



ENVIRONMENTAL MANAGEMENT GROUP

Technical report

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Lake Hatuma Ecological Monitoring 2005

June 2006
EMI 06/10
HBRC Plan No. 3860

Environmental Management Group Technical Report

Internal

Environmental Monitoring Section

Lake Hatuma Ecological Monitoring 2005

Prepared by:
Geoff Walls – Consultant Ecologist

Reviewed by:
Anna Madarasz – Scientist Coastal Quality

Approved:
Murray Buchanan, Group Manager – Asset Management

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LAKE HATUMA ECOLOGICAL MONITORING 2005

Contract document prepared for Hawke's Bay Regional Council



**Geoff Walls
Consultant Ecologist
5 Paulus Tce, Cashmere, Christchurch**

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INTRODUCTION

Regular monitoring of ecological condition and trend is built into the planned management of Lake Hatuma, Hawke's Bay, by the Hawke's Bay Regional Council.

In December 1999, a regime for monitoring the ecological condition and trend of the lake was set up on contract for the Hawke's Bay Regional Council by Geoff Walls. This was done using the experience gained in establishing a similar monitoring regime in Pekapeka Swamp, Hawke's Bay, a year earlier. It also had the benefit of the local knowledge of adjacent landowners and Department of Conservation staff. Baseline surveys of vegetation and fauna were carried out at the same time.

That work was reported upon (Lake Hatuma Ecological Monitoring, 1999). A companion report provides more background information and forms a monitoring plan (Lake Hatuma Ecological Monitoring Plan, February 2000).

In early December 2001 and again in early December 2003, the monitoring programme was repeated, using the same sites and methods, and was reported upon.

In October 2005, the monitoring programme was repeated as before. This document chronicles the monitoring results and draws comparisons with those obtained in 1999, 2001 and 2003.

1. VEGETATION

1.1 Terrestrial vegetation

There were three aspects to monitoring of the terrestrial vegetation of the lake: mapping of the current vegetation cover; establishment of photopoints; establishment of permanent vegetation monitoring plots.

1.1.1 Vegetation map

Method:

The patterns of terrestrial vegetation were mapped in 1999 using recent colour aerial photos. A copy of this map is shown in Appendix 1. Re-mapping was scheduled for 2004 or thereafter.

Observations:

Five major vegetation types were identified and mapped:

- W** Willows dominant: forest and patches of trees, mostly crack willow but also much grey (pussy) willow and a few other willows; various grasses and herbs beneath; tussock sedges (*Carex virgata*) and swamp nettle (*Urtica linearifolia*) out of easy stock reach; most areas periodically flooded; mainly on the western side of the lake.
- R** Raupo dominant: forming dense stands around the shore on the western and northern sides of the lake; also forming “islands” in open water; containing willows in places.
- SR** Sedges and rushes dominant: various mixtures of *Juncus gregiflorus*, *J. effusus*, *Schoenoplectus validus*, *S. pungens* and *Eleocharis acuta* with grasses and herbs, forming a marshy shore fringe mostly on the eastern and northern sides of the lake.
- P** Pasture (both grazed and rank): mainly exotic pasture plants, but mixed with various rushes, sedges and marsh herbs in places.
- O** Open water.

Whilst little is left of the vegetation present in pre-human times, these types mimic the natural patterns to a certain extent. In the past, the lake would have been surrounded by tall dense forest, dominated by kahikatea on the wet soils near the shore. Fringing that would have been cabbage trees, harakeke (lowland flax) and purei (tussock sedges). Further into the water still would have been areas of tall rushes and sedges, including raupo.

Willows have been introduced to provide a replacement tree element in the system. Although this has created valuable habitat for fauna and flora, it has brought with it a significant problem. The willows are more tolerant of prolonged inundation than any native tree or shrub, and as a consequence are invading the entire shore area. This is exacerbated by fluctuating and artificially lowered water levels. It also makes the prospect of restoring natural shore vegetation a headache. Monitoring is required to assess the rate and ecological consequences of willow spread now that stock are being

fenced off from the lake margins. The vegetation map, photopoints and transects are designed to do that job.

A comparison with the vegetation patterns mapped by the NZ Wildlife Service following a survey in 1980 is very interesting. It shows several changes over the intervening two decades. Willows have invaded the artificial ponds at the south-west of the lake and the wet herbfields and rush-grasslands at the northern end of the lake, and have established in places on the eastern shore. Raupo has apparently contracted and been fragmented on the western shore, perhaps as a result of control operations. However, it has expanded at the northern and southern ends, forming substantial “islands” in places. Rushes and sedges have contracted on the eastern side of the lake, perhaps due to farming, but have invaded the wet herbfields at the northern end. *Schoenoplectus validus* (formerly known as *Scirpus lacustris*) has evidently much expanded. These changes illustrate the dynamic nature of such a modified wetland as Lake Hatuma. They also relate to the artificially altered water levels and the opportunities created for plant invasions, expansions and contractions as a result.

In 2001 there was no major change from the 1999 situation. However, willows and raupo had grown around the lake edge, occupying more of the open water area. This trend was expected to continue unless water levels were raised or vegetation control was carried out.

In 2003 the processes observed previously had continued. However, aerial herbicide control had been done around the western lake shore in late 2002. This had killed the crack willow and had knocked back the grey willow, raupo and purei.

In 2005 the situation was similar to that in 2003. The willow and raupo growth had been checked around many of the lake margins, particularly on the western side, but not around the SW ponds or inlet channels, in most places on the eastern side or at the northern tip. In the absence of a modern aerial photo, subsequent to the aerial control operations, it was not possible to re-map the vegetation.

Next monitoring:

General observations in November-December 2007; re-mapping of the vegetation in 2007 if a suitable aerial photo is available.

1.1.2 Photopoints

Method:

13 photopoints were set up the length and breadth of the wetland in December 1999. Each was marked with an aluminium label attached to a post, either an existing fence post or a new one driven in for the purpose. The photopoints were chosen to represent the spectrum of terrestrial vegetation types and situations around the wetland. They were also selected to be readily relocated. Photos were taken from the standing position at each photopoint: mostly panoramas of the vegetation; some more localised and specific. A SLR camera with a 50mm lens was used. Film was Kodak colour print, 200asa. Each photopoint was revisited and photographed again in December

2001. The procedure was repeated in early December 2003 and again in October 2005. The 2005 photos, in order, are in the album that accompanies this document.

The location of each photopoint is marked on the map (Appendix 1). It is also described on the photopoint recording sheet (one for each photopoint, Appendix 2). Also on each sheet is a description of the vegetation and the ecological patterns and processes occurring there.

Observations:

Overall, the lake water level in 2005 was the highest experienced during survey and monitoring. It was much higher than in 2003, when it was noticeably lower than at the time of the 2001 survey (when it was lower than in 1999). The process of willow and raupo expansion had continued, except on the western margin where it had been checked by aerial herbicide application.

Photopoint 1:

Sited at the north end of the lake, among willows on the edge of an open area subject to periodic inundation. In 2001, the willows had bulked out, and the water level was considerably lower than in 1999. This process had continued in 2003, with the water level lower still. In 2005 the willows had continued to bulk out in the absence of cattle (excluded by recent fencing) and the water level was high.

Photopoint 2:

Sited on the outer edge of the willow forest on the NW side of the lake. There is an area of wet pasture with rushes there that appears likely to be invaded by willows if stock are excluded. In 2001, as at Photopoint 1, the willows had bulked out, and the water level was considerably lower than in 1999. In 2003 the area had been fenced from stock and as a result the willows were spreading and invading open areas via fragments that were taking root. In 2005 the willows had continued to bulk and were also invading the open space. Rushes had bulked out also. The area was flooded at time of visit, very soggy from recent rain and retired from grazing. Two bitterns were seen nearby in wet pasture of marsh and meadow foxtail.

Photopoint 3:

Sited on the fenceline on the western side of the lake, where there is a hollow intermittently flooded. In 1999, stock had been recently excluded from this part of the lake edge, and willows and rushes looked likely to invade the wet pasture. In 2001, that process had begun. The pond surface was clear of floating vegetation, unlike in 1999. In 2003 there was little change. In 2005 there was little difference from 2003 except spike sedge had thickened in the wet hollow where not grazed and water buttercup had established in the grazed part of the wet hollow.

Photopoint 4:

Similar site to Photopoint 3, and nearby, but looking at the strip to the lake cleared of willows. Also the start point of Transect 1. In 2001, rushes had rapidly increasing in the wet ungrazed pasture, and willows had begun to resprout. In 2003, willows had been sprayed and partially killed on the lake edge. Willows had begun regenerating

within the cleared strip. In 2005 the most obvious change was the willow regeneration in the cleared 'avenue', bulked up significantly since 2003.

Photopoint 5:

The other end of Transect 1, at the lake edge. In 2001, willows had been cleared but were growing back from sprouts and seedlings. Rushes and sedges were dense and evidently getting denser. Raupo had grown noticeably at the lake edge. In 2003, willows had been sprayed and partially killed on the lake edge (crack willows killed; grey willows knocked back but sprouting again). Raupo had survived the spraying but *Carex secta* had been knocked back. The cleared area had been grazed by cattle and inundated at times, keeping the vegetation there down. In 2005, willow regeneration was evident in the 'avenue' and on a wee islet. Raupo regeneration had occurred near the shore. There was regeneration of rushes in the 'avenue' (not grazed heavily recently). A bittern was seen in the 'avenue' and another was seen flying. Black teal (NZ scaup) were nearby in the lake.

