Fungal Inoculation of Trees as a Habitat Enhancement Tool in Second-Growth Forests

TFL 37 and TFL 44 Operational Trial

Final Report

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March 2008

Acknowledgements

The author would like to thank John Deal and Bill Beese (WFP Inc.) for their enthusiasm and support of this project.

Laboratory work (isolation and culture of fungal specimens, and sectioning of stem samples) over the years was conducted by Brenda Callan and John Dennis (Natural Resources Canada, Pacific Forestry Center).

Funding for this project was provided by the British Columbia Forest Investment Account (FIA).

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1.0 Background

In some areas of British Columbia, especially where forest harvesting has been practiced for many years and second-growth stands are predominant, or where ecosystem restoration may be required (e.g., riparian rehabilitation), there is often a shortage of suitable wildlife tree habitat. Healthy, second-growth stands containing trees from 50-100 years of age can still take many decades before developing the primary wildlife tree attribute of heart rot. However, this natural process can be significantly accelerated through fungal inoculation. In these situations, artificial creation methods may be warranted in order to recruit wildlife trees more quickly than would otherwise occur through natural cycles. In Oregon, fungal inoculation trials have achieved trees with heart rot suitable for cavity excavation in 4-6 years, much earlier than natural fungal colonization and decay rates (C. Parks, USDA For. Service, pers. comm. 2000; Parks 1996). Consequently, an operational trial to create wildlife trees in second-growth Douglas-fir stands using fungal inoculation was initiated in TFL 37 and TFL 44 (north-central and western Vancouver Island, BC) in 2002.

This report provides a summary of the results of destructive sampling applied to 50 trees which were treated in 2002. A thorough description of the fungal collection, laboratory isolation and tree inoculation procedures, as well as the overall study design, can be found in Manning (2003) and Manning (2004).

2.0 Study Area

The study area is located in TFL 37 and TFL 44, within the tenure of Western Forest Products Inc. Englewood Forest and West Island Timberlands operations, respectively. Both sites have nearly identical forest types, consisting of approximately 60 year old second growth Douglas-fir (*Pseudotsuga menziesii*) dominated stands. These stands are relatively homogeneous in structure, with variations in stand composition primarily a function of micro-site and topographic conditions. In general, there is a lack of larger diameter standing dead and decaying trees (i.e., high suitability wildlife trees) in these stands.

Two cutblocks, block Hawthorn 700 (in TFL 44) and block NS050 (in TFL 37) were selected for fungal inoculation treatments. Both blocks were harvested in 2001 as partial retention blocks, with retention of small patches (Figure 1) and dispersed leave trees retained “inside” the block openings. Larger patch retention (e.g., riparian management areas, wildlife tree patches) also occurred along the block peripheries. Fungal inoculation treatments were conducted on trees located in all three types of retention.

Figure 1. Patch retention in Block NS050, TFL 37.

3.0 Methods

Fifty live Douglas-fir trees (25 from each study block) were felled, bucked and destructively sampled in October and December, 2007 (five years post-treatment). All trees were similar in size, ranging from 35-60 cm diameter at breast height (dbh). Trees were sampled from each of the treatments as follows:

- 20 rifle inoculated trees
- 15 climbed and drill inoculated trees
- 10 control drill (trees which were climbed and drilled, but no fungal inoculum dowel)
- 5 control rifle (trees which were shot but the bullet did not contain an inoculum dowel)

All sampled trees were bucked (Figure 2) at the point of treatment (drilling or rifle slug penetration) and inspected for signs of fungal colonization and decay (reddish-purple staining, softening of wood fiber). The amount of radial decay on the stem cross-section (measured at two positions to allow calculation of decay area) was measured and recorded. As well, the stem was bucked above and below the inoculation points in order to determine the vertical extent of any decay columns in the tree bole, and to permit a calculation of decay volume. All measurements were tallied using simple descriptive statistics.

Stem cross-sections were also removed from some of the sampled trees and taken to the Environment Canada Pacific Forestry Center laboratories in Victoria for analysis (i.e., in order to confirm that the heartrot inoculation fungus (*Phellinus pini*) was still present in the treated trees.

Figure 2. Treated tree with section around inoculation point being bucked out for analysis.

4.0 Results

A summary of stem decay condition (five years post-treatment) for the 50 trees destructively sampled in October and December 2007, is shown in Table 1.

