Forests for Tomorrow Adaptive Management Initiative

Synthesis of Information on Selected Topics & Clarification of Key Uncertainties

EXCERPT:

Effects of Stem Rusts and Stem Canker on Regeneration in Mountain Pine Beetle-Killed Lodgepole Pine Stands

Prepared for:

Alanya C. Smith
Forest and Range Evaluation Program/ Forests for Tomorrow
Ministry of Forests and Range, Forest Practices Branch
8th Floor - 727 Fisgard St.
Victoria, BC

Prepared by:

Laurie Kremsater, MSc, RPF, RPBio
Glen Dunsworth, MSc, RPBio
Alan Vyse, MSc, RPF
Carol Murray, MSc, RPBio, ESSA Technologies Ltd.

Contact: Laurie Kremsater
Ph: (604) 856-3329
lkrem@shaw.ca
28360 Starr Rd.
Abbotsford, B.C. V4X 2C5

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Effects of Stem Rusts and Stem Canker on Regeneration in Mountain Pine Beetle-Killed Lodgepole Pine Stands

The Forests for Tomorrow (FFT) program was established by the BC Government in 2005 in response to the devastating impact of major fires and the mountain pine beetle (MPB) epidemic on the forest land base of the Province. The program is aimed at improving the future timber supply and protecting other forest values through the re-establishment of young forests on lands that would otherwise remain underproductive.

The mountain pine beetle epidemic had affected over 10 million hectares of forest land by 2008 and is expected to expand further. This loss in forest cover is unprecedented in both scale and complexity. Many forest types have been affected across a range of ecological conditions from the dry Chilcotin to moist sub-boreal and high elevation zones. These twin factors of scale and complexity have, in turn, created numerous uncertainties for forest managers. Adaptive management strategies have been proposed as one approach for dealing with these uncertainties.

An adaptive management workshop held on June 26, 2008 under the FFT program for key staff engaged in restoring forest cover to the mountain pine beetle area raised a range of uncertainties or questions from participants. This is one of the topics for which our team was asked to review and summarize information in the existing literature.

Executive Summary

Several species of rust (particularly Western gall rust (*Endocronartium harknessii*), Comandra blister rust (*Cronartium comandrae*), and Stalactiform blister rust (*Cronartium coleosporioides*)) and one species of canker (Atropellis stemcanker (*Atropellis piniphilla)*) pose a risk to lodgepole pine regeneration in beetle-killed pine stands. Trees with rust infections or cankers are likely become crop trees because they do not die quickly. These trees compete with surrounding trees for resources and contribute little to stand productivity. Those trees that do reach rotation often suffer a serious degradation in wood quality. Foresters are concerned that these organisms infecting live pine stems in the overstory of un-salvaged beetle-killed stands might infect pine seedlings in the understory and reduce their future growth potential beyond the level that normally occurs in regenerating stands of pine. The levels of damage affect decisions about using underplanting or removing the overstory to gain successful regeneration.

Treatments for rusts include the selective removal of live host trees during spacing, removing infections (pruning infected branches and excising cankers), or through stand density management or combinations of these activities. However, the impact of rusts can be accentuated by premature stand entry and by spacing to low stand densities. A longer-term approach is to develop rust-resistant seedlings through an intensive tree improvement program (Wu and Ying 1998). A system of assessing thresholds for rust infection treatments is provided in the Stem Rust Guidebook. However, establishing and maintaining a high stand density for 2—30 years is probably the most effective form of management if pine stands are created.

In stands killed by mountain pine beetle and underplanted, the proportion of pine is likely to be low and the risk of rust infections also low. In stands where overstory is removed, risk of rust infection is likely not different than in non-beetle stands because the rust organisms die when the tree dies. Extensive areas of beetle kill might reduce future impacts from *Endocronartium*, because the regenerating pine stems would be some distance from spore sources but this is uncommon.

The risk of stem canker infection in beetle attacked stands is low and is not likely to differ from regeneration established in the absence of mountain pine beetle. Special management for stem canker measures are not recommended (van der Kamp and Hawksworth 1985).

Prepared for Alanya Smith, by the FFT AM team: Laurie Kremsater, Glen Dunsworth, Alan Vyse, Carol Murray.
Contact: Laurie Kremsater, Phone: (604) 856-3329, lkrem@shaw.ca, 28360 Starr Rd., Abbotsford, B.C., V4X 2C5

The Issue

Several species of rust and one species of canker pose a risk to lodgepole pine regeneration in beetle-killed pine stands. Foresters are concerned that these organisms infecting live pine stems in the overstory of un-salvaged beetle-killed stands might infect pine seedlings in the understory and reduce their future growth potential beyond the level that normally occurs in regenerating stands of pine. If this is the case, the case for stand replacement would be strengthened.

