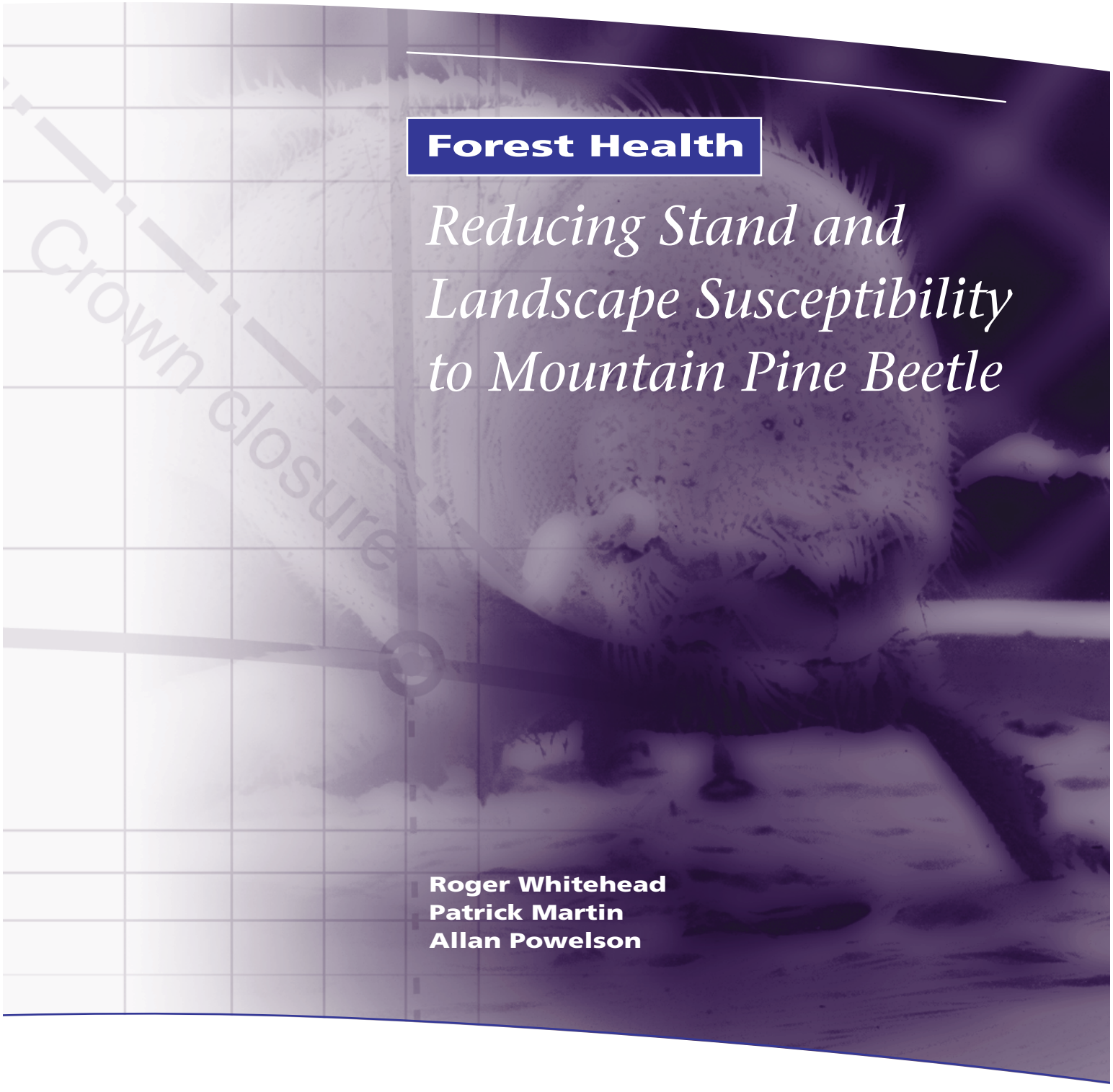
Stand Density Management Diagram

Supporting
Growth and Yield
Decision-making



Forest Health

Reducing Stand and Landscape Susceptibility to Mountain Pine Beetle

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Introduction

Stand management can alter the susceptibility of some lodgepole pine stands to mountain pine beetle attack. In this document, stand density management diagrams (SDMDs) are used to illustrate concepts important to managing stands to reduce tree, stand, and landscape susceptibility to epidemic outbreaks of mountain pine beetle.

