Northland Lakes Ecological Status 2013

Prepared for Northland Regional Council

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Te Paki Dune Lake

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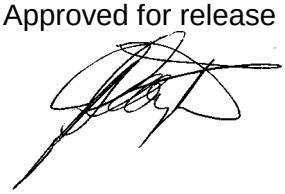

John Clayton

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Executive summary

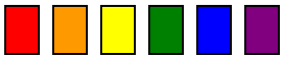
Northland Regional Council (NRC) engaged NIWA to assist achievement of its goal “to prevent deterioration in water quality and loss of biodiversity value in Northland lakes”.

This report presents a summary of information on native biodiversity values gathered on 87 Northland lakes and wetland margins. An inventory of Northland lakes was assembled with information including vegetation descriptions (submerged and wetland), a LakeSPI assessment of lake ecological condition, records of water birds, fish and macroinvertebrates. Ecological and lake condition changes were identified by comparison with previous surveys and major threats to the current lake conditions are identified and management recommendations are presented for each lake. This information is key for the NRC Lakes Strategy as it is essential for managers to know what they are managing and monitor responses to management initiatives.

The core information in this report is a ‘living’ document added to annually since 2005 to incorporate changes in lake values as they change. The annual updates are also reported in separate reports which include weed surveillance results as well.

The native biodiversity value ranking and summary of monitoring recommendations is tabulated below.

Table 1-1: Northland lakes ranked for biodiversity valueand summary of monitoring recommendations. Lakes are listed alphabetically within four geographic areas, with a Northland Regional Council lake number and rankings colour-coded (by colours of the rainbow) as outstanding (red), high (orange), moderate-high (yellow), moderate (green), moderate-low (blue), low (violet).



Name	NRC Lake Number	Rank	Lake Biodiversity Monitoring	Pest Plant Surveillance
Aupouri				
Austria	22	Moderate		
Bulrush	49	Low		
Carrot or Ngakapua West	118	Moderate		I yr
Forest Lake or Deans Swamp	14	Low		
Half Mile Lagoon	62	Low		
Heather	125	Moderate-low	5 yrs	1 yr
Katavich	103	Low		
Kihona	31	Low		
Little Gem	123	Moderate-high	5 yrs	
Mini (Split)	130	Low		
Morehurehu	32	High	Annual till recovered	
Morehurehu South 1	33	Moderate-low		
Morehurehu South 2	36	Moderate	Annual till recovered	
Ngakapua	115 & 117	Moderate-high	5 yrs	1 yr
Ngakaketa	14	Low		

Name	NRC Lake Number	Rank	Lake Biodiversity Monitoring	Pest Plant Surveillance
Ngakaketa North (Te Paki)	13	Moderate-high	5 yrs	
Ngatu	120	Outstanding	5 yrs	1 yr
Ngatuwhete	23	Low		
Pretty	24	Moderate		
Rotokawau	116	High	5 yrs	
Rotoroa	126	High	5 yrs	
Salt	48	Low		
Taeore	38	Low		
Te Arai Ephemeral Wetland & Pond	46	Moderate		
Te Arai Lake	47	Low		
Te Kahika	29	Moderate-High	5 yrs	
Te Kahika South	30	High	5 yrs	
Te Paki Dune Lake	15	High	5 yrs	
Te Paki Dune Lake south	16	Low		
Te Werahi Lagoon	6	Moderate		
Wahakari	35	Outstanding	5 yrs	
Waihopo	78	Outstanding	5 yrs	
Waimimiha North	136	Low		
Waimimiha South	137	Low		
Waipara/Dead	25	High		
Waiparera	102	Moderate-high	5 yrs	
Waitahora lagoon	2	Outstanding	10 yrs	
Waitahora lakes	3 & 4	Outstanding	10 yrs	
West Coast Rd	121	Low	5 yrs	
Yelavich	105	High	5 yrs	

Name	NRC Lake Number	Rank	Lake Biodiversity Monitoring	Pest Plant Surveillance
Karikari Peninsula, central and east				
Horahora Dune	199A	Low		
Jacks	180	Low		
Kaiwai	193	High	5 yrs	
Roadside pond, Matai		Low		
Manuwai	146	Low		
Omapere	173	High	5 yrs	
Ora	205	Low		
Owhareiti	177	Low		
Rotokawau East	96	Moderate		
Rotokawau West	95	Moderate		
Rotopokaka	104	Moderate		
Sand's Lake	309A	Moderate		
Smith's Dam	199B	Low		
Stanner's Rd Dam	148A	Low		
Tapui Rd Quarry Lake	199C	Low		
Tauanui	198	High	5 yrs	1 yr
Waingaro	167	Low		
Waiporohita	99	Outstanding	5 yrs	1 yr
Waro	410	Moderate		
Whau Dam	206	Low		
Kai Iwi lakes & north Dargaville				
Freidrich's	282	Low		
Kai-Iwi	236	Outstanding	5 yrs	1 yr
McEvoy	277	Low		
Midgeley	257	Low	5 to 10 yrs	

Name	NRC Lake Number	Rank	Lake Biodiversity Monitoring	Pest Plant Surveillance
Shag	221	Moderate		
Taharoa	229	Outstanding	5 yrs	1 yr
Te Riu	201	High	5 yrs	
Waikere	227	Outstanding	5 yrs	1 yr
Waingata	200A	High	10 yrs	
Pouto Peninsula				
Grevilles Lagoon	295	Moderate		
Humuhumu	350	Outstanding	5 yrs	1 yr
Kahuparere	384	High	5 yrs	
Kanono	377	Outstanding	5 yrs	3-5 yrs
Kapoai	296	Moderate-low	5 yrs	
Karaka	347	High	10 yrs	5-10 yrs
Mokeno	356	Outstanding	5 yrs	5 yrs
Parawanui	297	Low		
Phoebe's	346	Low		
Rotokawau	364	High	5 yrs	
Roto-otuauru (Swan)	355	Moderate		1 yr
Rotopouua	348	Outstanding	5 yrs	
Rototuna	328	High	5 yrs	
Waingata	371	Low		
Wainui	305	Moderate-high	5 yrs	
Wairere	339	Moderate-high	10 yrs	
Whakaneke	390	Moderate		

1 Introduction

Northland Regional Council (NRC) engaged NIWA to assist in achieving its goal “to prevent deterioration in water quality and loss of biodiversity value in Northland lakes”. The baseline report (Champion et al. 2005) has been updated annually and this is the 2013 update.

This report presents a summary of information gathered on each of the 86 lakes surveyed up to and including May 2013. The region is divided into 4 geographical areas: Aupouri; Karikari \ Central & East Northland; Kai-iwi lakes & North Dargaville; and Pouto Peninsula. Information includes vegetation descriptions (submerged and wetland), the LakeSPI method of assessing submerged plant indicators for lake ecological condition, records of water birds, fish and macroinvertebrates. Ecological and lake condition changes were identified by comparison with previous surveys and major threats to the current lake condition are identified. Finally, management recommendations are presented for each lake.

Assessment of biosecurity risks posed by freshwater pest plants are discussed, with recommendations for monitoring and control. Details of the 2013 update and surveillance activities and results are reported in Wells R.D.S. and P.D. Champion (2013).

This report presents a ranked inventory of lakes of high ecological value based on available ecological and water quality data. Data gathered on the lakes was analysed and used to prioritise the lakes for future monitoring, and to make recommendations on which lakes need to be monitored, for what purpose and what frequency, to assist managers aiming to preserve, protect and enhance water quality and ecological values.

The core information in this report is a living document to be further added to and modified as further information comes to hand, or if lake values change. This information is key for the NRC Lakes Strategy as it is essential for managers to rapidly respond to new incursions or other identified threats and monitor responses to past management initiatives.

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 vegetation

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

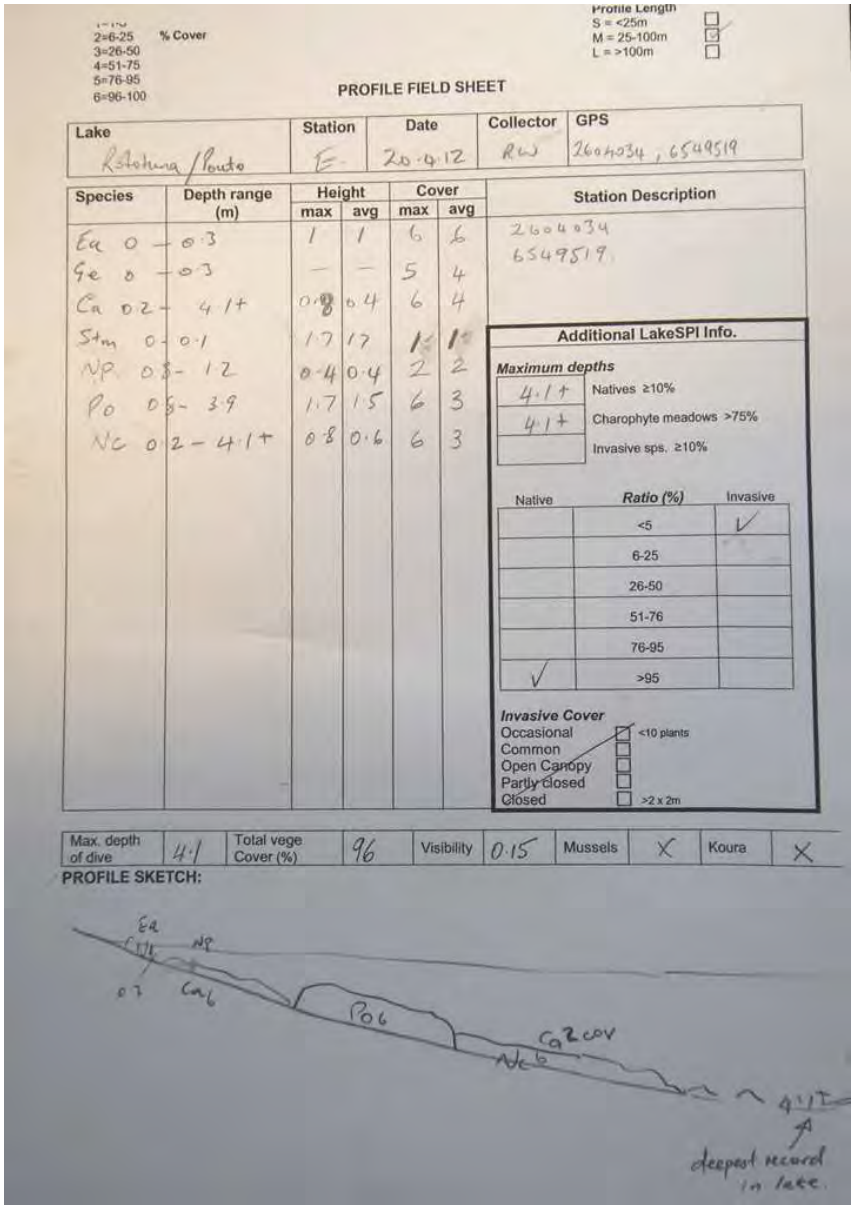
Presence of endangered species (de Lange et al. in press; Forester and Townsend 2004 and discussion of known occurrences with Department of Conservation (DOC) and NRC staff) and pest plants were reported along with an estimate of population size.

2.1.3 Submerged vegetation

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

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

Endangered species were considered as for wetland vegetation.