Basic Biology

The pine stem rusts of importance (Allen et al. 1996) are:

- Western gall rust (*Endocronartium harknessii*)
- Comandra blister rust (*Cronartium comandrae*)
- Stalactiform blister rust (*Cronartium coleosporioides*)

One stem canker is also of significance:

- Atropellis stemcanker (*Atropellis piniphilla*)

Pine stem rusts are widespread throughout most forested ecosystems in British Columbia, occurring on pines and alternate herbaceous hosts. They can reduce tree growth, lower wood quality, and cause early mortality. They often play a significant role in early stand development, acting primarily as a natural thinning agent. Pine stem canker is most common in northern regions.

Although trees of all ages can be affected by pine stem rusts, most infection occurs in the initial stages of stand development. Pine stem rusts infect live hosts (as obligate parasites) and have a very selective host range. White pine blister rust affects soft pines (5 needle pines) only, whereas all other pine stem rusts in B.C. affect hard pines (2 and 3 needle pines) only. Pine stem rusts have a complex infection biology which, in most cases, depends on an alternate (herbaceous) host plant for part of the life cycle.

The biology of these rusts is well described in Ziller (1974). The *Cronartium* rusts require alternate hosts in order to complete their life cycles. Only the spores from an infected alternate host may infect a lodgepole pine. The spores produced by the rust on an infected lodgepole pine may only infect an alternate host and cannot directly infect another lodgepole pine. The cankers caused by a rust infection continue to release spores each year in late spring until the infected branch or stem dies. Western gall rust does not require an alternate host; spores released from a gall rust infection may directly infect the expanding candles of the same or another pine tree.

Rust spores can travel hundreds of kilometres making sanitation difficult, if not impossible. However, spores from the alternate hosts are relatively fragile and may only spread up to several kilometres. Presence of alternate hosts in large part determines risk and levels of infection. A severe rust infection in a stand usually places nearby stands at a higher risk of becoming infected.

Humid weather is required for successful infection, and it doesn't take many humid days to allow infection on an otherwise dry summer. Optimal conditions for infection are temperatures about 10 degrees Celsius for a 1 to 2 day period accompanied by high humidity. Infection by pine

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stem rusts tends to occur in "wave years." These are years of high infection that occur at irregular intervals. Many stands are not exposed to wave years of rust infection when they are young and most susceptible. In these stands damage due to rusts is minor. In the stands that do experience wave years, and in certain areas where risk is high, damage can be considerable. Infection can lead to severe damage or death and young stands severely infected with any one or a combination of these rusts may fail to reach minimum stocking levels. The level of infection in a stand peaks before age 10. By age 10 to 12, most trees have a low risk of infection and stands older than this that are free of infection have likely escaped infection. By that age they have been exposed to spores multiple times.

The main impact of hard pine rusts occurs primarily in young stands, although mature trees may be infected. Stem rusts cause mortality when the rust mycelium girdles and kills the stem. The impacts of rusts are believed to be the greatest on the most vigorous trees. Since rusts are obligate parasites, good conditions for tree growth are also good for rust growth. Lower branches are the most susceptible infection sites and infection rates decline rapidly following crown closure, when lower branches are killed due to suppression. Crown closure also reduces the light available to the alternate host species.

Occurrence of lodgepole pine stem rusts

The stem rusts are found throughout the range of lodgepole pine in the province but the risk is greatest in the moister potions of the range. Planting of inappropriate provenances or susceptible families has aggravated the problem in some locations. A table has been appended which shows the most susceptible subzones (Table 1).

The occurrence of rusts depends in part on the abundance and location of alternate hosts, especially in the case of hard rusts and white pine blister rust. For Comandra blister rust, trees even a few meters away from the alternate host tend to have lower levels of infection. BC MoF has assessed 4 year old trees during 3 years of infection of Commandra blister rust that shows this pattern. The cumulative effects of infection over time are not yet known, but at least initially, trees a few metres away have lower levels of infection. The pattern is not as clear for stalactiform or western gall rust because they have multiple alternate hosts.

The distribution of stem rusts throughout young stands is often somewhat aggregated. Thus, mortality due to rusts may result in the stocking of some areas dropping below recommended minimum levels while other areas in the same stand remain overstocked.

Atropellis canker occurs in older pole sized stems and like the rusts, distribution is patchy.

Damage caused by stem rusts

Trees with rust infections or cankers are likely become crop trees. However, they do not die quickly. These trees continue to compete with surrounding trees for resources while contributing little to stand productivity. Those trees that do reach rotation often suffer a serious degradation in wood quality.