Inoculated Trees

Vertical (longitudinal) decay in the inoculated trees (n=35) ranged from 0.22-1.46 m, with a mean of 0.53 m. Mean radial decay (using two measures per cross-section) was 0.08 m, which equated to a mean cross-sectional decay area of 0.006 m^2 (or 60 cm^2). Interestingly, the shape of the decayed area was often "flared out in a bat wing shape" (Figure 3) relative to the point of inoculation (wounding). Mean decay volume was 0.004 m^3 (or 4000 cm^3).

As described above, observed decay in the heartwood region of the sampled stems (Figure 4) was visible as a combination of incipient staining (reddish-purple discoloration) and softening of wood fiber (selective delignification of heartwood). This condition is indicative of the onset and advancement of decay caused by *P. pini* (Hunt and Etheridge 1995, Allan et al. 1996).

No wildlife use or activity such as woodpecker excavations, was observed on inoculated trees.

Control Treatments

In general, the control (blank) treatments using either drilling or rifle induction did not result in any significant decay in treated trees. Mean decay area was 0.002 m^2 and mean decay volume was 0.001 m3 (or 1000 cm^3). These values were significantly different ($p<0.01$) from the non-blank treatments.

Table 1. Summary of trees destructively sampled in 2007 (N=50).

***** Treatment types: D=drill inoculated R=rifle inoculated, CD=control drill, CR=control rifle

Treatment*	Vert. decay (m)	Radial decay 1 (m)	Radial Decay 2 (m)	Area (m2)	Volume (m3)
D	1.200	0.050	0.062	0.003	0.004
D	0.430	0.025	0.032	0.001	0.000
D	0.220	0.035	0.032	0.001	0.000
D	0.300	0.024	0.023	0.001	0.000
D	0.490	0.080	0.030	0.002	0.001
D	0.490	0.110	0.045	0.005	0.002
D	0.330	0.240	0.060	0.014	0.005
D	0.310	0.160	0.028	0.004	0.001
D	0.180	0.105	0.025	0.003	0.000
D	0.270	0.063	0.025	0.002	0.000
D	0.400	0.085	0.050	0.004	0.002
D	0.700	0.025	0.063	0.002	0.001
D	0.600	0.152	0.085	0.013	0.008
D	0.440	0.063	0.068	0.004	0.002
D	0.520	0.060	0.080	0.005	0.002
Mean Drill (n=15)	0.459	0.085	0.047	0.004	0.002
R	0.450	0.130	0.067	0.009	0.004
R	0.430	0.110	0.050	0.006	0.002
R	1.460	0.160	0.080	0.013	0.019
R	0.350	0.110	0.055	0.006	0.002
R	0.560	0.168	0.085	0.014	0.008
R	0.690	0.105	0.071	0.007	0.005
R	0.720	0.058	0.173	0.010	0.007
R	1.240	0.123	0.090	0.011	0.014
R	0.330	0.060	0.130	0.008	0.003
R	1.150	0.140	0.075	0.011	0.012
R	0.300	0.045	0.100	0.005	0.001
R	0.300	0.088	0.063	0.006	0.002
R	0.530	0.110	0.040	0.004	0.002
R	0.430	0.160	0.038	0.006	0.003
R	0.420	0.070	0.153	0.011	0.004
R	0.430	0.080	0.103	0.008	0.004
R	0.460	0.137	0.036	0.005	0.002
R	0.460	0.075	0.083	0.006	0.003
R	0.460	0.103	0.046	0.005	0.002
R	0.440	0.105	0.048	0.005	0.002
Mean Rifle (n=20)	0.400	0.074	0.055	0.005	0.003
Treatment Mean (n=35)	**0.528**	**0.098**	**0.066**	**0.006**	**0.004**
CD	0.960	0.145	0.065	0.009	0.009
CD	0.450	0.110	0.110	0.012	0.005
CD	0.900	0.110	0.045	0.005	0.004
CD	0.000	0.000	0.000	0.000	0.000
CD	0.000	0.000	0.000	0.000	0.000
CD	0.000	0.000	0.000	0.000	0.000
CD	0.000	0.000	0.000	0.000	0.000
CD	0.000	0.000	0.000	0.000	0.000
CD	0.000	0.000	0.000	0.000	0.000
CD	0.000	0.000	0.000	0.000	0.000
CR	0.000	0.000	0.000	0.000	0.000
CR	0.000	0.000	0.000	0.000	0.000
CR	0.000	0.000	0.000	0.000	0.000
CR	0.200	0.050	0.057	0.003	0.001
CR	0.200	0.045	0.055	0.002	0.000
Control Mean (n=15)	**0.181**	**0.031**	**0.022**	**0.002**	**0.001**

Drilling versus Rifle Inoculation Methods

The amount of decay which resulted using the drilling method was similar but still significantly less ($p<0.05$) than that which resulted from the rifle inoculation method (mean decay volume drill inoculation method = 0.002 m^3 (2000 cm^3); mean decay volume rifle inoculation method = 0.003 m^3 (3000 cm^3), see Table 1). Given the much larger size of the dowels (and therefore inoculum biomass) used in the drilling method, versus those used in the rifle method (Figure 5), this result is at first perplexing. However, possible (and likely) reasons for this are described below in section 6.0.

