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Using isotopes to understand evaporation, moisture stress and re-wetting in forests and grasslands in the summer drought of 2018.

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To improve understanding of soil-plant-atmosphere interactions during drought conditions, we used isotope techniques in conjunction with soil, groundwater, vegetation and hydroclimatic monitoring in the mixed land-use Demnitz Mill Creek (DMC) catchment (69 km^2) in NE Germany. As the drought developed in summer 2018, we monitored spatially distributed patterns of drying soils, falling groundwater levels and decreasing stream flows. We further sampled stable isotopes in precipitation, throughfall, xylem water, soil water, streamwater and groundwater. As the drought evolved, isotopic signatures showed increased fractionation signals in the upper 25cm of the soils; this was most marked in forest areas. This indicated on-going evaporative losses, even as sap flow monitoring showed that transpiration was suppressed. Under forest, soil profiles were drier and water had a more depleted isotopic signature, likely reflecting lower net precipitation due to interception. Cessation of recharge resulted in falling groundwater levels and the termination of stream flows by mid-summer. Autumn re-wetting of the system replenished soil moisture deficits, though fractionated signatures in soil waters remained. However, long term (>30 years) hydrometric records showed that the recovery of groundwater levels and re-establishment of stream flow was significantly delayed. Isotopes have proven invaluable tools for understanding and modelling water use by different forest and crop stands in drought conditions. Such insight will be invaluable for developing land management strategies to build resilience to the increased probability of warmer, drier summers in future.