Environment Waikato Technical Report 2001/03

Aquatic & Marginal Vegetation of Lake Serpentine North

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PO Box 4010
HAMILTON EAST

ISSN: 1172-4005

4 May 2001

Environment Waikato
REGIONAL COUNCIL

Acknowledgements

The author wishes to thank John Clayton and Tracey Edwards of NIWA, Vicky Froude (Eco-logic), Catherine Beard and Gavin Reynolds of the University of Waikato and Rachel Kelleher (Department of Conservation) for their assistance in the field. Thanks also to Jim Price and Ian Buchanan, Environmental Monitoring, Environment Waikato for the provision of field equipment. Thanks to Chris McLay, Janice Stokes, Jo Hair, Gill Lawrence, Frances Barnett and Andrew Taylor of Environment Waikato for their assistance during the preparation this report and to Lisette Collins and Karen Denyer of Environment Waikato and Rachel Kelleher of the Department of Conservation for their constructive criticisms of the draft.

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1 Introduction

The Northern Waikato Region has an abundance of freshwater ecosystems ranging from large peatbogs, minerotrophic wetlands, peat lakes associated with developed peatlands, and small shallow riverine lakes. There are more than 40 lakes ranging in size from less than 0.01 km^2 (Lake Posa, near Koromatua) to 34.4 km^2 (Lake Waikare).

The peat lakes of the Waikato Region are concentrated around the Waikato, Hamilton and Waipa Districts, where their association with peat formations has had a marked effect on their physical, chemical and biological nature. There are 15 lakes located in the Waipa District, 12 in the Waikato District and one within Hamilton City.

The Waikato peat lakes form the largest group of peat lake habitats in New Zealand and are valuable conservation refuges for many unique plant and animal species. They also represent some of the few remaining areas of wetland in the formally extensive Komakorau, Rukuhia and Moanatuatua peat bogs, as well as being important recreational areas for hunting, boating and picnicking.

Aquatic macrophytes play an important role in regulating lake ecology. These plants enhance habitat complexity and heterogeneity, which in turn provides substrate for fish spawning, sessile invertebrates and periphyton communities, and refugia for zooplankton. Macrophytes can also improve water clarity by bank stabilisation, wave moderation and by promoting the settling out of suspended sediments from the water column.

The presence and composition of submerged vegetation within a lake is influenced by a number of interacting factors including water clarity, introduction of exotic species, competition by marginal vegetation, exposure and season. Exotic species influence aquatic vegetation composition by displacement by invasive oxygen weeds (Hydrocharitaceae and Ceratophyllaceae) and predation and/or disturbance by exotic herbivorous fish (rudd – *Scardinius erythrophthalmus*) and omnivorous fish (catfish – *Ameiurus nebulosus*).

A survey of the marginal and aquatic vegetation of the Waipa peat lakes was undertaken in the early 1990s where the presence of native submerged vegetation was noted in several lakes (Champion *et al*., 1993). Recent re-surveys of some of these lakes have found that the aquatic vegetation has completely collapsed, leaving Lake Serpentine North as the last remaining lake requiring survey. This report describes the results of a botanical survey of the marginal and submerged vegetation of Lake Serpentine North, undertaken during February 2001.

2 Site Description

Lake Serpentine North is a peat lake, a remnant of the once larger Lake Rotopiko. Drainage in the eastern catchment and the construction of a formed outlet channel during the 1920's resulted in a substantial lowering of water levels in the lake and the formation of three distinct waterbodies (Greenwood, 1996). Lake Serpentine North is now isolated from Serpentine South and East.

Lake Serpentine North is located within the Waipa District, approximately 8 kilometres north of Te Awamutu on the edge of the now largely drained Moanatuatua peat bog (Boswell *et al.*, 1985). The Lake Serpentine complex is Crown-owned and administered by the Department of Conservation as a government purpose reserve (wildlife management). The total area of open water of the three lakes combined is 11.5 hectares, of which Lake Serpentine North is approximately 1.5 ha (Department of Conservation, 1995)

Lake Serpentine North formed during the last glaciation some 17 000 years ago, as a result of the blocking of river valleys by silt and sand from the ancient Waikato River. Small lakes were formed behind these gravel bars (McCraw, 1967). As the New Zealand climate warmed, dense forest formed. Rushes and submerged vegetation developed as the climate became wetter and warmer. The peat rapidly deepened and spread outwards, with peat growth gradually covering the sandbars that had originally dammed the lakes. As the peat thickened, the lake waters deepened and turned dark brown and acidic as a result of leaching of humic materials from the peat (McCraw, 1967).

