

## Preventing further introduction and spread of aquatic weeds through the ornamental plant trade

Andrew Petroschevsky<sup>1</sup> and Paul Champion<sup>2</sup>

<sup>1</sup>NSW Department of Primary Industries, PMB 2 Grafton, New South Wales 2460

<sup>2</sup>National Institute of Water and Atmospheric Research, PO Box 11-115, Hamilton, New Zealand

Email: andrew.petroschevsky@dpi.nsw.gov.au

**Summary** The trading of aquatic plant species for aquarium and pond plant purposes poses an ongoing risk of both future introductions and spread of aquatic weeds in Australia. Over 400 species of freshwater aquatic plants have been legally traded in Australia over the last 30 years. Some of these have been known weeds whilst little was known about the weed potential of others.

To address this concern the National Aquatic Weeds Management Group, in partnership with state governments, aquatic plant trade industries and New Zealand's National Institute of Water and Atmospheric Research, initiated a Weed Risk Assessment (WRA) of aquatic plants within the ornamental plant trade. Using a WRA model tailored to aquatic plants the process has to date identified 25 high-risk aquatic plant species for recommended national bans. Twenty one other species with significant weed potential were identified but require further data to conduct an accurate evaluation.

The process ensures declarations will be based on research conducted under Australian conditions and made in consultation with industry.

**Keywords** Aquatic weeds, Weeds of National Significance, weed risk assessment, ornamental plant trade.

### INTRODUCTION

The contribution of the aquatic plants trade to the introduction and spread of aquatic weeds is significant. Over 85 percent of declared and naturalised aquatic weeds in Australia were historically traded as aquarium or pond plants. Studies in New Zealand identified that 75 percent of their declared aquatic weeds were introduced through the aquatic plant trade (Champion and Clayton 2000).

Natural transfer of introduced aquatic weeds between catchments is uncommon, with few weed species having seed spread by birds or wind, or being solely asexual in their naturalised range (Champion *et al.* 2002). Thus human transfer between catchments, which are analogous to 'islands in a sea of land', is the major dispersal mechanism for these species (Champion *et al.* 2002).

The aquatic plant trade distributes large numbers of potential weeds throughout Australia, thus increasing propagule pressure and the potential for new naturalised populations to occur (Kolar and Lodge 2002). There is also a direct link between the aquatic plant trade and infestations due to wild harvesting operations by aquatic plant suppliers. To meet consumer demand, aquatic plant suppliers traditionally 'seeded' waterways and returned later for wild harvesting.

This practice resulted in many aquatic weed infestations in waterways on the eastern seaboard, particularly in or near urban areas. Some aquatic suppliers still continue this practice, despite several recent industry initiatives to raise awareness amongst their constituents regarding responsible aquatic plant trading. Subsequent spread by water movement or via contamination of watercraft, nets and drainage machinery led to further dispersal from these initial weed sources.

### BACKGROUND

**Previous attempts at national bans** In 1982 the National Committee on Management of Aquatic Weeds developed a list of undesirable aquatic plants for aquaria purposes. This process used tier I and tier II lists; the former recommending national ban from sale and the latter requiring further monitoring. In recent times the Australian Weeds Committee considered national bans on sale on more aquatic plants, include those on the 1982 tier II list, and had agreed to ban a number of aquatic plant taxa.

The 1982 lists and the Australian Weeds Committee recommendations removed, or proposed to remove, some of the worst aquatic weeds from sale. However, they didn't address the issue of wild harvesting practices potentially introducing and spreading new species. The potential for plant suppliers to replace banned species with other species with similar weed potential remained as little was known about many of the plants within the trade.

**Towards a risk assessment based approach** The Weeds of National Significance cabomba strategic plan acknowledged wild harvesting issues and

recommended promotion of safer alternative species as one solution (Agriculture and Resource Management Council of Australia and New Zealand, Australian and New Zealand Environment and Conservation Council and Forestry Ministers 2001). However, this process was later deemed to be unfeasible by National Aquatic Weeds Management Group (NAWMG) due to difficulties of identifying and recommending safe alternatives on a national scale.