Stand Density Management Diagrams

SDMDs depict the development over time of healthy, single-species, even-aged stands. SDMDs are useful for displaying general stand development concepts and communicating research findings. SDMDs can aid in the assessment of the potential impacts of treatments on stand management objectives for stands of various densities. To understand this document, you must know how to use an SDMD. Refer to the references (*More Information*) to learn more about SDMDs.

Stand management can alter the susceptibility of some lodgepole pine stands to mountain pine beetle attack.

Assumptions and Limitations

The general concepts presented in this document will not apply to every stand. Spacing prescriptions have many objectives other than reducing stand and landscape susceptibility to mountain pine beetle infestation. In most cases, the best way to reduce future losses to mountain pine beetle infestation is to combine direct control of beetle pressure with the reduction of stand susceptibility across the landscape through silviculture. This pamphlet provides an overview of general concepts; the listed references give the detail required to apply these concepts in a prescription.

The general concepts presented in this document will not apply to every stand.

Glossary

Beetle pressure: *the amount of beetle activity near a stand*

Risk: a function of stand susceptibility and proximity to existing infestations (beetle pressure)

Stand trajectory: a curved line on an SDMD that charts the changes in a stand's structure as it grows

Susceptibility: a measure of stand characteristics associated with successful infestation if a stand is attacked

Top height: the mean height of dominant trees

Zone of imminent competition-mortality: a zone on an SDMD indicating the probable occurrence of competition-based mortality in stands. The lower limit of the ZICM approximates the point at which self-thinning starts to dramatically accelerate.

This pamphlet is one in a series of information booklets on using SDMDs. Other topics include using SDMDs to manage for timber production, forest health, wildlife habitat, and stand structural diversity.

Mountain Pine Beetle

The mountain pine beetle is endemic in lodgepole pine stands throughout western North America, and at low population levels causes little damage to forest resources. However, periodic epidemic outbreaks make it the most destructive insect pest of mature pine forests. These outbreaks can spread over hundreds of square kilometres, last from 3 to 20 years, and destroy the large-diameter pine in affected stands. Such outbreaks cause huge economic loss and severely disrupt landscape-level planning for all forest resources.

Mountain pine beetle

Mountain pine beetle is the most destructive insect pest of mature pine forests.

Three main conditions are required for the development of a landscape-level (epidemic) outbreak:

- sustained favourable weather (several mild winters and warm dry summers)
- lack of effective control action during the outbreak's incipient stage
- a landscape with an abundance of susceptible pine.

Sustained favourable weather, which occurs from time to time throughout the range of mountain pine beetle, cannot be controlled. Constant vigilance and consistent application of direct control of incipient populations (e.g., fall-and-burn treatments of infested trees or patch logging) can slow or prevent development of landscape-level outbreaks. These costly activities will be required until the underlying cause—too much susceptible pine—is addressed.

Stand Susceptibility

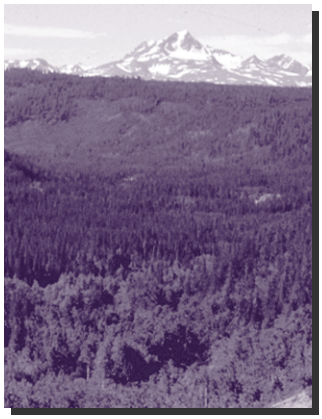
Stand characteristics that are usually associated with the development of mountain pine beetle outbreaks in natural lodgepole pine stands include:

- average tree diameters over 20 cm
- a substantial proportion of trees over 25 cm dbh
- trees more than 80 years of age
- stand densities between 750 and 1500 trees per hectare (tph).

