Priority lists for weed research in the wet- and dry-tropics of north Queensland

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Summary

A participatory decision making approach was used to prioritize weed research for the wet- and dry-tropics of north Queensland using stakeholders, an expert panel, external reviewers, and the computerized priority-setting system (QDNRM MODSS). From 246 weeds identified, 53 weeds were found to be of major concern. A score was developed for each weed, which accounted for its priority in individual shires and the number of times it was prioritized across the 47 shires. The 22 dry- and 31 wet-tropics weeds were scored by an expert panel against 12 criteria based on economic, environmental and social impacts and current research knowledge with higher scores for greater impact and greater amount of needed research. Several 'what if' scenarios were run through QDNRM MODSS by altering the relative importance of criteria. The best criterion for prioritizing weed research was when impact was given higher importance than research needs. *Mikania micrantha*, *Chromolaena odorata*, *Mimosa invisa*, and *Eupatorium catarium* were the top four weeds of the wet-tropics, and *Prosopis* spp., *Parthenium hysterophorus*, *Jatropha gossypiifolia*, and *Cryptostegia grandiflora* for the dry-tropics. Priority lists will be used to decide the order in which weeds should be researched and what type of research needed to be done.

Introduction

Exotic weeds are harmful to the economic, environmental, and social values of many Australian communities. They have been estimated to cost primary production some $3 billion annually (Combellack 1989). In environmental areas, they reduce biodiversity and invade areas of high conservation value. Social impacts although often underestimated can have a major impact on communities, particularly through health risks (e.g. parthenium *Parthenium hysterophorus*), or by reducing the attractiveness of areas promoted for tourism (Chippendale and Panetta 1994, Towers and Subba Rao 1992, and McFadyen 1992).

In recent years, reports on exotic plant naturalization in Queensland suggest that there have been alarming increases in numbers of weeds. For example in 1986, 66 weeds were recorded for the whole of Queensland (Wilson and Riding 1986), whereas in 1998, 72 environmental weeds were listed for the wet-tropics of north Queensland alone (Goosem 1998). Whilst there have been many findings of new weed and/or exotic plant naturalizations in Queensland (Swarbrick 1993, Swarbrick and Skarratt 1994, Parsons and Cuthbertson 2001) this marked increase in numbers may be partly due to changes in the current public perception of weeds. Some species previously not categorized as weeds under primary production values, are now included as environmental weeds, as their detrimental impacts become apparent.

Developing control techniques for these weeds as well as gaining an improved understanding of their biology is imperative if their impact is to be minimized. However, limited resources allow research to be undertaken on only a few at any one time. Consequently, there is a need by decision-makers to make an informed decision on which weeds to research as well as a need for a priority-setting system that provides a basis for allocation of research funds.

This paper addresses these needs and presents results of a process where a multi-stakeholder, participatory decision making approach was used in conjunction with a computerized package called QDNRM MODSS (Queensland Department of Natural Resources and Mines Multiple Objectives Decision Support System) to develop a priority list for weed research in the wet- and dry-tropics of north Queensland.

Material and methods

Scope of prioritization process

The term 'weed' is used herein for any exotic plant that has been identified in the Pest Management Plans of 47 Local Government Authorities and WTMA (Wet Tropics Management Authority) in Queensland located north of the Tropic of Capricorn.

Six models used in prioritization programs were considered for their suitability to simultaneously assess a large number of weeds against several conflicting criteria. The six models were 'Check List Model' (Prinsley 1994), 'Scoring Model' (Wilson and Panetta 1998), 'Benefit Cost Analysis Model' (Prinsley 1994), 'Risk Assessment Model' (Goosem 1998), 'MODSS (Multiple Objectives Decision Support System) Model' (Yakowitz *et al*. 1993, 1997), and a computerized priority setting system developed by Queensland Department of Natural Resources and Mines (QDNRM) called QDNRM MODSS Model' (Lawrence and Shaw 2000).

The QDNRM MODSS model was used in this study for two reasons. First, it was a computerized system that had the ability to prioritize a large number of weeds against several conflicting criteria. Second, it had already been successfully used in Australia to evaluate and prioritize proposed water infrastructure developments in northern Queensland (Lawrence *et al*. 2000) and to evaluate the Cattle Creek catchment irrigation management options in the Mareeba-Dimbulah Irrigation Area (MDIA) in north Queensland (Shaw 1997). Details of QDNRM MODSS are described in a paper published by Lawrence and Shaw (2000) and the software can be downloaded from the website, www.modss.org or at http://facilitator.netstorm.net.au/userguide.

Process development

The prioritization process had to be sufficiently objective, transparent, and open to ensure that various stakeholders would accept the results. To achieve this, three key groups were involved through the process: stakeholders, a weed expert panel, and external reviewers.

