NIWA
Taihoro Nukurangi

Northland Lakes Annual Report 2016

Prepared for Northland Regional Council

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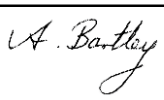	Formatting checked by:	Alison Bartley
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Executive summary

Northland Regional Council (NRC) has a programme of lake monitoring for around 90 lakes, of which 36 lakes are surveyed on a rotational basis over a maximum of five years. Lakes were assessed for ecological value including endangered species, wetland and emergent vegetation 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 calculation and interpretation of the Ecological Value Score. Identified threats and management recommendations were made for each lake. Additionally, annual surveillance is undertaken 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. The field assessments involved a team of NIWA, Northland Regional Council and Department of Conservation aquatic and wetland ecologists with diving capability. The programme for 2016 is summarised below:

Lakes assessed and work undertaken

1. Lake Ecological Assessments for:

   Aupouri: Lake Ngatu, Lake Yelavich, Lake Morehurehu and Lake Morehurehu Sth 2.

   Pouto: Lake Parawanui, Lake Mokeno.

2. Annual weed surveillance to detect any new incursions of aquatic pests in six priority lakes: (Lake Taharoa, Lake Ngatu, Lake Kai Iwi, Lake Waikare; and Lake Waiporohita).

3. Assessment of grass carp control towards eradication of target pest plant species in Lake Heather (Aupouri).

4. An assessment of the results of an endothall treatment to eradicate the lagarosiphon invasion in Lake Ngakapua (Aupouri).

5. Reconnaissance visits to two ponds off the Te Paki Stream, Lake Te Kahika South, ponds and the outlet stream to the east of Lake Te Kahika, Lake Morehurehu Sth 1, Lake Taeore and Lake Waiparera (Aupouri) and also three ponds to the east of Lake Kanono (Pouto).

Lake assessment results

Lake Ngatu appears to have deteriorated markedly in recent years and both emergent kuta and submerged charophyte dominated vegetation appears to be declining. However, none of the indicators LakeSPI TLI or Lake Ecological Value Rating have declined, rating the lake as Outstanding.

The Morehurehu lakes have not improved since 2013 when pine forests were harvested in the area with loss of submerged vegetation in these waterbodies.

Lake Yelavich remains stable, whereas the two Pouto lakes monitored appear to have improved since their last assessments. Lake Mokeno was essentially devegetated in 2015 but submerged vegetation has started to regrow, with scattered areas of charophytes to a depth of 4.5 m. Lake Parawanui is also improving since livestock have been mostly excluded from the lake. Emergent vegetation has colonised most of the lake margin and submerged vegetation has started to re-establish. In both cases water quality is still poor, with algal blooms noted in Lake Parawanui.

Weed surveillance results

No new weed incursions were found in the six high-value, high-risk lakes monitored. Hornwort (*Ceratophyllum demersum*) and elodea (*Elodea canadensis*) were recorded in Lake Waiparera for the first time in 2016.

Grass carp results

No hornwort or egeria *(Egeria densa)* were found in Lake Heather, with the apparent removal of these plants from October 2014 onwards. Removal of grass carp can be considered if no hornwort or egeria are recorded in 2017.

Endothall results

The endothall treatment targeting lagarosiphon (*Lagarosiphon major*) in Lake Ngakapua has been very successful with removal of lagarosiphon (with no damage observed in other plant species). Subsequent annual monitoring is recommended to check for possible lagarosiphon regrowth.

Reconnaissance visits

Only three of the ten lakes or ponds visited supported native submerged vegetation. Two of these were situated within a pasture catchment (Kanono Ponds 2 and 3). The other was situated within a natural catchment with an extensive wetland (Te Paki Stream Pond 1), but due to the small size and lack of endangered species, its Lake Ecological Value Rating was High to Moderate.

The submerged vegetation in Lake Waiparera had expanded since 2010, but was predominantly comprised of invasive species. Its Lake Ecological Value Rating had increased to High, but concern was raised over the potential of this lake to undergo a 'flip' to a devegetated state and also the additional impact that hornwort is likely to have in this lake.

A substantial population of the Nationally Critically Threatened *Utricularia australis* was discovered in the outlet stream from Lake Te Kahika, with a single shoot also noted in Lake Te Kahika South.

Recommendations

The lake ecological assessment programme has been running since 2001 and marked changes have been noted in the condition of a number of lakes. It is recommended that a NRC land management advisor be present on future lake surveys and land management recommendations be included in these reports.

Lakes Ngatu, Mokeno and Parawanui are badly affected by eutrophication and prolonged algal blooms. Lake Ngatu appears to be in the process of losing significant amounts of both submerged and emergent vegetation. The lake condition indicators used do not appear to reflect this change and assessment of areal extent of submerged vegetation and/or biovolume should be considered. This type of assessment would also prove useful for other lakes where similar observations are signalling decline. Links between land management practices and lake water quality need to be evaluated and remedial actions formulated in consultation with landowners.

Lake Humuhumu and Phoebe should be included in next year's ecological assessment. We could not access these lakes this year as the raupo had grown over the boat launching site at Humuhumu and locked gates prevented access to Phoebe.

A final assessment of Lake Heather for hornwort and egeria should be carried out in 2017. Following this assessment, should no weeds be located, removal of grass carp from Lakes Heather and Roto-otuauru is recommended.

Populations of the Nationally Critically Threatened *Utricularia australis* should be assessed on a three-yearly basis.

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 condition. 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 around 90 lakes that are surveyed on a rotational basis. This includes surveillance on prioritised lakes for early detection of weed incursions. From 17 – 23 April 2016 NRC engaged NIWA to undertake:

1. Lake Ecological Assessments for:
2. *Aupouri:* Lake Ngatu, Lake Yelavich, Lake Morehurehu and Lake Morehurehu Sth 2.
3. *Pouto:* Lake Parawanui, Lake Mokeno. Lakes Humuhumu and Phoebe were to have been included but access these lakes was not possible as the raupo had grown over the boat launching site at Humuhumu and locked gates prevented access to Phoebe.
4. Annual weed surveillance to detect any new incursions of aquatic pests in six priority lakes (Lake Taharoa, Lake Ngatu, Lake Kai Iwi, Lake Waikare; and Lake Waiporohita).
5. Assessment of progress towards eradication of target pest plant species in Lake Heather using grass carp.
6. Assessment of the endothall treatment to eradicate a lagarosiphon invasion in Lake Ngakapua.
7. Reconnaissance visits to Te Paki Stream 1 (nearest carpark) and Te Paki Stream 2 (nearest sea), Lake Te Kahika East and South (Aupouri), Lake Morehurehu Sth 1, Lake Taeore, Lake Waiparera (including one profile dive), and three ponds situated to the east of Lake Kanono.

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

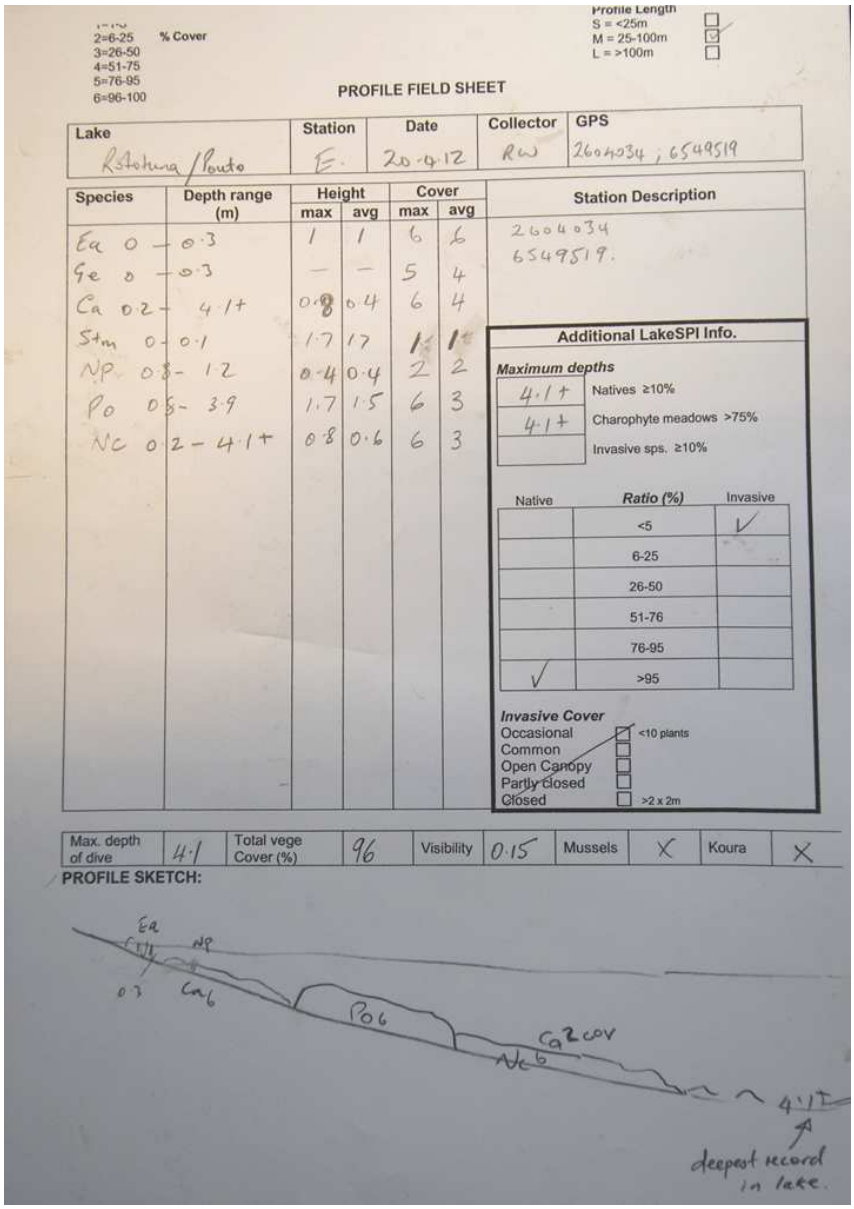
The extent of emergent vegetation (percentage of shoreline, width of beds and depth range), plant species present around the lake, and wetlands associated with the lake were described.

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 based on Clayton (1983). Divers swam perpendicular to the 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 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 (< 1ha) or de-vegetated.



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

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

PROFILE FIELD SHEET

Lake	Station	Date	Collector	GPS
Rotoiti / Loute	E	20-9-12	RW	2604034, 6549519

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

Station Description: 2604034 6549519.

Additional LakeSPI Info.

Maximum depths

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

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

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

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

PROFILE SKETCH:

Figure 1: Survey sheet for a submerged vegetation profile.

