Extension Note

BC Journal of Ecosystems and Management

Wildlife / danger tree assessment in unharvested stands attacked by mountain pine beetle in the central interior of British Columbia

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Abstract

This extension note outlines work that was part of a broader study designed to collect baseline forest structure data in the Sub-Boreal Spruce dry cool biogeoclimatic subzone (SBSdk) of the Lakes Timber Supply Area (TSA). This data will help to assess the future ecological impacts of the mountain pine beetle. A primary component of our research was to determine the safest possible work or recreation window for individuals planning entry into stands killed by the mountain pine beetle. The provincial Wildlife/Danger Tree Assessment criteria were used to determine the types and frequency of danger trees in these stands. Data collected included species, height, diameter at breast height, and the presence or absence of danger tree characteristics for each mature tree. The majority of the trees in this study were classified as either class 1 (alive and healthy) or class 3 (recently dead). One mountain-pine-beetle-killed tree had fallen. Approximately 85 stems per hectare, or 5.5% of all trees, had a defect considered potentially dangerous. Most defects were found in the smaller diameter classes. The study area was significantly affected by mountain pine beetle; areas of high use (e.g., recreation-, cultural-, or work-related) may require specific mitigation activities to ensure user safety.

KEYWORDS: *falldown, Lakes Timber Supply Area, mountain pine beetle, natural disturbance, workplace safety.*

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Introduction and Background

Central British Columbia is experiencing the largest mountain pine beetle (*Dendroctonus ponderosae* Hopkins) outbreak in recorded history (Eng *et al.* 2005). Ways to define and track the immediate and long-term effects of the outbreak are being sought by resource managers and researchers alike. This epidemic is expected to alter current stand and landscape structure and severely affect the province's Interior forest industry, especially for mid-term timber supply.[1]

The allowable annual cut (AAC) for the Quesnel, Lakes, and Prince George timber supply areas (TSAs) was increased on June 1, 2002, to help suppress the spread of mountain pine beetle (Pedersen 2004). Limited knowledge on the shelf life (decay rates) of lodgepole pine (*Pinus contorta* var. *latifolia*) spurred a second AAC increase on October 1, 2004 (Eng 2004). British Columbia's Chief Forester expedited this additional increase in the allowable rate of logging to specifically target the salvage of affected pine forests and mitigate timber losses (Pedersen 2004). These AAC increases for the Interior permitted the harvesting of an additional 38 million m^3 of beetle-killed pine; the previous combined AAC was 18.4 million m^3 (Eng 2004; Pedersen 2004). The beetle, however, has far outpaced logging activities. In any given year during the outbreak, this translates into a significant portion of dead timber on the land base in various stages of death and decay (Pedersen 2004). For reasons of safety, forest workers and other forest users should be aware of this dead tree component.

Information is available on the response of pine-dominated ecosystems to disturbances such as fire and harvesting (DeLong 2002); however, it is not known whether stand dynamics will respond similarly to a large-scale beetle epidemic (Eng 2004). Where homogenous stands of lodgepole pine exist, large-scale salvage cutblocks may be an appropriate response to recovering the economic losses associated with beetle-killed timber. Without a complete understanding of stand- and landscape-level responses to an outbreak of this magnitude, attempts to completely salvage all beetle-killed trees would be considered ecologically unsound (Eng 2004; Lindenmayer *et al.* 2004). The effects of such an outbreak, coupled with expedited large-scale salvage operations, could lead to conditions outside the historic range of disturbance of these ecosystems (Eng 2004). Additionally, potential climate shifts may cause alterations to the natural environment that have not yet been considered.

Understanding how stands killed by the mountain pine beetle will develop and shape the future landscape is essential for assessing the impending ecological and socio-economic impacts.

The ecological benefits of dead trees, whether standing or fallen, have long been recognized (Thomas *et al.* 1979; Bunnell and Kremsater 1990; Bate *et al.* 2002). Dead trees are important wildlife habitat for organisms such as birds, insects, amphibians, rodents, fish (near fish-bearing streams), and fungi. These trees are a source of nutrients as they decay and provide microhabitat for understorey regeneration; as dead trees, they also open up growing space for new growth beneath the canopy. Even when dead, these trees intercept precipitation, which regulates the flow of water and solar radiation to the soil, and provide structure in the soil for years after their demise (Shea *et al.* 2002).

