BUSTING MYTHS ON WATER WEEDS

Mary de Winton
Freshwater Ecologist, NIWA, Hamilton
Mary.deWinton@niwa.co.nz

Mary is a Freshwater Ecologist at NIWA, Hamilton, with over 25 years' research experience on submerged vegetation management. During this time Mary has worked on (and within) over 155 New Zealand lakes. Research interests include the biosecurity management of invasive water weeds, the enhancement and restoration of native submerged plants, resource survey, management of vegetation data and its application to research questions, and the taxonomy of New Zealand native charophytes.

ASTRACT
Troublesome aquatic weeds have been an issue for the Rotorua Te Arawa Lakes for decades, but what do we really know about what drives water weed problems? Some common held beliefs about water weeds are 'one weed is as bad as another', 'waterfowl move water weeds around' and 'nutrient enrichment drives weed invasion'. However, these assumptions are incorrect or represent an oversimplified view of the problem. Exploring these popular misconceptions on water weeds will help us get a better understanding of weed problems, the role of humans and what we can do about it. This talk will draw evidence from New Zealand and international research findings and information specific to the Rotorua Te Arawa Lakes.

Weed issues for the Rotorua Te Arawa Lakes involve just a few species of alien plant species that share characteristics including a high 'standing crop' (bulk biomass present at any one time), dense canopy at, or close to the water surface and generation of numerous fragments that can accumulate onshore. Nevertheless, these few species can be further distinguished and ranked in terms of 'weediness' and impact. Recognition that some weeds are worse than others allows for more effective and proactive management of weed threats.

Water fowl are often implicated in spreading the most problematic water weeds that we have in New Zealand and yet there little real evidence that this is the case. Instead there is ample evidence that human activities are primarily responsible for the spread of water weeds between lake catchments. This means that it should be possible to intercept the routes and mechanisms (pathways and vectors) by which these water weeds can enter lakes.

Weed invasions in freshwater systems are suggested to be linked with nutrient enrichment. However, the presence of our worst water weeds and the development of weed-related problems are not limited to eutrophied lakes, but can be equally problematic in oligotrophic New Zealand lakes. Indeed, the most enriched lake systems have very limited submerged vegetation development. Therefore improving water quality does not necessarily flow on to the anticipated improvements in weed problems and there may even be increased weed development as lakes become less enriched.

TRANSCRIPT

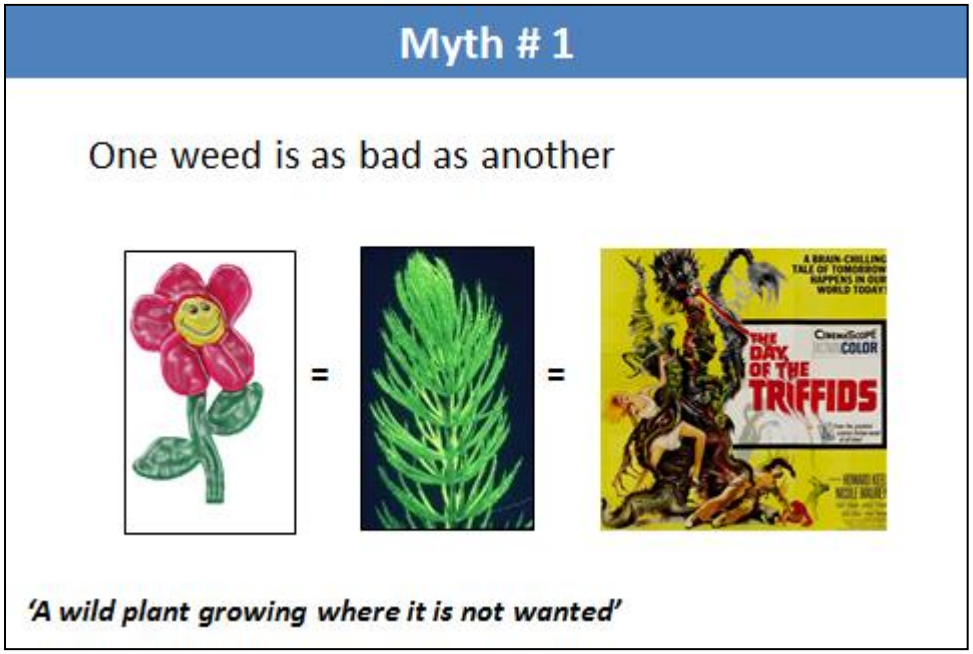
In this talk I want to explore some popular misconceptions about water weeds, particularly those myths relevant to the management of submerged weeds in the Rotorua Te Arawa Lakes. I want to look at evidence drawn from international and New Zealand research and, where possible to information specific to the Rotorua Te Arawa Lakes. The talk will

focus on submerged weed problems in lakes, the issues, and the role of some weed species, how these problem species invade lakes, and what conditions lead to weed problems.

