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Are tall trees more sensitive to prolonged drought in tropical per-humid forests?

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Seasonality of water flux was investigated for common tree species of a Central Sulawesi pre-montane perhumid forest located in the Lore Lindu National Park. Trees were exposed to reduced soil water levels under a rainfall exclusion experiment (Sulawesi Throughfall Displacement Experiment, STD), to simulate drought effects and to monitor species-specific short-term responses to extended water stress. Several climate scenarios predict more frequent occurrence of ENSO droughts with increasing severity induced by global warming. Detailed assessments of the ecological consequences of droughts in perhumid forests are scarce and knowledge whether and how these ecosystems are adapted to severe droughts is limited.

Key research questions were: (1) how do tall rainforest trees cope with long pathways under low evaporative demand, (2) how sensitive are trees from tropical perhumid forests and how do they acclimate to drought-stress and 3) does wood density determine the drought sensitivity of perhumid forest trees?

From June 2007 until October 2009 we monitored 95 trees from 8 common tree species. Half of them were located under the STD Experiment and the other half in control areas. We used the constant heated method to continuously monitor stem xylem flux density and conduct parallel measurements of xylem anatomy and hydraulic conductivity in twigs, stems and roots.

After almost 22 months of experimental drought only 25% of xylem flux density reduction was observed in the experimental trees. But the reaction to water stress was species-specific and in some species xylem flux went down to 50 % compared to the individuals located at the control plots.

Wood density did not correlate with any hydraulic measurement, but anatomy and hydraulic architecture observations showed a positive correlation between xylem conductivity and vessel size with tree height. These results reveal a well adapted hydraulic system of tall canopy trees allowing for highly efficient water flow under conditions of low atmospheric evaporative demand at the cost of cavitation security. But this is contradictory to the low reduction in xylem flux density with drought since tall trees undergo the risk of cavitation by having large vessels. With drought these vessels should be easily embolized and we should have observed a clear reduction in xylem flux.