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 plant 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 torowai or freshwater mussels (*Echyridella menziesii*), kewai or freshwater crayfish (*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

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

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 are 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 seven 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
Wahakari (35)	Survey access point at SE end	Annually
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 control on target pest plants in Lake Heather was assessed using baseline profiles, sonar and one profile dive. Sonar (Lowrance HDS12 depth sounder/GPS/chart plotter) was used to cover much of the lake to search for any weed growth. The lake margin was inspected to assess impacts of grass carp on the emergent communities and the presence of weed fragments.

2.4 Endothall assessment

The known areas of lagarosiphon in Lake Ngakapua were checked by snorkel to assess the effectiveness of the 2015 endothall treatment on this species.

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).

Practical measures that could mitigate or avert threats to Northland lakes are identified where appropriate. We recommend that:

- Lakes where pests threaten lake ecology are identified alongside possible mitigation measures.
- Lakes where indicators suggest nutrient enrichment or catchment activities have (or threatens to have) significant impacts on lake ecology are identified and mitigation strategies put in place.

3 Results and Discussion

3.1 Ecological assessments

3.1.1 Lake Morehurehu (Aupouri), NRC Lake No. 32.

Plate 1: Lake Morehurehu catchment has recently undergone significant change following the first harvest of mature plantation pine (top left 2009), with subsequent re-planting (top right 2013) and growth of young trees (below in 2016).

Summary

Survey dates 2006, 2009, 2013, 2014 and 2016.

Overall rating

High: 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, good water quality.

Threats

Pine harvesting impacts since 2009 appear to have exceeded all expectations with extensive loss of aquatic habitat and biodiversity.

Introduction of invasive species could still threaten to further degrade this lake.

Management recommendations

Investigate the impacts of pine harvesting on Lakes Te Kahika, Te Kahika South, Morehurehu and Morehurehu South 1 and 2. Review recent changes in the catchment and document impacts in all receiving waters. Three to five year lake monitoring to evaluate rate of recovery. Provide advice to forestry companies or other land-users in these poorly buffered water bodies to modify activities that caused such extensive environmental damage.

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 zone of manuka / hakea scrub between the lake and pines. Within the last five years the mature trees were harvested and a second crop planted.

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 and overgrown, making trailered boat access very difficult.

Wetland vegetation

Eleocharis sphacelata was present all around the lake with a diversity of other emergent species well represented, including *E. 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 *M. rubiginosa* and *Isachne globosa*.

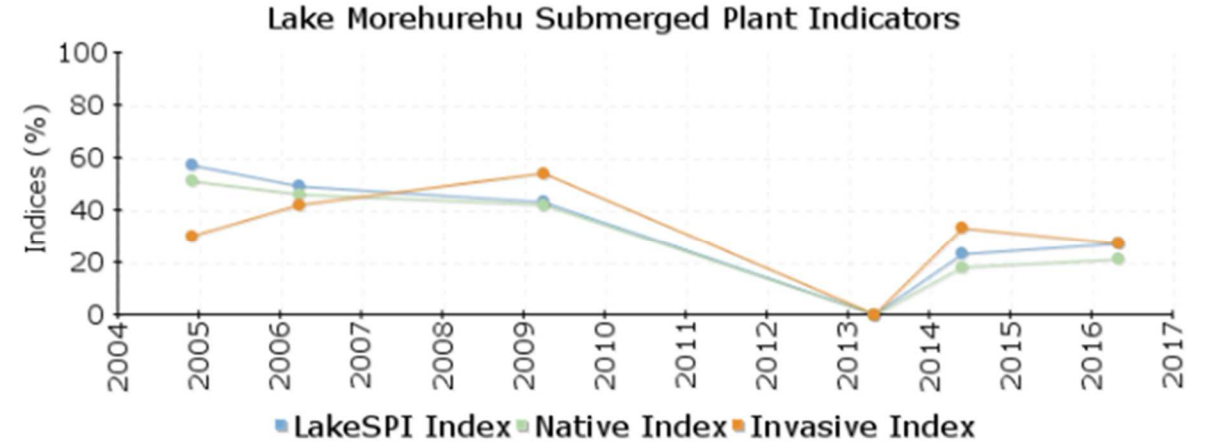
Wetlands contained all of the emergent species (above), but also flax (*Phormium tenax*), swamp coprosma (*Coprosma tenuicaulis*), manuka (*Leptospermum scoparium*), swamp kiokio (*Blechnum novaezelandiae*). Areas of bog vegetation had the regionally significant wire rush (*Empodisma robustum*) and umbrella 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 with tall-growing native species also present. *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.

The macrophytes were however lost prior to 2013 at which time there was almost no submerged vegetation present with only three submerged species recorded and none exceeding 5% maximum cover. This was associated with the water becoming highly coloured red/brown. In 2014 and 2016, the macrophytes had recovered slightly, growing at low covers to 2 – 3 m water depth and native species diversity was restored. The main impact still showing in the LakeSPI assessment is the marked reduction in macrophyte depth limits.

LakeSPI



Survey Date	Status	LakeSPI %	Native Condition %	Invasive Impact %
April 2016	Moderate	27%	21%	27%
May 2014	Moderate	23%	18%	33%
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%

Figure 1: LakeSPI for Lake Morehurehu. Six LakeSPI surveys are recorded. 2013 scored 0% due to very low abundance of submerged vegetation, followed by minor recovery in 2014 and 2016.

A decrease in LakeSPI score from 57% in 2004 to 27% in 2016 was a result of a decrease in submerged vegetation relating to a decline in water quality that occurred around 2013. This also resulted in a decrease of both the Native Condition Index and the Invasive Impact Index (invasive impact from *U. gibba*).

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 in previous visits. 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 or 2016, 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 are abundant.

Endangered species

The Nationally Critical species *Utricularia australis* has not been seen since 2009 and is apparently now extinct in this lake. Several plants of nationally threatened status were present with *Drosera pygmaea* noted in a lakeshore turf and *Todea barbara* on lake shore banks. The 'At Risk – Declining' inanga (*Galaxias maculatus*) is common in this lake.

Lake Ecological Value

In 2009 the Lake Ecological Value rating of Outstanding was calculated. A deterioration in the rating of the following parameters: water quality (water transparency and total nitrogen values from 2009 indicated Eutrophic condition whereas chlorophyll *a* and total phosphorus indicated Mesotrophic condition. The loss of aquatic vegetation integrity resulted in a revised score of 12 (High) in 2013 and 2016.

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 since 2013 (Plate.2). The impact of the invasive *U. gibba* increased from 2005 to 2009, but like other plants had decreased markedly in 2013 and has recovered since. The nationally endangered *U. australis* has not been seen since 2006.

Plate-2: Lake Morehurehu. This picture illustrates the stained colour of the water.

Threats

The marked change in water clarity and total nitrogen concentration was significant and its causes not clearly understood. This is of concern with regard to restoration and preventing this impact re-occurring in the future. Light is a major determinant of submerged vegetation. Such a marked change in water clarity could account for the loss of submerged vegetation. The recent harvesting of the pine plantation likely caused the change in water quality as similar changes were noted in other water bodies in the area (Lakes Te Kahika and Morehurehu South). 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.).

One hypothesis is the growth of pines has accumulated a layer of pine needles, resin acids and polar humics in the upper soil layer. However water testing did not identify resin acids as the problem (NRC unpublished information).

Another hypothesis is that pine tree transpiration had been keeping water levels lower in the soil profile for decades. Felling of the trees stopped water loss from transpiration and water logging of pine debris is likely to have occurred following heavy rainfall events occurring post-harvest. Removal of the pine canopy allows rain direct access to a broken soil layer. Quartz sands in the catchment have no ionic binding (M. Gibbs, NIWA, pers. comm.), which may have led to leaching of tannic substances through the sands.

The main risks for the introduction of invasive species come from the 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 an access road to facilitate logging has opened up this area to the public, so risk of pest introductions are heightened.

The lake is probably N limited (Gibbs et al. 2014) and thus sensitive to urea fertiliser addition in forestry or harvesting activities.

Management recommendations

Lake monitoring every three to five years will enable impacts to be documented and potential recovery rates tracked. A study of the possible causes of this major ecological impact should be undertaken and if related to human activity then it may be possible to mitigate ongoing impacts and avoid a re-occurrence in the future.

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

Plate 1: Morehurehu South, a coastal dune lake set in sand dunes, scrub and recently harvested plantation pine forest, 2016

Summary

Survey dates 2004, 2006, 2013, 2014 and 2016.

Overall rating

Moderate: with no submerged vegetation and heavily stained water recorded in 2016.

Threats

Pine plantation forestry in a catchment with poor filtering / buffering in the silica sand means this lake is very susceptible to the effects of forestry activities.

Management recommendations

This lake has lost all of its submerged vegetation for the second time in recent years. Kuta is still common on the margins. It requires monitoring to see if the previous species diversity returns.

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 harvested 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 but 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). *U. gibba* was present at high covers to 2.5 m covering indigenous vegetation on the relatively steep sides of the lake. *Utricularia australis* was found in small amounts amongst emergent vegetation.

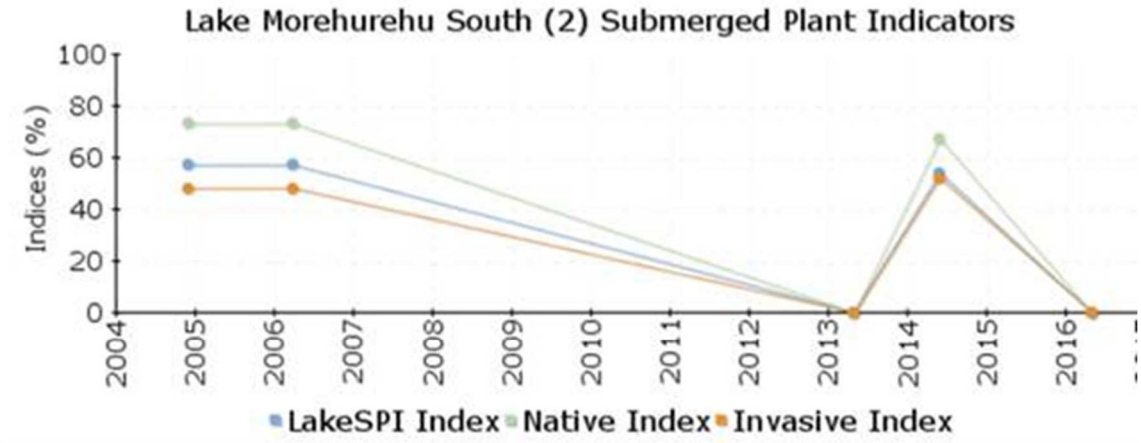
No significant submerged vegetation was found in 2013, but improved water clarity and corresponding increase in submerged macrophytes were noted in July 2013 (L. Forester pers. com.). *U. gibba* was present at high covers to 2.5 m with *P. cheesemanii* plants extending to 3 m deep.

In 2014, the lake was vegetated to 3.6 m (deepest point) comprised of *Nitella leonhardii*, *P. cheesemanii* and *U. gibba*. No other submerged species were recorded.

