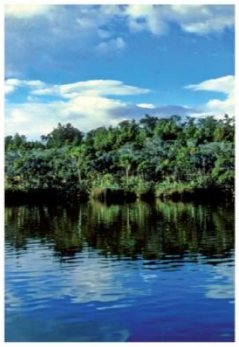

Prioritisation of targets for biological control of weeds in the Pacific region

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Contents

Summary

Project and Client

- Invasive weeds are one of the most serious threats to biodiversity and sustainable development in the Pacific region. Biocontrol is likely to be the only feasible way of managing many widespread weeds, but is not always appropriate or successful. With so many weed species to tackle and inevitably limited resources, prioritising where to direct control efforts most effectively is of key importance. Landcare Research recently developed a framework for the Australian government that allows the best and worst weed targets for biocontrol to be identified. Critical Ecosystem Partnership Fund and USDA Forest Service funding enabled this framework to be applied to weeds of the Pacific region.

Objectives

To apply a framework developed for Australia by Paynter et al. (2009) to prioritise biocontrol targets from a list of 96 weed species identified during a Pacific-wide biocontrol workshop held in November 2009 (Dodd & Hayes 2009) for 15 regions/nations – Micronesia, New Guinea, Solomon Islands, Vanuatu, New Caledonia, Fiji, Tonga, Tuvalu, Tokelau, American Samoa, Samoa, Cook Islands, French Polynesia, Pitcairn Islands, and Hawaii – as follows:

- Acquire information regarding traits of each weed that Paynter et al. (2009) showed were correlated with the impact and cost of biocontrol and review current and past biocontrol programmes against the 96 weeds listed by Dodd and Hayes (2009).
- Score and list prioritised weed biocontrol targets using the Paynter et al. (2009) framework, according to the predicted impact of biocontrol (feasibility) and effort required to conduct a biocontrol programme and overall score (feasibility score × 1/effort score).

Methods

Relevant data to parameterise the Paynter et al. (2009) scoring framework were acquired by using international scientific literature (e.g., CAB Abstracts®), regional floras, relevant websites (e.g. the Pacific Island Ecosystems at Risk (PIER) website http://www.hear.org/pier/ and Wikipedia http://www.wikipedia.org/ and by consulting with regional experts.

The project brief was to assess the priority of each species using the framework for 15 countries/territories: Micronesia, New Guinea, Solomon Islands, Vanuatu, New Caledonia, Fiji, Tonga, Tuvalu, Tokelau, American Samoa, Samoa, Cook Islands, French Polynesia, Pitcairn Islands, and Hawaii. Not all weeds were present in all countries/territories. Moreover, cost and probability of biocontrol success should vary, for example, according to the presence or absence of related species, which also vary between countries/territories. Rather than conducting a single prioritisation analysis covering all these countries/territories it was therefore decided to group the 15 countries/territories into four regions with similar floras and weed problems:

1. North-west: including New Guinea, Micronesia & the Solomon Islands

2. Central: including New Caledonia, Vanuatu, Fiji, Tuvalu, Samoa, American Samoa & Tonga
3. North-east: Hawaii
4. South-east: Cook Islands, French Polynesia & Pitcairn Islands.

The history of biocontrol throughout the Pacific region was then reviewed to identify and prioritize biocontrol targets within these four regions.

Results

- Information was found for most of the relevant attributes for all the weed species, enabling feasibility of biocontrol, effort and overall scores (based on both the feasibility and effort required to implement biocontrol) to be calculated for all weed species. These scores are listed in Appendices 4–15.

Conclusions

- Ideally, weeds should be prioritised on the basis of importance, as well as the potential cost and feasibility of biocontrol. The relative importance of the 96 weeds in each region has not been rigorously determined. Moreover, many of the 96 weed species were introduced because of perceived beneficial properties (e.g., ornamental, edible fruits or source of timber). The assumption made during this ranking exercise is that the negative aspects of the invasive weed outweigh these benefits, which may not be the case. It is therefore premature to make recommendations regarding the precise order of priority with which weeds should be targeted for biological control. Nevertheless, firm recommendations can be made regarding the redistribution of proven agents, and weed species are identified that are likely to be the most feasible novel targets for biocontrol, provided they are appropriate targets for biocontrol (i.e. that conflicts of interest are unlikely to prevent biocontrol from being implemented).

Recommendations

- There is considerable scope for redistribution of existing, proven biocontrol agents for some of the worst weeds in the Pacific region (listed in the report).
- A number of current weed targets for biocontrol where agents have not yet been released or where agents have been released but it is too early to evaluate the impact of biocontrol, are predicted to be good targets (*Coccinia grandis*, *Hedychium* spp. and *Psidium cattleianum*) or intermediate targets, (*Miconia calvescens, Mikania micrantha, Tecoma stans*), in terms of feasibility of success. This ranking exercise therefore supports the nomination of these species as targets for biocontrol in the Pacific region.
- A number of weeds that are serious problems in the Pacific but have never been targeted for biocontrol were identified as good targets in terms of feasibility of success, (*Antigonon leptopus*, *Clerodendrum chinensis*, *Spathodea campanulata*, and *Sphagneticola trilobata*), while others were consistently identified as difficult targets

(*Bidens pilosa*, *Cyperus rotundus*, *Mimosa pudica, Passiflora* spp., and *Senna tora/obtusifolia*).

- Conflicts of interest can delay or even prevent biocontrol programmes from proceeding. The assumption made during this ranking exercise is that the negative aspects of the invasive weed outweigh these benefits, which may not be the case. Another important aspect of prioritisation is weed importance. Determining the relative importance of the 96 weed species was beyond the scope of this ranking excercise. Decisions regarding whether a weed is an appropriate target, in terms of both importance and potential for conflicts of interest, must be made by the appropriate authorities in the relevant regions.
- As noted by Paynter et al. (2009), there is a risk that if the framework is used as the only tool for prioritisation, then it may become a self-fulfilling prophesy. If conventional wisdom states that biological control cannot succeed against a particular weed type, then it may result in that weed type never being targeted for biological control. Weeds that do not fall in the top 20 should still be considered for biocontrol if they are of importance to countries, as projects against more difficult targets can still succeed, but they just might require more resources. We recommend an integrated pragmatic decision-making process to stand alongside the framework, which will serve to deliver a portfolio of weed targets that includes a range of good, medium and hard weed management targets.
- The author is interested to receive any additional information about Pacific weeds or biocontrol programmes that was not available at the time of writing this report. He is also available to assist individual Pacific Island countries and territories to further refine and customise prioritised lists of the best weed biocontrol targets. He can be contacted on paynterq@landcareresearch.co.nz.

1 Introduction

Invasive species are considered to be one of the most serious threats to biodiversity and sustainable development in the Pacific region, which includes recognised biodiversity hotspots, such as New Caledonia and Polynesia-Micronesia. Invasive species are a growing problem in the Pacific as global trade, travel and tourism bring increasing numbers of invasive species to the Pacific, and troublesome species that are already present begin to naturalise and move out of lag phases. Better and more sustainable ways of combating invasive species are urgently needed.

Biocontrol is likely to be the only feasible way of managing many widespread weeds. Biocontrol is, however, not always appropriate or successful, and with so many species to tackle and inevitably limited resources, prioritising where to direct control efforts most effectively is of key importance. Landcare Research recently developed a framework for the Australian government that allows the best and worst weed targets for biocontrol to be identified (Paynter et al. 2009). This framework scored weed targets on the basis of their amenability to biological control (feasibility) and the likely effort required to implement a biological control programme. To determine a weed's amenability to biocontrol Paynter et al. (2009) investigated a range of weed attributes that were hypothesised to be associated with biocontrol success. Data on the impact of biological control were collected in a variety of ways (e.g., percentage cover; stems m^{-2}; weed biomass). To allow comparison between weeds, these data were converted into an 'impact index' (I), defined as the proportional reduction in weed density due to biological control. A scoring system was then developed that scored a weed according to attributes that were statistically significant indicators of impact index, namely:

1. Previous success or failure, if the weed had been already been targeted for biocontrol elsewhere (because successes/failures are often repeated);

2. Habitat(mean impact of biocontrol against aquatic and wetland weeds is significantly greater than against terrestrial weeds);

3. Life cycle (mean impact of biocontrol against temperate annuals was significantly lower, compared with tropical annuals, biennials and perennials);

4. Reproduction (mean impact of biocontrol against species capable of vegetative reproduction was greater versus weed species reproducing solely by seed);

5. Weed in native range (biocontrol impacts against species reported to be weeds in the native range were significantly lower, versus species not reported to be weeds in the native range);

6. Difficulty targeting multiple forms of weed, or probability of replacement of the weed by forms or congeners of the target following successful biological control thereby negating benefits (for example, species with multiple closely related forms, such as *Rubus fruticosus* agg. and *Lantana camara* are notoriously difficult targets, because biocontrol may only be effective against a limited subset of forms);

7. Growing in competitive environment (agricultural versus environmental weed, because the mean impact of biocontrol on agricultural weeds was lower versus environmental weeds);

8. Presence of a native or valued exotic congener to the weed. Even though this was not a significant factor influencing past success, Paynter et al. (2009) included it because when many past programmes were conducted, the risk of non-target attack on native plants was only a minor consideration. Consequently, a number of weed biocontrol agents were released that have been recorded attacking non-target plants. Subsequent concerns regarding non-target attack have resulted in increasingly risk-averse policies and fewer successful applications for the release of weed biocontrol agents. It is likely that past successful programmes against a number of weeds (e.g., the programmes against *Carduus nutans* and *C. acanthoides* in the USA; *Hypericum perforatum* in Australia, South Africa and the USA) would not be possible if they were current targets, due to the presence of native congeners and the potential for non-target attack.

The "Feasibility" score was given a maximum value of 100. Paynter et al. (2009) validated the scoring system by correlating feasibility score with impact index (Figure 1). The impact of biocontrol against weeds that scored >70 was invariably high; while impacts against weeds that scored ≤ 50 was almost invariably low. Programmes against weeds that scored between 51 and 70 had similar numbers of successes and failures, allowing weeds to be categorised as good, difficult or intermediate targets according to the feasibility score.

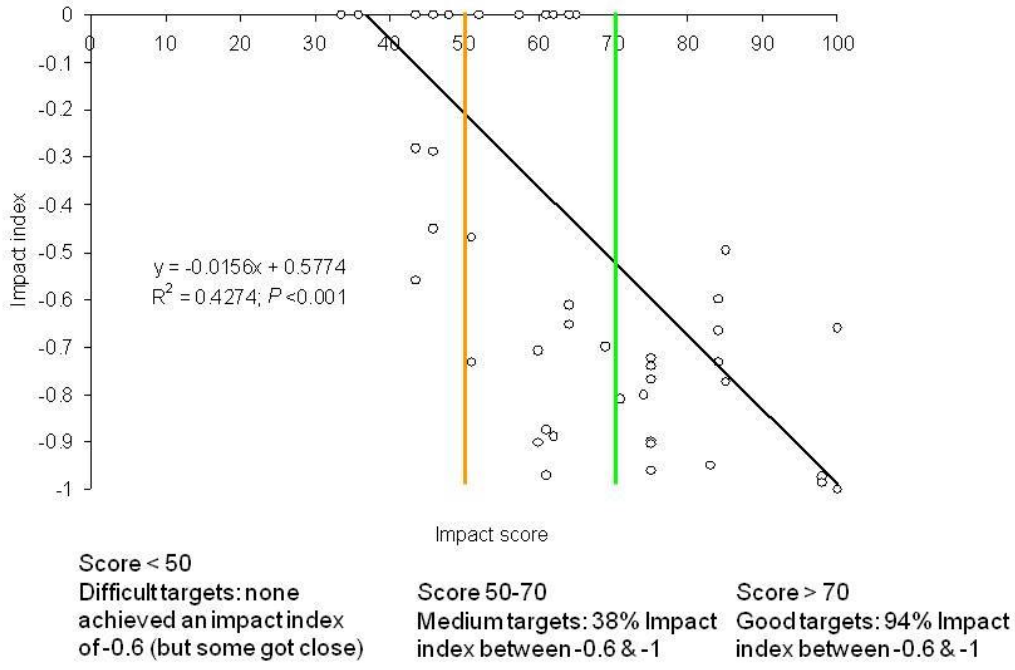

Figure 1 Biocontrol feasibility score versus actual 'impact index' (based on Paynter et al. (2009).

