

### 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.

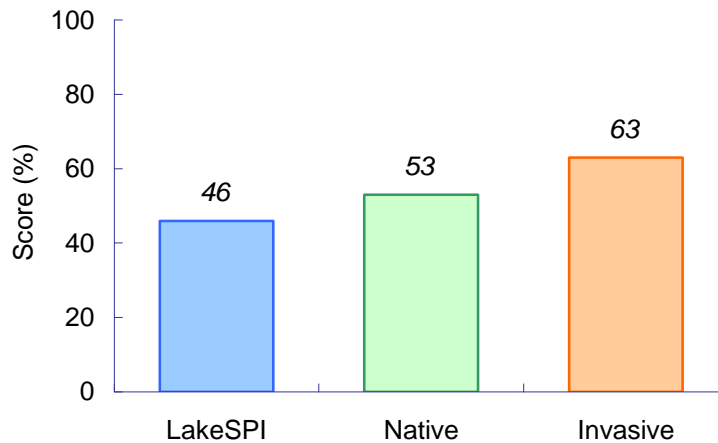
## Wetland vegetation

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 crane (*Porzana tabuensis plumbea*), dabchick (*Poliiocephalus 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 (*Poliiocephalus 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.

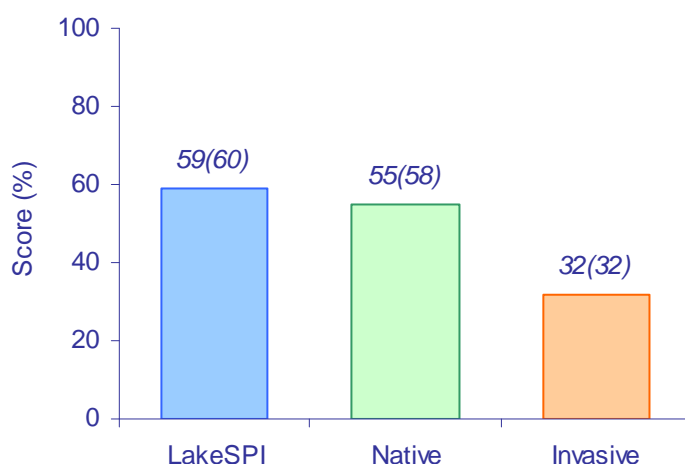
### Wetland vegetation

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 ( $\leq 0.4$  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* aff. *crinata* 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  $\sim 2$  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 (*Poliiocephalus 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  $\leq 5\%$ . Other species present then were *Potamogeton cheesemanii* in the shallows ( $\leq 0.5$  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  $\leq 5\%$ . 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<sup>2</sup>).

#### **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; surveyed in 2005 and 2008; rapid assessment in 2009 and two profiles surveyed in 2010**



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

**Summary**

***Overall ranking***

Moderate-low: The submerged native vegetation is highly impacted by exotic submerged weeds *C. demersum* and *E. densa*, but 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***

Eradicate *C. demersum* and *E. densa* from the lake using grass carp. Assess feasibility of alligator weed control/eradication. Lake native biodiversity value monitoring is recommended every 5 years and annually after grass carp introduction.



## 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

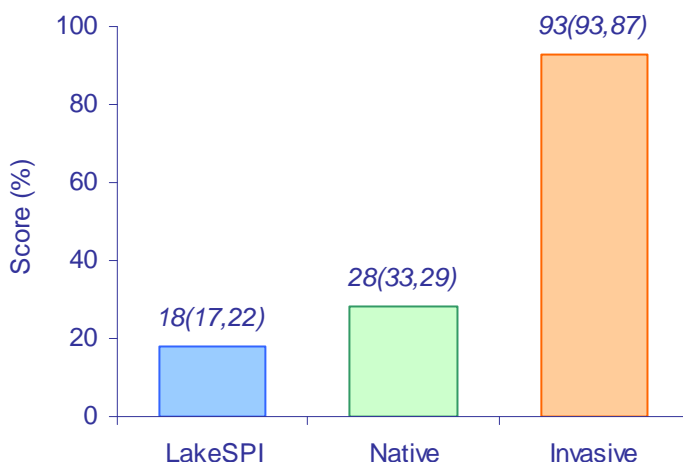
The entire lake is surrounded with emergent vegetation 5 to 20 m wide, extending from the shoreline to a maximum of 2.3 m depth. The margins have been fenced. The dominant species was kuta (*Eleocharis sphacelata*), with *Baumea articulata*, *E. acuta*, raupo (*Typha orientalis*) and *Schoenoplectus tabernaemontani* locally important. On the western edge, a low sudd dominated by *Ludwigia palustris*, *Isolepis prolifer* 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<sup>2</sup> amongst kuta and raupo in the vicinity of a maimai, and there was a crack willow cutting (April 2009), that has since been removed.