In place of the 'safe list' the NAWMG recommended a risk assessment and consultative-based approach to plants currently within the trade. The aim of this approach was, in cooperation with industry, to identify those plants with high weed risk potential and recommend through the Australian Weeds Committee national sales bans for each. This concept utilises more science and consultation in aquatic plant declarations and is supported by the Pet Industry Association of Australia (A. Ramsey pers. comm.).

The inclusion of industry representatives in the project was also likely to provide assistance in the evaluation process with information on aquatic plants in their cultivation, length of time traded in Australia, volume of trade and early identification of potentially weedy species.

Funds were obtained from the Defeating the Weeds Menace Program to identify the extent of potential weeds in the aquatic ornamental plant trade and a technical advisory group (TAG) of industry, regulatory and scientific members.

#### MATERIALS AND METHODS

A project steering committee consisting of state government and aquatic plant trade industry representatives developed and endorsed a project approach.

**Identification of species in the trade** An extensive compilation of historic and current sales lists for aquatic plants in Australia was provided by Ed Fraser of Pisces Enterprises, Brisbane. Price lists from other Australian companies such as Wormborough, Aquadepot and Austral Gardens were sourced and a compilation of species made. Wherever possible identification of these traded species was checked. A list of internationally traded plants was collated from an extensive database of aquarium species (Booth 2002) and various texts (e.g. Slocum and Robinson 1996, Oriental Aquarium 2002, Kasselmann 2003). Corrections for illegal species combination and synonyms were made based on IPNI (2004).

**Pre-screening of plants** Lists of traded species present and absent from Australia were made. Amongst these lists, potential weeds were identified from

various weed lists (e.g. Csurhes and Edwards 1998, Champion *et al.* 2002, Randall 2002, Randall and Kessal 2004, Groves *et al.* 2005, Barker *et al.* 2006, ISSG 2007) and recent reports of naturalisation (e.g. Weed Spotter Newsletters, CRC Weed Management 2007). These species were further assessed by Weed Risk Assessment (next section) and through discussion amongst the TAG.

**Risk assessment** In New Zealand an aquatic weed risk assessment model (Champion and Clayton 2000) has been used as a decision support tool to determine which cultivated freshwater plants should be banned from entry, or prevented from deliberate dispersal through the nursery trade. The model scores attributes such as habitat versatility, competitive ability, reproductive output and dispersal, impacts, resistance to management and potential distribution.

A similar use of this model was envisaged in this project, with modifications to cater for south-eastern mainland Australian conditions as discussed by the TAG. Changes included removal of attributes such as impedance of hydro-electric power generation and impacts of freezing while increasing the importance of competitive ability, the importance of fluctuating water levels, turbidity, increased salinity (southern and inland areas), irrigation and flood control. Additional information specific to the trade was included, with assessment of length of time and volume in the trade and whether the species is traded as an outdoor (i.e. pond) or aquarium plant. Length of time and volume in the trade were scored as having a decreased likelihood of a species becoming weedy if it had been traded for over 25 years without naturalising. Pond plants were seen as a much greater risk of naturalising than tropical aquarium species, normally grown at a constant 28°C.

Species with a weed risk assessment score greater than 50 were recommended for a national ban from sale in Australia. A score less than this could still indicate significant weed potential and if a plant not known to be present in Australia scored greater than 40 (e.g. *Stratoites aloides* (47)) then its importation should be prevented.

**Competition trials** Many of the currently traded species are not reported as weeds internationally and some species that are weedy overseas may not be as problematic in Australian conditions. A series of experiments growing candidate species in competition with known weeds (WONS species) and indigenous plants have been initiated to assess potential weediness under a range of climatic conditions ranging from central coastal Queensland to Central Victoria. These

experiments will not be discussed further in this paper.

## RESULTS

Of the 401 species of aquatic plants reported as being present in Australia, 90 species are reported as being weeds elsewhere. Of these species 25 are recommended for a federal ban on sale and distribution based on their ranking using the weed risk assessment model and agreement amongst the TAG of their weed potential (Table 1).

