Journal of Arid Environments 154 (2018) 51–60

Contents lists available at ScienceDirect

Journal of Arid Environments

journal homepage: www.elsevier.com/locate/jaridenv

# Vegetation and seed banks of arid ephemeral gilgai wetlands subject to contrasting grazing regimes

Richard J.-P. Davies[a,b,*], Duncan A. Mackay[a], Molly A. Whalen[a], Anita K. Smyth[b,c]

[a] School of Biological Sciences, Flinders University of South Australia, G.P.O. Box 2100, Adelaide, South Australia 5001, Australia
[b] Formerly CSIRO Sustainable Ecosystems, PO Box 2111, Alice Springs, Northern Territory 8701, Australia
[c] TERN, University of Adelaide, Adelaide, South Australia 5005, Australia

ARTICLE INFO

*Keywords:*
Seasonal variation
Palatability
Rangeland condition
Facilitation
Drought
Grazing impact

ABSTRACT

Ephemeral gilgai wetlands of the stony-plains of arid Australia have a relatively high diversity of native plant species and are extensively utilised for livestock grazing. We sampled the standing vegetation (SV) and germinable soil seed bank (SSB) of 40 gilgais, comparing gilgais near and far from watering points, and continually stocked versus rarely stocked. Despite historically heavy stock grazing, we found no significant differences in native species richness between treatments, indicating the general resilience of gilgai vegetation. One contributing factor is the abundance of *Atriplex nummularia* ssp. *omissa*. Cover of this long-lived shrub did not differ significantly between treatments and was positively correlated with "highly palatable" species' cover, suggesting that it may act as a nurse species. In contrast, two other long-lived species, *Atriplex vesicaria* and *Astrebla pectinata*, had significantly reduced cover or were absent near to watering points. These and other long-lived species had a poorly developed SSB and thus limited ability to regenerate from seed if killed by sustained heavy grazing. The absence of fifteen locally rare species (including 12 short-lived species) from water-near gilgais indicates the need for more intensive survey to determine whether the proliferation of watering points poses a threat to such species.

## 1. Introduction

Artificial watering points are critical for stock grazing in arid rangelands where permanent waters are scarce or non-existent (Fensham and Fairfax, 2008), but the concentration of grazing pressure around such waterpoints can have an impact on native plant communities (Landsberg et al., 2002). Because of the need for stock to drink daily in dry and hot conditions, grazing intensity and therefore impact are greatest close to watering points (the "sacrifice zone") and decreases with distance from water (Landsberg et al., 2003), forming a distinct grazing gradient (Fensham and Fairfax, 2008). In arid rangelands, cattle spend on average less than 5% of their time more than 6 km from water points, especially in hot, dry conditions, and thus such areas are infrequently grazed (Fensham and Fairfax, 2008).

Severe localised degradation occurred around waterholes in the arid regions of Australia during the nineteenth century when large numbers of stock were provided with few artificial watering points (James et al., 1999). Contemporary pastoral management has changed in response to the invention of polypropylene piping, with more watering points, each carrying fewer head of cattle (James et al., 1995). The aim is to reduce damage to soil and vegetation structure near watering points. The proliferation of water points has resulted in water-remote areas becoming rare across extensive areas of the Australian arid rangeland with few areas more than 6 km from water (Fensham and Fairfax, 2008; James et al., 1999). This is of concern for biodiversity conservation since there is evidence that some plant species show patterns of declining abundance nearer to water, both in the standing vegetation (SV) and the germinable soil seed bank (SSB) (Landsberg et al., 1999). The issue of whether some plant species can only persist at water-remote sites is more contentious. While Landsberg et al. (2003) found the number of species that occurred only once was greatest at the sites furthest from water, Fensham and Fairfax (2008) questioned whether these findings may be statistical artefacts resulting from inadequate sampling.