Paynter et al. (2009) determined the likely effort required to implement a biocontrol programme by reviewing factors that influence biocontrol programme cost. Factors influencing "effort" are listed below:

- Whether the weed had already been targeted for biocontrol elsewhere
- Access and ease of working in the native range
- Literature regarding natural enemies well known
- Presence of native or valued exotic plants that are related to the target weed

The biggest determinant of cost was whether a programme had already been conducted successfully elsewhere, because native range surveys and much, if not all, of the host-range testing required would have already been performed. For pioneering programmes, factors associated with cost include the risk of non-target attack: the average duration of host-range screening is longer for agents that attack weeds that are closely-related to native plants or valued exotic plants, compared to those which attack weeds that are unrelated to native or valued exotic plants. Other, less easily quantifiable determinants of effort include the ease of working (e.g., acquiring permits, travel and accommodation costs, quality of infrastructure, safety) in the native range and knowledge of the fauna in the native range (for example, the insect fauna of European plants is so well known and documented that promising candidate agents can often be short-listed on the basis of host records alone).

The benefit to cost ratio of successful weed biocontrol programmes can be so high, the initial effort spent implementing biocontrol can seem trivial. Paynter et al. (2009), nevertheless, recognised that effort is important because, given limited resources, it may be economically prudent to tackle a higher number of "low effort" weeds versus fewer "high effort" weeds. Effort was therefore scored out of 50 (the higher the score the more effort required), recognising that while it is important, effort is less important than feasibility of control. The scoring system used by Paynter et al. (2009) is given in Appendix 1.

Paynter et al. (2009) noted that it is important to take into account a weed's importance as well as the feasibility of biocontrol. For example, the economic or environmental benefits of partially controlling a major weed might exceed the benefits of completely controlling a minor weed. Paynter et al. (2009) incorporated weed importance by combining feasibility and effort scores with already published weed importance rankings for Australia (Thorp & Lynch 2000). The relative importance of weeds of the Pacific region has not been formally determined. Dovey et al. (2004) listed the top 24 potential candidate weeds for biological control in Pacific island countries and territories. Moreover, a Pacific-wide workshop of biocontrol experts held in November 2009 (Dodd & Hayes 2009) expanded this list by identifying 96 weed species that are of particular importance within the Pacific region. The Paynter et al. (2009) framework was therefore applied to rank these 96 weeds according to their likely amenability to biocontrol (feasibility) and the effort required to conduct a biocontrol programme. In addition to the 96 nominated weeds, *Cuscuta campestris* was also included because there was some concern that the similar parasitic weed *Cassytha filiformis*, which is native to the region, had been confused with the former species, which is an invasive weed throughout the Pacific region. *Senna obtusifolia* was also included, because this species has been confused with *Senna tora* (Jean Yves-Meyer, pers. comm.).

2 Methods

I used the framework developed by Paynter et al. (2009) to score and rank weeds according to their predicted susceptibility to biocontrol and the likely complexity and cost of a weed biocontrol programme as follows:

I acquired relevant data on those attributes that are statistically significant indicators of biocontrol success and the cost of implementing biocontrol (see Introduction). This included the current status of biocontrol programs for each of the 96 weed species, for which biocontrol is desired in the Pacific, that were identified at a Pacific-wide workshop (Dodd & Hayes 2009). These data were gathered by using international scientific literature (e.g., CAB Abstracts®), regional floras, the World Wide Web, especially the Pacific Island Ecosystems at Risk (PIER) website (http://www.hear.org/pier/) and Wikipedia (http://www.wikipedia.org/) and by consulting with regional experts.

Our brief was to assess the priority of each species using the framework for 15 countries/territories – Micronesia, New Guinea, Solomon Islands, Vanuatu, New Caledonia, Fiji, Tonga, Tuvalu, Tokelau, American Samoa, Samoa, Cook Islands, French Polynesia, Pitcairn Islands, and Hawaii. Conducting a single prioritisation analysis for these countries/territories could be misleading, because the probability of successful biocontrol should vary between them, for example, according to geographic variation in the presence of absence of native species that are closely related to the target weed. There were insufficient resources to conduct 15 separate ranking analyses so countries/territories were grouped into four regions (see Figure 2) with similar floras and weed problems as follows:

1. North-west: including New Guinea, Micronesia & the Solomon Islands
2. Central: including New Caledonia, Vanuatu, Fiji, Tuvalu, Samoa, American Samoa & Tonga
3. North-east: Hawaii
4. South-east: Cook Islands, French Polynesia & Pitcairn Islands.

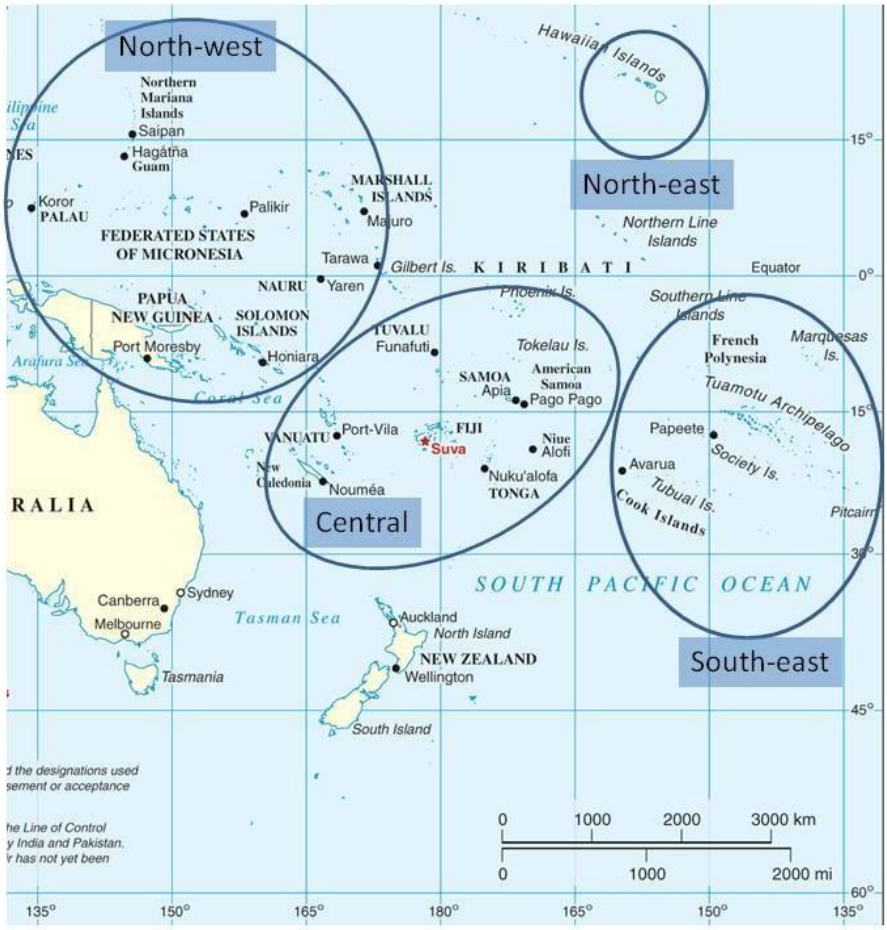

Figure 2 The four regions that were analysed separately (see text for details).

3 Results and Conclusions

Information was found for most attributes for all the weed species and these are listed in Appendices 2 and 3. There was, however, little information pertaining to the presence of hybrids or multiple forms of weeds. This factor was generally scored as unknown, with the exception of a few weeds such as *Broussonetia papyrifera*, which exists as sterile male clones in the Pacific region, and biocontrol targets for which multiple weed forms have already been demonstrated to be a potential problem (e.g., *Lantana camara*) or not (e.g., *Eichhornia crassipes*). However, it is possible that the genetic diversity of weeds such as *L. camara* is different within the Pacific region, compared with other studied populations, which could affect the feasibility of biocontrol.

Many of the 96 weed species were introduced because of perceived beneficial properties (e.g., ornamental, edible fruits or source of timber). The assumption made during this ranking exercise is that the negative aspects of the invasive weed outweigh these benefits, which may not be the case. Certainly some species, listed as cultivated on the PIER website (http://www.hear.org/pier/) are no longer cultivated and may even be banned from cultivation (e.g., *P. cattleianum, S. cumini, S. jambos, S. campanulata, T. stans* and *L. camara* in French Polynesia; Jean-Yves Meyer, pers. comm.). However, other plants, such as *Acacia* spp., that are cultivated for timber, may not be appropriate targets for biocontrol. Therefore, weeds identified as potentially good targets for biocontrol, in terms of predicted impact/feasibility,

may prove to be inappropriate targets due to the potential for conflicts of interest. These decisions have to be made by the appropriate authorities in the relevant regions.

Another similar source of uncertainty was the importance of exotic congeners of the target weed, for the same reasons as above: it was not always clear whether a 'cultivated' exotic congener is still cultivated within the region. We assumed that, as in New Zealand, economic considerations mean that non-target attack on exotic ornamental congener species is acceptable, but that non-target attack on valued exotic agricultural congeneric crops is unacceptable.

The feasibility, effort and combined scores for the twenty best targets (based on combined feasibility and effort scores) are listed for the four regions (Appendices 4–15).

3.1 Potential for repeat programmes and collaborative programmes

As expected, many of the best targets are species for which biocontrol has succeeded in other countries. Some of these species have already been targeted for biocontrol within the Pacific region. Nevertheless, as noted by Julien et al. (2007), there are numerous opportunities for redistribution of biocontrol agents that are already present in the Pacific. For example, *Heteropsylla spinulosa* has successfully controlled *Mimosa diplotricha* in many parts of Pacific, but has not yet been introduced in French Polynesia, New Caledonia or Vanuatu. Although biocontrol has succeeded against *Eichhornia crassipes* in many countries, in the Pacific region it has, to date, only been targeted for biocontrol in Papua New Guinea, Fiji and Vanuatu (Dodd & Hayes 2009). In addition, there are weeds such as *Parthenium hysterophorus* and *Xanthium strumarium* that have been successfully targeted for biocontrol outside the region for which agents have yet to be released in the Pacific region.

Several weeds are current biocontrol targets, although biocontrol agents have not yet been released against them. These species have lower effort scores, because native range surveys have already been performed and, in some cases such as *Tecoma stans*, host-range testing has been performed and specific candidate agents have been identified (Wood 2009). Weeds that have been targeted for biocontrol both within and outside the Pacific region are listed in Appendix 3.

3.2 Potential for novel targets

Although repeat programmes may incur a lower risk of failure, compared with tackling novel targets, novel programmes are required for weeds that are problems in the Pacific region and that have not been targeted for biocontrol elsewhere. The ranking system identified several such weeds as good targets for biocontrol, including *Antigonon leptopus, Psidium cattleianum, Sphagneticola trilobata* and *Spathodea campanulata* (see Appendices 6, 9, 12 and 15). *Costus speciosus, Merremia* spp. and *Stachytarpheta* spp. were identified as intermediate targets. Some serious weeds in the region were consistently identified as difficult targets, including *Bidens pilosa, Cyperus rotundus*, *Mimosa pudica* and *Senna tora/obtusifolia* (see Appendices 4, 7, 10 and 13).

4 Recommendations

It may be premature to make recommendations regarding which weeds should be targeted for biological control in this report, because the relative importance of each weed and the need for biocontrol in each region has not been rigorously determined (see Appendix 16, for information regarding determining weed importance). Nevertheless, on the basis of information presented by Dodd and Hayes (2009) a number of recommendations can be made with some confidence:

- There is considerable scope for redistribution of existing, proven biocontrol agents, for some of the worst weeds in the Pacific region. A list of weeds for which proven biocontrol agents are available for redistribution throughout the Pacific region is provided in Table 1, below, but note that the list of regions where biocontrol is required list is considered to be incomplete. This is because at the meeting reported by Dodd and Hayes (2009), weed experts were not present from all the15 countries/territories included in this ranking excercise.

- A number of current weed targets for biocontrol where agents have not yet been released or where agents have been released but it is too early to evaluate the impact of biocontrol, are predicted to be good targets (*Coccinia grandis, Hedychium* spp. and *Psidium cattleianum*) or intermediate targets, (*Miconia calvescens, Mikania micrantha, Tecoma stans*), in terms of feasibility of success. This ranking exercise therefore supports the nomination of these species as targets for biocontrol in the Pacific region.

- A number of weeds that are serious problems in the Pacific but have never been targeted for biocontrol were identified as good targets in terms of feasibility of success (*Antigonon leptopus, Clerodendrum chinensis, Spathodea campanulata* and *Sphagneticola trilobata*). We recommend that biocontrol programmes against these weeds should proceed, provided there are no conflicts of interest.

- Conflicts of interest can delay or even prevent biocontrol programmes from proceeding. The assumption made during this ranking exercise is that the negative aspects of the invasive weed outweigh these benefits, which may not be the case. Another important aspect of prioritisation is weed importance. Determining the relative importance of the 96 weed species was beyond the scope of this ranking excercise. Decisions regarding whether a weed is an appropriate target, in terms of both importance and the potential for conflicts of interest, must be made by the appropriate authorities in the relevant regions.

