4.17 Lake Waingaro (Central Northland), NRC Lake No. 167; surveyed in 2005

Plate: Lake Waingaro showing the dam edge and planted pines.

Summary from 2001 survey

Overall ranking

Low: This artificially dammed reservoir has limited ecological value.

Threats

Probably low impact of invasive species due to steep topography.

Management recommendations

No monitoring.

Description

This reservoir (1679774E, 6097659N) is formed from a dam on the Waiwhakangarongaro Stream. The lake is 22 ha in size and over 10 m deep. Surrounding catchment is mostly pasture and forest. The reservoir is closed to the public with no boat access.

Wetland vegetation

Emergent vegetation is absent due to the steep topography and exposed nature of the lake.

Submerged vegetation

An open charophyte meadow (predominantly *Nitella pseudoflabellata* and *N.* aff. *cristata*) extended from 0.5 to 6.4 m deep with scattered plants of *Potamogeton ochreatus* emerged from this vegetation (up to 1m tall) at low density extending to 6.7 m.

LakeSPI

LakeSPI score is not generated from previous survey data.

Water birds

The restricted emergent vegetation would provide limited water bird habitat, but the lake is fairly isolated. Only common species were recorded in the recent survey.

Fish

No fish were seen. The coarse fish tench (*Tinca tinca*) was recorded on the NIWA FBIS database.

Aquatic invertebrates

No invertebrates were recorded.

Threats

Lake Waingaro is very unlikely to have any weed introductions under current management conditions because there is no public access. *Egeria densa* was sampled in neighbouring streams and dams but should this or other weeds establish the probable impact would be low due to steep topography.

Management recommendations

No monitoring.

4.18 Lake Waiporohita (Karikari), NRC Lake No. 99; surveyed in 2005 and 2011

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

Summary

Overall ranking

Outstanding: Although water quality is variable and often poor, and the pest plant *Alternanthera philoxeroides* is common, this lake contains nationally endangered plants and birds with an indigenous submerged vegetation. The first New Zealand records for four vagrant Australian plants have been made here.

Threats

Significant potential for pest plant impacts. Already nutrient enriched with frequent algal blooms, but no deterioration apparent since 2004.

Management recommendations

Annual pest plant surveillance monitoring. Lake native biodiversity value assessment monitoring every 5 years.

Description

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

Wetland vegetation

There were areas of emergent vegetation around the northern end of the lake, mostly up to 20 m across, with bare iron pan in the remaining areas. Dominant species were *Typha orientalis* with an outer fringe of *Eleocharis sphacelata*, with other areas of *Schoenoplectus tabernaemontani, E. acuta* and *Apodasmia similis*. The first record of *Gratiola pedunculata*, probably a natural introduction from Australia (de Lange 1997), was made at this lake in 1996 and found again in exposed grass/herb land between tall emergent vegetation. Other species present were *Alternanthera denticulata* (also an Australian vagrant), *Paspalum distichum* and *Centella uniflora*. In 2007 *A. denticulata* had expanded its range over much of the lake margin growing on the lakeward side of some emergent vegetation. The hybrid introduced willow weed *Persicaria lapathifolia* x*persicaria*, previously only collected from the Waikato was recorded in 2007. The nationally endangered grass *Amphibromus fluitans* was collected in 1998 but not seen since.

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

A 2 m^2 patch of alligator weed (*Alternanthera philoxeroides*) was noted in 2005 at the north end where the access point was. In 2011 this area had increased and it was also found amongst much of the marginal emergent vegetation.

A species of rush *Juncus polyanthemus* not previously recorded from New Zealand, was recognised growing in the marginal vegetation of Lake Waiporohita in 2009. This plant looked like a robust form of J. usitatus and was previously overlooked. It is likely to be another Australian vagrant. de Lange et al. (2011) have recently published the first New Zealand record of the minute herb *Crassula natans* var. *minus* at Lake Waiporohita. It is a winter annual and was not seen during the March 2011 visit.

Submerged vegetation

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

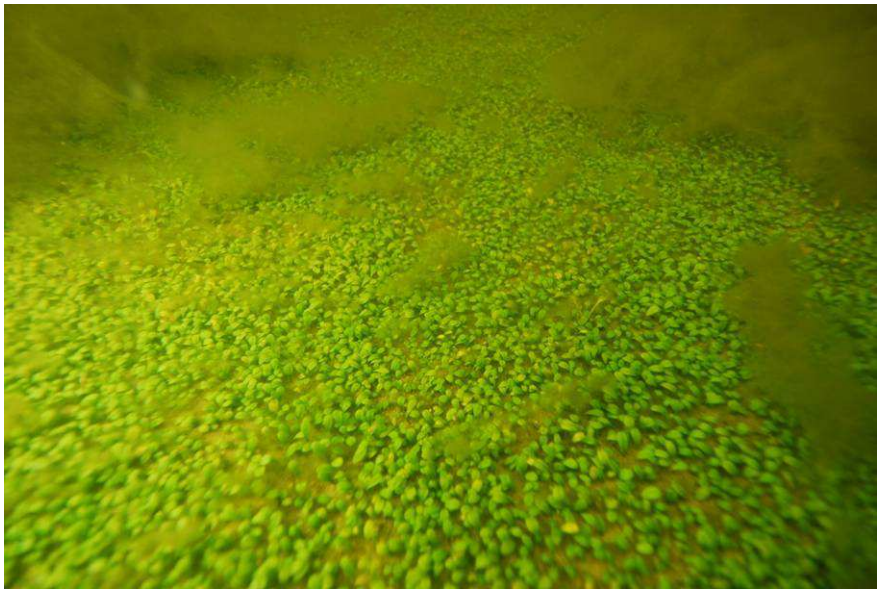


Plate: Submerged turfs of *Glossostigma elatinoides* in Lake Waiporohita.

LakeSPI

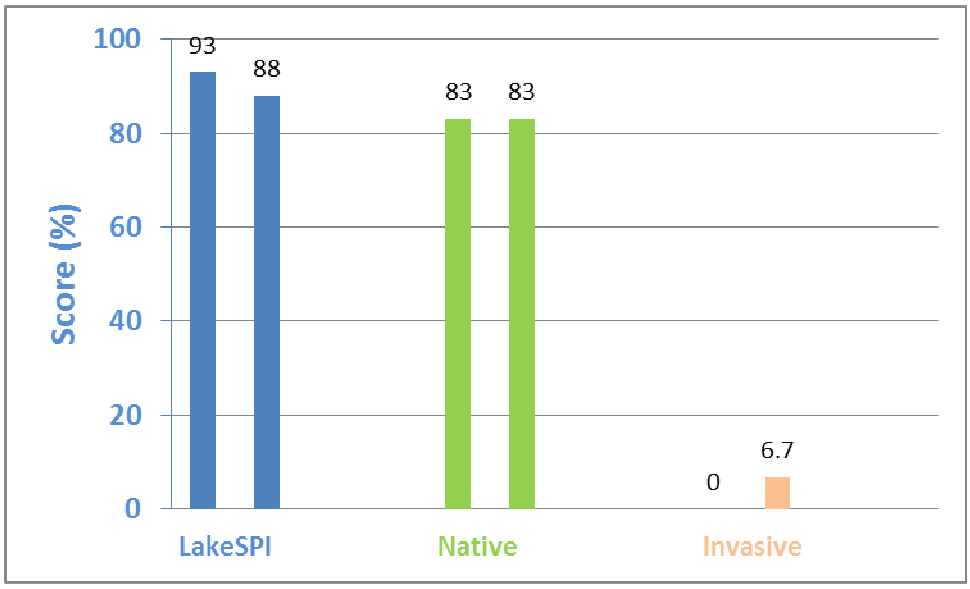


Figure: 2011 LakeSPI Index for Lake Waiporohita as % of potential score, Native Condition Index, and Invasive Impact Index (from left to right). 2005 values shown first then 2011.

The excellent LakeSPI score of 88% (Figure 3-3) reflects the extent of the native vegetation, with no influence of invasive exotic species. The invasive impact increased from 0 to 6.7 is due to *Utricularia gibba* appearing since last surveyed albeit in small amounts restricted to shallow water.

Water birds

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

Fish

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

Aquatic invertebrates

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

Changes in indicators

A vegetation survey in 1991 recorded similar species to the 2005 survey, however dominant charophytes changed but vegetation extent remained the same. In 2011 *Chara australis* was co-dominant with *Potamogeton ochreatus* in deeper vegetation, with no record of *Nitella* sp. aff. *cristata*. *C. australis* was only present in areas shallower than 1 m in 2005, although the vegetation bottom limit of ~3 m was similar.

Threats

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

Alligator weed has now spread around the lake in the marginal vegetation and is likely to increase in abundance over time, especially in nutrient enriched areas. Unfortunately, the opportunity to eradicate this plant as recommended when a 2 m^2 patch in 2005 has been lost (Champion et al. 2005). Eradication is now not feasible without considerable off-target damage to endangered plant species present at this lake. Water is nutrient enriched and algal blooms frequent.

Management recommendations

Annual pest plant surveillance monitoring.

Lake native biodiversity value assessment monitoring every 5 years.

4.19 Lake Waro (Hikurangi) Lake No. 410; surveyed in 2006 and 2011

Plate: Lake Waro is a recreational park and used for contact recreation, particularly swimming. It is not used for boating, but is a prime site for further pest liberations.

Summary

Overall ranking

Moderate: Water quality is good but with an anoxic layer now present below 5 m. There is a dense vegetation cover, with the pest plant *Egeria densa* common throughout the lake and high covers of *Utricularia gibba* to 4 m water depth.

Threats

High potential for additional pest fish and plant introductions.

The lake water was black and indicative of anoxia below the 5 m thermocline. Dense growths of nuisance weed are likely contributing to the anoxia but the catchment inputs should also be checked for high nutrients sources. Anoxic bottom waters will lead to sediment nutrient release and deteriorating water quality, threatening the safety of human contact during recreational activities.

Management recommendations

Delimit the E. densa in the catchment and then consider grass carp to eradicate it and stop the excessive build-up of organic matter leading to anoxia and sediment nutrient release.

Lake native biodiversity value monitoring every 5 years.

Description

This lake (2627470E 6623010N) is a 4 ha lake, just a little over 5 m deep. The surrounding catchment is reserve with a refuse dump, some pasture and residential development. Access is by road but no power boating is permitted. It is used for contact recreation with distance swimming popular.

Wetland vegetation

There were two wetland areas at each end of the lake and a margin around most of the rest of the lake. The main species were *Typha orientalis* and *Eleocharis sphacelata*. There was a small patch of the invasive giant reed *Arundo donax*. In 2011 there were large patches of dead emergent vegetation, indicating that these had been illicitly sprayed with herbicide (E. Simpson, NRC pers. comm.).

Submerged vegetation

The whole lake floor was vegetated to 5 m deep but then there was no light and putrefying plant material to the maximum lake depth of 6 metres. There was a diverse native community with charophyte meadows dominated by *Chara fibrosa* and *Nitella* sp. aff. *cristata*. Tall growing natives, *Potamogeton cheesemanii* and *Myriophyllum propinquum* with some *Potamogeton ochreatus* were present. However there was also a blanket of the invasive *Utricularia gibba* to 4 m water depth and significant growths of the oxygen weed *Egeria densa* through the lake.

The plants were large-leaved and quite robust, probably reflecting the higher calcium content of water in this limestone quarry.

The plants were large-leaved and quite robust looking; *Potamogeton cheesemanii* left and *Myriophyllum propinquum* on the right photographed in 2006 when the water was much clearer.