Heavy grazing can result in the replacement of palatable perennial plants by short-lived species (James et al., 1999; Diaz et al., 2007). This has been explained by short-lived species being in disequilibrium with grazing pressure by being able to complete their life cycle rapidly before grazing impacts on them (Fensham et al., 2010). It is hypothesised that the adaptations of ephemeral species to unreliable rainfall

* Corresponding author. School of Biological Sciences, Flinders University of South Australia, G.P.O. Box 2100, Adelaide, South Australia 5001, Australia.
*E-mail address:* richard.davies@flinders.edu.au (R.J.-P. Davies).

https://doi.org/10.1016/j.jaridenv.2018.03.006
Received 30 July 2017; Received in revised form 6 March 2018; Accepted 13 March 2018
Available online 26 March 2018
0140-1963/ 

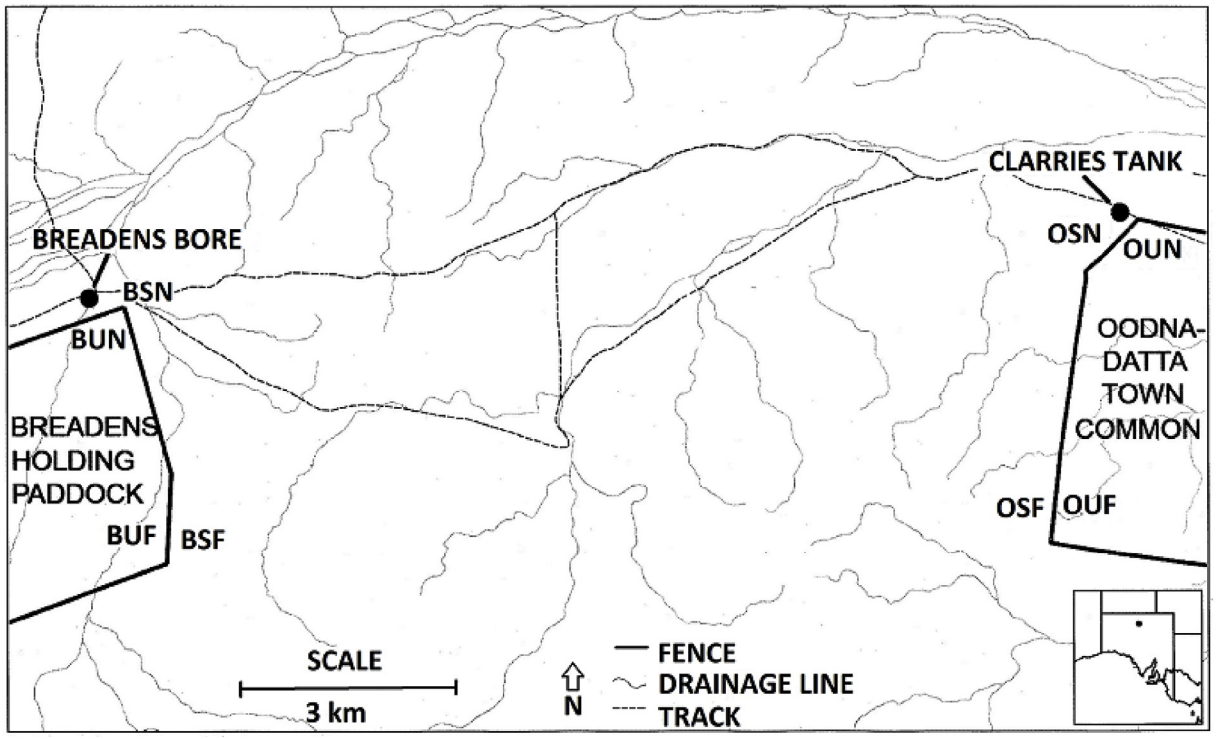


**Fig. 1.** Map of Oodnadatta Town Common (O) and Breadens Holding Paddock (B) showing layout of waterpoints and sampling sites for each treatment (SN = stocked & near-to-water, UN = unstocked & near-to water, SF = stocked & far-from-water, UF = unstocked & far-from-water).

effectively also serves as an adaptation to surviving grazing pulses (Silcock and Fensham 2013). Yet some short-lived species also appear to be sensitive to grazing pressure (Landsberg et al., 1999). High levels of grazing in arid rangelands can decrease total seed densities (Navie et al., 1996), and alter the composition (Kinloch and Friedel, 2005) and relative abundances of species in the SSB (Kinucan and Smeins, 1992; Landsberg et al., 1999; Meissner and Facelli, 1999; Navie et al., 1996).

