7. Biosecurity – minimising the spread of aquatic weeds in Northland lakes

7.1 Introduction

Once weeds become established in a water body, eradication is rarely an option and many of the problem weeds (like hornwort, egeria and alligator weed) continue to spread through the country. Therefore a pro-active approach, attempting to keep unaffected water bodies weed-free, would appear to be the best approach. This strategy involves educating those groups responsible for spreading weeds, carrying out surveillance at high-risk sites and attempting eradication or containment of any new weed detections.

The Northland Regional Council (NRC) Plant Pest Management Strategy has the following objectives:

1. Collection of baseline data: Collection of current and historic data on aquatic vegetation of water bodies within the region and survey of water bodies for current weed status.

2. Prioritisation of water bodies: Rank water bodies in the region for biodiversity, factoring in current weed status and vulnerability to weed invasion from data collected in 1.

3. Identification of weed introduction pathways and risks: Identify nearest, or most accessible weed sources, vectors and consider the probability of weed transfer.

4. Surveillance of prioritised water bodies.

5. Preparation of contingency plans to enable a pre-considered rapid response to invasions at an early stage.

This section reports on these objectives and includes generic guidelines for a rapid response contingency plan.

7.2 Weed status of Northland lakes

The baseline vegetation methods and assessments are outlined in Sections 2 & 3. Alien invasive weeds which deleteriously impact or threaten the Northland lakes are listed in Table 4.1. Those not included in this exercise were: *Azolla pinnata, Callitriche stagnalis, Elodea canadensis, Juncus bulbosus, Landoltia* (*Spirodela*) *punctata, Ludwigia palustris, Nymphaea alba* and hybrids, *Ottelia ovalifolia, Paspalum distichum,* and *Potamogeton crispus.* The impacts of these weeds (Section 4.4) are minor compared to those weeds in Table 4.1, although elodea would need to be considered as a threat in a number of high priority water bodies.

Table 4.1: Pest plant species distribution in Northland (First record for each lake in parentheses).

Species	Lake or location	Lake No.	Grid reference (if not part of lake survey)	Comments
Submerged plants				
Ceratophyllum demersum	Heather (2001)	125		Co-dominant with *Egeria densa* and *Potamogeton ochreatus* (native)
	Kihona (2004)	31		Dominant throughout lake
	Mini (2004)	130		Reconnaissance survey at 1 site, local with *Egeria densa* dominant species
	Ngakeketa (1985)	14		Dominant throughout lake
	Te Werahi Lagoon (2004)	6		Reconnaissance survey at 1 site, co-dominant with *Egeria densa* and *Potamogeton ochreatus* (native)
	Waimimiha N (2004)	135		Dominant throughout lake
	Swan (2005)	355		Dominant through much of lake, displacing *Egeria densa* since 2001, increasing in abundance.
	Awanui River (2001)		2534465E; 6683974N	
	Drains west of Kaitaia (2004)			DoC records (L. Sherwood pers. comm.)
	Drains south of Karikari Peninsula (2004)			DoC records (L. Sherwood pers. comm.)
	Drains south of Dargaville (2008)			C. Cooper (NRC pers. comm.)

Species	Lake or location	Lake No.	Grid reference (if not part of lake survey)	Comments
Egeria densa	Heather (2001)	125		Co-dominant with *Ceratophyllum demersum* and *Potamogeton ochreatus*
	Mini (2004)	130		Reconnaissance survey at 1 site, dominant at this site
	Ngakeketa N (Te Paki) (2004)	13		A recent introduction, widespread and becoming dominant
	Rotoroa (1985)	126		Dominant throughout lake
	Te Werahi Lagoon (2004)	6		Reconnaissance survey at 1 site, co-dominant with *Ceratophyllum demersum* and *Potamogeton ochreatus*
	Waiparera (1985)	102		Limited impact, in lake with little vegetation
	Omapere (1983)	173		Formerly dominant throughout lake, now eradicated?
	Owhareiti (1983)	177		Dominant throughout lake
	Stanner's Road Dam (2008)	148A		Dominant throughout dam
	Waro (2006)	410		Early invasion, scattered throughout depth range
	Rotokawau (2001)	364		Patchy distribution and limited impact, not all native spp. displaced
	Roto-otuauru (2001)	355		Formerly dominant throughout lake, now common and locally dominant
	Awanui River (1964)		2534465E; 6683974N	Herbarium specimen
	Wairua Falls (1993)		2608753E; 6605562N	DoC record
	Waipapa River (2001)		2588888E; 6667723N	NIWA survey
	Waitangi River trib. (2001)		2589999E; 6658733N	NIWA survey
	Waitangi River trib. (2001)		2588643E; 6658333N	NIWA survey

