Reversing the decline of *Utricularia australis* in Northland

Medium Envirolink Grant
Prepared for Northland Regional Council

June 2015

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NIWA CLIENT REPORT No: HAM2015-085
Report date: June 2015
NIWA Project: ELF15228

Quality Assurance Statement		
	Reviewed by:	R. Wells
	Formatting checked by:	A. Bartley
	Approved for release by:	J. Clayton

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Executive summary

Northland Regional Council (NRC) gained a medium Envirolink grant to engage NIWA to review the decline of bladderwort (*Utricularia australis*) in lakes of the Northland region and its status elsewhere in the region and in New Zealand

Specifically, NRC requested:

- a review of the biology/ecology of this species
- field delimitation of lakes where populations of this plant may still exist (funded by NRC)
- document the decline of this species and investigate the role of possible causative factors
- identify possible conservation actions and recommend future activities towards a species-driven response to maintain suitable habitats for this bladderwort within the NRC lakes management programme.

Utricularia australis has declined at an alarming rate in Northland dune lakes, being restricted to only two (potentially three) of the 23 water bodies where populations of this species were found within the past 30 years, with most decline occurring during the past decade. Only one of these populations could be considered sustainable into the future, with the lake situated on Department of Conservation land within scrub.

Utricularia australis requires aquatic habitat with high concentrations of carbon dioxide (low pH and nutrient concentrations), and is often associated with beds of the erect emergent sedge kuta (*Eleocharis sphacelata*). *Utricularia australis* is an irregular flower producer and does not appear to produce seed in New Zealand. The plants here may well be of hybrid origin, dispersed from northeast Asia via migratory birds, with subsequent spread by vegetative means. Specialised propagules known as turions are produced in response to cool temperatures or desiccation and provide this plant with a mechanism to tolerate drought events.

The decline of this species is attributed to its competitive exclusion by another bladderwort *U. gibba*, which appears to have naturally colonised Northland water bodies within the past two decades. The spread and establishment of *U. gibba* also coincides with deterioration of water quality through nutrient enrichment in many of these lakes.

Initial steps to address this decline include the following actions:

- resurvey of all sites where recent collections/observations of *U. australis* have been made, ideally in the early to mid-summer period and characterise sites that still support populations of this plant
- investigate the genetic variability of *U. australis* plants within New Zealand
- attempt cultivation of representative populations of *U. australis*, and
- identify potentially suitable sites for translocation of *U. australis.*

1 Introduction

The native bladderwort (*Utricularia australis*) has undergone a major decline in the dune lakes on the west coast of Northland over the past ten years. Northland Regional Council (NRC) gained a medium Envirolink grant to engage NIWA to review the decline of bladderwort in lakes of the Northland region and its status in the region and elsewhere in New Zealand.

Specifically, NRC requested:

- a review of the biology/ecology of *U. australis*
- field delimitation of lakes where populations of this plant may still exist (funded by NRC)
- document the decline of this species and investigate the role of possible causative factors
- identify possible conservation actions and recommend future activities towards a species-driven response to maintain suitable habitats for this bladderwort within the NRC lakes management programme.

2 Methods

For the review of information, a literature and information search was carried out on the taxonomy and distribution of *Utricularia australis* in New Zealand based on the New Zealand Floras and examination of herbarium material at the Allan Herbarium (CHR) and Auckland Museum (AK). Additional data was obtained by a search of the NIWA aquatic plant database and Northland vegetation survey data (Wells and Champion 2014) and discussion with local botanists. A review of the global distribution of this species, its ecology and reproductive strategies was also undertaken.

Field surveys were undertaken in October 2014, April and May 2015. These surveys addressed ecological condition monitoring and included specific searches for *U. australis.* Visits were made to sites where *U. australis* was present on the previous survey date. Surveys were conducted by snorkel, focussing on the deep water edge of emergent vegetation, mostly dominated by kuta (*Eleocharis sphacelata*).

Estimates of population size were made when *U. australis* was located, along with records of depth range and associate species. Additional surveys for the plant were undertaken in sites outside of Northland (not funded by Envirolink grant or NRC).

An estimate of *U. australis* decline was made based on current and previous records in Northland. Biological and water quality data were used to explore possible causes of this decline. Recommendations for conservation actions were based on findings from this study and information searches on genetic analysis and cultivation methods.

3 Biology

3.1 Nomenclature and global distribution

Utricularia australis was described by Robert Brown based on plant material from New South Wales in 1810 (Brown 1810). This species has since been applied to material previously described in New Zealand as *U. protrusa* Hook. f. and *U. mairii* Cheesem., the latter species being restricted to Lake Rotomahana in the Rotorua lakes district prior to the Mount Tarawera eruption, which apparently led to the extinction of this population. *U. protrusa* was described based on material collected in Bay of Plenty bogs, but the type material is apparently lost (Allan 1961).

Utricularia australis R.Br. is described in the Flora of New Zealand Vol 4 (Webb et al. 1988) as follows:

“Type locality: Bay of Plenty, "bogs". Type: lost. Neotype: A, "8611, P. H. Allen, Waiharaheke Stream, Piako, March 1909."

