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Determinants of tree water use across a floodplain in arid, subtropical northwest Australia

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Riparian zones of ephemeral streams in hot arid regions are subject to unpredictable and generally short-lived flood periods. However, droughts tend to be longer and more severe than floods in their ecological impact as low water availability in surficial alluvium and on the floodplain results in hydrological stress. Resolving how riparian and floodplain vegetation respond to highly variable flow regimes remains a fundamental challenge for estimating water budgets in arid regions, particularly where water tables are subject to groundwater abstraction.

Here, we investigated patterns of water use by a range of tree species (Eucalyptus camaldulensis, E. victrix, Acacia citrinoviridis, A. coriacea, Hakea lorea, Atalaya hemiglauca) across a floodplain in the Pilbara region of northwest Australia and assessed vegetation responsiveness to both temporal and spatial variation in water supply. We sought to disentangle the varying contributions of soil water, groundwater and surface water to tree water use to determine the ecological implications of changes in hydrologic connectivity resulting from both seasonal water deficits and anthropogenic management. Diurnal and seasonal dynamics of water use were assessed using sapflux measurements coupled with observations of changing source availability. Source utilization was examined using water stable isotope compositions of xylem, soil, rain, surface water and groundwater. Depending on distance from the stream channel and time since last rainfall, we found that small trees were primarily accessing shallow soil water of meteoric origin while larger eucalypts accessed water deeper in the profile (either stored soil water or groundwater), especially as surface soils dried out. However, tree species were highly variable in their diurnal patterns of water use,including some evidence of nocturnal sapflux in A. coriacea adjacent to streams. Sapflux rates also varied almost four-fold among species but generally declined with increasing depth to watertable i.e on to the floodplain.

Ongoing studies are investigating how hyporheic zones expand and contract in response to episodic flows and vegetation water use in order to develop an integrated 3D hydrological/ecohydrological model to explore relationships between regional and local water tables, surface water flows, and evaporative and evapotranspiration fluxes. New insights into the biological, ecological and physical processes that control the flow of water between the biotic and abiotic compartments of ephemeral streams will be used to target specific aspects of flow regimes that are critical to maintaining riparian and floodplain ecosystems in dryland environments, particularly where streams are subject to altered hydrology.