The Lake Serpentine North catchment is completely pastoral, surrounded on all sides by intensive dairy farming (Figure 1). The conversion of peatland to agricultural land with drainage and the use of fertilisers have resulted in the characteristics of Lake Serpentine North's water chemistry changing from highly dystrophic to mildly eutrophic.

Figure 1: Aerial view of the Lake Serpentine complex looking south west towards State Highway 3. Lake Serpentine North is obscured to the right. (John Greenwood Photography, date unknown).

3 Method

The submerged and marginal vegetation of Lake Serpentine North was investigated during February 2001. Species unfamiliar to the author were identified using Johnson, (1998), Webb *et al.*, (1988) and Coffey & Clayton, (1988).

Marginal vegetation was surveyed along three transects established from the minimum summer water level to the edge of the wetland (in this case defined by the fence separating the reserve from the farmland). Along each transect a 2 m wide band of vegetation was assessed with species composition and abundance measured. Species abundance was determined using an estimate of cover, which was defined as the vertical projection of the crown or shoot area of a species onto the ground surface, (Greig-Smith, 1983). It is difficult to accurately assess the cover of an area using the eye; however, the use of a cover abundance scale allows an estimate that is repeatable across transects.

The Braun-Blanquet cover abundance scale comprising the following seven sub-classes, was used (Braun-Blanquet, 1932).

p	<1%
1	1-5%
2	6-25%
3	26-50%
4	51-75%
5	76-95%
6	96-100%

Vegetation type was described according to Atkinson (1962) describing dominant species with associates e.g. *Salix cinerea – S.fragilis*/*Coprosma* spp. *S.cinerea* dominant canopy with lesser amounts of *S. fragilis* with *Coprosma* species dominant in the sub-canopy (deWinton & Champion, 1993). A complete species list is contained in Table 1.

Transect one was located in the southeast corner and ran from the farm boundary fence in a northwesterly direction to the lake edge and was 44 m long (note: the fence represents 0 m; Figure 2).

Transect two began at a farm boundary fence located in the southwest corner of the reserve where the lake flows out across a farm race to the rest of the Lake Serpentine complex. The transect headed in a northeasterly direction to the lake edge. This transect was 14 m long.

Transect three was located at a farm boundary fence in the northern edge of the Reserve. The transect headed in a southerly direction and was 18 m long.

General descriptions of observations made during the field work are also included within section 4 of this report.

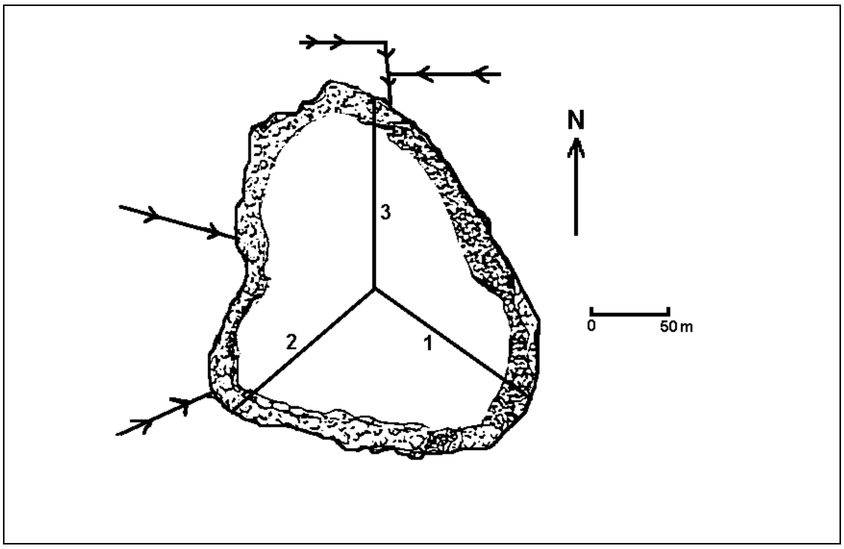

Figure 2: Location of marginal and submerged monitoring transects (1 – 3) in Lake Serpentine North. farm drains flowing into Lake Serpentine North (adapted from Champion et al. (1993).

