Northland Lakes 2011

Prepared for Northland Regional Council

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Grass carp release and capture is being used for lake restoration in Lakes Roto-otuauru and Heather.

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Contents

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Executive summary

The Northland Regional Council engaged NIWA to update the Wells et al. 2010 Northland Lakes Status report by providing the following assessments of lakes and water bodies:

Waiporohita – ecological assessment and weed surveillance

Ngatu – weed surveillance

Heather – grass carp assessment

Carrot – egeria surveillance

Omapere – ecological assessment

Tauanui – reconnaissance

Waro – ecological assessment

Kai-iwi – ecological assessment and weed surveillance

Taharoa - ecological assessment and weed surveillance

Waikere - ecological assessment and weed surveillance

Te Riu - ecological assessment

Waingaata - ecological assessment

Midgley - ecological assessment

Humuhumu – weed surveillance

Swan – grass carp assessment

Ecological assessments

Waiporohita: The lake remains stable and in good condition. *Utricularia gibba* was recorded as present for the first time.

The Lake Omapere ecological assessment was postponed due to difficulties with Iwi approval.

Tauanui: This lake was surveyed for the first time in 2011. It had an all native, diverse submerged vegetation growing to 4 m water depth. It had an excellent LakeSPI result with the lake scoring 79% of its potential.

Waro: The lake still has a diverse native vegetation, however the lake water quality is deteriorating and water below 5 m deep was black and probably anoxic. The invasive plants *E. densa* and *U gibba* are having a significant impact in the lake. Nutrient sources need to be identified and controlled or this lake will become unsuitable for contact recreation in future.

Kai-iwi: The condition of this lake remains very high with extensive deep growing native vegetation. *U. gibba* has extended its habitat into 9 m deep water, but native ecological values remain very high.

Taharoa: This oligotrophic lake has shown almost no change in the last 30 years of monitoring. It remains exceptionally clear and has the deepest submerged plant growths in the North Island.

Waikere: This lake remains a highly valued native plant dominated lake with some minor impacts from seed dispersed pest plants. *U. gibba* was recorded to 16 m, the deepest record for this species yet.

Te Riu: The native flora in this isolated lake is still abundant despite the recent incursion of *U. gibba* and its very dense growths now present. The nationally threatened *U. australis* was still present co-existing with the *U. gibba*.

Waingaata: This lake was not surveyed due to access problems along forestry tracks at the time.

Midgley: In 2005 this lake had high native ecological values including a large population of the nationally endangered *U. australis*, and no exotic threat was present. The release of grass carp was approved by DOC and they were stocked in the lake in 2007, possibly to improve the open water available for ducks. Almost all submerged species have been removed (except for sparse *Chara australis*). An attempt was made to remove all the fish from the lake using intensive netting. 141 of 250 released were removed but it is not known how many may have died, so vegetation monitoring is required to indicate if further fish need to be removed. Open water can be increased by alternative methods targeting just the emergent species kuta (*Eleocharis sphacelata*) and raupo (*Typha orientalis*) with much less impact on other lake values.

Weed surveillance

No new weed incursions were found in the six high-risk lakes.

In Lake Carrot the *Egeria densa* incursion was much larger than the single plant discovered in 2010, and extended amongst the *E. sphacelata*. This and the poor water clarity in Lake Carrot make eradication by hand removal impossible. Grass carp would now be the most cost effective way of removing it. An eradication programme should be initiated to protect the nearby high-value Lake Ngakapua.

Grass carp assessments

Lake Swan: Progress with *C. demersum* and *E. densa* eradication has been rapid with nearly all traces of these weeds removed in 2 years with the exception of a few fragments of *C. demersum* remaining amongst the marginal plants. The risk of transfer of these weeds to neighbouring high value lakes is near zero now.

Lake Heather: After 1 year in the Lake Heather, grass carp have removed nearly all the *E. densa* and about 20% of the *C. demersum*. Even since the last survey *C. demersum* has displaced the large area of *Potamogeton ochreatus* in the northern basin and still was growing to heights up to 3.4 m throughout most of the lake. The state of Lake Heather after one year of grass carp grazing is similar to Lake Swan at the same stage. We therefore expect nearly all the hornwort could be removed by March 2012.

1 Introduction

Northland Regional Council (NRC) has a programme of lake monitoring for 85 lakes that are surveyed on a rotational basis. NRC also undertakes surveillance on prioritised lakes for early detection of weed incursions. The most recent update of the baseline report on the status of lakes is Wells and Champion (2010). NRC engaged NIWA to update this report by providing the following assessments of lakes and water bodies: Waiporohita – ecological assessment and weed surveillance

Ngatu – weed surveillance

Heather – grass carp assessment

Carrot – egeria surveillance

Omapere – ecological assessment

Tauanui – reconnaissance

Waro – ecological assessment

Kai-iwi – ecological assessment and weed surveillance

Taharoa - ecological assessment and weed surveillance

Waikere - ecological assessment and weed surveillance

Te Riu - ecological assessment

Waingaata - ecological assessment

Midgley - ecological assessment

Humuhumu – weed surveillance

Swan / Roto-otuauru – grass carp assessment

In addition to this report, lake ecological updates will be added to the compilation of Northland lakes ecological information as last presented in Wells and Champion (2010).

Northland Region has some of New Zealand's highest ranked examples of intact natural aquatic ecosystems. However, they are being lost at an alarmingly rapid rate as invasive species continue to be spread as a result of human activities, and land use practices impact on lake integrity. Often pristine lakes are limited to remote areas with difficult human access and lower development. With adequate recognition, community support and active protection, such exceptional lakes could be maintained in a pristine state for perpetuity.

Regarding weed surveillance, assessment of biosecurity risks posed by the freshwater pests is part of the NRC Regional Surveillance Strategy for pest management within Northland Region. Native aquatic flora and fauna are highly susceptible to displacement by invasive species, and freshwater systems are much more vulnerable than forest and other terrestrial ecosystems. Active management of threats involves addressing the pathways and vectors for pests, regular surveillance for early pest detection and timely response, and strategic management of high risk pest incursions.

The two lakes assessed for grass carp impacts (Lake Roto-otuauru and Heather) are part of a programme to remove the threat of invasive weeds to nearby high value lakes and restoring these lakes to a native condition. Monitoring is needed to effectively manage stocking and timing of removal of the grass carp.

2 Methods

2.1 Ecological assessments

2.1.1 Lake description

Lakes were referenced according to assigned lake number and location (NZTM Easting and Northing) in the NRC lakes database. In addition, water bodies were photographed and lake size, observations of catchment features and ease of access were noted.

2.1.2 Wetland vegetation

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

Presence of endangered species (de Lange et al. 2009; Forester and Townsend 2004 and discussion with DOC and NRC staff) and pest plants were reported along with an estimate of population size.