Species	Lake or location	Lake No.	Grid reference (if not part of lake survey)	Comments
Lagarosiphon major	Waiparera (1970)	102		Limited impact, lake poorly vegetated but not all native spp. displaced
	Ngatu (1988)	120		Patchy distribution and localised impact in shallows (<3 m), limited native spp. displacement
	Phoebe (2000)	346		Reconnaissance survey at 1 site, dominant from 1 to 2.5 m, native vegetation below this
Vallisneria spiralis	Purerua, Kerikeri (2004)		2597300E; 6668600N	Artificial dam 20 x 24m, 90-100% cover
Utricularia gibba				Rapid spread from 1999 to 2009, spreading from one lake to most of the region including the Kai-Iwi lakes.
	Austria (2004)	22		Covers of >50% over most submerged vegetation
	Carrot (2004)	118		Low covers (<5%) to 2.5 m
	Forest Lake/Deans Swamp	114		Not surveyed in 2004, but likely to be similar impact to other lakes in area
	Heather (2004)	125		Locally dominant in shallows (to 1.3 m deep), absent below this
	Little Gem (2007)	123		Dominant amongst emergents, scattered to 2.6 m
	Mini (2004)	130		Covers of 25-50% in shallows (~ 1 m)
	Morehurehu (2004)	32		Dominant amongst emergents, scattered to 3 m, native vegetation below this
	Morehurehu S (2004)	36		Covers of >50% over most submerged vegetation
	Ngakapua N (2004)	115		Covers of 25-50% over most submerged vegetation to 3 m deep
	Ngakapua S (2004)	117		Covers of 25-50% over most submerged vegetation to 2.6 m deep
	Ngatu (2004)	120		Common in shallow water sprawling over *Lagarosiphon major* and emergents
	Rotokawau (2004)	116		Covers of >50% over most submerged vegetation to 2.8 m deep
	Rotoroa (2004)	126		Low covers (<5%) to 2.5 m, absent from 3 of 5 profiles
	Te Arai Lake (2004)	47		Low covers and limited apparent impact amongst emergents

Species	Lake or location	Lake No.	Grid reference (if not part of lake survey)	Comments
Utricularia gibba	Te Paki Dune (2007)	13		One small fragment found
	Wahakari (2008)	35		Dominant amongst emergents, scattered to 1.5 m
	Waihopo (2004)	78		Covers of >50% over most submerged vegetation
	Waikaremu (1999)			Kaimaumau Wetland (Salmon 2001)
	Waiparera (2004)	102		Limited impact in emergent /turf zone, absent from exposed shores
	W. Coast Rd (2007)	121		Dominant throughout open water areas in emergents
	Yelavich (2008)	105		Dominant to 2 m over much of lake
	Matai roadside pond (2005)			Dominant and surface-reaching outside of emergent zone
	Omapere (1999)	173		Local surface mats in eastern basin, probably eradicated
	Owhareiti (2006)	177		Small amounts widespread
	Sands Lake (2008)	309A		Common throughout lake
	Stanner's Road Dam (2008)	148A		Common to 2 m deep
	Waro (2006)	410		High covers to 3 m deep
	Fredericks (2005)	282		Covers of >50% over most submerged vegetation to 1 m deep
	Kai iwi (2008)	236		Small amounts
	Taharoa (2008)	229		Small amounts
	Waikere (2009)	227		Small amounts
	Kahuparere (2007)	384		Dominant and surface-reaching outside of emergent zone
	Rotokawau (2007)	364		Dominant in sheltered lagoon, sparse elsewhere
	Roto-otuauru (2006)	355		Common in shallow water sprawling over *Egeria densa*
	Rotopouua (2008)	348		Dominant amongst emergents
	Phoebes (2008)	346		Common in shallow water sprawling over *Lagarosiphon major*
	Humuhumu (2008)	350		Common in very shallow water on landward edge of emergents
	Jack Bisset Wetlands near Tangiteroria		2706800E; 6600800N	Collected Sept. 2004 (herbarium specimen)