The submerged vegetation was surveyed using the technique of Clayton (1983). The three transects investigated were spaced evenly around the lake margin starting at the end of each marginal vegetation transect and converging in the middle of the lake (Figure 2).

Along each transect a 2 m wide band of vegetation was visually assessed from the shore to maximum plant depth using snorkel equipment. Species depth ranges, covers and heights were recorded. Plant species covers were assessed using the Braun-Blanquet cover scale.

An abundance rating (AR) was formulated for each submerged species encountered (Champion *et al.*, 1993)

$$AR = \text{No of sites} \times \frac{\text{Depth range of species}}{\text{Total vegetation depth range}} \times \text{average species cover}$$

<10%	= occasional
10 to 50	= common
>50%	= abundant

Water transparency (seechi depth) and water depth measurements were recorded during the survey.

4 Results

4.1 Marginal Vegetation

4.1.1 Emergent

deWinton & Champion (1993) define emergent vegetation as that growing within the range of normal lake levels, with roots in the bottom sediments and foliage emergent above the water. *Eleocharis sphacelata* formed a monospecific community around the entire margin of Lake Serpentine North. Vegetation cover typically ranged between 25–50% and extended from 0.5 m to depths of 1 m. No species were found associated with *E.sphacelata* despite attempts to confirm previous recordings of *Utricularia australis*.

4.1.2 Wetland

Included within this section are observations made from each transect and include marginal herbaceous (marginal sudd, marginal turf) and marginal woody communities. Species abundance and composition for transects one to three appears in Table 1.

Only a limited marginal sudd community was observed (Transect two), consisting of a small floating mat of *Isachne globosa* extending from the lake edge to the *E.sphacelata* community.

Table 1: Species composition and abundance of marginal vegetation along all transects. Plant species covers were assessed using Braun-Blanquet cover scale (Braun-Blanquet, 1932).

	Transect One		Transect Two		Transect Three	
	0 – 22m	23 – 44m	0 – 6m	7 – 14m	0 – 8m	9 – 18m
Canopy species						
Salix cinerea	3	1	3	3	2	2
Leptospermum scoparium		4				1
Cordyline australis	1				1	
Ground Species						
Agrostis stolonifera	1		1		1	
Alopecuris geniculatus	1		1		1	
Baumea articulata		1		1		1
Baumea huttonii		p	p	p		p
Baumea teretifolia		1		1		1
Bidens frondosa	1	2	1	2	1	2
Blechnum minus	1	2	2	2	1	2
Callitriche stagnalis		1				1
Calystegia sepium	1	1				
Carex maorica	p	p	p		p	
Carex virgata	1	1	1	1	1	
Coprosma propinqua					p	
Cordyline australis	1				1	
Cortaderia solleana			p			
Dacrycarpus dacrydioides			p	p	p	
Eleocharis acuta		1		1		1
Eleocharis sphacelata		2		2		2
Galium palustre		1		1		p
Gleichenia microphylla	1	2			1	2
Holcus lanatus	1		1		1	
Isolepis prolifer		p		p		p
Isolepis reticularis		p		p		p
Isachne globosa				p		
Juncus bulbosus		1		1		1
Juncus effusus	p		p		p	
Juncus gregiflorus	1		1	1	p	
Leptospermum scoparium		2				1
Lycopus europeaus		1	1	1		1
Myosotis laxa		p		p		p
Myriophyllum propinquum		1				1
Nertera scapanioides		p		p		p
Paspalum distichum	1		1		1	
Phormium tenax	p		p	p	p	
Poa annua	1		1		1	
Polygonum hydropiper	p		p	p	p	
Pteridium esculentum	1				3	
Rumex conglomeratus	p		p		p	
Rubus fruticosus	2				1	
Ulex europeaeus	p					

A distinct delineation was observed in all transects at the point where the marginal woody community extended towards the open water and the point where the *E.sphacelata* community established. The area between these two communities consisted of marginal turf species growing on exposed lake sediment. Seasonal water level fluctuations result in this community being inundated to depths up to 30 cm for 9 to 10 months of the year (Hamill, 1995).

