SUSTAINABLE FOREST MANAGEMENT NETWORK
RÉSEAU DE GESTION DURABLE DES FORÊTS
Networks of Centres of Excellence
Réseaux de centres d'excellence

SFMN Research Note Series No. 12

Deadwood in Canadian Boreal Forests

by Kristin Kopra and James Fyles

Highlights

- More deadwood can be found in naturally disturbed forests than in managed ones. This difference could result in loss of habitat for wildlife species and loss of nutrients in boreal forests if harvesting practices are not altered.
- Tree length harvesting will result in more deadwood—and a greater variety of deadwood sizes and decay stages—being left in the forest than will full tree harvesting.
- Harvesting rotations need to be carefully considered, and perhaps altered, as it is possible that current harvesting rotations are removing large amounts of deadwood at a time when forests naturally have the least amount of deadwood in them.

It wasn't long ago that deadwood was viewed as a nuisance to forest management. Much in the same way that old growth forests were viewed as unproductive, wasteful forests in need of intensive management, dead woody debris has typically been considered to be an unnecessary nuisance. As our knowledge of forest ecology has increased, however, we have come to see deadwood as an important part of forests.

Deadwood in the form of standing dead trees (snags), fallen woody debris, and stumps plays important roles in the forest. Deadwood provides structure that improves habitat for many species of mammals, birds, amphibians, insects, and numerous fungi, moss, and lichen communities. Deadwood is also involved in many functional aspects of the forest. It is a critical component of nutrient cycles, regulates water flows, aids in stabilizing slopes and preventing soil erosion, and contributes to carbon storage in the forest.

Forest policy across Canada has, in recent years, encouraged management that emulates natural disturbance processes and patterns. Dead woody debris has become one of several focal points in emulation silviculture. However, the lack of knowledge with regards to how much deadwood is needed in a forest, as well as the challenges presented when managing for multiple values, has made implementing emulation policies difficult.

This note summarizes current knowledge of the structural and functional characteristics of deadwood in the boreal forests of Canada with the goal of addressing some of the questions facing forest managers with regards to this important forest ecosystem component.

Size and decay class

Coarse vs. fine woody debris

Downed woody debris is normally divided into two general categories: coarse and fine woody debris. There is quite a bit of variability between studies in specific size criteria; for the purposes of our discussion here, coarse woody debris (cwd) was defined as logs over 10 cm in diameter while fine woody debris refers to logs less than 10 cm in diameter.

The distinction between these two types of deadwood is usually most important when identifying habitat requirements of animal and plant species. In a Swedish boreal forest, higher percentages of fine woody debris generally resulted in greater species richness for wood-inhabiting fungi, mosses, and lichens when overall log loads were under 16 m^3/ha (loads typical of managed stands in the area).[5] The same study found that certain threatened or endangered species were dependant on cwd for survival. This seems to indicate that a mixture of log sizes can result in greater species diversity as well provide essential habitat to endangered species.

Decay class

The stage of decay of woody debris largely determines what species will grow on (plants, fungi, etc…) or utilize (small mammals, insects, etc…) the debris. In a boreal aspen forest in east central Alberta, logs in different stages of decay supported different species of bryophytes, lichens, and fungi.[2] This finding has been supported in other forest types across Canada1 in the U.S.[7], and in Sweden.[9] These findings suggest that certain species run the risk of extirpation if deadwood in a variety of decaying stages is not maintained.

In addition to downed woody debris, the decay stages of snags are important to total deadwood composition. As snags become older, they will fall to the ground, resulting in a loss of habitat for species such as cavity nesting birds that depend on snags. At the same time, the fallen snags will create an increase in habitat for plant species dependant on downed logs in early stages of decay.

