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# Patterns of vegetation greenness during flood, rain and dry resource states in a large, unconfined floodplain landscape

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ABSTRACT

Floodplains are multi-state systems in which vegetation distribution is associated with the presence or absence of water as a resource. Less is known about the associations between the presence and absence of water and vegetation productivity. We examined patterns of vegetation productivity in a large (10 519 $km^2$) unconfined floodplain during flood, rain and dry resource states. Mosaics of vegetation greenness were derived at two scales using the Normalized Difference Vegetation Index: a whole-of-landscape scale and a geomorphic unit scale with a riparian and floodplain unit. The NDVI was also calculated within *a-priori* vegetation community types within the floodplain. In all resource states over 50% of the floodplain showed no discernible vegetation greenness. When water is added as rain or flooding vegetation greenness increases, but the highest greenness occurs in the flood state. Trees situated in the riparian geomorphic unit maintain greenness during the dry resource state, whereas grasses situated in the floodplain contribute greenness during rain and flood resource states, with the highest greenness in the flood resource state. Aligned with views that dryland floodplains are boom-bust ecosystems, we suggest that flooding is a fundamental driver of vegetation productivity in this unconfined floodplain, contributing functional heterogeneity to the landscape.

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## 1. Introduction

Flooding is a key driver of the heterogeneity of floodplain ecosystems. Floods erode and deposit sediment, remove and introduce woody debris, transport and transform nutrients, trigger the reproductive cycles of many organisms, stimulate biomass production, prompt migration, influence population dynamics and community composition, create geomorphological features and support human uses such as agriculture and recreation (Tockner and Stanford, 2002). However, floods are not the only mechanism by which water is delivered to floodplains. Floodplains may be wetted during rainfall events that do not cause overbank floods. Floodplains may also exist for long periods in a dry state, with limited surface moisture. Thus, floodplains are multi-state systems where structure and function may change according to the presence or absence of water as a resource. It is important to understand floodplain heterogeneity during different resource states because floodplains are highly variable (Leigh et al., 2010) and, particularly in semi-arid areas, such ‘boom and bust’ cycles are presumed to be central to floodplain-river ecosystem integrity (Bunn et al., 2006; Leigh et al., 2010; McClain et al., 2003).

Much is known about the way that the presence or absence of water influences patterns of vegetation distribution in floodplain landscapes. Associations between the distribution of floodplain vegetation and hydro-geomorphic factors such as flood frequency, inundation duration, substrate disturbance, soil nutrients and large wood deposition have been demonstrated across floodplain landscapes (e.g. Naiman et al., 2005). Droughts may influence the distribution, composition and abundance of floodplain vegetation by killing species or individual plants that do not have physiological mechanisms to withstand prolonged dry periods (Lite et al., 2005). Areas of higher or more predictable rainfall may also support different vegetation communities than areas of lower or unpredictable rainfall, or localized rainfall may influence the abundance and biomass of herbaceous floodplain vegetation, particularly in semi-arid areas (Reid et al., 2011). Groundwater may also influence the distribution and composition and productivity of floodplain vegetation (Jones et al., 2008; Martinet et al., 2009). Implicit in the relationship between the presence and absence of water and vegetation distribution in floodplains is that flooding also influences vegetation productivity (e.g. Balian and Naiman, 2005), although we know little about comparative patterns of vegetation productivity in floodplain landscapes during flood, rain and dry resource states.

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Patterns of vegetation productivity during flood, rain and dry resource states may also differ among floodplain types. Valley setting and physical dimensions ultimately set the boundary conditions for floodplain hydro-geomorphological character and processes (Hynes, 1975), particularly among confined and unconfined floodplains (Thoms, 2003). Relatively simple ecotonal gradients of sediment, nutrients and vegetation may occur in confined floodplains in response to flooding (e.g. Yang et al., 2011) whereas flooding may result in complex spatial patterns of sediment, nutrients and vegetation in unconfined floodplains (e.g. Thoms and Parsons, 2011; Thoms et al., 2000). Views of floodplain vegetation distribution and productivity classically focus on a narrow riparian corridor adjacent to or connected with the main river channel (Ward et al., 2002), often from a land management perspective (Richardson et al., 2012). However, such views may not encompass the full extent of unconfined floodplains, which may stretch for tens of kilometres either side of the main channel. Given the unique hydro-geomorphological character of unconfined floodplains it is important to understand patterns of vegetation productivity across the entire area of unconfined floodplains, not just in riparian areas adjacent to main channels.

