Using fungal inoculation and mechanical modification techniques to enhance wildlife tree habitat – post treatment effectiveness monitoring and evaluation

Project #11.W.BRG.10 – 2011 Final Project Report

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Executive Summary

In British Columbia, approximately 70 species of birds, mammals and amphibians depend on wildlife trees (dead or dying trees with special characteristics such as size, condition and species) for nesting, denning, feeding, perching or roosting. High value wildlife trees have attributes that are generally associated with older trees (e.g., large size, heavy branching, internal decay). These types of trees are often not available in second-growth stands that have previously been managed without objectives for wildlife tree retention, nor in areas where a loss of valley bottom habitat (i.e., due to hydro reservoir development) has artificially removed large areas of lowland forest.

Fungal inoculation and mechanical tree modification techniques were used to enhance the supply of wildlife trees in the Bridge-Seton watershed west and northwest of Lillooet, British Columbia in 2006. In June and August 2011 (5-years post-treatment), the following information was collected in order to evaluate the effectiveness of the inoculation treatments applied in 2006 (n=120 trees):

1) evidence of wildlife use;
2) any change in tree condition (i.e., stem damage or breakage, blowdown, internal stem decay);
3) viability of the treatment fungus within the inoculated trees. A subsample of trees (n=20) was partially destructively sampled to more closely evaluate the effectiveness of the fungal inoculation treatments (i.e., presence and condition of decay).

Results of the destructive sampling confirmed the effectiveness, at least in part, of the fungal inoculation treatments which were applied in 2006. A few salient conclusions were apparent from these results, as follows.

1) The high amount of pitch flow observed around the wooden inoculum dowels in the immediate region of the drill hole, suggests that live conifers (especially ponderosa pine) are reasonably effective at limiting or slowing the progress of decay associated with the inoculation treatment (spread rate and spatial extent).
2) Five trees were inoculated and stem girdled in 2006, and two of these were destructively sampled. However, the girdling treatment was applied above the inoculation points – while this effectively killed the upper part of the tree it did not limit sap flow to the region of the inoculum dowels. This may have inhibited colonization by the inoculum fungi.
3) While *Fomitopsis pinicola* was successfully isolated from the treated trees and re-cultured in the lab (which indicates its continued viability as a decay organism within the treated trees), this species is primarily recognized as a colonizer of dead wood. It normally occurs on standing dead trees, downed wood, and dead or damaged sections of live trees. Consequently, this species of fungi is not ideal for fungal inoculation treatments of live standing trees. More recent inoculation treatments conducted by Manning (2008, 2009, 2010) have used other species of fungi for inoculation of live trees.

Recommendations were provided for increasing the effectiveness of future wildlife tree enhancement and fungal inoculation treatments in the Bridge-Seton watershed, and elsewhere.

Project benefits include increased habitat supply for cavity dependent wildlife; increased public awareness of the ecological value of wildlife trees and the potential utility of habitat enhancement techniques; and skills training provided to local First Nations.

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Introduction

In British Columbia, approximately 70 species of birds, mammals and amphibians depend on wildlife trees (dead or dying trees with special characteristics such as size, condition and species) for nesting, denning, feeding, perching or roosting (Fenger et al. 2006). Some of these species, including the Williamson's Sapsucker (*Sphyrapicus thyroideus*), Western Screech-Owl (*Otus kennicottii macfarlanei*), Spotted Owl (*Strix occidentalis*) and Flammulated Owl (*Otus flammeolus*), are on the federal (COSEWIC) and provincial Red- and Blue status lists as endangered, threatened or special concern. Our largest primary cavity excavator, the Pileated Woodpecker (*Dryocopus pileatus*), is considered an important keystone species in all forested ecosystems throughout the province (i.e., its nest and roost cavities provide habitat for numerous secondary cavity using birds and mammals, including the above owl species).

