IMPACTS OF MOUNTAIN PINE BEETLES ON FOREST MANAGEMENT AND SUCCESSION

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ABSTRACT

Keywords: Mountain Pine Beetle, Forest Management, Succession, Sustainability, Disturbance, Biodiversity.

The mountain pine beetle has been an ongoing issue in large forest landscapes for decades and has continued to create issues revolving around forest management and succession. This thesis will go into depth on the intensity and devastation the mountain pine beetle has caused in North American forests, and how different forest management schemes are in the works on how to properly manage massive outbreaks of the mountain pine beetle.

Findings of the mountain pine beetle traveling northeast and its attack on the jack pine species have been causing concerns about adjustments to management strategies and future successional trajectories.

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INTRODUCTION

The mountain pine beetle has been around for decades and has had major outbreaks starting from the early 1970s into the early 2000s and is still creating havoc today. The mountain pine beetle, *Dendroctonus ponderosae* (Coleoptera: Curculionidae: Scolytinae), is the most aggressive member of its genus in the western United States (Amman G.D. 1977). Forest management has had to shift in knowledge and procedure in order to maintain and deal with the mountain pine beetles' damage to the forests in North America. For my thesis, I wanted to research more into the mountain pine beetle from my previous year of doing a presentation on the insect. This study was mainly done as a literature review of the mountain pine beetle. Below is the list of my scientific question which I will be answering with solid proof from published scientific articles.

My scientific questions are:

1. How are stands managed after an attack?
2. What are future plans for dealing with further outbreaks of the mountain pine beetle?
3. What happens to lodgepole pine stands after an attack?

The mountain pine beetle in Central British Columbia is currently subject to the largest outbreak of mountain pine beetles (Ritchie, 2008). Massive expansions of natural disturbances are a result of both the natural and human-associated influences including warmer winter weather and changes to fire suppression policies (Ritchie, 2008). Results from changes, in British Columbia responses have moved from a control or sanitation phase to an economic recovery or salvage phase (Ritchie, 2008).

The condition the landscape is in due to the mountain pine beetles destruction is affecting not only management and succession but wildlife as well (Ritchie, 2008). The distribution and number of different types of species will increase or decline in a response to the changes in forest vegetation and hydrologic regime (Ritchie, 2008). Some key species that will be affected are the boreal woodland caribou *(Rangifer tarandus caribou),* fisher *(Martes pennanti)*, marten *(Martes americana)*, woodpeckers, and pygmy nuthatches *(Sitta pygmaea)* are considered species with high sensitivity to mortality of pine trees that will adversely affect their forage, cover, and nesting/denning habitat (Ritchie, 2008). Moose (*Alces alces*), is a species that will benefit in the short-term with there being the availability of increased forage resources, but this won't last long from intensive forest management to recover mature forest stands (Ritchie, 2008). Managers critically require more information about the effects of unsalvaged mountain pine beetle stands on wildlife and wildlife habitats, but few studies have addressed these issues (Chan-McLeod, 2006). Forest managers need to make decisions on where to focus salvage logging (Chan-McLeod, 2006). Although the mountain pine beetle has no direct effects on wildlife other than its food source, some species effects are mediated through the forest structure, which represents the habitat for wildlife (Chan-McLeod, 2006). The objective of this thesis is to go into t depth of the destruction the mountain pine beetle has caused and explain methods on how forest management and succession will be handling the mountain pine beetle in the future.

MATERIALS AND METHODS

Research in this literature review was conducted by searching other research articles about the mountain pine beetle as well as comparing a healthy stand to a stand affected by the mountain pine beetle. Samples have been included in ways of figures and explanations throughout this thesis as well as tables showing data on the destruction the mountain pine beetle has created in North America and how it has affected forest management operations and succession.

The research was found by reading through many scientific articles as well as many books found in libraries and online.