## 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 cheesemaniae* 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.

### 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.

### **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 they 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**

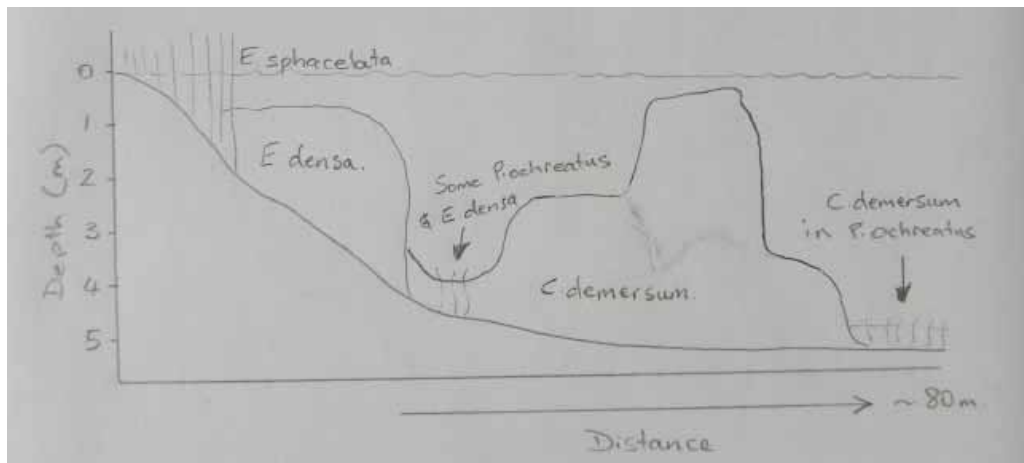
An assessment of lake native biodiversity value at 5 year intervals is recommended.

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

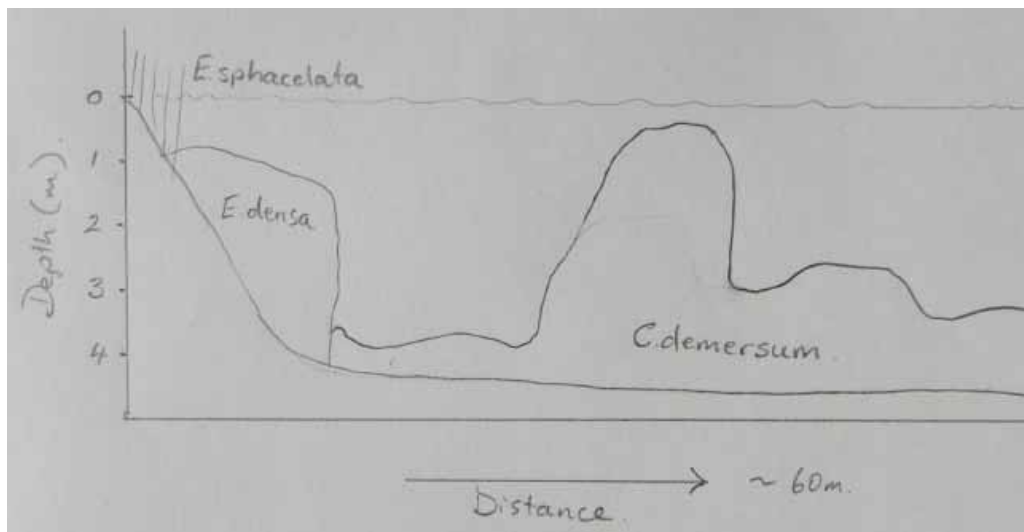
Control / eradication of *E. densa* and *C. demersum* using grass carp, with annual survey to assess their effectiveness.