In 2016 water clarity was very low and no submerged species were recorded.

Plate 2: Morehurehu South, showing low clarity due to very dark coloured water, 2016. No submerged plants were recorded.

LakeSPI



Survey Date	Status	LakeSPI %	Native Condition %	Invasive Impact %
April 2016	Non-vegetated	0%	0%	0%
May 2014	High	54%	67%	52%
April 2013	Non-vegetated	0%	0%	0%
March 2006	High	57%	73%	48%
November 2004	High	57%	73%	48%

Figure 1: LakeSPI for Lake Morehurehu South 2. Five LakeSPI surveys are recorded. 2013 and 2016 scored 0% due to very low abundance of submerged vegetation.

A decline in water quality occurred around 2013. Since that time, Lake Morehurehu South 2 has fluctuated between a devegetated condition (as was the case in 2016) and re-establishment of submerged vegetation.

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 also noted 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 migrations 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 6 (Moderate). Water quality was not measured at this lake but water transparency had declined (Plate 2).

Threats

Water quality impacts from catchment activities of foresters.

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 every three to five years will enable impacts to be documented and potential recovery rates tracked.

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

Plate 1: **Lake Ngatu.**

Summary

Survey dates 1984, 2001, 2004, 2006, 2010, 2014 and 2016.

Overall ranking

Outstanding: Good emergent and submerged vegetation with some endangered biota, but indications of significant vegetation decline. Pest plants and fish present. Water quality varies considerably.

Threats

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

Management recommendations

Annual surveillance of *L. major* and for new plant pests. Five yearly lake native biodiversity value monitoring. Eradicate water lily, alligator weed, mile-a-minute and Christmas berry from Lake Ngatu.

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 kuta (*Eleocharis sphacelata*) growing from the lake margin to 2.6 m depth, with other species including *Apodasmia similis, Machaerina articulata, M. arthrophylla, M. juncea* and *Schoenoplectus tabernaemontani* all common. *Eleocharis sphacelata* appears to be declining in parts of the lake.

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 and has been repeatedly treated with the herbicide metsulfuron-methyl (Kevin Matthews, pers. comm.), with 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 weeding and picloram gel was applied to remaining stems. The problem woody wetland weed Christmas berry (*Schinus terebinthifolius*) was found amongst manuka on the eastern edge of the lake and has been removed. It has yet to invade wetland margins in New Zealand as it does in warm temperate Australia and Florida.

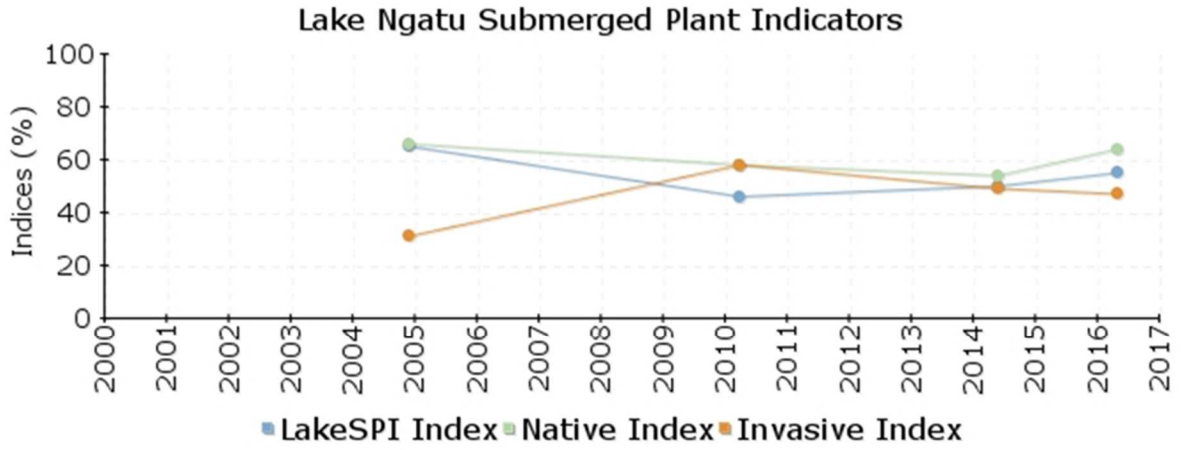
Submerged vegetation

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, Utricularia gibba* and the exotic *Juncus bulbosus*.

Charophytes dominated vegetation from the edge of emergent or turf communities to a maximum depth of 5.1 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 also been declining over the years from nearly 100% cover up to 2006, reducing to average covers of 51 -75 % in 2010 and 2014, but in 2016 is less than 5% with occasional patches only across the main body of the lake. This is a marked change in charophyte abundance.

The alien invasive *Lagarosiphon major* was present at the main launching site at depths between 0.5 and 3.0 m with an average cover less than 25%. The abundance of *L. major* has declined since 2010 possibly due to *U. gibba* forming extensive smothering mats and lower water clarity. Large mats of *U. gibba* associated with periphyton raft-up near the water surface in autumn. *Utricularia australis* was once common within this lake but has not been seen here since 2007.

LakeSPI



Survey Date	Status	LakeSPI %	Native Condition %	Invasive Impact %
April 2016	High	55%	64%	47%
May 2014	Moderate	50%	54%	49%
March 2010	Moderate	46%	58%	58%
November 2004	High	65%	66%	31%

Figure 1: **LakeSPI for Lake Ngatu.** Four LakeSPI surveys are recorded between 2004 and 2016.

Lake Ngatu is categorised as being in high ecological condition with a LakeSPI Index of 55%.

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. LakeSPI does not yet reflect the extent of loss of the charophyte meadows because there are still occasional patches greater than 2 m^2 to depths of 5.1 m. However, these declines are of major ecological significance.

Water birds

Extensive emergent vegetation provides a good habitat for water birds, however human disturbance reduces the desirability for more secretive species. The 2016 survey recorded ten waterfowl species including, scaup (*Aythya novaezeelandiae*) dabchick (*Poliocephalus rufopectus*) and Caspian tern (*Hydroprogne caspia*). Bittern (*Botaurus poiciloptilus*) were seen on previous lake surveys.

Fish

Common bullies (*Gobiomorphus cotidianus*), inanga (*Galaxias maculatus*) and the exotic pest 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 presence was not been confirmed. 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. Perch could have a major impact on other fish

species. Holes in vegetation and 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 and 1 shortfin eels (all large ≥680 mm long) with 56 diving beetles (*Onychohydrus hookeri*) also caught.

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

Lake Ecological Value

Lake Ngatu charophyte species composition has changed over the monitoring programme and since 2010, charophyte abundance has markedly diminished lake wide, indicating that nutrient enrichment stress is likely. Similar declines in kuta have also been recorded. No trends in degrading water quality using TLI have been detected. The lake is classified as mesotrophic and 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 then the TLI has improved. No trend are now evident, but it is clear that water quality fluctuates markedly. Nitrogen levels have been close to all-time highs for more than a year. Despite these changes the ecological value rating of Lake Ngatu remains "Outstanding"'. However, on a broader time scale 1988 to 2016 the appearance of the lake has changed markedly (Plate 2).

Plate 2: Lake Ngatu 1988 left 2016 right, showing deteriorating water clarity and appearance from the surface.

Threats

Lagarosiphon major has been present in the lake since 1988, has spread little and is restricted to a few locations. 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.

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

Five additional weeds have been detected at an early stage of invasion at Lake Ngatu. Of these, yellow flag iris has been eradicated, while mile-a-minute and alligator weed eradication programmes near completion. The Christmas berry incursion requires follow up inspections. Two patches of Water lily (*Nymphaea* sp. – possibly *N. mexicana*) have been discovered in October 2016 at the northern end of the lake (A. Macdonald pers. comm.). Both sites were around 10m^2 in knee deep water. This species was previously thought to have been eradicated in the 1990's where it was found at the southern end of the lake.

The pest fish *Gambusia affinis* may have a deleterious impact on other fish like the nationally significant 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 log removal from the catchment. No clear trends are evident in the TLI or LakeSPI condition indicators. But there has been significant ecological change with marked loss of the previously abundant charophyte and emergent kuta communities and marked fluctuations in water clarity.

Management recommendations

It is recommended that lake native biodiversity value monitoring is undertaken every five years and that pest plant surveillance is undertaken at access points for new incursions of aquatic weeds every year.

Previous recommendations for an eradication programme for lagarosiphon using endothall in Lake Ngatu should be postponed until issues with water quality and the decline of submerged vegetation are resolved.

Continued management of other marginal weeds and water lilies towards eradication is recommended.

3.1.4 Lake Yelavich (Aupouri), NRC Lake No. 105.

Plate 1: **Lake Yelavich, a dune lake within plantation pine forestry.**

Summary

Survey dates 2008, 2010 and 2016.

Overall ranking

High-Moderate: A shallow lake with a large population of the endangered *Myriophyllum robustum*, a large entire marginal fringe of emergent species, and a submerged vegetation dominated with high covers of *Utricularia gibba*.

Threats

Low: Isolated with access through private forestry, but it is visited by duck hunters.

Management recommendations

Monitoring for nutrient status and 5 yearly condition monitoring.

Description

Lake Yelavich (1614575E, 6132392N) is about 3 ha in area. The lake was tannin stained, but not turbid with visibility of around 2.5 m. The lake lies in a scrub and pine plantation catchment. Access was through forestry roads.

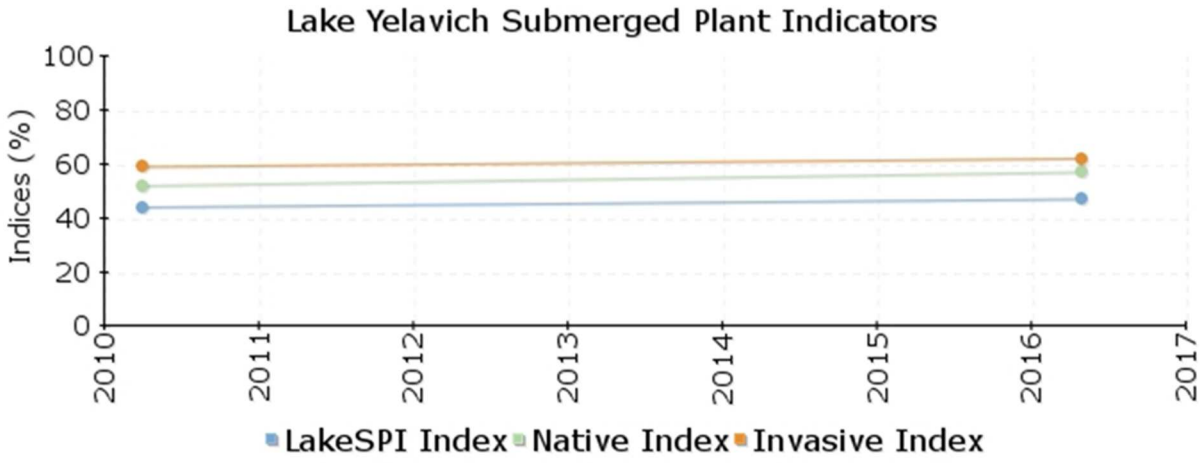
Wetland vegetation

The lake was encircled with emergent vegetation 10 – 20 m wide dominated by *Eleocharis sphacelata* extending to 2.2 m depth. The wetland extends through to Lake Waiparera 1.6 km to the east.

