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Slashing Phragmites *(Phragmites australis)* prior to planting does not promote native vegetation establishment

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Summary

Phragmites or Common Reed (*Phragmites australis*) is a tall rhizomatous cosmopolitan grass. While native to Australia, it can be invasive in wetlands, forming dense monocultures and reducing their ecological integrity. We assessed the potential for the cutting of Phragmites reeds prior to planting to promote the establishment of indigenous shrubs that might ultimately outcompete Phragmites.

We established ten 5 m x 5 m quadrats in an area dominated by Phragmites, brush-cut the reeds to ground level in five of them and left five uncut as controls. Within each quadrat, we planted 20 plants (~40 cm tall) of each of five indigenous shrub species, unguarded (4 plants/m^2). We surveyed the plants one month after planting and annually for the following four years for survival, height and browsing damage.

Browsing damage to plants was common (>50%) and unaffected by cutting. After four years, overall plant survival rates were ~25% and mean plant heights for the five shrub species ranged between 120–174 cm. Cutting of Phragmites had no positive effect on plant survival or height. In fact, two *Melaleuca* species grew taller in the uncut quadrats.

Cutting of Phragmites reed beds prior to planting is unlikely to promote the establishment of woody plantings. However, planting within established Phragmites with or without prior brush-cutting is

worthy of further trialling as a potential tool for reinstating native diversity at Phragmites-dominated sites.

Keywords

Woody plant establishment; wetland forest restoration; *Phragmites australis*; reed slashing; competition; plant invasions.

Introduction

Land-use changes and other anthropogenic impacts can favour invasive plants which can in turn alter ecosystems irrevocably. Phragmites or Common Reed (*Phragmites australis*) is a tall rhizomatous wetland grass species with a cosmopolitan distribution including Australia. It grows to 2–3 m tall and is tolerant of a broad range of water regimes in both freshwater and brackish ecosystems. It can reproduce both sexually and asexually, and often forms large dense clonal stands or reed beds (Roberts and Marston 2011). While Phragmites reed beds can provide important habitat for fauna, the species can be invasive in wetlands, forming monocultures, supressing native vegetation and reducing their ecological integrity (Silliman and Bertness 2004). Its extensive underground rhizomes and broad ecological niche make Phragmites particularly difficult to control, with control measures such as herbicides, brush-cutting/mowing, grazing, fire and flooding all being generally unsuccessful unless applied repeatedly or in concert (Hazelton *et al.* 2014; Marks *et al.* 1994).

In intact wetland forests in south-eastern Australia, Phragmites is often present, but in low abundances; presumably maintained through shading and competition for other resources. However, when forests are cleared, Phragmites can proliferate to form a dense monoculture precluding the regeneration of woody vegetation (Pearce 2000). There is some evidence to suggest that if woody wetland plants were able to re-establish and overtop the Phragmites, that Phragmites abundance may be suppressed (Ekstam 1995; Havens *et al.* 2003). Thus, accelerated forest succession may provide a management strategy whereby Phragmites removal could be coupled with planting trees and shrubs to shade out Phragmites (Hazelton *et al.* 2014).

In this study, we assessed the potential for the cutting of Phragmites reed beds prior to planting to promote the establishment and growth of planted shrubs with the aim of helping restore wetland forests. We expected that by removing the above-ground Phragmites biomass we would help accelerate the establishment of the plantings. Specifically, we predicted that seedlings planted in quadrats where Phragmites was cut would have higher survival rates and greater height growth compared to quadrats where brush-cutting was not undertaken.

