Border control for potential aquatic weeds

Stage 3. Weed risk management

Paul D. Champion, Deborah E. Hofstra and John S. Clayton

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Cover: *Saururus cernuus* in a garden at Okarito, South Island, New Zealand.
Photo: Paul Champion.

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ABSTRACT

This is the third and final report of a programme investigating border control for potential aquatic weeds in New Zealand. We investigate whether the 25 potential weed species identified in the Stage 2 report are present in New Zealand, evaluate the weed potential of *Hygrophila polysperma*, *Hydrocotyle verticillata*, *Cabomba caroliniana* and *Saururus cernuus*, recommend a protocol for the determination of aquatic plants as Unwanted Organisms, and review Import Health Standards relating to the importation of aquatic plants. Four potential aquatic weed species were confirmed in New Zealand: *Butomus umbellatus*, *Typha laxmannii*, *T. latifolia* and a *Sagittaria* species. These plants, excluding *T. laxmannii*, were recommended for eradication as they pose an immediate threat to aquatic habitats in New Zealand. Further investigation of the weed potential of *T. laxmannii* is recommended. None of the four were regarded as significant threats to natural ecosystems in New Zealand or recommended as candidates for Unwanted Organism status. A series of criteria were recommended for future determination of aquatic plants as Unwanted Organisms, including the use of the weed risk assessment model developed in Stage 1. The recommendations for aquatic plant imports include: divide imported plant material into risk categories and design an appropriate Import Health Standard for each; review protocols for post-entry quarantine inspectors to increase their awareness of potential pest plant imports; and review current legislation for the importation of plant material providing more incentives for the screening of new material entering New Zealand.

Keywords: potential weed evaluation, Unwanted Organism determination, Import Health Standards, New Zealand

Champion et al. 2007: Border control for potential aquatic weeds. Stage 3. Weed risk assessment. *Science for Conservation 271*. Department of Conservation, Wellington. 41 p.

1. Introduction

This report is the third and final of a series of reports investigating border control for aquatic plants that have the potential to become ecological weeds in New Zealand.

The overall aim of this programme is to assist the Department of Conservation (DOC) with providing policy advice to the Minister for Biosecurity on the risks to indigenous flora and natural habitats from non-naturalised aquatic plant species and new genetic varieties of established species. This risk assessment will also help with the development of a justifiable rationale for entry restrictions on further importation of weed pests that are already established in New Zealand, and will help to establish criteria for the Environmental Risk Management Authority (ERMANZ) to assess new organisms under the Hazardous Substances and New Organisms (HSNO) Act 1996.

The Stage 1 report (Champion & Clayton 2000) included the development of a revised Aquatic Weed Risk Assessment Model (AWRAM) suitable for aquatic plants, and outlined potential impacts from new aquatic plant species and possible entry pathways. It also identified several key areas that required further investigation, including a comprehensive survey of aquatic plants present but not naturalised in New Zealand, and an assessment of the amount of trade interest in (and thus the likelihood of importation of) aquatic plants with weed potential.

The Stage 2 report (Champion & Clayton 2001) outlined the results of a survey of major importers and traders of aquatic plants, and identified plant species that they currently hold or have kept previously. The AWRAM was applied to likely pest plant species (those with a documented weed potential in other countries), with recommendations for the management of the worst-ranked species, which included both species currently in New Zealand and those not reported there. Further information relating to the volume of aquatic plants entering New Zealand and identification of vulnerable indigenous aquatic species and communities that may be further impacted by aquatic weeds was also provided.

This Stage 3 report has four objectives:

- To investigate whether any of the 25 potential aquatic weed species identified in the Stage 2 report are present in New Zealand.
- To evaluate the weed potential of four potentially problematic species (*Hygrophila polysperma, Hydrocotyle verticillata, Cabomba caroliniana* and *Saururus cernuus*) using controlled experiments in secure facilities.
- To recommend a protocol for the determination of aquatic plants as Unwanted Organisms (undertaken in 2002).
- To review current Import Health Standards (IHS) relating to the importation of aquatic plants, making recommendations for changes in management where deficiencies are identified (undertaken in 2003).

Experimental investigations were carried out at the NIWA Ruakura Experimental Facility in the secure area used to culture current unwanted organisms. Exemption permits for the culture of unwanted organisms (under Sections 52 and 53 of the Biosecurity Act 1993) were obtained from Biosecurity New Zealand and the Department of Conservation.

See section 8 for a glossary of all acronyms used in this report.

2. Identification of potential aquatic weed species in cultivation in New Zealand

Champion & Clayton (2001) identified the possibility that the following potential weed species were present in New Zealand: *Azolla caroliniana, Blyxa aubertii, Butomus umbellatus, Hottonia palustris, Hydrocharis morus-ranae, Hydrocotyle bonariensis, Limnobium spongia, Lobelia dortmanna, Marsilea crenata, Myriophyllum matagrossense, M. scabrum, Najas guadalupensis, N. marina, N. indica, Nelumbo lutea, Neptunia plena, Ottelia alismoides, O. ulvifolia, Nuphar minimum, N. pumilio, Potamogeton gayi, Salvinia* spp. (not *S. molesta*), *Sagittaria sagittifolia, Sparganium erectum, Typha latifolia* and *T. domingensis.*

People from from the aquatic plant trade that were interviewed reported these species as being present amongst the collections of amateur aquarists or having formerly been here but not persisting.

To confirm the presence of these species, all traders of aquatic plants were again contacted, along with hobby aquarists sourced through the Pet Industry Association of New Zealand (PIJAC) and the Federation of New Zealand Aquarium Societies (FNZAS).

A series of booklets and weblinks have been produced by PIJAC, containing information on 32 unwanted organisms within New Zealand, ten potential weed species not present in New Zealand, and 40 alternative species, either indigenous or of lower weed potential, that are suitable for cultivation in aquaria and ornamental ponds. These information booklets ask aquarium/pond keepers to report any of the unwanted species to the National Institute of Water & Atmospheric Research (NIWA). The booklets and weblinks are available on the NIWA website: www.niwascience.co.nz/ncabb/aquaticplants (viewed April 2006).

The President and Plant Committee member of FNZAS, Warren Stilwell, has forwarded a questionnaire to all members asking for information on plants that are currently kept and also requesting that any field sites of aquatic plants that are Unwanted Organisms are reported to NIWA. NIWA has offered to identify any unknown plants for FNZAS members.

To date, only three species of the potential weed species identified by Champion & Clayton (2001) have been confirmed as present in New Zealand: *Butomus umbellatus*, *Typha laxmannii* and *T. latifolia*. All were collected as part of the survey of aquatic plant growers (Champion & Clayton 2001). A new *Sagittaria* species has also been identified in both field and cultivated sites (Champion 2002).

Butomus umbellatus was found on the premises of a grower in spring 2002; identification was based on flowering material. It has not been propagated for sale.

The invasive potential of *B. umbellatus* was briefly discussed in Champion & Clayton (2001) and it was ranked with an AWRAM score of 54. Based on its seed production, asexual reproduction (rhizomes and bulblets), competitive ability, toxicity to grazing animals and temperature tolerance attributes (White et al. 1993; Haber 1997; Rice 2004), this species meets the criteria for Unwanted Organism (Biosecurity Act 1993) status, as outlined in section 4 of this report.

Two *Typha* taxa that superficially looked different from the New Zealand indigenous raupo (*T. orientalis*) were collected as part of the survey of aquatic plant growers (Champion & Clayton 2001). The specimen with a smaller growth habit and narrower leaves than raupo flowered in the first summer after collection and was identified as the southeastern European *T. laxmannii* based on the following diagnostic characters: plant slender, leaf sheaths auriculate, female flowers with linear scales, female spike pale brown, male spike 2–4 × longer than female spike, and pollen grains simple. In comparison, *T. orientalis* has the following characteristics: plant robust, leaf sheaths auriculate, female flowers with no apparent scales, female spike chestnut brown, male spike ± equal to female spike, and pollen grains simple.

Seedlings have been produced from the flower heads of *T. laxmannii* and these will be grown on to flowering to ascertain whether these are selfed or pollinated by *T. orientalis*.

For the larger *Typha* specimen, no flowering was apparent after 2 years of culture. Flowering was induced in summer 2003/04 by adding treated effluent during spring. *Typha latifolia* was distinguished by the following characters: plant robust, leaf sheaths tapering to lamina, female flower with no scales, female spike dark brown, male spike ± equal in length to female spike, and pollen grains in tetrads (groups of four grains).

Literature used to distinguish these species included Fassett & Calhoun (1952), Aston (1973), Tutin et al. (1980), and Smith (1987). The three species and differences between them are illustrated in Figs 1 and 2.

Typha latifolia is already classified as an Unwanted Organism and is part of the Ministry of Agriculture and Forestry (MAF) National Plant Pest Accord (MAF Biosecurity Authority 2002). Fruiting heads of the plants grown in culture were removed before seed was dispersed. The original collection site (in the Auckland Region) has been checked to ensure that no flowers and seed were produced. Eradication of all remaining plants at the one known collection site is advocated.

Typha laxmannii is banned from entry into Western Australia (as is the entire genus apart from species indigenous to Western Australia), but does not have a weed profile in any country (Randall 2002). Should the seedlings currently being cultured at the NIWA Ruakura Experimental Facility be a result of hybridisation with the indigenous *T. orientalis*, designation of this species as an Unwanted Organism is recommended. If this is not the case, competition experiments similar to those undertaken in section 3 of this report are recommended.

The *Sagittaria* species was first identified at a field site in Coromandel (Champion 2002). This plant had arrow-shaped leaves like the pest plant *Sagittaria montevidensis*, but unlike the latter species, it also had creeping horizontal rhizomes and tubers (Fig. 3). These vegetative characters alone are insufficient

Figure 1. Inflorescences of (from left to right) *Typha latifolia, T. orientalis* and *T. laxmannii*. Scale in cm.

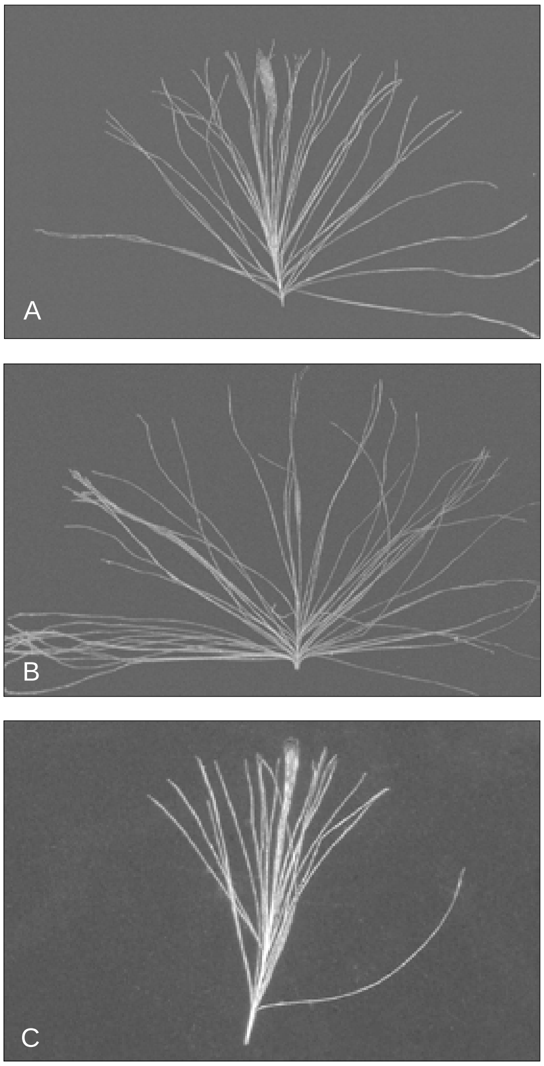

Figure 2. Pistillate flowers of *Typha*. A = *Typha latifolia,* B = *T. orientalis* and C = *T. laxmannii*.

Figure 3. *Sagittaria* species showing rhizomes and tubers.

to identity the species. Fruit characters are needed to distinguish between *Sagittaria latifolia*—a North American species, and *S. sagittifolia*—a European species. Both species are actively spread throughout the world as ornamental pond plants. We cultivated this plant over two growing seasons, but no flowers were produced; nor have flowers been seen from other cultivated plants in Christchurch. Plants die off over winter, sprouting from tubers in late spring/early summer and growing to a stage summer/autumn where they competitively exclude existing vegetation.