### **Baseline Survey Pre-grass carp 2010**

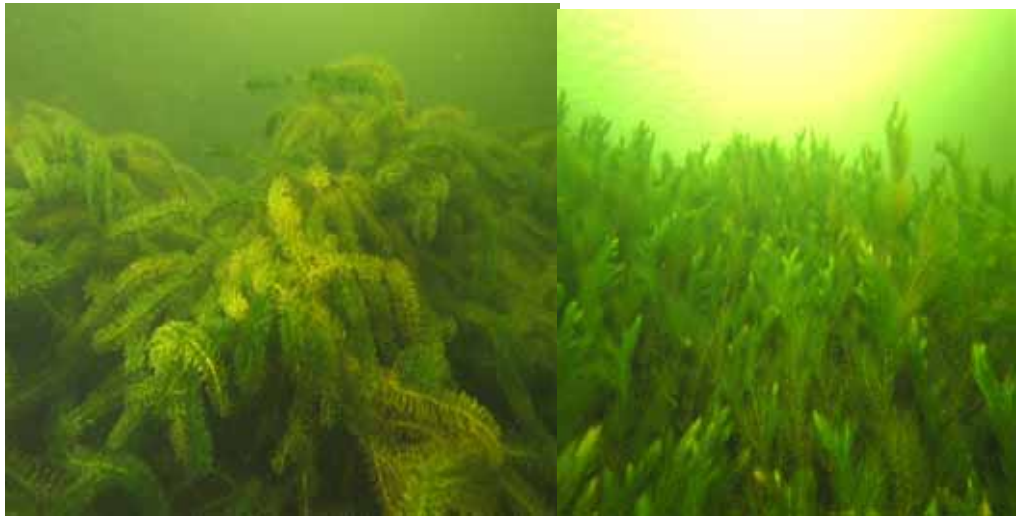
Two profiles, one representative of the north basin and one of the south basin, were surveyed by scuba divers. Unfortunately the sonar unit failed so the profiles have been drawn from diver notes (Profiles 1 and 2 below). *E. densa* formed a tall (average 2 m) band from the edge of the *E. sphacelata* to about 4 m deep around the margins of the whole lake (as in Profiles 1 and 2 and the Plate). In deeper water (> 4 m) *C. demersum* formed tall beds (4 – 5 m maximum height) reaching the surface in places as depicted in Profiles 1 and 2 and photographed in the Plate 2 below.



**Profile 1:** Stylised outline of the weed beds in Lake Heather, South Basin April 2010 (NZMG 2528650; 6683650).



**Profile 2:** Stylised outline of the weed beds in Lake Heather, North basin April 2010 (NZMG 2528340; 6683250).



**Plate 2:** Tall weed beds *E. densa* (left) and *C. demersum* (right) in Lake Heather extending to near the water surface. These plants dominate more than 90% of the open lake area and are likely to de-oxygenate the lake overnight causing fish\ invertebrate kills and nutrient release.

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 generated 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 crane (*Porzana tabuensis plumbea*). Mallard ducks (*Anas platyrhynchos*) 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

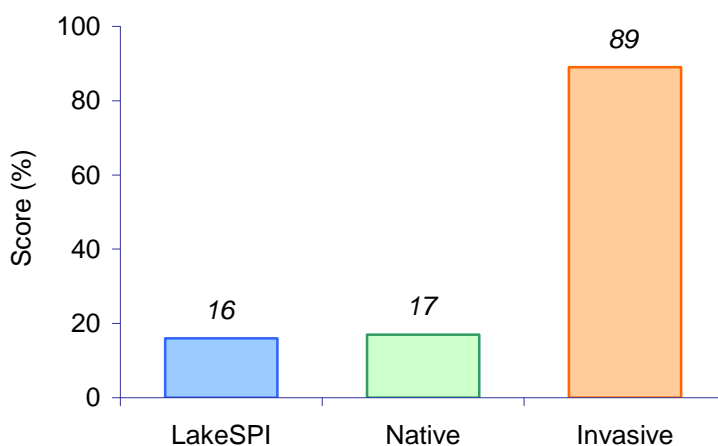
A low density margin of emergents up to 2 m across was present with *Eleocharis sphacelata* the dominant species, present around most of the lake with an average cover of about 10%, growing to a maximum depth of 2.5 m. *Typha orientalis*, *Baumea articulata*, *Cyperus ustulatus*, *Carex secta*, *Carex 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 ( $\leq 5\%$ ) 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 rhynchos*) 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

