Leaching of dissolved organic carbon, dissolved organic nitrogen, and other solutes from coarse woody debris and litter in a mixed forest in New York State

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Abstract. Coarse woody debris (CWD) may play a role in nutrient cycling in temperate forests through the leaching of solutes, including dissolved organic carbon (DOC) and dissolved organic nitrogen (DON), to the underlying soil. These fluxes need to be considered in element budget calculations, and have the potential to influence microbial activity, soil development, and other processes in the underlying soil, but studies on leaching from CWD are rare. In this study, we collected throughfall, litter leachate, and CWD leachate \textit{in situ} at a young mixed lowland forest in NY State, USA over one year. We measured the concentrations of DOC, DON, NH\textsubscript{4}\textsuperscript{+}, NO\textsubscript{3}\textsuperscript{−}, dissolved organic sulfur, SO\textsubscript{4}\textsuperscript{2−}, Cl\textsuperscript{−}, Al, Ca, K, Mg, Na, and P, estimated the flux of these solutes in throughfall, and measured the cover of CWD to gain some insight into possible fluxes from CWD. Concentrations of DOC were much higher in CWD leachate than in throughfall or litter leachate (15 vs. 0.7 and 1.6 mM, respectively), and greater than reported values for other leachates from within forested ecosystems. Other solutes showed a similar pattern, with inorganic N being an exception. Our results suggest that microsite scale fluxes of DOC from CWD may be an high relative to throughfall and litter leaching fluxes, but since CWD covered a relatively small fraction (2\%) of the forest floor in our study, ecosystem scale fluxes from CWD may be negligible for this site. Soil directly beneath CWD may be influenced by CWD leaching, in terms of soil organic matter, microbial activity, and N availability. Concentrations of some metals showed correlations to DOC concentrations, highlighting the possibility of complexation by DOM. Several solute concentrations in throughfall, including DOC, showed positive correlations to mean air temperature, and fewer showed positive correlations in litter leachate, while negative correlations were observed to precipitation, suggesting both biological and hydrologic control of solute concentrations.

Introduction

Dissolved organic matter (DOM) is involved in numerous processes in forest ecosystems and their drainage waters. The production, movement, and fate of dissolved organic carbon (DOC) and dissolved organic nitrogen (DON) are important components of carbon (C) and nitrogen (N) cycles in forest
ecosystems (Yavitt and Fahey 1986, Michalzik et al. 2001). Dissolved organic compounds contribute to the formation of soil organic matter (Dawson et al. 1978; McDowell and Wood 1984), facilitate metal and organic pollutant mobilization (McCarthy and Zachara 1989; Christensen and Christensen 1999), may play an important role in stream chemistry (Moore and Jackson 1989; Driscoll and Fuller 1994), and react to produce toxic chlorinated organic compounds in drinking water (Hoadley and Gould 1976; Kalmez and Kalmez 1981). Considering the current interest in C and N cycling due to changes in local and global cycles, there is considerable motivation to more completely understand these processes.

Numerous studies have documented the leaching of high concentrations of DOC (mean values up to 7 mM), and associated high fluxes (up to 4 mol m$^{-2}$ y$^{-1}$), from the litter layer or forest floor in deciduous and coniferous temperate forests across the globe (McDowell et al. 1998, and see reviews by Michalzik et al. 2001 and Neff and Asner 2001). Concentrations and fluxes of DON have been documented in fewer cases, but range from 30 to 240 $\mu$M and 20 to 90 mmol m$^{-2}$ y$^{-1}$, respectively (McDowell et al. 1998; Solinger et al. 2001, and see review by Michalzik et al. 2001).

Coarse woody debris (CWD) may constitute a much larger fraction of the total aboveground detritus in temperate forests than litter (Lang and Forman 1978; Harmon and Cromack 1987; Stewart and Burrows 1994), and thus may contribute a substantial flux of DOC to the underlying soil. Additionally, because of a highly ‘clumped’ distribution of woody detritus, it may create ‘hot spots’ (McClain et al. 2003) with very high solute concentrations and fluxes on a microsite scale. Whereas elements with no prominent gaseous phase must leave CWD and enter the soil at approximately the rate at which they fall in CWD on an ecosystem level in systems near steady state, this is not the case for C and N; respiration can cause substantial loss of C, while N$_2$ fixation can add N to CWD (e.g. Jurgensen et al. 1984; Mattson et al. 1987).

Despite the potential significance of leaching from CWD, few studies have measured the concentrations or estimated the fluxes of solutes in leachate from decaying CWD (Yavitt and Fahey 1985; Mattson et al. 1987; Spears et al. 2003). Simulation models and budget calculations of C movement in forests have assumed this flux to be zero (Raich and Nadelhoffer 1989; Currie and Aber 1997). Ignoring a potentially substantial movement of C could lead to flawed understanding of C cycling in temperate forests, and errors in budget calculations and simulation results.

Understanding the importance of the leaching of other elements (e.g., P and S), as well as inorganic forms of N, from CWD is important for understanding the role of CWD in the cycles of these elements. Many studies on the chemistry of CWD decay have suggested that some elements (especially N) are temporarily immobilized in CWD (Grier 1978; Brown et al. 1996; Laiho and Prescott 1999), while other studies have demonstrated decreases in the concentrations or total mass of N and other elements beginning early on in decomposition (Means et al. 1992; Creed et al. 2004; Ganjegunte et al. 2004). Some of these differences