Northland Lakes - Annual Report 2014

Prepared for Northland Regional Council

June 2014

Waitahora Lagoon

Authors/Contributors:
Rohan Wells
Paul Champion
Tracey Edwards

For any information regarding this report please contact:

Rohan Wells
Aquatic ecologist
Aquatic Plants
+64-7-856 753
r.wells@niwa.co.nz

National Institute of Water & Atmospheric Research Ltd
Gate 10, Silverdale Road
Hillcrest, Hamilton 3216
PO Box 11115, Hillcrest
Hamilton 3251
New Zealand

Phone +64-7-856 7026
Fax +64-7-856 0151

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Reviewed by

Kerry Bodmin
Wetland Ecologist

Approved for release by

Dr David Roper
Regional Manager

Formatting checked by

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:

Aupouri: Lake Morehurehu, Lake Morehurehu South 2, Lake Ngatu, Lake Rotokawau, Lake Te Kahika and Waitahora Lagoon.

Lakes Morehurehu, Morehurehu South 2, and Te Kahika were repeated this year to track their recovery following 2013 when the lakes had become heavily stained brown / red (likely a forest harvesting impact) and had consequently lost most submerged vegetation.

Karikari Peninsula: Lake Waiporohita.

Kai iwi Lakes: Lake Kai iwi, Lake Taharoa and Lake Waikare.

Pouto: 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 Heather and 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 Phobe 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, Lake Kai iwi, Lake Ngatu, Lake Taharoa, Lake Waikare and Lake Waiporohita. 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. Terrestrial woody weeds were surveyed around Lake Taharoa and data will be made available to NRC to incorporate into their GIS system.

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

Aupouri:

Lake Morehurehu was rated as **"**Outstanding" in 2009 with good water quality and a diverse native submerged flora including endangered species, but since 2013 has been rated "High" due to loss of most submerged vegetation. It was also noted that there has been a marked increase in total nitrogen concentration and water clarity had reduced with red/brown colouring. Much of the pine plantation in the catchment was logged in 2013.

Lake Morehurehu South 2 was impacted much as Lake Morehurehu even though trees in its immediate catchment were not felled. It would suggest that these lakes are hydrologically connected and the ground water feeding these lakes was heavily contaminated. This lake was rated as "High" in 2006 with high native biodiversity but in 2013 was rated "Moderate" as submerged vegetation was lost. A subsequent visit in July 2013 by NRC reported a much improved clarity and re-establishment of some submerged vegetation and the 2014 visit found a rapid recovery had occurred and the lake was rated as "High to Moderate".

Lake Te Kahika was rated as "High" in 2009. It was a unique clear-water acidic lake with submerged vegetation limited to some *Sphagnum* and high covers of the Nationally Critically Endangered *Utricularia australis* in the southern inflow. There has been a recent marked increase in total nitrogen concentration and water clarity has reduced with red/brown colouring and trophic level index (TLI) has changed from oligotrophic to mesotrophic. This coincided with pine logging in the catchment. No *U. australis* was found in 2014 and the invasive *U. gibba* had extensively colonised the lake margins to a maximum depth of 4 m. These changes have reduced the lake ecological rating down to "High to Moderate".

Waitahora Lagoon was rated as "High" using the Lake Ecological Value Rating and it is a rare example of a pristine marine contact lake (unique in the North Island). Storm surge during the recent Cyclone Lusi inundated much of the lower wetlands with sea water causing burn off of saltmarsh rushes to around 1 m above their normal extent. Despite this, healthy populations of the Nationally Critical *Hibiscus diversifolius* (largest known population), Nationally Vulnerable *Lamprothamnium papulosum* (only site in northern half of the North Island) and Naturally Uncommon *Thyridia repens* (largest Northland population) persisted. However, the Nationally Critical *U. australis* was not found this time.

Lake Ngatu charophyte species composition has changed, and since 2010 charophyte abundance has markedly diminished lake wide indicating that nutrient enrichment stress is likely. The lake is classified as mesotrophic and no trends in degrading water quality have been detected using TLI. However, total nitrogen levels have been close to all-time highs for more than a year. *Lagarosiphon major* has been present in the lake since 1988 but has spread little and is restricted to a few locations. It is possible it could be eradicated with endothall. Eradication of three marginal weeds,

alligator weed, mile-a-minute and Christmas berry is advocated. Its ecological value rating remains "Outstanding".

Lake Rotokawau charophyte meadows have steadily declined in abundance since 2004 with *Chara fibrosa* declining markedly indicating a probable increase in nutrients. Additionally water quality monitoring has shown an increase in ammoniacal nitrogen and the lake TLI has changed from mesotrophic to eutrophic. Cattle access to the south-western lake edge could be involved as heavy pugging of the area was noted and addition of urine and faeces and grazing of marginal vegetation well into the lake was evident. Previously, average charophyte cover was 76 - 95 % but was only 1 – 5% in 2014. The Nationally Endangered *U. australis* was prominent in 2009 and still persists, albeit as only a few plants. *U. gibba* is very abundant and the dominant plant within the lake. Its ecological value rating changed from "High" to "High to Moderate".

Karikari Peninsula:

Lake Waiporohita has improved in condition, is now fully vegetated and the water clear. It is one of four lakes (out of the 27 Northland lakes monitored by NRC) showing improved water quality with the TLI recently changing from supertrophic to eutrophic. Its ecological value rating remains "Outstanding". The introduced weed primrose willow (*Ludwigia peploides* var. *montevidensis*) was restricted to an area of < 10 m^2 and this is the only known site of this species north of Dargaville. Its eradication is recommended urgently while it is still an easily achievable task. Alligator weed (*Alternanthera philoxeroides*) is now dispersed around the whole of Lake Waiporohita and eradication is now not thought feasible.

Kai Iwi Lakes:

Lake Kai iwi water quality has deteriorated with increases in chlorophyll *a* (planktonic algae), total nitrogen, decreasing water clarity and a change in TLI from Oligotrophic to Mesotrophic. However, charophyte composition and bottom limits have not changed markedly since 1984 and its ecological value rating remains "Outstanding". This lake probably contains the largest Northland population of the Nationally Endangered *Trithuria inconspicua* (only Lake Rotokawau, Pouto not surveyed may have more).

Lake Taharoa remains the best example of a clear-water lake in Northland with the deepest recorded (currently 22 m) submerged vegetation in the North Island. It is charophyte dominated and is mostly all *Chara fibrosa*. TLI indicates this lake is stable with an oligotrophic status. Its ecological value rating remains "Outstanding". The major woody weeds on the lake surrounds were Sydney golden wattle (*Acacia longifolia*), coastal banksia (*Banksia integrifolia*) and the wilding pines (*Pinus pinaster* and *P. radiata*).

Lake Waikare supported dense *Chara fibrosa* dominated charophyte meadows within the upper profile and *C. australis* from 13 m to a maximum recorded depth of 19.7 m. Before 2005, *Chara fibrosa* dominated the charophytes to the bottom limit. While the bottom limits remain deep the species change is indicative of a change in water chemistry. These changes were not detected in TLI trends with no change from oligotrophic status and a decreasing trend in total phosphorus. The lake does however stratify over summer and low oxygen levels in the hypolimnion could threaten its future status. Its ecological value rating remains "Outstanding".

Pouto:

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 the six high-value, high-risk lakes monitored.

Grass carp results:

Lake Heather: After 4 years of grass carp in Lake Heather no trace of submerged weed beds or the weed *E. densa* were found, with only one detached fragment of *C. demersum* (hornwort) seen.

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. Lakes Morehurehu and Te Kahika continue to be monitored annually to document the impacts of forest harvesting and their recovery rate. Consideration should be given to mitigating ongoing impacts and provisions to avoid a re-occurrence of events in these lakes in future and elsewhere.

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

3. 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. Lakes Ngatu, Rotokawau (Aupouri) and Humuhumu show signs of deterioration and urgent intervention is needed to maintain or restore their values.

4. Against the trends elsewhere Lake Waiporohita has improved. If this lake is responding to a change in land management, it would be useful to document this as it could benefit other lakes. Eradication of primrose willow is advocated at this lake.

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

6. Lagarosiphon control in Lake Ngatu could be attempted using endothall (following favourable results with endothall in Lake Phoebe). Enclosures erected short term would increase the dose. Eradication of three marginal weeds, alligator weed, mile-a-minute and Christmas berry is also advocated.

7. 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:

   Aupouri: Lake Morehurehu, Lake Morehurehure South 2, Lake Ngatu, Lake Rotokawau, Lake Te Kahika, and Waitahora Lagoon.

   Karikari Peninsula: Lake Waiporohita.

   Kai Iwi Lakes: Lake Kai iwi, Lake Taharoa, and Lake Waikere.

   Pouto: 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; Lake Kai-iwi; Lake Ngatu; Lake Taharoa; Lake Waikere; Lake Waiporohita).

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.

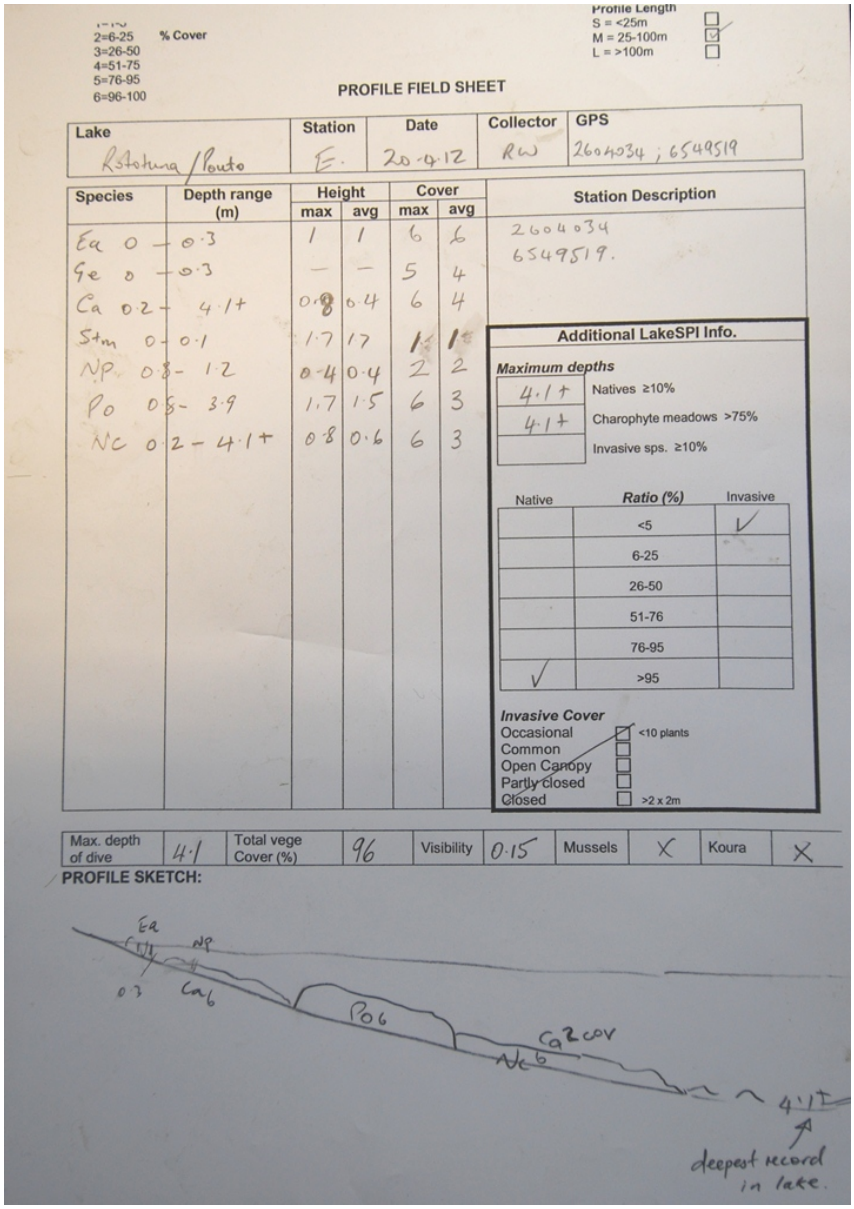


Figure 2-1: Survey sheet for submerged vegetation surveys.

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
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

2.3 Grass carp assessment

The progress of grass carp on target pest plants in Lakes Swan and Heather 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 Morehurehu (Aupouri), NRC Lake No. 32.

Plate A: Lake Morehurehu set in mature plantation pine (top 2009), but recently felled and re-planted (bottom 2013).

Summary

Survey dates 1988, 2004, 2006, 2009, 2013 and 2014.

Overall rating

High: but now with very little submerged vegetation and heavily stained water.

In 2009 rated **Outstanding**: Remote lake with diverse native submerged and emergent vegetation including endangered species and good water quality.

Threats

The cautionary note that pine harvesting has potential impacts on water quality in 2009 appears to have exceeded all expectations with extensive loss of aquatic habitat. There has been no recovery of submerged vegetation when 2013 results were compared with the 2014 survey. Continued impact needs to be mitigated and future events like this avoided. There are still significant areas in the catchment that have not been harvested.

Introduction of invasive species could threaten and further degrade this lake.

Management recommendations

Undertake a full investigation of the impact of logging on Lakes Te Kahika, Morehurehu and Morehurehu South 2. Review recent changes in the catchment and document impacts in all receiving waters. Continue lake monitoring annually to evaluate rate of recovery in these lakes. Provide advice to forestry companies or other land-use in these poorly buffered water bodies to modify activities that caused such extensive environmental damage. There are still significant areas in the catchment that have not been felled.

Description

Lake Morehurehu is a dune lake situated 1599711E, 6166691N and is 36.3 ha in area. Depth is c. 14 m. It is situated on Lower Quaternary sand dunes, formed by a stream system impounded by dunes. The catchment is all plantation pine trees, with a narrow zone of manuka/hakea scrub between the lake and pines. Areas of mature trees have been recently harvested and replanted for a second crop. The woody leguminous weeds oxylobium (*Callistachys lanceolata*) and Sydney golden wattle (*Acacia longifolia*) have established as the dominant cover in much of the cleared pine forest.

There are 3 inlet streams entering the south-west, north-west and south-eastern arms of this lake, with the outlet flowing through a wetland at the south-eastern end of the lake into Great Exhibition Bay (East Coast). Wetlands are also associated with the inflow streams. Access is through private forestry roads (4-WD), is steep and the track is loose sand, making trailered boat access difficult.