To protect workers from the potential hazards of dead trees (often referred to as snags) and to manage these trees as valuable wildlife habitat, the Wildlife Tree Committee of British Columbia developed a wildlife tree classification system along with objectives, protocols, and coursework. The committee is composed of representatives from the B.C. Ministry of Forests and Range, the B.C. Ministry of Environment, and WorkSafeBC (formerly The Worker's Compensation Board of British Columbia), as well as industry and public interest groups. The standards developed by the committee are recognized provincially as the best available standards of practice and care (Wildlife Tree Committee 2006).

[1] The "mid-term" is defined as the period of transition between the short and long-term (Cortex 1999) in which a shift occurs from harvesting only existing natural stands to harvesting only plantation stands. The mid-term for the province's central interior will vary between locations, but can be expected to begin approximately 10–20 years from present (J. Pousette, Tenures Officer, B.C. Ministry of Forests and Range, Prince George Forest District, pers. comm., 2005).

In British Columbia, WorkSafeBC's Occupational Health and Safety Regulation 26.11 (1) states that: "if work in a forestry operation will expose a worker to a dangerous tree, the tree must be removed." The regulation is relevant only when a tree is deemed dangerous and workers will be exposed to this danger (Wildlife Tree Committee 2006). To assess a tree for potential hazards and make the best safety decisions, an individual must meet the requirements under section 26.11 (6) of the regulation. A "dangerous tree" presents a hazard to people or facilities owing to various traits, such as:

- its location;
- the angle at which it leans;
- physical damage;
- overhead hazards; and
- deterioration of limbs, stems, or roots.

Determining whether a tree or group of trees is dangerous requires both an assessment of the tree's physical signs and information about the type of activities that will take place near the tree(s). Manning *et al.* (2002) provide a thorough summary of the danger tree assessment process.

Understanding how stands killed by the mountain pine beetle will develop and shape the future landscape is essential for assessing the impending ecological and socio-economic impacts. The research outlined in this extension note was part of a broader study designed to collect baseline forest structure data in the Sub-Boreal Spruce dry cool subzone (SBSdk) of the Lakes Timber Supply Area. The data collected will help to assess the future ecological impacts of the mountain pine beetle. A primary component of our study was to determine the safest possible entry window in mature beetle-killed stands for forestry workers, First Nations using traditional sites, and recreation-seekers. We present our current results. When reassessed in 3–5 years, the stand structure reported here can be compared with the updated stand structure.

Methods

Between May and October, 2004, 303 sample plots were established in the Lakes TSA (Figure 1). To collect mature tree data, pine-leading stands in the dry cool and transitional moist cold biogeoclimatic subzones (SBSdk and SBSmc, respectively) in age classes 6, 7, and 8 (taken from forest cover inventory data, and cross-checked with tree cores) were randomly selected and surveyed using transect lines and fixed radius plots (5.64 m radius). Species, height, diameter at breast height (DBH), and the presence or absence of danger-tree characteristics were recorded for each mature tree. Mature trees were defined as those above 1.35 m in height and greater than 7.5 cm DBH. Data on smaller trees (seedlings and saplings) were also collected, but are not presented here.

The provincial Wildlife/Danger Tree Classification System's assessment criteria (Wildlife Tree Committee 2006) were used to determine the types and severity of danger trees in these stands. Table 1 presents the system's

TABLE 1. Modified summary of the coniferous wildlife tree classification system (Wildlife Tree Committee 2006)

Tree class	Description
1	Live, healthy; no decay.
2	Live, unhealthy; signs of decay or growth deformities.
3	Dead tree, relatively recently; stem wood still hard, needles and (or) fine twigs still present.
4	Dead tree, stem wood still hard, no needles or fine twigs remaining, only coarse limbs. Upwards of 50% of branches gone; loose bark; top generally broken.
5	Dead tree, outer stem wood still relatively solid, some internal decay occurring; branches and bark are absent.
6	Dead tree generally 2/3 of its original height, stem rather spongy due to more advanced decay. Sapwood/heartwood sloughing from upper bole.
7	Dead tree, approximately 1/2 its original height. Extensive internal decay; outer shell may still be hard. Lateral roots completely decomposed.
8	Dead tree, approximately 1/3 its original height. Extensive internal decay; outer shell may still be hard. Lateral roots completely decomposed.
9	Considered debris at this point; downed trees or stumps.

