Just beneath the surface: The distribution and dynamics of fine roots in a forested peat bog

Terrestrial Ecosystem Sciences Program

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Fine plant roots, which are narrow-diameter, ephemeral roots responsible for plant water and nutrient acquisition, contribute to wetland carbon dioxide and methane fluxes through respiration, exudates of labile carbon compounds, input of root detritus, and the presence of aerenchyma. However, the distribution and dynamics of fine roots have rarely been examined in wetlands, in part because of methodological difficulties associated with cold, saturated soils. Our objective was to determine the production of ephemeral roots throughout the soil profile in an ombrotrophic bog that is the location of the Spruce and Peatland Responses Under Climatic and Environmental change (SPRUCE) experiment (http://mnspruce.ornl.gov/). We used several methods to characterize ephemeral roots, including species-specific sampling to investigate the relationships among root order, root morphology, and root chemistry; minirhizotrons installed across gradients of tree density and microtopography to quantify root production and mortality throughout the peat profile; in-growth cores to quantify the chemistry and morphology of newly-produced roots; peat cores to determine rooting depth distribution; and novel, automated minirhizotron technology to track the dynamics of ephemeral roots and mycorrhizal hyphae at high spatial and temporal resolution. The common vascular plant species in the bog encompassed a range of root morphology, diameter distributions, and mycorrhizal colonization. Across a range of root orders, root diameter was strongly related with root mass per length and root nitrogen concentration. Root phenology was bimodal for both trees and shrubs; the first peak in production occurred early in the growing season before peak leaf and woody growth, and the second peak occurred late in the growing season after needle expansion was complete and peak woody growth was past. Root standing crop and production were greater in raised hummocks than in saturated hollow depressions, and living roots were generally confined to the aerobic zone above the average summer water table level. Well-preserved dead shrub roots were found in peat samples as deep as 2 m, with a calibrated ^{14}C age of ~5000 years. Similarly, fungal hyphae occurred only in shallow peat. These measurements are being used to parameterize ecosystem and land surface models to refine hypotheses regarding the expected effects of warming and elevated CO_2 on root distribution, dynamics, and carbon and nitrogen cycling in globally important peatland ecosystems.