A unique weed problem — the control of fairy grass *Lachnagrostis filiformis* seedheads on Lake Learmonth in western Victoria

Andrew D. Warnock, Singarayer K. Florentine, F. Patrick Graz and Martin E. Westbrooke
Centre for Environmental Management, University of Ballarat, PO Box 663, Ballarat, Victoria 3353, Australia
Email: a.warnock@ballarat.edu.au

Summary The native fairy grass (*Lachnagrostis filiformis* (G. Forst.) Trin.) has colonised extensive areas of dry lake beds in western Victoria during the current drought. Large numbers of the plants' detached mature panicles (seed heads) lodge against housing, fences, railway lines and other obstacles. This can be a fire hazard, degrades township aesthetics and creates a general nuisance to communities of lakeside towns. Current control measures are costly and only provide short-term solutions. A three-year study commencing in 2006 was designed to assess current and innovative control measures and develop a potential long-term management solution to the problem. Treatments applied to the bed of Lake Learmonth during the first year of the study included late-season glyphosate herbicide at two concentrations, late-season slashing, and seed broadcasting of two native species to reduce *L. filiformis* inflorescence biomass through competition. Slashing reduced *L. filiformis* inflorescence biomass and herbicide treatments successfully killed *L. filiformis* plants, while having no effect on germination of seed collected from sprayed plants. Although these treatments successfully limited the impact of *L. filiformis* on lakeside towns during the first year, the longer term efficiency is doubted. Treatment effects will be monitored over a further two years.

Keywords Glyphosate, herbicide, late-application, native weed, slashing.

INTRODUCTION

Fairy grass or common blown-grass (*Lachnagrostis filiformis* (G.Forst.) Trin.) is an emerging native weed in Australia which has colonised extensive areas of dry lake beds in western Victoria during the current drought (Poussard 2004). Large numbers of the plants' detached mature panicles (seed heads) lodge against fences, railway lines, machinery and buildings. This accumulation of material initiates concerns with respect to the safety, fire hazard, and the general nuisance it provokes (Poussard 2004). Fires have destroyed infrastructure as a result of vehicle exhausts igniting accumulated *L. filiformis* panicles. The increased wind resistance associated with the accumulation of *L. filiformis* panicles against mesh fencing has also resulted in damage to fencing.

Control measures to reduce the impact of the grass panicles and associated safety risks currently involve glyphosate-based herbicide, slashing and burning. These control measures cost local councils up to $50,000 per year (D. Wallis, City of Ballarat pers. comm.) and only provide short term solutions. Managers require a more economical, and long-term solution to the problem.

The study aims to determine the effect of the following control treatments: slashing with removal and retention of slashed material; broadcasting seed of desired native species; and glyphosate herbicide at different concentrations on vascular plant cover and *L. filiformis* inflorescence biomass.

MATERIALS AND METHODS

Study site Lake Learmonth extends over an area of 520 ha adjacent to the township of Learmonth, Victoria (15 km north-west of Ballarat). The lake had predominantly been used for recreational water sports, although it has not had year-round standing water since 2001. *Lachnagrostis filiformis* has since been able to colonise the lake bed. The close proximity of the township to the lake has caused much concern due to panicles that collect against residents' houses and fencing. The lake is sprayed annually with glyphosate during November when *L. filiformis* panicles begin to open to reduce the impact of the grass panicles on the township of Learmonth (Poussard 2004).

Application of treatments The following treatments were applied to the bed of Lake Learmonth in a latin square design: i) slashing (slashed material removed), ii) slashing (slashed material retained), iii) broadcasting native orache (*Atriplex australasica* Moq.) seeds at 3.5 kg ha^{-1}, iv) broadcasting plains saltmarsh grass (*Puccinellia stricta* var. *perlaxa* N.G.Walsh) seeds at 6 kg ha^{-1} and v) control. Slashing treatments were applied on 23rd November 2006. Seed broadcasting (14th June 2006) aimed to reduce *L. filiformis* inflorescence biomass through competition with desired native species.

In addition, the following herbicide treatments were later applied in 64 m^2 plots in a randomised block with five replicates: i) non-selective glyphosate herbicide (Roundup Biactive™) at 3.6 g a.i. L^{-1}, ii) non-selective glyphosate herbicide at 1.8 g a.i. L^{-1} and iii) control. These plots were established adjacent to the latin square plots. The herbicide was applied 24 November 2006 with a vehicle mounted sprayer to prevent wind-drift into other treatments.

The latin square and randomised blocks were replicated twice on Lake Learmonth on the northern and southern halves of the lake bed. Blocks were placed at equal intervals between the lake centre and edge on the north and south of the lake, avoiding the seasonally flooded centre of the lake and extreme lake edge.

Measurement and sampling A buffer of 2 m surrounded sampling areas. Foliage cover was measured in January 2007, using a point frame with twenty five sub-samples. *Lachnagrostis filiformis* inflorescence biomass was collected within five randomly placed 30 × 40 cm quadrats, dried at 105°C for 24 h and weighed.

Lachnagrostis filiformis seed was collected from randomly selected plants that were sprayed with herbicide under the current management regime and from control plots. Spraying was conducted 21 November 2006 and seeds collected 12 December 2006. Seeds were tested for germination under 15/20°C, 15/25°C and 15/30°C 12 h thermoperiods with 12 h dark/light cycles. Fifty seeds were placed in a Petri dish lined with filter paper and replicated four times per treatment. Seeds were watered daily to moisten filter paper. Ungerminated seeds were viability tested using tetrazolium chloride (Freeland 1976).

Statistical analysis To examine the effects of the treatments on *L. filiformis*, inflorescence biomass and foliage cover were analysed using two-way ANOVAs followed by a Tukey's pair-wise comparison. Two sample t-tests were used to analyse effects of herbicide on seed germination.