In addition to these species, four additional plants (*Trapa natans* 74, *Myriophyllum spicatum* 71 and *Lagarosiphon major* 70) were reported by growers or on sales lists as being present in Australia, but no records could be found. They would be recommended for a national ban if this were the case. Three aquatic WONS species *Cabomba caroliniana*, *Salvinia molesta* and *Alternanthera philoxeroides* are already banned from sale nationally.

A further group of 21 potential weed species (Appendix) were recommended for further evaluation, either because there was not enough information to assess them using the weed risk assessment model and/or there was disagreement between TAG members. Included in this group are species of uncertain taxonomy (e.g. *Limnobiium* sp.) and taxa where both indigenous and alien cultivars are sold (e.g. *Lythrum salicaria*). Currently *Heteranthera reniformis*, *Hygrophila polysperma*, *H. triflora* and *Limnophila heterophylla* are being experimentally evaluated in competition trials.

## DISCUSSION

**Progressing national bans** By June 2008 the TAG will have reviewed results of competition trials and finalised the list for a national ban. This list will be forwarded to the Australian Weeds Committee for further consideration and recommendations.

The removal of high-risk species from sale should reduce the likelihood of future aquatic weeds invading waterways through wild harvesting. Remaining plants in the trade will be less likely to thrive in waterways. Instead supply of such species will be more economically and reliably supplied from purpose built facilities.

If adopted by states and territories the resulting sales bans may lead to the loss of some of the industry's highly regarded species. In such cases further consultation with industry will be required to identify iconic species and negotiate timeframes for a phase out period. The loss of low value species are unlikely to be of high concern to the industry (A. Ramsey pers. comm.).

**Table 1.** List of aquatic ornamental plant species recommended for a national ban from sale in Australia.

Species	Weed risk assessment score
<i>Alisma gramineum</i>	A
<i>Egeria densa</i>	83
<i>Eichhornia azurea</i>	75
<i>Eichhornia crassipes</i>	88
<i>Equisetum</i> spp.	A
<i>Gymnocoronis spilanthoides</i>	88
<i>Houttuynia cordata</i>	A
<i>Hydrocotyle ranunculoides</i>	68
<i>Hygrophila costata</i>	74
<i>Iris pseudacorus</i>	76
<i>Limncharis flava</i>	60
<i>Ludwigia longifolia</i>	84
<i>Ludwigia peruviana</i>	84
<i>Menyanthes trifoliata</i>	52
<i>Myriophyllum aquaticum</i>	92
<i>Najas guadelupensis</i>	57
<i>Nelumbo lutea</i> excluding hybrids	59
<i>Neptunia oleracea</i>	A
<i>Nymphaea mexicana</i> (possibly also <i>N. plena</i> )	62
<i>Pistia stratiotes</i> <sup>B</sup>	80
<i>Sagittaria graminea</i>	73
<i>Sagittaria montevidensis</i>	67
<i>Sagittaria platyphylla</i>	73
<i>Sagittaria sagittifolia</i>	67
<i>Typha latifolia</i>	76

<sup>A</sup> either not strictly aquatic but sold as a pond plant, or insufficient information but total agreement amongst advisory group members.

<sup>B</sup> assumed to be an introduced species.

Despite this risk assessment initiative, further risk assessments on aquatic plants are required. Firstly, some of the 21 species identified by the TAG requiring further evaluation will need to be pursued. Also, this project doesn't address potential propagule pressure from culinary aquatic plants utilised in permaculture and by ethnic communities.

## ACKNOWLEDGMENTS

We would like to thank the other members of the TAG (Steve Csurhes, Ed Frazer, Stephen Johnson, Kevin Metelik, Jackie Steele and Anthony Ramsey) for their input into this project. Kerry Bodmin (NIWA) provided useful critique of this paper.