2.1.3 Submerged vegetation

The submerged vegetation was surveyed by divers using a method similar to Clayton (1983). Divers swam perpendicular to shore recording plant species present, their depth ranges, average and maximum heights and covers. These and other details were recorded on data sheets (Figure 2-1). LakeSPI (Clayton & Edwards 2006a; Clayton & Edwards 2006b; http://lakespi.niwa.co.nz/index.do) information was extracted from this data, and by recording the following additional information: the maximum depth of native and invasive species with cover >10%, the maximum depth of charophyte meadows with ≥75% cover, the % ratio of native to exotic vegetation cover, and an assessment of invasive cover. A sketch was made of the profile relief and spatial distribution of vegetation with notes on height and cover. Generally lakes were sampled at five localities selected as representative of the underwater vegetation and the range of plant communities present in the lake. Fewer than five sites were surveyed where lakes were small or de-vegetated.

Presence of endangered species (de Lange et al. 2009; Forester and Townsend 2004 and discussion with DOC and NRC staff) and pest plants were reported along with an estimate of population size.

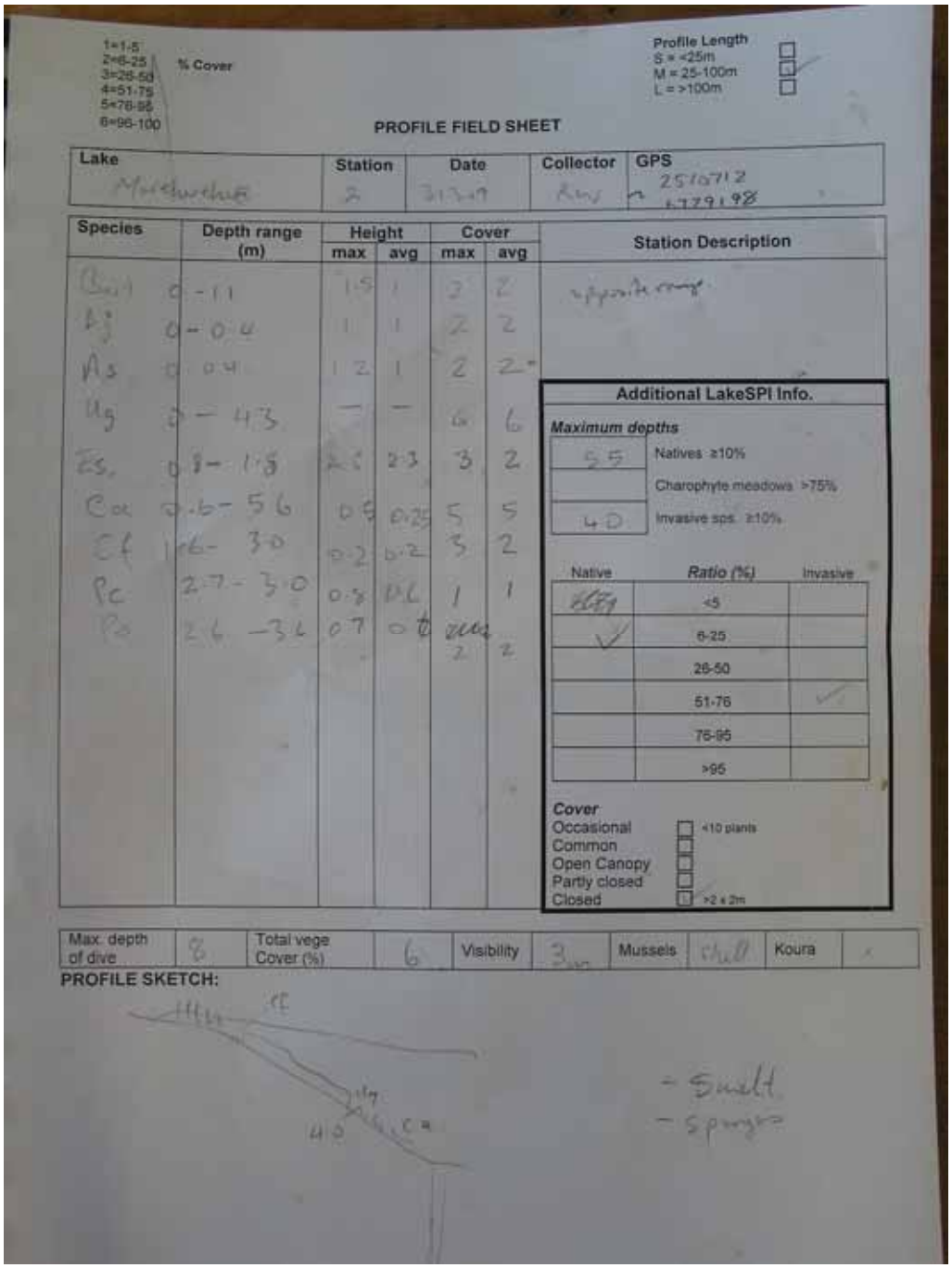

Figure 2-1: Survey sheet for submerged vegetation surveys.

LakeSPI data was entered into the NIWA LakeSPI database, to calculate three ecological indices. The Native Condition Index provides a measure (score) of the diversity, quality and abundance of indigenous submerged vegetation. The Invasive Impact Index scores the impact by any of ten invasive alien plant species that may be present. A high Invasive Impact Index indicates large impacts by invasive alien plants. The LakeSPI Index integrates components of the previous indices, together with additional ecological information. The specific features that are assessed to generate each score are detailed on the web-reporting pages (http://lakespi.niwa.co.nz/index.do). In this report the indices are expressed as a percentage of their maximum potential score to enable direct comparisons between different

types of lake. The LakeSPI Index provides a measure of how close a water body is to its potential or unimpacted (by human) state, and can be used to detect changes in lake condition over time and make comparisons between lakes. LakeSPI is not suitable for lakes where a factor such as salinity or pH restricts submerged vegetation communities. Where submerged plant growth at most sites is less than 10% cover, a default LakeSPI score of 0% is assigned.

LakeSPI measures lake ecological condition and should not be confused with the 'Lake Native Biodiversity Value Assessment'. LakeSPI Index scores will place lakes into one of five narrative classes of lake condition, either as Non-vegetated (0%), Poor (>0-20%), Moderate (>20- 50%), High (>50-75%) and Excellent (>75%).

LakeSPI results presented in this report are also available on NIWA's web-reporting pages (http://lakespi.niwa.co.nz/index.do)., where a report can be generated for any lake, summarising all available assessments.

2.1.4 Prioritisation of lakes

The lakes were prioritised for 'Lake Native Biodiversity Value Assessment'. based on three components: Indigenous biota, endangered species and habitat availability.

1. Indigenous biota

For native species or indigenous biota we assessed the value of what species were present at the time and the metrics scored were: species richness, abundance and representativeness:

- 'Species Richness' was the total number of indigenous macroscopic species (fauna and flora) in the lake and wetland margins.
- 'Abundance' was for native flora present and was assessed on the basis of area and cover, and for fauna it was population size.
- 'Representativeness' of the species assemblage was obtained by assessing the significance of the communities present (not species rarity) in regional and national context.