In this document, these characteristics delineate high susceptibility, though attacks do occur in stands of moderate (and low) susceptibility when beetle pressure is high, and other factors such as location are also influential.

The tree size (diameter) and density characteristics associated with high susceptibility can be easily portrayed on an SDMD. To portray the age characteristic, site index curves are used to translate age to height. On site index 18 and 21 m, 80 years total age occurs at 22 and 25 m top height, respectively.

Figure 1 indicates the zone of high susceptibility for stands on site index 18 and 21 m. Note that on sites of lower quality, stands are shorter at age 80, so the zone of high susceptibility on the SDMD begins at a lower height.



Lodgpole pine stands susceptible to beetle infestation

Figure 1
Zone of high susceptibility for site index 18 m (light and dark purple) and site index 21 m (dark purple).

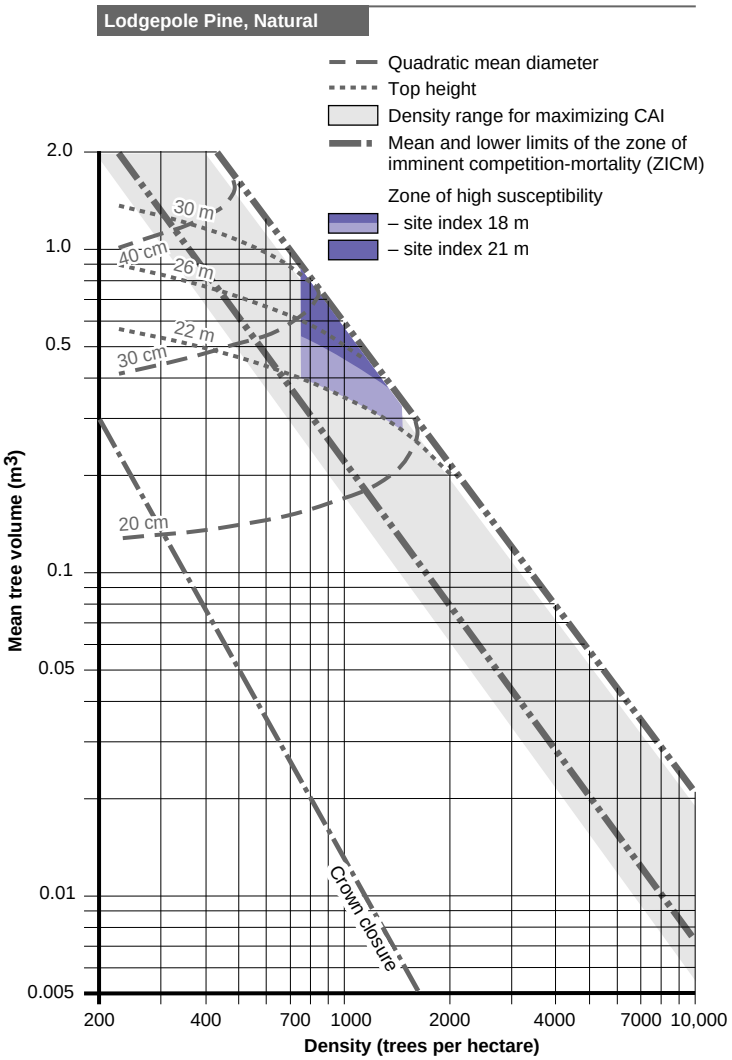
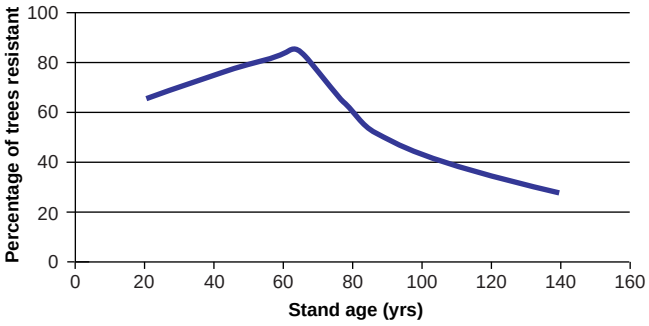