Collation of weed list

Pest Management plans produced by the 47 Local Government Authorities and the WTMA located north of the Tropic of Capricorn were used to develop an inventory of weeds. In most instances, these plans were developed in collaboration with a group of stakeholders, which did comprise affected landholders, local and state government staff, research organizations and community group members. It was recognized that adopting such a strategy may not necessarily lead to the identification of all weeds but should highlight those that have significant economic, environmental and social impacts.

From the pest plans a total of 246 weeds were identified. This was considered far too many to evaluate objectively in detail at one time. Consequently, a shortlist of the 50 weeds considered the biggest concern to stakeholders across northern Queensland was developed. This was again achieved by utilizing the

information provided within the pest plans. In most instances, stakeholder groups representing respective shires had prioritized weeds using a classification system. These were standardized across all shires into five classes: H (high), H/M (high to medium), M (medium), M/L (medium to low), and L (low). For individual pest plans, a numerical score of 1.0, 0.75, 0.5, 0.25, and 0.125 was assigned to H, H/M, M, M/L and L priority weeds, respectively. Scores for individual weeds were then added across the 50 pest plans. Those weeds having the top fifty scores proceeded to the next step in the prioritization process.

Stakeholder feedback

The list of 50 weeds was circulated to over 140 individuals/organizations considered representative of the key stakeholders affected by weeds in northern Queensland. Feedback received from 53 of these was used to amend the list, with an additional three weeds added (Table 1). Amendments were made if three or more stakeholders provided justification why a particular weed should be added to or deleted from the list.

Wet- and dry-tropics weeds

The 53 weeds were split into an interim list of 31 wet- and 22 dry-tropics weeds (Table 1). Weeds occurring in shires or cities with an average annual rainfall ranging between 1600 and 3400 mm were considered wet-tropics weeds and those with rainfall between 200 and 1500 mm were considered dry-tropics weeds. However, there were instances where some weeds occurred in both the wet- and dry-tropics. In this situation, 'straddle' weeds were included in the group where they had the highest occurrence. For example, Singapore daisy (*Sphagneticola trilobata*) was listed under the wet-tropics because its occurrence across shires and cities of the wet-tropics was relatively higher (80%) than in the dry-tropics (24%).

Assessment criteria

Quantitative criteria were developed to assess each weed, with three orders of criteria namely first, second, and third implemented (Figure 1). Two first order criteria considered were (i) the level of impact, and (ii) the research that had already been undertaken on control methods, ecology and socio-economic aspects. The impact criteria were given a higher order of importance than research criteria because weed research is primarily driven by weed impact. This effectively moved weeds up or down the list to confirm the weeds most in need of research.

Second order criteria for weed impact included economic, environmental, social and cultural impact considerations. Third order criteria then split each of these into current and potential impact. For the weed research criteria, second order criteria categorized the type of research into either control, ecological or socio-economic. Third order criteria expanded on the type of control methods available into herbicides, fire, mechanical and biological control.

Scoring criteria

Scoring of impact and research criteria was undertaken by a seven-member weed expert panel, which comprised entomologists, ecologists, agronomists and extension staff familiar with weeds of northern Queensland. All criteria were given scores in the range of 0 to 1. With impact criteria, scores increased as the impact increased whereas with research, scores increased with the amount of research needed to be done on weeds.

Since impact assessments were determined quantitatively, a benchmark was developed to introduce not only a degree of objectivity into the process but also to

Table 1. List of wet- and dry-tropics weeds.

