

Monitoring protocols to assess the recovery of native plant species following the control of widespread weed species

Paul O. Downey^{1,2} and Nelika K. Hughes^{1,3}

¹ Pest Management Unit, Parks and Wildlife Group, Department of Environment, Climate Change and Water, PO Box 1967, Hurstville, NSW 1481, Australia

² Current address: Institute for Applied Ecology, University of Canberra, ACT 2601, Australia

³ Current address: Australian Wildlife Conservancy, North Head Sanctuary, 33 Scenic Drive, Manly, NSW 2095, Australia

Corresponding author: paul.downey@iae.canberra.edu.au

Summary Despite many environmental weed control programs having conservation aims (i.e. the protection of native plant species), few contain monitoring programs to evaluate their success in terms of the recovery of native species. There are many reasons for this situation, including a lack of resources (time and money), monitoring skills, guidance and emphasis on monitoring. To resolve this situation a comprehensive monitoring manual was recently produced. This manual contains standardised descriptive methods to assess both the control of weeds and the recovery of native plant species. In addition, the manual is divided into three tiers, which enables all stakeholders to undertake some level of monitoring regardless of their skills and resources. In addition, the manual contains standardised data sheets, and simple analysis techniques. While this manual was developed specifically for bitou bush (*Chrysanthemoides monilifera*), it has been designed to be used for other environmental weeds. A revised version is currently being developed to encompass all weed species. The use of standardised monitoring methods, with a focus on assessment of the recovery of native plant species and the collection of standardised data will greatly enhance our ability to assess the recovery of native species following weed control at both specific sites and across multiple sites and species. This will fill a significant gap and greatly enhance our understanding of the impact to and recovery of native plants (both listed as threatened or otherwise) following weed control, as well as develop more effective weed control programs.

Keywords Monitoring methods, native plant species, control, bitou bush, *Chrysanthemoides monilifera*.

INTRODUCTION

There is an ever increasing emphasis on the need to monitor the effects of weed control programs (Grice 2004, Martin and van Klinken 2006, Reid *et al.* 2009, Maxwell *et al.* 2009). However, monitoring poses a series of challenges to many land managers in terms of what to monitor, which techniques to use and where

to monitor, let alone how to design a monitoring program or analyse and report the data to their managers or others. This situation is compounded by a lack of guidance and definitive texts aimed at land managers, despite many land managers wanting such advice and training (King and Downey 2008). Thus many weed management programs either (i) don't include any form of monitoring, (ii) use very simplistic qualitative monitoring methods like photo points, or (iii) collect data that are not analysable for a number of reasons, mostly associated with the use of an inappropriate experimental design, inconsistent collection of data, or collection of data that can't answer the aim of the control program or management and (iv) don't contain mechanisms to report on the monitoring that has been undertaken.

To prevent this situation from reoccurring, monitoring techniques need to be developed that match or align with the practicalities of management, and the skills and resources (time and money) of those responsible for collecting monitoring data. However, this does not mean that the quality and effectiveness of the monitoring programs has to be compromised. In addition, monitoring guidance needs to better align with the objectives of individual weed management programs. This is critical to achieving effective monitoring programs and the collection of meaningful data. This is also important given the number of land managers that need to collect monitoring data and report on their progress.

Another significant challenge is ensuring that land managers have clear objectives for their control and monitoring programs. Whilst many identify conservation as a goal, few know what native species they are trying to protect. Many operate on an untested (and often incorrect) assumption that weed control alone will lead to a positive biodiversity outcome (Downey 2008). This is perpetuated by the fact that many land managers are able to identify the target weed species of their control program, but their ability to identify the native plant species at risk is more variable. In many instances such species are rare and poorly known

and as a result information to assess the threat and/or identify them in the field is patchy and not readily available. This is a significant problem.

Monitoring is a key action in the NSW Bitou Bush Threat Abatement Plan (Bitou TAP, DEC 2006). Given the issues raised above, a monitoring manual has been developed to ensure that land managers collect consistent data, which can be analysed across the distribution of bitou bush (*Chrysanthemoides monilifera* subsp. *rotundata* (DC.) T.Norl.) as part of implementation of the TAP (see Hughes *et al.* 2009). In addition, an identification guide was developed for the native plant species identified in the Bitou TAP as being at risk from bitou bush (Hamilton *et al.* 2008), to help land managers identify and thus protect them.

MONITORING MANUAL

Below we briefly outline the three tiers of the 'Monitoring manual for bitou bush control and native plant recovery' (Hughes *et al.* 2009). Each tier is aimed at a different set of stakeholders depending on their skills and resources. To help engage the appropriate stakeholder each tier can be downloaded separately, either as the complete tier or as individual sections containing specific methods (www.environment.nsw.gov.au/bitouTAP/monitoring.htm). In addition, the manual was field tested on a wide range of potential users (including volunteer groups) and the text was circulated to several experts and users for comment.

