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Strategic Phosphorus Allocation Under Stress: Root-Mycorrhizal Traits Driving Nutrient Efficiency in Forests

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Phosphorus (P) limitation and intensifying drought critically constrain forest productivity. Beyond the total amount of P in plants, its allocation (how it is divided among different biochemical fractions) strongly influences how efficiently plants use P and how well they cope with stress. These fractions include inorganic phosphate, nucleic acid P (a key component of DNA and RNA), phospholipid P (a key component of cell membranes), and metabolite P (involved in energy transfer and metabolic regulation).

My research has shown that greater allocation to nucleic acid P supports active protein synthesis and cellular repair, while higher phospholipid P helps maintain membrane integrity. Together, these contribute to plant stress resilience—the ability of plants to maintain function and recover from environmental pressures.

Root functional traits, such as carboxylate exudation (the release of negatively charged salts derived from organic acids, e.g., citrate or malate), help mobilise otherwise inaccessible P by binding to and releasing it from mineral surfaces like iron or aluminium oxides. Mycorrhizal associations further expand the soil volume accessible for nutrient uptake and mediate long-term plant–soil feedbacks.

However, the combined influence of P fraction allocation, root exudation, and mycorrhizal function under simultaneous P and drought stress remains poorly quantified, limiting our ability to predict forest resilience. In the anticipated second phase of the DFG research group “Forest Floor” (https://uni-freiburg.de/forestfloor/), by explicitly linking biochemical P allocation with root and mycorrhizal traits under realistic dual-stress conditions, my research will: (1) advance mechanistic understanding of forest nutrient efficiency, covering both P acquisition and use under stress, (2) improve predictions of carbon–nutrient dynamics under climate change.

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