16 Extension Note

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Fall-down Rates of Subalpine Fir Snags at Sicamous Creek: Implications for Worker Safety and Habitat Supply[1]

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The Problem: Benefits vs. Costs of Snag-falling

Current regulations require that all dead trees over 3 m tall are felled when an area is being logged (Workers' Compensation Board regulation 60.38). This clearly protects workers because tree-falling, especially hand-falling, is more dangerous when other trees, live or dead, could interfere with the falling tree. Snags must also be removed within 1.5 tree heights of work areas. This buffer is intended to decrease the risk that a worker in a block will be injured by a falling dead tree. However, there are several costs to snag-falling:

- Ecological damage. Many wildlife species require snags, including 35% of bird species and 30% of mammal species in British Columbia (Bunnell and Kremsater 1990). Different species require different stages of decay, from recently dead snags to soft stubs, and many species require canopy-sized snags. Many other, lesser-known species are linked to snags, including lichens (Goward and Arsenault 1997), fungi, and invertebrates—in Sweden, 268 species of invertebrates are threatened or endangered due to loss of snags in managed forests (Berg et al. 1994).
- Worker hazard. Snag-falling is one of the most dangerous occupations in forestry. It is particularly dangerous in the 1.5 tree-height buffer around cutblocks because these areas are not accessible by mechanical harvesters, and because standing live trees can interfere with the snag-falling. Piles of fallen snags also make subsequent work hazardous, including timber cruising and surveying of adjacent stands.
- Economic costs. Because their job is so dangerous, snag-fallers are well-paid, and the work cannot be done quickly. As a result, snag-falling costs are high ($670/ha in 1995 at the Sicamous Creek site). Also, snag-falling buffers around cutblocks can be large areas—a 10-ha cutblock, 400 x 250 m, requires snag-falling in 6.5 adjacent hectares if trees are 30 m tall.

The Question: When do Decaying Snags Become Dangerous?

Dead trees pass through a series of stages as they decay (Figure 1). Recently dead trees are identified by their

1 This is a summary of Forest Renewal BC project TO96091-RE. For study details, please request a final project report from D. Huggard or Forest Renewal BC.

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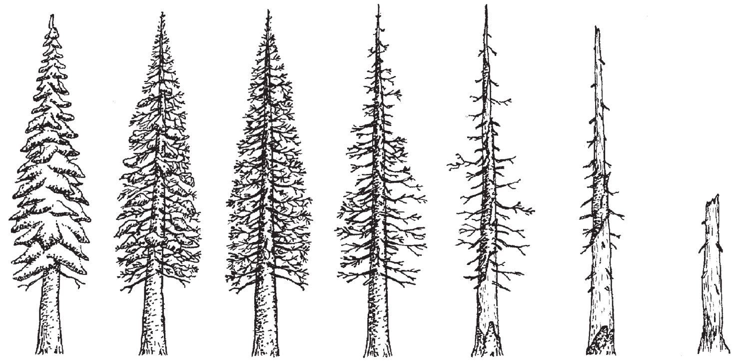

	LIVE	3A	3B	3C	4	5	SOFT
Needles:	Green	Red	None	None	None	None	None
Fine branches:	All	All	All	Some/Few	None	None	None
Bark:	Solid	Solid	Solid	Cracks	98–50%	<50%	None
Wood:	Hard	Hard	Hard	Hard	Hard	Most hard	Soft
Safety:	Safe	?	?	?	?	?	Unsafe

FIGURE 1 *Snag classes used in this study. Modified from Thomas (1979).*

red needles. The needles then fall off, leaving a "skeleton" snag with its fine branches intact. The fine branches are then lost, and the bark cracks. Later, larger branches and pieces of bark fall off, leaving a snag that is still hard, but with little or no bark or branch stubs. Finally, the wood softens and the snag decomposes into woody material on the ground.

Snags with extensive rotten wood are clearly more likely to fall over than live trees, but are recently dead trees any more dangerous than live trees? The Wildlife Tree Committee provides a procedure to assess the safety of individual snags, but this is time-consuming, and may be as expensive as snag-falling over large areas. If there was an easily identified decay stage when snags become more dangerous than live trees, operators in the field could leave more recent snags without increasing the hazard to workers. This would reduce the costs, risks, and ecological damage of snag-falling.

Study Methods

This study was conducted to measure the fall-down rates of snags in the Engelmann Spruce – Subalpine Fir (essf) biogeoclimatic zone at the Sicamous Creek Silvicultural Systems site.[2] It looked at subalpine fir snags with a diameter at breast height (dbh) >15 cm, which are canopy or subcanopy stems in this forest. Subalpine fir snags at the site are created by endemic (non-outbreak), scattered, bark beetle attacks. Snags were classified in the stages above (Figure 1) prior to operational snag-falling. We noted whether the top of the snag was broken (diameter at break >5 cm). Snags that had broken off at a height of less than 15 m were excluded from the study—from a safety perspective, they were considered the same as snags that had fallen.