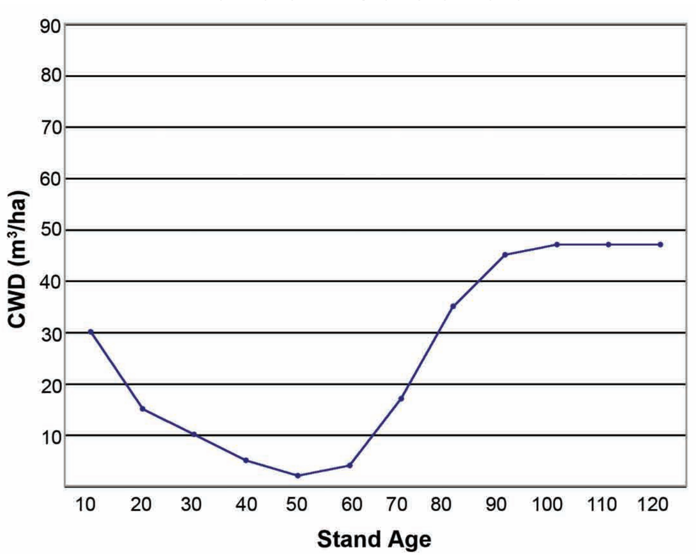
Nutrient cycling and deadwood

Deadwood can act as a temporary storage site for carbon (C), providing a source of C for microorganisms (decomposers) and for soils, and allowing it to be released slowly back into the atmosphere in the form of CO_2. This slow release aids in the potential of CO_2 inputs to the atmosphere to be offset by outputs to new vegetation when deforested lands are reinhabited which, in turn, has the potential to moderate global temperatures by decreasing the buildup of CO_2 (a greenhouse gas). To date, most studies show that deadwood plays a much less significant role in the cycling of nitrogen (N), phosphorus (P), Potassium (K), Calcium (Ca), and Magnesium (Mg). For a more detailed look at deadwood and nutrient cycling, please refer to the SFMN Research Note entitled *Woody debris and nutrient cycling: should we care???*.

Woody debris over time

Woody debris of both size classes are created by disturbances such as fire, insect outbreaks, and harvesting. In addition, self-thinning and death due to old-age can result in substantial inputs of deadwood to boreal forests. Several factors can affect the abundance and distribution of woody debris over the life of a forest stand. These include the nature of disturbance and the tree species. Recognizing this variability can be helpful to forest managers trying to mimic natural levels of deadwood in managed forests.

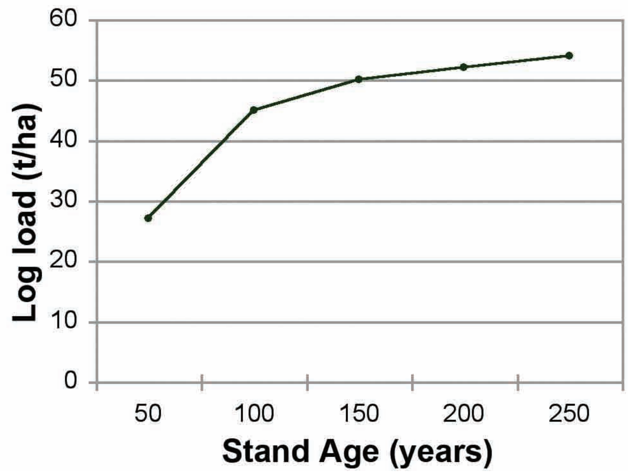
Figure 1. Volume of woody debris over time found in a boreal forest in Newfoundland. Numbers are estimated from chart in Sturtevant *et al.*[10]



Fire and severe insect epidemics usually result in high levels of deadwood in both young and old stands, with minimal amounts found in middle age stands. This U-shaped pattern has been observed in various forest types in British Columbia and the Pacific Northwest U.S.[3], as well as in aspen forests in Alberta[6] and boreal coniferous forests in Newfoundland (Figure 1).[10] In these forests, a fire or insect outbreak can kill large numbers of trees that may remain standing as snags, or fall to the ground immediately, becoming surface debris. Following such disturbances, woody debris input typically decreases while new growth regenerates. As the new forest grows, debris begins to accumulate on the forest floor as snags decay and fall. Input of debris increases as canopy closure occurs and trees begin to die during the stem exclusion stage. Inputs continue to increase as forests age, eventually reaching a point where they taper off until the next disturbance comes along.