The weedy characteristics of *S. sagittifolia* were assessed using AWRAM (Champion & Clayton 2001) and it scored 53, ranking it as potentially as significant a weed as *Sagittaria platyphylla* (52) and *S. montevidensis* (46). This species has now been declared as an Unwanted Organism and is part of the MAF National Plant Pest Accord (MAF Biosecurity Authority 2002). If the scores of the AWRAM relating to seed set and dispersal of such seed were adjusted to reflect the lack of sexual reproduction in *S. sagittifolia,* this species would score 44. This is still comparable to the scores of plant pests such as the weedy water poppy (*Hydrocleys nymphoides*) (45) and yellow water lily (*Nuphar lutea*) (43), both of which are classed as Unwanted Organisms and controlled at all known sites within New Zealand. Therefore, even if the new *Sagittaria* does not flower and produce seed in New Zealand, it still has major weed potential, so that control at such an early stage of naturalisation is warranted. The field site is currently under active management by Environment Waikato.

The continued search for other potential aquatic weeds held by hobbyist aquarists and pond keepers, in addition to regular checks of aquatic plant retailers who may be given such specimens, is recommended.

3. Experiments to determine the competitive potential of four aquatic plants in cultivation within New Zealand

3.1 INTRODUCTION

There are several non-naturalised aquatic plant species present in New Zealand that are weedy in other parts of the world. For example, *Cabomba caroliniana* is now classed as a 'Weed of National Significance (WONS)' in Australia (ARMCANZ 2000). The inclusion of this species as an Unwanted Organism under the Biosecurity Act (1993) was contemplated by DOC pending the competitive performance of this species in New Zealand. Using AWRAM, Champion & Clayton (2001) scored *C. caroliniana* at 58, based on overseas information relating to this plant; this score is similar to that of the current problem weed *Lagarosiphon major* (60).

To investigate their potential weediness under New Zealand conditions, *C. caroliniana* and three other candidate species (*Hygrophila polysperma*, *Hydrocotyle verticillata* and *Saururus cernuus*) were grown in combination with known alien weeds and native New Zealand species under experimental conditions. These species are either weedy in other countries (e.g. *H. polysperma* in USA (Van Dijk 1986)) or have recently naturalised in New Zealand (e.g. Heenan et al. 2002). Sufficient material of other potential weed species (*Butomus umbellatus, Hydrocharis morus-ranae, Limnobium spongia, Najas* spp., *Potamogeton gayii, Sparganium erectum, Typha domingensis* and *T. latifolia*) was not sourced to enable their evaluation. For documentation of their presence in New Zealand, see section 2 of this report.

There are few documented examples of experimental evaluation of the competitiveness of aquatic weed species (Moen & Cohen 1989; Sutton 1990; Hofstra et al. 1999); most estimates of invasiveness are based on observation of the displacement of less-competitive species in the field (e.g. de Kozlowski 1991; Wells et al. 1997). Where a species has yet to establish as a naturalised species, an experimental approach allows some quantification of weed potential without risking presently unaffected natural environments. Although the specific light, nutrient and temperature regimes present in such experimental conditions do not represent the ranges experienced within New Zealand, the displacement or severe reduction of competitor species would indicate significant weed potential, and this approach allows the invasiveness of the candidate species to be compared with that reported in literature from elsewhere.

3.2 METHODS

3.2.1 Experimental design

Vegetative propagules (stem fragments, cuttings or rhizomes) were collected from all plant species, stored in plastic bags and transported back to and grown on in containment facilities at the NIWA Ruakura Experimental Facility, Hamilton, New Zealand, until the experiments were set up.

An exemption under the Biosecurity Act (1993) was sought from and approved by DOC (Biosecurity Section) to allow the Unwanted Organisms *Egeria densa, Ceratophyllum demersum, Lagarosiphon major, Myriophyllum aquaticum* and *Zizania latifolia* to be cultivated at the NIWA Ruakura Experimental Facility.

Five experiments were set up in four different tank types to assess the competitive ability of the four potential weed species *Hygrophila polysperma*, *Hydrocotyle verticillata*, *Cabomba caroliniana* and *Saururus cernuus* with selected competitor species (which included both known weeds and native species) under different water level and/or light conditions that may be typical of those experienced in the field where the selected competitors grow. Experimental tanks were located at the NIWA Ruakura Experimental Facility. The large number of combinations of species required to test the competitive ability of the four candidate species constrained the number of replicates to three per combination. Consequently, large standard deviations resulted.

3.2.2 Competition experiments

Hygrophila polysperma, *Hydrocotyle verticillata*, *Cabomba caroliniana* and *Saururus cernuus* were grown in combination with at least one species that was a known serious introduced weed, one naturalised minor weed and one indigenous plant, each of a similar life-form to the plant under evaluation. The growth rates and over-wintering capability of the potential weeds and their competitive ability and impacts on native species were of particular interest.

Cabomba caroliniana is an obligate submerged species and *Hygrophila polysperma* is a facultative submerged species. These were compared with four alien submerged species—*Elodea canadensis, Egeria densa, Ceratophyllum demersum* and *Lagarosyphon major* (Experiment 1), each of which has different invasive capabilities, as indicated by their AWRAM scores of 46, 64, 67 and 60 respectively (Champion & Clayton 2000), with a high score conferring greater weed potential. Native submerged species used in the trial comprised two vascular species—*Potamogeton ochreatus* and *Myriophyllum triphyllum*—and the charophyte *Chara globularis* (Experiments 2 and 3).

Hygrophila polysperma also grows as a sprawling emergent, as does *Hydrocotyle verticillata.* These two species were compared with a major problem alien weed (*Myriophyllum aquaticum*, AWRAM score of 56), an alien species with minor impact (*Ludwigia palustris*, AWRAM score of 34) and the indigenous *Persicaria decipiens* (Experiment 4).

Saururus cernuus is an erect rhizomatous emergent and was compared with a major problem alien weed (*Zizania latifolia*, AWRAM score of 68), an alien sprawling emergent species with minor impact (*Ludwigia palustris*, AWRAM score of 34) and the two indigenous species *Typha orientalis* and *Eleocharis acuta* (Experiment 5). *Typha orientalis* is occasionally regarded as weedy, as it rapidly colonises still, shallow, fertile water bodies and can obstruct drainage and recreational activities (Coffey & Clayton 1988), whereas *Eleocharis acuta* is a much smaller species that is rarely considered a nuisance.

Experiment 1: **Hygrophila polysperma** *and* **Cabomba caroliniana** *v. submerged weeds*

The concrete tanks (1.3 m long × 1 m wide and 1 m deep) used for this experiment were located outdoors. A 100-mm-deep layer of topsoil was placed in the bottom of each of the tanks, followed by a 20-mm layer of sand. The tanks were filled with at least 300 mm of water prior to planting, and were completely filled with water following planting.

Hygrophila polysperma and *Cabomba caroliniana* were each planted in 12 tanks with one of four competitor species (*Egeria densa*, *Lagarosiphon major*, *Ceratophyllum demersum* and *Elodea canadensis*). Treatments or species combinations were randomly assigned to tanks, and each species was randomly assigned to half of each tank. One half of each tank was planted with the competitor species, and the other half was planted with *Hygrophila polysperma* or *Cabomba caroliniana* or left vacant. All six species were also planted without competitor species, as controls.

For all species, healthy single shoots were selected, cleaned and cut to 200–250 mm in length for planting. Shoots of the appropriate species were planted

c. 50 mm into the sediment. Sixty shoots were planted per tank half, in six rows, with plants 100 mm apart; all external rows were equidistant from the tank walls. After planting, tanks were covered to provide 95% shade.

Experiment 2: **Hygrophila polysperma** *v. native macrophytes*

The circular tanks (1.4 m in diameter and 1.4 m deep) used for this experiment were located in a greenhouse. Soil depth and planting methods were the same as in Experiment 1.

Hygrophia polysperma was planted throughout each of three tanks, and in half of each of another three tanks. In a further four tanks, *H. polysperma* was planted in half of each tank, and a mixture of the native pondweed (*Potamogeton ochreatus*), milfoil (*Myriophyllum triphyllum*) and charophyte (*Chara globularis,* referred to hereafter as chara) was planted at the same density as *H. polysperma* in the other half. The plant density was 72 plants per tank half, which was equivalent to one plant every 10 cm. The native assemblage was mostly chara, with only four stems each of milfoil and pondweed replacing eight of the chara per half tank. Chara was planted as small (30–50-mm) clumps rather than as individual plants. *Hygrophia polysperma* was planted as shoot fragments c. 150–200 mm long. Native macrophytes were also planted throughout four tanks, to which one *H. polysperma* plant was added (planted in the centre) 8 weeks later. Native macrophytes only were planted in an additional six tanks, over the whole area in three tanks and half the area in the remaining three tanks.

As in Experiment 1, treatments or species combinations were randomly assigned to tanks and tank halves. Once planted, each tank was covered in shade cloth. In conjunction with the greenhouse roof, this provided c. 95% reduction of light to the tanks.

Experiment 3: **Cabomba caroliniana** *v. native macrophytes*

The tanks (550 mm in diameter and 800 mm deep) used for this experiment were located in a greenhouse. Soil depth and planting methods were the same as in Experiment 1.

Cabomba caroliniana was planted throughout each of three tanks, and over half of each of another three tanks. In a further six tanks, *C. caroliniana* was planted in half of each tank either at time zero (the same time as the native macrophytes) or 8 weeks later. The same native species as used in Experiment 2 were planted at the same density as *C. caroliniana* in the other half of each of these tanks. The plant density was 16 plants per half tank, which was equivalent to one plant every 75 mm. *Cabomba caroliniana* was planted as shoot fragments c. 150–200 mm long. Native macrophytes were also planted throughout three tanks with one *C. caroliniana* plant (planted in the centre); and throughout a further three tanks, to which *C. caroliniana* was added 8 weeks later. In an additional three tanks, *C. caroliniana* and the native macrophytes were planted at a ratio of 1:3 respectively. Native macrophytes only were planted in an additional six tanks, over the whole area in three tanks and half the area in the remaining three tanks.

As in Experiment 1, treatments or species combinations were randomly assigned to tanks and tank halves. Once planted, shade cloth was placed over each tank. In conjunction with the greenhouse roof this provided c. 95% reduction of light to the tanks.

Experiment 4: **Hygrophila polysperma** *and* **Hydrocotyle verticillata** *v. sprawling emergent plants*

Circular plastic tubs (540 mm in diameter and 360 mm deep) located outdoors, were half-filled with topsoil, covered with a 200-mm layer of sand, and filled with water.

Plant combinations included *Hygrophila polysperma* or *Hydrocotyle verticillata*, planted with one of *Ludwigia palustris, Persicaria decipiens* or *Myriophyllum aquaticum*. Each of these five species was also planted without competitor species, as controls. In combination tanks, the two species being trialled were planted adjacent to one another, and in control tanks species were planted centrally. For all species, a 100–120-mm clump of each plant (including roots) was planted.

Experiment 5: **Saururus cernuus** *v. marginal aquatic plants*

The plastic tubs for this experiment were set up as in Experiment 4.

Saururus cernuus was planted with one of *Ludwigia palustris, Typha orientalis, Eleocharis acuta* or *Zizania latifolia*. Each of these five species was also planted without competitor species, as controls. In combination tanks, the two species were planted adjacent to one another, and in control tanks species were planted centrally. For all species, a 100–120-mm clump of each plant (including roots) was planted.

3.2.3 Monitoring

The water level in the tanks was adjusted as required to ensure that the tanks remained full, and the tanks were flushed monthly to remove any surface algae. A temperature logger (Optic StowAway®) was placed in one of the tanks (previous unpubl. data showed that temperature did not vary between the tanks) to record the water temperature throughout the study period.

For Experiments 1–3, light levels (PAR) at the water surface and below the plant canopy (bottom of the tanks for all submerged species) were recorded in December 2003 (the second summer) using a Licor (LI-192SB), in at least one of each of the experimental and control tanks. Ambient light (midday sun) was also recorded simultaneously, so that percentage of ambient light in the trial tanks could be calculated.

