Northland Lakes – Pouto Annual Report 2014

Prepared for Northland Regional Council

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Waitahora Lagoon

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Executive summary

Northland Regional Council (NRC) has a programme of lake monitoring for 86 lakes that are surveyed on a rotational basis. This includes surveillance on prioritised lakes for early detection of weed incursions. NRC engaged NIWA to update its information by conducting the following assessments of lakes and water bodies using the methods outlined below:

1. Ecological assessment

A Lake Ecological Value Rating was calculated from values assigned to endangered species, wetland extent and species composition, submerged vegetation abundance and composition (including LakeSPI assessment), water bird, fish and aquatic invertebrate presence and abundance. NRC water quality sampling results and trends detected are referred to in this annual report to assist with interpretation of biological trends.

Emergent vegetation extent and composition was assessed for six lakes and data will be made available to NRC to incorporate into their GIS system.

Lakes assessed were:

Lake Humuhumu, Lake Kapoai, Lake Rototuna, Lake Wairere including Round Hill Lake 2 (reconnoitre) and Lake Wainui.

2. Grass carp assessment

The abundance of aquatic vegetation lake-wide was assessed for Lake Roto-otuauru / Swan (using sonar, scuba observations and shoreline searches) to describe the level of progress grass carp had made towards eradicating the target pest plant species hornwort and egeria.

3. Endothall assessment

The aquatic vegetation of Lake Phoebe was assessed lake-wide to monitor the effects of the 2012 endothall treatment for *Lagarosiphon major*.

4. Weed surveillance

Annual surveillance was carried out in priority lakes: Lake Humuhumu. Surveillance involved visually inspecting prioritised areas for new pest incursions where introductions would be most likely, such as known access points and popular anchoring spots. The areas were inspected thoroughly using scuba and snorkel at depths where weed colonisation was likely to occur. The lake margins were walked and checked for drift of weed fragments on shore and marginal vegetation was also checked for emergent and sprawling wetland weeds.

The field assessments involved a team of NIWA, Northland Regional Council and Department of Conservation aquatic and wetland ecologists with diving capability.

Lake assessments

Ecological value ratings and notable changes

Lake Humuhumu shows macrophyte indicators of nutrient enrichment including extensive blue green algal mats, receding bottom limits, a change in charophyte species dominance and declining charophyte cover occurring. Water quality trends show a decline in water clarity and increase in total

nitrogen, although the TLI remains mesotrophic and its ecological value rating remains "Outstanding". *Trithuria inconspicua* appears to have disappeared from this lake, with Lake Rotokawau the only remaining Pouto location of this plant.

Lake Rototuna submerged vegetation has been dominated by *Nitella* sp. aff. *cristata* over the last 14 years with depth limits steadily decreasing from 5.6 m to 3.1 m. This is driven by steadily decreasing water levels rather than the bottom limit retracting. Water quality trends show a decline in water clarity and increases in both ammoniacal and total nitrogen, total phosphorus and TLI. Its ecological value rating has reduced to "Moderate" and should future surveys fail to detect populations of dwarf inanga (*Galaxias gracilis*), this would reduce further.

Lake Wairere and Round Hill Lake 2 (reconnoitre) Lake Wairere was first surveyed in 2005 during a heavy algal bloom (0.3 m visibility) when only remnant plant communities were present. Water clarity was considerably better in 2014 (~ 2.5 m) and healthy native submerged and emergent vegetation was present in this and the two smaller lakes.

Lake Wainui bottom limits are now at their deepest since records began 13 years ago, but the dominant charophyte shifted from *Nitella* sp. aff. *cristata* in 2005 to *Chara australis* in 2014, with very little *Nitella* sp. aff. *cristata* now present. This is one of four lakes (out of the 27 Northland lakes monitored by NRC) showing improved water quality. The recent TLI rank changed from eutrophic to mesotrophic, making it one of only three Pouto lakes with this rank. The improvement in bottom limits and water quality could be due to the recent fencing of the margins excluding cattle access to the lake. Its ecological value rating also increased from "Moderate-High" to "High".

Lake Kapoai is rated as Low ecological rating with highly enriched nutrient status, poor wetland and emergent buffering and poor species diversity. However, there are signs of improvement as fencing has permitted regeneration of some emergent species and submerged plants were recorded for the first time in 2014.

Weed surveillance:

No new weed incursions were found in Lake Humuhumu.

Grass carp results:

Lake Roto-otuauru / Swan: Progress with *C. demersum* and *E. densa* eradication was rapid with no traces of either weed after 3 years of grass carp grazing. It is now 5 years since the carp were introduced and no traces of *C. demersum* or *E. densa* have been found since April 2013. There is no longer a risk of transfer of these weeds to neighbouring high-value lakes. Netting of fish is advocated now, in the knowledge that past efforts to recover all fish using netting has not been achieved, thus leaving some fish to ensure eradication has been achieved.

Endothall results:

Since endothall treatment of Phoebe's Lake there has been no sign of lagarosiphon in surveillance surveys in April 2013 and May 2014. The area (to 2.6 m water depth) where lagarosiphon once dominated is now densely vegetated with native charophytes and pondweed (*Potamogeton ochreatus*).

Recommendations:

Recommendations for the management of Northland lakes include:

1. The falling water level and increasing eutrophication in Lake Rototuna requires attention. The status of dwarf inanga in this lake warrants investigation.

2. Virtually all of Northland's lakes are located in modified catchments with the potential for increased nutrient levels to threaten biodiversity and lake ecological health. Lake Humuhumu shows signs of deterioration and urgent intervention is needed to maintain or restore their values.

3. Removal of grass carp from Lake Roto-otuauru commencing with netting is recommended now.

4. The improvement in Lake Wainui following fencing off the lake from stock encourages efforts to fence other lakes impacted by stock access.

1 Introduction

Northland Region has some of New Zealand's highest ranked examples of intact natural aquatic ecosystems Champion and de Winton (2012). However, they are being lost at an alarmingly rapid rate as invasive species spread as a result of human activities, and land use practices impact on lake integrity. Often pristine lakes are limited to remote areas with difficult human access and limited land use development. With adequate recognition, community support and active protection, such exceptional lakes could be maintained in a close to pristine state for perpetuity.

Northland Regional Council (NRC) has a programme of lake monitoring for 86 lakes that are surveyed on a rotational basis. This includes surveillance on prioritised lakes for early detection of weed incursions. NRC engaged NIWA to update this report by providing the following assessments of lakes and water bodies:

1. Lake Ecological Value Assessment:

   Lake Humuhumu, Lake Kapoai, Lake Rototuna, Lake Wairere and Round Hill Lake 2 (reconnoitre), and Lake Wainui.

   Assessments included endangered species identification, wetland extent and species composition, submerged vegetation abundance and composition, water bird, fish and aquatic invertebrate presence and abundance.

2. LakeSPI (Submerged Plant Indicators) assessment of lake ecological condition measured using submerged plant indicators for those lakes with suitably selected profiles.

3. Annual weed surveillance to detect any new incursions of aquatic pests was repeated in six priority lakes (Lake Humuhumu).

4. Assess grass carp progress towards eradication of target pest plant species in Lake Heather and Lake Roto-otuauru / Swan.

5. Assess the results of endothall treatment of Lake Phoebe.

Water quality trends detected by NRC sampling (Simpson 2014) have been referred to in this annual report to assist with interpretation of biological trends.

In addition to this report, lake ecological updates will be added to the compilation of Northland lakes ecological information as last presented in Wells and Champion (2013).

2 Methods

2.1 Ecological assessments

2.1.1 Lake description

Lakes were referenced according to assigned lake number and location (NZTM Easting and Northing) in the NRC lakes database. In addition, water bodies were photographed and observations of catchment features and ease of access were noted.

2.1.2 Wetland and emergent vegetation

The extent of emergent vegetation (percentage of shoreline, width of beds and depth range), plant species present at profiles and elsewhere around the lake, and wetlands associated with the lake were described.