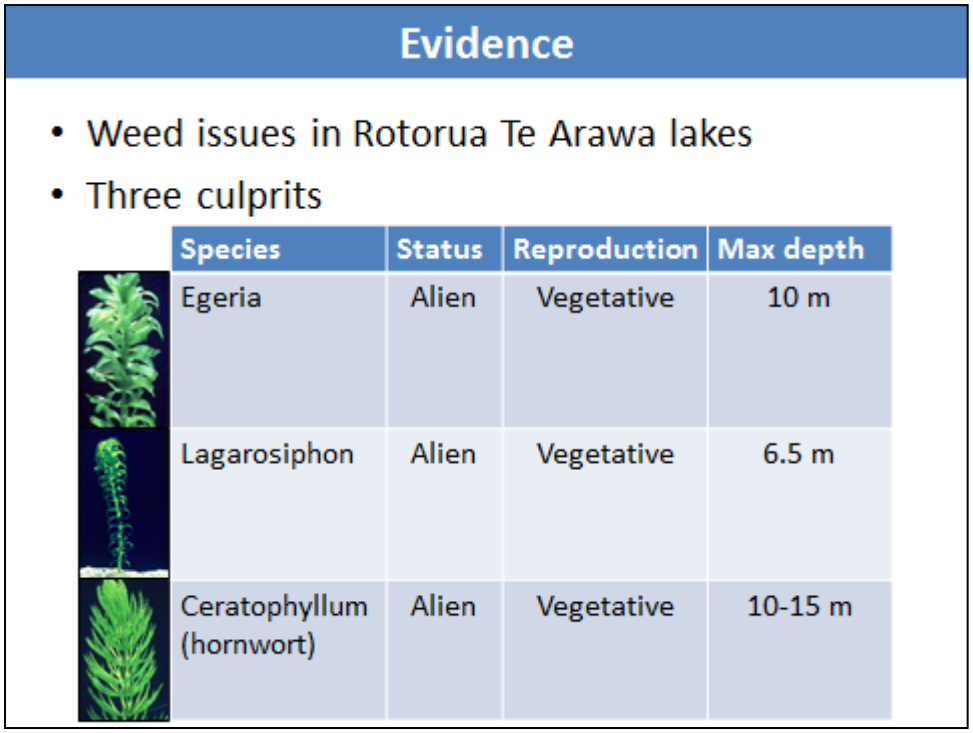
Myth # 1 One weed is as bad as another

It is the common perception that any plant that grows in the water is a 'water weed'. Certainly the common definition of a weed – 'a plant growing where it is not wanted' would suggest that weed issues are situational and any plant has the potential to be a weed.

Slide 1



Slide 2



However when we look at the Rotorua Arawa Lakes in **Slide 2** we can see it is a small number of submerged plant species that are the usual culprits, these are the tongue twister species; egeria, lagarosiphon and ceratophyllum, better known as hornwort. These are alien plants, none produce seed in this country so all are reliant on vegetative fragments of shoots to spread and establish new populations. They can grow to considerable depths in lakes.

But these species share additional, sinister characteristics. They are all phenomenal space invaders, able to grow into 5 to 10 m tall weed beds that can occupy the entire water column. It is hard to believe it but these plants comprise over 90% water, these water-filled tissues can create a very large bulk biomass or 'standing crop' – the fresh biomass present in the water at any one time. For instance on the left hand of **Slide 3** you can see a snorkel diver beside a massive bed of ceratophyllum.

Slide 3

Our American colleagues have a great term, 'topping out', to describe weed beds that reach the water surface. The photo in the centre of the slide shows a topped out lagarosiphon weed bed in Lake Wanaka. These can strike fear into the recreational boater because they are so difficult to navigate through.