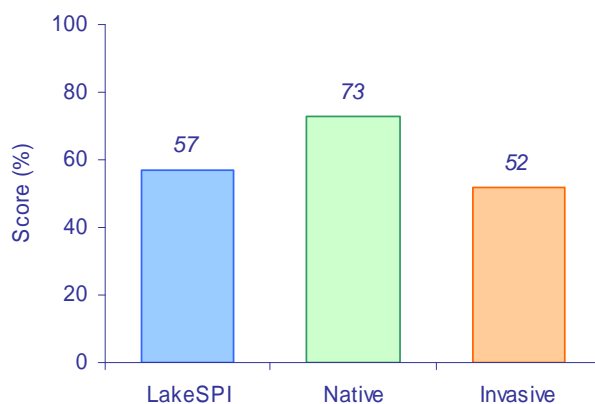
Lake Little Gem was surrounded by continuous wide beds of emergent species *Eleocharis sphacelata* growing from the lake margin to 2.6 m depth with scattered areas of *Baumea articulata*, *Phormium tenax*, *Typha orientalis* and *Leptospermum scoparium*. Within the *E. sphacelata* was *Isachne globosa*, *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 prolifer* 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* 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 (*Onychohydus 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 prolifer* 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* 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 (*Poliiocephalus 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.

**3.11 Lake Morehurehu (Aupouri), NRC Lake No. 32; surveyed in 2006 and 2009**



**Plate:** Morehurehu set in plantation pine, with extensive emergent beds.

**Summary**

***Overall ranking***

Outstanding: Remote lake with diverse native submerged and emergent vegetation including endangered species, good water quality.

***Threats***

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 weeds. Pine harvesting could impact water quality and nutrient status. 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***

Leaving the zone of scrub would offer some buffer for the lake from nutrient additions associated with logging activities. Lake native biodiversity value monitoring every 5 years.

## Description

Lake Morehurehu is a dune lake situated 1599711E, 6166691N and is 36.3 ha in area. Depth is c. 14 m. The catchment is all plantation pine trees, with a zone of manuka/hakea scrub between the lake and pines. 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) through a locked gate and permission to cross Maori-owned land is required. There is a track leading to the lake on the peninsula, however access is steep and the track is loose sand, making all but light boat access 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*, *Baumea articulata*, *B. teretifolia*, *B. juncea* and *B. arthropphylla*. The emergent fringe was wide, from 10 to 30 m across, with *E. sphacelata* the deepest growing species (to 2.0 m).

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 minus*) and umbrella fern (*Gleichenia dicarpa*). Several plants of nationally threatened status were present with *Drosera pygmaea* noted in a lake-shore turf, *Todea barbara* on lake shore banks, and *Dianella haemata* in a marginal wetland.

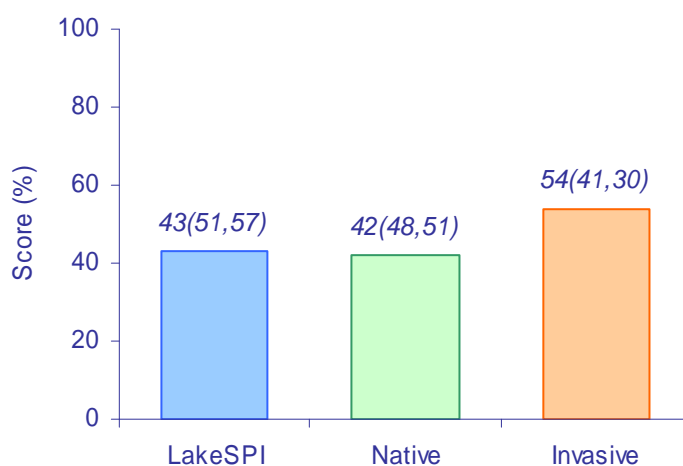
## Submerged vegetation

Turf species were not well represented as most of the margins were covered with emergent species. A diverse range of native species (9 spp.) dominated the submerged vegetation extending from the margin of emergent plants to a maximum depth of 5.3 m. *Chara fibrosa* was the dominant species, with *C. australis*, *Nitella leonhardii* and *N. pseudoflabellata* locally dominant, and the tall-growing native *Potamogeton cheesemanii* was common. The invasive exotic *Utricularia gibba* covered native species to about 4 m depth. The nationally endangered *Utricularia australis* was found on 4 of the 5 profiles, scattered throughout other vegetation to 4.6 m depth limit in 2006, but was not found in 2009.