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

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

PROFILE FIELD SHEET

Lake	Station	Date	Collector	GPS
Rotoiti / Loute	E	20.4.12	RW	2604034, 6549519

Species	Depth range (m)	Height max	Height avg	Cover max	Cover avg
Ea	0 – 0.3	1	1	6	6
Ge	0 – 0.3	–	–	5	4
Ca	0.2 – 4.1+	0.8	0.4	6	4
Stm	0 – 0.1	1.7	1.7	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	Total vege Cover (%)	Visibility	Mussels	Koura
4.1	96	0.15	X	X

PROFILE SKETCH:

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

2.1.4 LakeSPI

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

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

- Native Condition Index –which characterises the status of native vegetation within a lake.
- Invasive Impact Index –which 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 indicators of lake ecological condition and should not be confused with the 'Lake Ecological Value Assessment'.

2.1.5 Lake Ecological Value Assessment

The rating of Lake Ecological Value uses the methodology presented in Champion & 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 to for each parameter are described in Appendix 1. The higher the score the higher the Lake Ecological Value Rating.

2.1.6 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 flew allowing their detection, whereas shore-based observation would probably not detect such species.

2.1.7 Fish

Fish records for the Northland Region extracted from NIWA FBIS comprised 295 records since 1980. These records were assessed to identify lakes containing species of regional or national significance (Hitchmough et al. 2007) and those containing pest fish. While sampling plants, divers also recorded observations of fish but these were not specifically sampled for or quantified.

2.1.8 Aquatic invertebrates

Large aquatic invertebrates such as freshwater mussels (*Echyridella menziesii*), koura (*Paranephrops planifrons*) and snails were noted by divers in the course of macrophyte surveys. Mussels and koura (both classified as 'At Risk – Decling' species (Hitchmough et al. 2007)) are potentially important indicators of lake condition and are likely to be incorporated into LakeSPI methodology in the future.

2.1.9 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.

2.1.10 Threats

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

2.2 Summary

A summary of overall ranking, identified Threats and recommendations is presented for each lake in the inventory.

2.3 Management recommendations

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

- Lake biodiversity monitoring and LakeSPI with additional assessment of nationally or regionally significant biota with assessment of any new threats to ecological condition.

- Pest plant surveillance targeting lake access and anchoring sites to detect early incursions of weed species.

- Additional routine monitoring of water quality, including measurement of all parameters required to generate the Trophic Level Index (TLI) as outlined by Burns et al. (2000).

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

- Identifying lakes where pests threaten lake ecology (and possible mitigating measures).

- Identifying those lakes where indicators suggest nutrient enrichment has or threatens to have significant impacts on lake ecology.

A proposed Phase II of the Lakes Monitoring Strategy will develop individual lake management plan templates that will guide Council's management of Northland's highest priority lake systems and include actions and measurable performance indicators.

2.4 Biosecurity – managing the spread of aquatic weeds in Northland lakes

An evaluation of the risks posed by aquatic weeds to Northland lakes is presented in Section 4. Problem species were identified, current and potential impacts for each species, mechanisms and likelihood of spread, evaluation of threat posed by aquatic weed species and management implications are discussed. For selected water bodies prioritised for monitoring, the monitoring methods, areas searched, and results for the 2007 surveillance are reported. From 2011 on these results are reported in a more detailed companion report on the annual work (most recent being, Wells and Champion, 2013).

3 Inventory of Lakes in Northland - Aupouri Lakes

3.1 Lake Austria (Aupouri), NRC Lake No. 22; surveyed in 2005

Plate: Lake Austria margin showing exposed turf communities and *Apodasmia similis* tussocks. Note humic stained water and floating mats of *Utricularia gibba* (centre right).

Summary

Overall ranking

Moderate: This humic-stained lake was severely impacted by the pest plant *Utricularia gibba* and water level is decreasing, but it provides valuable habitat for endangered water birds.

Threats

Low risk of introduction of further invasive pests. Moderate-low risk of nutrient enrichment from pine plantation activities (logging, fertilisers). Continued decline in water level may further deteriorate lake values.

Management recommendations

No monitoring or active management.

Description

This dune lake (1584726.7E, 6174708.5N) is 18 ha in area, with a maximum recorded depth of 3 m. It is situated on a ponded area between Holocene and Pleistocene sand dunes. The catchment is vegetated by pine plantation forestry (50% of margin) and kanuka scrub (50%). The lake has no inflows or outflows. Access is through well-formed private forestry roads but boat access would require a 4-WD.

Wetland vegetation

There is a sparse fringe of emergent vegetation in the vicinity of the access point, but extensive beds (30% lake area) dominated by *Eleocharis sphacelata* with lesser amounts of *Baumea articulata* grew at the western end of the lake to depths of 2 m. Exposed turfs with a mosaic of amphibious and annual herbs was common at the access point and bordering pine forestry, interspersed with tussocks of oioi (*Apodasmia similis*).

Submerged vegetation

Turf communities were also prevalent to a depth of 1 m, occurring where dense beds of emergent sedges were absent. Dominant species included *Glossostigma elatinoides* and *Lilaeopsis novae-zelandiae*. A range of charophytes were also present in this shallow water zone, with *Chara australis* locally abundant and the milfoil *Myriophyllum propinquum* growing to the maximum vegetation depth recorded in the lake (2.5 m). The nationally endangered *Utricularia australis* was found at low covers throughout the submerged vegetation. The exotic *U. gibba* formed dense surface-reaching mats and extended over much of the submerged vegetation with average covers exceeding 50%.

LakeSPI

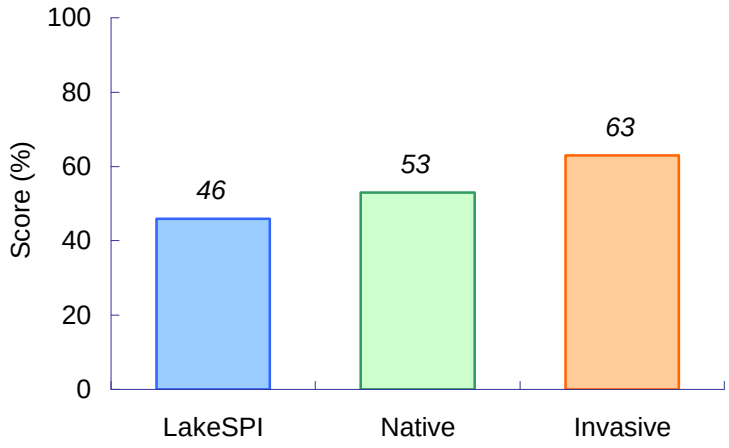


Figure: LakeSPI Index as % of potential score, Native Condition Index, and Invasive Impact Index (from left to right).

The low LakeSPI score of 46% reflects the smothering impact of the invasive *U. gibba* on the submerged vegetation. Profiles were limited so this LakeSPI assessment should be considered provisional.

Water birds

The isolated nature of the lake and large areas of emergent and wetland vegetation provide good habitat for many aquatic birds, although no endangered species were observed during the field visit. The following rare species are reported: fernbird (*Bowdleria punctata vealeae*), spotless crake (*Porzana tabuensis plumbea*), dabchick (*Poliocephalus rufopectus*), Australasian little grebe (*Tachybaptus novaehollandiae*) and scaup (*Aythya novaezeelandiae*).

Fish

No fish were seen in the lake.

Aquatic invertebrates

No aquatic invertebrates were noted.

Changes in indicators

This lake was surveyed for the first time in November 2004.

Threats

The alien bladderwort (*U. gibba*) is having a major impact, forming a sprawling mat that extends over other submerged vegetation. The access through private forestry roads (3 km off access road) mean the likelihood of introduction of other alien species is low, but if introduced, these would have major deleterious impacts on the lake values.

There is apparently some livestock access (cattle, horses?) based on pugged lake margins and absence of emergent vegetation in shallow water areas (see plate).

The water level appeared to have had dropped about 1 m since pines were planted in the catchment, and future decreases could occur.

Management recommendations

The lake is highly impacted by *U. gibba*, but the likelihood of introduction of other alien species is low. No monitoring is recommended.

3.2 Lake Bulrush (Aupouri), NRC Lake No. 49; surveyed in 2005

Plate: Lake Bulrush showing the lack of emergent vegetation and unfenced shoreline.

Summary

Overall ranking

Low: Minimum submerged, emergent and riparian vegetation. Nutrient enriched with cattle access.

Threats

Risk of introduction is moderate and some species could establish, but with little impact on ecological values.

Management recommendations

None recommended.

Description

Located at 1599677.7E, 6159353.9N, this lake is 4.9 ha in size and at least 2 m deep. The catchment is pine plantation and scrub to the west and pasture surrounding the remainder. Inflow to north end of lake drains 2 km of pine, native forest and pasture. No outflow stream. Access is via a well-formed track across 2 km of private land, with relatively easy boat access from the shoreline.

Wetland vegetation

Marginal vegetation sparse. Fenced area on eastern side vegetated with *Juncus pallidus* and turf communities dominated by the exotic *Ludwigia palustris* and *Myriophyllum propinquum*. No emergent vegetation.

Submerged vegetation

Sparse covers of Glossostigma elatinoides, Potamogeton ochreatus, P. cheesemanii and Chara australis to 0.7 m.

LakeSPI

Reconnaissance only – no LakeSPI score generated.

Water birds

Common water birds present, historical records of dabchick (*Poliocephalus rufopectus*).

Fish

No fish seen.

Aquatic invertebrates

The snails *Potamopyrgus antipodarum* (indigenous) and *Physella acuta* (exotic) were common.

Changes in indicators

A large wetland adjacent to the south western end of the lake reported in 1991 appears to have been drained. Two formerly separate lakes have coalesced into one.

Threats

Risk of introduction is moderate, with a well-formed track through private land affording relatively easy access and some invasive species could establish. However current indigenous values are minimal. Prolonged cattle access to this lake has removed emergent vegetation and the lake appears to be highly nutrient enriched.

Management recommendations

No monitoring recommended.

3.3 Lake Carrot or Ngakapua West (Aupouri), NRC Lake No. 118; surveyed in 2005 and 2010

Plate: Carrot Lake photographed from the east end, showing areas of unfenced pastoral catchment and cattle access to lake.

Summary

Overall ranking:

Moderate: Predominantly native vegetation, but now much reduced and with first record of *E. densa*.

Threats

E. densa impacts are likely to be high. Nutrient run-off from pastoral practices threatens water quality and is a likely cause of submerged vegetation bottom limits retracting from 5.7 m in 2004 to 3 m in 2010.

Management recommendations

Hand removal of *E. densa* should be attempted, with annual surveillance for this plant. Signage warning of *E. densa* risks on access road. Completion of lake edge fencing and livestock exclusion.

Description

This dune lake is part of the Sweetwater group of lakes (1617118.4E, 6124466N). The catchment also includes forestry land (c. 25%) which had been harvested recently. The lake is small (1.7 ha), but relatively deep (8.2 m) and has no defined inflows or outflows. Access is through plantation forestry and steep private pastoral land; boat access is difficult.

Wetland vegetation

Extensive emergent vegetation is present on the north-western side of the lake with beds up to 12 m across. Elsewhere the emergent zone is sparse with evidence of extensive loss of emergent vegetation from the south-western end of the lake (submerged bases of *T. orientalis* on the lake bottom). Water level fluctuations or controlled spraying are speculated as possibilities. The dominant species were *Eleocharis sphacelata* and *Typha orientalis* growing to 0.3 and 0.2 m respectively. In 2005 these depth limits were about 1 m deeper, suggesting lower water levels in 2010 or spraying on the lake side. The regionally rare maru (*Sparganium subglobosum*) was present in the emergent vegetation.