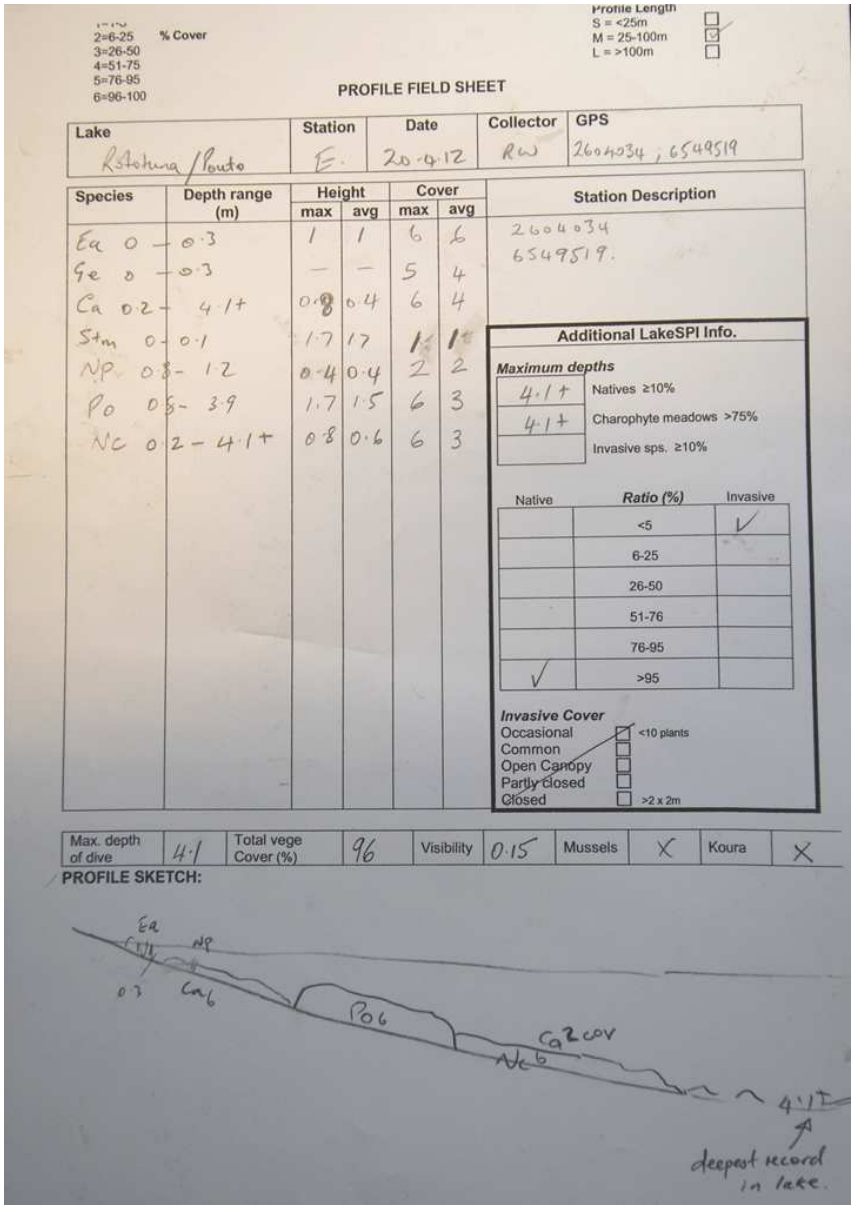
Presence of pest plants were reported along with an estimate of population size.

2.1.3 Submerged vegetation

The submerged vegetation was surveyed by divers using a method similar to Clayton (1983). Divers swam perpendicular to shore recording plant species present, their depth ranges, average and maximum heights and covers. These and other details including those required to complete LakeSPI surveys were recorded on data sheets (Figure 2-1).

Generally lakes were sampled at five localities with profiles selected as representative of the underwater vegetation and the range of plant communities present in the lake. Fewer than five sites were surveyed where lakes were small or de-vegetated.

Endangered species were considered as for wetland vegetation.



2=6-25 % Cover
3=26-50
4=51-75
5=76-95
6=96-100

Profile Length
S = <25m
M = 25-100m
L = >100m

PROFILE FIELD SHEET

Lake	Station	Date	Collector	GPS
Rotoiti / Loute	E.	20-4-12	RW	2604034, 6549519

Species	Depth range (m)	Height max	Height avg	Cover max	Cover avg
Ea	0 – 0.3	1	1	6	6
Ge	0 – 0.3	–	–	5	4
Ca	0.2 – 4.1+	0.8	0.4	6	4
Stm	0 – 0.1	1.7	17	1	1
NP	0.8 – 1.2	0.4	0.4	2	2
Po	0.8 – 3.9	1.7	1.5	6	3
Nc	0.2 – 4.1+	0.8	0.6	6	3

Station Description: 2604034 6549519.

Additional LakeSPI Info.

Maximum depths

4.1+	Natives ≥10%
4.1+	Charophyte meadows >75%
	Invasive sps. ≥10%

Native	Ratio (%)	Invasive
	<5	✓
	6-25	
	26-50	
	51-76	
	76-95	
✓	>95	

Invasive Cover
Occasional ☑ <10 plants
Common ☐
Open Canopy ☐
Partly closed ☐
Closed ☐ >2 x 2m

Max. depth of dive	4.1	Total vege Cover (%)	96	Visibility	0.15	Mussels	X	Koura	X

PROFILE SKETCH:

Figure 2-1: Survey sheet for submerged vegetation surveys.

2.1.4 LakeSPI

LakeSPI (Submerged Plant Indicators) is a well-used method of measuring lake ecological condition (Clayton and Edwards 2006 a & b, de Winton et al. 2012). LakeSPI surveys were carried out at pre-selected baseline sites to record key characteristics of the vegetation structure and composition. These included measures of diversity from the presence of up to six key plant communities; emergent or amphibious low-growing turf plants, isoetes, native tall vascular plants (milfoils and pondweeds), charophytes and high-cover charophyte meadows, and the depth extent of vegetation. Also scored was the presence of invasive exotic weeds and the extent to which they dominated (based on cover, height and depth range).

Survey data was then entered into the NIWA LakeSPI database and used to generate three LakeSPI Indices:

- Native Condition Index – characterises the status of native vegetation within a lake.
- Invasive Impact Index – captures the degree of impact from invasive weed species (note that higher scores for the Invasive Impact Index denote lower lake ecological condition).
- LakeSPI Index – integrates scores from the other two indices and provides an overall indicator of lake ecological condition.

LakeSPI indices are expressed as a percentage of their maximum potential score (adjusted for lake depth) to enable direct comparisons of small, shallow water bodies with different lake types (e.g., larger, deeper ones).

A full description of the vegetation features that were assessed for the LakeSPI method can be found in the technical report and user manual (Clayton and Edwards 2006a) and on the LakeSPI web-reporting website (www.lakespi.niwa.co.nz).

LakeSPI assesses aquatic plant indicators of ecological condition and should not be confused with the 'Lake Ecological Value Assessment' which provides an overall assessment of indigenous biota and their habitat.

2.1.5 Water birds

Habitat suitability for birds was assessed during the field visit, with bird species presence and abundance observed with binoculars. Results were compared with previous records from Ornithological Society of New Zealand (OSNZ) and DOC Species-Specific Biological Information (SSBI) surveys, with any nationally or regionally threatened species noted. The combination of scuba divers and various water craft involved in this survey was not conducive to observing water birds, with many flying away before their identity was ascertained. However, some secretive species such as the nationally endangered bittern (*Botaurus poiciloptilus*) were often disturbed and flight allowed their detection, whereas shore-based observation would probably not detect such species.

2.1.6 Fish

Fish records for the Northland Region extracted from NIWA FBIS comprised 295 records since 1980. These records were assessed to identify lakes containing pest fish. While sampling plants, divers also recorded observations of fish but these were not specifically sampled for or quantified.

2.1.7 Aquatic invertebrates

Large aquatic invertebrates such as freshwater mussels (*Echyridella menziesii*), koura (*Paranephrops planifrons*) and snails were noted by divers in the course of macrophyte surveys. Mussels are potentially important indicators of lake condition and are likely to be incorporated into LakeSPI methodology in the future.

2.1.8 Endangered species

Presence of endangered species (de Lange et al. 2013; Forester and Townsend 2004; Goodman et al. 2014; Grainger et al. 2014), discussion of known occurrences with Department of Conservation (DOC) and NRC staff and estimation of population sizes were made.