There is some evidence that tree species can affect the abundance of cwd over time. In a boreal forest in northwestern Quebec, cwd accumulation was found to steadily increase over time.[4] This finding is in contrast to the commonly reported U-shaped pattern. The sequence in the Quebec forest was attributed to the shift in stand canopy composition from deciduous to coniferous species. Initially, high inputs of aspen deadwood, due to self-thinning, were observed, followed by a rapid replacement of aspen by balsam fir. Balsam fir died from cyclic spruce budworm outbreaks over time, creating a steady increase of overall cwd until the forest was quite old (Figure 2).

Figure 2. Volume of cwd over time found in a boreal forest in northwestern Quebec. Numbers are estimated from chart in Hely et al.[4]



Natural disturbance vs. harvesting

Natural disturbances such as fire and insect outbreaks often produce different amounts of snags and cwd than harvesting. In general, fire results in more cwd input than does harvesting, as was found in a northwestern Ontario boreal forest (Figure 3).[8] This difference can be affected by harvesting method. Full tree (FT) harvesting results in a removal of all cwd by removing stems, foliage, and branches. Tree length (TL) harvesting, on the other hand, will leave branches of various sizes on the forest floor to decay. In addition to quantity, the variability in size of woody debris is less in harvested stands (either TL or FT) compared to naturally disturbed ones. Fires, for instance, can leave relatively large, partially burned logs on the forest floor whereas such logs will not be found in harvested stands.

Like cwd, snags tend to be more abundant in naturally disturbed stands than in managed ones (Figure 3). The importance of snags as critical habitat for many bird species, as well as other animals, has been well recognized. However, policy with strict guidelines as to how much and what sizes of snags to leave when harvesting is largely lacking. This has sometimes resulted in inadequate amounts, sizes, and/or species being left behind to serve as habitat for wildlife.

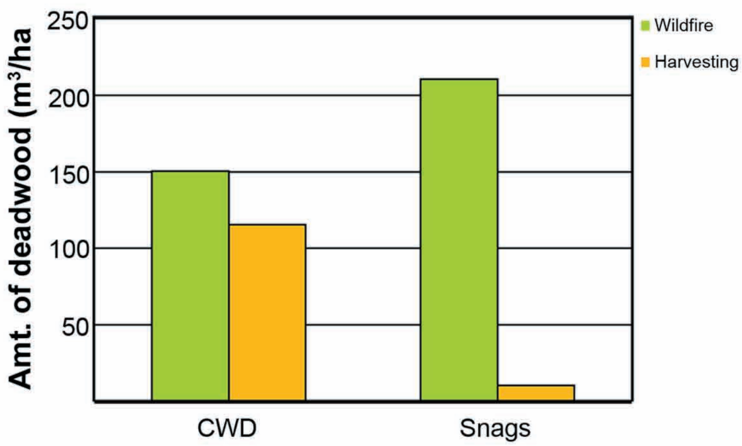


Figure 3. Abundance of CWD in fire vs. harvested stands in northwestern Ontario. Numbers estimated from graph in Pedlar *et al.*[8]

Summary

Deadwood plays an important role in forested ecosystems. Its abundance over time varies in both naturally disturbed and harvested boreal forests, although generally, the amount of deadwood in naturally disturbed forests is substantially higher than that in harvested stands. Size (i.e. coarse or fine) and decay class are both of factors that influence the type and abundance of species that will use deadwood for habitat and feeding.

