Determining current and future alien plant threats: a screening tool for population

establishment and expansion under climate change

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**Abstract**

# Introduction

Introduced plant species can pose tangible ecological and economic threats to natural and agricultural systems worldwide (Pimentel, 2002; Gurevitch & Padilla, 2004; Coutts-Smith & Downey, 2006). Given that non-native plants have the potential to respond to shifting niches more rapidly than native species (Dukes & Mooney, 1999), the potential for anthropogenic climate change to affect the distribution, physiology and management of established, invasive species has emerged as a major area for ecological research (Dukes & Mooney, 1999; Hellman *et al*., 2008). However, in the rush to understand how well-established invaders may respond, few studies have focussed on the potential for changing climates to facilitate new invasions, or to enable presently non-invasive naturalised species to become invasive either more rapidly *in situ*, or invade new areas. Naturalised species are introduced, non-native organisms which have formed self-sustaining, reproductive populations which are yet to significantly spread throughout the landscape (Richardson *et al*., 2000). As abiotic conditions continue to change under human influences, it is increasingly likely that a new suite of plant invaders will emerge and that these species are likely to reside in the pool of naturalised plants (Richardson & Pysek, 2012). With the advent of climate change and the impending consequences for biodiversity and conservation, decision processes will be needed that enable policy makers and land managers to allocate priorities now to limit or prevent future invasions by naturalised species.

In Australia, almost 30,000 non-native plant species have been introduced since European settlement (Randall, 2007) and of those, approximately 3,000 plant species are classified as naturalised within Australia and the majority have yet to become invasive. In order to address this, the Australian Government has established both a Weed Risk Assessment (WRA) system to screen all new plant species imports and a Weed Risk Management (WRM) system to assess the risk of weeds already present in Australia (Downey & Glanznig 2006; Downey et al. 2010). Both systems rely on a screening protocol to determine the risk relative to the action or management required. Whilst the number of weed risk assessments that have been completed is increasing, this number is still relatively small because considerable resources and time are required for each assessment. Furthermore, in a thorough review of weed risk assessments across the spectrum of weed management, Downey et al. (2010) highlighted that neither the WRA nor the WRM systems have been developed to address the future weed threat associated with climate change. What is needed is an assessment of the implications of climate change on naturalised plant management strategies or prioritisation processes, especially using a pre-emptive approach to reduce future threats from either current alien plants or future ones.

Predicting the influence of climate change on the potential distribution of naturalised plant species is an important and challenging task (Araújo and Guisan 2006; Thuiller et al. 2008; Thuiller et al. 2007), outputs of which will be fundamental to management. While formal risk management processes (see Anon 2004) present a framework that could be adapted, in that the future threat can be assessed against the consequence of that threat and the likelihood of it occurring, the concept of a prioritisation approach, is more applicable due to the limited resources available and the need to limit investment in those areas where management may not result in a positive outcome. Employing a prioritisation approach can provide a basis for making decisions with respect to the appropriate level of conservation management required, ranging from the need for prompt management action to protect or restore important habitat, through to preventative threat minimisation. While prioritisation of management actions for alien plants has been used extensively (Owen 1998; Skinner et al. 2000; Robertson et al. 2003; Timmins 2004; Tassin et al. 2006), the concept of employing a system that also incorporates future climate is relatively new (for exception see Crossman et al. 2008).

There is consensus amongst weed managers of the need to incorporate climate change in risk assessment processes (see Downey et al. in prep). On a practical level, an understanding of the potential effects of climate change on naturalised plants, in particular which regions may be most vulnerable, can be used to devise pro-active management strategies and locate target regions for monitoring and eradication. Knowledge of suitable habitat beyond the species’ current distribution under future climate conditions is important for determining projections of future spread. One tool that has been used extensively to understand the likely threat of potential future invaders under climate change has been species distribution models (SDMs) (Thuiller et al. 2007; Beaumont et al. 2009; O’Donnell et al. 2012). Prioritisation methods that are informed by suitability modelling are a way to incorporate climate change into a risk assessment process. An effective prioritisation approach should have the capacity to rate species based on changes in their current and future distributions for likelihood of population establishment and expansion under future climate conditions. Importantly the method should assess species at the scale most relevant for management.

We focussed on a representative sample of approximately 10% of Australia’s known, naturalised plants (*n* = 292 species) as the basis for our prioritisation approach. Our objective was to develop a tool that incorporated species distribution modelling with criteria developed in weed management workshops to rank species according to a projected current and future threat level. Our specific aims were to: (1) use existing models of the distribution of abiotically suitable habitat for 292 naturalised species under baseline climate conditions for the period 1950-2000 and future climates for the decades 2035 and 2065, (2) use expert opinion to develop five spatially explicit criteria to assess the likelihood of population establishment and expansion and (3) develop a screening tool that rates species according to current and future threat so that management can focus on those species that rank the highest and pose the biggest potential threat under changing climate conditions. Our results are designed to aid management in assessing invasion risk so that detailed weed risk assessments can focus on those species that pose the largest threat now and in the future.