Wet-tropics weeds		Dry-tropics weeds	
Scientific name	Common name	Scientific name	Common name
Allamanda cathartica	Yellow allamanda vine	*Acacia nilotica*	Prickly acacia
Alternanthera philoxeroides	Alligator weed	*Agave* spp.	Sisal hemp
Andropogon gayanus	Gamba grass	*Alternanthera pungens*	Khaki weed
Annona glabra	Pond apple	*Bryophyllum delagoense*	Mother-of-millions
Brachiaria mutica	Para grass	*Calotropis procera*	Calotrope, Kings crown
Cabomba caroliniana	Cabomba	*Cascabela thevetia*	Yellow oleander, Captain Cook tree
Chromolaena odorata	Siam weed	*Cryptostegia grandiflora*	Rubber vine
Cyperus aromaticus	Navua sedge	*Datura stramonium*	Thornapple
Eichhornia crassipes	Water hyacinth	*Echinochloa polystachia*	Aleman grass
Elephantopus mollis	Tobacco weed	*Eriocereus* spp.	Harrisa cactus
Eupatorium catarium	Praxelis	*Jatropha gossypiifolia*	Bellyache bush
Euphorbia heterophylla	Milk weed	*Lantana camara*	Lantana
Harungana madagascariensis	Harungana	*Opuntia* spp.	Pest pear
Hymenachne amplexicaulis	Hymenachne, Ponded pasture grass	*Parkinsonia aculeata*	Parkinsonia
Hyptis spp.	Knob weed, Stinking Roger, Comb hyptis	*Parthenium hysterophorus*	Parthenium
Leucaena leucocephala	Leucaena	*Prosopis* spp.	Mesquite
Miconia calvescens	Miconia	*Ricinus communis*	Castor oil plant
Mikania micrantha	Mikania	*Sporobolus* spp.	Giant rats tail
Mimosa invisa	Giant sensitive plant	*Themeda quadrivalvis*	Grader grass
Pistia stratiotes	Water lettuce	*Tribulus terrestris*	Caltrop, Goats head burr
Psidium guajava	Guajava	*Xanthium* spp.	Noogoora burr
Rottboellia cochinchinensis	Itch grass	*Ziziphus mauritiana*	Chinee apple
Salvinia molesta	Salvinia		
Sansevieria trifasciata	Mother-in-laws tongue		
Senna obtusifolia	Sicklepod		
Spathodea campanulata	African tulip tree		
Stachytarpheta spp.	Snakeweed		
Thunbergia spp.	Thunbergia		
Tithonia diversifolia	Tithonia		
Turbina corymbosa	Turbine vine		
Sphagneticola trilobata	Singapore daisy		

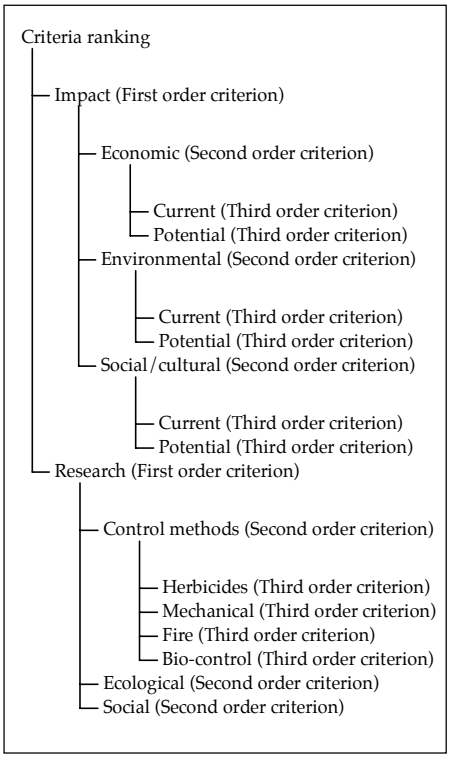

Figure 1. Flowchart of first, second and third order criteria used to compare weeds.

facilitate adequate discrimination between weeds. The panel selected parthenium weed (*Parthenium hysterophorus*) to be the benchmark as there was a substantial body of information available regarding its impacts and it was a weed with which all panel members were very familiar. Once parthenium was scored for economic, environmental and social impacts all other weeds were scored comparatively.

Scoring of impact criteria was not only guided by general weed knowledge of the panel but also by a prepared list of specific considerations relevant to each impact criterion. Examples of considerations relevant to current and potential environmental impact criteria included net biodiversity change (takes into account the biodiversity costs of weeds, ability to completely dominate a habitat displacing most to all other plants e.g. ability to form dense thickets), ecological processes, downstream and in-stream effects, whether a weed creates a fire hazard in natural ecosystems or not, aesthetics, indigenous and non-indigenous heritage. Scorings on impact criteria were arrived at by consensus and are given in Table 2.

Current research knowledge was also assessed quantitatively. Data on existing levels of research were assembled for each weed principally from published (QDNRM and CSIRO technical reports and papers published by scientists in journals, conferences, symposia, and workshops) sources and from current research projects. The panel then used this information along with their collective knowledge to come up with research scores for each weed. Scorings on research criteria are given in Table 3.

Table 2. A QDNRM MODSS matrix showing impact criteria scorings.