Figure 2
The percentage of lodgepole pine trees resistant to attack by mountain pine beetle and blue-stain fungi decreases after 60 years of age.
Source: Safranyik, Shrimpton, and Whitney (1974).



Tree pitching out a beetle

The tree size parameters of susceptibility are associated with the food and space needed to support brood development of an expanding beetle population.

The age factor is associated with declining tree vigour in natural stands, which affects individual tree resistance to inoculation by a blue-stain fungus carried by attacking mountain pine beetles (Figure 2). It is the combined action of bark beetles and fungus that results in tree mortality.

Stand density affects tree vigour and within-stand microclimate (light, temperature, and wind). These factors, in turn, affect the success of bark beetle dispersal, attack, or brood development.

The higher light levels, warmer bark temperatures, and stronger winds in more open stands make them less favourable for attack by mountain pine beetle. Trees with higher vigour produce more resin and may successfully "pitch out" attacking beetles (see photo).

Management actions that promote tree vigour (e.g., thinning) increase tree resistance to attack.

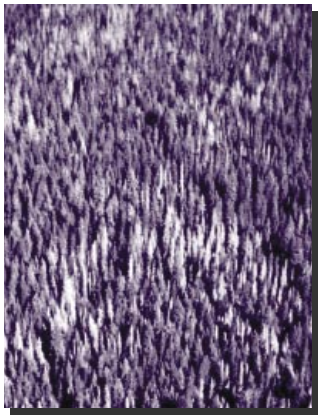
Landscape Susceptibility

Aggressive fire suppression over the past 60 years and a history of limited commercial harvesting of lodgepole pine until about 1970 have resulted in large areas of susceptible mature or overmature pine across the Interior of British Columbia. This concentration of susceptible stands in large areas makes expansion to landscape-level outbreaks (epidemics) possible and underscores the need for long-term management of mountain pine beetle at both the landscape and stand levels.

Stand Density Management in a Landscape Plan

The overall strategy for managing landscapes with a large mature pine component should aim at creating a landscape mosaic where age-class, size, stand density, and species distributions do not favour the development of large-scale outbreaks. Such a strategy requires orderly harvest scheduling to remove susceptible stands and crop planning to develop vigorous and diverse replacement stands across the landscape.

Stocking control in young stands, thinning maturing stands, and partial cutting to remove susceptible pine from older mixed stands can all contribute to reducing stand and landscape susceptibility.



Beetle-infested stand

Harvest Scheduling

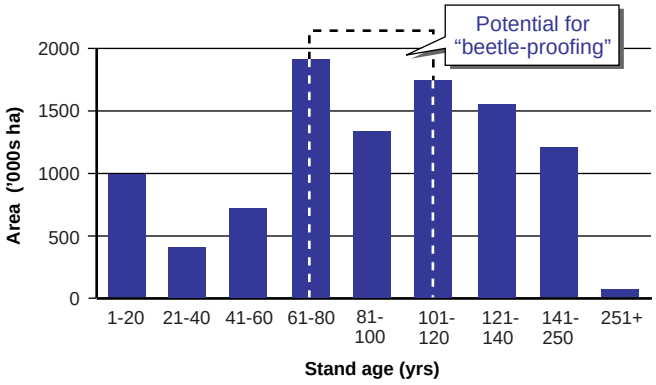
A critical step in harvest scheduling is to assess the susceptibility of, and risk to, existing stands. To this end, risk and susceptibility rating systems have been developed combining the stand parameters associated with beetle infestations and beetle pressure on a stand.[1]

High-risk stands should be removed at the earliest harvesting chance, while large areas of susceptible pine, not at current high risk, should be broken into smaller patch mosaics of age, species, and tree size.