2.1.9 Lake Ecological Value Assessment

The rating of Lake Ecological Value uses the methodology presented in Champion and de Winton (2012), and is a refinement of the 'Lake Biodiversity Assessment' method undertaken in previous NIWA lake reports.

The Lake Ecological Value Assessment is based on the following parameters:

- Habitat size
- Buffering
- Water quality
- Aquatic vegetation diversity
- Aquatic vegetation integrity
- Endangered species
- Presence of key species
- Connectivity.

The protocols followed for each parameter are described in Appendix 1. The higher the score, the higher the Lake Ecological Value Rating.

2.1.10 Changes in indicators

Any significant changes in biota and lake condition compared with previous surveys were reported; for example new species records, and / or change in species dominance, or vegetation depth range.

2.1.11 Threats

Biosecurity threats (current pest plant and fish impacts, potential impacts and risk of introduction), nutrient enrichment (nutrient sources, livestock access) and decreasing water levels were considered for impacts on ecological condition on each lake based on the surveys and discussion with landowners, NRC and DOC staff. Water quality monitoring is carried out by NRC for high ranked lakes and data held by NRC.

2.1.12 Summary

A summary of overall ranking, identified threats and recommendations is presented for each lake in the report Section 3.1 Ecological Assessments.

2.2 Pest plant surveillance

Annual surveillance for aquatic weeds was undertaken for six high-risk lakes (Table 2-1).

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 at depths where weed 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 2-1: Submerged weed surveillance programme for Northland lakes.

Lake and Lake No.	Surveillance areas	Frequency
Humuhumu (350)	Survey access point (NE side).	Annually

2.3 Grass carp assessment

The progress of grass carp on target pest plants in Lake Swan was assessed using baseline profiles, sonar and one shoreline inspection. In Lake Swan the baseline profiles were repeated for submerged vegetation. Sonar (Lowrance HDS9 depth sounder/GPS/chart plotter) was used to cover much of the lake to search for any weed growth and to record profiles. A shoreline inspection of the lake by boat was undertaken to inspect the lake margin for impacts on the emergent communities and presence of weed fragments.

For Lake Heather the two baseline profiles were repeated as for the lake ecological assessment and sonar was used to detect any signs of macrophytes the length of the lake.

2.4 Endothall assessment

The perimeter of Lake Phoebe was searched for lagarosiphon to the bottom limits of the submerged vegetation at 3.8 m deep. The whole lake was searched and the submerged vegetation was described as for an ecological assessment with species depth ranges, heights and covers.

2.5 Management recommendations

A monitoring strategy for each of the highest ranked lakes was reviewed and includes:

- Lake biodiversity monitoring, LakeSPI, additional assessment of nationally or regionally significant biota and assessment of any new threats to ecological condition.
- Pest plant surveillance targeting lake access and anchoring sites to detect early incursions of weed species.
- Additional routine monitoring of water quality, including measurement of all parameters required to generate the Trophic Level Index (TLI) as outlined by Burns et al. (2000).

For those lakes where there are some practical measures that could mitigate or avert threats to the lake ecology recommendations also include:

- Identifying lakes where pests threaten lake ecology (and possible mitigating measures).
- Identifying those lakes where indicators suggest nutrient enrichment or catchment activity has or threatens to have significant impacts on lake ecology.

3 Results and Discussion

3.1 Ecological assessments

3.1.1 Lake Humuhumu, Pouto, NRC Lake No. 350.

Plate A: Lake Humuhumu showing pastoral catchment in foreground, pine forest in background (Left photo) and harvested (Right photo) left side of lake to the west.

Summary

Surveyed 1984, 1985, 1988, 2001, 2005, 2007, 2012, and 2014.

Overall ranking

Outstanding: A large, relatively deep, clear lake with diverse biota including nationally rare plants, fish and birds, with no major pest species.

Threats

High risk of introduction and establishment of invasive pests. High risk of nutrient enrichment from pine plantation activities (harvesting and fertilisers) and nutrient run-off from farmland. Indicators of nutrient enrichment were present with receding bottom limits and a change in charophyte species dominance and cover occurring.

Management recommendations

Annual invasive weed surveillance at access point. Condition monitoring every 3 years. Monitor for populations of the Nationally Endangered *Trithuria inconspicua* not seen during 2014 survey.

Description

Lake Humuhumu is a large (139.4 ha) dune lake (1700789E, 5979177N) with a maximum depth of 16 m. The lake has a predominantly pastoral catchment with scattered pockets of manuka and kanuka scrub, except for the western shore, which was comprised of sand dunes with pine forest. A large island with indigenous vegetation divides the lake into two basins. There are no inlet or outlet

streams. The lake is easily accessed from the roadway across firm grassed ground. Small boats can be launched with 4-WD.

Wetland vegetation

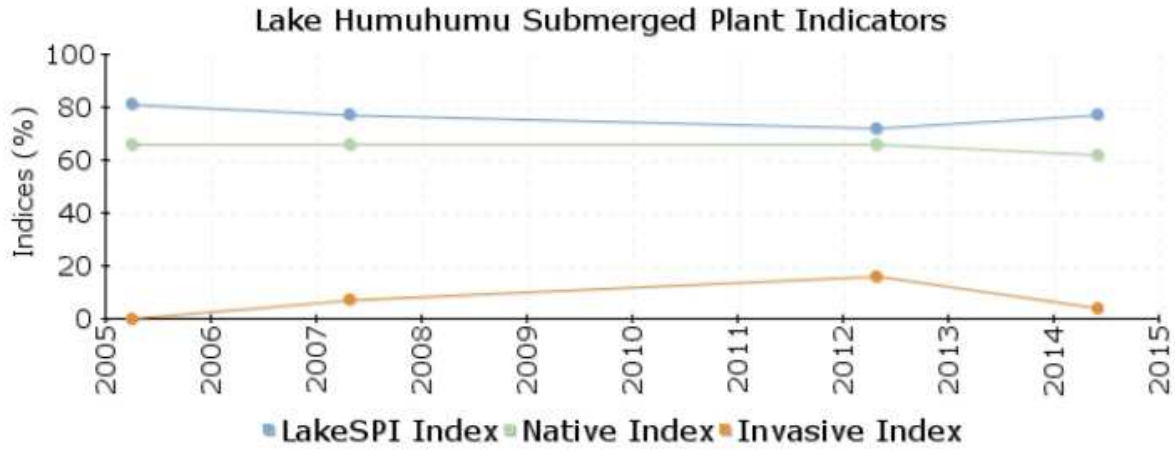
About 70% of the shoreline had a narrow (< 5 m) band of emergent species extending into about 1 m depth of water. *Schoenoplectus tabernaemontani* and *Eleocharis acuta* were the most common species with *Apodasmia similis, Bolboschoenus fluviatilis, Cyperus ustulatus, E. sphacelata, Juncus pallidus, Machaerina articulata, M. arthrophylla, M. juncea* and *Typha orientalis* also present. The invasive exotic weed alligator weed (*Alternanthera philoxeroides*) was present in the marginal vegetation on the north-east shore and the invasive royal fern (*Osmunda regalis*) was also recorded (B. Searle pers. comm.).

Submerged vegetation

Turf plants were common with *Lilaeopsis novae-zelandiae* and *Glossostigma elatinoides* the dominant turf species. Overall, the submerged vegetation was dominated by *Chara globularis* and *Chara australis* at high covers. In 2014 the an average bottom limit was 6.5 m over the five profiles with one profile recording *Chara australis* to a depth of 8.4 m, the deepest recorded vegetation for the lake. There were some scattered low-density growths of tall-growing natives commonly *Myriophyllum triphyllum* but also *Potamogeton cheesemanii* and *P. ochreatus* (mostly to 3 m but some as deep as 5 m). The native *Ruppia polycarpa* was recorded at one transect near the access point.

The lake was predominantly comprised of native vegetation. Two exotic species, *Otellia ovalifolia* and *Potamogeton crispus* (found outside profiles), were found, but they are of little consequence to native biodiversity. Localised impacts occurred from *Utricularia gibba*, which was less common than in 2007 and 2012, being recorded on only one profile in 2014.

