

# Border control for potential aquatic weeds

Stage 2. Weed risk assessment

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### ABSTRACT

This report is the second stage in the development of a Border Control Programme for aquatic plants that have the potential to become ecological weeds in New Zealand. Importers and traders in aquatic plants were surveyed to identify the plant species known or likely to be present in New Zealand. The Aquatic Plant Weed Risk Assessment Model was used to help assess the level of risk posed by these species. The report presents evidence of the various entry pathways and considers the impact that new invasive aquatic weed species may have on vulnerable native aquatic species and communities.

Aquatic plant importers surveyed regarded the current importation regulations as impractical and costly, making legal importation too expensive when compared with the value of imported stock. The survey indicated that at least 27% of the species present within the aquatic plant trade were not previously known to be present in New Zealand. Many species appear not to have been screened by border control, and many are likely to have been obtained by amateur enthusiasts. Some species were not seen or positively identified in the survey, but were reported as being present in New Zealand by interviewees. The survey identified the apparent acceptability of seed of four *Typha* species and *Sparganium erectum* to be imported even though these species are not permitted entry into other countries and *S. erectum* is a Federal Noxious Weed in the USA. Therefore it appears that the current system regulating the importation of aquatic plants into New Zealand has notable deficiencies, in that the species entering this country are not being screened for weed potential. However, although a weed risk model is useful for identifying high risk species, it will not always indicate how they will behave as weeds in New Zealand.

Experimental evaluation of the weed potential of selected high-risk species (including *Hygrophila polysperma*, *Hydrocotyle verticillata*, *Cabomba caroliniana* and *Saururus cernuus*) should be considered.

**Keywords:** border control, aquatic plants, introductions, illegal importation, potential weeds, risk assessment, biodiversity.

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# 1. Introduction

This report is the second stage in the development of a Border Control Programme 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 provide policy advice to the Minister for Biosecurity on the risks to indigenous flora and natural habitats from new aquatic plant species and new genetic varieties of established species. This risk assessment will also help develop a justifiable rationale for entry restrictions on weed pests which are already established in New Zealand, and will help to establish criteria for the Environmental Risk Management Authority (ERMA) to assess new organisms under the Hazardous Substances and New Organisms (HSNO) Act 1996.

The Stage 1 report (Champion & Clayton 2000) was the development of a revised Weed Risk Assessment Model suitable for aquatic plants. The potential impacts from new plant species, and possible entry pathways for aquatic species were also identified and discussed.

That report identified several key areas that required further investigation, including a comprehensive survey of aquatic plants introduced to but not naturalised in New Zealand, and the amount of trade interest and therefore likelihood of importation of aquatic plants with weed potential.

This report outlines the results of a survey of key importers and traders in aquatic plants. The survey identifies the plant species they have now or, in some cases, have had in the past. The Aquatic Plant Weed Risk Assessment Model was then applied to priority species (those with a documented weed potential in other countries), and recommendations for the management of priority species already present in New Zealand or not yet within the country. Further information relating to the volume of aquatic plants entering New Zealand by the various pathways identified in Stage 1, and the identification of vulnerable indigenous aquatic species and communities which may be further impacted by aquatic weeds is also provided.

A final stage to the completion of a risk analysis for aquatic species will assess existing management systems, particularly the determination of unwanted organisms, the development of import health standards and the assessment of new organisms; and to make recommendations on the need for new or enhanced management measures.

## 2. Verification of species in cultivation within New Zealand

The following nurseries, aquarium suppliers and importers (considered to be the major suppliers of ornamental aquatic plants) were visited from February to May 2000. All plant material cultivated was inspected and samples of specimens of uncertain identity were taken and grown on to assist in identification, where appropriate:

|   |                          |
|---|--------------------------|
| Wai Mara Water Gardens, Warkworth       | Pond and marginal plants |
| Able Aquatics, Te Aroha                 | Pond and marginal plants |
| Wilson's Aquatic Nursery, Lake Whangape | Pond and marginal plants |
| Braeside Aquaria, Te Aroha              | Aquarium plants          |
| O'Regan Aquatic Plants, Auckland        | Aquarium plants          |
| Redwood Aquatics, Christchurch          | Aquarium plants          |
| Amazon Aquatics, Whakamaru              | Aquarium plants          |
| Petworld, Christchurch                  | Aquarium plants          |

All owners were also interviewed regarding the volume of plants imported, their impression of the current importation system and additional plants they knew to be present in New Zealand. All were most helpful and showed a keen interest in the project we were undertaking, and also in sorting out the current problems with the importation of aquatic plants. A typical nursery where most species are grown hydroponically in their emergent form is shown in Figure 1.

The species found are listed in Table 1. Plant identification was carried out using a range of literature including Cook (1996), Muenscher (1944), Mühlberg (1982), Sculthorpe (1967), Slocum et al. (1996), Stodola (1967), Tropica Aquarium Catalogue (2000). The legitimacy of the names used was checked on

Figure 1. Aquarium plants grown hydroponically.



TABLE 1. SPECIES DISTRIBUTED AS ORNAMENTAL AQUATIC PLANTS WITHIN NEW ZEALAND.

| GENUS                    | SPECIES                   | FAMILY           | OTHER NAMES USED   | PRESENT/EVALUATED IN NZ | STATUS | LIFE-FORM |
|--------------------------|---------------------------|------------------|--|-------------------------|--------|-----------|
| <b>Ferns/Fern Allies</b> |                           |                  |  |                         |        |           |
| <i>Azolla</i>            | <i>caroliniana</i>        | Azollaceae       |  | n                       | x      | ff        |
| <i>Bolbitis</i>          | sp.                       | Lomariopsidaceae | <i>B. heudelotti</i> ,<br>African water fern                   | L                       | t      | as        |
| <i>Ceratopteris</i>      | <i>pteroides</i>          | Pteridiaceae     | Indian fern  | n                       | t      | ff        |
| <i>Ceratopteris</i>      | <i>siliquosa</i>          | Pteridiaceae     | Indian fern, water<br>sprite                                   | n                       | t      | as        |
| <i>Ceratopteris</i>      | <i>thalictroides</i>      | Pteridiaceae     | Indian fern, water<br>sprite                                   | L, M                    | t      | as        |
| <i>Equisetum</i>         | <i>hyemale</i>            | Equisetaceae     |  | L, M                    | n      | b         |
| <i>Marsilea</i>          | <i>crenata</i>            | Marsileaceae     |  | L                       | x      | wl        |
| <i>Marsilea</i>          | <i>birsuta</i>            | Marsileaceae     | Pepperwort, four<br>leaf clover                                | n                       | r      | wl        |
| <i>Microsorium</i>       | <i>pteropus</i>           | Polypodiaceae    | Java fern  | ?                       | t      | as        |
| <i>Salvinia</i>          | <i>spp. (not molesta)</i> | Salviniaceae     |  | n                       | x      | ff        |
| <b>Angiosperms</b>       |                           |                  |  |                         |        |           |
| <i>Acorus</i>            | <i>calamus</i>            | Araceae          | sweet flag, dwarf<br>rush                                      | L, M                    | t      | te        |
| <i>Acorus</i>            | <i>gramineus</i>          | Araceae          | Japanese rush  | L, M                    | t      | te        |
| <i>Alisma</i>            | <i>lanceolatum</i>        | Alismataceae     | water plantain   | L, M                    | n      | ee        |
| <i>Alisma</i>            | <i>parviflorum</i>        | Alismataceae     | water plantain   | L, M                    | t      | ee        |
| <i>Alisma</i>            | <i>plantago-aquatica</i>  | Alismataceae     | water plantain   | L, M                    | n      | ee        |
| <i>Alisma</i>            | <i>triviale</i>           | Alismataceae     | water plantain   | L                       | t      | ee        |
| <i>Alternanthera</i>     | <i>ficoidea</i>           | Amaranthaceae    | <i>A. sessilis</i> var.<br><i>rubra</i> ,<br>beetroot plant    | L, M                    | t      | se        |
| <i>Alternanthera</i>     | <i>reineckii</i>          | Amaranthaceae    | <i>A. lilacina</i> ,<br><i>A. roseacefolia</i> ,<br>copperleaf | L, M                    | t      | se        |
| <i>Anubias</i>           | <i>barteri</i>            | Araceae          |  | L, M                    | t      | as        |
| <i>Anubias</i>           | <i>congensis</i>          | Araceae          |  | n                       | x      | as        |
| <i>Anubias</i>           | <i>lanceolata</i>         | Araceae          |  | n                       | x      | as        |
| <i>Anubias</i>           | <i>nana</i>               | Araceae          |  | L, M                    | t      | as        |
| <i>Apodasmia</i>         | <i>sessilis</i>           | Restionaceae     | oioi   | L, M                    | i      | ee        |
| <i>Aponogeton</i>        | <i>bernierianum</i>       | Aponogetonaceae  | Madagascar lace  | n                       | x      | os        |
| <i>Aponogeton</i>        | <i>boivintanus</i>        | Aponogetonaceae  |  | n                       | x      | os        |
| <i>Aponogeton</i>        | <i>crispum</i>            | Aponogetonaceae  | Sri Lankan blade<br>plant                                      | L, M                    | t      | os        |
| <i>Aponogeton</i>        | <i>distachyus</i>         | Aponogetonaceae  | water hawthorn,<br>Cape pondweed                               | L, M                    | n      | wl        |
| <i>Aponogeton</i>        | <i>fenestrata</i>         | Aponogetonaceae  | Madagascar lace  | n                       | x      | oe        |
| <i>Aponogeton</i>        | <i>natans</i>             | Aponogetonaceae  |  | n                       | t      | oe        |
| <i>Aponogeton</i>        | <i>rigidifolius</i>       | Aponogetonaceae  |  | n                       | t      | os        |
| <i>Aponogeton</i>        | <i>ulvaceum</i>           | Aponogetonaceae  |  | L, M                    | t      | os        |
| <i>Aponogeton</i>        | <i>undulatum</i>          | Aponogetonaceae  | Sri Lankan blade<br>plant                                      | L, M                    | t      | os        |
| <i>Bacopa</i>            | <i>caroliniana</i>        | Scrophulariaceae | <i>B. amplexicaulis</i> ,<br>red bacopa                        | L, M                    | t      | as        |
| <i>Bacopa</i>            | <i>lanigera</i>           | Scrophulariaceae | giant babies tears   | n                       | t      | as        |
| <i>Bacopa</i>            | <i>monniera</i>           | Scrophulariaceae | babies tears   | L, M                    | t      | as        |