Submerged vegetation

In 2010 the turf species *Myriophyllum propinquum* was restricted to the few shallow (≤0.4 m) areas where emergent stands were not present. The exotic *U. gibba* was commonly found at low covers within the shallow zone in <2.5 m depth. Dense (>75% cover) beds of Nitella sp. aff. cristata comprised the majority of the submerged vegetation to a maximum depth of 3.0 m although it was much deeper (5.7 m) and taller (1.5 m) in 2005. Occasional plants of *Chara australis* and *Potamogeton cheesemanii* were present to <2 m depth. One plant of the nationally threatened *Utricularia australis* was found in 2005. A small clump of the invasive weed *Egeria densa* was found at ~ 2 m at the eastern end of the lake. This was carefully hand removed.

LakeSPI

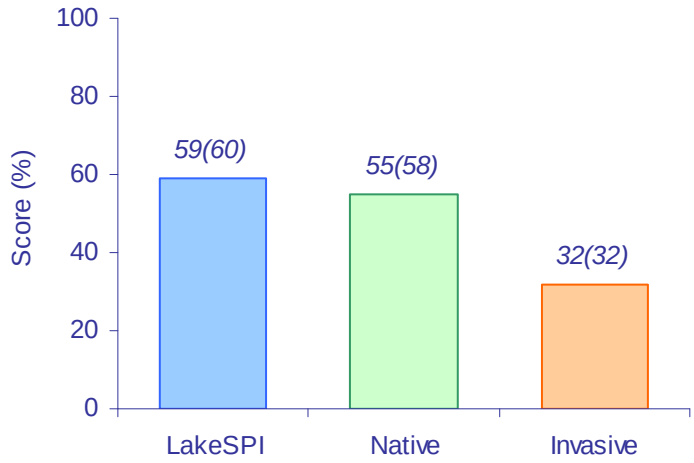


Figure: 2010 LakeSPI Index as % of potential score, Native Condition Index, and Invasive Impact Index (from left to right) and 2005 in brackets.

The moderately high LakeSPI score of 60% reflects the extent of development of the charophyte meadows and relatively small impact by the exotic species *Utricularia gibba*. *E. densa* was not found on the vegetation profiles but would have changed this result markedly if it was. 2010 LakeSPI scores were similar to 2005.

Water Birds

The emergent vegetation and scrub on the northwestern margin provide good water bird habitat. No birds were reported during the field visit but historical records report the nationally threatened bittern (*Botaurus poiciloptilus*) and regionally significant dabchick (*Poliocephalus rufopectus*) and Australasian little grebe (*Tachybaptus novaehollandiae*) (all in 1988) with a 1978 record of the critically endangered brown teal (*Anas aucklandica chlorotis*) nesting on this lake. No water birds were recorded in the OSNZ survey in 1996.

Fish

Common bullies (*Gobiomorphus cotidianus*) were recorded during the vegetation survey.

Aquatic invertebrates

The alien snail *Planorbarius corneus* and freshwater sponges were recorded.

Changes in indicators

A large increase in vegetation depth occurred between earlier surveys, from 2.5 m in 1985, to 5.5 m in 2001, and 5.7 in 2005, but retracted back to 3.0 m in 2010. None of the nationally threatened native *U. australis* recorded in previous surveys was found. It declined from average covers of over 25% in the 3 profiles in 2001 to only one plant in 2005 and none in 2010.

Threats

The appearance of *E. densa* in this lake is a significant threat to its current high status and that of the nearby Ngakapua lakes. The low cover of *U.* gibba suggests a minimal impact from this plant in this water body.

The predominantly pastoral catchment is a likely source of nutrients, with areas of the lake remaining unfenced and the infringing emergent plants susceptible to cattle grazing and trampling.

Management recommendations

A delimitation survey is required to find all the *E. densa* and then if practical repeated hand weeding (and or use of compression screens) in the lake may achieve eradication. It looks like the invasion has been identified early and eradication by this means might be achievable. It would require a minimum of 2 divers to carefully remove all viable parts of the *E. densa* plants to a catch bag at 6 weekly intervals until it has all gone and then annual surveillance with clear results for 5 years.

Retirement of the lake edges around the eastern sector of the lake will encourage wetland vegetation and some interception of diffuse nutrient run-off.

3.4 Forest Lake or Deans Swamp (Aupouri), NRC Lake No. 114; surveyed in 2005 and one profile sampled in 2010

Plate: Forest Lake.

Summary

Overall ranking

Medium: Complete margin of emergent vegetation. Native submerged vegetation to 3 m deep covered by *U. gibba*.

Threats

Additional pest impacts unlikely though deliberate introduction of pest plants and fish may occur.

Management recommendations

No monitoring recommended.

Description

This dune lake (1617411.9E, 6125152.1N) is 1 ha in area with a maximum depth of 4.5 m. The catchment is pasture with pine plantation forestry present further back from the lake edge. There are no inflows or outflows. Access is through well-formed forestry roads, 1 km from the main road, no boat access.

Wetland vegetation

Forest Lake was completely encircled by a dense *Eleocharis sphacelata* reed bed extending out to a maximum water depth of 3 m with a maximum height of 3.5 m tall, with lesser amounts of *Baumea articulata* in shallow areas.

Submerged vegetation

In 2010 vegetation covers were higher than 2001 with 100% cover to 3 m deep. The dominant species were *Chara australis* and *Potamogeton cheesemanii* and *Nitella leonhardii* with sprawling mats of *U. gibba* smothering much of the submerged and emergent zones.

In 2001 *Utricularia australis* was the most common species from 0.5 to 3 m depth with average covers of ≤5%. Other species present then were *Potamogeton cheesemanii* in the shallows (≤0.5 m depth) and at the outside edge of the reed beds (2.5 to 3 m depth), with *Nitella leonhardii* growing beneath the reed bed. Both had covers ≤5%. Submerged vegetation did not extend far from the *E. sphacelata* bed. A thick mat of blue-green algae was noted growing on the sediment to at least 3.5 m depth.

LakeSPI

No LakeSPI score generated as only one profile was surveyed.

Water birds

The dense emergent vegetation would provide good habitat. The most recent OSNZ survey (1996) reported a pair of the regionally significant Australasian little grebe (*Tachybaptus novaehollandiae*) at this lake.

Fish

Common bully (*Gobiomorphus cotidianus*) was the only species recorded in the NIWA FBIS records and were noted during the 2010 visit.

Aquatic invertebrates

None recorded.

Changes in indicators

The alien free-floating species *Salvinia molesta* was present in 1984/85 but was eradicated by 2000. *Chara australis* and *C. fibrosa* were present in 1984/85 but not in 2001 and the total submerged vegetation cover was also reduced from >75% to <26% over that period. The submerged vegetation had re-established by 2010 to its original depth of 3 m with *C. australis* dominant (100% cover) but no *C. fibrosa* or *Utricularia australis* was noted in 2010. The invasive *U. gibba* was also conspicuous throughout the vegetation profile.

Threats

Difficult access and lack of eel records would reduce the likelihood of pest introduction.

Management recommendations

No monitoring.

3.5 Half Mile Lagoon (Aupouri), NRC Lake No. 62; surveyed in 2005

Plate: Remnant pools in pasture occupying the area previously containing Half Mile Lagoon.

Summary

Overall ranking

Low: Almost completely dry.

Threats

Further decrease in water level.

Management recommendations

No monitoring.

Description

Half Mile Lagoon is situated 1599378E, 6157875N, and once covered an area 3.6 ha. The plate shows the largest of the remaining pools (approximately 100 m^2).

Wetland vegetation

Myriophyllum propinquum was present in marginal vegetation.

Submerged vegetation

None.

Threats

This area is an extreme example of decreasing water levels that have impacted on many of the smaller Aupouri dune lakes.

Management recommendations

No monitoring.

3.6 Lake Heather (Aupouri), NRC Lake No. 125.

Plate 1: Lake Heather set in a pasture catchment fenced off with a wetland margin.

Summary

Survey dates 2005, 2008; rapid assessment 2 profiles annually 2009 - 2013

Overall ranking

Moderate-low: The submerged native vegetation is highly impacted by exotic submerged weeds *C. demersum* and *E. densa*, but grass carp are removing them. The lake still has excellent water bird habitat.

Threats

Alligator weed (*Alternanthera philoxeroides*) poses a threat to emergent vegetation. *C. demersum* and *E. densa* are well established as surface-reaching beds throughout much of the lake. Crack willow (*Salix fragilis*) was removed from a maimai location since the 2009 visit and report.

Management recommendations

Eradication of *C. demersum* and *E. densa* from the lake using grass carp is progressing. Assess feasibility of alligator weed control/eradication. Lake native biodiversity value monitoring is recommended every 5 years and annually monitoring for grass carp progress with exotic weed removal.

Description

This dune lake (1617665E, 6121295N NZTM) is 8 ha in area with a maximum depth of 5.6 m (4.7 in April, 2008). The margins are fenced and recently enhanced with native planting. The lake is used for shooting and the catchment is mostly pasture, with scrub along the eastern edge. There are no inflow or outflow streams. Access is through 3 km of private land with a locked access gate.

Wetland vegetation

The entire lake is surrounded with emergent vegetation 5 to 20 m wide, extending from the shoreline to a maximum of 2.3 m depth. The margins have been fenced. The dominant species was kuta (*Eleocharis sphacelata*), with *Baumea articulata, E. acuta,* raupo (*Typha orientalis*) and *Schoenoplectus tabernaemontani* locally important. On the western edge, a low sudd dominated by *Ludwigia palustris, Isolepis prolifera* and mats of the exotic weed *Utricularia gibba* was present between the tall emergent vegetation and submerged vegetation. The nationally threatened *Myriophyllum robustum* was present amongst tall emergent vegetation at one profile in 2005, but not recorded since. DoC SSBI records the presence of another rare species, swamp fern (*Thelypteris confluens*) presumably in the wetland at the north-eastern end of the lake. The alien pest plant alligator weed (*Alternanthera philoxeroides*) was present over an area of 80 m^2 amongst kuta and raupo in the vicinity of a maimai, and there was a crack willow cutting (April 2009), that has since been removed. Grass carp are reducing the width of the wetland margin.

Submerged vegetation

In 2005 no turfs were present because of the dense encircling reed beds. *Myriophyllum propinquum*, the regionally significant *Utricularia australis* were uncommon and restricted to within the reed beds to <2 m depth. The exotic *U. gibba* was common. *Chara australis* and *Potamogeton cheesemanii* were also found in this shallow zone, but occasionally grew deeper. The vegetation from 2 m depth was dominated by combinations of three species: *Potamogeton ochreatus* (common in the northern basin only) and the exotic species, *C. demersum* and *E. densa*. *E. densa* (to 3.5 m tall) was common from the *Eleocharis sphacelata* margins on the steep sides of the lake with *C. demersum* (up to 4.3 m tall and often surface reaching) further out in the lake.

Since 2005, *C. demersum* abundance has increased markedly. *Potamogeton ochreatus* grew up to 2 m tall in the northern basin and extended right across the lake beyond the *E. densa* in 2009, but was much reduced in abundance in 2010 and is predicted to be replaced entirely with tall *C. demersum* beds within 2 years.

LakeSPI

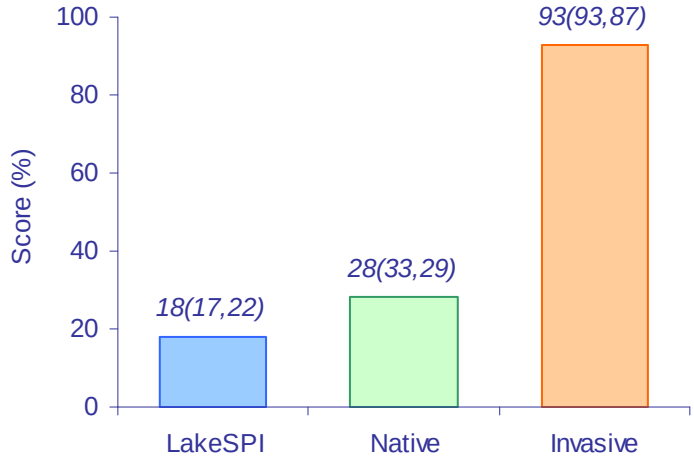


Figure: LakeSPI Index 2010 as % of potential score, Native Condition Index, and Invasive Impact Index (from left to right), with 2008 and 2004 figures in brackets.