The marginal community was consistently uniform in composition across transects one and three, with *Eleocharis acuta*, *Glossostigma elatinoides*, *Myriophyllum propinquum, Juncus bulbosus, Isolepis prolifer, I.reticularis, Myosotis laxa, Nertera scapanioides, Potamogeton cheesemanii* and *Schoenus maschalinus* present (Figure 3). *Eleocharis acuta, J.bulbosus, G.elatinoides and Callitriche stagnalis* were common while occasional occurrences of the other turf species were observed. Clumps of *Baumea huttonii* and *B.articulata* occurred infrequently. The marginal community at Transect two was depauparate with isolated pockets of *Eleocharis acuta*, *Glossostigma elatinoides* and *Myriophyllum propinquum* growing under a *Salix cinerea* canopy.

Figure 3: View of boundary between land and aquatic ecotone at Transect three. Photograph taken during winter when the level was elevated and the marginal turf community submerged (J Kelly photography, 2001).

Two woody marginal communities dominate the canopy of the Lake Serpentine North riparian vegetation, with a *Salix cinerea* carr completely surrounding an inner *Leptospermum scoparium* community. Transect one contained a relatively intact fringe of *L.scoparium,* however this species was found in low numbers at transect three and was completely absent in transect two.

In transect one, the graduation from a *S.cinerea* dominated canopy to a *L.scoparium* canopy occurred 23 m in from the boundary fence. Previous to this point rank pasture grasses such as *Paspalum distichum*, *Holcus lanatus*, *Agrostis stolonifera*, *Poa annua*, *Rumex conglomeratus*, *Galium palustre*, *Alopecuris geniculatus*, and individual clumps of *Carex virgata*, *C.maorica* and *Juncus gregiflorus*, and *J.globosa* dominated the ground vegetation. *Ulex europeaeus, Phormium tenax, Cordyline australis* and *Polygonum hydropiper* were also present. *Calystegia sepium* was present amongst the grasses.

At approximately 17m in from the boundary fence ground cover species in transect one changed from those described above to the ferns *Pteridium esculentum, Blechnum minus,* and *Gleichenia microphylla,* and in places dense pockets of *Rubus fruiticosus*.

As reported above, at 23 m canopy cover changed to *L.scoparium*. Associated with this change was a corresponding change in ground cover species. Sparsely covered in contrast to the other community types described, the ground cover species consisted of *L.scoparium* (seedlings)*, Baumea articulata, B.teretifolia, B.huttonii, Bidens frondosa, Carex virgata, C.maorica, Gleichenia microphylla, Isachne globosa,* and *Lycopus europeaus.*

Salix cinerea dominated the canopy of transect two with no *L.scoparium* present. No sub canopy species were encountered and the ground cover consisted of rank pasture grasses as found at transect two, *Lycopus europeaus*, *Phormium tenax*, *Dacrycarpus dacrydioides* (saplings), *Carex virgata*, and individual *Carex maorica*. Marginal species found in transects one and two were absent in transect two where *S.cinerea* grew out over open water (Figure 4).

Figure 4: View of grey willow carr with Eleocharis sphacelata in foreground, typical of transect two (J Kelly photography, 2001).

The species composition and abundance in transect three was similar to that found at transect one. Three large specimens of *Dacrycarpus dacrydioides* (approximate height 10 – 14 m) were encountered within five metres of the start of the transect. The canopy was dominated by *S.cinerea* with a few *L.scoparium* found at the lake edge. Rank pasture grasses numerically dominated species abundance and composition of ground cover species.

4.2 Submerged vegetation

Five species of submerged macrophytes were found during the investigation. A summary of the species found, their depth range, height and abundance are provided in Table 2.

The pondweed *Potamogeton ochreatus* and the charophyte *Nitella cristata* dominated the submerged flora of Lake Serpentine North. *N.cristata* was common from the edge of the *Eleocharis sphacelata* band, extending around the margin of the lake, to 1.5 m deep. In parts, *N.cristata* reached >75% abundance, though less than 50% was more typical. Individual *P. ochreatus* plants were interspersed amongst *N. cristata*, between 0.5 – 1.0 m deep. The relative abundance of *P. ochreatus* to *N. cristata* increased as the water depth approached 1 m. *P. ochreatus* was observed growing to 2 m depth with plant heights extending in parts to 1.5 m, though 1 m was more typical. Clumps of *Potamogeton cheesemanii* were observed at increasing frequency with depth amongst *P. ochreatus.* Figure 5 provides a diagrammatic representation of the submerged vegetation at transect 1.

Table 2: Summary of submerged species found in Lake Serpentine North, including their depth range, abundance and height. Results expressed as an average of all three transects measured.

