Forests for Tomorrow Adaptive Management Initiative

Synthesis of Information on Selected Topics & Clarification of Key Uncertainties

EXCERPT:

Effect of the Dwarf Mistletoe, *Arceuthobium americanum*, on Regeneration in Beetle-Killed Lodgepole Pine Stands

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Effect of the Dwarf Mistletoe, *Arceuthobium americanum*, on Regeneration in 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

Dwarf mistletoe species *Arceuthobium americanum* poses a potential risk to lodgepole pine regeneration in beetle-killed pine stands. Foresters are concerned that mistletoe occurring on, or infecting live pine stems in the overstory of unsalvaged beetle-killed stands can proliferate in the overstory and infect seedlings leading to growth losses. Estimates of damage caused by mistletoe are based on individual tree studies comparing stems with differing levels of infection on similar sites. At the highest levels of infection, stands may lose up to 35% of their growth potential.

Mistletoe is perhaps the most treatable of all of the pests of lodgepole pine. Several biological and ecological features make mistletoes especially amenable to silvicultural treatment (Muir and Geils 2002): *Obligate parasitism*, *host specificity, extended life cycles, limited seed dispersal, slow intensification within tree crowns, and easy identification.*

A Forest Practices Code guidebook provides advice on the control of all species of mistletoe in BC and more detailed prescriptions are available for lodgepole pine in Muir and Geils (2002). Treatment prescriptions are based on infection ratings based on a 6 point scale (BC Ministry of Forests 1995b). Stands with ratings of 3 or higher should not have overstory retained. Regenerating stems that are infected are not considered acceptable stems in free growing surveys and should be removed.

Stand modelling in the Rocky Mountains has suggested that lodgepole pine can be partially cut or thinned without the risk of damage from future mistletoe infections if the overstory infection level is low. The DM guidebook (BC Ministry of Forests 1995a) recommends against the use of partial cutting in stands where the proportion of lodgepole pine is greater than 50% and more than 20% of the pine trees are infected. However, these recommendations are based on stands with high densities of overstory stems.

The key decision points in Mountain pine beetle attacked stands with mistletoe is how many live overstory trees exist and how high infection levels are on those trees or tall (>1 m) understory. A simple decision tool could be applied using the 6 point infection rating scale. For example, if the residual density was higher than 50 stems per hectare (sph) and the average infection level was 3 or higher, and if lodgepole pine in the understory is at 50% or more of the stocking target,

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the stand should be replaced (clearcutting the overstory or applying a prescribed burn could be recommended). If infection level is low, and sufficient secondary structure is present or expected, no action would be a suitable option or partial cutting to retain live overstory would be acceptable. Planting of pine could take place outside pockets of infection. More detailed recommendations could be based on the detailed mistletoe spread and damage models that are available (see Robinson et al. 2002 for review).

The Issue

The dwarf mistletoe species *Arceuthobium americanum* poses a potential risk to lodgepole pine regeneration in beetle-killed pine stands. Foresters are concerned that mistletoe occurring on, or infecting live pine stems in the overstory of unsalvaged beetle-killed stands can proliferate leading to growth losses. Also, there is concern that mistletoe can infect pine seedlings in the understory and reduce their future growth potential.

Basic Biology

Dwarf mistletoes (*Arceuthobium spp*) are parasitic vascular plants that affect the growth and mortality of conifer species in many parts of the world. They are particularly pervasive and damaging in the western North America. Long standing infections cause growth loss and may result in tree mortality directly or in association with other mortality agents. Well developed infections lead to prolific branching and the characteristic "witches brooms". The plants spread from tree to tree primarily by means of seed dispersal, in which the seeds are "shot" from the plant, traveling up to 30m. Animals, including several species of birds and small mammals, provide a more far-reaching dispersal mechanism. The plants and the brooms provide food and habitat for a wide variety of animal species which in turn contribute to the spread of the plant (Geils et al. 2002).