Wetland vegetation

Eleocharis sphacelata was present all around the lake with a diversity of other emergent species well represented, including *Eleocharis acuta, Typha orientalis, Machaerina articulata, M. teretifolia, M. juncea* and *M. arthrophylla*. The emergent fringe was wide, from 10 to 30 m across, with *E. sphacelata* the deepest growing species (to 1.75 m). Additional emergent species recorded in 2013 were *Machaerina rubiginosa* and *Isachne globosa*.

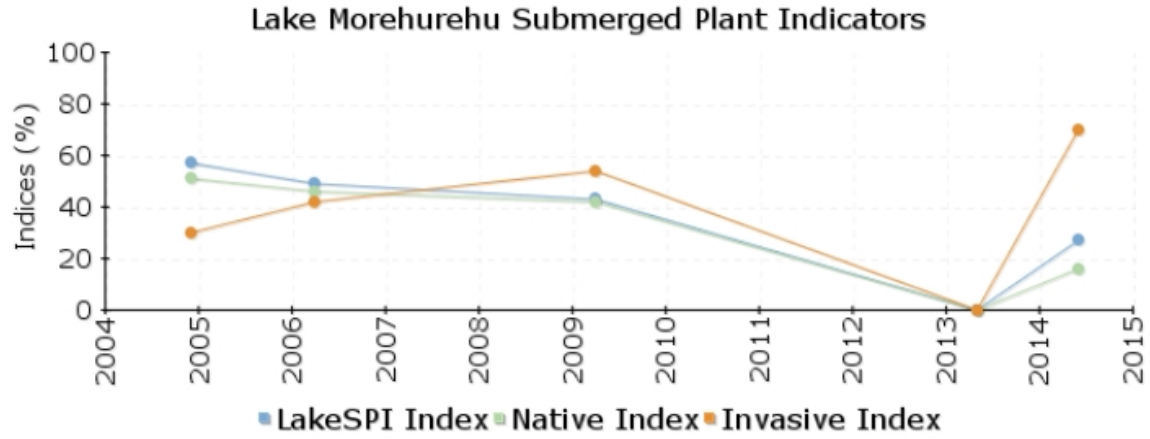
Wetlands contained all of the emergent species, but also flax (*Phormium tenax*), swamp coprosma (*Coprosma tenuicaulis*), manuka (*Leptospermum scoparium*), swamp kiokio (*Blechnum novaezelandiae*) and areas of bog vegetation with the regionally significant wire rush (*Empodisma robustum*) and umbrella fern (*Gleichenia dicarpa*).

Submerged vegetation

In 2009, the aquatic vegetation was abundant and extended down to 5.5 m deep. It was comprised of seven species with charophyte meadows common and abundant tall-growing native species. *Chara fibrosa* was the dominant species, with *C. australis, Nitella leonhardii* and *N. pseudoflabellata* locally dominant, and the tall-growing native *Potamogeton cheesemanii* was common. The invasive exotic *Utricularia gibba* covered native species to about 4 m depth. In 2006, *U. australis* was found on 4 of the 5 profiles, scattered throughout other vegetation to 4.6 m depth limit, but has not been found since.

In 2013, the lake had deteriorated markedly with almost no submerged vegetation. There were only three submerged species, none exceeded 5% maximum cover and were present in only the top 1.6 m water depth. In 2014, little improvement in submerged vegetation was recorded. Rooted plants were limited to 1.5 m water depth but a little more abundant than 2013, as reflected in the LakeSPI native condition index.

LakeSPI



Survey Date	Status	LakeSPI %	Native Condition %	Invasive Impact %
May 2014	Moderate	27%	16%	70%
April 2013	Non-vegetated	0%	0%	0%
March 2009	Moderate	43%	42%	54%
March 2006	Moderate	49%	46%	42%
November 2004	High	57%	51%	30%

LakeSPI indices have deteriorated since 2004. The apparent recovery in 2014 was very minor.

Water birds

A remote, large lake with scrub and wetland margins and extensive emergent beds would make this a good habitat for wetland birds. Canada geese (*Branta canadensis*), mallards (*Anas platyrhynchus*) and a bittern (*Botaurus poiciloptilus*) were seen during this visit. DOC SSBI records the regionally threatened fernbird (*Bowdleria punctata vealeae*) as common in the marginal vegetation and wetlands in 1991. None were noted during the field visit or from recent OSNZ visits.

Fish

No fish were seen in 2013 and 2014, but visibility was low. Common bully (*Gobiomorphus cotidianus*) and inanga (*Galaxias maculatus*) were seen during the 2009 survey. Shortfin eel (*Anguilla australis*) were also recorded on the NIWA FBIS database for this lake.

Aquatic invertebrates

Mussels and koura have not been recorded during surveys, but freshwater sponges were abundant in 2009.

Endangered species

Several threatened species were present with the Nationally Vulnerable sundew (*Drosera pygmaea*) noted in a lake-shore turf and the Nationally Endangered fern (*Todea barbata*) on lake shore banks. These populations do not appear to be threatened by logging of pines in the lake surrounds. The Nationally Critical bladderwort (*Utricularia australis*) is apparently extinct, not being recorded after 2006, with the loss occurring prior to logging activities.

At-Risk Declining inanga were not observed during the last two visits, but this is likely to be due to decreased underwater visibility rather than a loss from the lake. Connection to Parengarenga Harbour is maintained through the outlet to the south east of the lake allowing migrations of this species.

Lake Ecological Value

The impact of the invasive *U. gibba* has increased from 2005 to 2006 and 2009, but like other plants decreased markedly in 2013. It was the dominant plant in the lake in 2014. The Nationally Critical *U. australis* was not seen in the 2009, 2013 or 2014 surveys.

A 1988 vegetation survey recorded similar submerged vegetation to the 2009 description although *Chara australis* was more abundant and extended to a maximum depth of 9.5 m. *U. gibba* was not recorded. The lake has changed from being relatively clear when visited in 2009 to having a dark brown / red stain with less than 1 m in water visibility in 2013 (Plate B).

Based on the 2009 survey a Lake Ecological Value rating of 12 (Outstanding) was calculated. A deterioration in the rating of the following parameters: water quality (water transparency and total nitrogen values from 2010 to 2013 indicate eutrophic conditions whereas chlorophyll a and total phosphorus indicate mesotrophic condition) and loss of aquatic vegetation integrity resulted in a revised score of 11 (High).

Plate B: Lake Morehurehu with dark brown / red stained water and less than 1 m in water visibility.

Threats

The marked change in water clarity and total nitrogen concentration is significant. Light is a major determinant of submerged vegetation. Such a marked change in water clarity accounts for the loss of virtually all the submerged vegetation. The recent harvesting of the pine plantation is likely to have caused the change in water quality with similar changes noted in other water bodies in the area (Lakes Te Kahika and Morehurehu South 2). The event may have been much wider with a local reporting that the Parengarenga Harbour became heavily coloured making channels impossible to follow after an extended period of heavy rain (Kevin Mathews, local conservationist, pers. comm. 2013).

Hypotheses included pine tree transpiration kept water levels lower in the soil profile. Felling of the trees has stopped water loss from transpiration. Water logging of pine debris and peat soils was likely to have occurred following heavy rainfall events post-harvest. Removal of the pine canopy also allowed rain direct access to a broken soil layer. Quartz sands in the catchment have little ionic binding (M. Gibbs, NIWA, pers. comm.) so the lakes are also likely to have been impacted by a marked increase in nutrient inputs. Pine harvesting is usually associated with a tenfold increase in N input from the catchment which can lead to an increase in algae and lower water clarity.

The main risks for invasive species introduction come from use of diggers in associated streams, or pine plantation harvesting gear that may be contaminated with invasive weeds such as alligator weed (*Alternanthera philoxeroides*), or eel fishers using nets contaminated with submerged weeds. Introduced invasive species would establish and displace much of the indigenous vegetation. The construction of access roads to facilitate logging has opened up this area to the public, so risk of pest introductions are heightened.

The lake is probably N limited and thus sensitive to urea fertiliser addition in forestry and N losses during harvesting.

Management recommendations

Annual lake monitoring will enable impacts to be documented and recovery rates tracked. A cause and effect linking of this major ecological impact to a land-use practice would enable better management and avoid a re-occurrence in future.

3.1.2 Lake Morehurehu South 2 (Aupouri), NRC Lake No. 36.

Plate A: Morehurehu South, a coastal dune lake set in sand dunes, scrub and pine plantation forestry 2014 (Photo: Lisa Forester).

Summary

Survey dates 2004, 2006, 2013 and 2014.

Overall rating

High: with submerged vegetation having recovered and water clarity improved since 2013. Nationally Critical *Utricularia australis* has not been found since 2006.

Threats

Threatened by recent change in water quality, probably due to pine harvesting. There are still significant areas remaining to be harvested.

Exotic invasive species would displace the native vegetation but this lake is relatively remote. Eel fishers could be a source of invasive introductions. The construction of an access road to facilitate logging has opened up this area, so risk of pest introductions are heightened.

Management recommendations

Continue lake monitoring annually to evaluate rate of recovery in this lake.

Description

The lake (1600485E, 6165737N) is small (0.44 ha) and 3.6m deep, with no inflows or outflows. The catchment is 50% mobile sand (southern end) and scrub, with plantation forestry further to the north. Access is through a well-formed track.

Wetland vegetation

Emergent species encircled most of the lake in a band 5 to 10 m wide and were dominated by *Eleocharis sphacelata* growing to a depth of 2.0 m. Oioi (*Apodasmia similis*), *Machaerina teretifolia* and the regionally significant wire rush *Empodisma robustum* were all common marginal species. A population of the sundew *Drosera pygmaea* was observed growing in a lake-side turf.

Submerged vegetation

In 2006, no turf species were recorded. The regionally significant *Triglochin striata* was recorded and charophytes meadows dominated by *Nitella* sp. aff. *cristata* and *Chara australis* were recorded to the lake's maximum depth of 3.6 m. The tall-growing native *Potamogeton cheesemanii* was also abundant (to 1.5 m tall). *Utricularia gibba* was present at high covers to 2.5 m covering indigenous vegetation on the relatively steep sides of the lake. *U. australis* was found in small amounts amongst emergent vegetation.

No significant submerged vegetation was found in 2013, but improved water clarity and corresponding increase in submerged macrophytes were noted in July 2013 (L. Forester pers. com.). *U. gibba* was present at high covers to 2.5 m with *P. cheesemanii* plants extending to 3 m deep.

In 2014, the lake was vegetated to 3.7 m (deepest point) and comprised of *Nitella leonhardii*, *P. cheesemanii* and *U. gibba*. No other submerged species were recorded.

Water birds

No birds were seen or heard, but DOC SSBI reported fernbird (*Bowdleria punctata vealeae*).

Fish

Schools of inanga (*Galaxias maculatus*) were observed amongst the emergent vegetation in 2004 and noted again during the July 2013 visit (I. Middleton, NRC, pers. comm.).

Aquatic invertebrates

No mussels or koura were seen.

Endangered species

A population of the Nationally Vulnerable sundew *Drosera pygmaea* was noted in a lake-shore turf. This does not appear to be threatened by current land use. The Nationally Critical *Utricularia australis* is apparently extinct, not being recorded after 2006.

The At-Risk Declining inanga were observed in 2013 and 2014. Connection to Parengarenga Harbour is maintained through the outlet to the north of the lake, allowing migration of this species.

Lake Ecological Value

Based on the 2006 survey a Lake Ecological Value rating of 10 (High) was calculated. A deterioration in the rating of the following parameters: aquatic vegetation diversity and integrity (essentially a loss of submerged vegetation, with a decline of diversity from 1 to 0 and integrity from 3 to 0) and endangered species (loss of *U. australis*) has resulted in a revised score of 5 (Moderate). Water quality was not measured at this lake but water transparency had declined (Plate B).

Plate B: Morehurehu South 2 April 2013 with no pine harvesting in the immediate catchment. This lake has never-the-less deteriorated from clear (>3 m transparency) to very dark brown (< 0.5 m transparency) as did other lakes in the catchment following pine harvesting. By 2014 the water was clear (~2.5 m) again.

Threats

Water quality impacts from catchment activities of foresters.

Access for vectors of pest species is difficult, but introduced pest species could deleteriously impact on this lake. The improvement of the access road to facilitate logging has opened up this area increasing the risk of pest introductions.

Management recommendations

Management recommendations are the same as those for Lake Morehurehu. Lake monitoring annually is recommended to evaluate the rate of recovery. While vegetation has recovered, species diversity remains compromised.

3.1.3 Lake Te Kahika (Aupouri), NRC Lake No. 29.

Plate A: Lake Te Kahika set in a mature plantation pine catchment (top 2009); now de-forested and a section of shore line wetland vegetation affected by fire (bottom 2013).

Summary

Survey dates **2004, 2006, 2009, 2013 and 2014.**

Overall ranking

High-Moderate with water heavily stained red / brown, visibility now only 2 - 3 m (with a minimum recorded transparency of 0.3 m in May 2012) and the invasive *Utricularia gibba* the only submerged species present. The two threatened species recorded previously, *Utricularia australis* and *Isolepis fluitans*, have not been relocated.

In 2009 rated **High** as a unique clear-water oligotrophic acidic lake with sparse submerged vegetation limited to some *Sphagnum* and high covers of *Utricularia australis* in the south western inflow. *Isolepis fluitans* was also recorded in 2013.

Threats

Pine harvesting impacting water quality and nutrient status. Fire risk to marginal species.

Low risk of introduction and establishment of invasive pests.

Management recommendations

Review recent changes in the catchment and document impacts in all receiving waters. Lake monitoring annually to evaluate rate of recovery. Provide advice to forestry companies or other land-use in these poorly buffered water bodies to modify activities that caused such extensive environmental damage.

Description

The lake (1600007E 6168587N) is approximately 18 ha in area with a maximum recorded depth of 10.8 m. It is situated on Lower Quaternary sand dunes, formed by a stream system impounded by dunes. The catchment is in pine plantation forestry with a narrow zone of scrub (manuka and hakea) surrounding the lake. Sections of the mature pines have been harvested recently and re-planted. The woody leguminous weeds oxylobium (*Callistachys lanceolata*) and Sydney golden wattle (*Acacia longifolia*) have established as the dominant cover in much of the cleared pine forest (Plate C). The lake is comprised of two arms each fed by an inflow, with the outflow (Kahika Stream) at the western edge of the lake discharging into Great Exhibition Bay (East Coast). Access is through private forestry roads, not currently gated. There are no formed tracks leading to the lake edge (difficult 4WD access only) and no formed boat access.