In 2005 the lake had a moderate LakeSPI score of 57% and was driven by diverse native submerged communities but degraded by *U. gibba*, the only invasive species present. In 2006 the extent of *U. gibba* had increased reducing the LakeSPI score to

51; with the Invasive Impact Index up from 30 to 42 and the Native Condition Index down from 51 to 46 % of its maximum potential. In 2009 the Invasive Impact had further increased lowering the LakeSPI Index still further to 43%.

### LakeSPI



**Figure:** LakeSPI Index for 2009 (with 2006 and 2005 bracketed respectively) as % of potential score, Native Condition Index, and Invasive Impact Index (from left to right).

### 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 platyrhynchos*) 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

Common bully (*Gobiomorphus cotidianus*) and inanga (*Galaxias maculatus*) were seen during the 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.

### **Changes in indicators**

A 1988 vegetation survey recorded similar submerged vegetation to the current description although *Chara australis* was more abundant and extended to a maximum depth of 9.5 m. *U. gibba* was not recorded. The impact of *U. gibba* has increased from 2005 to 2006 and 2009. However, charophytes appear to persist below its dense mats, but *U. australis* was not seen in the 2009 survey.

### **Threats**

The main risks 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 to forestry or harvesting activities.

### **Management recommendations**

Leaving the zone of scrub would offer some buffer for the lake from nutrient additions associated with logging activities. Lake native biodiversity value monitoring every 5 years.

3.12 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***

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 spachelata* (growing to a depth of 2 m) but also included *Baumea juncea*, *B. arthropphylla* and *Typha orientalis*.

## **Submerged vegetation**

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

## **LakeSPI**

None generated.

## **Water birds**

Fernbirds 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.

**3.13 Lake Morehurehu South 2 (Aupouri), NRC Lake No. 36; surveyed in 2006**



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

**Summary**

***Overall ranking***

Moderate-High: A small remote lake, with high native biodiversity but also has the invasive *Utricularia gibba*.

***Threats***

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***

No monitoring.



## Description

The lake (1600485E, 6165737N) is small (0.44 ha), and 3.3m 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.

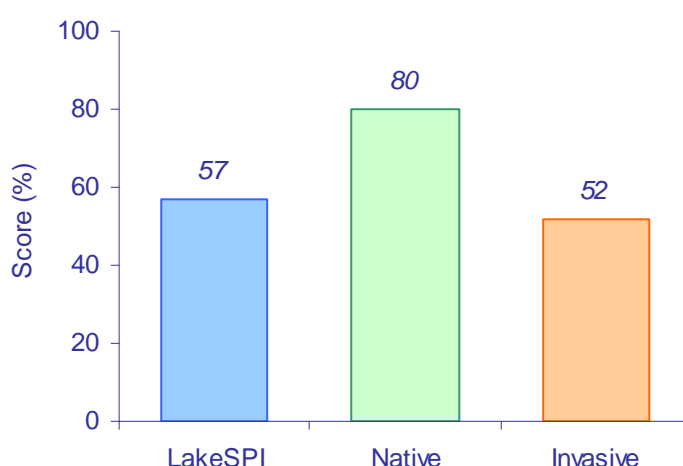
## Wetland vegetation

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*), *Baumea teretifolia* and the regionally significant *Empodisma minus* were all common marginal species. A population of the Nationally Vulnerable *Drosera pygmaea* was observed growing in a lake-side turf.

## Submerged vegetation

No turf species recorded. The regionally significant *Triglochin striata* was recorded and charophytes dominated by *Nitella hookeri* aff. *cristata* and *Chara australis* were recorded to the lake's maximum depth of 3.6 m. The tall-growing native *Potamogeton cheesemaniae* was also abundant and tall (to 3m). *Utricularia gibba* was present at high covers to 2.5 m covering indigenous vegetation over much of the lake. The nationally endangered *Utricularia australis* was found in small amounts amongst emergent vegetation.