Species of dwarf mistletoe are relatively host specialised. One species *A. americanum* (hereafter *A.a.*) establishes on lodgepole pine and is regarded as a major pest of this species throughout western North America (Baranyay and Safranyik 1970, van der Kamp and Hawksworth 1985), but it also damages jack pine and ponderosa pine.

A.a. is found throughout the range of lodgepole pine but infections are most intense and damaging on drier sites where lodgepole is the dominant species. In wetter areas, where lodgepole pine is an early seral species, the dominance of pine is highly variable. The level of infection is also a function of fire history. Stands of pine that develop following high-severity fires have low levels of mistletoe, but stands that have experienced low-severity fires often have very high levels of infection. High-severity fires leave few if any residual stems of pine and infection of the subsequent regeneration proceeds from infected pine on the fire edge. Low-severity fires leave many survivors and if these survivors are infected with mistletoe, the regenerating stand beneath may become heavily infected. This circumstance is frequently found in the drier portions of the Chilcotin region of BC.

Geographic Distribution of Lodgepole Pine Mistletoe

Lodgepole pine mistletoe is found throughout the southern portion of the host species from 56 degrees north to the US border. The intensity of infections varies widely. It is lowest in mixed species stands in the wetter portions of the range and most intense in the dry Chilcotin region.

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Damage

Estimates of damage caused by mistletoe are based on individual tree studies comparing stems with differing levels of infection on similar sites. At the highest levels of infection, stands may lose up to 35% of their growth potential (van Sickle and Wegwitz 1978). These estimates have been scaled up to the provincial level and growth losses of 2.5 million m3 per year have been calculated for the province (van Sickle and Wegwitz 1978). However these estimates are not based on detailed surveys of mistletoe infection levels in the province and must be considered with caution. Nevertheless, there is no doubt that A.a. can cause serious damage and high levels of infection can and should be avoided.

Managing Risk

Mistletoe is perhaps the most treatable of all of the pests of lodgepole pine. Several biological and ecological features make mistletoes especially amenable to silvicultural treatment (Muir and Geils 2002):

Obligate parasitism. Mistletoes require a living host to survive and reproduce. When an infested tree or branch dies (or is cut), the attached mistletoe plants die as well.

Host specificity. Mistletoes generally infect only a single, susceptible host species or group of related species. Mixed species stands with less susceptible hosts reduce spread.

Extended life cycles. Life cycles of mistletoes are relatively long compared to other tree disease agents; a generation ranges from 2 to 10 or more years. Mistletoe spread from tree to tree, and increase within tree crowns is relatively slow. Because numerous infections are required to cause serious damage, the effects accumulate slowly.

Limited seed dispersal. Mistletoe seeds are dispersed a maximum horizontal distance of only 10 to 15 m; gravity and foliage limit effective spread in the vertical and horizontal planes; animal vectoring of mistletoe (with one or two exceptions) is rare enough to be ignored other than from ecological and evolutionary perspectives. Consequently, mistletoe tends to occur as pockets of infestation and small, young understory trees are targets for infection in these pockets. Planting lodgepole pine in these pockets is not recommended but there is an opportunity to regenerate pine outside of these pockets of infection.

Slow intensification within tree crowns. Mistletoe infection typically begins in the lower tree crown. Vertical spread is slow enough that trees with rapid height growth can outgrow or at least keep pace with mistletoe intensification. Opening the stand through thinning can provide more light to mistletoe infections. Thus, density management could allow silviculturists to influence the balance between growth of the host and the pathogen.

Easy identification. The plant can be seen and identified relatively easily. Incidence and severity ratings can generally be used to characterize dwarf mistletoe infections (Muir and Moody 2002). Severely infected stands can be detected by aerial surveys but incidence and severity usually must be determined by ground surveys or inventory sampling (Muir and Moody 2002). The ease of detection in beetle-killed stands has not been tested to our knowledge.