Wetland vegetation

There was a complete fringe of emergent vegetation, although the burnt southern area destroyed marginal manuka and emergent vegetation prior to 2013. *Eleocharis sphacelata* dominated a zone 5 to 20 m across which grew to depths of 1.5 m, with swamp millet (*Isachne globosa*) and *Gleichenia dicarpa* also common. Several species typical of bog vegetation (including *Machaerina teretifolia* and the regionally significant wire rush *Empodisma robustum*) bounded much of the lake in shallow water (to 0.2 m deep).

Submerged vegetation

Despite good water clarity, the only submerged vegetation reported in 2009 in this lake were high covers of the moss *Sphagnum* sp. amongst *E. sphacelata* at two sites and the bladderwort *Utricularia australis* that formed 100% cover in the inlet stream (Plate B).

Since 2009 the invasive *Utricularia gibba* has extensively colonised the lake margins to a maximum depth of 4 m (Plate B). In 2013 a marked drop in water clarity was noted and prevented submerged plant growth at this site. However, *Isolepis fluitans* (previously only recorded from Lake Wahakari) was located at 2 m depth at one location in 2013. In 2014 *U. gibba* was the only submerged species recorded and water clarity remained very poor.

Plate B: Lake Te Kahika 2009 showing clear water with *Sphagnum* (top left) at 1.0 m deep water in marginal emergent vegetation; a rare sight, *Utricularia australis* (top right) abundant on the bottom of an inflowing stream >3 m deep; and 2013 (bottom), the same location but showing poor water clarity, *U. australis* absent on the bottom and *Sphagnum* replaced by *U. gibba* on the sides.

LakeSPI

Survey Date	Status	LakeSPI %	Native Condition %	Invasive Impact %
May 2014	Non-vegetated	0%	0%	0%
April 2013	Poor	19%	0%	74%
March 2006	Non-vegetated	0%	0%	0%
November 2004	Non-vegetated	0%	0%	0%

LakeSPI has not shown significant changes between successive surveys as the lake has never had significant amounts of submerged vegetation.

Water birds

The isolated nature of the lake and large areas of emergent and wetland vegetation provide good habitat for many wetland birds, although lack of submerged vegetation and fish would limit the habitat for some species. Few birds were noted during the field visit. Threatened species included fernbird (*Bowdleria punctata vealeae*) noted at the southern end of the lake, dabchick (*Poliocephalus rufopectus*) and little black shag (*Phalacrocorax silcirostis*) recorded in 2009. The endangered spotless crake (*Porzana tabuensis plumbea*) and Caspian tern (*Sterna caspia*) were previously recorded by DOC.

Fish

No fish were seen in the lake in 2013, however previously a shortfin eel (*Anguilla australis*) was noted in one inlet stream and eel holes were common in places.

Aquatic invertebrates

Few aquatic invertebrates were noted. *Sigara arguta* was the most prevalent, with caddisfly (Trichoptera) and dragonfly larvae (Odonata).

In 2009, the rarely seen whirligig beetle *Gyrinus convexiusculus* was noted at the access point. It is a self-introduced Australian species which lives in ponds and lakes in Waikato and Northland.

Endangered species

The submerged bladderwort *Utricularia australis* (Nationally Critical) and *Isolepis fluitans* (Nationally Vulnerable) were both recorded in 2013, albeit with a reduced abundance in the case of *U. australis*. Neither species were detected in 2014 with their habitat colonised by the invasive *U. gibba*.

The fern *Todea barbara* and turf plant *Centipeda minima*, both Nationally Endangered marginal species, persisted at Lake Te Kahika in 2014. It is likely that *C. minima*, an annual species, will be displaced once taller vegetation recovers from the 2013 fire.

Lake Ecological Value

Based on the 2009 survey a Lake Ecological Value rating of High was calculated. A deterioration in water quality (TLI changed from oligotrophic to mesotrophic) and drop in aquatic vegetation diversity has resulted in a revised downward value of Moderate to High.

Lake clarity changed from exceptionally clear >6 m visibility in 2009, to 0.3 m visibility in 2012 with dark brown / red colour. Visibility increasing to 2 m in 2014.

As is the case for nearby Lake Morehurehu, the recent pine plantation harvest has likely caused the change in water quality.

As this lake previously lacked extensive submerged vegetation, LakeSPI could not be used as a lake health indicator. Water quality records provide the best indicator of this change.

Threats

Plate C: At Lake Te Kahika the pine plantation in the foreground has been clear felled to the lake edge and the area re-planted. Oxylobium (*Callistachys lanceolata*) has made a head start and is currently the dominant plant.

The marked drop in water clarity and rise in total nitrogen concentration is significant and needs further attention to identify the causes and prevent it from re-occurring in future.

The main risks for invasive species introductions come from eel fishers using nets contaminated with weeds, deliberate introductions or digger use in associated streams contaminated with invasive weeds such as alligator weed (*Alternanthera philoxeroides*). However, due to the acid nature of the lake, the likelihood of establishment is low.

Fertilisation of pine forests and the effects of harvesting is often associated with nutrient enrichment. As the lake is possibly N limited, a ten-fold increase in N inputs (a figure attributed to pine harvesting) could deleteriously affect clarity and increase planktonic algal abundance.

Management recommendations

Annual lake monitoring will enable impacts to be documented and recovery rates tracked. A cause and effect linking of this major ecological impact to a land-use practice would enable better management and avoid a re-occurrence in future. Biosecurity threats are low. The chemistry of the lake is very unusual and warrants further study to explain the source of acidity (with a minimum pH of 3.3) and elevated sulphate concentrations. It is recommended that the lake be monitored every year to follow its recovery or further deterioration.

3.1.4 Waitahora Lagoon (Aupouri) NRC Lake No. 4.

Plate A: LEFT 2007 showing the east end of Waitahora Lagoon, showing a saline influenced wetland dominated by the green oioi (*Apodasmia similis*) and brown sea rush (*Juncus kraussii* var. *australiensis*). RIGHT 2009 showing a closer of the same area but with the oioi impacted by saltwater intrusion.

Summary

Survey dates 2007, 2009 and 2014

Overall ranking

Outstanding: Pristine wetland complex with both saline and freshwater components, secure populations of numerous endangered biota, and a catchment of indigenous vegetation. No pest species were recorded.

Threats

Low risk of introduction of invasive pests. The isolated nature of this lagoon and the surrounding indigenous vegetation indicates there is little immediate invasive threat to this site. Saline intrusions due to cyclical changes at the outlet periodically impact freshwater components but are a natural occurrence and seen as essential to maintain overall diversity.

Management recommendations

Ecological condition monitoring every 5 years.

Description

Waitahora Lagoon (NZMG 2493880E, 6749715N) is a large (20.7 ha) coastal lagoon surrounded by indigenous vegetation. It was linked to the sea at the western end and most of the lagoon was saline. The catchment was primarily scrub although a large wetland was present around the Waitahora Stream and other unnamed streams, at the east end of the lagoon. This section of the lagoon links with smaller freshwater lakes. The lagoon is accessed from the Cape Reinga Walkway some 6 km west of the Kapowairua Camp Ground. It can be accessed through a locked gate under DOC control and a 4 WD track.

Wetland vegetation

Plate B: Salt water intrusion has desiccated saline intolerant plants 2014.

The west half of Waitahora Lagoon, situated between scrub on the southern side and dunes to the north, lacked significant wetland margins. Dune vegetation included the At Risk Declining grass *Poa billardierei* (previously named *Austrofestuca littoralis*).

The east half of the lagoon was surrounded by an extensive wetland dominated by oioi (*Apodasmia similis*), sea rush (*Juncus kraussii* var. *australiensis*), the invasive introduced saltwater paspalum (*Paspalum vaginatum*) and smaller salt meadow species. Marginal areas contained *Machaerina juncea, Cyperus ustulatus* and *Hibiscus diversifolius*.

In 2014, a storm surge during cyclone Lusi inundated much of the lower wetlands. Sea water caused desiccation of saltmarsh, oioi and sea rush to around 1 m above their normal minimum elevation (see Plate B). Re-growth of salt meadow species *Lilaeopsis novaezelandiae*, *Thyridia* (formerly *Mimulus*) *repens* and *Selliera radicans* were noted, forming large beds amongst the stubble of dead taller vegetation.

Submerged vegetation

Most of the lagoon was saline with no submerged vegetation apart from the red alga *Gracilaria chilensis*. However, some sparse vegetation (5 - 25% cover class) was noted in 2007 in the upper channels. Species present included *Ruppia polycarpa, Triglochin striata, Thyridia repens* and the charophyte *Lamprothamnium macropogon*. All these species are typically from brackish areas, although the first of these plants is also relatively common in freshwater lakes.

In 2009, this habitat was devoid of vegetation, but a channel closer to the freshwater wetland supported *Utricularia australis* growing over dead rushes / sedges.

In 2014, *L. macropogon* was found in saline pools in the area formerly supporting *U. australis*.

LakeSPI

There was insufficient submerged vegetation to generate a LakeSPI score for this lagoon.

Water birds

Extensive emergent vegetation and the relatively undisturbed nature of this lake provides a good habitat for water birds. The regionally significant fernbird (*Bowdleria punctata vealeae*) was heard in the wetland areas at the east end of Waitahora Lagoon. OSNZ records from this locality include the nationally endangered brown teal (*Anas chlorotis*) and one of the few Northland records of marsh crake (*Porzana pusilla*).

Fish

A school about 40 strong of grey mullet (*Mugil cephalus*) up to 30 cm long was observed in the clear waters of the lagoon in 2007. There are no NIWA FBIS records of fish from this location.

Aquatic invertebrates

No invertebrates were noted.

Endangered species

Waitahora Lagoon supports very healthy populations of a range of threatened species including the Nationally Critical *Hibiscus diversifolius* (largest known population), Nationally Vulnerable *Lamprothamnium papulosum* (only site in northern half of the North Island) and Naturally Uncommon *Thyridia repens* (largest Northland population).

Hibiscus diversifolius dominated a narrow fringe of wetland vegetation between saltmarsh and dunes or scrub. The estimated area of occupancy exceeded 1 ha and was therefore likely to be the largest New Zealand population of this plant. Another Nationally Critical *Hibiscus,* the endemic *H. richardsonii,* was present adjacent to this plant near the boardwalk crossing the lagoon.

Prior to its discovery here in 2007, *Lamprothamnium papulosum* was recorded from the southern North Island, the South Island and Chatham (Rekohu) Island, with the northernmost record from the Whakaki Lagoon near Wairoa (Hawkes Bay). Mature plants were seen in 2014 and it likely that this species will persist at the site, re-growing from the seed-bank when growth conditions are suitable.

Thyridia repens is a rare plant in Northland, with only two other sites known. The Waitahora Lagoon site comprises the largest and least vulnerable population for the species. Saline intrusion and death of taller saltmarsh rushes had increased available habitat for this and other salt meadow species.

No plants of the Nationally Critical *Utricularia australis* were found in 2014 but pools within less accessible parts of the Waitahora wetland complex may still support this species.

Lake Ecological Value

Waitahora Lagoon was rated as “High” using the lake ecological value rating. However, it should be included in the group of “Northlands Outstanding water bodies” as it provides an almost unique example of a pristine New Zealand marine contact lake (certainly unique in the North Island).

Threats

The isolated nature of this lagoon (with locked gate) and the surrounding indigenous vegetation indicates little immediate threat to this site. Periods of saline inflow when the western end of the sand bar is open (as was the case in 2009 and 2014) along with periods where the lagoon is dominated by freshwater results in a highly dynamic habitat.

Management recommendations

Carry out 5 year ecological condition monitoring.

A fish survey is advocated to determine the fauna of the saline and freshwater parts of the Waitahora wetland complex.

3.1.5 Lake Ngatu, (Aupouri) NRC Lake No. 120.

Plate A: Lake Ngatu from the northern boat ramp.

Summary

Surveyed 1984, 2001, 2004, 2006, 2010, and 2014

Overall ranking

Outstanding: Good emergent and submerged vegetation with numerous endangered biota. Pest plants and fish present. Water quality varies considerably.

Threats

Expansion of *Lagarosiphon major*, high risk of further pest species introductions, threats of eutrophication from catchment activities such as residential development, farming intensification and possibly kauri log recovery from wetlands.

Management recommendations

Annual surveillance of *L. major* and for new pest plants. Five yearly lake native biodiversity value monitoring. Consider *L. major* management with endothall. Eradicate alligator weed, mile-a-minute and Christmas berry at this site.

Description

Lake Ngatu (2528991E, 6685555 N) is a large (50.3 ha) dune lake with a maximum depth of 6.5 m. The catchment is primarily manuka / kanuka scrub and fenced pasture. There are new houses overlooking the lake on the north-western fringe. It is a popular recreational lake with easy access from West Coast Road to the north and from Sweetwater Road along the eastern shore. Boats are

launched from firm sand at the northern and southern end and a large number of waka ama are stored on the south western edge of the lake.

Wetland vegetation

Most of the lake margins have large beds of emergent species, with up to 100 m wide beds on the eastern margin associated with islands in this area. The dominant emergent is *Eleocharis sphacelata* growing from the lake margin to 2.6 m depth. Other common emergent species included *Apodasmia similis, Machaerina articulata, M. arthrophylla, M. juncea* and *Schoenoplectus tabernaemontani*.

One small clump of the invasive alien yellow flag iris (*Iris pseudacorus*) was removed in 2007. The invasive alligator weed (*Alternanthera philoxeroides*) was noted for the first time in 2012. This has been repeatedly treated with the herbicide metsulfuron-methyl (Kevin Matthews, pers. comm.) and a few plants remain. The invasive climber mile-a-minute (*Dipogon lignosus*) was found near an inlet drain at the northern end of the lake. This was removed by hand and picloram gel applied to remaining stems. The problem woody wetland weed Christmas berry (*Schinus terebinthifolius*) was found in manuka on the eastern edge of the lake. This should be removed and checks for seedlings made in the area. It has yet to invade wetland margins in New Zealand as it does in warm temperate Australia and Florida.