Species	Environmental impact		Economic impact		Social and cultural impact	
	Current	Potential	Current	Potential	Current	Potential
Acacia nilotica	0.7	0.7	0.5	0.6	0.2	0.2
Agave spp.	0.1	0.1	0.1	0.1	0.2	0.2
Allamanda cathartica	0.1	0.2	0.1	0.1	0.1	0.1
Alternanthera philoxeroides	0.1	0.6	0.1	0.7	0.1	0.3
Alternanthera pungens	0.1	0.1	0.3	0.3	0.3	0.3
Andropogon gayanus	0.1	0.5	0.1	0.4	0.1	0.1
Annona glabra	0.2	0.6	0.1	0.6	0.1	0.2
Brachiaria mutica	0.3	0.4	0.1	0.2	0.2	0.3
Bryophyllum delagoense	0.1	0.1	0.2	0.3	0.1	0.1
Cabomba caroliniana	0.2	0.4	0.2	0.3	0.2	0.4
Calotropis procera	0.1	0.2	0.1	0.2	0.1	0.1
Cascabela thevetia	0.1	0.2	0.1	0.2	0.2	0.2
Chromolaena odorata	0.1	0.9	0.1	0.9	0.1	0.5
Cryptostegia grandiflora	0.8	0.8	0.6	0.6	0.6	0.6
Cyperus aromaticus	0.1	0.1	0.2	0.3	0.1	0.1
Datura stramonium	0.1	0.1	0.2	0.2	0.2	0.2
Echinochloa polystachia	0.1	0.4	0.1	0.2	0.2	0.2
Eichhornia crassipes	0.3	0.4	0.2	0.2	0.3	0.4
Elephantopus mollis	0.1	0.3	0.1	0.3	0.1	0.1
Eriocereus spp.	0.1	0.1	0.1	0.1	0.1	0.1
Euphorbia heterophylla	0.1	0.1	0.1	0.2	0.1	0.1
Eupatorium catarium	0.1	0.6	0.1	0.7	0.1	0.4
Harungana madagascariensis	0.1	0.4	0.1	0.3	0.1	0.2
Hymenachne amplexicaulis	0.2	0.7	0.1	0.4	0.1	0.4
Hyptis spp.	0.1	0.1	0.1	0.2	0.1	0.1
Jatropha gossypiifolia	0.4	0.6	0.3	0.7	0.3	0.5
Lantana camara	0.3	0.4	0.4	0.4	0.3	0.3
Leucaena leucocephala	0.1	0.4	0.1	0.3	0.1	0.2
Miconia calvescens	0.1	0.5	0.1	0.5	0.1	0.2
Mikania micrantha	0.1	0.9	0.1	0.8	0.1	0.5
Mimosa invisa	0.2	0.5	0.4	0.7	0.2	0.3
Opuntia spp.	0.1	0.1	0.1	0.2	0.1	0.1
Parkinsonia aculeate	0.5	0.5	0.4	0.4	0.2	0.2
Parthenium hysterophorus	0.7	0.7	0.8	0.8	0.7	0.8
Pistia stratiotes	0.1	0.1	0.1	0.1	0.2	0.2
Prosopis spp.	0.2	0.8	0.4	0.9	0.2	0.5
Psidium guajava	0.2	0.3	0.2	0.3	0.1	0.1
Ricinus communis	0.1	0.1	0.1	0.1	0.2	0.2
Rottboellia cochinchinensis	0.1	0.1	0.1	0.2	0.1	0.1
Salvinia molesta	0.2	0.2	0.1	0.1	0.2	0.2
Sansevieria trifasciata	0.1	0.1	0.1	0.1	0.1	0.1
Senna obtusifolia	0.2	0.4	0.2	0.3	0.2	0.2
Spathodea campanulata	0.1	0.2	0.1	0.2	0.1	0.1
Sporobolus spp.	0.2	0.6	0.2	0.6	0.1	0.2
Stachytarpheta spp.	0.2	0.3	0.2	0.3	0.2	0.2
Themeda quadrivalvis	0.1	0.1	0.1	0.1	0.1	0.1
Thunbergia spp.	0.1	0.7	0.1	0.7	0.1	0.3
Tithonia diversifolia	0.1	0.1	0.1	0.1	0.1	0.1
Tribulus terrestris	0.1	0.1	0.2	0.2	0.2	0.2
Turbina corymbosa	0.1	0.2	0.1	0.1	0.1	0.1
Sphagneticola trilobata	0.1	0.3	0.1	0.1	0.1	0.1
Xanthium spp.	0.1	0.1	0.1	0.2	0.1	0.2
Ziziphus mauritiana	0.1	0.2	0.3	0.5	0.2	0.4

Scenario testing

Having entered impact and research scores into QDNRM MODSS, the program was then ready to develop weed priority lists. Arranging the number and importance order (ranking) of selected criteria formed a scenario. For example, a simple scenario consisted of one criterion called 'economic impact of a weed' and formed a 'first order criteria'. This criterion may be at two temporal levels and form a 'second order criterion' composed of 'current

economic impact and potential economic impact'. The second order criteria may be ranked differently by a decision-maker into equal rankings (weighting importance) or unequal rankings with potential economic impact greater than current economic impact. Complex scenarios may consist of several conflicting criteria of equal or different rankings (weighting importance).

