Session Two : The Issues

SESSION CHAIR – Cr Lyall Thurston, Bay of Plenty Regional Council

WEEDS AND THE ROTORUA LAKES

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John is a Principal Scientist and Programme Leader with NIWA Hamilton and has carried out research on New Zealand freshwaters for over 44 years and did his PhD thesis on Lake Rotoma. His first paid job was as an environmental consultant; then as an Engineering Scientist for the NZ Electricity Department working on hydro lakes around New Zealand; then as a research scientist at MAF Ruakura Research Station, before joining NIWA in 1992. His speciality is applied research and technical consultancy on aquatic plants, including their management and control. His work encompasses weed risk assessment and biosecurity; aquatic weed management; biotic and environmental impacts, and lake health assessment using macrophyte indicators. He has been a key adviser on preventative weed management for the world rowing events at Lake Karapiro in 2010 and towards the eradication of alien aquatic weeds from New Zealand. John has also applied his knowledge and experience gained from over 1000 SCUBA dives in New Zealand freshwaters to develop rapid vegetation survey methods, including a recent management tool (LakeSPI) to assess lake ecological condition. Research in lakes has also involved a wide range of environmental impact assessments, including the effect of turbidity and boron from mining discharges, arsenic accumulation in macrophytes and water level fluctuations on hydrolakes. His aim is to supply robust and pragmatic solutions and tools for water body managers seeking to manage aquatic vegetation resources and issues.

ABSTRACT
The Rotorua Lakes are of volcanic origin and they form an integral feature of the regions landscape. No other region in New Zealand has such an interesting combination of lakes in close proximity, each of which offers unique cultural values and a diversity of recreational activities.

Rotorua lake weeds rose to public and political prominence in the 1960s and the first seminar addressing this issue was held in 1964. A second meeting followed in 1966 with a 'Seminar on Water Weeds'. These seminars involved outside experts and many will remember Prof Val Chapman, University of Auckland, who had a prominent role supervising research on these weed problems with his students. I was his last PhD student before he retired in c. 1975.

This talk will provide an outline of key changes in the Rotorua Lakes over time by focusing on the aquatic plants. The aquatic plants in a lake provide a window into understanding the health and condition of each lake and this talk explains how native and invasive plants can be used to assess or describe lake condition, enabling lakes to be ranked, monitored and compared. The native condition of each lake has been compromised by two key impacts; invasive plant species and declining water clarity. Other potential impacts are also discussed. Key invasive weed species will be illustrated and discussed, including

their spread and ecological impacts. Some of the history of management response will be discussed along with some thoughts about the future.

TRANSCRIPT

I am going to talk about weeds in the Rotorua Te Arawa lakes. I must first thank Dr John Madsen for his excellent talk and the opportunity that this seminar has provided to compare our countries' respective approaches around the politics of weed management and the science behind control. We are indeed relieved and pleased to see that a lot of his work in the USA endorses the approach that we have adopted in New Zealand.

Slide 1 looks at the distribution of the main Rotorua Lakes. The Rotorua Te Arawa Lakes face a number of challenges, including water quality and invasive species. Nutrients and sediments are two of the biggest drivers of water quality. However, an important point to note is that nuisance weed growths are not dependent upon water quality, so you can still have a weed problem with either good or bad water quality.

Slide 1

An increase in algae (including blue green algae) is often associated with an increase in nutrients; while the decline in kakahi (mussels) and koura (crayfish) is often associated with declining sediment density and increasing organic content. Although this symposium is about 'Weeds and Wallabies', there needs to be recognition of the major threat and impact that pest fish would have on these lakes if they were allowed to establish, which includes the decline of desirable aquatic vegetation and native koura.

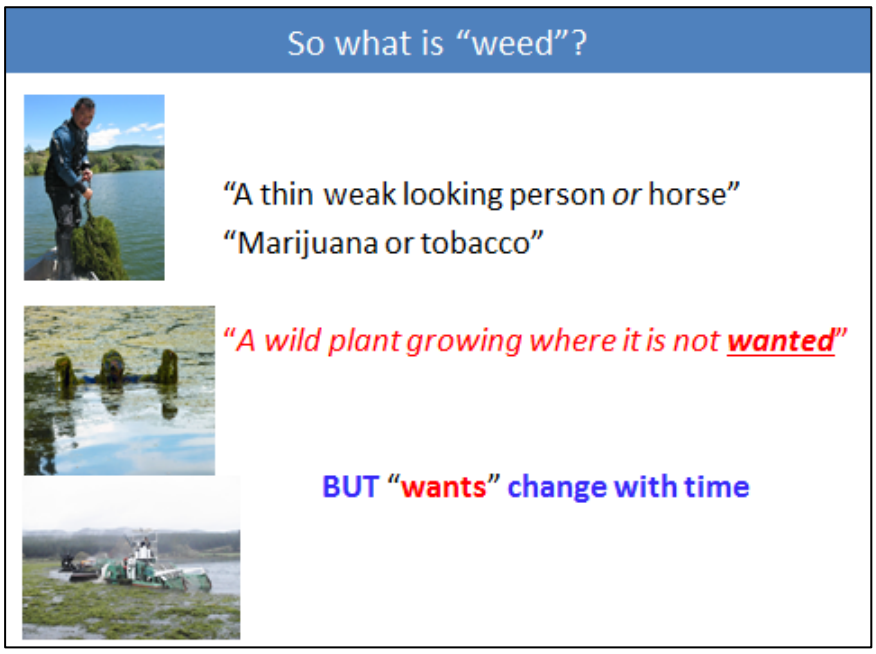
The decline of submerged plants can also be caused by reducing water quality, especially clarity. However despite changing water quality over the years, a major issue for the Rotorua Te Arawa Lakes has been the challenge from invasive plant or weed species. In 1961 residents of Lake Rotoiti met to decide on how to rid their lake of invasive weeds. The Lake Weed Society was formed, with a focus particularly on lagarosiphon and its control. Professors Chapman and John Brown (Auckland University) were key contributors in those days. Many of you here will remember those characters. (Professor

Val. Chapman was my PhD supervisor and Professor John Brown continued as my supervisor once Prof Chapman retired).

