The affinity of vascular plants and bryophytes to forest microclimate buffering

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Abstract:

With recent advances in technology and modelling, ecologists are increasingly advised to use microclimate, not the usual coarse-scale macroclimate based on weather stations, to better reflect the proximal conditions that species experience. This is especially relevant in forest ecosystems, where natural disturbances and forest management create substantial heterogeneity in microclimates. Under dense canopies, species experience buffered (less extreme) microclimate temperatures relative to macroclimate, as well as increased relative humidity, reduced light and wind.

Focusing on understory plants, we investigated species response curves to the buffering capacity of the canopy layer, measured as the log-transformed slope parameter of the microclimate to macroclimate linear relationship. If lower or higher than zero, microclimate temperatures are buffered or amplified, respectively, relative to macroclimate.

During leaf-on conditions (July-September 2021), we measured hourly microclimate temperatures in 157 plots across three temperate deciduous forests with different macroclimates in France. We used paired hourly macroclimate measurements from nearby weather stations to derive the slope parameter, quantifying microclimate buffering.

We surveyed both vascular plant and bryophyte communities in 400 m² plots centred on our microclimate sensors. Species were classified into three groups of forest affinity: forest core specialists; edge specialists; and generalists. We fitted generalized linear mixed-effects models, by forest affinity group and then by species, to obtain logistic response curves of the probability of occurrence against microclimate buffering. The species' microclimate optimum was computed as the microclimate effect that maximizes its probability of presence.

We found contrasted microclimate preferences: most bryophytes as well as the vascular plants classified as forest core specialists had an optimum in microclimate buffering (less extreme temperature fluctuations relative to macroclimate), while forest edge specialists and generalists among vascular plants had an optimum in microclimate amplification. For bryophytes as well as vascular plants, the more thermally buffered the forest, the higher the proportion of core specialists.

Assessing plant responses and vulnerability to forest management and climate change is an objective shared by many ecologists and conservationists, and our results confirm that forest microclimates are key to that endeavour. As canopies undergo increased disturbance frequency and

intensity with climate change, more generalists and less forest core specialists might be expected within understory communities, especially for bryophytes. Augmenting forest cover and limiting canopy openings could counterbalance the negative impacts of climate change on these specialists. At the landscape scale, a mosaic of buffered and amplified microclimates may be the best option to promote forest biodiversity, by accommodating species across the whole microclimate gradient.

Overall, we demonstrated that understory plants have a species-specific affinity to forest microclimate buffering, for which we provide the first quantitative index, that goes beyond an assignment to the discrete and expert-based classes of forest generalist or specialist. The investigation of species response curves to microclimate processes – buffering or amplification – can improve our understanding of the ecology of understory plants, and help us anticipate their redistribution under climate change.

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