LITERATURE REVIEW

1.0 About the mountain pine beetle

1.1 Background information

The mountain pine beetle (*Dendroctonus ponderosae*) is a small insect-based out of the Curculionidae family and the Coleoptera order (Figure 1). This is a wood-boring insect that primarily targets pine tree species. This insect species has a 1-year life cycle which can be either shortened or expanded depending on the temperature in which it is surrounded (Bleiker 2021). Adult beetles colonize new host trees in July or

Figure 1 The mountain pine beetle. (NRC, 2017)

August with the female beetles releasing a chemical called aggregation pheromones, which communicate and gather the attention of other beetles in the area to go to the tree that the female is at (Natural Resource Canada 2021). Newly hatched larvae are able to eat further into the tree as time passes (Natural Resource Canada 2021).

Larvae usually spend the winter submerged into the depths of the attacked tree to complete their development the following spring where pupating occurs in June or July (Natural Resource Canada 2021).

1.2 Distribution of the mountain pine beetle

This insect is native to Western North America where it expands from northern Mexico to northern BC and has expanded due to climate change and past forest management programs (Bleiker 2021). The mountain pine beetle is also found in an isolated population of pine near the Cypress Hills area of southwestern Saskatchewan (Natural Resource Canada 2021). In the 2000s, the beetle greatly expanded its range in Canada by invading new habitats in the eastern parts of British Columbia (Natural Resource Canada 2021, Figure 2).

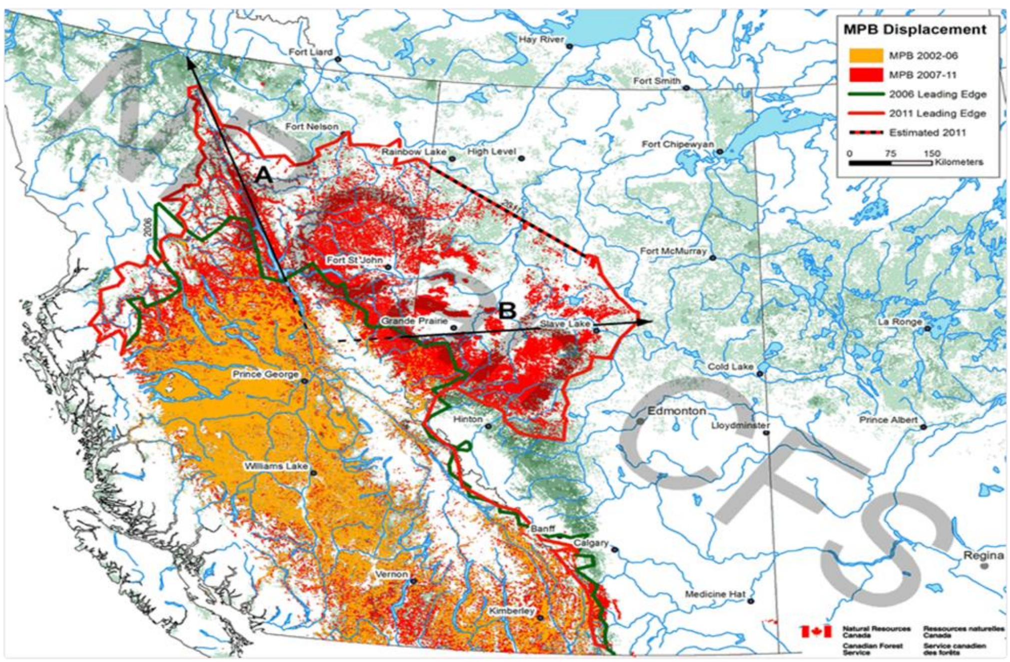

Figure 2 Map of the distribution of the mountain pine beetle in northwestern Canada. (CFS, Scarr, OMNRF 2011)

As you can see in figure 2, the distribution of the mountain pine beetle in Canada is showing the population spreading north towards the northwest territories, and east towards Saskatchewan. The mountain pine beetle has spread from its native range a long time ago due to climate change and past forest management programs. "They are found from the Pacific Coast east to the Black Hills of South Dakota, and from central British

Columbia and western Alberta to northern Baja California, Mexico (Figure 2). The mountain pine beetles habitat ranges from near sea level in British Columbia, to 11,000 feet in southern California" (Natural Resource Canada, 2022).