Often, the age-class distribution of pine in an operating area is highly skewed to overmature stands. When it is impossible to remove all susceptible stands without exceeding other constraints on harvest (e.g., allowable annual cut [AAC], visual quality objectives, habitat, adjacency rules, or other values), the susceptibility of some mature stands should be reduced so that they can be held in the harvest queue. One tactic that has shown considerable promise is commercial thinning of mature stands to a uniform spacing of less than 600 tph, often called "beetle-proofing."

[1] See, for example, Shore and Safranyik (1992).

Figure 3
Area of lodgepole pine leading stands in six major BEC zones in the B.C. Interior.



Reducing Susceptibility of Mature Natural Stands—"Beetle-Proofing"

Figure 3 shows the age-class distribution of pine-leading stands in the major biogeoclimatic ecosystem classification (BEC) zones of the B.C. Interior (ESSF, IDF, MS, SBPS, SBS, and ICH). Potential age classes for "beetle-proofing" are highlighted. Not all of this area is suitable for commercial thinning to reduce susceptibility to mountain pine beetle. In general, stands must also have these characteristics:

- mean diameter > 20 cm
- stand density 900–1600 tph
- beetle infestation < 10%
- no symptoms of mistletoe and root disease
- relative windfirmness.

Beetle-proofing reduces stand susceptibility—it does not make stands invulnerable to attack.

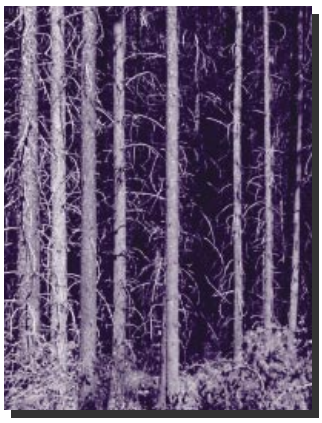
On the SDMD for natural origin pine, candidate stands will be found in the zone marked "Stands that may be suitable for beetle-proofing" (Figure 4).

Beetle-proofing reduces stand susceptibility because thinning to uniform spacing changes stand microclimate and negatively affects beetle dispersal, attack behaviour, or survival. Thinning from below enhances tree vigour, increasing the tree's ability to produce resins that are the primary defense against attack. To optimize these effects:

- stands must be uniformly thinned to at least a 4 m inter-tree distance (to increase wind penetration, light, and temperature)
- the largest, healthiest pine must be preferred for retention (for vigour and windfirmness)
- damage to leave trees must be avoided (to avoid stress).

Figure 4 illustrates the target stand density zone for beetle-proofing in natural origin lodgepole pine stands.

Operational experience with this prescription, which thins mature stands to 400–625 tph, confirms that enough volume of sufficient piece-size is usually removed to ensure a commercially viable operation. Figure 5 illustrates an example where thinning a stand with 1500 tph (**A**) to 500 tph (**B**) lowers its susceptibility to mountain pine beetle infestation and yields approximately 100 m^3/ha merchantable volume at thinning.



Stand suitable for beetle-proofing

Stand after beetle-proofing

Figure 4
The characteristics of stands that may be suitable for beetle-proofing and the target zone for stands after beetle-proofing.

