



Woody Debris and Nutrient Cycling: should we care???

by Kristin Kopra & James Fyles

Highlights

- Deadwood can act as an important storage site for carbon, and, in doing so, may play an invaluable role in moderating global climate.
- To date, there has not been enough convincing data to assert that deadwood has a significant impact on the cycling of macro nutrients.
- Maintaining deadwood in forests for its ability to cycle macro nutrients cannot be asserted at this time. However, its role in carbon cycling, as well as other critical roles it plays in forest ecosystems are well established and are reasons enough to maintain its presence on the landscape.

The role of woody debris in nutrient cycling has been the subject of much debate over the past decade. Policies encouraging and/or requiring that woody debris be left on site post-harvest, due to its inherent ability to retain essential nutrients, have been increasingly recognized in Canada and elsewhere. The research to date, however, has caused some researchers, managers, and policy makers to question the appropriateness of such policies, due to some findings that suggest dead wood plays little—if any—role in nutrient cycling in forests. Recently this subject was reviewed by Laiho and Prescott⁷, and it is sure to be the

subject of continued focused research and debate in years to come.

Drawing from findings of studies conducted across Canada, in the U.S., and in boreal Russian forests, this research note seeks to clarify the role that woody debris plays in nutrient cycling, summarizes current knowledge on this issue, and identifies the needs for future research into the importance of woody debris in nutrient cycling.

Carbon: sink or source?

Carbon (C) is a greenhouse gas, and, in the form of carbon dioxide (CO₂), represents one of the primary gases responsible for global warming. Our desire to understand the role of C in forests has increased dramatically in the past two decades, due to increasing concern over global warming and its effects on our planet.

Forests can store C (i.e. act as “sinks”) or can be sources of C through natural processes such as decomposition and natural disturbance (fire) that convert C in solid organic matter to gaseous CO₂. While there are significant amounts of C stored in live vegetation, several studies have suggested that dead wood can also hold a substantial amount of C.^{1,3,4} These findings point to the need to understand the importance of woody debris in holding C, relative to other ecosystem components. If woody debris represents a high proportion of stored C in the forest, then management that maintains debris on post-harvested sites would aid in retaining C in the ecosystem and retard its return to the atmosphere.

Forests and C storage pools

From the outset, it is imperative to differentiate between forests as sinks for C and forests as storage pools for C, as these terms have sometimes been confused. The term sink means that C is permanently taken out of the atmosphere. Forests act as C sinks by taking it out of the atmosphere through photosynthesis. On the other hand, forests act as storage pools for C by providing a temporary home for varying amounts of time. C is constantly being cycled from the atmosphere to living vegetation to dead vegetation to microorganisms and to the soil. At any point in this cycle, there is an opportunity for C to be returned to the atmosphere. All



Figure 1. Dead wood can act as a temporary storage site for C, releasing it to the atmosphere slowly and thus increasing the possibility of C inputs to the atmosphere being balanced by vegetation uptake rates. Photo courtesy of EMEND.

C eventually finds its way back into the atmosphere; what is important to consider here is the time frame in which such returns can be expected. C storage is important because C can remain bound up in forested ecosystems for long periods of time, resulting in the slow release of C over time. This is preferable to the quick release of C all at one time, because it allows for C to be taken up (by vegetation) at rates that may balance out the amount of C being released to the atmosphere.

Forests can store large amount of C in live vegetation, soils, and in dead wood. Young forests are stronger sinks than older forests due to higher photosynthesis than respiration occurring there. However, strong sinks do not necessarily equate to the storage of large quantities of C; in at least one study, old forests have been found to hold more C than young forests. In the Pacific Northwestern United States, it was found that old-growth (450 years old) forests there held 2.2-2.3

times as much C as did younger (60 years old) forests. These old-growth forests contained 88% more C stored in coarse woody debris (cwd) than did their younger counterparts and it was concluded that “conversion of old-growth forests to young plantations invariably reduces C storage...” This was due, in part, to the loss of cwd in younger forests.¹

Other studies have illustrated the importance of dead wood as a storage site for C. In old-growth Cedar-hemlock forests on Vancouver Island, it was concluded that detritus [dead plant and animal material] measured stored a considerable amount of C.³ Of the detritus measured in that study, 55% of the C was found in cwd. In the Rocky Mountains, cwd accounted for 18 and 23% of C in all aboveground litter (cwd, small woody litter, and nonwoody litter) input in lodgepole pine and subalpine fir forest, respectively.⁶

While several studies have hinted that the importance of C pools found in dead wood, relative to other ecosystem components (i.e. live biomass and/or soil), may be minor,^{1,4,5} at least one study⁴ has explicitly maintained that woody detritus can become “the dominant store of organic matter and C within the ecosystem” following either natural (fire) or human-induced (harvesting) disturbances. This is because harvesting removes much of the live biomass (which can represent a large pool of C) from site and fire can consume much of the litter and organic forest floor (which can also represent relatively larger pools of C), leaving dead wood to hold an important store of C for forests early in the regeneration period when other stocks have been removed.

Forests as sources of C

Forests act as sources of atmospheric C in several ways. First, fires can cause C to be released immediately to the atmosphere. Second, as noted above, harvesting can result in a net release of C to the atmosphere, partially due to the removal of woody debris.¹ Third, decomposition of dead material in the forest can result in a net release of C over time.

