FRESHWATER ECOLOGY

Restoring water plants

Mary de Winton

NIWA researchers are seeking ways to promote the growth of and protect those plants that have a beneficial role in aquatic habitats.

"WATER WEED" is not always a bad thing! Instead submerged plants have a very necessary role in our waterways – a role that is under threat from deteriorating water quality.

Friend not foe

Many people are aware of the problems caused by exotic water weeds that choke lakes and interfere with recreational pursuits. Few realise that beds of aquatic vegetation can protect and enhance water quality. Plants help to maintain clarity by dampening wave action and preventing the disturbance of bottom sediments. They also groom nutrients and dirt particles from the water (see panel below).

Native vegetation, especially charophytes, play a beneficial role in water bodies.

Despite their guardianship of water clarity, underwater plants can be overwhelmed by inflows of dirty water or by blooms of microscopic algae, both of which can deprive them of essential light. In extreme cases plants can be entirely lost from a lake and fail to re-establish. This is just what has happened in 10 of the shallow lakes in the Waikato region – water bodies that remain highly turbid today. This loss of plants and accompanying deterioration in water quality is an issue facing the managers of shallow lake systems.

NIWA's PGSF research programme "Aquatic Plant Management" aims to identify tools that could help lake managers to restore degraded aquatic habitats through re-establishing and enhancing desirable vegetation. One of the most promising avenues for restoring aquatic vegetation is based on harnessing plants' own strategies for survival.

Sowing seeds for the future

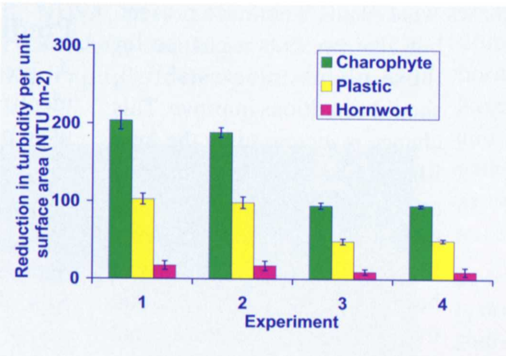
Many native New Zealand water plants invest in a "seed bank" – a deposit of living propagules (seeds and vegetative fragments) laid down in the bed of water bodies. While acting as a reservoir for species and genetic diversity, these seed banks also assist plants to re-establish after catastrophes such as storms. At least 12 native plants form seed banks in lake beds. In some places their propagules are so dense that over 100 can be found in a single teaspoon of mud!

We discovered that the size and diversity of seed banks is shaped by the vegetation history of a lake. As might be expected, lakes that have lost their water plants tend to have few seed species and lower seed numbers in the surface mud. Nevertheless, we found viable seed in lakes that had lost their vegetation over 20 years before. Other vegetation changes also affect the seed bank. In contrast to native water plants, exotic "oxygen weeds" do not produce seed; instead they spread by fragments. When these weeds

Charophytes and clear water – cause or consequence?

NIWA recently hosted Dr Michelle Casanova from Australia, an expert on the ecology of charophytes (macro-algae). Michelle, like us, was interested in a phenomenon noted all over the world – that the clearing of turbid lakes is often linked to the sudden appearance of charophytes. The question was, do these small plants in fact aid in clarifying turbid waters, or do they simply establish when water clarity increases?

We tested the ability of charophytes to clear turbid water. A dose of mud was added to water tanks planted either with charophytes, another plant (hornwort), plastic replica plants, or to tanks without any plants. Water turbidity was then measured over a few days. Turbid water cleared faster in the tanks with plants (including plastic plants), than in the tanks without plants. We then compared the plant types by their surface areas to give an indication of filtering or "dead" spaces for settling particles. Charophytes proved far more effective at reducing turbidity per unit surface area than hornwort or plastic plants.



When compared by surface area, charophytes reduced water turbidity more effectively than hornwort or plastic plants. Each of the four experiments was run over approximately 50 hours. Turbidity was measured as nephelometric turbidity units (NTU).

We also discovered that charophyte "seeds" (technically, oospores rather then true seeds) germinated equally well when placed in shallow water (0.6 m) that was highly turbid (33 NTU, 6% sunlight) as they did under clear water conditions (1 NTU, 20% sunlight). This was despite an estimated three-fold difference in the level of light for germination.

Charophytes have features that make them a particularly desirable plant in lakes (see panel, page 10). Charophytes contribute to keeping lake waters clear – maybe more so than other plants – and added to this is the fact that charophyte seeds can germinate in relatively turbid water. These water plants are a promising ally in the rehabilitation of degraded water bodies.