High value wildlife trees have attributes that are generally associated with older trees (e.g., large size, heavy branching, internal decay). These types of trees are often not available in second-growth stands that have previously been managed without objectives for wildlife tree retention, nor in areas where a loss of valley bottom habitat (i.e., due to hydro reservoir development) has artificially removed large areas of lowland forest. Approximately 9500 ha of habitat (total) has been flooded due to reservoir development in the Bridge-Seton watershed (BCRP 2000). Consequently, a lack of suitable wildlife trees in an area will result in reduced abundance of primary cavity excavators in this area. This is especially true for the larger Pileated Woodpecker, Northern Flicker (*Colaptes auratus*) and Hairy Woodpecker (*Picoides villosus*), which generally require trees greater than 40 cm diameter at breast height (dbh) with heart rot. This lack of cavities in turn restricts the availability of habitat for secondary cavity using species that depend on wildlife trees (e.g., various owls, flying squirrels, cavity nesting ducks, etc.).

Wildlife tree creation techniques (Parks 1996) have the advantage of creating or enhancing habitat in a relatively short period of time (i.e., 5-15 years), as opposed to otherwise recruiting similar stand structure through natural decay cycles (i.e., usually 100+ years are required to naturally recruit trees of sufficient size and decay condition to function as useful wildlife trees). Using fungal inoculation and mechanical tree modification (i.e., chainsaw techniques) as a method of creating decay in trees and subsequent use by wildlife has excellent potential, and will be useful for restoring or enhancing habitats where there may be a lack of suitable wildlife trees (Manning 2008, Manning 2003). These can include riparian areas, wildlife habitat areas, recruitment old growth management areas, immature forests, and other areas where an increase in stand structure will benefit certain species (e.g., species at risk).

Consequently, in order to enhance wildlife tree habitat for cavity dependent wildlife, BCRP previously funded a project in 2006 (see Manning 2007, *BCRP Project #06>W.BRG.06-2006*) to inoculate (and in some cases mechanically modify) 120 trees in the Cayoosh Creek, N. Carpenter Lake and Seton Lake/Seton Portage areas within the Bridge-Seton watershed. **One of the key recommendations from the 2006 project was "…to visually inspect in 2011 for changes in tree condition and any evidence of wildlife use."** The work in 2011 is a direct follow-up to the 2006 project work. Effectiveness monitoring and evaluation in this context provides an indication of how well the fungal inoculation technique is working, both in terms of potential wildlife use and change in tree condition.

Project Objectives

The main objectives of this project were to gather the following information 5-years post-treatment:

1) evidence of wildlife use;
2) any change in tree condition (i.e., stem damage or breakage, blowdown, internal stem decay); and
3) viability of the treatment fungus within the inoculated trees (i.e., determined by partial-destructive sampling a small number of trees at each treatment site to check for presence of fungus and extent of decay after 5 years).

Determining how well the fungal inoculation technique is working (i.e., by doing post-treatment analyses) will help refine the application of this technique here and in other areas of the province where similar work has also been conducted (see Manning 2008, Manning 2009), or will be considered in future.

New knowledge about fungal colonization and heart rot decay dynamics gained through partial-destructive sampling will also inform possible modifications to these techniques, thereby improving the overall efficacy, utility and wider application of this type of habitat enhancement tool.

Study Area

All field sites (7) were located west and northwest of Lillooet, British Columbia, including locations along the north side of Carpenter Lake, and near Seton Portage. Specific locations were Cayoosh Creek, Carol Lake, Jones Creek (former recreation site), Carpenter Lake Rd., Marshall Lake Rd., Seton Creek, and Seton River Rd. (Figure 1).

The study area falls within the western extent of the Interior Douglas-fir (IDF) biogeoclimatic zone, and is characterized by relatively dry site conditions (Meidinger and Pojar 1991). It is dominated by stands of Douglas-fir (*Pseudotsuga menziesii*), ponderosa pine (*Pinus ponderosa*), and minor components of lodgepole pine (*Pinus contorta*), trembling aspen (*Populus tremuloides*) and paper birch (*Betula papyrifera*). Stands of mature cottonwood (*Populus balsamifera trichocarpa)* are found along the streams and river estuaries in the area.

Elevations at field sites ranged from 650-1100 m, with aspects being predominantly south, southwest or southeast.

