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Residual tree mortality following variable retention harvesting in boreal mixedwoods

Highlights

- Increased wind speed can cause water stress in residual trees in open cutovers.
- Trees in larger clumps or sheltered by edges of cutblocks suffer the least water stress.
- White spruce has lower rates of post-harvest mortality than deciduous trees. In studies over a 5-year period, more than 33% of deciduous residual trees died.
- Deciduous trees mostly died as standing snags, while 80% of spruce that died blew down.
- Trees damaged by harvesting equipment are more likely to die.
- Deciduous trees with slender form (high height/diameter ratio) are less likely to survive.

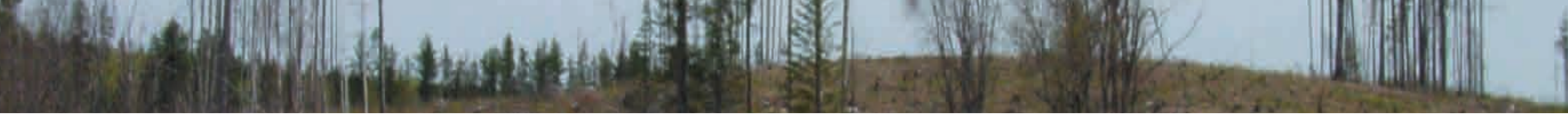
Structural retention harvesting, often referred to as variable retention or green tree retention, involves leaving individual trees or groups of living trees inside the boundaries of harvest blocks. This silvicultural approach has been inspired by natural disturbance patterns in unmanaged forests, which generally leave behind some standing and living trees. Trees prescribed for retention are expected to provide structural diversity that will contribute to sustaining ecosystem functions and biological diversity. The expectation is that these trees will remain alive to provide the characteristics of a mature forest (i.e. structural diversity) in the regenerating stand, thereby providing a potential 'lifeboat' for species between the mature and regenerated stand. In the past decade this strategy has been widely promoted and adopted in forest management of boreal and temperate forest ecosystems. The policies and guidelines for structural retention, however, have been developed predominantly from expert opinion and remain untested.

This research note summarizes the findings from several studies supported by the SFM Network, documenting the stresses and the mortality suffered by residual trees in boreal mixedwood forests (dominant species were either trembling aspen or white spruce with lesser amounts of balsam poplar and paper birch). These studies were intended to examine whether residual trees will live long enough to fulfill their objectives following structural retention.

Residual tree response to the stress of structural retention harvesting

Mature residual trees that are widely dispersed in open cutovers can suffer from various stresses following structural retention harvesting, including:

1) high levels of water stress because of increased exposure to light and wind,
2) increased risk of blowdown from exposure to wind, and
3) mechanical damage (e.g. harvester, skidder) to roots and stems.



Small patches of post-harvest residual trees in Lac Duparquet, Quebec. Photo courtesy of Kevin Bladin.

In our study of retained trees and adjacent uncut forests in boreal mixedwood sites near Drayton Valley, Alberta (Lower Foothills Natural Subregion) solar radiation nearly doubled and wind speed increased three-fold at the canopy level. There was little difference in air temperature or relative humidity between the structual retention site and the unharvested site. However, the greater wind speed and radiation in the structural retention site was enough to produce a three-fold increase in the evaporative demand, which may translate into greater water stress and potential whole-tree mortality.

The impact of these factors on accelerating mortality of post-harvest residual trees has not been well-documented. Also, it is not clear which species are most sensitive to these factors or which size of tree is more likely to die or be negatively affected in structural retention harvests.

Deciduous suffer more water stress than conifers

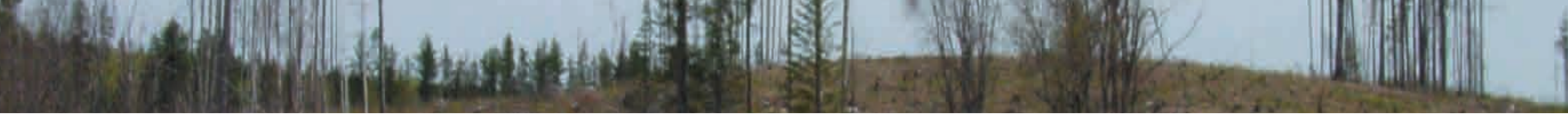
Measurements of the amount of water flow through post-harvest residual trees, compared to trees in unharvested stands at our sites in Drayton Valley, demonstrated that deciduous trees (paper birch and balsam poplar) were not able to keep up with the increased demand for water following partial retention. Like many deciduous trees, these two species are known to be highly susceptible to problems associated with water stress (i.e. a decreased ability to transport water to their leaves). Observations of residual poplar leaf rolling and wilting on hot days also indicated a high level of water stress in these trees. In contrast, white spruce were able to take up water fast enough to keep up with the increased rates of evaporation in the partial retention situation. The ability of spruce to respond favourably to the increased demand for water could potentially translate into increased growth, as observed in other conifers following partial harvesting.

Exposure and regional precipitation levels are important factors

Additional research in partial retention cutovers of boreal mixedwood forests in Drayton Valley and Calling Lake, Alberta and Lac Duparquet, Quebec showed that isolated residual trembling aspen trees had higher levels of water stress compared to trees on the cutblock edges. Further, edge trees had more water stress than trees in the interior of the stands. These observations suggested that trees on forest edges received some sheltering effect, reducing their stress compared with that of residual trees. Secondly, trees from areas with the lowest precipitation (Calling Lake) had higher stress than trees with more rainfall (Lac Duparquet). This indicates that deciduous residual or edge trees in drier regions, where trees may already be moisture stressed, are more likely to suffer additional and greater water stress following partial retention harvesting.