Submerged vegetation

Turf communities were common in areas to ~ 1 m deep where *E. sphacelata* did not form dense emergent beds. Common species were *Lilaeopsis novae-zelandiae, Myriophyllum votchii*, *Trithuria inconspicua, Triglochin striata,* the bladderwort *Utricularia gibba* and the exotic rush *Juncus bulbosus*.

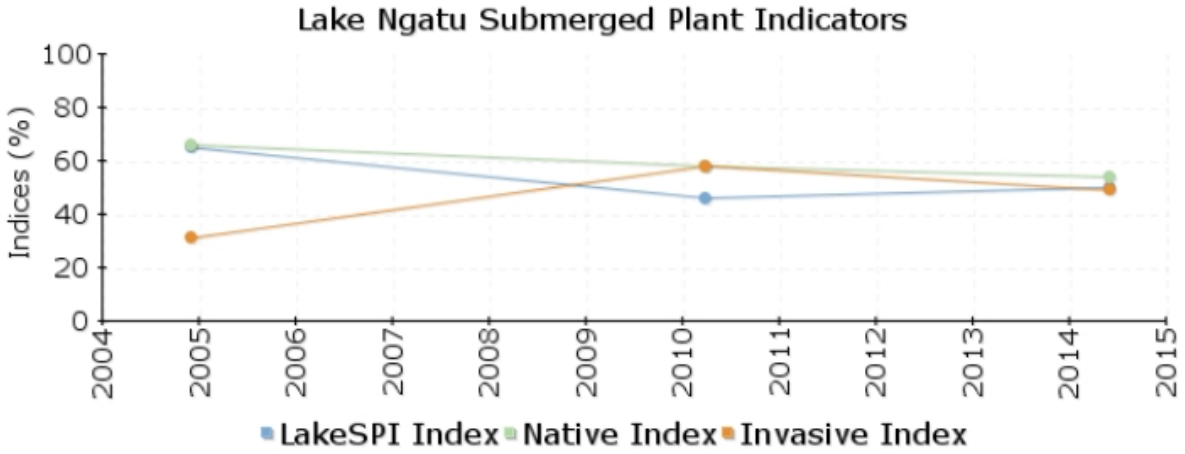
Charophytes dominated vegetation from the edge of emergent or turf communities to a maximum depth of 5.3 m. The dominant species were *Chara fibrosa* with *Chara australis* and *Nitella leonhardii*. Prior to 2010, *Chara fibrosa* and *Nitella leonhardii* were the dominant charophytes with only low covers of other species present (although Cunningham (1953) indicated some areas of the lake were dominated by *C. australis*). The average cover of charophytes has declined over the years from nearly 100% cover up to 2006, reducing to average covers of 51 -75 % in 2010 and 2014.

The alien invasive lagarosiphon (*Lagarosiphon major*) was present in a few locations at depths between 0.5 and 3.2 m. Significant infestations included c. 2 ha off the north access point, a narrow band from the waka ama launching area to the south beach (about 10 m x 200 m long) and a small patch (20 m x 10 m) opposite the rushes at the east end of the south beach. There has been little change in lagarosiphon extent since 2004 but less cover and height in the northern area.

Utricularia gibba formed an extensive smothering mat covering the lagarosiphon and indigenous charophyte vegetation to 4.0 m deep. Large mats of *U. gibba* were associated with a periphyton raft up near the water surface in autumn (Plate B). The bladderwort *U. australis* was common within this lake but has not been seen here since 2007.

Plate B: Lake Ngatu, *Utricularia gibba*, an invasive plant pictured in autumn lifting off the bottom and rafting on the surface (photo Kevin Matthews 30 May 2007).

LakeSPI



Survey Date	Status	LakeSPI %	Native Condition %	Invasive Impact %
May 2014	Moderate	50%	54%	49%
March 2010	Moderate	46%	58%	58%
November 2004	High	65%	66%	31%

A decrease in LakeSPI score from 65% in 2004 to 46% in 2010 was a result of increasing invasive impact from *U. gibba* and a decrease in native condition. A minor improvement driven by reduced invasive impact is indicated since 2010, but the Native Condition Index has declined slightly.

Water birds

Extensive emergent vegetation provides good habitat for water birds, however human disturbance would reduce the desirability for more secretive species. The Nationally Threatened bittern (*Botaurus poiciloptilus*) and Caspian tern (*Sterna caspia*) and the regionally rare dabchick (*Poliocephalus rufopectus*) were seen on the field visit, with 14 dabchicks seen in May 2005 (K. Matthews pers. comm.). OSNZ records also include the regionally significant scaup (*Aythya novaezeelandiae*).

Fish

Common bullies (*Gobiomorphus cotidianus*), inanga (*Galaxias maculatus*) and the exotic pest fish gambusia (*Gambusia affinis*) were observed. The landlocked population of inanga are of special status, possibly a new species with a larger number of gill rakers than migratory (diadromous) inanga (B. David, D. Rowe pers. comm.). The introduced rainbow trout (*Oncorhynchus mykiss*), rudd (*Scardinius erythrophthalmus*) and goldfish (*Carassius auratus*) were also reported in the NIWA FBIS database. A rudd was noted amongst emergent vegetation at the southern end of the lake. The pest fish perch (*Perca fluviatilis*) was reported by a diver in 2009, but has not been confirmed. This piscivorous species could have a major impact on other fish species. A combination of Gee minnow traps, seine and gill nets were deployed in 2010 but only inanga, bullies, gambusia and a goldfish were caught. An attempt was made to confirm perch presence in April 2010 by overnight gill netting but only goldfish were caught. Holes in vegetation and the sediment surface, indicative of bottom feeding pest fish, were noted in 2010.

DOC conducted a fish survey during 2014 using a combination of Gee minnow (10) and fyke nets (9). They recorded a total of >13,000 gambusia, 369 common bullies, 1,249 inanga, 5 longfin (*Anguilla dieffenbachii*) and 1 shortfin (*Anguilla australis*) eels (all large ≥680 mm long).

Aquatic invertebrates

The introduced ramshorn snail (*Planorbarius corneus*) was common in the lake. The introduced snail *Planorbella scalaris* was reported from Lake Ngatu and identified by Brian Smith (NIWA, Hamilton) in March 2007. It is endemic to the central and southern part of the Florida peninsula where it is found in marshes and lakes. This was the first record of this species in New Zealand. However, it was not found during the later surveys. Large numbers of New Zealand's largest dytiscid beetle *Onychohydrus hookeri*, were caught in the Gee minnow traps deployed in 2010 and 2014. They are carnivorous and were observed feeding on gambusia in the nearby Little Gem Lake.

Endangered species

The Nationally Endangered *Trithuria inconspicua* has apparently disappeared from amongst open emergent beds of *Machaerina arthrophylla* adjacent to the northern boat ramp. Conversely, this species appears to be increasing in abundance in shallow water at the south eastern edge of the lake and maintains a good population in the south western shallows between the waka ama area and the grassed southern end of the lake. This species is now restricted to Lakes Ngatu and Rotoroa in Aupouri, having been lost from three other lakes on this peninsula. The Nationally Critical *Utricularia australis* was a common component of the submerged vegetation up to 2004, but was last seen in this lake in 2007. The At Risk Declining fern *Cyclosorus interruptus* was reported from the marginal vegetation for the first time in 2007 and appears to persist in the same area.

The At Risk Declining inanga and longfin eels were sampled by DOC in 2014. These fish are land-locked, and inanga differ from migratory (diadromous) inanga by having a larger number of gill rakers. The lake population of this inanga appears to be secure, despite huge numbers of gambusia.

Lake Ecological Value

Lake Ngatu charophyte species composition has changed over the monitoring programme. Since 2010, charophyte abundance has markedly diminished lake wide, indicating that nutrient enrichment stress is likely. No trends in degrading water quality using TLI have been detected but total nitrogen levels have been close to all-time highs for more than a year. However its ecological value rating remains “Outstanding”.

Changes in indicators

The lake is classified as mesotrophic. Trend analysis showed water quality declined over the 5 years prior to 2011 with water clarity decreasing at a rate of 0.31 m per year and TLI degrading 1.64% per year. Since 2011 the TLI has improved so no trends are evident now. It is clear that water quality fluctuates markedly. Nitrogen levels have been close to all-time highs for more than a year.

Threats

Lagarosiphon major has been present in the lake since 1988. It has spread little and was restricted to a few locations, but may still expand further and have a greater impact. The poor growth of *L. major* in Lake Ngatu is likely due to its particular water chemistry. A change in nutrient status of Lake Ngatu driven by a change in catchment usage could lead to rapid weed growth. Other weed species, such as *Ceratophyllum demersum*, are able to tolerate lower nutrient conditions and could displace all other submerged vegetation. As access to Lake Ngatu is easy, the risk of spread from other areas by boat traffic is high.

Utricularia gibba has reached its potential and appears to have suppressed the lagarosiphon near the northern end of the lake.

Five additional weeds have been detected at an early stage of invasion at Lake Ngatu. Two of these, water lily (*Nymphaea alba*) and yellow flag iris have been eradicated, while mile-a-minute and alligator weed eradication programmes near completion. The Christmas berry incursion requires management action.

The pest fish *Gambusia affinis* may have a deleterious impact on other fish like the At Risk Declining inanga. Rudd do not appear to be impacting submerged vegetation under current conditions. Perch (reported in 2009) were not captured in the 2010 fish survey. Perch could have a major impact on other fish species as they are piscivorous.

Concerns have been raised about nutrient and other water quality impacts related to land use change, septic tanks and kauri logging in the catchment. No clear trends were evident in the TLI or LakeSPI condition indicators although reduction in charophyte cover could be an early warning signal.

Management recommendations

Undertake pest plant surveillance at access points for new incursions of aquatic weeds every year.

Carry out 5 year lake native biodiversity value monitoring.

Based on the success of endothall control of *L. major* in Phoebe's Lake (Section 3.14) and the limited distribution and slow growth of *L. major* in Lake Ngatu, an eradication programme for this plant is advocated.

Continued management of other marginal weeds towards eradication is recommended along with an eradication programme for Christmas berry.

3.2 Lake Rotokawau (Aupouri), NRC Lake No. 116.

Plate A: Lake Rotokawau from access point.

Summary

Surveyed 1985, 1988, 2001, 2004, 2009, and 2014.

Overall ranking

High-Moderate: Was ranked as **High-Moderate** in 2004 due to impact by *Utricularia gibba* and apparent loss of the 'Nationally Critically Endangered' *Utricularia australis.* Ranking changed to **High** after *U. australis* re-discovery in 2009. Although this species was still present 2014, decreases in TLI (to eutrophic) and LakeSPI and increased ammoniacal nitrogen concentration reduced the ranking back to **High-Moderate**.

Threats

Introduction of *Ceratophyllum demersum* or *Egeria densa* would displace remaining native vegetation. Nutrient enrichment from cattle and land use intensification would cause further deterioration.

Management recommendations

Lake native biodiversity value monitoring required at 5 year intervals. Greater marginal retirement and control of nutrient inputs is required.

Description

A dune lake (1618821E, 6124849N) accessible through private land with a 2-wheel drive under fair weather conditions with launching site for small boats. A small (14.2 ha), shallow (3.1 m) water body within a catchment of mostly fenced pasture (70%), scrub and planted forest (30%), with no major inflows or outflow. Despite much of the lake margin being fenced, direct cattle access on the south-

western lake edge allows added nutrients and grazing of emergent vegetation as photographed in 2014 (Plate B).

Plate B: Cattle pugging and heavy grazing of emergent vegetation on the margin of Lake Rotokawau, May 2014.

Wetland vegetation

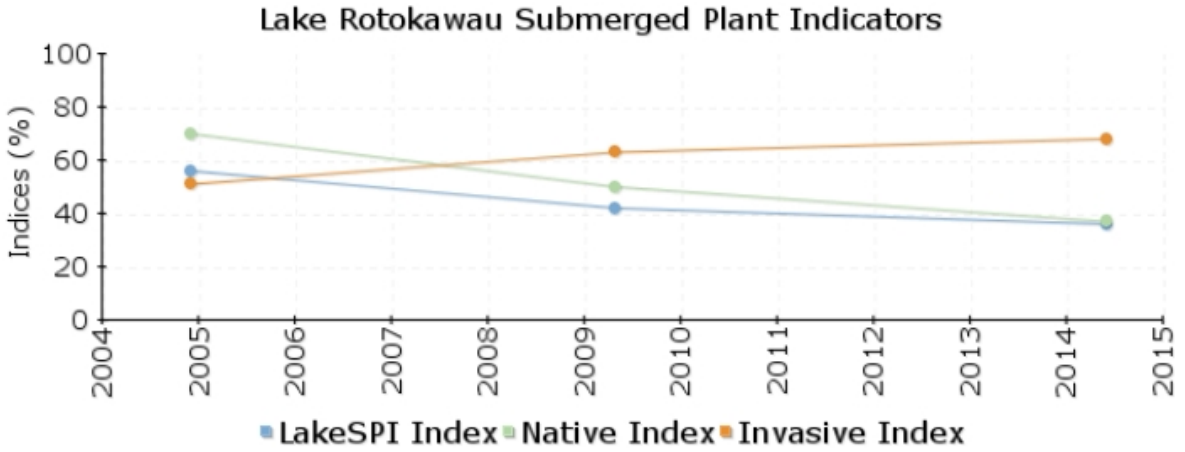
The lake was encircled by a reed bed of *Eleocharis sphacelata* (90% cover) extending 10 - 30 m into the lake to a maximum depth of 2 m. *Machaerina arthrophylla*, *M. articulata*, *M. juncea*, *Apodasmia similis* and *Eleocharis acuta* were also present. A small patch of raupo (*Typha orientalis*) was noted for the first time in 2014. This could indicate a local source of nutrient enrichment.

Submerged vegetation

Turf plants were occasional at the inshore edge of the reed bed and included the regionally rare *Gratiola sexdentata* and *Triglochin striata*.

The submerged vegetation was dominated by the charophytes *Chara fibrosa* and *Chara australis* to their maximum lake depth (~2.7 m) in the past. However, the exotic invasive species *Utricularia gibba* covers most of the lake (cover >50%) and charophyte species cover has decreased markedly from an average cover of 76 - 95 % to 1 – 5% at present. *Utricularia australis* was present at low covers on one profile in 2014 but was much more abundant in 2007.

