Contribution of belowground coarse woody roots to the soil organic carbon pool

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Introduction

The long-term storage of carbon (C) in forest ecosystems depends greatly on the allocation and sequestration of biomass C into soils. Many studies have been conducted to determine the amounts of C- and nutrients returned to the soil as a result of fine root turnover. However, the contributions of coarse roots to the soil C-pool is typically ignored because of the tremendous effort and time required for measuring this component of the belowground C-pool (Black *et al.*, 2007; Soethe *et al.*, 2007). A recent study (Black *et al.*, 2009) revealed that the C-stocks in a chronosequence of Sitka spruce stands (*Picea sitchensis* (Bong.) Carr.) (9–45-year old) ranged from 2.9-34 t C ha^{-1} for coarse roots, 0.6-3.4 t C ha^{-1} for fine roots and 102.1-137.3 t C ha^{-1} for soil organic matter (SOM). Coarse roots store a much larger amount of C than fine roots, thus making them a significant sink of belowground C, which becomes available to the soil C-pool after harvesting or tree death.

There are also many studies devoted to estimating the pool of aboveground coarse woody debris, created by natural successional dynamics (*e.g.* snags, fallen trees) as well as by management practices (*e.g.* logging residues and stumps). This same processes produce a pool of belowground root systems that begin to decay (at varying rates), and provide material for inclusion in the soil organic C-pool.

In a COFORD funded project, the decomposition rate of coarse roots is being examined. It will include a number of approaches including excavating a time-series of varyingly decomposed stumps, traditional decomposition bags have been set up and will be sampled over a period of time, and also an experiment where a series of stumps were sampled across six-monthly intervals. The project has run approximately half its course and preliminary results are beginning to take shape.

Study Description

An inventory of CWD was carried out in forests growing on surface water mineral gleys in the Irish midlands. The sites included three thinned Sitka spruce stands (28, 30 and 39-years old). The belowground component of stump CWD was taken to include entire root systems up to a root diameter of 2mm. The total CWD C-stock was estimated and decomposition rates estimated for each component of the CWD using decay classes (DC). The coarse roots C-pool was estimated in relation to the overall CWD C-pool.

Results and Discussion

The importance of coarse woody roots is demonstrated succinctly (Fig.1), accounting for 83, 84 and 87% of total CWD C ha^{-1}. Aboveground CWD stocks decrease with forest management intensity, due to effective harvesting techniques and removal of deadwood and snags from the forest floor. The reverse is the case for belowground CWD, as stumps and their adjoining roots are left to decompose and thus transfer their organic content to the soil C-pool. Fig. 2 shows that dead roots are the largest component of the total CWD C-pool. (Data sourced from Tobin *et al.* 2007).