Plant growth was assessed at monthly intervals. The percentage area of the tank in which the species occurred (presence or absence in a 10 × 10 cm cell grid) and percentage cover (shoot density) occupied by each species were estimated. Plant height was measured for five randomly selected plants in each tank. Other plant growth variables, such as branching, fragmentation and flowering, were also noted.

3.2.4 Harvest

All experiments were harvested after 18 months (i.e. two summers).

Tanks with submerged vegetation (Experiments 1–3) were harvested in depth layers (the canopy, i.e. the top 200 mm of the water column, and the sub-canopy, i.e. anything below the top 200 mm), and tank halves corresponding to the original planting plan. Plants were first cut with scissors down the central line of each tank, with as little water disturbance as possible. The canopy layer of plant material from each half was then cut 200 mm below the water surface, and removed to separate sorting trays. Roots were not sampled, as they made up a very small portion of biomass for submerged species (unpubl. data). Once plant species were cleaned of any epiphytic algae and separated into individual species, they were oven dried at 80°C to constant dry weight.

Tanks with emergent plants (Experiments 4 and 5) were harvested by separating above-ground (shoot) and below-ground (root and rhizome) biomass. Soil and attached dead organic material was removed by washing. Shoots were cleaned of any epiphytic algae present and plant species were separated. Plant material was dried at 80°C to constant dry weight.

3.3 RESULTS AND DISCUSSION

3.3.1 *Cabomba caroliniana*

Cabomba caroliniana grew well under all experimental conditions, being present in more than half of each tank by mid-summer (February 2003), and having over 50% cover (mean ± SD: 53% ± 10%) toward the end of the first summer (March 2003). It established as a canopy species when in competition with all native and alien-invasive submerged species with which it was tested. Surface-reaching *C. caroliniana* stems were recorded by the second spring, followed by floating leaf production and flowering in summer (January 2004). The performance of *C. caroliniana* was similar in competition and control tanks (i.e. growth was not negatively affected by the presence of the competitor species) (Figs 4A and 5A).

Neither the biomass of the alien invasive species (Fig. 4B) nor the native macrophyte assemblage biomass (Fig. 5B) differed markedly between their respective treatment tanks where *C. caroliniana* was present and their controls.

These results indicate that *C. caroliniana* could tolerate New Zealand growing conditions and would co-exist with (rather than displace) some indigenous and alien submerged macrophytes. There is no indication that it would present a weed threat when compared with the alien species trialled in this experiment. It was noted that fragments of *C. caroliniana* did not root and form new plants under the experimental conditions, meaning that it is unlikely to be spread accidentally (e.g. by stem fragments on boats and trailers, nets and drainage machinery), which is the predominant mechanism for spread of most submerged weeds currently in New Zealand.

Cabomba caroliniana achieved an AWRAM score of 58 based on information from elsewhere in the world (Riemer & Ilnicki 1968; Tarver & Sanders 1977; Sanders 1980). However, results from this competition experiment and other observations under New Zealand conditions suggest that this is excessive based on *C. caroliniana*'s competitive ability, inability to produce seed outside of the Americas and possible reduction in assumed temperature tolerance and available habitat within New Zealand. *Cabomba caroliniana* has been widely available in the aquarium trade for over 30 years (Champion & Clayton 2001) but has not established as a naturalised plant, unlike several other species with a similar record of introduction which are now classified as naturalised invasive pests (e.g. *Gymnocoronis spilanthoides* and *Sagittaria platyphylla*).

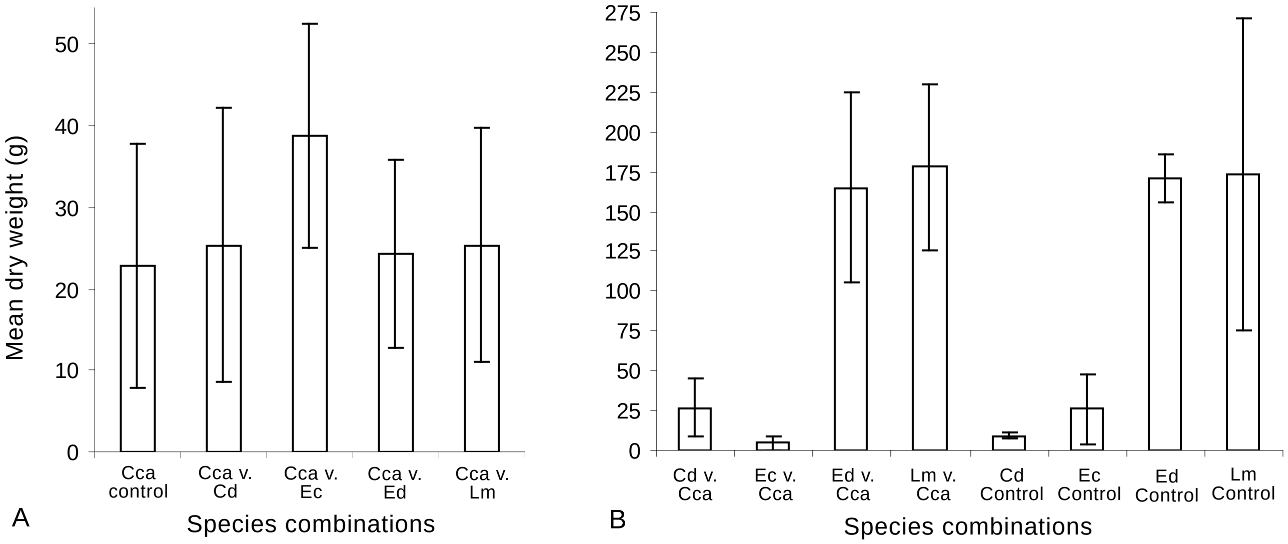

Figure 4. A—*C. caroliniana* (Cca) biomass in control and competition tanks with *C. demersum* (Cd), *E. canadensis* (Ec), *E. densa* (Ed) and *L. major* (Lm). Histograms represent mean dry weight (g) (n = 3); errors bars are standard deviations. B—Biomass of *C. demersum* (Cd), *E. canadensis* (Ec), *E. densa* (Ed) and *L. major* (Lm) in control and competition tanks with *C. caroliniana* (Cca). Histograms represent the mean dry weight (g) (n = 3); error bars are standard deviations.

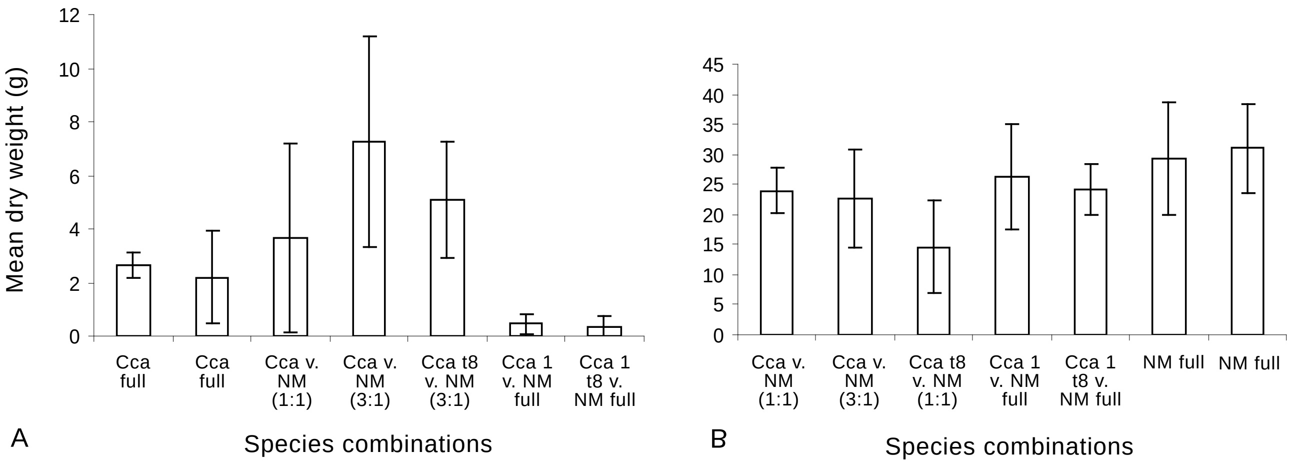

Figure 5. A—*C. caroliniana* (Cca) biomass in control and competition tanks with the native assemblage (NM). Histograms represent mean dry weight (g) (n = 3); errors bars are standard deviations; t8 indicates planting of Cca 8 weeks later than NM; numbers in parentheses indicate relative plant density in competition tanks other than full plantings. B—Biomass of native macrophytes (NM) in control and competition tanks with *C. caroliniana* (Cca). Histograms represent the mean dry weight (g) (n = 3); error bars are standard deviations; t8 indicates planting of Cca 8 weeks later than NM; numbers in parentheses indicate relative plant density in competition tanks other than full plantings.

3.3.2 *Hygrophila polysperma*

Hygrophila polysperma grew well in both the competition and control tanks in this study.

Hygrophila polysperma did not spread to unplanted areas of the tank when it was in competition with *Egeria densa* or *Lagarosiphon major*, but increased to occupy 70% (± 10%) of the tank when it was planted alone. Similarly, *H. polysperma* had a higher cover in control tanks than it did when grown with *E. densa* or *L. major,* which is illustrated by the biomass data (Fig. 6A). *Hygrophila polysperma* biomass was greater in control tanks than in competition tanks with *E. canadensis, E. densa* or *L. major* (Fig. 6A). In competition with the native macrophyte assemblage, *H. polysperma* performed poorly in comparison with plants in control tanks (e.g. *H. polysperma* control tanks had a mean dry weight of 73 g ± 26 g compared with 12.5 g ± 5 g when grown with the native macrophytes) (Fig. 7A). It should be noted that the majority of *H. polysperma* biomass was present in the sub-canopy, often occurring beneath a canopy of the competitor species (authors pers. obs.). In addition, neither the weed species nor the native macrophyte assemblage was affected by the presence of *H. polysperma,* with respect to biomass (Figs 6B and 7B).

As a sprawling emergent macrophyte, *H. polysperma* was also a poor competitor, not reducing the biomass of competitor species (Figs 8A and B).

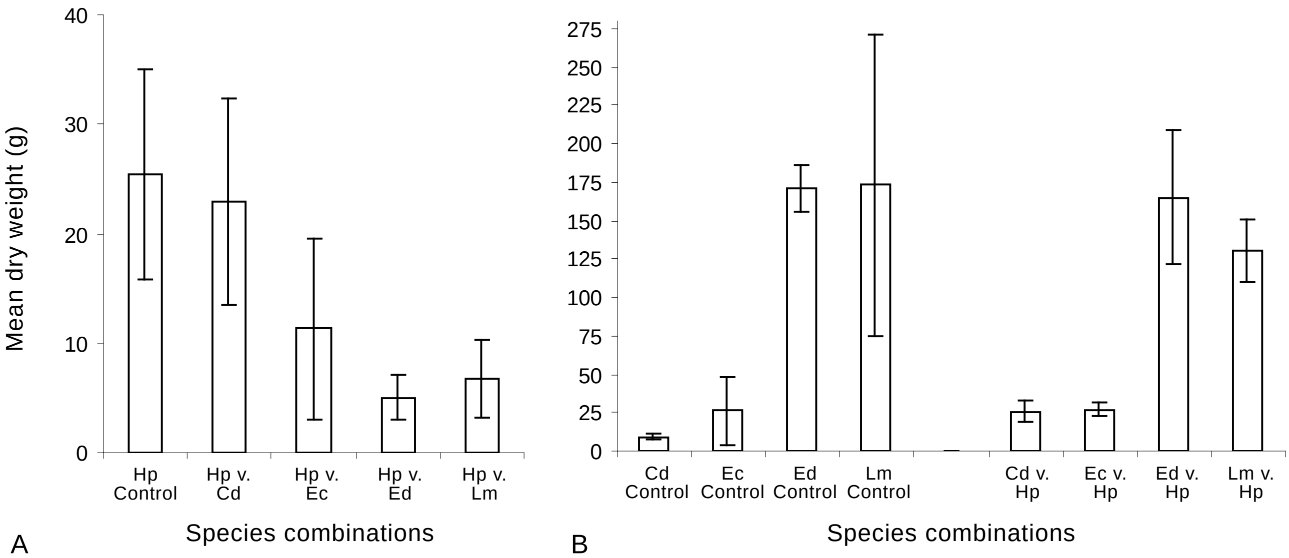

Figure 6. A—*H. polysperma* (Hp) biomass in control and competition tanks with *C. demersum* (Cd), *E. canadensis* (Ec), *E. densa* (Ed) and *L. major* (Lm). Histograms represent mean dry weight (g) (n = 3); errors bars are standard deviations. B—Biomass of *C. demersum* (Cd), *E. canadensis* (Ec), *E. densa* (Ed) and *L. major* (Lm) in control and competition tanks with *H. polysperma* (Hp). Histograms represent the mean dry weight (g) (n = 3); error bars are standard deviations.