Submerged vegetation

The submerged vegetation was mainly *Chara australis* with some *Potamogeton ochreatus*, *Potamogeton cheesemanii* and *Nitella* sp. aff. *cristata* to 3 – 3.5 m deep, extending beyond the dense emergent fringe. *Utricularia gibba* was dominant however and very thick to 2.5 m deep with covers exceeding 95% on all profiles. *Myriophyllum robustum* was widespread at low covers from 1.4 to 1.7 m deep amongst less dense fringes of *E. sphacelata* growing to 2.2 m.

LakeSPI



Survey Date	Status	LakeSPI %	Native Condition %	Invasive Impact %
April 2016	Moderate	47%	57%	62%
March 2010	Moderate	44%	52%	59%

Figure 1: LakeSPI Index as % of potential score, Native Condition Index, and Invasive Impact Index (graphed above and as bar diagrams from left to right below).

The LakeSPI Index of Lake Yelavich was moderate (47%), with limited (shallow) development of native submerged vegetation that is highly impacted by the invasive species *Utricularia gibba*.

Water birds

The lake has good habitat for birds (large expanses of tall emergent vegetation) although none were recorded during the visit.

Fish

Common bullies (*Gobiomorphus cotidianus*), were seen in 2016 with good visibility of around 3.5 m.

Aquatic invertebrates

None seen.

Endangered species

The At-Risk Declining *Myriophyllum robustum* was widespread at low covers from 1.4 to 1.7 m deep amongst less dense fringes of kuta (*Eleocharis sphacelata*).

Lake Ecological Value

Lake Yelavich has a High-Moderate ecological value rating of 8 and has remained stable since monitoring began in 2008.

Threats

Pines were recently harvested but no marked effects (e.g., high suspended sediments) were recorded. The isolated nature of the lake and large surrounding wetland indicate that there are few threats of nutrient enrichment or invasive species. Duck shooting was evident from empty cartridges around the margins; hopefully pest plants such as alligator weed, willow and oxygen weeds are not introduced misguidedly to 'enhance' the habitat for wildfowl.

Management recommendations

This is a good example of a shallow dystrophic (tannin-stained) lake with intact fringe of emergent vegetation and no livestock access. It is recommended that lake native biodiversity value monitoring is undertaken every five years.

Annual monitoring of water quality should be undertaken to determine the extent of nutrient enrichment.

3.1.5 Lake Mokeno (Pouto), NRC Lake No. 356.

Plate 1: **Lake Mokeno** surrounded by wetland and indigenous scrub vegetation.

Summary

Survey dates

2005, 2007, 2012, 2015 and 2016.

Overall ranking

High: A large lake set in a wetland / scrub / dune complex covering the south-western Pouto Peninsula, which contains nationally significant populations of endangered biota. Formerly with an intact native submerged vegetation, but prolonged poor water clarity has led to vegetation decline. Submerged vegetation appeared to be re-establishing in 2016.

Threats

Nutrient inputs from land use in the catchment has led to an enriched (supertrophic) water quality causing algal blooms and loss of most submerged vegetation. Submerged weed invasion is unlikely due to the lakes isolation and poor water clarity. Royal fern (*Osmunda regalis*) is present in the surrounding vegetation and poses a severe threat to the wetlands surrounding this lake and elsewhere in the region.

Management recommendations

Determine the drivers of poor water quality and consider remedial actions. A nutrient budget is recommended. Algal blooms indicate nutrient threat to ecological condition. Five yearly surveillance for pest plants and lake native biodiversity value monitoring.

Description

Lake Mokeno (1695174E, 5977171N) is a dune lake 148.3 ha in area with a 6.1 m maximum recorded lake depth. The catchment is mostly kanuka scrub adjacent to pine plantation forestry, with large areas of wetland and some unconsolidated dunes on the western margin. There are no inflow or outflow streams but it appears that water flows south from the lake towards Lake Whakaneke, eventually discharging to the entrance to Kaipara Harbour via an extensive wetland. Access to the northern end of the lake is through forestry and Māori land (7 km of well-formed tracks) requiring access through a locked gate. Small boats can be launched with difficulty using a 4-WD.

Wetland vegetation

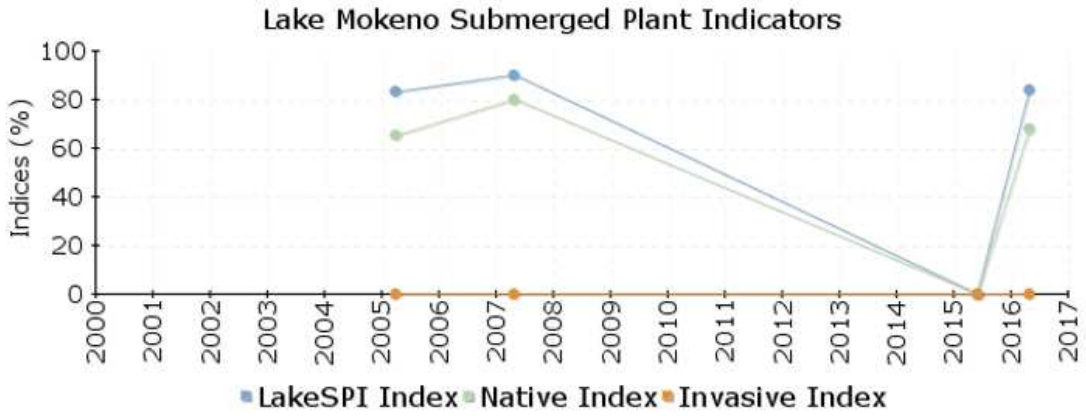
The lake was surrounded by extensive beds (up to 20 m across and extending from the lake edge to 2 m deep) of emergent species including *Typha orientalis, Eleocharis sphacelata, E. acuta, Machaerina articulata, M. arthrophylla, M. rubiginosa, M. juncea, Schoenoplectus tabernaemontani, Carex secta* and *Phormiun tenax*. This vegetation merged into a manuka (*Leptospermum scoparium*) / flax (*P. tenax*) wetland zone around much of the lake. At the south east end of the lake a distinctive *C. secta / M. arthrophylla* / *Thelypteris confluens* wetland was noted. *Thelypteris confluens* was also found on the lakeward edges of flax and *C. secta* tussocks. The invasive royal fern (*Osmunda regalis*) is presently being managed at the northern end of Lake Mokeno by DOC. This species poses a severe threat to the wetlands surrounding this lake and elsewhere in the region.

Submerged vegetation

Lake Mokeno had clear water and was 100% vegetated with a charophyte meadow to 6 m deep as recorded in 2005 and 2007. However in 2012 water clarity was poor with a dense algal boom and the deep charophytes were rotting in situ. In 2015 submerged plants were present but only within a few metres of the edge of the emergent vegetation, to a maximum depth of 2.5 m, and at average covers less than 10%.

In 2016 partial recovery was evident, the vegetated depth range had extended to a maximum depth of 4.2 m at covers between 10 and 20%. *Chara australis* was the most common submerged plant with lesser amounts of *Potamogeton ochreatus, Chara globularis* and *Myriophyllum triphyllum*.

LakeSPI



Survey Date	Status	LakeSPI %	Native Condition %	Invasive Impact %
April 2016	Excellent	84%	68%	0%
May 2015	Non-vegetated	0%	0%	0%
April 2007	Excellent	90%	80%	0%
March 2005	Excellent	83%	65%	0%

Figure 1: **LakeSPI Index as % of potential score for Lake Mokeno** with Native Condition Index, and Invasive Impact Index shown for 2005; 2007, 2015 and 2016. The lake deteriorated from excellent to non-vegetated and has returned to excellent again.

Lake Mokeno was in 'excellent' ecological condition as categorised by LakeSPI during the 2007 survey. Its LakeSPI index of 90% reflected the quality of native submerged vegetation and lack of invasive species. Due to very poor clarity and a dense algal bloom in April 2012 a Lake SPI score could not be generated, but it would have been high with charophyte meadows to beyond 5.3 m deep. However the vegetation was rotting in situ. Plant collapse followed at some point after that survey and a resulted in a LakeSPI Index of zero obtained when next surveyed in 2015. In 2016, LakeSPI status was again excellent. The excellent ranking was obtained because the 10% cover of native vegetation was present at depths beyond 4 m. However, this is only a partial recovery as the vegetation had a 100% cover to 6 m deep in 2005 and 2007.

Water birds

The indigenous scrub, wetland and emergent margins provide excellent water bird habitat reflected in the large number of species reported from this lake and seen during the field visit. Bittern (*Botaurus poiciloptilus*), dabchick (*Poliocephalus rufopectus*), fernbird (*Bowdleria punctata vealeae*), grey duck (*Anas superciliosa*), mallard duck (*Anas platyrhynchos*), shoveler (*Anas rhynchotis*), grey teal (*Anas gracilis*), scaup (*Aythya novaezeelandiae*), black swan (*Cygnus atratus*), red-billed gull (*Larus novaehollandiae scopulinus*), Caspian tern (*Hydroprogne caspia*), kingfisher (*Todiramphus sancta*) and four species of shag (*Phalacrocorax* spp.) were noted in 2015. Other threatened species reported include banded rail (*Rallus philippensis assimilis*), spotless crake (*Porzana tabuensis plumbea*), and formerly the critically endangered brown teal (*Anas aucklandica chlorotis*) were also recorded in this area.

Fish

The lake represents good habitat, with fish access to the sea. Species recorded were common bully (*Gobiomorphus cotidianus*), inanga (*Galaxias maculatus*), smelt (*Retropinna retropinna*) and shortfin eel (*Anguilla australis*). Longfin eel (*Anguilla dieffenbachii*) were also reported in Lake Mokeno by Rowe and Chisnall (1997). A possible sighting of grey mullet (*Mugil cephalus*) was made during the 2012 visit, which, if confirmed, would indicate temporary connection of Lake Mokeno to the sea during high water events.

Aquatic invertebrates

No living freshwater mussels (*Echyridella menziesii*) were found in 2015 and 2016, although dead mussels were found at 3 – 4 m deep. Mussels were previously common and introduced freshwater jellyfish (*Craspedacusta sowerbyi*) were also noted in previous surveys.

