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Wood Decomposition: Understanding Processes Regulating Carbon Transfer to Soil Carbon Pools Using FACE Wood at Multiple Scales

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Dead wood is a significant terrestrial carbon (C) pool, comprising approximately 20% of the forest biomass in the U.S. A major uncertainty in the terrestrial C cycle is the transfer of C from that dead wood into the underlying mineral soil C pool, where it may be incorporated into recalcitrant or protected soil C pools during the decomposition process. Documenting the fate of wood C during the decomposition process is difficult because (1) wood decomposition is inherently slow, (2) C from decomposing wood often cannot be differentiated from C in the soil matrix, and (3) microbial decomposers with distinct mechanisms can drive distinct outcomes, poorly predicted by climate alone. While Specific wood-decay fungi (brown rot & white rot) and invertebrates, especially termites, are understood to be the principal agents mediating wood decay, little is known about their ecology or their interactions, nor the process and pathways affecting the transfer of wood to the soil.

The FACE Wood Decomposition Experiment (FWDE) was established in 2011 with wood grown under the elevated CO_2 in the free-air carbon dioxide enrichment (FACE) experiment. By using the $\delta^{13}C$ signature in loblolly pine (*Pinus taeda*), birch (*Betula papyrifera*) and aspen (*Populus tremuloides*) from two FACE sites to monitor wood decomposition, measure the amounts of wood C incorporated into soil organic matter pools, and determine factors regulating decay processes mediated by fungi and termites within nine major forest – bioclimatic zones within the continental U.S. Our objectives are: (a) determine the influence of wood biochemistry, microbial process, soil properties, and climatic factors on log decomposition and incorporation of wood-C into mineral soil C pools; (b) determine the incidence of termite foraging, interaction between termite and fungal community activity and effects on the rate of wood decomposition and incorporation of wood C into mineral soil C pools; and (c) develop a model to simulate log decomposition and wood C movement into the mineral soil.

The work is being conducted principally on the continental-scale (FWDE), where ambient and elevated CO_2 FACE logs were placed on nine experimental forests. After six years of decay, the loss in wood density was 10-91% in aspen, 24-85% in birch, and 20-75% in pine; pine suspended above the soil to emulate standing-dead trees had the least decay 2-45%. Assays from upper 10 cm of the mineral soil affirm that the $\delta^{13}C$ signature of the FACE wood can be traced into the mineral soil. Wood-C was evident directly beneath the logs and adjacent within 50 cm. The proportion of wood C within the soil C pool varied from 3 to 9%. White rot fungi were the dominant group responsible for the wood decay.

However, the fungal community, based on DNA sequencing, exhibits distinct assemblages that appear to be related to abiotic factors. A mechanistic model, Coarse Wood Decomposition, has been developed to simulate wood decomposition, reflecting the interactions of microbial communities and arthropods, and mediated by soils, climate and vegetation attributes. The model has been parameterized for subtropical to boreal zones in North America; it is currently undergoing final testing with the FWDE data.