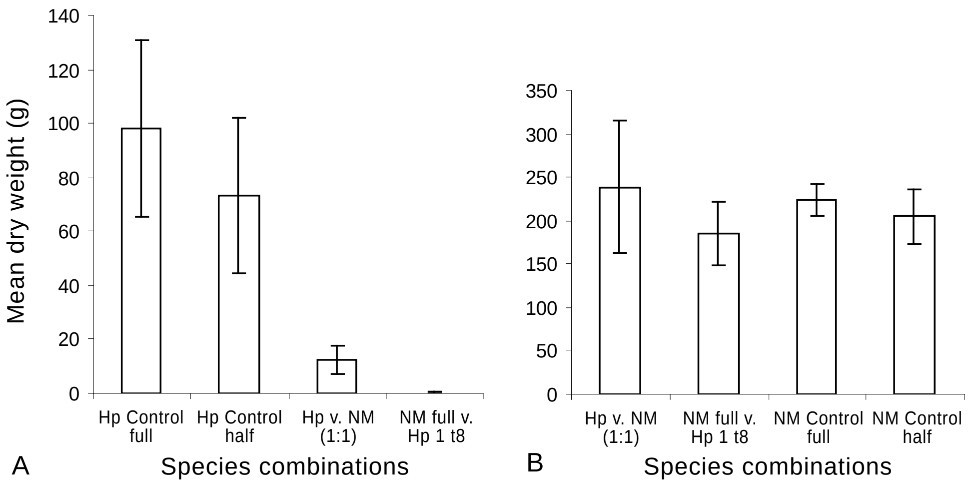

Figure 7. A—*H. polysperma* (Hp) biomass in control and competition tanks with the native macrophyte assemblage (NM). Histograms represent mean dry weight (g) (n = 3); errors bars are standard deviations; t8 indicates planting of Hp 8 weeks later than NM; numbers in parentheses indicate relative plant density in competition tanks other than full or half tank plantings. B—Biomass of native macrophytes (NM) in control and competition tanks with *H. polysperma* (Hp). Histograms represent the mean dry weight (g) (n = 3); error bars are standard deviations; t8 indicates planting of Hp 8 weeks later than NM; numbers in parentheses indicate relative plant density in competition tanks other than full plantings.

Hygrophila polysperma is unlikely to become a nuisance species should it naturalise in New Zealand. This species is invasive as a submerged aquatic in South Florida, where it apparently outcompetes *Hydrilla verticillata* in flowing water (van Djik et al. 1986). Therefore, increased invasiveness could be related to water flow or higher temperatures. Plants grown in New Zealand did not flower, whereas Florida plants flowered and produced abundant seed, apparently being self-fertile (Sutton 1995). Like *Cabomba caroliniana*, *H. polysperma* has been a common aquarium plant in New Zealand for at least 30 years, but no naturalised populations of this plant are known.

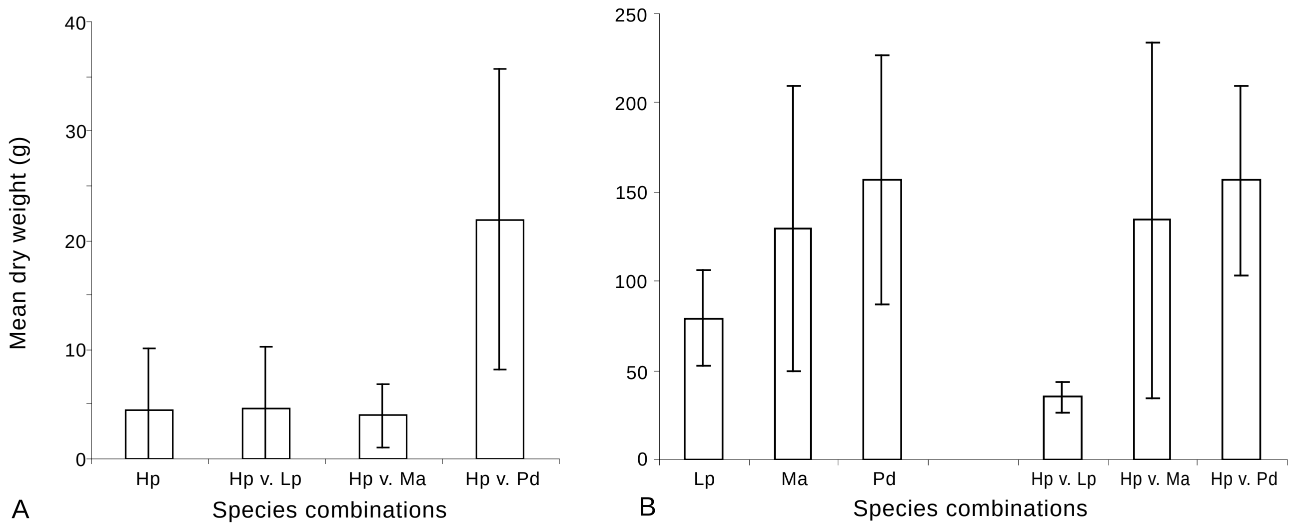

Figure 8. A—*H. polysperma* (Hp) biomass in control and competition tanks with sprawling emergent species *L. palustris* (Lp), *M. aquaticum* (Ma) and *P. decipiens* (Pd). Histograms represent the mean dry weight (g) (*n* = 3); error bars are standard deviations of the total biomass. B—Biomass of sprawling emergent species *L. palustris* (Lp), *M. aquaticum* (Ma) and *P. decipiens* (Pd) in control and competition tanks with *H. polysperma* (Hp). Histograms represent the mean dry weight (g) (*n* = 3); error bars are standard deviations of the total biomass.

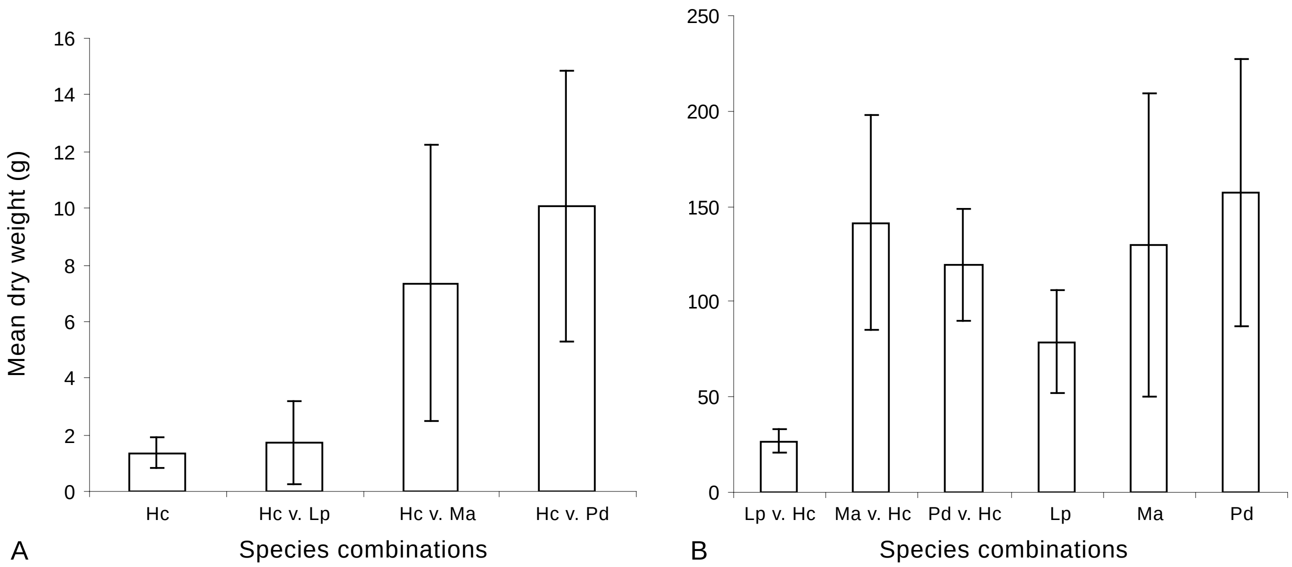

Figure 9. A—*H. verticillata* (Hc) biomass in control and competition tanks with *L. palustris* (Lp), *M. aquaticum* (Ma) and *P. decipiens* (Pd). Histograms represent the mean dry weight (g) (*n* = 3); error bars are standard deviations. B—Biomass of *L. palustris* (Lp), *M. aquaticum* (Ma) and *P. decipiens* (Pd) in control and competition tanks with *H. verticillata* (Hc). Histograms represent the mean dry weight (g) (*n* = 3); error bars are standard deviations.

3.3.3 *Hydrocotyle verticillata*

Hydrocotyle verticillata was variable in its performance during this study, but plants generally grew well, maintaining or increasing area occupied and percentage cover within competition and control tanks. Although flowering occurred in mid- to late-summer, there was no evidence of fertile fruit being produced in these trials.

Hydrocotyle verticillata did not affect the cover of the competitor species. Although *H. verticillata* appeared to grow better in association with the taller *Myriophyllum aquaticum* and *Persicaria decipiens*, it did not reduce the biomass of these species in the trial tanks (Figs 9A and B). However, there is some evidence that *Ludwigia palustris* did not grow as well in association with *H. verticillata* as it did alone (Fig. 9B), although this was not supported by the area occupied by each of the species or the percentage cover (authors pers. obs.).

At the only known field side at Grange Creek, Haumoana, Hawke's Bay (Heenan et al. 2002), this species is slowly expanding in area, growing amongst riparian vegetation and also submerged in shallow marginal areas. Immature fruit were seen at this site, but no evidence of seedlings could be found. This species did not appear to have displaced other species at the site, although it did form pure mats in the bottom of a shaded dry drain (pers. obs).

It is unlikely that hydrocotyle would become a significant weed. Therefore, the banning of this species from commercial propagation, sale and distribution is not advocated.

3.3.4 *Saururus cernuus*

Saururus cernuus grew rapidly in summer, aerial parts senesced over winter with vigorous regrowth the following summer. Flowers were also present in all competition and control tanks during both summer periods, but no seed set was observed.

Saururus cernuus biomass was significantly less in competition tanks with *Eleocharis acuta, Typha orientalis* and *Zizania latifolia* than in control tanks (Fig. 10A). Its growth was not affected by *Ludwigia palustris* (with biomass similar to control) (Fig. 10A). None of the competitors were impacted by *S. cernuus* presence as indicated by biomass (Fig. 10B). Therefore, *S. cernuus* does not seem to be competitive with the native and introduced erect emergent species with which it was trialled.