Endangered species

The At Risk – Declining lonfin eel (*Anguilla dieffenbachii*) and inanga (*Galaxias maculatus*) were recorded from Lake Mokeno. The At Risk – Naturally Uncommon *Theypteris confluens* was common, growing amongst emergent species at the water's edge and in the wetland to the south of the lake, with Pouto being the national stronghold of this species. Threatened birds noted in 2015 included the Nationally Critically Endangered grey duck, Nationally Endangered Australasian bittern, Nationally Vulnerable dabchick, pied shag, Caspian tern and red-billed gull, the At-Risk: Declining fernbird and pied stilt and Naturally Uncommon little black and black shags.

Lake Ecological Value

The current Lake Ecological Value score for 2016 is 11 (rated High). This score has improved from 2015 (score of 9, High-Moderate rating) where submerged vegetation had collapsed, but is lower than the Outstanding rating assigned in 2007 and before. Higher Lake Ecological Value rating in the future could result should the following improvement occur: submerged vegetation completely recover to form dense carpeting charophyte meadows, freshwater mussels re-establish and water quality improve.

Threats

The catchment is well buffered by an extensive wetland, but water quality and observations of algal blooms indicate nutrient enrichment from land use or climatic factors influence the catchment.

No pest plant or fish impacts are evident and the likelihood of introduction of freshwater pests are low. However, royal fern (*Osmunda regalis*) could invade large areas of the wetland fringe.

Management recommendations

Algal blooms had severely reduced in-water ecological values in this lake, so analysis of water quality monitoring and investigation of ground water nutrient fluctuations is required to determine the nutrient sources and the potential to mitigate these. The partial recovery in 2016 is encouraging and is an opportunity to record the potential recovery of a "flipping lake" and consider the drivers of change.

It is recommended that lake native biodiversity value monitoring and pest plant surveillance is undertaken every five years.

3.1.6 Lake Parawanui (Pouto), NRC Lake No. 297.

Plate 1: Southern end of Lake Parawanui showing the pasture catchment and grazed margin with an exposed turf community (Photo Lisa Forester).

Summary

Survey dates 2001 and 2016.

Overall ranking

High - Moderate: A degraded lake, with poor water quality, but fencing has prevented grazing from most of the lake margins, permitting the re-establishment of an emergent vegetation band around the lake. Submerged vegetation appears to be establishing despite the presence of pest fish.

Threats

Pest fish already established. Nutrient enrichment and algal blooms. Introduction of other pests from coarse or other fishing.

Management recommendations

5-yearly monitoring to track lake recovery after fencing and livestock exclusion.

Description

Lake Parawanui (1676581E, 6008811N) is a steep sided dune lake 6.47 ha in area with a 18.6 m maximum recorded depth. The catchment is pasture with grazing to the margin for much of it. There is one inflow entering the eastern bay at the southern end of the lake draining from approximately 1 km to the east. There is no outlet. Access is through 1 km of private farmland, mostly on well-formed tracks. Small boats can be launched from parts of the shore with a 4-WD.

Wetland vegetation

Emergent vegetation was sparse (5%) with *Schoenoplectus tabernaemontani* the dominant species in this lake in 2001. Since that time fencing has allowed the development of an almost entire dense margin of emergent species including *S. tabernaemontani, Apodasmia similis, Eleocharis sphacelata, Machaerina juncea* and *Juncus pallidus.* Floating rafts of alligator weed (*Alternanthera philoxeroides*) were noted spreading out from the lake edge, showing evidence of heavy browsing by the biocontrol

agent *Agascicles hygrophila* (Plate 2). The turf community lining the southern margin of the lake contained the locally rare *Fimbristylis velata*.

Plate 2: Alligator weed defoliated by alligator weed flea beetle on the margin of Lake Parawanui.

Submerged vegetation

In 2016, the submerged vegetation was predominantly native with *Myriophyllum triphyllum, Potamogeton ochreatus* and *Chara australis* (to 3.5 m deep) the most common. The introduced *P. crispus* was also present.

The only vegetation present in 2001 was the introduced weed *P. crispus*, present at low covers from 0.2 to 2.4 m depth.

LakeSPI

Lake Parawanui Submerged Plant Indicators

Survey Date	Status	LakeSPI %	Native Condition %	Invasive Impact %
April 2016	Moderate	42%	29%	20%

Figure 1: LakeSPI Index as % of potential score for Lake Parawanui

LakeSPI score was zero from previous survey data as plant cover was so low. In 2016 several of the profiles had dense plant growths to 3.5 m. Lake Parawanui is now categorised as being in moderate condition with a LakeSPI Index of 42%.

Water birds

Large numbers of mallard (*Anas platyrhynchos*) and paradise shelduck (*Tadorna variegata*) and 5 shags (mostly *Phalacrocorax carbo*) were recorded in 2016. One pair of dabchick (*Poliocephalus rufopectus*) were also seen.

Fish

The pest fish rudd (*Scardinius erythrophthalmus*), koi carp (*Cyprinus carpio*) and orfe (*Leuciscus idus*) were reported as liberated into Lake Parawanui. NIWA FBIS records include shortfin eel (*Anguilla australis*), common bully (*Gobiomorphus cotidianus*) and rudd caught in this lake.

Aquatic invertebrates

Abundant freshwater mussels (*Echyridella menziesii*) were noted.

Endangered species

Threatened species include abundant At-Risk Declining freshwater mussels and the At-Risk Naturally Uncommon sedge *Fimbristylis velata.*

Lake Ecological Value

Lake Parawanui has a 2016 ecological value rating of 8 (High-Moderate), improving from the previous rating of Moderate to Low in 2001. This improvement reflects the increase in native emergent and submerged vegetation, likely a result of livestock exclusion. The lake is still nutrient enriched with frequent cyanobacterial blooms (Plate 3). In 1988, seven submerged species were present, with beds of *P. ochreatus* and *Nitella* sp. aff. *cristata* extending to 5.5 and 8 m water depth respectively.

Threats

It appears that coarse or pest fish have been stocked in this lake. Possibly a combination of this, cattle access and nutrient run-off from the steep pasture catchment has resulted in nutrient enrichment, algal blooms and a loss of submerged vegetation. Further pest plant or fish introductions are unlikely unless these are introduced by fishing activities.

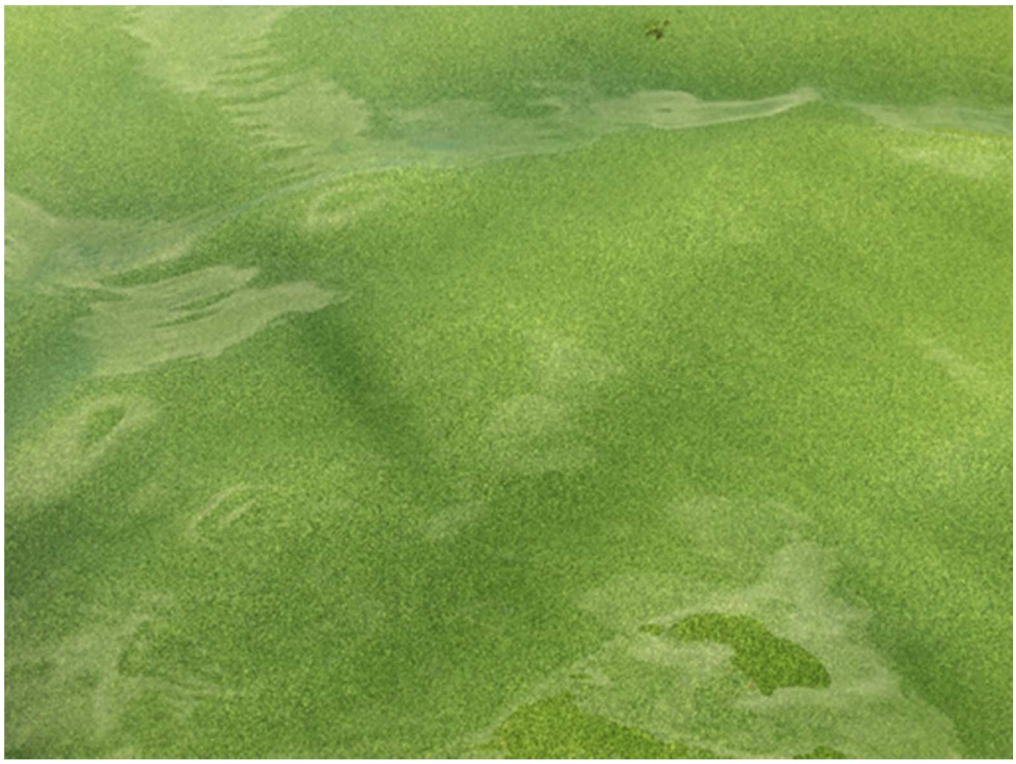


Plate 3: Cyanobacterial bloom in Lake Parawanui, 2016.

Management recommendations

NIWA recommend complete exclusion of livestock access to the lake and continuation of restoration initiatives. Five-yearly monitoring to track lake recovery after fencing and livestock exclusion is recommended.

3.2 Annual surveillance 2016

Annual surveillance was carried out in the priority lakes: Ngatu, Waiporohita, Kai iwi, Taharoa, and Waikare. No surveillance was carried out in Lake Humuhumu as emergent raupo had obstructed the entry point to this lake.

3.2.1 Lake Ngatu

The shallow bay at the main access point for Lake Ngatu, off West Coast Road (1618138E 6120886N), is intensively checked annually for new weed incursions deploying 3 SCUBA divers. No new weed incursions were found.

3.2.2 Lake Waiporohita

The eastern shore of the lake was checked for submerged weed, shoreline drift fragments and marginal weeds. Water clarity was poor (c. 1 m) and submerged vegetation was checked by snorkel divers. No new weeds were found. Primrose willow (*Ludwigia peploides*) was again located in 2016, occupying a small area (< 10 m^2). Eradication of this species should be attempted.

3.2.3 Lake Kai-iwi

The boat access point useable by 4-wheel drive in 2005 (1659447E 6036624N) 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. No new invasive species were noted. As boat access to this lake is limited by a locked gate, surveillance for weed incursion is regarded as less of a priority than the other lakes.

3.2.4 Lake Taharoa

At the south side beach launching site for boats 1658297E 6036686N), 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 (1659746E 6037089N), used for boat launching and mooring, was searched. About 500 m of the shore was checked and there 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 (1657711E 6037534N) a section of shoreline about 250 m long was checked by scuba divers using underwater scooters.

No new invasive species were found.

3.2.5 Lake Waikare

The shoreline 200 m either side of the concrete boat ramp (1656624E 6038306N) was searched by four passes using SCUBA. The water was very clear with about 6 m visibility. No new invasive weed species were found.

3.3 Lake Heather: Weed eradication using grass carp

The abundance of aquatic vegetation lake-wide was assessed for Lake Heather (using sonar, scuba observations and shoreline searches) to describe the level of progress grass carp have made towards eradicating the target pest plant species hornwort (*Ceratophyllum demersum*) and egeria (*Egeria densa*).

The two baseline profiles recorded prior to grass carp release in 2010 have been repeated annually (Figure 1 below).