TABLE 1 *continued.*

| GENUS               | SPECIES                 | FAMILY           | OTHER NAMES USED                        | PRESENT/<br>EVALUATED<br>IN NZ | STATUS | LIFE-FORM |
|---------------------|-------------------------|------------------|---|--------------------------------|--------|-----------|
| <i>Baldelia</i>     | <i>ranunculoides</i>    | Alismataceae     |   | L, M                           | t      | as        |
| <i>Barclaya</i>     | <i>longifolia</i>       | Nymphaeaceae     |   | L, M                           | t      | os        |
| <i>Baumea</i>       | <i>articulata</i>       | Cyperaceae       |   | L, M                           | i      | ee        |
| <i>Baumea</i>       | <i>juncea</i>           | Cyperaceae       |   | L, M                           | i      | ee        |
| <i>Blyxa</i>        | <i>aubertii</i>         | Hydrocharitaceae |   | n                              | x      | os        |
| <i>Butomus</i>      | <i>umbellatus</i>       | Butomaceae       | flowering rush                          | L                              | ID     | te        |
| <i>Cabomba</i>      | <i>caroliniana</i>      | Cabombaceae      | green cabomba,<br>fanwort               | L                              | t      | os        |
| <i>Cabomba</i>      | <i>furcata</i>          | Cabombaceae      | <i>C. piaubyensis</i> ,<br>red cabomba  | n                              | t      | os        |
| <i>Caltha</i>       | <i>palustris</i>        | Ranunculaceae    | marsh marigold                          | L, M                           | t      | ee        |
| <i>Caltha</i>       | <i>polysepala</i>       | Ranunculaceae    | marsh marigold                          | L, M                           | t      | ee        |
| <i>Canna</i>        | <i>flaccida</i>         | Cannaceae        | water canna                             | n                              | t      | ee        |
| <i>Canna</i>        | <i>glauca</i>           | Cannaceae        | water canna                             | n                              | t      | ee        |
| <i>Cardamine</i>    | <i>lyrata</i>           | Brassicaceae     | moneywort                               | L, M                           | t      | as        |
| <i>Cardamine</i>    | <i>pratensis</i>        | Brassicaceae     | cuckoo flower                           | L, M                           | t      | b         |
| <i>Carex</i>        | <i>remota</i>           | Cyperaceae       |   | L, M                           | t      | b         |
| <i>Carex</i>        | <i>trifida</i>          | Cyperaceae       |   | L, M                           | i      | b         |
| <i>Chlorophytum</i> | <i>bichetii</i>         | Liliaceae        | wheat plant                             | L, M                           | t      | ee        |
| <i>Colocasia</i>    | <i>esculenta</i>        | Araceae          | taro                                    | L, M                           | n      | ee        |
| <i>Cotula</i>       | <i>coronopifolia</i>    | Asteraceae       | batchelors buttons                      | L, M                           | i      | as        |
| <i>Crinum</i>       | <i>calamistratum</i>    | Amaryllidaceae   |   | L, M                           | t      | as        |
| <i>Crinum</i>       | <i>natans</i>           | Amaryllidaceae   |   | L, M                           | t      | as        |
| <i>Crinum</i>       | <i>tbaianum</i>         | Amaryllidaceae   |   | n                              | t      | ta        |
| <i>Cyperus</i>      | <i>alterniflorus</i>    | Cyperaceae       | umbrella plant                          | L, M                           | n      | ee        |
| <i>Cyperus</i>      | <i>baspan</i>           | Cyperaceae       | sheathed cyperus                        | L, M                           | t      | ee        |
| <i>Cyperus</i>      | <i>helferi</i>          | Cyperaceae       |   | n                              | t      | as        |
| <i>Cyperus</i>      | <i>papyrus</i>          | Cyperaceae       | papyrus                                 | L, M                           | t      | ee        |
| <i>Cryptocoryne</i> | <i>affinis</i>          | Araceae          |   | n                              | t      | as        |
| <i>Cryptocoryne</i> | <i>albida</i>           | Araceae          |   | n                              | t      | as        |
| <i>Cryptocoryne</i> | <i>aponogetifolia</i>   | Araceae          |   | n                              | t      | as        |
| <i>Cryptocoryne</i> | <i>beckettii</i>        | Araceae          |   | L, M                           | t      | as        |
| <i>Cryptocoryne</i> | <i>blassii</i>          | Araceae          |   | L, M                           | t      | as        |
| <i>Cryptocoryne</i> | <i>ciliata</i>          | Araceae          |   | n                              | t      | as        |
| <i>Cryptocoryne</i> | <i>cordata</i>          | Araceae          |   | L, M                           | t      | as        |
| <i>Cryptocoryne</i> | <i>crispatula</i>       | Araceae          |   | L, M                           | t      | as        |
| <i>Cryptocoryne</i> | <i>lingua</i>           | Araceae          |   | n                              | t      | as        |
| <i>Cryptocoryne</i> | <i>longicauda</i>       | Araceae          |   | n                              | t      | as        |
| <i>Cryptocoryne</i> | <i>minima</i>           | Araceae          |   | L, M                           | x      | as        |
| <i>Cryptocoryne</i> | <i>parva</i>            | Araceae          |   | n                              | t      | as        |
| <i>Cryptocoryne</i> | <i>pontederitifolia</i> | Araceae          |   | L, M                           | t      | as        |
| <i>Cryptocoryne</i> | <i>retrospiralis</i>    | Araceae          |   | n                              | t      | as        |
| <i>Cryptocoryne</i> | <i>undulata</i>         | Araceae          |   | L, M                           | t      | as        |
| <i>Cryptocoryne</i> | <i>walkeri</i>          | Araceae          |   | L, M                           | t      | as        |
| <i>Cryptocoryne</i> | <i>wendtii</i>          | Araceae          |   | L, M                           | t      | as        |
| <i>Cryptocoryne</i> | <i>x willisii</i>       | Araceae          |   | L, M                           | t      | as        |
| <i>Dianthus</i>     | <i>superba</i>          | Caryophyllaceae  |   | L, M                           | t      | b         |
| <i>Didiplis</i>     | <i>diandra</i>          | Lythraceae       | <i>Peplis diandrus</i> ,<br>Water hedge | n                              | t      | as        |
| <i>Echinodorus</i>  | <i>amazonicus</i>       | Alismataceae     | Amazon sword                            | L, M                           | t      | ee        |

TABLE 1 *continued.*

| GENUS                   | SPECIES               | FAMILY           | OTHER NAMES USED   | PRESENT/<br>EVALUATED<br>IN NZ | STATUS | LIFE-FORM |
|-------------------------|-----------------------|------------------|--|--------------------------------|--------|-----------|
| <i>Echinodorus</i>      | <i>argentinensis</i>  | Alismataceae     | Amazon sword   | L, M                           | t      | ee        |
| <i>Echinodorus</i>      | <i>bartonii</i>       | Alismataceae     | Amazon sword   | n                              | t      | ee        |
| <i>Echinodorus</i>      | <i>bleberi</i>        | Alismataceae     | Amazon sword   | L, M                           | t      | ee        |
| <i>Echinodorus</i>      | <i>cordifolius</i>    | Alismataceae     | Amazon sword,<br>burhead   | L, M                           | t      | ee        |
| <i>Echinodorus</i>      | <i>grandiflorus</i>   | Alismataceae     | Amazon sword   | L, M                           | t      | ee        |
| <i>Echinodorus</i>      | <i>boremanii</i>      | Alismataceae     | Amazon sword   | M                              | t      | ee        |
| <i>Echinodorus</i>      | <i>horizontalis</i>   | Alismataceae     | Amazon sword   | n                              | t      | ee        |
| <i>Echinodorus</i>      | <i>latifolius</i>     | Alismataceae     | Amazon sword   | L, M                           | t      | ee        |
| <i>Echinodorus</i>      | <i>macrophyllus</i>   | Alismataceae     | Amazon sword   | n                              | t      | ee        |
| <i>Echinodorus</i>      | <i>majus</i>          | Alismataceae     | <i>E. martii</i> , Amazon<br>sword   | L, M                           | t      | ee        |
| <i>Echinodorus</i>      | <i>muricatus</i>      | Alismataceae     | Amazon sword   | n                              | t      | ee        |
| <i>Echinodorus</i>      | <i>opacus</i>         | Alismataceae     | Amazon sword   | n                              | t      | ee        |
| <i>Echinodorus</i>      | <i>osiris</i>         | Alismataceae     | Amazon sword   | L, M                           | t      | ee        |
| <i>Echinodorus</i>      | <i>parviflorus</i>    | Alismataceae     | Amazon sword   | M                              | t      | ee        |
| <i>Echinodorus</i>      | <i>quadricostatus</i> | Alismataceae     | <i>E. magdalensis</i> ,<br>chain sword                                     | L, M                           | t      | as        |
| <i>Echinodorus</i>      | <i>schlueteri</i>     | Alismataceae     | Amazon sword   | L, M                           | t      | ee        |
| <i>Echinodorus</i>      | <i>tenellus</i>       | Alismataceae     | chain sword  | L, M                           | t      | as        |
| <i>Echinodorus</i>      | <i>uruguayensis</i>   | Alismataceae     | Amazon sword   | L, M                           | t      | ea        |
| <i>Eichbornia</i>       | <i>azurea</i>         | Pontederiaceae   | anchored water<br>hyacinth   | n                              | t      | os/wl     |
| <i>Eichbornia</i>       | <i>diversifolia</i>   | Pontederiaceae   |  | n                              | t      | os        |
| <i>Eichbornia</i>       | <i>paniculata</i>     | Pontederiaceae   |  | n                              | r      | ee        |
| <i>Eleocharis</i>       | <i>acicularis</i>     | Cyperaceae       | hair grass   | L, M                           | t      | as        |
| <i>Eleocharis</i>       | <i>acuta</i>          | Cyperaceae       |  | L, M                           | i      | ee        |
| <i>Eleocharis</i>       | <i>dulcis</i>         | Cyperaceae       | Chinese water<br>chestnut  | L, M                           | t      | ee        |
| <i>Eleocharis</i>       | <i>parvula</i>        | Cyperaceae       | hair grass   | n                              | t      | as        |
| <i>Eleocharis</i>       | <i>vivipara</i>       | Cyperaceae       | hair grass   | n                              | t      | as        |
| <i>Elodea</i>           | <i>canadensis</i>     | Hydrocharitaceae | Canadian<br>pondweed   | L, M                           | n      | os        |
| <i>Eriophorum</i>       | <i>angustifolium</i>  | Cyperaceae       | cotton grass   | n                              | t      | ee        |
| <i>Eriophorum</i>       | <i>scheuchzeri</i>    | Cyperaceae       | cotton grass   | L                              | x      | ee        |
| <i>Eupatoriadelphus</i> | <i>purpureus</i>      | Asteraceae       | <i>Eupatorium</i><br><i>purpurateum</i> ,<br>Sweet scented joe<br>pye weed | L, M                           | t      | b         |
| <i>Eupatorium</i>       | <i>cannabinum</i>     | Asteraceae       | hemp agrimony  | L, M                           | P*     | b         |
| <i>Eupatorium</i>       | <i>perfoliatum</i>    | Asteraceae       | boneset  | L, M                           | t      | b         |
| <i>Filipendula</i>      | <i>rubra</i>          | Rosaceae         |  | L, M                           | t      | b         |
| <i>Filipendula</i>      | <i>ulmaria</i>        | Rosaceae         |  | L, M                           | t      | b         |
| <i>Filipendula</i>      | <i>vulgaris</i>       | Rosaceae         |  | L, M                           | t      | b         |
| <i>Glossostigma</i>     | <i>elatinoides</i>    | Scrophulariaceae |  | L, M                           | i      | as        |
| <i>Gunnera</i>          | <i>manicata</i>       | Gunneraceae      | Brazilian rhubarb  | L, M                           | t      | ee        |
| <i>Gunnera</i>          | <i>prorepens</i>      | Gunneraceae      |  | L, M                           | i      | b         |
| <i>Gunnera</i>          | <i>tinctoria</i>      | Gunneraceae      | Chilean rhubarb,<br>giant gunnera  | L, M                           | n      | ee        |
| <i>Hemigrabhis</i>      | <i>colorata</i>       | Acanthaceae      | Timulus  | M                              | t      | ee        |
| <i>Hemigrabhis</i>      | <i>repanda</i>        | Acanthaceae      |  | n                              | t      | ee        |
| <i>Heteranthera</i>     | <i>zosterifolia</i>   | Pontederiaceae   | star grass   | L                              | t      | os        |