- As noted by Paynter et al. (2009), there is a risk that if the framework is used as the only tool for prioritisation, then it may become a self-fulfilling prophesy. If conventional wisdom states that biological control cannot succeed against a particular weed type, then it may result in that weed type never being targeted for biological control. Weeds that do not fall in the top 20 should still be considered for biocontrol if they are of importance to countries, as projects against more difficult targets can still succeed, but they just might require more resources. We recommend an integrated pragmatic decision-making process to stand alongside the framework, which will serve to deliver a portfolio of weed targets that includes a range of good, medium and hard weed management targets.

- The author is interested to receive any additional information about Pacific weeds or biocontrol programmes that was not available at the time of writing this report . He is also available to assist individual Pacific Island countries and territories to further refine and customise prioritised lists of the best weed biocontrol targets. He can be contacted on paynterq@landcareresearch.co.nz.

Table 1 List of weeds for which proven biocontrol agents are available for redistribution throughout the Pacific region. The areas where biocontrol is required are those listed by Dodd and Hayes (2009).

WEED	Where biocontrol is required
Chromolaena odorata	New Caledonia
Eichhornia crassipes	New Caledonia; Samoa
Lantana camara	Cook Islands; Samoa
Mimosa diplotricha	Cook Islands; French Polynesia; New Caledonia; Vanuatu
Mimosa pigra	Papua New Guinea
Parthenium hysterophorus	?
Salvinia molesta	Hawaii; New Caledonia
Sida acuta	Guam; Federated States of Micronesia; Niue; Samoa; Solomon Islands
Sida rhombifolia	Commonwealth of the Northern Mariana Islands; French Polynesia; Guam; New Caledonia; Samoa Solomon Islands
Xanthium strumarium	Fiji; Papua New Guinea

This list is considered to be incomplete because at the meeting reported by Dodd and Hayes (2009), weed experts were not present from all the15 regions/nations included in this ranking excercise. For example, nations where biocontrol of *Parthenium hysterophorus* is required were not listed by Dodd and Hayes (2009), but agents for this species have not yet been released in French Polynesia, Hawaii, New Caledonia or Vanuatu.

5 Acknowledgements

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Appendix 1

Scoring system for 'Effort' and 'Feasibility' used by Paynter et al. (2009).

EFFORT REQUIRED TO OBTAIN & HOST-RANGE TEST BIOCONTROL AGENTS	OUTCOME	Score
1. Has the weed been/is it a subject of adequately resourced biocontrol programme elsewhere?		
a. Yes, successful program	If specific agents are already known & host-range testing has already been conducted overseas, then programme is likely to be cheaper	1
b. Yes, unsuccessful program	Law of diminishing returns – if current known suite of agents is ineffective, finding new ones will be harder	15
c. Current target/too early/insufficient data to assess success elsewhere or variable success elsewhere	Potential for cost savings, but uncertainty factored into score	8
d No, never		20
2. Accessibility and ease of working in native range		
Difficult		5
Moderate		3
Easy		2

not applicable (if repeat programme)		1
3. Literature regarding natural enemies well known/accessible		
Yes		1
No	Formal identification of candidate agents (required for import/release permits) may be time consuming, delaying a program	5
4. Plant phylogeny: How closely related to indigenous/valued plants is the target weed?		
None in same family	Cheaper no-choice tests may be sufficient, larger pool of candidate agents	1
Same Family		10
Same Genus	More extensive host-range testing may be required, more species may require testing before a sufficiently specific species is identified	20
FEASIBILITY OF BIOCONTROL (LIKELIHOOD OF GOOD IMPACT)	OUTCOME	Score
1. Has the weed been a subject of adequately resourced biocontrol programme overseas?	Successes are frequently repeated	
a. Yes, successful target overseas 1 or more occasions	Maximum score: do not go to next set of questions	100
b. Yes, but with varying degrees of success or partial success		

i. Reason for partial/variable success known (e.g., agent only attacks certain forms of weed, or is restricted to certain habitats/climates) and considered unlikely to be a problem	Do not go to next set of questions	80
ii. Reason for partial/variable success unknown	Do not go to next set of questions	60
iii. Reason for partial/variable success known and considered likely to be a problem	Do not go to next set of questions	40
c. Unsuccessful target overseas only once		30
d. Unsuccessful target overseas more than once		20
e. Not a target elsewhere or too early to assess success of overseas program	Go to next set of questions	0
2. Habitat		
Aquatic/wetland	Higher probability of success	35
Terrestrial	Lower probability of success	14
3. Life cycle		
Predominantly temperate annual	Lower probability of success	3
Predominantly tropical/sub-tropical annual	Higher probability of success	4
Biennial/perennial	Higher probability of success	5
4. Reproduction		
Vegetative (+/- seed/spore)	Higher probability of success	25

Seed/spores only	Lower probability of success	10
5. Weed in native range		
Yes	Lower probability of success	3
No	Higher probability of success	10
6. Difficulty targetting multiple forms of weed, or probability of replacement of the weed by forms or congeners of the target following successful biological control thereby negating benefits		
Likely	Lower probability of success	0
Unlikely	Higher probability of success	5
Unknown		2
7. Growing in competitive environment (agricultural vs environmental)		
Predominantly agricultural/rangeland	Lower probability of success	1
Predominantly environmental	Higher probability of success	5
Unknown/both equally		3
8. Native/valued exotic congener		
Yes		0
No		15

Appendix 2

Attributes of the 96 nominated weed species and *Cuscuta campestris*. Key: Country abbreviations: AS = American Samoa; CI = Cook Islands; CNMI = Commonwealth of the Northern Mariana Islands; Fi = Fiji; FP = French Polynesia; FSM = Federated States of Micronesia; G = Guam; H = Hawaii; K = Kiribati; MaI = Mariana Islands; MI = Marshall Islands; Na = Nauru; Ni = Niue; NC = New Caledonia; NG = New Guinea; P = Palau; PI = Pitcairn Islands; S = Samoa; SI = Solomon Islands; To = Tokelau; T = Tonga; Tu = Tuvalu; V = Vanuatu; WF = Wallis and Futuna. Habitat: all weeds occur in terrestrial habitats, with the exception of the aquatic/wetland species *Eichhornia crassipes, Mimosa pigra* and *Salvinia molesta*; Lifestyle: A = annual; BP = biennial or perennial; Reproduction: V = capable of vegetative reproduction; S = reproduction by seed only; Weed in native range: Y = yes; N = no; Hy = Hybrids/multiple forms of weed: Y = yes; N = no; ? = unknown; [1]Confusion occurs between both *S. tora* and *S. obtusifolia*.

Weed species (Family)	Land use (Agricultural, Environmenal or both) and regions affected by weed	Native range of weed	Why & where is the weed cultivated in the region?	Native congener of weed in Pacific region?	Valued exotic congener of weed cultivated in Pacific region?	Lifestyle	Reprod -uction	Weed in native range	Hy
Acacia confusa (Fabaceae)	Both agricultural and environmental: CNMI, FSM, G, H, P	Asia	Timber: MaI; H, P	*A. auriculiformis* (NG); *A. simplex* (W Pacific to S). Acacias (e.g. *A. spirobis*, (see below), & *A. koa*) present V & H.	Acacias are widely planted	BP	S	N	?
Acacia mearnsii (Fabaceae)	Both agricultural and environmental: CI, H	Australia	Timber: CI; H	See above	Acacias are widely planted	BP	S	N	?
Acacia melanoxylon (Fabaceae)	Both agricultural and environmental: H, NC	Australia	Timber: H; NC	See above	Acacias are widely planted	BP	S	N	?

Acacia spirobis (Fabaceae)	Both agricultural and environmental: regions affected not clear; certainly FP	Australia, NG, V, NC	Apparently not cultivated, but native to some islands	See above	Acacias are widely planted	BP	S	N	?
Adenanthera pavonina (Fabaceae)	Environmental: AS, CNMI, CI, FSM, Fi, FP, G, H, Na, NC, Ni, P, PNG, S, SI, T, WF	India to NG; NC	Forage, ornamental, medicinal, timber: FP; G; MI	No	No	BP	S	N	?
Ageratum conyzoides (Asteraceae)	Agricultural: AS, CNMI, CI, FSM, Fi, FP, G, H, MI, Na, NC, Ni, P, PNG, S, SI, T, V, WF	Tropical America, especially Brazil; (SI)	?Medicinal: Fi; MI	No	No	A	S	Y	?
Albizia chinensis (Fabaceae)	Both agricultural and environmental: FP, H, NC, S	Asia	?Ornamental: NC	No	Albizias widely planted	BP	S	N	?
Albizia lebbeck (Fabaceae)	Environmental: CNMI, CI, FSM, Fi, FP, G, H, NC, P, PNG, SI, T, WF	South Asia	Forage, medicine, wood: MaI; FSM; Fi; FP; G; NC; P; SI; T; WF	No	Albizias widely planted	BP	S	N	?
Albizia saman = Samanea saman (Fabaceae)	Environmental: AS, CNMI, CI, FSM, Fi, FP, G, H, MI, Na, NC, Ni, P, PNG, S, SI, T	Neotropical	?Ornamental: AS; CI; FSM; Fi; FP; G; H; MI; Na; Ni; P; S, T	No	Albizias widely planted	BP	S	N	?

Antigonon leptopus (Polygonaceae)	Both agricultural and environmental: AS, CNMI, CI, FSM, Fi, FP, G, H, K, MI, Na, NC, Ni, P, PNG, PI, T	Mexico	Ornamental: CNMI; CI; FSM; Fi; FP; G; H; K; MI; Na; NC, Ni; P; PI; S; T	No	No	BP	V	N	?
Ardisia elliptica (Myrsinaceae)	Both agricultural and environmental: CI, FP, H, PNG, S	India to NG	?Not cultivated	No	No	BP	S	N	?
Bidens pilosa (Asteraceae)	Agricultural: AS, CNMI, CI, FSM, Fi, FP, G, H, K, MI, Na, NC, Ni, P, PNG, PI, S, SI, T, V, WF	South America	?Not cultivated	Yes (e.g. in H)	No	A	S	Y	?
Broussonetia papyrifera (Moraceae)	Both agricultural and environmental: Regions affected unclear	East Asia	Soil stabilization, homegarden (bark for cloth & traditional medicine): T, Fi, S, culturally significant in H	No	No	BP	V	N	N
Cardiospermum grandiflorum (Sapindaceae)	Agricultural: CI, FP, H	Southern Mexico to Brazil	?Not stated: H	No	No	BP	S	N	?
Cassytha filiformis (Lauraceae)	Both agricultural and environmental: Regions affected unclear, confused	Pantropical: native throughout Pacific, including H	Traditional uses etc	No	No	BP	V	Y	?

	with *Cuscuta*?								
Cecropia obtusifolia (Urticaceae)	Both agricultural and environmental: CI, H	Tropical Americas	?Not cultivated	No	NC (*C. peltata*)	BP	S	N	?
Cecropia peltata (Urticaceae)	Both agricultural and environmental: FP, NC	Caribbean & northern South America	?Not stated: NC	No	No	BP	S	Y	?
Cenchrus echinatus (Poaceae)	Agricultural: AS, CNMI, CI, FSM, Fi, FP, G, H, K, MI, Na, NC, Ni, P, PNG, S, SI, To, T, V, WF	North & South America (Soloman Islands)	Not cultivated	*C. agrimonoides* (H); *C. caliculatus* (much of the Pacific)	Fi (*C. ciliaris*)	BP	S	Y	?
Cestrum diurnum (Solanaceae)	Both agricultural and environmental: AS, CNMI, CI, FSM, Fi, FP, G, H, S, T, WF	West Indies	Ornamental: AS; Fi; FP; H; T; WF	No	See next sp.	BP	S	N	?
Cestrum nocturnum (Solanaceae)	Both agricultural and environmental: AS, CI, FSM, Fi, FP, G, H, K, MI, Na, NC, Ni, PI, S, T, WF	West Indies	Ornamental: AS; Fi; FP; G; H; K; MI; Na; NC; Ni; S	No	See above	BP	S	N	?
Chromolaena odorata (Asteraceae)	Both agricultural and environmental: CNMI, FSM, G, MI, P,	North America & to N. Argentina	Not cultivated: FSM Kosrae Island	No	No	BP	S	Y	Y