Species	Depth Range	Abundance	Average Height (m)
Potamogeton ochreatus	0.5 – 2	C	1 (1.5)
Potamogeton cheesemanii	0.5 – 3	O	1 (1.5)
Chara corallina	0.2 – 1	O	<0.5
Chara fibrosa	0.2 – 1	O	<0.5
Nitella cristata	0.5 – 1.5	C	<1

O = occassional, c = common. ( ) maximum height.

Chara corallina and *Chara fibrosa* were restricted in distribution, with individual plants observed only along transect two immediately adjacent to *E. sphacelata*. *C. corallina* extended to a maximum depth of 1 m, after which it was displaced by *N. cristata*. *C. fibrosa* was extremely restricted in distribution, limited to a few individual plants amongst *C. corallina*.

Observations were made of very thick growths of epiphytic filamentous algae covering most surfaces of all submerged plants. The colour of the algae suggested species of blue-green alga were dominating.

Submerged vegetation was estimated to cover approximately 80% of the lake bed with growth >3m deep probably restricted by light availability.

No exotic species of submerged macrophytes were observed.

Seechi depth was recorded at 1.8 m.

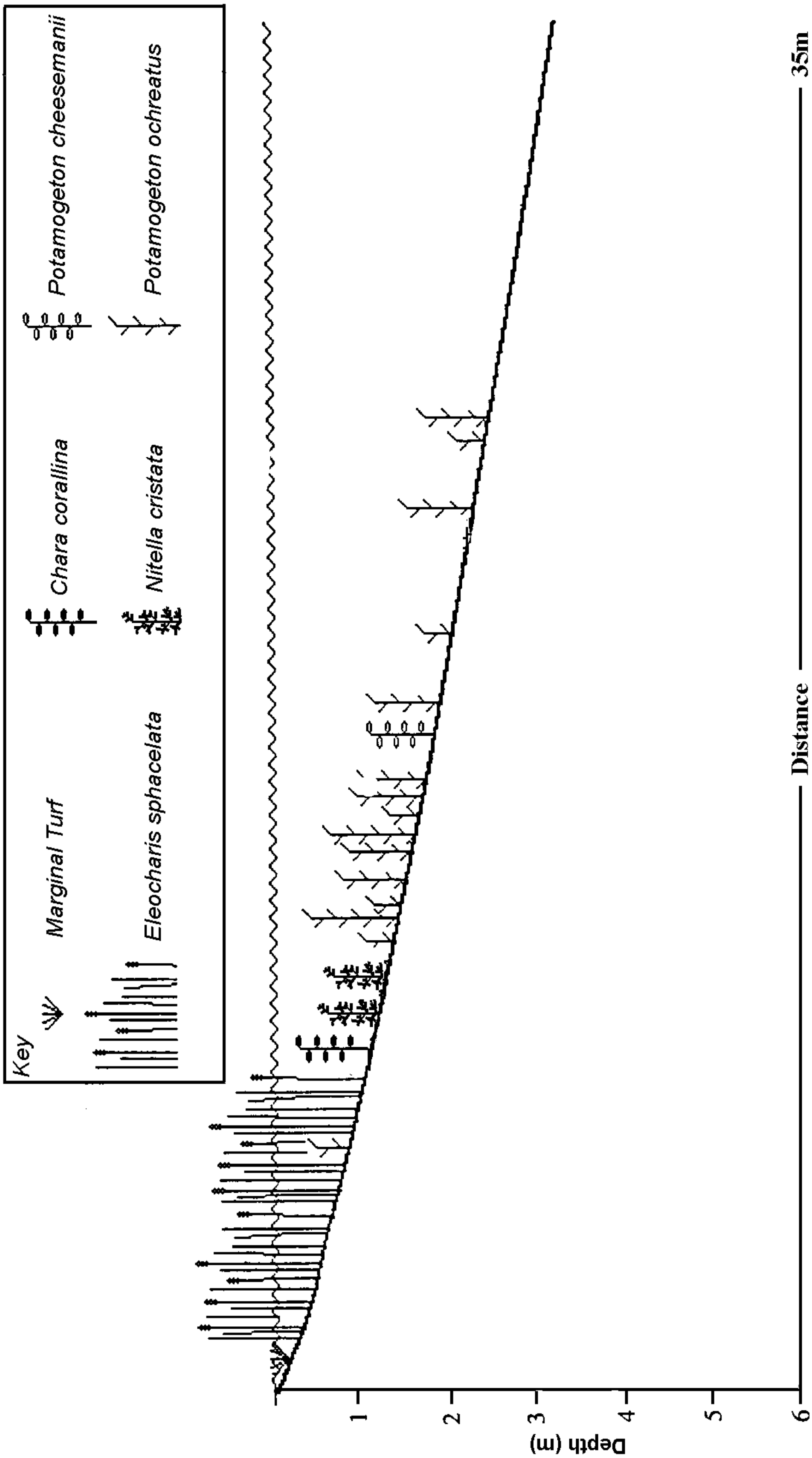

Figure 5: Diagrammatic illustration of the submerged vegetation at transect One, Lake Serpentine North (plant heights not to scale). Adapted from Champion et al., (1993).

5 Discussion

An investigation into the marginal and submerged vegetation of Lake Serpentine North was first undertaken by staff and students of Waikato University in 1976 (Chapman & Boubee, 1977). A more intensive descriptive survey was undertaken by the National Institute of Atmospheric and Water Research (NIWA) in 1989 and 1991 (Champion *et al.*, 1993).

Lake Serpentine North is a small dystrophic remnant of a once larger Lake Rotopiko. The mean annual secchi depth is approximately 2.0 m with water clarity influenced by tannins washed in from surrounding peat soils. The lake trophic state is described as eutrophic reflecting its pastoral catchment (Hamill, 1995).

The survey of aquatic and marginal vegetation in Lake Serpentine North has shown the lake has the best representation of an aquatic macrophyte assemblage in the Waikato region. Certainly the lack of any exotic macrophytes is extremely unusual in both a regional and national context (Wells & Champion, 2001). This author is only aware of one other lake in the Waikato Region (Lake Kuratau) that retains an exclusively native macrophyte community (Wells & Champion, 2001). Lake Serpentine North is also one of the few remaining vegetated Waikato peat lakes, following the collapse of aquatic macrophytes in Lakes Rotomanuka, Pataka, Posa, Ruatuna, Pikopiko, Rotokauri, Rotoroa and Hotoananga during the previous decade (observations of submerged plant communities during a survey of Lakes Rotomanuka, Pikopiko, Hotoananga in February 2001 for a Ministry for the Environment Sustainable Management Fund Project 5107 – Development of Aquatic Macrophyte Indicators of Lake Biological Condition, in prep.; Lakes Pataka, Posa and Rotoroa from Champion *et al.*, 1993).