TABLE 1 *continued.*

| GENUS               | SPECIES                | FAMILY           | OTHER NAMES USED   | PRESENT/EVALUATED IN NZ | STATUS | LIFE-FORM |
|---------------------|------------------------|------------------|--|-------------------------|--------|-----------|
| <i>Hibiscus</i>     | <i>palustris</i>       | Malvaceae        | water hibiscus, swamp rosemallow                         | n                       | t      | ee        |
| <i>Hibiscus</i>     | <i>moscheutos</i>      | Malvaceae        | water hibiscus   | L, M                    | t      | ee        |
| <i>Hottonia</i>     | <i>palustris</i>       | Primulaceae      | water primrose   | L                       | x      | os        |
| <i>Hydrocharis</i>  | <i>morus-ranae</i>     | Hydrocharitaceae | frogbit  | n                       | x      | ff        |
| <i>Hydrocotyle</i>  | <i>bonariensis</i>     | Apiaceae         |  | L, M                    | t      | se        |
| <i>Hydrocotyle</i>  | <i>leucocephala</i>    | Apiaceae         | <i>Cardamine lyrata</i>                                  | L, M                    | t      | se        |
| <i>Hydrocotyle</i>  | <i>sibtborpioides</i>  | Apiaceae         |  | L, M                    | t      | se        |
| <i>Hydrocotyle</i>  | <i>verticillata</i>    | Apiaceae         | <i>H. vulgaris</i> , pennywort                           | L, M                    | n*     | se        |
| <i>Hygrophila</i>   | <i>angustifolia</i>    | Acanthaceae      | <i>H. salicifolia</i> , blue hygrophila                  | L, M                    | t      | ee        |
| <i>Hygrophila</i>   | <i>corymbosa</i>       | Acanthaceae      | <i>Nomaphila stricta</i> , temple plants (several spp.?) | L, M                    | t      | ee        |
| <i>Hygrophila</i>   | <i>difformis</i>       | Acanthaceae      | <i>Synnema triflorum</i> , water wisteria                | L, M                    | t      | ee        |
| <i>Hygrophila</i>   | <i>polysperma</i>      | Acanthaceae      | polysperma   | L, M                    | t      | ee        |
| <i>Hypericum</i>    | <i>tetrapterum</i>     | Clusiaceae       | Square-stemmed St. John's wort, St. Peter's wort         | L, M                    | t      | b         |
| <i>Imperata</i>     | Red Baron              | Poaceae          |  | n                       | t      | b         |
| <i>Ipomoea</i>      | <i>aquatica</i>        | Convolvulaceae   | water spinach, swamp morning-glory                       | L, M                    | v      | ff/se     |
| <i>Iris</i>         | <i>bulleyana</i>       | Iridaceae        |  | L, M                    | t      | b         |
| <i>Iris</i>         | <i>chrysographes</i>   | Iridaceae        |  | L, M                    | t      | b         |
| <i>Iris</i>         | <i>ensata</i>          | Iridaceae        |  | L, M                    | t      | b         |
| <i>Iris</i>         | <i>laevigata</i>       | Iridaceae        |  | L, M                    | t      | b         |
| <i>Iris</i>         | <i>louisiana</i>       | Iridaceae        |  | L, M                    | t      | ee        |
| <i>Iris</i>         | <i>pseudacorus</i>     | Iridaceae        | yellow flag  | L, M                    | P      | ee        |
| <i>Iris</i>         | <i>setosa</i>          | Iridaceae        |  | L, M                    | t      | b         |
| <i>Iris</i>         | <i>sibirica</i>        | Iridaceae        |  | L, M                    | t      | b         |
| <i>Iris</i>         | <i>versicolor</i>      | Iridaceae        | blue flag  | L, M                    | t      | ee        |
| <i>Iris</i>         | <i>virginica</i>       | Iridaceae        | large blue flag  | L, M                    | t      | ee        |
| <i>Isolepis</i>     | <i>reticularis</i>     | Cyperaceae       |  | L, M                    | i      | as        |
| <i>Isolepis</i>     | <i>sepulcralis</i>     | Cyperaceae       |  | L, M                    | n      | as        |
| <i>Juncus</i>       | <i>effusus</i>         | Juncaceae        | corkscrew rush   | L, M                    | n      | ee        |
| <i>Juncus</i>       | <i>inflexus</i>        | Juncaceae        | <i>J. glaucus</i> , blue rush                            | L, M                    | n      | ee        |
| <i>Kosteletzkya</i> | <i>virginica</i>       | Malvaceae        | seashore mallow  | n                       | t      | ee        |
| <i>Lagenandra</i>   | <i>ovata</i>           | Araceae          | Malayan sword  | M                       | t      | ee        |
| <i>Lilaeopsis</i>   | <i>brasiliensis</i>    | Apiaceae         | <i>L. novae-zelandiae</i> , <i>L. zelandia</i>           | n                       | t      | as        |
| <i>Lilaeopsis</i>   | <i>mauritiana</i>      | Apiaceae         | <i>L. mauritis</i> , <i>L. muricatus</i>                 | n                       | t      | as        |
| <i>Lilaeopsis</i>   | <i>novae-zelandiae</i> | Apiaceae         |  | L, M                    | i      | as        |
| <i>Limnophila</i>   | <i>aromatica</i>       | Scrophulariaceae |  | L                       | t      | ee        |
| <i>Limnophila</i>   | <i>beterophylla</i>    | Scrophulariaceae | ambulia  | n                       | t      | as        |
| <i>Limnophila</i>   | <i>indica</i>          | Scrophulariaceae | ambulia  | n                       | t      | as        |

TABLE 1 *continued.*

| GENUS               | SPECIES                | FAMILY           | OTHER NAMES USED                                    | PRESENT/EVALUATED IN NZ | STATUS | LIFE-FORM |
|---------------------|------------------------|------------------|---|-------------------------|--------|-----------|
| <i>Limnophila</i>   | <i>sessiliflora</i>    | Scrophulariaceae | ambulia   | n                       | t      | as        |
| <i>Lindernia</i>    | <i>rotundifolia</i>    | Scrophulariaceae |   | L                       | t      | as        |
| <i>Lobelia</i>      | <i>cardinalis</i>      | Lobeliaceae      | red lobelia   | L, M                    | t      | as        |
| <i>Lobelia</i>      | <i>dortmanna</i>       | Lobeliaceae      | water lobelia                                       | L, M                    | x      | os        |
| <i>Lychnis</i>      | <i>flos-cuculi</i>     | Caryophyllaceae  | ragged robin,<br>meadow campion                     | L, M                    | t      | b         |
| <i>Lysimachia</i>   | <i>nummularia</i>      | Primulaceae      | moneywort   | L, M                    | n      | as        |
| <i>Limnobiium</i>   | <i>spongia</i>         | Hydrocharitaceae | frogbit   | n                       | r      | ff        |
| <i>Ludwigia</i>     | <i>arcuata</i>         | Onagraceae       | needle-leaved<br>ludwigia                           | L                       | t      | as        |
| <i>Ludwigia</i>     | <i>glandulosa</i>      | Onagraceae       |   | n                       | t      | ee        |
| <i>Ludwigia</i>     | <i>helminthorrhiza</i> | Onagraceae       |   | L                       | t      | ff        |
| <i>Ludwigia</i>     | <i>palustris</i>       | Onagraceae       | water purslane                                      | L, M                    | n      | as        |
| <i>Ludwigia</i>     | <i>perennis</i>        | Onagraceae       | <i>L. peruensis</i>                                 | L                       | t      | as        |
| <i>Ludwigia</i>     | <i>repens</i>          | Onagraceae       |   | L, M                    | t      | as        |
| <i>Lysichiton</i>   | <i>americanum</i>      | Araceae          | skunk cabbage                                       | L, M                    | t      | b         |
| <i>Lysichiton</i>   | <i>camschatcensis</i>  | Araceae          | skunk cabbage                                       | L, M                    | x      | b         |
| <i>Mayaca</i>       | <i>fluviatilis</i>     | Mayacaceae       | pine tree   | L                       | t      | os        |
| <i>Mentha</i>       | <i>aquatica</i>        | Lamiaceae        | water mint  | L, M                    | t      | se        |
| <i>Micranthemum</i> | <i>micranthemoides</i> | Scrophulariaceae |   | n                       | t      | as        |
| <i>Micranthemum</i> | <i>umbrosum</i>        | Scrophulariaceae |   | L                       | x      | as        |
| <i>Mimulus</i>      | <i>guttatus</i>        | Scrophulariaceae | monkey musk   | L, M                    | n      | se        |
| <i>Mimulus</i>      | <i>luteus</i>          | Scrophulariaceae |   | L, M                    | t      | b         |
| <i>Mimulus</i>      | <i>ringens</i>         | Scrophulariaceae |   | L, M                    | t      | b         |
| <i>Miscanthus</i>   | <i>nepalensis</i>      | Poaceae          | fairy grass   | L, M                    | n      | b         |
| <i>Miscanthus</i>   | <i>sinensis</i>        | Poaceae          | fairy grass   | L, M                    | n      | b         |
| <i>Myosotis</i>     | <i>scorpioides</i>     | Boraginaceae     | <i>M. palustris</i> ,<br>Water forget-me-<br>not    | L, M                    | t      | se        |
| <i>Myriophyllum</i> | <i>matagrossense</i>   | Haloragaceae     | red rattail   | n                       | x      | os        |
| <i>Myriophyllum</i> | <i>propinquum</i>      | Haloragaceae     |   | L, M                    | i      | os        |
| <i>Myriophyllum</i> | <i>scabratum</i>       | Haloragaceae     |   | n                       | ID     | os        |
| <i>Myriophyllum</i> | <i>varifolium</i>      | Haloragaceae     |   | L, M                    | ID     | os        |
| <i>Najas</i>        | <i>guadalupensis</i>   | Najadaceae       | <i>N. microdon</i> ,<br>southern naiad              | M*                      | x      | os        |
| <i>Najas</i>        | <i>indica</i>          | Najadaceae       |   | M*                      | x      | os        |
| <i>Najas</i>        | <i>marina</i>          | Najadaceae       | sawtooth,<br>hollyleaf naiad                        | M*                      | x      | os        |
| <i>Nelumbo</i>      | <i>nucifera</i>        | Nelumbonaceae    | Sacred lotus  | L, M                    | t      | w1        |
| <i>Nelumbo</i>      | <i>lutea</i>           | Nelumbonaceae    | yellow lotus  | n                       | x      | w1        |
| <i>Neptunia</i>     | <i>plena</i>           | Fabaceae         | <i>N. aquatica</i> ,<br>floating sensitive<br>plant | L, M                    | x      | ff        |
| <i>Nuphar</i>       | <i>minimum</i>         | Nymphaeaceae     |   | L, M                    | x      | w1        |
| <i>Nuphar</i>       | <i>pumila</i>          | Nymphaeaceae     |   | L, M                    | x      | w1        |
| <i>Nuphar</i>       | <i>hybrid</i>          | Nymphaeaceae     | spatterdock,<br>yellow water lily                   | L, M                    | t      | w1        |
| <i>Nymphaea</i>     | <i>lotus</i>           | Nymphaeaceae     | water lily  | L, M                    | t      | w1        |
| <i>Nymphaea</i>     | <i>rubra</i>           | Nymphaeaceae     | water lily  | n                       | t      | w1        |
| <i>Nymphaea</i>     | <i>hybrids</i>         | Nymphaeaceae     | water lily  | L, M                    | n      | w1        |
| <i>Nymphoides</i>   | <i>aquatica</i>        | Menyanthaceae    | banana plant  | L, M                    | t      | ff/w1     |