	PNG								
Clerodendrum chinense (Lamiaceae)	Both agricultural and environmental: AS, CI, FSM, Fi, FP, H, Ni, PNG, S, T	S China & N Vietnam border regions	?Ornamental: CI; FSM; Fi; FP; H;	*C. inerme*: NG, MI, V, Fi, NC, SI	See next 3 spp.	BP	V	N	?
Clerodendrum japonicum (Lamiaceae)	Both agricultural and environmental: AS, H	Phillipines, NG	?Ornamental : AS	*C. inerme*: NG, MI, V, Fi, NC, SI	See above	BP	V	N	?
Clerodendrum quadriloculare (Lamiaceae)	Both agricultural and environmental: AS, CNMI, FSM, FP, G, H, MI, P, PNG, S	southern Asia	?Ornamental: AS; CNMI; FSM; FP; G; H; MI; P; S	*C. inerme*: NG, MI, V, Fi, NC, SI	See above	BP	S	N	?
Clerodendurm paniculatum (Lamiaceae)	Both agricultural and environmental: AS, FSM, Fi, FP, G, MI, Na, P, PNG, S, SI	India, China & Taiwan S to Malaysia	?Ornamental: AS; Fi; MI; Na; P	*C. inerme*: NG, MI, V, Fi, NC, SI	See above	BP	S	N	?
Clidemia hirta (Melastomataceae)	Both agricultural and environmental: AS, FSM, Fi, H, P, PNG, S, SI, V, WF	Neotropics	No	No	No	BP	S	N	N
Coccinia grandis (Curcubitaceae)	Both agricultural and environmental: CNMI, FSM, Fi, G, H, MI, PNG, S, SI, T, V	Africa, Asia to NG	Edible: FSM; MI; S; T	No	No	BP	V	N	N

Commelina benghalensis (Commelinaceae)	Both agricultural and environmental: CNMI, G, H, NC, PNG, S, SI, T, V	Old world tropics, including FSM; SI	No	*C. diffusa* is described as native to some islands by PIER, but must surely be an ancient introduction	No	BP	V	Y	?
Costus speciosus (Zingiberaceae)	Environmental: AS, CI, FSM, Fi, FP, G, H, MI, NC, Ni, P, PNG, S, SI, T, WF	S E Asia & Pacific (e.g. FSM; G; NG; P & ?NC); not native Fi; CI; H	Ornamental: CI; Fi; FP; G; H; Ni; SI; WF	No?	No	BP	V	Y	?
Cuscuta campestris (Convolvulaceae)	Agricultural: CI, FSM, Fi, FP, G, H, K, MI, NC, Ni, S	North America	No	*C. australis*, (PNG ?NC); *C. sandwichiana* (H)	No	A	S	Y	?
Cyperus rotundus (Cyperaceae)	Agricultural: AS, CNMI, CI, FSM, Fi, FP, G, H, K, MI, Na, NC, Ni, P, PNG, S, SI, To, T, Tu, V, WF	Eurasia, including SI	No	Yes	?	BP	S	Y	?
Eichhornia crassipes (Pontederiaceae)	Both agricultural and environmental: AS, CI, FSM, Fi, FP, G, H, MI, Na, NC, P, PNG, S, V	South America	Ornamental: FSM; Fi; FP; MI; Na; NC; P	No	No	BP	V	Y	N
Epipremnum aureum (Epipremnum pinnatum	Both agricultural and environmental: CI, FSM, Fi, FP, G, H, MI,	SE Asia to NG; SI	?Ornamental: CI; Fi; FP; G; H; MI; Na; Ni;	No	No	BP	V	Y	?

'Aureum') (Araceae)	Na, Nuie, P, PNG, S, SI, T		P; S; T						
Euphorbia hirta (Euphorbiaceae)	Agricultural: G; MI; FSM; Northern MaI, H, CI, FP, PI, K	Southern USA to Brazil	No	*E. tannensis* (V, NC); *E. haeleeana* (H); *E. sachetiana* (Marquesas)	Yes e.g. *Euphorbia pulcherrima*	A	S	Y	?
Falcataria moluccana (Fabaceae)	Both agricultural and environmental: AS, CI, FSM, Fi, FP, G, H, NC, Ni, P, PNG, S, SI, T, WF	Africa, to NG: ?Bismark Archipelago, SI	Pulp wood: FSM; Fi; FP; H; NC; Ni; T; WF	No	No	BP	S	N	?
Hedychium coronarium (Zingiberaceae)	Both agricultural and environmental: AS, CI, FSM, Fi, FP, G, H, Na, NC, P, S, T, WF	Himalayas region of Nepal & India	Ornamental: AS; CI; FSM; Fi; FP; G; H; MI; Na; NC; P; S, T; WF	No	Yes	BP	V	N	?
Hedychium flavescens (Zingiberaceae)	Both agricultural and environmental: AS, CI, Fi, FP, G, H, NC, Ni, S, T	Himalayas, Eastern India	Ornamental: AS; CI; FP; H; NC; Ni	No	Yes	BP	V	N	?
Hedychium gardnerianum (Zingiberaceae)	Both agricultural and environmental: CI, Fi, FP, H, NC	Eastern India	Ornamental: CI; Fi; H; NC	No	Yes	BP	V	N	?
Imperata cylindrica (Poaceae)	Both agricultural and environmental: AS, CNMI, FSM, Fi, G, NC,	Africa, Asia, Micronesia, SI, Australia	No	No	No	BP	V	Y	?

	S, T, V								
Ischaemum polystachyum var. *chordatum* (Poaceae)	Both agricultural and environmental: CNMI, FSM, G, P, PNG, SI	Phillipines, to NG & Polynesia: Considered native throughout the pacific region	No	*I. byrone* (H); *I. indicum* (FSM; WF); *I rugosum* (P; G); *I timorense* (NG; P; FSM); *I. muticum* (NG; NC)	*I. Indicum* is ciltivated in Fi; Ni	BP	V	Y	?
Ischaemum timorense (Poaceae)	Both agricultural and environmental: AS, FSM, Fi, P, PNG, S	India to Polynesia, but considered exotic in H	No	see above	*I. Indicum* is ciltivated in Fi; Ni	BP	V	Y	?
Kyllinga polyphylla (Cyperaceae)	Agricultural: FSM, Fi, FP, NC, SI, To, V	Tropical east Africa, Mauritius	No	*K. brevifolia* native to much of the Pacific (not Fi; MI; FP); genus not native to H or Marquesas	No	BP	V	Y	?
Lantana camara (Verbenaceae)	Both agricultural and environmental: AS, CNMI, CI, FSM, Fi, FP, G, H, K, MI, Na, NC, Ni, P, PNG, PI, S, SI, T, Tu, V, WF	South America	Ornamental: AS; Rapa Nui; FSM; FP; G; H; K; MI; Na; NC; P; S	No	*L. montevidensis* is cultivated in Fi; FP; H; SI; WF	BP	S	N	Y

Leucaena leucocephala (Fabaceae)	Both agricultural and environmental: AS, CNMI, CI, FSM, Fi, FP, G, H, K, MI, Na, NC, Ni, P, PNG, PI, S, SI, T, Tu, V, WF	Mexico, Guatemala, Belize	Fodder, firewood: H; MI; SI; PI	No		BP	S	N	?
Melinis minutiflora (Poaceae)	Both agricultural and environmental: AS, CNMI, Fi, FP, G, H, NC, Ni, P, T, V, WF	Africa	?Not stated: Fi; G; NC; WF	No?	*M. repens* cultivated in Fi; G; NC	BP	V	N	?
Merremia peltata (Convolvulaceae)	Both agricultural and environmental: AS, CI, FSM, Fi, FP, G, MI, NC, Ni, P, S, SI, T, WF	SE Asia, considered native to parts of the Pacific region, but may be an early introduction	No	*M. pacifica* is found in the Louisiade Archipelago (NG), Solomons, V, Fi	*M. dissecta* cultivated in Fi; *M. tuberosa* below; *M. umbellata* Fi; H	BP	V	Y	?
Merremia tuberosa (Convolvulaceae)	Both agricultural and environmental: CNMI, FSM, Fi, FP, G, H, K, MI, NC, Ni, S	Probably Tropical Americas	Ornamental: CI; Fi; G; H; K; NC; S	Yes	see above	BP	V	N	?
Miconia calvescens (Melastomataceae)	Both agricultural and environmental: FP, H, NC	Mexico to Argentina	?Not stated: H; NC	No	No	BP	S	N	?
Mikania micrantha (Asteraceae)	Both agricultural and environmental: AS, CNMI, CI, FSM, Fi, FP, G, MI, NC, Ni, P, PNG,	Central & South America (SI)	No	*M. cordata* (NG, SI & S)	No	BP	V	N	?

	S, SI, To, T, Tu, V, WF								
Mimosa diplotricha (Fabaceae)	Both agricultural and environmental: AS, CNMI, CI, FSM, Fi, FP, G, NC, Ni, P, PNG, S, SI, V, WF	Brazil	?Not stated: Listed as cultivated in Fi; NC	No	No	BP	S	Y	N
Mimosa pigra (Fabaceae)	Both agricultural and environmental: PNG	Mexico to N. Argentina	No	No	*M. diplotricha* listed as cultivated in Fi; NC	BP	S	N	?
Mimosa pudica (Fabaceae)	Agricultural: AS, CNMI, CI, FSM, Fi, FP, G, H, MI, Na, NC, Ni, P, PNG, S, SI, To, T, V, WF	South America	No	No	*M. diplotricha* is listed as cultivated in Fi; NC	BP	S	Y	?
Ocimum gratissimum (Lamiaceae)	Agricultural: CI, FSM, Fi, FP, G, H, NC, S, T, V	Pantropical, native origin ?, widely naturalized	?Not stated: Rapa Nui	No	*O. basilicum* cultivated in CNMI; CI; Fi; FP; G; H; K; Na; Ni	BP	S	?	?
Panicum maximum (Poaceae)	Both agricultural and environmental: AS, CNMI, CI, FSM, Fi, FP, G, H, K, NC, Ni, P, PNG, S, SI, T, V, WF	Africa	Fodder: FSM ; Fi; G; H; NC; T	*P. repens* is considered native to N & N-central Pacific (e.g. Saipan); H has several endemic	*P. antitotale* cultivated in Fi	BP	S	Y	?

				spp					
Panicum repens (Poaceae)	Both agricultural and environmental: CNMI, H, P	Europe, Africa, Asia to CNMI; P	No	see above	P. antitotale cultivated in Fi	BP	V	Y	?
Parthenium hysterophorus (Asteraceae)	Agricultural: FP, H, NC, V	Mexico, Central & South America	Not cultivated: Described as cultivated in FP	No	No	A	S	Y	?
Paspalum conjugatum (Poaceae)	Both agricultural and environmental: AS, CNMI, CI, FSM, Fi, FP, G, H, MI, NC, Ni, P, PNG, PI, S, SI, T, Tu, V, WF	Tropical America	No	*P. scrobiculatum* (northern Marianas, FSM, FP, SI, T, WF, Na, probably native in H); *P. vaginatum* (CI, ?Marquesas); *P. fimbriatum* (SI)	*P. dilatatum* is cultivated in G; NC	BP	V	Y	?
Paspalum distichum (Poaceae)	Both agricultural and environmental: CNMI, FSM, Fi, FP, G, H, K, MI, P	Probably tropical America, but listed as native in many Pacific areas: CNMI; FSM; Fi; FP ; G; MI; P	No	see above	See above	BP	V	Y	?
Paspalum urvillei (Poaceae)	Both agricultural and environmental: AS, CNMI, CI, Fi, FP, G, H, NC	Tropical Americas	?Fodder: G; NC	see above	Yes	BP	S	Y	?

Passiflora foetida (Passifloraceae)	Environmental: AS, CNMI, CI, FSM, Fi, FP, G, H, K, Na, NC, Ni, P, S, SI, T, V, WF	Tropical Americas (SI)	No	*P. aurantia* (NG, V, NC, Fi, S, T Ni); *P. barclayi* (NC, Fi)	Yes e.g. *P. edulis* in Fi; H; MI; Na; NC; Ni; P; SI; WF	BP	S	Y	?
Passiflora laurifolia (Passifloraceae)	Environmental: CI, Fi, FP, H, Ni, PI, S, T	West Indies & South America	Edible: CI; Fi; FP; H; Ni	see above	see above	BP	S	N	?
Passiflora ligularis (Passifloraceae)	Environmental: CI, FP, H, S	Andes of S America	Edible: CI; FP; H	see above	see above	BP	S	N	?
Passiflora quadrangularis (Passifloraceae)	Environmental: AS, CI, FSM, Fi, FP, H, NC, Ni, P, S, SI, T	South America	Edible: FSM; Fi; FP; H; NC; Ni; SI; T	see above	see above	BP	S	N	?
Passiflora rubra (Passifloraceae)	Environmental: CI	South America	No	see above	see above	BP	S	N	?
Passiflora tarminiana (includes P. tripartita & P. mollissima) (Passifloraceae)	Environmental: G, H	Tropical America	No	see above	see above	BP	S	N	Y
Pennisetum clandestinum (Poaceae)	Both agricultural and environmental: H, NC, PNG, WF	Tropical Eastern Africa	Fodder: H; NC; WF	No	Yes	BP	V	Y	?
Pennisetum polystachion (Poaceae)	Both agricultural and environmental: CNMI, FSM, Fi, FP, G, H, K, MI, SI, V	Tropical Africa to India	Fodder: Fi;	No	Yes	A	S	Y	?