The absence of any exotic plant competitor within Lake Serpentine North, shallow and clear lake water, relatively stable trophic conditions and protection from ungulate browsing are believed to be the key factors in maintaining a native aquatic plant assemblage within the lake. This has interesting implications for the lake's ecology and has been described by previous studies in terms of the 'alternative stable state' hypothesis (Moss, Madgwick & Phillips, 1996).

The alternative stable state theorem states that over a wide range of phosphorus concentrations there are two alternative stable states: the turbid phytoplankton-dominated state and the clear water submerged plant-dominated state. Lakes such as Serpentine North dominated by water plants generally have far higher biological diversity (invertebrates, fish, birds) than those dominated by phytoplankton (Irvine, *et al*, 1989).

Subsequent to the vegetation survey, a survey of the fish fauna within the lake was undertaken by Environment Waikato and Department of Conservation staff (Speirs *et al.*, 2001). Of particular concern was the capture of one rudd (249 mm fork length) in an 8 cm gill net set in open water. Rudd greater than 180 mm in length are known to be highly selective herbivores preferentially grazing native charophytes and pondweeds over exotic oxygen weeds (Dugdale & de Winton, 2001). In lakes where native and exotic macrophytes occur, rudd have been found to reduce the biomass of native macropyhtes to the extent that exotic plants completely dominate species abundance (Dugdale & de Winton, 2001). In Lake Serpentine, rudd have the potential to significantly reduce the biomass of native charophytes and macrophytes and contribute to the loss of the native assemblage if the population reaches a sufficient density.

The high level of epiphytic algae on the submerged vegetation may be indicative of high in-lake nutrient levels and low grazing rates within Lake Serpentine North and is of concern due to the stress that this causes to photosynthesising plants. This may be indicative of increasing external loads of plant nutrients reaching the lake from the adjacent catchment. High levels of epiphytic algae on submerged vegetation in other lakes have often been the precursor to its eventual collapse e.g. Lake Rotomanuka North (J. Clayton pers. comm.).