LakeSPI

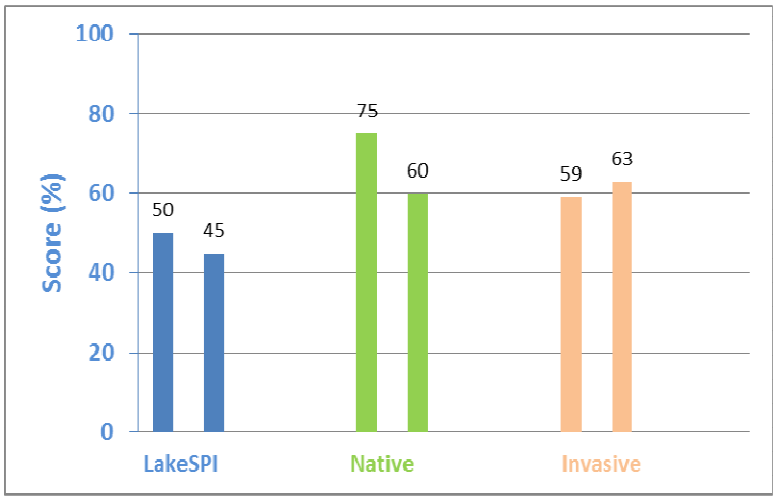


Figure: LakeSPI Index for Lake Waro as % of potential score, Native Condition Index, and Invasive Impact Index (from left to right). 2006 scores are shown first then 2011.

The decrease in the moderate LakeSPI score from 50 % to 45 % reflects the increasing extent of invasive exotic species *Utricularia gibba* and *Egeria densa* and retracting bottom limits likely due to anoxia. A high native condition index still exists but is expected to deteriorate further. Increased biomass of *E. densa* contributing large amounts of detritus must be adding to the biological oxygen demand (BOD) loading to the lake.

Water birds

Spotless crake, geese, domestic ducks have been noted during surveys.

Fish

A silver (migratory) shortfin eel and abundant gambusia were seen in 2011.

Aquatic invertebrates

Ramshorn snail and mollusc-feeding leeches were abundant in 2011.

Changes in indicators

In 2006 the lake water was very clear and aerobic to its maximum depth of nearly 6 metres and plants grew right across the lake bottom. The lake is changing rapidly and *E. densa* now forms dense growths through a lot of the lake and the hypolimnion is anoxic. Vegetation bottom limits have also retracted. Nutrient release associated with anoxia is a significant threat to water quality in the lake.

Threats

Water quality is threatened by stratification and anoxic bottom waters releasing nutrients from bottom sediments. Dense growths of *E. densa* and *U. gibba* will add more organic matter to the lake increasing BOD. There may also be other significant catchment sources of nutrients to the lake that require investigation. The ease of access to this lake gives it a relatively high likelihood of additional submerged weed transfer. Species such as *C. demersum* would drastically impact the lake. Alligator weed would also spread and dominate marginal vegetation.

Further nutrient enrichment could render the lake a health hazard to swimmers.

Management recommendations

Monitor and interpret water quality data. Aim to determine the cause and prevent anoxia in the bottom waters of the lake.

Annual pest plant surveillance monitoring.

Lake native biodiversity value monitoring every 5 years.

Remove the *Arundo donax*.

4.20 The Whau Dam (central and east Northland) NRC No. 206; first visit 2008

Plate: The Whau Dam (left) and looking away from the dam (right).

Summary

Overall ranking

Low: Steep sided artificial lake of low ecological value.

Threats

None identified.

Management recommendations

No monitoring recommended.

Description

The Whau Dam (1716550E, 6047511N) was a steep sided dam constructed for domestic water supply. The area was accessed by public road with gated access to the car park. The catchment was native bush.

Wetland vegetation

No wetland margin.

Submerged vegetation

Native species dominated with *Potamogeton ochreatus* the most abundant tall-growing species, with *Myriophyllum triphyllum* and *M. propinquum* and *P. cheesemanii* also present. A charophyte meadow of *Nitella* sp. aff. *cristata* grew from 2 to 4.2 m deep.

Water birds

None seen.

Fish

None seen.

Aquatic invertebrates

None seen.

Changes in indicators

This was the first time this lake has been surveyed.

Threats

The dam was of very low ecological value and is unlikely to deteriorate further.

Management recommendations

No further monitoring.

Threats

As there was no boat access, the risk of invasive weed spread is limited and furthermore the rocky substrate and steep sides was not suited to extensive submerged weed beds.

Management recommendations

No monitoring recommended.

5 Kai-iwi and north Dargaville lakes

5.1 Freidrich's Lake (north Dargaville), NRC Lake No. 282; surveyed in 2005

Plate: Freidrich's Lake showing the artificially maintained area of open water evidenced by the straight line of emergent kuta (*Eleocharis sphacelata*).

Summary

Overall ranking

Low: A shallow, modified lake in a pasture catchment.

Threats

The only lake surveyed south of Kaitaia with the invasive weed *Utricularia gibba*. This site is thus a possible threat to other waterbodies in the vicinity. *Alternanthera philoxeroides* may spread further and have a major impact in the future. Further pest incursions are unlikely.

Management recommendations

No lake native biodiversity value monitoring recommended.

Description

A small (3.5 ha) dune lake (1668632E, 6022433N), only 2-3 m deep. Pasture catchment grazed by cattle to lake edge in some areas, fenced elsewhere. No inflows or outflows. Access is across private farmland, and can be reached by 2WD in dry weather.

Wetland vegetation

Eleocharis sphacelata was the dominant emergent vegetation and would fill the lake if the owner had not sprayed it. The straight edge to the E. sphacelata beds was taken as evidence of spraying, presumably for duck hunting purposes. Biodiversity has been enhanced by this action as it creates habitat for submerged species. The invasive weed *Alternanthera philoxeroides* was well established amongst marginal kikuyu (*Pennisetum clandestinum*).

Submerged vegetation

No turf species, the submerged vegetation was dominated by *Chara australis* and there were two native tall-growing species, *Potamogeton cheesemanii* and *P. ochreatus*. Plants grew across the deepest parts of the lake to less than 3 m deep. The exotic bladderwort *Utricularia gibba* was common in areas to 1 m deep where it sprawled over other vegetation. One shoot of the nationally endangered *Utricularia australis* was found.

LakeSPI

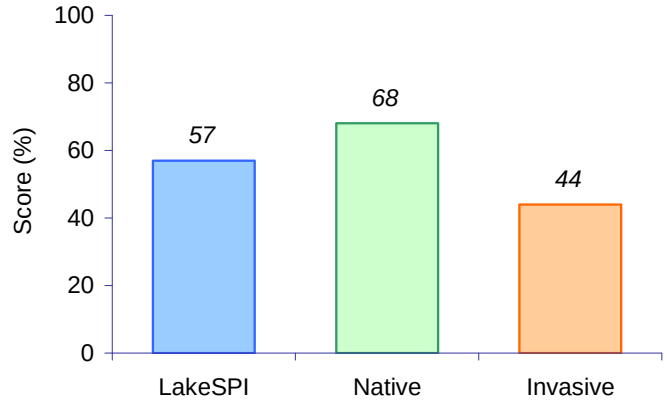


Figure: LakeSPI condition as % of potential score, native index, and invasive index from left to right.

The moderate LakeSPI score of 57% reflects the presence of the invasive *U. gibba* and its impact on native submerged vegetation. Profiles were limited so this LakeSPI assessment should be considered provisional.

Water birds

The areas of emergent vegetation provides moderate waterfowl habitat, with black swans (*Cygnus atratus*) and mallard (*Anas platyrhynchus*) the only species seen. There are 1980's records of the nationally threatened bittern (*Botaurus poiciloptilus*) and regionally important dabchick (*Poliocephalus rufopectus*).

Fish

Several shortfin eels (*Anguilla australis*) were seen.

Aquatic invertebrates

Freshwater sponges were noted on submerged vegetation.

Changes in indicators

This lake has no previous survey information.

Threats

A. philoxeroides and *U. gibba* were present, and both can be very invasive. Their impact on this lake was minimal at the time of survey but could increase in the future.

Tall-growing exotic pest weeds have potential to invade this lake if introduced, but risk of introduction is minimal.

The lake is unsuitable for boating, but eel fishing and shooting activities are likely.

Management recommendations

No monitoring for lake native biodiversity value required.

5.2 Lake Kai-iwi (Kai-iwi Lakes) NRC Lake No. 236; surveyed in 2005, 2007 and 2011

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

Summary

Overall ranking

Outstanding: A native plant dominated lake, with *U. gibba* the only pest plant species present, and nationally rare plants present.

Threats

Low risk of inadvertent pest plant introductions but subsequent impact is likely. Easy access allows deliberate pest introductions (e.g., coarse fish and weeds). High impact from Gambusia affinis has contributed to the possible extirpation of the nationally threatened dwarf inanga.

Management recommendations

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

Continue to deny trailer access to the lake.

Continue catchment nutrient controls.

Description

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

Wetland vegetation

Most of the lake had a 3 - 10 m wide margin of emergent vegetation, with *Apodasmia similis, Baumea arthrophylla* (especially on the exposed eastern shore). *B. articulata* and *B. juncea* were common in shallow water up to 0.7 m deep and an outer zone of *Eleocharis sphacelata* extending up to 2.6 m deep in one transect.

Submerged vegetation

Turf plants occurred to 2 m depth in several locations with the nationally rare *Trithuria inconspicua* and two other species. Charophyte meadows extended from < 2 m to 12.6 m and were dominated by *Chara australis* and *C. fibrosa* to c. 9 m depth. *Potamogeton cheesemanii*, a native tall-vascular plant, frequently occurred at low covers to about 4 m water depth. The invasive *Utricularia gibba* was common growing to 9 m deep.

LakeSPI

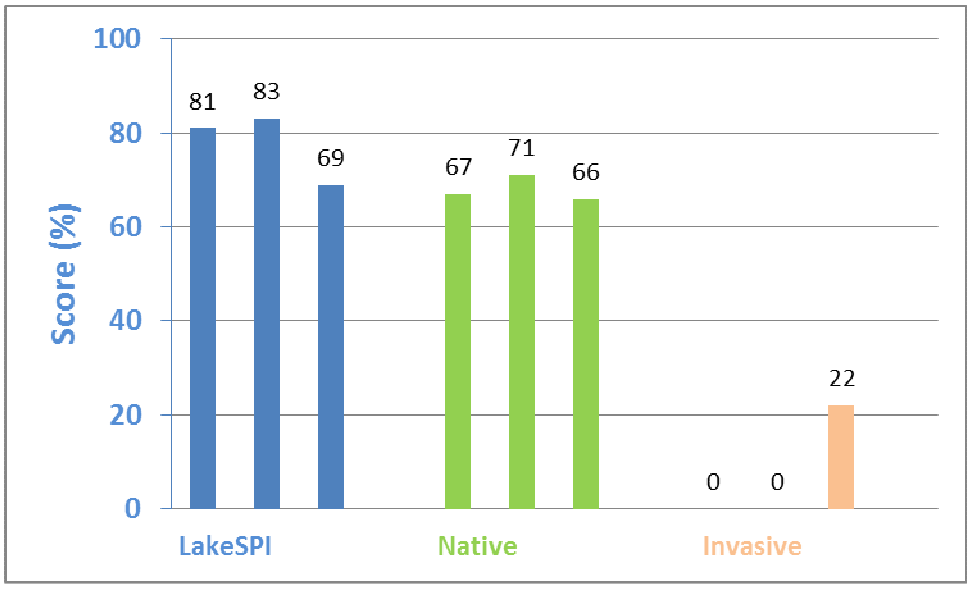


Figure: 2011 LakeSPI Index for Lake Kai-iwi as % of potential score, Native Condition Index, and Invasive Impact Index (from left to right) with 2005; 2007, 2011 values shown respectively.

The excellent LakeSPI score in 2007 of 81% reflected the extent of vegetation development, the presence of several key native plant communities and absence of invasive exotic species. However, in 2011 *U. gibba* impacts reduced the LakeSPI score to 69% and increased the invasive score to 22%.

Water birds

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

Fish

Native fish records include common bullies (*Gobiomorphus cotidianus*) and dwarf inanga (*Galaxias gracilis*), although this nationally endangered species may be extinct in this lake. Exotic fish present include *Gambusia affinis*, rudd (*Scardinius erythrophthalmus*), and a stocked population of rainbow trout (*Oncorhynchus mykiss*).

Aquatic invertebrates

Invertebrates were abundant in the lake. No freshwater mussels (*Echyridella menziesi*) were seen, but empty shells have been noted in previous surveys.

Changes in indicators

Fluctuations in the maximum depth of vegetation from 11.5 to 15 m depth are known from previous surveys. It is likely related to periods of anoxia in bottom waters, when conditions favour the establishment of a thermocline.