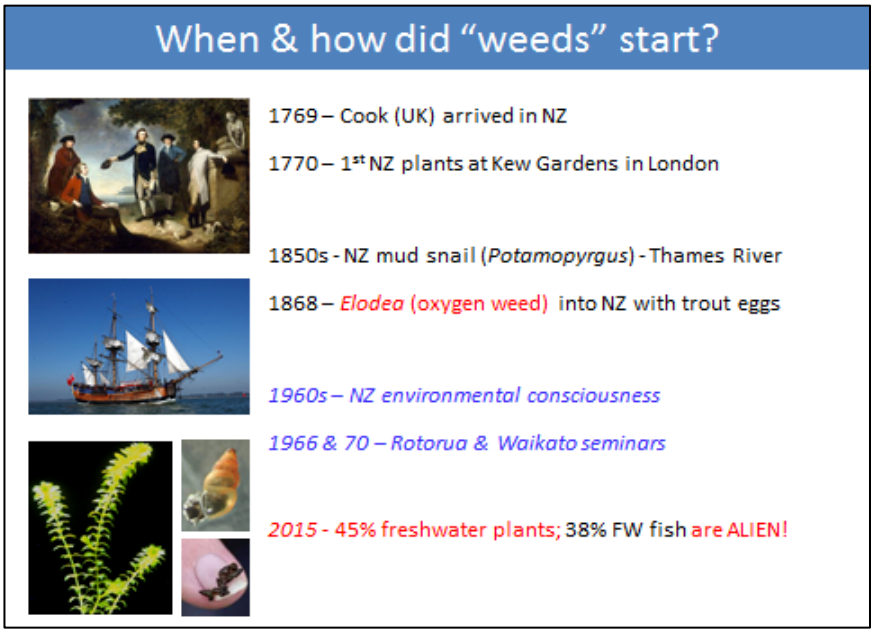
In 1966 and 1970 there were two interesting booklets published on weed control in the Rotorua and Waikato Lakes, produced by Prof. V. J. Chapman. I recommend you read these if you get a chance. In the late 1990s the focus of the Lake Weed Society expanded to include water quality and the name of the society changed to the LakesWater Quality Society.

Aquatic plants can be desirable and beneficial; however certain species are renowned for their weediness. Of course what is a weed in one country may not be in another. So, what is a weed? **Slide 2** attempts some definitions, the most relevant one being 'a wild plant growing where it is not wanted'. But 'want' is the operative word and 'wants' change with time.

Slide 2



Slide 3



When and how did weeds start? **Slide 3** goes back to 1769 when Captain Cook sailed the first ship to New Zealand from the United Kingdom. By 1770 the first of our New Zealand plants were growing in Kew Gardens in London. Over subsequent years, multiple voyages from the UK bought many European fauna and flora from the UK. Even the tiny New Zealand mud snail, *Potamopyrgus antipodarum*, first appeared in the Thames River around the 1850s because sailors filled up their water barrels from our rivers as a potable water supply before sailing back to the old country. On their return to London they emptied any remaining dregs into the river. Our pond snail has subsequently spread from the United Kingdom through Europe and more recently to America, which is causing them some upset at the moment. These examples demonstrate just how easily biota can spread between countries.

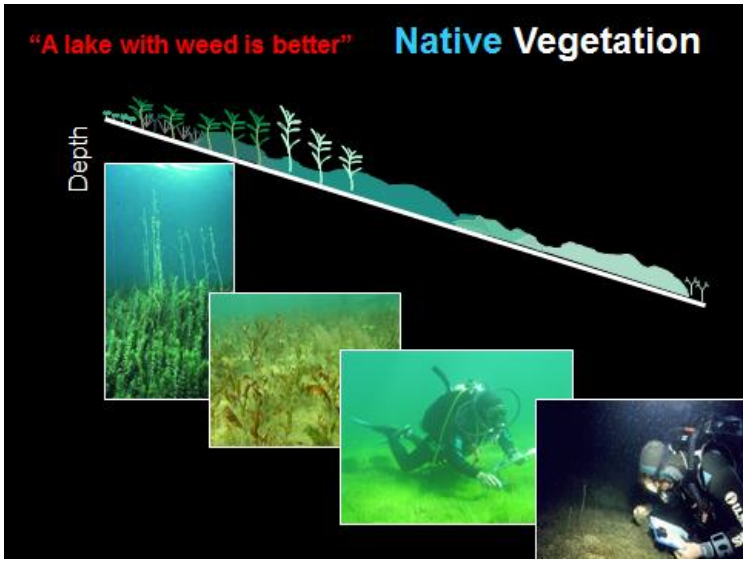
With respect to pest aquatic weed species, *Elodea Canadensis* (elodea or oxygen weed) was introduced to New Zealand with trout eggs in 1868. Public perception during these early years generally failed to appreciate or respect the inherent value of indigenous fauna and flora, so for many decades the introduction and acclimatisation of foreign species was considered acceptable and even desirable. Many mammal species were introduced as food for farming and for sport. It was another 100 years, to the 1960s, before environmental consciousness really took hold. Roll the clock forward to now (2015) and it is interesting to note that 45% of freshwater plants and 38% of the fish species that we have in New Zealand are alien.

However it is not all bad news. There has been significant progress made with weed control in New Zealand over the last 40-50 years. For example, several serious weed species have been eradicated from the country and because they are not seen any more it is a classic case of 'out of sight and out of mind'.

Several great successes in the Rotorua Lakes area are worth noting. **(Slide 4)** Water hyacinth was first identified in New Zealand in 1913, but its potential impact on waterbodies was recognised, so it was banned from import in 1927 and declared a noxious weed in 1950. At this time water hyacinth was already spreading and forming floating rafts on Lake Rotorua, but fortunately early control works enabled eradication.

