Using 'WeedSearch' to assess the feasibility of eradicating 34 high-risk invasive plant species in Queensland

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Summary The computer model 'WeedSearch' was used to estimate the cost of eradicating 34 high-risk plant species in Queensland. Eradication of six species is predicted to cost less than $100,000 per species. For 14 species, cost is predicted to be between $100,000 and $1M per species. For the remaining 14 species, eradication is predicted to cost more than $1M per species. The analysis allows species to be prioritized so that finite resources can be directed to species most vulnerable to eradication. Moreover, it identifies species for which eradication may no longer be a realistic management objective.

Keywords Invasive plant, eradication.

INTRODUCTION

The complete eradication of potentially high-impact invasive plant species is an appealing but often elusive management objective. Given finite resources and an ever-expanding list of candidate species, it is necessary to prioritise eradication targets and to ensure policy objectives remain practical and realistic. This paper presents a useful method for ranking candidates for eradication – a method that also provides a quick guide to the total quantum of funding and search-effort likely to be required for recently detected species.

MATERIALS AND METHODS

The study focused on 34 plant species considered to have significant long-term pest potential. All species are declared 'Class 1' pests in Queensland (as defined by the Queensland *Land Protection (Pest and Stock Route Management) Act 2002* and associated regulation). An additional eight species targeted for eradication under national cost-sharing arrangements were outside the scope of the study, as were six species believed to have been eradicated from Queensland and two species that have not yet been effectively delimited.

A computer model called 'WeedSearch' (Cacho and Pheloung 2007) was used to estimate cost and duration of eradication for 34 species. The model required 24 input parameters to be completed for each species. Parameters include an estimate of total search area, average plant density (per hectare), seed longevity, search speed, search frequency, population growth rate and administration costs (among others). Estimates of cost and search-effort are based on a premise that a defined area must be methodically and regularly searched to detect every specimen and to exhaust the soil seed-bank. The model estimates the number of years required to achieve eradication and the number of search-hours that must be invested to satisfy the mathematical calculations applied.

Operational biosecurity staff across Queensland were surveyed to collect input data. Distribution data was also gleaned from 'Pest Central', a database of information on the distribution of pests across the state. Data on various biological parameters required by the model were obtained from the literature. In cases where data did not exist, a reasonable estimate was made, often based on congeners or closely related taxa.

Search area and average plant density per hectare were particularly difficult parameters to estimate. For each site where a target had been detected, an arbitrary search area with a 200 metre radius was calculated (yielding a total search area of about 12 hectares for single specimens or small clumps of specimens). For species where populations were scattered across a larger area, GIS-based mapping was utilized to calculate total search areas (again using a 200 metre 'search buffer' around specimens). The 'search buffer' assumes propagules could be reasonably expected to disperse over this distance. Where data exists to indicate a larger 'search buffer', these data were used in the model.

RESULTS

Of the 34 species, eradication of six species is predicted to cost less than $100,000 per species. For 14 species, with larger populations, cost is predicted to be between $100,000 and $1M per species. For the remaining 14 species, eradication is predicted to cost more than $1M per species (Table 1).

DISCUSSION

Experience in Queensland and elsewhere clearly shows that the cost of eradication increases dramatically as the spatial size of a target population increases. Analysis of successful weed eradication projects from around the world by Waldendorp and Bomford (2004) estimated an average cost of $4270 for eradicating an infestation with a net area less than 0.1 ha, $19,700 for an area of 1 ha and $1,052,500 for an area of 400 ha.

Table 1. Cost of eradicating 34 weed species, as estimated by WeedSearch.