Rehabilitating Lake Rotoroa

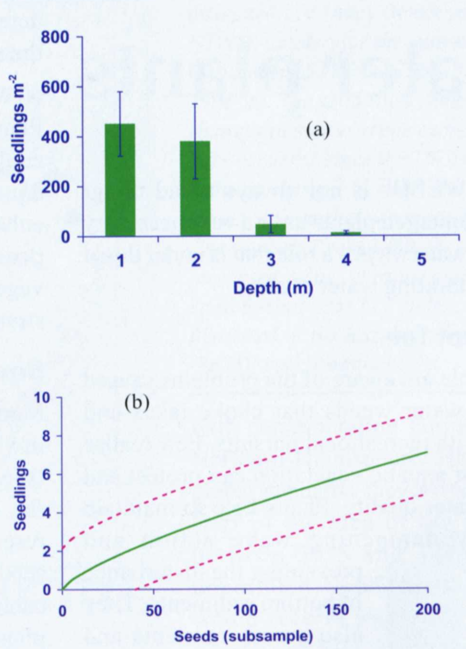
TOO FEW water plants can be as bad as too much water weed! This was the paradox discovered by the managers of a shallow New Zealand lake that has lost its water plants. Just as puzzling was how to go about restoring the lake to an ecological balance. NIWA research shows that one key may be the presence of long-lived seed banks in the bed of the lake.

Lake Rotoroa, located in Hamilton City, is managed as a park reserve by the city council (HCC). In the late 1980s the lake changed. Introduced water plants that once grew over the lake bed in nuisance amounts suddenly died out, and the lake waters became very turbid (see *Water & Atmosphere 1*(1): 18–19). As plants need light to grow, the poor water clarity contributed to the lack of a plant recovery.

HCC found that city residents were concerned about the poor water clarity and condition of the lake, so a plan was prepared to return the lake to a desirable state. One aim was to re-establish charophytes – a kind of native plant – across the bottom of the lake. These small plants don't interfere with boating. They also help to keep water clear and clean, as dense charophyte beds bind the lake bed so that waves and fish cannot stir up the bottom. The plants also filter particles from the water and help to prevent algal blooms.

NIWA scientists confirmed that charophyte "seeds" are present in the lake mud and that these can germinate. Divers collected samples of mud and we cultured these under the light level expected at the lake bottom under clear water conditions. The result showed that within six months seedlings could germinate in large numbers (≥350 per m^2) over at least 38% of the lake bed. Most seedlings emerged from samples collected at shallow sites, and the variation in seedling number was closely linked to the density of viable seed. In turn, seed density probably reflects where and when charophytes grew within Lake Rotoroa, with most seeds now likely to be over 10 years old.

The water clarity in the lake can be increased for a short time by applying a flocculent (a chemical that causes particles to settle out). If clarity is increased, it is likely that light reaching the lake bed will germinate charophyte seeds lying in the mud. Our next step will be to find out how quickly these seedlings will grow and whether fish within Lake Rotoroa will eat or uproot the plants as they develop (see accompanying article, pages 11–13: "Are rudd a threat to water plants?").



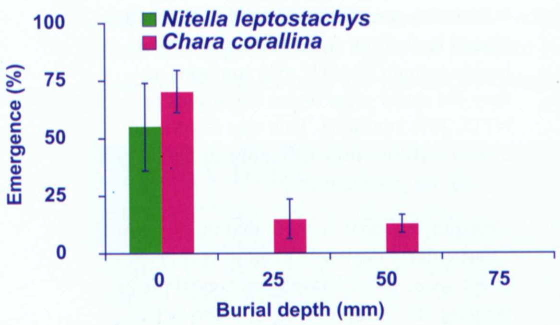
The number of germinating charophytes from Lake Rotoroa muds relates to (a) water depth and (b) the density of "seeds".

photo: *Charophytes growing in intact cores of mud taken from Lake Rotoroa. These plants have established after six months.*

invade a lake, native plants are excluded and the underlying seed bank is not replenished.

Promising properties

The presence of viable seed in degraded lakes not only shows what plants were once present, but also presents a chance for those plants to re-establish, should conditions improve. This chance is increased by the long life of some seed. As mentioned previously, seed banks may persist for more than 20 years. In addition, viable seeds have been found buried in lake mud over 30 cm deep, suggesting that they must have been laid down many years before. Seed bank persistence is further enhanced by a conservative germination strategy in which not all seeds germinate in response to favourable conditions so that seed reserves remain for subsequent establishment attempts. We also found that seed does not require special treatments to germinate (such as drying, freezing or abrasion of the seed coat) and will respond under permanently submerged conditions at realistic light levels.