Methods

Study site

Our field-based trial was conducted within the Yellingbo Nature Conservation Reserve ~50 km east of Melbourne, Australia. The reserve supports wetland forests along several creeks that provide habitat for the critically endangered Leadbeater's Possum (*Gymnobelideus leadbeateri*) and Helmeted Honeyeater (*Lichenostomus melanops cassidix*) (Harley and Lill 2007; Pearce and Minchin 2001). These forests include Mountain Swamp Gum (*Eucalyptus camphora*)-dominated swamp forests on near permanently waterlogged sites, and shrub thickets of *Leptospermum* and *Melaleuca* species along swamp margins and ephemeral channels (Pearce and Minchin 2001). Phragmites is typically present but in low abundances in relatively undisturbed swampy areas, but is often dominant within disturbed (e.g. previously cleared) areas where it putatively precludes woody plant recruitment (Greet *et al.* 2016; Pearce 2000). In these habitats, only large older trees are present, or they are treeless and lack a midstorey. Our trial was established adjacent to the Cockatoo Creek on swamp margins in an area with large Mountain Swamp Gums and an understorey almost entirely dominated by Phragmites but with some native sedges and forbs also present in low abundances.

Study design

Ten 5m x 5m quadrats were established in the summer of 2014. Within five of the quadrats, all the Phragmites reeds were cut at ground level (using a brush-cutter) and the thatch raked to the side. Reeds were cut in late summer as Phragmites growth is strongly seasonal: energy stored in its rhizomes feeds shoot growth in spring–summer with energy from its culms then recharged back to its rhizomes in autumn following seed set (Hocking 1989). Thus, timing of cutting for control is important and should be performed after flowering but prior to seed set. Reeds within the other five quadrats were not cut and functioned as controls. Quadrats were randomly allocated to either treatment group.

Within each quadrat, 100 shrubs were planted at a rate of 4 plants/m^2 (Appendix 1). This included 20 plants of each of 5 locally common habitat-forming shrub species: Yarra Burgan (*Kunzea leptospermoides*), Woolly tea-tree (*Leptospermum lanigerum*), Manuka (*L. scoparium*), Swamp Paperbark (*Melaleuca ericifolia*), and Scented Paperbark (*M. squarrosa*). These plants were not guarded despite high levels of browsing pressure within the area as it was anticipated that the surrounding Phragmites reed beds would provide some level of protection from browsers. The native browsers, Swamp Wallaby (*Wallabia bicolor*) and Common Wombat (*Vombatus ursinus*), and the non-native Sambar Deer (*Rusa unicolor*), Fallow Deer (*Dama dama*) and European Rabbit (*Oryctolagus cuniculus*) are all common at the site.

Plant surveys

The plantings were surveyed one month after being planted (March 2014) and in winter in each year for the next four years (2015–2018). For each survey, up to 10 seedlings of each species within each quadrat were haphazardly selected and their height recorded. In years 2015–2018, browsing damage to each surveyed seedling was scored using an ordinal scale (0 – absent, 1 – present, 2 – common, 3 – prevalent). In 2016–2018, the total number of plants of each species within each quadrat were recorded to determine survival rates. While there was variable cover of Phragmites (mean ± SE: cut, 66% ± 14%; uncut, 49% ± 11%), maximum flooding depth in any year (cut, 8cm ± 3cm; uncut, 15cm ± 6cm) and tree canopy cover (cut, 22% ± 6%; uncut, 24% ± 4%), these variables did not differ significantly between quadrats allocated to the two treatments (analyses not presented).

Data analyses

Survival rates for each species for the 2016–2018 surveys were calculated as the proportion of total live plants that were located out of the 20 plants that were initially planted within each quadrat. We modelled survival using beta regression as the response variable ranged between 0 and 1 (Ferrari and Cribari-Neto 2004). We used normal linear regression to model plant heights for the 2014–2018 surveys. Models for both survival and plants heights included Treatment (2 levels: cut, uncut), Year (survival model, 3 levels: 2016, 2017, 2018; heights model, five levels: 2014, 2015, 2016, 2017, 2018), and Species (5 levels) as fixed factors, with all possible interactions modelled (i.e. full model), with quadrat as a random factor. A similar model was fitted for browsing damage using ordinal regression (browsing was scored using an ordinal scale) but with four levels for Year (2015, 2016, 2017, 2018). In the results, we present the results of Wald tests for the fixed effects and predicted means and standard errors (SEs) from the models. All analyses were done in R.