Pennisetum purpureum (Poaceae)	Both agricultural and environmental: AS, CNMI, CI, FSM, Fi, FP, G, H, K, MI, NC, Ni, P, PNG, S, SI, To, V, WF	Tropical Africa	Fodder: Fi; FP; G; H; MI; NC; SI; WF	No	Yes	BP	V	Y	?
Pennisetum setaceum (Poaceae)	Both agricultural and environmental: Fi, G, H, NC, P	North Africa	Fodder: Fi; G; H; NC; P	No	Yes	BP	S	N	?
Piper aduncum (Piperaceae)	Both agricultural and environmental: Fi, H, PNG, SI	Tropical America	No	*P. methysticum* is found throughout the Pacific, this genus is not present in H	Yes *P. auritum*, below; *P. lolot* FSM; *P. nigrum* in H (elsewhere??)	BP	S	N	?
Piper auritum (Piperaceae)	Both agricultural and environmental: FSM, H, S, T	Mexico, Central America, northern South America & West Indies	Edible: FSM; H	see above	see above	BP	V	N	?
Psidium cattleianum (Myrtaceae)	Both agricultural and environmental: CI, FSM, Fi, FP, H, NC, P, PI, S	Mexico to northern South America	Edible: CI; FP; H; NC	No	see below	BP	V	N	?
Psidium guajava (Myrtaceae)	Both agricultural and environmental: AS, CNMI, CI, FSM, Fi, FP, G, H, K, Na, NC, Ni, P, PNG, PI, S, SI, T, Tu, V,	Brazil	Edible: FSM; FP; G; H; K; MI; Na; NC; Ni; P; SI	No	see above	BP	S	N	?

	WF								
Rottboellia cochinchinensis (Poaceae)	Agricultural: Fi, PNG, SI	Africa, Asia and Australia	No	Rottboellia coelorachis native to V, NC	No	BP	S	Y	?
Rubus argutus (Rosaceae)	Environmental: H	Central & eastern United States	No	*R. probus* (NG); *R moluccanus* (FSM, Fi, NC, NG, SI); *R. rosifolius* (W Pacific including V); 2 native spp (H)	Yes	BP	V	Y	?
Rubus ellipticus (Rosaceae)	Environmental: H	Tropical & subtropical India	Ornamental: H	see above	Yes	BP	V	Y	?
Rubus glaucus (Rosaceae)	Environmental: H	Tropical Middle & South America: southern Mexico to Ecuador & Peru	No	see above	Yes	BP	S	N	?
Rubus moluccanus (Rosaceae)	Environmental: FSM, Fi, NC, PNG, SI, V	Himalayas through Malaysia to Australia, FSM; Fi; NC; NG; SI; V	No	see above	Yes	BP	V	Y	?

Rubus niveus (Rosaceae)	Environmental: H	Asia	Edible: H	see above	Yes	BP	V	N	?
Rubus rosifolius (Rosaceae)	Environmental: FP, H, NC, PNG, SI	Asia, Australia, NG; SI; NC; V	No	see above	Yes	BP	V	N	?
Salvinia molesta (Salviniaceae)	Both agricultural and environmental: Fi, FP, H, NC, PNG, V	South east Brazil, N. Argentina	Ornamental: NC	No	No	BP	V	Y	N
Senna tora/S. obtusifolia(Fabaceae)	Agricultural: AS, CNMI, CI, FSM, Fi, FP, G, NC, Ni, PNG, S, SI, T, V, WF	India into Polynesia, but not indigenous east of Melanesia & perhaps not there	No	*S. gaudichaudii* is indigenous to Hawai'i & other islands throughout the Pacific.	No	A	S	Y	Y[1]
Sida acuta (Malvaceae)	Agricultural: AS, CNMI, CI, FSM, Fi, FP, G, H, K, MI, Na, NC, Ni, P, PNG, S, SI, T, V	Perhaps indigenous in Central America	No	*S. fallax* is native to most of the Pacific Islands, including H	No	BP	S	Y	N
Sida rhombifolia (Malvaceae)	Agricultural: AS, CNMI, CI, FSM, Fi, FP, G, H, K, MI, Na, NC, Ni, P, PNG, PI, S, SI, To, T, V, WF	New world tropics & sub-tropics	No	see above	No	BP	S	Y	N
Solanum torvum (Solanaceae)	Agricultural: AS, CNMI, FSM, Fi, FP, G, H, K, MI, NC, Ni, P, PNG, S, SI, T, V, WF	Mexico to Peru & Venezuela, & in the West Indies & Bermuda (SI)	Edible: FSM	Native throughout Pacific e.g. *S repandum; S.*	Yes	BP	S	N	?

				americanum					
Sorghum bicolor subsp. drummondii (Poaceae)	Environmental: CNMI, CI, FSM, Fi, FP, G, H, MI, NC, Ni, P, PI, T, WF	Mediterranean region of Europe, & Syria	Edible: CNMI; FSM; Fi; G; H; MI; NC; Ni	*S. laxiflorum* & *S. nitidum* (NG)	Yes	A	S	N	?
Sorghum halepense (Poaceae)	Both agricultural and environmental: AS, CNMI, CI, FSM, Fi, FP, G, H, K, MI, NC, P, PNG, PI, S, SI, T, V, WF	Tropical & subtropical Eastern Africa	?Not stated: NC; SI	see above	see above	BP	V	Y	?
Spathodea campanulata (Bignoniaceae)	Both agricultural and environmental: AS, CNMI, CI, FSM, Fi, FP, G, H, K, MI, Na, NC, Ni, P, S, SI, T, V, WF	West Africa	Ornamental: AS; CI; FSM; Fi; FP; G; H; K; Na; NC; Ni; P; S; SI; T; WF	No	No	BP	V	N	?
Sphagneticola trilobata (Asteraceae)	Both agricultural and environmental: AS, CNMI, CI, FSM, Fi, FP, G, H, K, MI, Na, NC, Ni, P, S, To, T	Central America	Ornamental: AS; CNMI; CI; FSM; Fi; H; K; MI; Na; NC; Ni; P; T	No	No	BP	V	N	?

Stachytarpheta jamaicensis (Verbenaceae)	Both agricultural and environmental: AS, CNMI, CI, FSM, FP, G, H, K, MI, Na, NC, Ni, P, PNG, S, SI, T, Tu, V, WF	Tropical & subtropical areas of the New World (SI)	No	No	No	BP	S	N	?
Stachytarpheta urticifolia = Cayennensis (Verbenaceae)	Both agricultural and environmental: AS, CNMI, CI, FSM, Fi, FP, G, H, K, MI, Na, NC, Ni, P, PNG, S, SI, T, Tu, V, WF	Tropical & subtropical areas of the New World	No	No	No	BP	S	N	?
Syzygium cumini (Myrtaceae)	Environmental: CI, Fi, FP, G, H, NC, Ni, P, S, T	Indo-Malaysian	Edible: Fi; FP; G; H; NC; Ni	Genus widespread in Pacific e.g. *S. suborbiculare* (NG); *S. wolfii* (Fi); *S. sandwicensis* (H)	Yes	BP	S	N	?
Syzygium (=Waterhousea) floribundum (Myrtaceae)	Environmental: FP	Australia		see above	Yes	BP	S	N	?
Syzygium jambos (Myrtaceae)	Environmental: AS, CI, FSM, Fi, FP, G, H, NC, Ni, P, PI, S, T, WF	Southeast Asia	Edible: AS; FSM; Fi; FP; H; Ni; WF	see above	Yes	BP	S	N	?

Tecoma stans (Bignoniaceae)	Both agricultural and environmental: AS, CNMI, CI, FSM, Fi, FP, G, H, K, MI, Na, NC, Ni, P, PNG, S, SI, T, WF	Caribbean & South America	AS; FSM; Fi; FP; G; H; K; MI; Na; NC; Ni; P; SI; T; WF	No	Yes *T. capensis* in CI; NC; Ni	BP	S	N	?
Vachellia farnesiana = *Acacia farnesiana* (Fabaceae)	Both agricultural and environmental: CNMI, CI, Fi, FP, G, H, K, Na, NC, P, SI, V	Mexico & Central America	?In H formerly cultivated for an attempted perfume industry: MaI; H; P, SI	No	No	BP	S	Y	?
Xanthium strumarium (Asteraceae)	Agricultural: CI, Fi, FP, H, NC, PNG	North America	No	No	No	A	S	Y	No

Appendix 3

Current status of biocontrol programmes against weed species listed in Appendix 1.

Weed species	Regions affected by weed	Status of biocontrol programme(s)	Regions Biocontrol used in Pacific
Acacia mearnsii (Fabaceae)	Cook Islands, Hawaii	Programme in South Africa limited to seed-feeders to contain weed, without impacting on beneficial attributes	Not used
Acacia melanoxylon (Fabaceae)	Hawaii, New Caledonia	Programme in South Africa limited to seed-feeders to contain weed, without impacting on beneficial attributes	Not used
Cardiospermum grandiflorum (Sapindaceae)	Cook Islands, French Polynesia, Hawaii	Native range surveys conducted	Not used
Chromolaena odorata (Asteraceae)	Commonwealth of the Northern Mariana Islands, Federated States of Micronesia, Guam, Marshall Islands, Palau, PNG	Biocontrol ongoing & showing signs of success (e.g. in New Guinea), but still required in other regions	Commonwealth of the Northern Mariana Islands, Federated States of Micronesia, Guam, Palau, PNG
Clerodendrum chinense (Lamiaceae)	American Samoa, Cook Islands, Federated States of Micronesia, Fiji, French Polynesia, Hawaii, Niue, PNG, Western Samoa, Tonga	Native range surveys conducted	Not used
Clerodendurm paniculatum (Lamiaceae)	American Samoa, Federated States of Micronesia, Fiji, French Polynesia, Guam, Marshall Islands, Nauru, Palau, PNG, Western Samoa, Solomon Islands	Native range surveys conducted	Not used
Clidemia hirta (Melastomataceae)	American Samoa, Federated States of Micronesia, Fiji, Hawaii, Palau, PNG, Western Samoa, Solomon Islands, Vanuatu, Wallis and Futuna	Good control in pasture, but not in shade: ongoing programme in Hawaii	Fiji, Hawaii
Coccinia grandis (Curcubitaceae)	Commonwealth of the Northern Mariana Islands, Federated States of Micronesia, Fiji, Guam, Hawaii, Marshall Islands, PNG, Western Samoa, Solomon Islands, Tonga, Vanatu	Ongoing programme, but promising results in Hawaii	Commonwealth of the Northern Mariana Islands, Guam, Hawaii

Cyperus rotundus (Cyperaceae)	American Samoa, Commonwealth of the Northern Mariana Islands, Cook Islands, Federated States of Micronesia, Fiji, French Polynesia, Guam, Hawaii, Kiribati, Marshall Islands, Nauru, New Caledonia, Niue, Palau, PNG, Western Samoa, Solomon Islands, Tokelau, Tonga, Tuvalu, Vanuatu, Wallis and Futuna	Unsuccessful programme in Hawaii	Hawaii, unsuccessful
Eichhornia crassipes (Pontederiaceae)	American Samoa, Cook Islands, Federate States of Micronesia, Fiji, French Polynesia, Guam, Hawaii, Marshall Islands, Nauru, New Caledonia, Palau, PNG, Western Samoa, Vanuatu	Successful programme in Papua New Guinea (still needed elsewhere)	PNG, Fiji, Vanuatu
Hedychium coronarium (Zingiberaceae)	American Samoa, Cook Islands, Federated States of Micronesia, Fiji, French Polynesia, Guam, Hawaii, Nauru, New Caledonia, Palau, Western Samoa, Tonga, Wallis and Futuna	Native range surveys conducted	Not used
Hedychium flavescens (Zingiberaceae)	American Samoa, Cook Islands, Fiji, French Polynesia, Guam, Hawaii, New Caledonia, Niue, Western Samoa, Tonga	Native range surveys conducted	Not used
Hedychium gardnerianum (Zingiberaceae)	Cook Islands, Fiji, French Polynesia, Hawaii, New Caledonia	Native range surveys conducted	Not used
Lantana camara (Verbenaceae)	American Samoa, Commonwealth of the Northern Mariana Islands, Cook Islands, Federated States of Micronesia, Fiji, French Polynesia, Guam, Hawaii, Kiribati, Marshall Islands, Nauru, New Caledonia, Niue, Palau, PNG, Pitcairn Islands, Western Samoa, Solomon Islands, Tonga, Tuvalu, Vanuatu, Wallis and Futuna	Varying success	Commonwealth of the Northern Mariana Islands, Cook Islands, Federated States of Micronesia, Guam, Hawaii,
Miconia calvescens (Melastomataceae)	French Polynesia, Hawaii, New Caledonia	Biocontrol agent released in French Polynesia, ongoing programme & too early to assess full impact	French Polynesia
Mikania micrantha (Asteraceae)	American Samoa, Commonwealth of the Northern Mariana Islands, Cook Islands, Federated States of Micronesia, Fiji, French Polynesia, Guam, Marshall Islands, New Caledonia, Niue, Palau, PNG, Western Samoa, Solomon Islands, Tokelau, Tonga, Tuvalu, Vanuatu, Wallis and Futuna	Biocontrol agents have been released, but not in Pacific (*Liothrips mikaniae* failed to establish in the Solomon Islands) ongoing & too early to assess full impact	