Emergent or Wetland Plants				
Species	**Lake or location**	**Lake No.**	**Grid reference (if not part of lake survey)**	**Comments**
Zizania latifolia	Phoebe's (2000) Common on N. Wairoa River	346		Dominates ~50% of lake margin
Alternanthera philoxeroides				Widespread throughout Northland
	Heather (2004)	125		One patch (80 m^2) seen associated with maimai
	Kihona (2004)	31		Small area seen at outlet, probably recent introduction
	Mini (2004)	130		Common at northern end of lake
	Rotoroa (2004)	126		Small areas at south western end of lake
	Waimimiha N (2004)	135		Common in outlet stream
	Waiparera (2004)	102		Common with floating mats at south west of lake
	Omapere (2005)	173		Common on shoreline near outlet
	Rotokawau (E) (2005)	96		Common with floating mats around margins
	Rotokawau (W) (2005)	95		Common with floating mats around margins
	Waiporohita (2001)	99		One small (2 m^2) patch growing on boat ramp
	Fredericks (2005)	282		Abundant in emergent and marginal vegetation
	Grevilles Lagoon (2005)	295		Common with floating mats amongst raupo
	Humuhumu (2005)	350		Seen at boat access point
	Midgeley (2005)	257		On property, but not adjacent to lake
	Roto-otuauru (2005)	355		Seen at boat access point
	Waingata (1995)	371		Widespread, introduced with squash cultivation

Species	Lake or location	Lake No.	Grid reference (if not part of lake survey)	Comments
Myriophyllum aquaticum				Widespread in Hikurangi Swamp
	Wairua River		2621800E; 6619800N	DoC record 1998
Iris pseudacorus	Ngatu (2005)	120		One small patch ~ 1m^2 since removed
	Near Waipu (2004)			DoC controlling this infestation
Ludwigia peploides subsp. *montevidensis*				Common inland of Tokatoka
	Wainui	305		Restricted to south eastern end of lake
Glyceria maxima				Widespread throughout Northland
	West Coast Road (2005)	121		
	Waimimiha S (1988)	136		Herbarium record 1988
	Jacks (2005)	180		Locally common at north eastern edge of lake
	Rototuna (2007)	328		Small patch amongst raupo near entry point
Osmunda regalis	Mokeno	356		Scattered plants at northern end of lake. DoC controlling this infestation
	Maitahi, near Dargaville (1996)		None available	In peat reedland

7.3 Aquatic weed risk

The Aquatic Weed Assessment Risk Model (AWRAM; Champion and Clayton, 2000) scores aquatic weeds accounting for weediness and biological success so that success or potential success of one aquatic species can be compared to another (Champion and Clayton 2000). The free-floating *Salvinia molesta* (salvinia) and *Eichhornia crassipes* (water hyacinth) were once found at several lakes and many other Northland water bodies in the past. Ministry of Agriculture and Fisheries (MAF) eradication programmes in the 1980's and 1990's eradicated these weeds at most sites, but they remain a potential threat to all but the largest exposed Northland lakes. These species are not considered further.

The wetland weed royal fern (*Osmunda regalis*) is not aquatic and therefore was not be ranked using AWRAM. However it has Unwanted Organism Status (Biosecurity Act 1993 designation) and low incidence in Northland merits its inclusion.

7.4 Aquatic weed distribution and potential impacts

High-risk species are discussed within life-form groups and in order of weed risk as scored by AWRAM.

7.4.1 Submerged species

Ceratophyllum demersum

Ceratophyllum demersum (hornwort) was only known from 3 sites in Northland prior to commencing the NRC Lakes Strategy in 2005; with 2 of these records from the 2001 NIWA survey (Champion et al. 2002). There are now 11 sites in three geographically distinct areas; North Cape (Lakes Te Werahi, Ngakeketa and Kihona), South Aupouri (Lakes Heather, Mini, Waimimiha North, Awanui River and drains near Kaitaia and Karikari) and Pouto (Lake Rotootuaruru / Swan and drains south of Dargaville). The incursion in Lake Swan is likely to have occurred since 2001, whereas other new sites had not been surveyed previously. *C. demersum* has a widespread distribution in much of the North Island, including the northwest coastal lakes in Auckland Region and the Waikato River system.

It is currently the worst submerged weed in New Zealand, with major impacts on power generation, irrigation, flood control and recreational activities in addition to severe impacts on aquatic ecosystems (Hofstra 2002). Its potential to displace all submerged vegetation (including other introduced species) is illustrated in several central North Island lakes where it grows from the waters edge in sheltered bays to depths exceeding 15 m. The species dominates Lakes Ngakeketa, Kihona, Rotootuaruru and Waimimiha North. If introduced to other lakes, this species is likely to displace all submerged vegetation from sheltered sites and would have the greatest

impact on deep-water charophyte meadows. Unlike all other submerged weeds hornwort has the ability to grow below ~15 m deep.