# Materials and methods

Insert abbreviated modelling methods here

*Stakeholder workshops*

We convened two workshops in which stakeholders representing various aspects of weed management were asked to define a prioritisation approach and identify criteria for ranking species under current and future climate projections. Workshops were attended by both government and research sectors with experience in the ecology and control of both invasive and naturalised plant species. A continental? and state-wide scale of analysis was also agreed upon as the one most likely to benefit and help inform management. One follow up workshop was help at the end of this process in which the modelling results were presented and the process was refined and agreed upon. At the end of this process it was agreed that the goal of the screening tool would be to identify priority species that are projected to increase under current and future climate as a way of prioritising which species should undergo more comprehensive risk assessment processes.

*Identification of criteria*

Five criteria to assess the likelihood of population range establishment and expansion were developed within the stakeholder workshops (Table 1). Gridded observations per 100,000 km2  was chosen as a way of standardising the number of observations per unit area. Minimum distance was chosen as a variable that provides a measure of the likelihood that if a species occurs in highly suitable habitat then it is more likely to be able to reproduce and progress through the invasion continuum from naturalised to invasive. Likewise habitat suitability of observations was selected to reflect that if observations occur in areas with suitable habitat then the chance of dispersing would also increase. Area of habitat suitability was chosen as a spatial criteria that assumes that the larger the area of suitably habitat then the more likely it is that the environmental conditions where a species occurs will be favourable for rapid reproduction and range expansion. Similarly area of highly suitable habitat was chosen to represent that the likelihood of range expansion would be higher in areas that are most suited to a particular species. It is important to note that none of the criteria involved specific plant traits (i.e. dispersal mechanism). Workshop attendees agreed

*Development of a screening tool*

The data (on an individual state/territory basis) for each of the five attributes described above was cut based on the following quantiles: 0.05, 0.25, 0.75, and 0.95. This resulted in the data being grouped into five bins (0-0.05, 0.05-0.25, 0.25-0.75, 0.75-0.95, and 0.95-1). Each species was assigned a score of 2, 4, 6, 8 or 10 points for each of the 5 attributes based on what quantile it fell into. Each attribute had an equal weighting of 10 points. The points were summed for each species to give a total score out of 50. We applied a points-based scoring system using five critical attributes (described above) to assign each species to one of three threat levels.

Species were rated as having low, medium or high potential for population establishment and expansion now and in the future. The rating is a way of evaluating which species should undergo further assessment for weed risk potential. Species were placed into threat categories of low, medium and high based on the following scale:

Likelihood scale (points) Potential for population establishment and expansion

≤24 points Low

25-41points Medium

≥ 42 points High

# Results

# Discussion

One of the greatest future conservation challenges will be the interaction of invasive alien plant species with native biodiversity under climate change. Whilst information on how alien plant species interact with native biodiversity is increasing, knowledge of how both groups will interact under climate change is relatively scarce. Whilst modelling can help, management action now to prevent future impacts represents a more efficient approach in terms of risk management.

* **Importance of considering climate change**

It is envisaged that this prioritisation approach for determining weed management priorities for naturalised plants, will be the basis for allocating economic and human resources for on-the-ground actions now and in the future in light of climate change.

* + Discussion of SDMs as a useful tool to provide basis for assessing current and future threat.
* **Benefits of prioritisation scheme**

While designation of any point score is arbitrary in absolute terms, it is the relative score that is of importance. Further, by designating a set of clear, transparent rules to assign points, such an assessment can be updated rapidly, given new information, or alternative expert opinion. As such, this preliminary assessment provides a framework for improved ongoing evaluation as more information becomes available. Using our point-based species prioritisation scheme we identified species at the state and territory scale and national scale as having a high invasion risk.

* **Discussion of findings**

Are there species that are a high risk in multiple states/territories?

If so- importance of a coordinated approach

Are there any species that should now be listed as WoNs?

Are there any species that were thought to be priorities but are projected to decrease in the future?

* **WRA and WRM**

Focusing research, survey, and ultimately eradication efforts on these species is thus likely to be the most cost-effective use of resources to prevent future weed problems. Having identified these species as posing threats under current and future conditions, more detailed assessment as to their likely impacts on biodiversity and ecosystem function is justified. Once such an assessment of likely impacts has been made, further refinement of our threat assessment will be possible. These species could also be the subject of an awareness raising program directed at the nursery industry, home gardeners, and bush regenerators, amongst others, regarding their potential to become serious weeds. The species ranked as having medium invasion risk should be given a full weed risk assessment within the next two to three years. Information is fully accessible through a dedicated website (weedfutures.net) that includes a searchable database for use as a decision tool for land managers so they can more effectively and efficiently prioritise resources to cope with emerging weed threats.

* **Summary**

The preliminary assessment performed in this project now provides a list of species for both current and future time periods at the state and territory scale that should be prioritised for a full weed risk assessment prior to the design of an active management program. For identified high risk species, long-term management programs and allocation of resources will be required.

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