2. Endangered species

Endangered species were scored on the basis of the 'New Zealand Threat Classification System lists' (Hitchmough et al. 2007) and also using de Lange et al. (2009). The categories are 'acute', 'chronic' and 'at risk':

Within 'acute' there are four categories:

- 'Extinct in the wild' (e.g., *Isoetes kirkii var. 'flabellata'*, Omapere) was not used in this evaluation, as we were assessing what species were present at the time, not past species or potential.
- 'Critical' e.g., white heron (a casual visitor to Northland).

- ‘Endangered’ e.g., brown teal, grey duck, bittern, Northland mudfish, native bladderwort; and

- ‘Vulnerable’ e.g., *Trithuria inconspicua*.

‘Chronic’ has two sub-categories:

- ‘Serious decline’ e.g., dune lakes galaxias (dwarf inanga), *Myriophyllum robustum*, and black-billed gull.

- ‘Gradual decline’ e.g., longfin eel, giant kokopu, black mudfish, kakahi, koura, marsh fern, and red-billed gull.

The ‘At-risk’ category are for those naturally uncommon, relict (sparse) species such as North Island fernbird, dabchick, crakes, freshwater crab, *Centipeda aotearana, Mimulus repens*, and *Sporodanthus ferruginea*.

3. Habitat availability

The extent or area of indigenous vegetation (wetland, emergents and submerged vegetation) was quantified as it is a measure of habitat availability for native biota.

Each of the parameters was subjectively scored on a 1-6 scale and these metrics used to obtain rankings (from best to worst) for ‘Lake Native Biodiversity Value Assessment’ of: outstanding; high; moderate-high; moderate; low-moderate; and low. Outstanding lakes are nationally important, containing a diverse indigenous biota, with sustainable populations of endangered species. Conversely, low ranked lakes are either de-vegetated with poor water quality, or severely impacted by exotic pest species.

2.1.5 Water birds

Habitat suitability for birds was assessed during the field visit, with bird species presence and abundance observed with binoculars. Results were compared with previous records from OSNZ and DoC SSBI surveys, with any nationally or regionally threatened species noted. The combination of scuba divers and various water craft involved in this survey was not conducive to observing water birds, with many flying away before their identity was ascertained. However, some secretive species such as the nationally endangered bittern (*Botaurus poiciloptilus*) were often disturbed and flew allowing their detection, whereas shore-based observation would probably not detect such species.

2.1.6 Fish

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

2.1.7 Aquatic invertebrates

Large aquatic invertebrates such as freshwater mussels (*Echyridella menziesii*), koura (*Paranephrops planifrons*) and snails were noted by divers in the course of macrophyte

surveys. Mussels and koura are potentially important indicators of lake condition and are likely to be incorporated into LakeSPI methodology in the future.

2.1.8 Changes in indicators

Any significant changes in biota and lake condition compared with previous surveys were reported; for example new species records, and / or change in species dominance, or vegetation depth range.

2.1.9 Threats

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

2.1.10 Management recommendations

Monitoring strategies for the highest ranked of the lakes were recommended including:

- Lake native biodiversity value monitoring and LakeSPI with additional assessment of nationally or regionally significant biota and assessment of any new threats to ecological condition.
- Pest plant surveillance – targeted monitoring of lake access and anchoring sites to detect early incursions of weed species.

2.1.11 Summary

A summary of overall ranking, identified threats and recommendations is presented for each lake in the report Section 3.1; ecological assessments.

2.2 Surveillance

Annual surveillance was undertaken for six high-risk lakes (Table 2-1).

Lakes were surveyed using scuba and snorkel, visually inspecting sites where introductions would be most likely, such as known access points and popular anchoring spots. The areas were inspected thoroughly at depths where weed colonisation was likely to occur. Where large areas required surveillance, a diver was towed behind a boat to cover likely sites of colonisation.

The lake margins were also walked and checked for drift of weed fragments on shore and marginal vegetation also checked for emergent and sprawling wetland weeds both from the landward edge (where possible) and by boat.

Table 2-1: Submerged weed surveillance programme for Northland lakes (Champion et al. 2005).

Lake and No.	Surveillance programme	Frequency
Ngatu (120)	Survey boat ramp area and access points on eastern and southern margins	Annually
Waiporohita (99)	Survey lake and wetland from roadside access point on eastern margin to north end by the road	Annually
Kai-iwi (236)	Survey access point at NE end	Annually
Taharoa (229)	Survey access points at 2 camp grounds, jetty, and Sin Bin.	Annually
Waikere (227)	Survey boat ramp area and roadside access points on western margin	Annually
Humuhumu (350)	Survey access point (NE side)	Annually

2.3 Grass carp assessments

The progress and impacts of grass carp in Lake Swan and Heather were assessed as part of on-going monitoring. In Lake Swan the 5 baseline profiles were repeated as for the lake ecological assessment for submerged vegetation. In addition sonar (Lowrance LCX-15MT depth sounder) was used to cover much of the lake to search for any remaining weed growth and to record profiles. A full shoreline inspection of the lake by boat was undertaken to inspect the lake margin for impacts on the emergent communities and presence of weed fragments.

For Lake Heather the two baseline profiles were repeated as for the lake ecological assessment and sonar used to record weed bed profiles.

3 Results and Discussion

3.1 Ecological assessments

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

Figure 3-1: 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 *P. 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,* (Figure 3-2) *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. Observations of submerged vegetation in 2011 showed only minor change since 2005 such as the establishment of some *Utricularia gibba*..

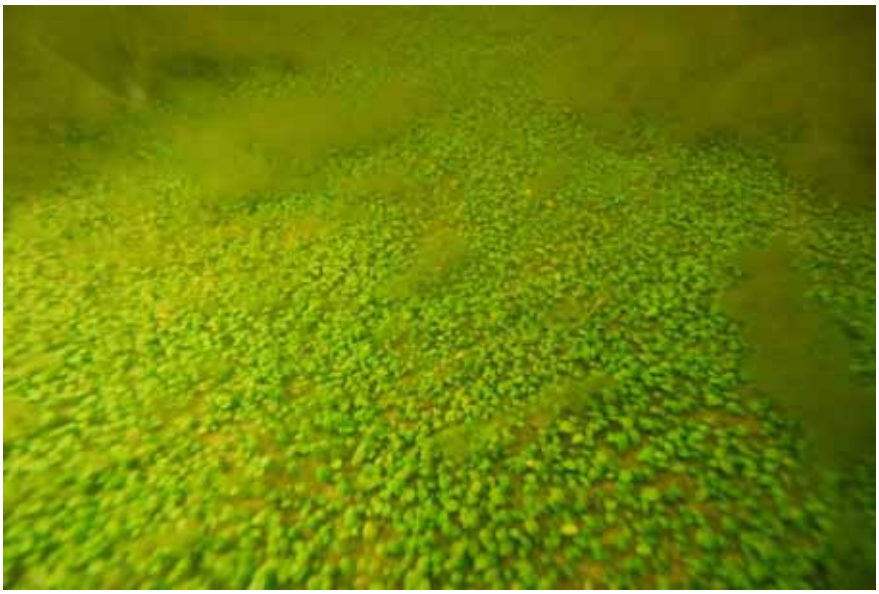

Figure 3-2: Submerged turfs of *Glossostigma elatinoides* in Lake Waiporohita.