Slide 4

Yellow Water Poppy (*Hydrocleys nymphoides*) was discovered in a pond at the margin of Lake Rotoehu and was eradicated in 1976; while marshwort (*Nymphoides geminate*) was found growing along the margins of Lake Okareka in 1981, where it had spread from an original 1976 planting in an ornamental pond on an adjacent property. The entire weed population was covered with polythene and was ultimately eradicated. Many of you will remember the water net saga. Apart from some initial progress controlling submerged weed bed habitat that supported surface floating rafts of water net, this weed largely disappeared on its own accord without explanation.

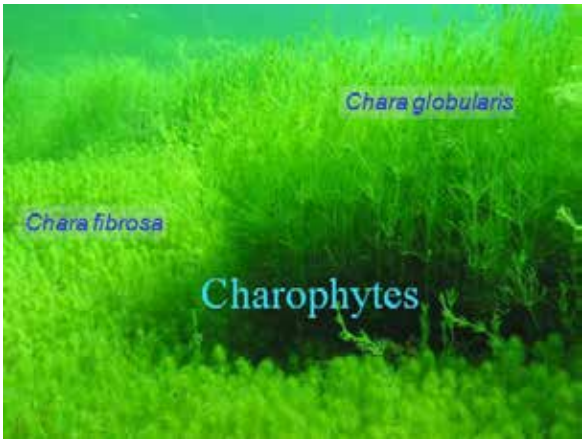


Slide 4

A lake without weed is often a relatively sterile unproductive environment. Ideally it would be preferable to have entirely native plants, but foreign plant species may still be better than no aquatic vegetation at all. It is well recognised that invasive species pose most of the problems. **Slide 4** is an example of a native vegetation profile through a lake that has good water clarity. As the water becomes more turbid submerged aquatic plants will not grow as deeply. Most of the Rotorua Lakes can support a moderate to good depth of vegetation, and the clearest lakes have plants growing down to around 15 metres and sometimes deeper.

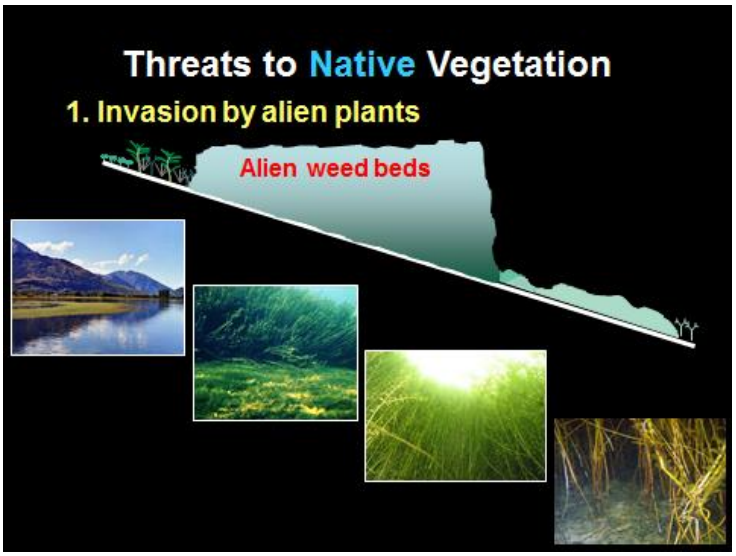
Slides 5, 6 and 7

In shallower water, native milfoils and pondweeds **(Slides 4-6)** are common. In deeper waters **(Slide 7)** charophytes (comprised of several *Chara* and *Nitella* species) can form undulating carpets down to 15 metres; and in some clear South Island



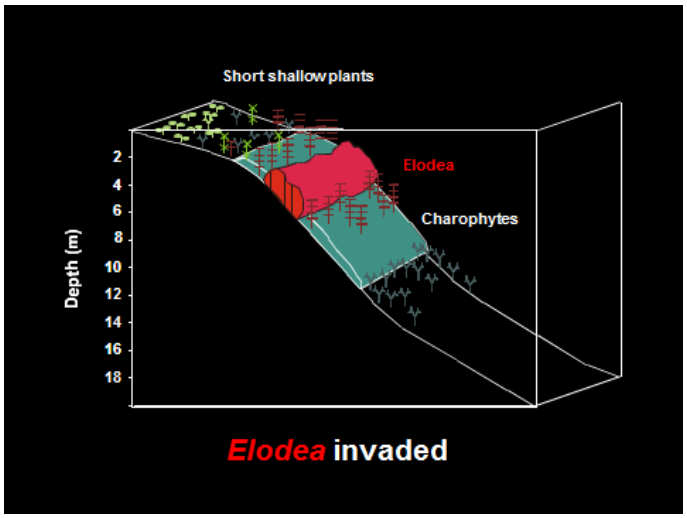
lakes they can reach 30-40 metres. There are many different species of *Chara* and *Nitella*.

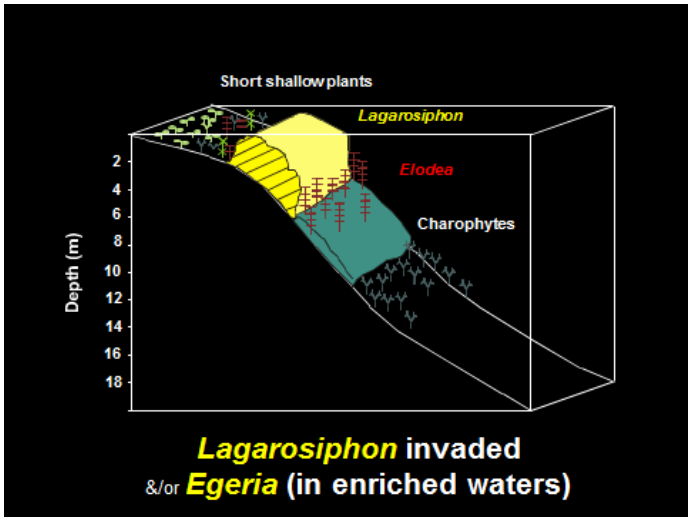
Alien plants are a major threat to native vegetation. **Slide 8** shows what can happen when alien plants invade and displace the native plants. Generally native plants may survive in shallow water where wave action or fluctuating water levels create a disturbance zone. Likewise, if the water is clear, native plants can still occupy the deep water zone.