TABLE 1 *continued.*

| GENUS                 | SPECIES                                | FAMILY           | OTHER NAMES USED                                 | PRESENT/EVALUATED IN NZ | STATUS | LIFE-FORM |
|-----------------------|--|------------------|--|-------------------------|--------|-----------|
| <i>Oenanthe</i>       | <i>javanica</i>                        | Apiaceae         | Flamingo, rainbow water parsley                  | L, M                    | t      | se        |
| <i>Opbiopogon</i>     | <i>japonicus</i>                       | Liliaceae        | mondo grass                                      | L, M                    | t      | ee        |
| <i>Otellia</i>        | <i>alismoides</i>                      | Hydrocharitaceae | water plantain                                   | n                       | x      | os        |
| <i>Otellia</i>        | <i>ovalifolia</i>                      | Hydrocharitaceae |  | L, M                    | n      | wl        |
| <i>Otellia</i>        | <i>ulvifolia</i>                       | Hydrocharitaceae |  | n                       | x      | os        |
| <i>Pistia</i>         | <i>stratiotes</i>                      | Araceae          | water lettuce                                    | L, M                    | xP     | ff        |
| <i>Plantago</i>       | <i>australis</i>                       | Plantaginaceae   | swamp plantain                                   | L, M                    | t      | b         |
| <i>Potentilla</i>     | <i>palustris</i>                       | Rosaceae         | marsh cinquefoil                                 | L, M                    | t      | b         |
| <i>Polygonum</i>      | <i>amplexicaule</i>                    | Polygonaceae     |  | L, M                    | t      | se        |
| <i>Polygonum</i>      | <i>bistorta</i>                        | Polygonaceae     |  | L                       | x      | se        |
| <i>Pontederia</i>     | <i>cordata</i>                         | Pontederiaceae   | pickerel weed                                    | L, M                    | t      | ee        |
| <i>Potamogeton</i>    | <i>gayi</i>                            | Potamogetonaceae |  | n                       | x      | os        |
| <i>Potamogeton</i>    | <i>perfoliatus</i>                     | Potamogetonaceae | clasped pondweed                                 | L, M                    | r      | os        |
| <i>Ranunculus</i>     | <i>ampbitricbus</i>                    | Ranunculaceae    |  | L, M                    | i      | as        |
| <i>Ranunculus</i>     | <i>flammula</i>                        | Ranunculaceae    | <i>R. lingua</i>                                 | L, M                    | n      | as        |
| <i>Rotala</i>         | <i>indica</i>                          | Lythraceae       | beanstalk  | L, M                    | t      | as        |
| <i>Rotala</i>         | <i>macrandra</i>                       | Lythraceae       |  | L, M                    | t      | as        |
| <i>Rotala</i>         | <i>rotundifolia</i>                    | Lythraceae       | tooth cup  | L, M                    | t      | as        |
| <i>Rotala</i>         | <i>wallichii</i>                       | Lythraceae       | pine tree  | L, M                    | t      | as        |
| <i>Ruellia</i>        | <i>brittoniana</i>                     | Acanthaceae      | water bluebell, var. Katie                       | n                       | t      | b         |
| <i>Sagittaria</i>     | <i>sagittifolia</i>                    | Alismataceae     | arrow head                                       | L, M                    | x      | ee        |
| <i>Sagittaria</i>     | <i>subulata</i>                        | Alismataceae     |  | L, M                    | n      | as        |
| <i>Sagittaria</i>     | <i>teres</i>                           | Alismataceae     | mini sag   | n                       | t      | as        |
| <i>Samolus</i>        | <i>valerandi</i>                       | Primulaceae      | <i>S. floribundus</i> , brookweed, water rose    | L, M                    | n*     | as        |
| <i>Saururus</i>       | <i>cernuus</i>                         | Saururaceae      | mouse ear  | L, M                    | n*     | se        |
| <i>Schizostylis</i>   | <i>coccinea</i>                        | Iridaceae        | Kaffir lily                                      | L, M                    | n      | ee        |
| <i>Schoenoplectus</i> | <i>tabernaemontani</i>                 | Cyperaceae       | zebra sedge                                      | L, M                    | i/t    | as        |
| <i>Sbinnertia</i>     | <i>rivularis</i>                       | Asteraceae       | <i>Trichocoronis rivularis</i> , Mexican oakleaf | n                       | t      | as        |
| <i>Sparganium</i>     | <i>erectum</i>                         | Sparganiaceae    | tall bur reed                                    | L, M                    | x      | ee        |
| <i>Spathiphyllum</i>  | <i>wallisii</i>                        | Araceae          | Borneo sword, peace lily                         | L, M                    | t      | ee        |
| <i>Thalia</i>         | <i>dealbata</i>                        | Marantaceae      |  | L, M                    | t      | ee        |
| <i>Thalia</i>         | <i>geniculata</i>                      | Marantaceae      |  | n                       | t      | ee        |
| <i>Typba</i>          | <i>domingensis</i>                     | Typhaceae        | <i>T. angustifolia</i> , narrow-leaf cattail     | L, M                    | x      | ee        |
| <i>Typba</i>          | <i>latifolia</i>                       | Typhaceae        | great reedmace                                   | L, M                    | ID     | ee        |
| <i>Typba</i>          | <i>laxmanni</i>                        | Typhaceae        |  | n                       | ID     | ee        |
| <i>Typba</i>          | <i>minima</i>                          | Typhaceae        |  | L, M                    | ID     | ee        |
| <i>Typba</i>          | <i>orientalis</i>                      | Typhaceae        | <i>T. muelleri</i> , raupo                       | L, M                    | i      | ee        |
| <i>Typba</i>          | <i>shuttleworthii</i>                  | Typhaceae        |  | L, M                    | x      | ee        |
| <i>Vallisneria</i>    | <i>asiatica</i>                        | Hydrocharitaceae | val  | L, M <sup>W</sup>       | t      | os        |
| <i>Vallisneria</i>    | <i>spiralis</i>                        | Hydrocharitaceae | eelgrass, eelweed, tape grass, val               | L, M <sup>W</sup>       | P      | os        |
| <i>Vallisneria</i>    | <i>americana</i> var. <i>biwaensis</i> | Hydrocharitaceae | <i>V. torta</i> , twisted val                    | L, M <sup>W</sup>       | t      | os        |
| <i>Veronica</i>       | <i>beccabunga</i>                      | Scrophulariaceae | brooklime  | L, M                    | t      | se        |

TABLE 1 *continued*.

| GENUS               | SPECIES            | FAMILY         | OTHER NAMES USED                            | PRESENT/EVALUATED IN NZ | STATUS | LIFE-FORM |
|---------------------|--------------------|----------------|---|-------------------------|--------|-----------|
| <i>Victoria</i>     | <i>amazonica</i>   | Nymphaeaceae   | Amazon water lily                           | L, M                    | t      | wl        |
| <i>Wachendorfia</i> | <i>thyrsifolia</i> | Haemodoraceae  | bloodroot                                   | L, M                    | n      | ee        |
| <i>Zosterella</i>   | <i>dubia</i>       | Pontederiaceae | <i>Heteranthera dubia</i> , water stargrass | n                       | t      | as        |

**Key to symbols used:*****Present/evaluated in New Zealand***

- L listed on the Landcare database of vascular plant species present in New Zealand  
M listed on the MAF Biosecurity Index with information on importation status/standards  
N not present on either list  
Ψ All vallisnerias probably treated as the one species by MAF (following Healy & Edgar 1980)

***Status***

- I indigenous to New Zealand  
N naturalised in New Zealand  
P plant pest (Biosecurity Act 1993)  
T sold or distributed in aquarium/pond plant trade  
X not seen by authors  
R known to have been present in New Zealand, but not seen recently  
ID plants in cultivation awaiting production of diagnostic features (e.g. flowers)  
v sold as vegetable  
\* recently reported as naturalised or included in Plant Pest Strategy

***Life-form***

- as amphibious submerged  
ee erect emergent  
ff free-floating  
os obligate submerged  
se sprawling emergent  
wl waterlily type  
b bog plant

the International Plant Name Query Index (2000). Most of the plant material was cultivated to a stage where identity could be ascertained; however there were several plants that had not flowered at the time of production of this report (see Table 1). Several other species were cited by several of the interviewees to be available in New Zealand, being distributed through a network of private aquarium keepers but not sold. Some of these plants are listed in Parsons et al. (1997). The status of such plants has yet to be determined. Other aquatic species were listed in the Landcare list of species present in New Zealand but have not been verified by the present study.

Alternative names under which these species have been traded are included in Table 1 along with the current status within New Zealand (i.e. indigenous, naturalised, introduced but not naturalised, status unknown), and life-form (obligate submerged, amphibious, free-floating, waterlily type, sprawling emergent, erect emergent, and bog plants). Bog plants are not true aquatics, being intolerant of long periods of immersion in water, but are included as they are typically sold at the same outlets as aquatic plants, and several species presently being distributed are potential or actual environmental weeds in New Zealand.

Table 1 also lists species on the Landcare database recorded as present in New Zealand, or as being assessed for importation as shown in the MAF Biosecurity Index (2000). The Landcare database has not received funding since 1998 and has not been updated since then (A. Wilton, Landcare pers. comm.).

A total of 179 aquatic and 25 bog plant species are reported as introduced, but not naturalised in New Zealand. Two aquatic species, *Hydrocotyle verticillata* and *Samolus valerandi*, were found by one of the authors (PDC) as naturalised for the first time during the course of this study, and also *Saururus cernuus* was recently found naturalised by Auckland Regional Council staff (D. Galloway pers. comm.).

Of the 181 aquatic species reported in Table 1:

- 138 plants were seen in the survey of nurseries, aquarium suppliers and importers.
- 30 species were reported as present in New Zealand but were not seen during the survey.
- 5 species have been seen in New Zealand by the authors during the past 10 years, but not during this survey.
- *Ipomoea aquatica* is commonly sold as a vegetable in markets and ethnic food shops.
- 65 were not recorded as present within New Zealand in the Landcare database, or evaluated for entry via the MAF Biosecurity database, with 51 of those species seen during the survey of nurseries, aquarium suppliers and importers.

This last group of plants have either been imported prior to restrictions imposed in 1976 (Champion & Clayton 2000), or have entered since then, but not been declared to Border Control authorities. Many of the plants were not known to be within the aquarium trade by the authors prior to the 1980s.