LakeSPI



Survey Date	Status	LakeSPI %	Native Condition %	Invasive Impact %
May 2014	Moderate	36%	37%	68%
April 2009	Moderate	42%	50%	63%
November 2004	High	56%	70%	51%

The LakeSPI scores have shown a significant and steady deterioration over time. The invasive *Utricularia gibba* has increased in cover markedly, with a corresponding decrease in charophyte cover.

Water birds

The extensive emergent beds and adjacent scrub areas provide good habitat for water birds. The Nationally Endangered bittern (*Botaurus poiciloptilus*) and regionally significant dabchick (*Poliocephalus rufopectus*) and Australasian little grebe (*Tachybabptus novaeholandiae*) were all previously recorded from this lake. Fernbird (*Bowdleria punctata vealeae*) were heard in the manuka scrub at the western edge of the lake in 2014.

Fish

Common bullies (*Gobiomorphus cotidianus*) and the exotic pest fish gambusia (*Gambusia affinis*) were observed in 2009 and previous sampling occasions. There were also reports of a landlocked population of inanga (*Galaxias maculatus*) although none were observed.

DOC conducted a fish survey during 2014 using a combination of Gee minnow (4) and fyke nets (2). The recorded a total of 3,246 gambusia but no other fish species.

Aquatic invertebrates

The introduced snail *Physella acuta* was noted. During the 2014 DOC fish survey 200 diving beetles (*Onychohydrus hookeri*) and 4 dragonfly nymphs were caught.

Endangered species

The Nationally Critical *Utricularia australis* was a common component of the submerged vegetation but has markedly declined since its re-discovery in 2007. Ongoing water quality deterioration is likely

to lead to the loss of this species in the future. The Nationally Endangered *Trithuria inconspicua* was last recorded in 1992 and can be considered locally extinct from this lake.

A land-locked population of At Risk, Declining inanga were previously sampled in Lake Rotokawau. However, no native fish were caught during the DOC sampling in 2014.

Lake Ecological Value

Vegetation (both LakeSPI and deterioration of charophytes) and water quality monitoring has shown a recent decline in this lake. Its ecological value rating has changed from High to High to Moderate and this may further deteriorate should current land management practices continue.

Utricularia gibba is now the dominant plant within the lake. The charophyte meadows have reduced markedly in abundance with a conspicuous *Chara fibrosa* decline. Previous observations recorded the 'Nationally Vulnerable' *Trithuria inconspicua* (1988, 1991). The 'Nationally Endangered' *Utricularia australis* was prominent in 2009 raising the lake ranking from Moderate-High to High, with the subsequent decline in 2014 due to water quality decline.

Threats

Access through private land minimises the risk of further exotic plant introductions. Water quality deterioration combined with invasive impacts of *U. gibba* and gambusia appear to be the most immediate threats to this lake, with no native fish sampled in 2014.

Management recommendations

All indicators point to a deterioration of the ecological status of this lake. The landowner on the northern side of the lake has fenced off lake access, but it was evident that direct cattle access occurs on the southern lake shore. Such a relatively small and shallow lake is very sensitive to nutrient enrichment unless carefully managed.

3.3 Lake Waiporohita (Karikari), NRC Lake No. 99.

Plate A: Lake Waiporohita showing emergent communities on the east side of the lake accessible from the road.

Summary

Surveyed 1991, 2004, 2006, 2005, 2011 and 2014.

Overall ranking

Outstanding: Indigenous submerged vegetation completely carpets this shallow lake. The first New Zealand records for four vagrant Australian plants have been made at this lake Water quality has been poor with a ten-year average supertrophic state. However, the lake has substantially improved and the 5-year median TLI is now eutrophic. It is one of only four lakes (out of 27 monitored by NRC) with an improving water quality trend.

Threats

Significant potential for pest plant impacts. Alligator weed (*Alternanthera philoxeroides*) is well established, but primrose willow (*Ludwigia peploides*) is very limited in extent.

Management recommendations

Annual pest plant surveillance monitoring. Lake native biodiversity value assessment monitoring every 5 years. Attempt eradication of primrose willow.

Description

This lake (1631763E 6137937N) is 5.6 ha in area and 3 m deep. The surrounding catchment is pasture (fenced off) with some areas of manuka scrub with pohutukawa. The lake has no inflows or outflows. Access is off Inland Road with a firm (iron pan overlaid by sand) lake shore.

Wetland vegetation

There were areas of emergent vegetation around the northern end of the lake, mostly up to 20 m across, with bare iron pan in the remaining areas. Dominant species were *Typha orientalis* with an outer fringe of *Eleocharis sphacelata*, with other areas of *Schoenoplectus tabernaemontani, E. acuta* and *Apodasmia similis*.

Species colonising the hard iron pan area included annual weeds, *Chenopodium pumilio* and *Conyza parva*, but also indigenous species such as *Alternanthera nahui* and *Centipeda aotearoana*.

The first record of *Gratiola pedunculata*, probably a natural introduction from Australia (de Lange 1997), was made at this lake in 1996 and found again in exposed grass/herb land amongst tall emergent vegetation. Other species present were *Alternanthera denticulata* (also an Australian vagrant), *Paspalum distichum* and *Centella uniflora*. In 2007, *A. denticulata* had expanded its range over much of the lake margin growing on the lake side of some emergent vegetation. A species of rush, *Juncus polyanthemus*, not previously recorded from New Zealand, was recognised growing in the marginal vegetation of Lake Waiporohita in 2009. This plant looked like a robust form of *J. usitatus* and was previously overlooked. It is likely to be another Australian vagrant. The first New Zealand record of the minute annual herb *Crassula natans* var. *minus* was also made at Lake Waiporohita in 2011. In 2014, all four vagrant species were common around the lake and can be regarded as established at this site.

A 2 m^2 patch of alligator weed (*Alternanthera philoxeroides*) was noted in 2005 at the north end access point. In 2014 this species had increased and it was also found amongst much of the marginal emergent vegetation. The introduced weed, primrose willow (*Ludwigia peploides* var. *montevidensis*), was restricted to an area of < 10 m^2 and its eradication is advocated. This is the only known site of this species north of Dargaville.

Submerged vegetation

Turf communities were conspicuous in many areas of the lake with *Glossostigma elatinoides, Lilaeopsis novae-zelandiae, Myriophyllum propinquum*, the exotic *Ludwigia palustris* and at one site *Gratiola pedunculata* extending from the shore to ~ 1 m deep. *Potamogeton ochreatus* and *Nitella* sp. aff. *cristata* or *Chara australis* dominated deep vegetation extending to 2.7 m (the bottom) in 2011.

In 2004 and 2006, the charophyte bottom limit was around 1.5 m but in the 2011 and 2014 surveys the lake has improved to be fully vegetated to its deepest point at 3 m. The charophyte composition has changed with *Nitella* sp. aff. *cristata* decreasing at the expense of *Chara australis*. In 2014, *Nitella* sp. aff. *cristata* was not recorded and *Chara australis* formed tall extensive mono-specific meadows.

Small amounts of *Utricularia gibba* were noted in shallow areas associated with emergent vegetation in 2014.

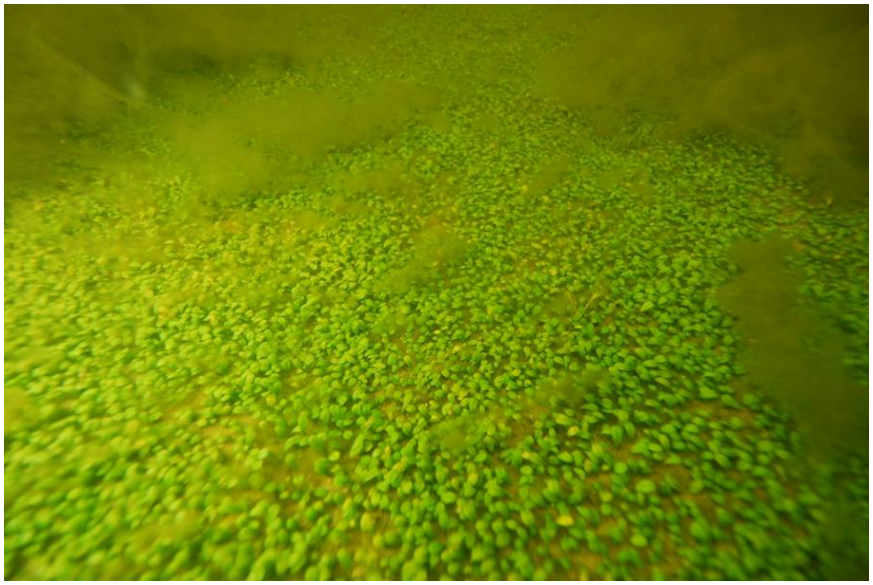
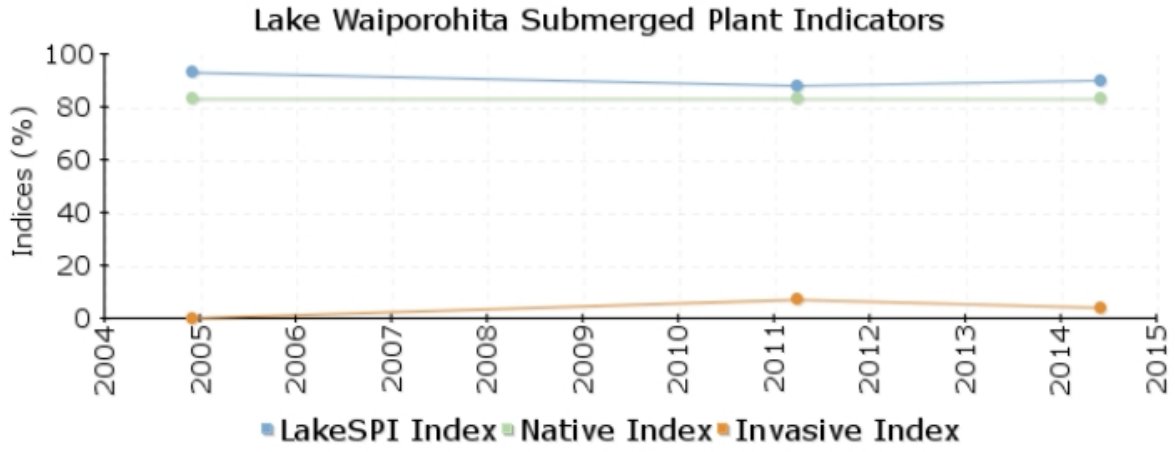


Plate B: Submerged turfs of *Glossostigma elatinoides* in Lake Waiporohita.

LakeSPI



Survey Date	Status	LakeSPI %	Native Condition %	Invasive Impact %
May 2014	Excellent	90%	83%	4%
March 2011	Excellent	88%	83%	7%
November 2004	Excellent	93%	83%	0%

The excellent LakeSPI scores of 88 - 93% reflect the extent of the native vegetation, with limited influence of invasive exotic species. The invasive impact of *Utricularia gibba* was minimal and restricted to shallow water.

Water birds

The large areas of wetland and removal of cattle browsing on the northern edge of the lake provides good habitat for many aquatic birds. Mallards (*Anas platyrhynchus*), black swans (*Cygnus atratus*), grey duck (*Anas superciliosa*) and the Nationally Threatened Caspian tern (*Sterna caspia*) were seen on the field visit. Also reported previously were the Nationally Threatened bittern (*Botaurus poiciloptilus*), the regionally threatened dabchick (*Poliocephalus rufopectus*) and the vagrant chestnut-breasted shelduck (*Tadorna tadornoides*) was seen on this lake in 1985.

Fish

Common bullies (*Gobiomorphus cotidianus*) and the pest fish *Gambusia affinis* have been seen during field visits.

Aquatic invertebrates

Backswimmers (*Sigara arguta*) were noted in abundance. Leeches (*Richardsonianus mauianus*) were also seen.

Endangered species

The Nationally Vulnerable grass *Amphibromus fluitans* was collected in 1998 but has not been seen since. This was the only recent record of this species in Northland. It is a cryptic species, superficially similar to other grasses common in this lake but may have disappeared from this site.

There are four vagrant species first recorded in New Zealand from this lake; *Gratiola pedunculata, Alternanthera denticulata, Juncus polyanthemus* and *Crassula natans* var. *minus*. These are classified as Non Resident Native - Coloniser by de Lange et al. (2013), naturally spreading here from Australia, but currently have a limited population size. Interestingly, *C. natans* var. *minus* is not native to Australia (being a South African species) but has arrived in New Zealand without human transfer.

Lake Ecological Value

The condition of Lake Waiporohita has improved and was fully vegetated with clear water. This is one of four lakes with improving water quality (out of the 27 Northland lakes monitored by NRC), with recent TLI changing from supertrophic to eutrophic. Its ecological value rating remains "Outstanding".

It is not known if the continued improvement in lake condition is due to change in land management in the surrounding catchment, or whether changes are wholly due to the complete cover of submerged vegetation preventing re-suspension of nutrient-rich bottom sediments. It would be relevant to explore what, if any, changes in the catchment might be driving this improvement.

Threats

The ease of access to this lake after removal of the roadside fence on the eastern shore makes it relatively easy to access and inadvertently transfer weeds. However this lake is not sought out for recreation, being shallow, small and relatively isolated. Submerged weed species would significantly impact the lake.

Alligator weed has now spread around the lake in the marginal vegetation and is likely to increase in abundance over time, especially in nutrient enriched areas. Eradication is no longer deemed feasible.

Conversely, primrose willow is restricted to an area of < 10 m^2 and could easily be eradicated from its only known site north of Dargaville.

The lake is currently improving in clarity and plant health but has the potential to be further nutrient enriched with consequent frequent algal blooms.

Management recommendations

Annual pest plant surveillance monitoring.

Lake native biodiversity value assessment monitoring every 5 years.

Eradication of the emergent weed primrose willow is advocated.

3.4 Lake Kai-iwi (Kai-iwi Lakes), NRC Lake No. 236.

Plate A: Lake Kai-iwi showing an extensive margin of emergent vegetation.

Summary

Surveyed 1984, 1985, 1987, 2001, 2005, 2007, 2011 and 2014.

Overall ranking

Outstanding: A native plant dominated lake, with nationally rare plants and *U. gibba* the only pest plant species present. However, water quality trends show increases in chlorophyll a (planktonic algae) and total nitrogen with decreased water clarity and a change in TLI from oligotrophic to mesotrophic.