Slide 8

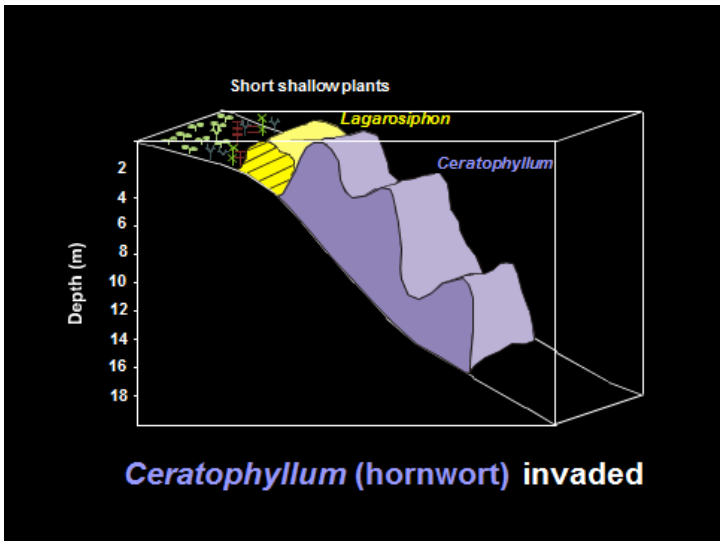
Slides 9-11 show the increasing impact caused by three key invasive species (*Elodea*, *Lagarosiphon* and *Ceratophyllum*). *Elodea* and *lagarosiphon* are now widespread around New Zealand, while *Ceratophyllum* (commonly called 'hornwort') has so far been restricted to the North Island. Each of these species respectively has an increasingly large impact on the displacement of native plant communities and on lake usage (e.g., recreational and power generation). The worst of these weeds is undoubtedly hornwort, which has unfortunately spread around most of the Rotorua Lakes and much of the North Island.



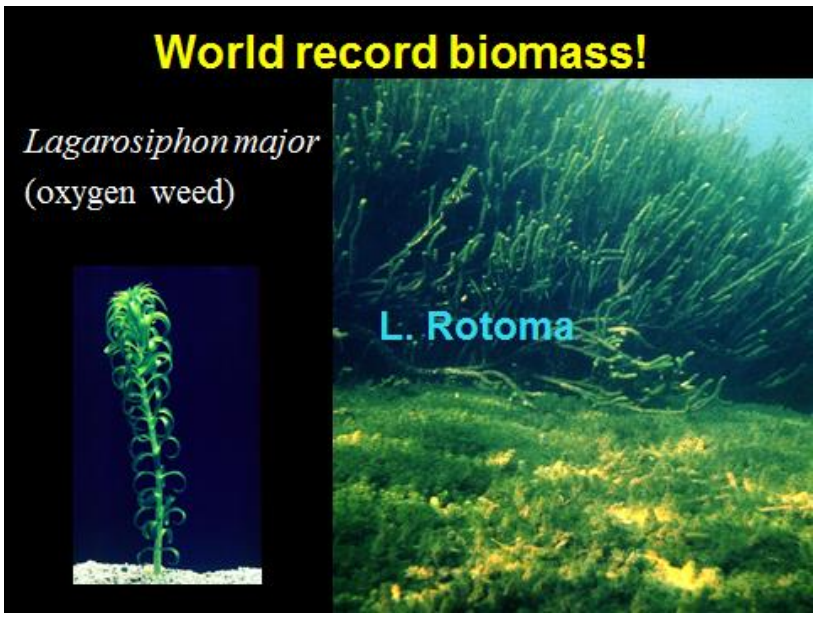


Slides 9 and 10

Slide 11

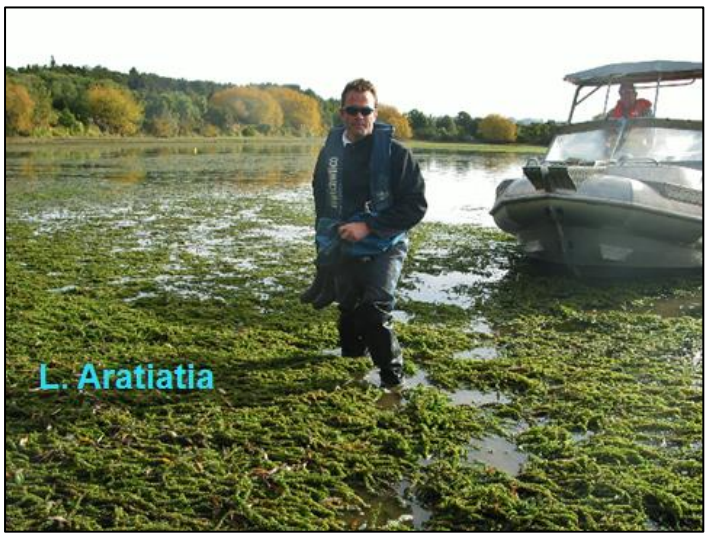


Slide 12 - Lake Rotoma shows tall lagarosiphon beds invading into and displacing low-growing native charophyte meadows in deeper water. If you dive inside a weed bed you find it is usually a dark inhospitable environment with a lot of organic matter and low oxygen levels. A world biomass record for lagarosiphon was collected from a $1m^2$ quadrant taken in Lake Rotoma.