Glabrous aquatic; stems floating, up to 40 cm or more long, filiform, sparingly branched. Lvs numerous, submerged, multifid, 3–(4) cm long; segments capillary, to ± 1 cm long. Bladders numerous, (1)–2–3–(4) mm long, obliquely ovoid, attached by short stalk to near base of lf segments; mouth usually with 2 long setae. Scape rather stout, to c. 17 cm long, erect, 2–4–(5)-flowered; bracts c. 3 mm long, broad; pedicels to 17 mm long, slender. Calyx lobes oblong to elliptic. Corolla yellow; upper lip 3-lobed; lower entire, 7–9 mm wide, broad; palate protruded; spur short, obtuse. Capsule c. 1.5–2 mm diam., globose.”

Taylor (1989) published a monograph of the genus *Utricularia* and synonymised *Utricularia australis* R.Br. with other taxa from a number of countries and this species has a distribution including most of Europe, Asia (temperate and tropical including Japan and SE Asian islands including New Guinea), tropical and South Africa, Australia and New Zealand.

3.2 New Zealand and Northland distribution

A search of New Zealand herbaria, NIWA plants database and Salmon’s (2001) book on carnivorous plants was undertaken to determine the known sites that have supported populations of *U. australis*.

Collections of *U. australis* have predominantly been made from Northland, with scattered other North Island sites in Auckland, Waikato, Bay of Plenty and Wellington Regions. There is one South island collection from near the Dobson River, near Twizel (F. Overmaars 2001, CHR 526069) but it was not available for examination. Other South Island (West Coast) plants are attributable to the introduced *U. geminiscapa*.

There is some evidence to suggest variability within New Zealand material, with collections from Bethells Swamp (Salmon 2001) and Whangamarino (P. Heenan, Landcare Research pers. comm.) being more robust and with differing features to other New Zealand material. These may have more affinities with *U. macrorhiza* than *U. australis*.

Northland *U. australis* sites include 22 lakes where records have been made since 1984, with two other lakes – Lake Tangonge (Figure 3-1) from 1898-1925 (now drained) and Lake Waiparera (R.C. Cooper 1967 AK115175) where plants have not been seen since 1984 despite extensive surveys. Table 5-1 lists the other lakes where *U. australis* was collected and sampled as part of NIWA and earlier MAF survey data (held in the NIWA aquatic plant database). Two CHR collections made by the

Aquatic Plant Group at NIWA from Lake Kahuparere CHR463737 (Pouto Peninsula) and Lake Waiparera CHR 463883 (Aupouri) do not match records of this plant from those locations in NIWA diaries, plant lists and data presented in Tanner et al. 1986 and should be disregarded as valid records for this species. These records are not included in Table 5-1.

Two additional water bodies supporting populations of *U. australis,* but not surveyed by NIWA, were Lake Waikaramu, near Kaimaumau (collections made from 1990 -2002) and Lake Ohia, at the foot of Karikari Peninsula (collection made in 1999, but still present in spring 2014 – K. Matthews pers comm.). All but three of the NIWA lake records are from the Aupouri Peninsula and this area was regarded as the national stronghold of the species (Champion et al. 2002). The remaining lakes were on the west coast from Waipoua to Baylys Beach near Dargaville.

Figure 3-1: R.H. Matthews collection of *Utricularia australis* from Lake Tangonge (photo courtesy of Lisa Forester, Northland Regional Council).

Wetland sites in Northland where *U. australis* has been collected include Paranoa Swamp, Whareana Stream and Te Werahi Swamp in Te Paki, Omiango Swamp near Mount Camel, the Ahipara Gumlands and Omamari and Maitahi Wetlands near Dargaville.

3.3 Reproduction and perennation

Utricularia australis rarely appears to flower, with most herbarium sheets being of sterile material, and only one flowering plant seen to date on the annual Northland lakes survey (Midgley's Lake near Baylys Beach). Flowering material is present on herbarium sheets collected from Motuoapa Wetlands, Lake Taupo, collected in February to March. Salmon (2001) has photographs and illustrations of flowers from near Kaimaumau. He states the main flowering period is January to February (occasionally November to late March).

No ripe fruiting capsules or seed have reliably been reported in New Zealand plants. Aston (1973) also reports that *U. australis* rarely flowers in Australia and that mature fruit and seed have not been seen. Taylor (1989) reports that the only fertile material seen was from China and Japan. In Japan, fertile plants are recognised as *U. australis* f. *tenuicaulis*, a different form to sterile plants f. *australis* (Kameyama et al. 2005). Furthermore, Kameyama et al. (2005) used genetic analysis and experimental crossing of the two forms of *U. australis* and *U. macrorhiza* to demonstrate the hybrid origin of sterile *U. australis* f. *australis* from two fertile taxa, *U. australis* f. *tenuicaulis* and *U. macrorhiza.* Although the hybrid plant is essentially sterile, there is a degree of genetic variability in different populations of this plant, suggesting that more than several crosses between the parent plants have occurred and dispersed to different waterbodies. After germination and establishment spread is clonal, as commonly occurs with other aquatic plants and the population is uniform genetically. Interestingly, neither parent plant has been observed at sites where the hybrid plant grows, hypothesised by Kameyama et al. (2005) to be due the competitive nature of *U. australis* f. *australis. Utricularia macrorhiza* is found in North America and eastern temperate Asia. This range is much more restricted than that of the putative hybrid *U. australis* f. *australis*, which extends into Europe, Africa, tropical Asia and Australasia. Presumably these populations originated from seed produced between the two parents, with dispersal of seed via migratory birds which travel from north eastern Asia through tropical Asia to Australia and New Zealand (Salmon 2001, Kameyama et al. 2005). Taylor (1989) suggests that turions (see later in this section) may be dispersed long distances by migratory birds, but this seems unlikely compared with seed dispersal. Once introduced into New Zealand, further spread would likely be exclusively clonal and turions could potentially be spread short distances by waterfowl.