### 3. Assessing the weed potential of species already in New Zealand

Prior to evaluation using the Aquatic Plant Weed Risk Assessment model (Champion & Clayton 2000), the plants listed in Table 1 were screened for species known to be either:

- Weedy elsewhere, cited in Parsons & Cuthbertson (1992), Pieterse & Murphy (1993), Holm et al. (1997), Cook (1985), Lazarides et al. (1997), Aquatics (1978–2000), USDA Natural Resources Conservation Service (2000).
- Cited in the West Australian Weed List (Randall 2000). This weed list is derived from a compilation of all the records relating to plants as weeds anywhere in the world and the naturalised flora in Australia. Currently the list has over 16 000 records. The number of weed citations for each species is listed in Table 2.
- Included on prohibited federal or state lists for USA, Australia and New Zealand.

Bog plants and species already naturalised within New Zealand were excluded from this screening. Of the 30 bog plants currently being sold or propagated,

several may pose future weed problems. These include *Equisetum hyemale*, *Eupatorium* spp., *Imperata* 'Red Baron', and *Miscanthus* spp. It is recommended that these species be assessed using the DOC Weed Risk Assessment (Owen 1997).

Results of the aquatic plant screening exercise are shown in Table 2.

Twenty-five of the 74 species reported to be present in New Zealand and listed in Table 2 were not seen or positively identified during the current study. These species are mostly those known by the interviewees in Section 1 to be present amongst amateur aquarists, which were outside the brief of the current study. However, also of great concern is the apparent acceptability of seed of four *Typha* species (including the potential weeds *T. latifolia* and *T. domingensis*) and *Sparganium erectum* for importation with only basic seed standard requirements (i.e. a required level of purity) as stated in the MAF Biosecurity Index<sup>1</sup>. These species are not permitted entry into other countries, and *S. erectum* is a federal noxious weed in the USA.

Many of the species in Table 2 are only a problem in tropical or sub-tropical areas (e.g. South Florida), and are unlikely to pose any serious threat to New Zealand under the current climate. However, earlier assessments of the weed potential (or lack of potential) of such tropical/sub-tropical species such as water hyacinth (*Eichhornia crassipes*), salvinia (*Salvinia molesta*) and water poppy (*Hydrocleys nymphoides*) in warm temperate parts of New Zealand have been wrong.

Accurate assessment of weed potential is dependent on knowledge of the evaluated species' biology and ecology. Unfortunately, such information is not available for many of the species listed in Table 2, and assessment of these species using the Aquatic Weed Risk Assessment Model would not produce a meaningful result. Species for which sufficient information is available are assessed in Table 3 along with other potential weeds not suspected as being present in New Zealand (Champion & Clayton 2000). Information used to assess these species was sourced from the texts cited earlier in this section along with others which are listed in the references.

## 4. Recommendations for high risk species

Recommendations for the management of priority aquatic species not already naturalised in New Zealand (selected from Table 4) are presented in the following sections.

Photographs or images can be found of all of the following species at these websites:

<http://ww.tamu.edu/FLORA/gallery.htm>

<http://aquat1.ifas.ufl.edu/>

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<sup>1</sup> Seeds of these species are now not permitted for importation, following the submission of this report and alerting MAF to this situation.



TABLE 2. AQUATIC PLANTS PRESENT BUT NOT NATURALISED IN NEW ZEALAND, THAT ARE WEEDS OR ON NOXIOUS WEEDS LISTS ELSEWHERE.

| GENUS                    | SPECIES                    | AUSTRALASIA | N. AMERICA   | NO. CITATIONS<br>WA WEED LIST | CONTINENT<br>WHERE WEEDY |
|--------------------------|----------------------------|-------------|--------------|-------------------------------|--------------------------|
| <b>Ferns/Fern Allies</b> |                            |             |              |                               |                          |
| <i>Azolla</i>            | <i>caroliniana</i>         | WA          |              | 3                             | EU/NA/SA                 |
| <i>Ceratopteris</i>      | <i>pteroides</i>           |             |              | 1                             | NA                       |
| <i>Ceratopteris</i>      | <i>thalictroides</i>       |             |              |                               | NA/SA/AS                 |
| <i>Marsilea</i>          | <i>crenata</i>             |             |              | 2                             | AS                       |
| <i>Salvinia</i>          | spp. (not <i>molesta</i> ) | WA          | Fed, FL,NC   |                               | NA/SA                    |
| <b>Angiosperms</b>       |                            |             |              |                               |                          |
| <i>Alisma</i>            | <i>triviale</i>            |             |              | 1                             |                          |
| <i>Acorus</i>            | <i>calamus</i>             |             |              | 1                             |                          |
| <i>Aponogeton</i>        | <i>natans</i>              | WA          |              | 1                             |                          |
| <i>Aponogeton</i>        | <i>rigidifolius</i>        | WA          |              | 1                             |                          |
| <i>Bacopa</i>            | <i>caroliniana</i>         |             |              | 4                             | NA                       |
| <i>Bacopa</i>            | <i>monniera</i>            |             |              | 1                             | NA                       |
| <i>Blyxa</i>             | <i>aubertii</i>            |             |              | 2                             |                          |
| <i>Butomus</i>           | <i>umbellatus</i>          |             | NE1, Can     | 1                             | NA                       |
| <i>Cabomba</i>           | <i>caroliniana</i>         | NWS         | NE5          | 9                             | NA,AU,AS                 |
| <i>Caltha</i>            | <i>palustris</i>           |             |              | 1                             |                          |
| <i>Cyperus</i>           | <i>baspan</i>              |             | HAW          | 2                             | WWW                      |
| <i>Cyperus</i>           | <i>papyrus</i>             |             |              | 2                             | AF                       |
| <i>Didiplis</i>          | <i>diandra</i>             |             |              |                               |                          |
| <i>Echinodorus</i>       | <i>cordifolius</i>         | WA          |              | 3                             | NA                       |
| <i>Echinodorus</i>       | <i>grandiflorus</i>        |             |              |                               | SA                       |
| <i>Eleocharis</i>        | <i>acicularis</i>          |             |              | 4                             | WWW                      |
| <i>Eleocharis</i>        | <i>dulcis</i>              |             |              | 3                             | WWW                      |
| <i>Eleocharis</i>        | <i>parvula</i>             |             |              | 1                             |                          |
| <i>Eleocharis</i>        | <i>vivipara</i>            |             |              |                               | NA                       |
| <i>Eichbornia</i>        | <i>azurea</i>              | WA          | Fed, FL, NC  | 3                             | SA                       |
| <i>Eichbornia</i>        | <i>diversifolia</i>        |             | FL           |                               |                          |
| <i>Eichbornia</i>        | <i>paniculata</i>          |             | FL           |                               |                          |
| <i>Heteranthera</i>      | <i>zosterifolia</i>        |             |              | 1                             |                          |
| <i>Hibiscus</i>          | <i>palustris</i>           |             |              | 1                             |                          |
| <i>Hydrocharis</i>       | <i>morus-ranae</i>         |             | Can          |                               | EU/NA                    |
| <i>Hydrocotyle</i>       | <i>bonariensis</i>         |             |              | 3                             |                          |
| <i>Hydrocotyle</i>       | <i>sibthorpioides</i>      |             |              | 2                             |                          |
| <i>Hydrocotyle</i>       | <i>verticillata</i>        | WA          |              | 2                             | NA/SA                    |
| <i>Hygrophila</i>        | <i>difformis</i>           |             |              | 1                             |                          |
| <i>Hygrophila</i>        | <i>polysperma</i>          |             | Fed, FL2,NC  | 3                             | NA                       |
| <i>Ipomoea</i>           | <i>aquatica</i>            |             | Fed, FL, NC  | 5                             | NA,AS                    |
| <i>Iris</i>              | <i>versicolor</i>          |             | Sta          | 2                             |                          |
| <i>Iris</i>              | <i>virginica</i>           |             | Sta          |                               |                          |
| <i>Kosteletzkya</i>      | <i>virginica</i>           |             |              | 1                             |                          |
| <i>Limnobium</i>         | <i>spongia</i>             |             |              | 1                             |                          |
| <i>Limnophila</i>        | <i>beterophylla</i>        | WA          |              | 2                             |                          |
| <i>Limnophila</i>        | <i>sessiliflora</i>        |             | Fed, FL2, NC | 2                             |                          |
| <i>Ludwigia</i>          | <i>perennis</i>            |             |              | 1                             |                          |
| <i>Ludwigia</i>          | <i>repens</i>              |             |              | 3                             |                          |
| <i>Mentha</i>            | <i>aquatica</i>            |             |              | 3                             | EU                       |
| <i>Najas</i>             | <i>guadalupensis</i>       | WA          |              | 5                             | NA                       |

TABLE 2 *continued.*

| GENUS              | SPECIES                                   | AUSTRALASIA | N. AMERICA  | NO. CITATIONS<br>WA WEED LIST | CONTINENT<br>WHERE WEEDY |
|--------------------|---|-------------|-------------|-------------------------------|--------------------------|
| <i>Najas</i>       | <i>indica</i>                             |             |             | 1                             |                          |
| <i>Najas</i>       | <i>marina</i>                             |             | SC          | 5                             | WWW                      |
| <i>Nelumbo</i>     | <i>nucifera</i>                           |             |             | 1                             | AS                       |
| <i>Nelumbo</i>     | <i>lutea</i>                              | WA          |             | 4                             |                          |
| <i>Nuphar</i>      | <i>minimum</i>                            | WA          |             | 2                             |                          |
| <i>Nuphar</i>      | <i>pumila</i>                             | WA          |             | 3                             |                          |
| <i>Nuphar</i>      | <i>hybrid</i>                             | WA          |             | 3                             |                          |
| <i>Otellia</i>     | <i>alismoides</i>                         | WA          | Fed         | 4                             |                          |
| <i>Otellia</i>     | <i>ulvifolia</i>                          | WA          |             | 2                             |                          |
| <i>Pontederia</i>  | <i>cordata</i>                            |             |             | 5                             | NA                       |
| <i>Potamogeton</i> | <i>gayi</i>                               | WA          |             | 1                             |                          |
| <i>Potamogeton</i> | <i>perfoliatus</i>                        | NZ          |             |                               |                          |
| <i>Potentilla</i>  | <i>palustris</i>                          |             |             | 1                             |                          |
| <i>Rotala</i>      | <i>indica</i>                             | WA          |             | 4                             | AS                       |
| <i>Rotala</i>      | <i>rotundifolia</i>                       | WA          |             | 4                             |                          |
| <i>Sagittaria</i>  | <i>sagittifolia</i>                       |             | Fed, NC     | 2                             | EU, WWW                  |
| <i>Samolus</i>     | <i>valerandi</i>                          |             |             | 3                             |                          |
| <i>Saururus</i>    | <i>cernuus</i>                            |             |             | 1                             |                          |
| <i>Sparganium</i>  | <i>erectum</i>                            | WA          | Fed, FL, NC | 4                             | EU                       |
| <i>Typba</i>       | <i>domingensis</i>                        | WA          | NE5         | 8                             | NA, AU, WWW              |
| <i>Typba</i>       | <i>latifolia</i>                          | WA          | NE5         | 11                            | NA, WWW                  |
| <i>Typba</i>       | <i>laxmanni</i>                           | WA          |             | 3                             |                          |
| <i>Typba</i>       | <i>minima</i>                             | WA          |             | 3                             |                          |
| <i>Typba</i>       | <i>shuttleworthii</i>                     | WA          |             | 3                             |                          |
| <i>Vallisneria</i> | <i>asiatica</i>                           | WA          |             | 2                             |                          |
| <i>Vallisneria</i> | <i>americana</i> var.<br><i>biwaensis</i> | WA          |             | 2                             |                          |
| <i>Zosterella</i>  | <i>dubia</i>                              | WA          |             | 1                             |                          |