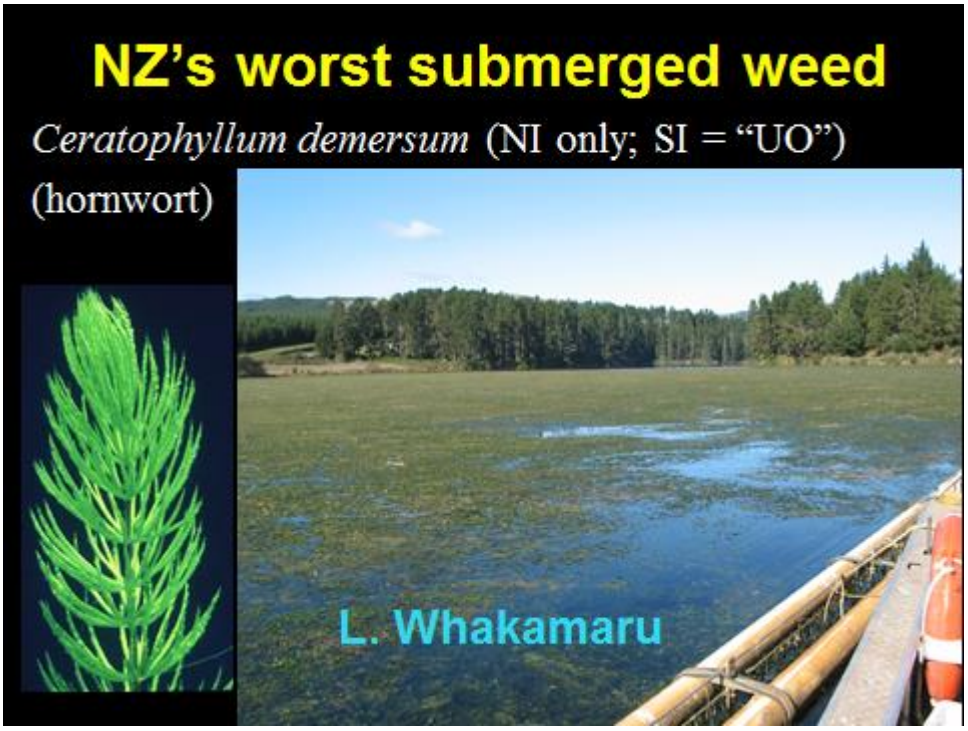
Slide 12

Slide 13 also shows lagarosiphon weed beds in Lake Aratiatia, the first hydro lake below Lake Taupo.



Slide 13

Slide 14



Slide 14 shows floating rafts of *Ceratophyllum* (hornwort) at Lake Whakamaru, a hydro lake half way down the Waikato River. This weed is widespread in the North Island; but it is an 'unwanted' organism (UO) in the South Island; a Biosecurity NZ classification that means it is targeted for eradication whenever found.

Slide 15

Slide 15 (above) shows dense floating rafts of seasonal weed drift accumulating on a boom above the power station. If this weed drift gets passed the boom and down to the hydro power station, the cost of clearance and potential risk of station shut down is significant.

Slide 16

Slide 16 shows the extent of hornwort drift around the Lake Rotoehu shoreline; while the photo at bottom left (Hamish Lass from Bay of Plenty Regional Council) shows how easily hornwort can be spread by a boat anchor. Clearly, it is very difficult not to spread weed. Although 'Check, Clean and Dry' messages are widely displayed, it is obvious how easy it is for this weed to be spread.

There are key problems caused by invasive weeds. Firstly, invasive weed species grow vegetatively and after a few years of invasive weed growth, the native seed bank becomes so deeply buried it has no chance of regenerating.

Another problem is the reduction in animal biodiversity. Dense weed beds are often associated with low oxygen levels and pH can fluctuate wildly from photosynthesis. Furthermore, organic accumulation often leads to low density sediments beneath invasive weeds that can impede or prevent kakahi and koura survival. As sediment becomes more organic, kakahi sink below the sediment surface and drown in the soft silt.

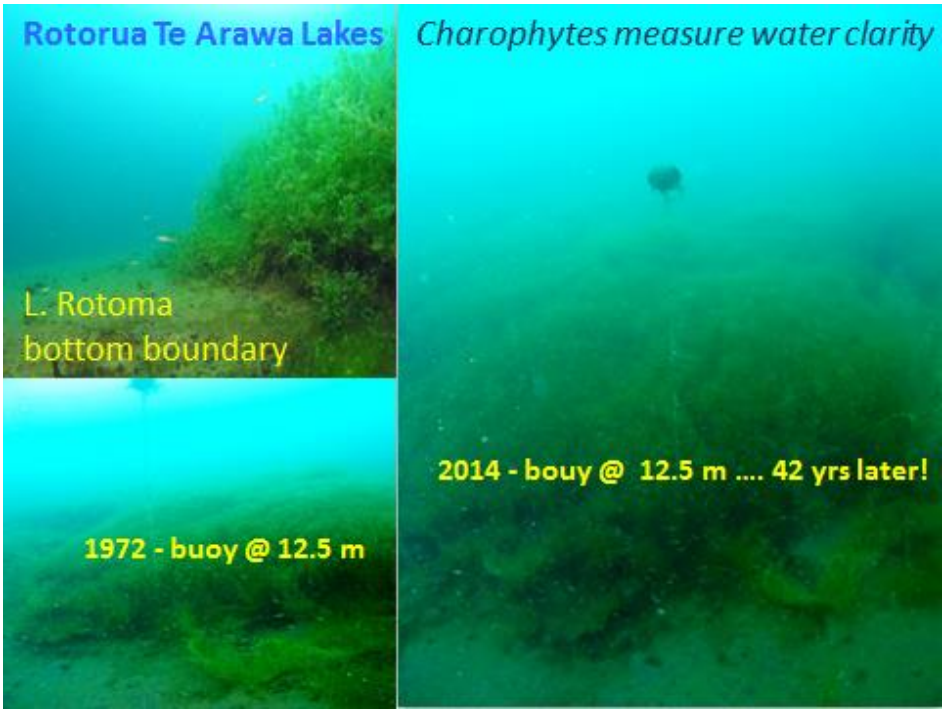
Slide 17 is a picture taken in Lake Rotokakihi where organic matter has built up. Some mussels are visible at the surface, but many are partially 'buried', struggling to keep their

siphons open as they slowly sink into sediment. Crayfish mostly avoid weed beds growing on soft organic sediment. If catfish become established in these lakes; it will be the cat fish mouths that any remaining koura will end up (Slide 20 – bottom left).

