Determination and management of the impacts of weeds on biodiversity

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Summary Weeds are widely acknowledged as a major cause of global biodiversity decline. However, information on the native species at risk or the weed species posing the threat is limited. Here we review current approaches to determining and assessing the impacts of weeds on biodiversity. These approaches include scientific studies of individual weed species and the native species they threaten, the synthesis of such studies, assessments of unpublished data through the Weed Impacts to Native Species assessment tool, and examination of the threats to the schedule of threatened species in New South Wales.

These approaches illustrate the nature of the weed threat to biodiversity in terms of the diversity and number of native species at risk, as well as how much we still have to learn. In addition, they illustrate the broad range of weed species posing the threat.

The second part of our review focuses on the challenge of delivering effective weed management to conserve the biodiversity identified at risk. While there has been progress towards addressing many aspects of weed management in Australia, urgent attention is needed to understand and reduce impacts to biodiversity. To address the problem, requires innovative approaches to management that are supported by effective national policies.

Keywords Biodiversity, determining species at risk, threat, management.

INTRODUCTION

Until recently, information on the native plant and animal species at risk from weeds in Australia was very scarce (e.g. see Grice *et al*. 2004, Vidler 2004), with information available for relatively few native species. For example a review of the 20 Weeds of National Significance Strategies showed that very few identified the native species at risk or outlined actions to save such species (Downey and Cherry 2005).

Here we present a review of current approaches to determining the species at risk from weed invasions, their strengths and weaknesses, and how the lack of knowledge has hampered management and policy initiatives. In addition, we also discuss how a lack of information on the mechanisms by which weeds cause species declines has contributed to the current situation.

QUANTITATIVE STUDIES

Impacts of weeds can be quantified by a number of different means. A common approach is to select sites at which a target weed species is present that can be compared with sites at which that weed is absent. The major challenge with this approach is in selecting sites that are identical except in terms of the impacts of the weed in question. Another approach involves the addition of a weed or weeds to a site. With this approach too, it is necessary to ensure that areas for comparison are similar except for the presence of the weed. In addition, there may be confounding effects from any methods used to establish the weed at the site and studies may need to be long term in order to document the weed's impacts. Such experiments may also encounter difficulties in documenting impacts analogous to those experienced at sites invaded 'naturally' if, for example, particular seasonal conditions are required for establishment of the weed. The weed addition approach also faces regulatory and/or ethical challenges around the establishment of a weed at sites where it does not already occur. Also another challenge would be the removal of the weed at the conclusion of the experiment

A third approach to quantifying weed impacts is through weed removal experiments. One challenge here is to distinguish between the effects of the weed not being present and the effects of the methods used to remove it. This approach requires a method for removing the weed and assumes that the ecosystem in question can return to the state it was in before the weed arrived at the site, within the life-span of the experiment.

Lastly, time sequence studies can be used to assess the invasion process, whereby pre-invasion reference conditions (i.e. native species richness) can be determined ahead of an advancing weed invasion. This approach requires identification of un-invaded sites that will become invaded and require a long time-frame (Adair and Groves 1998).

Regardless of the approach, another limitation is that most studies have only examined the effects of individual species (either weed or native), whereas, typically, weed-invasions involve multiple species and the impacts are not confined to individual native species. All approaches can be strengthened by incorporating methods that seek to elucidate the processes whereby weeds have an impact rather than simply quantifying what those impacts are (Grice *et al.* 2004).

REVIEWS

There have been several reviews of published quantitative studies on the impacts of weeds on biodiversity (e.g. Grice *et al*. 2004). These show trends across studies, help identify gaps in knowledge, and suggest directions for future work.

WEED IMPACTS TO NATIVE SPECIES

Following the listing of bitou bush (*Chrysanthemoides monilifera* (DC.) T.Norl.) as a Key Threatening Process under the NSW *Threatened Species Conservation Act 1995*, there was a need to determine the species at risk in order to prepared a Threat Abatement Plan within the time-frame set out under the Act. There was not sufficient time to undertake quantitative studies, so a new method was needed. The Weed Impacts to Native Species (WINS) assessment tool as was developed to address the need (Downey 2006).