Figure 1: Lake Heathershowing the location of the 2 profiles monitored, with one in each basin.

No plants of either pest species were detected in October 2014 or 2016. A final assessment should be undertaken in 2017 and then should no hornwort or egeria be detected, removal of grass carp can be contemplated.

3.4 Lake Ngakapua: Lagarosiphon eradication using endothall treatment

Endothall was first used in Northland to eradicate lagarosiphon in Lake Phoebe in April 2012. It has apparently been successful with no signs of the infestation or damage to other aquatic life.

In Lake Ngakapua, lagarosiphon was first found in April 2014 at an early stage of invasion. In April 2015, 270 L of Aquathol K and 10 kg of Aquathol Super K pellets were applied targeting c. 10 – 15% of the lake area. A number (how many) of plants were marked (how) prior to treatment for follow-up monitoring.

In May 2015, the results of the endothall treatment were evaluated one month after treatment. All lagarosiphon was reduced to prostrate stems. Some of the lagarosiphon was collected and grown on at NIWA to determine its viability. It all died indicating the lagarosiphon had received a lethal dose of endothall.

Four snorkelers surveyed the southern and eastern basins of Lake Ngakapua in 2016, searching amongst all vegetation along the lakeward edge of emergent vegetation (including any open areas within the emergent fringe) and adjacent submerged vegetation. No lagarosiphon plants were located.

Annual surveys are recommended until no lagarosiphon has been detected for three consecutive years.

3.5 Reconnaissance visits and updates to ecological assessments

3.5.1 Lake Morehurehu South 1 (Aupouri), NRC Lake No. (33).

Plate 1: Morehurehu South 1, a coastal dune lake set in wetland margin of Lake Morehurehu mobile sand dunes, scrub and pine plantation forestry (photo 2010).

Summary

Survey dates 2010, 2016.

Overall ranking

Moderate-low: A small remote lake, with no submerged vegetation.

Threats

Limited, due to the lakes isolation.

Management recommendations

No monitoring.

Description

The lake (2511075E, 6728439N) is small (0.71 ha), shallow 2.3 m deep, with a wetland and narrow shallow water connection to Lake Morehurehu. The catchment is plantation forestry, lake and wetland. Access is along a very rough forest track, with no boat access except via Lake Morehurehu.

Wetland vegetation

Emergent species encircled the lake in a band 30 to 70 m wide and was dominated by *Eleocharis sphacelata* (growing to a depth of 2 m) but also included *Machaerina juncea*, *M. arthrophylla* and *Typha orientalis*.

Submerged vegetation

No submerged vegetation was present in 2016. In 2010, there were a few plants of *Nitella leonhardii* and *Potamogeton cheesemanii* in the shallows; otherwise *U. gibba* formed dense mats across the lake.

LakeSPI

Lake Morehurehu South 1 is categorised as being in a non-vegetated condition with a LakeSPI Index of 0%.

Water birds

Fernbirds (*Bowdleria punctata vealeae*) were heard in 2010.

Fish

No fish were seen in 2016, but visibility was low. Common bullies (*Gobiomorphus cotidianus*) were seen in 2010.

Aquatic invertebrates

None reported in 2016. *Sigara* and three species of Odonata (1 damselfly and 2 dragonflies) were seen in 2010.

Endangered species

Apart from the At-Risk Declining fernbird, no endangered species were recorded.

Lake Ecological Value

In 2010, the Lake Ecological Value rating was 4 (Moderate to Low). Water quality was not measured at this lake but water transparency had declined in 2016.

In 2016, there was no submerged vegetation recorded (from 2511075E, 6728464N to 2511115E, 6728414N). The water clarity was about 0.5 m and the water coloured brown / red.

Threats

Water quality impacts from catchment activities of foresters.

Access for vectors of pest species is difficult, but introduced pest species could impact on this lake.

Management recommendations

No monitoring recommended at this lake as it is of low ecological value, very remote and additional impacts are unlikely.

3.5.2 Lake Taeore (Aupouri), NRC Lake No. 38

Plate 1: **Lake Taeore, 2016.**

Summary

Survey dates 2010, 2016.

Overall ranking

Moderate: Ephemeral lake, dried up in 2010, filled in 2016.

Threats

Further decline in water table would reduce the habitat value.

Management recommendations

No monitoring.

Description

Lake Taeore (2512332E, 6725132N) is a shallow basin of 14.7 ha area. The catchment is in farmland with a wetland margin. There are no inlets or outlets. Access is through private farmland by permission only.

Wetland vegetation

The lake basin was surrounded by *Typha orientalis, Bolboschoenus fluviatilis, Machaerina articulata* and *Schoenoplectus tabernaemontani*. Other indigenous wetland species seen included *Cotula coronopifolia, Persicaria decipiens, Eleocharis acuta, Cyperus ustulatus, Isolepis prolifera, Elatine gratioloides* and *Myriophyllum propinquum*. The annual herbs *Fimbristylis velata* (northern most record in NZ), *Alternanthera nahui* and *Centipeda aotearoana* were common on the lake margins.

Submerged vegetation

In 2016, the lake basin was covered in a maximum of 0.4 m of water. The water was turbid and brown stained with no submerged vegetation seen.

LakeSPI

No LakeSPI score could be generated.

Water birds

A large number of Canada geese (*Branta canadensis*) and mallard duck (*Anas platyrhynchos*) were noted on Lake Taeore in 2016. Indigenous birds included grey duck (*Anas superciliosa*), shoveler (*Anas rhynchotis*) and dabchick (*Poliocephalus rufopectus*).

Fish

Desiccated eels were seen in 2010.

Aquatic invertebrates

Desiccated mussels were seen in 2010.

Endangered species

A pair of the Nationally Critically Endangered grey duck (*Anas superciliosa*) and Nationally Vulnerable dabchick (*Poliocephalus rufopectus*) were seen in 2016. The northernmost population of the At-Risk Naturally Uncommon sedge *Fimbristylis velata* was also recorded.

Lake Ecological Value

The 2016 Lake Ecological Value rating is 7 (Moderate). There was no submerged vegetation recorded with poor water quality. However, good emergent vegetation was present.

Threats

A lowering water table is the main threat to this lake and many other Northland lakes and wetlands.

Management recommendations

No monitoring.

3.5.3 Te Paki Stream Pond No. 1 (Aupouri), NRC Lake No. 14A

Plate 1: Te Paki Stream Pond No. 1, 2016.

Summary

Survey dates 2016.

Overall ranking

High -Moderate: Small pond, in a native catchment, surrounded by wetland and emergent fringe, native submerged vegetation.

Threats

Introduction of pest species.

Management recommendations

No monitoring.

Description

Te Paki Stream Pond No. 1 (1579380E, 6179545N) is a small 0.75 ha waterbody situated amongst a 1.5 ha wetland in a tributary of the Kauaeparaoa (Te Paki) Stream. The catchment is in scrub. Access is from the Te Paki Road, off the stream.

Wetland vegetation

The pond was surrounded by *Typha orientalis, Eleocharis sphacelata, Machaerina articulata, M. juncea, M. rubiginosa, Apodasmia sessilis* and *Schoenoplectus tabernaemontani*. Other indigenous wetland species seen included *Persicaria decipiens, Eleocharis acuta, Cyperus ustulatus, Isolepis prolifera, Carex secta, C. maorica* and *Myriophyllum propinquum*.

Submerged vegetation

Submerged vegetation was dominated by low covers of *Nitella* sp. aff. *cristata* growing to 3.5 m, with lesser amounts of *Potamogeton cheesemanii* and *Myriophyllym propinquum* and the invasive *Utricularia gibba*. Underwater visibility was c. 1.5 m.

LakeSPI

No LakeSPI score was generated.

Water birds

Pied stilt (*Himantopus himantopus*) were noted wading in shallow water.

Fish

Shortfin eels (*Anguilla australis*), inanga (*Galaxias maculatus*) and common bullies (*Gobiomorphus cotidianus*) were commonly observed.

Aquatic invertebrates

No invertebrates were noted.

Endangered species

The At-Risk Declining pied stilt (*Himantopus himantopus*) and inanga (*Galaxias maculatus*) were noted.

Lake Ecological Value

A 2016 Lake Ecological Value rating of 8 (High - Moderate) was scored due to the entire fringe of emergent and wetland species within a natural scrub catchment. Submerged vegetation was limited.

Threats

The pond is adjacent to the popular Te Paki Stream Road link to Ninety Mile Beach and potentially pest species could be introduced.

Management recommendations

No monitoring.

3.5.4 Te Paki Stream Pond No. 2 (Aupouri), NRC Lake No. 14B

Plate 1: Te Paki Stream Pond No. 2, 2016.

Summary

Survey dates 2016.

Overall ranking

Moderate-Low: Small pond, in a native catchment, surrounded by a narrow wetland and emergent fringe, no submerged vegetation.

Threats

Introduction of pest species.

Management recommendations

No monitoring.

Description

Te Paki Stream Pond No. 1 (1579265E, 6179190N) is a small 0. 5 ha waterbody with a narrow emergent fringe in a tributary of the Kauaeparaoa (Te Paki) Stream. The catchment is in scrub. Access is from the Te Paki Road, off the stream.

Wetland vegetation

The pond was surrounded by *Typha orientalis, Eleocharis sphacelata, Machaerina articulata, M. juncea, M. rubiginosa, Apodasmia sessilis* and *Schoenoplectus tabernaemontani*. Other indigenous wetland species seen included *Persicaria decipiens, Cyperus ustulatus, Isolepis prolifera, Carex secta* and *C. maorica*.

Submerged vegetation

Submerged vegetation was absent although the invasive *Utricularia gibba* grew amongst emergent species. Underwater visibility was 0.6 m.

LakeSPI

No LakeSPI score was generated.

Water birds

No birds seen.

Fish

No fish seen.

Aquatic invertebrates

No invertebrates were noted.

Endangered species

None seen.

Lake Ecological Value

A 2016 Lake Ecological Value rating of 5 (Moderate - Low) was scored due to the narrow fringe of emergent species and lack of submerged vegetation.

Threats

The pond is adjacent to the popular Te Paki Stream Road link to Ninety Mile Beach and potentially pest species could be introduced.

Management recommendations

No monitoring.

3.5.5 Te Kahika Ponds and outlet stream (Aupouri)

Plate 1: The Nationally Critically Endangered *Utricularia australis* (yellow arrow) in the Te Kahika outlet stream, 2016.

Plate 2: The Nationally Endangered fern *Todea barbara* next to Andrew Townsend (DOC) adjacent to the Te Kahika eastern pond, 2016.