Slide 18

As nutrients increase there tends to be more algae suspended in the water and detritus also accumulates on plant surfaces thereby reducing plant health. Declining water clarity also decreases the depth that submerged plants can grow. **(Slide 18)**

Slide 19



Lake Rotoma is a good example of a clear lake. It has some well-formed deep charophyte boundaries **(Slide 19)**. Charophyte bottom depth boundaries represent an annually

integrated light limiting compensation point for sustainable plant growth. These boundaries can be used to measure changes in water clarity or lake level. In 1972, I placed a submersed float on a nylon line attached to a brick. Periodic inspections up to 2014 have demonstrated that over a 42 year period that bottom boundary has been stable, which therefore supports a relatively consistent water clarity. Lake Rotoma has had periods of lake level fluctuation and during these times the bottom plant boundary has responded proportionally, but with a notable lag phase.

Lake Okataina is the best example of a lake with no outlet. As a consequence the lake level rises and falls in direct proportion to rainfall. During an earthquake the lake level has also been known to drop. **Slide 20** shows a 5 metre water level fluctuation over a 3 year period. The lake level reached up to the store windowsills in 1972, dropping 5 metres over the next 3 years.

Slide 20

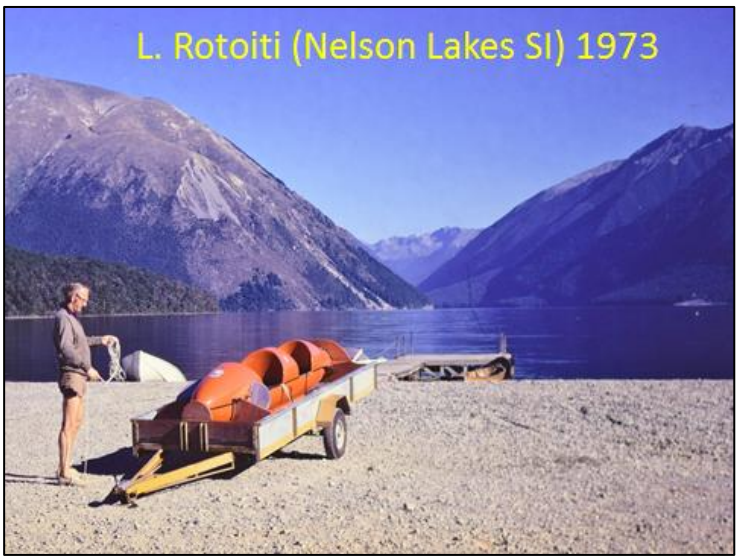
Slide 21

Charophytes integrate long term water clarity conditions

Charophyte Mean max depth (m)		1980/90s	2013/14	Years
Stable	Rotoma	14.5	14.5	30
	Okareka	9	8.5	30
	Okataina	15	13.5	30
Declining	Rotomahana	18	9.5	25
	Tarawera	16	7	25
Improving	Rotorua	0	7.1	last 10 yrs
	Okaro	0	1	last 4 yrs

Slide 21 compares charophyte depth limits from several lakes as a measure of water clarity. As previously noted, Rotoma has been stable for 42 years, while Okareka and Okataina have also remained relatively stable over the last 30 years. Tarawera and Rotomahana are two lakes where charophyte depth limits have declined substantially over the last 25 years. On the other hand, Lakes Rotorua and Okaro are showing recent improvements based on plant bottom depth boundaries.

Slide 22 shows the use of a two man underwater submarine, which the Auckland University bought in 1973. We surveyed the underwater vegetation in Lakes Rotoiti & Rotoroa in the Nelson Lakes National Park and several of the Rotorua Te Arawa Lakes.



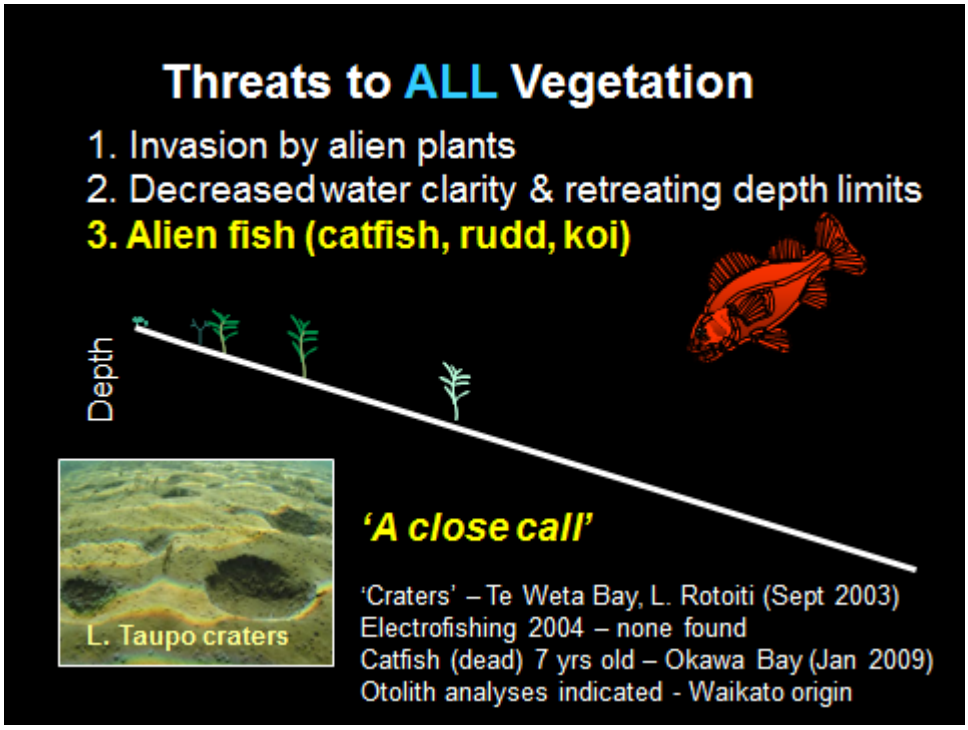
Slide 22

Slide 23 provides some excerpts from my Dive Log 43 years ago. In Lake Okataina we found the crayfish appeared rather aggressive as they reared up and confronted us with their claws raised. In other lakes they scurried into the charophytes meadows and hid. In Lake Rerewhakaaitu my professor went for one of his rare dives in extremely poor visibility at the time and I noted in my dive notes that he was, 'surprisingly agile but somewhat nervous'. I retrospectively worked out that he was 63, which is younger than I am now and still diving in these lakes!