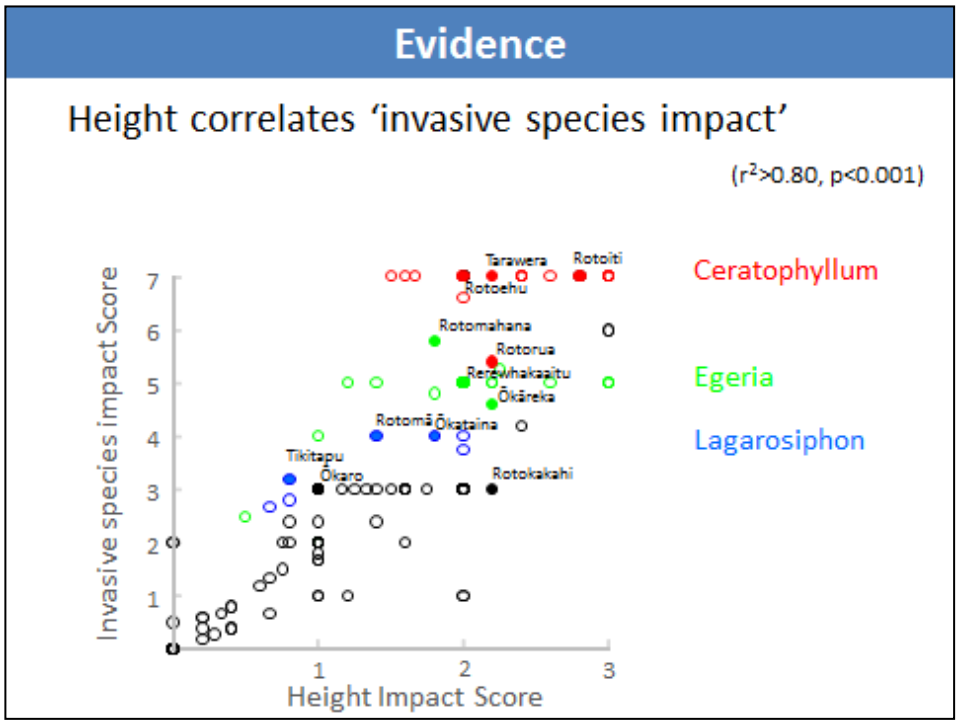
Flow on impacts include the deposition of their debris on beaches. These problem weed species are built to disperse by fragmentation, they are brittle and prone to dislodgement by waves and strong currents. Dense accumulations on beaches, decay and release odours that may necessitate their removal by mechanical means at some cost.

The influence of our worst weeds can be seen in New Zealand wide measurements of the weed impacts in lakes. LakeSPI is a monitoring method using submerged plants as indicators (SPI). Measurements made include weed height, as well as canopy cover, proportion of vegetation occupied and their depth impact.

Slide 4 shows the average height impact scores for 194 NZ lakes, but the other measures had a similar pattern. A score for weed height is along the horizontal axis, greater score means taller beds. You can see that ceratophyllum in red, egeria in green and lagarosiphon in blue tend to have greater impact in terms of height than other weeds, shown in black. This tendency for weediness is recognised by a higher ranking for a potential invasive impact score for these species in LakeSPI, shown on the vertical graph axis.

Where do the Rotorua lakes fall on this graph? Rotoiti, Tarawera and Rotoehu already experience large weed beds of ceratophyllum. Although ceratophyllum has also recently invaded Okataina and Okareka, ongoing management is currently preventing major impacts. Lakes with lower weed impacts, Rotoma, Tikitapu, Rotokakahi and Okaro would benefit from protection against the introduction of worse weed species.

Slide 4



So there are species that are strongly associated with water weed problems in lakes, and even within this group, some weeds prove worse than others. Agencies like BOP Regional Council can use this information to recognise the worst threats to the Rotorua lakes, and to prioritise protection and proactive responses to threats.

Myth # 2 water fowl move water weeds around

Just last year the CEO of an NGO stated that international research 'finds that weed [egeria in this context] is most likely spread by geese and swans, and suggested that hunting ought to be viewed as part of the risk management.[1]

Slide 5

I want to look at this concept more closely. Firstly, how would birds transport weeds that can only reproduce vegetatively and which lack barbs or burs to attach to feathers. Could weed get entwined around legs or necks? More plausible perhaps is nest building by birds. This crested grebe has built a nest out of locally available materials, in this case using lagarosiphon. **(Slide 5)** But it is still a stretch to think this a major means by which our worst weeds are spread lake to lake.

