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From litter decomposition to soil organic matter formation: using leaf traits to predict dissolved organic carbon leaching

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New evidence suggests that leaching of dissolved organic carbon (DOC) during litter decomposition is a major process by which decomposing litter forms stabilized soil organic matter (Cotrufo et al. 2013). Understanding this DOC flux based on plant leaf litter traits would strengthen our ability to predict ecosystem carbon (C) cycling across different vegetation types. In this study we aim to quantify the proportional relationship between CO_2 and DOC partitioning during decomposition of fresh leaf litter from five different plant species, alfalfa, ash, bluestem grass, oak and pine, ranging in structural and chemical composition. The results from this laboratory incubation show a clear relationship between the lignin to cellulose ratios of litter and DOC to CO_2 partitioning during four distinct phases of litter decomposition. For example, bluestem grass litter with a low lignin to cellulose ratio loses almost 50% of its C as DOC whereas pine needles with a high lignin to cellulose ratio loses much less C as DOC, indicating a potential ligno-cellulose complexation effect on carbon use efficiency and CO_2 vs. DOC fluxes during litter decomposition. DOC production also decreases with time during decomposition, correlating with increasing lignin to cellulose ratios and decreasing availability of soluble, non-structural, leaf compounds (based on FTIR analysis). Initial DOC leaching can be predicted based on the amount of labile fraction in each litter type. Field data using stable isotope labeled bluestem grass show that while 18% of the surface litter C lost in 18 months of decomposition enters the soil, over 50% of litter derived C in the soil is recovered in mineral associated heavy SOM fractions, not as litter fragments in the light fraction, confirming the relative importance of the DOC flux of C from the litter layer to the soil for soil organic matter formation. These results are being used to parameterize a new litter decomposition sub-model to more accurately represent the movement of decomposing surface litter C to CO_2 and the mineral soil using a Bayesian hierarchical framework. This surface litter sub-model can be used to strengthen our understanding of the litter C and microbial processes that feed into larger ecosystem models such as Daycent.