LakeSPI



Survey Date	Status	LakeSPI %	Native Condition %	Invasive Impact %
May 2014	Excellent	77%	62%	4%
April 2012	High	72%	66%	16%
April 2007	Excellent	77%	66%	7%
March 2005	Excellent	81%	66%	0%

The most recent LakeSPI Index shows a lake in excellent ecological condition with a LakeSPI index of 77%. This reflects the extent of native submerged vegetation with charophyte meadows present in the lake and a decreased impact of *Utricularia gibba*, first report in this lake in 2007. However, native condition also decreased in 2014 which is of concern.

Water birds

The lake provides significant bird habitat with abundant waterfowl noted on the lake including the regionally significant dabchick (*Poliocephalus rufopectus*) and scaup (*Aythya novaezeelandiae*). The Nationally Endangered bittern (*Botaurus poiciloptilus*) and Caspian tern (*Sterna caspia*) were also seen at this lake. OSNZ also recorded the regionally significant fernbird (*Bowdleria punctata vealeae*) and spotless crake (*Porzana tabuensis plumbea*).

Fish

The common bully (*Gobiomorphus cotidianus*) was most commonly seen. Dwarf inanga (*Galaxias gracilis*) were also common, being observed on most profiles in the shallows and during weed surveillance monitoring. There were no introduced fish species recorded.

Aquatic invertebrates

Nine invertebrates have been recorded including koura (*Paranephrops planifrons*) and freshwater mussels (*Echyridella menziesii*) and the snail (*Glyptophysa variabilis*). Freshwater jellyfish (*Craspedacusta sowerbyi*) medusae were present in the lake.

Endangered species

The Nationally Endangered *Trithuria inconspicua* was not found during 2014, but had been located in all previous surveys. A survey to ascertain the status of this plant in Lake Humuhumu is recommended. The Nationally Vulnerable *Lepilaena bilocularis* was reported in 2001 but the

specimen held at the Auckland Herbarium (AK) was subsequently determined (by PC) to be *Ruppia polycarpa.* In 2012 the uncommon fern *Thelypteris confluens* (At Risk – Declining) was found on the lake margin in two localities. The Pouto Peninsula is the national stronghold for this species.

The At Risk Naturally Uncommon dwarf inanga (*Galaxias gracilis*), a species restricted to the Pouto lakes, remains abundant in Lake Humuhumu with large schools of this fish commonly seen during dive surveys.

The At Risk Declining kakahi (freshwater mussels) were abundant in the lake.

Lake Ecological Value

Lake Humuhumu shows macrophyte indicators of nutrient enrichment with extensive blue green algal mats, receding bottom limits, a change in charophyte species dominance and declining charophyte cover occurring. Water quality trends show a decline in water clarity and increase in total nitrogen, although the TLI remains mesotrophic. Its ecological value rating also remains "Outstanding" but this status could quickly change should deteriorating water quality trends continue. *Trithuria inconspicua* may have disappeared from this lake with Lake Rotokawau the only remaining Pouto location of this plant.

Threats

The vegetation pattern has changed over the years since 1984. *Nitella* sp. aff. *cristata* was dominant until 1985 then *Chara australis* increased in abundance in 1988 to become the dominant plant in 2005 with *Chara globularis*. *N.* sp.aff. *cristata* presence decreased to low covers, was present in only one profile in 2007 and has not been recorded since. Maximum vegetation depth limits were 9 – 10 m but have reduced to 8.4 m on only one profile in 2014 (6.5 mean) with lower plant cover than previous years. Increased blue green algae cover was also noted in 2014.

This lake has no pest fish; Lake Rototuna with *Gambusia affinis* is the closest threat. No invasive submerged plants of any consequence were present but invasive species would do well in this lake. Nearby Lake Roto-otuauru, had presented the most immediate threat with regard to a source of invasive weeds, but grass carp control in that lake has effectively minimised this threat.

Alternanthera philoxeroides is well established near the boat access point at Lake Humuhumu and could threaten other vegetation in sheltered margins of the lake.

Management recommendations

Annual pest plant surveillance at access point. Lake ecological monitoring every 3 years.

Surveillance for *Trithuria inconspicua*.

Nutrient limits need to be set for the catchment to protect the lake.

3.1.2 Lake Kapoai (Pouto), NRC Lake No. 296

Plate A: Lake Kapoai set in a pastoral catchment.

Summary

Surveyed 2005, 2007 and 2014.

Overall ranking

Low: Limited submerged vegetation and marginal vegetation sparse. Fencing of lake margin almost complete, water quality may improve over time.

Threats

Access difficult and likelihood of submerged pest plant establishment is currently low.

Management recommendations

Lake native biodiversity value monitoring every 5 years. Complete fencing the lake and consider planting options around the margins.

Description

A dune lake (1674985E, 6010755N) 1.6 ha where depth has not been determined. The lake is set within a pastoral catchment but has been recently fenced around much of the perimeter. There is an inlet at the northern end of the lake, draining approximately 2 km of pasture to the north-east. Access to the lake is across 2 km of private farmland with access through a locked gate.

Wetland vegetation

The emergent sedges *Schoenoplectus tabernaemontani* and *Eleocharis sphacelata* were re-establishing on the lake margins but much of the lake margin was fringed by kikuyu (*Cenchrus clandestinus*). Short turf communities were common at the lake edge with *Fimbristylis velata, Centipeda aotearoana* and *Alternanthera nahui* present with the amphibious *Limosella lineata, Myriophyllum propinquum* and *Callitriche petriei*.

The problem weed African feather grass (*Cenchrus macrourus*) was noted adjacent to the pump shed on the eastern side of the lake.

Submerged vegetation

No submerged vegetation was present in 2004 or 2007. In 2014 *Potamogeton ochreatus* formed submerged beds from 0.5 to 2 m deep. The lake also had a heavy algal bloom.

LakeSPI

No LakeSPI score was generated.

Water birds

The lack of emergent vegetation and the modified catchment would provide limited habitat for water birds. However 20 mallard ducks (*Anas platyrhynchus*), a pair of black swans (*Cygnus atratus*) and 6 black shags (*Phalacrocorax carbo*) were observed on the lake during the field visit in 2005. Black swan, mallard and grey duck (*Anas superciliosa*) were noted in 2007. DOC SSBI reports the regionally threatened scaup (*Aythya novaezeelandiae*) and dabchick (*Poliocephalus rufopectus*) from this lake.

Fish

NIWA FBIS records from this lake include common bully (*Gobiomorphus cotidianus*), shortfin eel (*Anguilla australis*) and the pest fish rudd (*Scardinius erythrophthalmus*). There are reports of tench (*Tinca tinca*) introduced to this lake. A dead goldfish (*Carassius auratus*) was noted in 2007.

Aquatic invertebrates

No invertebrates were recorded.

Endangered species

The At-risk Naturally Uncommon sedge *Fimbristylis velata* was common in the exposed lake-shore turf.

Lake Ecological Value

Lake Kapoai was evaluated as a low ecological rating with highly enriched nutrient status, poor wetland and emergent buffering and poor species diversity. However, there are signs of improvement as fencing has permitted natural regeneration of some emergent species and submerged plants were recorded for the first time in 2014.

Threats

Access difficulty and likelihood of submerged pest plant establishment is currently low. High levels of nutrients remain its highest threat.

Management recommendations

Lake native biodiversity value monitoring every 5 years.

Complete fencing the lake and consider planting options around the margins.

3.1.3 Lake Rototuna (Pouto), NRC Lake No. 328.

Plate A: Lake Rototuna has a pastoral catchment with a lot of pines in the wider catchment.

Summary

Surveyed 1988, 2001, 2005, 2007, 2012 and 2014.

Overall ranking

Moderate: A lake with retired margins, native vegetation, endangered biota previously recorded and pest fish. Declining water level and water quality parameters have reduced the lake ecological value from **High-Moderate**.

Threats

A lowering water level and declining water quality, with regular heavy algal blooms, threaten the lake's ecology. Invasive submerged weeds would displace the existing vegetation, though access is now more difficult. The invasive reed sweet grass (*Glyceria maxima*) threatens the lake margins.

Management recommendations

Address water level and nutrient concerns. Lake ecological assessment every 5 years. Eradicate *Glyceria maxima*.

Description

Lake Rototuna is a dune lake 6 ha in area and 5.1 m deep, depending on water levels. The catchment is pasture with some pine trees. The lake margin has been fenced since 1999 and a thick mat of kikuyu (*Cenchrus clandestinus*) surrounds the lake. There were no inflow or outflow streams. The lake is adjacent to Pouto Road, accessible with a 4-WD.

