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Assessing the contribution of hydrologic and climatic factors on vegetation condition changes in semi-arid wetlands: An analysis of the Narran Lakes

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Abstract: Semi-arid wetlands often serve as a critical habitat and refuge for a wide range of species. Among the dynamic changes in such water-limited ecosystems, vegetation plays a crucial role in interacting with eco-hydrological processes including canopy interception, evapotranspiration, and infiltration. As a result, vegetation is an important indicator of wetland health with the function of maintaining semi-arid wetland ecosystem services.

Degradation of vegetation is a pressing environmental concern under changing environments and human activities, particularly in semi-arid wetlands. For instance, a significant decrease in vegetation condition or shift in species composition can result from an altered flow regime in such an ecosystem. In this sense, an understanding of the vegetation condition and its driving factors is necessary to inform effective management to maintain ecosystem integrity.

In many wetlands, on-ground monitoring of vegetation is neither comprehensive nor available. However, basic data on climate variables and hydrological monitoring as well as remote sensing information can often be acquired. The Narran lakes system, a Ramsar-listed wetland in the lower Balonne catchment, is an international exemplar in this category.

In this study, we first collected hydro-climatic monitoring data and Moderate Resolution Imaging Spectrometer (MODIS) Normalized Difference Vegetation Index (NDVI) products in the Narran Lakes over a reasonably long-term period, from 2000 to 2021. Then we conducted correlation analysis between the anomaly of NDVI as the response variable and hydro-climatic factors including inflow, precipitation, temperature, solar exposure, soil moisture (ERA5-Land), as explanatory variables taking into account time-lag and accumulation effects. The generalized additive model (GAM) framework was used to identify the contribution of the individual variables to NDVI. We further examined the non-linear interactions of the water availability factors on NDVI change using tensor product and factor-smooth interaction terms within the Narran Lakes.

The results suggest that: (1) soil moisture is the primary factor influencing NDVI; (2) water availability factors, including soil moisture, precipitation, and inflow interact in a complex manner to affect NDVI; (3) the impact of the hydrological and climatic factors is highly variable between wet and dry resource states, both for the whole floodplain and its lignum community. Overall, the analysis improved our understanding of how the driving factors affect vegetation growth, thus supporting the monitoring and management of vegetation communities in the Narran Lakes.

Keywords: *Narran Lakes, semi-arid wetlands, vegetation, NDVI, generalized additive model*