The hybrid status of New Zealand plants requires confirmation along with the level of genetic variability between extant populations of this species. This would help determine whether the remaining populations of this plant are relict populations of historical introductions by migratory waterfowl or whether introductions are still occurring. This could also help to define the relationship of plants described as *U*. aff. *macrorhiza* with other *U. australis* plants (see Section 3.2).

Utricularia australis and other species in this genus produce specialised overwintering structures known as turions (Figure 3-2). These turions are a modified shoot apex, adapted to protect the apical bud during periods of harsh environmental conditions. Turions were not evident in material examined in the field during late April 2015, but are illustrated in Salmon (2001) and are preserved in herbarium material (e.g., AK 293005). Turions of aquatic plants are primarily adapted to overwintering in the hypoxic or anoxic conditions found in the sediments at the bottom of water courses. Here, the temperature is above freezing. Some turions, however, overwinter above the surface on wet substrates where they are subject to drying out and frost (Adamec and Kucerova 2013).

Figure 3-2: Turion on apex of *Utricularia* shoot. Poznan, Poland 2012.

In Northland, these structures would permit the survival of *U. australis* plants in ephemeral pools with turion production initiated when these pools dry out and then sprouting to form a new plant once the pool refills (Salmon 2001). Salmon (2001) reports viable turions of *U. australis* after six months desiccation.

Turions may also be tolerant of other adverse conditions, for instance *U. australis* was the only submerged plant seen in the freshwater section of Waitahora Lagoon in 2010, following a period of sea water intrusion (Wells and Champion 2014). However, another salt water intrusion had occurred subsequent to this and no further plants of *U. australis* were found in 2014, with the same area supporting saline tolerant species including *Ruppia polycarpa, Triglochin striata, Thyridia repens* and *Lamprothamnium macropogon*.

3.4 Ecology

Utricularia australis is a free-floating species, normally found sprawling over other macrophytes or bare substrate and has been reported in depths between the water's surface and over 5 m deep in lowland still waters. Salmon (2001) reports habitats including lakes, pools and drainage ditches, normally in dystrophic waters. Normally habitats supporting populations of this plant had a high peat content and were acidic with a pH of 5 or less, although it was recorded in a lake with a pH of 7.4 (Salmon 2001). Taylor (1989) also states this species prefers acid water. Adamec (2012) characterises dystrophic waters as having low conductivity, low concentrations of inorganic nitrogen and phosphorus, oligotrophic to mesotrophic trophic status and low density organic sediments with relatively high concentrations of carbon dioxide. Under high CO_2 concentrations *U. australis* has a very high growth rate (Adamec 2013). However, *U. australis* plants are strictly reliant on dissolved CO_2 at concentrations greater than 0.15 mM in their habitats (Adamec 2013). The bladder traps of *Utricularia* are generally thought to be a mechanism to supplement nutrients through the digestion of animals (mostly cladocerans and calanoid copepods) captured within low nutrient environments (Ellison and Gotelli 2009). However, the apparent allocation of fixed carbon to newly formed traps by *U. australis* is postulated to be a mechanism to enhance symbiotic bacteria within the traps and enhance uptake of nutrients from this microbial source (Sirova et al. 2009).

Dystrophic conditions, with low density organic sediments would be unsuitable for the growth of many rooted submerged plants. However, they are suitable for mosses such as *Sphagnum* spp. and some charophytes which have a rhizoid attachment system.

In New Zealand, *U. australis* is reported as being usually found in association with kuta or tall spike sedge (*Eleocharis sphacelata*) (Salmon 2001 and de Lange et al. 2010). Not all of the lakes that previously supported populations of *U. australis* in Northland would have had dystrophic waters, e.g., Lakes Ngatu and Wahakari. However, in these water bodies *U. australis* was often restricted to areas amongst kuta, presumably with the litter of this plant forming habitat equivalent to dystrophic waters. Other associated plants include beds of the charophytes *Chara fibrosa, C. australis* and *Nitella leonhardii,* over which *U. australis* sprawled (Figure 3-3), often associated with *U. gibba*. In some lakes *U. australis* grew amongst other emergent species such as *Machaerina teretifolia* and *Empodisma robustum.*