A dense patch of *S. cernuus* was investigated at a garden in Puhoi, Auckland Region (Champion 2001). Since its original planting, this species had not displaced *Gunnera tinctoria, Cyperus involucratus* or *Zantedeschia aethiopica* where it grew adjacent to them. Within its native range (North America), *S. cernuus* forms dense patches due to its rhizome structure; however, it is threatened in much of its range, and may be replaced by taller woody species or invasive wetland species such as *Lythrum salicaria* and *Phalaris arundinacea* (Batcher 2002). No seed set has been observed in New Zealand, but a small plant of *S. cernuus* was found downstream of the Puhoi garden site, probably as a result of erosion and the water-borne spread of rhizome by a small stream (R. Gribble, Auckland Regional Council, pers. comm.). *Saururus cernuus* was also recently observed by one of the authors (PDC) in a garden at Okarito, West Coast, South Island,

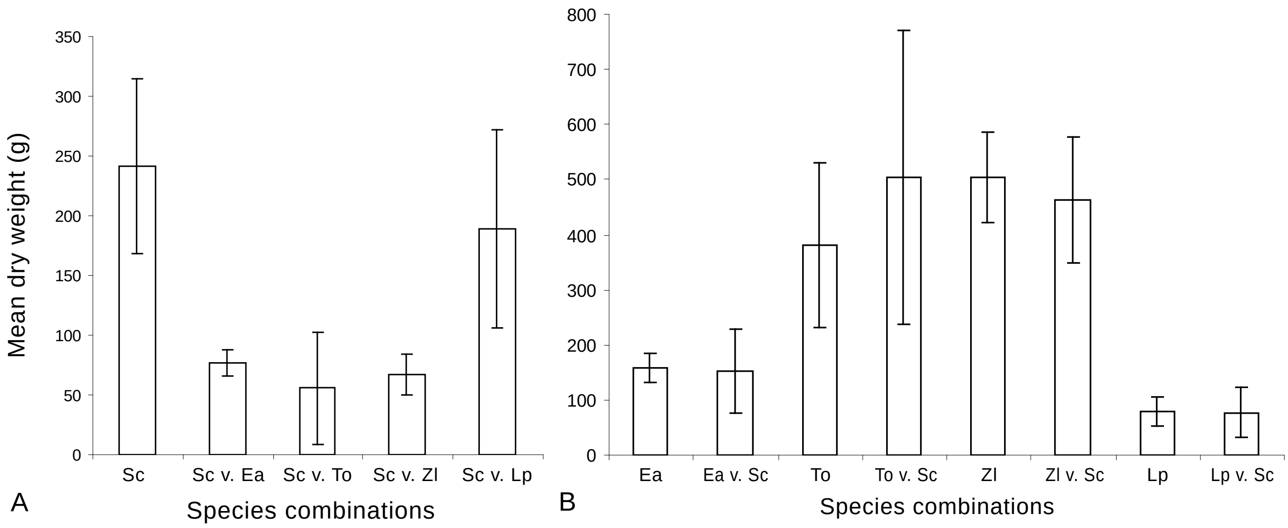

Figure 10. A—*S. cernuus* (Sc) biomass in control and competition tanks with *E. acuta* (Ea), *T. orientalis* (To), *Z. latifolia* (Zl) and *L. palustris* (Lp). Histograms represent the mean dry weight (g) (n = 3); error bars are standard deviations. B—*E. acuta* (Ea), *T. orientalis* (To), *Z. latifolia* (Zl) and *L. palustris* (Lp) biomass in control and competition tanks with *S. cernuus*. Histograms represent the mean dry weight (g) (n = 3); error bars are standard deviations.

which suggests that it could probably grow in lowland areas throughout much of the country. It had not spread outside the garden, but future visits to assess its spread are recommended.

Thus, *S. cernuus* appears to have little potential as a naturalised weed, although the production of a dense rhizome system (around 75% of the plant biomass) is of concern regarding management of this plant.

3.4 RECOMMENDATIONS FOR EXPERIMENTAL EVALUATION OF WEED POTENTIAL

As neither *Hygrophila polysperma*, *Hydrocotyle verticillata*, *Cabomba caroliniana* nor *Saururus cernuus* displaced or significantly reduced the biomass of indigenous or alien plant species, they are not regarded as significant threats to natural ecosystems in New Zealand. Therefore, none of these plants are recommended as candidates for Unwanted Organism status at present.

Further research into the competitive ability of *C. caroliniana* and *H. polysperma* in flowing water, and the ability of *C. caroliniana* to establish from fragments is recommended to enable improved assessment of their weed potential.

Monitoring of field or garden sites where *H. verticillata* and *S. cernuus* occur should continue to assess growth and competitive ability.

4. Recommendations for the determination of Unwanted Organism status for freshwater aquatic plants

4.1 INTRODUCTION

The Chief Technical Officer—Conservation (CTO—Conservation) may declare any species as an Unwanted Organism under the Biosecurity Act (1993), Section 2 (1), which defines these as:

> 'Any organism that a chief technical officer believes is capable or potentially capable of causing unwanted harm to any natural and physical resources or human health; and a) includes any new organism, if the Authority (ERMANZ) has declined to import that organism; and any organism specified in the Second Schedule of the HSNO Act 1996; but b) does not include any organism approved for importation under the HSNO Act 1996 unless the organism is an organism which has escaped from a containment facility; or a CTO, after consulting the Authority and taking into account any comments made by the Authority concerning the organism, believes that the organism is capable or potentially capable of causing unwanted harm to any natural and physical resources or human health.'

DOC has a policy on the determination of Unwanted Organisms (Hicks 2001), in which a minimum of one of the below criteria from each of sections 1 and 2 must be met to determine an organism as unwanted:

1. An Unwanted Organism is an organism that:
   - Is not established in New Zealand
   - Is possibly established in New Zealand (for which there is insufficient information to confirm whether or not it is established)
   - Has been established in New Zealand, but from which a Chief Technical Officer has announced or is shortly to announce that New Zealand is provisionally free
   - Is established in New Zealand and subject to statutory controls or an area of low prevalence can be demonstrated
   - Is established in New Zealand and determination as an Unwanted Organism is required so that powers under the Biosecurity Act can be used in the management of the organism

2. and is capable or potentially capable of forming self-sustaining populations in New Zealand, taking into account the ease of eradication, and:
   - Displacing or reducing any native species or any introduced species for which DOC is responsible
   - Causing the alteration or deterioration of natural habitats
   - Causing adverse effects to New Zealand's indigenous biological diversity
   - Causing disease, being parasitic, or becoming a vector for animal or plant disease affecting indigenous flora and fauna or introduced species for which DOC is responsible

In addition to recommendations for Unwanted Organism status made within DOC, the CTO—Conservation must also evaluate any organisms where they are most likely to impact on conservation values when requested by other government biosecurity agencies or the principal officer of a Regional Council via the Director General of MAF.

Other issues regarding the decision process in the declaration of Unwanted Organisms are summarised below and fully outlined in Hicks (2001):

> 'The definition of organism is applied at the species level. Unless specified otherwise, the declaration that a species is unwanted will apply to all subspecies, hybrids and varieties, etc. For clarity, this should be stated in the application (although this is not required under law). Where there are common impacts from species within a genus, the whole genus may be declared unwanted. In these cases, it is not necessary to specify each species. However, in situations where only certain species from within a genus are included within the declaration, these must be specified individually. The declaration of whole genera as Unwanted Organisms is unlikely to occur unless the impacts are common to many of the species within that genus, or where classification at the genus level is required to avoid uncertainty about whether or not any particular organism falls within the unwanted category.'

Organisms that are established in New Zealand should not be determined to be Unwanted Organisms unless they are subject to statutory controls (e.g. are part of a Pest Management Strategy), or where it can be demonstrated that the distribution of the organism is in a restricted area with low prevalence.

There is no onus for management agencies to control Unwanted Organisms under the Biosecurity Act (1993), but if declared as such, several management actions are facilitated. Under DOC Policy (Hicks 2001), the Department's management of an Unwanted Organism must be seen to be consistent.

Declaring an organism to be unwanted does not directly expose DOC to compensation claims under the Biosecurity Act. However, under some circumstances actions relating to the declaration could be an issue according to Section 162 A of the Act. The ramifications of declaring an organism as unwanted need to be explored legally before such a determination is made.

There are provisions under the Act for exemptions to be sought. Applications detailing the purpose, justification and description of containment facilities are to be evaluated by the CTO.

The declaration of an organism as unwanted may affect other legislation if the organism is covered in that legislation.

Where other CTOs (e.g. MAF and Ministry of Health) are potentially affected by the declaration of an Unwanted Organism, the CTO–Conservation must consult with that CTO in making the declaration. Any disagreement over a proposed declaration will be referred to the Biosecurity Council. The responsibilities of CTOs with regard to the determination of organisms as Unwanted Organisms are outlined in the Policy Statement on Unwanted Organisms for the Purposes of the Biosecurity Act 1993 (www.biosecurity.govt.nz/node/7254 (viewed April 2006)).

An Unwanted Organism may be considered to warrant the status of Notifiable Organism under Section 45 of the Biosecurity Act. Organisms that have recently established or naturalised, or are thought to have been eradicated, and potentially have high impact on indigenous values may be recommended by the CTO–Conservation to the MAF Chief Executive for Notifiable Organism status. Such a declaration is made by an Order in Council on the recommendation of the Minister for Biosecurity. Notifiable Organism status places a duty on any person who becomes aware of the presence of the organism in a new place to notify the CTO.

4.2 THE RATIONALE FOR THE DECLARATION OF POTENTIAL AQUATIC WEEDS AS UNWANTED ORGANISMS

The determination of Unwanted Organism status provides many benefits in the management of aquatic weed species, which are notoriously difficult to control once they establish naturalised populations.

There are two key criteria for the determination of an aquatic plant as an Unwanted Organism:

- The species must be capable of forming self-sustaining populations in New Zealand
- The species must have the potential to cause adverse impacts on indigenous species and communities or introduced species for which DOC is responsible

The vast majority of aquatic species have been intentionally introduced, or are currently traded in other parts of the world as ornamental pond or aquarium plants. Many do not reproduce sexually and would only be dispersed by deliberate or unintentional transfer by human activities. Therefore, the prevention of sale, distribution and propagation (Sections 52 and 53 of the Biosecurity Act) is an effective mechanism to circumvent their dispersal around New Zealand. In 1983, six aquatic weed species were banned from sale and distribution under the Noxious Plant Act (1978), and this has effectively limited their deliberate movement and reduced the number of potential sources for new weed incursions into natural water bodies.

As many potential aquatic weed species are yet to be detected within New Zealand, their determination as Unwanted Organisms effectively signals the weed potential of those species to the agencies policing the importation of plant material.

Publication of information on the identification and recognition of Unwanted Organisms through the National Plant Pest Accord (MAF Biosecurity Authority 2002) will increase the probability of detection of these aquatic plant species prior to their escape and naturalisation. This may also reduce the desirability of such species (which have attractive growth features, such as showy flowers and attractive foliage) to the public, again reducing the number of potential sources for new weed incursions into natural water bodies.

Any new incursion of an Unwanted Organism into an area where the species is not a current plant pest under a Regional or National Plant Pest Management Strategy allows the potential management of that incursion under the powers of Section 100 of the Biosecurity Act. Action may be taken without the need for its inclusion into a Pest Management Strategy, provided that:

- The unwanted organism present in the region could cause serious adverse and unintended effects unless early action is taken, and restrictions on sale, propagation, release and commercial display are not adequate for management.
- The organism can be eradicated or controlled effectively within 3 years, because the distribution of the organism is limited, and practical means to control it are available.
- Control measures are likely to cost less than a sum prescribed by Order in Council by the Governor General ($100,000).
- Control measures are unlikely to result in significant monetary loss to any person (other than someone who has contributed to the presence or spread of the organism).

4.2.1 Evaluation of species capable of forming self-sustaining populations in New Zealand

Species that have indigenous and naturalised ranges solely in tropical habitats are likely to pose a lower risk of naturalising within New Zealand, except within geothermally heated water bodies, which provide suitable water temperatures. Several tropical fish, including guppies (*Poecilia reticulata*) and sailfin mollies (*P. latipinna*), have established following release into natural thermal springs (McDowall 1990).

Examples of species that are major problem weeds in tropical areas but are most unlikely to establish as naturalised populations in New Zealand include *Eichhornia azurea* and *Ottelia alismoides.* A precautionary approach needs to be taken, however, as several species without a weed history in temperate climates have already become problematic here (e.g. water poppy *Hydrocleys nymphoides*, and salvinia *Salvinia molesta*).

Climate models (e.g. CLIMEX; Sutherst & Maywald 1985) offer the possibility of determining potential habitat of a tropical species within New Zealand; however, microclimate variability and the capacity of aquatic habitats to ameliorate temperature extremes are possibly the reason why some tropical species not only establish but also become problematic under New Zealand conditions. The experimental evaluation of cold temperature tolerance should be carried out on a range of other species that may be able to survive in warmer parts of New Zealand, including *Hygrophila polysperma, Cabomba caroliniana* and ambulia (*Limnophila heterophylla*). If this evaluation shows that a species is unable to survive under the range of winter temperatures experienced in the warmest parts of New Zealand, its evaluation should not proceed, as the species does not meet the criteria for determining an Unwanted Organism (section 4.1.2).

