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The seed bank as a mechanism for resilience and connectivity in a seasonal unregulated river

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ABSTRACT

The seed bank of a seasonally flowing river was sampled to assess ecosystem resilience and evidence of connectivity. Seed banks were sampled from 'Floodplain', 'Top of Bank' and 'In Channel' hydrogeomorphic areas in seven reaches of the Wannon River, and the distribution of species and water plant functional groups (WPFGs) among these sites was assessed. The seed bank material was exposed to two treatments (damp and flooded) to stimulate germination of terrestrial (Tdr Tda), flooding-tolerant (ATe, ATl, ARp, ATw) and flooding-dependent (ARf, Se, Sr, Sk) species. There was a high degree of similarity among seed banks from all parts of the river, and all hydrogeomorphic areas. Few species were restricted to any one area (i.e., 'In Channel', 'Top of Bank', 'Floodplain') or any one reach of the river. This indicates that the wetland areas of the Wannon River have a high degree of longitudinal and lateral connectivity, and the riparian zone retains the capacity to provide resources to wetland fauna, even with large variation in the natural flow regime and long-term agricultural land-use. Provided the seed bank remains intact, the perennial vegetation is allowed to regenerate, and a natural flow regime is maintained, seasonal rivers like the Wannon are likely to be resilient to the consequences of climate change, despite the surrounding agricultural land-use and the influx of saline ground-water.

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1. Introduction

This study aimed to determine the character and content of a riparian wetland seed bank, in different hydrogeomorphic zones, and in different reaches of a seasonal river impacted by c.180 years of agricultural activity. Riparian zones throughout the world have been the focus of agricultural activity over millennia. High soil fertility and proximity to a permanent source of water have made these areas desirable for grazing and cropping agriculture (Jansen and Robertson, 2001; Van der Valk et al., 2009). However, agricultural activity is a major alteration of riparian zones, and can impact negatively on riparian biodiversity, landscape connectivity, the capacity of the floodplain to provide ecosystem services (such as flood mitigation, carbon cycling and habitat) and can contribute to sedimentation and poor water quality downstream (Robertson, 1997; Casanova, 2007). The capacity of riparian vegetation to regenerate after disturbances (its resilience) is dependent on the presence or dispersal of seeds and propagules of flooding-tolerant species (Van der Valk et al., 2009; Nicol and Ward, 2010). In many cases a bank of geminable seeds provides this resource (Van der Valk et al., 2009; Brock and Rogers, 1998; Brock, 2011). Examination of riparian seed banks can provide information about the past and present species composition of riparian communities (Boudell and Stromberg, 2008; Reynolds and Cooper, 2011), resilience of plant communities (Brock, 2011), their linear connectivity (i.e., along the run of the river) (Bornette and Arens, 2002) and their lateral connectivity (i.e., across different hydrogeomorphic zones within the same site on the river) (Brock and Rogers, 1998). An assessment of the seed bank can give a measure of ecosystem response to change (Reynolds and Cooper, 2011), response to disturbance (Brock, 2011) and potential community composition when water is available.

There have been relatively few seed banks studies in riparian zones of seasonal or ephemeral rivers (e.g., Pettit and Froend, 2001; Capon and Brock, 2006; Nicol and Ward, 2010), compared to the number of studies in lakes or wetlands (van der Valk and Davis, 1978; Leck and Simpson, 1987; Brock and Casanova, 1997; Casanova and Brock, 1990; Brock et al., 2003; Nicol et al., 2007), or regulated rivers (Goodson et al., 2001; Bornette and Arens, 2002). Results from these few studies on temporary systems indicate that the seed bank and the extant vegetation can be quite different from