A Forest Practices Code guidebook (BC Ministry of Forests 1995a) provides advice on the control of all species of mistletoe in BC and more detailed prescriptions are available for lodgepole pine in Muir and Geils (2002). Most treatment prescriptions are based on surveys of the pine overstory to establish infection ratings based on a 6 point scale (BC Ministry of Forests 1995b). Stands with ratings of 3 or higher are considered unsuitable for silvicultural systems

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which retain overstory stems during the regeneration phase because of the risk of infecting the understory. Regenerating stems that are infected are not considered acceptable stems in free growing surveys and may require treatment.

Stand modelling work in the Rocky Mountains (cited by van der Kamp and Hawksworth 1985) has suggested that the partial cutting or thinning in lodgepole pine stands can be carried out without the risk of damage from future mistletoe infections if the overstory infection level is low (a low rating). The Dwarf Mistletoe guidebook (BC Ministry of Forests 1995a) recommends against the use of partial cutting in stands where the proportion of lodgepole pine is greater than 50% and more than 20% of the pine trees are infected. However, these recommendations are based on stands with high densities of live overstory stems.

The Risk and the Unknowns

Where stands of lodgepole pine have been attacked by mountain pine beetle, the risk of mistletoe infections are considerably reduced because when the tree dies and the mistletoe infection also dies. Mistletoe infections in residual stems will increase with the reduction in competition and increase in light. The risk of mistletoe infection in the stand depends on the density and infection level of surviving overstory stems of lodgepole pine, the proportion of pine in the understory, and its size and the existing infection level.

The primary unknown is the density of surviving lodgepole pine stems in pine beetle attacked stands planned for treatment and the level of mistletoe infection in those stems. This is part of the broader issue of a general lack of knowledge about the density of surviving stems of all species.

Ideally this uncertainty should be resolved by a province wide inventory of dead pine stands that identifies remaining live overstory and basic understory structure. In the absence of such an inventory, project planners will have to make do with low cost, local inventory approaches. Once the species and density of live stems is known, and levels of infection are known, then treatments for mistletoe are straightforward.

Risk Management Considerations and Options

Management options range from doing nothing, to removing the overstory and destroying the understory, to retaining the overstory and various combinations of sanitation thinning and supplementary underplanting. Prescribed burns have also been proposed as a method of eliminating mistletoe infections (Hessburg et al. 2008).

Results from recent surveys in pine beetle attacked stands have shown that the density of surviving lodgepole pine stems across a wide range of the epidemic area is low and the proportion of pine in the understory across the same area is also low (Vyse et al. 2007; Astrup et al. 2008; although Forest Practices Board 2007 among others have reported high levels of pine regeneration in the Chilcotin region). Prescribing foresters must be aware of the potential for future damage and record mistletoe infections in surveys before preparing prescriptions. They should also be aware that mistletoe infestations can create desired habitat features (Muir et al. 2004).

Risk Management Recommendation

A simple decision tool could be applied using the 6 point infection rating scale. For example, if the residual density was higher than 50 stems per hectare (sph) and the average infection level

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was 3 or higher, and if lodgepole pine in the understory is at 50% or more of the stocking target, replacing the stand (clearcutting the overstory or applying a prescribed burn could be recommended). If infection level is low, and sufficient secondary structure is present or expected, no action would be a suitable option. The same tool could be applied in developing a prescription for underplanting lodgepole pine. More detailed recommendations could be based on the detailed mistletoe spread and damage models that are available (see Robinson et al. 2002 for review).

Key Uncertainties

The density of surviving lodgepole pine stems in pine beetle attacked stands planned for treatment. This is part of the broader issue. There is a lack of knowledge about the density of surviving stems of all species.

Short-Term Learning

Ideally this uncertainty should be resolved by a province wide inventory of dead pine stands. In the absence of such an inventory, project planners will have to make do with low cost, local inventory approaches.

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