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New Zealand's native freshwater flora: Living the life aquatic

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This talk focused on our little-known native submerged aquatic flora, but also briefly discussed the very topical state of New Zealand's freshwaters, the strategies that aquatic plants use to survive in water, and threats to and conservation of aquatic plants.

We live on the Blue Planet, with 75% of the Earth's surface occupied by water. However, 97.5% of this is in our oceans and is toxic to most terrestrial and freshwater organisms. Of the remainder, only 0.4% is present in surface water. How New Zealand manages our freshwater resources has become a major public concern. Recent publications by Sir Peter Gluckman (2017) and Ministry for the Environment/Stats NZ (2017) provide good science-based information on this issue. Of concern regarding our freshwater biota is the continued loss of wetlands (e.g., a 10% loss of Southland's wetlands between 2007 and 2015), continuing inputs of the plant nutrients nitrogen and phosphorus and fine sediments in urban and pastoral water bodies, water allocation, pest plants, algae and fish and the future impacts of climate change on all these factors.

Globally the most threatened ecosystems are freshwaters, with approximately 30% of all freshwater fauna being nationally threatened (Gerbeaux et al. 2016; DOC 2017). Thirty six percent of aquatic plants are nationally threatened or at risk of extinction (de Lange et al. 2013; NIWA unpublished data).

Unlike our terrestrial flora, where 80% of species are endemic, only about 40% of our indigenous aquatic plants are found nowhere else. This demonstrates the effective trans-Tasman dispersal efforts of migratory birds like grey teal (*Anas gracilis*) (Gerbeaux et al. 2016).

Living under water has major challenges for aquatic plants, as water contains low concentrations of both oxygen and carbon dioxide, the latter especially essential for photosynthesis. Light availability is also an issue, with suspended sediments and planktonic algae often intercepting light before it reaches submerged plants. Because few plants are able to pollinate underwater, reproductive strategies include either getting their flowers to the water surface, such as having long filamentous stalks (peduncles), or waiting for drought conditions that expose plants that then trigger flowering, or essentially remaining asexual. Dispersal to new freshwater islands across a sea of dry land is also problematic unless plants have adaptations for water fowl- or wind-dispersal. Beneficial characters of freshwater include buffering temperature extremes, providing buoyancy thereby reducing the need for structural tissue, and of course being surrounded by unlimited supplies of water!

Submerged plants structure their environment, buffering wave action, remediating the impacts of dissolved nutrients on algal blooms, providing shelter and food for aquatic fauna, causing daily fluctuations of dissolved oxygen and pH and providing habitat and flow diversity (Champion & Tanner 2000).

Other freshwater-dependent plants can overcome some of those challenges by sitting at or above the water surface, or essentially completing a rapid life-cycle in periods of drought. A large number of our annual plants belong to the latter category of plants, including many threatened species (e.g., *Centipeda minima* and *Centrolepis strigosa*; Fig. 1).

Our deepest-growing plants are bryophytes, with around 40 species of mosses and liverworts found in clear South Island lakes, such as Lake Wakatipu, to depths of up to 70 m (de Winton & Beever 2004). While many species are obligate aquatic plants, others are also found in deeply shaded terrestrial environments.

Fig. 1. *Centrolepis strigosa*, Lake Waikare marginal vegetation, Kai Iwi Lakes. Photo: Paul Champion, 13 October 2014.

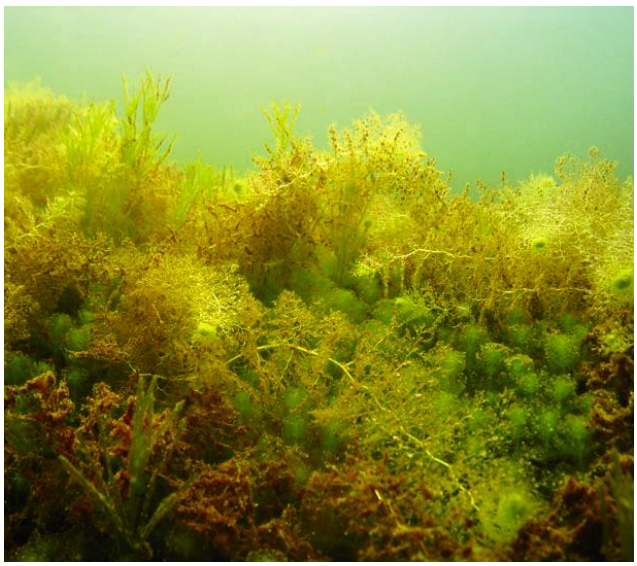

Fig. 2. *Utricularia australis* sprawling over *Chara fibrosa* (front right) and *C. australis* (back), Te Paki Dune Lake. Photo: Rohan Wells, 17 April 2007.

Fig. 3. Quillwort (*Isoetes alpina*) showing corm-like stem and spores in the bases of the quill-like sporophylls, Lake Manapouri. Photo: John Clayton, 18 January 2005.