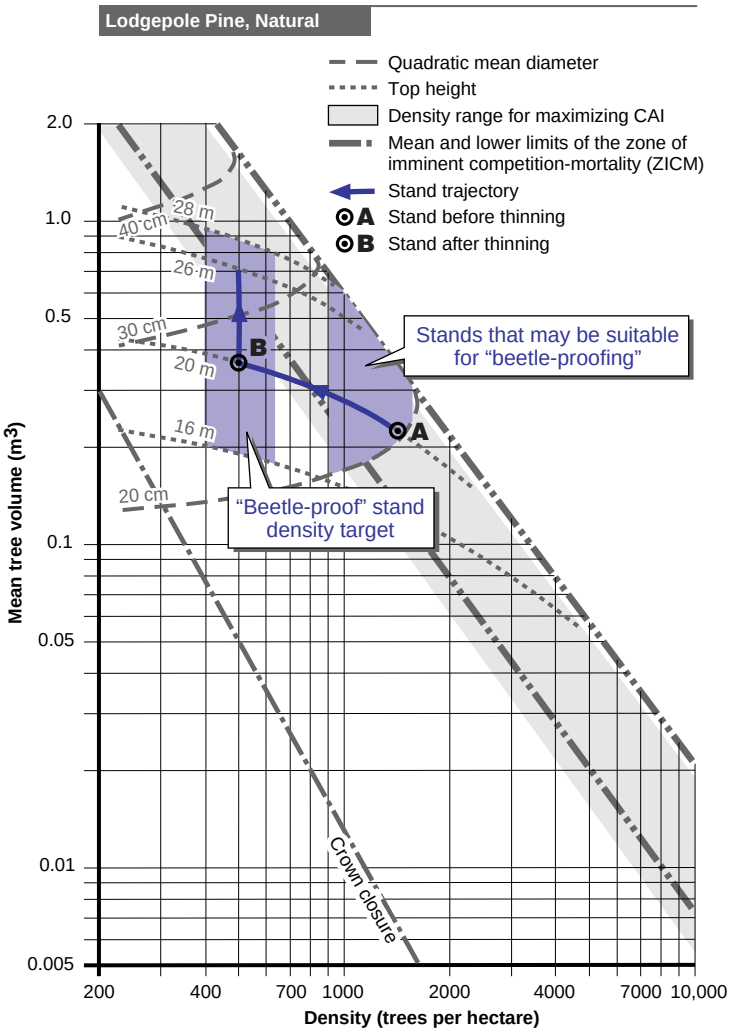
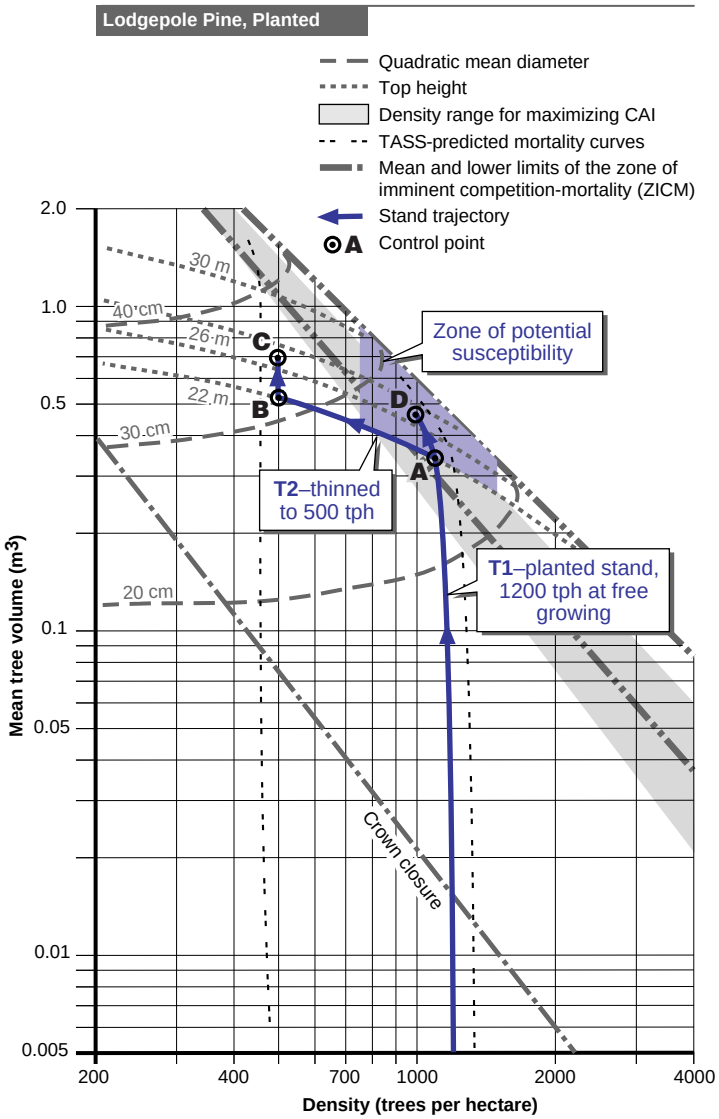


