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Which traits can prevent thermal damage and stimulate boreal forest productivity under a changing climate?

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Climate is a key regulator of most terrestrial biogeochemical processes and has the potential to markedly modify the function and services of forest ecosystems. Climate change will thus alter biogeochemical cycling with potentially dramatic effects on forest productivity. At the same time, the EU targets to fulfil the goal of 20% renewable energy and 10% renewable fuels in transport by 2020 have spurred the interest in bioenergy production, intensifying thus forest harvesting particularly over Fennoscandia. In this region, while the development and extraction of natural resources will likely impose more pressure on boreal forest health, the boreal biome is expected to experience the largest increase in temperatures of all forest biomes. Consequently, plants‘ thermotolerance might be exceed, jeopardizing their performance and fitness and compromising the role played by boreal forest from local to regional scale.

It is thus imperative to explore avenues to guarantee this role under harsher weather conditions and more intensive exploitation. One potential and still partially explored avenue is the identification of traits that might underpin the ability of boreal forest to keep or increase assimilation rates under a changing climate. Indeed, plant traits could be exploited to buffer existing forest communities against thermal damage while keeping and/or stimulating high assimilation rates. We aimed thus to determine whether selecting sets of traits could be used as strategy to simultaneously avoid thermal damage and stimulate forests productivity and, at the same time, capture the physiological mechanisms associated to the explored traits.

To asses this goal, we performed a modelling approach based on Monte-Carlo techniques and exploring up to 100 virtual combinations of traits under three different climate scenarios: (1) current conditions, (2) only increasing temperatures and (3) increasing temperatures combined with decreasing rainfall frequency. We found that the optimal trait combination to prevent thermal damage and ensure productivity is the one that allows the highest leaf thermoregulation capacity - narrowing the variation of temperature experienced by the leaves in the face of wide variation in ambient air temperatures, allowing thus to keep leaf temperature near to the optimum temperature. We also found that the lack of precipitation during the growing season triggers thermal damage even though air temperature is within average values – pointing out the importance of water stress for boreal forest fitness. This modelling approach also provided the optimal range of variation of the most dominant traits (Vcmax, effective leaf thickness, albedo, etc) in relation to different weather conditions – outcome that is vital for designing future field experiments and can shed light for future modelling improvements.