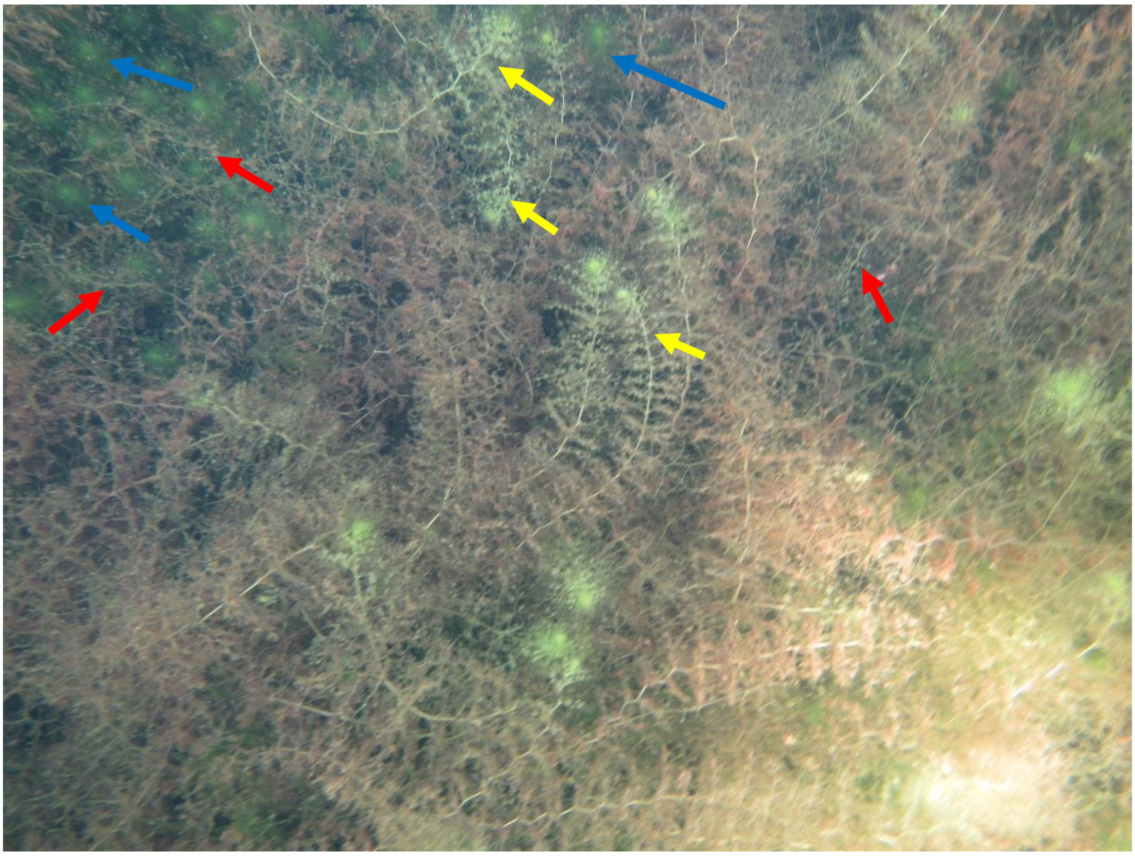

Figure 3-3: *Utricularia australis* (yellow arrows) and *U. gibba* (red arrows) sprawling over *Chara fibrosa* (blue arrows) bed. Te Paki Dune Lake, April 2015.

Salmon (2001) reported that *U. gibba* often grew in the same habitats as *U. australis*, but *U. australis* was usually found in deeper water. Based on NIWA Northland lake scuba surveys this distribution pattern was not observed, with depth ranges of both species overlapping and maximum depth records for *U. gibba* being 10 m in Lake Kai Iwi and 16 m in Lake Waikare (Wells and Champion 2014).

4 Results of 2015 surveys

A large population of *Utricularia australis* persists in Te Paki Dune Lake, with similar covers to those described in 2005 (Wells and Champion 2014). In this lake, it coexists with *U. gibba*, growing over *Chara fibrosa* and *C. australis* in basins amongst *Eleocharis sphacelata* beds. Deeper water (> 2.5 m) was colonised by *Potamogeton cheesemanii* and the dune face (western edge of lake) was dominated by *Myriophyllum propinquum. Utricularia australis* was not present in these areas, but occupied approximately 50% of the open water area, with average covers of 10% up to a maximum of 80% and a maximum depth of 2.5 m.

In Lake Ngakapua, three plants of *U. australis* were found amongst *U. gibba* mats on the western edge of the northern basin on the edge of emergent *E. sphacelata*. The outer edge of emergent beds of the southern and eastern basins were thoroughly searched on three occasions (October 2014, April and May 2015) with no *U. australis* found.

No plants of *U. australis* were found at the following sites where this species was present on the previous survey date; Lake Austria, Lake Te Kahika, Lake Te Riu, Waitahora Lagoon and pools adjacent to this and in the Paranoa Swamp. Waitahora Lagoon was still very saline in the area where *U. australis* was noted in 2010 (Wells and Champion 2014). Lakes Pretty, Waipara and Rotopokaka (all unsurveyed since 2004) and a small unnamed bog pool to the south of Rotopokaka (1635715E, 6131390N) appeared to have suitable habitat for *U. australis* but none was found.

