Using the New Zealand aquatic weed risk assessment model to manage potential weeds in the aquarium/ pond plant trade

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Summary

The aquatic weed risk assessment model (AWRAM) has been used as a decision support tool to prevent the importation of potentially invasive aquatic weeds distributed in the international ornamental plant trade. The model has also been used to rank potential weeds already in Australia and New Zealand, supporting management tools such as banning from sale and distribution, and eradication programs. Competition experiments to evaluate the weed potential of aquatic plants where little information on weediness is available are discussed as an additional tool to assist with weed risk assessment.

Keywords: Potential aquatic weeds, ornamental pond and aquarium plant trade, importation, banning sale and distribution.

Introduction

The aquatic weed risk assessment model (AWRAM) developed by Champion and Clayton (2001a) assesses the potential invasiveness of an aquatic plant. This model was developed because previous general weed risk assessment models failed to adequately separate aquatic plants which have different levels of impact. AWRAM assesses characters such as habitat versatility, competitive ability, reproductive output, dispersal mechanisms, range of potential impacts, potential distribution and resistance to management activities. The AWRAM score is thus a synthesis of information relevant to the assessment of weed potential and management effectiveness providing a tool for managers and policy makers to prioritize weeds for control actions. It can also be used to compare species which are yet to naturalize with established aquatic weeds. To do this, the model requires reliable information on a range of species characters which can also be augmented by field observations (e.g. effective control methods, displacement of other species and dispersal methods).

Most current aquatic weeds (~75%) in New Zealand were imported originally as ornamental pond and aquarium plants. Many of these species and many other potential weeds are still traded internationally, with large numbers of growers and suppliers based in many countries especially South East Asia. Unlike other ornamental plant industries, a significant amount of plant material is collected from the wild.

Two studies of imported plants showed that material was often mislabelled or contained contaminant material. Maki and Galatowitsch (2004) ordered aquatic plants from around the USA and found 93% of 40 orders contained contaminant additional plants, animals, fungi, or algae. Ten percent of the orders included other plants classified as alien invasive species. A month-long survey of plants imported into Europe via Charles de Gaulle airport (EPPO 2007) found 98 966 plants of 162 taxa in 38 consignments with many misspelled or erroneous botanical names on phytosanitary certificates. Thus importation and sale of ornamental pond and aquarium plants is an important pathway for the introduction of potential aquatic weeds into a country and their subsequent spread.

Ban from importation into New Zealand

The geographical isolation of New Zealand means the natural or accidental introduction of freshwater plants from other countries is unlikely. This would require a plant to be taken from a freshwater habitat in the donor country, survive a journey of over 1000 km out of water and establish in a new freshwater habitat within New Zealand (Closs *et al*. 2004). Unsurprisingly the indigenous freshwater flora of New Zealand is depauperate with only slightly more than 50 obligate aquatic plant species known. Deliberate importation of aquatic plants via the ornamental plant trade, or other pathways such as culinary or fodder plants is therefore the main method of introduction into New Zealand and most other countries.

The *New Zealand Biosecurity Act (1993)* provides legislation to enable the management of problem species. Any organism capable of forming self-sustaining populations and with the potential to cause adverse impacts may be declared an Unwanted Organism. The majority of introduced species could be interpreted to qualify for this status, so a system of prioritization was required to ensure that Unwanted Organism status was reserved for potentially serious pests. Champion and Clayton (2000, 2001b) identified a number of aquatic plants not known to be present in New Zealand which ranked highly as potential weeds using AWRAM (Table 1) and these were recommended for declaration as Unwanted Organisms by the Department of Conservation (DOC). This designation would make importation of those species into New Zealand an illegal activity.

These species were duly declared Unwanted Organisms by the Chief Technical officer of DOC in July 2001. Their status was upgraded to Notifiable Organisms in 2006 (Ministry of Agriculture and Forestry Biosecurity New Zealand (MAFBNZ) 2006), a status requiring any person knowing of the presence of one of these plants to report it to MAFBNZ.

A survey of ornamental pond and aquarium plants in New Zealand (Champion and Clayton 2001b) and subsequent cultivation of this material found *Typha latifolia* L. and *Sagittaria sagittifolia* L. to be already present in New Zealand with the latter species well established in a stream at one site. This survey also found that 27% of all species identified were unknown from New Zealand in the 1980s, suggesting that illegal importation of aquatic plants was occurring, with these species being distributed by the trade. A recent (July 2007) case saw the prosecution of an offender responsible for importing at

Table 1. Aquatic weed risk assessment model (AWRAM) scores for some potential weed species traded internationally, but not known to be present in New Zealand in 2009.

Species	AWRAM score
Myriophyllum spicatum L.	73
Ludwigia peruviana (L.) H.Hara	64
Trapa natans L.	63
Typha latifolia L.	58
Najas marina L.	57
Typha domingensis Pers.	56
Najas guadalupensis (Spreng.) Magnus	54
Sagittaria sagittifolia L.	53

least 11 new aquarium species into New Zealand, through mislabelled mail. These plants were offered for sale on the internet and subsequent sales led to the dispersal of plants from Taipa near the northernmost point of the North Island to Invercargill in the south of the South Island.

Ban from sale and distribution in New Zealand

The majority of New Zealand's aquatic weeds are or were historically sold as aquarium or pond plants. The aquatic plant trade distributes large numbers of plants, increasing propagule pressure and the potential for new naturalized populations to occur (Kolar and Lodge 2002). Few problem aquatic weeds reproduce sexually in New Zealand, so spread by bird or wind dispersed seed does not occur (Champion *et al*. 2002). Thus human transfer between catchments is the major dispersal mechanism for these species and movement of plants through the ornamental trade is potentially a major long-distance dispersal pathway (Champion *et al*. 2002).