1.3 Impacts and targeted species

The species this insect targets are Lodgepole pine which is the most commonly targeted tree species for the mountain pine beetle (Figure 3), other species are almost every other pine which include ponderosa pine, western white pine, white bark, limber pine, and recently jack pine in expanded ranges with the exception of Jefferey pine (Reid 2008). Tests were performed to examine the effect of tree species composition on the

Figure 3 "Pitch tubes on a lodgepole pine tree killed by the mountain pine beetle" K. Bleiker

occurrence of the mountain pine beetles, and the stand which was dominated by lodgepole pine, white spruce, or burned lodgepole pine were used to compare which species would be affected the most from the mountain pine beetle and the results came back that the lodgepole pine was unsurprisingly the most affected tree species in the stand (Reid 2008). Since the early 90s, 50% of the total volume of commercial lodgepole pine in BC has been attacked and over 18 million hectares of forest have been affected in the 1990s and 2000s in BC as well, which was the largest recorded epidemic of the mountain pine beetle (Bleiker 2021). With all of the damage and death to species in northern Canada, the mountain pine beetle has increased the risk of large forest fires due to the highly flammable dead tree stems which also creates a loss in logging revenue as well as wildlife and wildlife habitat (Bleiker 2021).

During outbreaks (see Figure 4), the widespread tree mortality reduces the forest carbon uptake and increases future emissions from the decay of killed trees in stands

Figure 4 Damage done by the mountain pine beetle in B.C. (Rosen, 2014)

(Kurz et al., 2008). Damage and impacts from insects on the forests and the carbon dynamics are typically ignored (Kurz et al., 2008). The current outbreak in British Columbia is larger in area and intensity than all previously recorded outbreaks in North America (Kurz et al., 2008). In addition, 75% of the average annual direct forest fire emissions from all of Canada from 1959 to 1999 were a result of beetle outbreaks in BC (Kurz et al., 2008). The resulting reduction in production was similar to the increased observations during the 1980s and 1990s, this has climate change contributing to the extent and severity of the outbreak (Kurz et al., 2008). Insect outbreaks represent an important mechanism by which climate change undermines the ability of northern forests to take up and store atmospheric carbon (Kurz et al., 2008).

Log conditions and veneer peeling have been an issue when the mountain pine beetle has attacked the lodgepole pine species. For the beetle-killed logs, in a study that showed cracks appearing after rounding up, “after peeling, sap veneer ribbon broke regardless of how blocks were conditioned” (Wang and Dai 2009). These studies showed, beetle attacked logs affect the conditioning of processed veneered wood(Figure 5).

Figure 5 pine beetle damaged veneer wood. (Pinterest, 2022)

1.4 Mountain pine beetle features and anatomy

The mountain pine beetles Life cycle consists of 4 stages: Egg, Larva, Pupae, and the adult stage. Larvae are white with brownish heads and are approximately 5 mm long. Pupae are white first but change to light brown and are also 5 mm long. The adults are black in color, small, dull, with elbowed antennae. They can grow to be 3.7 to 7.5 mm long (Figure 6).

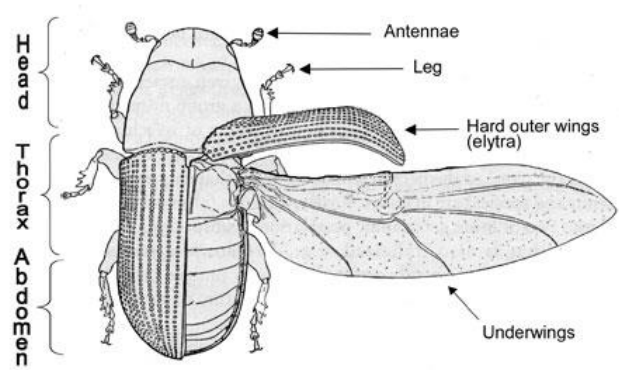

Figure 6 Diagram of the mountain pine beetle anatomy. (Niki Wilson, 2017)