A "life-table" approach (see Krebs 1989) was used to estimate fall-down rates of the different stages of snags shown in Figure 1. The life-table method is commonly used in wildlife population studies and in human life insurance calculations. As used here, it calculates the fall-down rates of different stages of snags by combining two sets of information: the abundance of the different stages in the forest, and the ages of the snags. (The "age" of a snag here means the number of years since the tree died.) The abundance of

2 The Sicamous Creek Silvicultural Systems research site is located in the essfwc2 biogeoclimatic zone in the mountains southeast of Sicamous, B.C.

the different classes is based on numerous sample plots and line transects across the study area. Ages of the snags (years since tree death) were measured by cross-dating, a technique that compares the ring pattern in a dead tree to the rings of many live trees, to determine the year the tree died. Approximately 30 snags of each decay class from 3a to 5 were aged.

Results

Subalpine fir snags are abundant at the Sicamous Creek site, as they are in many mature essf stands (Table 1).

The abundance of snags means either that many snags have been produced recently, or that snags remain standing for a long time. The ages of the snags show that the latter is the case (Figure 2). Many of the class 5 snags have been standing dead for over 70 years.

The life-table analysis of these two data sets gives the fall-down rates of each snag stage (Table 2). The results show that class 3a and 3b snags have low fall-down rates, while classes 4 and 5 are much more likely to fall down in a given year. Class 3c is intermediate. This technique does not give the fall-down rate of live trees, but this rate is unlikely to be much lower than the 0.2% per year of the two most recent snag classes.

The percentage of snags with broken tops increased with decay stage (Figure 3). The percentage of 3a snags with breaks is similar to the 5–10% estimated for live trees in the forest. After this class, the average annual rate of breakage is between 0.5 and 1.5% per year (shown by the slope of the line in Figure 3).

TABLE 1 *Abundance of live trees and snags of different classes at Sicamous Creek (≥15 cm dbh and ≥15 m tall only)*

Tree/snag class		Percent of stems*
Live		69.3
Snags – hard	3A	1.8
	3B	7.9
	3C	6.6
	4	11.7
	5	2.6

* 2% of stems are "soft" snags, but all of these are broken and <15 m tall.

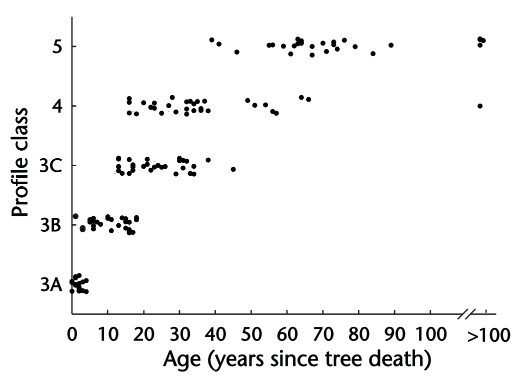

FIGURE 2 *Cross-dated ages (years since tree death) of standing snags in five profile classes.*

Implications: Worker Safety

In this study, subalpine fir snags in classes 3a and 3b had low fall-down rates. Fall-down rates for live trees are probably similiar or higher—this is currently being measured at the site. This indicates that these stems are no

TABLE 2 *Fall-down rates for subalpine fir snags in different decay classes at Sicamous Creek. Rates are the percentage of the class that fall down each year, or the annual percent chance of a particular snag falling down.*

Class	Description	Annual fall-down rate (%)
3A	"Red" — recently dead with needles	0.20
3B	"Skeleton" — no needles, all fine branches	0.18
3C	Losing fine branches, bark cracking	0.70
4	Few fine branches, 98–50% bark left	3.73
5	Few branches, <50% bark left, wood still hard	6.04

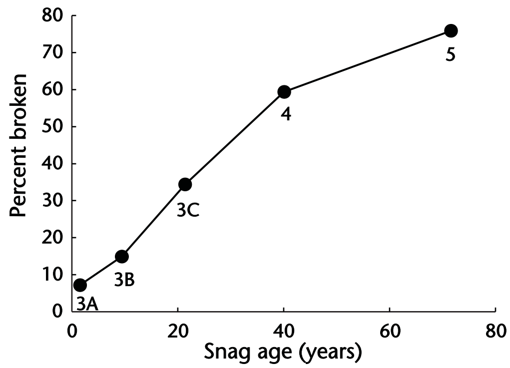

FIGURE 3 *Percentage of snags with broken tops by decay class. Decay classes are plotted at their average age so that the slope indicates the annual rate of top breakage.*

more likely to fall on a worker than are live trees. Top breakage increases slightly in class 3b, but is not common until class 3c. Leaving class 3a and 3b stems in the buffer adjacent to cutblocks should therefore not substantially increase hazards to workers. This class of snags would be even safer if obviously hazardous stems, such as leaning snags, were removed. This study does not address the stability of snags subjected to mechanical vibration from heavy ground equipment.