Standard monitoring methods The standard tier outlines the base level of monitoring required to enable stakeholders to monitor both the effect of their bitou bush control program [on bitou bush] as well as the recovery of the native plant species at risk at their site. The methods described are: (i) mapping; (ii) photopoints; (iii) observation data to support photopoints and (iv) measures to assess the cost of control and monitoring. Detailed instructions for each method are presented, along with standard data sheets and how to undertake a simple analysis.

The mapping section outlines the layers required to produce a composite site map for managing and monitoring weed programs. The layers include a base map, distribution of the weed, locations of native plant species and ecological communities at risk, other significant weed species, the areas to be treated each year, the monitoring locations, and an updated annual layer to show the effects of management (i.e. changes in the distribution of the weed and native plant species at risk). By comparing this last layer with the initial distribution layer (and/or previous years) and the locations of the native plants at risk, a threat reduction measure can be determined (i.e. the

distance the weed population has been moved away from the species at risk).

Many weed programs use photopoints to assess their weed control programs and whilst these before and after photos can show dramatic results, the data are only qualitative and typically only reflect a reduction in the target weed. Here we have combined photopoints with simple observational assessment to provide quantitative values to support the photos. This will significantly enhance the quality of the results presented.

It is anticipated that the bulk of land managers will use the Standard monitoring methods (Figure 1). The Standard monitoring methods also form the basis of the Advanced and Research monitoring tiers. This enables a comparison of all datasets irrespective of which tier the data was collected with.

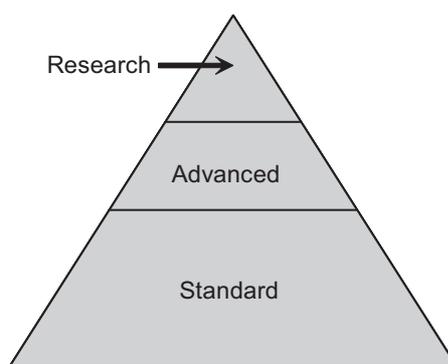


Figure 1. Breakdown of the proportion of stakeholders using each tier of the monitoring manual.

Advanced monitoring methods The advanced tier outlines a more detailed level of monitoring, aimed at land managers who have undertaken monitoring previously and want more robust data to answer their objectives. The methods described are: (i) line-intercept transects; (ii) quadrats and (iii) t-squares (for assessing trees) and are essentially a before and after control [treatment] measurement. The selection of specific methods is dependent on the life-form of the species at risk (specifically trees, shrubs and herbs/grasses). For most life-forms there is a preferred and alternative set of methods outlined, based on characteristics of the species and constraints of the site and methods. In addition, there is a section on how to combine multiple methods if the user is sampling multiple species with different life-forms, for example, shrub methods for bitou bush and grass/herb methods for the native species at risk.

For each method described there is a range of variables that can be collected. These include: (i) indices of abundance, specifically percentage cover, and density; (ii) demographic data, specifically on life history (age), size and reproductive status and (iii) the effect of control on the species.

The advanced tier also includes information on random sampling and its importance as well as the concept of pseudo-random sampling aimed specifically at the practicality of undertaking monitoring in the field, and that for many land-managers truly random samples can create a barrier to monitoring, in that they are unlikely to search for a random spot in the middle of a dense weed invasion. They are, however, much more likely to go a random distance along an access path and then a random distance along a fixed direction into an infestation, which we call pseudo-random sampling. In addition, this tier includes further information to help users better understand the theory behind and importance of various aspects of a monitoring program, as well as experimental design (e.g. unbiased sampling, interspersed, independence, replication and stratified sampling). Detailed instructions for each method are presented, along with standard data sheets and how to undertake simple analysis once the data have been collected and entered into a database.

Research monitoring methods The research tier uses the methods outlined in the Advanced monitoring methods to establish a monitoring program aimed at determining causality (i.e. that bitou bush control alone lead to a recovery of a specific native species at risk). This is achieved by developing an appropriate experimental design relative to the objectives of the control program, using twelve steps. Eight of the steps address the experimental design, including setting objectives, experimental control and treatments, treatment combinations, sampling methods, dependent variables, monitoring frequency, replication, sample size and randomness. This tier is aimed specifically at those who want to undertake a research or experimental level of monitoring and to determine causality. Thus only a small number of programs will have this level of monitoring attached to them (Figure 1).

DISCUSSION

Developing monitoring methods for all weed species that threaten native plant species Whilst the monitoring manual described here was developed for bitou bush as part of the Bitou TAP, it has broader application. During the development of the manual it became very apparent that a broad manual was also critically needed. Thus, where possible the manual was developed to be applicable for other weeds as well as

bitou bush. In addition, there was a need to sample/assess other weeds that replace/invade after bitou bush control through the manual. Firstly the Standard monitoring methods are applicable to all weed species (including some aquatic weeds like free-floating and emergent species). Mapping, photopoints, observational data and assessments of costs and resources are methods relevant to all weed programs. Second, the structure of the Advanced monitoring methods based on life-form, enables it to be used for all weed species that have a shrub habit or life-form without any modifications. Weeds that have other life-forms (specifically, trees and herbs/grasses) can also be monitored with this manual but this requires additional inputs (and some minor modifications) especially when combining methods to account for the different life-forms of the native species at risk. The notable exceptions include aquatic weed species, vine weeds and weeds that have invaded rainforests or other habitats with a high level of vertical vegetation/foilage projection. Lastly given the structure of the Research monitoring methods (i.e. they build on the Advanced tier), those weed species that can be monitored with the advanced techniques can also be monitored using the research methods. Thus with a few notable exceptions this monitoring manual can be used for weeds other than bitou bush and has already been adopted for *Lantana camara* L., despite the manual's focus on bitou bush.