Wetland vegetation

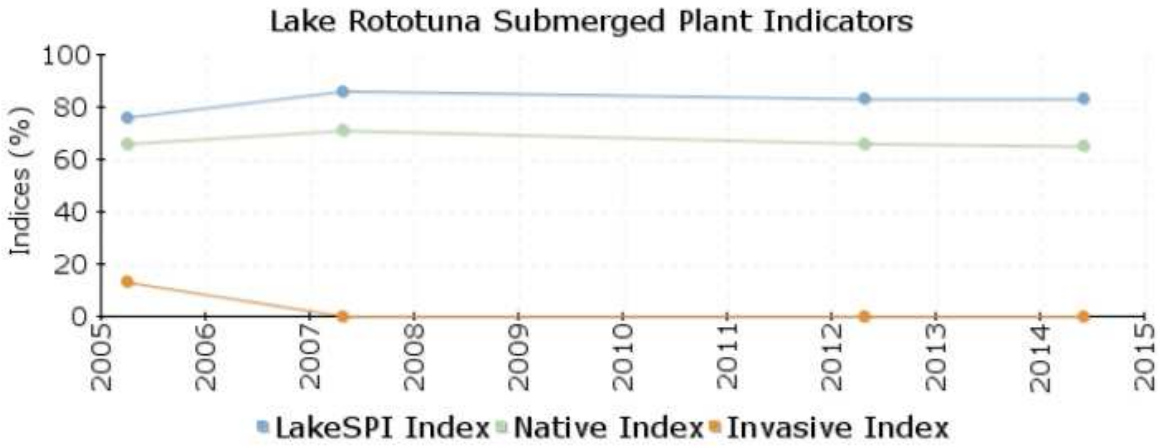
About 80% of the shoreline had emergent species with raupo (*Typha orientalis*), *Eleocharis sphacelata*, *E. acuta*, *Machaerina articulata* and *Schoenoplectus tabernaemontani* forming a narrow band 5 - 10 m wide. *E. sphacelata* beds extended to 1.8 m deep, the other species were < 0.5 m. The invasive reed sweet grass (*Glyceria maxima*) was found for the first time in 2007. It was located amongst raupo on the south-eastern shore of the lake.

Submerged vegetation

Over the last 14 years the lake has been dominated by *Nitella* sp. aff. *cristata* with depth limits steadily decreasing from 5.6 m to 3.1 m. This appears to be driven by lower water levels rather than the bottom limit retracting.

At times the surveys have been difficult with heavy algal blooms and low visibility (0.4 m, in 2012). Turf species were present around about 20% of the lake, with *Glossostigma elatinoides* and *Lilaeopsis novae-zelandiae* most common but always at low covers (<26%). Tall-growing native species were present on all profiles with *Potamogeton ochreatus, P. cheesemanii* and *Myriophyllum triphyllum* the most abundant (0-5% median cover). No tall-growing exotic species were present except *Potamogeton crispus* and *Juncus bulbosus*, found in 2005 but have not been seen since. Charophytes were the dominant vegetation in the lake, with *Nitella* sp. aff. *cristata* at high (>75%) average cover at all profiles and growing to a depth of 3.1 m in 2014. *Chara australis* was also present but *Nitella pseudoflabellata* and *Nitella hyalina* were not recorded this time. The At Risk Naturally Uncommon *Stuckenia pectinata* was recorded in 2005 but has not been found since.

LakeSPI



Survey Date	Status	LakeSPI %	Native Condition %	Invasive Impact %
May 2014	Excellent	83%	65%	0%
April 2012	Excellent	83%	66%	0%
April 2007	Excellent	86%	71%	0%
March 2005	Excellent	76%	66%	13%

Lake Rototuna is categorised as being in 'excellent' ecological condition with a high LakeSPI index of 83%. LakeSPI values for this lake have remained stable since surveys began in 2001 with only a small change noted in the invasive impact scores during the 2001 and 2005 surveys on account of *Potamogeton crispus* and *Juncus bulbosus* being present at that time.

Water birds

The regionally significant dabchick (*Poliocephalus rufopectus*) and scaup (*Aythya novaezeelandiae*) were noted in previous visits, with 18 other common birds, the most dominant being black swans (*Cygnus atratus*) and paradise shelduck (*Tardorna variegata*). In addition to the two regionally significant birds, an endangered Australasian bittern (*Botaurus poiciloptilus*) was seen during the 2012 and 2014 visits.

Fish

Nationally threatened dwarf inanga (*Galaxias gracilis*) were recorded by the NIWA FBIS database although none were seen during the survey. Common bully (*Gobiomorphus cotidianus*) and exotic *Gambusia affinis* were observed. Rudd (*Scardinius erythrophthalmus*) were also reported.

Aquatic invertebrates

The introduced snail *Physa acuta* was recorded during the vegetation survey.

Endangered species

No threatened plant, fish or aquatic invertebrate species were observed during 2014.

Lake Ecological Value

In 2001 the vegetated bottom limits were around 5.6 m. Water level in 2012 was low with the maximum depth 4.2 m and the clarity was poor at around 0.4 m with a dense algal bloom. In 2014 bottom limits were further reduced to a little over 3 m, but water clarity had improved to 1.5 m. The diversity of charophytes was diminished in 2014 with *Nitella pseudoflabellata* and *N. hyalina* not recorded.

Lake Rototuna ecological value has declined from High-Moderate to Moderate and will be downgraded further should the population of dwarf inanga be extinct in this lake.

Threats

Five degrading water quality trends have been recorded in Lake Rototuna – decreasing water clarity and increasing ammoniacal nitrogen, total nitrogen, total phosphorus and TLI. This may be related to the steady fall of Lake Rototuna's water level with a loss of 2.74 m of head since 2004. There was also an apparent earlier level drop in excess of 1 m when the lower Rototuna lake blew out during a storm in the late 1990s (L. Forrest pers comm.). The lake is approaching a supertrophic TLI. Periodic heavy algal blooms indicate the lake is receiving too much nutrient from its catchment. They could reach a level where they are toxic to most of the biota in the lake.

The vegetation is native dominated and introduction of other weed species is a risk. The sprawling emergent weed reed sweet grass, threatens much of the marginal vegetation.

Pest fish (gambusia and rudd) are of concern. Gambusia have been implicated in the possible loss of galaxiids from Lake Kai Iwi, and they may have similar impacts on dwarf inanga in Lake Rototuna. Rudd are largely herbivorous and have been implicated in the loss of vegetation in nutrient stressed lakes similar to Lake Rototuna. However, rudd have been present in the lake for around a decade with little apparent impact.

Management recommendations

Lake ecological assessment every 5 years. Eradicate reed sweet grass from the lake margin using a grass-specific herbicide.

Investigate dwarf inanga population.

Investigate hydrology, the reduction of lake levels and sources of nutrients.

3.1.4 Lake Wainui (Pouto), NRC Lake No. 305.

Plate A: Lake Wainui viewed from the north (access point south end by sheds). Note the steep sided pasture catchment. Photo Lisa Forester 2010.

Summary

Surveyed 2001, 2005, 2007 and 2014.

Overall ranking

High: A small lake with native submerged vegetation, prone to nutrient enrichment, but showing the benefits of stock exclusion with an increase of lake ecological condition from **High-Moderate** to **High** in 2014.

Threats

Risk of pest introduction is low, but should these be introduced there would be major impacts on the lake. Nutrient enrichment and nutrient release from anoxic bottom sediments from stratification turnover.

Management recommendations

Lake ecological assessment monitoring every 5 years. Re-vegetation of steep sloping margins.

Description

A small (4.8 ha) dune lake (1679414E, 6004475N) with a maximum depth of 11.8 m and situated in a pastoral catchment with cattle fenced from the lake edge. No surface inflow or outflow. Access across 1 km private farmland by 4-WD with launching areas either end.

Wetland vegetation

Narrow (2 to 5 m) marginal fringe on almost all the shoreline dominated by *Schoenoplectus tabernaemontani* with some areas of *Typha orientalis, Machaerina articulata, Eleocharis acuta* and *E. sphacelata* growing to a maximum depth of about 1 m.