The low LakeSPI score of 17% reflects the very high invasive impact on the native vegetation. Since grass carp introduction LakeSPI has not been repeated as vegetation status is now only indicative of grass carp grazing pressure and not lake health.

Water birds

Over 50 paradise shelducks (*Tardorna variegata*) and 3 Canada geese (*Branta canadensis*) were seen during the field visit in 2005. Records from the 1990's include the nationally threatened bittern (*Botaurus poiciloptilus*) and the regionally significant dabchick (*Poliocephalus rufopectus*) and Australasian little grebe (*Tachybaptus novaehollandiae*). This lake is an important moulting site for paradise shelduck.

Fish

Common bullies (*Gobiomorphus cotidianus*) were abundant in this lake; the NIWA FBIS database also recorded shortfin eels (*Anguilla australis*). NRC water quality sampling team reported a large fish leaping from the lake.

Aquatic invertebrates

Sigara arguta was commonly observed in the lake.

Changes in indicators

An increase in the maximum depth of submerged vegetation took place between 1985 (3 m depth limit) and 2001 (to the maximum lake depth of ~5 m). Invasion by *C. demersum* and *E. densa* took place between 1988 and 2001, and *E. densa* and *C. demersum* have shown an increase in abundance since 2001. *U. gibba* was a new record in 2001. Nationally significant species *U. australis* and *M. robustum* were rare in 2005, but were not found in searches in 2008, 2009 or 2010. Grass carp are reducing weed presence steadily.

Threats

The pest plants *C. demersum* and *E. densa* have had an extensive impact on the native vegetation, with only *P. ochreatus* co-existing; though this is now mostly restricted to the deepest parts of the northern basin and will likely be displaced by *C. demersum* within 2 years. If these species are present long term in the lake whey will change the lake sediments in time making them highly organic, flocculent and unsuitable for future submerged vegetation. The pest plant *U. gibba* was abundant in shallow water sprawling over *E. densa*. Alligator weed was present adjacent to a maimai (also the case in Lake Rotoroa and some Karikari lakes) and discussion of its distribution with several locals and its proximity to miamias suggests that it was deliberately introduced. By another maimai there was a crack willow cutting (April 2009). Crack willow is highly invasive and threatens the wetland margin's native character and habitat values for other biota. This plant has since been removed, but this example highlights the threat that ill-informed locals present to this lake.

Management recommendations

An assessment of lake native biodiversity value at 5 year intervals is recommended.

Recommend surveying lake-margin for alligator weed and control if feasible.

Control / eradication of *E. densa* and *C. demersum* using grass carp is underway, with annual surveys to assess their effectiveness.

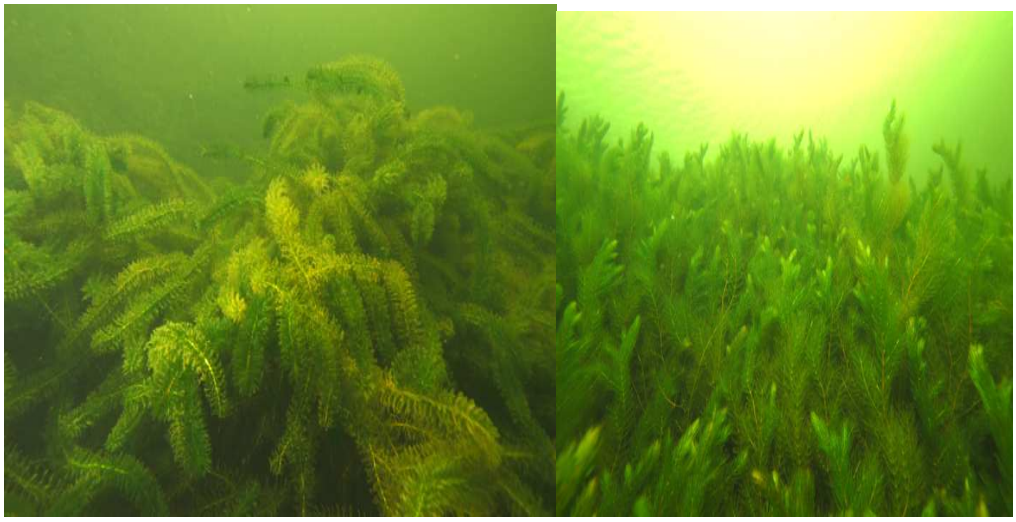


Plate 2: Tall weed beds *E. densa* (left) and *C. demersum* (right) in Lake Heather extending to near the water surface 2010. These plants dominated more than 90% of the open lake area prior to grass carp being introduced later in the year.

Monitoring to date (full detail in annual reports)

The two baseline profiles recorded prior to grass carp release in 2010 were repeated in 2011, 2012 and 2013 (Figure below).

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

In 2011 the *E. densa* had been heavily grazed but little damage was noted on the *C. demersum*. In April 2012 the *E. densa* had been heavily grazed and reduced to basal stalks (Figure below) but only about 50% of the *C. demersum* has been removed. Most of the *C. demersum* was still recorded up to 2.2 m tall. In 2013 the *E. densa* had all gone and *C. demersum* further reduced. The rate of progress for grass carp in removing the weed beds is slower than in Lake Swan, probably because of the large amount of *T. orientalis* accessible for consumption, but they are making steady progress.

Figure: *E. densa* remnants 2012 in Lake Heather at 2.6 m deep heavily grazed by grass carp.

3.7 Katavich Lake - west of Lake Waiparera (Aupouri), NRC Lake No. 103; surveyed in 2005

Plate: **Katavich Lake showing margin of lake impacted by cattle access.**

Summary

Overall ranking

Low: impacted by cattle grazing, no submerged and limited emergent vegetation.

Threats

Appears to be highly nutrient enriched.

Management recommendations

No monitoring recommended.

Description

This lake (1614995E, 6133225N) is 6.3 ha in area. The catchment is predominantly (90%) pasture with unimpeded cattle access to the lake, with some scrub and pine plantation to the west. A drain enters the western end of this lake, but there is no outlet. Access is 500 m along a private, well-formed track off Katavich Road, with relatively easy boat access.

Wetland vegetation

There is a sparse fringe comprised predominantly of *Typha orientalis, Eleocharis sphacelata, Schoenoplectus tabernaemontani* and *Baumea articulata*.

Submerged vegetation

No LakeSPI score generates as vegetation cover <10%.

LakeSPI

No LakeSPI index generated.

Water birds

Previously there were large areas of dense, tall emergent vegetation providing good habitat for many aquatic birds, with DoC SSBI survey in 1991 recording several regionally significant spotless crake (*Porzana tabuensis plumbea*). Mallard ducks (*Anas platyrhynchus*) and paradise shelduck (*Tardorna variegata*) were seen on this survey.

Fish

The pest fish *Gambusia affinis* were seen in the lake. NIWA FBIS records common bullies (*Gobiomorphus cotidianus*) and shortfin eels (*Anguilla australis*).

Aquatic invertebrates

No aquatic invertebrates were noted.

Changes in indicators

Lake flora and fauna were assessed for the first time in November 2004.

Threats

Access is easy, but introduced pest plants would not threaten any significant habitat.

Water quality appears to be already very poor.

Management recommendations

No monitoring is recommended.

3.8 Lake Kihona (Aupouri), NRC Lake No. 31; surveyed in 2005

Plate: Lake Kihona set in a forestry catchment, note the recent harvesting and limited development of emergent vegetation.

Summary

Overall ranking

Low: Submerged vegetation dominated by *Ceratophyllum demersum*, poor water quality and emergent vegetation.

Threats

Invasives already present.

Management recommendations

Evaluate options for control of alligator weed (*Alternanthera philoxeroides*).
No monitoring.

Description

A dune lake (1591072E, 6168119N) formed from a gully system dammed by sand dunes to the west and is 7.8 ha and 8.3 m deep. The catchment is pine plantation forest (half recently logged) with a manuka scrub buffer between the lake and pines on the northern side. The inflow stream enters the north-eastern end of the lake, with the outlet (Pukekura Stream) discharging to the west coast 5 km to the south-west. Access is through approximately 10 km of well-formed forestry roads to the outlet. Small boat access can be made at this point.

Wetland vegetation

A low density margin of emergents up to 2 m across was present with *Eleocharis sphacelata* the dominant species, present around most of the lake with an average cover of about 10%, growing to a maximum depth of 2.5 m. *Typha orientalis*, *Baumea articulata*, *Cyperus ustulatus*, *Carex secta*, *Carex virgata*, *Carex maorica* and *Eleocharis acuta* were also present.

Alligator weed (*Alternanthera philoxeroides*) was present at the access point.

Submerged vegetation

The lake was steep sided and no significant turf communities were present. The vegetation was dominated by the invasive weed *Ceratophyllum demersum,* present throughout the lake with an average cover 26-50% and extending to 3.8 m deep. *Chara australis* was present at low (≤5%) average cover. The endangered *Utricularia australis* was recorded on one of the 3 profiles.

LakeSPI

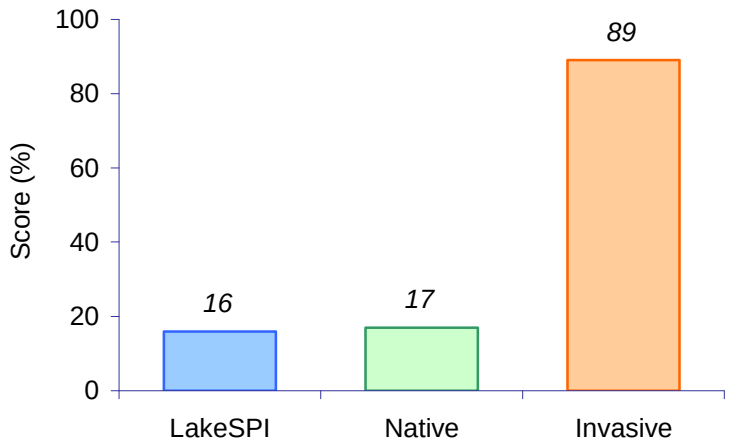


Figure: LakeSPI Index as % of potential score, Native Condition Index, and Invasive Impact Index (from left to right).

The LakeSPI score of 16% is low as the lake is dominated by the invasive weed hornwort (*Ceratophyllum demersum*), with little native vegetation present.

Water birds

A poor water bird habitat. Black swan (*Cygnus atratus*), pukeko (*Porphyrio melanotus*), pied shag (*Phalacrocorax varius*) and shoveler (*Anas rhynchotis*) were seen. Fernbird (*Bowdleria punctata vealeae*) were previously recorded in 1991 (DoC SSBI) but were not noted by this survey or the 1996 OSNZ survey. Recent logging would have caused major disruption of the lake and its surrounding vegetation.

Fish

Shortfin eel (*Anguilla australis*) and common bully (*Gobiomorphus cotidianus*) were seen during the vegetation survey. DoC SSBI also reports grey mullet (*Mugil cephalus*) in this lake.

Aquatic invertebrates

No koura or mussels were found.

Changes in indicators

No previous vegetation surveys.

Threats

The lake is isolated with difficult access, however both *C. demersum* and alligator weed have been introduced; the former probably with eel nets, the latter via a digger used to deepen the outlet as an emergency water supply for forest fire management. Alligator weed poses a threat to emergent vegetation and is absent from the main body of the lake.