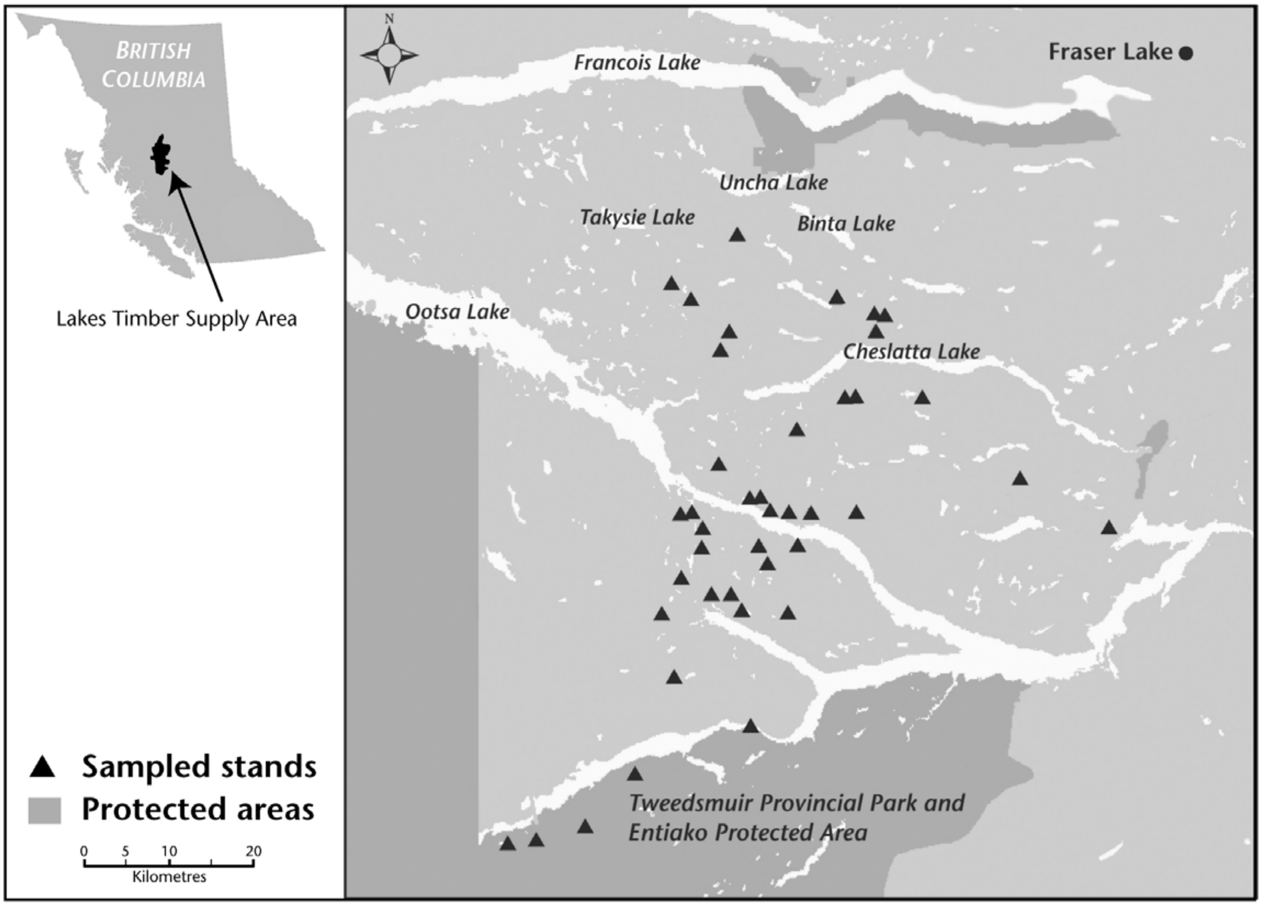

FIGURE 1. Location of stands with temporary sample plots. From the southern-most point northward, plots are located in the Entiako Protected Area, throughout the southern portion of the Lakes Timber Supply Area, and into the Cheslatta Community Forest.

nine categories of live and dead tree attributes. Our study was carried out on the assumption that level-1 disturbance activities would occur in the vicinity (i.e., only "light" activities, such as tree planting, brushing, or spacing), and wind speeds < 40 km/h (Wildlife Tree Committee 2006). Site-specific data were also collected such as site series (mesic or submesic), slope, aspect, and latitude and longitude.

