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Identifying and mapping groundwater dependent ecosystems from phenological behaviour in time series of satellite imagery in the Northern Territory

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Abstract: Groundwater dependant ecosystems (GDEs) are ecological assets that depend upon groundwater for some or all of their needs. GDEs include vegetation, wetlands and other biological communities which do not have a reliable surface water source. In the Northern Territory (NT), many aquifers in the region support vegetation that relies on groundwater. Identifying and mapping these groundwater-dependent ecosystems (GDEs) is essential for effective groundwater management.

The occurrence of terrestrial GDEs in remote areas of the NT is poorly known, partly because traditional approaches that rely on vegetation indices from remote sensing imagery cannot readily distinguish between vegetation sustained by groundwater and vegetation that responds primarily to rainfall. These methods generally lack the temporal depth needed to capture long-term vegetation behaviour.

In this study, we present an adaptation of a novel, data-driven methodology that overcomes these limitations by analysing long-term phenological behaviour of vegetation, which has been used to map GDEs in the NT (Brim Box et al, 2022). The method uses a variety of satellite-derived vegetation indices (NDVI and similar) time series from Geoscience Australia's Open Data Cube, and matrix decomposition techniques to identify persistent vegetation greenness that is statistically decoupled from rainfall variability (Box & Brim Box et al., 2025).

Our study area is the Oolloo Dolostone aquifer within the Daly Basin covering an area of around 5,277 km² (~165 km long, ~50 km wide). Groundwater levels in the aquifer range from 5-40 m below ground level. In the basin we assume a maximum rooting depth of 15 m below ground.

To improve validation of the phenological separation methodology, we integrate daily rainfall data from the SILO database and groundwater depth time series from NT monitoring bores within the study area. Where aquifers are greater than ~15 m below ground level we expect temporal patterns in NDVI and other vegetation indices to be strongly correlated with rainfall. Transpiration losses and phenological patterns in known GDE areas are relatively independent of rainfall. Our study demonstrated that these areas are likely to correspond with shallow groundwater levels of less than 10 m below ground level, observed in adjacent bore records. Where we find vegetation that apparently behaves independently of rainfall in areas where the aquifers are deep, this may be an indicator of perched aquifers or local topographical conditions that allow for extended storage of water and indicate need for further field verification. The multi-source integration reinforces the ecological signal of groundwater dependency.

The workflow in this project is scalable and can be applied anywhere in the NT. It is cost-effective and built entirely on open-source tools and publicly available data. This approach provides a significant advancement in identifying terrestrial GDEs and supports evidence-based groundwater management in regions with limited ground-truthing capacity.

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