Figure 5
Example of the impact on future susceptibility of some of the management alternatives for a low density plantation on site index 18 m.



Managing Future Stands to Minimize Landscape Susceptibility—Crop Planning

SDMDs are a useful aid in crop planning because they depict stand development through time and allow a rapid, preliminary consideration of density management options.

When developing crop plans, minimizing stand susceptibility to mountain pine beetle should be considered along with other management objectives such as the timing and characteristics of timber yield. Several possible management regimes for stands of planted and natural origin are illustrated in Figures 5 and 6 with reference to the zone of high susceptibility to mountain pine beetle. These figures show how harvest timing and density management may be used to reduce landscape susceptibility to mountain pine beetle.

To maintain low susceptibility to mountain pine beetle, manage lodgepole pine stands on shorter rotations or use commercial thinning to increase inter-tree spacing.

Low Initial Stand Densities

Figure 5 shows the growth trajectory (**T1**) of a planted stand with approximately 1200 tph at free growing. On site index 18 m, MAI culminates at about the same time that the stand enters the zone of high susceptibility to mountain pine beetle (**A**). To reduce landscape susceptibility to mountain pine beetle, this stand could be harvested at (**A**) or thinned (**T2**) to 500 tph (**B**) and harvested later (**C**). If the risk of beetle attack is low, even though the stand is susceptible, the **T1** stand could be retained without thinning and harvested at a later date (**D**).

The zone of potential susceptibility in Figure 5 is based on the untested hypothesis that the stand characteristics associated with high susceptibility are the same in both managed and unmanaged stands.

High Initial Stand Densities

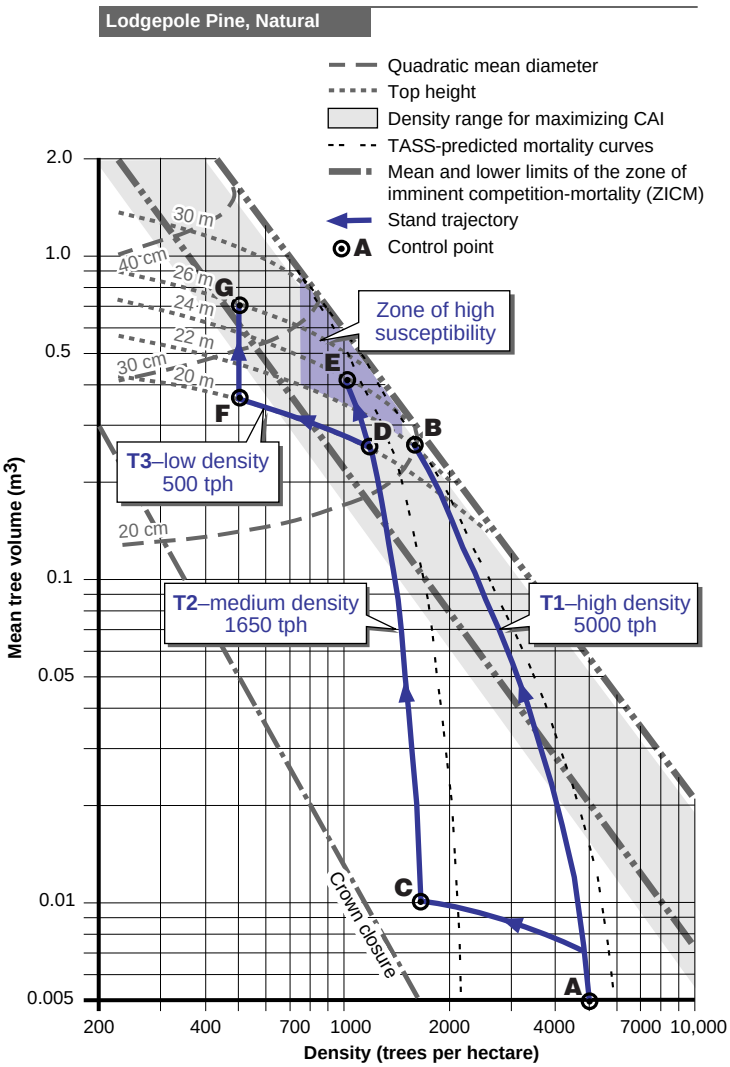
Figure 6 displays some of the many possible management regimes that could be applied to a stand naturally regenerated to 5000 tph on site index 18 m.