LakeSPI

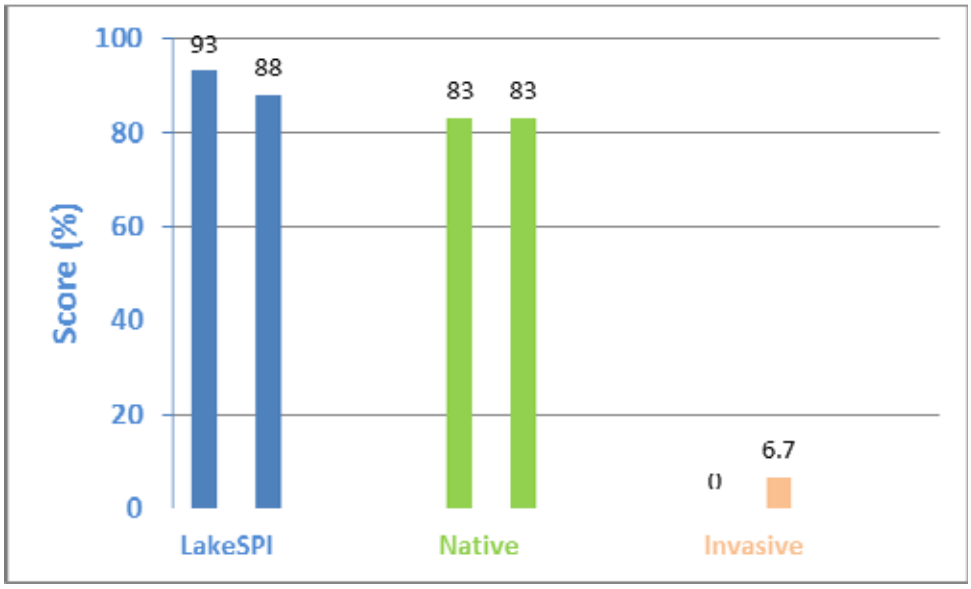

Figure 3-3: 2011 LakeSPI Index for Lake Waiporohita as % of potential score, Native Condition Index, and Invasive Impact Index (from left to right). 2005 values shown first then 2011.

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.

3.1.2 Lake Tauanui Lake No. 198; surveyed in 2011

Figure 3-4: Lake Tauanui a volcanic lake with steep boulder strewn margins.

Summary

Overall ranking

High: There was a native vegetation cover to 4 m water depth and no exotic species present.

Threats

An isolated lake with low potential for inadvertent pest fish and plant introductions. Water quality is impacted by farming and a nutrient rich volcanic catchment.

Management recommendations

Lake native biodiversity value monitoring every 5 years.

Description

This lake (1677769E 6071132N) is 6.2 ha in area and about 9 m deep. The surrounding catchment is in pasture and grazed native forest. Access is off Mangakahia Road and via 2 km of farm tracks.

Wetland vegetation

There was little emergent or other wetland vegetation present, apart from isolated patches of kuta (*Eleocharis sphacelata*) and *Baumea articulata* on the shore of the north eastern island.

Submerged vegetation

The whole lake was vegetated to 4 m. There was a diverse native community with charophyte meadows dominated by *Chara fibrosa* and *Nitella* sp. aff. *cristata*. *Potamogeton ochreatus* was the tall growing native plant present and *Glossostigma elatinoides* was the dominant turf plant, with lesser amounts of *Elatine gratioloides*, a plant rarely encountered in Northland lakes.

LakeSPI

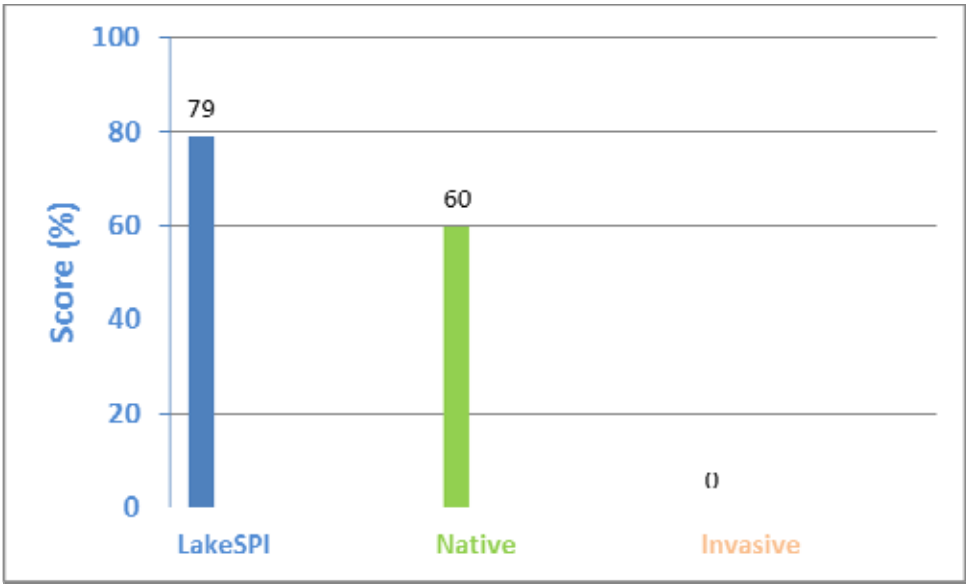

Figure 3-5: LakeSPI Index for Lake Tauanui as % of potential score, Native Condition Index, and Invasive Impact Index (from left to right).

The LakeSPI score was excellent at 95% (Figure 3-5) reflecting an indigenous submerged flora with high covers and diversity. No weed species were present.

Water birds

Swan, paradise ducks, mallard.

Fish

None seen.

Aquatic invertebrates

No mussels or koura seen, *Physa* abundant.

Changes in indicators

No previous survey

Threats

Water quality is eutrophic and could be threatened by stratification and anoxic bottom waters releasing nutrients from bottom sediments. If exotic weeds were introduced they would have a high impact as conditions would favour extensive growths.

Management recommendations

Lake native biodiversity value monitoring every 5 years.

Survey lake for fish.

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

Figure 3-6: 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.

