Forest Management Impacts on Tree Species Diversity: Effectiveness and Costs in Light of a Beetle Epidemic

Caren Dymond[1], David Spittlehouse[2], and Sinclair Tedder[3]

[1]Government of British Columbia
[2]BC Ministry of Forests
[3]Organization Not Listed

November 22, 2022

Abstract

In western North America, a recent epidemic of mountain pine beetle (Dendroctonus ponderosae) caused widespread forest mortality. This outbreak was in part due to the changing climate, and damage from pests and diseases is expected to increase in the future. To learn from this event, we used a historical retrospective approach to evaluate business-as-usual and alternative management strategies effects on tree species diversity. The insurance hypothesis proposed that ecosystems with greater species diversity will have greater productivity due to the buffering effect against natural disturbances. Therefore, we hypothesized that management strategies to increase diversity before the beetle outbreak could result in higher growing stocks, harvest rates, and net present value. The assessment was based on simulation modelling of a 1.1 million ha landscape in British Columbia, Canada for 1980–2060. We applied different strategies to affect diversity: harvest more of the most dominant tree species, planting more diverse species, and increase natural regeneration. The most aggressive strategy resulted in higher diversity and growing stocks, higher harvest rates, and higher, more consistent net revenue over time than the business-as-usual strategy. However, the strategy that only employed a diversity of planting negatively affected those indicators. Thus, we have identified limitations to what management strategies may be able to achieve. Sensitivity analyses of species productivity and log price indicated a high level of robustness in the results. Our study showed that reducing forest health risks may be economically viable.

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Caren C. Dymond, David L. Spittlehouse, Sinclair Tedder

BRITISH COLUMBIA
Ministry of Forests, Lands, Natural Resource Operations and Rural Development

Contact:
Caren.Dymond@gov.bc.ca

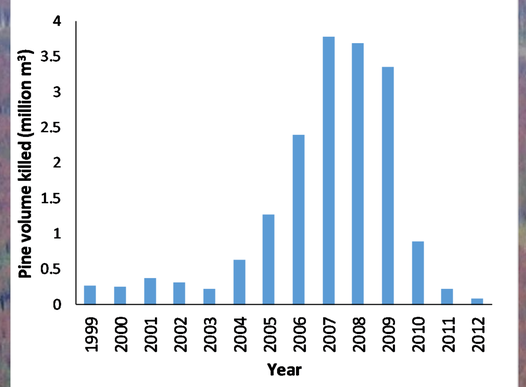
Introduction

- In western North America, a recent epidemic of mountain pine beetle (*Dendroctonus ponderosae*) caused widespread forest mortality as a result of warmer winters (Figure 1).
- Insect outbreak frequency and severity is expected to increase under climate change
- The insurance hypothesis states that in a fluctuating environment "*biodiversity insures ecosystems against declines in their functioning because many species provide greater guarantees that some will maintain functioning even if others fail.*" Yachi and Loreau 1999

Purpose

Assess the effectiveness of applying the insurance hypothesis theory to a managed landscape that has experienced severe climate change impacts using modelling.

Figure 1. Volume of *Pinus contorta* and *Pinus ponderosa* (pine) killed by mountain pine beetle annually in the Merritt Timber Supply Area, British Columbia, Canada. (BC Government 2015)



Methods

- Historical retrospective
- Simulation of a forest estate 1980 – 2060
  - CASH6 model, similar to timber supply methods
  - Post-beetle harvest rate determined based on growing stock, growth rates, and a consistent flow of timber
- Cost/Benefit analyses

Figure 2. Study area: the Merritt Timber Supply Area (TSA), British Columbia, Canada. It is 1.1 million ha, with a cold and dry climate.

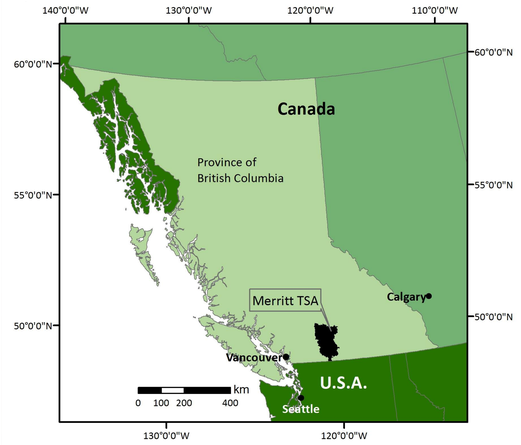


Table 1. Management strategies assessed

	Pre-beetle Harvest assumptions	Planting assumptions
Business as usual	Volume and species based on statistics	Historical based on statistics and future based on existing timber supply analysis
Mixed planting	Same as Business as usual	Mixed species planting on appropriate sites
Early pine cut, mixed planting, more natural regeneration	Volume based on statistics but prioritized harvest of pine and including partial cutting	Mixed species planting on appropriate sites and more natural regeneration especially in partial cut areas