Forestry activities e.g., fertiliser application and logging within the catchment could impact the nutrient status of the lake although it is already nutrient enriched.

Management recommendations

Recommend surveying lake-margin for alligator weed and control if feasible.

No monitoring required.

3.9 Lake Little Gem, near Ngatu (Aupouri) NRC Lake No. 123; surveyed in 2007 and 2010

Plate 1: Lake Little Gem viewed from the north-western access point.

Summary

Overall ranking

Moderate-high: Complete fringe of emergent plants limited submerged vegetation but numerous endangered biota recorded. The introduced pest plant *Utricularia gibba* is widespread and the pest fish *Gambusia affinis* was recorded, but no other pest species were recorded.

Threats

Low risk of introduction of further invasive pests, but deliberate introduction would not be difficult. Existing emergent vegetation provides a good nutrient buffer for surrounding pastoral land, but intensified land use could threaten this lake.

Management recommendations

Lake native biodiversity value monitoring every 5 years.

Description

Lake Little Gem (NZMG 2528656E 6684691N) is a small (0.36 ha) dune lake with a maximum depth of 3.5 m. The lake is unfenced and surrounded by pasture. There are no inlets or outlets. The lake is accessed from southwest end of Lake Ngatu via a walking track through private property.

Wetland vegetation

Lake Little Gem was surrounded by continuous wide beds of emergent species *Eleocharis sphacelata* growing from the lake margin to 2.6 m depth with scattered areas of *Baumea articulata*, *Phormium tenax*, *Typha orientalis* and *Leptospermum scoparium*. Within the *E. sphacelata* was *Isachne globosa*, *Hydrocotyle pterocarpa, Myriophyllum propinquum* and large patches of nationally endangered *Myriophyllum robustum* (classified as Gradual Decline, see Plate 2) around much of the lake. The pest species *Utricularia gibba* formed surface floating mats in parts of emergent vegetation (Plate 2). The shallow shoreline was grazed and dominated by *Isolepis prolifera* and also including regionally uncommon *Sparganium subglobosum*.

Submerged vegetation

In 2007 charophytes dominated the vegetation from the outer edge of emergent communities to a maximum depth of 3.3 m. The dominant species was *Nitella* sp. aff. *cristata* growing to 1 m tall with local areas of *Chara australis* with the pondweed *Potamogeton cheesemanii* growing up to 2.8 m tall to a depth of 3.0 m. The alien invasive *U. gibba* sprawled over submerged species from the edge of emergent *E. sphacelata* beds to 2.6 m depth.

In 2010 however there were no submerged plants beyond the *E. sphacelata* and visibility was low. This lake is fluctuating between a vegetated and non-vegetated state.

LakeSPI

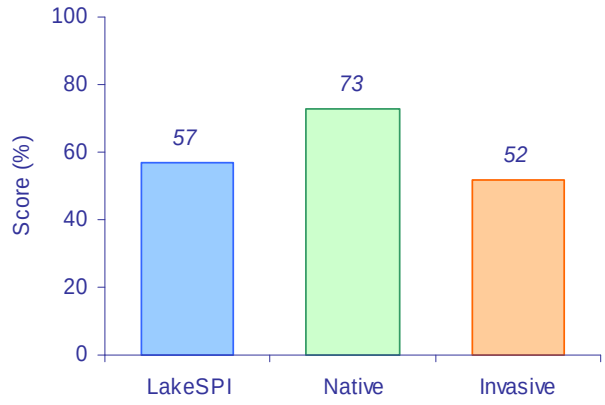


Figure: 2007 LakeSPI Index as % of potential score, Native Condition Index, and Invasive Impact shown. In 2010 was not repeated as there was no submerged vegetation at >10 % cover. The zero default should therefore be applied.

A moderate LakeSPI score of 65% in 2007 reflected predominantly indigenous vegetation, including extensive charophyte meadows, but reduced by presence of invasive *U. gibba*. In 2010 a default zero LakeSPI score is a marked departure, but is likely to be a fluctuating situation with the photic zone retracting to only 2.6 m (or less) which is the depth limit occupied by dense *Eleocharis sphacelata* beds. A minor and perhaps seasonal improvement in light climate could see these seed dispersed species recover former status quickly.

Water birds

Extensive emergent vegetation and relatively undisturbed nature of this lake provides a good habitat for water birds. The nationally threatened bittern (*Botaurus poiciloptilus*) and the regionally rare dabchick (*Poliocephalus rufopectus*) are commonly found on this lake (K. Matthews pers. comm.).

Fish

No fish were seen (except for *Gambusia affinis*) during the current visit, though NIWA FBIS recorded inanga (*Galaxias maculatus*) and the pest fish gambusia (*Gambusia affinis*). The inanga are likely to be similar to Lake Ngatu fish, requiring further investigation.

Aquatic invertebrates

The introduced freshwater jellyfish (*Craspedacusta sowerbyi*) were noted during the submerged vegetation survey in 2007. Two dytiscid beetles (*Onychohydrus hookeri*) were observed feeding on gambusia in 2010.

Changes in indicators

First sampled in 2007 when charophyte meadows were present below the *E. sphacelata* beds. In 2010 this submerged vegetation was not present. It indicates a changing light climate.

Threats

The impact of the sprawling growths of the weed *U. gibba* is uncertain but is likely to be significant.

The pest fish *Gambusia affinis* may have a deleterious impact on other fish like the potentially nationally significant inanga reported from this lake.

Existing emergent vegetation provides a good nutrient buffer for surrounding pastoral land, but intensified land use could threaten this lake.

Management recommendations

Carry out 5 - year lake native biodiversity value monitoring.

Plate 2: The nationally threatened *Myriophyllum robustum* growing amongst the emergent sedge *Eleocharis sphacelata* in Lake Little Gem in about 0.5 m of water. Note the dense mat of the invasive *Utricularia gibba* with lone small flower stalk (red arrow).

3.10 Mini Lake (Split Lake) (Aupouri), NRC Lake No. 130; surveyed in 2005

Plate: Mini Lake, set in pasture, showing the narrow ribbon-like nature of the lake with large emergent beds of raupo (*Typha orientalis*) and kuta (*Eleocharis sphacelata*).

Summary

Overall ranking

Low: Submerged vegetation dominated by invasive *Egeria densa*, margin grazed to edges, but deep water protects much of emergent vegetation from cattle, good water bird habitat.

Threats

Invasive *E. densa, Ceratophyllum demersum, Utricularia gibba* and alligator weed (*Alternanthera philoxeroides*) already present. Grazing and nutrient enrichment impacts.

Management recommendations

Evaluate options for control of alligator weed.

No monitoring.

Description

A dune lake (1617390S, 6118790N), 8.7 ha in area and ~ 2 m deep. The catchment is pasture with unimpeded access for livestock. There are no inflow or outflow streams. Access is through approximately 1 km of private farmland with difficult boat access to the lake.

Wetland vegetation

Despite grazing impacts, approximately 50% of this lake is occupied by dense emergent beds. *Eleocharis sphacelata, Typha orientalis, Baumea articulata*, *Schoenoplectus tabernaemontani* and *Isolepis prolifera* were the dominant species.

The invasive alligator weed (*Alternanthera philoxeroides*) was present at the southern end of the lake.

Submerged vegetation

The lake was dominated by the invasive weed *Egeria densa* forming a dense surface-reaching bed from 0.5 to 1.5 m deep. Lesser amounts of the exotics *Ceratophyllum demersum* and *Utricularia gibba* and the native *Chara australis* were also present in this area. Nitella sp. aff. cristata covered the deepest parts of the lake (to ~ 2 m) with 50% cover.

LakeSPI

Reconnaissance only – no LakeSPI score generated.

Water birds

Moderate water bird habitat. The nationally threatened bittern (*Botaurus poiciloptilus*) and the regionally significant dabchick (*Poliocephalus rufopectus*) were reported in the 1990's. Large numbers of black swan (*Cygnus atratus*) and Canada geese (*Branta canadensis*) were noted during the field visit.

Fish

Longfin eel (*Anguilla dieffenbachii*) were reported on the NIWA FBIS database.

Aquatic invertebrates

No invertebrates were reported.

Changes in indicators

No previous vegetation surveys.

Threats

The lake is highly impacted with the worst pest plants already present and impacting on the vegetation.

Lack of riparian vegetation between steep sided pasture and this lake and also the grazing/trampling impacts of cattle provide no buffer to catchment nutrients entering the lake.

Management recommendations

No monitoring.

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

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

Summary

Survey dates 2006, 2009 and 2013

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

The cautionary note that pine harvesting might impact on water quality in 2009 appears to have exceeded all expectations with extensive loss of aquatic habitat. Continued impact needs to be mitigated and future events like this avoided.

Introduction of invasive species could still threaten further degradation of this lake.

Management recommendations

Undertake a full investigation of the impact of logging on Lakes Te Kahika, Te Kahika South, Morehurehu and Morehurehu South 1 and 2 (also Parengarenga Harbour). Review recent changes in the catchment and document impacts in all receiving waters. Lake monitoring annually to evaluate rate of recovery. Provide advice to forestry companies or other land-use in these poorly buffered water bodies to modify activities that caused such extensive environmental damage.

Description

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. The mature trees have been recently harvested and replanted for a second crop.

There are 3 inlet streams entering the south-west, north-west and south-eastern arms of this lake, with the outlet flowing through a wetland at the south-eastern end of the lake into Great Exhibition Bay (East Coast). Wetlands are also associated with the inflow streams. Access is through private forestry roads (4-WD), is steep and the track is loose sand, making trailered boat access 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, but also flax (*Phormium tenax*), swamp coprosma (*Coprosma tenuicaulis*), manuka (*Leptospermum scoparium*), swamp kiokio (*Blechnum novaezelandiae*) and areas of bog vegetation with the regionally significant wire rush (*Empodisma robustum*) and umbrella fern (*Gleichenia dicarpa*). Several plants of nationally threatened status were present with *Drosera pygmaea* noted in a lake-shore turf and *Todea barbara* on lake shore banks.

Submerged vegetation

In 2013 there was almost no submerged vegetation present with only three submerged species and none exceeded 5% maximum cover. In contrast in 2009, the aquatic vegetation was abundant and extended down to 5.5 m deep. It was comprised of 7 species with charophyte meadows common and abundant tall-growing native species.

Chara fibrosa was the dominant species, with *C. australis, Nitella leonhardii* and *N. pseudoflabellata* locally dominant, and the tall-growing native *Potamogeton cheesemanii* was common. The invasive exotic *Utricularia gibba* covered native species to about 4 m depth. In 2006 the nationally endangered *Utricularia australis* was found on 4 of the 5 profiles, scattered throughout other vegetation to 4.6 m depth limit, but was not found in 2009 or 2013.

LakeSPI

Table 3-1: LakeSPI for Lake Morehurehu. Four LakeSPI surveys are recorded. 2013 scored 0% due to very low abundance of submerged vegetation.

Survey Date	Status	LakeSPI %	Native Condition %	Invasive Impact %
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%

Water birds

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

Fish

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

Aquatic invertebrates

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

Lake Ecological Value

The impact of the invasive *U. gibba* increased from 2005 to 2006 and 2009, but like other plants had decreased markedly in 2013. The nationally endangered *U. australis* was not seen in either the 2009 or 2013 surveys.

A 1988 vegetation survey recorded similar submerged vegetation to the 2009 description although *Chara australis* was more abundant and extended to a maximum depth of 9.5 m. *U. gibba* was not recorded. But the lake has changed from being relatively clear when visited in 2009 to having a dark brown / red stain with less than 1 m in water visibility in 2013 (Figure 3-1).

