Implications of successful biological control of bridal creeper (*Asparagus asparagoides* (L.) Druce) in south-west Australia

Peter J. Turner[1,2,3,4], John K. Scott[1,3] and Helen Spafford[1,2]
[1] CRC for Australian Weed Management
[2] University of Western Australia, 35 Stirling Highway, Crawley, Western Australia 6009, Australia
[3] CSIRO Entomology, Private Bag 5 PO, Wembley, Western Australia 6913, Australia
[4] Current address: Pest Management Unit, Department of Environment and Climate Change, PO Box 1967, Hurstville, New South Wales 1481, Australia
Email: Pete.Turner@environment.nsw.gov.au

Summary The assessment of environmental weed control programs must encompass more than measurements of weed density reduction. Measurements are also needed on the vegetation that replaces the target weed. Bridal creeper (*Asparagus asparagoides* (L.) Druce) has invaded a variety of habitats across southern Australia. The only viable option for widespread control is the use of biological control agents. We report that the biocontrol agent, the bridal creeper rust (*Puccinia myrsiphylli* (Thuem.) Wint.), is having a significant impact on bridal creeper in south-west (SW) Australia. However, following the biological control of bridal creeper, with a reduction in bridal creeper cover from 49.9% (± 4.4 SE) to 10.2% (± 2.7 SE), there has been little change in both native and exotic plant cover.

Although there was a reduction in cover of bridal creeper, it may take many years for the belowground tuberous mats of this weed to be exhausted. Another major barrier to restoring invaded areas is the invasion or increase in density of other exotic species. A more holistic approach is needed in conjunction with the successful biological control of bridal creeper. This would involve targeting all undesirable exotic species while encouraging native species recovery. It should also include the identification of sites with high conservation value, where biological control should be used in conjunction with other restoration techniques.

Keywords Conservation, evaluation, impacts, succession, weed substitution.

INTRODUCTION

Serious environmental weeds have an impact on native biodiversity, and control measures (including biological control) are sought to reduce these impacts. Lesica and Hanna (2004) suggested that monitoring of community-level effects should accompany biological control releases into native ecosystems, as the desired outcome of the biological control of weeds should include the indirect effects of increased diversity and abundance of native species (Denslow and D'Antonio 2005). To measure these effects a biological control program needs to be evaluated beyond assessing an agent's release, establishment and the subsequent decrease in the target weed, to determining whether the impacts on native biodiversity have also been reduced.

In Australia, the environmental weed, bridal creeper, a Weed of National Significance (WoNS), has been targeted for biological control (Morin *et al.* 2006). In June 2000, the bridal creeper rust, *Puccinia myrsiphylli*, which destroys the tissue of bridal creeper's cladodes and causes early defoliation, was approved for release (Morin *et al.* 2002). Morin *et al*. (2006) have documented the life cycle and the initial impact of this agent.

Before biological control, the impacts of bridal creeper were also determined at four sites in SW Australia. Areas invaded by bridal creeper contained fewer native species than nearby native uninvaded reference areas (Turner *et al.* in press). The plots established during this study were maintained and vegetation was monitored following the release of the bridal creeper rust. The response of the plant communities following the biological control of bridal creeper is reported here.

MATERIALS AND METHODS

This study was undertaken at four sites across SW Australia. Within each site, plots were established in stands of bridal creeper or in nearby reference areas. These reference areas were within native vegetation with little or no bridal creeper present (see Turner *et al.* in press for full description of sites and plots).

Each of the four sites contained relatively homogeneous stands of bridal creeper of a sufficient size to accommodate at least two 10 × 1 m plots, separated by at least 10 m. Two of the sites had larger bridal creeper infestations, allowing for three plots to be established within each bridal creeper stand, while at the other two sites, two plots were established. This represented a total of 10 bridal creeper plots. Each of these plots was paired to a reference plot (also

10 × 1 m) located directly adjacent to the bridal creeper areas and at least 10 m away from other plots.

Plots within both bridal creeper and reference areas were established in October 2004. At this time, all vascular plant species were identified and percentage areal shoot cover of the understorey (to a maximum height of 1.5 m) was estimated visually for each species within each plot. The methods and results for this survey are reported in Turner *et al*. (in press). During October 2004, when the first vegetation surveys were undertaken, all sites were either free of the bridal creeper rust or there was only a small amount of infection (<5% cladode damage), with the rust colonising two of the sites in that year (P. Turner unpublished data). In June 2005 these sites were yet to come under substantial attack; consequently the rust was released in the centre of each bridal creeper stand at each site. Additional rust spores may have also naturally dispersed into sites, given that other releases had been made nearby.

In September 2006, the sites were revisited and all vascular plant species were identified and the cover of the understorey estimated, again using the same methods as described above and in Turner *et al.* (in press). Across the four invaded areas, one-way analyses of variance were undertaken to compare the two surveys (GenStat 2003).

RESULTS

Between 2004 and 2006, average bridal creeper cover had decreased from 49.9% (± 4.4 SE) to 10.2% (± 2.7 SE) (Figure 1).