The mountain pine beetle is a natural insect of the British Columbia and Alberta Rocky Mountain Ecosystem (Parks Canada Agency, 2019). These beetles colonize and kill mature pine trees by boring through the bark and digging through the cambial layer between the bark and the wood of the host tree (Parks Canada Agency, 2019).

The relationship between mountain pine beetle and their host pine tree has been changing rapidly throughout the last century (Wilson, 2017). The anatomy of this bark beetle reflects the relationship it has with adaptations designed specifically for cutting through the bark and phloem of the host tree (Wilson, 2017). Bark beetles have a tough and hard exterior shell which is known as an exoskeleton which is a three-region compound (Head, thorax, and abdomen), it has two compounded eyes, three pairs of jointed legs, and two antennae (Wilson, 2017). The legs and wings are attached to the thorax. The front pair of hardened wings forms the "elytra" which protects the hind wings. The Mountain pine beetle is small, dull (not shiny), cylindrical, and has an elbowed, club-like antenna (Wilson, 2017). Larvae compete for food and space not only with each other but with larvae of the round-headed wood borers, which also feed within the inner bark, occasionally destroying almost all of the mountain pine beetle brood found in the tree (Amman et al., 1985).

2.0 Succession & Management

2.1 Lodgepole pine succession after mountain pine beetle outbreaks

Mountain pine beetle populations and lodgepole pine stands have apparently coexisted for a long time (Safranyik, 2016). The similarity of distribution of lodgepole type by age classes (Continuous Forest Inventory of B.C, 1957) between areas with low and high beetle hazards suggests that beetle activity has had no major effect on the regeneration or survival of lodgepole pine (Safranyik, 2016). Succession trajectories are altered in both pure lodgepole pine stands and spruce-fir stands (Kayes & Tinker, 2012). When non-host tree species are present in the lodgepole stand canopy, mountain pine beetle-induced mortality of lodgepole pine can advance forest succession towards more long-lived and shade-tolerant species such as spruce, Douglas-fir, and subalpine fir. These tree species are capable of releasing seeds from open cones, which then germinate on the undisturbed forest floor, and within the partial sunlight created by canopy gaps, can successfully establish and grow, eventually reaching the canopy (Hawkes et al., 2017). When the beetles produce the blue stain fungus in the lodgepole pine, preparation for the successional forest types through cropping the stands is initiated (Safranyik, 2016). This interaction is a dynamic process thathas a primary effect on variations in beetle population size and quality in space and time as postulated by Safranyik (2016). Mountain pine beetle outbreak effects on forest succession appear to vary by forest type. In the absence of fire, pure lodgepole pine stand trajectories are shifted towards an uneven-aged lodgepole pine forest, while spruce-fir stand trajectories are shifted towards late-seral species dominance (Kayes & Tinker, 2012). As documented in British Columbia (Nigh et al., 2008; Axelson et al., 2009; Coates et al., 2009; Vyse et al., 2009) and Colorado (Diskin et al., 2011), stands with primarily lodgepole pine in the overstory were dominated by lodgepole pine in the advanced regeneration (Kayes & Tinker, 2012). The pure lodgepole pine forests in this study appear to be ‘‘climax’’ lodgepole pine with lodgepole pine advanced regeneration under lodgepole pine overstory (Kayes & Tinker, 2012). These forests will become uneven-aged lodgepole pine forests with successive mountain pine beetle outbreaks and the development of lodgepole pine advanced regeneration (Amman, 1977; Romme et al., 1986; Sibold et al., 2007; Diskin, 2010).