Description

There are several ponded areas on the eastern side of Lake Te Kahika that appear to have been dry before forest harvesting in 2013 (Google Earth photograph series), the largest being a narrow pond, extending for 60 m (1600380E, 6169210N). These ponds did not contain any submerged species but are surrounded by some wetland plants. The outlet stream runs from the eastern edge of Lake Te Kahika (1600260E, 6168700N) discharging into Great Exhibition Bay (1601100E, 6168770N). Lake Taeore (2512332E, 6725132N) is a wetland of 14.7 ha area. The catchment is in harvested pine plantation forestry. Access is through forest tracks.

Wetland vegetation

Wetland species in surrounding vegetation included *Isolepis inundata, Machaerina teretifolia, Dianella haematica, Empodisma robustum, Gleichenia dicarpa* and *Eleocharis sphacelata*. The endangered fern *Todea barbara* was noted amongst *G. dicarpa* dominated vegetation (Plate 2).

Submerged vegetation

There were no submerged species in the ponded areas, but a significant population of *Utricularia australis* was located in ponded areas of the outlet stream, probably the second largest remaining population of this species in Northland.

LakeSPI

No LakeSPI score could be generated.

Water birds

No birds seen.

Fish

No fish seen.

Aquatic invertebrates

No invertebrates were noted.

Endangered species

The population of the Nationally Critically Endangered *Utricularia australis* in ponded areas of the outlet stream is probably the second largest remaining population of this species in Northland. The Nationally Endangered fern (*Todea barbara*) is occasional in suitable habitats in the Te Kahika/Morehurehu area.

Lake Ecological Value

Not assigned, but a nationally significant population of *Utricularia australis* was present.

Threats

Fluctuating water tables and input of nutrients associated with plantation forestry are likely to be the main threats to these wetlands.

Management recommendations

It is recommended that monitoring of *Utricularia australis* in the Te Kahika outlet stream is undertaken every three years.

3.5.6 Lake Te Kahika South (Aupouri), NRC Lake No. 30

Plate 1: Te Kahika South, a coastal dune lake surrounded by a narrow wetland \ scrub margin within pine plantation forestry.

Summary

Survey dates 2010, 2016.

Overall ranking

High-Moderate: A small remote lake, with the endangered *Utricularia australis, Todea barbara* and *Drosera pygmaea.*

Threats

Low risk of introduction and establishment of invasive pests. Low to moderate risk of nutrient enrichment from pine plantation forestry fertilisation with urea. Pine harvesting could impact water quality and nutrient status.

Management recommendations

Lake native biodiversity value monitoring every 5 years.

Description

The lake (2511204E, 6730451N) is small (1.43ha), shallow 3 m+ deep. Peat-stained acidic water (pH 4.7). The catchment is plantation forestry, lake and wetland. Access is through forest track with the lake situated down steep banks. No boat access.

Wetland vegetation

Emergent species encircling the lake were *Baumea arthrophylla*, *B. rubiginosa*, *B. juncea*, *B. teretifolia, Gleichenia dicarpa*, *Empodisma robustum*, *Eleocharis sphacelata* and *Phormium tenax* growing to a depth of 1.8 m. The endangered *Todea barbara* was common in a narrow fringe between wetland and scrub vegetation. *Drosera pygmaea* was abundant on the margins of the vehicle access track, in recently logged pine forest (Plate 2).

Plate 2: ***Drosera pygmaea*** **(Nationally Vulnerable) adjacent to Lake Te Kahika South.**

Submerged vegetation

There was no submerged vegetation present in the dark tea-stained water, but scattered plants of *Utricularia gibba* were noted amongst emergent species and one plant of *U. australis* was noted.

LakeSPI

None generated.

Water birds

No birds seen.

Fish

No fish seen.

Aquatic invertebrates

Dragonfly nymphs and adults and *Sigara arguta* were noted. No mussels or koura seen.

Endangered species

The lake supports a large population of the Nationally Endangered *Todea barbara,* and is one of the few Northland waterbodies still supporting the Nationally Critically Endangered *Utricularia australis* albeit in much reduced numbers from 2010. The Nationally Vulnerable *Drosera pygmaea* is a colonist of open areas created by logging and is unlikely to persist once taller vegetation develops.

Lake Ecological Value

A 2016 Lake Ecological Value rating of 8 (High - Moderate) reflects the entire fringe of emergent and wetland species and presence of nationally threatened plants. Submerged vegetation was absent.

Threats

Access for vectors of pest species is difficult, and low water clarity and acid pH would make this threat unlikely. Forestry fertilising would have impacts on lake nutrients pH and clarity, although wetland and scrub vegetation is likely to buffer much of this impact.

Management recommendations

It is recommended that lake native biodiversity value monitoring is undertaken every five years.

3.5.7 Lake Waiparera (Aupouri), NRC Lake No. 102

Plate 1: **Lake Waiparera.**

Summary

Survey dates 2005, 2010, 2016.

Overall ranking

High: Submerged native vegetation to 3 – 4 m deep with invasive species (weeds and fish) present, but good water bird habitat and threatened plants and fish present.

Threats

An easily accessed lake with discovery of hornwort (*Ceratophyllum demersum*) and elodea (*Elodea canadensis*) for the first time in 2016. The lake is nutrient enriched and submerged vegetation is threatened by further enrichment.

Management recommendations

Lake native biodiversity value monitoring every 5 years.

Description

The lake (1616526E, 6133135N) is the largest of the Aupouri lakes (103 ha) but relatively shallow (6 m). This catchment is approximately 70% pasture (mostly fenced) with the remainder in native scrub or wetland. The lake has several inflows, mostly drains on the south western side, but also a drain on the north-western and north eastern shores. There are no obvious outflows. Access for vehicles and boats is easy with a driveway off SH 1.

Wetland vegetation

Emergent vegetation nearly encircled the lake extending over 10 m wide in many places. Vegetation was dominated by monocultures of: *Typha orientalis, Apodasmia similis, Machaerina articulata, M. arthrophylla, M. juncea, Eleocharis sphacelata* and *Schoenoplectus tabernaemontani*.

The alien invasive alligator weed (*Alternanthera philoxeroides*) formed floating mats on the south western shore and appeared to be well established around the southern part of this lake. One 2 m tall royal fern (*Osmunda regalis*), a major wetland weed, was located at the north western end of the lake amongst manuka in 2010, the first record of this species north of Kaipara District. It was not found at this site in 2016 and is likely to have been eradicated. Several plants of the endangered fern *Cyclosorus interruptus* were found amongst emergent vegetation.

Submerged vegetation

The lake is shallow and gently slopes, so the area vegetated is large with all profiles over 100 m long and some ~200m long. Low cover turf vegetation occurred at shallow (<1 m) shoreline areas, except where dense emergents occurred. Turfs were dominated by *Lilaeopsis novae-zelandiae* with several charophytes including *C. globularis, Nitella hyalina* predominantly restricted to this vegetation. The exotic *Utricularia gibba* was present at low covers in 2005 and 2016.

In 2010, the exotic oxygen weeds *Egeria densa* and *Lagarosiphon major* formed low average covers (<26%) from 1 m to 3 m deep. The native *Potamogeton ochreatus* had a similar depth range but much higher average covers (79 – 95%). *Nitella* sp. aff. *cristata* also formed dense covers 51 - 75% as did *Chara australis*, though the latter was mostly found >2 m deep. The native vegetation cover and depth range was greater than in 2005.

One vegetation profile was swum from the boat ramp in 2016. Plants grew to greater depths than the previous two surveys, with *E. densa* and the *P. ochreatus* extending to a maximum depth of 4.3 m, with dense beds extending to 3.5 m, while *L. major* was dominant down to 2.1 m. A total of 8 native submerged species were recorded.

Fragments of hornwort (*Ceratophyllum demersum*) and elodea (*Elodea canadensis*) were discovered in shallow water during the 2016 survey, the first record of both species from this lake. Neither species was present in the vegetation transect.

LakeSPI

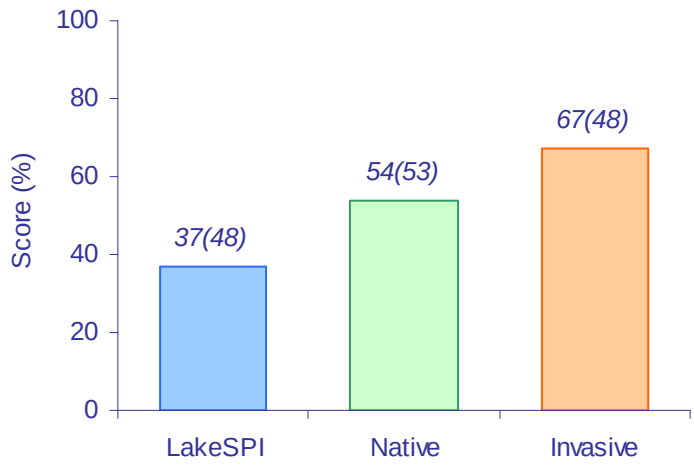


Figure 1: 2010 LakeSPI Index as % of potential score, Native Condition Index, and Invasive Impact Index (from left to right). 2005 score in brackets.

The low LakeSPI score of 37% reflects the increased impact (growing in deeper water) of the invasive alien species *E. densa* and *L. major* in 2010 compared to 2005. No LakeSPI was generated in 2016 as only one profile was swum.

Water birds

The extensive emergent vegetation and fenced areas provided good water bird habitat. The 2016 survey recorded 14 native species, the most numerous including over 100 paradise shelduck (*Tadorna variegata*) and black swan (*Cygnus atratus*), 65 pied stilt (*Himantopus himantopus*), 25 dabchick (*Poliocephalus rufopectus*) and 24 little shag (*Phalacrocorax melanoleucos*). Fernbird (*Bowdleria punctata vealeae*) were heard in the marginal vegetation.

Several of the regionally significant scaup (*Aythya novaezeelandiae*) were present on the lake at the time of the 2010 survey (also in 2016) with other common species such as black swans and paradise shelduck. DOC SSBI records include the nationally threatened bittern (*Botaurus poiciloptilus*).

Fish

NIWA FBIS database reports common bullies (*Gobiomorphus cotidianus*), lake-bound inanga (*Galaxias maculatus*), long and shortfin eels (*Anguilla dieffenbachii* and *A. australis*) and the pest fish *Gambusia affinis* from this lake. DOC fishing on the 2005 field trip sampled many goldfish (*Carassius auratus*), but no rudd (*Scardinius erythrophthalmus*) were caught, despite being seen in 2001. Several goldfish and numerous inanga, common bullies and gambusia were observed in 2016.

Aquatic invertebrates

Freshwater sponges and the native snail *Potamopyrgus antipodarum* were commonly observed in the lake.

Endangered species

Threatened plants included the At-Risk Declining fern *Cyclosorus interruptus* and the At-Risk Naturally Uncommon sedge *Fimbristylis velata*. The nationally endangered turf species *Trithuria*

inconspicua, was last recorded here in 1993. Two At-Risk Declining fish inanga (*Galaxias maculatus*) and longfin eels (*Anguilla dieffenbachii*) are reported from Lake Waiparera. Nationally threatened birds seen in 2016 were one Critically Endangered grey duck (*Anas superciliosa*) and 25 Nationally Vulnerable dabchick (*Poliocephalus rufopectus*).