U. gibba was recorded to 9 m for the first time, downgrading the overall LakeSPI score from 'excellent' to 'high'. However *U. gibba* is at low covers and not threatening to displace native plants.

Threats

The lack of motorised boat traffic to this lake reduces the risk of pest introduction. However conditions in this lake are suitable for the establishment and growth of large vascular weeds, so if pest plants were introduced they would be expected to establish and impact on lake values to a significant extent. Impacts of *U. gibba* need monitoring, as it is no longer restricted to shallow-water sites amongst emergent vegetation.

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

The recent removal of pines has not appeared to impact on the lake.

Management recommendations

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

5.3 McEvoy's Lake (north Dargaville) NRC Lake No. 277; surveyed in 2005

Plate: McEvoy's Lake showing the pasture catchment and impacts of cattle access.

Summary

Overall ranking

Low: No submerged vegetation, cattle access has displaced emergent vegetation to deep water, *Gambusia affinis* present.

Threats

Few Threats due to already degraded habitat.

Management recommendations

No Management recommendations apart from cattle exclusion.

Description

A small (1 ha), probably shallow (depth not ascertained) dune lake (1666781E 6023612N) situated in a pasture catchment. There is an inflow at the south-eastern end of the lake linking with a smaller waterbody further up-stream. The outlet on the western side flows to the west coast approximately 2 km north of the lake. Access is through private land on a well-formed track, but boat access would be difficult due to pugged, muddy margins.

Wetland vegetation

The dominant emergent species was *Eleocharis sphacelata* which formed a 3 to 5 m wide zone, excluded from the lake edge by cattle grazing/trampling. A zone of exposed turf plants was occasionally seen including *Myriophyllum propinquum* and *Potamogeton cheesemanii*.

Submerged vegetation

No submerged vegetation was observed.

LakeSPI

Reconnaissance only – no LakeSPI score generated.

Water birds

Poor aquatic habitat with disturbed grazed lake margin, poor emergent vegetation and no submerged vegetation. No birds were seen.

Fish

Poor aquatic habitat, *Gambusia affinis* common around the margins.

Aquatic invertebrates

No invertebrates were sampled.

Changes in indicators

This is the first time the lake has been surveyed.

Threats

Access is through private land, and the current lake condition is not conducive for submerged plant growth, therefore risk of introduction and establishment is low. The pest fish *G. affinis* is established in the lake. The lake is severely degraded, with turbid water.

Management recommendations

No monitoring recommended.

5.4 Midgley's Lake (north Dargaville), NRC Lake No. 257; surveyed in 2005 and 2011

Plate: Midgley's Lake 2011 showing the pasture and pockets of plantation pine catchment with remnant emergent vegetation remaining after grass carp introduction in 2007.

Summary

Overall ranking

Low (previously was moderate-high): Small lake with contiguous native submerged vegetation including a large population of the nationally endangered *Utricularia australis*, but has been de-vegetated since grass carp were introduced.

Threats

Isolated lake with access through private land would make introduction of pest species unlikely, but impact would be high. A steep catchment, but the inflow stream enters the lake through a dense wetland and provides a nutrient stripping function.

Grass carp are incompatible with native lake values. If the fish are all removed the native values might be restored. However, the nationally endangered *U. australis*, which does not appear to produce seed in New Zealand, may well be lost.

Management recommendations

Remove the grass carp.

Lake native biodiversity value monitoring every 5 to 10 years.

Description

A small (2 ha), shallow (3 m) dune lake (1664168E 6028159N) situated in a pasture catchment with a small wood lot of pines on the northern side. There is an inflow at the eastern end of the lake entering through a dense wetland area. The outlet on the western side flows to the Moremonui Gully on the west coast approximately 2.5 km south-west of the lake. Access is through private land across pasture, and boat access would be difficult due to the steep lake margins.

Wetland vegetation

The past dominant emergent species were *Eleocharis sphacelata* and *Typha orientalis* that formed extensive beds over 30% of the lake wide zone. *E. sphacelata* grew to a maximum depth of 2 m but has been substantially reduced by introduction of high density grass carp. A zone of exposed turf plants bordered the lake, including the native *Myriophyllum propinquum* and *Glossostigma elatinoides* and the exotic *Ludwigia palustris*, was not at risk from grass carp. The invasive weed *Alternanthera philoxeroides* (alligator weed) is present on the property (landowner pers. comm.) so risk of future spread to the lake is high.

Submerged vegetation

At the profile site, turf species extended to 0.5 m including dense areas of J. bulbosus. The 2005 dominant submerged vegetation was an extensive bed of *Chara australis* extending from 0.6 to 3 m, with patches of the taller (approximately 1 m tall) *Potamogeton ochreatus*. The nationally endangered *Utricularia australis* was also common in shallow water in the vicinity of the inlet, with scattered plants elsewhere in the lake.

In 2011, apart from the turf species and a few stunted *Chara australis* plants, all submerged vegetation has been removed by grass carp.

LakeSPI

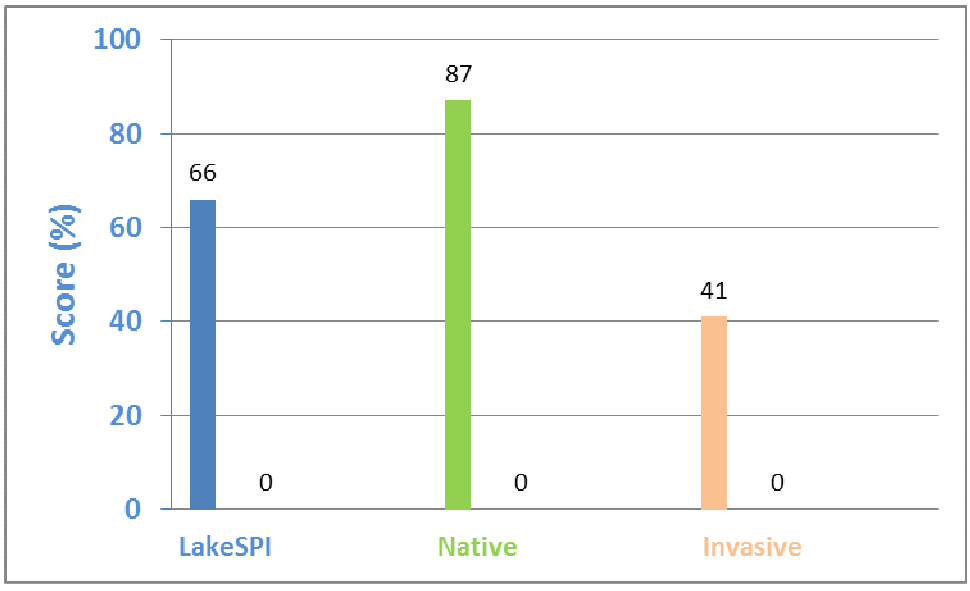


Figure: 2005 LakeSPI Index as % of potential score, Native Condition Index, and Invasive Impact Index (from left to right) in 2005 prior to grass carp introduction. A default score of zero was generated in 2011 as there was no submerged vegetation > 5%cover.

Previously, a high LakeSPI score of 66% reflected native vegetation values, including extensive charophyte meadows but impacted by dense stands of the invasive exotic J. bulbosus to depths of 1 m. In 2011 a LakeSPI score of 0% was generated as submerged vegetation cover was <10%.

Water birds

In 2005 good aquatic habitat was provided by the emergent vegetation. Areas of dense emergent plants provide ideal habitat for crakes and rails. Common water birds were noted with 12 mallard (*Anas platyrhynchus*) and 3 black swan (*Cygnus atratus*) seen. One bittern (*Botaurus poiciloptilus*) (nationally threatened) was observed in the eastern area. OSNZ recorded regionally important dabchick (*Poliocephalus rufopectus*) in 1991. These values are at risk with continued grass carp grazing and removal of submerged and emergent vegetation.

Fish

No fish apart from grass carp were observed in the lake. On June 24th 141 grass carp were removed from the lake using nets (J. Fulcher, NRC pers. comm.). It is not known how many remain, but there could be up to 100.

Aquatic invertebrates

The introduced *Physa acuta* snail was common amongst submerged vegetation.

Changes in indicators

2005 was the first time this lake had been surveyed. Grass carp have a huge impact on lake values by removing all vegetation (except turf species).

Threats

Grass carp in this lake are an on-going threat to the native ecological values of the lake if insufficient numbers have been removed to allow vegetation recovery.

Access through private land, therefore risk of introductions is low but should pest species be introduced, their impact is likely to be great (when grass carp are absent). The lake is moderately enriched, and some nutrient stripping role is performed by wetland/emergent vegetation. Water quality measurements indicate nitrogen sensitivity (NRC data) so application of fertiliser to pasture in the immediate catchment could lead to increased algal blooms/decrease in water clarity. Access to the lake by livestock is also a threat to water quality and marginal emergent vegetation.

Management recommendations

The lake is apparently being managed as a pond for duck shooting with no regard to native biodiversity values including rare plants and birds (*Utricularia australis* and bittern). There was no exotic invasive threat that would warrant use of grass carp and alternative methods are available to maintain open water areas free of emergent plants.

Lobby DOC to reconsider its position in supporting the use of grass carp in this lake or in other similar inappropriate situations.

Monitor vegetation recovery annually and if no recovery, attempt additional grass carp removal. Lake native biodiversity value monitoring every 5 to 10 years.

Pest species are only likely to be introduced through deliberate introduction or contaminated nets from eel fishing. Inform the land owner of these risks.

Fencing the lake perimeter will reduce the risk of alligator weed introduction via cattle, promote marginal species development, and reduce nutrient inputs.

5.5 Shag Lake (Kai-Iwi), NRC Lake No. 221; surveyed in 2005 and 2010

Plate: Shag Lake showing grazing to the lakeshore.

Summary

Overall ranking

Moderate: A nutrient rich lake with no significant invasive aquatic plants and submerged vegetation to 6.9 m; cattle access has displaced emergent vegetation to deep water, bullies, eels and *Gambusia affinis* present.

Threats

Susceptible to submerged vegetation loss.

Management recommendations

Retire the margins and encourage emergent species. Look at ways to reduce nutrient inputs. This lake has much potential.

Description

A 15 ha dune lake (1654908E 6039010N) with a maximum depth of 12 m, situated in a pasture catchment. There was a small inflow at the south-eastern end of the lake but no outlet. Access is through private land via paddocks, boat access requires a 4-WD.

Wetland vegetation

The dominant emergent species occupying <20% of the shoreline was *Eleocharis sphacelata,* which formed a 3 to 15 m wide zone, extending to depths of 2 m but excluded from the lake edge (depths less than 1 m) by cattle grazing/trampling.

Submerged vegetation

The turf species *Lilaeopsis novae-zelandiae* and *Glossostigma submersum* were present in less than 1.3 m depth. *Chara australis, Potamogeton cheesemanii* and *P. ochreatus* were the most common species with maximum depth of vegetation extended to 6.9 m with average overall covers of about 50%.

In 2005 the submerged vegetation was much less with all profiles having median average covers of ≤5% and a bottom limit of plant colonisation of only 4.5 m.

LakeSPI

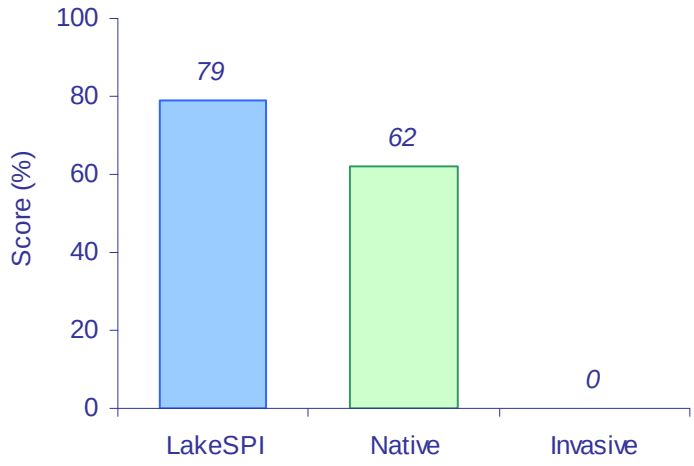


Figure: 2010 LakeSPI Index as % of potential score, Native Condition Index, and Invasive Impact Index.