Seedlings of Chara corallina *can emerge from a greater seed burial depth than* Nitella leptostachys, *which has seed that is 10 times smaller.*

Predicting seedling response

At present, the focus of our programme is on identifying seed bank behaviour that will assist us to predict re-vegetation response.

The first question we are considering is how the depth of seed burial will affect seedling emergence. Preliminary investigations suggest that seed species have different burial limits from which they can germinate and emerge (see graph, left). It also appears that these limits are related to the size of energy reserves within the seed. The next question is whether the age of seeds might affect their germination. If so, we might expect that seed from the deepest (oldest) sediment layers would have a germination response that was different from seed in the shallowest (youngest) sediments. Another question is the effect of season. Many terrestrial seeds germinate according to seasonal cues. We need to establish if water plants have such strategies and if seedling establishment is more successful at one particular time of the year.

Future research will focus on establishment responses of key seed bank species and assessment of the techniques and requirements for restoration of vegetation resources in our water bodies. ■

Mary de Winton is based at NIWA in Hamilton.

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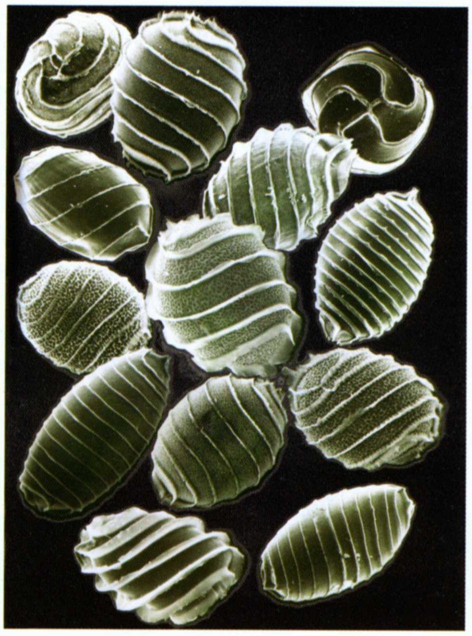

Further reading

de Winton, M.D. and Clayton, J.S. 1996. The impact of invasive submerged weed species on seed banks in lake sediments. *Aquatic Botany* 53: 31-45.

de Winton, M.D., Clayton, J.S. and Champion, P.D. in press. Seedling emergence from seed banks of 15 New Zealand lakes with contrasting vegetation histories. *Aquatic Botany*.

left: *The unique size and appearance of plant propagules help to identify the species in the seed bank.*

FRESHWATER ECOLOGY

Are rudd a threat to water plants?

Rohan Wells

The coarse fish, rudd, is one of several factors that could hamper programmes to restore submerged vegetation to many water bodies in New Zealand.

RUDD *(Scardinius erythrophthalmus)* are freshwater fish that feed mainly on aquatic plants. They look like large goldfish, except that they have red fins. These fish were illegally imported into New Zealand in the 1960s, bred up in numbers and then released in the Waikato, Auckland and Northland regions. The offender wanted to establish a popular game fish in warmer nutrient-rich waters unsuitable for trout (*Auckland Star,* 5 June 1971).

Rudd are now well established, forming large populations in many water bodies from the Waikato northwards. They usually grow to 200–300 mm long but can exceed 600 mm (B. Chisnall, NIWA, pers. comm.). Their main predators are shags and larger eels, which, if numerous enough, can decimate a rudd population.

High densities of rudd in lakes may cause negative "top-down" effects on the ecosystem, especially on other organisms that depend on aquatic plants. Other freshwater fish are also known to be capable of severe impacts. For example, European carp in Australia and the UK have turned lakes and rivers permanently muddy as their foraging activities stir up bottom sediments and uproot plants.

Lake degradation and aquatic plants

In the Waikato region of New Zealand, most water bodies have been degraded over the last two decades by a loss of plant and animal diversity. Many hydro-electric lakes are now dominated by the introduced pond plant, hornwort *(Ceratophyllum demersum).* Others have lost all their submerged aquatic vegetation and become dominated by algae. Both these paths of degradation are undesirable, but "weed" growths are usually preferred to an algal nuisance.

Excessive plant growth may interfere with recreational activities, accumulate on lake shores, block water intakes, or cause overnight oxygen depletion. On the other hand, the switch from a plant-dominated water body to a murky, algal-dominated or muddy-water lake has consequences for many other organisms. Invertebrates associated with aquatic plants may decline or disappear and this can affect some