In this study, we ran several 'what if' scenarios of increasing complexity to determine whether different criteria weightings (importance order) had any marked effect on the ranking order of weeds as well as to identify the most suitable scenario that met the objectives of the prioritization process (Table 4). Examples of simple scenarios tested one criterion at a time: solely economic and solely environmental with potential > current impact. An example of a complex scenario tested three criteria simultaneously with economic > environmental > social impact with potential > current impact. A more complex scenario tested 12 criteria simultaneously with 6 impact criteria [economic > environmental > social and cultural with potential > current impact] > 6 research criteria [control methods (herbicides research = mechanical research = fire research) > biocontrol research] > ecological research > socio-economic research.

External reviewing

A draft report of the prioritization process was circulated to six external reviewers for comment on the outcomes, particularly the order in which weeds were prioritized. Feedback from external reviewers was taken into consideration and changes made where appropriate.

Results

Scenarios

For all scenarios tested there was only one change in the species composition in the top 10 weeds (Table 4). For example, in the dry-tropics list, the ranking order of weeds based on economic impact revealed minor differences in movement of species up or down the list when compared with the environmental one. Movement down the list was in the order of 1, 2, 1, 1, and 3 steps for parthenium, mesquite (*Prosopis* spp.), bellyache bush (*Jatropha gossypiifolia*), giant rats tail (*Sporobolus* spp.), and Chinee apple (*Ziziphus mauritiana*), respectively. Movement down the list indicated that the potential economic impact of these weeds was greater than their potential environmental impact and vice versa for movement of weeds up the list (Table 4).

Minor changes also occurred in the ranking order of the top 10 weeds when a combination of the three impact criteria (economic, environmental, and social) were analysed in MODSS. A similar pattern was also noted in the more complex scenario, where research was added into the process. It was observed that weeds that have had substantial research undertaken on them, such as prickly acacia and rubber vine, tended to move down the list (Table 4).

Since there were minor differences between simple, complex, and more complex scenarios tested, the more complex scenario was selected as the most suitable scenario because it took into account both impact and research criteria. Outcomes of this scenario for both dry- and wet-tropics weeds are given in Table 5 and illustrated for the dry-tropics weeds in Figure 2. Table 5 shows the ranking order of the 31 wet-tropics weeds with mikania, Siam weed, giant sensitive plant and praxelis leading the group. Similarly, the 22 dry-tropics weeds were ranked in descending order of priority with mesquite,

Table 3. A QDNRM MODSS matrix showing research criteria scorings.

	Ecology	Chemical	Biocontrol	Mechanical	Fire	Socio-economic
Acacia nilotica	0.4	0.1	0.5	0.1	0.5	0.5
Agave spp.	0.9	0.3	1	1	1	1
Allamanda cathartica	0	0	0	0	0	0
Alternanthera philoxeroides	0	0.3	0.5	0.1	0.1	0.1
Alternanthera pungens	1	0.5	1	1	0.5	1
Andropogon gayanus	0	1	1	1	0.5	1
Annona glabra	0.6	0.2	1	1	0.7	1
Brachiaria mutica	0	0.7	1	1	1	1
Bryophyllum delagoense	1	0.7	0.8	1	0.3	1
Cabomba caroliniana	1	0.3	1	0.1	1	1
Calotropis procera	1	0.3	1	1	1	1
Cascabela thevetia	1	0.5	1	1	1	1
Chromolaena odorata	0.8	0.7	0.8	1	0.7	1
Cryptostegia grandiflora	0.2	0.1	0.1	0.1	0.1	0.1
Cyperus aromaticus	1	0.7	1	1	1	1
Datura stramonium	0.9	0.7	1	0.5	1	1
Echinochloa polystachia	1	1	1	1	1	1
Eichhornia crassipes	0.1	0.1	0.3	0.1	1	0.1
Elephantopus mollis	0.9	0.8	1	1	1	1
Eriocereus spp.	0	0.1	0.1	0.1	0.1	0.5
Euphorbia heterophylla	0.9	0.7	1	1	1	1
Eupatorium catarium	1	1	1	1	1	1
Harungana madagascariensis	0.8	0.5	1	1	1	1
Hymenachne amplexicaulis	0.6	0.7	1	1	0.1	1
Hyptis spp.	1	0.7	1	1	1	1
Jatropha gossypiifolia	0.5	0.2	0.8	0.9	0.3	1
Lantana camara	0.7	0.1	0.3	0.3	0.7	0.1
Leucaena leucocephala	0	0.3	0.8	1	1	1
Miconia calvescens	0	0	0	0	0	0
Mikania micrantha	1	1	1	1	1	1
Mimosa invisa	1	0.5	0.3	0.9	1	1
Opuntia spp.	0.1	0.1	0.1	0.1	0.1	0.1
Parkinsonia aculeata	0.9	0.2	0.5	0.7	0.3	0.5
Parthenium hysterophorus	0.2	0.1	0.1	0.9	0.5	0.1
Pistia stratiotes	0.7	0.5	0.5	0.1	0.1	1
Prosopis spp.	0.7	0.2	0.5	0.1	0.7	1
Psidium guajava	0	0.3	1	1	1	0.5
Ricinus communis	1	0.5	1	1	1	1
Rottboellia cochinchinensis	0	0.3	0	0	0	0
Salvinia molesta	0.1	0.1	0.5	0.1	0.1	0.1
Sansevieria trifasciata	0	0	0	0	0	0
Senna obtusifolia	0.8	0.7	0.8	0.7	1	0.5
Spathodea campanulata	1	0.5	1	1	1	1
Sporobolus spp.	0	0.1	1	0.7	0.5	1
Stachytarpheta spp.	1	0.7	1	0.7	1	1
Themeda quadrivalvis	0.7	0.3	1	0.3	0.5	1
Thunbergia spp.	1	0.7	1	1	1	0.5
Tithonia diversifolia	0	0	0	0	0	0
Tribulus terrestris	1	0.5	1	1	1	1
Turbina corymbosa	0	0	0	0	0	0
Sphagneticola trilobata	0.9	0.7	1	1	1	1
Xanthium spp.	0.1	0.3	0.1	0.3	0.5	0.5
Ziziphus mauritiana	0.8	0.1	1	1	0.7	1