Results

Our study area contained trees that had been attacked by the mountain pine beetle over a range of time (i.e., from 1996 to 2004). The oldest attack regions were located in the southernmost portions of the study area; newer attack occurred to the north and east. A total of 4719 mature trees were sampled, which provided a baseline average of 1557 stems per hectare for these stand types in the SBSdk.

Ninety-four percent of the stems were lodgepole pine. The remaining 6% consisted of small amounts interior spruce (*Picea glauca* × *engelmannii*), subalpine fir (*Abies lasiocarpa*), and aspen (*Populous tremuloides*). Fifty-six percent of the lodgepole pine had been attacked by mountain pine beetle, of which 43% were killed in previous years (red or grey attack) and 12% were green-attacked in 2004. Twenty-five percent were alive and not attacked at the end of the 2004 field season, and 20% were dead from causes other than mountain pine beetle. At the stand level, attack rates ranged from 0% on the leading edge of the infestation to 91% in stands that had experienced multiple years of attack (specifically the Entiako Protected Area).

The bulk of the trees were either class 1 (alive and healthy) or class 3 (recently dead) (Figure 2). The majority of the class 3 trees were recently dead from mountain pine beetle attack.

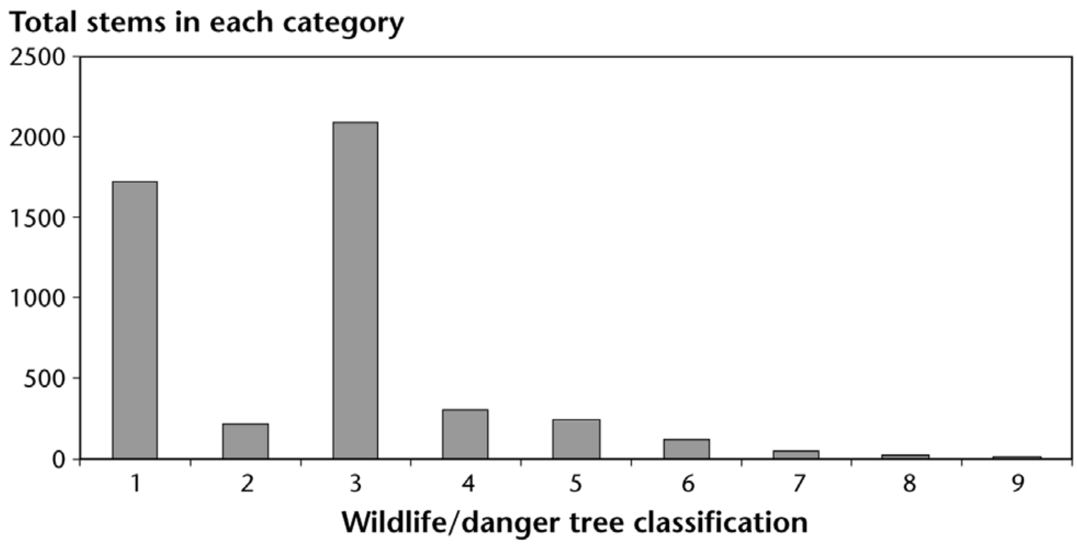

FIGURE 2. The distribution of all the mature stems sampled in study in each of the nine provincial wildlife tree classification decay classes.

Six diameter classes were created (range 10–35 cm). The majority of trees with defects (classes 2, 4, 5, and 6) were in the smaller-diameter classes (10 cm and 15 cm; Figure 3). Subalpine fir had no defects. Two aspen trees had considerable lean (> 30%), as did two interior spruce; two interior spruce also had considerable stem damage. The remaining defects were all found in lodgepole pine.