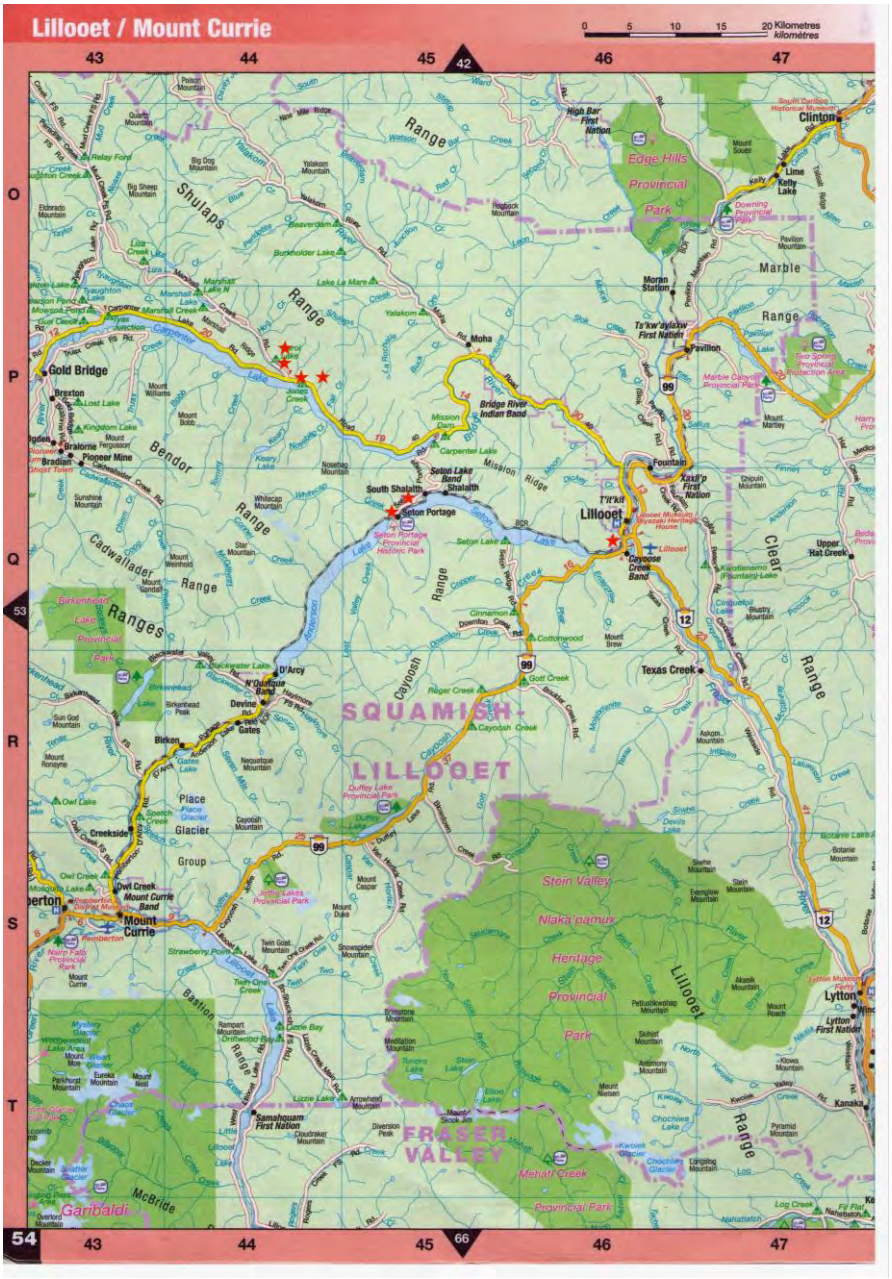

Figure 1. Project study area. The "red stars" indicate the approximate locations of the 7 field treatment sites.

Methods

Field methodology in 2011 was straightforward, and was conducted in two sessions. Work in June 2011 involved visiting all 120 trees which had been inoculated in 2006 at the 7 field site locations described above. Any changes in tree condition since 2006 were recorded (e.g., beetle-killed, wind-snapped, evidence of decay, wildlife use). Where appropriate, photographs of individual trees or tree condition were taken. Trees suitable for partial-destructive sampling were also selected at this time.