Mimosa diplotricha (Fabaceae)	American Samoa, Commonwealth of the Northern Mariana Islands, Cook Islands, Federated States of Micronesia, Fiji, French Polynesia, Guam, New Caledonia, Niue, Palau, PNG, Western Samoa, Solomon Islands, Vanuatu, Wallis and Futuna	Successful in many parts of Pacific, still needed French Polynesia, Vanuatu, New Caledonia	Successful in many parts of Pacific
Mimosa pigra (Fabaceae)	PNG	Big impacts measured Australia, but too early to assess full impact	
Parthenium hysterophorus (Asteraceae)	French Polynesia, Hawaii, New Caledonia, Vanuatu	Variable success in Australia: biocontrol effective in central Queensland, less so in North Queensland	
Passiflora tarminiana (includes P. tripartita & P. mollissima) (Passifloraceae)	Guam, Hawaii	Yes, partially successful: initial reduction in biomass due to *Septoria*, but virulence of the pathogen appears to have reduced	Hawaii
Psidium cattleianum (Myrtaceae)	Cook Islands, Federated States of Micronesia, Fiji, French Polynesia, Hawaii, New Caledonia, Palau, Pitcairn Islands, Western Samoa	Native range surveys conducted and host-range testing performed	
Rottboellia cochinchinensis (Poaceae)	Fiji, PNG, Solomon Islands	Overseas surveys and host-range testing performed, unclear if any agents have been released	
Rubus argutus (Rosaceae)	Hawaii	Agents only partially effective & have non-target impacts on native Rubus in Hawaii	Hawaii
Salvinia molesta (Salviniaceae)	Fiji, French Polynesia, Hawaii, New Caledonia, PNG, Vanuatu	Yes, successfully controlled in Papua New Guinea, Fiji. Agents not released yet in Hawaii, New Caledonia, Vanuatu	Fiji, PNG
Senna tora (Fabaceae)	American Samoa, Commonwealth of the Northern Mariana Islands, Cook Islands, Federated States of Micronesia, Fiji, French Polynesia, Guam, New Caledonia, Niue, PNG, Western Samoa, Solomon Islands, Tonga, Vanuatu, Wallis and Futuna	Native range surveys were done, but no adequately specific agents were found	

Sida acuta (Malvaceae)	American Samoa, Commonwealth of the Northern Mariana Islands, Cook Islands, Federated States of Micronesia, Fiji, French Polynesia, Guam, Hawaii, Kiribati, Marshall Islands, Nauru, New Caledonia, Niue, Palau, PNG, Western Samoa, Solomon Islands, Tonga, Vanuatu	Successful control in Australia, Fiji, Vanuatu, Papua New Guinea, but control still required elsewhere	Fiji, PNG, Vanuatu
Sida rhombifolia (Malvaceae)	American Samoa, Commonwealth of the Northern Mariana Islands, Cook Islands, Federated States of Micronesia, Fiji, French Polynesia, Guam, Hawaii, Kiribati, Marshall Islands, Nauru, New Caledonia, Niue, Palau, PNG, Pitcairn Islands, Western Samoa, Solomon Islands, Tokelau, Tonga, Vanuatu, Wallis and Futuna	Successful control in Australia, Fiji, Vanuatu, Papua New Guinea, but control still required elsewhere	Fiji, PNG, Vanuatu
Tecoma stans (Bignoniaceae)	American Samoa, Commonwealth of the Northern Mariana Islands, Cook Islands, Federated States of Micronesia, Fiji, French Polynesia, Guam, Hawaii, Kiribati, Marshall Islands, Nauru, New Caledonia, Niue, Palau, PNG, Western Samoa, Solomon Islands, Tonga, Wallis and Futuna	Agents released in South Africa, but too early to assess impact	
Xanthium strumarium (Asteraceae)	Cook Islands, Fiji, French Polynesia, Hawaii, New Caledonia, PNG	*Epiblema strenuata* & an accidentally introduced fungus (*Puccinia xanthii*) have had major impact in humid regions of Australia	

Appendix 4

Feasibility scores for the north-west Pacific. Green shading = easier targets; orange shading = intermediate targets; red shading = harder targets.

BIOCONTROL FEASIBILITY SCORE	WEED
100	*Eichhornia crassipes*
100	*Mimosa diplotricha*
100	*Salvinia molesta*
100	*Sida acuta*
100	*Sida rhombifolia*
100	*Xanthium strumarium*
83	*Mimosa pigra*
80	*Chromolaena odorata*
74	*Antigonon leptopus*
74	*Coccinia grandis*
74	*Hedychium coronarium*
74	*Psidium cattleianum*
74	*Spathodea campanulata*
74	*Sphagneticola trilobata*
69	*Costus speciosus*
67	*Commelina benghalensis*
67	*Epipremnum aureum*
67	*Imperata cylindrica*
61	*Adenanthera pavonina*
61	*Albizia lebbeck*
61	*Albizia saman = Samanea saman*
59	*Ardisia elliptica*
59	*Cestrum diurnum*
59	*Cestrum nocturnum*
59	*Clerodendrum chinensis*
59	*Clerodendrum quadriloculare*
59	*Clidemia hirta*
59	*Lantana camara*
59	*Leucaena leucocephala*
59	*Melinis minutiflora*
59	*Meremia tuberosa*
59	*Mikania micrantha*
59	*Piper auritum*
59	*Psidium guajava*
59	*Stachytarpheta jamaicensis*
59	*Stachytarpheta urticifolia*
59	*Tecoma stans*
57	*Paraserianthes (Albizia) falcataria*
52	*Ischaemum timorense*
52	*Ischaemum polystachyum var. chordatum*
52	*Merremia peltata*
52	*Panicum repens*
52	*Paspalum conjugatum*
52	*Paspalum distichum*
52	*Pennisetum purpureum*
52	*Sorghum halepense*
52	*Vachellia farnesiana*

50	*Kyllingia polyphylla*
50	*Mimosa pudica*
49	*Ageratum conyzoides*
49	*Rottboellia cochinchinensis*
46	*Passiflora quadrangularis*
46	*Syzygium cumini*
46	*Syzygium jambos*
45	*Sorghum bicolor subsp. drummondii*
44	*Acacia confusa*
44	*Clerodendurm paniculatum*
44	*Passiflora tripartata*
44	*Pennisetum setaceum*
44	*Piper aduncum*
42	*Solanum torvum*
39	*Passiflora foetida*
37	*Panicum maximum*
37	*Paspalum urvillei*
36	*Pennisetum polystachion*
35	*Cenchrus echinatus*
35	*Ocimum gratissimum*
34	*Bidens pilosa*
34	*Cuscuta campestris*
34	*Euphorbia hirta*
30	*Senna tora*
20	*Cyperus rotundus*

Appendix 5

Effort Scores for the North-west Pacific (where a low score indicates less effort required to conduct a biocontrol programme).

EFFORT SCORE	WEED
4	*Eichhornia crassipes*
13	*Mimosa diplotricha*
13	*Salvinia molesta*
13	*Xanthium strumarium*
13	*Chromolaena odorata*
13	*Tecoma stans*
15	*Lantana camara*
17	*Hedychium coronarium*
20	*Mimosa pigra*
22	*Mikania micrantha*
23	*Sida acuta*
23	*Sida rhombifolia*
29	*Sphagneticola trilobata*
29	*Stachytarpheta jamaicensis*
31	*Spathodea campanulata*
31	*Costus speciosus*
31	*Stachytarpheta urticifolia*
32	*Psidium cattleianum*
36	*Imperata cylindrica*
36	*Clerodendrum chinensis*
36	*Rottboellia cochinchinensis*
36	*Clerodendurm paniculatum*
38	*Antigonon leptopus*
38	*Coccinia grandis*
38	*Albizia saman = Samanea saman*
38	*Cestrum diurnum*
38	*Cestrum nocturnum*
38	*Clidemia hirta*
38	*Leucaena leucocephala*
38	*Vachellia farnesiana*
38	*Mimosa pudica*
38	*Cyperus rotundus*
40	*Commelina benghalensis*
40	*Epipremnum aureum*
40	*Adenanthera pavonina*
40	*Albizia lebbeck*
40	*Ardisia elliptica*
40	*Clerodendrum quadriloculare*
40	*Melinis minutiflora*
40	*Meremia tuberosa*
40	*Paraserianthes (Albizia) falcataria*
40	*Merremia peltata*
40	*Kyllingia polyphylla*
40	*Ageratum conyzoides*
41	*Senna tora*
43	*Sorghum halepense*
43	*Cuscuta campestris*
44	*Psidium guajava*

46	*Passiflora quadrangularis*
46	*Syzygium cumini*
46	*Sorghum bicolor subsp. drummondii*
46	*Passiflora tripartata*
46	*Passiflora foetida*
47	*Euphorbia hirta*
48	*Piper auritum*
48	*Panicum repens*
48	*Pennisetum setaceum*
48	*Solanum torvum*
48	*Cenchrus echinatus*
50	*Ischaemum timorense)*
50	*Ischaemum polystachyum var. chordatum*
50	*Paspalum conjugatum*
50	*Paspalum distichum*
50	*Pennisetum purpureum*
50	*Syzygium jambos*
50	*Acacia confusa*
50	*Piper aduncum*
50	*Panicum maximum*
50	*Paspalum urvillei*
50	*Pennisetum polystachion*
50	*Ocimum gratissimum*
50	*Bidens pilosa*

Appendix 6

The top 20 targets for North-west Pacific region, based on both feasibility and effort where Total score (= Feasibility score × 1/Effort score). Green shading = easier targets; orange shading = intermediate targets. *Weeds for which biocontrol agents are already established in the region. Information regarding where biocontrol is required is extracted from Dodd and Hayes (2009).

Total Score	WEED	Rank	Where in region is biocontrol required?
25.000	*Eichhornia crassipes**	1	
7.692	*Mimosa diplotricha**	2=	
7.692	*Salvinia molesta**	2=	
7.692	*Xanthium strumarium*	2=	Papua New Guinea
6.154	*Chromolaena odorata**	5	
4.538	*Tecoma stans*	6	
4.353	*Hedychium coronarium*	7	Papua New Guinea
4.348	*Sida acuta**	8=	Guam; Federated States of Micronesia; Solomon Islands
4.348	*Sida rhombifolia**	8=	Commonwealth of the Northern Mariana Islands; Guam; Solomon Islands
4.150	*Mimosa pigra**	10	Papua New Guinea
3.933	*Lantana camara**	11	
2.682	*Mikania micrantha*	12	Palau; Commonwealth of the Northern Mariana Islands; Federated States of Micronesia; Guam
2.552	*Sphagneticola trilobata*	13	Federated States of Micronesia; Solomon Islands, Papua New Guinea
2.387	*Spathodea campanulata*	14	Federated States of Micronesia; Solomon Islands
2.313	*Psidium cattleianum*	15	
2.226	*Costus speciosus*	16	Palau; Federated States of Micronesia
2.034	*Stachytarpheta jamaicensis*	17	Commonwealth of the Northern Mariana Islands; Federated States of Micronesia; Guam; Solomon Islands, Papua New Guinea
1.947	*Antigonon leptopus*	18=	Palau; Commonwealth of the Northern Mariana Islands; Federated States of Micronesia; Guam
1.947	*Coccinia grandis**	18=	Solomon Islands, Papua New Guinea
1.903	*Stachytarpheta urticifolia*	20	Commonwealth of the Northern Mariana Islands; Federated States of Micronesia; Guam; Solomon Islands, Papua New Guinea

Appendix 7

Feasibility scores for the central Pacific. Green shading = easier targets; orange shading = intermediate targets; red shading = harder targets.