Based on the 2009 survey a Lake Ecological Value rating of 12 (Outstanding) was calculated. A deterioration in the rating of the following parameters: water quality (water transparency and total nitrogen values from 2010 to 2013 indicate Eutrophic condition whereas chlorophyll a and total phosphorus indicate Mesotrophic condition) and loss of aquatic vegetation integrity has resulted in a revised score of 10 (High).

Figure 3-1: Lake Morehurehu with dark brown / red stained water with less than 1 m in water visibility.

Threats

The marked change in water clarity and total nitrogen concentration is significant and needs further study to elucidate its causes in case the present condition can be ameliorated and prevented from re-occurring in future. Light is a major determinant of submerged vegetation. Such a marked change in water clarity would account for the loss of submerged vegetation recorded. The recent harvesting of the pine plantation may have caused the change in water quality with similar changes 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. Pine transpiration has also been keeping water levels lower in the soil profile. Felling of the trees has 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.) so the lakes are likely to have been impacted by resin acids washed into the lake causing the deterioration in water transparency and loss of submerged vegetation. Alternatively, disturbance of peat soils in the catchment during the logging operations may have led to leaching of tannic substances through the quartz sands.

The main risks for invasive species come from use of diggers in associated streams, or pine plantation harvesting gear that may be contaminated with invasive weeds such as alligator weed, (*Alternanthera philoxeroides*), or eel fishers using nets contaminated with submerged weeds. Introduced invasive species would establish and displace much of the indigenous vegetation. The construction of 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 and thus sensitive to urea fertiliser addition in forestry or harvesting activities.

Management recommendations

Resin acids only come from pine trees. It is recommended that this be confirmed by measuring lake water for colour, total suspended solids, resin acids, and pH. Sampling for resin acids has been carried by NRC in July 2013 (L. Forester pers. comm.).

Resin acids are likely to persist for some time as they continue to be washed in from the catchment. Rotting pine wood will continue to give off resin acids if water logged. They are broken down by UV light in water and some microbial actions. The addition of lime to the water could help it disappear more quickly but trials would need to confirm this.

Annual lake monitoring would enable impacts to be documented and 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 future.

3.11 Lake Morehurehu South 1 (Aupouri), NRC Lake No. (33); reconnaissance 2010

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

Summary

Overall ranking

Moderate-low: A small remote lake, submerged vegetation completely dominated by the invasive *Utricularia gibba*.

Threats

None

Management recommendations

No monitoring.

Description

The lake (2511501E, 6723165N) is small (0.71 ha), shallow 2.3 m deep, with a wetland connection to Lake Morehurehu. The catchment is plantation forestry, lake and wetland. Access is along a very rough forest track. No boat access.

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 *Baumea juncea*, *B. arthrophylla* and *Typha orientalis*.

Submerged vegetation

A few plants of *Nitella leonhardii* and *Potamogeton cheesemanii* were in the shallows; otherwise *U. gibba* formed dense mats across the lake.

LakeSPI

None generated.

Water birds

Fernbirds (*Bowdleria punctata vealeae*) were heard.

Fish

Common bully.

Aquatic invertebrates

Sigara and three species of Odonata (1 damselfly and 2 dragonfly) were seen. No mussels or koura seen.

Changes in indicators

Not previously surveyed.

Threats

Minimal with access difficult.

Management recommendations

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

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

Plate: Morehurehu South 2, a coastal dune lake set in mobile sand dunes, scrub and pine plantation forestry 2006.

Summary

Survey dates 2006 and 2013.

Overall rating

Moderate: with very little submerged vegetation and heavily stained water. *Utricularia australis* not located in 2013.

In 2006 rated High: A small remote lake with high diversity including endangered species, good water quality.

Threats

Threatened by recent change in water quality.

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

Management recommendations

Undertake an investigation of the impact of logging on the lake. Lake monitoring annually 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

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

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 *Empodisma robustum* were all common marginal species. A population of the Nationally Vulnerable *Drosera pygmaea* was observed growing in a lake-side turf.

Submerged vegetation

No submerged species were present in 2013 except for a small amount of *Utricularia gibba*.

In 2004 and 2006 no turf species were recorded but the regionally significant *Triglochin striata* was recorded and charophytes meadows dominated by *Nitella hookeri* 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 and tall (to 3m). *U. gibba* was present at high covers to 2.5 m covering indigenous vegetation on the relatively steep sides of the lake. The nationally endangered *Utricularia australis* was found in small amounts amongst emergent vegetation.

No significant amounts of submerged vegetation were 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.

Water birds

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

Fish

Schools of the 'At risk – Declining' 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.

Lake Ecological Value

Based on the 2006 survey a Lake Ecological Value rating of 10 (High) was calculated. A deterioration in the rating of the following parameters: aquatic vegetation diversity and integrity (essentially a loss of submerged vegetation, with a decline of diversity from 1 to 0 and integrity from 3 to 0) and endangered species (loss of *U. australis*) has resulted in a revised score of 5 (Moderate). Water quality was not measured at this lake but water transparency had declined (Figure 3-2).

Figure 3-2: Morehurehu South April 2013 with no pine harvesting in the immediate catchment, but this lake has never-the-less gone from clear (>3 m transparency) to very dark brown (< 0.5 m transparency) as have other lake in the catchment.

Threats

Water quality impacts from catchment activities of foresters.

Access for vectors of pest species is difficult, but if introduced pest species could deleteriously impact on this lake. Forestry fertilising would have impacts on lake nutrients and clarity, although scrub vegetation may buffer much of this impact. The construction of an access road to facilitate logging has opened up this area to the public, so risk of pest introductions are heightened.

Management recommendations

Management recommendations are the same as those for Lake Morehurehu. It is recommended to undertake a full investigation of the impact of logging on Lakes Te Kahika, Te Kahika South, Morehurehu and Morehurehu South 1 and 2 (also Parengarenga Harbour). Lake monitoring annually is recommended to evaluate the rate of recovery.

3.12 Lake Ngakapua (Aupouri), NRC Lake No. 115 (South Basin) and 117 (North Basin); surveyed in 2005 and 2010

Plate: Ngakapua South Basin looking towards the North Basin separated by a bed of emergent kuta (*Eleocharis sphacelata*). Note the grazing impacts confining emergent vegetation to deeper water.

Summary

Overall ranking

Moderate-high: Predominantly native vegetation (including regionally rare and nationally endangered species) with some impact by *Utricularia gibba*, declining water quality, cattle access could disturb water birds.

Threats

Invasive pest plants pose a risk with egeria just recently introduced into adjacent Carrot Lake, indicating recent activity by a vector of spread (likely a duck shooter). Nutrient run-off from pasture/stock access threatens water quality.

Management recommendations

Fencing of lake edge is recommended. Lake native biodiversity value monitoring should be undertaken at 5 yearly intervals along with annual weed surveillance.

Description

This dune lake (North Basin; 1617479E, 6124818N, South Basin; 1617755E 6124790N) is comprised of two lake basins separated by a shallow area of reed bed and a manuka/flax island. The North Basin is 2.2 ha in size, is c. 8.2 m deep and has a pastoral and planted forest catchment. The South Lake is 6.7 ha in size, is c. 5.2 m deep and the catchment is predominantly pastoral with some scrub on the southern side. There are no inflow or outflow streams. Access is via well-formed forestry roads then a short distance across of farm land.

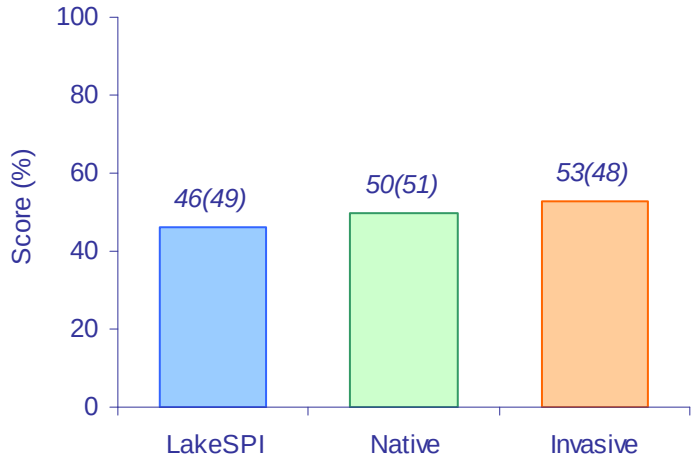
Wetland vegetation

Emergent vegetation of both basins was dominated by *Eleocharis sphacelata* extending from the lake edge (where fenced) but more commonly from 0.8 to 1 m deep to a maximum depth of ~1.8 m. This bed varied from 5 to 20 m across and formed an almost complete zone apart from the eastern part of the South Basin. *Baumea arthrophylla* and *B. articulata* were locally present. The regionally rare *Gratiola sexdendata* was found on the northern shore of the South Basin in 2005.

Submerged vegetation

Turf plants were restricted to two sites in the South Basin where the shoreward reed beds had been grazed by cattle. A high cover band of the exotic *Utricularia gibba* extending from within the reed beds to c. 3 m depth in the North Basin and to 2.0 m in the South. The remainder of the submerged vegetation was dominated by *Nitella* sp. aff. *cristata* with patchy covers of *Chara australis* to a maximum of 5.0 m depth in the North Basin and 4.5 m in the South Basin. This charophyte was usually accompanied by low covers of *Potamogeton cheesemanii*. The exotic *Juncus bulbosus* was recorded at low cover at one site in each basin. The nationally endangered *Utricularia australis* was recorded on 3 profiles in the South Basin and in 2005 the regionally significant *Triglochin striata* was recorded in shallow turfs in the South Basin but not found in 2010.

LakeSPI



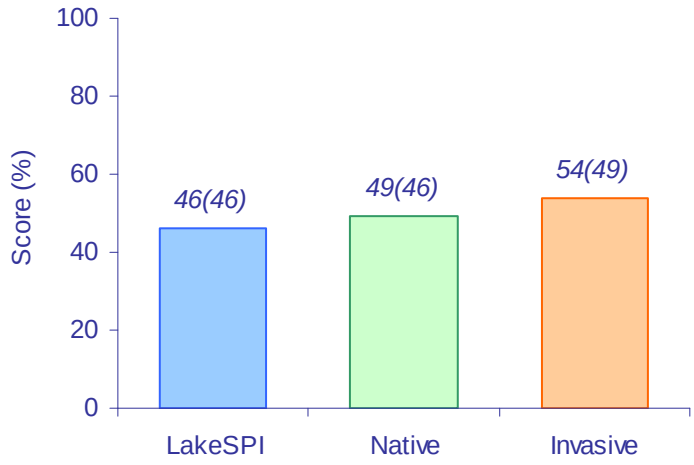


Figure: 2010 LakeSPI Index as % of potential score, Native Condition Index, and Invasive Impact Index (from left to right) for North Basin (Top) and South Basin (Bottom) with 2005 figures within brackets.

A moderately low LakeSPI score of 46% for the North Basin and South Basin reflects the limited depth extent of native vegetation and the significant presence of *U. gibba*.

Water birds

The extensive emergent vegetation provided suitable habitat for many water birds although grazing access could be a disturbance factor. The nationally endangered bittern (*Botaurus poiciloptilus*) was seen with several common birds such as black swan (*Cygnus atratus*), mallard (*Anas platyrhynchus*) and paradise shelduck (*Tardorna variegata*). OSNZ annual surveys reported the regionally uncommon dabchick (*Poliocephalus rufopectus*) and Australasian little grebe (*Tachybaptus novaehollandiae*) on most surveys (1996-1999 and 2000 respectively).