Work in August 2011 involved partial-destructive sampling trees which had been pre-selected in June. Trees were selected from each of the 7 treatment sites, and also from the range of tree species which had been previously inoculated.

Partial-destructive sampling consisted of climbing the tree and removing the middle-upper portion of the stem (i.e., at approximately 6-12 m height, which was about 1-2 m below the original points of inoculation, Figure 2). The felled portion of the stem was then carefully bucked (in cross-section, Figure 3) and in some cases longitudinally dissected, in order to assess the condition of the wood in proximity to the fungal inoculation points. Any evidence of decay (e.g., wood staining or softening, presence of fungal mycelium) was recorded. Wood tissue samples were collected for laboratory analysis from some sample sections in order to determine whether the original treatment fungus (*Fomitopsis pinicola*) was still present and viable within the tree.

The "stub trees" (i.e., short trees approx. 6-12 m height) which remained after topping and partial-destructive sampling, were subsequently re-inoculated twice with *F. pinicola* within 2-3 m of the top (this species of heart rot fungi is saprophytic and colonizes dead and damaged wood (Allen et al. 1996)). If some live limbs still remained in the lower portion of the bole, then the stem was ring-girdled below the new inoculation point (Figure 4), which effectively kills the upper portion of the remaining stem. A more detailed description of fungal inoculation methods (laboratory and mechanical) can be found in Manning (2007, 2008).

Figure 2. Douglas-fir tree shortly after being topped for partial-destructive sampling.

Figure 3. Bucking a felled stem section just below the inoculum point (white PVC tube).

Figure 4. Re-inoculating a "stub tree" with *Fomitopsis pinicola*, subsequent to topping. Note girdling ring near climber's boot – this procedure kills the upper 2 m section of the tree which is then inoculated.

Results

From August 23-26, 2011, twenty trees which had been treated in 2006 (inoculated and/or mechanically modified) were partial-destructively sampled at five field sites (Carol Lake (8), Jones Creek (5), Carpenter Lake Rd. (2), Seton Creek (2), and Seton River Rd. (3). Most of the re-topped trees (19/20) were re-inoculated twice with heart rot fungus (*Fomitopsis pinicola*), resulting in a short dead "stub tree" approximately 6-12 m in height. For safety reasons, tree #89 (cottonwood, Seton Cr. site) was felled completely for destructive sampling.

Destructive sampling was not conducted at the Cayoosh Creek and Marshall Lake Rd. field sites because of the high public use, and steep ground (making falling difficult), respectively, at these locations.

Of the 20 trees sampled, twelve were Douglas-fir, six were ponderosa pine, and two were black cottonwood. The mean diameter (at breast height) of sampled trees was 46.7 cm.

A complete summary of treatment tree characteristics (i.e., tree ID #, species, diameter), tree locations (UTMs), 2006 treatments, and observations of 2011 condition, is provided as a separate Appendix to this report.

Observations from Destructive Sampling

Douglas-fir

Analysis of stem sections sampled near the points of inoculation from treated Douglas-fir trees (12) indicated the following:

- inoculation with *F. pinicola* generally produced minor staining (reddish-brown discoloration) in the wood tissue immediately surrounding the inoculum dowel (Figure 5). In most cases the resultant decay can be described as incipient (i.e., early beginning stages) with limited vertical spread along the tree trunk (10-20 cm). In a few cases (tree #), decay was more advanced with staining and some wood softening evident (Figure 5).
- in most cases, the inoculated live tree produced abundant resin (pitch) flow as a defense mechanism to injury (Figure 6).
- in one case (tree #20, Figure 7), a woodpecker had begun a cavity nest start approximately 30 cm below the point of inoculation. This tree had been topped and chainsaw scarred in 2006, but was not girdled (i.e., it was a topped live tree). Some minor purple staining was evident in the wood near the cavity start, but insufficient wood decay/softening had occurred to enable excavation of a successful nest cavity. After destructive sampling, this tree was re-topped at 6.5 m height (below any live limbs), then re-inoculated twice with *F. pinicola*.

