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Adaptive fine root foraging patterns in climate experiments and natural gradients

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Site based manipulative experiments and studies along climatic gradients have long been keystones of ecological research. We aimed to compare the response of ectomycorrhizal (EcM) and fine roots in manipulative studies and along climate gradient to describe the universal trends in root traits and to raise hypotheses about general mechanisms in fine root system adaptation of forest trees in global change. The root traits from two climate manipulation experiments – Bangor FACE and FAHM in Estonia, manipulated by CO_2 concentration and relative air humidity in silver birch forest ecosystems, respectively and the data for three most ubiquitous tree species - Norway spruce (Picea abies), Scots pine (Pinus sylvestris) and silver birch (Betula pendula) stands along natural gradient encompassing different climate and forest zones in Northern Europe were analysed.
There are two main strategies in response of fine root system of trees: A) an extensive increase in absorptive root biomass, surface area and length, or B) a greater reliance on root-associated EcM fungi and bacterial communities with a smaller investment to absorptive root biomass. Trees in all studies tended to increase the EcM root biomass and the proportion of EcM root biomass of total fine root biomass towards harsh (northern boreal forests) or changed conditions (stress created by the increase in CO_2 concentration or relative air humidity).
We envisage a role of trilateral relation between the morphological traits of absorptive fine roots, exploration types of colonising EcM fungi and rhizosphere and bulk soil bacterial community structure. A significant change in EcM absorptive fine root biomass in all experiments and for all studied tree species coincided with changes in absorptive root morphology, being longer and thinner root tips with higher root tissue density in poor/treated sites. These changes were associated with significant shifts in community structure of dominating EcM fungi as well as soil and rhizosphere bacterial communities. We suggest a multidimensional concept of absorptive fine root foraging strategies involving both qualitative and quantitative changes in root-mycorhizosphere along environmental gradients and in climate experiments.