Threats

A locked gate has stopped access to the lake for trailered boat traffic, with a decreased risk of inadvertent pest plant introductions. However, should an introduction occur then subsequent impact is likely (cf. Lake Taharoa). High impact from *Gambusia affinis* has contributed to the possible extirpation of the nationally near-threatened dune lakes galaxias. Water quality parameters have deteriorated indicating nutrient enrichment from surrounding land. Pine harvesting could be a cause.

Management recommendations

Lake native biodiversity value monitoring every 5 years, pest plant surveillance annually.

Continue investigation of catchment nutrient sources and mitigation options.

Description

Lake Kai iwi charophyte composition and bottom limits have not changed markedly since 1984 indicating the lake is not deteriorating. However, water quality trends have detected increases in chlorophyll *a* (planktonic algae) and total nitrogen, with decreased water clarity and a change in TLI from oligotrophic to mesotrophic. Nonetheless, its ecological value rating remains “Outstanding”.

This lake contains one of, if not the largest Northland population of the Nationally Endangered *Trithuria inconspicua*.

This dune lake (1659066E, 6036450N) is 22.6 ha in area, with a 16 m maximum depth. The lake margin is predominantly vegetated by scrub (70%) and (recently felled) pine plantation (30%), with pasture in the larger catchment. Minor drainage inflows from Lake Taharoa at the south of the lake with no outlet. There is no road access to this lake and the final approach is prevented by a locked gate and no formed boat ramp.

Wetland vegetation

Most of the lake had a 3 - 10 m wide margin of emergent vegetation, with dense *Apodasmia similis* and occasional *Schoenus brevifolius* closest to the terrestrial margin and *Machaerina arthrophylla* (especially on the exposed eastern shore). *Machaerina articulata* and *M. juncea* were common in shallow water up to 0.7 m deep and an outer zone of *Eleocharis sphacelata* extended up to 2.6 m deep on one transect. One patch of raupo (*Typha orientalis*) was noted for the first time in 2014. This could indicate a local source of nutrient enrichment.

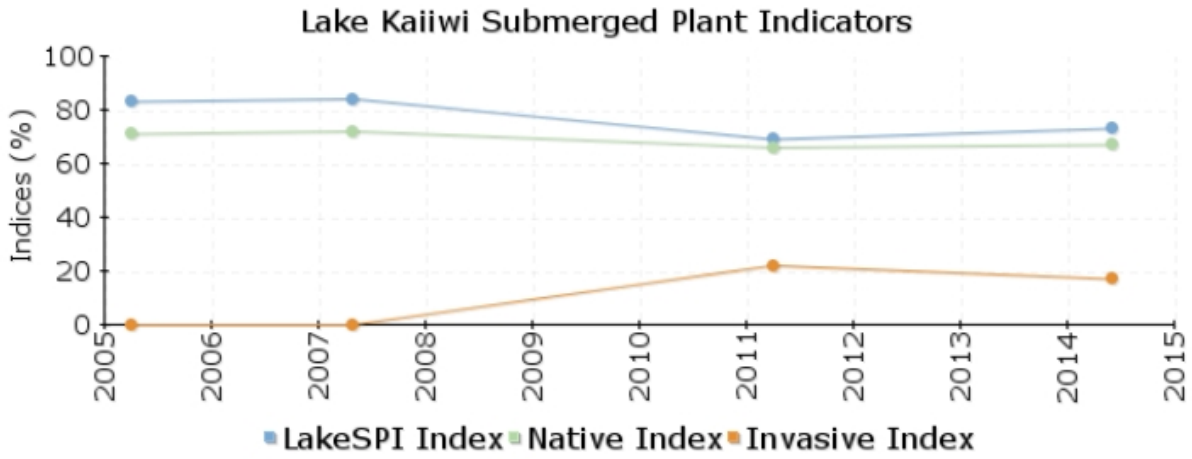
Submerged vegetation

Turf plants occurred to 2 m depth in several locations with abundant *Trithuria inconspicua, Triglochin striata, Lilaeopsis novae-zelandiae* and *Myriophyllum votschii*.

Charophyte meadows extended from < 2 m to 11.8 m and were dominated by *C. fibrosa* to c. 7 m and *Chara australis* to c. 12 m deep. *Potamogeton cheesemanii*, a native tall vascular plant, frequently occurred at low covers to about 4 m water depth. The invasive *Utricularia gibba* was found in deep water in three of the five transects to depths approaching 10 m deep. However, it was localised and of low covers not apparently impacting other submerged vegetation.

Vegetation bottom limits have varied in the past averaging around 12 m. However, in 1985 the bottom limit was only 8.5 m and there was very poor visibility in the hypolimnion suggesting anoxia. Subsequent surveys showed bottom limits had extended to around 12 m. The charophyte community in 2014 remains in good health with *C. fibrosa* beds still prominent.

LakeSPI



Survey Date	Status	LakeSPI %	Native Condition %	Invasive Impact %
May 2014	High	73%	67%	17%
March 2011	High	69%	66%	22%
April 2007	Excellent	84%	72%	0%
March 2005	Excellent	83%	71%	0%

The excellent LakeSPI score in 2007 of 84% reflected the extent of vegetation development, the presence of several key native plant communities and absence of invasive exotic species. However, in 2011 *U. gibba* presence reduced the LakeSPI score to 69% and increased the invasive score to 22%. The impact of *U. gibba* reduced in 2014 with subsequently improved LakeSPI scores.

Water birds

The isolated nature of much of this lake and extensive emergent and scrub vegetation provide good habitat for water birds, probably acting as a refuge from the human-mediated disturbance in the two adjacent lakes. Pied shags (*Phalacrocorax varius*) were noted during the field visit and there are earlier reports of large numbers of waterfowl utilising this lake, including the Nationally Threatened bittern (*Botaurus poiciloptilus*) and regionally rare dabchick (*Poliocephalus rufopectus*).

Fish

Native fish records include common bullies (*Gobiomorphus cotidianus*) and historically dune lakes galaxias were found. Exotic fish present include gambusia (*Gambusia affinis*), rudd (*Scardinius erythrophthalmus*) and a stocked population of rainbow trout (*Oncorhynchus mykiss*).

Aquatic invertebrates

Invertebrates were abundant in the lake. No freshwater mussels (*Echyridella menziesi*) were seen but empty shells have been noted in previous surveys. The remains of koura (*Paranephrops planifrons*) were commonly observed along the water's edge in 2014.

Endangered species

Lake Kai iwi supports possibly the largest Northland population of the Nationally Endangered *Trithuria inconspicua* with a c.10 m band of this species in shallow water or exposed sand (average cover of 10%) around much of the lake. The total population size was estimated at 2 ha. It was most

commonly associated with open emergent beds of *M. arthrophylla*, but was absent in local areas of dense *M. articulata*.

The At-Risk Naturally Uncommon dune lakes galaxias (restricted to the Kai Iwi lakes) is apparently extinct in this lake although dedicated fish surveys have not been carried out recently. An increase in threat status is advocated for this species as is a targeted fish survey.

Lake Ecological Value

Water quality has deteriorated with increases in chlorophyll *a* (planktonic algae), total nitrogen and decreasing water clarity resulting in a change in TLI from oligotrophic to mesotrophic. However, charophyte composition and bottom limits have not changed markedly since 1984 despite fluctuations in the maximum depth of vegetation seen from previous surveys. It is likely periods of anoxia in the hypolimnion occurred in the past that reduced the maximum vegetation depth. The Lake Kai iwi ecological value rating remains “Outstanding”.

Threats

The lack of motorised boat traffic to this lake reduces the risk of pest introduction. However conditions in this lake are suitable for the establishment and growth of invasive vascular weeds. If pest plants were introduced they would be expected to establish quickly and would severely impact on lake values.

Rudd have been present in the lake since c.1991 with little apparent impact on plants, however, these herbivorous fish have been implicated in loss of vegetation elsewhere so remain a threat.

Management recommendations

Invasive pest plants pose a greater threat to this lake than the adjacent lakes as higher nutrient conditions would favour their rapid growth. Continuance of annual surveillance of the access point for pest plant incursion is important.

A targeted fish survey is recommended for pest fish and also the At Risk Naturally Uncommon dune lakes galaxias. An increase in threat status of this fish would be advocated should no fish be located during this survey.

3.5 Lake Taharoa (Kai-iwi), NRC Lake No. 229.

Plate A: Lake Taharoa shoreline at the south end showing the motor camp in 2011. Note the exposed beach, the paucity of emergent vegetation and the pine tree removal.

Summary

Surveyed 1984, 1987, 2001, 2005, 2007, 2011 and 2014.

Overall ranking

Outstanding: The best example of a clear-water lake in Northland, with the deepest recorded (18 - 27 m) submerged vegetation in the North Island.

Threats

Biosecurity: high risk of pest plant introduction but subsequent impact likely to be low due to very low nutrient status and steep sides.

Catchment: moderate-high risk of increased nutrient loading with impact on current values and increased biosecurity risk.

Management recommendations

Surveillance for pest plant introductions at access points annually and lake native biodiversity value monitoring at 5 year intervals.

A survey of Lake Taharoa fish is advocated and should also target the freshwater crab.

Continue investigations into ground water and identification of possible nutrient sources from the catchment with consideration of appropriate mitigation measures.

Description

This dune lake (1658567E, 6037260N) is the second largest (197 ha) and deepest lake (37 m) in Northland. It is a situated in a catchment comprised of ~ 1.8 M year old consolidated, nutrient-poor, sand dunes with shrub land, pastoral land and planted forest. The immediate surrounds include a domain with two camping grounds and the lake is popular for boating swimming and water skiing. There are two minor inflows at the south-west end of the lake, with no outflow. Access is via public roads with three boat launching areas.

Wetland vegetation

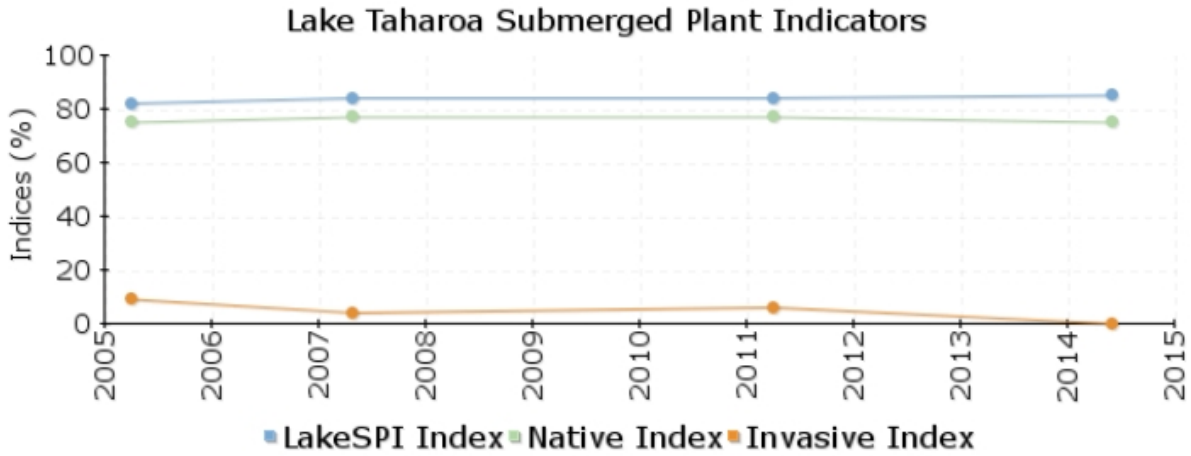
Much of shore was wave exposed with hard iron pan and compacted sand that is unsuitable for emergent vegetation. Low covers (25%) of oioi (*Apodasmia similis*) and *Schoenus brevifolius* were present in places. Additional emergent species recorded included *Machaerina arthrophylla, M. articulata, M. juncea, Eleocharis acuta, E. sphacelata, Ficinia nodosa, Isachne globosa, Isolepis prolifera* and *Juncus pallidus*.

The major woody weeds on the lake surrounds were delimited during 2014 with Sydney golden wattle (*Acacia longifolia*), coastal banksia (*Banksia integrifolia*) and two wilding pines (*Pinus pinaster* and *P. radiata*) the dominant species found.

Submerged vegetation

Sparse turf plants grew on the shallow (0-1 m) sandy substrates of the wave-cut shelves and included *Trithuria inconspicua, Triglochin striata* and *Myriophyllum votschii*. The exotic rush, *Juncus bulbosus*, was also recorded in these areas along with isolated plants of the bladderwort *Utricularia gibba*. Steep slopes immediately beyond these shelves were largely devoid of plants from 1 to 6 m. Charophyte meadows, dominated by *Chara fibrosa* extended from < 4 m to 22 m water depth. The depth limits have fluctuated from 18 to 27 m over the 7 surveys since 1984, but no trend in these fluctuations was apparent.

LakeSPI



Survey Date	Status	LakeSPI %	Native Condition %	Invasive Impact %
May 2014	Excellent	85%	75%	0%
March 2011	Excellent	84%	77%	6%
April 2007	Excellent	84%	77%	4%
March 2005	Excellent	82%	75%	9%

An ‘Excellent’ LakeSPI score of 85% reflects the depth extent of vegetation, the predominance of the native charophyte community and minimal impact by invasive exotic plants. Lake condition remains Excellent and very stable.

Water birds

The limited development of marginal and emergent vegetation and popular use of this lake by the public reduce its suitability for water birds. Despite this, large numbers of waterfowl are reported to utilise the Kai-iwi lakes although the numbers were noted to be declining. The regionally rare dabchick (*Poliocephalus rufopectus*) was reported. Few birds were seen during the current survey.

Fish

Native fish sighted during surveys include common bullies (*Gobiomorphus cotidianus*), while the exotic pest gambusia (*Gambusia affinis*) were also observed. Previous surveys have recorded shortfin eels (*Anguilla australis*), and rainbow trout (*Oncorhynchus mykiss*) have been stocked. Dune lakes galaxias were last recorded in the 1999 survey.

Aquatic invertebrates

Koura (*Paranephrops planifrons*) were observed during the current survey, as was the freshwater crab (*Amarinus* (was *Halicarcinus*) *lacustris*).