Figure 3-7: 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

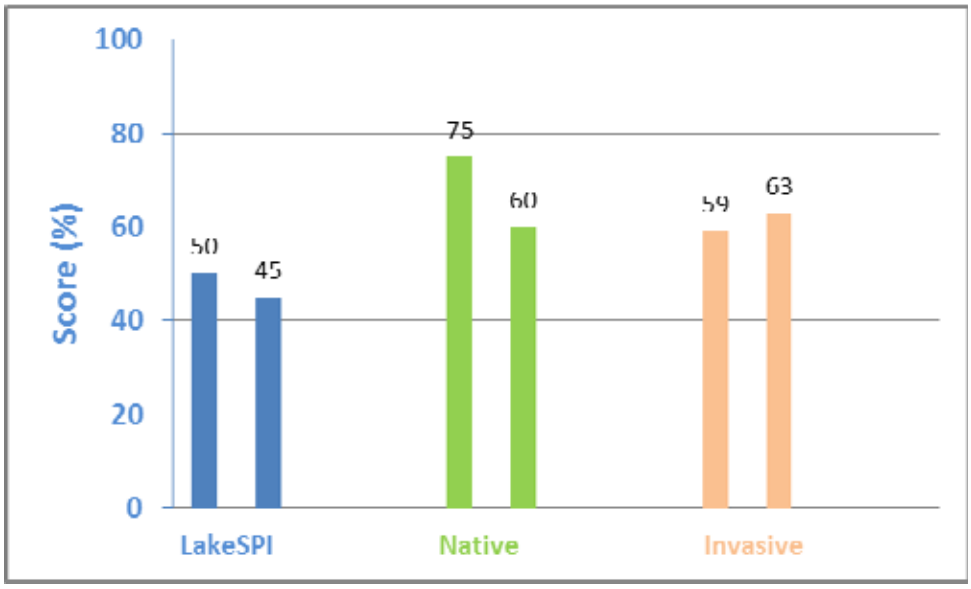

Figure 3-8: LakeSPI Index for Lake Waro as % of potential score, Native Condition Index, and Invasive Impact Index (from left to right). 2006 scores are shown first then 2011.

The decrease in the moderate LakeSPI score from 50 % to 45 % (Figure 3-8) 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*.

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

Figure 3-9: Lake Kai-iwi from the access point showing an extensive margin of emergent vegetation and pines cleared in the background.

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. The invasive *Utricularia gibba* was amongst emergent vegetation in 2011.

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 *U. gibba* was common growing to 9 m deep.

LakeSPI

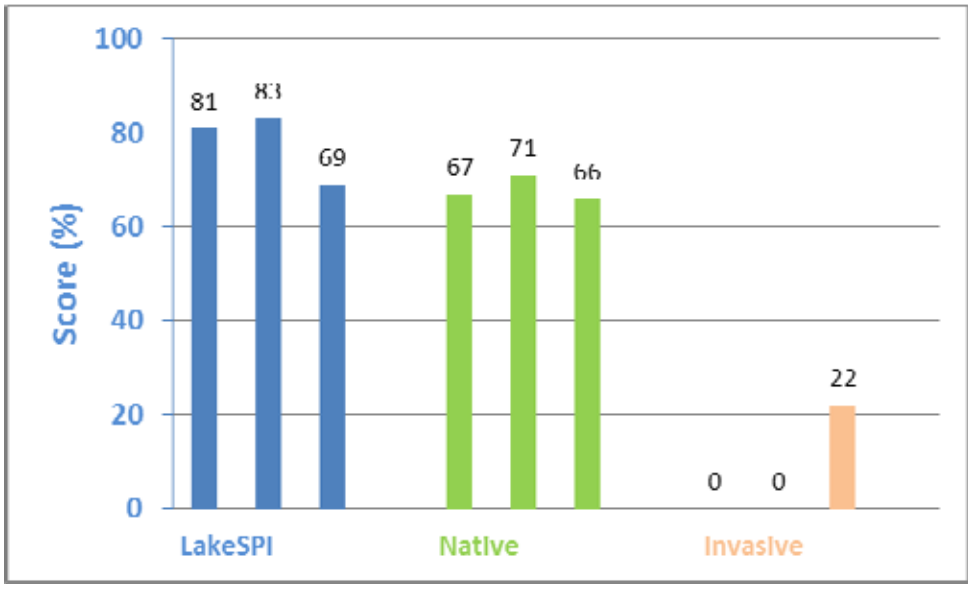

Figure 3-10: 2011 LakeSPI Index for Lake Kai-iwi as % of potential score, Native Condition Index, and Invasive Impact Index (from left to right) with 2005; 2007, 2011 values shown respectively.

The excellent LakeSPI score in 2007 of 81% (Figure 3-10) 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.

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

Figure 3-11: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 prolifer, 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

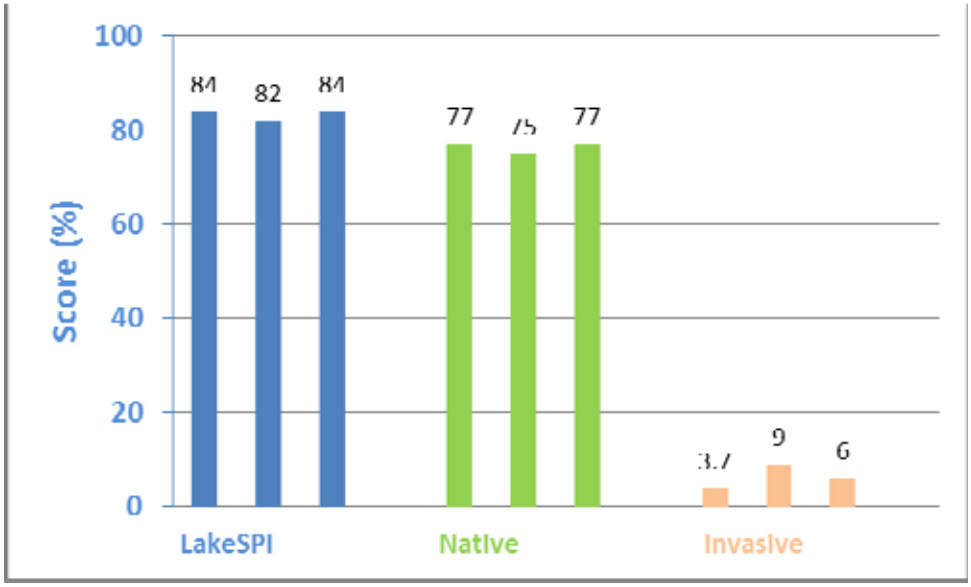

Figure 3-12: 2011, LakeSPI Index for Lake Taharoa as % of potential score, Native Condition Index, and Invasive Impact Index . 2005, 2007 and 2011 values shown respectively from left to right.

A excellent LakeSPI score of 84% (Figure 3-12) 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*) and koaro (*Galaxias brevipinnis*), 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.

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

Figure 3-13: Lake 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.

