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Impact of Native and Invasive Earthworm Activity on Forest Soil Organic Matter Dynamics

Sara Top and Timothy Filley

Purdue University, Purdue Climate Change Research Center, Earth and Atmsopheric Sciences, Wst Lafayette, United States (filley@purdue.edu)

Many northern North American forests are experiencing the introduction of exotic European lumbricid species earthworms with documented losses in litter layers, expansion of A-horizons, loss of the organic horizon, changes in fine root density, and shifts in microbial populations as a result. Some of these forests were previously devoid of these ecosystem engineers. We compare the soil isotope and molecular chemistry from two free air CO2 enrichment (FACE) forest experiments (aspen FACE at Rhinelander, Wisconsin and sweet gum FACE at Oak Ridge National Lab, Tennessee) that lie within the zones of earthworm invasion. These sites exhibit differences in amounts of exotic and native species as well as endogeic (predominantly mineral soil dwelling) and epigeic (litter and organic matter horizon dwelling) types. We investigated the impact of earthworm activity by tracking the relative abundance and stable carbon isotope compositions of lignin and substituted fatty acids extracted from isolated earthworms and their fecal pellets and from host soils. Additionally, 15N-labeled additions to the soil provide additional methods for tracking earthworm impacts. Indications of root vs leaf input to earthworm casts and fecal matter were derived from differences in the chemical composition of cutin, suberin, and lignin. The isotopically depleted CO2 used in FACE and the resulting isotopically depleted plant organic matter afford an excellent opportunity to assess biopolymer-specific turnover dynamics. We find that endogeic species are proportionately more responsible for fine root cycling while some epigeic species are responsible for microaggregation of foliar cutin. CSIA of fecal pellet lignin and SFA indicate how these biopolymer pools can be derived from variable sources, roots, background soil, foliar tissue within one earthworm. Additionally, CSIA indicates the distinct roles that different earthworm types have in “aging” surface soil biopolymer pools through encapsulation and upward transport of deeper soil carbon, and “freshening” deeper soil biopolymer pools through downward transport of surface carbon to deeper layers. Although, endogeic species burrow down below 30 cm in these systems, comparison of 13C and 15N in soil layers and fecal matter indicate their greatest impact is restricted to the upper 5 cm. As earthworm species abundance and activity are not is steady state in these forests, the role of these important invertebrates should be more considered when assessing the ability of forest soils to accumulate new plant input.