Lake Ecological Value

The 2016 Lake Ecological Value rating is 12 (High). It has improved from a High to Moderate rating in 2010. Lake Waiparera is a large, relatively shallow lake with a wide band of emergent vegetation around much of its margin. There are a number of At-Risk taxa present, but the submerged vegetation is heavily impacted by invasive species (with additional new incursions recently found) and this lake has poor water quality, relating to its mostly pastoral catchment.

Threats

The lake is already impacted by introduced species with further impacts likely as hornwort was detected in 2016 for the first time. Access to the lake is easy and has resulted in several pest plant incursions in the last 40 years. Egeria seems to be increasing in density and height, possibly as a result of improving water clarity and potentially could lead to submerged vegetation collapse, as occurred in Lake Omapere and several Waikato shallow lakes. *U. gibba* and alligator weed are predicted to have limited impact. Pest fish may impact on the vegetation and native fish within the lake.

Royal fern (*Osmunda regalis*) was located at the north western end of the lake amongst manuka, the first record of this species north of Kaipara District. Department of Conservation is managing this species (G. Williams pers. comm.). This has apparently been a successful eradication, with no plants seen in 2016.

The lake is now fenced and development of riparian and emergent vegetation in formerly grazed lake margins is likely to reduce nutrient inputs, however drains entering the lake provide point sources of nutrients draining from pastoral land.

Management recommendations

The lake may provide a source of pest plants and fish to other water bodies. Signage and possible weed control in the vicinity of the boat ramps are suggested. With the presence of four submerged weeds (hornwort, egeria, lagarosiphon and elodea) and possibility of subsequent vegetation collapse, control options should be discussed and a containment/control/eradication plan developed.

It is recommended that lake native biodiversity value monitoring is undertaken every five years.

3.5.8 Lake Kanono Pond 1 'Egg' (Pouto), NRC Lake No. 377A

Plate 1: Lake Kanono Pond 1 'Egg', showing the unfenced pond margin (image from Google Earth 2012).

Summary

Survey date 2016.

Overall ranking

Low: Shallow pond in pasture, with no emergent or submerged vegetation.

Threats

Highly impacted by livestock access, unlikely to be further impacted.

Management recommendations

No monitoring.

Description

Lake Kanono Pond 1 'Egg' (1703280E, 5975265N) occupies an area of c. 1 ha and was shallow, up to 50 cm deep. The catchment is in pasture and livestock currently have unimpeded access to the waterbody. There are no inlets or outlets. Access is through private farmland by permission only.

Wetland vegetation

The lake was surrounded by bare mud with a turf mostly comprised of common pasture weeds but did include the following native species *Glossostigma elatinoides*, *Myriophyllum propinquum, Cotula coronopifolia, Pseudognaphalium luteo-album, Juncus australis, Alternanthera nahui* and *Centipeda aotearoana*.

Submerged vegetation

No submerged vegetation was seen, but young seedlings of *Potamogeton crispus* were seen stranded on the lake edge.

LakeSPI

No LakeSPI score could be generated.

Water birds

Four paradise shelduck (*Tadorna variegata*) were noted with one adult and three juvenile scaup (*Aythya novaezeelandiae*).

Fish

No fish were seen.

Aquatic invertebrates

No invertebrates were seen.

Endangered species

No endangered species were seen.

Lake Ecological Value

A 2016 Lake Ecological Value rating of Low was scored due to the small size of the waterbody, unimpeded cattle access and consequent lack of emergent and submerged vegetation.

Threats

N/A.

Management recommendations

No monitoring.

3.5.9 Lake Kanono Pond 2 ‘West Spectacle’ (Pouto), NRC Lake No. 377B

Plate 1: Lake Kanono Pond 2 ‘West Spectacle’, 2016.

Summary

Survey date 2016.

Overall ranking

Moderate: Deep pond in pasture, with almost complete fringe of emergent vegetation and well developed submerged vegetation.

Threats

Margins impacted by livestock access, pest introduction is unlikely apart from spread of alligator weed from the East Pond.

Management recommendations

No monitoring.

Description

Lake Kanono Pond 2 ‘West Spectacle’ (1703660E, 5975460N) is c.2 ha water body, up to 4 m deep. The catchment is in farmland. There is an ephemeral inlet from East Spectacle Pond that was dry at the time of inspection. Access is through private farmland by permission only.

Wetland vegetation

The pond was almost completely was surrounded by *Typha orientalis* growing from the pond edge to 1.2 m deep, with lesser amounts of *Eleocharis sphacelata, E. acuta* and *Machaerina articulata*. *Persicaria decipiens* was common on the outer edge of this vegetation, where livestock had prevented tall emergent growth. Turf species such as *Glossostigma elatinoides*, *Myriophyllum propinquum, Centella uniflora, Cotula coronopifolia, Alternanthera nahui* and *Centipeda aotearoana* were found in the areas most impacted by grazing.

Submerged vegetation

Dense charophyte beds extended from the outer edge of the emergent raupo that were dominated by *Chara australis* (to 2 m) and *Nitella* sp. aff. *cristata* to 3 m with scattered plants extending to 3.5 m deep. Amongst this vegetation were scattered *Potamogeton cheesemanii, P. crispus, Myriophyllum propinquum* and *M. triphyllum*. *Utricularia gibba* was abundant amongst emergent species. *Glossostigma elatinoides* was abundant in the one area where emergent plants did not grow.

LakeSPI

No LakeSPI score was generated.

Water birds

No birds were seen.

Fish

No fish were seen.

Aquatic invertebrates

No invertebrates were seen.

Endangered species

No endangered species were seen.

Lake Ecological Value

The 2016 Lake Ecological Value rating is 7 (Moderate). There was well developed submerged and emergent vegetation recorded.

Threats

Cattle access to the pond is likely to increase nutrient status, pest species may be introduced by diggers or fishing activities.

Management recommendations

No monitoring.

3.5.10 Lake Kanono Pond 3 ‘East Spectacle’ (Pouto), NRC Lake No. 377C

Plate 1: **Lake Kanono Pond 3 ‘East Spectacle’ 2016.**

Summary

Survey date 2016.

Overall ranking

Moderate: Deep pond in pasture, with almost complete fenced off fringe of emergent vegetation and well developed submerged vegetation.

Threats

Livestock access, additional pest introduction is unlikely.

Management recommendations

No monitoring.

Description

Lake Kanono Pond 2 'West Spectacle' (1703995E, 5975490N) is c.1 ha water body, up to 4 m deep. The catchment is in farmland and a wetland fringe has developed where access is fenced off to livestock. There is an ephemeral outlet to West Spectacle Pond that was dry at the time of inspection. Access is through private farmland by permission only.

Wetland vegetation

The pond was almost completely was surrounded by *Typha orientalis* growing from the pond edge to 1.2 m deep, with lesser amounts of *Eleocharis sphacelata, E. acuta, Machaerina articulata* and *Schoenoplectus tabernaemontani*. *Persicaria decipiens, Myriophyllum propinquum, Hydrocotyle pterocarpa, H. novae-zeelandiae, Centella uniflora, Isachne globosa and Isolepis inundata* were common in the fenced off wetland.

Submerged vegetation

Dense charophyte beds extended from the outer edge of the emergent raupo and were dominated by *Nitella* sp. aff. *Cristata,* which grew to 3 m with scattered *Potamogeton crispus* and *Myriophyllum propinquum*. *Utricularia gibba* was abundant amongst emergent species.

LakeSPI

No LakeSPI score was generated.

Water birds

No birds were seen.

Fish

No fish were seen.

Aquatic invertebrates

No invertebrates were seen.

Endangered species

No endangered species were seen.

Lake Ecological Value

The 2016 Lake Ecological Value rating is 7 (Moderate). There was well developed submerged and emergent vegetation recorded.

Threats

Cattle access to the pond is likely to increase nutrient status, alligator weed was well established and other pest species may be introduced by diggers or fishing activities.

Management recommendations

No monitoring.

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5 References

Burns, N., Bryers, G., Bowman, E. (2000) Protocol for Monitoring Trophic Levels of New Zealand Lakes and Reservoirs. *Lakes Consulting Client Report*, 99/2: 122.

Champion, P.D., de Winton, M.D. (2012) Northland Lakes Strategy. *NIWA Client Report* HAM2012-121. Project ELF12213: 42.

Clayton, J.S. (1983) Sampling aquatic macrophyte communities. In: Biggs, B.J., Gifford, J.S., Smith, D.G. (eds.) Biological methods for water quality surveys. *Water and Soil Miscellaneous Publication,* 54, Wellington, Ministry of Works and Development.

Clayton, J.S., Edwards, T. (2006a) LakeSPI: A method for monitoring ecological condition in New Zealand Lakes. *User Manual,* Version 2: 57. http://www.niwa.co.nz/__data/assets/pdf_file/0009/38655/lakespi_manual.pdf

Clayton, J., Edwards, T. (2006b) Aquatic Plants as Environmental Indicators of Ecological Condition in New Zealand Lakes. *Hydrobiologia,* 570: 147-151.

de Lange, P.J., Rolfe, J.R., Champion, P.D., Courtney, S.P., Heenan, P.B., Barkla, J.W., Cameron, E.K., Norton, D.A., Hitchmough, R.A. (2013) Conservation status of New Zealand vascular plants, 2012. *New Zealand Threat Classification Series* 3. Department of Conservation, Wellington: 70.

de Winton M.D., Clayton, J.S., Edwards, T. (2012) Incorporating invasive weeds into a plant indicator method (LakeSPI) to assess lake ecological condition. *Hydrobiologia,* (DOI) 10.1007/s10750-012-1009-0.

Forester, L., Townsend, A. (2004) *Threatened plants of Northland Conservancy.* Department of Conservation, Wellington: 80.

Gibbs, M., Albert, A., Croker, G. (2014) Nutrient limitation in Northland lakes. *NIWA Client Report* HAM2014-098: 19.

Goodman, J.M., Dunn, N.R., Ravenscroft, P.J., Allibone, R.M., Boubee, J.A.T., David, B.O., Griffiths, M., Ling, N., Hitchmough, R.A., Rolfe, J.R. (2014) Conservation status of New Zealand freshwater fish, 2013. *New Zealand Threat Classification Series* 7: 12.

Grainger, N., Collier, K., Hitchmough, R., Smith, B., Sutherland, D. (2014) Conservation status of New Zealand freshwater invertebrates, 2013. *New Zealand Threat Classification Series,* 8: 28.

Robertson, H., Dowding, J., Elliott, G., Hitchmough, R., Miskelly, C., O'Donnell, C., Powlesland, R, Sagar, P., Scofield, P., Taylor, G. (2013) Conservation status of New Zealand birds, 2012. *New Zealand Threat Classification Series,* 4: 22.