Climatic and edaphic effects on root- and leaf-litter carbon inputs to temperate forest soils

Julie Jastrow (jdjastrow@anl.gov) - Argonne National Laboratory (PI), Roser Matamala, ANL ; Karis McFarlane, LLNL; Zhaosheng Fan, ANL; Rachel Porras, LBNL; Margaret Torn, LBNL; Tom Guilderson, LLNL; Paul Hanson, ORNL (Co-PIs).

The contributions of root- versus leaf-litter sources to soil organic matter (SOM) are not well understood. As part of the Enriched Background Isotope Study (EBIS), our objectives were to study how climate and edaphic factors affect root decomposition, the transfer of root-derived materials to soil, and the transfer of leaf-litter C to mineral-associated SOM pools. We established 14C-enriched root- and leaf-litter manipulations at four sites representing the climatic extent of Eastern deciduous forest. We measured root decomposition and incorporation of root-derived C into soil for four years. We also assessed inputs of leaf-derived C into the heterogeneous mineral-associated dense fraction (DF) of SOM in site soils by isolating acid-hydrolyzable and acid-resistant C pools from the DF.

Root decomposition progressed through time with an average total mass loss of 27% in Y1, 42% in Y2, 56% in Y3 and 60% in Y4. Root decay constants were significantly affected by climate and edaphic factors. Soils showed 14C enrichment after only one month, suggesting that root C was quickly transferred to SOM. Across all years, root-derived C retained in soil varied by site and ranged from 13-68% of root inputs. Sites with slower root decomposition rates retained more root-derived C. Soil retention of root-derived C averaged 36% across the studied sites; however, climate and site edaphic factors greatly affected soil C retention. Root-derived C retention was lower at the warmest site than at two of the colder sites, but higher than the cold site with sandy soils. Hence, root litter retention in soils was shown to vary greatly across temperate forests.

Across all sites, 50-75% of the C in the mineral-associated DF was acid-hydrolyzable. The mean turnover time of C in this pool was 1-2 orders of magnitude faster (~35-350 y) than that of the acid-resistant pool (~300-1500 y). After only two years, leaf-derived C accounted for up to 6% of the C in one or both DF pools at some sites, demonstrating that a component with very rapid turnover can exist within both pools. Mid-infrared spectroscopy confirmed hydrolysis removes proteinaceous and lightly decomposed materials (e.g., polysaccharides), which varied among sites. Differences in the SOM chemistries of the two DF pools corresponded well to turnover times. Climatic effects on turnover times were altered by site-specific factors (especially bioturbation and texture).

These results provide new understanding of the factors controlling the movement, fate, and retention of root- and leaf-litter in Eastern deciduous forest soils.