Photopoint 6:

Sited a little north of Photopoint 5 and also on the lake edge. Chosen to follow the interplay between raupo, willows, sedges and water at a site where control of willows and raupo had been done. In 2001, sedges (*Carex secta* and *C. lambertiana*) had grown up considerably, raupo had proliferated and closed in on open water dramatically, and there had been much regrowth in willows cut in about 1998. Swamp nettle (*Urtica linearifolia*) had appeared at the base of the marker post. In 2003, willows had been sprayed and partially killed on the lake edge (crack willows killed; grey willows knocked back but sprouting again). *Carex secta* had been knocked back but was beginning to recover. *Carex lambertiana* had flourished and swamp nettle had continued to proliferate, even where sprayed. In 2005, it was too wet (water too deep) to reach the post. Willows were still alive along the edge despite being sprayed. Raupo was similar to its 2003 state. Prolific growth had occurred of *Carex lambertiana* and there had been continued *Carex secta* recovery.

Photopoint 7:

Sited at an artificial pond and the lake margin south of Photopoint 5. In 2001, there had been a great proliferation in raupo since 1999, and willows had grown dramatically too. What was largely open water in 1999 had become covered in the floating fern Pacific azolla (*Azolla filiculoides*), and the pond had become colonised by herbs, rushes and grasses of damp pasture and shallow water. In 2003, the raupo in the pond had continued to advance, and rushes had begun to invade. At the lake edge, willows had been sprayed and partially killed (crack willows killed; grey willows knocked back but sprouting again). Raupo had survived the spraying but *Carex secta* had been killed. Water pepper and Mercer grass had proliferated. In 2005, raupo had continued to advance in the pond, and rushes continued to invade. Follow-up spraying had killed regenerating willow and raupo on the lake edge, though raupo was beginning to regenerate again. A predator-killed pukeko was found at the site.

Photopoint 8:

Sited on the old inlet stream (Ngahape Stream), in the middle of the broad willow forest fringe there. The stream banks had been recently cleared of willows in 1999, but were being rapidly recolonised by them. Sheep were currently using the area then. In

2001, there had been much willow regeneration from fragments left on the banks after clearance, and the big willow trees had grown substantially. Grasses and rushes had grown rank on the banks following sheep removal. The water channel was filled with aquatic vegetation, mostly exotic species. Swamp nettle had appeared at the marker post. In 2003, there was quite dramatic regeneration of willows from rooted fragments and sprouts from adult trees. Cattle had grazed the area. Hare and possum signs were apparent. In 2005, it was much as before on the grazed south side. On the ungrazed north side, willow regeneration was prolific and very rapid, swamp nettle was still present in the vicinity and rushes and sedges were continuing to expand. A bittern was heard nearby.

Photopoint 9:

Sited at the mouth of the artificial inlet channel. There is a lakeshore fringe of willows, some of which had been recently cut back in 1999. In 2001, there had been spectacular bulking up of the willows on the islets and on the fringes of the lake where stock did not have access. Raupo had also expanded significantly in area. In 2003 there had been continued bulking of the willows and expansion of raupo. Where deer and cattle used the lake edge there was no raupo and the willows were kept in check. There was heavy use of the area by birds. In 2005, raupo had continued to expand. Willows where not browsed by cattle or deer had continued to bulk up. Bitterns were booming.

Photopoint 10:

Sited at the outlet to the lake. In 2001, little change was observed except for bulking up of willows on the lake edge and out in the body of the lake. Mercer grass had apparently thickened within the channel at the lake outlet. In 2003, the willows had continued to bulk up. There was heavy use of the lake edge between the inlet and outlet by deer and cattle. In 2005, the water level was much higher, and flowing in a strong stream over the weir. It was therefore not possible to cross the weir in safety, so photos were taken from the south side. Willows on 'islands' had bulked out a little, but the raupo in the background had retreated a bit (herbicide in the last two years). Raupo had regenerated to the north where not chewed down by deer.

Photopoint 11:

Sited at a representative part of the SE lakeshore with a marshy fringe of rushes, sedges and grasses. This fringe was being invaded by willows at a rapid rate, judging by the dramatic increase between 1999 and 2001. Lake clubrush (*Schoenoplectus validus*) had increased somewhat at the water's edge. In 2003, willows had continued to increase around the shore. In 2005, water levels were much higher, so *Schoenoplectus validus* was inundated and it was not possible to quite get to the same photopoints. Some small willows had been killed (sprayed?), and others had established since. Larger willows had bulked up.

Photopoint 12:

Sited near the former boat shed on the NE lakeshore with a broad marshy fringe of rushes, sedges and grasses. In 2001, the site was also being invaded rapidly by willows. Lake clubrush had apparently diminished somewhat, possibly because of grazing. In 2003 there had been continued growth in willows and the raupo 'islands' had expanded. Lake clubrush had increased, possibly reflecting diminished grazing. A

bittern was seen hunting in the shallows. In 2005, there had been continued growth of willows with new establishment from fragments. Willow poles had been planted for maimai habitat. Willow 'islands' had increased in size. *Schoenoplectus validus* beds were similar to 2003.

Photopoint 13:

Sited just north of Photopoint 12, and chosen to complement it. In 2001, raupo and willows had grown, and lake clubrush had retreated where grazed. In 2003, raupo had continued to advance into the lake, young willows were colonising and old willows had spread except where sprayed. A portion of the foreshore vegetation had been grazed down to a turf of Mercer grass with little spike sedge. Lake clubrush had increased somewhat to the south. In 2005, it was too wet to reach the photopoint.

Next monitoring:

November-December 2007; thence every second year. Photos to be repeated; recording sheets to be used.

1.1.3 Permanent vegetation plots

Method:

Three permanent vegetation monitoring plots were established in sites chosen to represent the main parts of the lake edge. Their locations are marked on the map (Appendix 1), and described on the recording sheets (one for each plot, Appendix 3). Two of the plots are formal line transects. They sample a sequence of vegetation from the lakeshore, along a strip two metres either side of the transect line. The vegetation composition is described in obvious segments or types, using transect recording sheets. The ecological processes are also outlined. The third plot is an informal transect established to serve a dual purpose: to keep an eye on the shore vegetation sequence and (more important) to monitor the health of the strong population of swamp nettle (*Urtica linearifolia*) at the site. Photos taken to portray each transect are in the album with the photopoint photos.

Observations:

Vegetation transect 1:

Sited on the western side of the lake and chosen to sample the vegetation sequence where there is a cleared strip to the water's edge through the willow forest. Willows, raupo, rushes and sedges were expected to proliferate now the site was no longer grazed. This 1999 prediction had been borne out in 2001: rushes and sedges had increased in dominance, willow saplings and resprouts had appeared along the transect and lake clubrush had appeared at the water's edge. Raupo had grown there too, but was not within the actual transect. Marsh bedstraw (*Galium palustre*) was abundant in the ex pasture, providing a pretty floral display and fragrance. In 2003 the story was much the same, but cattle had grazed the vegetation down somewhat and the shore had been sprayed to control willows. Some changes in composition and zoning had apparently been caused by generally lower water levels: in damp pasture, spike sedge and creeping bent had proliferated; in wet pasture, creeping bent and turf plants had proliferated; at the water's edge Mercer grass and creeping bent had proliferated. The cattle were doing no great harm ecologically, and were probably helping to preserve the cleared strip. In 2005, the water level was much higher and stock use of the cleared

strip had been minimal in recent times. Rushes and sedges had therefore increased and young willows were growing up. Willows were collapsing where sprayed, and swamp nettle was prolific amongst the dead willows. Mercer grass, creeping bent, marsh foxtail and spike sedge had all proliferated, and marsh clubrush and *Glyceria fluitans* had appeared.

Vegetation transect 2:

Also sited on the western shore of the lake but within willow forest. In 2001, the population of swamp nettle was even more vigorous than in 1999. Its opportunistic nature was illustrated by its appearance at the site of a fallen willow branch in the rank pasture, otherwise too dense for swamp nettle. Purei (*Carex secta*) had appeared and grown substantially in the absence of grazing. In 2003, the processes had continued. In 2005, the swamp nettle was extremely healthy, and the population around the western side of Lake Hatuma must now be among the best in Hawke's Bay. The regeneration of purei, marsh clubrush and *Carex lambertiana* was impressive and the ability of crack willow to grow up from a fallen branch was evident.

Vegetation transect 3:

Sited on the north-eastern lakeshore, and chosen to monitor the sequence of marsh vegetation. In 2001, there was a considerable change in composition from that in 1999, possibly due to an altered grazing regime in the interim. Creeping bent (*Agrostis stolonifera*), Mercer grass (*Paspalum distichum*), *Juncus gregiflorus*, *J. articulatus* and marsh bedstraw had all increased substantially, at the expense of other grasses, various herbs and rushes (particularly lake clubrush and three-square, *Schoenoplectus pungens*). In 2003, further changes had taken place, probably reflecting changes in the grazing regime and water levels. In damp grassland, meadow foxtail had increased and perennial ryegrass had decreased; in wetter ground creeping bent had proliferated and young crack willow had appeared; the vegetation was thinner in standing water. In 2005, the lone willow marking the transect start had blown over and the water level was very high, making re-measurement of the transect difficult. The vegetation was similar to that of 2003, despite recent use by cattle. Young willows had increased in size and number and Mercer grass and marsh bedstraw had increased; spike sedge (*Eleocharis acuta*) had diminished accordingly.

Next monitoring:

November-December 2007; thence every second year. Photos to be repeated; recording sheets to be used.