Egeria densa

Egeria densa is more widespread than *C. demersum* occurring in at least 17 sites in four geographically distinct areas; North Cape (Te Werahi and Ngakeketa North), Sweetwater (Waiparera, Heather, Rotoroa, Mini and Awanui River), Central Northland (Omapere, Owhareiti, rivers near Kerikeri, Stanner's Road Dam, Wairua Falls and Waro) and Pouto (Rotootuaruru and Rotokawau). *E. densa* is widespread in the North Island and is well established in the southwest coastal lakes and Lake Pupuke in Auckland Region and the Waikato River system.

It is a major concern in eutrophic water bodies and has displaced native and introduced species like *Elodea canadensis* and *Potamogeton crispus* from many sites. In clear lakes it can grow to depths of around 8 m forming tall dense beds, but unlike *C. demersum* it is unable to grow to depths where it would threaten deep-water charophyte beds. In shallow nutrient-rich lakes this species is implicated in the collapse of submerged vegetation and consequent toxic algal blooms as has occurred in Lake Omapere and many lower Waikato lakes (Champion and Burns 2001).

Lagarosiphon major

Lagarosiphon major is sparsely distributed in Northland restricted to 3 sites in Sweetwater (Waiparera and Ngatu) and Pouto (Phoebe's Lake).

It has similar impacts to *E. densa* although it is more tolerant of wave exposure and grows successfully in oligotrophic waters, but is unlikely to grow to depths greater than 6.5 m. Wells et al. (1999) document its displacement of *E. canadensis* in Lake Tarawera from depths between 2 and 4 m, and following the subsequent invasion of that lake by *C. demersum, L. major* was still able to occupy this zone in moderately exposed sites.

Utricularia gibba

Prior to commencing the NRC Lakes Strategy in 2005, the invasive bladderwort (*Utricularia gibba*) was sampled on one occasion in Northland, from Lake Omapere (Champion & Burns 2001). Introduction to Lake Omapere could have occurred either from contaminated nets for eels or when grass carp were liberated into the lake, but is also spread easily by water fowl. *U. gibba* is widespread in Waitakere and South Rodney Districts in Auckland but appeared to be spreading slowly there.

It was collected from a Kaimaumau peat lake, Lake Waikaremu, with the first collection made in December 1999. Salmon (2001) reports this "Far-North" form to differ from West Auckland plants, with a short flower spur and the ability to self-

pollinate and produce viable seed. He speculated that this may be self-introduced (via water birds) from Eastern Australia, much in the same way that *Gratiola pedunculata* and *Alternanthera denticulata* (both occurring at Lake Waiporohita) have been recently recorded. As the plants are dispersed by birds they can rapidly colonise new water bodies.

In 2004/05 *U. gibba* was found in 20 Northland sites, with isolated occurrences in Karikari (pond near Matai), Bayleys Beach (Friedrich's Lake) and a swamp near Tangiteroria, but the majority of sites are at Aupouri, from Sweetwater to Lake Austria (west of Parengarenga Harbour). There was no record of *U. gibba* in 9 of those lakes in Aupouri surveyed in 2001. In 2006, 3 new sites were recorded Lakes Owhareiti and Waro and the drains in the Hikurangi wetland. Lake Owhareiti was previously surveyed in 2001, with no *U. gibba* reported. In 2007, *U. gibba* was found in Te Paki Dune Lake (not present in 2004) and Lakes Roto-otuaru and Rotokawau on the Pouto Peninsula (not recorded in 2006). The 2008 survey has found the species for the first time in Lakes Wahakari (not recorded in 2004), Yelavich, Stanner's Road Dam, Kai Iwi (not recorded in 2007), Humuhumu (not recorded in 2007), Rotopouua, Phoebe and Sands Lake at Mangawai. In 2009 it was found in all water bodies visited in Aupouri (except acid Lake Te Kahika), and was present in all lakes visited on the Pouto Peninsula. Thus this species has probably reached its potential range in Northland. It is now spreading in Auckland and Waikato Regions.

It is the sprawling nature of *U. gibba*, smothering other submerged species, which differs from the impacts of other submerged weeds, which are rooted or attached to bottom sediments and competitively displace other species through forming dense tall canopies. In the smaller, shallower, less exposed Northland water bodies impacts seemed severe, especially where associated epiphyton (attached algae) formed a dense mat which reduced light to plants growing beneath. *U. gibba* seldom appears to grow deeper than 3.0 m, and in most larger lakes its main impacts appear to be in the zone sheltered by emergent sedges such as *Eleocharis sphacelata*. Unfortunately this is also the favoured habitat of *Utricularia australis*, now classified as nationally endangered, although the two species do co-exist in Lake Rotokawau (near Ngatu).