Figure 5. Tree #23 (Douglas-fir at Jones Cr. site) showing minor purple stain and pitching, but no decay. This type of staining is indicative of the initial stages of decay.

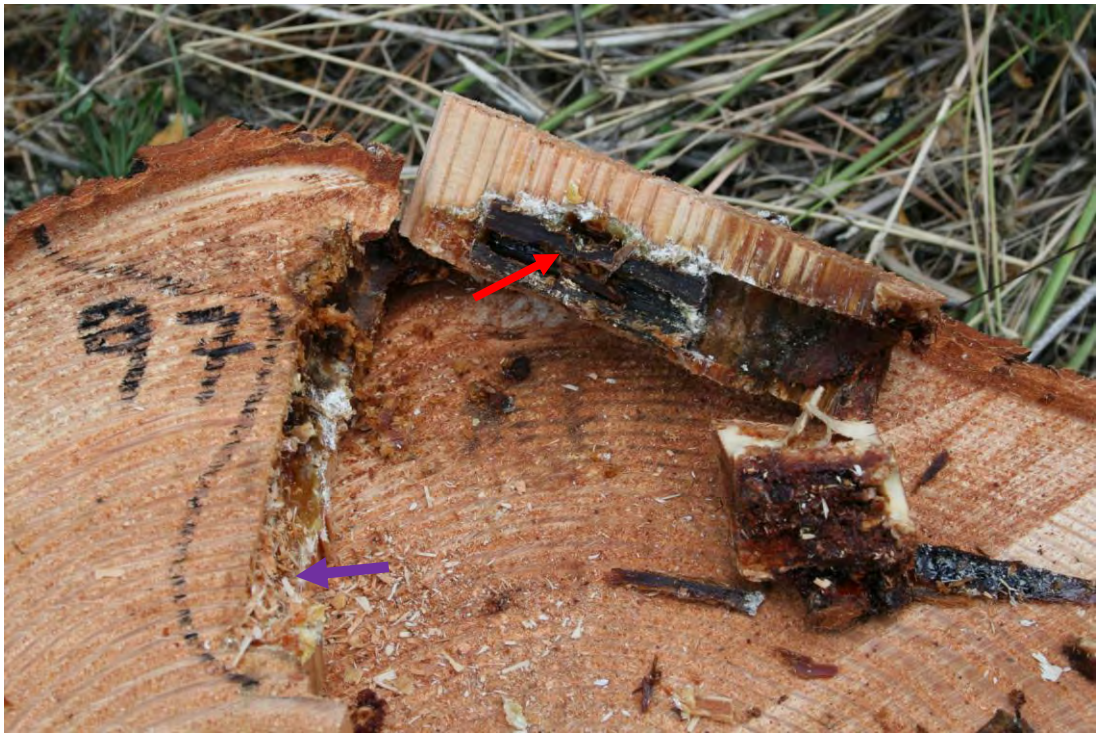

Figure 6. Tree #97 (Douglas-fir at Seton River Rd. site), showing dark staining and some decay (wood softening at purple arrow) below point of inoculation. Note pitch which has impregnated the wood tissue (around the wooden dowel); also note part of the original inoculum dowel at red arrow.

Figure 7. Tree #20 (Douglas-fir at Jones Cr. site) showing nest cavity start (just below knife and approx. 30 cm below point of inoculation). This tree had been topped and girdled below the top, in 2006. This cavity excavation was a false start and had not been successfully completed.

Ponderosa pine

Analysis of stem sections sampled near the points of inoculation from treated ponderosa pine trees (6) indicated the following:

- ponderosa pine tended to exude abundant pitch in order to seal off and compartmentalize the wound (drill hole) and invading pathogen (inoculum dowel). In most cases, the wooden dowel was completed surrounded with pitch, which would have limited colonization and spread by the fungal inoculum into the adjacent woody tissue (Figure 8).
- 15 ponderosa pine had been killed by mountain pine beetle (*Dendroctonus ponderosae*) since 2006. Beetle-killed ponderosa pine typically show significant saprot decay within 1-3 years post-death. This was the case with the destructively sampled beetle-killed trees, which also showed significant heart rot decay associated with the inoculum (Figure 9).
- Tree #8 (Carol Lake site) was topped in 2006. This tree showed noticeable staining and some wood softening associated with the inoculum treatment (Figure 10).

