Deep roots mitigate drought impacts on tropical trees despite limited quantitative contribution to transpiration

JournalArticle (Originalarbeit in einer wissenschaftlichen Zeitschrift)

ID 4684102
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Year 2023
Title Deep roots mitigate drought impacts on tropical trees despite limited quantitative contribution to transpiration
Journal The science of the total environment
Volume 893
Pages / **Article-Number** 164763
Keywords Biosphere 2, Drought resistance, Plant-water relations, Root water uptake depth, Water content, Water stable isotopes
Deep rooting is considered a central drought-mitigation trait with vast impact on ecosystem water cycling. Despite its importance, little is known about the overall quantitative water use via deep roots and dynamic shifts of water uptake depths with changing ambient conditions. Knowledge is especially sparse for tropical trees. Therefore, we conducted a drought, deep soil water labeling and re-wetting experiment at Biosphere 2 Tropical Rainforest. We used in situ methods to determine water stable isotope values in soil and tree water in high temporal resolution. Complemented by soil and stem water content and sap flow measurements we determined percentages and quantities of deepwater in total root water uptake dynamics of different tree species. All canopy trees had access to deep-water (max. uptake depth 3.3 m), with contributions to transpiration ranging between 21 % and 90 % during drought, when surface soil water availability was limited. Our results suggest that deep soil is an essential water source for tropical trees that delays potentially detrimental drops in plant water potentials and stem water content when surface soil water is limited and could hence mitigate the impacts of increasing drought occurrence and intensity as a consequence of climate change. Quantitatively, however, the amount of deep-water uptake was low due to the trees' reduction of sap flow during drought. Total water uptake largely followed surface soil water availability and trees switched back their uptake depth dynamically, from deep to shallow soils, following rainfall. Total transpiration fluxes were hence largely driven by precipitation input.

ISSN/ISBN 0048-9697
URL https://www.sciencedirect.com/science/article/pii/S0048969723033867?via%3Di hub
Full Text on edoc ;
Digital Object Identifier DOI https://doi.org/10.1016/j.scitotenv.2023.164763