1.2 Aquatic vegetation

Method:

The composition of the aquatic vegetation was assessed at three sites, chosen to represent the main parts of the lakeshore. Macroinvertebrate sampling and fish survey was done at these sites too. The site locations are marked on the map (Appendix 1) and described on the combined aquatic vegetation and macroinvertebrate recording sheets (one for each site, Appendix 4).

Sampling at each site was done by hand-pulling aquatic vegetation and "washing" it in white plastic trays for examination. The aquatic macrophytes present were identified,

and their relative abundance was recorded. Macroinvertebrates were searched for in each sample (see 2.4), and their standard sensitivity scores recorded to give a measure of water quality.

Observations:

The aquatic macrophytes were dominated by the exotic species hornwort (*Ceratophyllum demersum*), water speedwell (*Veronica anagallis-aquatica*), Canadian pondweed (*Elodea canadensis*) and curly pondweed (*Potamogeton crispus*). Various native green algae were common. Also common in standing water were the marsh species water forget-me-not (*Myosotis laxa* subsp. *caespitosa*), Mercer grass, *Schoenoplectus validus*, *Eleocharis acuta* and water pepper (*Polygonum salicifolium*). Floating plants were the natives: duckweed (*Lemna minor*) Pacific azolla (*Azolla filiculoides*) and watermeal (*Wolffia australiana*). Overall, the native submerged macrophytes have largely been displaced by exotic species, but the floating native species are still common.

Significant changes observed in 2001 were that curly pondweed and the native mud pondweed (*P. suboblongus*) appeared to have increased in standing water and Mercer grass had increased on the wet margins. Whether these changes are due to an altered nutrient regime or successional processes is not known.

Significant changes observed in 2003 were that the density of macrophytes was less at Site 1 (western side of lake), possibly because of the aerial herbicide application to control willows the previous year; that the macrophyte density at Site 2 (eastern side of lake) was greater than before and included *Potamogeton pectinatus* (not noted at the lake before), Canadian pondweed and hornwort (not noted at the site before); and that the inlet channel (site 3) was stagnant and eutrophied (less water flow and more fertiliser runoff?).

In 2005, the water levels at the monitoring sites were higher than usual which made sampling of the deeper-growing species more difficult. That probably explains the apparently smaller amounts of *Potamogeton suboblongus*, *P. pectinatus*, *P. crispus* and hornwort. Otherwise, the macrophyte composition was similar to that in 2003.

Next monitoring:

November-December 2007; thence every second year. Sampling to be repeated; recording sheets to be used.

1.3 Weeds

Method:

Weeds were searched for during the survey and monitoring of both the terrestrial and aquatic vegetation (1.1, 1.2). Their presence and impact were noted.

Observations:

The following terrestrial weeds were regarded as requiring surveillance in 1999. They still are.

Crack willow (*Salix fragilis*) and **grey or pussy willow (*Salix cinerea*)**, well established and capable of spreading right around the lakeshores; also considered aquatic weeds; should be controlled where encroaching on open water, streams and traditional access ways, but provide the only forest habitat around the lake, vital to the continued survival of several native birds (including the rare Australasian Bittern) and the only rare native plant (swamp nettle, *Urtica linearifolia*). Had continued to spread and bulk up, particularly where not grazed or sprayed.

The following aquatic weeds are regarded as requiring surveillance:

Hornwort (*Ceratophyllum demersum*), common in inlets and shallow shores, capable of forming very dense beds;

Purple-backed duckweed (*Spirodela punctata*), that could displace the native floating species;

Curly pondweed (*Potamogeton crispus*), common in inlets and shallow shores, capable of forming very dense beds.

Canadian pondweed (*Elodea canadensis*), common in places, capable of forming very dense beds.

Water net (*Hydrodictyon reticulatum*), a serious algal invader of shallow wetlands, present in Lake Poukawa and probably spread on commercial eeling gear.

Raupo is not considered an ecological problem at present, in fact precisely the opposite: it provides vital habitat for wetland birds, including the rare Australasian Bittern, Spotless Crake and Marsh Crake. It should be subject to limited control at traditional access ways and some margins only. The control done in recent years is appropriate.

Next monitoring:

November-December 2007, along with other vegetation monitoring; thence every second year.

1.4 Notable flora

Method:

Plants of note were searched for during baseline survey and monitoring set-up. They were searched for in the 2001, 2003 and 2005 monitoring as well.

Observations:

To date, the only rare plant to have been recorded from the wetland is swamp nettle (*Urtica linearifolia*), which is present in the willow forests of the western shore. This endemic species is listed as nationally threatened (Molloy and Davis 1994; de Lange et al 2004; Hitchmough 2002). It is known from a handful of other wetland sites in the Hawke's Bay lowlands, including Lakes Poukawa, Oingo and Runanga. It is still on the western shore of Lake Hatuma, and is now so abundant there that it must be among the best populations in Hawke's Bay. It will continue to be informally monitored through one permanent plot and general observation as it does not appear to be currently at risk. In fact, in 2001 it had definitely increased at the permanent plot site and had appeared elsewhere. It was still present and thriving in 2003 and 2005, and is apparently capable of withstanding some disturbance. However, its presence and condition is dependent at present on the willow forest, which must be seriously

considered when willow control is being planned. Photographs of swamp nettle are in the photo album that accompanies this report, along with the photopoint and vegetation plot photos.

Should any other notable plants be detected or introduced in future, extra monitoring will be needed.

Next monitoring:

November-December 2007, along with other monitoring; thence every second year.

2. FAUNA

2.1 Waterbirds

Method:

Two methods were used:

1. **Directed searches**, whereby a number of sites around the lake were visited to listen and look for crakes, rails and bitterns. Taped calls were played to elicit responses. The search sites are marked on the map (Appendix 1).
2. **General fauna survey**, whereby waterbirds were searched for during other survey and monitoring activities.

Observations:

Twenty-four species of waterbirds have now been recorded from Lake Hatuma (Hawke's Bay Regional Council Draft Management Plan 1999-2004; NZ Wildlife Service file reports; this survey). Not all may still be present. The list includes NZ Dabchick (an uncommon endemic that gathers in the winter on the lake) and Australasian Bittern (a rare native, resident at the lake). Both are listed as threatened by the Department of Conservation (Hitchmough 2002, Molloy and Davis 1994). The list also includes two native wetland birds a little more common nationally but now very rare in Hawke's Bay: Spotless Crake and Marsh Crake. These latter two species may have now gone from the scene.

No definite detection of crakes was made. It was probably generally too late in the birds' breeding season for strong responses to taped calls to be expected and traffic noise was somewhat disruptive to good listening. Discussions with wetland bird experts also suggest that the technique is a bit hit-and-miss: it can be highly successful where birds are numerous or tapes are played in their immediate territories, but it can draw a blank where birds are uncommon or taped calls are played on their territorial margins. This suggests that there may be few such birds remaining in Lake Hatuma. No NZ Dabchick were seen, although that was not surprising given the transience of that species.

Australasian Bitterns, however, were seen and heard calling from right along the western side of the lake, in 1999, 2001, 2003 and 2005, so at least one rare species is still present in reasonable numbers. It appears that this part of Lake Hatuma may be one of the best remaining sites for the species in Hawke's Bay. The dense raupo, backed by willow forest, whilst not good for recreational hunters, seems to suit these rare birds well. In 2003 a bittern was seen on the eastern shore of the lake, hunting in the shallows, perhaps indicating a healthy and expanding population. In 2005, several sightings were made in different places, and it appeared as though the population was stronger than ever.

The other wetland birds recorded in 1999 included swans, ducks, shelducks, shags, herons, Cattle Egret, Pukeko, Australasian Harrier, Welcome Swallow, Spur-winged Plover, Pied Stilt, Australian Coot, gulls and terns. All were again recorded in 2001,

with the exception of Cattle Egret, Australian Coot and Little Shag. There were many more Paradise Shelduck in 2001 than in 1999, otherwise estimated numbers were similar. In 2003 the same suite of waterbirds was found as in 2001, except that Little Shag was again present. The numbers of Pied Stilt and White-faced heron were considerably greater, but there seemed to be fewer ducks. There were numerous cygnets (little swans). The swans, ducks (except Grey Teal), shelducks and Pukeko are seasonally hunted in the wetland. Although it is the nature of waterbirds to be somewhat shy, they are extremely wary, suggesting that hunting is making it difficult for them to feed, roost and breed in safety. In 2005, NZ Shoveler was not seen, but a pair of NZ Scaup (Black Teal), a species not previously reported at Lake Hatuma, was seen. The numbers of Grey Teal, Pied Stilt and White-faced Heron were lower, perhaps because it was earlier in the season, whilst the numbers of Australasian Harrier were greater.

The full list of birds detected during the October 2005 monitoring and their estimated numbers is in Appendix 5.

Next monitoring:

November-December 2007; thence every second year.

2.2 Other birds

Method:

General fauna survey, whereby birds other than waterbirds were searched for during other survey and monitoring activities. These birds will be recorded every second year for the wetland as a whole during late spring – early summer. Bird names will be according to Heather and Robertson (1996; revised edition 2000).

Observations:

Fifteen other species of birds have previously been recorded at the lake. Four are common natives, whilst the remainder are common introduced species typical of the Hawke's Bay rural scene. In 2001, all those recorded in 1999 were detected, in about the same estimated numbers, with the exception of Shining Cuckoo. That species was also found to be absent from Pekapeka Swamp in 2001, where the loss of habitat through willow control was thought to be a significant contributor. In 2003, all 15 bird species were recorded, including Shining Cuckoo, in about the same numbers as before. In 2005, the situation was very similar but Shining Cuckoo was not detected.

Next monitoring:

November-December 2007; thence every second year.