BIOCONTROL FEASIBILITY SCORE	Weed Species
100	*Eichhornia crassipes*
100	*Mimosa diplotricha*
100	*Salvinia molesta*
100	*Sida acuta*
100	*Sida rhombifolia*
100	*Xanthium strumarium*
74	*Antigonon leptopus*
74	*Coccinia grandis*
74	*Hedychium coronarium*
74	*Hedychium flavescens*
74	*Hedychium gardnerianum*
74	*Psidium cattleianum*
74	*Spathodea campanulata*
74	*Sphagneticola trilobata*
69	*Costus speciosus*
67	*Commelina benghalensis*
67	*Epipremnum aureum*
67	*Imperata cylindrica*
63	*Broussonnetia papyrifera*
61	*Adenanthera pavonina*
61	*Albizia lebbeck*
61	*Albizia saman = Samanea saman*
61	*Rubus rosifolius*
60	*Parthenium hysterophorus*
59	*Albizia chinensis*
59	*Ardisia elliptica*
59	*Cestrum diurnum*
59	*Cestrum nocturnum*
59	*Clerodendrum chinensis*
59	*Clerodendrum quadriloculare*
59	*Clidemia hirta*
59	*Lantana camara*
59	*Leucaena leucocephala*
59	*Melinis minutiflora*
59	*Meremia tuberosa*
59	*Miconia calvescens*
59	*Mikania micrantha*
59	*Piper auritum*
59	*Psidium guajava*
59	*Stachytarpheta jamaicensis*
59	*Stachytarpheta urticifolia*
59	*Tecoma stans*
57	*Paraserianthes (Albizia) falcataria*
54	*Rubus moluccanus*
52	*Vachellia farnesiana*
52	*Cecropia peltata*

52	*Ischaemum polystachyum var. chordatum*
52	*Merremia peltata*
52	*Paspalum conjugatum*
52	*Paspalum distichum*
52	*Pennisetum clandestinum*
52	*Pennisetum purpureum*
52	*Sorghum halepense*
50	*Kyllingia polyphylla*
50	*Mimosa pudica*
49	*Ageratum conyzoides*
46	*Passiflora laurifolia*
46	*Passiflora ligularis*
46	*Passiflora quadrangularis*
46	*Syzygium cumini*
46	*Syzygium jambos*
45	*Sorghum bicolor subsp. drummondii*
44	*Acacia melanoxylon*
44	*Acacia spirobis*
44	*Clerodendrum japonicum*
44	*Clerodendurm paniculatum*
44	*Pennisetum setaceum*
44	*Piper aduncum*
42	*Solanum torvum*
39	*Passiflora foetida*
37	*Panicum maximum*
37	*Paspalum urvillei*
36	*Pennisetum polystachion*
35	*Cenchrus echinatus*
35	*Ocimum gratissimum*
34	*Bidens pilosa*
34	*Euphorbia hirta*
34	*Rottboellia cochinchinensis*
34	*Cuscuta campestris*
30	*Senna tora*
20	*Cyperus rotundus*

Appendix 8

Effort scores for the central Pacific (where a low score indicates less effort required to conduct a biocontrol programme).

EFFORT SCORE	*Weed species*
4	*Eichhornia crassipes*
13	*Mimosa diplotricha*
13	*Salvinia molesta*
23	*Sida acuta*
23	*Sida rhombifolia*
13	*Xanthium strumarium*
38	*Antigonon leptopus*
38	*Coccinia grandis*
17	*Hedychium coronarium*
17	*Hedychium flavescens*
17	*Hedychium gardnerianum*
32	*Psidium cattleianum*
31	*Spathodea campanulata*
29	*Sphagneticola trilobata*
31	*Costus speciosus*
40	*Commelina benghalensis*
40	*Epipremnum aureum*
36	*Imperata cylindrica*
40	*Broussonnetia papyrifera*
40	*Adenanthera pavonina*
40	*Albizia lebbeck*
38	*Albizia saman = Samanea saman*
47	*Rubus rosifolius*
13	*Parthenium hysterophorus*
40	*Albizia chinensis*
40	*Ardisia elliptica*
38	*Cestrum diurnum*
38	*Cestrum nocturnum*
36	*Clerodendrum chinensis*
40	*Clerodendrum quadriloculare*
38	*Clidemia hirta*
15	*Lantana camara*
38	*Leucaena leucocephala*
40	*Melinis minutiflora*
40	*Meremia tuberosa*
22	*Miconia calvescens*
22	*Mikania micrantha*
48	*Piper auritum*
44	*Psidium guajava*
29	*Stachytarpheta jamaicensis*
31	*Stachytarpheta urticifolia*
13	*Tecoma stans*
40	*Paraserianthes (Albizia) falcataria*
50	*Rubus moluccanus*
38	*Vachellia farnesiana*
40	*Cecropia peltata*
50	*Ischaemum polystachyum var. chordatum*

40	*Merremia peltata*
50	*Paspalum conjugatum*
50	*Paspalum distichum*
50	*Pennisetum clandestinum*
50	*Pennisetum purpureum*
43	*Sorghum halepense*
40	*Kyllingia polyphylla*
38	*Mimosa pudica*
40	*Ageratum conyzoides*
46	*Passiflora laurifolia*
46	*Passiflora ligularis*
46	*Passiflora quadrangularis*
46	*Syzygium cumini*
50	*Syzygium jambos*
46	*Sorghum bicolor subsp. drummondii*
31	*Acacia melanoxylon*
47	*Acacia spirobis*
40	*Clerodendrum japonicum*
36	*Clerodendurm paniculatum*
48	*Pennisetum setaceum*
50	*Piper aduncum*
48	*Solanum torvum*
46	*Passiflora foetida*
50	*Panicum maximum*
50	*Paspalum urvillei*
50	*Pennisetum polystachion*
48	*Cenchrus echinatus*
50	*Ocimum gratissimum*
50	*Bidens pilosa*
47	*Euphorbia hirta*
36	*Rottboellia cochinchinensis*
43	*Cuscuta campestris*
41	*Senna tora*
38	*Cyperus rotundus*

Appendix 9

The top 20 targets for the central Pacific region, based on both feasibility and effort where Total score (= Feasibility score × 1/Effort score). Green shading = easier targets; orange shading = intermediate targets. *Weeds for which biocontrol agents are already established in the region. Information regarding where biocontrol is required is extracted from Dodd and Hayes (2009).

Total score	Weed species	Rank	Where is biocontrol needed in region?
25.000	*Eichhornia crassipes*	1	New Caledonia; Samoa
7.692	*Mimosa diplotricha**	2=	New Caledonia; Vanuatu
7.692	*Salvinia molesta**	2=	New Caledonia
7.692	*Xanthium strumarium*	2=	Fiji
4.615	*Parthenium hysterophorus*	5	
4.538	*Tecoma stans*	6	
4.353	*Hedychium coronarium*	7=	Niue; Fiji
4.353	*Hedychium flavescens*	7=	Niue; Fiji
4.353	*Hedychium gardnerianum*	7=	Niue; Fiji
4.348	*Sida acuta**	10=	Niue; Samoa
4.348	*Sida rhombifolia**	10=	New Caledonia; Samoa
3.933	*Lantana camara**	12	Samoa
2.682	*Miconia calvescens*	13=	
2.682	*Mikania micrantha*	13=	New Caledonia
2.552	*Sphagneticola trilobata*	15	Fiji; Vanuatu
2.387	*Spathodea campanulata*	16	Niue; Samoa; Tonga; Vanuatu
2.313	*Psidium cattleianum*	17	
2.226	*Costus speciosus*	18	
2.034	*Stachytarpheta jamaicensis*	19	Fiji; New Caledonia; Niue; Samoa; Tonga; Vanuatu
1.947	*Antigonon leptopus*	20=	Niue; Samoa
1.947	*Coccinia grandis*	20=	Fiji; Samoa; Vanuatu

Appendix 10

Feasibility scores for Hawaii. Green shading = easier targets; orange shading = intermediate targets; red shading = harder targets.

BIOCONTROL FEASIBILITY SCORE	Weed Species
100	*Eichhornia crassipes*
100	*Salvinia molesta*
100	*Sida acuta*
100	*Sida rhombifolia*
100	*Xanthium strumarium*
74	*Antigonon leptopus*
74	*Clerodendrum chinensis*
74	*Clerodendrum quadriloculare*
74	*Coccinia grandis*
74	*Hedychium coronarium*
74	*Hedychium flavescens*
74	*Hedychium gardnerianum*
74	*Melinis minutiflora*
74	*Meremia tuberosa*
74	*Piper auritum*
74	*Psidium cattleianum*
74	*Spathodea campanulata*
74	*Sphagneticola trilobata*
69	*Costus speciosus*
67	*Commelina benghalensis*
67	*Epipremnum aureum*
67	*Sorghum halepense*
63	*Broussonetia papyrifera*
61	*Adenanthera pavonina*
61	*Albizia lebbeck*
61	*Albizia saman = Samanea saman*
61	*Rubus niveus*
61	*Rubus rosifolius*
60	*Sorghum bicolor subsp. drummondii*
59	*Albizia chinensis*
59	*Ardisia elliptica*
59	*Cecropia obtusifolia*
59	*Cestrum diurnum*
59	*Cestrum nocturnum*
59	*Clerodendrum japonicum*
59	*Clidemia hirta*
59	*Lantana camara*
59	*Leucaena leucocephala*
59	*Miconia calvescens*
59	*Piper aduncum*
59	*Psidium guajava*
59	*Stachytarpheta jamaicensis*
59	*Stachytarpheta urticifolia*
59	*Tecoma stans*
57	*Cardiospermum grandiflorum*
57	*Paraserianthes (Albizia) falcataria*

54	*Rubus ellipticus*
52	*Vachellia farnesiana*
52	*Panicum repens*
52	*Paspalum conjugatum*
52	*Paspalum distichum*
52	*Pennisetum clandestinum*
52	*Pennisetum purpureum*
51	*Rubus argutus*
50	*Cyperus rotundus*
50	*Mimosa pudica*
49	*Ageratum conyzoides*
46	*Passiflora laurifolia*
46	*Passiflora ligularis*
46	*Passiflora quadrangularis*
46	*Rubus glaucus*
46	*Syzygium cumini*
46	*Syzygium jambos*
44	*Acacia confusa*
44	*Acacia mearnsii*
44	*Acacia melanoxylon*
44	*Passiflora tripartata*
44	*Pennisetum setaceum*
42	*Solanum torvum*
39	*Passiflora foetida*
37	*Panicum maximum*
37	*Paspalum urvillei*
36	*Pennisetum polystachion*
35	*Cenchrus echinatus*
35	*Ocimum gratissimum*
34	*Bidens pilosa*
34	*Euphorbia hirta*
34	*Cuscuta campestris*
0	*Cassytha filiformis*

Appendix 11

Effort scores for Hawaii (where a low score indicates less effort required to conduct a biocontrol programme).

EFFORT SCORE	Weed species
4	*Eichhornia crassipes*
13	*Salvinia molesta*
13	*Xanthium strumarium*
13	*Tecoma stans*
15	*Lantana camara*
17	*Hedychium coronarium*
17	*Hedychium flavescens*
17	*Hedychium gardnerianum*
21	*Cardiospermum grandiflorum*
22	*Miconia calvescens*
23	*Sida acuta*
23	*Sida rhombifolia*
24	*Rubus argutus*
29	*Sphagneticola trilobata*
29	*Stachytarpheta jamaicensis*
31	*Spathodea campanulata*
31	*Costus speciosus*
31	*Stachytarpheta urticifolia*
31	*Acacia mearnsii*
31	*Acacia melanoxylon*
32	*Psidium cattleianum*
36	*Clerodendrum chinensis*
38	*Antigonon leptopus*
38	*Coccinia grandis*
38	*Albizia saman = Samanea saman*
38	*Cestrum diurnum*
38	*Cestrum nocturnum*
38	*Clidemia hirta*
38	*Leucaena leucocephala*
38	*Vachellia farnesiana*
38	*Cyperus rotundus*
38	*Mimosa pudica*
40	*Clerodendrum quadriloculare*
40	*Melinis minutiflora*
40	*Meremia tuberosa*
40	*Commelina benghalensis*
40	*Epipremnum aureum*
40	*Broussonetia papyrifera*
40	*Adenanthera pavonina*
40	*Albizia lebbeck*
40	*Albizia chinensis*
40	*Ardisia elliptica*
40	*Cecropia obtusifolia*
40	*Clerodendrum japonicum*
40	*Paraserianthes (Albizia) falcataria*
40	*Ageratum conyzoides*
43	*Sorghum halepense*

43	*Cuscuta campestris*
44	*Psidium guajava*
46	*Sorghum bicolor subsp. drummondii*
46	*Passiflora laurifolia*
46	*Passiflora ligularis*
46	*Passiflora quadrangularis*
46	*Syzygium cumini*
46	*Passiflora tripartata*
46	*Passiflora foetida*
47	*Rubus niveus*
47	*Rubus rosifolius*
47	*Euphorbia hirta*
48	*Piper auritum*
48	*Panicum repens*
48	*Rubus glaucus*
48	*Pennisetum setaceum*
48	*Solanum torvum*
48	*Cenchrus echinatus*
50	*Piper aduncum*
50	*Rubus ellipticus*
50	*Paspalum conjugatum*
50	*Paspalum distichum*
50	*Pennisetum clandestinum*
50	*Pennisetum purpureum*
50	*Syzygium jambos*
50	*Acacia confusa*
50	*Panicum maximum*
50	*Paspalum urvillei*
50	*Pennisetum polystachion*
50	*Ocimum gratissimum*
50	*Bidens pilosa*

Appendix 12

The top 20 targets for Hawaii, based on both feasibility and effort where Total score (= Feasibility score × 1/Effort score). Green shading = easier targets; orange shading = intermediate targets. *Weeds for which biocontrol agents are already established in the region. Information regarding where biocontrol is required is extracted from Dodd and Hayes (2009).