Table 4. Ranking order of the top 10 dry-tropics weeds as affected by criteria weighting and illustrated in four scenarios.

Scenario 1 Economic with P>C	Scenario 2 Environmental with P>C	Scenario 3 Environmental>Economic> Social and cultural with P>C	Scenario 4 Impact (Environmental>Economic>Social and cultural with P>C) > Research {(Control Herbicide=Mechanical= Fire)>Biocontrol))>ecological>socio-economic}
Parthenium	Rubber vine	Rubber vine	Mesquite
Mesquite	Parthenium	Parthenium	Parthenium
Rubber vine	Prickly acacia	Mesquite	Bellyache bush
Bellyache bush	Mesquite	Prickly acacia	Rubber vine
Prickly acacia	Bellyache bush	Bellyache bush	Prickly acacia
Giant rats tail	Parkinsonia	Giant rats tail	Chinee apple
Chinee apple	Giant rats tail	Parkinsonia	Giant rats tail
Parkinsonia	Lantana	Lantana	Parkinsonia
Lantana	Aleman grass	Aleman grass	Khaki weed
Khaki weed	Chinee apple	Chinee apple	Aleman grass

P: potential; C: current; >: greater than.

Table 5. Prioritized list of wet- and dry-tropics weeds.

	Wet-tropics weeds		Dry-tropics weeds	
	Scientific name	Common name	Scientific name	Common name
1	*Mikania micrantha*	Mikania	*Prosopis* spp.	Mesquite
2	*Chromolaena odorata*	Siam weed	*Parthenium hysterophorus*	Parthenium
3	*Mimosa invisa*	Giant sensitive plant	*Jatropha gossypiifolia*	Bellyache bush
4	*Eupatorium catarium*	Praxelis	*Cryptostegia grandiflora*	Rubber vine
5	*Thunbergia* spp.	Thunbergia	*Acacia nilotica*	Prickly acacia
6	*Miconia calvescens*	Miconia	*Ziziphus mauritiana*	Chinee apple
7	*Annona glabra*	Pond apple	*Sporobolus spp.*	Giant rats tail
8	*Alternanthera philoxeroides*	Alligator weed	*Parkinsonia aculeata*	Parkinsonia
9	*Hymenachne amplexicaulis*	Hymenachne, Ponded pasture grass	*Alternanthera pungens*	Khaki weed
10	*Andropogon gayanus*	Gamba grass	*Echinochloa polystachia*	Aleman grass
11	*Cabomba caroliniana*	Cabomba	*Lantana camara*	Lantana
12	*Stachytarpheta* spp.	Snakeweed	*Bryophyllum delagoense*	Mother-of-millions
13	*Harungana madagascariensis*	Harungana	*Cascabela thevetia*	Yellow oleander, Captain Cook tree
14	*Senna obtusifolia*	Sicklepod	*Tribulus terrestris*	Caltrop; Goats head burr
15	*Elephantopus mollis*	Tobacco weed	*Calotropis procera*	Calotrope, Kings crown
16	*Cyperus aromaticus*	Navua sedge	*Datura stramonium*	Thornapple
17	*Psidium guajava*	Guajava	*Ricinus communis*	Castor oil plant
18	*Leucaena leucocephala*	Leucaena	*Agave* spp.	Sisal hemp
19	*Brachiaria mutica*	Para grass	*Themeda quadrivalvis*	Grader grass
20	*Spathodea campanulata*	African tulip tree	*Xanthium* spp.	Noogoora burr
21	*Hyptis* spp.	Knob weed, Stinking Roger, Comb hyptis	*Eriocereus* spp.	Harrisa cactus
22	*Rottboellia cochinchinensis*	Itch grass	*Opuntia* spp.	Pest pear
23	*Euphorbia heterophylla*	Milk weed		
24	*Allamanda cathartica*	Yellow allamanda vine		
25	*Turbina corymbosa*	Turbine vine		
26	*Sphagneticola trilobata*	Singapore daisy		
27	*Tithonia diversifolia*	Thithonia		
28	*Sansevieria trifasciata*	Mother-in-laws tongue		
29	*Eichhornia crassipes*	Water hyacinth		
30	*Pistia stratiotes*	Water lettuce		
31	*Salvinia molesta*	Salvinia		

