An alpine treeline in a carbon dioxide-rich world : synthesis of a nine-year free-air carbon dioxide enrichment study

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We evaluated the impacts of elevated CO2 in a treeline ecosystem in the Swiss Alps in a 9-year free-air CO2 enrichment (FACE) study. We present new data and synthesize plant and soil results from the entire experimental period. Light-saturated photosynthesis (A (max)) of ca. 35-year-old Larix decidua and Pinus uncinata was stimulated by elevated CO2 throughout the experiment. Slight down-regulation of photosynthesis in Pinus was consistent with starch accumulation in needle tissue. Above-ground growth responses differed between tree species, with a 33 % mean annual stimulation in Larix but no response in Pinus. Species-specific CO2 responses also occurred for abundant dwarf shrub species in the understorey, where Vaccinium myrtillus showed a sustained shoot growth enhancement (+11 %) that was not apparent for Vaccinium gaultherioides or Empetrum hermaphroditum. Below ground, CO2 enrichment did not stimulate fine root or mycorrhizal mycelium growth, but increased CO2 effluxes from the soil (+24 %) indicated that enhanced C assimilation was partially offset by greater respiratory losses. The dissolved organic C (DOC) concentration in soil solutions was consistently higher under elevated CO2 (+14 %), suggesting accelerated soil organic matter turnover. CO2 enrichment hardly affected the C-N balance in plants and soil, with unaltered soil total or mineral N concentrations and little impact on plant leaf N concentration or the stable N isotope ratio. Sustained differences in plant species growth responses suggest future shifts in species composition with atmospheric change. Consistently increased C fixation, soil respiration and DOC production over 9 years of CO2 enrichment provide clear evidence for accelerated C cycling with no apparent consequences on the N cycle in this treeline ecosystem.
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