Slightly fewer than 20 species of a specialized group of algae form underwater meadows usually less than a metre tall, from the shallows to over 40 m depth. The characeans or charophytes are closely related to land plants – approximately 450-500 million years ago, an ancestral charophyte emerged on to land and ultimately gave rise to terrestrial plants (Domozych et al. 2017). The largest genera are *Nitella* (12 spp.) and *Chara* (5 spp.), distinguished by the forked end-branches produced by *Nitella.*

A few tall (>1 m high) vascular plant species are found permanently submerged to depths of around 10 m, with the milfoils *Myriophyllum propinquum* and *M. triphyllum* and the pondweeds *Potamogeton ochreatus* and *P. cheesemanii* the most common, forming taller vegetation at the upper extent of charophyte meadows. A number of other vascular plants are usually found in saline-influenced waters including two species of *Ruppia* and *Stuckenia pectinata.* One of the most specialized plants in this group is the carnivorous bladderwort *Utricularia australis* (Fig. 2). Once common in Northland dune lakes, it has undergone a spectacular decline in abundance this century, mirroring the expansion of another Australian species *U. gibba*, and is now regarded as critically endangered (de Lange et al. 2013).

The fern ally quillworts (*Isoetes alpina* and *I. kirkii*) are found in the South and North Islands respectively. These plants form dense up to 0.5 m tall turfs (Fig. 3), especially in relatively exposed lake habitats usually growing in 1 to 4 (up to 6) m depth.

The most diverse group of submerged plants occur in the shallows, with over 40 tiny (< 5 cm tall) amphibious species from many different families occupying the zone between taller submerged vegetation and tall riparian vegetation. They are of highest abundance in water bodies with annual water level fluctuations between one and three metres, occupying the varial zone between permanent wet and dry habitats (Johnson and Rogers 2003). Families represented include the predominantly terrestrial Asteraceae, Apiaceae, Brassicaceae, Crassulaceae, Plantaginaceae and Ranunculaceae and one fern, as well as many other obligate aquatic families (Figs. 4, 5, 6). They are similar morphologically, an example of convergent evolution, with either linear, pinnate or spathulate leaves. They are commonly referred to as the 'knife, fork and spoon' plants, often having relatively large flowers much more obvious than their vegetative form.

Submerged freshwater plants are threatened by a number of human activities including the addition of plant nutrients to water bodies (eutrophication), artificial changes in water level (including drainage, excessive fluctuation but also stabilized water levels), invasive plants and pest fish, and combinations of all these. Extreme impacts can include the complete loss of native plant communities through shading by algae or other sources of prolonged turbid water, displacement by taller denser submerged weeds, and direct browsing and sediment disturbance by pest fish.

Many lowland shallow lakes, especially on the west coast of the North Island, are now essentially devegetated through a combination of impacts. Lake Omapere in Northland, has undergone two devegetated phases over the past 30 years, with increased catchment-based nutrients and the destabilizing impact of the aquatic weed *Egeria densa* implicated in these switches from plant to algal-dominated phases (Champion 2002).

Many initiatives have been undertaken around New Zealand since the turn of the century focusing on mitigating the impacts of surrounding land-use on water bodies, fencing and planting riparian buffers, leading to improved water quality. Similarly, the role of invasive pests has been recognized with prevention of spread targeted, including publicity campaigns such as Check-Clean-Dry, surveillance for new incursions and incursion responses to eliminate new invaders.

More species-focused conservation is needed for the large number of nationally endangered freshwater-dependent plants, with few of our unique species receiving this attention. They are our 'canaries in the coalmine' and ultimately their survival will be a measure of effective freshwater restoration.

Fig. 4. *Pilularia novae-hollandiae* showing sporangia, Lake Manapouri. Photo: Paul Champion, 14 October 2012.

Fig. 5. *Myriophyllum propinquum*, with male (upper) and female (lower) flowers, Lake Waiporohita, Karikari Peninsula, Northland. Photo: Andrew Townsend, 24 March 2010.

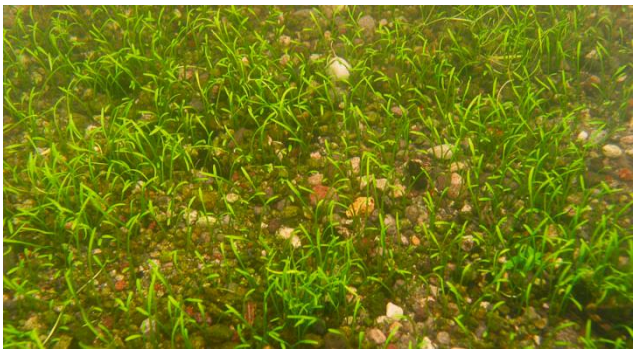

Fig. 6. *Ranunculus limosella*, cultivated plant ex. Lake Lyndon. Photo: John Clayton, 22 November 2007.

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