Species	Estimated search area (ha)	Estimated total cost ($)
Opuntia elatior (red-flower prickly pear)	12	57,200
Opuntia puberula (puberula cactus)	12	57,200
Salix cinerea (grey willow)	12	59,900
Salix alba (white willow)	12	59,900
Vachellia gerrardi (grey-haired acacia)	12	79,500
Senegalia nigrescens (knob-thorn)	12	79,500
Vachellia xanthophloea (yellow fever tree)	25	159,000
Chrysanthemoides monilifera subsp. *rotundata* (bitou bush)	460	163,500
Salix nigra (black willow)	12	179,700
Ulex europaeus (gorse)	25	190,400
Prosopis laevigata (smooth mesquite)	50	258,800
Opuntia leucotricha (Aaron's beard cactus)	62	272,500
Vachellia karroo (Karroo thorn)	50	318,000
Opuntia elata (Riverina pear)	600	471,000
Neptunia oleracea/plena (water mimosa)	22	695,200
Opuntia sulphurea (sulphur cactus)	2,012	766,700
Cylindropuntia rosea/tunicata (Hudson pear)	842	811,700
Solanum viarum (tropical soda apple)	867	867,000
Gmelina elliptica (badhara bush)	871	709,800
Senegalia insuavis (pennata wattle)	125	879,000
Senegalia rugata (soap-pod wattle)	137	1,072,500
Hygrophila costata (hygrophila)	317	1,132,800
Gymnocoronis spilanthoides (Senegal tea plant)	172	1,461,900
Acaciella glauca (redwood)	192	1,496,900
Opuntia microdasys (bunny ears cactus)	400	1,552,000
Cecropia peltata/palmate (Mexican bean tree)	800	1,612,800
Mimosa pigra (giant sensitive tree)	1,000	1,725,800
Alternanthera philoxeroides (alligator weed)	91	1,993,500
Pithecellobium dulce (madras thorn)	425	2,033,200
Acaciella angustissima (white-ball acacia)	375	2,637,000
Asparagus asparagoides (bridal creeper)	1,500	5,586,400
Nassella neesiana (Chilean needle grass)	14,000	14,780,000
Gleditsia triacanthos (honey locust tree)	62,600	22,729,500
Chromolaena odorata (Siam weed)	14,776	47,812,500

Similarly, based on an analysis of eradication programs undertaken by the California Department of Food and Agriculture, comprising 16 species and 50 infestations, Rejmánek and Pitcairn (2002) concluded that for infestations less than 1 ha in size, eradication was almost always possible; for infestations between 1 and 100 ha, approximately 30% were successfully eradicated; and for infestations between 100 and 1000 ha, only about 25% of eradication attempts were successful. Woldendorp and Bomford (2004) found that seven out of eight successful eradication programs involved species that had net infestation sizes less than 4 ha.

Estimated cost of eradication for 34 weed species in Queensland increases dramatically as search area increases, with 14 species estimated to require more than $1M per species. The high costs highlight the importance of detecting potentially serious weed species at a very early stage of population development, preferably when the population affects no more than a few hectares.

WeedSearch not only offers a method for ranking candidates for eradication, it also provides a guide to the total quantum of funding and search-effort likely to be required. However, the quality of the predictions is dependent on the quality of the input parameters, especially distribution data for each species. While the Department has invested heavily in hand-held data capture devices over many years of field operations, certain species are difficult and costly to delimit, especially once they have spread over more than a few hectares. While there is scope to collect more precise data in the future, as surveillance techniques evolve, delimitation will probably remain a challenge. The level of confidence associated with delimitation undoubtedly declines as the area infested increases.

It is worth noting that the predicted cost of eradication is heavily influenced by a species' detectability. For example, WeedSearch predicts that eradication of alligator weed will cost $1,993,500, despite a relatively small search area of 91 hectares. This is due to the fact that alligator weed grows within very dense aquatic vegetation at a number of sites in Queensland and the model takes into account the 'effective search width' – the distance (in metres) that an observer can visually detect the target species. In the case of alligator weed, the 'effective search width' is small. The more readily a target species can be detected growing among other vegetation, the lower the number of search hours required and the lower the cost. For example, the cost of eradication for visually conspicuous species such as *Opuntia sulphurea* is relatively modest ($766,700) despite a sizeable search area (2012 hectares). Seed longevity and other factors also interact in complex ways to influence eradication costs.

Despite a level of uncertainty associated with the model's predictions, the study offers evidence-based recommendations for future management objectives for 34 eradication targets. For example, eradication can continue to be pursued if cost is predicted to be affordable, whereas more realistic policy objectives, such as containment or biological control, can be adopted for high-cost or particularly cryptic or otherwise resilient species. In addition, results from this study can be compared to a similar study completed in 2009 (Panetta and Csurhes 2011), so that managers can see whether progress is being made towards eradication and at what rate.

With on-going refinement, there seems little doubt that the model will help ensure finite resources are directed at species most vulnerable to complete eradication. While not as sophisticated as the methodology applied to nationally cost-shared eradication projects, this study offers a relatively low cost, rapid, transparent and repeatable method to assess eradication feasibility for fairly large numbers of species – a method that is transferable to other state and territory jurisdictions.

ACKNOWLEDGMENTS

Dr Sheldon Navie from IVM Group was contracted to help collect data and analyse results. Operational staff from Biosecurity Queensland provided considerable information and assistance. Taxonomic advice and location data was provided by the Queensland Herbarium. Detection and eradication of high-risk invasive species is undertaken in close partnership with local governments across Queensland.

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