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Unpalatable neighbours reduce browsing on woody seedlings

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ABSTRACT

High levels of browsing by mammalian herbivores can negatively affect the survival and growth of seedlings, and consequently revegetation and forest regeneration outcomes. Typical forms of protection (e.g. tree guards and fencing) are costly, particularly when used in large-scale projects, therefore, low-cost alternatives are needed. Based on associational refuge theory, we assessed the revegetation technique 'cryptic planting', whereby woody seedlings are planted within the foliage of unpalatable plants to deter browsing. We established a trial where 432 six-month-old tubestock of three woody species (*Eucalyptus camphora*, *Melaleuca squarrosa* and *Leptospermum lanigerum*) were cryptically (within the foliage perimeter of unpalatable plants) or non-cryptically planted across three wetland forest sites. The plants were left for four weeks before being scored for browsing damage based on an estimate of biomass removed. To further assess cryptic planting, we surveyed 352 plants of the same three woody species two years after they were planted cryptically or non-cryptically at the same three sites, and surveyed each plant for browsing damage. Overall, cryptic planting reduced browsing damage from 37% to 22%, and from 51% to 23%, in the trial and survey, respectively. *E. camphora* plants were particularly susceptible to browsing. These results suggest that cryptic planting provides an alternative to costly tree guards and fencing and can be used to reduce browsing on woody seedlings.

1. Introduction

High levels of mammalian browsing are known to reduce the survival and growth of seedlings (Bulinski and McArthur, 1999; Horner et al., 2016). Consequently, severe browsing can negatively impact on revegetation projects by hampering restoration outcomes and reducing regeneration growth rates (Wilkinson and Neilsen, 1995). Current forms of control measures are costly (e.g. tree guards and fencing) particularly when used in large-scale projects, therefore, effective low-cost alternatives are needed.

Various control measures are used worldwide to reduce the impacts of browsers on seedlings. For example, tree guards are known to reduce browsing damage to seedlings by providing protection in the early years of growth (Kasel, 2008; Alexander et al., 2016). However, high economic costs are associated with the installation, post-planting maintenance and eventual removal of the tree guards. Similarly, while exclosures can be used to keep browsers out of areas targeted for revegetation, the installation and maintenance of fences is also costly. Lethal control is another method used to manage high populations of browsers, but ethical and safety concerns from the community may arise from such approaches, particularly when controlling populations of native browsers (Baker et al., 2007).

An alternative approach is to use plant-herbivore interactions and the traits of the surrounding vegetation to reduce browsing damage. Associational refuge theory (Pfister and Hay, 1988) suggests that unpalatable neighbouring plants can provide protection to a focal plant from browsers, thereby reducing browsing. Protection may come in the form of physical structures like thorns and spines (Hanley et al., 2007), or chemical characteristics such as toxins that influence palatability. Similar to indirect interactions whereby one species lessens the effect of another species on a third species (Sotomayor and Lortie, 2015), associational refuge also shares similarities to the concepts of facilitation and nurse plants, where one plant indirectly improves conditions for another plant (Callaway, 1995; Mandujano et al., 1998).

In south-east Australia, associational refuge is being used in wetland restoration through the planting method of 'cryptic planting', whereby seedlings are planted within the foliage perimeter of unpalatable plants to reduce post-planting mammalian browsing (Raulings et al., 2014). The term 'cryptic planting' is not evident in the literature, instead it appears to be primarily used among land managers. Nonetheless, the concepts of associational refuge and nurse plants have been used to minimise herbivory in the restoration of woodlands (Smit and Ruifrok, 2011; Stutz et al., 2015), wooded pastures (Smit et al., 2005), and in forest plantations (Miller et al., 2006). However, little is known of its efficacy to deter browsing in wetland areas.

