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Tree and forest water use under elevated CO_2 and temperature in Scandinavian boreal forest

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According to experimental studies and models, rising atmospheric carbon dioxide concentration ([CO_2]) and temperature have the potential to affect stomatal conductance and, consequently, tree and forest transpiration. This effect has in turn the capacity to influence the terrestrial energy and water balance, including affecting of the magnitude of river runoff. Furthermore, forest productivity is currently water-limited in southern Scandinavia and in a near future, under the projected climatic change, this limitation may become a reality in the central and northern parts of Scandinavia. In this study we examine the water-use responses in 12 40-year old native boreal Norway spruce (Picea abies (L.) Karst.) trees exposed to a factorial combination of two levels of [CO_2] (ambient and doubled) and temperature (ambient and +2.8 °C in summer / +5.6 °C in winter), as well as of entire boreal forests to temporal variation in [CO_2], temperature and precipitation over the past 50 years in central and northern Sweden. The controlled factorial CO_2 and temperature whole-tree chamber experiment at Flakaliden study site demonstrated that Norway spruce trees lacked elevated [CO_2]-induced water savings at guard cell, shoot, and tree levels in the years of measurements. Experimentally, elevated temperature did not result in increased shoot or tree water use as stomatal closure fully cancelled the effect of higher vapour pressure deficit in warmed air environment. Consistent with these results, large scale river runoff data and evapotranspiration estimates from large forested watersheds in central Sweden supported lack of elevated CO_2-mediated water savings, and rather suggested that the increasing evapotranspiration trend found in this study was primarily linked to increasing precipitation, rising temperature and more efficient forest management. The results from the whole-tree chamber experiment and boreal forested watersheds have important implications for more accurate predictions of boreal atmosphere–biosphere interactions, indicating that tree responses to precipitation and temperature are more important than responses to elevated [CO_2] in determining the future forest water-use and hydrology of Scandinavian boreal ecosystems.