Other surveys (outside of Northland) at Lake Rotomanuka (Waipa District, Waikato) and sites near Motuoapa (Lake Taupo) failed to detect any plants of *U. australis* in May 2015, although they supported populations of this plant previously. It is possible that *U. australis* may have already died back at this time of year in these cooler areas. In the case of the Lake Taupo sites, the lake level was very low and shallow pools where this plant had been found earlier in the summer (Nicholas Singers pers. comm.) had dried out.

5 Decline of *Utricularia australis* in Northland lakes

de Lange et al. (2013) elevated the threat status of *U. australis* to the highest threat class – National Critical, based on an ongoing or predicted decline greater than 70% over the past 10 years.

Tanner at al. (1986 and unpublished data) carried out macrophyte surveys of 26 Northland lakes and a total of 33 lakes were surveyed by Champion et al. 2001. Nine lakes surveyed by Tanner supported populations of *U. australis,* with an additional two more lakes found in 2001. Since that time annual surveys of Northland lakes have been undertaken since 2004 (Wells and Champion 2014 and more recent data), totalling over ninety lakes investigated. *Utricularia australis* was found in twenty two of these lakes (Table 5-1). This table presents the lakes where *U. australis* was found, the last date when this species was recorded, its relative abundance and maximum depth, the first record of *U. gibba*, the first survey when *U. australis* was not found, and the number of surveys subsequent to that.

These data are also presented graphically showing the decline of lake populations of *U. australis* and corresponding increase in lakes with *U. gibba* (Figure 4-1). Assumptions made are that *U. australis* was present in lakes prior to their first discovery date and that *U. gibba* had not colonised any lake prior to the first record. Additionally, two lakes where only one plant of *U. australis* was found in 2004 (Lakes Kihona and Friedrich) and not resurveyed since are considered likely to have lost this species, whereas another lake where *U. australis* was relatively common, but not resurveyed since 2010 (Lake Te Kahika South), potentially still supports a population of this species.

Only two of the 23 lakes were confirmed as containing plants of *U. australis* and only Te Paki Dune Lake contains a sizeable population in 2015.

Table 5-1: Status of *Utricularia australis* in lakes surveyed as part of NIWA lake assessments.

Lake	First survey date	Last survey when *U. australis* found				First survey when *U. gibba* present	First survey when *U. australis* absent	Subsequent visits
		Date	%sites	Maximum cover	Maximum depth			
Austria	3/11/2004	3/11/2004	100	1	2	3/11/2004	28/04/2015	0
Carrot	23/01/1985	19/04/2001	100	6	5.5	9/11/2004	9/11/2004	2
Forest	24/01/1985	24/05/2001	100	3	2.9	23/03/2010	23/03/2010	0
Friedrich	8/03/2005	8/03/2005	1	1	1	8/03/2005	no resurvey	0
Heather	1/02/1988	10/11/2004	33	1	1.7	10/11/2004	8/04/2008	3
Kihona	4/11/2004	4/11/2004	1	1	1		no resurvey	0
Little Gem (Ngatu S)	3/02/1988	3/02/1988	100	2	3	18/04/2007	18/04/2007	1
Midgley	8/03/2005	8/03/2005	1	1	1	24/03/2011	24/03/2011	0
Morehurehu	2/02/1988	4/03/2006	80	2	4.6	5/11/2004	31/03/2009	3
Morehurehu S2	5/11/2004	5/11/2004	100	1	0.2	4/03/2006	4/03/2006	2
Ngakapua	23/01/1985	28/04/2015	1	1	1	9/11/2004	3 plants	0
Ngakeketa N	2/11/2004	5/03/2006	20	1	0.3	30/03/2009	30/03/2009	0
Ngatu	12/12/1984	1/11/2004	40	1	1.8	1/11/2004	3/03/2006	2
Rotokawau (Sweetwater)	21/01/1985	1/04/2009	75	3	1.8	1/11/2004	6/05/2014	0
Te Kahika	5/11/2004	9/04/2013	20	1	1	9/04/2013	5/05/2014	1

Lake	First survey date	Last survey when *U. australis* found				First survey when *U. gibba* present	First survey when *U. australis* absent	Subsequent visits
		Date	%sites	Maximum cover	Maximum depth			
Te Kahika S	22/03/2010	22/03/2010	100	1	1		no resurvey	0
Te Paki	2/11/2004	29/04/2015	100	5	2.5	17/04/2007	still there	0
Te Riu	2/03/2006	23/03/2011	33	1	1.8	23/03/2011	27/05/2015	0
Wahakari	22/01/1985	7/04/2008	1	2	0.5	7/04/2008	7/04/2008	2
Waihopo	22/01/1985	3/11/2004	1	1	0.5	3/11/2004	4/03/2006	2
Waitahora Lagoon	17/04/2007	30/03/2009	50	1	1		5/05/2014	1
Waitahora Pools (incl. Paranoa Swamp)	17/04/2007	17/04/2007	100	2	1.5	30/03/2009	30/03/2009	1
West Coast Road (Sweetwater)	16/04/2001	16/04/2001	100	4	1	10/11/2004	10/11/2004	2

