Deep moisture measurements give insight into dry-season hydrology of a parkland agroforestry system in the Sahel

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The native woody shrub *Guiera senegalensis* grows throughout the Sahel and is an integral part of a highly successful parkland agroforestry system that helps buffer rain-fed millet and peanut crops against frequent moisture stress in nutrient poor sandy soils. The shrubs improve access to nutrients and moisture through their function as "resource islands" with elevated microbial activity, the existence of hydraulic lift, and changes to soil properties. Part of the success of using this agroforestry system relies on planting an increased density (1500-1800 individuals ha^{-1}) of shrubs in agricultural fields compared to their native distribution on the landscape (230-410 individuals ha^{-1}). Using a deep (3m) moisture sensor monitoring network from 2012-2015, we show that shrubs utilize moisture from below 2m depth for 7-9 months of the dry season, depending on the year. In this preliminary study using a combination of published literature, field data, and a 1-D hydrologic model (HYDRUS) we investigate the effects of increased shrub density on moisture use below 2m. The maximal daily moisture use during the dry-season amounts to 0.0025-0.0035 m^3m^{-3} over a depth range of 1m, or approximately 2.5-3.5 mm day^{-1} near the shrubs. This study helps us predict the local hydrologic response to shrub manipulation and can help inform shrub management recommendations in an optimized agroforestry system moving forward.