Endangered species

The Nationally Critical *Centrolepis strigosa,* an annual, was found in the marginal turf in 2010 (first known collection from the Kai-iwi Lakes since the 1980's) and has been found in the same location subsequently, usually as dead plants. Over 100 plants of this species were found on iron pan outcrops and beach areas in November 2013. No sign of this species was found in most of these areas during our 2014 survey, suggesting our annual surveys do not correspond with the actively growing stages of its life-cycle. The National Endangered *Trithuria inconspicua* was uncommon in this lake, with few plants seen during our shoreline survey in 2014. It was locally common at one site amongst *Machaerina arthrophylla* in the “Sin-bin” area. The Nationally Vulnerable sundew *Drosera pygmaea* was noted amongst mosses on iron pan outcrops.

The At-Risk Naturally Uncommon dune lakes galaxias (restricted to the Kai iwi lakes) has not been seen during our vegetation surveys since 1999 and a survey of Lake Taharoa fish is advocated.

There appears to be a secure population of the freshwater crab (At Risk Naturally Uncommon).

Lake Ecological Value

Lake Taharoa remains the best example of a clear-water lake in Northland with the deepest recorded (currently 22 m) submerged vegetation in the North Island. This is dominated by the charophyte, *Chara fibrosa*. The deepest extent of high cover *C. fibrosa* meadows has varied between 18 and 27 m between vegetation surveys and is currently 22 m. This measure will be a sensitive baseline for future assessments of long-term water clarity. Water quality trends show this lake is stable with an oligotrophic status. Its ecological value rating remains “Outstanding”.

Threats

The only pest plants present were *J. bulbosus* and *U. gibba*, which were sparse and of insignificant impact on the lake's ecology. While good boat access to the lake results in a high risk for introduction of pest plants, the potential impacts are currently very low. Firstly, the exposed wave cut platforms around the lake reduce the likelihood of establishment and secondly, unusual water chemistry limits the development of large vascular plants, likely due to dissolved carbon limitation. However changes in water chemistry could make the lake more vulnerable to pest plant invasion. Such a change would be initially indicated by development of tall-growing native vascular plants such as *Myriophyllum* spp. and *Potamogeton* spp.

The pest fish gambusia is known to harass some native fish and could threaten the endangered dune lake galaxias. Gambusia has been implicated in the extirpation of this fish from the adjacent Lake Kai-iwi.

Nutrient loading from the catchment is a major threat with potential sources from nitrogen-fixing woody vegetation, pine harvesting and livestock farming. Resulting changes in water chemistry would not only decrease water quality but could also facilitate pest plant establishment.

Management recommendations

Pest plant surveillance at access points annually. Lake native biodiversity value monitoring every 5 years.

A survey of Lake Taharoa fish is advocated and should also target the freshwater crab.

Continue investigations into ground water and identification of possible nutrient sources from the catchment with consideration of appropriate mitigation measures.

3.6 Waikare (Kai-iwi Lakes), NRC Lake No. 227

Plate A: Lake Waikare (was Waikere), view from the boat ramp at the west end of the lake in 2007, pine trees since removed.

Summary

Surveyed 1985, 1987, 2001, 2005, 2007, 2011, and 2014.

Overall ranking

Outstanding: A native plant dominated lake with the presence of nationally rare plants and fish. Negligible impact by pest plants.

Threats

Biosecurity: high risk of pest plant introduction but subsequent impact likely to be low due to very low nutrient status and steep sides.

Catchment: moderate risk of increased nutrient loading with impact on current values and increased biosecurity risk.

Management recommendations

Pest plant surveillance at access points annually. Lake native biodiversity value monitoring every 5 years.

Continue investigations into ground water and possible nutrient sources from the catchment and consider appropriate mitigation measures.

Description

The lake (1656902E, 6038255N) is accessible for trailer boat traffic via a sealed road and concrete boat ramp. The catchment is predominantly manuka scrub (50%), felled pine plantation (45%), and a campground. This moderately large (26.5 ha) and deep (30 m) dune lake is an important venue for water skiing. There is no outlet and only minor drains enter the lake.

Wetland vegetation

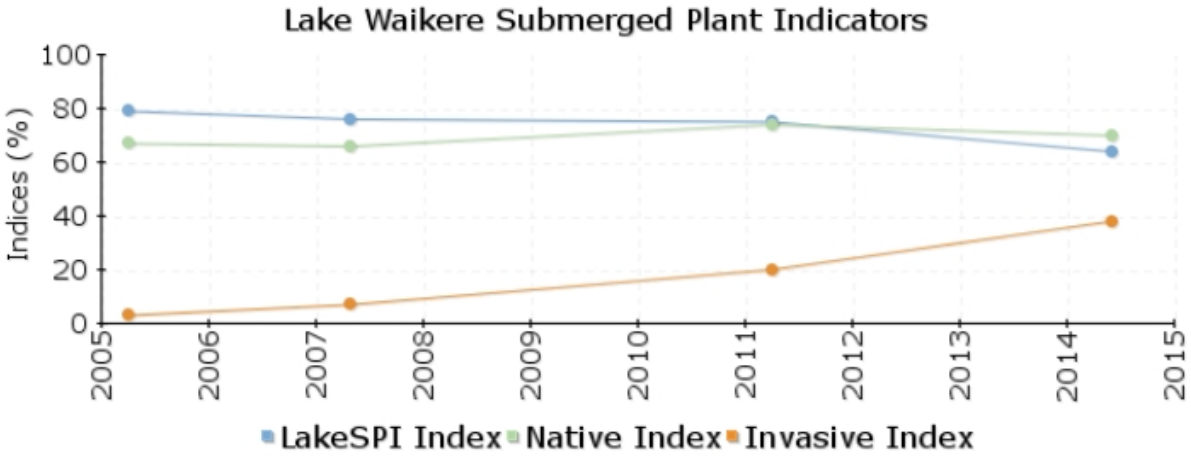
Emergent vegetation was sparse, only occurring around 15% of the lake shore, with *Eleocharis sphacelata, Machaerina arthrophylla, M. articulata, M. juncea, Apodasmia similis* and *Schoenus brevifolius* present in some areas. Emergent plants were usually in narrow bands < 2 m wide extending to water depths between 0.5 m and 2 m.

Submerged vegetation

Turf plants were not abundant due to the prevalent iron pan reefs around the lake but were locally common and associated with emergent vegetation. Species included *Trithuria inconspicua, Lilaeopsis novae-zelandiae* and *Myriophyllum votschii*. Isolated plants of the exotic rush*, Juncus bulbosus* were also recorded in shallow areas.

Charophytes comprised the remainder of the vegetation. Dense charophyte meadows were present from < 2.5 m to 19 m depth with *Chara fibrosa* dominant in the upper profile and *C. australis* solely from 13 m to a maximum recorded depth of 19.7 m. Before 2005 *Chara fibrosa* dominated the charophytes to the bottom limit, being 19 m in 2001. *Utricularia gibba* was recorded from between 11 and 16 m, the deepest record yet for this invasive species, where it formed high covers on charophyte meadows. One small patch of the native *Potamogeton ochreatus* was noted near the boat ramp in 2012. This may indicate increased nutrients in that area.

LakeSPI



Survey Date	Status	LakeSPI %	Native Condition %	Invasive Impact %
May 2014	High	64%	70%	38%
March 2011	High	75%	74%	20%
April 2007	Excellent	76%	66%	7%
March 2005	Excellent	79%	67%	3%

A ‘High’ LakeSPI score of 64% was driven by the large extent of native vegetation and presence of charophyte meadows but with impact from invasive deep-growing *U. gibba* increasing the Invasive Index of this lake from 3% in 2005 (derived from *Juncus bulbosus* impact) to 38%.

Water birds

The limited emergent vegetation and high use of the lake for water skiing limits the habitat available in this lake to water birds (temporally at least). Nevertheless, grey heron (*Ardea novaehollandiae*) and little shag (*Phalacrocorax melanoleucos*) were noted during the survey.

Fish

Native fish records include common bullies (*Gobiomorphus cotidianus*) and dune lakes galaxias, shortfin eel (*Anguilla australis*) and longfin eel (*Anguilla dieffenbachii*). Large pelagic schools of juvenile bullies were noted at several sites. Exotic fish present were gambusia (*Gambusia affinis*), common in shallow areas, and a stocked population of rainbow trout (*Oncorhynchus mykiss*). DOC conducted a fish survey during 2014 using a combination of Gee minnow (4) and fyke nets (2). They recorded a total of 96 gambusia, 589 common bullies, 20 dune lakes galaxias, 8 longfin and 2 shortfin eels (all large ≥540 mm long) with 3 dragonfly nymphs and one koura also caught.

Aquatic invertebrates

Koura (*Paranephrops planifrons*) and pea mussels (*Sphaerium novaezelandiae*) were recorded from Lake Waikare, although they were not abundant.

Endangered species

Two plants of the Nationally Critical *Centrolepis strigosa* were found in the marginal turf in 2014 (Plate B). It is unusual to find living plants of this annual species during the March / April annual lakes surveys. The plant has been previously recorded here with the most recent record in 2011 (de Lange 2011).

Plate B: The National Critical *Centrolepis strigosa* on the margin of Lake Waikare.

The Nationally Endangered *Trithuria inconspicua* was locally abundant in this lake with three large populations adjacent to the concrete boat ramp on the western shore and the eastern side of the southernmost bay.

The At Risk Naturally Uncommon dune lake galaxias (restricted to the Kai iwi lakes) appears to be abundant in Lake Waikare with large schools of this fish commonly seen during dive surveys and also sampled during the 2014 DOC fish survey. A few At Risk Declining longfin eel were sampled by DOC in 2014.

Lake Ecological Value

Lake Waikare, like the neighbouring Lake Taharoa, is a good example of a clear-water Northland lake. Submerged vegetation is dominated by dense charophyte meadows with *Chara fibrosa* dominant in the upper profile and *C. australis* from 13 m to a maximum recorded depth of 19.7 m. Before 2005 *Chara fibrosa* dominated the vegetation to the bottom vegetated limit. While the bottom limits remain deep, the species change is indicative of a change in water chemistry. These changes were not detected in water quality monitoring with no change from oligotrophic TLI and a decreasing trend in total phosphorus. The lake does stratify over summer and should low dissolved oxygen levels develop in the hypolimnion this could threaten its future status. Its ecological value rating remains "Outstanding".

Threats

The ease of access and high boat traffic to this lake results in a very high risk of pest plant introduction, however the subsequent impacts would be low. Water chemistry currently limits the development of large vascular plants and pest plants are unlikely to establish. However, changes in water quality parameters could increase the likelihood of pest plant establishment. Nevertheless, hornwort (*Ceratophyllum demersum*) may be able to thrive in this lake under current nutrient levels. *Potamogeton ochreatus* was noted near the boat ramp in 2012 and may indicate increased nutrient enrichment in that area.

The exotic *Utricularia gibba* has established as a band around the lake with maximum covers of >75% on deep submerged charophyte vegetation between 11 and 16 m.

The biggest threat would be if increased nutrient loading from the catchment were to occur which would not only impact upon water clarity and current ecological values but also create an increased threat of pest plant establishment. Given the excellent water quality of this lake and 'Outstanding' ecological value rating, the possibility of water quality deterioration requires further consideration.

Management recommendations

Pest plant surveillance should be carried out at access points annually, also monitoring the extent, density and impact of deep water *U. gibba* infestation.

Lake native biodiversity value should be monitoring every 5 years.

Lake water quality and catchment nutrient sources need to be closely monitored and managed.

3.7 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

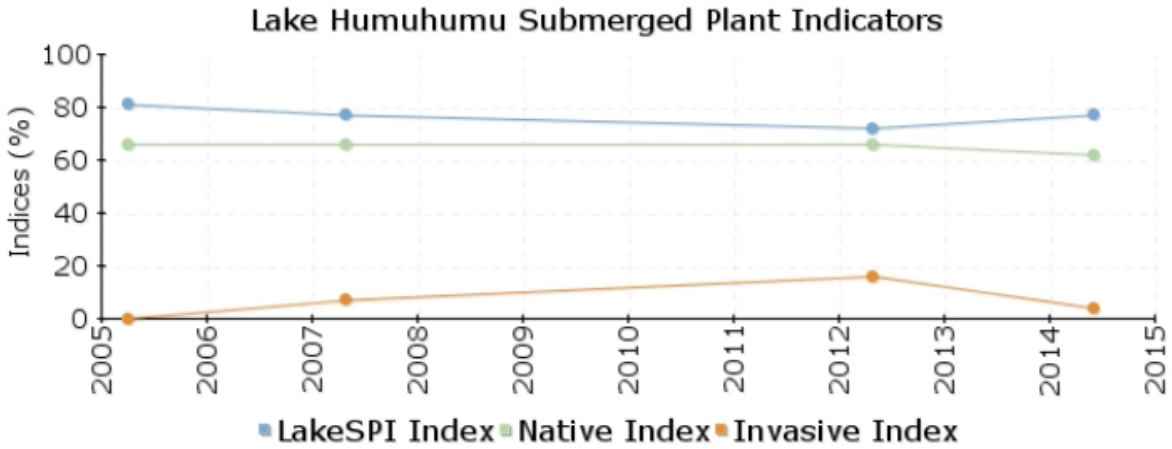
About 70% of the shoreline had a narrow (< 5 m) band of emergent species extending into about 1 m depth of water. *Schoenoplectus tabernaemontani* and *Eleocharis acuta* were the most common species with *Apodasmia similis, Bolboschoenus fluviatilis, Cyperus ustulatus, E. sphacelata, Juncus pallidus, 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.

3.8 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.