Six species of submerged plants (*Hydrilla verticillata* (L.f.) Royle, *Ceratophyllum demersum* L., *Egeria densa* Planch., *Lagarosiphon major* (Ridley) Moss, *Vallisneria australis* S.W.L.Jacobs & Les and *V. spiralis* L.) were banned from sale in 1983 under the *Noxious Plants Act (1978)*. A range of aquatic plant species already present in New Zealand were evaluated with AWRAM as part of the process to determine which species could be effectively managed by banning their sale and distribution (Champion 2005, Newfield and Champion 2010). This resulted in 30 aquatic species (Table 2) being included on the National Pest Plant Accord (NPPA) in July 2007. The NPPA is a MAFBNZ initiative involving regional and central government agencies and representatives from the plant nursery trade.

Other management of highly ranked species in New Zealand

MAFBNZ initiated eradication programs for six aquatic weeds in their national interest pest program beginning in 2007 (MAFBNZ 2009). These are the five highest ranked species (Table 2) along with *Salvinia molesta* D.S.Mitchell, a species already subjected to a national program since 1983. Programs for the eradication or containment of most other species in Table 2 are also currently being undertaken and funded by one or more Regional Council. Four of these species (*Nymphoides peltata* (S.G.Gmel.) Kuntze, *Potamogeton perfoliatus* L., *Menyanthes trifoliata* L. and *Pistia stratiotes* L.) are already considered eradicated from all known sites outside of containment.

Evaluation of aquatic plants offered for sale in Australia

Sales lists for aquatic plants in Australia were collated and compared with a list of internationally traded plants (Booth 2002, Slocum and Robinson 1996, Oriental Aquarium 2002, Kasselmann 2003). 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 naturalization (e.g. Weed Spotter Newsletters, CRC Weed Management 2008).

AWRAM was changed to reflect factors relevant to mainland Eastern Australia including 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 aquatic plant 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. Period 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 30 years without naturalizing. Pond plants were seen as a much greater risk of naturalizing than tropical aquarium species, normally grown at a constant 28°C. Species with a weed risk assessment score greater than 50 (25 species) were recommended for a national ban from sale in Australia (Petroeschevsky and Champion 2008).

Experimental evaluation of competitive performance

When there is little information on the impact posed by a plant (e.g. where a species has yet to establish as a naturalized species, or has only recently naturalized),

Table 2. Aquatic weed risk assessment model (AWRAM) scores for aquatic weed species banned from sale and distribution in New Zealand in 2009.

Species	AWRAM score
Phragmites australis (Cav.) Trin. ex Steud.	75
Hydrilla verticillata (L.f.) Royle	74
Zizania latifolia (Griseb.) Turcz. ex Stapf	68
Ceratophyllum demersum L.	67
Eichhornia crassipes (Mart.) Solms	67
Egeria densa Planch.	64
Alternanthera philoxeroides (Mart.) Griseb.	63
Lagarosiphon major (Ridley) Moss	60
Nymphoides peltata (S.G.Gmel.) Kuntze	58
Typha latifolia L.	58
Gymnocoronis spilanthoides (D.Don ex Hook. & Arn.) DC.	57
Salvinia molesta D.S.Mitchell	57
Myriophyllum aquaticum (Vell.) Verdc.	56
Lythrum salicaria L.	54
Potamogeton perfoliatus L.	54
Utricularia gibba L.	54
Sagittaria sagittifolia L.	53
Iris pseudacorus L.	52
Sagittaria platyphylla (Engelm.) J.G.Sm.	52
Ludwigia peploides (Kunth) P.H.Raven	51
Vallisneria australis S.W.L.Jacobs & Les	51
Vallisneria spiralis L.	51
Nymphaea mexicana Zucc.	48
Nymphoides geminata (R.Br.) Kuntze	47
Sagittaria montevidensis Cham. & Schltdl.	46
Schoenoplectus californicus (C.A.Mey.) Palla	46
Hydrocleys nymphoides (Humb. & Bonpl. ex Willd.) Buchenau	45
Menyanthes trifoliata L.	45
Nuphar lutea (L.) Sm.	43
Pistia stratiotes L.	42

an experimental evaluation of competitive performance has been developed to allow ranking of the species by AWRAM. A series of competition experiments where candidate species are grown with selected competitor species (which included both known weeds and native species) have been carried out both in New Zealand (Champion *et al*. 2007) and Australia (Petroeschevsky and Champion 2008).

More recent trials have used the experimental system of Burnett *et al*. (2007) to replicate a range of water temperatures approximating other climatic zones of Australia. Currently the potential weeds *Hygrophila polysperma* (Roxb.) T.Anderson, *H. difformis* (L.f.) Blume, *Heteranthera reniformis* Ruiz & Pav. and *Limnophila sessiliflora* (Vahl) Blume are being assessed, growing in competition with *Cabomba caroliniana* A.Gray and *Alternanthera philoxeroides* (Australian Weeds of National Significance) or *Ludwigia peploides* and *Hydrilla verticillata* (indigenous to Australia). The displacement or severe reduction of cover/biomass of competitor species in these experiments would indicate significant weed potential providing a basis for banning the deliberate distribution of these species.

Conclusions

The Aquatic Weed Risk Assessment Model (AWRAM) is an important decision support tool providing a defensible and science-based approach for policy makers wishing to ban the importation or sale of potential aquatic weeds or prioritize their management actions. Banning the importation of species ranked highly by AWRAM effectively keeps biosecurity risks off-shore, whilst banning a species from sale and distribution is a highly effective way of restricting both long-distance dispersal and density of propagules thereby reducing the occurrence of new infestations.

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