Fish

Common bullies (*Gobiomorphus cotidianus*), goldfish (*Carassius auratus*) and mosquito fish (*Gamubusia affinis*) were recorded during the vegetation survey.

Aquatic invertebrates

Freshwater mussels (*Hyridella menziesi*) were common amongst the turf community at one site sampled in the South Basin, but not in other areas. Other invertebrates seen were the introduced ramshorn snail *Planorbarius corneus*, backswimmers (*Sigara arguta*) and the leech *Richardsonianus mauianus.*

Changes in indicators

The South Lake has been sampled on five occasions since 1991. The current Secchi depth is lower than previous records (2.2 cf. >2.7 m). Current nutrient and algal concentrations are within the range or slightly higher than previously reported (TN 600-800 mg N m^{-3}; TP 14-40 mg P m^{-3}, 6-20 mg m^{-3}).

The South Basin underwent a reduction in maximum plant depth in the 2005 from between 4 and 4.3 m in previous earlier surveys to 3.0 m. However, the maximum depth was 4.4 in 2010. Vegetation limits in the North Lake decreased from 5 m in 1985 to 3.8 m in 2001, remained similar at 4 m in 2005 and was 5.0 m in 2010. The exotic *U. gibba* appeared after 2001 and is still abundant covering the charophytes in water to a maximum of 3 m deep. However, nationally endangered, *Utricularia australis* was however relatively abundant on 3 profiles, despite the dominance of *U. gibba*. The regionally significant *Myriophyllum votschii* was recorded in 1988 only.

Threats

Invasive pest plants pose a significant risk with *Egeria densa* recently introduced into adjacent Carrot Lake (Ngakapua East), indicating recent activity by a vector of spread (likely a duck shooter). Major impacts are likely should aquatic weeds be introduced.

The predominantly pastoral catchment is a likely source of nutrients, with cattle access to much of the shoreline impacting those emergent plants susceptible to grazing and trampling.

Management recommendations

Some detective work to find possible pathways for the egeria introduction into Lake Carrot could avert its introduction to these water bodies.

Retirement of the lake edges around the lake will encourage vegetation development around the margins and some interception of diffuse nutrient-runoff.

Annual weed surveillance at access points and assessment of lake native biodiversity value at 5 year intervals is recommended.

3.13 Lake Ngakeketa (Aupouri), NRC Lake No. 14; surveyed in 2005

Plate: Lake Ngakeketa showing steep scrub catchment, mobile dune (right) with outlet behind this.

Summary

Overall ranking

Low: This lake is completely dominated by the submerged pest plant *Ceratophyllum demersum* with poor water clarity and marginal vegetation.

Threats

Moderate risk of introduction and establishment of additional invasive pests. Low risk of nutrient enrichment from fertiliser application to pasture.

Management recommendations

No monitoring.

Description

The lake is situated (1578964E, 6180322N) on sand dunes, formed by a stream system impounded by dunes, and occupies 12.5 ha with a maximum depth of 8.7 m. The catchment is vegetated by native scrub (70%), pasture and pines (20%) and mobile dune (10%) near the outlet. The lake is comprised of two arms, the western arm fed by a stream flowing from the north, with the outflow obstructed by beds of emergent *Typha orientalis*, but presumably flowing into the Te Paki Stream. Access is through privately owned pasture off the Te Paki Stream Road. There are no formed tracks leading to the lake edge and no easy boat access.

Wetland vegetation

There is an almost complete (except the mobile dune face) but narrow fringe of emergent vegetation, mostly < 1 m across. This was dominated by *Typha orientalis,* with lesser amounts of *Baumea articulata* and *Eleocharis sphacelata* which grew to depths of around 1 m, or forming floating sudds extending over water 2.5 m deep.

Submerged vegetation

The submerged vegetation was dominated by the exotic *Ceratophyllum demersum* extending from shallow water to 5 m depth. Beds were up to 2 m tall. Occasional plants of *Potamogeton ochreatus* were seen amongst these beds.

LakeSPI

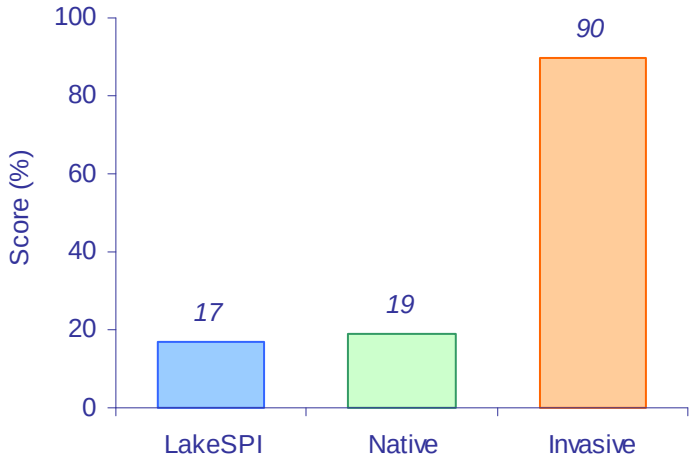


Figure: LakeSPI Index as % of potential score, Native Condition Index, and Invasive Impact Index (from left to right).

The low LakeSPI score of 17% reflects the major impact of the alien invasive *C. demersum* on submerged vegetation in the lake.

Water birds

There is limited emergent and wetland vegetation habitat, but much of the lake is inaccessible to humans and would provide good habitat for aquatic birds, evidenced by the ducklings of paradise shelduck (*Tardorna variegata*) and black swan cygnets (*Cygnus atrata*) seen on the field visit. A nationally endangered bittern (*Botaurus poiciloptilus*) was reported by DoC SSBI in 1991.

Fish

Schools of juvenile and adult mullet (*Mugil cephalus*) and bullies (*Gobiomorphus cotidianus*) were abundant in the lake.

Aquatic invertebrates

Freshwater sponges were noted encrusting submerged logs and plants.

Changes in indicators

Water quality has been sampled on only one other occasion (April 2001) when thermal stratification of the lake was not detected. The current Secchi depth is close to the previous record (1.6 m). Current nutrient concentrations differ from those previously reported (TN 350-500 mg N m^{-3}; TP 18-21 mg P m^{-3}) being lower for N and much higher for P.

Threats

The submerged vegetation of this lake is completely dominated by the submerged pest plant *C. demersum.* No pest fish or marginal weeds were recorded, and their risk of introduction is moderate to low due to the likely low usage of the lake, although access is relatively easy. Nutrient run-off from pasture fertilisation could increase the likelihood of planktonic algal blooms in the future.

Management recommendations

No monitoring or active management is recommended.

3.14 Lake north of Ngakeketa, Te Paki Lake (Aupouri), NRC Lake No. 13; surveyed in 2004 and 2009

Plate: Lake north of Lake Ngakeketa (head of Te Paki Stream), showing the forested surrounds, with pasture and mobile dunes also in the catchment.

Summary

Overall ranking

Moderate-High: The invasive weed *Egeria densa* has continued its spread throughout the lake, but has not yet completely displaced the indigenous aquatic vegetation. Lake margins are surrounded by native scrub/forest.

Threats

Egeria densa will become the dominant species displacing most of the native vegetation. Low risk of introduction of *Ceratophyllum demersum* from Lake Ngakeketa or Te Werahi Lagoon due to difficult access, but *E. densa* was presumably introduced by the same vector, an eel-fisher. Low risk of nutrient enrichment from inflow stream (partially in pasture).

Management recommendations

Lake native biodiversity value monitoring every 5 years.

Description

This lake is situated north of Lake Ngakeketa (1577791E, 6180590N) and is 12.7 ha in area with a depth >7 m. It is situated in sand dunes, formed by a stream system impounded by dunes. The lake level continues to rise as evident by the flooding and death of trees (mostly kanuka – *Kunzea ericoides*) on the margins. The catchment is cattle grazed pasture, but the steep-sided lake edges are fenced, with native kanuka dominated bush surrounding most of

the lake except for mobile dunes near the outlet stream (Te Paki or Kauaeparaoa Stream). There is a small inflow to the north of the lake. Access is through private farmland (4-WD) with no boat access to the lake apart from up the Te Paki Stream or through bush on the steep sided lake margins.

Wetland vegetation

There was an almost complete fringe of emergent vegetation (apart from the dune face), mostly narrow, about 1 m across due to the steep sided lake edges, apart from the northern area where a larger emergent band was present. Vegetation was dominated by *Eleocharis sphacelata* or *Typha orientalis* which grew to depths of 1.8 and 1 m respectively. Swamp millet (*Isachne globosa*) was also notably common amongst the emergent species. The lake level continues to raise as some marginal plants such as flax (*Phormium tenax*) and cabbage trees (*Cordyline australis*) were partially submerged and dying.

Submerged vegetation

Few areas of turf plants were present, due to high covers of emergent vegetation and the steep bathymetry. However, *Ranunculus amphitrichus* and *Myriophyllum propinquum*, *Myriophyllum votchii*, *Glossostigma elatinoides*, and *Ludwigia palustris* were noted in 2009. The pondweed *Potamogeton ochreatus* dominated the vegetation with tall (up to 2.5 m) beds extending from 0.3 to 4.4 m depth. In 2004 survey found the exotic *Egeria densa* within the mid-depth range at all profiles and up to 2.5 m tall, but with low average covers <25%. *E. densa* was more abundant in 2009, with depth range and cover increasing, although *P. ochreatus* was still common. Other submerged species included *Potamogeton crispus*, *Myriophyllum propinquum*, *Chara fibrosa*, and *Chara australis*.

LakeSPI

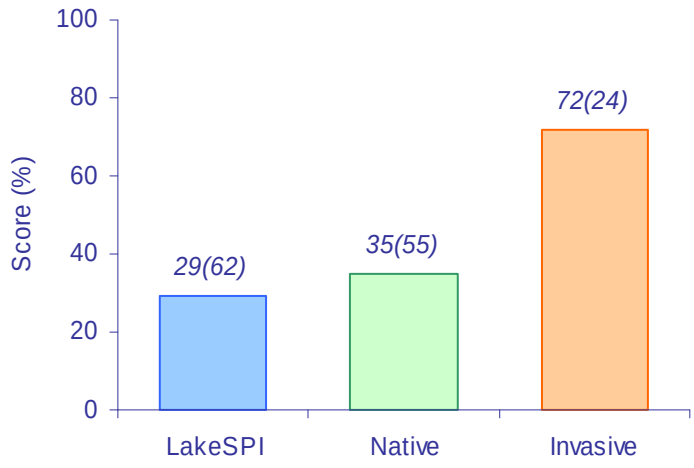


Figure: LakeSPI Index as % of potential score, Native Condition Index, and Invasive Impact Index (from left to right) for 2009 with 2004 data in brackets.

The LakeSPI score of 29% has dropped markedly from 62 in 2004 reflecting the increasing impact of the invasive *E. densa*.

Water birds

The isolated nature of the lake provided good habitat for many aquatic birds, although lack of large emergent vegetation beds would limit habitat value for some species. Marginal trees provided a nesting and roosting site for pied shag (*Phalacrocorax varius*) with nests less than 1 m above the lake level. Large numbers of paradise shelduck (*Tardorna variegata*) were also noted and some black swan (*Cygnus atratus*) and pukeko (*Porphyrio melanotus*).

Fish

Bullies (*Gobiomorphus cotidianus*) were widespread in the lake.

Aquatic invertebrates

The snail *Potamopyrgus antipodarum*, was common as were a freshwater sponges and empty shells of freshwater mussels (*Hyridella menziesi*).

Changes in indicators

This lake was sampled for the first time in November 2004. A fringe of dead trees around the lake indicated a rise in lake level, probably due to water impoundment by the mobile sand dune. *E. densa* has continued to spread within the lake and is having a much greater impact in 2009 than in 2004. The lake has been downgraded in ranking from High to Moderate-High.