Understanding the ecology of short-lived plant species in arid rangelands is essential because these species often comprise most plant species in such habitats (Brandle, 1998; James et al., 1995; Landsberg et al., 2003; Waudby and Petit, 2015) and dominate the ground stratum after significant rainfall events (Waudby and Petit, 2015). Studying the effect of grazing on the SSB of short-lived species is important since these species are usually present in the arid zone only as seed (Inouye, 1991; Kinloch and Friedel, 2005) and often do not have other mechanisms to survive dry periods (Thompson, 1992).

This study differs from most other arid rangeland studies in that we examined both the SV and SSB of ephemeral gilgai wetlands, and did this during a period of extreme, prolonged drought, when abundances of plant species in both the SV and SSB would be expected to be at their lowest. We examined the impact of long-term grazing on the composition and species richness of both the SSB and SV, as well as on the cover and soil-borne seed density of each species.

The study examined three questions: 1) How does the composition and abundance of plant species differ between the SV and SSB during prolonged severe drought; 2) how are these measures affected by distance from water; and 3) do any differences persist when the gilgais are largely spelled from grazing (only very infrequently grazed) for several decades?

## 2. Methods

### 2.1. Study area, grazing history and climate

This study was conducted in the cracking-clay gibber-gilgai system of South Australia's Stony Plains region, chosen for its high biodiversity values and for pastoralism's reliance on the dense flushes of ephemeral plants it supports in wet years (Brandle et al., 1999; Waudby and Petit, 2015). This landform consists of extensive shelves of stone pavements on flats, rises and plateaux, interspersed with gilgai depressions (Jessup, 1960). The soils of the stone pavements have extremely low rates of water infiltration, leading to runoff into adjacent gilgai depressions in which cracked soil surfaces typically facilitate water infiltration (Hunter and Melville, 1994). Gilgai soils can thus become wet after relatively small rainfall events and can hold water for extended periods of time after heavy and prolonged rainfall events (Waudby and Petit, 2015), although inundation occurs erratically and infrequently due to the aridity and highly irregular rainfall pattern of the region (Stafford Smith and Morton, 1990) and the catchments for each gilgai being very localised. This concentration of run-off enables gilgai vegetation to regenerate readily following relatively small rainfall events, making such vegetation particularly important for the pastoral industry during the frequent extended dry periods (Brandle, 1998).

While the gibber pavement between the gilgais is largely devoid of vascular plants, the gilgai depressions support a high diversity of flora characteristic of both semi-arid tropical and temperate regions, and of both wetland and dryland habitats (Brandle, 1998). The long-lived shrub *Atriplex nummularia* subsp. *omissa* dominates the sparse perennial overstorey. The ground stratum is most frequently dominated by the perennial grasses *Astrebla pectinata* and *Eragrostis setifolia*, with short-lived grasses and forbs also abundant during wetter times (Waudby and Petit, 2015).

Our study was undertaken at two locations in northern South Australia – one adjacent to the eastern boundary of Breadens Holding Paddock (referred to as "BHP" below) within a cattle pastoral lease (Todmorden Station; 7169 $km^2$) and another adjacent to the western boundary of Oodnadatta Town Common ("OTC") a nearby public reserve, where it abuts the same lease (Fig. 1). Historically, grazing rates were up to 600 head of cattle per watering point, compared with contemporary rates of 50–100 head over each of 30 watering points (G. Lillecrapp, pers. comm., 2006) which is average for pastoral leases in this bioregion (Stony Plains; Bastin, 2008).