As bridal creeper cover decreased, the cover of other exotic species increased, although this was not significant (d.f. 1,6; F = 3.56; P = 0.108). In the bridal creeper invaded plots, cover of other exotics increased from 4.2% (± 2.2 SE) in 2004 to 12.8% (± 4.0 SE) in 2006. However, this was comparable to the exotic cover in the reference plots at the same time in 2006 (10.8% ± 3.2 SE) (Figure 2). In the most isolated site, Quell Creek, there was a dramatic increase in the cover of other exotic species. At this site, although bridal creeper cover had decreased from 60.3% (± 7.3 SE) to 9.8% (± 2.3 SE), cover of other exotics had increased from 0.03% (± 0.03 SE) to 23.4% (± 6.7 SE), compared to only 3.8% (± 0.5 SE) in the reference areas in 2006.

There was no change in the cover of native species (d.f. 1,6; F = 0.75; P = 0.420), with total native cover in bridal creeper plots in 2004 averaging 21.1% (± 4.2 SE) and in 2006 cover was 25.7% (± 3.1 SE). But again at Quell Creek, native climbers had increased from 0.07% (± 0.07 SE) to 5.0% (± 2.2 SE) in 2006. In contrast, in reference plots at Quell Creek in 2006, native climbers averaged only 0.8% (± 0.3 SE).

DISCUSSION

When the results from this study are coupled with those from other studies, indications are that further restoration will be needed, at least at some sites. Many barriers to the recovery of the native vegetation exist in bridal creeper invaded areas, including bridal creeper's dense tuberous root mat that can remain in the soil long after control (Turner *et al.* 2006), a germinable seed bank in invaded areas that contains a large number of exotics (Turner *et al.* in press), as well as elevated soil nutrients in invaded areas (P. Turner unpublished data). In Australia, soil nutrient enrichment has been shown to favour exotic species and many exotic species in the seed bank at these study sites will germinate readily (Turner *et al.* in press). However, native species may require specific conditions for germination (see Turner and Virtue 2006). Given the above, biological control needs to be coupled with other restoration techniques.

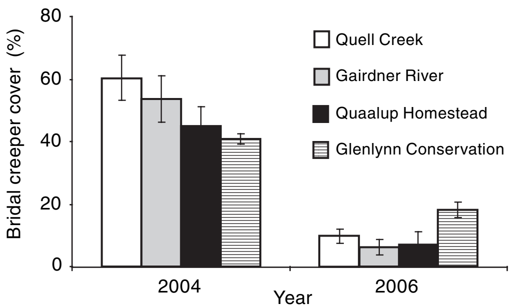

Figure 1. Change in bridal creeper cover between two years, following the arrival and release of the bridal creeper rust at four sites in SW Australia.

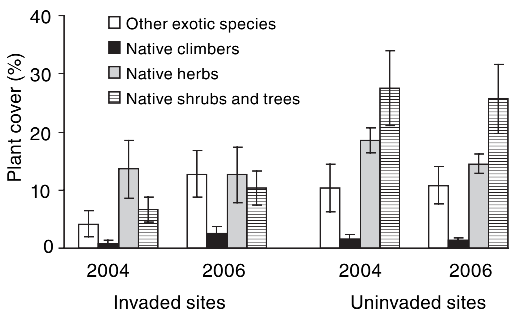

Figure 2. Change in plant cover over two years, averaged across four sites.

The bridal creeper rust has had a significant impact on bridal creeper across these four sites in SW Australia. Although long-term monitoring is needed to fully evaluate the response of other plant species to the control of bridal creeper, these early results already suggest that both exotic species and a set of native species (especially at Quell Creek) benefit from the control of bridal creeper.

While studies of the response of native communities to weed biological control are rare, the few studies that have undertaken this monitoring have had varying results (Denslow and D'Antonio 2005), with results depending on individual site conditions (Lesica and Hanna 2004). Denslow and D'Antonio (2005) reported that in some cases there was an increase in native species diversity, while other cases showed that biological control led to the replacement of the target weed with secondary invaders. The Quell Creek site, and a site reported in Turner and Virtue (2006) had increases in cover of other weeds following the control of bridal creeper. The latter site had an increase in the exotic *Oxalis pes-caprae* L. eight years after control. Thus both sites will require additional restoration following the control of bridal creeper.

Support of ecosystem restoration was identified as the main priority for bridal creeper management in Australia following the National Asparagus Weeds Management Workshop in November 2005 (Gannaway and Virtue 2006). It was suggested that this restoration could be undertaken within high priority biodiversity areas that were invaded by this weed. To date these areas have not been identified. Yet, a method for identifying these high conservation areas is available and has been demonstrated for two other WONS (see Turner *et al.* 2008) and the first step in this approach has already been trialled for *Asparagus* weeds (Downey 2006). The biological control of bridal creeper in SW Australia has been very successful. Failure to identify these high priority areas as well as the additional restoration that may be required at each site, may see many sites change from bridal creeper dominance to dominance by secondary, exotic invaders following the successful biological control of bridal creeper.

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