A high LakeSPI score of 79% reflects the predominance of the native macrophytes community with no invasive impact. LakeSPI score was zero, the default score as there was insufficient submerged vegetation (<10% on a majority of profiles). This indicates the fragile balance that this lake is in.

Water birds

Poor aquatic habitat with mostly disturbed, grazed lake margins, limited emergent vegetation. Black swans (*Cygnus atrata*) were seen in 2001. The nationally threatened bittern (*Botaurus poiciloptilus*) and regionally important dabchick (*Poliocephalus rufopectus*) and Australasian little grebe (*Tachybaptus novaehollandiae*) were recorded in the late 1970's-1991. The lake was then regarded as an important refuge for birds disturbed from the Kai-iwi lakes when used for water skiing. It appears that the habitat provided by this lake was severely degraded in the 1990's but has recovered somewhat since the 2004 survey.

Fish

Bullies (*Gobiomorphus cotidianus*) observed in 2001 and also in 2010 along with large numbers of eels holes and the odd eel. NIWA FBIS reports both longfin and shortfin eels (*Anguilla dieffenbachii* and *A. australis*), bullies and the exotic *Gambusia affinis,* as present in Shag Lake.

Aquatic invertebrates

Pea mussels (*Sphaerium novaezelandiae*) and backswimmers (*Sigara arguta*) were recorded in 2001 and 2010.

Changes in indicators

The number of submerged species noted in 1984/85 and 1988 was 9 and 10 respectively, compared with 6 in 2001. In addition to the lower number of species seen in 2001, the plant cover and maximum depth colonised had reduced markedly over that time (from >95% to < 10% and 6.5 to 4.5 m). The 2010 survey results are encouraging with vegetated depth limits restored and a marked increase in submerged vegetation cover to around 50%.

Threats

The current lake condition is marginal for good submerged plant growth. The lake is prone to nutrient enrichment and could also be threatened by liberation of pest fish and plants. The pest fish *G. affinis* is established in the lake. Access is through private land so recreational boating is not a strong pressure on this lake; introductions would be more like to come from eel fishers with contaminated nets or duck shooters thinking pest plants would enhance the habitat.

Management recommendations

This lake would be suitable for enhancement, by retiring and planting the margins and considering ways to reduce pastoral enrichment of water.

5.6 Lake Taharoa (Kai-iwi) NRC Lake No. 229; surveyed in 2005, 2007 and 2011

Plate: Lake Taharoa shoreline at the south end showing the motor camp in 2011. Note the exposed beach and paucity of emergent vegetation and the pine trees have been removed.

Summary

Overall ranking

Outstanding: Probably the best example of a clear-water lake in Northland, with the deepest recorded (24 m) submerged vegetation in the North Island.

Threats

Invasive species: high risk of pest plant introduction, but impact likely to be low. High risk of pest fish impacts.

Rudd could enter the lake from Lake Kai iwi through the connecting drain during high water levels.

Catchment: moderate with nutrient enrichment to be avoided.

Management recommendations

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

Consider ways of preventing rudd movement through the connecting drain from Lake Kai-iwi.

Description

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

Wetland vegetation

Much of shore was wave exposed, with hard iron pan and compacted sand that is unsuitable for emergent vegetation. Low covers (25%) of oioi (*Apodasmia similis*) and *Schoenus brevifolius* were present in places, and seedlings of *Eleocharis sphacelata* were also observed at one site. Species recorded have included *Baumea arthrophylla, Baumea articulata, Baumea juncea, Eleocharis acuta, Eleocharis sphacelata, Ficinia nodosa, Isachne globosa, Isolepis prolifera, Juncus pallidus* and *Typha orientalis*. The nationally 'at-risk' *Centrolepis strigosa* was also found in the marginal turf of this vegetation in 2010 (first known collection from the Kai-iwi Lakes since the 1980's) and found in the same location in 2011.

Submerged vegetation

Sparse turf plants grew on the shallow (0-1 m) sandy substrates of the wave-cut shelves and included the nationally rare *Trithuria inconspicua* and regionally significant *Triglochin striata*. The exotic rush, *Juncus bulbosus*, was also recorded in these areas and small amounts of *Utricularia gibba*, but it was limited to isolated plants. Steep slopes immediately beyond these shelves were largely devoid of plants from 1 to 6 m. Charophyte meadows, dominated by *Chara fibrosa*, extended from < 4 m to 24 m water depth.

LakeSPI

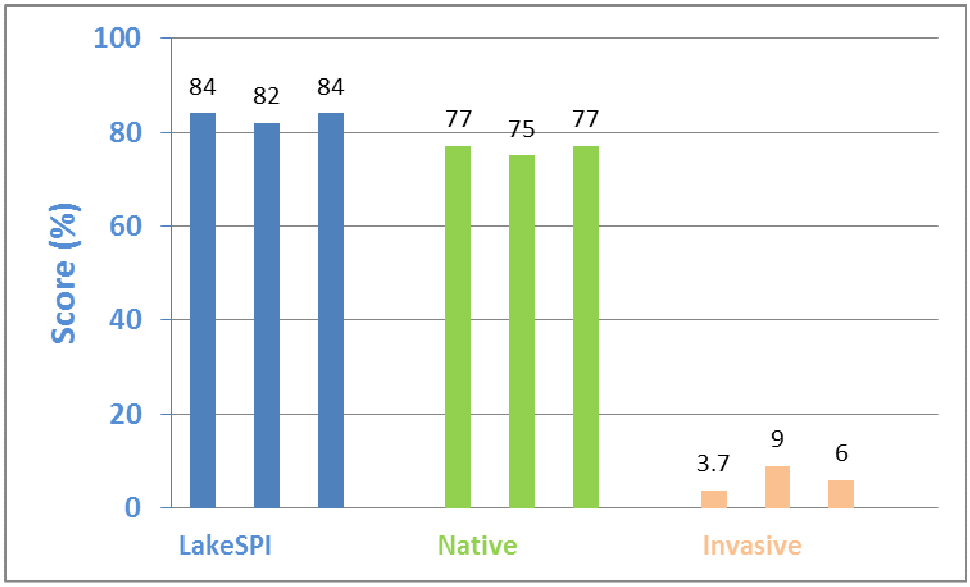


Figure: 2011, LakeSPI Index for Lake Taharoa as % of potential score, Native Condition Index, and Invasive Impact Index. 2005, 2007 and 2011 values shown respectively from left to right.

An excellent LakeSPI score of 84% reflects the depth of vegetation extent, the predominance of the native charophyte community and the limited impact by invasive exotic plants. Lake condition remains excellent and very stable.

Water birds

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

Fish

Native fish sighted during surveys include common bullies (*Gobiomorphus cotidianus*), while the exotic pest gambusia (*Gambusia affinis*) were also observed. Previous surveys have recorded shortfin eels (*Anguilla australis*), and rainbow trout (*Oncorhynchus mykiss*) have been stocked. The nationally threatened dwarf inanga (*Galaxias gracilis*) was last recorded in 1999.

Aquatic invertebrates

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

Changes in indicators

Lake condition has remained very stable. The depth extent of the high cover C. fibrosa meadows has varied between 18 and 25 m between vegetation surveys and is currently 24 m. This measure will be a sensitive baseline for future assessments of long-term water clarity and probably reflects the extent the lake has recently been thermally stratified. The nationally significant species, *T. inconspicua*, was recorded on two previous surveys as well as presently, while regionally significant *Myriophyllum votschii* (last recorded in 1987) was rediscovered. The exotic rush, *J. bulbosus* was recorded at similar abundance to previous surveys.

Threats

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

The pest fish gambusia is known to harass some native fish and could threaten the endangered dwarf inanga, and is implicated in the extirpation of this fish from the adjacent Lake Kai-iwi.

Nutrient loading from the catchment is of greatest threat, with potential sources from vegetation management and livestock. Such changes in water chemistry could facilitate pest plant establishment.

Management recommendations

Pest plant surveillance at access points annually.

Lake native biodiversity value monitoring every 5 years.

Seasonal sampling targeting the summer stratification and autumnal mixing period is recommended to gauge the duration, and extent of stratification and oxygen concentrations in bottom waters.

5.7 Te Riu (Waipuoa), NRC Lake No. 409; surveyed in 2006 and 2011

Plate: Te Riu Lagoon, showing the west half of the lagoon left and eastern on the right.

Summary

Overall ranking

High: A predominantly native lake with the nationally endangered *Utricularia australis*, and the only pest plant present being *Utricularia gibba*.

Threats

Biosecurity, low risk of pest plant introduction but subsequent impact likely to be high. Catchment: sand dune forestry is likely the cause of lower water levels.

Management recommendations

Lake native biodiversity value monitoring every 5 years.

Description

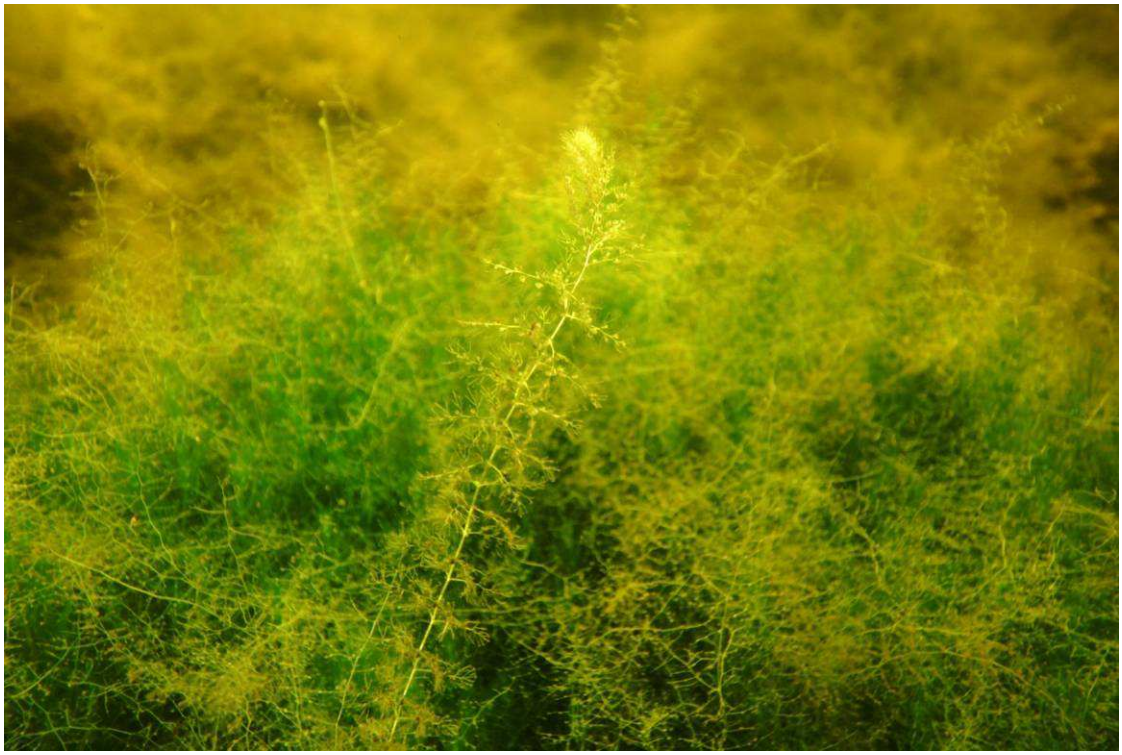
The lake (2555191E, 6613202N) is 4.4 ha in area with a maximum depth of 3.7 m. It is only accessible by 4 WD via forestry roads and a rough sandy track. It is long and narrow and open water is not continuous between the eastern and western basins. The catchment is pine plantation with some scrub.

Wetland vegetation

The lake is fringed with wetland plants, predominantly *Eleocharis sphacelata, Baumea articulata, B. arthrophylla* and some *Typha orientalis* and *Schoenoplectus tabernaemontani*.

Submerged vegetation

Most of the lake is vegetated with charophytes growing down to 3.5 m, the maximum depth of the lake being 3.7 m. *Chara australis* was the dominant charophyte present and formed continuous meadows with some tall growing *Potamogeton cheesemanii* and the nationally endangered *Utricularia australis*. Dense mats of the exotic *U. gibba* co-existed with this vegetation. Small patches of *C. fibrosa* and *C. globularis* were found in the northern basin.