Slide 23

Slide 24 (over**)** returns to the threat of alien fish. There has already been one close call in Lake Rotoiti when in 2003 I found several 'craters' scalloped into Te Weta Bay sediments (see Slide 24 – 'L Taupo craters', caused by catfish). The University of Waikato was notified and they attempted electrofishing, but unfortunately this was not successful. However, 7 years later there was a dead catfish washed up in Okawa Bay. Luckily that

Slide 24

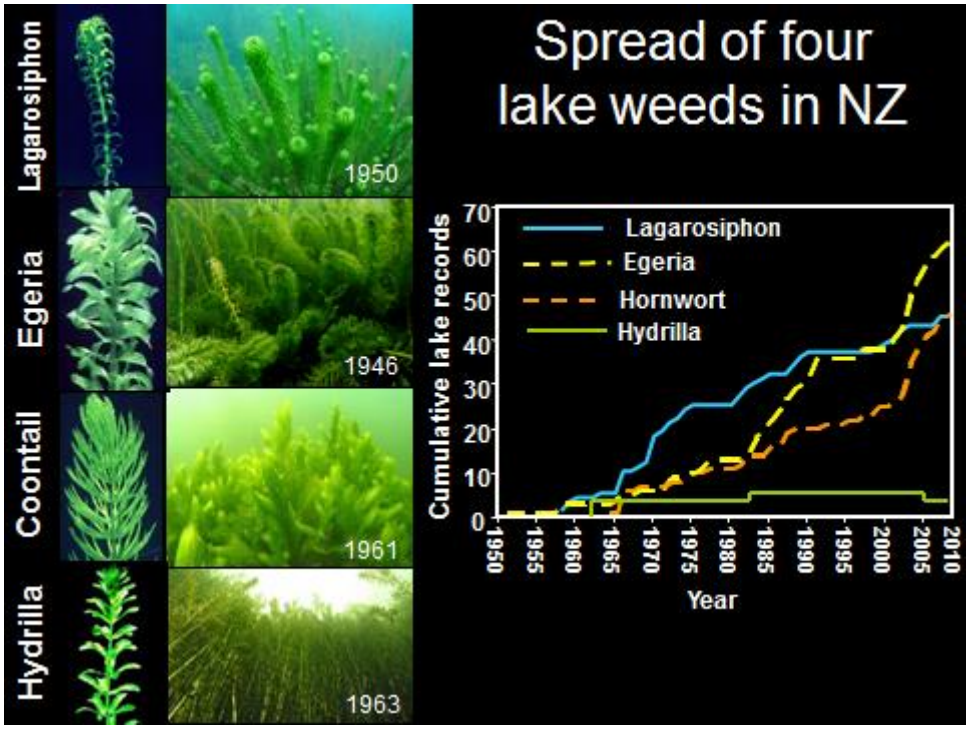


catfish was a male. It may well have been a very different outcome if this had been a fertile female! It is almost inevitable that sooner or later catfish will establish in the Rotorua Lakes, but we must do everything possible to prevent them establishing and this applies to other alien biota too.

Slide 25

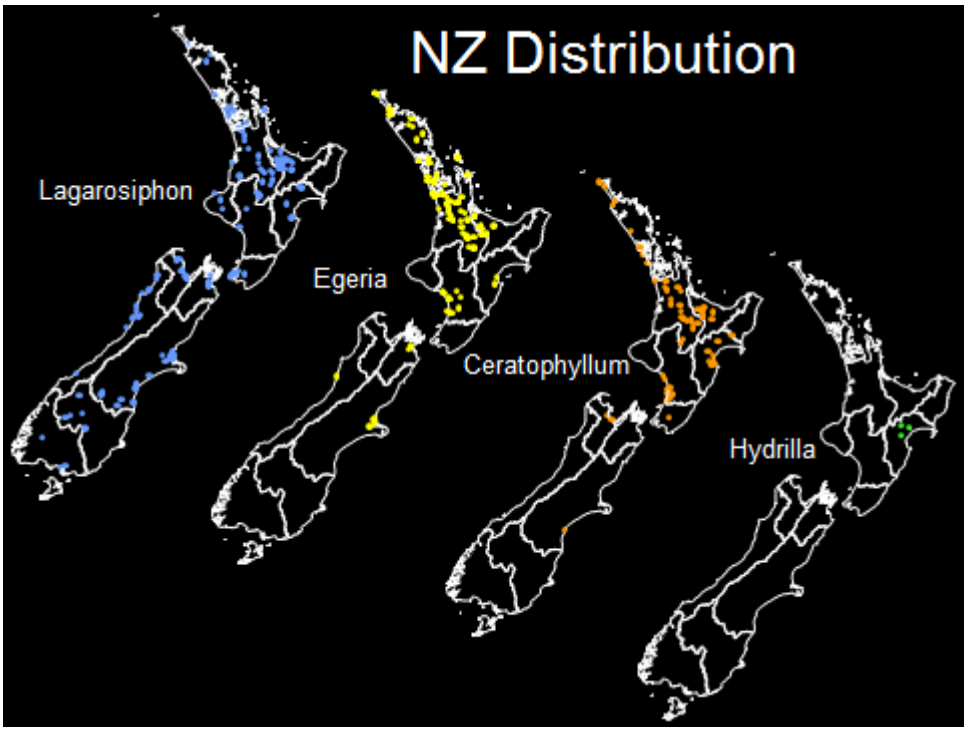
Slide 25 illustrates some of New Zealand's worst aquatic weeds. **Slide 26** shows the rate of spread since 1950; with all species steadily expanding their range, with the exception of hydrilla which has been contained and controlled. **Slide 27** shows the distribution of lagarosiphon right across the country; egeria mostly in the North Island with a little in the