LakeSPI

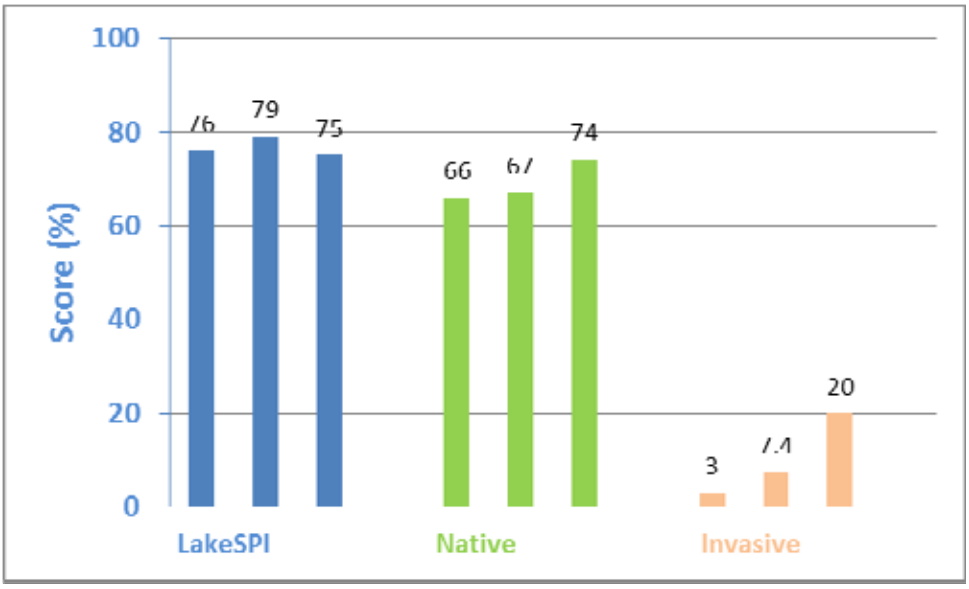

Figure 3-14: LakeSPI Index for Lake Waikere 2011 as % of potential score, Native Condition Index, and Invasive Impact Index (from left to right) with 2005, 2007 and 2011 values shown respectively.

An excellent LakeSPI score of 75% (Figure 3-14) 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.

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.

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

Figure 3-15: 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.

Figure 3-16:The nationally endangered *Utricularia australis* co-existing with dense mats of the exotic *U. gibba* in Te Riu Lagoon.

LakeSPI

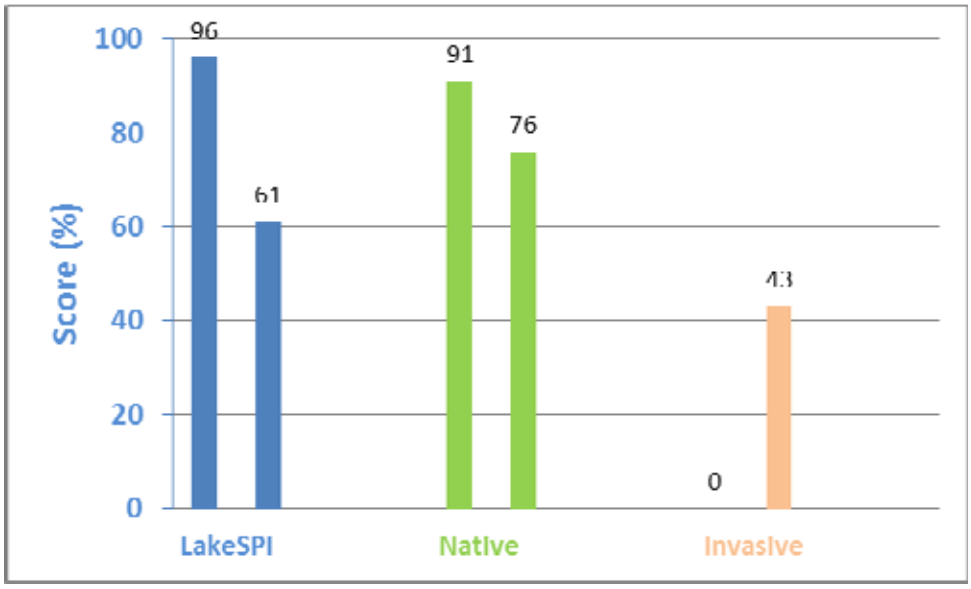

Figure 3-17:LakeSPI Index for Te Riu lagoon as % of potential score, Native Condition Index, and Invasive Impact Index (from left to right) with 2006 then 2011 values shown.

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.

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

Figure 3-18: 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

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

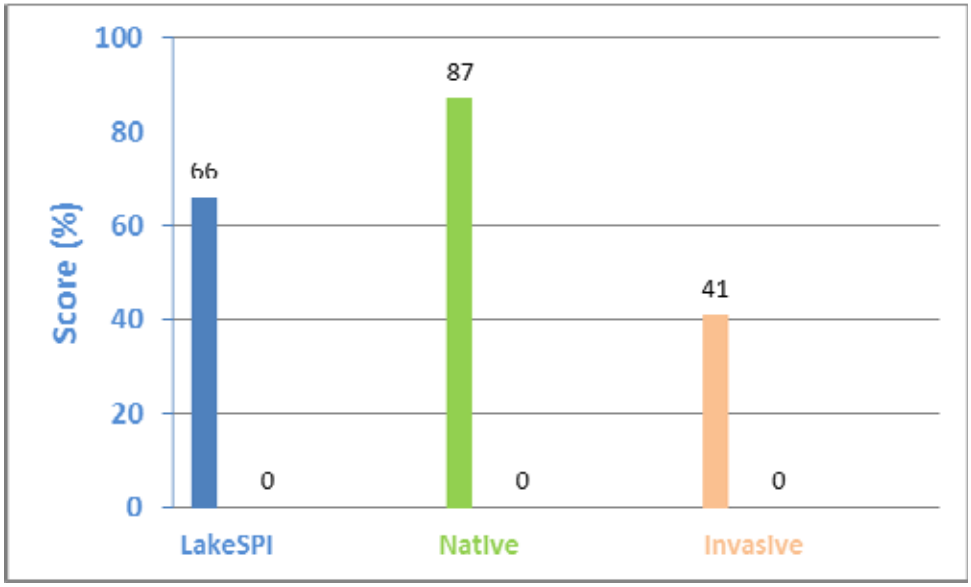

Figure 3-19: 2005 LakeSPI Index as % of potential score, Native Condition Index, and Invasive Impact Index (from left to right) in 2005 prior to grass carp introduction. A default score of zero was generated in 2011 as there was no submerged vegetation > 5%cover.

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 ongoing 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.

3.2 Biodiversity ranking

Table 3-1: Northland lakes ranked for native biodiversity value and summary of monitoring recommendations. Lakes are listed with a Northland Regional Council lake number and rankings) as outstanding, high, moderate-high, moderate, moderate-low, low. * indicates a lake that has significantly changed since initial biodiversity ranking.

Name	NRC Lake Number	Rank	Lake Biodiversity Monitoring	Pest Plant Surveillance
Kai-Iwi	236	Outstanding	5 yrs	1 yr
Midgley*	257	Low	5 to 10 yrs	
Taharoa	229	Outstanding	5 yrs	1 yr
Te Riu	201	High	5 yrs	
Waikere	227	Outstanding	5 yrs	1 yr
Tauanui	198	Outstanding	5 yrs	1 yr
Waiporohita	99	Outstanding	5 yrs	1 yr
Waro	410	Moderate-high	5 yrs	

Two of the lakes surveyed during 2011 have declined in biodiversity ranking:

Midgley's Lake has declined from Moderate-High in 2005 to Low in 2011. The introduction of grass carp has essentially de-vegetated the lake, removing contiguous native submerged vegetation and probably extirpating the nationally endangered *Utricularia australis*.

Lake Waro showed some indication of water quality decline as a retraction of vegetation depth limit combined with a slight increase in invasive species abundance but no decline in biodiversity ranking was apparent, however this would be expected in the future should these trends continue.