U. gibba does not appear to threaten *Trithuria inconspicua* (formerly *Hydatella*) which generally favours more exposed sites than those colonised by *U. gibba* mats.

Vallisneria spiralis

Vallisneria spiralis was commonly available in the aquarium trade, and is now naturalised in a few sites (the closest site being Meola Creek in Western Springs, Auckland) and more recently in Blenheim. It has now been banned from sale, placed on the National Pest Plant Accord in 2006 (http://www.biosecurity.govt.nz/nppa accessed July 2009).

This species had been collected from a farm dam near Kerikeri in 2004.

All but one field site of this plant is in flowing water. At the lake site (Lake Wiritoa near Wanganui) it grows to a depth of 2 m, with *C. demersum* or *E. densa* below this depth (Wells and Taumoepeau 2003). It could threaten many Northland water bodies and could be deliberately planted (see Section 4.5 on Introduction Pathways).

7.4.2 Emergent and wetland species

Zizania latifolia

Zizania latifolia (Manchurian wild rice) is of limited distribution in New Zealand, but is extremely abundant in the vicinity of Dargaville, being introduced there around 100 years ago. Joynt and Newby (1998) estimated a total infested area of 338 ha, mostly in drains, river margins and flood-prone pasture. The only lake impacted by this weed is Phoebe's Lake in Pouto. Manchurian wild rice is now scheduled for eradication at this and other outlier sites, funded by the MAF BNZ National Interest Pest Response programme (http://www.biosecurity.govt.nz/pests/surv-mgmt/mgmt/prog/nipr accessed July 2009).

Z. latifolia is taller (up to 4 m) and grows more densely than native emergent species which it is likely to invade in small lakes, sheltered bays of larger lakes, and wetlands. Impacts on indigenous biota were documented by Champion et al. (2001).

Alternanthera philoxeroides

Alternanthera philoxeroides (alligator weed) is widespread in wetlands, drains and cultivated land in Northland, especially in the low-lying alluvial plains surrounding the Northern Wairoa River, but is sparsely distributed in other parts of the region. It was reported from two of the 33 lakes surveyed in 2001, but since then it has spread to a further five of these lakes. It is now known from 15 lakes throughout the region (from Kihona west of Parengarenga Harbour to Waingata at the bottom of the Pouto Peninsula). In seven of these lakes (Kihona, Heather, Rotoroa, Mini, Waiporohita, Humuhumu and Roto-otuauru) only small areas of this plant were seen and management could be contemplated before impacts become greater.

Alligator weed is a sprawling emergent forming dense floating mats which raft over and shade out submerged vegetation. Alligator weed can be a major weed in nutrient enriched water bodies, growing in sheltered areas amongst tall emergent plants. It is likely to invade and displace other herbaceous plants in nutrient-rich wetlands, but would have minimal impact on vegetation of larger lakes.

Alligator weed does not appear to be spreading significantly in Lakes Waiporohita, Roto-otuaru and Humuhumu, despite its presence there for several years. It seems to be unable to rapidly dominate the wetland fringes of these lakes (as it does in several

other lakes such as the 2 Rotokawau Lakes on Karikari Peninsula and Waiparera in Aupouri). Perhaps nutrient status or substrate type limits its success in these lakes.

Myriophyllum aquaticum

Myriophyllum aquaticum (parrots feather) is widespread throughout the North Island but surprisingly has only been collected from the Wairua River in Northland, with no records from the lakes sampled in 2004/05. It is widespread in the drains of the Hikurangi Swamp and is likely to occur in similar habitats elsewhere in Northland.

Parrots feather could be a major drain weed throughout Northland, but would have minimal impact on vegetation in large exposed lakes. It could impact on shallow aquatic areas within sheltered, nutrient-rich lakes and swamps, with floating mats displacing shallow water vegetation.

Iris pseudacorus

Iris pseudacorus (yellow flag iris) has a widespread naturalised distribution in New Zealand, but is apparently rare north of the Waikato, with only two known Northland sites, Lake Ngatu and Mill Brook near Waipu. A further site was reported from the 1960's near Haruru Falls, Waitangi but this appears to have been eradicated. It was propagated and distributed for sale until relatively recently and it is likely to be widely cultivated, potentially present in gardens anywhere within the region.