2.3 Fish

Lake Hatuma is regionally significant for native freshwater fish, and is a traditional harvesting site for eels at least. Longfin Eel, Shortfin Eel and Common Bully, all natives, are recorded from the lake, as are the introduced Goldfish and Rainbow trout. Common names are according to McDowall (2000).

Method:

Fish were surveyed largely using netting and trapping. Fyke nets, hinaki and minnow traps were set overnight at the three aquatic sampling sites (for locations, see map, Appendix 1, and aquatic vegetation and macroinvertebrate recording sheets, Appendix 4). Meat was used as bait in the fyke nets and hinaki; vegemite in perforated film canisters was used as bait in the minnow traps. Fish were also observed in open water sites and caught for identification using a scoop net. In 2003 the lake was too shallow at the western sampling site to set nets, but in 2005 it was quite deep enough.

Observations:

The fish detected during the 2005 survey were:

- Shortfin eel (*Anguilla australis*): a few caught, all small (less than 40cm long). As before, there seem to be substantial grounds for concern about the numbers and structure of the remaining eel population because of commercial eeling, and the prospects of introduction to the lake via eel nets of serious water weeds such as water net (*Hydrodictyon reticulatum*, present in Lake Poukawa which is also being commercially eeled).
- Common bully (*Gobiomorphus cotidianus*): many seen and caught at various places. Undoubtedly a sustainer for eels and many wetland birds.

Not recorded during the survey were:

- Longfin eel (*Anguilla dieffenbachii*): reported from the lake. In serious decline in the North Island because of commercial eeling.
- Rainbow trout (*Oncorhynchus mykiss*): introduced to New Zealand; reported from the lake.
- Goldfish (*Carassius auratus*): erroneously known as carp (McDowall 2000); introduced to New Zealand; reported from the lake.

Next monitoring:

November-December 2007; thence every second year.

2.4 Aquatic invertebrates

Method:

Macroinvertebrates (invertebrates big enough to see with the naked eye) were sampled along with aquatic vegetation at three representative sites (see 1.2 and 2.3; locations marked on the map, Appendix 1, and described in the aquatic vegetation and macroinvertebrate recording sheets, Appendix 4). Aquatic vegetation samples were gathered by hand, and "washed" into trays to dislodge invertebrates. Water and substrate (mud, etc.) samples were also gathered and examined with the use of trays and a hand lens. Invertebrates were identified using the Taranaki Regional Council guidebook (1997) and Parkinson and Cox (1990). Sensitivity scores, indicative of water quality, were assigned from the Taranaki Regional Council guidebook (1997) but updated from Boothroyd & Stark (*in* Collier and Winterbourn 2000). Species found and their scores are listed in the aquatic vegetation and macroinvertebrate recording sheets (Appendix 4).

Observations:

In all three sites, the invertebrates found had sensitivity scores ranging from 1 (very low water quality) to 5 (moderate water quality; 10 is very high water quality). The numbers of invertebrate species found at each site are tabulated below. They show that at none of the sites was the water of very good quality. The number of species found ranged from 11-14 in 1999, from 11-17 in 2001, from 11-15 in 2003 and from 11-15 in 2005. There was little difference between the species compositions in 2001 and 2003 but some differences between 2003 and 2005 (probably a result of the earlier time and higher water levels in 2005). The range of sensitivity scores was unchanged at all sites.

	Number of species found			
	1999	2001	2003	2005
Site 1	14	14	15	12
Site 2	11	17	15	15
Site 3	14	11	11	11

Next monitoring:

November-December 2007; thence every second year. Sampling to be repeated; recording sheets to be used.

2.5 Mammalian pests

Method:

General fauna survey, whereby signs of mammalian pests were searched for during other survey and monitoring activities.

Observations:

Six mammals that can be regarded as pests in the wetland were detected during baseline survey and monitoring set-up:

- Domestic cattle and sheep: largely fenced out of the lake, but still penetrating the fences in places and unimpeded in others.
- Hare: present around the margins in low numbers.
- Possum: present around the lake margins, previously in high numbers especially in the western willow forests but much reduced by contract control operations (“about 1100” reportedly taken out on the western side in 2002-5!).
- Hedgehog: present around the lake margins.
- Feral cat: present around the lake margins, especially in the western willow forests; a serious threat to bird life.

All were still present in 2001. In 2003, all were still present except sheep. Stoat signs were found as well. Possum control had been done in the western willow forests, but there were still quite high numbers, especially to the south. Stoat and cat control was regarded as imperative for the safety of birds. In 2005, possum control had continued and cattle had been excluded from the western side. Other mammalian pests probably present but not detected include:

- Ship rat and Norway rat: known predators of birds, lizards and invertebrates.

- Mouse: known predator of invertebrates.
- Ferret and weasel: known predators of birds, lizards and invertebrates; good swimmers.

Next monitoring:

November-December 2007; thence every second year.

2.6 Terrestrial invertebrates

Not deliberately surveyed or included in the monitoring plan, but worthy of attention during general survey. No particularly noteworthy species were detected in December 1999, in December 2001, in December 2003 or in October 2005.

2.7 Reptiles and amphibians

Also not deliberately surveyed or included in the monitoring plan, but worthy of attention during general survey. No species were detected in December 1999. However, frogs were heard croaking and were seen fleetingly at various points around the lake in December 2001. They had not been recorded from the wetland previously (1999). They were probably the southern bell frog (*Litoria raniformis*), native to Australia and reasonably widespread in New Zealand. In 2003 they were confirmed as present, but in 2005 they were not detected. Frogs have rapidly declined recently world-wide (and in New Zealand) through fungal disease. The continued presence of frogs in this wetland can therefore be viewed as positive, particularly considering that they are not regarded as having a significant adverse impact on the natural ecology.

Next monitoring:

General observation, November-December 2007; thence every second year.

CONCLUSIONS AND RECOMMENDATIONS

The monitoring regime has allowed a series of conclusions to be drawn about various aspects of the ecological condition and trend of Lake Hatuma, and the efficacy of management. Out of these conclusions flow a consequent series of recommendations. There have been some changes since 2003, but most of the findings and hence the recommendations are similar. They are split into two sections:

- Monitoring methods
- State of the Environment (SOE) monitoring and reporting

Monitoring methods

1. Vegetation

The monitoring regime for terrestrial and aquatic vegetation is practical and meaningful, therefore appropriate in addressing the current management issues.

Recommendation: That the current monitoring regime for vegetation (including weeds) continue.

2. Notable flora

Swamp nettle (*Urtica linearifolia*) is the only known rare plant in the wetland. It is currently flourishing and is widespread on the western side of the lake. Willow forests seem to provide the habitat this plant requires currently, mimicking the role played by the native forest fringe in the past.

Recommendation: That swamp nettle continue to be monitored, and that the older willow forest be retained for the interim to ensure there is habitat for the nettle.

3. Fauna

The monitoring regime for most terrestrial fauna and aquatic macroinvertebrates is practical and meaningful, therefore appropriate in addressing the current management issues. However, it is insufficient to properly determine the condition and trend of rare water bird and fish populations, each of which would require more effort and different timing. Separate contracts would probably be needed for these aspects.

Recommendation: That the current monitoring regime for terrestrial fauna and aquatic macroinvertebrates continue.

Recommendation: That additional emphasis be given to monitoring rare water birds and fish (see below).

4. Rare water birds

The variety and numbers of water birds appear to be holding their own at present. One nationally rare species - Australasian Bittern - is resident at the lake, particularly on the western side, in good numbers. In fact, Lake Hatuma holds one of the best populations in Hawke's Bay, and it is the most accessible site to listen or watch for this bird. It is not known whether spotless crane, banded rail or marsh crane still persist; they are notoriously hard to detect, especially after the breeding season. A specific search by experts in spring might reveal these birds.

Recommendation: That a specific search be mounted biennially in spring for rare water birds, using local expertise.

5. Fish

Indications from this monitoring are that there has been a serious decline in the populations of native eels. This aspect needs more in-depth study (survey and monitoring) than possible during the current monitoring regime.

Recommendation: That a comprehensive eel survey be carried out in the wetland and that an in-depth eel monitoring regime be established.

6. Aquatic invertebrates and water quality

Aquatic macroinvertebrates provide a useful measure of water quality and habitat condition. They indicate that the lake can support a considerable diversity of small animal life, but that the water quality is compromised by artificial nutrient input. There are limitations to the technique though, because it was primarily developed for stream systems, and other measures of water quality are necessary for comprehensive monitoring of condition and trend. The Ecological Monitoring Plan for Lake Hatuma (Walls 2000), adopted by Hawke's Bay Regional Council, proposed regular (monthly or quarterly) sampling of standard parameters. These included pH, conductivity, turbidity, colour absorbances, biochemical oxygen demand, dissolved reactive phosphorus, ammoniacal-nitrogen, nitrate-nitrogen, total phosphorus and total nitrogen. To date, this is the only aspect of the Ecological Monitoring Plan not to have been enacted.

Recommendation: That aquatic macroinvertebrate monitoring continue.

Recommendation: That monitoring of other standard water quality parameters be seriously considered.

7. Monitoring techniques and frequency

In the light of eight years' experience in Pekapeka Swamp and other wetlands in Hawke's Bay, the suite of techniques being used to monitor the ecological condition and trend of Lake Hatuma appear to be appropriate and valuable. The only issues are the difficulty of detecting rare water birds, inadequate information on eels and the lack of monitoring of water quality parameters (see above). In view of the relative stability of the wetland but some pressing management needs, monitoring at two-yearly intervals seems sensible.

Recommendation: That the current ecological monitoring programme be continued.