Utricularia gibba has increased in abundance in many of the lakes, but although this species has smothered other submerged vegetation, especially in Lake Te Riu, biodiversity ranking has yet to be affected.

4 Surveillance

4.1 Lake Ngatu

The shallow bay out from the main access point for Lake Ngatu, at the north end of the lake off West Coast Road (2529000E 6683000N), was intensively checked for new weed incursions deploying 3 SCUBA divers and 3 snorkelers.

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

The beach at the south end of the lake was also checked and at the eastern end of the beach (2528960E 6684870N) an area extending from the edge of the *Eleocharis sphacelata* was also checked. The lake currently still has no *E. canadensis*, *E. densa* or *C. demersum* present, and all are potential weeds (particularly *C. demersum*) that could markedly impact on the ecological and recreational lake values. *L. major* remains present but has not increased in abundance since surveyed in 2006. In fact it has reduced in abundance possibly due to extensive smothering growths of *Utricularia gibba* which forms on the *L. major*.

Currently the *L. major* present in the lake is not causing a nuisance to recreation but it is a well used lake and could potentially provide a source of weed fragments for dispersal to other weed-free lakes. Information displayed on signage for boaters would be a useful way to inform users that any weed fragments could pose a significant risk to the next water body they visit. Advice on cleaning boats, boating equipment and trailers should be included on the signage.

4.2 Lake Waiporohita

The eastern shore of the lake was checked for submerged weed, shoreline drift fragments and marginal weeds including monitoring the spread of alligator weed. No new weeds were found (although *U. gibba* was seen elsewhere during ecological monitoring), but alligator weed had spread from the old boat launching site (north corner by the road) to now be present around the lake. Water clarity was good (~1.5 m) for this lake and submerged vegetation was checked by snorkel and SCUBA.

4.3 Lake Kai-iwi

The boat access point useable by 4-wheel drive in 2005 (25701100E 6598580N) has had public access restricted by a gate since 2006. Scuba divers and snorkelers made two passes of the shoreline up to 150 m either side of this site to cover the depth range to 5 m. No new invasive species were found.

4.4 Lake Taharoa

At the beach launching site for boats (2568960E 6598645N) near the beginning of Domain Rd, about 400 m of the shoreline was searched for invasive weed with towed scuba divers covering the 0 - 10 m depth range. No invasive weed was found.

The camping ground beach at the eastern end of the lake (2570410E 6599045N), which is used for boat launching and mooring, was checked. About 500 m of the shore was checked and was mostly bare sand on the shallow shelving beach with suitable habitat at about 7 to 9 m deep. Scuba divers were towed along this upper vegetated depth limit. Visibility was good

and sparse native vegetation was low growing, enabling large areas to be effectively searched. No new invasive species were found.

At the Peninsula boat launching area (2568375E 6599495N), a section of shoreline about 250 m long, was checked by towing scuba divers. Also the other side of the Peninsula, in the Sin Bin area (the most southern part of the northwest bay), was searched. No invasive species were found, nor are there any other submerged plants in this area.

4.5 Lake Waikere

The shoreline 200 m either side of the concrete boat ramp (2567290E 6600270N) was searched by a scuba divers and two towed snorkelers. The water is very clear so snorkelers could see well into 5 m of water. No invasive weed species were found.

In the southeast bay of the lake (2567725E 6599910N), about 400 m of shoreline was checked by towing two snorkelers. Conditions were very still and water clarity very good so rapid inspection was possible. No invasive weed species were found except for *U. gibba* which has been found in small quantities since 2009 and in the present ecological survey it was found on a number of profiles between 11 and 15.5 m.

4.6 Lake Humuhumu

The access at the eastern side of the lake was checked by 3 scuba divers and 3 snorkelers covering about 300 m of shoreline and out to the 6 m depth contour. Alligator weed was abundant amongst the marginal vegetation, and it has spread. No invasive submerged weedy species were found apart from some *U. gibba*, which was present in small patches growing over other submerged species.

4.7 Carrot Lake (Ngakapua East)

In 2010 *Egeria densa* was discovered in Carrot Lake (Ngakapua East) for the first time. Plants found were hand weeded, but poor water clarity made it difficult to detect. In 2011 the *E. densa* incursion in Lake Carrot was found to be larger than the previous year and it was also growing amongst the *E. sphacelata*. This made it impossible to remove by hand and now grass carp would be the most cost effective way of removing it. *E. densa* removal is advocated also to protect the nearby highly ranked Lake Ngakapua.

The presence of *E. densa* in Lake Carrot has increased the likelihood of *E. densa* invading Ngakapua so annual surveillance of this lake is now recommended until the Lake Carrot infestation is controlled by grass carp.

5 Grass carp assessments

5.1 Lake Swan (Lake Roto-otuauru)

E. densa was first reported in the lake in 1992, and *C. demersum* was first recorded in the 2005 survey. Grass carp were introduced in May 2009 to eradicate the *C. demersum* and *E. densa,* to eliminate the risk of weed spread to high value neighbouring lakes, and to enable eventual native vegetation restoration in Lake Swan.