The WINS system uses four stages: 1) literature review; 2) collation and assessment of knowledge about specific biodiversity at risk held by botanists, zoologists, ecologists and weed managers specifically involved with the weed and native biodiversity; 3) evaluation of an interim list of biodiversity at risk; and 4) using a model to rank the biodiversity at risk (Downey 2006).

This process quickly provides insights about the likely impacts of a weed on biodiversity and the species most likely to be at risk, both those listed as threatened (i.e. under threatened species legislation) and those not listed. For example, the WINS assessment for bitou bush identified 158 plant species currently threatened by bitou bush invasion (see DEC 2006) with 65% of these not listed under the legislation.

The WINS system is currently being used to assess the impact of lantana (*Lantana camara* L.) on biodiversity nationally. This process has identified over 1200 plant species and 150 animal species as being at threat from lantana. Many of these species do not occur outside of lantana's distribution (Turner *et al*. 2007).

EXAMINATION OF SPECIES LISTS

NSW Threatened Species Conservation Act The lists of threatened species provides a basis for the examination of threats to biodiversity in that these lists cover a diverse range of biodiversity and information on their threats has been documented in one form or another. Coutts-Smith and Downey (2006) assessed the 972 species listed as threatened in NSW to determine the threat posed by weeds. The authors found that 45% ($n = 419$) of these threatened species were at risk from weed invasions. In addition, they identified 127 weed species posing the threat. Garden escapes accounted for 65% of the weed species identified. As a specific weed species could not be identified for half of the biodiversity threatened by weeds, these numbers under represent the problem. Such incomplete information reduces our ability to manage weeds and the biodiversity they threaten adequately.

Environment Protection and Biodiversity Conservation Act To illustrate that the process developed by Coutts-Smith and Downey (2006) could be adopted nationally, Downey (2008a) undertook a preliminary assessment of the biodiversity listed as threatened nationally. This assessment showed that weeds threatened only 17% ($n = 291$) of the threatened biodiversity. For approximately two-thirds of the biodiversity at risk from weeds, no specific weed species could be identified. Thus the 57 weed species identified is also an underestimation; 31 of which were also identified by Coutts-Smith and Downey (2006). In addition, 72% are considered to be garden escapes, which is a higher value than that identified in NSW.

While these two approaches highlight the value of examining threatened species lists, the number of threatened species in Australia only accounts for a small subset of the biodiversity likely to be at risk from weeds. There are likely to be other weed species that threaten non-listed biodiversity which are not accounted for.

DISCUSSION

While our understanding and awareness of weed impacts on biodiversity has increased substantially in recent years, the scale of the problem has not been thoroughly documented. There is a real value in having lists of native species at risk, because they help tailor weed management strategies and research into the mechanism by which weeds cause native species to decline, as well as inform and direct policy and funding.

Research on the mechanisms by which weeds invade, transform ecosystems, interact with native species and are managed over an extended period (e.g. over several decades) is critical for future management and biodiversity conservation. For example see comparative studies of impacts on ecosystems

for weeds like gamba grass (*Andropogon gayanus* Kunth – Rossiter *et al*. 2004) and bitou bush (French *et al.* 2008).

It is imperative that we continue to use a range of approaches to understand weed impacts on biodiversity over the coming decades in order to assess the problem accurately and respond effectively. We must also ensure that such information is reported and disseminated widely to ensure that weed management and policy focuses on biodiversity outcomes.

While Adair and Groves (1998) outlined a methodology to determine the impact of environmental weeds, significant progress towards understanding the impacts and developing effective management strategies still requires action a decade later.

Management New management initiatives, like the NSW Bitou Bush Threat Abatement Plan (DEC 2006), highlight how information on the native species threatened by weeds can be used to ensure that weed control is focused on biodiversity conservation outcomes on a landscape scale. Information on the biodiversity at risk needs to be matched with information on specific locations about the ability to achieve effective control and the likelihood of delivering conservation successes (Downey 2008b). In addition, new management strategies need to be supported by weed management policies and legislation aimed at biodiversity conservation.

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