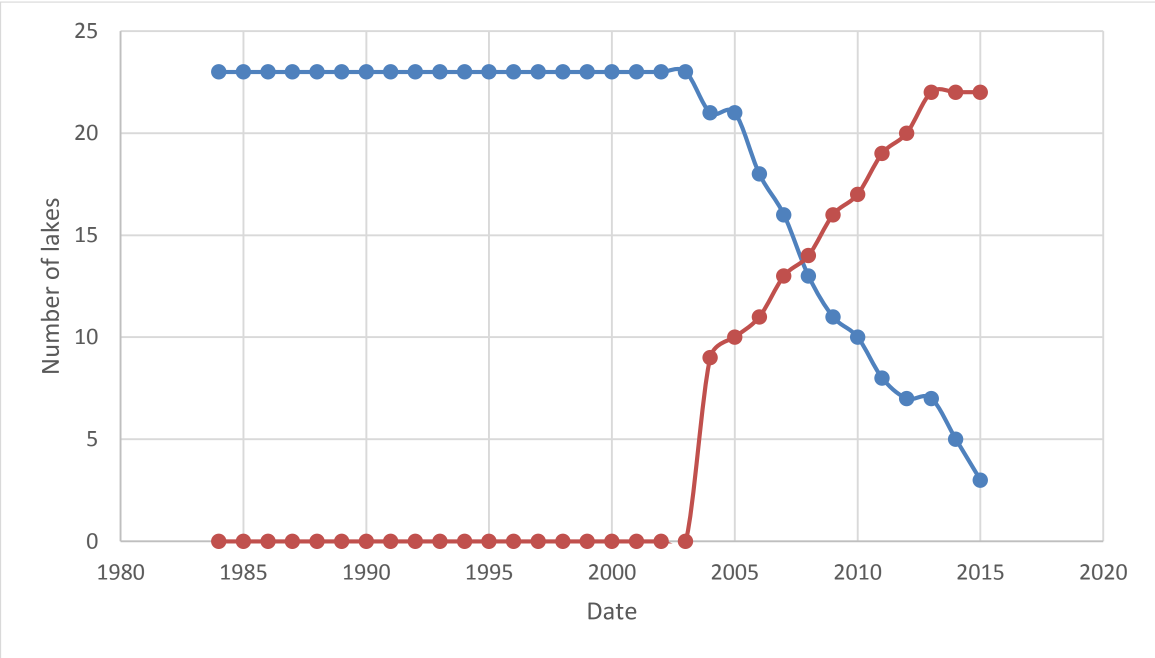

Figure 4-1: Decline of *Utricularia australis* populations in Northland lakes and corresponding increase in lakes colonised by *Utricularia gibba*. From 1984 to present.

The decline coincides with the establishment of a sexually reproducing bladderwort, *Utricularia gibba* in Northland (Figure 4-2). Salmon (2001) described *U. gibba* from Lake Waikaramu, near Kaimaumau in the late 1990s, recognising it as different from plants of this species previously recorded in West Auckland, which did not produce many fruit capsules. Asexual material of *U. gibba* was recorded by the author from Lake Omapere in 1999, but it has not been seen there since. In the field work culminating in the Champion et al. (2002) report, *U. gibba* was not evident in any of the 33 lakes (including nine lakes with populations of *U. australis*). Four years later, *U. gibba* was recorded in nine of the 22 lakes with *U. australis* and by 2015 only one of those lakes, Waitahora Lagoon had no *U. gibba*. Lake Te Kahika South had no *U. gibba* when last surveyed in 2010. The rapid extension of water bodies invaded by this species is documented in de Winton et al. (2009) with 59 water bodies apparently invaded by this species up to 2008. These sites were mostly Northland records, but also occurred in Auckland and the lower Waikato. Subsequent spread has undoubtedly occurred in these regions as for Northland (Figure 4-1). Unlike other submerged aquatic weeds found in Northland, *U. gibba* spread is not related to water body roading access and proximity to urban populations, reflecting dispersal by waterfowl rather than exclusively by human activities (Compton et al. 2012). Compton et al. (2012) also predict *U. gibba* could spread further south to coastal bay of Plenty, Gisborne, Hawkes Bay and Taranaki.

Utricularia gibba forms free-floating plants, but unlike *U. australis,* it produces rhizoids and can anchor itself to beds of macrophytes over which it grows. It can form dense mats that smother underlying submerged vegetation. Taylor (1989) and Salmon (2001) note that flowering only occurs when plants grow near the water’s surface. However, submerged mats of *U. gibba* produced submerged, probably cleistogamous (self-fertile) flowers in water more than one metre deep (Figure 4-2).