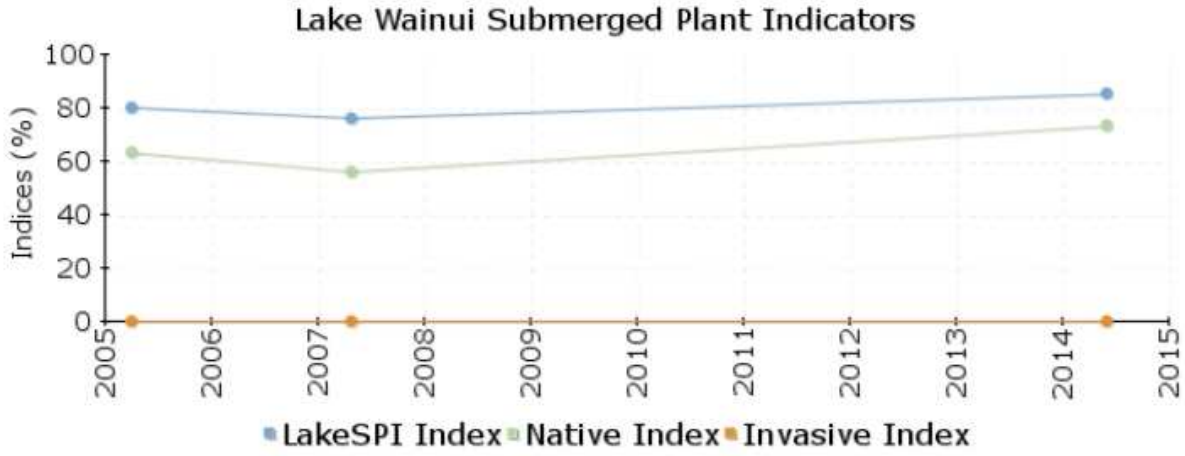
The pest plant primrose willow, (*Ludwigia peploides*) formed floating mats at the ends of the lake. A non-weedy exotic, swamp lily (*Ottelia ovalifolia*), was also present with both submerged and floating leaved forms.

Submerged vegetation

No turf species were noted and charophyte meadows composed mostly of *Chara australis* grew to 7.9 m deep with some *Chara globularis* and *Nitella* sp. aff. *cristata.* Tall-growing native species mostly *Potamogeton ochreatus* (to 5.4 m deep), some *P. cheesemanii* and *Myriophyllum triphyllum* were present. No exotic submerged species were recorded.

Bottom limits have been 2.6 m, 5.9 m, 5 m, and 7.9 m deep in 2001, 2005, 2007 and 2014 respectively. The dominant charophyte has shifted from *Nitella* sp. aff. *cristata* in 2005 to *Chara australis* in 2014 with very little *Nitella* sp. aff. *cristata* remaining.

LakeSPI



Survey Date	Status	LakeSPI %	Native Condition %	Invasive Impact %
May 2014	Excellent	85%	73%	0%
April 2007	Excellent	76%	56%	0%
March 2005	Excellent	80%	63%	0%

A high LakeSPI score of 85% resulting from a totally native vegetation.

Water birds

Fencing of the lake has increased the marginal emergent habitat. Four regionally rare dabchick (*Poliocephalus rufopectus*) and black swan (*Cygnus atrata*) and paradise shelduck (*Tadorna variegata*) were seen during the 2007 field visit. Earlier reports include the Nationally Endangered bittern (*Botaurus poiciloptilus*) and regionally significant scaup (*Aythya novaezeelandiae*).

Fish

No species were recorded.

Aquatic invertebrates

Leeches (*Richardsonianus mauianus*), backswimmers (*Sigara arguta*) and *Physella acuta* snails were common.

Endangered species

The At Risk Naturally Uncommon sedge *Fimbristylis velata* was recorded in the past on bare lake margins. However, since exclusion of cattle in 2010, the open habitat required by this species no longer exists.

Lake Ecological Value

Lake Wainui bottom limits are now at their deepest since records began 13 years ago. This is one of four lakes with improving water quality (out of the 27 Northland lakes monitored by NRC). Recent TLI changed from eutrophic to mesotrophic, only one of three Pouto lakes with this rank. The improvement in bottom limits and water quality was likely due to the recent fencing of the margins excluding cattle access to the lake and subsequent increase in emergent vegetation that now almost encircles the lake. Its ecological value rating increased from “Moderate-High” to “High”.

Threats

An indigenous submerged vegetation with tall-growing natives, is very susceptible to invasion by tall-growing exotic species. However, due to isolation and difficult access, the risk of introduction is low. The catchment is grazed pasture, but fencing and current land management practices have permitted an improvement in the lake.

Management recommendations

Lake ecological assessment monitoring every 5 years.

3.1.5 Lake Wairere (Pouto), NRC Lake No. 339 & Round Hill Lake 2.

Plate A: Round Hill Lake 2 (top), and Lake Wairere north end (middle) and Lake Wairere further south (bottom). Raupo (*Typha orientalis*) dominated emergent vegetation.

Summary

Surveyed 2005 and 2014.

Overall ranking

High-Moderate: Isolated and set within mostly indigenous vegetation with native aquatic vegetation, but subject to algal blooms. Endangered bird species present.

Threats

Low risk of introduction of invasive weeds. Water quality variable.

Management recommendations

Lake ecological assessment monitoring every 5 years.

Consider nutrient issues.

Description

This narrow (~2 km long, <100 m wide) dune lake (1691256E, 5985189N) is 16.5 ha in size and around 2 m deep. There are two small cut-offs to the north (Plate B). Roundhill lake 2 was situated just north of Lake Wairere (1690678E, 5986484N). Lake Wairere has a margin of steep scrub covered cliff to the east and rough pasture, wetland and mobile sand dunes to the west. Access is through 3 km of pine forestry roads and rough pasture, mostly on a well-formed track requiring 4-WD. No boat access.

Plate B: Yellow lines indicate path swum. Line 1 is Round Hill Lake 2, and lines 2 & 3 are paths swum in Lake Wairere (north end).

Wetland vegetation

Extensive wetlands occurred in the south west of the lake with *Typha orientalis, Schoenoplectus tabernaemontani, Machaerina articulata, M. arthrophylla, Eleocharis acuta, E. sphacelata* and *Carex secta* common. The southern end of the lake was fringed with a dense 5-10 m bed of raupo (*Typha orientalis*).

Additional native emergent species seen in 2014 were *Machaerina juncea, Carex virgata, C. maorica, Cyperus ustulatus, Isachne globosa, Isolepis prolifera, Persicaria decipiens* and *Juncus pallidus* and the exotic grass *Paspalum distichum*.

Submerged vegetation

In 2014 in Round Hill Lake 2 *Chara australis* was the dominant species to 2.8 m deep. Also present were *Potamogeton cheesemanii* (1.6 m) and *Potamogeton ochreatus* (2.5 m).

In the northernmost cut-off section of Lake Wairere, *Chara australis* was also the dominant species to 1.2 m deep, with *Potamogeton ochreatus* (2.1 m), and *Potamogeton cheesemanii* (1.8 m).

In the northern end of Lake Wairere the water depth was only 1 m and it was vegetated with *Chara australis*, *C. globularis*, *Utricularia gibba*, *Potamogeton cheesemanii, P. ochreatus* and *Myriophyllum triphyllum* all attaining high covers.

LakeSPI

Reconnaissance only – no LakeSPI scores were generated.

Water birds

The lake and surrounding wetlands provide excellent bird habitat. DOC SSBI (1977) recorded the Nationally Threatened bittern (*Botaurus poiciloptilus*) and regionally threatened dabchick (*Poliocephalus rufopectus*) and scaup (*Aythya novaezeelandiae*). A spotless crake (*Porzana tabuensis plumbea*) was seen in the wetland during the 2014 field visit.

Fish

Eels were seen.

Endangered species

No endangered plant, fish or aquatic invertebrate species were recorded in 2014, although At Risk Declining longfin eel (*Anguilla dieffenbachii*) were potentially present (eel species were not determined during the ecological survey).

Lake Ecological Value

Lake Wairere was first surveyed in 2005 with a heavy algal bloom (0.3 m of visibility) and some remnant plant communities. Water clarity was considerably better in 2014 (around 2.5 m) and more extensive submerged vegetation was present.