The nationally endangered *Utricularia australis* co-existing with dense mats of the exotic *U. gibba* in Te Riu Lagoon.

LakeSPI

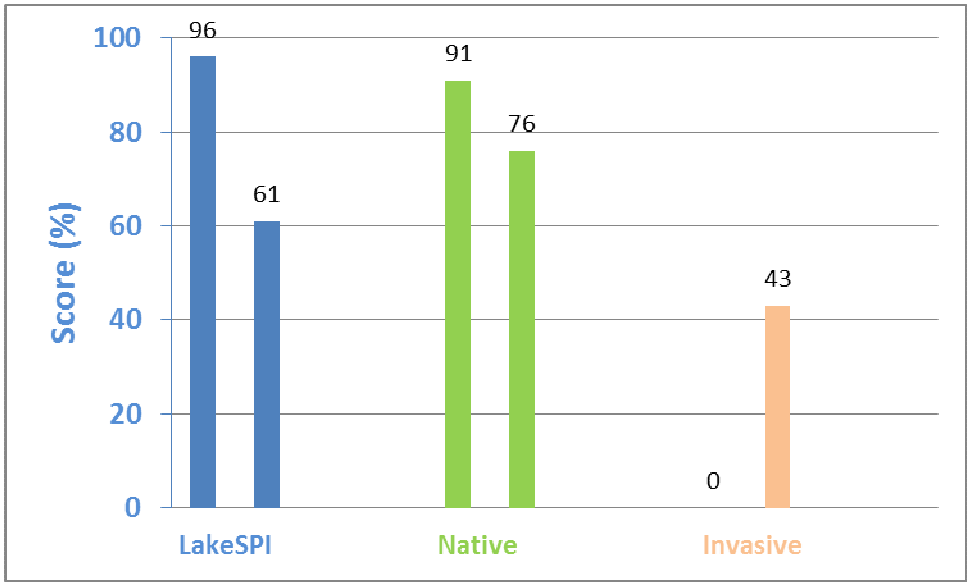


Figure: LakeSPI Index for Te Riu lagoon as % of potential score, Native Condition Index, and Invasive Impact Index (from left to right) with 2006 then 2011 values shown.

The large reduction in LakeSPI index from an excellent 96% to a high 61%, and increase in invasive values of 43% highlight the significant impact that U. gibba has had in this lagoon.

Water birds

None noted.

Fish

A shortfin eel (*Anguilla australis*) was seen. Bullies were abundant, many with distended abdomens symptomatic of an intestinal endoparasitic cestode or trematode species (only previously observed in Lake Karaka). Dwarf inanga were released by DOC into this lake (A. MacDonald, DOC Northland pers. comm.), but none were noted despite extensive searching.

Aquatic invertebrates

No mussels or koura noted, but *Physa* were abundant.

Changes in indicators

An excellent LakeSPI Index 96% in 2006 was driven by high native cover over most of the lake and no invasive species. The invasive species *U. gibba* present in 2011 at such high densities throughout the depth range of the vegetation has had a large influence on degrading the LakeSPI score to 61% and raising the Invasive Index from 0% to 43%. However all the native species are still present and of similar abundance to 2006, but smothered by entangling mats of U. gibba.

Threats

Low water levels threaten the survival of this lagoon, which was much larger in the past. Access is difficult and so pest introductions are unlikely but would displace the native vegetation if this occurred.

Management recommendations

Lake native biodiversity value should be monitoring every 5 years.

5.8 Waikare (Kai-iwi Lakes) NRC Lake No. 227; surveyed in 2005, 2007 and 2011

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

Summary

Overall ranking

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

Threats

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

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

Management recommendations

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

Description

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

Wetland vegetation

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

Submerged vegetation

Turf plants were not abundant due to the predominance of iron pan reefs around the lake, but include the nationally rare *Trithuria inconspicua*. Isolated plants of the exotic rush*, Juncus bulbosus* were also recorded in shallow areas. Charophytes comprised the remainder of the vegetation. Dense charophyte meadows were present from < 2.5 m to 16.5 m depth, with *Chara fibrosa* dominant in the upper profile and *C. australis* solely from 13 m to a maximum recorded depth of 19 m. *U. gibba* was recorded from between 11 and 16 m, the deepest record yet for this invasive species. One small patch of the native *Potamogeton ochreatus* was noted near the boat ramp in 2012. This may indicate increased nutrients in that area.

LakeSPI

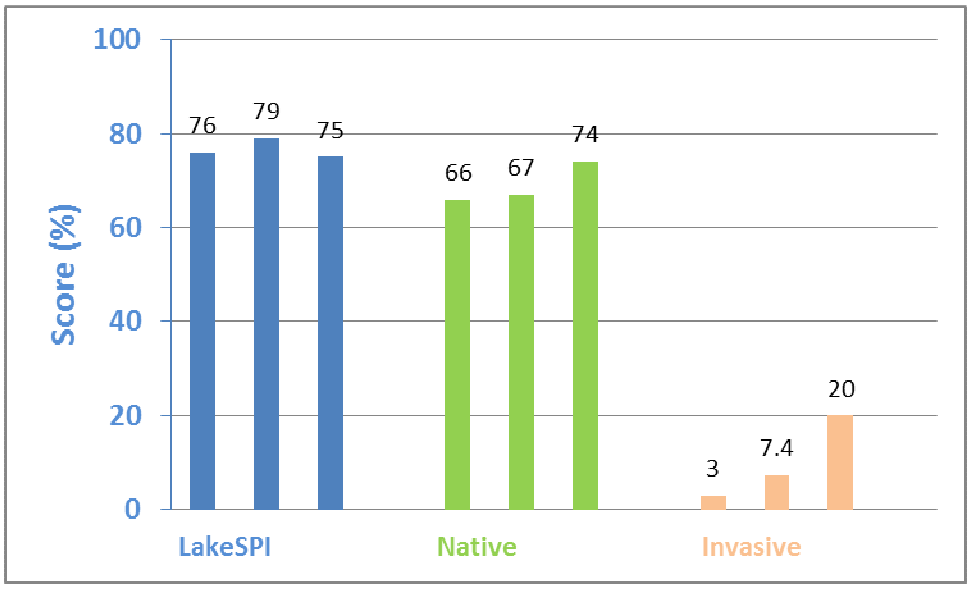


Figure: LakeSPI Index for Lake Waikare 2011 as % of potential score, Native Condition Index, and Invasive Impact Index (from left to right) with 2005, 2007 and 2011 values shown respectively.

An excellent LakeSPI score of 75% was driven by the large extent of native vegetation and presence of charophyte meadows with little impact from invasive exotic plants. Deep-growing *U. gibba* is a new observation for New Zealand and has increased the Invasive Index of this lake from 3% to 20%.

Water birds

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

Fish

Native fish records include common bullies (*Gobiomorphus cotidianus*) and dwarf inanga (*Galaxias gracilis*), shortfin eel (*Anguilla australis*) and longfin eel (*Anguilla dieffenbachii*). Large pelagic schools of juvenile bullies were noted at several sites. Exotic fish present were gambusia (*Gambusia affinis*), common in shallow areas, and a stocked population of rainbow trout (*Oncorhynchus mykiss*).

Aquatic invertebrates

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

Changes in indicators

The vegetation remains similar to previous surveys, including the abundance of the nationally rare *T. inconspicua*. The exotic *J. bulbosus* has been present since at least 1985 and does not impact on the ecology of the lake. The depth for charophyte meadows has changed (21 m in 2011 increasing from 16.5 m in 2005) but is likely due to the thermocline rather than epilimnion water clarity.

Potamogeton ochreatus was noted near the boat ramp in 2012 and may indicate increased nutrient enrichment in that area.

U. gibba was found for the first time growing from 11 – 16 m deep at mostly low covers but it was not displacing the native vegetation it was associated with.

Threats

The ease of access and high boat traffic to this lake results in a very high risk of pest plant introduction, however the subsequent impacts would be low. Water chemistry currently limits the development of large vascular plants, and pest plants are unlikely to establish, but changes in water quality parameters could increase the likelihood of pest plant establishment. However, *C. demersum* may be able to thrive in this lake.

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

Management recommendations

Pest plant surveillance should be carried out at access points annually.

Lake native biodiversity value should be monitoring every 5 years.

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

5.9 Lake Waingata (Waipoua) NRC Lake No. 200; surveyed in 2006

Plate: Lake Waingaata.

Summary

Overall ranking

High: An all native plant lake, but with low covers due to steep bathymetry.

Threats

Biosecurity, low risk of pest plant introduction because it is remote and access difficult
Catchment: moderate risk of increased nutrient loading with forestry nutrient additions.

Management recommendations

Lake native biodiversity value monitoring every 5 years.

Description

The lake (2555791E, 66137496N) is accessible via forestry roads, then by walking down a steep bank through pine plantation. No outflows are apparent.

Wetland vegetation

The lake had a fringe of emergent vegetation dominated by *Eleocharis sphacelata* in a band 2- 5m wide. At one end there was a 5 metre wide bed of *Baumea articulata* and at the other a 10 metre wide bed of *B. arthrophylla*. *B. juncea* and *Isachne globosa* were also present.

Submerged vegetation

The *Eleocharis sphacelata* extended with a high cover into about 2.5 m of water. Submerged vegetation was all native but generally sparse throughout the lake down to 5-6 m deep, with most in the north end where the slope was much less. *Chara australis* was the dominant charophyte but *Chara fibrosa* and was also present with some *Potamogeon ochreatus*.

LakeSPI

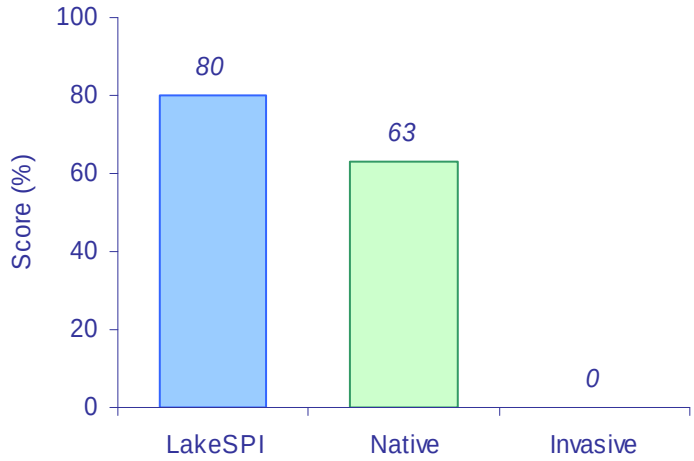


Figure: LakeSPI Index as % of potential score, Native Condition Index, and Invasive Impact Index (from left to right).

No invasive species present but also a low cover of native species accounted for the LakeSPI Index of 80.

Water birds

None recorded.

Fish

Eels are probably present as holes were frequent in the bottom sediment.

Aquatic invertebrates

None noted.

Changes in indicators

No previous records.

Threats

There is a low risk of pest plant introduction because it is remote and access difficult. However, *Utricularia gibba* is a possibility if brought in by birds. The catchment has a moderate risk of increased nutrient loading from forestry nutrient additions.

Management recommendations

Lake native biodiversity value should be monitoring every 5 years.

6 Pouto Peninsula

6.1 Grevilles Lagoon, the lake north of Kapoai (Pouto), NRC Lake No. 295; surveyed in 2005

Plate: Grevilles Lagoon, set in a pastoral catchment, with margins retired.

Summary

Overall ranking

Moderate: Fully fenced with native submerged vegetation, but emergent zone impacted by the weed *Alternanthera philoxeroides.*

Threats

Difficulty of access makes likelihood of pest plant introduction low, but a major impact could result should introduction occur. Catchment impacts are unlikely to change in the immediate future.

Management recommendations

No monitoring is recommended.

Description

This sand dune lake (1674139E; 6011706N) is approximately 2 ha in area and over 4 m in depth, with a steep-sided catchment comprised of rough pasture heavily impacted by the terrestrial weed african feather grass (*Pennisetum macrourum*), or planted dune to the north-

west (see plate) with wide retired margins. Access to the lake is across 3 km of steep private farmland and access to the lake perimeter by vehicle not possible.