Of the total 4719 mature trees sampled, 5.5%, or approximately 85 stems per hectare, were moderately to severely suspect trees. Since the mountain pine beetle is not the cause of the defects, this number of stems per hectare is considered "normal" for the type of pine-leading stands sampled. The impact of the beetle will most likely be seen in trees eventually falling down due to mortality and this will be assessed in the future.

Potential dangers included hazardous tops, considerable lean, significant stem damage, and dangerously forked boles. Rotting bases were found on numerous small trees (< 10 cm DBH) that were in the process of falling out of the stand. Trees with hazardous tops included those whose top was:

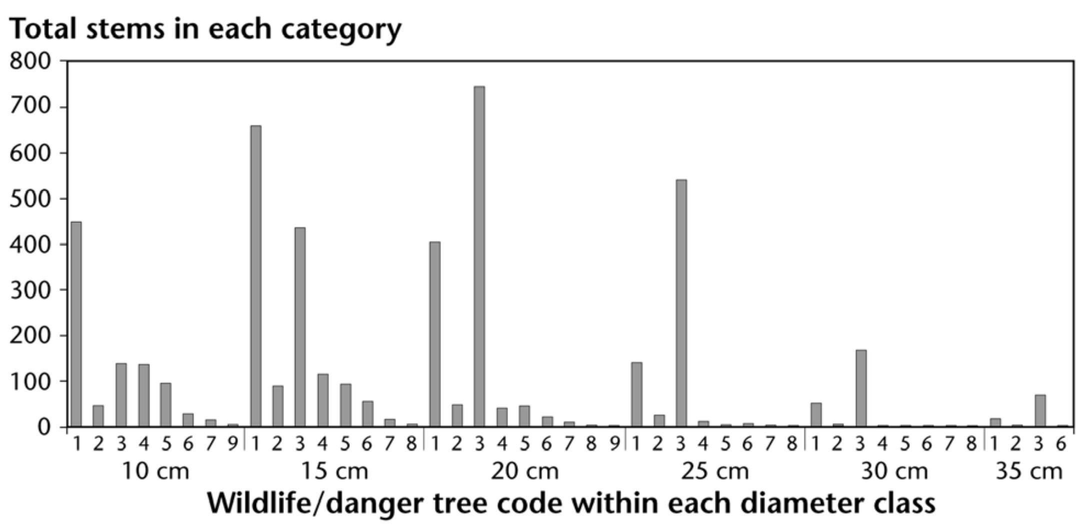

FIGURE 3. Frequency of each decay class within each diameter class.

- disproportionately weighted to one side;
- dead-hanging or spiked with cracks; or
- unstable dead forked or split (Figure 4).

The average DBH of leaning trees was 15 cm; trees with significant stem damage had an average DBH of 20 cm, as did trees with forked boles. One beetle-killed tree was observed to have been knocked to the ground by a neighbouring tree when it fell.

Trees recorded as dead from other causes, which had fallen either onto the ground or against another tree, were 5% more abundant on mesic sites than on the drier site types. The proportion of such trees still standing was the same on both mesic and submesic sites.

