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 early.

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*
	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* below 2.8m 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.)
	North Wairoa and Kaihu Rivers and associated drains (2010)			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*
	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
	Carrot (2010)	118		One 1 m tall plant found
	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
	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 from 2 – 2.8 m deep
	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
	Ngatu (1988)	120		Patchy distribution and localised impact at entry point 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 2010, 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		Abundant (to 1.3 – 3m deep),on *E. densa*
	Little Gem (2007)	123		Dense 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 1(2010)	33		High covers across the lake and in wetland vegetation
	Morehurehu S 2 (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		Abundant 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		Abundant throughout open water areas in emergents
	Yelavich (2008)	105		High covers 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 but not in 2010
	Taharoa (2008)	229		Small amounts but not in 2010
	Waikere (2009)	227		Small amounts but not in 2010
	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		2706800E; 6600800N	Collected Sept. 2004 (herbarium specimen)

	near Tangiteroria			
Emergent or Wetland Plants				
Species	**Lake or location**	**Lake No.**	**Grid reference (if not part of lake survey)**	**Comments**
Zizania latifolia	Phoebe's (2000)	346		Dominates ~50% of lake margin, since subjected to an eradication programme (C. Cooper pers. comm.) with few shoots seen in 2008
	Common on N. Wairoa River			
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	Waiparera (2010)	102		One 2 m tall plant. DoC controlling this plant
	Rotokawau (2010)	364		Two plants seen and removed
	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 and 2 of these records were 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 waterways in the vicinity of Dargaville). The incursion in Lake Swan is likely to have occurred since 2001, whereas other new sites were in lakes that had not been previously surveyed. *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 around 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 charophyte meadows. Unlike all other submerged weeds *C. demersum* has the ability to grow to ~15 m deep.

Egeria densa

Egeria densa is more widespread than *C. demersum* occurring in at least 18 sites in four geographically distinct areas: North Cape (Te Werahi and Ngakeketa North), Sweetwater (Waiparera, Heather, Rotoroa, Mini, Carrot 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. 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 will not grow to depths greater than 6.5 m. Wells et al. (1999) documented 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 sheltered and 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*, covering 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) and Lake Ngakapua South.

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 much 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 much 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 (now removed) 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 seeds prolifically and spreads rapidly along stream and river banks. 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. *montevidensis

Ludwigia peploides subsp. *montevidensis* (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.

Royal fern is known from the vicinity of Lake Mokeno and a 1996 record from a peat reedland near Maitahi, just off SH12, about 8km north of Dargaville. New records of this plant in 2010 from Lakes Waiparera (Sweetwater) and Rotokawau (Pouto) indicate this species maybe more widespread in Northland. DoC is continuing to target this species for eradication wherever it occurs in Northland Conservancy (T. McCluggage and G. Williams pers.comm.)

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 native biodiversity value 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;
    - plantings in natural water bodies (ornamental or misguided 'enhancement' e.g., duck shooters planting willow, *S. molesta*, *A. philoxeroides* and *E. densa*;
    - 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 an 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 *C. demersum*, 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. *U. gibba* seems to be dispersed by natural means, either by seed or by fine filamentous stems tangled around bird's 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 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 *C. demersum* 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., *E. densa*, *L. major* and *E. canadensis*), *C. demersum* and most likely *U. gibba* 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 some 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.
	Deliberate planting	High near shooting hides	Notify Fish and Game, educate shooters
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).

8. Weed surveillance programme 2010

8.1 Introduction

The 2005 Northland Lakes Assessment (Champion et al. 2005) developed a surveillance strategy for invasive weeds in prioritised water bodies. Lakes identified for annual surveillance were Lakes Ngatu, Wahakari, Waiporohita, Kai-iwi, Taharoa, Waikere, Humuhumu, and Rotokawau. These lakes have been monitored for weed incursions annually since 2006 with the exception of Lake Wahakari in 2007, where access was not obtained from the owners at that time. As boat access to Lake Wahakari is now effectively prevented, this lake is no longer a high-risk and lake native biodiversity value monitoring every 5 years is recommended as the only monitoring required. Lake Rotokauri could not be accessed in 2009 due to maize cropping.