Yellow flag iris has a major impact on the emergent vegetation of sheltered lakes, as it may form dense floating mats of rhizomes that displace other vegetation. It is also a weed of salt marshes and has spread into saline influenced sites on the Avon River, Christchurch, and will invade wet pasture. It can be toxic to livestock (Connor 1977) and is of low value to wildlife and exposes nests to greater predatory risk from rodents and cats.

The Lake Ngatu site has probably been eradicated by digging up the plant (L. Sherwood, DoC, pers.comm.), but regular visits to ensure re-establishment from rhizome material or seed is required at this site.

Ludwigia peploides* subsp. *montevidesis

Ludwigia peploides subsp. *montevidesis* (primrose willow) has a limited naturalised distribution, predominantly restricted to the lower Waikato Basin where it is abundant, and has significant populations in Manawatu and West Auckland. It was only found in Lake Wainui and the adjacent pond, however it is widespread in limestone country in the vicinity of Tokatoka (P. Joynt, NRC, pers. comm.).

It is unlikely to impact most lakes within Northland, but can form large sprawling mats over shallow, sheltered, nutrient-rich lakes extending into adjacent nutrient-rich swamps.

Glyceria maxima

Glyceria maxima (reed sweet grass) is widespread in much of Northland and the rest of New Zealand, being a common weed of drains. It was recorded from Jack's Lake in 2005, with previous records from Lakes Waimimiha South and West Coast Road from where it has probably been eradicated.

This highly productive and competitive species has come to dominate riparian areas along many nutrient rich lowland waterways, also forming floating mats which can block pumps and promote flooding. In nutrient rich sites, it could exclude other emergent species, but impacts on the Northland lakes are not likely to be significant. Livestock readily eat it although sometimes it can cause stock deaths (Connor 1977).

Osmunda regalis

Osmunda regalis (royal fern) is restricted in its New Zealand distribution being locally abundant in Waikato, with scattered sites in the Bay of Plenty, Taranaki, Wellington and Great Barrier Island.

DoC is currently controlling this plant in the vicinity of Lake Mokeno (T. Birch, DoC, pers. comm.), with only one other record of the plant in Northland, a 1996 record from a peat reedland near Maitahi, just off SH12, about 8km north of Dargaville.

Royal fern is a potential weed of many of Northlands wetlands, found in a range of habitats from *Empodisma minus* dominated bog to fens and even some fertile swamps (usually but not exclusively under a canopy of willow or manuka) within the Waikato. In areas previously disturbed by fire or vegetation clearance, royal fern can dominate the understorey of these areas forming 100% covers up to 2 m tall (Champion 2006).

7.5 Prioritisation of lakes

The method of lake prioritisation is covered in Section 2.4 with the ranking of lakes given in the Executive Summary Table.

7.6 Introduction pathways, risks and targeted surveillance

Submerged weeds may be dispersed to new sites by a range of natural and human means. Pathways and likelihood of spread of the highest-ranking weeds are discussed in this section.

Natural dispersal includes the movement of propagules by:

- water (e.g., flood waters spreading contents of ornamental ponds);
- waterfowl (e.g., seed palatable to ducks or attached to their legs etc.);

- wind (e.g., spores of royal fern)

Weed dispersal by humans can be divided into deliberate and accidental means as follows:

- Deliberate dispersal:
    - liberation of aquarium contents and dumping of garden waste;
    - ornamental plantings in natural water bodies;
    - introduction of aquatic plants with coarse fish.
- Accidental dispersal:
    - contaminated watercraft or vehicles;
    - contaminated fishing nets;
    - contaminated drain clearing or weed cutting machinery;
    - contaminated dive gear (dive training or surveillance staff).

The risk of transfer of these propagules to unimpacted water bodies is essentially the probability that one or more of the pathways noted above will move plant material (seeds and vegetative fragments) from a weed source to that unimpacted area.

These distribution pathways and their relevance to the spread of aquatic weeds are discussed in the following sections.

7.6.1 Natural dispersal

Most of submerged aquatic weeds discussed in Section 3 do not set seed in New Zealand, either because only one sex is present or, in the case of hornwort, due to unfavourable environmental conditions and/or self-incompatibility. Therefore natural dispersal is not going to move these species to a new catchment. Flood events could feasibly transfer those species to downstream sites should an outdoor pond containing one of those species be inundated by floodwaters.