Results

Phragmites stands completely regrew after 1 year (Appendix 1), however culms were noticeably shorter (~1.5 m cf. 2–2.5 m) and skinnier in quadrats where culms had been cut the previous year (a typical response to cutting for this species; Greet and Rees 2015). Of the 1000 seedlings planted in

2014, 375, 281 and 243 were relocated in years 2016, 2017 and 2018, respectively. Very few dead plants were located (<2% in any given year, typically desiccated Woolly Tea-tree plants, which are particularly flood-dependent) and most plants surveyed appeared in good condition. It is suspected that the relatively low numbers of plants able to be relocated was largely due to plant loses due to browsing; browsing damage to located plants was common (>50% of plants).

There were no significant differences in survival rates between the cut and uncut treatments overall (pooling across species and years; $p = 0.585$), or at the species level; however, Swamp Paperbarks tended to survive better in the cut treatment compared to the uncut treatment ($p = 0.088$). Overall, plant survival rates were 25% after four years (2018), while Scented Paperbarks had the highest survival rate (36%) and Woolly Tea-tree the lowest (23%) (Appendix 2).

Similarly, there was no positive effect of cutting Phragmites on plant heights overall ($p = 0.228$). In fact, plant heights for both *Melaleuca* species were taller in the uncut than in the cut quadrats (2018 means: *M. ericifolia*, 192 cm v 156 cm; *M. squarrosa*, 224 cm v 119 cm) (Figure 1). Swamp Paperbarks and Scented Paperbarks were tallest (174 cm and 171 cm, respectively) and Woolly Tea-tree shortest (120 cm) (Figure 3). Two Swamp Paperbarks and 10 Scented Paperbarks were observed flowering in 2018.

Browsing damage to plants was prevalent (76%, 73%, 59% and 57% of plants surveyed in 2015, 2016, 2017 and 2018 respectively). Typically, browsed but extant plants had been 'tip pruned', but had produced lateral shoots and appeared healthy. There were no differences in browsing damage scores between the cut and uncut treatments overall ($p = 0.152$), while Yarra Burgan plants were least browsed compared to the other four species ($p < 0.001$).

Discussion

Contrary to our expectations, the cutting of Phragmites reeds prior to planting did not promote the establishment or growth of planted shrubs. In fact, the two *Melaleuca* species grew taller when planted directly into uncut reed beds. Regardless, considerable numbers of shrubs established (>1 plants/m^2) in both cut and uncut areas at four years post-planting. These plants, as they continue to increase in cover, will potentially reduce the dominance of Phragmites (Ekstam 1995; Havens *et al.* 2003) and restore critical midstorey habitat where it has been previously cleared.

The cutting of Phragmites was not intended, or expected to, control Phragmites. As expected, Phragmites reed beds recovered completely after one year via resprouts from its extensive belowground biomass (principally rhizomes, Phragmites is virtually absent from the the local soil seed bank; Greet 2016). It is likely that this occurred before the planted shrubs could develop extensive root systems to fuel growth. Plants were planted towards the end of the growing season, when cutting of reeds is most effective. Phragmites shoots readily resprouted at the beginning of the following growing season, and the transient reduction in competition for light via cutting proved ineffective in promoting shrub growth. Moreover, the greater competition for light in uncut reed beds may have promoted those shrubs planted in them to grow taller than shrubs planted in cut red beds in which the resprouting culms were shorter.

Despite the high levels of browsing pressure and associated plant losses, after four years most established plants were in good condition and had almost grown level with the Phragmites. Indeed, many plants were already taller than the extant reeds, i.e. there were 52 plants >2 m tall. Furthermore, some of the taller plants had already reached sexual maturity, i.e. they were flowering and possessed woody capsules. This suggests that while Phragmites may inhibit woody plant seedling recruitment (e.g. via allelopathic effects; Uddin and Robinson 2015), where water and nutrients are not limiting, planted trees/shrubs may be able to persist and eventually grow taller and out-compete Phragmites. This has previously been proposed as a potential method of Phragmites control (Hazelton *et al.* 2014) and has been demonstrated for other wetland systems with similarly dense understorey vegetation (McLeod *et al.* 2000). While the sample size was small, our results suggest that planting trees/shrubs within established reed beds is worthy of further trialling as an appropriate approach to revegetating Phragmites-dominated sites and restoring wetland forests.