Conversely, *Eleocharis sphacelata* is indicative of low nutrient acid conditions common amongst the Waikato Region's more pristine peat lakes (Lake Serpentine complex, Lake Rotomanuka North, Lake Maratoto) (deWinton & Champion, 1993). deWinton & Champion (1993) also note in lakes where nutrient status has increased due to eutrophication and peat decomposition, beds of this species are open, with evidence of disease and insect damage. This was not apparent in Lake Serpentine North where emergent beds of *E.sphacelata* formed a dense mono specific community typically reaching 50% cover. No insect damage or disease was apparent and flowering appeared abundant. This is consistent with the relatively stable catchment conditions observed with Lake Serpentine North, especially when compared to other lakes in the Region where cattle have access to the lake edge and dairy shed effluent discharges contribute to external nutrient loading.

The flora of transition zones between land and water are characteristically diverse due to the dynamic and heterogeneous nature of these areas. Flora adapted to the marginal zone of Lake Serpentine North are tolerant of these conditions, having various structural, physiological or life history adaptations.

Marginal herbaceous vegetation is largely determined by the degree of exposure, soil type, presence and intensity of grazing both by cattle and introduced waterfowl, fire and the introduction of exotic plants. Lake Serpentine North was fully fenced in the early 1980's effectively preventing cattle from grazing to the lake edge (Greenwood, 1996).

The marginal zone of Lake Serpentine North has a major influence on the limnology of the lake affecting; hydrology, carbon cycling, and the removal of sediment, nutrients and toxins. The marginal zone of the lake is likely to function like the riparian zones of rivers and streams, providing a buffer to contaminants including nutrients. Marginal vegetation has been found to remove up to 90% of nitrate from surface waters either through direct uptake or through the facilitation of denitrification (Hamill, 1995). Exclusion of stock access from the edge of Lake Serpentine North would have greatly enhanced the nutrient stripping capabilities of the marginal vegetation.

Salix cinerea is an introduced species typical of wet marginal areas on all but the most acid soils (deWinton & Champion, 1993). This species is commonly found throughout the lakes and wetlands of the Waikato Region where its ability to reproduce sexually and its tolerance of a wide range of environmental factors makes it a highly invasive weed able to displace many native wetland plant communities. *S.cinerea* alters the community composition of wetland areas within the Waikato Region, including the Waikato peat lakes, by aggressively outcompeting native species and by shading out lower stature plants.

Rank pasture grasses dominated the understory of the willow carr reflecting the historic grazing which occurred before 1980, the proximity to the adjoining dairy farm and high proportion of edge. The species present are generally tolerant of short periods of inundation or of damp, boggy conditions e.g. *Paspalum distichum, Holcus lanatus, Agrostis stolonifera.*

The presence of *Pteridium esculentum* is indicative of a disturbance regime. The disturbance could have been in the form of fire, grazing or changing hydrological regime (lowering water table). The incidence of grazing around Lake Serpentine North and recent changes to the invert level of the lake outlet could explain the abundance of *P.esculentum* along the middle reaches of each transect.

6 Conclusion

The importance of vegetation around lake margins and in particular submerged vegetation is being increasingly recognised by managers of freshwater systems. Marginal vegetation provides wildlife habitat, a food source and refuge, and has an important role to play in the maintenance and enhancement of water quality by intercepting and processing diffuse sources of pollutants that may enter the lake.

Lake Serpentine North's assemblage of native submerged vegetation is highly unusual in the Waikato Region and is due in part to the protection afforded the lake by the well-protected marginal zone and its low importance to the Waikato eel fishery. Macrophytes within the lake are likely to play an important role in promoting the Lake's clear water status by inhibiting the growth of phytoplankton, stabilising suspended sediments and by providing a refuge for zooplankton.

The presence of rudd within Lake Serpentine and the high levels of epiphytic algae are of great concern. Immediate consideration must be given to controlling the population of rudd to levels below which changes in species composition and abundance of the submerged plant assemblage occurs. In the medium term, steps must be taken to reduce the external loading of nutrients to the lake.

It is important that lake managers acknowledge the lake's unique characteristics and that steps are taken which ensure that the aquatic and marginal plant communities are maintained and enhanced. Initiatives such as the reservation of additional esplanade strips, willow control and restorative plantings around the lake are encouraged.

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