Those species that do produce seed like *P. crispus* and *R. trichophyllus* can be spread by waterfowl and are widespread in the Rotorua lakes. Bladderwort seems to be dispersed by natural means, either by seed or by fine filamentous stems tangled around bird feet.

Thus aquatic weeds adapted for dispersal by birds have the potential to be effectively dispersed between catchments and their spread is impossible to contain if naturalised

within the Northland. However, most species are dispersed between catchments by human activities, as discussed in the following sections.

7.6.2 Deliberate dispersal

The majority of alien submerged aquatic weeds present in New Zealand were intentionally introduced for ornamental ponds or aquaria.

As the majority of these weeds do not reproduce sexually, deliberate or unintentional transfer by human activities provides the main means of dispersal. A number of species with high weed potential have been declared as Unwanted Organisms and included on the National Pest Plant Accord (http://www.biosecurity.govt.nz/nppa accessed July 2009), under legislation to prevent sale, distribution and propagation (Sections 52 and 53 of the Biosecurity Act 1993) to strongly discourage their dispersal around New Zealand.

Despite their ban from sale and distribution (some from as early as 1983), some of these plants are still being illegally distributed around New Zealand as pond and aquarium plants. The deliberate transfer of coarse fish is often accompanied by release of aquatic plants that may have been used to transport fish or eggs from site to site, as evidenced in the two recent hornwort incursions in the South Island (Matthew Bloxham pers. comm., authors pers. observations), where this species was found in water bodies also containing the pest fish rudd (*Scardinius erythrophthalmus*).

7.6.3 Accidental dispersal

The submerged plants in the family Hydrocharitaceae (e.g., egeria, lagarosiphon and elodea), hornwort and most likely bladderwort are all dispersed via stem fragmentation and their main mode of spread to new water bodies is via contaminated watercraft, drainage machinery and weed harvesters and fishing nets. Scuba equipment is also a potential mechanism, with both recreational diving and scuba dive training classes in some lakes.

The risk of accidental spread of these weeds is dependant on a number of factors:

- adaptations of weed species enabling dispersal to new sites (such as tolerance to desiccation, ease of attachment to a vector, regenerative capacity);
- proximity of weed source to an unimpacted site. Generally the closer the distance, the greater the risk (Johnstone et al. 1987);
- abundance of weed sources. The greater the number and extent of sources, the greater the risk of spread;
- type of dispersal vector (boats nets or digger);

- accessibility of the weed site(s) and unimpacted sites to the potential vector (such as well formed boat ramps);

- frequency of vector movements between sites.

7.6.4 Targeted surveillance

Before undertaking a surveillance programme, selection of sites based on the analysis of introduction pathways (Sections 4.1 to 4.3) allows for a targeted search of high risk areas within each of the lakes. Likely sites of introduction in the case of watercraft would be boat entry points (e.g., boat ramps and commonly used beach accesses) and mooring areas (such as common fishing areas and sheltered bays) where plant fragments in the anchor well could be unwittingly liberated.

Other pathways are through planting contaminated water lily rhizomes and liberation of aquaria / pond contents either through deliberate release or the result of a flood event. Therefore a survey of ponds within the catchment of each high-risk lake and publicity warning of the risks posed by the target species (outlined in this report) in aquaria and ornamental ponds should be part of the strategy. Surveillance should also include nurseries and pet shops along with regular contact with Aquarium Societies.

7.7 Threat evaluation and management implications

The consideration of vectors and associated risks discussed in Sections 4.5.1 to 4.5.3, along with the risks posed by each species to high priority lakes needs addressing in order to make appropriate management decisions to lessen aquatic weed spread. These are presented in Table 4.3 below:

Table 4.3: Vectors, risk of spread and management opportunities for aquatic weed species in the Northland.