Wetland vegetation

Typha orientalis dominated emergent vegetation, 5 – 10 m wide, growing to 0.5 m deep, rings the lake. Scattered plants of *Schoenoplectus tabernaemontani* were also present. The pest plant alligator weed (*Alternanthera philoxeroides*) was abundant at the sample point, at the western end of the lake, forming floating mats amongst *T. orientalis*.

Submerged vegetation

No turf plants were found – suitable sites were absent. Tall-growing native species were *Potamogeton ochreatus* and *P. cheesemanii,* with charophyte meadows of *Nitella* sp. aff. *cristata* and some *Chara australis* present. The maximum depth of the vegetation was 4 m (*N*. aff. *cristata*).

LakeSPI

Reconnaissance only – no LakeSPI score generated.

Water birds

This isolated and inaccessible lake would provide good habitat for water birds. None were recorded during the field visit. DoC SSBI reports the nationally endangered bittern (*Botaurus poiciloptilus*) and the regionally threatened dabchick (*Poliocephalus rufopectus*).

Fish

No fish were seen during the dive.

Aquatic invertebrates

No invertebrates were seen during the dive.

Changes in indicators

No previous surveys.

Threats

Exotic species would grow well in this lake, but access is difficult.

Management recommendations

The margins have recently been retired from grazing and planting has been undertaken. Alligator weed is well established at this site. No monitoring is recommended.

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

Plate: Lake Humuhumu showing pastoral catchment in foreground, pine forest in background and the large island (centre right) which divides the lake.

Summary

Survey dates

2005, 2007, 2012.

Overall ranking

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

Threats

High risk of introduction and establishment of invasive pests. High risk of nutrient enrichment from pine plantation activities (fertilisers) and nutrient run-off from farmland.

Management recommendations

Annual invasive weed surveillance at access point. Condition monitoring every 3-5yrs.

Description

A large (139.4 ha) dune lake (1700789E, 5979177N) with a maximum depth of 16 m. The lake has a predominantly pastoral catchment with scattered pockets of manuka and kanuka scrub, except for the western shore, which was comprised of sand dunes with pine forest. A large island with indigenous vegetation divides the lake into two basins. There are no inlet or outlet streams. Easy access from roadway across firm grassed ground. Small boats can be launched with 4-WD.

Wetland vegetation

About 70% of the shoreline had a narrow (< 5 m) band of emergent species extending into about 1 m depth of water. *Schoenoplectus tabernaemontani* and *Eleocharis acuta* were the most common species with *Apodasmia similis, Bolboschoenus fluviatilis, Cyperus ustulatus, E. sphacelata, Juncus pallidus, Machaerina articulata, M. arthrophylla, M. juncea* and *Typha orientalis* also present. The invasive exotic weed alligator weed (*Alternanthera philoxeroides*) was present in the marginal vegetation on the north-east shore and the invasive royal fern (*Osmunda regalis*) was recorded (B. Searle pers. comm.). In 2012, the nationally threatened fern *Thelypteris confluens* (At Risk – Declining) was found on the lake margin in two localities, the first records for this lake.

Submerged vegetation

The vegetation pattern has remained similar since regular surveys began in 2005. Turf was common with *Lilaeopsis novae-zelandiae* and *Glossostigma elatinoides* the dominant turf species. The nationally rare *Trithuria inconspicua* was present at very low levels in the lake with occasional plants found in 2005, 2009 and 2010, but not during the 2012 survey. The regionally uncommon *Myriophyllum votschii* was also recorded. Overall the submerged vegetation was dominated by *Chara globularis* and *Chara australis* at high covers and on two profiles to depths approaching 10 m. There were some scattered low-density growths of tall-growing natives commonly *Myriophyllum triphyllum* but also *Potamogeton cheesemanii* and *P. ochreatus* (5.7 m deep). The native *Ruppia polycarpa* was recorded at one transect near the access point. The nationally threatened *Lepilaena bilocularis* was reported in 2001, but the specimen held at the Auckland Herbarium (AK) was subsequently determined (by one of the authors) to be *Ruppia polycarpa*.

The lake had all native vegetation except *Otellia ovalifolia* and *Potamogeton crispus* (found outside profiles), which are of little consequence to native biodiversity, and localised impact from *Utricularia gibba* which was common in shallow water on three profiles in 2012.

LakeSPI

Table 6-1: LakeSPI results for Lake Humuhumu. LakeSPI Indices expressed as a percentage of lake maximum potential.

State	Year	LakeSPI Index (%)	Native Condition Index (%)	Invasive Impact Index (%)
Pristine		96	92	0
Historical data	1984	86	74	0
	1988	80	64	0
	2001	84	71	0
	2005	81	66	0
	2007	77	66	7
Present day	2012	72	66	16

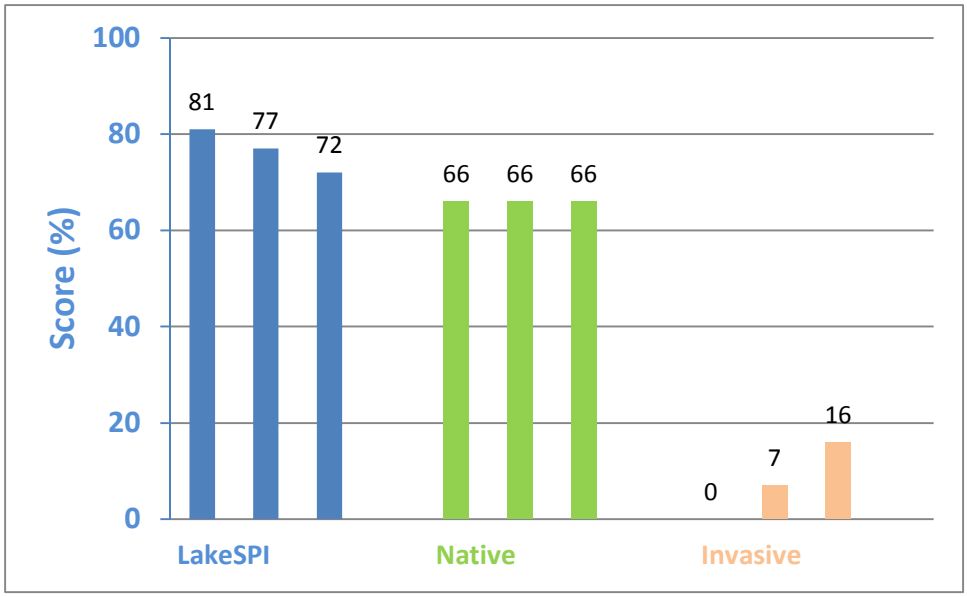


Figure 6-1: LakeSPI Index as % of potential score for Lake Humuhumu with Native Condition Index, and Invasive Impact Index for 2005; 2007 and 2012 from left to right.

The most recent LakeSPI Index (Figure 6-1) shows a lake in high ecological condition with a LakeSPI index of 72%. This reflects the extent of native submerged vegetation present in the lake with charophyte meadows growing down to a maximum depth of 9.1 m. However the presence of *Utricularia gibba* for the first time at 3 of the 5 LakeSPI sites, has seen the Invasive Impact Index more than double since the 2007 survey and impact negatively on LakeSPI values.

Water birds

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

Fish

The common bully (*Gobiomorphus cotidianus*) was most commonly seen. The rare dwarf inanga (*Galaxias gracilis*) was present on most profiles in the shallows. There were no introduced fish species recorded.

Aquatic invertebrates

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

Changes in indicators

Previous surveys 1984, 1985, 1988, 2001 and 2005, 2007 have shown little change in comparison with the latest 2012 survey. At times the depth limits of the vegetation have been up to 1 m shallower than present, possibly reflecting inter-annual variations with water clarity. The increase in the Invasive Impact Index came about with *Potamogeton crispus* being recorded on one profile at 3 m depth only in 2007, and *Utricularia gibba* has further increased the Invasive Impact Index in 2012.

Threats

This lake has no pest fish; Lake Rototuna with *Gambusia affinis* is the closest threat. No invasive submerged plants of any consequence are present but invasive species would do well in this lake. Nearby Lake Swan would present the most immediate threat with regard to a source of invasive weeds, but near eradication of these species using grass carp has reduced the risk to negligible.

Alternanthera philoxeroides and *Utricularia gibba* were recorded at Lake Humuhumu and both species could threaten other vegetation in sheltered margins of the lake.

Management recommendations

Annual pest plant surveillance at access point.

Lake ecological monitoring every 3-5 yrs.

Surveillance of margins for alligator weed and control for removal if deemed achievable.

6.3 Lake Kahuparere (Pouto), NRC Lake No. 384.

Plate: Lake Kahuparere showing pasture foreground, and pine forest on sand dunes to the rear.

Summary

Survey dates

1985, 1988, 2001, 2005, 2007, 2012.

Overall ranking

High: Medium sized lake with native vegetation, but nutrient enriched with livestock and forestry in the catchment.

Threats

Access restricted, but tall-growing native vegetation would be easily invaded by tall-growing exotic species. Already nutrient enriched and low water clarity. Susceptible to further enrichment and possible plant collapse.

Management recommendations

Lake native biodiversity value monitoring every 5 years. Livestock have been excluded from the lake margins.

Description

A small (9.4 ha) dune lake (1703965E, 5974380N) with a maximum depth of 7.5 m. The lake is situated on sand dunes in a mostly pastoral catchment, with pine forest fringed by kanuka scrub on the steep western dune face. Access across 2 km of private farmland, 4-WD access only and no trailer boat access.

Wetland vegetation

The lake was ringed with emergent vegetation 10 to 15 m wide and dominated by *Schoenoplectus tabernaemontani* (growing to 0.7 m deep), *Typha orientalis* (growing to 1 m deep) and lesser amounts of *Eleocharis sphacelata, Baumea articulata* and *Bolboschoenus fluviatilis*. Other marginal species recorded in 2007 were *Carex secta, Cyperus ustulatus, Eleocharis acuta*, *Juncus pallidus*, *Myriophyllum propinquum, Persicaria decipiens* and the introduced *Ludwigia palustris.* Cattle have now been excluded from the lake.

Submerged vegetation

No turf species (due to emergent), dense *Potamogeton ochreatus* beds to 5.9 m deep with high covers of *Chara australis* to nearly 5 m, Myriophyllum triphyllum to 3.5 m and *Utricularia gibba* formed a blanketing cover down to 2 – 4.5 m deep. The west profile had no submerged plants.

LakeSPI

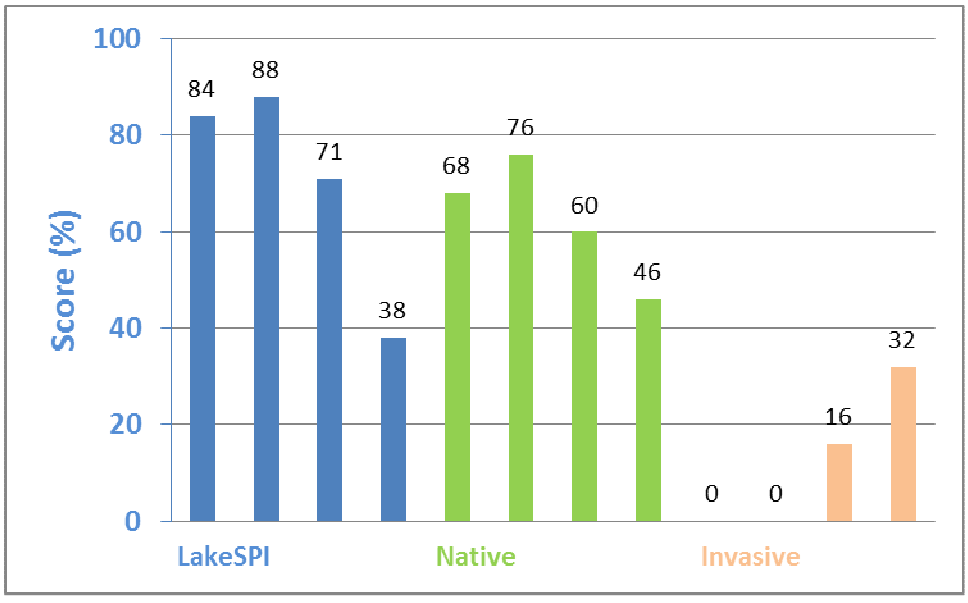


Figure: LakeSPI Index as % of potential score, Native Condition Index, and Invasive Impact Index (from left to right) with 2001, 2005, 2007, 2012, values shown respectively.