4.2.2 Potential of a species to cause adverse impacts on indigenous species and communities or introduced species for which DOC is responsible

Arguably, any aquatic plant (indeed any organism) that has naturalised within New Zealand has already, in some way, adversely impacted on some part of our indigenous ecosystems through:

- Displacement of what was previously present at the site of its naturalisation
- Modification of food-webs built around what has been displaced
- Competition for resources that would have been available for indigenous species

Clearly, not all introduced species would warrant Unwanted Organism status and it would be unacceptable to most people to attempt this. Determination of an Unwanted Organism will be dependent on what benefit would be achieved by providing access to Biosecurity Act powers in terms of enhancing management. Therefore, an attempt to define the significance of any adverse impact must be made.

Species that have been eradicated from New Zealand, including where eradication was initiated and achieved under previous legislation, automatically qualify for Unwanted Organism status under the current policy statement (Hicks 2001) because they are regarded as New Organisms under the HSNO Act (1996).

4.3 USING THE AQUATIC WEED RISK ASSESSMENT MODEL TO DETERMINE AQUATIC PLANTS AS UNWANTED ORGANISMS

The Aquatic Weed Risk Assessment Model (AWRM) provides a mechanism to compare the potential/actual impact of various aquatic weed species in New Zealand and is a useful tool for the determination of Unwanted Organisms (Champion & Clayton 2000). Species scoring greater than 50 in AWRAM have a high weed potential, those scoring 40–50 have a moderate weed potential, and those scoring < 40 have a low potential. Examples of each group are shown in Table 1.

TABLE 1. RANKING OF VARIOUS AQUATIC PLANTS USING THE AQUATIC WEED RISK ASSESSMENT MODEL (AWRAM) (CHAMPION & CLAYTON 2000).

HIGH (> 50)	MEDIUM (40–50)	LOW (< 40)
[4]*Phragmites australis* (75)	[6]*Apium nodiflorum* (50)	[6]*Spirodela punctata* (39)
[4]*Hydrilla verticillata* (74)	[4]*Sagittaria montevidensis* (46)	[3]*Saururuscernuus* (36)
[1]*Myriophyllum spicatum* (69)	[4]*Nymphoides geminata* (46)	[6]*Nymphaea alba* (33)
[6]*Azolla pinnata* (54)	[6]*Elodea canadensis* (46)	[6]*Ottelia ovalifolia* (28)
[5]*Iris pseudacorus* (52)	[2]*Pistia stratiotes* (42)	[1]*Regnellidium diphyllum* (20)

Status of the plants is indicated as follows:

[1] Not known to be present in New Zealand.
[2] Formerly present in New Zealand but thought to have been eradicated.
[3] Currently known to be cultivated but not naturalised.
[4] Sparingly naturalised, where there is potential for eradication.
[5] Well-naturalised; some regionally co-ordinated control programmes.
[6] Well-naturalised; uncontrolled or rarely managed.

Scores in excess of 40 in AWRAM can be used as a guideline to prevent the importation of aquatic plants into New Zealand. Surveillance of possible sightings within this country are enhanced by Unwanted Organism status.

Once a species is already present within New Zealand, additional factors relating to the implications of Unwanted Organism status should be taken into account. For example, the determination of Unwanted Organism status for a species that is widespread, distributed by natural agents such as wildlife or wind, and to which control/eradication methods are lacking, would achieve little (apart from public education), no matter what impact that species has on the natural environment. In such cases, the species should not be determined as an Unwanted Organism.

The following characteristics of aquatic plant species influence the level at which the AWRAM ranking will influence their potential determination as Unwanted Organisms:

- Abundance in New Zealand
- Appeal as an ornamental pond or aquarium plant
- Method of dispersal
- Ease of control

These characteristics are all considered as part of the AWRAM; however, their importance in the determination of Unwanted Organisms warrants additional consideration.

4.3.1 Abundance in New Zealand

The lower the incidence of a potential weed species within New Zealand, the greater the potential gain from it being designated as an Unwanted Organism, through prevention of further spread (stopping sale, distribution and propagation) and active (regional or national) management. Low incidence plants with AWRAM rankings of > 40 should be considered for Unwanted Organisms status.

4.3.2 Appeal as an ornamental pond or aquarium plant

Species currently cultivated and dispersed within aquarium/ornamental pond trade/hobby groups have greater potential to establish, as they are potentially distributed throughout the country in large numbers; in contrast, species of limited distribution that are not cultivated have a much lower dispersal potential. The rationale for their designation as Unwanted Organisms is the same as outlined in section 4.3.1.

4.3.3 Method of dispersal

Species that are potentially dispersed by natural agents pose the greatest threat. For example, fringed water lily (*Nymphoides peltata*) produces seeds in New Zealand and these are adapted for spread by mallard (*Anas platyrhynchos*) and other duck species. This species has been intensively managed at all known sites. In this case, Unwanted Organism status should be afforded to species with an AWRAM ranking > 40. However, if a species becomes naturalised and has begun to be spread by natural agents, then Unwanted Organism status provides little benefit, even if the species is highly ranked. Conversely, a species that is well established in some areas but is only dispersed by deliberate or accidental human introduction would benefit from Unwanted Organism classification (based on an AWRAM ranking of > 50 if accidentally transferred, > 40 if solely deliberately transferred).

4.3.4 Ease of control

Control or eradication of aquatic plant species is dependent on several factors, including ease of detection, ease of access to the plant, available control/ eradication techniques, and acceptability of control methods to the community. As with method of dispersal, the more difficult control is, the higher the priority to stop a species establishing; therefore, Unwanted Organism status should be given to those species with an AWRAM score > 40. However, once a plant is widely established, the benefit of Unwanted Organism designation would significantly decrease.

4.4 RECOMMENDATIONS FOR DETERMINATION OF UNWANTED ORGANISM STATUS FOR FRESHWATER AQUATIC PLANTS

The following process is recommended to determine which non-indigenous aquatic plants should be determined as Unwanted Organisms:

Step 1 Determine whether the plant can survive and establish under New Zealand climatic conditions. This potentially could be determined by culturing the plant under the range of water temperatures experienced in New Zealand. If it can, proceed with these further evaluation steps.

Step 2 Undertake AWRAM (Champion & Clayton 2000) evaluation.

Step 3 If AWRAM score is > 50, confer Unwanted Organism status, unless the plant is already naturalised within New Zealand and is:

- Not kept in ornamental ponds and aquaria
- Common throughout its potential range
- Distributed by natural agents such as wildlife or wind
- Unable to be controlled by currently available methods

If a species meets these criteria (e.g. *Azolla pinnata*), Unwanted Organism status would not serve any purpose, regardless of the species' potential weed impact, as it cannot be managed effectively.

Step 4 If AWRAM score is between 40 and 50, confer Unwanted Organism status if the plant meets one of the following criteria:

- Not currently verified as present in New Zealand
- Of low incidence and either potentially distributed by natural dispersal agents or difficult to control
- Not yet naturalised but distributed as an aquarium/ornamental pond plant
- Only dispersed by deliberate human activity

4.5 REVIEW OF UNWANTED ORGANISM DESIGNATION

Often the information available on the biology, ecology, weedy tendencies and distribution details of a newly naturalised aquatic plant or species assessed for importation is either lacking or limited, so that the assessment for Unwanted Organism status is only based on information available at that time. Therefore, it is important to have regular reviews of species that have been either accepted or rejected for Unwanted Organism status, based on further information about plant distribution and/or weed impact that may change any of the parameters outlined in Steps 1–5 above, or that may increase the precision of the AWRAM evaluation. Where necessary, research should be undertaken to provide further information on relevant aspects of a species.

A review every 5 years should keep the list of Unwanted Organisms current and relevant to changing levels of abundance and increased available information.

5. Review of Import Health Standards for freshwater aquatic plants

5.1 INTRODUCTION

Pathways for the introduction of aquatic plants to New Zealand were discussed by Champion & Clayton (2000), and included natural vectors such as migratory waterfowl, deliberate introduction for a range of purposes, the most common being as ornamental plants for aquaria or outdoor ponds, and a number of accidental pathways, including transport in contaminated drainage machinery, crates and potentially shipping containers. For freshwater organisms, transfer across oceans requires transport across inhospitable environments, during which they may be exposed to a variety of harsh conditions, e.g. removal from water for prolonged periods, high salinity or perhaps extremes of temperature as a ship sails through tropical regions. The longer such adverse conditions persist, the lower the probability of survival. Consequently, the likelihood of a particular organism being transferred tends to decline with increasing distance from a potential source population. Given the geographic isolation of New Zealand, it is perhaps not surprising to find that the majority of freshwater alien species present were introduced deliberately (Closs et al. 2004). It is unlikely that accidental pathways not associated with the aquarium/ornamental pond trade will provide a significant source of new aquatic weed threats to New Zealand.

Not only is the indigenous biota of New Zealand endangered by the introduction of alien aquatic weeds, but the potential for hitch-hikers (pest animals and diseases) to enter the country attached to imported plants poses an additional risk. MAF regulates the importation of risk goods, including aquatic plant propagules, through Import Health Standards (IHS), which outline steps including Post Entry Quarantine (PEQ) conditions required to import and manage the risks of contamination of imports with potential pest species once introduced into New Zealand. This report reviews IHS, identifies deficiencies in the current system and provides recommendations for improved import procedures.

5.2 IMPORTATION OF AQUATIC PLANTS

Only plant species listed on the MAF Biosecurity Authority Plants Biosecurity Index, which is provided as a search engine on the website www.maf.govt.nz/cgi-bin/bioindex/bioindex.p1 (viewed April 2006), are allowed entry into New Zealand. This site also lists import specifications for both nursery stock and seed for sowing. This index lists species that have been evaluated by the MAF weed risk assessment model prior to 1998 or subsequently by Environmental Risk Management Authority (ERMANZ) (discussed in Champion & Clayton 2000). The specifications that importers are required to meet for seed or nursery stock plant imports are listed in the respective IHS.

If the plant species is not included on the Plants Biosecurity Index, there is a requirement to determine whether the species is already present in New Zealand. The importer has to apply to ERMANZ, providing evidence of its presence in New Zealand prior to the instigation of the Plants Biosecurity Index in July 1998. If this is proven, pursuant to Section 26 of the HSNO Act (1996), ERMANZ declares that the candidate organism is not a new organism through a New Zealand Gazette Notice.

If the species is not found to be present in New Zealand, it will require evaluation through ERMANZ to determine its safety and suitability for entry. As reported in Champion & Clayton (2001), no aquarium or pond plant species have been evaluated by this process since July 1998.

To illustrate the importation process, the generic names of several aquatic plants commonly sold within the aquarium trade (taken from the Tropica Aquarium Catalogue (2000)) were entered into the Plants Biosecurity Index (www.maf.govt.nz/cgi-bin/bioindex/bioindex.p1 (viewed April 2006)), that lists the current relevant specifications for aquatic plant species (Table 2). The import specifications listed in this table are discussed in section 5.3 of this report. Where a plant is listed as 'Requires Assessment', a new standard for importation and PEQ conditions is needed for that species.

5.3 IMPORT HEALTH STANDARDS

Import Health Standards (IHS) specify the requirements to be met for the effective management of risks associated with the importation of risk goods (in this case aquatic plants) before those goods can be imported, moved from a biosecurity control area or a transitional facility, or given a biosecurity clearance.

New Zealand IHS are based upon risk analyses, which assess either a commodity or a pest/pathway combination. New Zealand's legislative requirements and international obligations are taken into account when applying the findings of risk analysis to the development of IHS. Import Health Standards for plants and plant products imported into New Zealand are a requirement under the Biosecurity Act 1993; all plants and plant products are prohibited entry into New Zealand unless an IHS has been issued in accordance with the Act. IHS for plants and plant products are made available for public access on the MAF website: www.biosecurity.govt.nz/commercial-imports/plant-imports/relevant-import-health-standards-and-application (viewed April 2006).