Threats

The alien plant *E. densa* was only present at low covers in 2 of the 4 profiles investigated in 2004 and formed low covers throughout the depth range of submerged vegetation at those sites. This species has increased in abundance and spread to all profiles. The average cover of *E. densa* in 2009 was still less than 50% so native vegetation persists. The isolated nature of and difficult access to this lake make further introductions of other pest species (e.g., *Ceratophyllum demersum* from Lake Ngakeketa or Te Werahi Lagoon) a low probability. However, *E. densa* was introduced to the lake, presumably by eel nets.

Fertilisation of pasture near the inflow stream would result in some nutrient addition, although the fringe of emergent vegetation would reduce the level of lake enrichment.

Management recommendations

Further biosecurity Threats are low, but any further change in condition (biota) of this lake should be monitored every 5 years.

3.15 Lake Ngatu, (Aupouri) NRC Lake No. 120; surveyed in 2004, and 2010

Plate 1: Lake Ngatu from the northern boat ramp.

Summary

Overall ranking

Outstanding: Good emergent and submerged vegetation with numerous endangered biota. Pest plants and fish present, possible water quality decline.

Threats

Expansion of *Lagarosiphon major*, high risk of further species introductions, threats of eutrophication from septic tanks. The pest fish perch (*Perca fluviatilis*) was suspected in 2009, but has not been confirmed. This piscivorous species could have a major impact on other fish species.

Management recommendations

Annual surveillance of *L. major* and for new plant pests. Five yearly lake native biodiversity value monitoring. Consider *L. major* management with endothall. Eradicate alligator weed at this site.

Description

Lake Ngatu (2528991E, 6685555 N) is a large (50.3 ha) dune lake with a maximum depth of 6.5 m. The catchment is primarily manuka/kanuka scrub and fenced pasture. There are new houses overlooking the lake on the north-western fringe. There are no inlets or outlets. 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.

Wetland vegetation

Most of the lake margins still have large beds of emergent species, with up to 100 m wide beds on the eastern margin associated with islands in this area. The dominant emergent is *Eleocharis sphacelata* growing from the lake margin to 2.6 m depth, with other species including *Apodasmia similis, Baumea articulata, B. arthrophylla* and *Schoenoplectus tabernaemontani* all common. One small clump of the invasive alien *Iris pseudacorus* was removed in 2007. The nationally threatened fern *Cyclosorus interruptus* was reported from the marginal vegetation for the first time in 2007. The invasive alligator weed (*Alternanthera philoxeroides*) was noted for the first time in 2012.

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*, the nationally threatened *Trithuria inconspicua* and *Utricularia australis* (2007 not 2010), the regionally significant *Triglochin striata* (2007 not 2010), and the exotic *Utricularia gibba* and *Juncus bulbosus*. Charophytes dominated vegetation from the edge of emergent or turf communities to a maximum depth of 5.3 m. The dominant species was *Chara fibrosa* with locally dominant *Nitella leonhardii* and lesser amounts of the pondweed *Potamogeton cheesemanii*. The alien invasive *Lagarosiphon major* was recorded on 3 of the 5 profiles between 0.5 and 3.2 m, occasionally forming dense beds at the northern end. Significant areas of lagarosiphon are: c. 2 ha off the north access point, a narrow band from the waka launching area to the south beach (about 10 m x 200 m long) and a small patch (20 m x 10 m) opposite the rushes at the east end of the south beach. In 2007 and 2010 there was little change, but with less cover and height in the northern area. *U. gibba* formed an extensive smothering mat covering the *L. major* and indigenous charophyte vegetation to 3.5 m deep. Large mats of *U. gibba* with associated periphyton raft up near the water surface in autumn (Plate 2).

LakeSPI

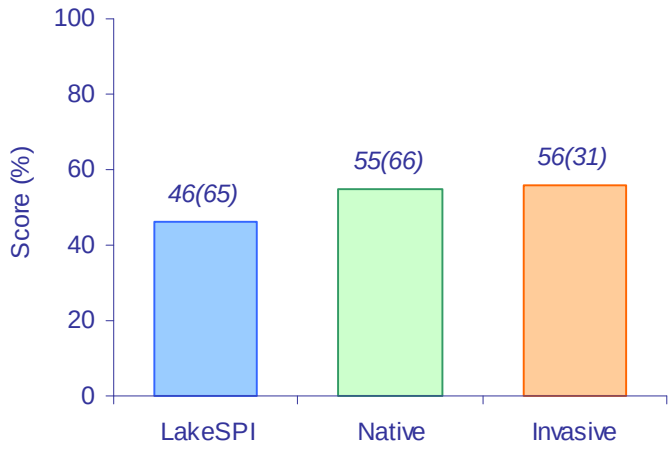


Figure: 2010 LakeSPI Index as % of potential score, Native Condition Index, and Invasive Impact Index (from left to right), Nov. 2004 in brackets.

A decrease in LakeSPI score from 65% in 2004 to 45% in 2010 was a result of increasing invasive impact from and *U. gibba*, and a decrease in native condition.

Water birds

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

Fish

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

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.

Changes in indicators

The vegetation in Lake Ngatu has been sampled since 1984 and generally the same vegetation patterns are present. *L. major* was first recorded in 1988 and its distribution in the lake is still very limited. Its rate of spread has been very slow and is limited to patches (near the marina) and an area (~330 m^2) to the east of the boat ramp. More intensive searching of the lake may find other areas. *U. gibba* is a new record for this lake (not present in 2001) and it occupies sheltered areas amongst emergent vegetation with low covers extending to 2.6 m. It had increased its abundance in 2007 (Plate 2) and was smothering other vegetation. *I. pseudacorus* is possibly eradicated from Lake Ngatu. The fern *Cyclosorus interruptus* is an additional endangered species record for this lake.

Threats

L. major may still expand further and have a greater impact. The poor growth of *L. major* in Lake Ngatu is likely due to its particular water chemistry. A change in nutrient status of Lake Ngatu driven by a change in catchment usage could lead to rapid weed growth. Other weed species, such as *Ceratophyllum demersum* are able to tolerate lower nutrient conditions and could displace all other submerged vegetation. The nearest source of this species is Lake Heather, with spread likely to occur in eel nets. 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 the lagarosiphon near the northern 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.

Algal blooms in the lake indicate a decline in lake condition.

Management recommendations

Undertake pest plants surveillance at access points for new incursions of aquatic weeds every one to two years.

Carry out 5 year lake native biodiversity value monitoring.

The slow growth of *L. major* in Lake Ngatu suggests it could be maintained at minimal levels at least in the medium term by control measures.

Plate 2: Lake Ngatu, *Utricularia gibba*, an invasive plant pictured in autumn lifting off the bottom and rafting on the surface (photo Kevin Matthews 30 May 2007).

Options for *L. major* control are:

- Diquat herbicide (subject to resource consent) will reduce the quantity of green stems markedly but will not kill the basal portion of the plant. This is probably the only practical option for the 2 hectare northern site and would assist in reducing fragments to other sites.
- Recent trials (2008) with endothall near Invercargill, have shown it can kill *L. major*, including the root crowns.
- Hand weeding is suitable for removal of individual small plants. It would only be practical in areas of low level infestation or as a follow up after spraying to reduce the area of infestation.
- Suction dredging (diver operated) can remove *L. major* at a rate of 100 m^2 per hour, and if done well with follow up can potentially remove all plants in small targeted areas. It is expensive and needs to be carried out by a competent operator to be effective. It is not a favoured options for this lake considering the large areas needing attention. It could be a useful option following targeted diquat applications.

Bottom-lining of smaller patches (coving with plastic sheets) is also now an impractical option because of the extent of the infestation.

A herbicide trial using endothall to evaluate the feasibility of eradication of *L. major* (and possible control of *U. gibba*) is recommended for Lake Ngatu. Charophyte species are tolerant of this herbicide.

3.16 Lake Ngatuwhete (Aupouri), NRC Lake No. 23; surveyed in 2005

Plate: Lake Ngatuwhete with a mostly pasture catchment, note the beds of emergent vegetation dominated by kuta (*Eleocharis sphacelata*) (middle left).

Summary

Overall ranking

Low: Shallow dammed water body with limited vegetation, possibly good wader habitat.

Threats

Little threat from invasive species, nutrient enriched.

Management recommendations

No monitoring recommended.

Description

Lake Ngatuwhete (6735915E, 1589385N) is a shallow (~ 5.1 m), dammed 8.6 ha lake with a firm iron-pan base. The catchment is primarily unfenced pasture with small areas of pines and manuka scrub. There are no inlet or outlet streams. There is a well-formed track to lakeside across 1 km of private land from the main road. Small boats can be launched from the firm-bottomed lake margins.

Wetland vegetation

Most of the margins lack emergent species, but approximately 25% of the lake margins has beds up to 10 m wide on the southern margin. The dominant emergent is *Eleocharis sphacelata* growing from 1.5 to 1.6 m depth, with lesser amounts of *Baumea articulata* and *Schoenoplectus tabernaemontani* growing in shallower water.

Submerged vegetation

Open turf communities (<10% cover) were common in areas to ~ 1.5 m deep dominated by *Glossostigma elatinoides, Lilaeopsis novae-zelandiae, Myriophyllum propinquum* and low-growing *Potamogeton cheesemanii.* On the southern vegetation profile, surface-reaching areas of the exotic *Ludwigia palustris* were noted from the shore to 0.2 m deep. Also on this profile dense bed of *Nitella* sp. aff. *cristata* extended from the emergent *E. sphacelata* to 1.8 m deep. *P. ochreatus* was also present in this area at low covers (≤5%). No other submerged vegetation was found in the 2 profiles swum.

LakeSPI

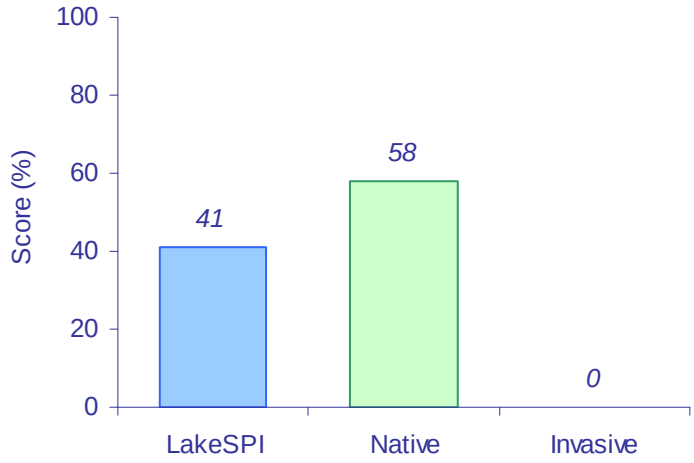


Figure: LakeSPI Index as % of potential score, Native Condition Index, and Invasive Impact Index (from left to right).

A moderately low LakeSPI score of 41% reflects the almost de-vegetated lake bed, although there were no invasive exotic species present (*L. palustris* is not ranked as invasive by LakeSPI). Profiles were limited so this LakeSPI assessment should be considered provisional.

Water birds

The large extent of shallow water may provide good habitat for wading birds. Royal spoonbill (*Platalea regia*), a regionally significant species, were recorded from this lake in 1978 (DoC SSBI). An important moulting site for paradise shelduck (*Tardorna variegata*).

Fish

No fish seen.

Aquatic invertebrates

Backswimmers (*Sigara arguta*) were common in the lake.

Changes in indicators

This lake has not been sampled previously.

Threats

Pest impacts are unlikely due to the hard bottom and shallow exposed nature of the lake.

Management recommendations

No monitoring recommended.