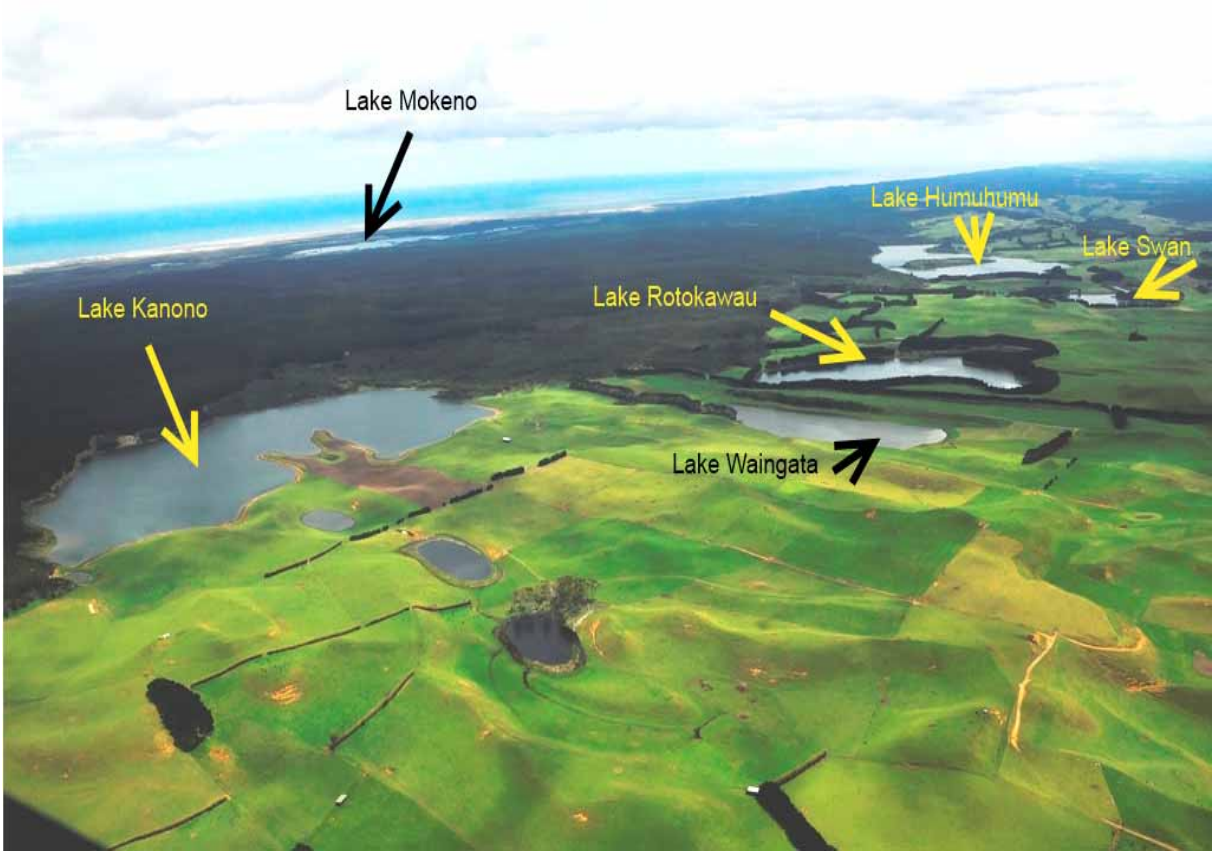

Figure 5-1: The location of Lake Swan is shown in relation to other lakes on the Pouto Peninsula. [Photo Rod Budd, NIWA, Hamilton].

In April 2010 virtually all the *E. densa* had gone and about half the *C. demersum* had been removed (Figure 5-2). At a few locations with sandy margins, a wide range of turf species were present with *Glossostigma elatinoides* the dominant species. Also charophytes persisted at one small site in water to 1.8 m deep on the eastern shore of the main body of the lake.

Figure 5-2: Lake Swan after 11 months of grass carp grazing with a few remnant stalks of *E. densa* (foreground left) and the rest is *C. demersum*.

In March 2011, the five SCUBA profiles for the lake were repeated (Figure 5-3) and much of the lake scanned using sonar to search for weed growth.

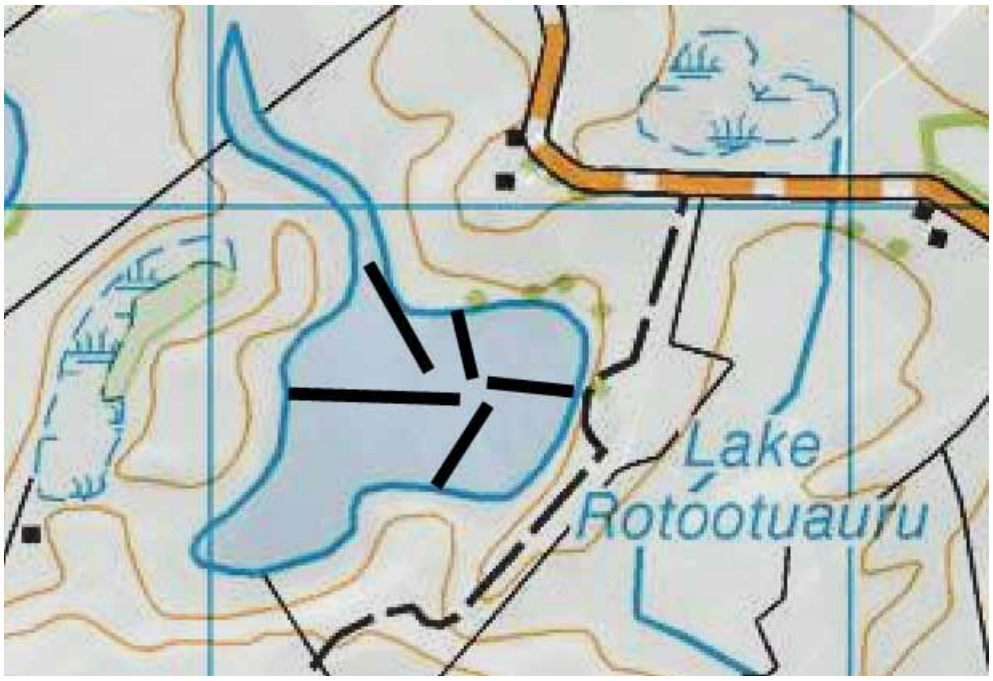

Figure 5-3: Lake Swan showing the location of 5 profiles monitored in the lake.

We confirmed that, with the exception of a few pieces of *C. demersum* found floating amongst the emergent species on the lake margin the lake basin was de-vegetated and *C. demersum* and *E. densa* were no longer present. The marginal emergent species were also reduced considerably in extent with only remnants of *Typha orientalis* stands left (Fig. 5-4). The area least grazed was in the arm at the north end of the lake where the lake extends into a wetland (Fig. 5-5). Low growing turf species were not affected by grass carp grazing.

Water clarity at the time was low, having been reduced from about 4 m in 2009 to 0.5 m in 2011. The deterioration in water clarity is likely to have resulted from the removal of submerged weed species. The tall beds of hornwort and egeria would have enhanced water clarity by uptake of nutrients from the water column and also stabilising bottom sediments preventing wind re-suspension. However, water clarity prior to the establishment of introduced weed beds in 1992 was poor (Champion et al. 1993). A greater deterioration in water quality would have been expected if the weed beds were unmanaged and underwent a collapse similar to that in Lake Omapere and most Waikato shallow lakes.

Exclusion of stock from the marginal vegetation of this lake and continued annual monitoring of grass carp impacts are recommended until no fragments of invasive submerged weeds have been observed for a total of five years. Efforts to reduce grass carp numbers could then be initiated, along with restoration initiatives to improve the ecological condition of this lake. In the meantime, the threat of spread by hornwort and egeria from Lake Roto-otuauru to adjacent high-value lakes has been mitigated.

Figure 5-4: Grass carp were introduced in May 2009 to lake Swan and by 2011 had removed much of the *T. orientalis* (raupo) from the margins.

Figure 5-5: The margins were least grazed in the north arm of Lake Swan.

5.2 Lake Heather

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

The two baseline profiles recorded prior to grass carp release in 2010 were repeated in 2011 (Fig. 5-6).

Figure 5-6: Lake Heather showing the location of the 2 profiles monitored, with one in each basin.

The *E. densa* had been heavily grazed and reduced to basal stalks (Fig. 5-7) but only about 20% of the *C. demersum* has been removed. Most of the *C. demersum* was still recorded up to 3.4 m tall and had also expanded further in the north basin and displaced the *Potamogeton ochreatus* beds. The rate of progress for grass carp in removing the weed beds is similar to that seen in Lake Swan. On that basis we would expect the *C. demersum* to be almost gone by March 2012.

Figure 5-7: Lake Heather in 2011 with *E. densa* remnants (2.6 m deep) heavily grazed by grass carp.

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