Managing the risk of rust infection

Regeneration and stand management activities can change the course of pine stem rusts in stands. Treatments include the selective removal of live host trees during spacing, removing infections (pruning infected branches and excising cankers), or through stand density management or combinations of these activities. However, the impact of rusts can be accentuated by premature stand entry and by spacing to low stand densities. A longer-term

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approach is to develop rust-resistant seedlings through an intensive tree improvement program (Wu and Ying 1998).

Risk of infection differs by zone. Generally as elevation rises, risk decreases. At high elevation (as in most of the ESSF) it is usually too cold for rust spores to cause infection before temperature and humidity drop to low to allow infection to be completed. The SBS zone has the highest risk. Dry zones and subzones are also at risk because even though they are generally dry they tend to have humid, warm days quite frequently.

Dealing with rusts in beetle-killed stands

Risk of rust infections is high only where pine is a large proportion of the regenerating stand. This would usually be the case when FFT removes the overstory and plants predominantly pine back on the site. In underplanting situations, pine is likely to be a smaller comment of the planted stock and as such risk of infections should be lower.

The impact of rust infections on future rehabilitated stand potential in mountain pine beetle-killed stands is unlikely to differ from that in regular stand management. Increased risk is unlikely because the rust organisms die when the tree dies. Extensive areas of beetle kill might reduce future impacts from *Endocronartium*, because the regenerating pine stems would be some distance from spore sources. But such conditions are rare because patches of younger pine stands have been created by past logging and regeneration practices. Infected alternative hosts of the *Cronartium* hosts are likely to be close at hand.

Risk must be assessed at landscape level and stand basis. At the stand level, it is difficult to assess risk to new stands by looking at levels of rust in old stands. By the time stands mature the infected stems have largely dies out and fallen. Rather, it is easier to look at nearby age class 2 and 3 stands and assess those stands by identifying cankers. Experts find more rust and recognize the multiple alternate hosts better than most operational foresters, so in areas of high risk, professional assessment would be useful. At the landscape level, assessments should include an examination of young stands within a 1- to 2-km radius for rust incidence. Suggestions for survey procedures are provided in the Stem Rust guidebook (BC Ministry for Forests 19960on in mature stands.

In areas of high risk and where alternate hosts are present, then resistant tree species should be chosen (note that Ponderosa pine is also susceptible to these rusts). Non-pine species or lodgepole pine seedling that are resistant to rusts can be used. Kalamalka nursery has seedlings resistant seedling to Western gall rust. Prince George area also screens families for resistance. There may be a 3000 fold difference in susceptibility of families to western gall rust, and about a two fold difference in susceptibility to Comandra rust.

Where pine is the dominant species, more stems could be left to allow for damage by infection while still producing enough acceptable stems by rotation age. Establishing and maintaining a high stand density for 2—30 years is probably the most effective form of management if pine stands are created. A system of assessing thresholds for rust infection treatments and details on density management in these stands are provided in the Stem Rust Guidebook (BC Ministry of Forests 1996).

The risk of stem canker infection is low and is not likely to differ from regeneration established in the absence of mountain pine beetle. Special management measures are not recommended (van der Kamp and Hawksworth 1985).

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Key Uncertainties

The risk of rust and canker infections in stands developing under dead pine is thought to be low, but this prediction is highly uncertain.

Short-Term Learning

Rust and canker infection levels should be monitored in all FFT programs.

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Stem Rust Hazard and Risk by Forest Region (from Stem Rust Guidebook)

Table 1 identifies regional high hazard biogeoclimatic subzones that have a high probability of pine stem rust occurrence.

Table 1. Stem rust hazard and risk by forest region (B.C. Ministry of Forests 1996).

Forest region	BEC zone	BEC subzone	Rusts of hard pine (DSG, DSS, DSC)
Cariboo	IDF	all	H
	SBPS	all	H
	SBS	all	H
Kamloops	ICH	mk1	H
	ESSF	dc1	H
		dc2	H
	IDF	dk1	H
		dk2	H
		dm1	H
	MS	dm1	H
		dm2	H
		xk	H
		dc	H
Nelson	ICH	mk1	H
	ESSF	dc1	H
	IDF	dk1	H
		dk2	H
	MS	dm1	H
Prince George	BWBS	all	H
	ICH	mm	H
	SBS	all	H
Prince Rupert	SBS	all	H
Vancouver	IDF	ww	H

"H" denotes pine stem rust is considered a high hazard in this subzone and, as such, requires attention in any prescription.

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