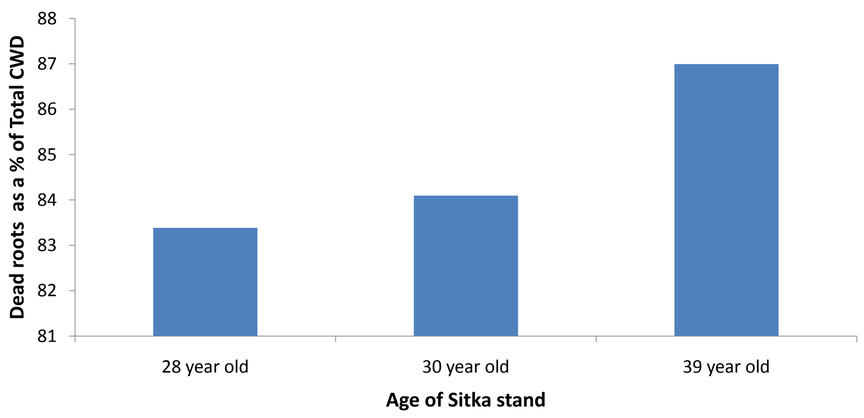

Fig 1. Coarse woody roots as a percentage of Total CWD C-pool

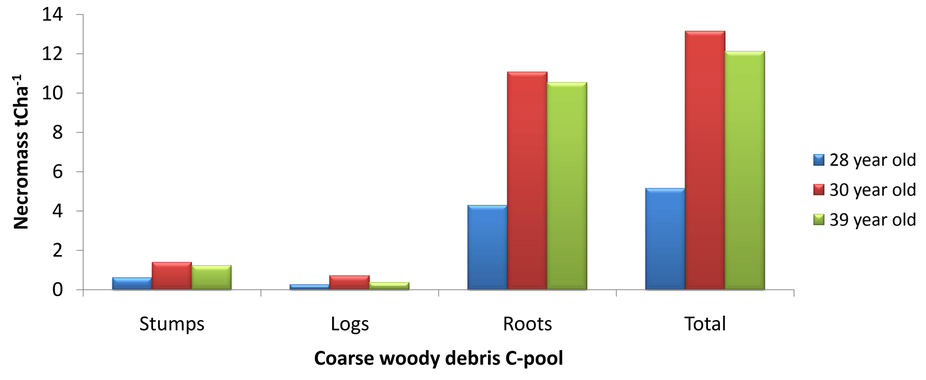

Fig. 2 Above- and belowground C-stocks

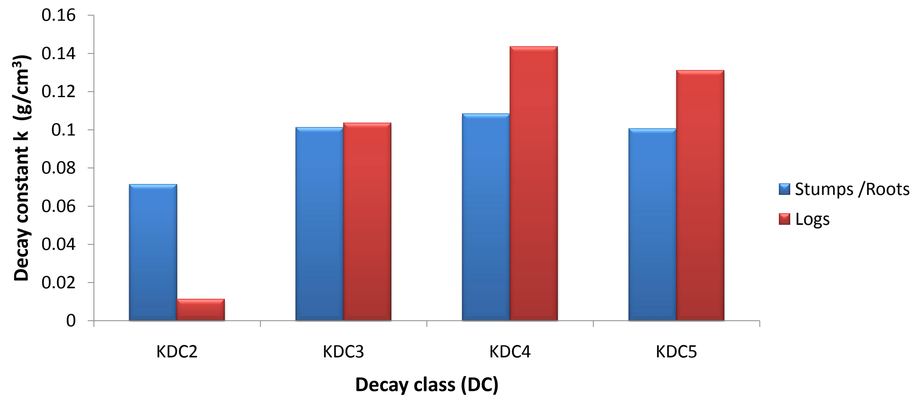

Fig. 3. Decay constants of Stump/Roots and Logs in different DC's

Decay rates for Stumps/Roots (Fig. 3) indicates a slow rate of decomposition which implies a long residence time for the belowground necromass, and a slow but steady turnover of C to the soil C-pool.

Ongoing Activities

- Root decomposition bag experiment
- Time series excavation of decomposing stumps
- Root decay class excavation
- C-N Analysis of decaying roots

Conclusion

The contribution of soils to carbon sinks of the forests is expected to increase with increasing forest age and harvesting intensity. Thus, greater attention needs to be given to the measurement of coarse roots, which accounts for about 70% of the total root biomass. An overestimation of net ecosystem productivity is due to unaccounted soil decomposition losses (Kolari *et al.*, 2004), especially from coarse roots. Information on the residence time (including its rate of decomposition) of dead coarse roots in the belowground C-pool will improve our understanding of the extent of its contribution to total C-balance in the forest ecosystem. Belowground decay processes and rates remain a source of error when estimating C-stock and stock change interactions. Thus, emphasizing the need for long term assessment of coarse root turnover in the soil C-pool.

Acknowledgements

▪COFORD (National Council for Forest Research and Development)

▪Coillte Teoranta

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COST Action FP0803: Belowground carbon turnover in European forests

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