A high stocking, short rotation regime (**T1**) allows the stand to develop from (**A**) to (**B**) without spacing. Trees in this stand are unlikely to develop characteristics associated with high susceptibility (phloem thickness in stems of less than 20 cm dbh is generally too low to support an expanding population of mountain pine beetle), so this management regime will not add to landscape susceptibility.

If the stand is spaced to 1650 tph (**T2**), and managed on a moderate stocking, medium rotation regime, the stand develops from (**C**) to (**E**) and by late in the rotation the stand is in a state of high susceptibility. If it is necessary to extend rotation length and reduce susceptibility, the stand may be thinned (**T3**) from (**D**) to (**F**) with final harvest at (**G**).

Juvenile spacing dense stands may shift them onto a growth trajectory with a more susceptible end-point.

Figure 6
Example of the impact on future susceptibility of some of the management alternatives for a high density stand on site index 18 m.



Conclusion

SDMDs can help communicate important concepts about managing lodgepole pine stands to reduce susceptibility to mountain pine beetle.

- Managers can use SDMDs to portray key aspects of the characteristics of susceptible stands.
- Density management alternatives, such as beetle-proofing mature stands and spacing young stands, can be plotted on SDMDs to illustrate the impact of management on future susceptibility.
- Existing stands can be located on the SDMD and their development projected to give advance estimates of future susceptibility.

The overall strategy for managing landscapes with a large mature pine component should aim at creating a landscape mosaic where age-class, size, stand density, and species distributions do not favour the development of large-scale outbreaks. Such a strategy requires orderly harvest scheduling to remove susceptible stands and crop planning to develop vigorous and diverse replacement stands across the landscape.

Landscape mosaic

Acknowledgements

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Photographs:
Canadian Forest Service and B.C. Ministry of Forests

Concept of portraying susceptibility on an SDMD from:
Anhold, Jenkins, and Long (1996)

More Information

Stand Density Management Diagrams

http://www.for.gov.bc.ca/hfp/pubs/standman/standen.htm

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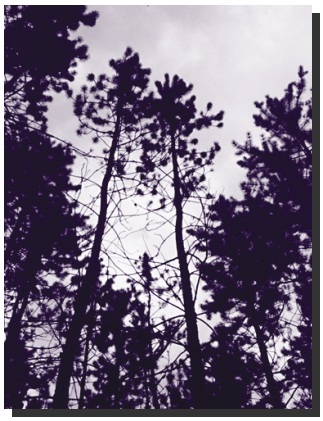

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