Figure 8. Sampled ponderosa pine (tree #25, Jones Cr. site) showing outline of inoculum dowel completely encased in pitch. Note there is no staining or any other indication of early decay in this region.

Figure 9. Tree #7 (beetle-killed ponderosa pine at Carol Lake site), showing extensive saprot caused by blue-stain fungus, and advanced heartrot in the core associated with the inoculum treatment. Note inoculum dowel at red arrow.

Figure 10. Tree #8 (ponderosa pine topped in 2006 at Carol Lake site) showing blue staining in the sapwood layer and minor wood softening in the heartwood layer.

Cottonwood

Analysis of stem sections sampled near the points of inoculation from treated cottonwood trees (2) indicated the following:

- both cottonwood trees which were destructively sampled showed significant staining and moderate to advanced decay (wood softening) extending outward from the inoculum dowel.
- Tree #16 (Jones Cr. site) had prominent dark staining and moderate decay around the inoculum dowel (Figure 11). Staining extended approximately 2 m longitudinally along the stem.
- Tree #89 (Seton Cr. site) was killed by fire in 2009. The decay associated with inoculation was approximately 12-15 cm in radial width (Figure 12) and extended 2 m longitudinally along the stem. White mycelial felts were evident within the cross-sectioned stem wood, and indication of well-established fungi within the tree at this position.

Figure 11. Tree #16 (cottonwood at Jones Cr. Site). Observe significant darkish staining in the heartwood and wood softening surrounding the inoculum dowel (at knife). This decay extended approx. 2 m vertically along the stem from the inoculation point.

Figure 12. Tree #89 (cottonwood at Seton Cr. site). Note softened wood with white mycelial flecks throughout the wood tissue. Also note white mycelial felt at tip of knife blade. This felt was taken from the cross-sectional surface of the dissected disk. Mycelial felts are thickened accumulations of vegetative fungal filaments which form once the fungus is well established within the wood tissue.

Laboratory Analyses

Samples of woody tissue extracted adjacent to the inoculum dowels in tree #7 and #8 (ponderosa pine, Carol Lake site), tree #11 (Douglas-fir, Carol Lake site), and tree #16 and #89 (cottonwoods, Jones Cr. and Seton Cr. sites), were all isolated in the lab in order to determine the presence and identity of wood decay fungi.

For all samples, *F. pinicola* was successfully re-isolated and cultured on growth medium. This confirms that the original fungal inoculum is present and viable in each of these sampled trees. Tree #11 also had an old wound scar near the base. Significant decay (long established) was present in this area of the tree (Figure 13) – this was not associated with the inoculation treatment, however, two native endemic heart rot fungi were isolated from this sample (*Ganoderma applanatum* and *F. pinicola*).

Figure 13. Tree #11 (Douglas-fir at Carol Lake site). Bucked out section of trunk near old basal scar. This natural wound resulted in significant internal brown cubical decay and associated hollowing of the stem.

Discussion

The results of destructive sampling confirm the effectiveness, at least in part, of the fungal inoculation treatments which were applied in 2006. A few salient conclusions are apparent from these results, as follows.

1) The high amount of pitch flow observed around the wooden inoculum dowels in the immediate region of the drill hole, suggests that live conifers (especially ponderosa pine) are reasonably effective at limiting or slowing the progress of decay associated with the inoculation treatment (spread rate and spatial extent).

2) Since only two trees were inoculated and topped in 2006, and only one of these was destructively sampled, the effectiveness of the topping treatment is inconclusive.

3) Five trees were inoculated and stem girdled in 2006, and two of these were destructively sampled. However, the girdling treatment was applied above the inoculation points – while this effectively killed the upper part of the tree it did not limit sap flow to the region of the inoculum dowels. This may have inhibited colonization by the inoculum fungi.