TABLE 2. TEN RESULTS OF A SEARCH OF AQUATIC PLANT GENERA (TAKEN FROM THOSE LISTED IN THE TROPICA AQUARIUM CATALOGUE (2000)) USING THE MAF BIOSECURITY AUTHORITY PLANTS BIOSECURITY INDEX[1]. IMPORT SPECIFICATIONS FOR SEED FOR SOWING AND NURSERY STOCK ARE DEFINED IN SECTIONS 4.3.1 AND 4.3.2 RESPECTIVELY.

SCIENTIFIC NAME	IMPORT SPECIFICATION: SEED FOR SOWING	IMPORT SPECIFICATION: NURSERY STOCK
Acorus calamus	Basic	Requires assessment
Acorus gramineus	Basic	Requires assessment
Alternanthera ficoidea	Basic	L2 (Basic)
Alternanthera philoxeroides	Unwanted import, but no action taken as it was a contaminant	Entry prohibited
Alternanthera roseacefolia	Basic	L2 (Basic)
Alternanthera sessilis	Basic	L2 (Basic)
Anubias afzeli	Basic	L2 see 155.02.06 under *Anubias*
Anubias barteri	Basic	L2 see 155.02.06 under *Anubias*
Anubias gigantea	Basic	L2 see 155.02.06 under *Anubias*
Sagittaria latifolia	Entry prohibited	Entry prohibited

[1] www.maf.govt.nz/cgi-bin/bioindex/bioindex.p1 (viewed April 2006).

Currently, there are no species-specific IHS developed for any aquatic plants.

Importation of plant material into New Zealand is governed either by the Nursery Stock IHS or the Seed for Sowing IHS, both of which are currently under review (Christine Reed, Manager, Indigenous Flora and Fauna team, MAF, pers. comm. 19 June 2003).

The current standards are available on the MAF Biosecurity website: www.biosecurity.govt.nz/files/imports/plants/standards/155-02-05.pdf (viewed April 2006) for importation of seed for sowing, and www.biosecurity.govt.nz/files/imports/plants/standards/155-02-06.pdf (viewed April 2006) for importation of nursery stock.

The following sections outline some general requirements for importation under the Seed for Sowing and Nursery Stock IHS.

5.3.1 Seed for sowing

No aquatic plants are currently imported as seed. However, this is a potential pathway of introduction for a number of species. Import Health Standards for most aquatic species listed in Table 2 are basic.

For seed imports, **basic** conditions require that seed be:

- In clean, new packages
- Clearly labelled with botanical name to species level
- Either with a phytosanitary certificate issued by the country of origin, or sampled by MAF and inspected by MAF Quarantine Service
- Either accompanied by a Seed Analysis Certificate, or sent to a MAF-approved seed testing laboratory for analysis for weed seeds and other contaminants

No seed lot will be released for sowing in New Zealand if it contains any of the following:

- Seed not clearly identified as above

- Regulated pests
- An excess of 0.1% by weight of soil particles
- Contaminant weed seeds, as listed on Schedule 1.5.2 of the IHS
- Other seeds above the Maximum Pest Limit of 0.01% using international seed sampling standards

Other aquatic species were either **prohibited** (being listed on Schedule 1.5.2), or listed as 'unwanted import—but no action taken as contaminant'. These species are all Unwanted Organisms listed in the MAF Pest Plant Accord on the website www.biosecurity.govt.nz/pests-diseases/plants/accord.htm (viewed October 2006).

5.3.2 Nursery stock

Most aquatic plants are imported under the Nursery Stock IHS, and many are classified under the basic import condition Level 2 (L2) standards.

There are four levels of post entry quarantine (PEQ) facilities, depending on the level of threat posed by the aquatic plant's associated pests. The four levels of PEQ range from open-ground sites (L1) to much higher levels of security, e.g. filtered air ducts and foot baths with disinfectant (L4).

Level 2 (L2) standards for import

Basic L2 standards require that plant material be:

- As budsticks or scionwood, cuttings without roots, whole plants (including rooted cuttings), or as dormant bulbs, corms, rhizomes or tubers
- Accompanied by a species-specific import permit
- Clearly labelled with its scientific name (genus and species)
- Packaged in inert/synthetic materials (no soil contaminants)
- Accompanied by a phytosanitary certificate from the country of origin with appropriate required declarations (e.g. insecticide treatment)
- Kept in PEQ for a minimum of 3 months

PEQ facility specifications are outlined on the website www.biosecurity.govt.nz/border/transitional-facilities/plants/pbc-nz-tra-pqcon.htm (viewed April 2006).

A L2 quarantine facility is designed for the containment of plant material that may be infested/infected with pests that cannot be detected by visual inspection at the port of entry.

Additional L2 quarantine containment requirements for aquarium plants (referred to in the IHS as L2 see 155.02.06 under *Anubias*) include the following:

- The aquarium must be kept in a watertight tray, sitting in a tray of 5 ppm copper sulphate solution. This would kill any organisms crawling out of the containment area (e.g. snails or worms).
- The aquarium must be kept 5 m away from the nearest non-quarantine aquarium.
- The aquarium must be kept inside a building that can be secured.

L2 quarantine containment requires that the glasshouse/screenhouse must be operated and constructed in a way to contain in isolation the quarantined material and associated pests as follows:

- The structure shall be completely enclosed in glass, polythene, or other continuous material except for the entry/exit and ventilation requirements. The requirement for plastic-film cladding is a minimum of 200 μm thick (heavy duty) polyfilm.

- All windows, louvres or vents shall be effectively screened with insect-proof mesh with a maximum aperture of 0.6 mm or a 30 × 30 (holes per sq. inch) mesh.
- The vents and doors shall be tight-fitting and constructed of a material that shall maintain rigidity at all times.
- The structure shall have a concrete floor, be strong enough to withstand the normal range of weather conditions and not be subject to flooding.
- The structure shall have an insect-proof anteroom or porch with a double door for entry/exit. There must be sufficient space to permit the entry of people and planting material whilst one door remains closed at all times.
- A gully or soil trap connected to sewage, septic tank or a suitable rubble drain shall be used. The quarantine operator shall ensure that all material released into the sewage or waste-water system is in compliance with local or regional by-laws/regulations.
- A foot bath utilising an effective disinfectant shall be used.
- Appropriate plant hygiene measures (e.g. disinfection of cutting tools) shall be maintained at all times.
- The facility shall be maintained free of weeds, lichen and moss.
- Yellow sticky insect traps shall be appropriately installed in each quarantine house at a minimum rate of one per 15 m^2 of planted area and replaced for every new consignment after inspection by the Supervisor.
- All plants must be grown in sterilised or inert media and be easily accessible for inspection by the Supervisor.
- During the quarantine period, the quarantine facility shall only be used for the registered purpose.
- The quarantine facility shall have a prominent sign labelled 'level 2 quarantine facility', 'access restricted to authorised personnel only' and the MAF Registration number and name of the quarantine operator.

All L2 facilities shall be inspected at least three times during the first 3 months of quarantine by a suitably qualified Supervisor appointed under the Biosecurity Act (1993). All inspectors undertaking inspection of plants and plant products shall have suitable, documented training and be approved for the task. Regular competency checks are to form part of the training. (e.g. the inspector must be capable of finding evidence of hard-to-detect organisms, such as thrips (Thysanoptera), scale insects and mealy bugs (Coccoidea), mites (Acarina), fungi and bacteria).

Imported material within L2 facilities is inspected using a 10× hand lens. Should pests or pest symptoms be found, samples shall be taken and sent to a MAF-registered plant-pest diagnostic facility.

Inspection at the port of entry includes inspection of documentation and inspection of a randomly selected 600-unit (minimum) sample (achieving a 95% level of confidence that a Maximum Pest Limit of 0.5% infected units per consignment would be found at this sample level). Designation of contaminant pests is discussed in section 5.3.3 of this report.

MAF requirements for border inspection quality management and administration are outlined on the website www.biosecurity.govt.nz/border/inspection-services/152-01-02s.htm (viewed April 2006).

Where a facility no longer meets Biosecurity New Zealand's requirements, the operator is to be advised in writing that the facility is no longer approved, and uncleared goods are not to be directed/permitted to go to that facility.

In the case of tissue-cultured plants, there is no requirement for PEQ provided that imported material meets other phytosanitary requirements.

For aquarium plants, the IHS L2 standard has additional requirements:

- The designation of quarantine pest snails, snail eggs, worms and leeches and the declaration that none of these organisms were found in a 600-unit inspection of the consignment prior to export.
- The minimum PEQ of one growing season (cf. 3 months for basic L2 requirements).
- The aquarium used must be clear-sided and labelled as 'Quarantine Aquarium' with the MAF registration number and name of the quarantine operator.

There is currently no species-specific IHS developed for any aquatic plants. MAF indicated that a review of IHS requirements for aquarium plants was unlikely in the near future (L. Beaven, Technical Adviser, Import Health Standards, MAF pers. comm.).

5.3.3 Categorisation of contaminant organisms

The designation of contaminant organisms associated with plant imports was formerly placed into one of six quarantine categories, which still appear in any IHS that have yet to be revised (as is the case for nursery stock).

Quarantine Risk Group 1: A quarantine pest which, if introduced into New Zealand, has the potential to cause unacceptable economic impacts on the production of [a] commodity/commodities and/or on the environment.

Quarantine Risk Group 2: A quarantine pest which, if introduced into New Zealand, would cause a major disruption to market access and/or significant economic impacts on the production of a particular commodity/commodities, and for which some other importing countries require specific pre-export phytosanitary treatments.

Quarantine Risk Group 3: A quarantine pest which, if introduced into New Zealand, would cause major disruption to market access for a wide range of New Zealand commodities and/or significant economic effects on their production, and for which some other importing countries impose stringent phytosanitary measures, including prohibiting the entry of the host commodity.

Regulated non-plant pests: A pest (including a parasite or predator), which is not a pest of plants but may be associated with plants or plant products and is of concern to human or animal health.

Non-regulated non-quarantine pests: A non-quarantine pest, which is not regulated and has no potential to vector a regulated pest into New Zealand.

Non-regulated non-plant pests: A pest that is not a quarantine pest for an area.

This designation has now been simplified to two quarantine categories: regulated or non-regulated organisms. All regulated pests are placed on the Unwanted Organisms Register (UOR) found on the website www.biosecurity.govt.nz/commercial imports/unwanted-organisms-register (viewed April 2006).

There are currently over 15 000 regulated pests of plant species on the UOR.

Non-regulated organisms are either already present in New Zealand and not under any official control programme or are not of any concern to MAF or any other government department.

5.4 IMPORT RISK ANALYSIS

All new IHS are developed using import risk analyses as outlined on the website www.biosecurity.govt.nz/pests-diseases/risk-policy.htm (viewed April 2006) and by applying a precautionary approach to managing biosecurity risks associated with importation of risk goods, as outlined on www.biosecurity.govt.nz/publications/biosecurity-magazine/biosecurity-26.pdf (viewed April 2006).

The import risk analyses process includes the following four steps:

- Identify all organisms that may cause unwanted harm
- Assess the likelihood that these may be introduced into New Zealand, and the predicted impacts of the organism on people, the environment and the economy
- Identify appropriate measures to manage the risks posed by these organisms
- Communicate the results, conclusions and recommendations to all interested parties

The development of all plant IHS must adhere to international guidelines under the International Plant Protection Convention (IPPC) for the International Standards for Phytosanitary Measures (ISPM) (http://193.43.36.94/servlet/CDSServlet?status=ND0xMzM50SY3PWVuJjY1PWtvcw (viewed April 2006)).

The IPPC is an international treaty for plant protection to which 120 governments (including New Zealand) currently adhere. The Convention has been deposited with the Director-General of the Food and Agriculture Organization of the United Nations (FAO), since it was first adopted by the FAO Conference in 1951. The IPPC came into force in 1952 and has been amended twice: in 1979 and 1997. The revision of the IPPC that was approved in 1997 reflects contemporary phytosanitary concepts and the role of the IPPC in relation to the Uruguay Round Agreements of the World Trade Organization (WTO), particularly the Agreement on the Application of Sanitary and Phytosanitary Measures (the SPS Agreement). The SPS Agreement identifies the IPPC as the organisation providing international standards for measures implemented by governments to protect their plant resources from harmful pests through phytosanitary measures. The IPPC complements the SPS Agreement by providing the international standards that help to ensure that phytosanitary measures have a scientific basis for their placement and strength and are not used as unjustified barriers to international trade.