Class 3a and 3b snags are easy to identify in the field. Because they retain all their fine branches, the "red" and "skeleton" snags have the same shape as a live tree. 3c snags, on the other hand, are losing their fine branches, and develop an obviously "scraggly," snag-like silhouette. In fact, snag-fallers often find it difficult to distinguish 3a and 3b snags from live trees in the poor light and snowy conditions typical of ESSF logging.

Implications: Habitat Supply

Leaving class 3a and 3b snags in partial cuts, or adjacent to clearcut blocks, not only retains these stages, it also allows older snag stages to recover more quickly. A simple model of snag dynamics on the landbase available for harvest was used to examine the effects of leaving class 3a and 3b snags versus falling all snags in or adjacent to two harvesting systems: a 3-entry uniform partial cut system, and a 3-pass clearcut system with 15 ha blocks. A 120-year rotation was assumed. The model used the snag abundances, transition ages from one class to the next, and fall-down rates from this study for the projections. The model projections for snags in classes 3c and 4 are shown in Figure 4.

Several points are clear from these projections:

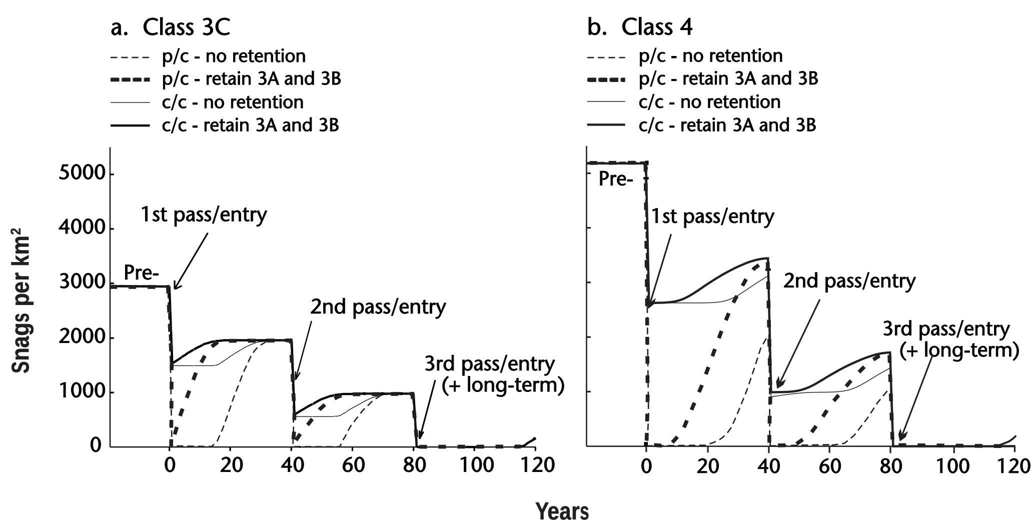

FIGURE 4 *Examples of projections of abundances of two classes of snags under partial cut (p/c) and clearcut (c/c) systems, with and without retention of class 3A and 3B snags at harvest.*

- Clearcut systems retain more snags than partial cut systems for the first two passes. If no snag retention is possible in the work area, the part of the leave strips outside the 1.5 tree-height buffer strip around clearcuts is the only place older snags remain.
- With either harvesting system, retaining class 3a and 3b snags allows greater abundance of these and older snags through the first two passes or entries. In partial cuts with no snag retention, class 4 snags are present for only a short part of the first two 40-year periods.
- Regardless of the harvesting system or type of snag retention, there are no snags at all for several years following the third pass or entry. At this point, all original trees and snags have been removed, and the regenerating trees are not old enough to have produced canopy or subcanopy snags. In the long run, none of the scenarios will provide older-stage snags in forests managed on an industrial rotation (at least, not in the part of the landbase available for harvesting). The only options for a long-term supply of snags are: 1) reserve areas, such as wildlife tree patches, riparian reserves, and environmentally sensitive areas (esas), that are large enough to include areas >1.5 tree-heights from openings, 2) individual stems retained throughout the rotation, or 3) extended rotation lengths.

Are these Results Typical of Other Types of Snags?

The high abundance of snags at Sicamous Creek is typical of other essf sites. Sicamous Creek is subject to the same high winds and extreme high-elevation weather as other essf sites. Fall-down rates of subalpine fir should therefore be comparable in other essf sites. Subalpine fir is faster growing and softer than spruce—spruce snags are therefore likely to have even longer persistence times, and lower fall-down rates, than the subalpine fir snags studied here. However, snags created by root rot or fires have higher fall-down rates than the insect-killed trees examined here (Harrington 1996). Species in other ecosystems may also be quite different (Harmon et al. 1986).

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