4) While *F. pinicola* was successfully isolated and re-cultured in the lab (which indicates its continued viability as a decay organism within the treated trees), this species is primarily recognized as a colonizer of dead wood (Allen et al. 1996). It normally occurs on standing dead trees, downed wood, and dead or damaged sections of live trees. Consequently, this species of fungi is not ideal for fungal inoculation treatments of live standing trees. More recent inoculation treatments conducted by Manning (2008, 2009, 2010) have used other species of fungi for inoculation of live trees. These latter projects only used *F. pinicola* for inoculation of dead sections of treated trees (i.e., in upper sections which were girdled to create a dead top). This conclusion was not known at the time of the initial inoculation treatments at Bridge-Carpenter in 2006.

Studies from elsewhere in the Pacific Northwest have shown promising results using similar inoculation techniques in 5+ years (Bull and Partridge 1986, Parks 1996, Brandeis et al. 2002, Manning 2003). This timeframe is much sooner than natural fungal colonization and decay rates, which can take more than 100 years (Allen et al. 1996, Parks 1996).

Recommendations

The results of this project support the following recommendations for improving the effectiveness of fungal inoculation treatments at this, and other projects in British Columbia.

1) For future inoculation treatments, use native heart rot fungi which are host-tree specific. For example, *F. officinalis* and *Phellinus pini* are being used successfully in the East Kootenays (Manning 2009, 2010) for inoculation of live Douglas-fir, ponderosa pine and western larch (*Larix occidentalis*).

2) In addition to recommendation #1, future inoculation treatments should also employ partial or full-stem girdling techniques, applied below the inoculum points as a means of reducing sapflow to the region of the dowel (i.e., thereby reducing "resin-sealing"). This is especially important when inoculating ponderosa pine, which like most pine species, normally has abundant sap/pitch flow.

3) Wildlife tree enhancement treatments involving ponderosa pine are most effective when:

    a) the upper-third to one-half of the tree is topped (with girdling below the lowest live limbs) – this treatment kills the tree and results in a shorter "stub tree" which can be inoculated with *F. pinicola*.
    b) a smaller dead top section (2-3 m length) is created by topping – girdling is then applied immediately below this upper section. *F. pinicola* can be used to inoculate this newly dead section, and if desired, a secondary inoculation can be applied in the lower live half of the tree (using an alternate suitable heart rot fungi such as *F. officinalis* or *Stereum sanguinolentum*).

    These two types of treatments are being used in other projects in the East Kootenays (Manning 2009, 2010). The result is a standing dead stub tree (treatment #3a, Figure 14), or a live tree with a dead top section (treatment #3b). Natural sap rot decay will occur quickly in the dead sections of these trees, as well as longer-term columnar heart rot decay extending from the points of inoculation . Such combined treatments will result in near-term feeding activity and longer-term nesting potential. As well, removing the upper-third or more of the tree greatly reduces the chances of future windthrow/breakage.

4) The effectiveness of fungal inoculation as a wildlife tree enhancement treatment for black cottonwood looks very promising. Future treatments involving this tree species should use a more host-appropriate heart rot fungus such as *Ganoderma applanatum* or *Spongipellis delectans*. Additional mechanical treatments such as stem scarring can also be used in conjunction with inoculation. Enhancement of live cottonwood in this fashion can be used to increase denning or nesting habitat supply for target species such as fisher (*Martes pennanti*) and western screech-owl.

5) Consider conducting supplementary wildlife tree creation treatments in areas which are scheduled for NDT-4 thinning and prescribed burning treatments[1]. Stubbing treatments (as per #3a) are especially valuable in these locations.

[1] NDT-4 ecosystems are characterized by historically frequent stand-maintaining disturbance events, typically low intensity wildfire which maintains a relatively sparsely treed open canopy overstory and a herbaceous understory.

Figure 14. A "stub treatment" applied to a Douglas-fir at Foosey Pasture (E. Kootenay region, 2011). Note full-ring girdle (at red arrow) applied about 5 m above ground.

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Photographs courtesy of Todd Manning and Eric Manning.

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