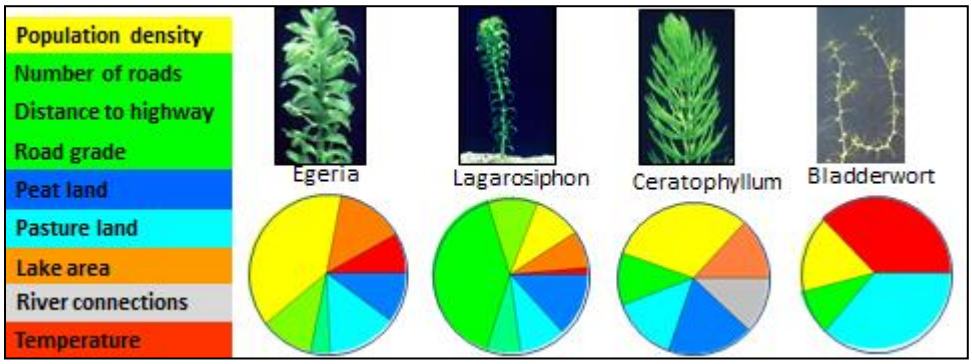
[1] https://au.news.yahoo.com/a/24818204/duck-hunting-ban-breaches-treaty-settlement/ https://nz.news.yahoo.com/a/-/top-stories/24818204/duck-hunting-ban-breaches-treaty-settlement/

There is definitely plenty of evidence that waterfowl carry seed of water plants internally and over long distances[2], many seeds passing through their digestive systems unharmed. At least 10 published papers confirm this ability. But I was unable to find any published accounts of vegetative propagules being moved long distance by birds.

We also note that adjacent lakes in New Zealand often differ in vegetative weed composition. For example, Lake Waikaremoana remained lagarosiphon free for 30 years despite close proximity to invaded Lake Whakamarino.[3] The first weed discovery in lakes is frequently noted at boat ramps which strongly implicates boat traffic as the major vector.[4]

What other evidence do we have? A statistical modelling approach was used to identify lake and catchment characteristics that were most strongly associated with weed invasion by 4 species.[5] We used species presence and absence from surveys of 381 lakes. Over 15 lake and catchment characteristics were screened, and whittled this down to 9 which performed the best. **(Slide 6)**

Slide 6



The clear result was that measures of human access explained the distribution of ceratophyllum, lagarosiphon and egeria. The density of human population in the vicinity, and roading infrastructure measures in yellow and green. This contrasts with the fourth species which produces seed and is spread by waterfowl.

What does busting this myth mean for management of weeds in the Rotorua Te Arawa Lakes. Spread of the worst weeds is preventable. There are a number of proactive actions that can be taken (education campaigns like the check, clean dry message, events like this symposium, signage, weed cordons such as instigated by Bay of Plenty Regional Council or wash down facilities. Boaties enjoying the lakes need to take responsibility for

[2] Figuerola, J., and A. J. Green. 2002. Dispersal of aquatic organisms by waterbirds: a review of past research and priorities for future studies. *Freshwater Biology,* 47:483–494.

[3] de Winton, M.D.; Champion, P.D.; Clayton, J.S.; Wells, R.D.S. 2009. Spread and status of seven submerged pest plants in New Zealand lakes. *New Zealand Journal of Marine & Freshwater Research*, 43: 547–561.

[4] Johnstone IM, Coffey BT, Howard-Williams C 1985. The role of recreational boat traffic in interlake dispersal of macrophytes: a New Zealand case study. *Journal of Environmental Management* 20: 263–279.

[5] Compton T. J.; de Winton, M.; Leathwick J. R.; Wadhwa, S. 2012. Predicting spread of invasive macrophytes in New Zealand lakes using indirect measures of human accessibility. *Freshwater Biology*, 57: 938–948, doi:10.1111/j.1365-2427.2012.02754.x.

trailer and boat hygiene. Surveillance, such as undertaken by the Regional Council at hotspots such as boat ramps can intercept weeds at an early stage when something can be done. **(Slide 7)**

Slide 7

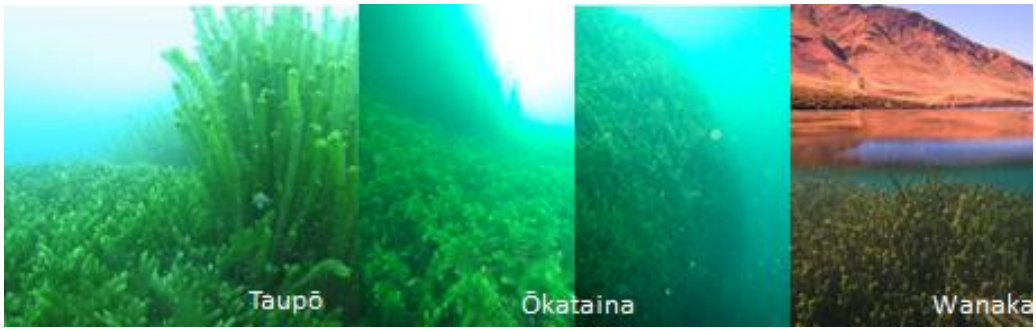
Myth # 3 Nutrient enrichment drives weed invasion