parthenium, bellyache bush, and rubber vine leading the dry-tropics weeds.

External reviewing

The general consensus by the reviewers was one of satisfaction with the process although they stressed the need for the process to be repeated as circumstances change.

Discussion

The current study has developed priority lists for weed research in both the wet- and dry-tropics of north Queensland. The priority lists will be used by decision-makers in north Queensland to make an informed decision when deciding which weeds should be researched and what type of research needed. The process used adopted many of the principles implemented to determine Australia's 20 weeds of National Significance (Thorp and Lynch 2000), but operated at a much smaller scale. Both priorities relied heavily on stakeholder inputs to develop an inventory of weeds and to evaluate the weeds, and in both instances, the outcomes derived were largely dependant on

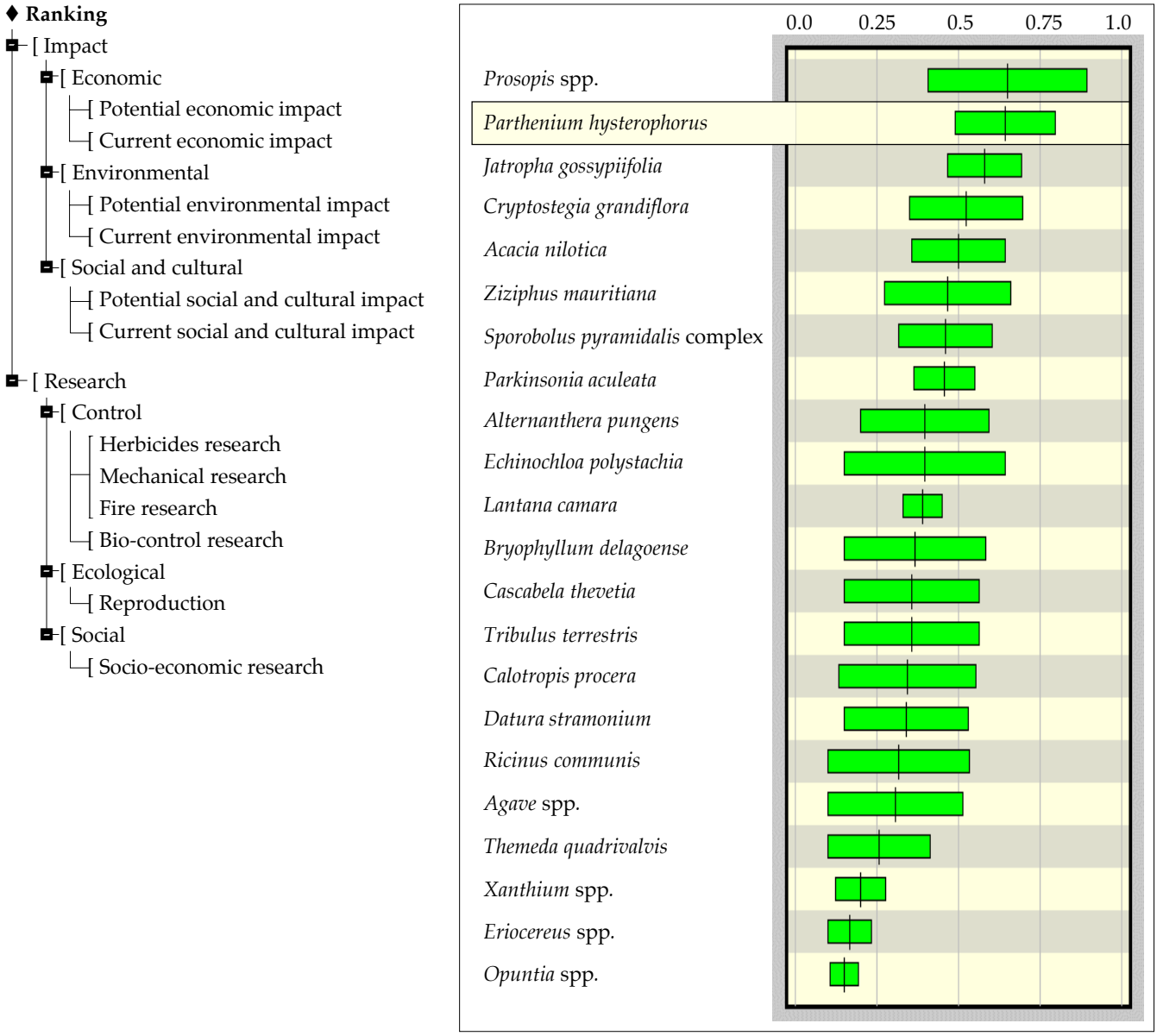

Figure 2. MODSS graphical display of criteria ranking (top left corner). Weeds with average scorings closer to 1.0 ranked higher and were closer to the right axis of the graph and *vice versa*. The length of the bars is an indicator of the sensitivity of assessment to certain criteria.

their inputs. For the north Queensland prioritization, feedback from an independent group of reviewers supported the lists developed. They did however recognize that the process needed to be reviewed as circumstances changed. This could include the arrival of new weeds into the area, development of effective controls for some weeds or a dramatic increase in the spread of a weed. Already since the development of these lists, a new weed, *Limnocharis flava*, has been found in the wet-tropics region (Waterhouse personal communication 2000). The prioritization process used to develop the current weed research priority list was also adopted for weeds of south-east Queensland.

Formulation of an inventory of weeds for the Weeds of National Significance prioritization program involved a traditional approach whereby questionaries were sent to representatives of States and Territories involved in some aspect of weed management (Thorp and Lynch 2000). Feedback from these led to 71 weeds being nominated as possible candidates. An alternate approach was used for north Queensland prioritization. The recent development of pest management plans in Queensland for local Government Shires provided a logical source from where an inventory of weeds could be developed, as most of these were formulated following extensive stakeholder consultation. The difficulty with this approach however, was the large number of weeds identified within the 47 relevant pest management plans and the WTMA (there were 246 weeds) and subsequent development of a more manageable shortlist. This was largely achieved by taking into account the priority given to the weed in individual shires and the number of times it was prioritized across the shires. The deficiency in this approach however, was that all shires were treated as equal with no consideration of the actual area that they represented. For example, Dalrymple Shire alone covers an area of 68 427 km^2, which is nearly 52-, 21-, 14- and 7-fold greater than that of the shires of Sarina (1327 km^2), Mirani (3292 km^2), Burdekin (4979 km^2), and Emerald (10 230 km^2). There was a risk that a highly detrimental weed growing all over one or a few large shires may rate less than a low impact weed growing in many shires.