State of the Environment (SOE) monitoring and reporting

Parameters used in this monitoring regime are directly applicable to State of the Environment (SOE) monitoring and reporting. Using a basic assessment of status (or condition) and trend for each parameter, they can be used as environmental indicators, and an overall condition and trend rating for the wetland as at October 2005 can be arrived at. It is shown in the table below.

The conclusion is that the wetland is not in a very natural state but is beginning to improve in condition as a result of restoration management. A distinct improvement has been noted since 2003, particularly in the native flora (and perhaps water levels). It is expected that continued restoration management will produce a marked improvement in status/condition in future, particularly if the wetland is provided with more water, more natural vegetation and predator control.

Indicator	Status/Condition (High, Medium, Low)	Trend (Improving, Stable, Deteriorating)
Native vegetation	L	S
Native flora	L-M	I
Native birds	M-H	S
Native fish	L	S
Native macroinvertebrates	M	S
Water levels	L-M	I?
Water flows	L-M	S
Water quality parameters	?	?
Overall ecology	L-M	S-I

Recommendation: That a similar tabulation of ecological condition and trend be used as part of the regular monitoring reporting for the wetland.

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APPENDIX 1: Vegetation map of Lake Hatuma

Vegetation types and monitoring site locations, December 1999

Vegetation types

- W** Willows dominant
R Raupo dominant
SR Sedges and rushes dominant
P Pasture (both grazed and rank)
O Open water

Monitoring sites

- Photopoints
- Vegetation transects
- Aquatic sampling sites
- Waterbird search sites

APPENDIX 2: Photopoint recording sheets, October 2005

- Photopoint no. 1
- Photopoint no. 2
- Photopoint no. 3
- Photopoint no. 4
- Photopoint no. 5
- Photopoint no. 6
- Photopoint no. 7
- Photopoint no. 8
- Photopoint no. 9
- Photopoint no. 10
- Photopoint no. 11
- Photopoint no. 12
- Photopoint no. 13

PHOTOPOINT RECORDING SHEET

Location/Area: Lake Hatuma		Photopoint no: 1
Establishment date: 8/12/99		GPS reference: E2811410 N6126668
Photopoint relocation notes:		Observer/Photographer: Geoff Walls
<p>Northern end of wetland. Along fenceline from W side. Photopoint is at a big strainer post on fenceline. Post tagged.</p> <p>Direction from marker/post (magnetic bearing): 1 photo, SE</p> <p>Camera info (lens, film, etc): 50mm, 100asa colour</p>		
<p>Vegetation (composition, structure, patterns, processes):</p> <p>Willows (grey and crack) around water's edge, periodically inundated. Some rushes and water pepper. Used by cattle. Much frequented by waterfowl. Willows checked by cattle, but spreading nevertheless.</p>		
REPHOTOGRAPHY DETAILS:		
Date	Observer/ Photographer	Comments (changes, processes, etc)
3/12/01	G. Walls	Water levels considerably lower than in 1999, despite a relatively wet season. Not a lot of change except willows have bulked out and the tagged fence strainer is becoming smothered.
6/12/03	G. Walls	Water levels a little lower than in 2001. Willows have continued to bulk out. Turf of water pepper much frequented by waterfowl.
6/10/05	G. Walls	Water levels higher than in 2003. Willows have bulked out further, now cattle are excluded.

PHOTOPOINT RECORDING SHEET

Location/Area: Lake Hatuma		Photopoint no: 2
Establishment date: 8/12/99		GPS reference: E2810862 N6126561
Photopoint relocation notes:		Observer/Photographer: Geoff Walls
<p>Northern end of wetland, c. 200m beyond Bob Haldane's boundary fence around willow edge. Lone new post with tag marks site.</p> <p>Direction from marker/post (magnetic bearing): 1 photo, SE</p> <p>Camera info (lens, film, etc): 50mm, 100asa colour</p>		
<p>Vegetation (composition, structure, patterns, processes):</p> <p>Willows (grey and crack) around a ponded area, periodically inundated. Many rushes and water pepper. Used by cattle. Much frequented by waterfowl. Willows checked by cattle, but may spread into area nevertheless.</p>		
REPHOTOGRAPHY DETAILS:		
Date	Observer/ Photographer	Comments (changes, processes, etc)
3/12/01	G. Walls	Much drier than in 1999. Little change except willows have bulked up somewhat. Grazed by cattle; post half out of ground.
6/12/03	G. Walls	Post has been removed, but site relocated with GPS. Periodically inundated and turf maintained by waterfowl. Stock fenced out now, therefore willows bulking out, shooting from bases and invading open space via fragments ('cuttings'). Rushes have bulked up somewhat.
6/10/05	G. Walls	Willows have continued to bulk and are also invading the open space. Rushes have bulked out further. The area flooded at time of visit, very soggy from recent rain and retired from grazing. 2 bitterns seen nearby in wet pasture of marsh and meadow foxtail.

PHOTOPOINT RECORDING SHEET

Location/Area: Lake Hatuma		Photopoint no: 3
Establishment date: 8/12/99		GPS reference: E2810239 N6125782
Photopoint relocation notes:		Observer/Photographer: Geoff Walls
<p>W side of lake, on fenceline where it crosses a small waterway. Photopoint is at the fence post on the S side of the waterway. Post tagged.</p> <p>Direction from marker/post (magnetic bearing): 1 photo, NE</p> <p>Camera info (lens, film, etc): 50mm, 100asa colour</p>		
<p>Vegetation (composition, structure, patterns, processes):</p> <p>Pasture on willow edge. Intermittent wet hollow with <i>Azolla</i> and <i>Lemna</i>, and some <i>Eleocharis acuta</i>. Site chosen to study edge processes now that stock are excluded.</p>		
REPHOTOGRAPHY DETAILS:		
Date	Observer/ Photographer	Comments (changes, processes, etc)
3/12/01	G. Walls	Lower water level. No <i>Azolla</i> or <i>Lemna</i> ; instead water buttercup, <i>Myriophyllum triphyllum</i> , <i>Potamogeton suboblongus</i> and some Mercer grass.
6/12/03	G. Walls	Little different from 2001 except appearance of spike sedge.
6/10/05	G. Walls	Little different from 2003 except spike sedge has thickened in the wet hollow where not grazed and water buttercup has established in the grazed part of the wet hollow.

PHOTOPOINT RECORDING SHEET

Location/Area: Lake Hatuma		Photopoint no: 4
Establishment date: 8/12/99		GPS reference: E2810214 N6125753
Photopoint relocation notes:		Observer/Photographer: Geoff Walls
<p>W side of lake, very close to Photopoint 3. Photopoint is at second post S on fenceline. Post tagged. Also start point of Transect 1.</p> <p>Direction from marker/post (magnetic bearing): 1 photo, SE</p> <p>Camera info (lens, film, etc): 50mm, 100asa colour</p>		
<p>Vegetation (composition, structure, patterns, processes):</p> <p>Avenue to lake, recently cleared of willows. Wet pasture being taken over by rushes (<i>Juncus effusus</i> and <i>J. gregiflorus</i>). Some <i>Carex virgata</i> and <i>C. dipsacea</i>. Flanked by grey and crack willow, poised to reinvade.</p>		
REPHOTOGRAPHY DETAILS:		
Date	Observer/ Photographer	Comments (changes, processes, etc)
3/12/01	G. Walls	Willows have resprouted on 'avenue' margins; raupo has grown on lake edge.
6/12/03	G. Walls	Willows sprayed on lake edge and partly killed. Some willow regeneration in 'avenue'. Otherwise similar to 2001.
6/10/05	G. Walls	The most obvious change is willow regeneration in the cleared 'avenue'; bulked up significantly since 2003.

PHOTOPOINT RECORDING SHEET

Location/Area: Lake Hatuma		Photopoint no: 5
Establishment date: 8/12/99		GPS reference: E2810316 N6125670
Observer/Photographer: Geoff Walls		
Photopoint relocation notes: At lakeshore from Photopoint 4, other end of Transect 1. Post (tagged) marks site. Also Aquatic site 1.		
Direction from marker/post (magnetic bearing): 4 photos, N, W, S, SW		
Camera info (lens, film, etc): 50mm, 100asa colour		
Vegetation (composition, structure, patterns, processes): Willows (grey and crack) around water's edge. Dense fringe of rushes and some raupo. Will probably be reinvaded by willows; rushes may advance further into lake.		
REPHOTOGRAPHY DETAILS:		
Date	Observer/ Photographer	Comments (changes, processes, etc)
3/12/01	G. Walls	Willows have resprouted since being cut/cleared, including 'island' willows and some new arrivals in the wet pasture. <i>Carex secta</i> has increased a lot; raupo and <i>Schoenoplectus validus</i> have proliferated via regeneration and thickening. <i>Azolla</i> and <i>Lemna</i> on water in shallows. Much marsh bedstraw (<i>Galium palustre</i>) in full fragrant bloom in wet pasture. Both meadow foxtail and marsh foxtail here. Much swamp nettle on willow slash.
6/12/03	G. Walls	Willows aerially sprayed on water's edge, killing crack willow and knocking back grey willow. Raupo has survived; <i>Carex secta</i> knocked back. 'Avenue' has been grazed by cattle and inundated for long periods, therefore much of the former vegetation of rushes, sedges and grasses has been knocked down. Swamp nettle abundant on willow slash. Turf at water's edge maintained by waterfowl.
6/10/05	G. Walls	Willow regeneration in the 'avenue' and on a wee islet. Raupo regeneration near the shore. Regeneration of rushes in the 'avenue' (not grazed heavily recently). Bittern seen in the 'avenue' and another seen flying. Black teal (NZ scaup) in the lake.