Results

Figure 3. Landscape-scale diversity

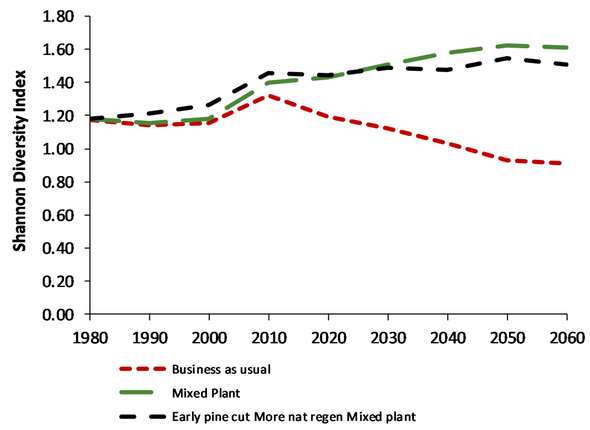


Figure 4. Volume in living trees per decade.

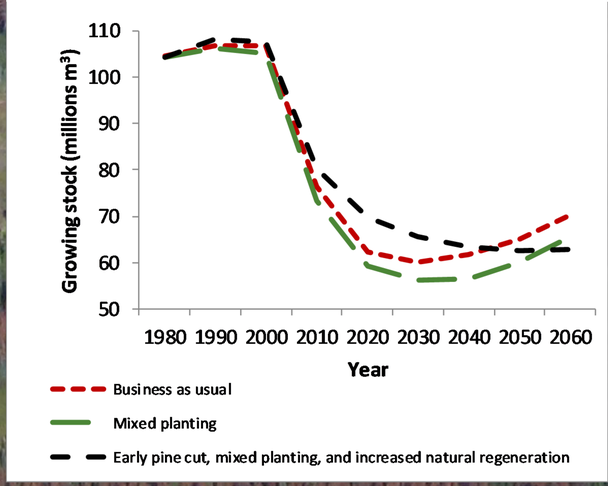


Figure 4. Volume harvested per year.

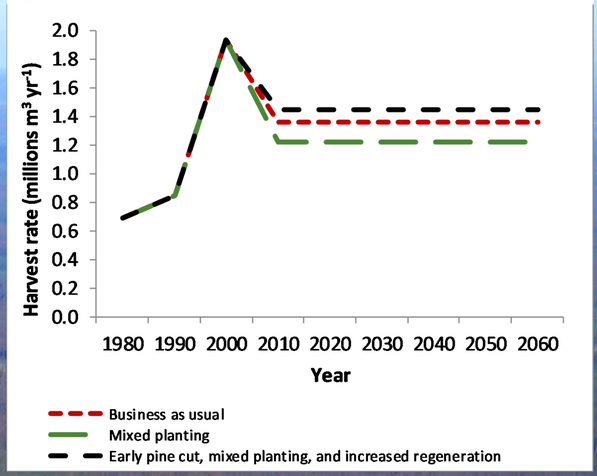


Table 2. Net present value by management strategy for 1980–2060 in millions of 2005 dollars.

Management strategy	Discount rate 0%	1%	3%	5%
Business as usual	1569	1061	574	372
Mixed planting	1524	1023	552	359
Early pine cut, mixed planting, more natural regeneration	**1790**	**1181**	**611**	**380**

Conclusions

- Diversifying stands and landscapes was effective at increasing survivorship and harvest post-beetle only under the most aggressive strategy.
- The Mixed planting strategy was insufficient to affect the beetle mortality after only 2 decades.
- Diversifying forest stands and landscapes was cost effective in light of a beetle outbreak.
- This indicates that the support for the insurance hypothesis depends on the forest characteristics and silviculture regimes interacting with the timing of forest health disturbances.

References

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Citation

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Acknowledgements

- Funding from the Government of BC
- Thanks to Ecora for modelling support
- Thanks also to Brian Raymer, Katherine Hopkins, Katharine McCallion, and James Sandland who contributed to the original paper
- Photo credit: Lorraine Maclauchlan