Threats

The isolation of the lake provides a low risk of introduction of invasive weeds but establishment is likely should this occur. Water clarity is variable, probably due to nutrient additions from the forestry area to the east. While conditions were suitable for macrophyte growth in 2014, nutrient losses from land management practices are likely cause periodic algal blooms that threaten water quality and ecological health.

Management recommendations

Lake ecological assessment monitoring every 5 years.

3.2 Surveillance

3.2.1 Lake Humuhumu

The access at the eastern side of the lake was checked by a scuba diver with underwater scooter and 3 snorkelers covering about 300 m of shoreline and out to the 6 m depth contour. Alligator weed has spread and was abundant amongst the marginal vegetation. No invasive submerged species were found apart from some *U. gibba*, which remains present (but not abundant) growing over submerged species.

3.3 Grass carp assessments

3.3.1 Lake Roto-otuauru (Lake Swan)

Egeria (*Egeria densa*) was first reported in the lake in 1992, and hornwort (*Ceratophyllum demersum*) was first recorded in the 2005 survey. The risk of spread by hornwort and egeria from Lake Roto-otuauru to adjacent high-value lakes (Plate A) was high. Grass carp were introduced in May 2009 to eradicate hornwort and egeria, to eliminate the risk of weed spread to high value neighbouring lakes, and to enable native vegetation restoration in Lake Swan once these weeds were eradicated.

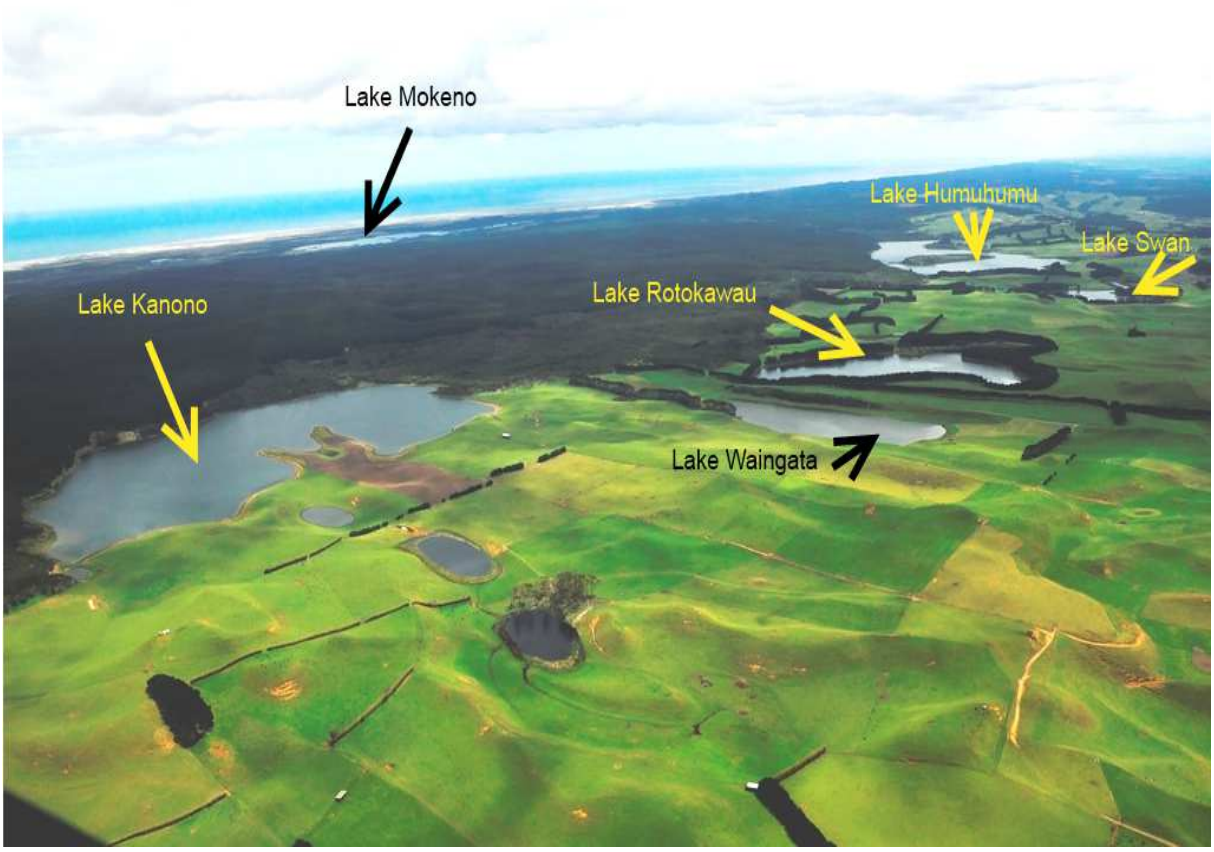


Plate A: The location of Lake Swan shown in relation to other lakes on the Pouto Peninsula. [Photo Rod Budd, NIWA, Hamilton].

In April 2010 virtually all the egeria had gone and about half the hornwort had been removed. At a few locations with sandy margins, a wide range of turf species were present with *Glossostigma elatinoides* the dominant species. Charophytes persisted at one small site in water to 1.8 m deep on the eastern shore of the main body of the lake.

In March 2011 only a few pieces of hornwort were found floating amongst the emergent species on the lake margin and the lake basin was de-vegetated. The marginal emergent species were also reduced considerably in extent with only remnants of raupo (*Typha orientalis*) stands left (Plate B). The area least grazed was in the arm at the north end of the lake where the lake extends into a wetland. Low growing turf species were not affected by grass carp grazing.

In 2012 five sites were surveyed (A = 2613090E 6540457N; B = 2612861E 6540388N; C = 2612641E 6540444N; D =2612652E 6540548N; E = 2612879E 6540643N) and no hornwort or egeria were found.

The risk of spread by hornwort and egeria from Lake Roto-otuauru to adjacent high-value lakes had been reduced to negligible.

Plate B: Lake Swan margins. Grass carp were introduced in May 2009 and by 2011 had removed significant amounts of the raupo (*Typha orientalis*) from the margins.

In 2013 no fragments of the targeted weeds were found. Patches of alligator weed were present and it appears that grass carp won't eat it. No hornwort or egeria were found in 2014.

No evidence of either hornwort or egeria has been found for three years. It is appropriate to begin removal of grass carp using netting.

3.4 Endothall Assessment: Phoebe's Lake

Plate A: Phoebe's Lake with a dense margin of *Eleocharis sphacelata*.

Description pre-treatment April 2012

A small (0.9 ha) dune lake (1696778E, 5981948N), 4 m deep. The catchment is primarily pasture. There are no inflows or outflows. Access is through less than 1 km of well-formed track but with no easy access into the lake.

Emergent vegetation was dense and surrounded the lake with abundant raupo (*Typha orientalis*), *Eleocharis sphacelata* and *Machaerina articulata* and small amounts (now heavily controlled) of Manchurian wild rice (*Zizania latifolia*). *Lagarosiphon major* was the dominant submerged species in shallow water forming dense surface-reaching beds extending to 2.6 m water depth. Below this, 1.5 m tall beds of *Potamogeton ochreatus* with occasional plants of *Nitella* sp. aff. *cristata* were found to a maximum depth of 3.6 m. *Utricularia gibba* was common in shallow areas.

Endothall treatment and effects

One hundred litres of Aquathol K was applied in three doses: 28 L on 17 April 2012, 46 L on 24 April 2012 and 26 L on 2 June 2012. The maximum theoretical concentration once dispersed through the lake was 1.5 mg L^{-1} (ppm). Delivery was spread over three applications spanning two weeks to extend the contact time. The water temperature during treatments was a little below 20°C. The percentage dissolved oxygen varied from 88 to 93% pre-trial (in two spot measures) and dropped to 76% at 20 and 30 days post trial when the lagarosiphon weed beds had collapsed and were decaying. By 30th October 2012 the lagarosiphon was gone except for one patch which had disappeared by April 2013 when next checked. In January 2014 and May 2014 no lagarosiphon was found in the lake.

Regular post spray monitoring found birds (dabchick, black swan paradise ducks), bell frogs and water boatmen in good health with no signs of fish kills and the water remained clear (secchi 2.8 m). Apart from the target plant lagarosiphon, no herbicidal effects were seen in the plants and the native pondweeds and charophytes increased in abundance to vegetate the area previously occupied by lagarosiphon.