Monitoring native species recovery following weed control Many environmental weed management programs contain conservation aims. However, few collect data to show the response of native plant species following weed control (Reid *et al.* 2009). In part this is because many weed managers operate under the assumption (incorrectly) that weed control alone will lead to a conservation outcome (Downey 2008). Of the weed managers that do undertake monitoring, many found that either the initial weed species or another weed species invaded following control, with few showing the recovery of native species (Reid *et al.* 2009). However, such information has not led to a better understanding of: (i) the impact of weed invasions on native species; (ii) the impact (positive or negative) of weed control efforts on native species; (iii) what additional measures are needed to save native species impacted by weeds following control or (iv) alternative control methods, let alone improved weed management methods. Yet such information is critical to management and recovery of native species threatened by weeds. Only through improved monitoring and reporting and using appropriate methods along with subsequent evaluations of control techniques can this situation be resolved.

Matching monitoring programs to weed management aims

In order to deliver effective monitoring outcomes, monitoring programs need to align with management aims. However, this is rarely the case in weed management. For example many control programs for widespread environmental weeds in Australia have the number of hectares treated as the assessment measure. Such a measure does not provide any indication of the response of biodiversity to weed control, except to perpetuate an incorrect assumption that weed control alone will lead to a biodiversity conservation outcome. For weed management programs that have biodiversity conservation as an aim however, the monitoring program needs to assess the response of the biodiversity at risk to weed control (and restoration) measures, like those methods described here, as well as the effect of control on the target weed.

Assessing the recovery of native plants following weed control

At present, 107 sites are committed to implementing the Bitou TAP in NSW (Hamilton *et al.* 2010). Many of these sites are now starting to use these monitoring guidelines. The results from several case studies illustrate the value of combining strategic planning, information on the species at risk and strategic control with effective monitoring (Hamilton *et al.* 2010). The value of this concerted effort in standardising the monitoring programs will be of immeasurable benefit when the Bitou TAP is reviewed in 2011 after 5 years of implementation. The ability to compare data across sites will also be of significant value to management of any other widespread weed that poses a threat to native species.

ACKNOWLEDGMENTS

We thank the many people who helped in the development of the monitoring manual including field testing it in the field. We also thank Peter Turner for comments on a previous draft.

REFERENCES

- DEC (2006). NSW Threat Abatement Plan – invasion of native plant communities by *Chrysanthemoides monilifera* (bitou bush and boneseed). Department of Environment and Conservation, Hurstville.
- Downey, P.O. (2008). Determination and management of alien plant impacts on biodiversity: examples from New South Wales, Australia. In 'Plant invasion: human perception, ecological impacts and management', eds B. Tokarska-Guzik, J. Brock, G. Brundu, L. Child, C. Daehler and P. Pyšek, pp. 369-85. (Backhuys Publishers, Leiden).
- Grice, A.C. (2004). Weeds and the monitoring of biodiversity in Australian rangelands. *Austral Ecology* 29, 51-8.
- Hamilton, M.A., Turner, P.J., Downey, P.O. and Rendell, N. (2010). Reducing the threat of a nationally significant weed to biodiversity: four years of implementation of the NSW Bitou Bush Threat Abatement Plan. Proceedings of the 17th Australasian Weeds Conference, ed. S.M. Zydenbos, pp. 166-9. (New Zealand Plant Protection Society, Christchurch, New Zealand).
- Hamilton, M.A., Winkler, M.A. and Downey, P.O. (2008). 'Native plant species at risk from bitou bush invasion: a field guide for New South Wales'. (Department of Environment and Climate Change, Sydney).
- Hughes, N.K., Burley, A.L., King, S.A. and Downey, P.O. (2009). 'Monitoring manual: for bitou bush control and native plant recovery.' (Department of Environment and Climate Change, Sydney).
- King, S.A. and Downey, P.O. (2008). Assessing the recovery of native plant species following bitou bush control – the need for monitoring. *Plant Protection Quarterly* 23, 40-1.
- Martin, T.G. and van Klinken, R.D. (2006). Value for money? Investment in weed management in Australian rangelands. *The Rangeland Journal* 28, 63-75.
- Maxwell, B.D., Lehnhoff, E. and Rew, L.J. (2009). The rationale for monitoring invasive plant populations as a crucial step for management. *Invasive Plant Science and Management* 2, 1-9.
- Reid, A.M., Morin, L., Downey, P.O., French, K. and Virtue, J.G. (2009). Does invasive plant management aid the restoration of natural ecosystems? *Biological Conservation* 142, 2342-9.