The LakeSPI score of 38% was low due to one of the 3 profiles having no submerged vegetation present. Otherwise indicators were good with a slightly deeper bottom limit and an increase in charophyte meadows. *U. gibba* invasive impact has increased further but is not displacing native vegetation. It is now categorised by LakeSPI as being in a moderate ecological condition with a LakeSPI index of 37%.

Water birds

The dense emergent beds on the western side of the lake along with marginal scrub provide good habitat for waterbirds. Pukeko (*Porphyrio melanotus*) and the regionally threatened dabchick (*Poliocephalus rufopectus*) were seen during sampling. DoC SSBI reports these species and also nationally endangered bittern (*Botaurus poiciloptilus*) and Caspian tern (*Sterna caspia*) and the regionally threatened scaup (*Aythya novaezeelandiae*) and spotless crake (*Porzana tabuensis plumbea*). The migrant Eastern little tern (*Sterna albifrons sinensis*) was noted in 2007.

Fish

The extensive emergent beds and tall submerged vegetation provide suitable habitat for various fish and NIWA FBIS records include the nationally endangered dwarf inanga (*Galaxias gracilis*), whilst common bully (*Gobiomorphus cotidianus*) were noted during the vegetation sampling.

Aquatic invertebrates

Koura (*Paranephrops planifrons*) were recorded in 2007 and freshwater mussels (*Hyridella menziesi*) were noted in the 2001 survey. The native snail *Glyptophysa variabilis* was seen in 2007.

Changes in indicators

Previous surveys, 1985, 1988, 2001, 2005 and 2007 show no change in species, with the bottom depth limit for *P. ochreatus* changing from 4.5, 5.5, 5.9, 5.6 and 5.6 m respectively. 5.9 m was the bottom limit measured in 2012. *Utricularia gibba* was found for the first time in 2007 and increased the Invasive LakeSPI index since then.

Threats

Currently no pest species are present apart from *Utricularia gibba*. Access is through 2 km of private farmland so the risk of introduction is low for the oxygen weeds but the lake would be very susceptible to invasion if introduced.

The relatively poor visibility and presence of filamentous algae covering the submerged vegetation indicated nutrient enrichment. Cattle access to the east shoreline not only has damaged the marginal vegetation through grazing and trampling, but can also lead to direct addition of nutrients to the lake by defecation and urine. Fencing of the margin was noted in 2009, with a corresponding decline in the abundance of filamentous algae.

Management recommendations

Maintain the awareness of the threats posed by introduced weeds and their mode of introduction on contaminated fishing nets to the owner. Fencing of the lake margin has occurred.

Lake native biodiversity value monitoring every 5 years.

6.4 Lake Kanono (Pouto), NRC Lake No. 377.

Plate: Lake Kanono. Photo: Rod Budd NIWA 2010.

Summary

Surveyed 1985, 1988, 2001, 2005, 2007 and 2013.

Overall ranking

Outstanding: This large lake has diverse submerged and emergent vegetation with no significant weed species and provides habitat for large numbers of water birds including several endangered species.

Threats

Access is restricted, but if invasive species were introduced, they would likely displace most of the native species and affect water quality. There are indications of nutrient enrichment and a decline in water quality although the lake is currently mesotrophic and much of the pasture margin is fenced. Plantation pine harvesting could potentially have a significant effect.

Management recommendations

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

Evaluate threat from pine harvesting. Marginal planting when funding permits.

Description

This lake (1702592E, 5975202N) is large (74.4 ha) and 15.5 m deep. The lake is situated on sand dunes with a pastoral catchment to the east and forestry to the west. Access is across 3 km of private farmland and the lake margin is fenced. Access to shore was through a locked gate and it was possible to launch tailored boats off a firm sloping beach using 4-WD.

Wetland vegetation

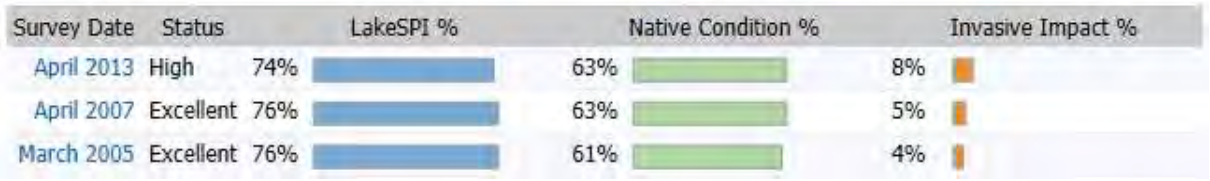
Much of the normally emergent vegetation was exposed or only extended into shallow water (< 0.5 m). It was sparse on the east side, usually less than 1 m wide, but had a broad 5 to 10 m zone present on the western lake edge. *Schoenoplectus tabernaemontani* was most common with some *Typha orientalis*, *Bolboschoenus fluviatilis, Cyperus ustulatus* and *Eleocharis acuta*. Exposed turf areas contained several amphibious species including *Glossostigma elatinoides* and *Limosella lineata*.

Submerged vegetation

Turf species were not common but were present on the exposed sandy locations with *Lilaeopsis novae-zelandiae* and *G. elatinoides* dominant. *Nitella* sp. aff*. cristata* was the most abundant species until 2001. *Chara australis* has become the deepest growing and most abundant species since then. Charophytes dominated the vegetation with *Chara australis*, *C. globularis*, and *Nitella* sp. aff*. cristata* the most abundant and deepest growing. Maximum charophyte depth was 7.4 m in 2013 and has been consistent since 2005. When *Nitella* sp. aff*. cristata* was prominent it grew to 9.0 m deep in 1985 and 9.7 m in 2001. Tall-growing natives were present with *Potamogeton ochreatus* consistently the most abundant since 1985. The 'At Risk – Naturally Uncommon' pondweed *Stuckenia pectinata* was recorded in shallow water. The exotic pondweed *Potamogeton crispus* was found at one site from 2005 to 2013 but was not significantly displacing native vegetation.

LakeSPI

Figure: LakeSPI Index as % of potential score, Native Condition Index, and Invasive Impact Index.



Lake Kanono is categorised as being in high ecological condition with a LakeSPI Index of 74%. This high score reflects a high cover of native vegetation to 7.7 m and a lack of invasive species (most notably *Utricularia gibba*, a species common in adjacent lakes), apart from a few plants of *P. crispus* at one profile.

Water birds

A large isolated lake with retired margins and extensive areas of emergent vegetation makes it a good habitat for water birds. Large numbers (over 100 and approximately 40 respectively) of black swan (*Cygnus atratus*) and the regionally significant scaup (*Aythya*

novaezeelandiae) seen on the field visit illustrated this. Two pairs of the 'Nationally Vulnerable' dabchick (*Poliocephalus rufopectus*) were also noted. The migrant Eastern little tern (*Sternula albifrons sinensis*) was noted in 2007. DOC SSBI reports these species and also 'Nationally Endangered' bittern (*Botaurus poiciloptilus*), 'Nationally Vulnerable' Caspian tern (*Sterna caspia*) and 'At Risk – Relictural' spotless crake (*Porzana tabuensis plumbea*).

Fish

The extensive aquatic vegetation provides good habitat for fish, with schools of the 'At Risk – Naturally Uncommon' dwarf inanga (*Galaxias gracilis*) and also common bullies (*Gobiomorphus cotidianus*) were observed during this survey.

Aquatic invertebrates

The indigenous koura (*Paranephrops planifrons*), large freshwater mussels (*Hyridella menziesi*) and *Glyptophysa variabilis* snails were all abundant in 2013.

Lake Ecological Value

Based on the 2007 survey a Lake Ecological Value rating of 12 (Outstanding) was calculated. Although there has been a slight improvement in vegetation diversity the score remains at 12 (still Outstanding).

Bottom limits for vegetation were in the 9 – 10 m range in 1985 – 2001 surveys when *Nitella* sp. aff*. cristata* was present. Since it disappeared from the lake *Chara australis* has formed the deepest growing vegetation at 7.5 m since. Tall-growing native *Potamogeton ochreatus* has been consistently abundant since records began. Heavy filamentous algal growths were present particularly in the north east bay, indicative of localised nutrient enrichment from the surrounding catchment.

Threats

Currently the submerged vegetation is comprised of native submerged plants except for *P. crispus*, which is having almost no impact on native species. The isolated nature of the lake and lack of easy access reduce the threat of introduction, but if introduced, pest species are likely to grow well and threaten indigenous lake values.

The lake may be undergoing nutrient enrichment that could contribute to a future decline in water clarity. The heavy growths of filamentous algae are a good indicator. Although water quality is still assessed as Mesotrophic, the trend is moving towards Eutrophic based on TLI calculations. Nutrients from the catchment and those generated from lake stratification could be impacting on the lake with poorer water clarity and progressively shallower depth limits for the vegetation. The water level was down 0.5 m (owner pers. comm.) at the time of the survey.

Management recommendations

Lake native biodiversity value monitoring and pest plant surveillance recommended every 5 years.

It was noted that parts of the lake were inadequately fenced and livestock access to the lake at the north eastern edge is evident. Referencing and, where possible, riparian planting is advocated in an attempt to rectify the ongoing decline in water quality evident in the lake.

6.5 Lake Kapoai (Pouto), NRC Lake No. 296; surveyed in 2005, visited in 2007

Plate: Lake Kapoai set in a pastoral catchment.

Summary

Overall ranking

Low-moderate: No submerged vegetation and marginal vegetation sparse. Fencing of lake margin almost complete, water quality may improve over time.

Threats

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

Management recommendations

Lake native biodiversity value monitoring every 5 years.

Description

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

Wetland vegetation

The emergent sedges *Schoenoplectus tabernaemontani* and *Eleocharis sphacelata* were re-establishing on the lake margins. Short turf communities were common at the lake edge with the regionally significant *Fimbristylis velata, Centipeda aotearana* and *Alternanthera* aff. *sessilis* present with the amphibious *Limosella lineata, Myriophyllum propinquum* and *Callitriche petriei*.

Submerged vegetation

The lake had a heavy algal bloom and no submerged native species seen in 2007 although some detached leaves of *Potamogeton ochreatus* were noted on the shoreline in 2005.

LakeSPI

No LakeSPI score generated as no plant cover present for this method.

Water birds

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

Fish

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

Aquatic invertebrates

No invertebrates recorded.

Changes in indicators

No previous surveys.

Threats

Access difficult and likelihood of submerged pest plant establishment is currently low. A small part of the lake is still open to cattle grazing.

Management recommendations

Much of the lake margin has recently been retired from grazing. Fencing the remainder of the lake margin is advocated.

6.6 Lake Karaka (Pouto), NRC Lake No. 347.

Plate: Lake Karaka viewed from the access point showing pasture to the lake edge. The remainder of the lake margin is wetland.

Summary

Survey dates

2005, 2007, 2012.

Overall ranking

High: A lake with an indigenous vegetation and fauna, much of the margin surrounded by wetland with nationally endangered plants, fish and birds present.

Threats

Isolation and difficulty of access make likelihood of pest introduction low, but a major impact could result should introduction occur. Water quality likely to be impacted by cattle access.

Management recommendations

Infrequent pest plant surveillance and lake ecological assessment (5 years). Recommend fencing of the eastern margin to exclude cattle. A consideration of nutrient sources might reveal why this lake is so eutrophic and mitigations measures might be self-evident.

Description

This dune lake (1693415E, 5980559N) is 11.1 ha in size and about 6 m deep with an undulating bottom. It is one of the lakes situated on the south-western Pouto Peninsula between consolidated dunes to the east and mobile dunes to the west. The catchment is pastoral (25%), and flax/sedge/raupo wetlands (75%) extend to the north and south of the lake, linking it with other water bodies with mobile sand dunes at the western end. There are no inflow or outflow streams. Access is difficult through forestry roads and rough pasture over consolidated dunes. 4-WD access only, not suitable for trailered boats.