The relationship between deadwood and nutrient cycling remains largely unstudied in the boreal forests of Canada. Most research linking deadwood and nutrition have been conducted in the western North American forests or boreal Russian forests where nutrient dynamics can be quite different from the boreal forests of

Canada due to differences in disturbance regimes, climate, and tree species. The lack of understanding as to the role deadwood plays in nutrient cycling points to the need for more research to be conducted in these forests in the future.

Implementation

- TL harvesting will more closely mimic the pattern of cwd input found in naturally disturbed forests than will FT harvesting. De limbing on site will come closer to creating the high initial inputs of cwd that are observed in young, naturally disturbed sites.
- The low input of deadwood to naturally disturbed boreal forests in intermediate years of succession calls for caution with harvesting rotations. If stands are continually being harvested at the time when deadwood inputs are at their lowest, long term loss of deadwood (and, thus, nutrient cycling and diver sity components dependant on deadwood) may occur.
- Size and decay class should be considered when determining what (and how much) deadwood to leave in managed forests.

References

1) Arsenault, A. 2000. *Patterns of bryophyte and lichen diversity in interior and coastal cedar-hemlock forests of British Columbia.* Final report for Forest Renewal British Columbia. Project No. FRBC#T096048.

2) Crites, S. and M. Dale. 1998. *Diversity and abundance of bryophytes, lichens, and fungi in relation to woody substrate and successional stage in aspen mixedwood boreal forests*. Can. J. Bot. 76: 641-651.

3) Feller, M.C. 2003. *Coarse woody debris in the old-growth forests of British Columbia.* Envir. Rev. 11(Supp. 1): S135-S157.

4) Hely, C., Y. Bergeron, and M.D. Flannigan. 2000. *Coarse woody debris in the southeastern Canadian boreal forest: composition and load variations in relation to stand replacement.* Can. J. For. Res. 30: 674-687.

5) Jonsson, B.G. and N. Kruys. 2001. *Ecology of Woody Debris in Boreal Forests.* Blackwell Publishing: Oxford. 280 pp.

6) Lee, P.C., S. Crites, M. Neitfeld, M.V. Nguyen, and J.B. Stelfox. 1995. *Changes in snags and down woody material characteristics in a chronosequence of aspen mixedwood forest in Alberta.* **In:** Relationships between stand age, stand structure and biodiversity in aspen mixedwood forests in Alberta. J.B. Stelfox, (Ed.) Alberta Enviro. Centre (AECV95-R1) and Can. For. Serv. (Proj. No. 0001A). Edmonton, Alberta, pp. 29-48.

7) Lesica, P., B. McCune, S.V. Cooper & W.S. Hong. 1991. *Differences in lichen and bryophyte communities between old-growth and managed second-growth forests in the Swan Valley, Montana.* Can. J. Bot. 69: 1745-1755.

8) Pedlar, J.H., J.L. Pearce, L.A. Venier, and D.W. McKenney. 2002. *Coarse woody debris in relation to disturbance and forest type in boreal Canada.* For. Ecol. Mgmt. 158: 189-194.

9) Söderström, L. 1988. *The occurrence of epixylic bryophyte and lichen species in an old natural and managed forest stand in northwest Sweden.* Biol. Conserv. 45: 169-178.

10) Sturtevant, B.R., J.A. Bissonette, J.N. Long, and D.W. Roberts. 1997. *Coarse woody debris as a function of age, stand structure, and disturbance in boreal Newfoundland.* Ecol. Applic. 7: 702-712.

For more information on the SFMN Research Note Series and other publications, visit our website at **http://sfm-1.biology.ualberta.ca** or contact the Sustainable Forest Management Network, University of Alberta, Edmonton, AB. Tel: 780-492-6659.

The Forest Nutrition Group is:
James Fyles, Dave Morris, Suzanne Brais, David Pare, Robert Bradley, Cindy Prescott, Andrew Gordon, Alison Munson, Barbara Kischuk, and Benoit Cote

Graphics & Layout: Kristin Kopra

ISSN 1715-0981