## REFERENCES

- Agriculture and Resource Management Council of Australia and New Zealand, Australian and New Zealand Environment and Conservation Council and Forestry Ministers (2001). 'Weeds of National Significance cabomba (*Cabomba caroliniana*) strategic plan'. (National Weeds Strategy Executive Committee, Launceston).
- Booth, G. (2002). Aquarium Plant List. (<http://www.thekrib.com/Plants/Plants/big-plant-list.html> accessed October 2007).
- Barker, J., Randall, R.P. and Grice, T. (2006). Weeds of the future? Threats to Australia's grazing industries from garden plants. Final Report Project number NBP.357, 129 p. (Meat and Livestock Australia Ltd, prepared by the CRC for Australian Weed Management).
- Champion, P.D. and Clayton, J.S. (2000). Border control for potential aquatic weeds. Stage 1. Weed risk model. *Science for Conservation 141*. 48 p.
- Champion, P.D., Clayton, J.S. and Rowe, D.K. (2002). 'Lake managers' handbook: alien invaders'. 49 p. (Ministry for the Environment, New Zealand).
- CRC Weed Management (2007). Weed Spotters Newsletters ([http://www.weeds.crc.org.au/documents/weed\\_spotters\\_winter07\\_newsletter.pdf](http://www.weeds.crc.org.au/documents/weed_spotters_winter07_newsletter.pdf) accessed October 2007).
- Csurhes, S. and Edwards, R. (1998). 'Potential environmental weeds in Australia'. (Commonwealth of Australia, Canberra).
- Groves, R.H., Boden, R. and Lonsdale, W.M. (2005). Jumping the garden fence: Invasive garden plants in Australia and their environmental and agricultural impacts. WWF Australia ([http://www.wwf.org.au/publications/jumping\\_the\\_garden\\_fence/](http://www.wwf.org.au/publications/jumping_the_garden_fence/) accessed October 2007).
- International Plant Names Index (2004). (<http://www.ipni.org> accessed October 2007).
- Invasive Species Specialist Group (ISSG) (2007). Global Invasive Species Database (<http://www.invasivespecies.net/database/welcome/> accessed October 2007).
- Kasselmann, C. (2003). 'Aquarium plants'. 518 p. (Kreiger Publishing, Florida, USA).
- Kolar, C.S. and Lodge, D.M. (2002). Ecological predictions and risk assessments for alien species. *Science 298*, 1233-6.

**Appendix.** List of aquatic ornamental plant species recommended for further evaluation as potential weeds.

Species	Evaluation
<i>Bacopa caroliniana</i>	Future experiment
<i>Blyxa japonica</i>	Check taxonomy of the dwarf form in Australia
<i>Echinodorus cordifolius</i>	Future experiment
<i>Heteranthera reniformis</i>	Current experiment
<i>Heteranthera zosteriifolia</i>	Check status in Australia
<i>Hydrocleys nymphoides</i>	Future experiment
<i>Hygrophila polysperma</i>	Current experiment
<i>Hygrophila triflora</i> ( <i>H. difformis</i> )	Current experiment
<i>Ipomoea aquatica</i>	Compare cultivated and indigenous material
<i>Limnium laevigatum</i>	Confirm ID
<i>Limnophila sessiliflora</i>	Current experiment
<i>Ludwigia repens</i>	Future experiment
<i>Lythrum salicaria</i>	Check overseas cultivars for weedy traits
<i>Myriophyllum pinnatum</i>	Future experiment
<i>Nuphar lutea</i>	Future experiment
<i>Otella ulvafolia</i>	Future experiment
<i>Pontederia cordata</i> var. <i>lanceolata</i>	Future experiment
<i>Rorippa aquatica</i>	Confirm ID
<i>Sagittaria latifolia</i>	Future experiment
<i>Typha laxmannii</i>	Future experiment
<i>Zantedeschia aethiopica</i> cv. Green Goddess	Check status of cultivar

- Oriental Aquarium (2002). 'The aquarium plant handbook', 184 p. (Oriental Aquarium, Singapore).
- Randall, R.P. (2002). 'A global compendium of weeds'. (R.G. and F.J. Richardson, Melbourne).
- Randall, R.P. and Kessal, O. (2004). 'National list of naturalised invasive and potentially invasive garden plants in Australia'. (WWF Australia, Sydney).
- Slocum, P.D. and Robinson, P. (1996). 'Water gardening', 322 p. (Timberland Press, Oregon, USA).