High mortality of mixedwood species following structural retention

Studies in the area of Drayton Valley and Rocky Mountain House, Alberta showed high mortality of both deciduous and coniferous residual trees following structural retention (Figure 1). Deciduous species suffered greater annual mortality rates than spruce. The mean annual mortality rates of residual trees were 9.4% for poplar, 8.7% for birch, 5.8% for aspen and 2.6% for spruce, which was around 3-4 times higher than for aspen, birch, and poplar in unharvested stands. Over a five-year period, more than 33% of the deciduous residual trees died, and 57% of the deciduous that were still alive showed evidence of decline. While faring better than deciduous trees, spruce residuals had nearly double the rate of mortality compared to spruce trees in unharvested areas.



Cause of residual tree death

There was a clear difference between deciduous and spruce in the way residual trees died. Almost all of the spruce mortality (80%) was the result of blowdown. Additionally, the larger, more dominant spruce residuals were more likely to be wind-thrown than smaller, less dominant spruce. Lower-bole damage by logging equipment also increased the frequency of mortality of spruce residuals. If the bole of a residual spruce tree was damaged during the harvesting, it was 2.6-times more likely to die shortly after harvest than an undamaged tree. Thus, while spruce could supply enough water to the foliage, their shallow roots could not resist the forces from the increased wind and many trees blew down. Further, damage to the bole likely also means damage to the root system of the trees; this would further limit uptake of water and the stability of the tree.

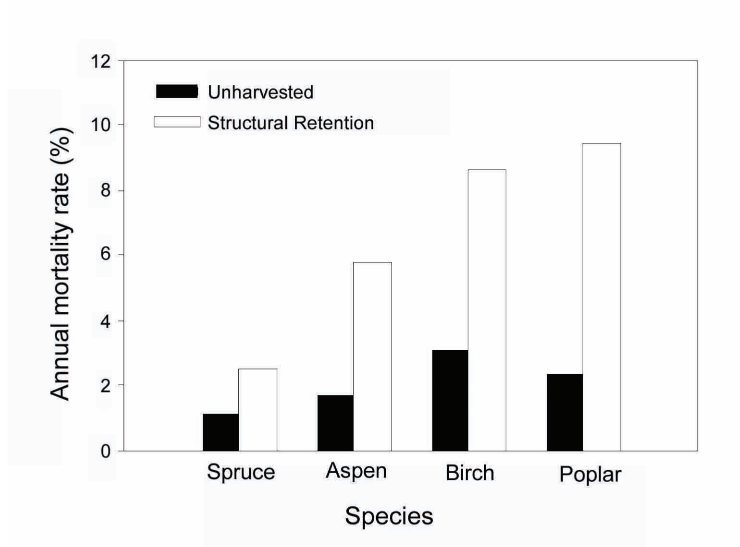


Figure 1: Annual mortality rates from unharvested stands and structural retention areas in a study of post-harvest residual trees near Drayton Valley, Alberta, from 2001 to 2005, illustrating higher mortality rates in post-harvest stands.

An example of high blowdown mortality of spruce residual trees. Photo courtesy of Victor Lieffers.

Trembling aspen trees left on partial retention cutovers showing signs of water stress (leaf loss and dieback) following variable retention in Calling Lake, AB. Photo courtesy of Victor Lieffers.

In contrast, almost all of the deciduous trees remained standing after death, with poplar producing the most dead snags (93% of all dead poplar residuals), followed by aspen (76%), and birch (69%). Slender poplar and birch residuals were more likely to remain as snags than larger trees. Observations of heavy crown dieback among the deciduous species prior to mortality, suggests that the majority of deciduous mortality was probably related to water stress. This supports the theory that increased wind exposure and bending may damage the water conducting tissue (xylem) of tree stems, reducing hydraulic conductivity and intensifying moisture stress. The xylem of deciduous trees, particularly the balsam poplar, is likely damaged by the increased demand for water, and death is often the result.

Further reading

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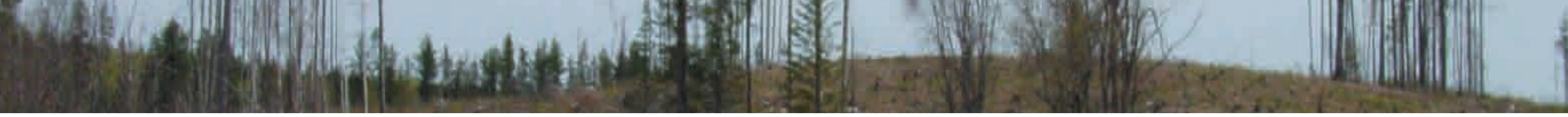

Management Recommendations

- If living residual trees are desired, leave residual trees in clumps and in sheltered locations on the landscape. This limits both blowdown and water stress.
- If snags are desired, deciduous trees (particularly balsam poplar) are the better species to leave on sites. Spruce trees are more likely to create downed logs a short while after logging.
- Retained trees are more likely stay alive in zones with high rainfall.
- Extra care must be taken to not damage residual trees with harvesting and site preparation equipment, since this increases stress and mortality rates of residual trees.
- Shorter spruce trees or deciduous tree with stout boles are more likely to survive after logging.

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