PHOTOPOINT RECORDING SHEET

Location/Area: Lake Hatuma		Photopoint no: 6
Establishment date: 9/12/99		GPS reference: E2810559 N6125980
Photopoint relocation notes:		Observer/Photographer: Geoff Walls
<p>W side of lake, at shore. Access from concrete fence angle post through obvious cut gap in willow forest. Also Transect 2. Post (tagged) marks site.</p> <p>Direction from marker/post (magnetic bearing): 3 photos, W, NE, SW</p> <p>Camera info (lens, film, etc): 50mm, 100asa colour</p>		
<p>Vegetation (composition, structure, patterns, processes):</p> <p>Willows (grey and crack) around water's edge, cut back for hunting. Some raupo and rushes. Lots of floating <i>Azolla</i> and <i>Lemna</i> and various water weeds. Willows and raupo likely to expand at site.</p>		
REPHOTOGRAPHY DETAILS:		
Date	Observer/ Photographer	Comments (changes, processes, etc)
3/12/01	G. Walls	<p>Lower water levels than in 1999. <i>Carex secta</i> and <i>C. geminata</i> have grown up much. Much regrowth in willows that were cut c. 1998-9. Raupo has proliferated and closed in on open water dramatically. <i>Azolla</i>, <i>Lemna</i>, willow weed and water forget-me-not not abundant at site. Swamp nettle growing at marker post. [<i>Bolboschoenus fluviatilis</i> has begun growing up in the edge of the wet pasture zone on the landward side of the willows].</p>
6/12/03	G. Walls	<p>Aerial sprayed in 2002, killing marginal crack willow and knocking back the grey (which is resprouting). <i>Carex secta</i> has been killed, though some recovering. Meanwhile, considerable growth/colonisation by <i>Carex lambertiana</i>. Swamp nettle proliferating, even where sprayed.</p>
7/10/05	G. Walls	<p>Too wet (water too deep) to reach the post. Willows still alive along the edge despite being sprayed. Raupo similar to 2003 state. Prolific growth in <i>Carex lambertiana</i>. Continued <i>Carex secta</i> recovery.</p>

PHOTOPOINT RECORDING SHEET

Location/Area: Lake Hatuma Photopoint no: 7 (a & b)		
GPS references: E2810141 N6125465; E2810210 N6125464		
Establishment date: 9/12/99 Observer/Photographer: Geoff Walls		
Photopoint relocation notes: W side of lake. Access from fenceline to obvious gap in willow fringe, signalled by lots of raupo. 7a is at edge of artificial pond; 7b is at lake edge c. 100m away, clockwise around pond. Tagged new posts mark both photopoints. Direction from marker/post (magnetic bearing): 1 photo at each site, E Camera info (lens, film, etc): 50mm, 100asa colour		
Vegetation (composition, structure, patterns, processes): 7a: open pond being invaded by raupo; lots of floating <i>Azolla</i> and <i>Lemna</i> . 7b: mosaic of open water, raupo, small and large willows, rushes, sedges and grasses, in a complex interplay.		
REPHOTOGRAPHY DETAILS:		
Date	Observer/ Photographer	Comments (changes, processes, etc)
3/12/01	G. Walls	7a: Great proliferation of raupo; pond colonised by water speedwell, water forget-me-not, <i>Juncus articulatus</i> , <i>Myriophyllum triphyllum</i> , creeping bent and <i>Azolla</i> . Willows have resprouted after clearance. 7b: Tremendous regeneration of raupo, willows and <i>Carex secta</i> . Water covered in <i>Azolla</i> , water speedwell and water forget-me-not.
6/12/03	G. Walls	7a: raupo continuing to advance in a 'wall'. Pond with more water, and many of the 2001 macrophytes have gone. <i>Juncus effusus</i> and <i>J. gregiflorus</i> beginning to invade. Willows on lake edge partly killed by aerial spray. 7b: aerial spray has killed some crack willow and knocked back others and grey willow: both resprouting now. Spray has killed <i>Carex secta</i> but not raupo. Site much used by waterfowl. Proliferation on water pepper and Mercer grass.
6/10/05	G. Walls	7a: Raupo continuing to advance. Rushes continuing to invade. 7b: Follow-up spraying around the lake edge has killed regeneration of willow and also raupo, although the raupo is now regenerating. A pukeko killed by a predator was found here.

PHOTOPOINT RECORDING SHEET

Location/Area: Lake Hatuma		Photopoint no: 8
Establishment date: 9/12/99		GPS reference: E2810045 N6124926
Photopoint relocation notes:		Observer/Photographer: Geoff Walls
<p>Down inlet stream (Ngahape Stream) about 200m from fence. True left bank. Tagged post marks site.</p> <p>Direction from marker/post (magnetic bearing): 5 photos, 3 downstream, 2 upstream</p> <p>Camera info (lens, film, etc): 50mm, 100asa colour</p>		
<p>Vegetation (composition, structure, patterns, processes):</p> <p>Banks of meandering large stream. Willows have been cleared back recently but are regenerating. Likely to overtake the current cover of exotic pasture grasses and herbs and aquatic plants. Sheep using area in 1999 and doubtless influencing regeneration process.</p>		
REPHOTOGRAPHY DETAILS:		
Date	Observer/ Photographer	Comments (changes, processes, etc)
3/12/01	G. Walls	<p>Sheep apparently now absent. Much regeneration of willows from fragments, and big trees have continued to put on bulk. Grasses and rushes have grown rank on banks. Occasional <i>Carex virgata</i> appearing. Water channel full of plants, including lots of 'weeds': <i>Azolla</i>, <i>Lemna</i>, water pepper, <i>Potamogeton suboblongus</i>, <i>P. crispus</i>, <i>Juncus articulatus</i>, water speedwell, water forget-me-not, Mercer grass, hornwort, Canadian pondweed, <i>Myriophyllum triphyllum</i> and filamentous green algae. As yet no raupo. Swamp nettle right at post.</p>
6/12/03	G. Walls	<p>Cattle have been here; grass grazed down somewhat. Quite dramatic regeneration of willows via fragments and as resprouts from adult trees. Water channel much as before: very weedy with hornwort present. Swamp nettle gone from post vicinity but plentiful in nearby willows. Rushes and sedges (<i>Carex dipsacea</i>) expanding.</p>
6/10/05	G. Walls	<p>Grazed on the south side, so much as before. Not grazed on the north side, so willow regeneration prolific and very rapid. Swamp nettle still present in the vicinity. Rushes and sedges continuing to expand. Bittern heard nearby.</p>

PHOTOPOINT RECORDING SHEET

Location/Area: Lake Hatuma		Photopoint no: 9
Establishment date: 10/12/99		GPS reference: E2810415 N6124677
Observer/Photographer: Geoff Walls		
Photopoint relocation notes:		
Mouth of artificial inlet channel, S end of lake. About 40m N of tagged fencepost on true right of channel. Also Aquatic site 3.		
Direction from marker/post (magnetic bearing): 8 photos, up channel and NW-SE panorama		
Camera info (lens, film, etc): 50mm, 100asa colour		
Vegetation (composition, structure, patterns, processes):		
Fringe of willows, some cleared at channel mouth. In front of this, rushes (<i>Juncus effusus</i> and <i>J. gregiflorus</i>) in marshy pasture. Out in lake, islands of raupo with willows, probably expanding. Areas of floating <i>Azolla</i> and <i>Lemna</i> .		
REPHOTOGRAPHY DETAILS:		
Date	Observer/ Photographer	Comments (changes, processes, etc)
4/12/01	G. Walls	Spectacular bulking up of willows on islets and around lake fringes where there are no stock. Raupo has also expanded.
7/12/03	G. Walls	Continued dramatic bulking up of willows and expansion of raupo. Where deer and cattle use the lake edge, no raupo and willows kept in check. This part of the lake is heavily used by waterfowl and wading birds.
7/10/05	G. Walls	Raupo has continued to expand. Willows where not browsed by cattle or deer have continued to bulk up. Water level much higher than in 2003. Bitterns booming.

PHOTOPOINT RECORDING SHEET

Location/Area: Lake Hatuma		Photopoint no: 10
Establishment date: 10/12/99		GPS reference: E2810944 N6124681
Photopoint relocation notes:		Observer/Photographer: Geoff Walls
<p>Outlet of lake (crump weir). Photos taken from E side near deer fence corner (tagged) and from water gauging platform.</p> <p>Direction from marker/post (magnetic bearing): 10 photos, down outlet channel and W, NW, NE</p> <p>Camera info (lens, film, etc): 50mm, 100asa colour</p>		
<p>Vegetation (composition, structure, patterns, processes):</p> <p>Lake edge of willows, grasses and herbs (rank where not grazed). Channel banks of rank grasses and herbs. Raupo in distance.</p>		
REPHOTOGRAPHY DETAILS:		
Date	Observer/ Photographer	Comments (changes, processes, etc)
4/12/01	G. Walls	Little change except fringing and 'island' willows have bulked up and water level lower than in 1999. Mercer grass has thickened at outlet.
7/12/03	G. Walls	Willows have continued to bulk up. Water level lower than in 2001; nothing going over weir. Very heavy use by deer and cattle of the lake edge to south of weir, between it and the old inlet.
7/10/05	G. Walls	Water level much higher, and flowing in a strong stream over the weir. Not possible to cross the weir in safety, so photos taken from the south side. Willows on 'islands' have bulked out a little, but the raupo in the background has retreated a bit (herbicide in the last two years). Raupo has regenerated to the north where not chewed down by deer.