**Key to symbols used****Australasia**

NWS Listed in National Weed Strategy

WA Prohibited entry into Western Australia

NZ Listed in a New Zealand Plant Pest Management Strategy

**N America**

Fed USA Federal Noxious Weed

FL Florida List of Prohibited Aquatic, Wetland and Invasive Plants (Class 1)

FL2 Florida List of Prohibited Aquatic, Wetland and Invasive Plants (Class 2)

NC North Carolina Aquatic Weed Control Act

NE1 Invasive Plants from the Eastern Region (south to W. Virginia) (High priority)

NE5 Invasive Plants from the Eastern Region (Native invasive)

SC South Carolina state-listed noxious weed

HAW Listed in Hawaiian Ecosystems at Risk Project Index

State Noxious weed in other US state

Can Invasive plant of Natural Habitats in Canada (White et al. 1993)

**Continent where weedy**

AF Africa

AS Asia

AU Australia

EU Europe

NA North America

SA South/Central America

WWW recorded as one of world's worst weeds in Holm et al. (1997)

TABLE 3. WEED ASSESSMENT OF POTENTIAL PROBLEM PLANTS IN NEW ZEALAND USING THE AQUATIC WEED RISK ASSESSMENT MODEL\*.

|                                 | <i>Cabomba caroliniana</i> | <i>Typha latifolia</i> | <i>T. domingensis</i> | <i>Salvinia</i> spp. (not <i>molesta</i> ) | <i>Hygrophila polysperma</i> | <i>Sagittaria sagittifolia</i> | <i>Potamogeton perfoliatus</i> | <i>Hydrocotyle verticillata</i> | <i>Butomus umbellatus</i> | <i>Ipomoea aquatica</i> | <i>Najas guadalupensis</i> | <i>N. marina</i> | <i>Eichhornia azurea</i> | <i>Trapa natans</i> | <i>Ludwigia peruviana</i> | <i>Panicum repens</i> | <i>Myriophyllum spicatum</i> | <i>Pistia stratiotes</i> |
|---------------------------------|----------------------------|------------------------|-----------------------|--|------------------------------|--------------------------------|--------------------------------|---------------------------------|---------------------------|-------------------------|----------------------------|------------------|--------------------------|---------------------|---------------------------|-----------------------|------------------------------|--------------------------|
| <b>Versatility</b>              | 7                          | 7                      | 7                     | 6  | 7                            | 5                              | 7                              | 7                               | 7                         | 6                       | 7                          | 8                | 5                        | 4                   | 5                         | 7                     | 7                            | 5                        |
| temperature                     | 2                          | 1                      | 1                     | 1  | 1                            | 1                              | 2                              | 2                               | 2                         | 0                       | 3                          | 3                | 0                        | 0                   | 1                         | 1                     | 3                            | 0                        |
| salinity                        | 0                          | 1                      | 1                     | 0  | 0                            | 0                              | 0                              | 0                               | 0                         | 0                       | 0                          | 1                | 0                        | 0                   | 0                         | 1                     | 0                            | 0                        |
| habitat                         | 2                          | 2                      | 2                     | 2  | 2                            | 1                              | 2                              | 2                               | 2                         | 3                       | 2                          | 2                | 2                        | 1                   | 2                         | 3                     | 2                            | 2                        |
| water/substrate                 | 2                          | 2                      | 2                     | 2  | 2                            | 2                              | 2                              | 2                               | 2                         | 2                       | 2                          | 2                | 2                        | 2                   | 1                         | 1                     | 2                            | 2                        |
| clarity                         | 1                          | 1                      | 1                     | 1  | 1                            | 1                              | 0                              | 1                               | 1                         | 1                       | 0                          | 0                | 1                        | 1                   | 1                         | 1                     | 0                            | 1                        |
| <b>Habitat</b>                  | 5                          | 4                      | 4                     | 3  | 4                            | 4                              | 4                              | 4                               | 4                         | 4                       | 4                          | 4                | 4                        | 3                   | 4                         | 6                     | 5                            | 3                        |
| lentic                          | 2                          | 0                      | 0                     | 0  | 2                            | 0                              | 2                              | 2                               | 1                         | 1                       | 2                          | 2                | 2                        | 0                   | 1                         | 1                     | 2                            | 0                        |
| lotic                           | 3                          | 3                      | 3                     | 3  | 1                            | 1                              | 2                              | 1                               | 1                         | 1                       | 2                          | 2                | 2                        | 3                   | 0                         | 2                     | 3                            | 3                        |
| wetland                         | 0                          | 1                      | 1                     | 0  | 1                            | 3                              | 0                              | 1                               | 2                         | 2                       | 0                          | 0                | 0                        | 0                   | 3                         | 3                     | 0                            | 0                        |
| <b>Competition</b>              | 6                          | 5                      | 3                     | 6  | 5                            | 4                              | 3                              | 5                               | 4                         | 4                       | 2                          | 2                | 10                       | 10                  | 10                        | 10                    | 7                            | 7                        |
| within                          | 6                          | 5                      | 3                     | 5  | 4                            | 4                              | 3                              | 3                               | 3                         | 3                       | 2                          | 2                | 8                        | 8                   | 8                         | 8                     | 7                            | 6                        |
| between                         | 0                          | 0                      | 0                     | 1  | 1                            | 0                              | 0                              | 2                               | 1                         | 1                       | 0                          | 0                | 2                        | 2                   | 2                         | 2                     | 0                            | 1                        |
| <b>Dispersal</b>                | 4                          | 7                      | 7                     | 5  | 5                            | 8                              | 8                              | 3                               | 5                         | 5                       | 8                          | 8                | 4                        | 4                   | 9                         | 3                     | 4                            | 5                        |
| bird/wind                       | 0                          | 5                      | 5                     | 0  | 0                            | 5                              | 5                              | 0                               | 0                         | 0                       | 5                          | 5                | 0                        | 0                   | 5                         | 0                     | 0                            | 0                        |
| accidental                      | 2                          | 1                      | 1                     | 3  | 3                            | 1                              | 2                              | 1                               | 3                         | 3                       | 2                          | 2                | 2                        | 2                   | 2                         | 2                     | 2                            | 3                        |
| deliberate                      | 1                          | 0                      | 0                     | 1  | 1                            | 1                              | 0                              | 1                               | 1                         | 1                       | 1                          | 1                | 1                        | 1                   | 1                         | 0                     | 1                            | 1                        |
| within                          | 1                          | 1                      | 1                     | 1  | 1                            | 1                              | 1                              | 1                               | 1                         | 1                       | 1                          | 1                | 1                        | 1                   | 1                         | 1                     | 1                            | 1                        |
| <b>Maturation</b>               | 3                          | 1                      | 1                     | 3  | 3                            | 2                              | 3                              | 2                               | 2                         | 3                       | 3                          | 3                | 2                        | 3                   | 3                         | 3                     | 3                            | 3                        |
| <b>Seeding</b>                  | 3                          | 4                      | 4                     | 0  | 2                            | 4                              | 4                              | 2                               | 5                         | 2                       | 5                          | 5                | 5                        | 3                   | 5                         | 0                     | 4                            | 0                        |
| quantity                        | 1                          | 3                      | 3                     | 0  | 1                            | 3                              | 2                              | 1                               | 3                         | 1                       | 3                          | 3                | 3                        | 1                   | 3                         | 0                     | 2                            | 0                        |
| viability                       | 2                          | 1                      | 1                     | 0  | 1                            | 1                              | 2                              | 1                               | 2                         | 1                       | 2                          | 2                | 2                        | 2                   | 2                         | 0                     | 2                            | 0                        |
| <b>Cloning</b>                  | 5                          | 3                      | 3                     | 3  | 3                            | 3                              | 3                              | 3                               | 3                         | 5                       | 3                          | 3                | 5                        | 5                   | 5                         | 5                     | 5                            | 3                        |
| <b>BIOLOGICAL SUCCESS</b>       | 33                         | 31                     | 29                    | 26   | 29                           | 31                             | 31                             | 26                              | 30                        | 24                      | 32                         | 33               | 35                       | 32                  | 41                        | 34                    | 35                           | 27                       |
| <b>Obstruction</b>              | 8                          | 4                      | 4                     | 5  | 6                            | 3                              | 3                              | 3                               | 1                         | 6                       | 3                          | 3                | 9                        | 4                   | 5                         | 8                     | 9                            | 4                        |
| water use                       | 2                          | 1                      | 1                     | 1  | 1                            | 0                              | 1                              | 0                               | 0                         | 2                       | 1                          | 1                | 2                        | 2                   | 1                         | 1                     | 2                            | 1                        |
| access                          | 0                          | 1                      | 1                     | 1  | 0                            | 1                              | 0                              | 1                               | 1                         | 0                       | 0                          | 0                | 1                        | 0                   | 1                         | 2                     | 1                            | 1                        |
| flow                            | 2                          | 0                      | 0                     | 1  | 2                            | 0                              | 0                              | 1                               | 0                         | 1                       | 1                          | 1                | 2                        | 0                   | 0                         | 2                     | 2                            | 0                        |
| irrigation                      | 2                          | 1                      | 1                     | 1  | 2                            | 2                              | 1                              | 1                               | 0                         | 2                       | 1                          | 1                | 2                        | 0                   | 2                         | 2                     | 2                            | 1                        |
| aesthetic                       | 2                          | 1                      | 1                     | 1  | 1                            | 0                              | 1                              | 0                               | 0                         | 1                       | 0                          | 0                | 2                        | 2                   | 1                         | 1                     | 2                            | 1                        |
| <b>Natural areas</b>            | 6                          | 6                      | 6                     | 7  | 3                            | 3                              | 4                              | 4                               | 3                         | 4                       | 2                          | 2                | 7                        | 6                   | 6                         | 7                     | 9                            | 6                        |
| biodiversity                    | 5                          | 5                      | 5                     | 5  | 2                            | 3                              | 2                              | 3                               | 3                         | 3                       | 2                          | 2                | 5                        | 5                   | 5                         | 5                     | 5                            | 4                        |
| water quality                   | 0                          | 1                      | 1                     | 1  | 0                            | 0                              | 1                              | 0                               | 0                         | 0                       | 0                          | 0                | 1                        | 0                   | 0                         | 1                     | 3                            | 2                        |
| physical                        | 1                          | 0                      | 0                     | 1  | 1                            | 0                              | 1                              | 1                               | 0                         | 1                       | 0                          | 0                | 1                        | 1                   | 1                         | 1                     | 1                            | 0                        |
| <b>Other</b>                    | 0                          | 0                      | 0                     | 1  | 0                            | 0                              | 0                              | 0                               | 0                         | 0                       | 0                          | 0                | 1                        | 1                   | 0                         | 0                     | 1                            | 1                        |
| health                          | 0                          | 0                      | 0                     | 1  | 0                            | 0                              | 0                              | 0                               | 0                         | 0                       | 0                          | 0                | 1                        | 1                   | 0                         | 0                     | 1                            | 1                        |
| weed                            | 0                          | 0                      | 0                     | 0  | 0                            | 0                              | 0                              | 0                               | 0                         | 0                       | 0                          | 0                | 0                        | 0                   | 0                         | 0                     | 0                            | 0                        |
| <b>Habitat</b>                  | 8\8                        | 10\10                  | 10\11                 | 5\5  | 2\2                          | 9\9                            | 10\10                          | 8\8                             | 10\10                     | 2\2                     | 8\8                        | 10\10            | 1\1                      | 10\10               | 5\5                       | 2\2                   | 10\10                        | 1\1                      |
| <b>Resistance to management</b> | 6                          | 2                      | 2                     | 4  | 2                            | 3                              | 3                              | 3                               | 6                         | 4                       | 6                          | 6                | 4                        | 5                   | 2                         | 4                     | 5                            | 3                        |
| implementation                  | 1                          | 1                      | 1                     | 1  | 1                            | 1                              | 1                              | 0                               | 0                         | 0                       | 1                          | 1                | 1                        | 1                   | 1                         | 1                     | 1                            | 1                        |
| recognition                     | 1                          | 0                      | 0                     | 0  | 0                            | 0                              | 0                              | 0                               | 0                         | 0                       | 1                          | 1                | 0                        | 0                   | 0                         | 0                     | 1                            | 0                        |
| scope                           | 1                          | 0                      | 0                     | 1  | 0                            | 0                              | 1                              | 1                               | 2                         | 1                       | 1                          | 1                | 1                        | 1                   | 0                         | 0                     | 0                            | 1                        |
| suitability                     | 1                          | 0                      | 0                     | 1  | 1                            | 0                              | 0                              | 0                               | 0                         | 1                       | 1                          | 1                | 1                        | 1                   | 0                         | 1                     | 1                            | 1                        |
| effectiveness                   | 1                          | 0                      | 0                     | 0  | 0                            | 0                              | 0                              | 1                               | 2                         | 1                       | 1                          | 1                | 0                        | 1                   | 0                         | 1                     | 1                            | 0                        |
| duration                        | 1                          | 1                      | 1                     | 1  | 0                            | 2                              | 1                              | 1                               | 2                         | 1                       | 1                          | 1                | 1                        | 1                   | 1                         | 1                     | 1                            | 0                        |
| <b>Other countries</b>          | 5                          | 5                      | 5                     | 4  | 2                            | 4                              | 3                              | 4                               | 4                         | 2                       | 3                          | 3                | 2                        | 5                   | 5                         | 5                     | 4                            | 2                        |
| <b>WEEDINESS</b>                | 25                         | 27                     | 27                    | 22   | 15                           | 22                             | 24                             | 22                              | 24                        | 18                      | 22                         | 24               | 24                       | 31                  | 23                        | 27                    | 38                           | 15                       |
| <b>TOTAL SCORE</b>              | 58                         | 58                     | 56                    | 48   | 44                           | 53                             | 55                             | 48                              | 54                        | 42                      | 54                         | 57               | 59                       | 63                  | 64                        | 61                    | 73                           | 42                       |