## LakeSPI



**Figure:** LakeSPI Index as % of potential score, Native Condition Index, and Invasive Impact Index (from left to right) for 2006 with 2005 data being the same.

A moderate LakeSPI score of 57% reflects continuous charophyte meadows impacted by *U. gibba*, the only invasive species. *U. gibba* was flowering and had seed. The data is unchanged since 2005.

#### **Water birds**

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

#### **Fish**

Schools of inanga (*Galaxias maculatus*) were observed amongst the emergent vegetation.

#### **Aquatic invertebrates**

No mussels or koura seen.

#### **Changes in indicators**

Not previously surveyed.

#### **Threats**

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 is likely to 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**

No monitoring recommended.

**3.14 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.

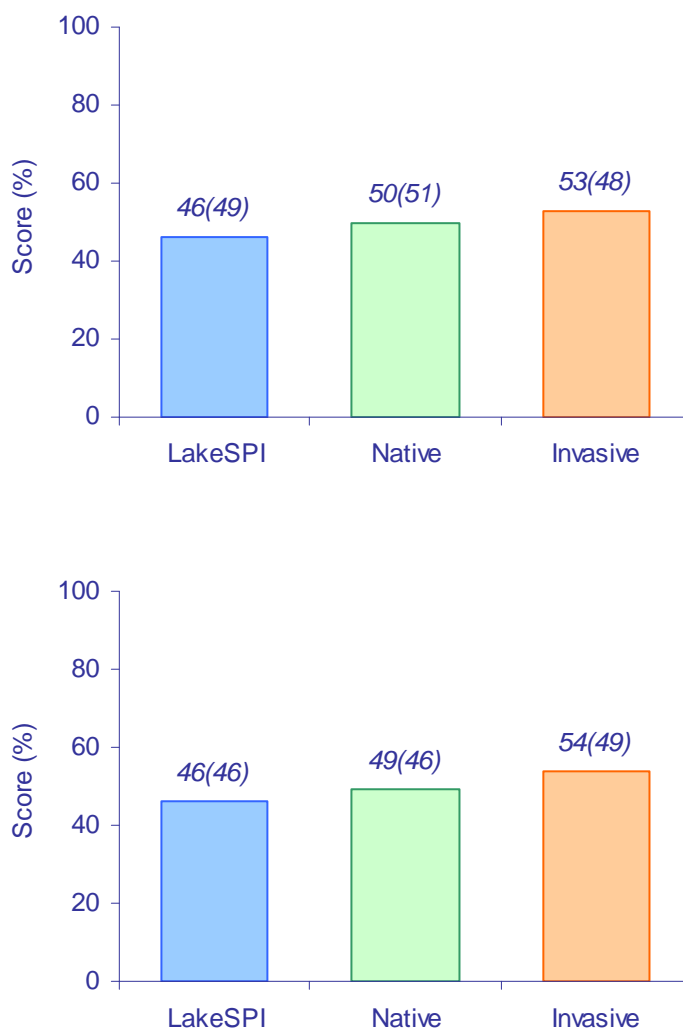
## Wetland vegetation

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 arthropphylla* 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 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 platyrhynchos*) and paradise shelduck (*Tardorna variegata*). OSNZ annual surveys reported the regionally uncommon

dabchick (*Poliiocephalus 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 (*Gambusia 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 *Planorbis 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<sup>-3</sup>; TP 14-40 mg P m<sup>-3</sup>, 6-20 mg m<sup>-3</sup>).

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.

3.15 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.