Figure 3. Decay (affected area outlined in black) caused in the heartwood of one of the sample trees which had been rifle inoculated.

Figure 4. Purplish staining and softening of wood fibre (at green arrow) caused by *P. pini* inoculation.

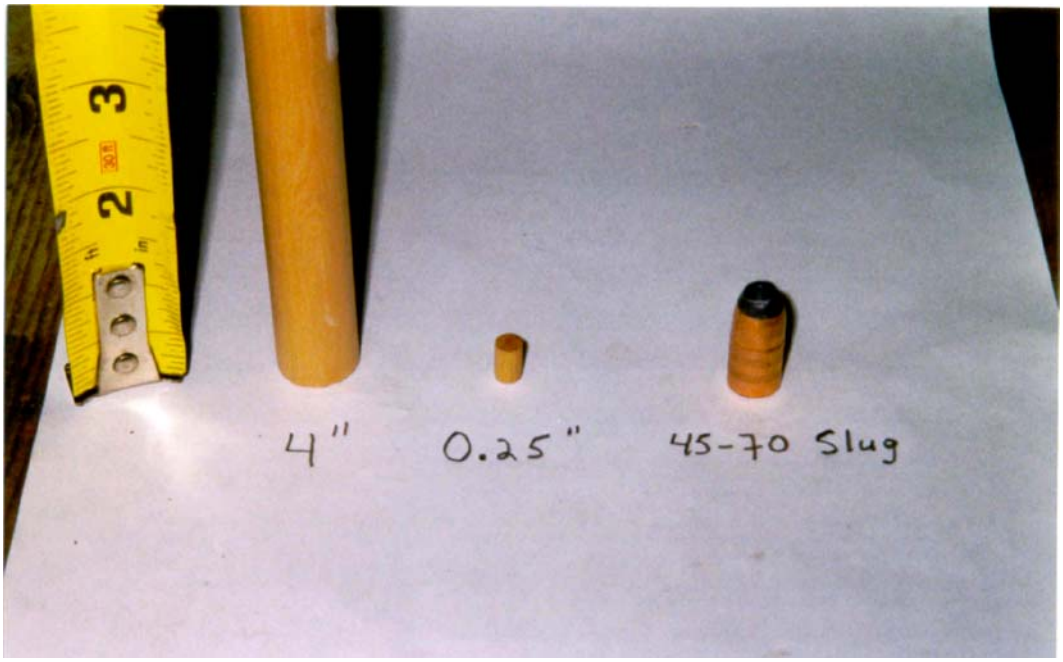

Figure 5. Comparison of drill method wooden dowel (4 inch length) and rifle method wooden dowels (0.25 inch length) which are used to introduce heart rot fungi into the tree stem.

5.0 Discussion

Based on the destructive sampling conducted in 2007 (five years post-treatment), it appears that fungal inoculation using both the climbing/drilling and rifle induction methods will successfully introduce heartrot decay into live Douglas-fir trees. This technique has also proven to be successful in other studies from the Pacific Northwest (Bull and Partridge 1986; Lewis 1998; Parks 1996).

Results from a subsample of trees (this study) which were destructively sampled in 2004 (see Manning 2004), showed significant early decay/staining after only one year post-treatment (Figure 6) – laboratory re-isolates of samples taken from these stems at the time showed that *P. pini* was still alive and viable within the heartwood. Unfortunately, logistic problems in getting 2007 wood samples quickly back to the laboratory for re-isolation, prohibited reconfirmation of the identity of the fungal vectors described and quantified in the *Results* section above. Nevertheless, the significant lack of staining and decay in the control samples indicates that heart rot fungi were still active within the inoculated trees.