For this study, we assessed cryptic plantings in wetland forests in

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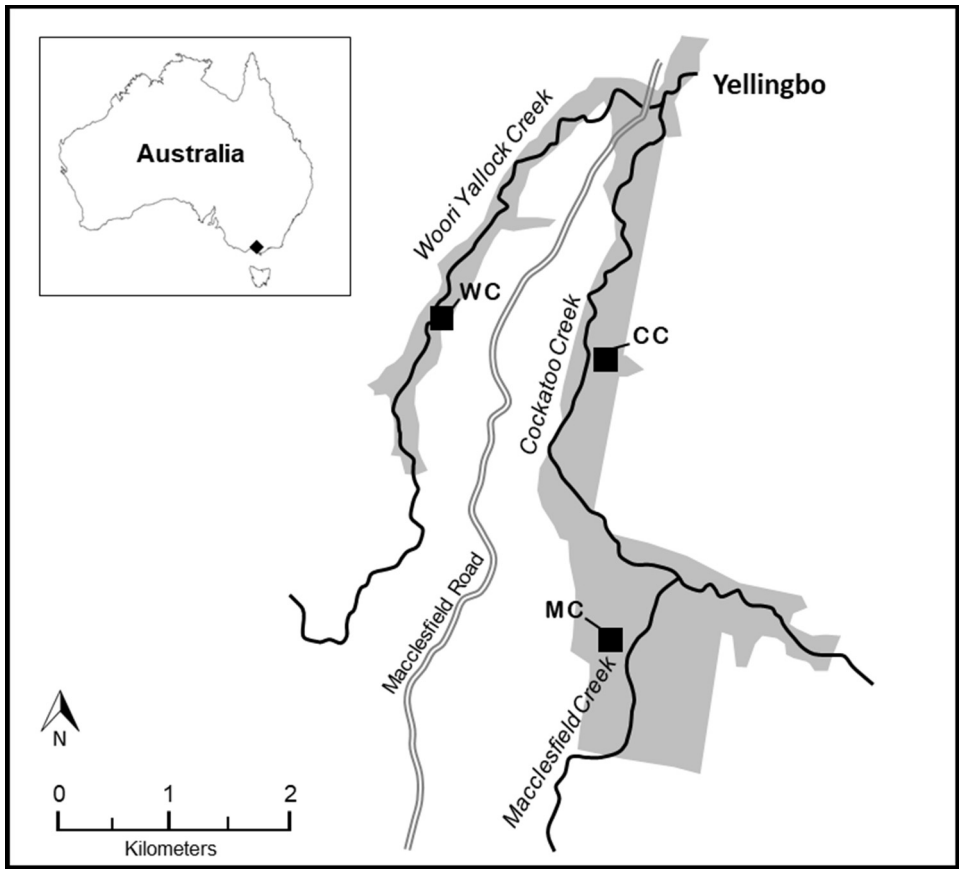

Fig. 1. Map of Yellingbo NCR with study sites denoted by black squares (WC: Woori Yallock Creek; CC: Cockatoo Creek; MC: Macclesfield Creek). Grey shading shows the extent of the reserve, black lines indicate streams, double lines indicate roads. The insert shows the location of reserve (black filled diamond) in relation to Australia.

the Yellingbo Nature Conservation Reserve (Victoria, Australia). Our research aimed to assess whether cryptic planting could be used as an effective tool for minimising browsing damage to planted woody seedlings. Using both field trial and survey methods, we assessed whether cryptic planting within sedges reduced browsing damage to planted seedlings of three woody species.

2. Material and methods

2.1. Study area

Our study was conducted at three wetland forest sites located within the Yellingbo Nature Conservation Reserve (NCR), located approximately 50 km east of Melbourne (Victoria, Australia) (Fig. 1). The reserve covers an area of ~640 ha and is surrounded by cleared agricultural land. It contains the largest extent of the 'Sedge-rich *Eucalyptus camphora* (mountain swamp gum) Swamp Community', which is listed as threatened under the Victorian *Flora and Fauna Guarantee Act (1998)* (Turner, 2003). This vegetation community provides habitat for the critically endangered Leadbeater's possum (*Gymnobelideus leadbeateri*) and helmeted honeyeater (*Lichenostomus melanops cassidix*) that occur in the reserve (Blackney and Menkhorst, 1993; Harley et al., 2005).

This reserve has been the target of extensive revegetation since the late 1970s due to declining vegetation condition (Gadsen and Ashby, 1995). In the absence of costly tree guarding or fencing, revegetation efforts within the reserve are often severely hampered by browsing damage from herbivores. These include the native swamp wallaby (*Wallabia bicolor*), a medium-sized macropod that mainly feeds on forbs and shrubs, the introduced fallow deer (*Dama dama*), a medium-sized deer that mainly grazes but has been observed browsing on planted seedlings in the reserve, and the introduced sambar deer (*Rusa unicolor*), a large deer that both grazes and browses (Davis et al., 2008; Forsyth and Davis, 2011). The eastern grey kangaroo (*Macropus giganteus*) and European rabbit (*Oryctolagus cuniculus*) are also present but are less likely to browse on woody plant seedlings due to habitat and dietary preferences (Davis et al., 2008).

We selected three riparian sites for this study located adjacent to three creeks that flow through the reserve: Cockatoo Creek, Macclesfield Creek and Woori Yallock Creek (Fig. 1.). The sites cover an area of 1.5 ha, 3.5 ha, and 2.3 ha respectively and consist of wet forests dominated by *E. camphora* on swampy sites and *E. viminalis* (manna gum) on more elevated sites, in association with shrub thickets dominated by either *Melaleuca squarrosa* (scented paperbark) or *Leptospermum lanigerum* (woolly tea tree). The understorey of these forests supports a diversity of large sedge species, including *Carex* spp., *Gahnia sieberiana* and *Lepidosperma laterale*.

Due to the low natural recruitment of woody species within the reserve, Greening Australia (a not-for-profit conservation organisation) revegetated the study sites from September–December 2014 as part of a national government-funded Landcare program, the Two Million Trees Project. The project involved planting 286,500 trees and shrubs within the reserve (Raulings et al., 2014). Due to funding constraints, plants were not guarded, however, cryptic planting was used where possible. Prior to planting, seedlings were also sprayed in the nursery with the browsing deterrent Sen-Tree™, an egg-based, acrylic polymer adhesive mixed with silicon carbide grit. Although the texture and odour of the product are thought to deter browsers, it has been found to be only effective in the short-term because the product does not protect new foliage growth (Miller et al., 2011).