To ensure that the developed shortlist represented the views of the majority of stakeholders it was circulated to over 140 individuals/organizations for feedback. While this confirmed that in most cases the exotic weeds short-listed were truly indicative of the major threats to north Queensland, some conflict of interest

issues arose. For a limited number of weeds, such as hymenachne, buffel grass and leucaena, some stakeholders considered them useful while others considered them detrimental. Incorporating a requirement that feedback had to be received from three or more stakeholders before removal/addition of a weed could occur largely overcame this problem.

Scoring impact and research criteria using a panel of weed experts were difficult, particularly for weeds where limited information was available. Using a benchmark species proved invaluable, as in some instances it was easier to compare the relative importance of weeds in relation to others than provide absolute values. These issues also arose in the Development of the Weeds of National Significance (Thorp and Lynch 2000).

When interpreting the priority lists, decision makers need to be mindful that some of the weeds that rated extremely highly are still restricted to relatively small areas and while we know little about them it would be better to go for eradication than commence any research activities. The only research that could be justified would be testing of suitable chemicals. There will also be situations where weeds prioritized low in the list may be researched for political reasons or availability of research dollars by private industries. Although these deviations from normal are very rare they do not undermine efforts to develop weed research priority lists. This is because stakeholders develop weed lists and the probability that a weed is not picked from developed lists would be low.

Conclusions

The outcomes of the prioritization process were to a large extent dependent on the current knowledge and utilization of a multiple objective decision support system. The process used can be revisited at anytime to update the priority list in the event of (i) changes occurring in impact of a listed weed, (ii) a new invasive weed appearing on the scene or, (iii) an update in a research profile of a prioritized weed. It is hoped that this study has exposed others, such as weed management authorities in other regions of Australia or elsewhere, to the benefits, usefulness and deficiencies of the process that not only prioritized weeds in terms of amount of research needed to be done, but also showed what type of research needed to be done.

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