Wetland vegetation

Emergent species encircle most of the lake, except the margin bordered by pasture and open to cattle grazing. *Typha orientalis* and *Machaerina articulata* dominated. These extended over a 20 m wide band in most areas growing to depths of 1.5 m. Other emergent species seen included *Apodasmia similis, Carex maorica, Carex secta, Cyperus ustulatus, Eleocharis acuta, Isachne globosa, Isolepis prolifera, Juncus pallidus, Machaerina arthrophylla, M. juncea, Schoenoplectus tabernaemontani,* flax and cabbage trees. Common amongst the *M. juncea* vegetation were extensive areas of the nationally threatened fern *Thelypteris confluens*.

Submerged vegetation

All native vegetation. Few turf species recorded (only at access point where marginal species grazed). Charophyte dominated, with exceptionally abundant *Chara australis* that was tall, surface reaching (to 1.8 m) and extended to 2.5 m deep. Tall-growing native species were also present at low average covers with *Potamogeton cheesemanii* dominant and growing to 2.3 m deep. *Chara globularis* was noted in shallow water at the access point. *Chara australis* was fragmenting and rotting, most likely because of the algal bloom.

LakeSPI

Table 6-2: LakeSPI results for Lake Karaka. LakeSPI Indices expressed as a percentage of lake maximum potential.

State	Year	LakeSPI Index (%)	Native Condition Index (%)	Invasive Impact Index (%)
Pristine		95	90	0
	2005	83	65	0
	2007	81	62	0
Present day	2012	81	62	0

**LakeSPI surveys are based on only 3 sites.*

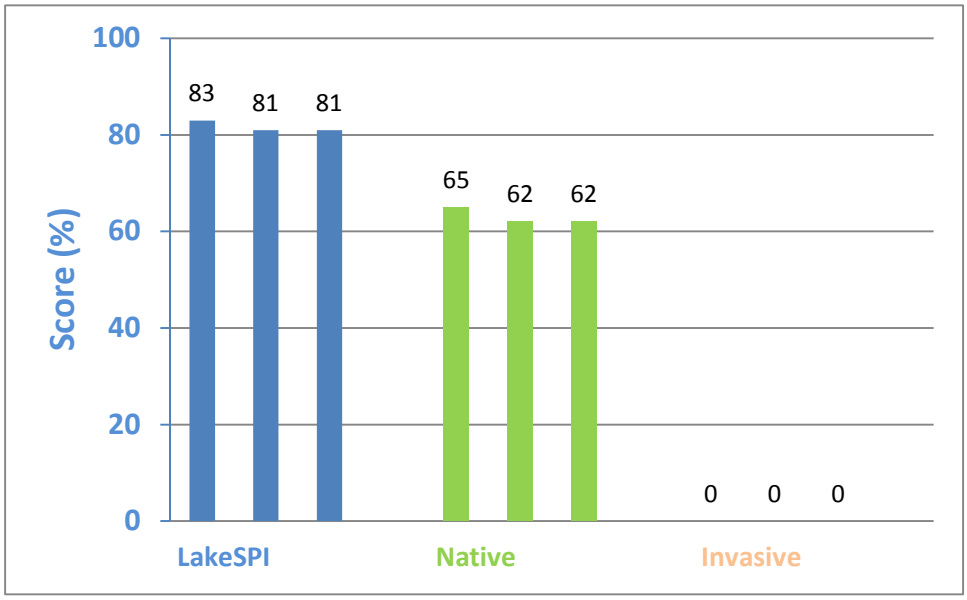


Figure 6-2: LakeSPI Index as % of potential score for Lake Karaka with Native Condition Index, and Invasive Impact Index 2005; 2007; 2012 (from left to right).

Lake Karaka is in 'excellent' ecological condition as categorised by LakeSPI (Table 6-2, Figure 6-2). Its high LakeSPI index of 81% reflects its extensive charophyte meadows and a lack of invasive species.

Water birds

The extensive wetland areas provide outstanding habitat for water birds. Threatened species reported include the nationally rare bittern (*Botaurus poiciloptilus*) and regionally significant banded rail (*Rallus philippensis assimilis*), spotless crake (*Porzana tabuensis plumbea*), dabchick (*Poliocephalus rufopectus*), fernbird (*Bowdleria punctata vealeae*) and scaup (*Aythya novaezeelandiae*). Formerly the Critically Endangered brown teal (*Anas aucklandica chlorotis*) were also recorded in this area and the western Poutu lakes are a stronghold for grey duck (*Anas superciliosa*) and several aggregations of birds fitting their description were seen. These may be hybrids with mallard duck, the main reason for the Nationally Critical ranking of this species.

Fish

Moderate water quality and diverse macrophyte habitat. The common bully (*Gobiomorphus cotidianus*) was very common, with most specimens having swollen abdomens indicative of an infestation of endoparasitic cestode or trematode species. Both longfin and shortfin eels (*Anguilla dieffenbachii* and *A. australis*) are reported from this lake and several eels were seen during the survey. The endangered giant kokopu (*Galaxias argenteus*) has been collected from Lake Karaka (T. Birch, DOC pers. comm.)

Aquatic invertebrates

The native snail *Potamopyrgus antipodarum* was recorded from one profile.

Changes in indicators

No change since 2007.

Threats

Relative isolation and difficulty of access makes risk of introduction of pest species low. However, should these be introduced they would displace or significantly impact indigenous biota. Nutrient enrichment from farming and forestry may be the cause of algal blooms noted and charophytes in poor health.

Management recommendations

Lake ecological assessment and pest plant surveillance every 5 years.

Advocate fencing off the eastern shoreline to prevent cattle access to the lake. A consideration of nutrient sources might reveal why this lake is so eutrophic and mitigations measures might be self-evident.

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

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

Summary

Survey dates

2005, 2007, 2012.

Overall ranking

Outstanding: A large lake with all native vegetation, functioning as an integral part of a wetland/scrub/dune complex covering the south-western Pouto Peninsula. Contains nationally significant populations of endangered biota.

Threats

Exotic plant invasion, though risk low due to isolation. Possible impacts from forestry fertiliser inputs causing algal blooms.

Management recommendations

Five yearly surveillance for pest plants and lake native biodiversity value monitoring. Algal blooms indicate possible nutrient threat to ecological condition. A nutrient budget is recommended.

Description

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

Wetland vegetation

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

Submerged vegetation

In 2012 water clarity was only 0.15 m (heavy algal bloom) making scuba assessment impossible. We did confirm *Chara australis* was still present to 5.3 m using a rake. If the bloom were to continue for too long then the submerged vegetation will die due to low light levels. Anoxia would exacerbate the problem by generating more nutrients from the sediments. It would require a period of improved water clarity for charophytes to re-establish from the seed bank.

In previous surveys an entirely native vegetation was present with the whole main lake bottom vegetated to 5.3 m deep and clear water with ~ 4 m of visibility. Turf species including *Lilaeopsis novae-zelandiae* (growing to 0.4 m tall) and *Glossostigma elatinoides* were seen in shallow margins growing amongst emergent vegetation. *Chara australis* filled the lake, with a maximum height of 1.8 m recorded in the past. *C. australis* grew to 5.3 m deep with only a small area of the lake deeper than this (6.0 m max. depth, near 2606019E, 6538508N). Tall-growing native species, *Potamogeton cheesemanii* and *P. ochreatus* were the only other submerged species found in the main body of the lake, however *Chara*

globularis and *Myriophyllum triphyllum* were also found in the narrow channelised northern part of the lake.

LakeSPI

Table 6-3: LakeSPI results for Lake Mokeno. LakeSPI Indices expressed as a percentage of lake maximum potential.

State	Year	LakeSPI Index (%)	Native Condition Index (%)	Invasive Impact Index (%)
Pristine		95	90	0
Historical data	2005	83	65	0
Present day	2007	90	80	0

**LakeSPI results are based on 1 representative site.*

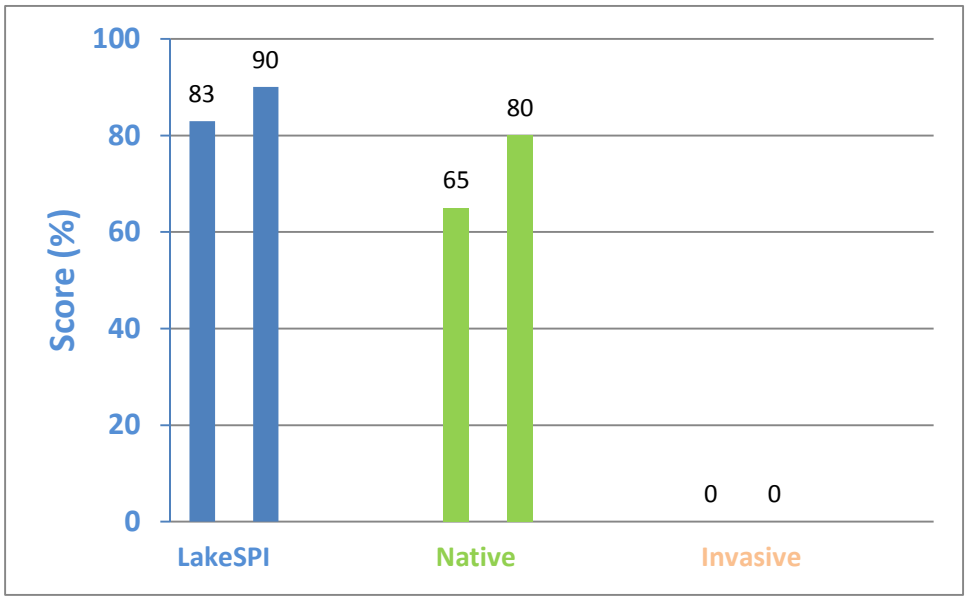


Figure 6-3: LakeSPI Index as % of potential score for Lake Mokeno with Native Condition Index, and Invasive Impact Index shown for 2005; 2007 (from left to right).

Lake Mokeno was in 'excellent' ecological condition as categorised by LakeSPI during the 2007 survey. Its high LakeSPI index of 90% reflected the quality of native submerged vegetation and lack of invasive species. Due to poor clarity a LakeSPI Index could not be generated in 2012.

Water birds

The indigenous scrub, wetland and emergent margins provide excellent water bird habitat reflected in the large number of species reported from this lake and seen during the field visit. Threatened species reported include the nationally rare bittern (*Botaurus poiciloptilus*) and Caspian tern (*Sterna caspia*) and regionally significant banded rail (*Rallus philippensis*

assimilis), spotless crake (*Porzana tabuensis plumbea*), dabchick (*Poliocephalus rufopectus*), fernbird (*Bowdleria punctata vealeae*) and scaup (*Aythya novaezeelandiae*). Formerly the critically endangered brown teal (*Anas aucklandica chlorotis*) were also recorded in this area. The indigenous species dabchick, fernbird, scaup, possibly grey duck (*Anas superciliosa*), shoveler (*Anas rhynchotis*) and two species of shag (*Phalacrocorax* spp.) were seen during the 2012 field visit.

Fish

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

Aquatic invertebrates

Freshwater mussels (*Ecechyridella menziesii*) were common, introduced freshwater jellyfish (*Craspedacusta sowerbyi*) were also noted. In 2012, dead mussels were recorded at 5 to 6 m depth indicating oxygen depletion at times.

Changes in indicators

Previous vegetation surveys in 2000, 2001 and 2005 were similar to the latest survey. There was a dense algal bloom which reduced underwater visibility to 0.1 m in May 2001, but the water was very clear (~4m) in the 2007 m survey and poor again when visited in 2012. Dead mussels at this depth indicated oxygen depletion at times.

Threats

No pest plant or fish impacts evident and the likelihood of introduction of freshwater pests are low. Exotic species would establish in this lake if introduced. Royal fern could invade large areas of the wetland fringe.

The catchment is well buffered by an extensive wetland, but water quality and observations of past algal blooms indicate nutrient enrichment, possibly from fertilisation of pine forests. This would be a worthwhile area for further study.

Management recommendations

Five year monitoring of lake native biodiversity value and pest plant surveillance recommended. Algal blooms threaten in-water values in this lake, so analysis of water quality monitoring and investigation of ground water nutrient fluctuations is required to determine the nutrient sources and potential to manage these.