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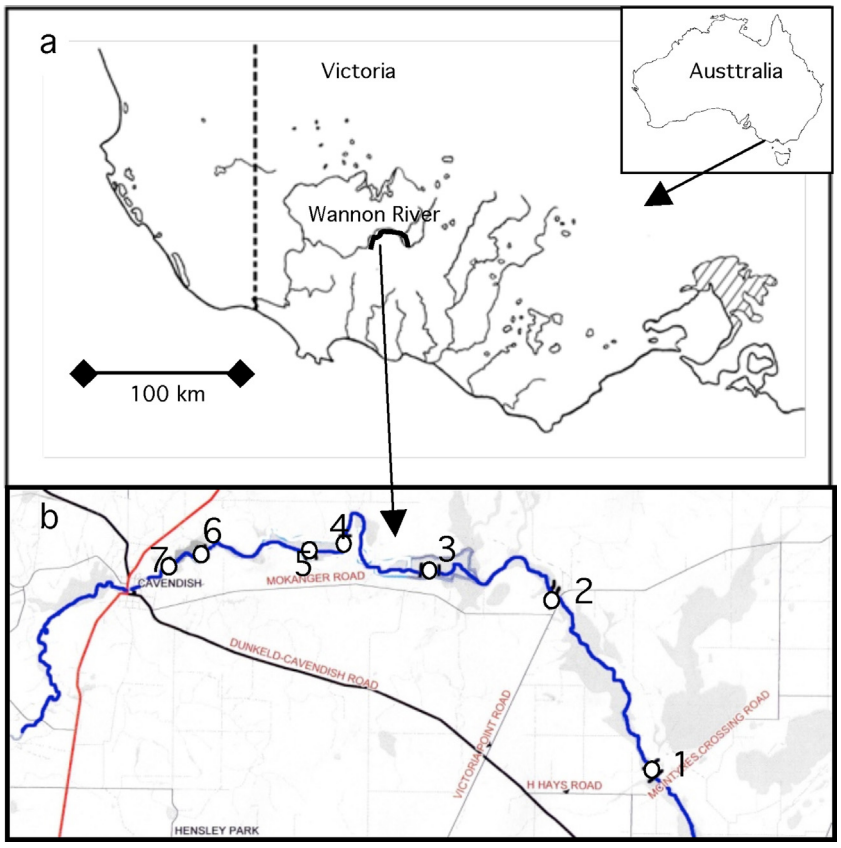

Fig. 1. (a) Map of the Wannon River in Western Victoria, Australia. Lines indicate major drainage lines and wetlands, the hatched site is urban Melbourne. Reaches are within the highlighted area, (b) location of sampling reaches on the Wannon River.

each other. The species composition and diversity of the extant vegetation can differ from the seed bank in relation to successional events (van der Valk and Davis, 1978; Abernethy and Willby, 1999), and the degree to which the system is disturbed (Thompson and Grime, 1979McGraw, 1987Leck and Simpson, 1987; Leck and Simpson, 1995 Capon and Brock, 2006). High similarity can be a consequence of a high frequency of natural disturbance and dominance of annual or ephemeral species in the extant vegetation, low similarity can indicate a lower frequency of disturbance and dominance of perennial species, or species with different regeneration strategies.

The largest rivers with the most reliable flow in southern Australia have been dammed for 50–150 years, and most of the remaining riparian systems have been considered generally uneconomic for damming. In southern-flowing riparian systems of south–west Victoria (a region with relatively reliable winter-spring rain: DSE, 2013) there is only one major dam (Rocklands reservoir) on the Glenelg River. The other major watercourses (the Hopkins River, Fiery Creek, Mt Emu Creek, tributaries of the Glenelg River and smaller coastal river systems) have relatively un-modified water regimes, and are free to flood and dry depending on the regional climate (WRSWS, 2010). Although the region is considered an area of reliable rainfall, its climate has been highly variable in the last 15 years, experiencing the 'Millennium Drought' (1997–2010), the largest floods on record (2010–2011), and the driest continuous 7 months on record (Oct. 2012–Mar. 2013) in relation to records covering the last 150 years (BOM, 2013). Given the likelihood that the region will experience higher variability and more extremes into the future (DSE, 2013), we aimed to determine the resilience and restoration potential of one of these un-regulated rivers through assessment of one of the mechanisms of resilience and response: germination from the seed bank.

The composition and characteristics of the seed bank conevey resilience to change through diversity (number of species, and number of functional groups of species), abundance (density of seeds of different species) and a capacity to respond (temporally and to different stimuli).

Additionally, the similarity of the seed bank and the extant vegetation along the river (among reaches), and across the river (among hydrogeomorphic areas) was compared to determine the degree of longitudinal and lateral connectivity within the plant community. The study site (on the Wannon River) has potential to be a natural corridor from the well-vegetated Grampians National Park to the areas of high natural value along the Glenelg River and the coast (Debus et al., 2012), so understanding the regenerative characteristics, and capacity of the vegetation to respond to disturbance or changes in management, can lead to strategies to enhance landscape connectivity.

2. Materials and methods

2.1. Study area

The Wannon River rises as a seasonal river along the Serra and the Mt William Ranges in the Grampians National Park in western Victoria (Fig. 1a). The river usually flows during winter and spring, and dries to isolated deep pools during summer and autumn. It is fed along its upper valley by a number of streams (Stockyard Creek, Second Wannon Creek, Jimmys Creek), emerging into swampy land (Walker Swamp and Bradys Swamp) before re-establishing a channel flowing west. Once past the Mt William range (Mt Sturgeon and Mt Abrupt), the river is fed by Back Creek and Dwyer Creek (through Bryan Swamp), then spreads out across a broad floodplain (100 m to >2 km wide). Between the towns of Dunkeld and Cavendish the

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