While no evidence of woodpecker excavation or other wildlife activity associated with the fungal inoculation treatments were observed in 2007, the extent of decay observed within five years of treatment is still far greater than the amount of decay which could be expected within this same time period as a consequence of natural tree wounding and infection processes (i.e., airborne fungal spores usually enter through broken branches and stem injuries, Hunt and Etheridge 1995; Manning 2007). Trees which exhibit advanced heartrot decay from *P. pini* typically take well over 100 years from the time of initial infection (Manning 2007), through incipient decay (staining), to advanced decay (white pocket rot, delignification and eventual breakdown of cellulose, softness, brittleness and loss of wood strength). Results from a recent study in Oregon

(Filip et al. 2004) involving rifle inoculation of live Douglas-fir with *P. pini* or *Fomitopsis cajanderi*, found internal decay associated with this inoculation treatment after five years. However, the extent of this decay was limited and no evidence of wildlife activity was observed. The authors concluded that while shooting trees is effective in creating internal decay within five years, it may take several more years to form a decay column large enough to be used by cavity-nesting birds (Filip et al. 2004).

Figure 6. Tree destructively sampled in 2004 (one year post-treatment) showing early signs of decay (reddish-brown staining) in the heartwood surrounding the 4" dowel inoculation court. Red arrow points to the area of staining.

6.0 Conclusions – What was Learned?

1. **Both the climbing/drilling and rifle induction methods are successful in introducing heart rot decay** into live host trees (Figure 7), and can be effective wildlife tree creation and enhancement tools. The rifle method will take longer to produce useable decay columns, but this technique is much faster and therefore cheaper to conduct (i.e., depending on site factors, the rifle method is approximately 6 times faster and 47% cheaper than the climbing/drilling method (Manning 2003).

2. **The drilling method will likely produce much greater decay when PVC tubing is NOT inserted into the drill hole** (i.e., let the drill hole seal over naturally, creating a dark, low aerobic environment more amenable to the fungal organisms and decay process). Under natural wounding and infection processes the wound (infection) court gradually seals over. When the site of fungal entry is subsequently overtaken by new heartwood (i.e., "compartmentalization of decay" (Shigo 1991), decay usually begins (Haddow 1938, Zeglen 1997).

3. **The climbing/drilling method will produce the greatest amount of decay in treated trees, and can be done in conjunction with other tree modification treatments** (e.g., arboreal chainsaw modifications for wildlife (Manning 2008), or windfirming treatments).

4. Depending on project and habitat objectives, intended host species and ecosystems, and because *P. pini* has a very slow decay physiology, **other native heart rot fungi may be better suited for use in inoculation treatments**. Species such as *Fomitopsis pincola* and *Fomitopsis officinalis* (see Allen et al. 1996) have different decay dynamics and are likely faster acting than *P. pini*, and are being used elsewhere in British Columbia to create future wildlife tree habitat (Manning 2008).

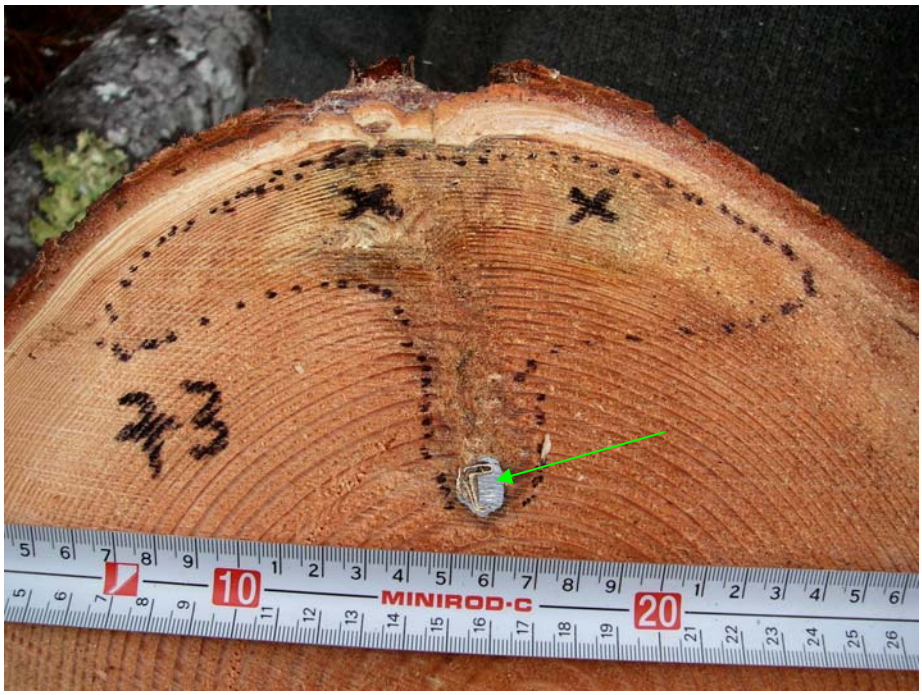

Figure 7. Staining and decay (wood softening at positions marked "x") caused by rifle inoculation with *P. pini*. Note bullet fragment at green arrow.

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