2.2 Management of mountain pine beetle

It appears that active management intervention is not necessary to ensure reforestation following the severe mountain pine beetle outbreak (Kayes & Tinker, 2012). The mountain pine beetle is a native insect and forests have historically recovered from mountain pine beetle outbreaks via advanced regeneration (Romme et al., 1986; Heath and Alfaro, 1990; Sibold et al., 2007). With advanced regeneration established naturally before the harvesting of a stand of mature timber, advanced regeneration sometimes provides the species composition desired for the next rotation species that may be difficult to regenerate subsequent to the harvest as well as from outbreaks

(Ferguson, 1984). Additionally, relying on the advanced regeneration for reforestation should not substantially alter the species composition of these forests, particularly on dry sites dominated by only lodgepole pine (Kayes & Tinker, 2012). Based on the density of advanced regeneration compared to the pre-outbreak canopy, advanced regeneration appears to be a suitable means for regenerating stands following mountain pine beetle outbreaks in the Medicine Bow Range (Kayes & Tinker, 2012). Relying on advanced regeneration may increase heterogeneity in forest structure that may make these forests more resistant to mountain pine beetle attacks in the future (Kayes & Tinker, 2012). Since lodgepole pine is generally thought to be shade-intolerant and to regenerate following disturbance (Burns and Honkala, 1990), it is likely that lodgepole pine density will continue to increase in these stands over time (Kashian et al., 2005). Fire would also favor lodgepole pine over more shade-tolerant species (Kayes & Tinker, 2012). In areas that exhibit limited advanced regeneration as seen in one stand in the current study and recovery to closed-canopy forests may take longer (Diskin, 2010). Forests recovering naturally from advanced regeneration are more likely to have a diversity of tree size and age classes both within and among stands (Kayes & Tinker, 2012).

Treatments used to mitigate the effects of mountain pine beetle are grouped into three broad categories: Treatments that strive to reduce or eliminate beetle populations are termed direct controls, Treatments aimed at increasing tree vigor and altering stand conditions to be less favorable for beetles are called indirect controls, and prophylactic treatments aimed to protect high-value individual trees or stands of trees from infestation (Six et al., 2014). Direct control includes sanitation treatments such as removing single trees or small patches of trees that are infested with the insect, clearcutting, and prescribed burning of infested trees, as well as falling and burning, trapping trees, debarking, and application of insecticides or toxins such as MSMA (Six et al., 2014). Experience with the direct control of mountain pine beetle epidemics by chemical sprays, salvage logging, or other techniques aimed at reducing beetle numbers, indicates that the effects of suppression work are temporary. Thus, these control techniques are primarily useful for holding stands until all the potentially susceptible trees can be removed (Roe and Amman 1970). Sanitation cuts attempt to remove most or all beetles in an area by removing infested trees before the beetles developing within them can emerge and disperse (Six et al., 2014). Prescribed burns, fell and burn, debarking, and toxin applications attempt to destroy beetles in infested trees on-site (Six et al., 2014). Trap trees are trees that are baited with attractant pheromone baits in an attempt to draw beetles into specific areas where they are concentrated into the baited trees which are subsequently taken to the mill or destroyed (Six et al., 2014). The main treatment used for mountain pine beetle is thinning. Thinning is thought to act by reducing inter-tree competition for water, nutrients, and light, enhancing greater tree vigor, and thus defenses against the beetle (Six et al., 2014).

CONCLUSION

The mountain pine beetles are a natural part of the southern Rocky Mountain ecosystem and have historically existed at manageable levels. With the increase in temperature, warmer winters and drier summers, the management, and succession of the forest affected by this beetle will continue to change. With future plans being to continue monitoring the beetles travel from western Canada to eastern regions in an attempt to manage it properly, the future in managing this beetle is still unclear. However, with the current management tactics in place, both direct and indirect management for bark beetles have their place (Six et al., 2014). However, to manage our forests in a proper way that will best ensure the long-term survival of our forests while also using limited financial resources, forest management, and also the public, need a clearer understanding of the current science (Six et al., 2014).

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