Patterns of vegetation productivity can be examined at large scales in unconfined floodplains using satellite and remote sensing technologies. The Normalized Difference Vegetation Index (NDVI) measures vegetation greenness, which is related to the ability of vegetation to absorb photosynthetically active radiation (Gamon et al., 1995). Vegetation greenness has subsequently been used as a surrogate for vegetation productivity, on the basis that higher photosynthetic activity is associated with higher biomass production. The NDVI has been applied in terrestrial landscapes to examine vegetation productivity under different climate and land management conditions (e.g. Barbosa et al., 2006; Li et al., 2004; Wang et al., 2004). The NDVI has also been used in riparian zones to examine changes in vegetation condition in response to flooding (Jones et al., 2008). This study used the NDVI to examine patterns of vegetation productivity in a large (10 519 km$^2$) semi-arid floodplain landscape in flood, rain and dry resource states. We examined patterns of floodplain vegetation productivity at two spatial scales: the whole-of-landscape scale and the geomorphic-unit scale consisting of a narrow riparian corridor unit adjacent to the main channels, and a broader floodplain geomorphic unit.

## 2. Methods

### 2.1. Study area

The Condamine–Balonne catchment, located in the northern region of the Murray Darling Basin, Australia (Fig. 1), has a catchment area of 143 900 km$^2$. The Condamine–Balonne River originates in a relatively well-watered headwater region with a long-term (1889–2008) average annual rainfall of 670 mm at Chinchilla in the headwaters of the catchment, but flows for most of its length through a semi-arid to arid region with a long-term (1888–2007) average annual rainfall of 456 mm at Lightning Ridge. Most rainfall occurs in the summer months (November–April) and is influenced by monsoonal airflow across tropical Northern Australia. Mean maximum January temperature (1998–2010) is 35.8 °C and mean maximum July temperature is 19.0 °C at Lightning Ridge. On average (1998–2010) there are 15 frost days per year at Lightning Ridge, occurring mostly in July.

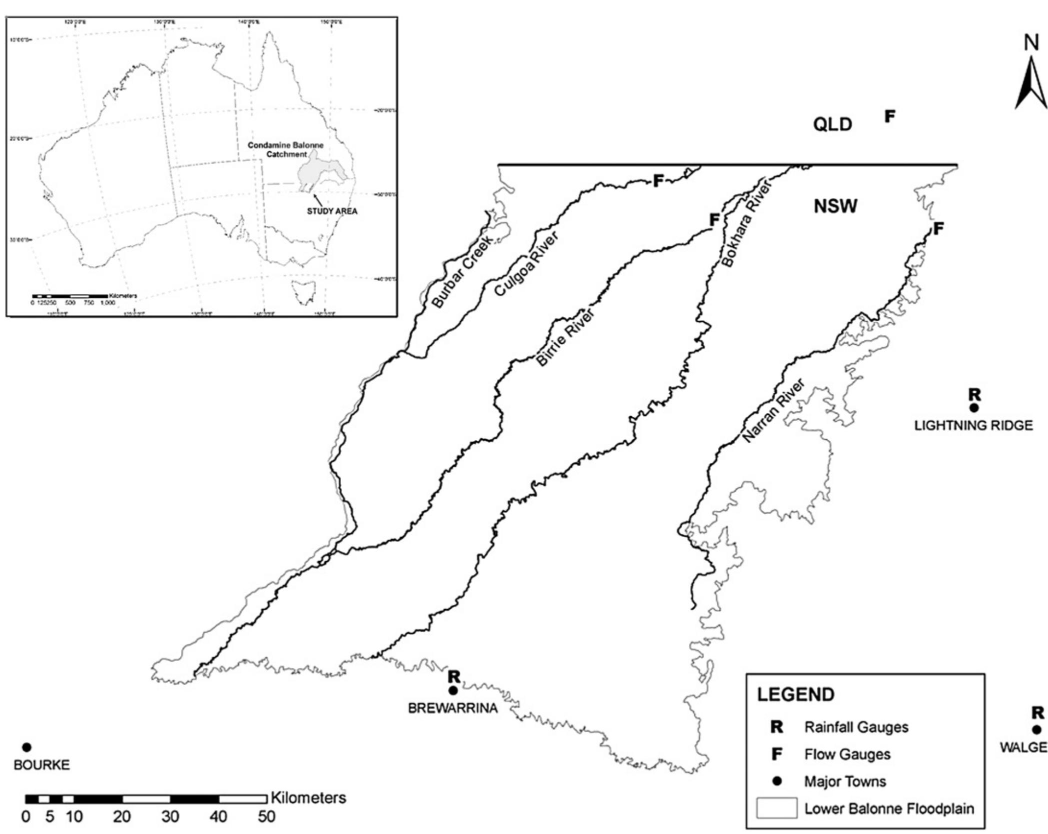


**Fig. 1.** Location of the Lower Balonne floodplain study area within the Condamine–Balonne catchment showing the main river channels and the locations of the rainfall and flow-gauging stations used to identify flood, rain and dry events.

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