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Appendix 1 Lake Ecological Value Assessment Method

Habitat size

The largest and deepest lakes are likely to be the most stable in terms of water quality and resilience and support the greatest diversity of habitat and biota. Lake area and depth data were ranked as shown in **Table 5-1: Lake area and depth ranking.**

Table 5-1: Lake area and depth ranking.

Lake area (ha)	Rank	Lake depth (m)	Rank
>100	3	>25	3
10-100	2	10-25	2
10>1	1	<10 >2	1
≤1	0	≤ 2	0

The two rankings were averaged to produce an overall habitat size rank (maximum score 3 – minimum score 0).

Buffering

Lakes are likely to be the most stable when their catchments are predominantly in indigenous vegetation, connected to large wetland systems and are surrounded by extensive beds of emergent vegetation. Information from the FENZ database was used for percent native vegetation extent of wetland (percentage Freshwater Sedgeland / Rushland and Flaxland Catchment area) relative to lake area and extent of emergent vegetation were ranked as shown in Table 5-2.

Table 5-2: Buffering. Percentage native vegetation, extent of wetland and extent of emergent vegetation ranking. To score a maximum (3) emergent beds must >20 m.

% native vegetation catchment cover	Rank	Wetland extent (% of lake area)	Rank	Emergent extent (% of lake perimeter)	Rank
>50	3	>100	3	100	3
25-50	2	10-100	2	<100 >50	2
10-24	1	<10 >0	1	25-50	1
<10	0	0	0	<25	0

The three rankings were averaged to produce an overall buffering rank (maximum score 3 – minimum score 0).

Water quality

Un-impacted lakes are likely to have water quality TLI (Trophic Level Index) of 3 or less (oligotrophic). NRC TLI scores for 28 lakes were rated as shown in Table 5-3.

Lakes where water quality data were not available were assumed to be supertrophic or worse (TLI >5) (maximum score 3 – minimum score 0).

Table 5-3: Water Quality rating.

TLI Score	Trophic level	Rank
<3	Oligotrophic, microtrophic or ultra-microtrophic	3
3-4	Mesotrophic	2
4-5	Eutrophic	1
>5	Supertrophic or hypereutrophic	0

Aquatic vegetation diversity

Lakes are likely to be in good ecological condition when diverse aquatic vegetation is present.

Data on vegetation composition was analysed from the most recent ecological lake surveys (Wells and Champion 2013 and unpublished data from field sheets) and rated as shown in Table 5-4.

Table 5-4: Aquatic vegetation diversity rating.

Number of indigenous emergent, free-floating and submerged plant species	Rating
>20 species	3
15-20 species	2
5-14 species	1
<5 species	0

Exceptions to this assumption are lakes where water chemistry restricts the development of diverse vegetation (e.g., Lake Taharoa has low bicarbonate concentration likely to prohibit the growth of submerged vascular plants and Lake Te Kahika where acid water (pH <4) prohibit the growth of all but two submerged species). However, these lakes are likely to score highly for other ecological values.

Aquatic vegetation integrity

In addition to high diversity of aquatic plant species, the higher the percentage cover of littoral habitat occupied and the deeper the maximum depth that native aquatic plants grow to (relative to lake depth), the better the lake ecological condition.

LakeSPI is a bio-assessment tool that uses Submerged Plant Indicators (SPI) to assess the ecological condition of New Zealand lakes and to monitor trends. Part of this index is the Native Condition Index (NCI) that scores the integrity of submerged vegetation as a percentage of the predicted pre-European (un-impacted reference) state.

Table 5-5: Aquatic vegetation integrity.

LakeSPI Native Condition Index	Rating
>75%	4
>50-75%	3
>20-50%	2
1-20%	1
0%	0

Data was analysed from the most recent ecological lake surveys to rate lakes according to the NCI (Table 5-5).

Endangered species

Much of New Zealand's endangered biota has been recently ranked using the protocols of Townsend et al. (2008) as Nationally Threatened (Nationally Critical, Nationally Endangered & Nationally Vulnerable), or At Risk (Declining, Relictual, Recovering and Naturally Uncommon), with recognition of new species that have naturally colonised New Zealand (Vagrant or Coloniser). Where there is insufficient information the taxon is recorded as Data Deficient. Table 5-6 outlines the current (2013) threat ranking of freshwater biota recorded from Northland lakes and their wetland margins.

Table 5-6: Threat status of Northland lakes biota based on de Lange et al. (2013), Robertson et al. (2013), Goodman et al. (2014), Grainger et al. (2014).

Threat ranking	Taxonomic group	Species
Nationally Critical	Vascular plants	*Centrolepis strigosa*
		Hibiscus diversifolius
		Ophioglossum petiolatum
		Utricularia australis
		Isoetes sp. aff. *kirkii* (CHR 247118A; Lake Omapere)
Nationally Endangered	Vascular plants	*Centipeda minima*
		Todea barbara
		Trithuria inconspicua
	Birds	*Botaurus poiciloptilus*

Threat ranking	Taxonomic group	Species
Nationally Vulnerable	Vascular plants	*Drosera pygmaea*
		Isolepis fluitans var. *fluitans*
		Mazus novae-zeelandiae ssp. *impolitus* f. *impolitus*
	Charophytes	*Lamprothamnium papulosum*
	Birds	*Poliocephalus rufopectus*
		Sterna caspia
	Fish	*Neochanna helios*
At Risk - Declining	Vascular plants	*Cyclosorus interuptus*
		Myriophyllum robustum
	Birds	*Bowdleria punctata vealeae*
	Fish	*Anguilla dieffenbachii*
		Galaxias maculatus
		Galaxias gracilis (Pouto Lakes)
	Invertebrates	*Echyridella menziesii*
At Risk - Relictural	Birds	*Porzana pusilla affinis*
		Porzana tabuensis plumbea
	Fish	*Neochanna diversus*
At Risk - Recovering	Birds	*Anas chlorotis* 'North Island'
At Risk - Naturally Uncommon	Vascular plants	*Fimbristylis velata*
		Thyridia repens
		Stuckenia pectinata
-		*Thelypteris confluens*
	Birds	*Phalacrocorax carbo novaehollandiae*
		Phalacrocorax melanoleucos brevirostris
		Phalacrocorax sulcirostris
		Gallirallus philippensis
	Fish	*Galaxias* sp. (Kai Iwi Lakes)
	Invertebrates	*Amarinus lacustris*
Coloniser	Vascular plants	*Gratiola pedunculata*
		Juncus polyanthemus

Only plants and fish have been used in this ranking, as most endangered birds are mobile and may utilise a range of degraded lakes as well as those with high ecological integrity. Each Nationally Threatened taxa was given a score of 5, At Risk Declining species a score of 2 and other At Risk and new to New Zealand species a score of 1. These were summed and rated as shown in Table 5-7.

Table 5-7: Endangered species rating. Each "Nationally Threatened" taxa was given a score of 5, declining species a score of 2 and other At Risk and new to New Zealand species a score of 1. These were summed to give a threatened score and then rated.

Threatened score	Rating
>9	3
5 - 9	2
1 -5	1
0	0

Regionally uncommon species were not assessed. Endangered species were not scored when they were formerly recorded but not found during the latest assessment.

Presence of key species

Freshwater mussels, also known as kakahi or torewai (*Echyridella menziesii*), are an important species in shallow water bodies as their ability to filter feed and remove planktonic algae assists in-lake buffering to nutrient enrichment. Presence of living mussels also indicates aerobic conditions prevail and adds an additional point to the ranking.

Connectivity

Conning & Holland (2003) noted that the abundance of dune lakes and associated wetlands, although discontinuous, collectively provide important habitat for a number of threatened and regionally significant birds. An additional point was added to the ranking of lakes associated with high concentrations of other lakes / wetlands (e.g., Pouto and Aupouri lakes).

Total Ecological Value Score

Based on these criteria a maximum total Lake Ecological Value score of 20 could be attained. Lakes assessed were rated as shown in Table 5-8.

Table 5-8: Lake Ecological Value score and Rating.

Ecological Value Score	Rating	Number of lakes in category
13-20	Outstanding	12
10-12	High	8
8-9	High-Moderate	14
6-7	Moderate	18
4-5	Moderate-Low	16
<4	Low	8