Total score	Weed Species	Rank	Is biocontrol needed in Hawaii?
25.000	*Eichhornia crassipes*	1	No
7.692	*Salvinia molesta*	2=	Yes
7.692	*Xanthium strumarium*	2=	No
4.538	*Tecoma stans*	4	No
4.353	*Hedychium coronarium*	5=	Yes
4.353	*Hedychium flavescens*	5=	Yes
4.353	*Hedychium gardnerianum*	5=	Yes
4.348	*Sida acuta*	8=	No
4.348	*Sida rhombifolia*	8=	No
3.933	*Lantana camara**	10	No?
2.714	*Cardiospermum grandiflorum*	11	No
2.682	*Miconia calvescens*	12	Yes
2.552	*Sphagneticola trilobata*	13	No
2.387	*Spathodea campanulata*	14	Yes
2.313	*Psidium cattleianum*	15	Yes
2.226	*Costus speciosus*	16	No
2.125	*Rubus argutus**	17	No
2.056	*Clerodendrum chinensis*	18	No
2.034	*Stachytarpheta jamaicensis*	19	No
1.947	*Antigonon leptopus*	20=	No
1.947	*Coccinia grandis**	20=	Yes

Appendix 13

Feasibility scores for the south-east Pacific. Green shading = easier targets; orange shading = intermediate targets; red shading = harder targets.

BIOCONTROL FEASIBILITY SCORE	
100	*Eichhornia crassipes*
100	*Mimosa diplotricha*
100	*Salvinia molesta*
100	*Sida acuta*
100	*Sida rhombifolia*
100	*Xanthium strumarium*
74	*Antigonon leptopus*
74	*Clerodendrum chinensis*
74	*Clerodendrum quadriloculare*
74	*Hedychium coronarium*
74	*Hedychium flavescens*
74	*Hedychium gardnerianum*
74	*Melinis minutiflora*
74	*Meremia tuberosa*
74	*Mikania micrantha*
74	*Spathodea campanulata*
74	*Sphagneticola trilobata*
69	*Costus speciosus*
67	*Epipremnum aureum*
67	*Merremia peltata*
67	*Sorghum halepense*
65	*Kyllingia polyphylla*
61	*Adenanthera pavonina*
61	*Albizia lebbeck*
61	*Albizia saman = Samanea saman*
61	*Rubus rosifolius*
60	*Lantana camara*
60	*Parthenium hysterophorus*
60	*Sorghum bicolor subsp. drummondii*
59	*Albizia chinensis*
59	*Ardisia elliptica*
59	*Cecropia obtusifolia*
59	*Cestrum diurnum*
59	*Cestrum nocturnum*
59	*Clerodendurm paniculatum*
59	*Leucaena leucocephala*
59	*Miconia calvescens*
59	*Psidium cattleianum*
59	*Stachytarpheta jamaicensis*
59	*Stachytarpheta urticifolia*
59	*Tecoma stans*
57	*Cardiospermum grandiflorum*
57	*Paraserianthes (Albizia) falcataria*
52	*Vachellia farnesiana*
52	*Cecropia peltata*
52	*Panicum repens*
52	*Paspalum conjugatum*
52	*Paspalum distichum*

52	*Pennisetum purpureum*
50	*Cenchrus echinatus*
50	*Mimosa pudica*
49	*Ageratum conyzoides*
46	*Passiflora laurifolia*
46	*Passiflora ligularis*
46	*Passiflora quadrangularis*
46	*Passiflora rubra*
46	*Syzygium cumini*
46	*Syzygium floribundum*
46	*Syzygium jambos*
44	*Acacia mearnsii*
44	*Acacia spirobis*
44	*Psidium guajava*
42	*Solanum torvum*
39	*Passiflora foetida*
37	*Panicum maximum*
37	*Paspalum urvillei*
36	*Pennisetum polystachion*
35	*Ocimum gratissimum*
34	*Bidens pilosa*
34	*Euphorbia hirta*
34	*Cuscuta campestris*
30	*Senna tora*
20	*Cyperus rotundus*

Appendix 14

Effort scores for the south-east Pacific (where a low score indicates less effort required to conduct a biocontrol programme).

EFFORT SCORE	Weed Species
4	*Eichhornia crassipes*
13	*Mimosa diplotricha*
13	*Salvinia molesta*
13	*Xanthium strumarium*
13	*Parthenium hysterophorus*
13	*Tecoma stans*
15	*Lantana camara*
17	*Hedychium coronarium*
17	*Hedychium flavescens*
17	*Hedychium gardnerianum*
21	*Cardiospermum grandiflorum*
22	*Mikania micrantha*
22	*Miconia calvescens*
23	*Sida acuta*
23	*Sida rhombifolia*
29	*Sphagneticola trilobata*
29	*Stachytarpheta jamaicensis*
31	*Spathodea campanulata*
31	*Costus speciosus*
31	*Stachytarpheta urticifolia*
31	*Acacia mearnsii*
32	*Psidium cattleianum*
36	*Clerodendrum chinensis*
36	*Clerodendurm paniculatum*
38	*Antigonon leptopus*
38	*Albizia saman = Samanea saman*
38	*Cestrum diurnum*
38	*Cestrum nocturnum*
38	*Leucaena leucocephala*
38	*Vachellia farnesiana*
38	*Mimosa pudica*
38	*Cyperus rotundus*
40	*Clerodendrum quadriloculare*
40	*Melinis minutiflora*
40	*Meremia tuberosa*
40	*Epipremnum aureum*
40	*Merremia peltata*
40	*Kyllingia polyphylla*
40	*Adenanthera pavonina*
40	*Albizia lebbeck*
40	*Albizia chinensis*
40	*Ardisia elliptica*
40	*Cecropia obtusifolia*
40	*Paraserianthes (Albizia) falcataria*
40	*Cecropia peltata*
40	*Ageratum conyzoides*
41	*Senna tora*
43	*Sorghum halepense*

43	*Syzygium floribundum*
43	*Cuscuta campestris*
44	*Psidium guajava*
46	*Sorghum bicolor subsp. drummondii*
46	*Passiflora laurifolia*
46	*Passiflora ligularis*
46	*Passiflora quadrangularis*
46	*Syzygium cumini*
46	*Passiflora foetida*
47	*Rubus rosifolius*
47	*Acacia spirobis*
47	*Euphorbia hirta*
48	*Panicum repens*
48	*Cenchrus echinatus*
48	*Solanum torvum*
50	*Paspalum conjugatum*
50	*Paspalum distichum*
50	*Pennisetum purpureum*
50	*Passiflora rubra*
50	*Syzygium jambos*
50	*Panicum maximum*
50	*Paspalum urvillei*
50	*Pennisetum polystachion*
50	*Ocimum gratissimum*
50	*Bidens pilosa*

Appendix 15

The top 20 targets for the south-east Pacific region, based on both feasibility and effort where Total score (= Feasibility score × 1/Effort score). Green shading = easier targets; orange shading = intermediate targets. *Weeds for which biocontrol agents are already established in the region. Information regarding where biocontrol is required is extracted from Dodd and Hayes (2009). **Biocontrol programme underway (Dodd & Hayes 2009).

Total score	Weed Species	Rank	Where in region is biocontrol required?
25.000	*Eichhornia crassipes*	1	
7.692	*Mimosa diplotricha*	2=	Cook Islands**; French Polynesia
7.692	*Salvinia molesta*	2=	
7.692	*Xanthium strumarium*	2=	
4.615	*Parthenium hysterophorus*	5	
4.538	*Tecoma stans*	6	
4.353	*Hedychium coronarium*	7=	
4.353	*Hedychium flavescens*	7=	
4.353	*Hedychium gardnerianum*	7=	
4.348	*Sida acuta*	8=	
4.348	*Sida rhombifolia*	8=	French Polynesia
4.000	*Lantana camara*	12	Cook Islands**
3.364	*Mikania micrantha*	13	
2.714	*Cardiospermum grandiflorum*	14	
2.682	*Miconia calvescens**	15	French Polynesia**
2.552	*Sphagneticola trilobata*	16	
2.387	*Spathodea campanulata*	17	Cook Islands; French Polynesia
2.226	*Costus speciosus*	18	
2.056	*Clerodendrum chinensis*	19	French Polynesia
2.034	*Stachytarpheta jamaicensis*	20	

Appendix 16

Factors influencing weed "importance".

Considerable resources are required if a biological control project is to be completed well (Fowler 2000) and so it is critical that weeds selected for management by this technique justify the investment. Whether biological control is the best response to a weed problem depends not only on the likelihood of achieving sufficient control to overcome weediness (likelihood of success), but also on the ecological and/or environmental importance of the weed (the potential benefits of its control). Hiebert (1997) has described the ecological, economic and managerial rationales for the prioritisation of weeds. He advocated the development of score-based decision-making tools to rank weeds on the basis of present level of impacts, future threat, and the feasibility and cost of conventional control. Systems of varying complexity exist for assessing the relative risk (and hence the economic and environmental importance) of invasive plant species in New Zealand (Owen 1997; Pheloung et al. 1999; Williams & Newfield 2002; Williams et al. 2005) Australia (Thorp & Lynch 2000), Canada and USA.

In Australia, the Weeds of National Significance (WoNS) have been identified by an objective scoring system to identify those invasive plants that have nationally significant economic and ecological impacts (Thorp & Lynch 2000). More recently the National Post-Border Weed Risk Management (WRM) Protocol (Anon. 2006) was formulated to further develop a risk-based decision support system for prioritising weed species management at the regional, state/territory, and national levels. This Protocol provides a generic guide to the development of a post-border WRM decision framework, including the key criteria that should be considered in assessing and comparing weed risks posed by different plant species and the feasibility of managing these species through coordinated control.

This Protocol relates to decision support systems for determining:

- Species for inclusion in (or removal from) noxious weed lists
- Priorities for eradication or containment programs
- Priorities for prevention of and early intervention against new weed incursions
- Plant species with existing or potential commercial uses which pose a weed risk and require active management to limit their spread from plantings
- Priorities for investment into research and extension leading to improved weed management (e.g. biocontrol priorities)

This Protocol is an adaptation of the approaches and content of the two Australia/New Zealand Standards:
AS/NZS 4360:2004, Risk Management; and
HB 203-2006, Environmental risk management-Principles and process
(http://www.fao.org/ag/AGP/agpp/IPM/Weeds/doc/FAOprocedure for post-border weed risk m.pdf).

Other approaches to the assessment of weed importance exist. Robertson et al. (2003) proposed a scoring system for South African weeds that allows prioritisation of weed risk according to potential invasiveness, distribution and density, potential environmental,

economic and social impacts, potential weed impacts, potential for control, and conflicts of interest (the system did not examine the feasibility of biological control in any depth). They noted that it was desirable for a range of assessors to score each weed to limit bias. They introduced a separate 'confidence score' so that assessors could indicate the reliability of data associated with each attribute, or the absence of such information. The overall confidence score then informed the reliability of the criterion scores.

Most national schemes for setting priorities for weed management are based on the current or future economic or environmental impact of the weed (e.g. Moran et al. 2005). Weed risk assessment systems may not adequately distinguish the relative importance of abundant weeds that are a problem currently and those that are of limited distribution but high potential. Nel et al. (2004) concluded that value of scoring systems is limited if there is no objective threshold at which a weed qualifies for management action, and the comparison of weed species with different suites of important attributes is difficult. They devised a system to 'cluster' weed species into those with established distributions and levels of current impact (major invaders) and those with high potential for invasion and impact (emerging invaders). Biological control against plants in an early stage of invasion has not been widely practised. However, the principle of formally recognizing and funding research on biological control of emerging weeds was established in South Africa in 2003 when the Working for Water program decided to support studies on five species of incipient weeds (Olckers 2004). Similarly, Groenteman et al. (2008) introduced the concept of multi-targeting: selecting agents that could simultaneously affect major weeds and related, less abundant plants with potential to become weeds in the future.

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