8.2 Methods

Annual surveillance was undertaken for six high-risk lakes (Table 1).

Lakes were surveyed using scuba and snorkel, visually inspecting sites where introductions would be most likely, such as known access points and popular anchoring spots. The areas were inspected thoroughly throughout the vegetation profile at depths where colonisation was likely to occur. Where large areas required surveillance, a diver was towed behind a boat to cover likely sites of colonisation.

The lake margins were also walked and checked for drift of weed fragments on shore and marginal vegetation also checked for emergent and sprawling wetland weeds both from the landward edge (where possible) and by boat.

Table 1: Submerged weed surveillance programme for Northland lakes (Champion et al. 2005).

Lake and No.	Surveillance programme	Frequency
Ngatu (120)	Survey boat ramp area and access points on eastern and southern margins	Annually
Waiporohita (99)	Survey lake and wetland from roadside access point on eastern margin to north end by the road	Annually
Kai-iwi (236)	Survey access point at NE end	Annually
Taharoa (229)	Survey access points at 2 camp grounds, jetty, and Sin Bin.	Annually
Waikere (227)	Survey boat ramp area and roadside access points on western margin	Annually
Humuhumu (350)	Survey access point (NE side)	Annually

8.3 Results and discussion

Lake Ngatu (2010)

The shallow bay out from the main access point for Lake Ngatu, at the north end of the lake off West Coast Road (2529000E 6683000N), had changed from 2007 to 2008 with *L. major* spread to most of the bay (estimated at 2-3 ha) with about a 70% cover of *L. major* up to about 1 m tall. This area of *L. major* extended >200 m from the ramp and was mostly less than 2.5 m deep. In 2009 and 2010 there was less *L. major*, with a cover of about 40% estimated for the same area.

In the Southwest of the lake where waka ama are launched, the *L. major* grew from 0.3 m to 2.5 m deep in clumps with up to 100% cover but overall with a low cover (<5%) for the area. This area extended south to the sandy beach.

The beach at the south end of the lake was also re-checked but has no *L. major*. At the eastern end of the beach (2528960E 6684870N) *L. major* formed a bed with a 100% cover from the edge of the *Eleocharis sphacelata* bed to a depth of 2.5 m and extended into the *E. sphacelata* with a 50% cover in 2008. In 2010 cover had reduced to about 50% overall.

It is evident that the *L. major* has not increased in abundance since surveyed in 2006. In fact it has reduced in abundance possibly due to smothering from *Utricularia gibba* which forms extensive smothering growths on the *L. major*. Eradication of lagarosiphon in Lake Ngatu would be a major undertaking and would require a concerted programme of diquat herbicide use, suction dredging and hand weeding and has a low chance of success. However recent trials with endothall near Invercargill, have shown it can kill *L. major*, including the root crowns and achieve eradication. The problem in Lake Ngatu would be to achieve a lethal dose for all *L. major* shoots in such a large water body.

Currently the *L. major* present in the lake is not causing a nuisance to recreation but it is a well used lake and could potentially provide a source of weed fragments for dispersal to other weed-free lakes. Information displayed on signage for boaters would be a useful way to inform users that any weed fragments could pose a significant risk to the next water body they visit. Advice on cleaning boats, boating equipment and trailers should be included on the signage. The lake currently still has no *E. canadensis, E. densa* or *C. demersum* present, and all are potential weeds (particularly *C. demersum*) that could markedly impact on the ecological and recreational values lake.

Lake Waiporohita (2010)

The eastern shore of the lake was checked for submerged weed, shoreline drift fragments and marginal weeds including monitoring the spread of alligator weed. No new weeds were found in 2010 (including *U. gibba* not seen here), and alligator weed was still confined to the old boat launching site (north corner by the road) and adjacent areas amongst raupo at the north eastern edge of the lake. Water clarity was good (~1.5 m) for this lake and submerged vegetation was checked by snorkel and SCUBA.