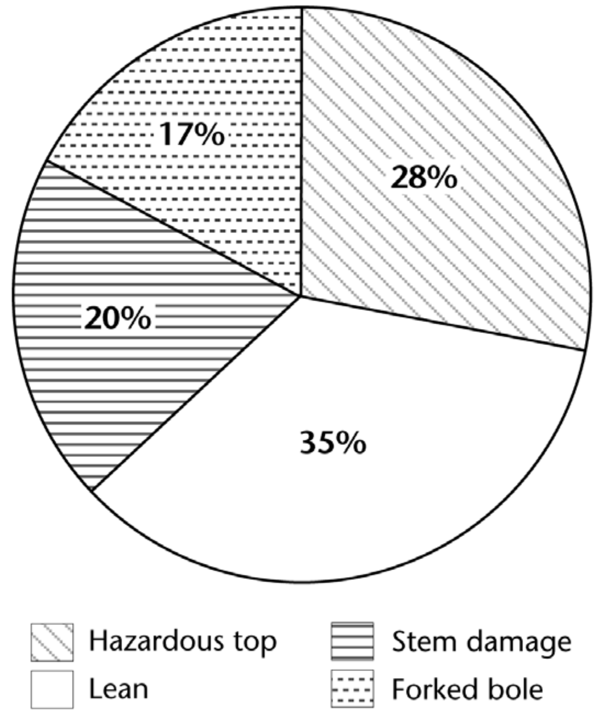

FIGURE 4. Physical defects found represented as a percentage of the total. Breakdown for each defect: hazardous tops, 24 stems per hectare; lean, 30 stems per hectare; stem damage, 16 stems per hectare; forked bole, 15 stems per hectare.

Discussion

In the central interior of British Columbia, mountain pine beetle and fire play important ecological and biological roles in the successional dynamics of lodgepole pine stands. Fire–beetle interactions have maintained ecosystems in the Sub-Boreal Spruce zone with an estimated stand replacement cycle of approximately 120 years at lower elevations and 300 years at higher elevations (DeLong 2002). The fire intervention protocol throughout the central interior has possibly altered the historical range of variability within these forested landscapes (Taylor and Carroll 2004).

Although standing dead trees are recognized as a valuable ecological component of stand-level structure (e.g., as providing habitat for bird species, vertical structure in the canopy, and a source of nutrients), they are also a potential danger to humans. This knowledge is reflected in British Columbia's Occupational Health and Safety Regulation as it relates to the treatment of dead or dying trees.

Alternative practices (e.g., stubbing individual trees—that is, cutting potentially dangerous trees off at a height of 3–5 m—or reserving small wildlife tree patches) are used to provide habitat structure and a safe working environment for forest workers, such as tree planters and silviculture surveyors (Huggard 1997). These practices have proven effective in improving worker safety, but their success from a wildlife-habitat or species-diversity perspective is a topic for a different paper.

The province is faced with beetle-attacked forests that are in varying stages of death and decay (green, red, grey attack). Under certain circumstances, these degrading trees can pose a real safety risk to workers—from falling branches to whole trees toppling over. Managing these risks makes protecting the ecological values inherent in standing dead or dying trees (habitat, food source, shelter, etc.) much more challenging.

The majority of potentially hazardous trees in this study area were found in the smaller-diameter classes (Figure 3) possibly because these smaller trees may be more prone to wind damage (fall over or breakage) and also to successional pressures as larger trees out-compete them for space (light) and nutrients. Individually, these small trees were not considered a workplace hazard; however, density and time could be a contributing factor to this, increasing any hazards associated with this phenomenon, especially as more and more smaller trees succumb to beetle pressure. The results may be different when stands are reassessed in 3–5 years.

The data for this survey were collected from stands that experienced initial mountain pine beetle attack 0–8 years ago. As only a single tree in this sample had fallen, tree-fall results for the SBSdk remain relatively inconclusive at this time.

Based on past observations of tree fall-down in coniferous stands, we can expect trees to begin falling anywhere from 3 to 20 years after the beetle has passed through (Keen 1955; Harrington 1996; Mitchell and Preisler 1998). Higher fall rates have also been observed with increased soil moisture (Lewis and Hartley 2005).

Regardless of cause, relatively few trees are currently on the ground in the SBSdk. Beetle-killed trees in this dry region may remain standing longer than was initially thought, which makes them ideal candidates for vertical structure and wildlife habitat.

Although moisture regimes and climate will likely dictate the rate at which timber degrades (Eng *et al.* 2005), the rate at which different climate and soil moisture regimes will vary is unknown. Estimates of fall-down and decay rates can be based on past research (Dahms 1949; Keen 1955; Harvey 1986; Huggard 1997; Mitchell and Preisler 1998; Waterhouse and Armleder 2004) and experiential information (Lewis and Hartley 2005), but the rush for both salvage and reforestation activities could be better evaluated with more complete site-specific information.

The current mountain pine beetle epidemic will result in an increasing number of trees approaching the potentially dangerous classes of the wildlife/danger tree classification spectrum (Figure 2). This does not necessarily mean that they will be hazardous to humans. Each situation will warrant careful observation and site-specific planning.