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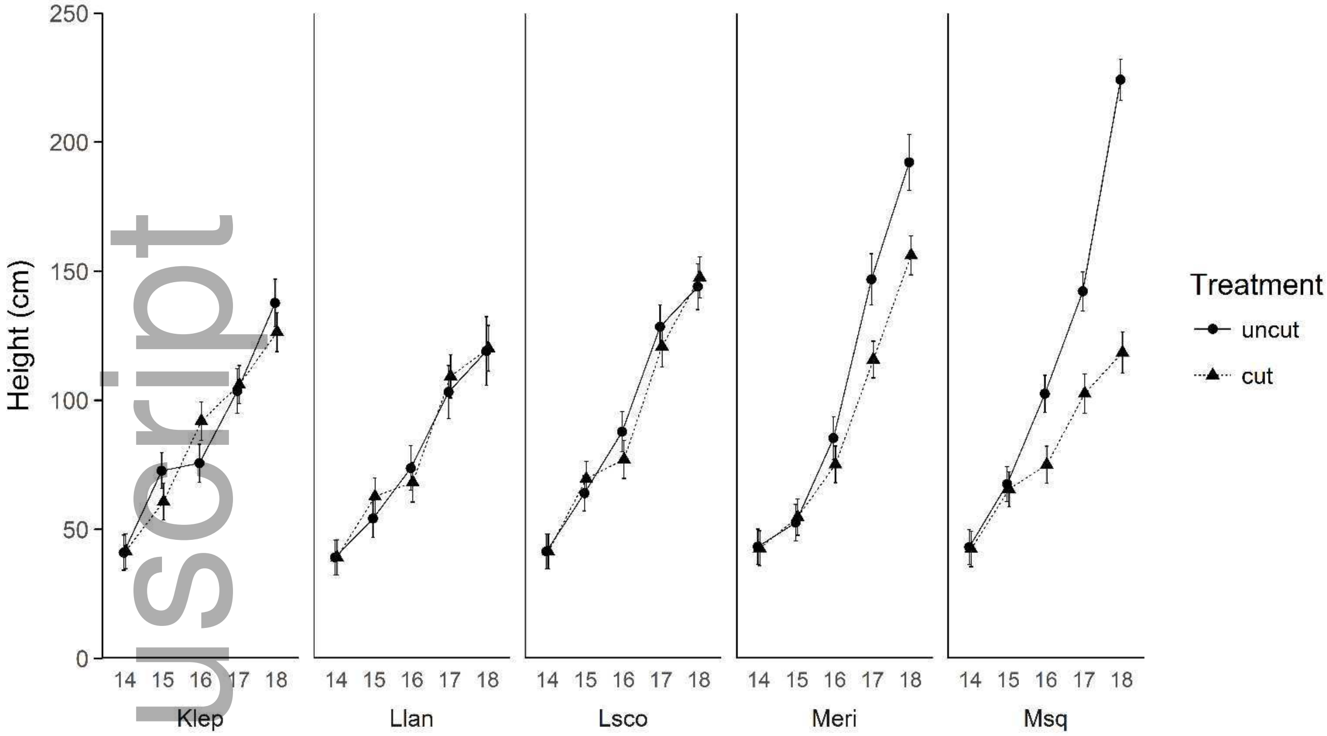

Figure 1. Mean (±SE) plant height of five shrub species planted within cut and uncut *Phragmites* over time from planting in 2014 to present (2018). Species codes: Klep – *Kunzea leptospermoides*; Llan – *Leptospermum lanigerum*; Lsco – *Leptospermum scoparium*; Meri – *Melaleuca ericifolia*; Msq – *Melaleuca squarrosa*.