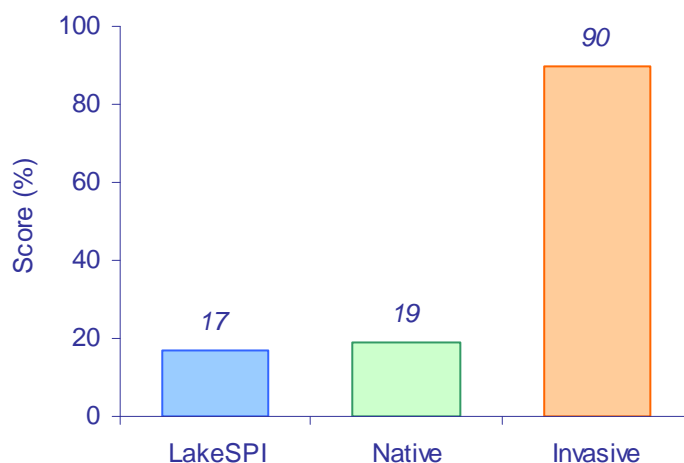
## Wetland vegetation

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<sup>-3</sup>; TP 18-21 mg P m<sup>-3</sup>) 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.

**3.16 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.

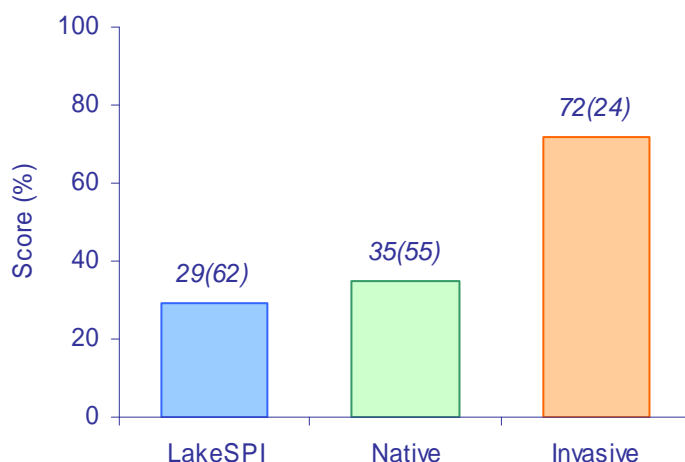
## Wetland vegetation

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.

3.17 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.

## 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

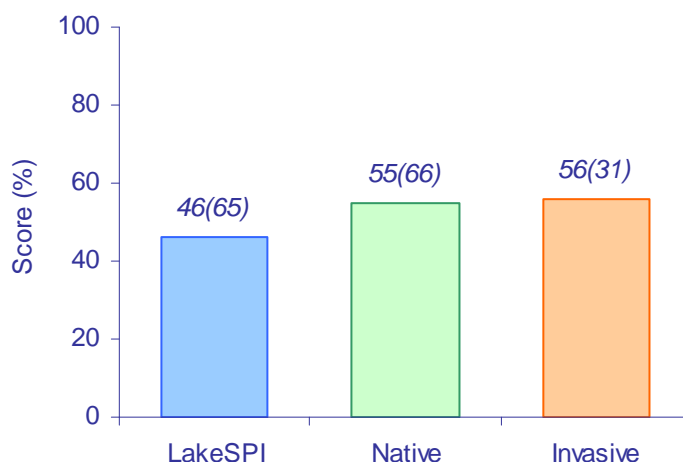
Most of the lake margins still have large beds of emergent species, with up to 100 m wide beds on the eastern margin associated with islands in this area. The dominant emergent is *Eleocharis sphacelata* growing from the lake margin to 2.6 m depth, with other species including *Apodasmia similis*, *Baumea articulata*, *B. arthropphylla* 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.

## 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 novaeseelandiae*).

## Fish

Common bullies (*Gobiomorphus cotidianus*), inanga (*Galaxias maculatus*) and the exotic pest gambausia (*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, seine and gill nets were deployed in 2010 but

only inanga, bullies, gambusia and a goldfish were caught. An attempt was made to confirm perch presence in April 2010 by overnight gill netting but only goldfish were caught. Holes in vegetation and 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 *Onychohydus 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<sup>2</sup>) 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<sup>2</sup> 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.

3.18 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.