Many beetle-attacked areas will remain unsalvaged (Pedersen 2004). Dead lodgepole pine trees in these locations may pose an increased safety risk to workers and recreation-seekers during high wind events or storms. Depending on stand densities and percent attack (or percent lodgepole pine composition), forestry workers may be exposed to risks during restoration activities (e.g., fill-planting in proximity to decadent stands, broadcast burning, or underplanting in dead lodgepole pine stands. Risks can be expected to increase depending on site and weather conditions. Over time, site-specific natural events occur as dead trees deteriorate—limbs and tops will break and fall, wind events will uproot trees, and falling trees may knock over other trees.

To safely and efficiently implement broadcast or spot-burning and stand underplanting or fill-planting efforts, management plans will require foresight and better information. Until more is known about the time frame of fall-down for beetle-killed trees, safety planning is essential to ensure that workers are not exposed to the hazards of danger trees in these stands. Rehabilitation planners must be cognizant of the level of mortality and the hazards present on any given site, especially in wetter areas and during extreme weather events. Large-scale, long-range planning provides more design options to reserve both residual live and dead trees and meet wildlife needs safely.

Until more is known about the time frame of fall-down for beetle-killed trees, safety planning is essential to ensure that workers are not exposed to the hazards of danger trees in these stands.

Management Implications

Retaining stands of dead lodgepole pine provides immeasurable ecological benefits; however, compromises are sometimes required both to ensure human safety and to preserve ecological benefits. Although the mountain pine beetle has significantly affected the lodgepole pine component of our forests, it is not economically practical or ecologically appropriate to salvage all dead pine. Over time, however, specific mitigation measures will be required in certain locations to ensure human safety. These locations include work sites, recreation areas, and recreation trails. Required mitigation activities may include:

- establishing no-work zones;
- felling dangerous trees;
- stubbing individual dangerous or suspect trees;
- rerouting trails; and
- relocating recreation infrastructure (e.g., picnic tables).

Where relocating recreation infrastructure or establishing no-work zones is possible, the preservation of ecologically important wildlife tree patches and single trees will be much easier to achieve. Over the long term, felling dangerous trees along frequented trails and in recreation sites may be inevitable. Dead trees, however, should be retained for the length of time that they are safe and sound. Annual inspection of suspect trees will help determine the best time for felling dangerous trees, thus providing the longest possible window for wildlife usage.

Reforestation planning should include a critical review of site potential and site properties. In some instances, advance regeneration will release under the dead crowns and provide new forests. This will mitigate potential problems of worker safety. Advance regeneration can be relied on to reforest remote areas, where time associated with reforestation obligations is less of an issue. In stands with inadequate advance regeneration, spot-burning or underplanting unharvested stands or planting through wildlife tree patches in areas of established access will be possible during the early window of opportunity. Our study results show that the safe work window on dry sites is most likely longer than originally anticipated. The most important factors in determining rates of degrade and subsequent fall-down of beetle-killed pine—and the associated workplace hazards—are time since beetle attack and percent attack. We suspect that dead trees will fall down sooner on wetter sites, but site-specific inspection and subsequent judgement will still be required to plan safe work or recreation activities throughout the area sampled.

Although our study results are specific to the SBSdk, our recommendations should help improve workplace safety in other biogeoclimatic zones affected by the mountain pine beetle.

The most important factors in determining rates of degrade and subsequent fall-down of beetle-killed pine—and the associated workplace hazards—are time since beetle attack and percent attack.

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Test Your Knowledge . . .

Wildlife/danger tree assessment in unharvested stands attacked by mountain pine beetle in the central interior of British Columbia

How well can you recall some of the main messages in the preceding extension note? Test your knowledge by answering the following questions. Answers are at the bottom of the page.

1. The current outbreak is the largest in recorded history.
   - A) True
   - B) False

2. Potentially dangerous tops averaged approximately:
   - A) 10 sph
   - B) 26 sph
   - C) 24 sph
   - D) 50 sph

3. Safer options for retaining live or dead trees include:
   - A) Wildlife tree patches
   - B) Stubbing on block suspect trees
   - C) Patch cutting
   - D) No-work zones
   - E) All the above

ANSWERS

1. A 2. C 3. E