Slide 26



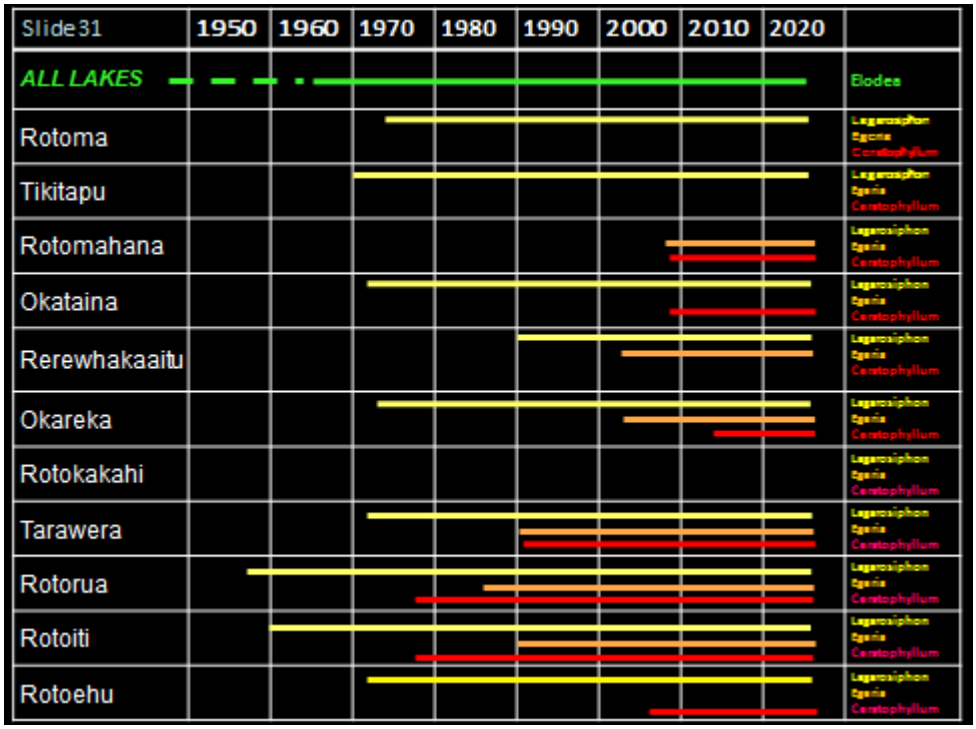
South Island. Ceratophyllum, is an 'unwanted' organism in the South Island (Ministry of Primary Industries classification), and is therefore targeted for eradication from all South Island sites. Hydrilla is only recorded in the Hawkes Bay and the introduction of grass carp into these lakes has effectively eliminated any risk of further spread. Previously hydrilla was one of the biggest weed threats to New Zealand waterbodies.

Slide 27



Slide 28 shows the approximate arrival date of the major aquatic weed species into the Rotorua Te Arawa Lakes. Elodea was the first of the oxygen weeds, introduced during the 1950's, most probably as an escapee from a trout hatchery in the Lake Rotorua catchment. Elodea has one of lowest impacts on these lakes out of all the main aquatic weed species. Its use in hatcheries, along with deliberate spread, preceded the awareness of undesirable impacts that exotic species can have on native aquatic vegetation. Lagarosiphon was the second submerged weed to have a prominent impact on these lakes, establishing in the late 1950s in Lakes Rotorua and Rotoiti, and subsequently through many of the remaining lakes in the 1960s. Lakes Rotokakihi and Rotomahana are the only two large lakes still free of lagarosiphon. Egeria first established in Lakes Rotorua, Rotoiti and Tarawera in the late 1980s, followed by three more lakes after the year 2000. Finally ceratophyllum (hornwort), which is undoubtedly the worst of all these weed species, has now established in seven of the lakes, with only Lakes Rotoma, Tikitapu and Rotokakahi still clear.

Slide 28



In the year 2000 a survey of plant traders showed that there were 27% new species which we did not know were present in New Zealand at that time. There are now over 50 naturalised alien aquatic plants in New Zealand, 75% of which have been introduced as ornamental plants. However, there are many more aquatic threats, both plants and fauna, outside New Zealand borders that could still enter the country. Common low impact species are often spread naturally by birds and wind; but the high impact species are spread mostly by humans, particularly through use of water craft and ornamental ponds.

The key trends and drivers that are or have the potential to impact on New Zealand freshwaters are:

- a continuing spread of existing pest species - fish and plants
- increasing human pressure from tourism, infrastructure and road access to lakes
- new weeds coming through the New Zealand border
- weed escalation due to climate change
- changing water use patterns:

- water storage and reticulation systems developing for agricultural development which impacts on water quality through the nutrients and water clarity from the sediments
- water level change compromises the habitat quality

The implications for the future include:

- increasing loss (often irreversible) of aquatic vegetation from lakes
- a decline of ecological function and benefits in terms of water quality and habitat
- loss of habitat including wetlands for dependent biota
- extinction of indigenous species
- the decline of water quality and the value of freshwater resources

We can conclude that the spread of existing weeds will continue largely due to human behaviour, and new invasive species will arrive through commerce, travel and the internet (e.g., TradeMe). But New Zealand has got unique opportunities based on its history, isolation and legislation, to face these problems but the challenges are vast. There are multiple managers, costs and priorities. At the end of the day we are all human; we need food, we need shelter, and we need safety. We also want the comforts of life; one example being the need for electricity which requires dams.

It is the environment that is often compromised as a consequence of our anthropocentric priorities. However we can make a difference. We need to appreciate our natural heritage, and educate ourselves and others; since awareness is critical in terms of being able to change behaviour. Research is also needed for better tools to help prevent pests entering New Zealand; including more effective lake interceptions. We have many examples of successful containment and restoration, including the eradication of five aquatic weed species from the country. We have the opportunity to manage many of our lakes as if they were islands; so just like the restoration of native wildlife on off-shore islands, we can achieve similar restoration goals for targeted fresh water lakes.

I would like to acknowledge the Bay of Plenty Regional Council; Te Arawa Lakes Trust and Land Information New Zealand for their proactive management, public engagement and research support; the responsible tour operators that follow the ‘Check. Clean & Dry’ initiatives; the many Rotorua Lakes residents that watch out and care for these lakes; and finally my awesome Freshwater Biosecurity team who have worked together with me on these and many other New Zealand lakes and waterbodies for most of their careers.