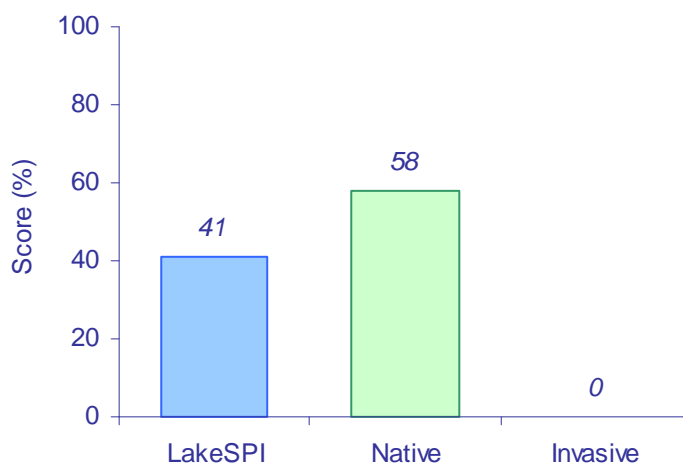
### Wetland vegetation

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* aff. *cristata* extended from the emergent *E. sphacelata* to 1.8 m deep. *P. ochreatus* was also present in this area at low covers ( $\leq 5\%$ ). 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.

**3.19 Lake Pretty (Aupouri), NRC Lake No. 24; surveyed in 2005**



**Plate:** Lake Pretty from the access point (north-eastern end of lake) showing sparse emergent vegetation.

**Summary**

***Overall ranking***

Moderate: Small shallow lake with no invasive biota, low vegetation covers, poor habitat for fauna

***Threats***

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

***Management recommendations***

No monitoring or active management.



### Description

The lake (1584443E 6173185N) is approximately 5.7 ha in area with a maximum recorded depth of 4.4 m. Catchment of plantation pine forestry on Holocene sand dune field. No inflows or outflows. Accessed through well-formed private forestry roads, no boat access.

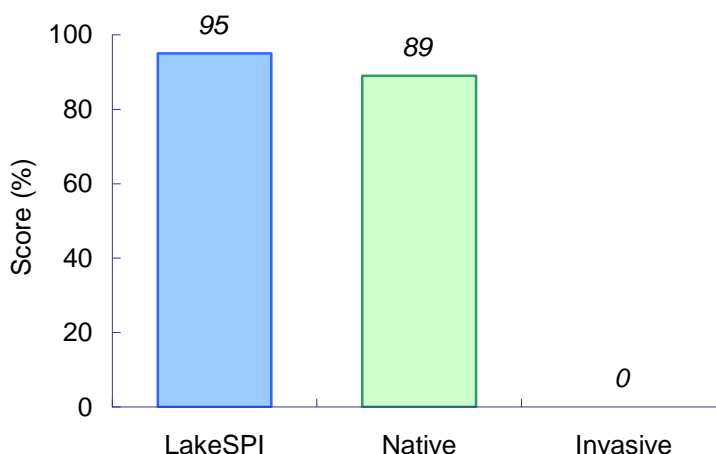
### Wetland vegetation

Mostly steep sided, with margin predominantly of kanuka scrub with rushland at access point. Emergent vegetation was sparse (30% of lake shore), forming a narrow (~1 m wide) intermittent fringe. Dominant species were *Eleocharis sphacelata*, *E. acuta*, *Baumea articulata* and *Juncus pallidus*.

### Submerged vegetation

Open turf was dominated by *Myriophyllum propinquum* from lake margin to 1.2 m deep. Below this a charophyte meadow dominated by *Nitella pseudoflabellata* in a mosaic with *Potamogeton ochreatus* extended to 3m, with scattered plants of these spp. deeper than this (to maximum depth of 4.4 m). It is the only Northland lake surveyed with *N. pseudoflabellata* dominated vegetation. No endangered or invasive plant species were found.

### LakeSPI



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

A high LakeSPI index of 95% reflects the totally native submerged vegetation present over most of this shallow lake.

#### **Water birds**

Poor water bird habitat provided by the sparse wetland vegetation. No birds seen on field inspection, with common waterbirds reported in earlier surveys.

#### **Fish**

Common bullies (*Gobiomorphus cotidianus*) frequently observed on field inspection.

#### **Aquatic invertebrates**

No aquatic invertebrates recorded on field inspection.

#### **Changes in indicators**

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

#### **Threats**

There are currently no pest plants or fish reported from this lake. The access through private forestry roads (6 km off access road) and poor boat access mean the likelihood of introduction of alien species is low, but if introduced, these could have major deleterious impacts on the lake.

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 had dropped by approximately 3 m since pines were planted in the catchment and future decreases could occur.

#### **Management recommendations**

No monitoring is recommended.