\* This table does not include 55 species in Table 2 as there was insufficient information to apply the Aquatic Weed Risk Assessment Model.

TABLE 4. COMPARISON OF WEED RISK ASSESSMENT SCORES OF THE WORST POTENTIAL AND ACTUAL AQUATIC WEEDS IN NEW ZEALAND\*.

| AQUATIC WEED SPECIES               | STATUS | AQUATIC WEED RISK ASSESSMENT RANKING |
|------------------------------------|--------|--------------------------------------|
| <i>Phragmites australis</i>        | PPS    | 75                                   |
| <i>Hydrilla verticillata</i>       | NS     | 74                                   |
| <i>Myriophyllum spicatum</i>       | n      | 73                                   |
| <i>Zizania latifolia</i>           | NS     | 68                                   |
| <i>Ceratophyllum demersum</i>      | NS     | 67                                   |
| <i>Eichbornia crassipes</i>        | PPS    | 67                                   |
| <i>Egeria densa</i>                | NS     | 64                                   |
| <i>Ludwigia peruviana</i>          | n      | 64                                   |
| <i>Alternanthera philoxeroides</i> | NS     | 63                                   |
| <i>Trapa natans</i>                | n      | 63                                   |
| <i>Panicum repens</i>              | n      | 61                                   |
| <i>Lagarosiphon major</i>          | NS     | 60                                   |
| <i>Eichbornia azurea</i>           | t      | 59                                   |
| <i>Cabomba caroliniana</i>         | t      | 58                                   |
| <i>Nymphoides peltata</i>          | PPS    | 58                                   |
| <i>Typha latifolia</i>             | ?      | 58                                   |
| <i>Gymnocoronis spilanthoides</i>  | PPS    | 57                                   |
| <i>Najas marina</i>                | ?      | 57                                   |
| <i>Salvinia molesta</i>            | PPS    | 57                                   |
| <i>Myriophyllum aquaticum</i>      | NS     | 56                                   |
| <i>Typha domingensis</i>           | ?      | 56                                   |
| <i>Potamogeton perfoliatus</i>     | xt     | 55                                   |
| <i>Azolla pinnata</i>              | UC     | 54                                   |
| <i>Butomus umbellatus</i>          | ?      | 54                                   |
| <i>Lytbrum salicaria</i>           | PPS    | 54                                   |
| <i>Najas guadalupensis</i>         | ?      | 54                                   |
| <i>Spartina anglica</i>            | PPS    | 54                                   |
| <i>Utricularia gibba</i>           | NS     | 54                                   |
| <i>Sagittaria sagittifolia</i>     | ?      | 53                                   |
| <i>Spartina alterniflora</i>       | PPS    | 53                                   |
| <i>Iris pseudacorus</i>            | NS     | 52                                   |
| <i>Sagittaria platyphylla</i>      | PPS    | 52                                   |
| <i>Glyceria maxima</i>             | UC     | 51                                   |
| <i>Ludwigia peploides</i>          | NS     | 51                                   |
| <i>Mimulus guttatus</i>            | UC     | 51                                   |
| <i>Vallisneria gigantea</i>        | PPS    | 51                                   |
| <i>Vallisneria spiralis</i>        | PPS    | 51                                   |
| <i>Apium nodiflorum</i>            | UC     | 50                                   |

**Key to symbols used**

|     |   |  |
|-----|---|--|
| PPS | Present in NZ                               | Controlled under Plant Pest Management Strategy (PPMS) |
| NS  | Present in NZ                               | Not controlled by PPMS, but banned from sale           |
| UC  | Present in NZ                               | Not controlled or banned from sale by PPMS             |
| t   | Present in NZ                               | Not naturalised  |
| xt  | Present in NZ                               | Not naturalised, banned from sale by PPMS              |
| ?   | Reported as present in NZ, but not verified |  |
| n   | Not present in NZ                           |  |

\* This table does not include the species in Table 2 as there was insufficient information to apply the Aquatic Weed Risk Assessment Model.

#### 4.1 *Myriophyllum spicatum*

*Myriophyllum spicatum* (Fig. 2) is ranked as the world's second most problematic submerged aquatic weed (after *Hydrilla verticillata*), is classified as a weed in more than 50 countries (Holm et al. 1997), and ranked third using the Aquatic Weed Risk Assessment Model (Table 4).

It is unknown from within New Zealand. Its current distribution includes temperate Eurasia (its native range) and in North America and South Africa where it is an established alien. It is distributed by the aquarium trade in Europe and is most likely to enter New Zealand as an aquarium or ornamental pond plant.



Figure 2. *Myriophyllum spicatum*.

#### 4.2 *Ludwigia peruviana*

*Ludwigia peruviana* is a tall (up to 3 m) emergent macrophyte native to South America. It is not known to be present in New Zealand but is naturalised in the southern USA, India, S.E. Asia and Australia. In Australia it is spreading north and south from Sydney, and dominates wetlands and watercourse margins. It is distributed by the aquarium trade, produces copious seed that may be distributed by birds, and seed could potentially be introduced to New Zealand through contaminated machinery or containers. Introduction as an ornamental pond plant is assessed as the most likely entry pathway, but inspection of container storage/transit areas in Sydney may be warranted.

#### 4.3 *Trapa natans*

*Trapa natans* (Fig. 3) is a free-floating, or waterlily-type macrophyte with a disjunct native distribution in parts of Europe, Africa and Asia. It is a problem in E. Europe, Iran, Botswana, and the USA where it forms dense floating mats that can completely cover the surface of waterbodies. Its status in Australia is unknown, but it appears to be absent from New Zealand. The large spiny fruit are eaten in many Asian countries where the plant is known as water chestnut (not to be confused with *Eleocharis dulcis* which has the same common name), and it is also distributed as an ornamental pond plant overseas. This plant could be introduced into New Zealand for either of these purposes.



Figure 3. *Trapa natans* showing spiny fruit.

#### 4.4 *Panicum repens*

*Panicum repens* is a sprawling marginal emergent grass distributed throughout tropical and subtropical areas, where it is a weed in many countries. It is unknown in New Zealand and Australia. It usually spreads vegetatively, and very small fragments containing only one node are sufficient to act as propagules. This plant is not spread through the aquarium or pond plant trade; the main mode of entry into New Zealand would be via contaminated machinery or containers.

#### 4.5 *Eichhornia azurea*

*Eichhornia azurea* is a waterlily-type plant native to tropical South America. It has also been reported as naturalised in Texas and S.E. Asia. It is present in the aquarium trade in New Zealand, but not currently offered for sale. Previous to this investigation plants were obtained by the authors and cultured at the Ruakura experimental facility. Plants grew poorly outside during summer, and did not produce emergent foliage, even at temperatures of 25–30°C in controlled temperature rooms. This species is seen as an obligate tropical plant, unlikely to become established under New Zealand climatic conditions.

#### 4.6 *Cabomba caroliniana*

*Cabomba caroliniana* is an obligate submerged macrophyte native to Central and South America (possibly southern USA) and now naturalised in eastern USA, southern Europe, India and Australia. It has been cultivated in New Zealand as an aquarium plant for at least 30 years, but has not naturalised.

This plant is included as one of the four true aquatic plants on the list of 20 Australian Weeds of National Significance (the others being *Alternanthera philoxeroides*, *Hymenachne amplexicaule* and *Salvinia molesta*), and a draft management strategy has recently been published for public comment (Edwards 2000). Climate modelling suggests that this species could potentially grow in most lowland New Zealand water bodies; however, it does not reproduce sexually outside of its native range and limited competitive studies have shown that it would be displaced by *Egeria densa*. It may thus be premature to ban this species from sale and distribution without undertaking some experimental assessment of its weed potential in New Zealand.

#### 4.7 *Typha latifolia* AND *T. domingensis*

*Typha latifolia* and *T. domingensis* are almost cosmopolitan erect emergent species. *T. latifolia* is not indigenous in Australia, Polynesia, southern Asia or central and southern Africa, whereas *T. domingensis* is absent from South America. *T. latifolia* has established as a naturalised alien in Australia, and both species cause weed problems there and in much of their native range. Where these species grow together, *T. latifolia* is the most aggressive, displacing *T. domingensis* to deeper water (Grace 1988). Neither species is naturalised in New Zealand, and positive identification of plants in cultivation has yet to be confirmed. It is still possible to legally import seed of either species. If these species are not yet found in New Zealand, then importation of seed is the most likely entry pathway. However, wind-blown seed, produce or machinery contaminated with seed are also possible paths of entry.

