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Tropical rainforests under severe drought stress: distinct water use strategies among and within species

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Increasing drought in the tropics is a major threat to rainforests and can strongly harm plant communities. Understanding species-specific water use strategies to drought and the subsequent recovery is therefore important for estimating the risk to tropical rainforest ecosystems of drought. Conducting a large-scale long-term drought experiment in a model rainforest ecosystem (Biosphere 2 WALD project), we evaluated the role of plant physiological responses, above and below ground, in response to drought and subsequent recovery in five species (3 canopy species, 2 understory species). The model rainforest was exposed to a 9.5-week lasting drought. Severe drought was ended with a deep water pulse strongly enriched in ^{2}H, which allowed us to distinguish between deep and shallow rooting plants, and subsequent rain (natural abundance range of ^{2}H). We assessed plant physiological responses by leaf water potential, sap flow and high resolution monitoring of leaf gas exchange (concentrations and stable isotopes of H_2O and CO_2). Thereby, we could derive plant water uptake and leaf water use efficiency (WUE_{leaf}) in high temporal resolution, revealing short-term and long-term responses of plant individuals to drought and rewetting. The observed water use strategies of species and plants differed widely. No uniform response in assimilation (A) and transpiration (T) to drought was found for species, resulting in decreasing, relatively constant, or increasing WUE_{leaf} across plant individuals. While WUE_{leaf} of some plant individuals strongly decreased due to a breakdown in A, others maintained relatively high T and A and thus constant $WUE_{leaf,}$ or increased WUE_{leaf} by decreasing T while keeping A relatively high. We expect that the observed plant-specific responses in A, T and WUE_{leaf} were strongly related to the plant individuals' access to soil water. We assume that plant individuals with constant WUE_{leaf} could maintain their leaf gas exchange due to access to water of deeper soil layers, while plants with increasing/decreasing WUE_{leaf} mainly depended on shallow soil water and only had limited or no access to deep soil water. We conclude that the observed physiological responses to drought were not only determined by species-specific water use strategies but also by the diverse strategies within species, mainly depending on the plant individuals' size and place of location. Our results highlight the plasticity of water use strategies beyond species-specific strategies and emphasize its importance for species' survival in face of

climate change and increasing drought.