The impacts of the SPS Agreement are outlined on the website www.biosecurity.govt.nz/strategy-and-consultation/sps/agreement/provisions.htm (viewed April 2006).

5.5 INTERPRETATION OF SPS AGREEMENT AND POSSIBLE RISKS TO THE NEW ZEALAND ENVIRONMENT

Although there are more than 15 000 regulated pests of plants placed on the UOR, more often than not the environmental impact of organisms associated with plant imports is unknown; therefore, adding the condition that an organism may cause unwanted harm is limited in its usefulness.

Section 2.2 of the SPS Agreement states the following:

> 'Members shall ensure that any sanitary or phytosanitary measure is applied only to the extent necessary to protect human, animal or plant life or health, is based on scientific principles and is not maintained without sufficient scientific evidence, except as provided for in paragraph 7 of Article 5.'

Section 5.7 states:

> 'In cases where relevant scientific evidence is insufficient, a Member may provisionally adopt sanitary or phytosanitary measures on the basis of available pertinent information, including that from the relevant international organizations as well as from sanitary or phytosanitary measures applied by other Members. In such circumstances, Members shall seek to obtain the additional information necessary for a more objective assessment of risk and review the sanitary or phytosanitary measure accordingly within a reasonable period of time.
>
> 'A WTO member is allowed to provisionally adopt an SPS measure if the measure is imposed in respect of a situation where "relevant scientific evidence is insufficient"; and the measure is adopted "on the basis of available pertinent information" (so there still has to be real evidence of risk).'

If a WTO member does this, there are two obligations: they must 'seek to obtain the additional information necessary for a more objective assessment of the risk' (i.e. must look for the information necessary), and 'review the sanitary or phytosanitary measure within a reasonable period of time' (to be determined on a case-by-case basis).

The Ministry of Agriculture and Forestry follows a policy that requires robust 'technical information' of a pest's impacts before management measures can be put in place as outlined in the SPS Agreement. Often there is insufficient literature on a new organism's potential impact, and without this the restriction cannot be put in place. Should the organism establish and form pest populations within New Zealand, it could be controlled under other provisions of the Biosecurity Act. However, if an organism is known to be associated with a commodity, measures should be put in place to prevent contamination because, under HSNO, it is illegal to import new organisms (knowingly) without ERMANZ approval.

The precautionary approach advocated by DOC is to treat any new organism with unknown impact as a regulated pest and therefore actionable.

The interests of maintenance of international trade and protection of indigenous ecosystems are difficult to reconcile. It is acknowledged that no system will keep out all potential pest and disease species, but effective, practical and robust border processes are sought.

5.6 COMPARISON WITH OTHER COUNTRIES

In addition to the IPPC treaty (section 5.4), Canada and the USA have the additional requirement that aquarium plants are bare rooted, and do not allow any growing media, e.g. rock wool, to be imported in association with plant material (www.inspection.gc.ca/english/plaveg/internate (viewed April 2006).

The Canadian Food Inspection Agencies (CFIA) has recently (December 2001) changed its position concerning the control of aquatic plants, and has cancelled the restrictions and prohibition on the importation of aquatic plants, which had been in place since at least the early 1980s. This decision has been justified as follows:

- Some of the aquatic plants that are or may be imported into Canada do not fall under the definition of 'pest' under the Plant Protection Act
- The lack of scientific capacity does not allow the Agency to adequately evaluate environmental and plant-pest risks associated with aquatic plants
- The lack of an interdepartmental policy

The CFIA has revoked Directive-94-27 and, consequently, no longer regulates the importation and movement of any aquatic plants in Canada (www.inspection.gc.ca/english/plaveg/protect/dir/d-94-27-2e.shtml) (viewed April 2006). Any aquatic plant may now be imported into Canada provided it has an import permit and Phytosanitary Certificate.

5.7 STATUS OF AQUARIUM-PLANT PESTS IN NEW ZEALAND

Slocum et al. (1996) identified pests of aquatic plants in the Northern Hemisphere; this source was used to ascertain the status of known aquatic species in New Zealand. NIWA queried the existence of records of these pest species in the Plant Pest Information Network (PPIN), which is administered by MAF, and also sought other sources of information on introduced pests present in New Zealand. Apart from the waterlily aphid (*Rhopalosiphum nymphaeae*), which has the fruit trees of the genus *Prunus* as alternative hosts, there were no records of other insects and snails occurring in New Zealand as pests of aquatic plants (Slocumet al. 1996). George Gill (Senior Advisor, Surveillance and Incursion Response, Biosecurity New Zealand, suggested the New Zealand Arthropod Collection at Tamaki, the Auckland War Memorial Museum and the Otago Museum as additional sources of information for insects occurring in New Zealand.

Brian Smith (NIWA Hamilton) has identified nine species of alien snail currently distributed in the aquarium trade: *Lymnaea auricularia, L. stagnalis, L. truncatula, Melanoides tuberculata, Physa acuta, Pseudosuccinea columella, Planorbarius corneus, Pomacea bridgesi* and *P. canaliculata*. All except the two *Pomacea* spp. are naturalised, although some have very restricted ranges (Champion et al. 2004).

5.8 AQUATIC PLANTS AS CONTAMINANTS OF OTHER IMPORTED FRESHWATER ORGANISMS OR AQUARIUM MATERIALS

There is a possibility that the importation of tropical fish or other freshwater aquarium organisms or materials could provide a pathway for the import of potential aquatic weeds. The importation of ornamental fish and invertebrates is subject to similar conditions to the importation of plants under the IHS for the importation into New Zealand of ornamental fish and marine invertebrates from all countries, as outlined on the website www.biosecurity.govt.nz/imports/animals/standards/fisornic.all.htm (viewed April 2006).

Under this standard, the following sections are relevant to the management of possible contaminant plants:

- During unloading, the water in the containers shall be treated with a chlorine-based disinfectant as described in the MAF Biosecurity Authority Standard 154.02.06: Transitional facilities for ornamental fish and marine invertebrates
- Any plants and the containers themselves are to be incinerated or similarly treated with chlorine-based disinfectant

The ornamental fish and marine invertebrates must be held in the facility named in the permit to import for a quarantine period of not less than 6 weeks in the case of freshwater fish or 3 weeks in the case of marine fish and marine invertebrates. Any contaminant plants in water associated with the fish or any plant propagule (e.g. seeds or spores) ingested by an imported fish would be voided from the fish within the 6-week quarantine timeframe, and the water containing the fish would be treated with a chlorine-based disinfectant and/or incinerated, which would be sufficient to kill any plant propagule.

Provided the quarantine procedures outlined in the IHS are adhered to, there is minimal risk of aquatic plants establishing in New Zealand as a result of this pathway.

5.9 ASSESSMENT OF BORDER CONTROL FOR IMPORTED AQUATIC PLANTS

The current approach of using IHS to manage aquatic plant imports provides an adequate framework for the detection of any associated pest or disease organisms associated with imported plants and of hitchhiker organisms that are not directly dependent on the imported plant. International standards for phytosanitary measures administered by the United Nations Food and Agriculture Organisation are met by this New Zealand approach.

A new approach adopted by MAF, using risk-analysis techniques to determine IHS, is also good, provided that any unknown or unlisted organism is treated as a regulated organism until its status is determined. Should the organism be identified as an established organism within New Zealand that is not under any official control programme, the organism would be regarded as non-regulated. If the status of the organism is unknown in New Zealand, it would require evaluation through Section 26 of the HSNO Act (1996), while new imports are considered under Sections 34 to 45 of this act.

The risks relating to aquatic plant imports would vary depending on the source of the plant. The highest risk is posed by plants harvested in the wild, followed by plants grown outside in soil, especially where the propagule is a difficult structure to disinfect (e.g. waterlily (*Nymphaea* spp.) tubers). Currently, the majority of imports are plants grown hydroponically under glasshouse conditions, which pose a very low risk. The lowest risk is posed by tissue-culture material, which has virtually a zero risk of contamination. Evaluation of the plant source and risk profiling of these imported aquatic plant propagules would undoubtedly lead to a reduction in the PEQ measures required for many species, but may be far more stringent where a higher perceived risk of regulated pest contaminants occurs. The current inflexibility of import standards for aquatic plants is a major concern of plant importers.

The lack of readily available information on alien pests and diseases that are not associated with commercially important produce is a concern. An attempt to generate a checklist of species that threaten indigenous biota (perhaps aligned with Plant Pest Information Network) would be a first step to defining which species are already present within New Zealand, providing a useful assessment tool for future import risk analyses.

In addition to the threats posed by unwanted hitchhikers on imported aquarium plants, there are two other issues relating to aquarium plant imports:

- Firstly, it is noted that not all inspectors are suitably qualified to identify plants. While supervisors are competent to check for contaminant organisms, they may not have the necessary botanical training to accurately identify imported plants; thus, plant identification is often based on the importers'/exporters' integrity. This was identified in Champion & Clayton (2000) and is a source of concern frequently aired by importers of aquatic plants. The necessity for inspectors to be able to identify plants is further emphasised in a recent study by Maki & Galatowitsch (2004), who investigated the contents of aquatic plant shipments in Minnesota. They found that 93% of all shipments contained contaminant plants or animals, including prohibited plants; in 18% of shipments, plants had been misidentified. These findings are similar to those presented in Champion & Clayton (2000) regarding mislabelling and the ease with which plants can be illegally transported through the aquarium trade.
- Secondly, no new aquatic plants are entering New Zealand through the ERMANZ-administered evaluation system due to the requirement for full cost recovery and a lack of commercial protection for this investment afforded by the HSNO Act (1996). Champion & Clayton (2001) discuss the likely scale of illegal imports and the fact that this offers the potential for further pest plants and any associated contaminant organisms to enter New Zealand through smuggling.

5.10 RECOMMENDATIONS FOR BORDER CONTROL FOR IMPORTED AQUATIC PLANTS

- Debate the implications of the SPS Agreement for designation of regulated organisms where there is insufficient information about impacts to our natural environment. Documentation of newly established pests and the likelihood of their entry as contaminant organisms would be required to justify New Zealand adopting phytosanitary measures as covered in Section 2.2 of the SPS Agreement.
- Review current standards for aquatic plant imports to New Zealand by classifying imported plant material into different risk categories; design appropriate IHS for each risk category.
- Construct a database of all introduced pest species reported to impact on indigenous flora and fauna (along the lines of the PPIN), initially through

existing collections held in various institutions within New Zealand (see section 5.7). This is seen as critical for the future determination and recognition of Regulated Organisms.
- Review protocols for PEQ inspectors, to increase their awareness of potential pest plant (weed) imports. To improve the ability of inspectors to correctly identify plant imports, appropriate training should be provided and samples taken of all plants of uncertain identification. A national identification service should be provided. This would prevent the importation of mislabelled plants and also maintain an up-to-date record of which plant species are present within New Zealand.
- Review current legislation for the importation of plant material, removing prohibitive charges for the screening of new material entering New Zealand. This requires critical attention, as illegal importation of organisms poses a potential biosecurity threat.

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8. Glossary of acronyms

AWRAM	Aquatic Weed Risk Assessment Model (Champion & Clayton 2000)
CFIA	Canadian Food Inspection Agency
CTO	Chief Technical Officer (under Biosecurity Act 1993)
ERMANZ	Environmental Risk Management Authority (under HSNO 1996)
FAO	Food and Agriculture Organization of the United Nations
FNZAS	Federation of New Zealand Aquarium Societies
HSNO Act	Hazardous Substances and New Organisms Act 1996
IHS	Import Health Standard
ISPM	International Standards for Phytosanitary Measures
IPPC	International Plant Protection Convention
MAF	Ministry of Agriculture and Forestry
PEQ	Post Entry Quarantine
PIJAC	Pet Industry Association of New Zealand
PPIN	Plant Pest Information Network
SPS	Agreement on the Application of Sanitary and Phytosanitary Measures
UOR	Unwanted Organisms Register
WONS	Weed of National Significance (Australia)
WTO	World Trade Organisation