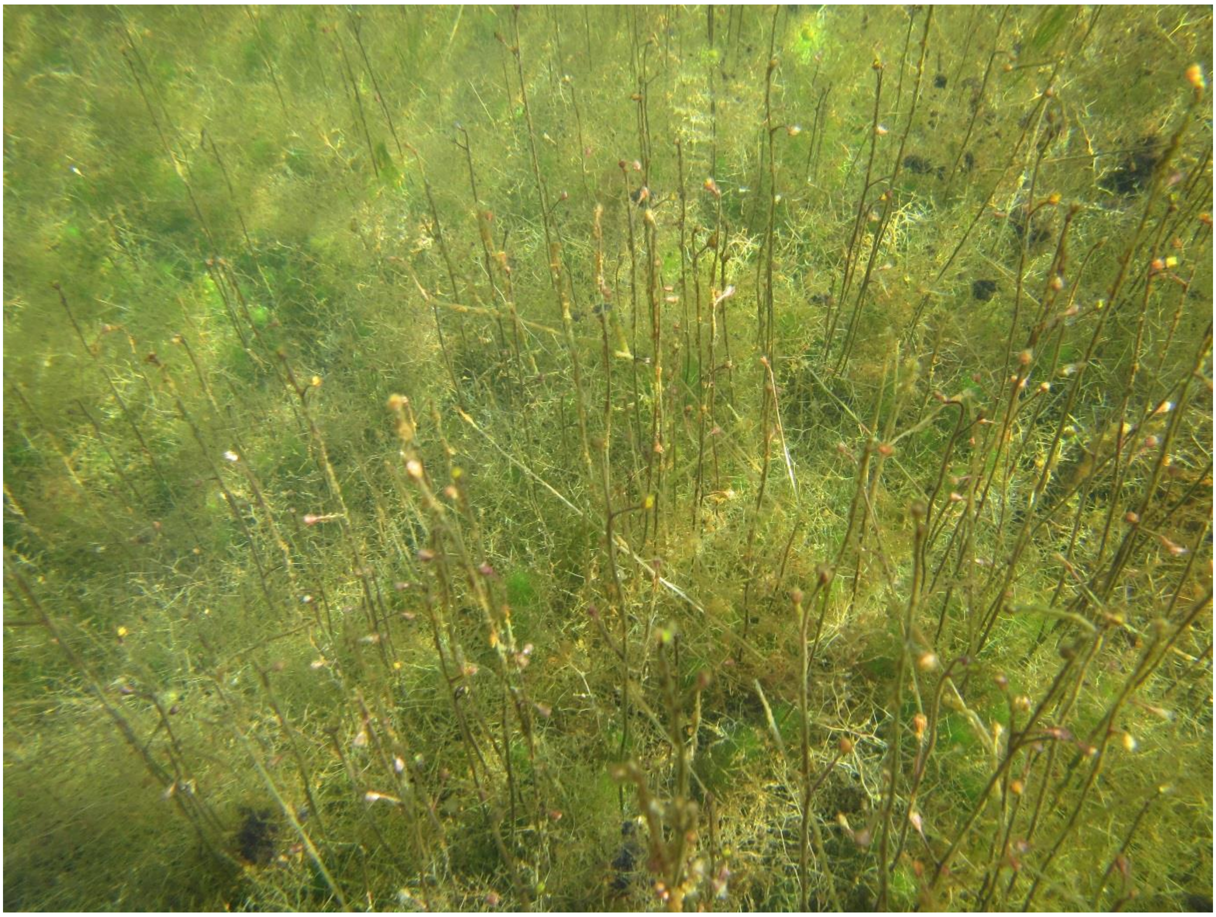

Figure 4-2: Submerged cleistogamous flowers of *Utricularia gibba*. Te Paki Dune Lake, April 2015.

The disappearance of *U. australis* from many water bodies where it was once abundant also appears to be linked with declining water quality through eutrophication as documented in many of the lakes that formerly supported populations of this plant (Simpson 2014). One apparently stable population of *U. australis* occurred in Lake Te Kahika, an unusual oligotrophic lake with very clear water, low pH (3.95) and a high concentration of sulphate. *Utricularia australis* was the only submerged vascular species in the lake and it was one of the few Northland lakes without *U. gibba* in 2009. Subsequent to this, pine plantation harvesting appears to have caused great changes to the lake, with low clarity, tea-staining and increased total nitrogen concentration in lake water and invasion by *U. gibba* to the point where it dominated the littoral zone in 2012. No *U. australis* was found on the 2014 and 2015 surveys. The only water body lacking *U. gibba* appears to be Waitahora Lagoon, possibly due to fluctuating salinity, although Lakes Kihona and Te Kahika South require resurvey to ascertain the status of both *Utricularia* species.

Utricularia gibba can form dense mats that accumulate heavy epiphyton growth, especially in productive (eutrophic) water bodies smothering other vegetation. Over summer, these mats can lift up and raft to the surface (Figure 4-3), presumably due to build-up of gas trapped under the mats.

Figure 4-3: A mat of *Utricularia gibba* and attached periphyton lifting off the bottom and rafting to the water surface. Lake Ngatu, photo courtesy of Kevin Matthews May 2007.

These periphyton covered mats are likely to have a high photosynthetic output during the day which is likely to increase pH levels resulting in alkaline conditions. In these conditions almost all dissolved inorganic carbon is in bicarbonate form (HCO_3^-) and inaccessible to *U. australis*, a plant reliant on dissolved CO_2 for photosynthesis. Presumably *U. gibba* has a mechanism to allow it to survive these conditions, potentially through its rhizoid system.