The direct ordination method, Canonical Analysis of Principal Coordinates (CAP, Anderson and Willis 2003) was used to test for vegetation composition differences among treatments and blocks.

All underlying assumptions were checked prior to conducting the analysis. All univariate analysis was conducted using Minitab 14.11 and multivariate analysis using the R statistics package (version R 2.1.1) and the R-library, Vegan (Oksanen *et al.* 2006).

RESULTS

Lake bed vegetation community All sampled areas of the lake were dominated by *L. filiformis* with exception of block five, closest to the lake edge on the south of the lake where the native *P. stricta* var. *perlaxa* dominated.

Foliage cover (F_{48} = 1.4, P = 0.02; Table 1) and inflorescence biomass (F_{48} = 26.9, P = 0.03) of *L. filiformis* was lower on the northern half of the lake bed compared to the southern half. A mean inflorescence biomass of 22.3 ± 3.5 g m^{-2} and 40.7 ± 25.9 g m^{-2} was recorded in control plots on the northern and southern half of the lake bed respectively.

Table 1. Mean foliage cover ± SD of plant species from control plots on the northern and southern halves of the lake bed.

Species	Foliage cover (%)	
	North	South
**Aster subulatus*	0.5 ± 0.7	0.2 ± 0.4
**Atriplex prostrata*	1.0 ± 1.3	0.0 ± 0.0
Chenopodium glaucum	3.4 ± 6.9	0.2 ± 0.4
Epilobium hirtigerum	0.1 ± 0.2	0.0 ± 0.0
Lachnagrostis filiformis	14.4 ± 13.7	30.6 ± 20.5
**Lactuca serriola*	0.2 ± 0.4	0.4 ± 0.4
Puccinellia stricta	0.0 ± 0.0	6.6 ± 9.5

* denotes exotic species.

Effect of control treatments Inflorescence biomass was not significantly different between control plots within the adjacent latin square and randomised blocks (F_8 = 0.26, P = 0.875). Thus all treatments from both latin square and randomised blocks were analysed using a single ANOVA for each half of the lake bed.

Inflorescence biomass differed between treatments on the southern half of Lake Learmonth ($F_{6, 24}$ = 6.4, P <0.01) but not the northern half ($F_{6, 24}$ = 0.8, P = 0.60). Specifically, lower inflorescence biomass was found under the slashing treatments (with thatch removed, P = 0.02; with thatch retained, P = 0.02) compared to the control treatment. There was no difference between the two slashing treatments (P = 1.00).

Herbicide treatments (both rates) killed all *L. filiformis* plants but herbicide did not reduce the development of *L. filiformis* inflorescence biomass on the northern (P = 1.00) or southern (P = 1.00) halves of the lake bed. However, panicles failed to emerge from the flag leaf, thereby reducing their capacity to disseminate in the wind. No difference in germination was found between *L. filiformis* seeds collected from plants sprayed with glyphosate and control plants (F_6 = 1.2, P = 0.28). A mean of 86.0 ± 4.8% seeds successfully germinated.

Other than herbicide treated plots where all *L. filiformis* plants were killed, no treatment effected *L. filiformis* cover on the northern ($F_{6, 24}$ = 1.2, P = 0.36) or southern halves of the lake bed.

Only herbicide treated plots differed in vegetation community assemblage compared to control plots on the northern ($F_{4, 24}$ = 3.9, P <0.01) and southern halves of the lake bed ($F_{4, 24}$ = 4.0, P <0.01). But *L. filiformis* was the only species affected by the control treatments (r^2 = 0.97, P <0.01; r^2 = 0.95, P <0.01).

DISCUSSION

Lake Learmonth vegetation community Lake Learmonth is dominated by *L. filiformis* (Table 1). Toward the southern edge of the lake the dominance shifts and the native grass *P. stricta* var. *perlaxa* dominates. The application of control treatments in this part of the lake should be avoided to retain the desired native species dominance, reduce treatment costs and limit the effect on non-target species.

Effect of control on vegetation community The application of glyphosate herbicide and slashing appears to be successful in reducing the impact of wind-blown *L. filiformis* panicles during the year of treatment. Herbicide concentrations can be reduced to 1.8 g a.i. L^{-1}, reducing application costs and the possibility of undesired side effects. Although herbicide application successfully killed *L. filiformis*, seeds remaining on the plant remained viable and germinated readily. In addition, the panicles from herbicide treated plants failed to emerge from the flag leaf, thereby reducing dispersal capacity, and the seed bank on the lake bed is likely to increase. For these reasons, the efficiency of herbicide applied late-season is questionable.

There was lower foliage cover and inflorescence biomass of *L. filiformis* on the northern half of the lake bed. This may explain why slashing was less successful in this region of the lake bed. It is recommended that surveys of the lake bed be done to determine the area requiring treatment prior to treatment application. This will reduce the effect on non-target species and treatment costs. As slashing is carried out at the same time of year as herbicide application, seeds from slashed plants are also likely to be viable. Thus, the efficiency of late-season slashing is likewise questionable. Slashing/spraying at an earlier stage should be considered before seed maturation.

Seed broadcasting treatments were unsuccessful in reducing *L. filiformis* foliage cover and inflorescence biomass. A high seed bank of *L. filiformis* was likely to have remained from the previous season, and thus there was high propagule pressure. Future seed broadcasting treatments should also aim to reduce propagule pressure of *L. filiformis*.

Non-target species did not appear to be affected by control treatments in this study including herbicide, possibly due to the low abundance of these species or patchy distribution.

The effect of the control treatments will be monitored over the next two years to determine their long term efficiency.

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