The C storage sites provided by woody debris become sources of C when decomposition takes place. During decomposition, C can be transferred to the atmosphere (in the form of CO₂) or it can be added to C stocks



Figure 2. Carbon, as well as other primary nutrients, are lost to the atmosphere when forests burn. Photo courtesy of the EMEND research team.

in soils where it then becomes a part of the ongoing C cycle. To date, there has been little research focused on C fluxes within ecosystem components. One study in Rocky Mountain pine and spruce forests found that C in woody debris contributed between 2 and 20% of the total C released from decaying aboveground litter.⁶ The amount of C that is supplied to a forest ecosystem through decomposition remains largely undetermined at this time.



Figure 3. The removal of dead wood during harvesting can result in a net release of C to the atmosphere. Photo courtesy of the EMEND research team.

Woody debris and primary nutrients

Woody debris can serve as a temporary storage site for macronutrients such as nitrogen (N), phosphorus (P), potassium (K), Calcium (Ca) and Magnesium (Mg). Like C, these nutrients remain in woody debris for a period of time but are released by decomposition eventually. Nutrients can be immobilized in woody debris, rendering them unusable to plants for long (or short) periods of time, but they are eventually released through mineralization by microorganisms.

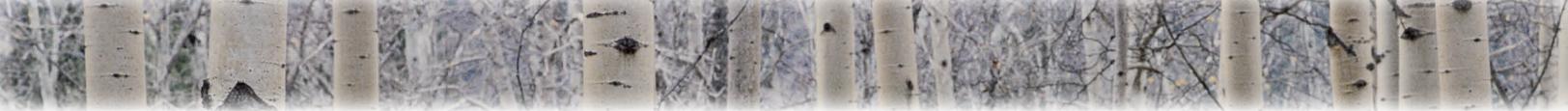
A review of studies conducted to date reveals that the importance of woody debris in nutrient cycling, relative to other ecosystem components (namely forest floor, mineral soil and live biomass) may be minor. In old-growth forests of the Pacific Northwest United States, it was shown that dead boles contributed only 5% of the total N uptake by plants.² Similarly, in boreal Russian forests, the amount of N, Ca, and K released from cwd was much smaller than the total quantities of these nutrients cycled through the forests.⁵ This last study, however, pointed out that, the loss of N, K, and Ca from cwd in 140 year old forests represented nearly 90% of the amount accumulated in live biomass. The authors suggested the possibility that the nutrients for live biomass were obtained from the nutrient store in cwd but also emphasized the need to determine whether or not the nutrients could be gotten from other storage pools (i.e. mineral soil) if cwd were to be removed from the system.

The literature to date, then, seems to suggest that woody debris plays an insignificant part in nutrient cycling of N, P, K, Ca, and Mg in forests. It would be helpful to have studies that looked at managed vs. unmanaged forests to determine whether or not removal of woody debris will result in drops in productivity.⁵ We found no such studies.

Summary

In general, it appears that dead wood has much more of an impact on C cycling than it does on N, P, K, Ca, and Mg cycling in forests across North America and boreal Russia. Dead wood can store relatively large amounts of C for varying amounts of time. This storage provides a source of C for microorganisms (decomposers) and for soils, all of which eventually return this C to the atmosphere in the form of CO₂. The rate at which CO₂ is added to the atmosphere is of concern to us because of the implications of CO₂ in global warming. Studies to date seem to suggest that dead wood can act as a storage site that adds CO₂ to the atmosphere slowly, aiding in the potential for inputs to the atmosphere to be offset by outputs to vegetation when deforested lands become reinvaded.

As for N, P, K, Ca, and Mg, the verdict is still out, although many studies suggest that dead wood is relatively insignificant in the cycling of these nutrients. Some have added that cwd may actually make N and P



unavailable to plants through immobilization and that the accumulation of these nutrients in cwd may actually decrease primary productivity on sites where N and P are limiting factors in plant growth. On the other hand, it has been suggested that dry sites where lack of moisture limits plant growth, cwd make actually aid in cycling nutrients (by retaining moisture) and increasing primary productivity.

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Implementation & Future Research

Maintaining woody debris on the landscape benefits, in the very least, C cycling—both within the forest and within the larger global C cycle. Insofar as recommending that it be maintained on site post-harvest to aid in the cycling of N, P, K, Ca, and Mg, we have not found enough evidence to support such a claim. Our work here, however, points to the need for further research in several areas.

Firstly, most data presented in this research note was not obtained in boreal forests of Canada. While some similarities may be drawn between forest types, significant differences in disturbance histories, forest age, and site factors (i.e. temperature, moisture) between the temperate forests of western North America and, to a lesser extent, the boreal forests of Russia, and the boreal forests of Canada exist. These differences point to the possibility for variations to be found in the way dead wood affects nutrient cycling in the boreal forests of Canada. Research that is aimed at quantifying total amounts of N, P, Ca, Mg, and K in dead wood found in Canadian boreal forests would be helpful in determining what, if any, differences exist between studies done to date and those conducted in boreal Canada.

Secondly, determining actual nutrient supplies and comparing nutrient releases from cwd and other types of litter would be helpful in estimating the relative importance of dead wood in nutrient cycling.

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