Species	Vectors	Risk of spread	Management opportunities
Submerged			
Ceratophyllum demersum *Egeria densa* *Lagarosiphon major*	Ornamental ponds or aquaria	Moderate– not quantified but has often been found to be the source of infestation.	Surveillance of properties near lakes or tributaries of lakes.
	Accidental (fishing nets)	Moderate-High – requires transfer from infested water bodies. Can get into remote water bodies sometimes with no defined access.	Notify fishers of contaminated water bodies. Monitor eel fishing patterns. Compel net sterilisation or exclude from infested areas*. Control weed at sites likely to source material (e.g., Lake Swan).
	Accidental (boats)	Moderate-High in lakes with public access – requires transfer from infested lakes.	Educate boat users in publicly accessible lakes (e.g., Ngatu, Waiparera, Manuwai, Waikere, Taharoa). Monitor boat use to quantify number of boats using these lakes.
	Accidental (drainage equipment)	Moderate - High – if infested sites nearby.	Surveillance of drains near lakes. Monitor drainage machinery use in contaminated areas. Notify contractors of contaminated sites. Compel equipment cleaning on leaving contaminated sites.
	All		Exclude vectors access to extra high value, water bodies.
Vallisneria spiralis	Ornamental ponds or aquaria	Low – Kerikeri field site or commercially obtained plants (potential sources). Plants require deliberate planting into new sites.	Eradicate field site. Ban from sale and distribution.
Utricularia gibba	Natural and accidental	High – appears to be widely distributed in Northland.	Too widespread (and spreading naturally) to effectively manage.

*****Remove fragments on site and soak in 1 part salt per 14 of water (by volume) for one hour (Matheson et al. 2004).

Species	Vectors	Risk of spread	Management implications
Emergent			
Zizania latifolia	Accidental (drainage machinery)	Moderate/high – if infested sites are nearby (plants would be obvious to informed operators)	Educate and notify contractors of contaminated sites, clean diggers before moving to new sites.
	Natural (water borne seed)	High – seed dispersed in infested catchments	Investigate control/eradication where naturalised in high-risk sites
Alternanthera philoxeroides	Accidental (drainage machinery)	High – requires transfer from infested sites (plants not obvious to operator – widespread in region)	Educate and notify contractors of contaminated sites, clean diggers before moving to new sites.
Myriophyllum aquaticum	Ornamental ponds or aquaria	High –often the source of the weed in an un-infested region / area.	Surveillance of ornamental ponds near lakes or tributaries of lakes
	Accidental (drainage machinery)	High – if infested sites are nearby (plants not obvious to operator – widespread in parts of region)	Educate and notify contractors of contaminated sites, clean diggers before moving to new sites.
Iris pseudacorus	Deliberate planting	Low – probably scattered in gardens and ponds	Surveillance for Northland sites
	Natural (water borne seed)	High – seed dispersal in infested catchments	Investigate control/eradication where naturalised in high-risk sites (e.g., DoC control at Waipu)
	Accidental (drainage machinery)	Moderate – rhizomes and seed could be dispersed from infested sites	Notify contractors of contaminated sites.
Ludwigia peploides subsp. *montevidensis*	Accidental (drainage machinery)	Low – requires transfer of seeds or stem fragments from infested sites (plants limited in distribution)	Surveillance of suspected areas for plants. Educate and notify contractors of contaminated sites, clean diggers before moving to new sites.
Glyceria maxima	Natural (water borne seed)	High – seed dispersal in infested catchments	Instigate control/eradication where naturalised in high-risk sites (e.g., tributaries of high-ranking lakes).

Species	Vectors	Risk of spread	Management implications
	Accidental (drainage machinery)	High – rhizomes and seed could be dispersed from infested sites	Educate and notify contractors of contaminated sites, clean diggers before moving to new sites.
Wetland			
Osmunda regalis	Natural (wind borne spores)	High – spore dispersal	Surveillance for sites of plant around Lake Mokeno and similar habitats. Control/eradication where found (DoC currently doing this).

7.8 Contingency planning

One of the benefits of surveillance is early detection of invasive species. In order to respond rapidly and appropriately to an incursion it is necessary to plan for the contingency. It is a useful exercise to work through likely scenarios for selected invasive weeds and locations and consider appropriate contingencies. It is apparent that for a rapid response a number of things need to be in place:

- adequate emergency funds need to be allocated;
- a dive team (for most submerged species) with appropriate skills need to be available to respond. The extent of the infestation needs to be surveyed as soon as possible. The divers also need to have excellent plant identification skills and experience with hand weeding (knowledge of the methods of dispersal of the target species, and how to remove them without dispersing them further);
- compression screens (a frame with a light screen attached such as weed mat) need to be available at short notice and divers available to place them over small infestations at short notice;
- herbicide options considered in advance with approvals for use in place so they can be used at short notice.

Prior meetings with owners and stakeholders (DoC, Fish and Game, and LINZ) Iwi, and public are necessary to establish acceptable contingency plans for implementation in the event of an incursion. Thought needs to be given to containment within a water body using enclosure netting, and quarantine capability such as control of lake access and departures or activities undertaken.

Detailed recommendations for an aquatic weed strategy have been prepared for the Kai Iwi Lakes (Wells and Bodmin, 2008).