#### 4.8 *Najas marina* AND *N. guadalupensis*

Both *Najas* species are obligate submerged macrophytes widely distributed in temperate and tropical regions, although *N. guadalupensis* is restricted to the Americas. Both species are reported as weedy, but usually only in disturbed habitats. Each species produces large amounts of seed which may be spread by waterfowl. Neither species has been seen by the authors in New Zealand, but we are reliably informed that these are grown by some hobbyists.

It is unlikely that these species would be competitive against the hydrocharitacean species currently in New Zealand, but they could establish in frequently disturbed sites, or colonise areas where weed beds are controlled either mechanically or chemically. As they can be spread by waterfowl there is also the potential that they could be spread to remote waters which are currently at little risk from most of our aquatic weeds. *N. marina* is tolerant of brackish water and could invade areas not presently impacted by alien macrophytes in New Zealand.

Figure 4. *Najas marina*.



#### 4.9 *Potamogeton perfoliatus*

*Potamogeton perfoliatus* is an obligate submerged macrophyte with an almost cosmopolitan temperate distribution. It was first found in an ornamental pond near Queenstown and was traced back to nurseries in Queenstown and Christchurch. Since its discovery this plant has been banned from sale and distribution and all plant material from three sites has been destroyed. This species can apparently set seed in New Zealand (authors unpublished records) and, being a favoured food of waterfowl, it could rapidly spread. Further introductions into New Zealand could occur through the aquarium trade.

#### 4.10 *Butomus umbellatus*

*Butomus umbellatus* is an erect emergent macrophyte with a native range of Europe and temperate Asia. This species is naturalised in Canada and northern USA, where it is spreading slowly. The plant may have been introduced into New Zealand as an ornamental plant, we are awaiting flowering material to confirm this. It is widely grown and distributed overseas as an ornamental pond plant.

Although most Canadian ecologists consider *B. umbellatus* to be only a minor weed (White et al. 1993), its seed production, asexual reproduction and temperature tolerance attributes make the plant a potential risk to New Zealand water body margins.

#### 4.11 *Sagittaria sagittifolia*

*Sagittaria sagittifolia* is an erect emergent macrophyte native to Europe and temperate Asia, where it is regarded as a minor nuisance. It is widely cultivated as an ornamental pond plant and was regarded as being present in New Zealand (Landcare database). However, critical examination of all herbarium material and plants being sold as this species have shown these to be *S. montevidensis*,



an American species which has a similar leaf-shape and flower coloration, but lacks spreading rhizomes, tubers and reflexed sepals. *S. montevidensis* is banned from sale and distribution by Regional Plant Pest Management Strategies (prepared by all Regional Councils and Unitary Authorities in New Zealand) and the only known sites where it is naturalised (both in Auckland) are actively managed to prevent its spread. Introduction as an ornamental pond plant is assessed as the most likely entry pathway.

## 5. Pathways of imported aquatic plants

In the two years since its initiation (1<sup>st</sup> July 1998), the Environmental Risk Management Authority (ERMA) assessed only four plant species for importation. Under the legislation setting up this authority (the Hazardous Substances and New Organisms Act 1996) all organisms not already present within New Zealand must be evaluated by ERMA prior to importation. Two of the plants evaluated (two species of *Xanthorrhoea*, the endemic Australian grass trees) were probably already present in New Zealand prior to this application (P.J. de Lange pers. comm.). No imports of aquatic plants already present in New Zealand (as reported on the Landcare database/Biosecurity Index) have been processed by ERMA or the Ministry of Agriculture and Forestry in the last two years (M. Dickson pers. comm.). From this it could be assumed that no aquatic plants are currently being imported.

The aquatic plant importers almost unanimously regarded the current importation regulations as impractical, with the costs involved with ERMA evaluation and post-entry quarantine conditions making legal importation too expensive when compared with the value of imported stock. All were critical of the lack of botanical expertise of personnel involved in plant inspections and considered the regulations to be draconian, and had little confidence in the authorities involved in protection of New Zealand's borders.

The results of our survey of importers and exporters would indicate that at least 52 aquatic plant species (possibly 65 or more) are now being distributed as aquarium or pond plants, and yet they were not previously known to be present in New Zealand. This equates to at least 27% of the species present within the aquatic plant trade. It is highly likely that many of these species have been imported without screening by border control. Many of the plants available in the trade are likely to have been obtained from amateur enthusiasts; indeed, at least one of the major aquarium plant suppliers does not import.

It is therefore difficult to gauge the volume of imported aquatic plants entering New Zealand, but it would appear that any species entering within the last two years would have done so illegally and were therefore not screened for potential weediness.

## 6. Vulnerable indigenous aquatic communities and species

Freshwater ecosystems are among the most heavily impacted ecosystems in New Zealand due to the invasion of introduced plant species. Since European settlement, introduced plants have spread throughout most New Zealand water bodies. Few waterbodies are still free of introduced species. Those that remain in their natural condition are usually isolated from human settlements or, in the case of the Kai Iwi lakes, Northland, have water with very low dissolved CO<sub>2</sub>/bicarbonate status which prevents the colonisation of vascular species (NIWA unpublished data). Isolated waterbodies still supporting a wholly indigenous aquatic flora include Lake Waikareiti in the North Island and Lake Lochnagar in the South Island. At least 50 aquatic plant species are now naturalised in New Zealand and many of them have a significant impact on indigenous vegetation and other biota (Champion 1998).

Most of these alien species (75%) were introduced to New Zealand as ornamental plants. Their subsequent spread into natural water bodies has mostly been from deliberate planting by humans. Of the remainder, some are presumed to have been introduced as contaminants of other water plants (e.g. *Spirodela punctata*), in ships' ballast (e.g. *Alternanthera philoxeroides*), or as seed in contaminated soil (e.g. *Callitriche stagnalis*).

New Zealand has a diverse native aquatic flora, although most species are low growing. Unlike much of the terrestrial flora, there is a relatively low rate of endemism, with only 17 of the 59 (29%) indigenous aquatic species restricted to New Zealand. Prior to European settlement, obligate submerged native vegetation was dominated by the macro-algae, known as charophytes, in the genera *Chara* (four common species) and *Nitella* (seven common species) with seven common flowering plants (three species of *Myriophyllum*, three species of *Potamogeton* and *Utricularia protrusa*) and the fern ally *Isoetes*. A much larger assemblage of plants (over 30 species belonging to many different plant families) formed low amphibious turfs in the shallow margins of water bodies. Free-floating plants were found in sheltered areas and included the fern (*Azolla rubra*), duckweed (*Lemna minor*) and two species of liverwort. A diverse range of tall sedges (greater than 1 m tall) and raupo (*Typha orientalis*) commonly grew on the shallow fringes of water bodies with leaves emergent above the waters surface. Swamp willow weed (*Persicaria decipiens*) and several grasses were also emergent plants, but had a sprawling growth form. These emergent plants grew in water as deep as 3 m in sheltered areas.

Only a few aquatic species are considered endangered with the following species recognised by de Lange et al. (1999):

### ***Critically Endangered***

*Amphibromus fluitans*                      erect emergent in ephemeral pools

### ***Endangered***

*Crassula hunua*                              amphibious submerged

*Triglochin palustris*                      amphibious submerged

### ***Vulnerable***

*Utricularia protrusa* free-floating

### ***Declining***

*Hydatella inconspicua* obligate submerged

*Myriophyllum robustum* obligate submerged/sprawling emergent

All of these species are currently under threat from various alien plants (Reid, 1998) and most are now restricted to habitats where weeds are not well established.

Alien aquatic plants threaten both indigenous aquatic systems and rare component species of these systems. As the remaining intact indigenous aquatic systems and species are usually isolated from human influences, the greatest immediate threats are posed by species that may be spread by non-human activities, i.e. dispersed by waterfowl or other biota, or wind-borne propagules. Of the species reviewed in Sections 1 and 2, major threats come from genera that freely produce avian-dispersed seed including *Myriophyllum*, *Potamogeton*, *Najas*, *Sagittaria*, and *Ludwigia*, and wind-dispersed seed of *Typha*.

## 7. Discussion

The Aquatic Plant Weed Risk Assessment Model indicates the need for a review of the status of several plants present (some still requiring confirmation of this) but not yet naturalised within New Zealand. Well known problem species not known to be introduced here (e.g. *Myriophyllum spicatum*, *Trapa* spp., and *Ludwigia peruviana*), as well as genera which freely produce avian-dispersed or wind-dispersed seed (including *Myriophyllum*, *Potamogeton*, *Najas*, *Sagittaria*, and *Ludwigia*, and *Typha*) should be prohibited entry into New Zealand.

There is a lack of information available on the biology and ecology of many aquatic plants, and there is also the possibility that some species could become a problem even though they are not weedy elsewhere in the world. Several current weed species in New Zealand (including *Nymphoides geminata* and *Menyanthes trifoliata*) are not known to be weeds elsewhere. This means that evaluation of many species using weed risk models as the sole screening process for entry into New Zealand will not always indicate how they would behave as weeds here. Added to this is the current lack of surveillance once a plant has entered New Zealand.

It is recommended that all newly introduced aquatic species should be monitored for invasive tendencies under New Zealand conditions. This approach has previously been carried out under the Noxious Plants Act (1978), where 14 aquatic species were gazetted as target noxious plants due to their observed weed threat under New Zealand conditions combined, where available, with evidence of weediness overseas. This approach has led to the eradication or near eradication of 11 of these species, but depends on a high level of expertise and vigilance of field staff carrying out this role.

A more active approach would be the post-entry evaluation of species with weed potential advocated by Hazard (1988). Performance under New Zealand conditions and competition experiments with existing problem species and indigenous plants could be undertaken in virtual quarantine conditions (e.g. Grace 1988; Hofstra et al. 1999).

## 8. Recommendations

Specific recommendations arising from this investigation are:

- The status of the 25 potential weed species referred to but not seen in this study should be clarified.
- Weed potential of *Hygrophila polysperma*, *Hydrocotyle verticillata*, *Cabomba caroliniana* and *Saururus cernuus* should be determined by experimental evaluation. Other species such as *Butomus umbellatus*, *Hydrocharis morus-ranae*, *Limnobium spongia*, *Najas* spp., *Potamogeton gayii*, *Sparganium erectum*, *Typha latifolia* and *T. domingensis* should also be evaluated if they are confirmed as being present in New Zealand.
- The importation of seed of *T. latifolia*, *T. domingensis* and *S. erectum* should be prevented by reclassifying these species as Prohibited Entry on the MAF Biosecurity Index<sup>2</sup>.
- In light of the apparent failure of current legislation and post-entry evaluation to adequately regulate the importation of aquatic plants, this study should be extended to:
  - Assess existing management systems (including determination of unwanted organisms, development of import health standards, and assessment of new organisms) and make recommendations on alternative, more effective management measures.
  - Co-ordinate inputs from legislators, trades people and hobbyists involved with the culture of aquatic plants to determine such measures.

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<sup>2</sup> Seeds of these species are now not permitted for importation, following the submission of this report and alerting MAF to this situation.

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