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Species-specific drought responses and the influence on the catchment scale carbon and water cycle

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Trees and forests are sensitive to the local soil moisture conditions, but as they transpire water whenever their stomata are open, they influence local soil moisture conditions. Experimental data from a mature deciduous forest suggest that tree species transpiration responded differently to severe soil moisture conditions. Here we investigate how these species specific differences in transpiration influence soil moisture conditions in the short-term and species carbon uptake and hence competition in the long-term. We used the ecosystem model LPJ-GUESS and implemented the observed differential drought stress response. The reduction in ecosystem evapotranspiration on days with low soil moisture was considerable for the species that reduced transpiration, but less important for other species or mixed forests. This pattern could be reversed during prolonged droughts, because reduced water uptake earlier in the drought may result in higher water availability later on. This implies that tree species with lower transpiration rates during drought can maintain a positive carbon balance during longer drought periods and prevent carbon starvation. We found that the long-term trends in tree diversity differed depending on the assumptions about the amount of drought-induced transpiration response, root and rooting depth, and the length and characteristics of the drought periods.We illustrate how an ecosystem model can be used to scale up experimental finding to a larger scale and estimate the consequences at larger scales and longer time periods.