In the last known stronghold of *U. australis*, Te Paki Dune Lake, the mats of *U. gibba* are relatively free of periphyton (Figure 4-2) and the two species co-exist. Unfortunately, in all other lakes presence of thick mats of *U. gibba* seems to be implicated in the decline of *U. australis*, presumably exacerbated by declining water quality.

6 Recommended conservation actions

The following conservation actions should be undertaken to assist with the preservation of *U. australis* in New Zealand.

6.1 Census of all New Zealand populations

This report presents compelling evidence of the decline of *U. australis* in Northland, and similar trends may be occurring elsewhere within its New Zealand range. For example, Wildland Consultants (2009) undertook a survey of threatened plants in the Whangamarino Wetland and only found one site of *U. australis* out of ten previously reported populations. However, a new site was found during this survey. They point out that drought the previous summer may have contributed to the decline and also mention the potential threat posed by *U. gibba*, now established at Whangamarino.

A resurvey of all sites where recent collections/observations of *U. australis* have been made is recommended, ideally in the early to mid-summer period. This would provide a more accurate assessment of the status of *U. australis* in Northland and New Zealand. Sites still supporting plants should be characterised (e.g., size of population, depth range, associated species, presence/absence of *U. gibba*), water pH and conductivity), and where large populations are found material should be collected for genetic analysis and culture (Sections 6.2 and 6.3).

6.2 Genetic analysis

If the New Zealand *U. australis* plants are sterile and of hybrid origin (Kameyama et al. 2005 Section 3.3), there would be value in understanding the genetic variability of plants within this country, especially where there are already morphological differences noted. Characterisation of genetically distinct populations of *U. australis* has significant implications for the conservation of this plant in New Zealand, ensuring a.

The method used by Kameyama et al. (2005) involved extraction of genomic DNA and amplification of two regions of chloroplast DNA using primers and PCR amplification. Analysis of amplified fragment length polymorphism (AFLP) was performed on genomic DNA. They found a degree of polymorphism in their *U. australis* f. *australis* (hybrid) populations in Japan. However, both parent species are present in that country so there would be a continuing source of hybrid seed production. New Zealand populations may have very low genetic variability as was found in other New Zealand native macrophytes (pondweeds and milfoils) by Hofstra et al. 1995. This is likely due to the predominance of asexual reproduction through fragmentation within populations. In the case of *U. australis*, spread to New Zealand would be via long-distance dispersal of hybrid seed as discussed in Section 3.3. If New Zealand plants originated from one such introduction, with subsequent local dispersal via turion or vegetative shoot dispersal by waterfowl, then very limited variability would be expected. If the populations have arisen from several such introductions then more variability should be expected.

6.3 Cultivation

Most submerged *Utricularia* species, with the exception of *U. gibba*, are notoriously difficult to culture (Taylor 1989). However, there are many enthusiasts internationally that like to grow carnivorous plants and there are several websites dedicated to these plants. In order to replicate the dystrophic habitat required by *U. australis*, either sphagnum peat moss or cut dried stems of emergent sedges are added to a large container of rain water and allowed to age. Planting emergent species in these tanks also helps condition the water to suit *Utricularia* growth, including the reduction of filamentous and other algae that may smother the water surface and supress *Utricularia* growth. The water should be at least 0.5 m deep, with the best growth occurring in warm well lit conditions. Salmon (2001) details propagation requirements using peat or sphagnum moss (5 – 10 cm deep), rain water 60 cm deep and aging the water to discourage algal growth. He recommends a maximum temperature of 25°C during the summer and potentially seeding food species (e.g., small copepods and cladocerans) sourced from local ponds but avoiding introduction of pond snails that will decimate *Utricularia* plants. *Utricularia gibba* is a potential problem weed undesirable in tanks where *U. australis* is to be cultured.

6.4 Translocation and habitat enhancement

This study has shown that *U. australis* populations are severely threatened in Northland and while the causes of decline seem to be understood, it is premature to identify likely sites for translocation should cultivation be successful. Likewise, the key habitat variables permitting the survival of *U. australis* but not suiting the growth of *U. gibba* need to be understood before attempts are made to enhance habitats to promote the survival of *U. australis* in the Northland region. However, both translocation and habitat enhancement are key to the future survival and conservation of this intriguing plant in New Zealand.

7 Acknowledgements

I would like to thank Lisa Forester, Biodiversity Specialist – Land and Rivers at NRC, for organising this project and also securing NRC funding for field work, assisting with field surveys and discussions on the management of this plant.

Kevin Matthews (Bushlands Trust, Kaitaia) provided a wealth of knowledge on the habitats where this plant is found.

Ewen Cameron and Ines Schoenburger provided herbarium records of this species and allowed me to examine specimens from Auckland Museum and the Allan Herbarium respectively.

Rohan Wells and John Clayton (NIWA) kindly reviewed this report.

I gratefully acknowledge MBIE Envirolink funding allowing this project to proceed.

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