3.9 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

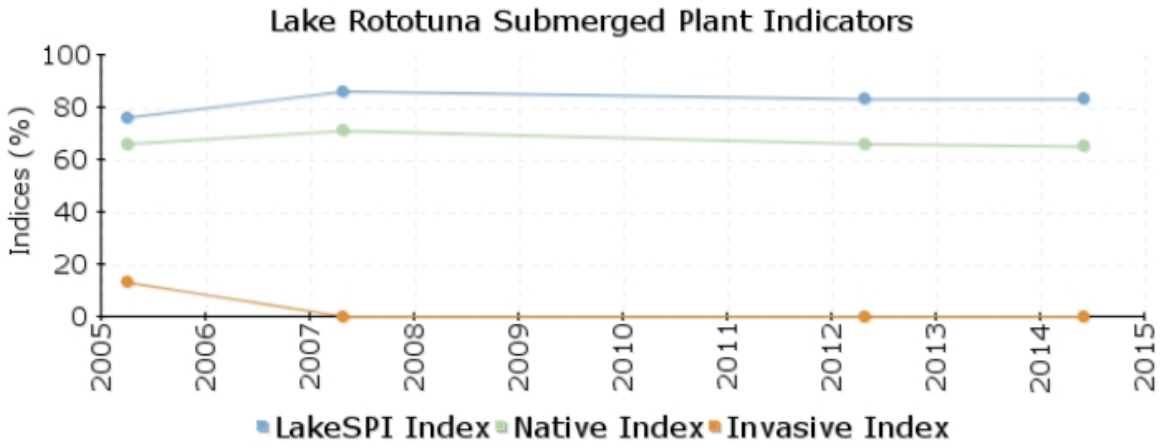
About 80% of the shoreline had emergent species with raupo (*Typha orientalis*), *Eleocharis sphacelata*, *E. acuta*, *Machaerina articulata* and *Schoenoplectus tabernaemontani* forming a narrow band 5 - 10 m wide. *E. sphacelata* beds extended to 1.8 m deep, the other species were < 0.5 m. The invasive 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.

3.10 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.

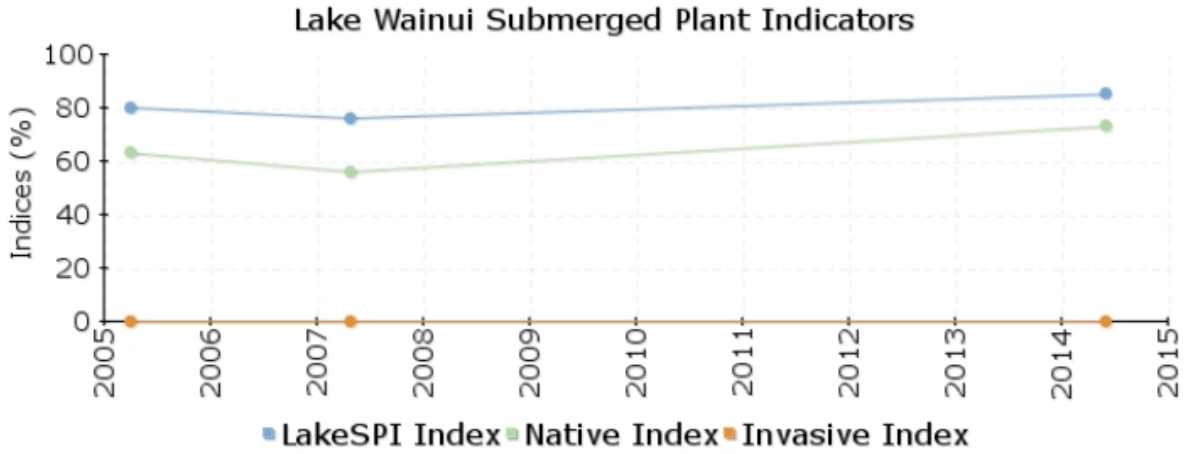
The pest plant primrose willow, (*Ludwigia peploides*) formed floating mats at the ends of the lake. A non-weedy exotic, swamp lily (*Ottelia ovalifolia*), was also present with both submerged and floating leaved forms.

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.

3.11 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.

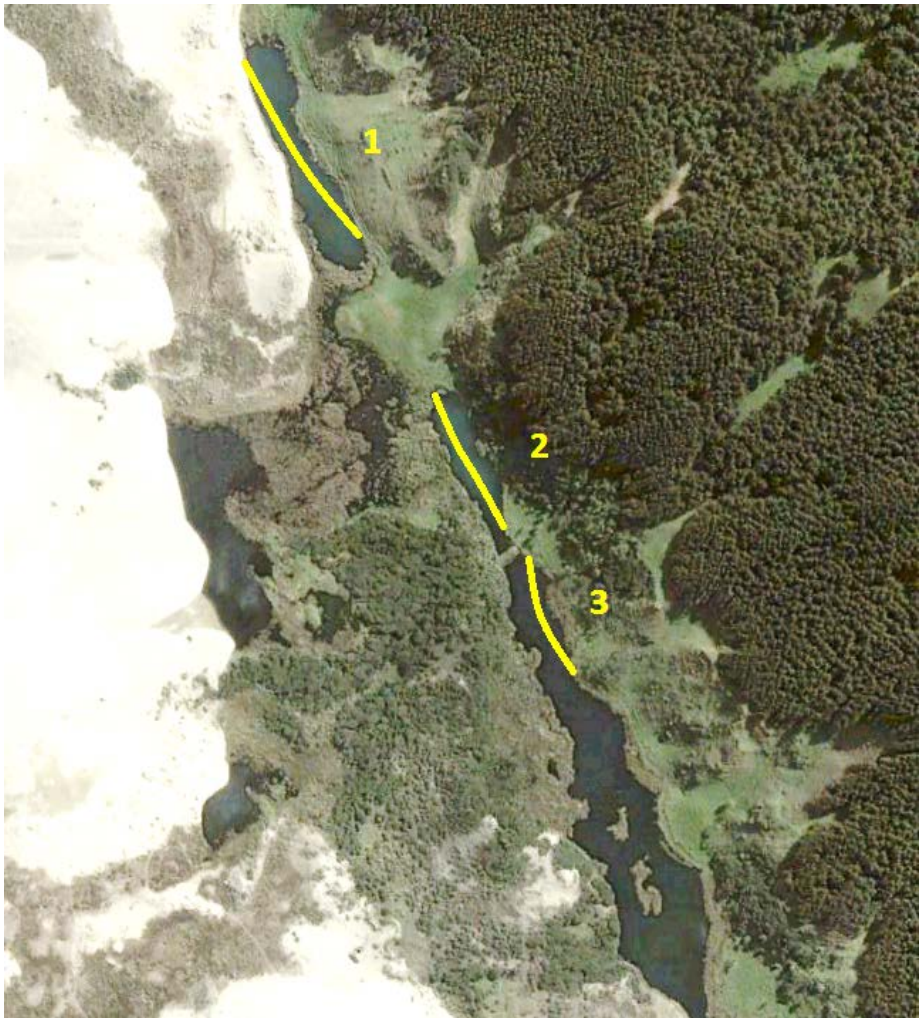


Plate B: Yellow lines indicate path swum. Line 1 is Round Hill Lake 2, and lines 2 & 3 are paths swum in Lake Wairere (north end).

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.

3.12 Surveillance

3.12.1 Lake Ngatu

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), was intensively checked for new weed incursions deploying 3 SCUBA divers and 3 snorkelers.

In the southwest of the lake an area was searched from where waka ama are launched south to the sandy beach.

The lake currently still has no elodea (*Elodea canadensis*), egeria (*Egeria densa*) or hornwort (*Ceratophyllum demersum*) present. All are potential weeds (particularly hornwort) that could markedly impact on the ecological and recreational lake values. Lagarosiphon (*Lagarosiphon major*) remains present but has decreased in abundance since surveyed in 2006.

Currently lagarosiphon presence in the lake is not causing a nuisance to recreation. However, it is a well-used lake and could provide a source of weed fragments for dispersal to other weed-free lakes.

Several marginal weeds were detected in 2014. The invasive climber mile-a-minute (*Dipogon lignosus*) was found near an inlet drain at the northern end of the lake. This was removed by hand and picloram gel applied to remaining stems. The problem woody wetland weed Christmas berry (*Schinus terebinthifolius*) was found in manuka on the eastern edge of the lake.

The invasive alligator weed (*Alternanthera philoxeroides*) was noted for the first time in 2012. This has been repeatedly treated with the herbicide metsulfuron-methyl (Kevin Matthews, pers. comm.) and a few plants remained in 2014.

3.12.2 Lake Waiporohita

The eastern shore of the lake was checked for submerged weed, shoreline drift fragments and marginal weeds. The lake was also dived to the centre from 5 well-spaced shoreline locations in the 2014 survey. Water clarity was good (~3 m) and submerged vegetation was checked by snorkel and scuba. No new weeds were found. Alligator weed (*Alternanthera philoxeroides*) had spread around the lake edge but had minor impact on the marginal aquatic vegetation. Primrose willow (*Ludwigia peploides*) occupied a small area (< 10 m^2) and eradication should be attempted.

3.12.3 Lake Kai-iwi

The boat access point useable by 4-wheel drive in 2005 (25701100E 6598580N) has had public access restricted by a locked gate since 2006. Snorkelers made two passes of the shoreline up to 150 m either side of this site to cover the depth range to 3.5 m. The lake was also dived at 5 locations for LakeSPI and no new invasive species were found.

3.12.4 Lake Taharoa

At the south side beach launching site for boats (2568960E 6598645N), about 400 m of the shoreline was searched for invasive weed by towing scuba divers to cover the 0 - 10 m depth range.

The camping ground beach at the eastern end of the lake (2570410E 6599045N), used for boat launching and mooring, was searched. About 500 m of the shore was checked and was mostly bare sand on the shallow shelving beach with suitable habitat to about 7 to 9 m deep. Scuba divers were

towed along the upper vegetated depth limit. Visibility was good and sparse native vegetation was low growing enabling large areas to be effectively searched.

At the Peninsula boat launching area (2568375E 6599495N) a section of shoreline about 250 m long was checked by scuba divers using underwater scooters.

The lake was also dived to 20 m at five locations for lake ecological assessments.

No new invasive species were found.

3.12.5 Lake Waikare

The shoreline 200 m either side of the concrete boat ramp (2567290E 6600270N) was searched by many school children and NRC staff. The water is 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 will be checked by NRC staff in the near future.

The lake was also dived at five sites for lake ecological assessment. No invasive weed species were found except for *U. gibba* which has been present in small quantities since 2009.

3.12.6 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.

3.13 Grass carp assessments

3.13.1 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.

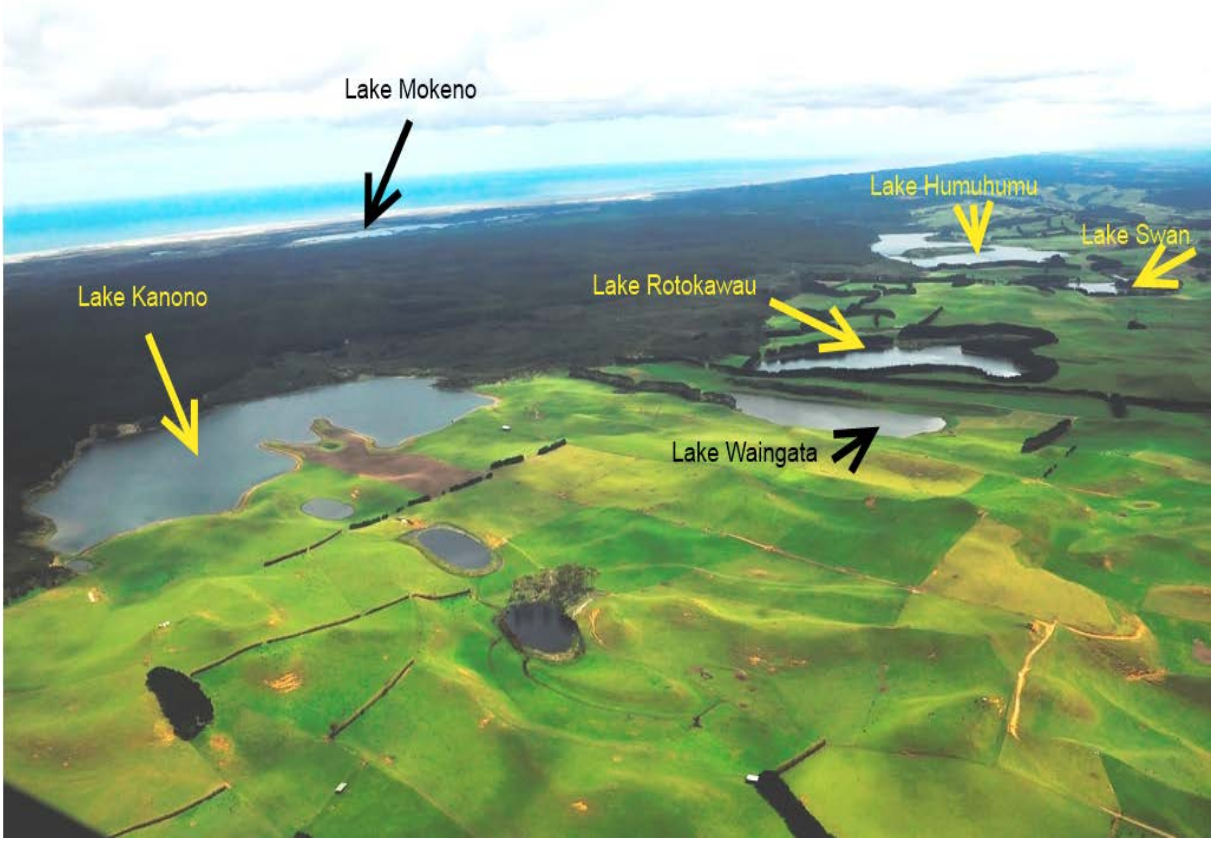


Plate A: The location of Lake Swan shown in relation to other lakes on the Pouto Peninsula. [Photo Rod Budd, NIWA, Hamilton].

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.

3.13.2 Lake Heather

Grass carp were introduced to Lake Heather as part of a lake restoration programme aimed at eradicating both hornwort and egeria and safeguarding nearby high-value lakes from the spread of these weeds.

The two baseline profiles recorded prior to grass carp release in 2010 were repeated in subsequent years (Plate C).

Plate C: Lake Heather showing the location of the 2 profiles monitored, with one in each basin.

In the first year egeria had been heavily grazed but little damage was noted on the hornwort (in 2011). During the following year to April 2012, egeria had been reduced to basal stalks (Plate D) and about 50% of the hornwort was removed with much of it still up to 2.2 m tall.

Plate D: Egeria (*Egeria densa*) remnants 2011 in Lake Heather at 2.6 m deep heavily grazed by grass carp.

After 3 years no egeria was found in the lake but hornwort was still present with 51-75% cover and an average height of 0.4 m tall. In the present survey (2014) with four years of grass carp grazing, beds of the submerged weeds were no longer to be found. A detached hornwort fragment was found in 2014. At least two more years of grass carp grazing is recommended before removal of fish is contemplated.

3.14 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