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**An exploration of ringbarking to reduce the severity of
armillaria root disease in logged areas in British Columbia**

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1 An exploration of ringbarking to reduce the severity of Armillaria root disease in logged areas in British
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Abstract

Ringbarking is a girdling technique that is used prior to timber harvesting to reduce losses to Armillaria root disease in some parts of the world. The technique had not previously been evaluated in British Columbia, Canada. Small plots of primarily Douglas-fir trees that were ringbarked prior to timber harvesting had approximately 50% lower levels of Armillaria root disease caused tree mortality in young trees after 15 years, than plots that were not ringbarked. Ring barking did not reduce Armillaria root disease in this trial as much as has been reported in other research. This could be attributable to even the core of the small plots being within 5 to 10 metres of live and dead Armillaria infected trees in the surrounding forest. The treatment did reduce the severity of the disease by both statistically and biologically significant amounts and so warrants further investigation as a possible treatment where timber harvesting is conducted in Armillaria root disease affected stands.

Key words

Armillaria, root disease, ringbark, cultural control, Douglas-fir

Introduction

Ringbarking is first discussed in the scientific literature by Leach (1939) where it is proposed as an effective treatment for Armillaria root disease caused by *Armillaria mellea sensu lato* in tung (*Aleurites fordei* and *A. montana*) orchards. *Armillaria mellea sensu lato* includes a number of species, some of which are pathogenic to plants. For the purpose of this document we will discuss Armillaria root disease implying root disease caused by pathogenic *Armillaria* species and where a particular species is implicated, it will be named. Ringbarking is tree girdling that is distinguished from other girdling in that only the phloem of the tree is interrupted- the xylem is left intact so that translocation of water and mineral nutrients up the tree will continue but carbohydrate translocation to roots is curtailed.

Leach attributed the effectiveness of ring barking to the depletion of starches in the root system. Reduced starch stores in the root at the time of death (which lags girdling by a year or more) purportedly reduce the ability of Armillaria root disease, (often present on living roots as quiescent lesions (Wargo and Shaw, 1985)), to spread rapidly and occupy root resource. Armillaria spreads through a root system via mycelial fans or rhizomorphs and Campbell (1933) showed that Armillaria rhizomorph production and hyphal growth is faster when “easily available” carbohydrate is present. Garrett (1939) suggested that when roots are depleted of starch, species which are better adapted to using cellulose and lignin as primary energy sources gain an advantage at occupying the root substrate. Thus the logical basis for the ringbarking technique is that the depletion of starches in roots before a tree’s defensive mechanisms can no longer resist Armillaria invasion will remove that source of energy from the pathogen after the tree has died. The reduction in easily metabolized substrate is reputed to

slow the spread of *Armillaria* mycelium through the root system and allow cellulose and lignin decaying fungi to compete more effectively.

If ringbarking is effective for the reasons given, the amount of *Armillaria* inoculum in the soil following ringbarking and timber harvesting would be reduced compared to after timber harvesting without ringbarking. In addition, the populations of fungi competitive to *Armillaria* will be elevated in a ring barked stand compared to a clear felled stand without ringbarking with or without root removal (stumping). Stumping has also been proposed as a means of reducing the inoculum potential of root disease causing *Armillaria*, but it has been shown to be theoretically (Kromroy et al. 2005) and operationally (Chapman et al. 2011) ineffective for controlling *Armillaria* root disease. Stumping is still used for *Armillaria* root disease mitigation in some areas which suggests disagreement on its efficacy. Stump removal should reduce the total amount of inoculum but it would not promote (and in fact might decrease) dead wood inhabiting fungi which are competitive with *Armillaria* root disease causing fungi.

Ring barking is recognized as an effective treatment for *Armillaria* root disease in parts of Africa and Australia but trials in England were inconclusive (Redfern 1968) and the treatment has not been comprehensively evaluated or used operationally in Europe or North America. This work is an exploratory evaluation of ringbarking to determine if it should be investigated further for potential to reduce losses to *Armillaria* root disease in typical timber harvesting situations found in the interior of British Columbia.

Methods

Site Selection

1 The trial was conducted at three separate sites with slightly varying conditions near Williams Lake in the
2 Central Interior of British Columbia, Canada. Two sites are located at at 950 m and the third was at
3 1150m elevation. The northernmost site is located at 52.26° N latitude and the southernmost site is
4 located at 51.25° N latitude, with one site in between. The predominant tree species at all sites is
5 Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco). The climate is humid continental with warm
6 summers and cold winters. Yearly mean temperature is about 4.5°C while the winter mean temperature
7 is about -6.0°C and annual precipitation is about 450mm (temperature data from Environment Canada
8 30 year normals). Soils are derived from ablation till from the last glaciation. There is much basaltic rock
9 in the vicinity and soils are typically base rich, with cold climate being the major limitation to growth. All
10 sites were on flat topography.

11
12 Each study site had high levels of Armillaria root disease caused mortality in the stand prior to the
13 treatments being applied. The pathogen was identified as *Armillaria ostoyae* Romagn. 1970 (also
14 known as *Armillaria solidipes* (Peck)) by diploid haploid pairing (Rizzo and Harrington 1992). The sites
15 were surveyed for Armillaria levels using a methodology that was in use in British Columbia at the time
16 to yield a quantitative assessment of disease levels but the methodology has since been shown to give
17 only qualitative results. Qualitatively the study areas had what would be considered to be high levels of
18 Armillaria root disease for the area and as such they would be considered to be at risk of not meeting
19 regeneration stocking targets as a result of losses from Armillaria root disease. Prior to harvest, most
20 trees in the stands exhibited some of the signs or symptoms of Armillaria root disease (rounded tops,
21 basal resinosis, characteristic mycelial fans in the phloem of some of the basal roots and Armillaria
22 sporocarps at the base of living and dead trees in season).