PHOTOPOINT RECORDING SHEET

Location/Area: Lake Hatuma		Photopoint no: 11
Establishment date: 10/12/99		GPS reference: E2811287 N6125188
Photopoint relocation notes:		Observer/Photographer: Geoff Walls
<p>SE side of lake, at bottom of Wynne-Lewis property. Waratah fence runs into lake from wooden gate. Tag on fence. Photos taken standing on log.</p> <p>Direction from marker/post (magnetic bearing): 4 photos, S, SW, W, N</p> <p>Camera info (lens, film, etc): 50mm, 100asa colour</p>		
<p>Vegetation (composition, structure, patterns, processes):</p> <p>Marshy fringe of grasses, rushes and sedges. Being invaded by willows to S, where not grazed; willows kept at bay by stock to N.</p>		
REPHOTOGRAPHY DETAILS:		
Date	Observer/ Photographer	Comments (changes, processes, etc)
3/12/01	G. Walls	Dramatic increase in willows (both crack and grey), saplings and young trees, in rank ungrazed pasture. Some increase in <i>Schoenoplectus validus</i> on water's edge.
7/12/03	G. Walls	Continued increase in willows around the shore.
7/10/05	G. Walls	Some small willows have been killed (sprayed?), and others have established since. Larger willows have bulked up. Water levels much higher, so <i>Schoenoplectus validus</i> inundated and not possible to quite get to the same photopoints.

PHOTOPOINT RECORDING SHEET

Location/Area: Lake Hatuma		Photopoint no: 12
Establishment date: 9/12/99		GPS reference: E2811448 N6125984
Photopoint relocation notes:		Observer/Photographer: Geoff Walls
<p>NE side of lake, at former boat shed, at end of public access. New post with tag at stile on fenceline on N side. Also Aquatic site 2.</p> <p>Direction from marker/post (magnetic bearing): 7 photos, N-S panorama</p> <p>Camera info (lens, film, etc): 50mm, 100asa colour</p>		
<p>Vegetation (composition, structure, patterns, processes):</p> <p>Marshy shore fringe of rushes and sedges (<i>Juncus effusus</i>, <i>J. gregiflorus</i>, <i>Schoenoplectus validus</i>, <i>S. pungens</i>, <i>Eleocharis acuta</i>) with various grasses and herbs. Periodically inundated. Willow clumps and raupo areas, possibly expanding. Area used by stock on occasion.</p>		
REPHOTOGRAPHY DETAILS:		
Date	Observer/ Photographer	Comments (changes, processes, etc)
4/12/01	G. Walls	Much growth in willows around margin. <i>Schoenoplectus validus</i> may have diminished a little, probably through grazing.
7/12/03	G. Walls	Continued growth in willows around margin. Raupo 'islands' have expanded. More <i>Schoenoplectus validus</i> than in 2001, probably reflecting lessened grazing. Water levels lower than 2001. Bittern seen here in lake shallows.
7/10/05	G. Walls	Continued growth of willows with new establishment from fragments. Willow poles have been planted for maimai habitat. Willow 'islands' have increased in size. <i>Schoenoplectus validus</i> beds are similar to 2003.

PHOTOPOINT RECORDING SHEET

Location/Area: Lake Hatuma		Photopoint no: 13
Establishment date: 9/12/99		GPS reference: E2810862 N6126561
Observer/Photographer: Geoff Walls		
Photopoint relocation notes:		
NE end of lake, c. 300m N of Photopoint 12. Tagged fence post marks site.		
Direction from marker/post (magnetic bearing): 3 photos, N, NW, S		
Camera info (lens, film, etc): 50mm, 100asa colour		
Vegetation (composition, structure, patterns, processes):		
Shore fringes of rushes, sedges, grasses, raupo and willows. Strategic site to monitor areas of willows and raupo that are proposed for control.		
REPHTOGRAPHY DETAILS:		
Date	Observer/ Photographer	Comments (changes, processes, etc)
4/12/01	G. Walls	Raupo and willows have grown. <i>Schoenoplectus validus</i> has retreated where grazed. Mercer grass, creeping bent, <i>Juncus articulatus</i> and <i>Eleocharis acuta</i> are dominant in the wet pasture. A strange silt-like deposit in places, possibly the result of an algal bloom, now rotted down.
7/12/03	G. Walls	Raupo has continued to advance into the lake. Young willows colonising; old ones spreading except where sprayed (killed or knocked back). A portion of the foreshore has been grazed down to turf of Mercer grass (less spike sedge than where not heavily grazed). Perhaps more <i>Schoenoplectus validus</i> to south.
7/10/05	G. Walls	Too wet to reach the photopoint, so not revisited this time.

APPENDIX 3: Vegetation transect recording sheets, October 2005

- Transect no. 1
- Transect no. 2
- Transect no. 3

VEGETATION TRANSECT RECORDING SHEET

Location/Area: Lake Hatuma		Transect no: 1	
Establishment date: 9/12/99		Grid reference (start point): V23/102258	
Observer: Geoff Walls			
Transect description (location, terrain, etc):			
W side of lake, from fence to shore down avenue cleared of willows. Numerous rushes.			
Relocation details (start point, compass bearing, etc.):			
Start point (also Photopoint 4) is a tagged fence post; finish point (also Photopoint 5) is a tagged new post at shore. Bearing 265 degrees mag.			
Photos taken (if any): 2 photos			
MEASUREMENT DETAILS			
Date: 7/10/05		Observer: Geoff Walls	
Distance (m)	Height class	Main species present % cover*	Notes
0-28	0-80cm	<u>Exotic pasture grasses</u> (mainly perennial ryegrass, meadow foxtail and browntop)	As before but grazed by fence
28-52	0-1m	<u>Exotic pasture grasses</u> (mainly marsh foxtail) <u>Juncus effusus</u> <u>J. gregiflorus</u> Marsh bedstraw <u>Eleocharis acuta</u> (<u>Carex virgata</u>) (<u>Crack willow</u>)	Has been invaded by E. acuta; grazed.
52-133	0-1.5m	<u>Juncus effusus</u> <u>J. gregiflorus</u> <u>J. articulatus</u> <u>Marsh foxtail</u> <u>Carex lambertiana</u> <u>C. virgata</u> <u>C. secta</u> <u>Eleocharis acuta</u> Water forget-me-not Water pepper Marsh bedstraw <u>Turf plants</u> <u>Creeping bent</u> <u>Crack willow</u>	Damp. Willow and creeping bent colonised Much; increase in marsh bedstraw and creeping bent.
133-135	0-1.5m	<u>Schoenoplectus validus</u> <u>Juncus effusus</u> <u>J. gregiflorus</u> <u>J. articulatus</u> <u>Marsh foxtail</u> <u>Carex lambertiana</u> <u>C. virgata</u> <u>C. secta</u> <u>Eleocharis acuta</u> Water forget-me-not Water pepper <u>Marsh bedstraw</u> <u>Crack willow</u> <u>Turf plants</u> <u>Creeping bent</u> <u>Glyceria fluitans</u> <u>Mercer grass</u>	Young willows up to 1.5m tall. Creeping bent and turf plants colonised much.
135-145	0-30cm	<u>Water</u> <u>Mercer grass</u> <u>Creeping bent</u> (Curly pondweed) Water speedwell <u>Lemna minor</u> <u>Azolla filiculoides</u>	Rushes have increased. Willows invading. Glyceria arrived
Comments (patterns, processes, changes):			
Rushes and sedges have increased latterly. Willows have continued to grow, although collapsing where sprayed. Swamp nettle prolific in dead willows. Mercer grass, creeping bent, marsh foxtail and spike sedge have proliferated. Marsh clubrush and			

Glyceria have appeared. Water levels higher than 2003. Grazing doing no harm.

Species list/Notable flora (in addition to above):

* () = <1% = 1-5% = 5-25% _____ = 25-50% ===== = 50-75% _____ = >75%

VEGETATION TRANSECT RECORDING SHEET

Location/Area: Lake Hatuma		Transect no: 2	
Establishment date: 9/12/99		GPS reference (start point): E2810525 N6125960	
Transect description (location, terrain, etc):		Observer: Geoff Walls	
<p>W side of lake, at shore. Access from concrete fence angle post through obvious cut gap in willow forest. Post (tagged) marks site. Photopoint 6 beyond at lake edge.</p> <p>Relocation details (start point, compass bearing, etc.):</p> <p>Start point is new tagged fence post. Informal plot here of about 20m radius, and transect along cut access gap.</p> <p>Photos taken (if any): 4 photos</p>			
MEASUREMENT DETAILS			
Date: 7/10/05		Observer: Geoff Walls	
Distance (m)	Height class	Main species present % cover*	Notes
		<p>Swamp nettle abundant at bases of willow trees in vicinity of start point. Has proliferated further in absence of grazing.</p> <p>Marshy rank pasture of exotic grasses and herbs with rushes on transect. Overhung by mature willows along eastern half of transect.</p>	
Comments (patterns, processes, changes):			
<p>Chosen to follow swamp nettle population health and processes in pasture and willows now that stock are more or less excluded: a tremendously healthy population. <i>Carex secta</i> has established and regenerated markedly. <i>Bolboschoenus fluviatilis</i> has appeared. <i>Carex lambertiana</i> has recently established. Regrowth of crack willow from fallen branches.</p>			
Species list/Notable flora (in addition to above):			

