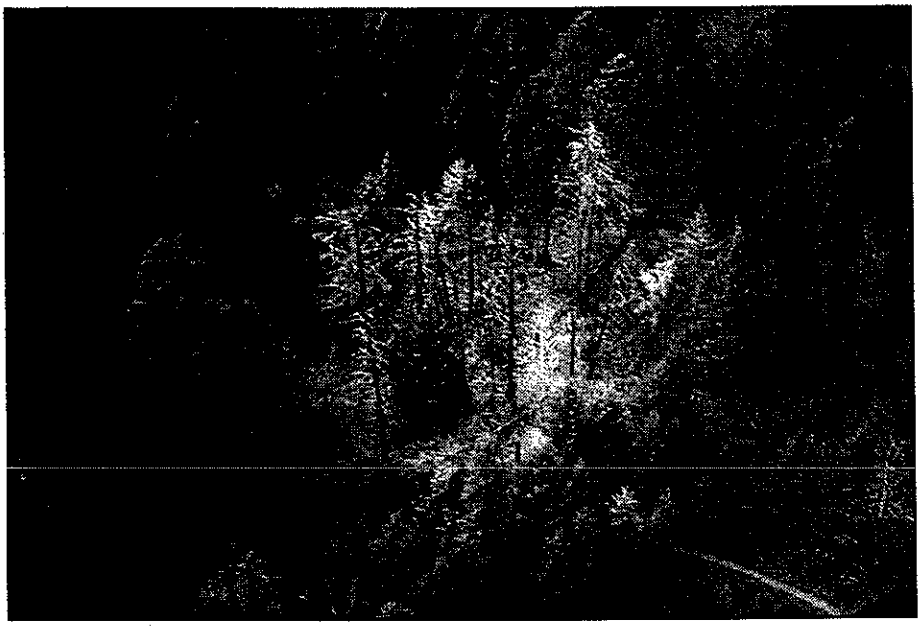

Birds-eye view of Armillaria *mortality in a Douglas-fir stand.*

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are smaller in relation to the surrounding trees.

Group selection

Other types of harvest such as group selection are expected to have less mortality. In this system, all the trees are removed in one area leaving only trees at the edge in contact with the stumps. This minimizes exposure of the trees to the fungus in comparison to other partial cuts. Trees regenerating within the cut area, now have some time before their roots touch the stump (similar to a clearcut).

Clearcuts

Clearcuts are least favourable to disease development because the root contacts between the stumps and new stand take up to 15 years to fully develop. In this period, the fungus has decayed some of the stump, especially the outer tissues where the transfer to new roots occurs, and its energy is lower.

Stump management

At present, stump removal is the only tested method for reducing the fungal food base. Pushover logging removes the whole tree (including roots) in harvesting operations, and pop-up spacing removes the root system with the tree in spacing operations. Stump removal on commercial thinning operations is much more difficult. Stump removal is expensive, and not possible in all cases due to site limitations. Every attempt should be made not to increase the fungal food base over time, so that drastic measures at a later date are not required. To keep the vigour of fungus low on a site, the number and size of stumps should be kept to a minimum. Where partial-cutting systems are required, stands could be cut to a diameter limit basis where the smallest trees are removed and the largest left.

Many trees may only have small root lesions and show no visible symptoms above ground, but, when cut, become food for the fungus.

Resistance

Resistant species (Table 1) can be used on sites where stumps cannot be removed. During precommercial thinning, some of the less susceptible conifers and deciduous species can be favoured and root contacts between susceptible conifers reduced. In clearcuts, planting resistant species near infected stumps and keeping the susceptible species away from stumps should also reduce the impact of disease. Planting alternate rows of susceptible and resistant species reduces root contact between the susceptible conifers and slows the disease's spread. Only broadleaf species show resistance to the fungus at an early age. Remember that even resistant species can be infected and once cut, their stumps can become a food base for the fungus.

Detecting the fungus

Detection and recognition of the disease in young stands is essential for management purposes. However, above-ground symptoms do not always equate with the below-ground distribution of the fungus: disease symptoms are also affected by stand age and species composition, and by the vigour of the fungus. Many trees may only have small root lesions and show no visible symptoms above ground, but, when cut, become food for the fungus. In such cases, a flush of mortality can occur. Stands less than ten years usually show few symptoms of disease because few crop trees have contacted the infected stumps. Most stand-tending decisions are made at an early age when symptoms may not be fully expressed, and therefore, the risk from disease can be underestimated.

Also, some tree species show much clearer and earlier symptoms of disease. Douglas fir is quite susceptible to *Armillaria* root disease, and is a good indicator of below-ground levels of the fungus.

Lodgepole pine is also quite susceptible, but does not show symptoms until the disease is advanced. The mix of tree species should be kept in mind when considering surveys based on above-ground symptoms. The threshold levels for treatment options will be set by the particular forest region, and the regional pathologist should be consulted.

Some indication of the disease's activity level can be gained by looking at the dead trees. If surveys show mostly newly killed red (dead less than two years) and few grey (dead more than five years) trees, then the disease symptoms are likely just beginning to become visible and the amount of disease is likely to increase. In stands that show mostly grey dead trees, the disease has probably balanced somewhat with the surrounding vegetation. The fungus is still present in the stand, but the trees have contained the lesions. Any new stumps created will increase the energy of the fungus, and additional flush of mortality will follow unless the stumps are removed.

Forest management decisions are dictated by a number of inputs such as ecology, economics, and social values. However, some consideration should be given to the stumps left by these activities and the disease-causing fungal species that colonize them. ▲

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Further reading

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