1 Experimental Design

2 Six paired plots were installed at each of three sites. One plot in each pair was ring barked prior to
3 harvest and the other was not. Each plot consisted of 20 to 50 mature trees located within a contiguous
4 area with varying levels of understory trees. Each pair of plots was chosen so that the plots within the
5 pair were similar in levels of Armillaria root disease (determined by visual assessment of Armillaria signs
6 and symptoms), similar in stand characteristics (e.g. ratio of overstory to understory trees), and in as
7 close proximity to each other as was practicable. Treatment was randomly assigned within the pairs.

8 9 Treatments

10 Ringbarking was applied in late summer and early fall and was accomplished by sawing through the bark
11 with a "Chainsaw in a Can". The brand of saw used no longer seems to be on the market but similar
12 devices are. The saw is a chain with teeth similar to a chainsaw chain except it is pulled back and forth
13 by hand. Hand sawing the bark gave good control of the depth of cut. Contact with the xylem was
14 detectable by the change in sawdust colour and so bark and phloem could be cut with minimal damage
15 to the xylem. Each tree was completely circled with two horizontal cuts extending to or through the
16 phloem and located approximately 15cm apart. The bark and phloem were stripped from the tree with
17 a mallet and chisel after the bark was cut through.

18
19 Three of the pairs of plots at each trial site were harvested after 1 year and the other three after 2 years.
20 Both plots in a pair were harvested at the same time, i.e., at the end of a one or two year period after
21 ring barking. The cut trees were extracted with horses to minimize damage to residual live understory.
22 The plots were fill planted in the third spring following harvesting with container grown Douglas-fir to a

density of 1200 stems/ha. Small areas of residual understory within the plots were sometimes stocked at much higher rates than 1200 stems/ha but they were not spaced.

Measurements

The plots were evaluated at intervals after harvesting but only the findings from 15 years after harvesting are reported here. The plots were assessed by counting the total number of trees and Armillaria killed trees greater than 0.5m tall and located within a 2 metre radius of stumps with a cut surface diameter of greater than 15 cm. A minimal height restriction was used because smaller trees decay quickly and in many cases cannot be found a few years after death. The mortality rate was determined as the percentage of putatively Armillaria-killed trees over total trees counted. Death by Armillaria was confirmed by the presence of Armillaria root-disease-characteristic mycelial fans in the phloem at the base of the dead trees. While the presence of mycelial fans is not considered to be an absolute indicator, it is so well correlated with death by Armillaria in the study area that the proportion of misdiagnoses likely to be made based on this characteristic is unimportant for this trial.

Analysis

The three trials were combined for analysis and significance was tested with a one tailed paired t-test and by fixed effects analysis of variance with treatment, site and treatment X site as factors.

Results

1 There was little difference in the mean mortality by duration of ringbarking and the low power of this
2 preliminary trial did not support another treatment so the duration treatments were combined into one
3 treatment for analysis.

4
5 The mean mortality rate over the duration of the trial was 0.12 (0.8%/a) in the treated plots versus 0.27
6 (1.8%/a) in the untreated plots. The reported mortality rates in the untreated plots are similar to what
7 occurs in the vicinity of this trial after timber harvesting in *Armillaria* affected blocks. Annual mortality
8 rates in the range of 1 to 3% per year are typical for the area (Chapman et al. 2004). The paired t-test
9 showed that the mean differences could be considered statistically significant with $P(T \leq t)$ one-tail of
10 0.034. The ANOVA showed that treatment, and treatment X site effects could be considered significant
11 with $P < 0.05$ but site was also marginally significant with $P = 0.07$. For all three sites, the proportion of
12 trees killed by *Armillaria* was smaller in the treated than the untreated plots.

14 Discussion

15
16 The consistent reduction in *Armillaria* root disease in three somewhat disparate sites is strongly
17 suggestive that ring barking may be an effective *Armillaria* root disease treatment in the general area of
18 the study. The level of disease reduction is not of the same degree as reported, for example, by Leach
19 (1939). There could be many reasons for the discrepancy with the differences between the African
20 ecosystems of Leach and the northern Canadian ecosystems in this trial being undoubtedly important.
21 However, complete or near complete control of *Armillaria* root disease would have been a surprising
22 outcome in this trial given that there were typically numerous live and dead *Armillaria* infected trees
23 along the border of each treated plot. The roots of these untreated trees likely extended throughout

the plots and treatment of small areas within a matrix of *Armillaria* affected forest could not be expected to have the same efficacy as ring barking over an area sufficiently large that edge effect was minimized.

As of 2006, Australian government publications (e.g. ISSN 1329-8062) were recommending ringbarking as a treatment for areas affected by *Armillaria luteobubalina*. In more recent trials we have experimented with chainsaw driven debarking tools used in the log home building industry. Such implements can ringbark very quickly which makes the treatment very inexpensive compared to, for example, root removal treatments (stumping or stumping and root raking). In Southern British Columbia, Douglas-fir beetle (*Dendroctonus pseudotsugae*) is a common pest of Douglas-fir. It attacks large, old, weak and stressed trees. We have noted that the beetle attacks ring barked trees and have experimented with anti-aggregation pheromones to reduce the infestation of treated trees. A better strategy for using ring barking in areas affected by Douglas-fir beetle might be to plan to harvest the trees in such a way that they could be used as trap trees for the beetle and so simultaneously reduce incidence of that pest.

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