* () = <1% = 1-5% = 5-25% _____ = 25-50% _____ = 50-75% _____ = >75%

VEGETATION TRANSECT RECORDING SHEET

Location/Area: Lake Hatuma		Transect no: 3	
		GPS reference (start point): E2811482 N6125857	
Establishment date: 10/12/99		Observer: Geoff Walls	
<p>Transect description (location, terrain, etc): NE side of lake, about 100m S of former boat shed, at end of public access. Relocation details (start point, compass bearing, etc.): Start point is a lone willow tree (blown over 2005) in a grassy paddock. Tag on lone post by tree. Bearing 265 degrees mag. Photos taken (if any): 1 photo, NW</p>			
MEASUREMENT DETAILS			
Date: 7/10/05		Observer: Geoff Walls	
Distance (m)	Height class	Main species present % cover*	Notes
0-31	0-80cm	<u>Exotic pasture grasses</u> (mainly perennial ryegrass, meadow & marsh foxtail, etc.)	Gentle descent from old shore to moist flat
31-40	0-80cm	<u>Exotic grasses</u> (<u>marsh foxtail</u> and <u>meadow foxtail</u>) <u>Juncus effusus</u> <u>J. gregiflorus</u> <u>Pasture herbs</u> <u>Carex dipsacea</u>	Big increase in marsh foxtail
40-55	0-60cm	<u>Creeping bent</u> <u>Other grasses</u> <u>J. gregiflorus</u> <u>Marsh foxtail</u> <u>Eleocharis acuta</u> <u>Marsh bedstraw</u> <u>Crack willow</u> <u>Watercress</u>	Wet zone of transition. Willows increasing. E. acuta decreased; more Mercer & bedstraw.
55-76	0-60cm	<u>Eleocharis acuta</u> <u>Juncus articulatus</u> <u>Schoenoplectus validus</u> <u>Creeping bent</u> <u>Mercer grass</u> <u>Water speedwell</u> <u>Marsh bedstraw</u>	Very wet, inundated at times.
	60-150cm	<u>Schoenoplectus validus</u> <u>Crack willow</u>	
76-95	0-40cm 40-120cm	<u>Mercer grass</u> <u>Schoenoplectus validus</u>	Standing water, too wet for Eleocharis acuta or creeping bent
95-114	0-1.5m	<u>Schoenoplectus validus</u> <u>Water</u>	Too wet for anything else;
>114		<u>Open water</u>	less S. validus
Comments (patterns, processes, changes): Essentially similar to 2003 but changes wrought by stock use (cattle in recent times) and higher water levels. Tree at start of transect blown over. Transect not able to be easily done therefore.			
Species list/Notable flora (in addition to above):			

* () = <1% = 1-5% = 5-25% _____ = 25-50% ===== = 50-75% _____ = >75%

APPENDIX 4: Aquatic vegetation and macroinvertebrate recording sheets, October 2005

- Site no. 1
- Site no. 2
- Site no. 3

AQUATIC VEGETATION AND MACROINVERTEBRATE
RECORDING SHEET

Location/Area: Lake Hatuma		Site no: 1
		GPS reference: E2810316 N6125670
Establishment date: 9/12/99		Observer: Geoff Walls
Site notes (location details, vegetation, etc):		
W side of lake where an access avenue has been cleared of willows. Also Photopoint 5. Site marked with new fence post. Rushes, raupo and willows nearby. Water level higher than in 2003.		
SAMPLING DETAILS		
Date: 7/10/05		Observer: Geoff Walls
Sampling methods/notes:		
Tray and handlens; samples taken from water's edge		
AQUATIC VEGETATION PRESENT		COMMENTS
Species	Relative abundance*	
Hornwort	u	Less than before
Water speedwell	s	
Potamogeton crispus	s	Less
Potamogeton suboblongus	?	Not seen (water too deep?)
Lemna minor	s	
Azolla filiculoides	m	
Wolffia	u	Increased
Mercer grass	m	
Water forget-me-not	s	
Canadian pondweed	s	More
Filamentous green alga	s	Some now
Creeping bent	s	Not previously seen
Callitriche stagnalis	s	
MACROINVERTEBRATES PRESENT		SENSITIVITY SCORE (1-10)
Dytiscid beetle		5
Copepod		5
Xanthocnemis damselfly larva		5
Microvelia bug		5
Anisops backswimmer		5
Water boatman		5
Potamopyrgus snail		4
Gyraulus snail		3
Physa snail		3
Ostracod		3
Chironomid midge larva		1
Oligochaete worm		1
		Abundant

* estimated % or: u = uncommon/rare s = some m = much

AQUATIC VEGETATION AND MACROINVERTEBRATE
RECORDING SHEET

Location/Area: Lake Hatuma		Site no: 2
		GPS reference: E2811448 N6125984
Establishment date: 10/12/99		Observer: Geoff Walls
Site notes (location details, vegetation, etc):		
NE side of lake, at former boat shed, at end of public access. New post with tag at stile on fenceline on N side. Also Photopoint 12. Rushes, sedges, wet pasture, raupo and willows nearby.		
SAMPLING DETAILS		
Date: 7/10/05		Observer: Geoff Walls
Sampling methods/notes:		
Tray and handlens; samples taken from water's edge		
AQUATIC VEGETATION PRESENT		COMMENTS
Species	Relative abundance*	
Water speedwell	s	
Lemna minor	s	
Azolla filiculoides	m	
Mercer grass	m	
Wolffia australiana	s	
Eleocharis acuta	s	
Schoenoplectus validus	s	
Dock	s	
Potamogeton crispus	m	
Potamogeton pectinatus	?	Seen previously (maybe inundated)
Water pepper	s	
Filamentous green alga	s	
Canadian pondweed	m	
Hornwort	?	Seen previously (maybe inundated)
MACROINVERTEBRATES PRESENT		SENSITIVITY SCORE (1-10)
Dytiscid beetle		5
Xanthocnemis damselfly larva		5
Anisops backswimmer		5
Water boatman		5
Microvelia bug		5
Copepod		5
Stratiomyid fly larva		5
Potamopyrgus snail		4
Gyraulus snail		3
Physa snail		3
Hirudinea leech		3
Mosquito larva		3
Ostracod		3
Chironomid midge larva		1
Oligochaete worm		1

* estimated % or: u = uncommon/rare s = some m = much

AQUATIC VEGETATION AND MACROINVERTEBRATE
RECORDING SHEET

Location/Area: Lake Hatuma		Site no: 3
		GPS reference: E2810415 N6124677
Establishment date: 10/12/99		Observer: Geoff Walls
Site notes (location details, vegetation, etc):		
Mouth of new inlet channel, S end of lake. About 40m N of tagged fencepost on true right of channel. Also Photopoint 9.		
Water level in 2003 considerably higher, so macrophytes harder to sample.		
SAMPLING DETAILS		
Date: 7/12/03		Observer: Geoff Walls
Sampling methods/notes:		
Tray and handlens; samples taken from water's edge		
AQUATIC VEGETATION PRESENT		COMMENTS
Species	Relative abundance*	
Water speedwell	u	
Potamogeton crispus	s	Less than before
Water pepper	s	
Canadian pondweed	s	
Green alga	s	Less
Potamogeton suboblongus	s	Less
P. pectinatus	?	Seen previously
Water buttercup	s	
Azolla	u	
Lemna	u	
Hornwort	s	
MACROINVERTEBRATES PRESENT		SENSITIVITY SCORE (1-10)
		COMMENTS
Dytiscid beetle		5
Freshwater mite		5
Damselfly larva		5
Anisops backswimmer		5
Water boatman		5
Microvelia bug		5
Ephydrid fly larva		4
Gyraulus snail		3
Potamopyrgus snail		3
Physa snail		3
Chironomid midge larva		1

* estimated % or: u = uncommon/rare s = some m = much

APPENDIX 5: Bird lists, Lake Hatuma, October 2005

Water birds			Other birds		
Species	Est. Nos.	Breeding (yes/no)	Species	Est. Nos.	Breeding (yes/no)
<u>Native species</u>			<u>Native species</u>		
Australasian bittern	10+	?	Fantail	15	?
Black shag	10	n	Riroriro	10	?
Little shag	10	n	Shining cuckoo	-	
Grey duck	?	?	Silvereye	40	y
NZ shoveler	-				
Paradise shelduck	150	y	<u>Introduced species</u>		
Grey teal	10	?	Starling	30	y
Pied stilt	6	n	Blackbird	20	y
White-faced heron	10	?	Thrush	20	y
Pukeko	50	y	Redpoll	30	y
Welcome swallow	30	y	Greenfinch	50	y
Australasian harrier	10	y	Goldfinch	50	y
Spur-winged plover	10	?	Chaffinch	20	y
Black-backed gull	4	n	Yellowhammer	20	y
NZ dabchick	-		House sparrow	50	y
NZ scaup	2+	y	Dunnock	10	y
			Magpie	30	y
<u>Introduced species</u>					
Mallard	150-200	y			
Black swan	150	y			

APPENDIX 6: Other animal lists, Lake Hatuma, October 2005

Species	Est. Nos.	Breeding (yes/no)	Species	Est. Nos.	Breeding (yes/no)
<u>Introduced mammals (detected)</u>			<u>Native reptiles</u>		
Cattle	occasional		<u>Introduced frogs</u>		
Rabbit	?	?	Southern bell frog	-	?
Hare	5	y	<u>Native fish</u>		
Hedgehog	20	y	Shortfin eel	Some	n
Feral cat	5+	y	Longfin eel	-	-
Possum	10	y	Common bully	many	y
Stoat	?	?	<u>Introduced fish</u>		
<u>Introduced mammals (probably present)</u>			Rainbow trout	-	-
Ferret			Goldfish	-	-
Weasel					
Ship rat					
Norway rat					
Mouse					