Lake Kai-iwi (2010)

The boat access point useable by 4-wheel drive in 2005 (25701100E 6598580N) has had public access restricted by a gate since 2006. Scuba divers and snorkelers made two passes of the shoreline up to 150 m either side of this site to cover the depth range to 5 m. No invasive species were found in 2010. *Utricularia gibba* found in 2008 amongst emergent vegetation on the north eastern shore of lake Kai-iwi, also in a wetland opposite the access to Lake Taharoa, and also in pools near that lake. It had increased in abundance in 2009, but was not seen in 2010.

Lake Taharoa (2010)

At the beach launching site for boats (2568960E 6598645N) near the beginning of Domain Rd, about 400 m of the shoreline was searched for invasive weed with towed scuba divers and snorkelers covering the 0 - 10 m depth range. No invasive weed was found except for a small amount of *U. gibba* in the shallows nearby (while doing the shoreline search).

The camping ground beach at the eastern end of the lake (2570410E 6599045N), which is used for boat launching and mooring, was checked. About 500 m of the shore was checked and was mostly bare sand on the shallow shelving beach with suitable habitat at about 7 to 9 m deep. Scuba divers were towed along this upper vegetated depth limit. Visibility was good and sparse native vegetation low growing, enabling large areas to be effectively searched. No invasive species were found.

At the Peninsula boat launching area (2568375E 6599495N), a section of shoreline about 250 m long, was checked by towing scuba divers. Also the other side of the Peninsula, in the Sin Bin area (the most southern part of the northwest bay), was searched. No invasive species were found.

Lake Waikere (2010)

The shoreline 200 m either side of the concrete boat ramp (2567290E 6600270N) was searched by a scuba divers and two towed snorkelers. The water was very clear so snorkelers could see well into 5 m of water. No invasive weed species were found.

In the southeast bay of the lake (2567725E 6599910N), about 400 m of shoreline was checked by towing two snorkelers. Conditions were very still and water clarity very good so rapid inspection was possible. No invasive weed species were found. *U. gibba* was found in small quantities in 2009 but not 2010.

Lake Humuhumu (2010)

The access at the eastern side of the lake was checked by 3 scuba divers and 3 snorkelers covering about 300 m of shoreline and out to the 6 m depth contour. Alligator weed was still present amongst the marginal vegetation, and it had spread a little. No invasive submerged weedy species were found apart from small amounts of *U. gibba* found in shallow water at the landward margin of emergent plants.

Lake Roto-otuauru (Lake Swan) – a biosecurity threat to the Pouto lakes

Lake Roto-otuauru is the only site of hornwort on the Pouto Peninsula. The lake is close to a number of other lakes and has a large source of invasive weed (both *E. densa* and *C. demersum*) which markedly increases the risk for other Pouto Lakes of weed invasion and loss of native plant biodiversity and habitat. It would take just one fragment with a viable bud to be transferred to infest another lake, such as adjacent Lake Humuhumu. This will not occur naturally. Containment is now more likely since the grass carp were introduced in May 2009 and *E. densa* has been virtually removed and *C. demersum* has been reduced in abundance by 50%.

Similarly Lake Heather will be included in the surveillance programme once grass carp are introduced there later in 2010.

Lake Rotokawau (2010)

The lake was accessed at the north east corner (2613645E 6599535N) and 2 scuba divers searched the shoreline around this access point and along to the end of the bay 500 m to the south east where there is a thick band of *E. densa* from 2 to 3 m water depth. The lake access at the south corner was also checked, but no new invasive weeds were found. The difficulty of access to this lake lowers the risk of new weed incursions and annual surveillance at this lake is no longer recommended.

Lake Ngakapua

The 2010 discovery of *Egeria densa* in adjacent Carrot Lake (Ngakapua East), indicates recent activity by a vector of spread (likely a duck shooter) and therefore a heightened risk to the North and South basins of Lake Ngakapua. Annual surveillance is now recommended for this lake and an attempt to eradicate *E. densa* in Lake Carrot is recommended before it spreads.