This may surprise, but in my opinion the role of nutrient enrichment of lake waters in driving weed invasion is overstated. It is difficult to reconcile statements like this one linking hornwort (ceratophyllum) invasion to nutrient enrichment of water when large weed beds, up to 8 m tall, can develop in oligotrophic lakes like Taupo and Okataina:-

> *'Parliamentary Commissioner for the Environment says: Invasive exotic weeds like hornwort grow prolifically in response to excess nutrients.'*[6]

Likewise pristine lakes such as Lake Wanaka exhibit weed problems from tall-growing lagarosiphon if it is left unchecked. **(Slide 8)**

Slide 8



This is an important concept. If invasive weeds are simply the passengers of environmental change, we would expect them to dominate only where habitat modification like nutrient enrichment has occurred. We would also expect our weed woes to lessen as eutrophication is managed and reversed.

Look at the evidence for weed issues being driven by the trophic status of lakes. When we look at the published literature about submerged plants and levels of nutrients N and P in the water, we can draw some conclusions:

- Plants *can* uptake nitrogen (N) and phosphorus (P) from water or sediments.[7]

[6] http://www.pce.parliament.nz/publications/all-publications/water-quality-in-new-zealand-land-use-and-nutrient-pollution

- There's good evidence that N & P in water can subsidise the nutrient requirements of establishing weed fragments.[8]
- In general nutrients are preferentially uptaken from where they are most available.[9] This is in the sediments of most lakes, unless waters are extremely enriched.[10]
- Plant growth (here as biomass increment over time) is commonly found to decrease across a nutrient gradient of eutrophic to hyper-eutrophic,[11] even for ceratophyllum, a species commonly assumed to respond to water enrichment.

Looking more closely at the literature on weeds and trophic status of New Zealand lakes, early researchers were surprised to find no relationship between trophic status and standing crop or plant re-growth in the Rotorua Te Arawa Lakes.[12] A world record standing crop of 3kg per m^2 dry weight was recorded in Lake Rotoma,[13] although this was in an atypical area of the lake. When grown on two sediment types within two lakes, lagarosiphon actually grew faster in oligotrophic Lake Taupo than eutrophic Lake Rotorua.[14]

Slide 9 looks at how 7 major water weeds are distributed over lakes of different trophic status as TLI.[15] Certainly microtrophic and ultra-oligotrophic lakes do not support the larger vascular plants. There were more eutrophic lakes with weeds than mesotrophic and oligotrophic lakes, but much fewer weed records in the most highly enriched lakes.

[7] Feijoó, C., García, M.E., Momo, F., Toja, J. 2002. Nutrient absorption by the submerged macrophyte *Egeria densa* Planch: effect of ammonium and phosphorus availability in the water column on growth and nutrient uptake. *Limnetica,* 21(1-2): 03-104.

[8] Rattray, M.R., Howard-Williams, C., Brown, J.M.A. 1994. Rates of early growth of propagules of *Lagarosiphon major* and *Myriophyllum triphyllum* in lakes of differing trophic status. *New Zealand Journal of Marine and Freshwater Research*, 28(3), 235-241.
Kuntz, K., Heidbuchel, P., Hussner, A. 2014. Effects of water nutrients on regeneration capacity of submerged aquatic plant fragments. *Annales De Limnologie - International Journal of Limnology*, 50(2):155-162.

[9] Carignan R. 1982. An empirical model to estimate the relative importance of roots in phosphorus uptake by aquatic macrophytes. *Canadian Journal of Fisheries and Aquatic Sciences*, 39, 243–247.

[10] Carignan R., Kalff J. 1980. Phosphorus sources for aquatic weeds: water or sediments? *Science*, 207: 987–988.

[11] Lombardo, P., Cooke, G.D. 2003. *Ceratophyllum demersum* - phosphorus interactions in nutrient enriched aquaria. *Hydrobiologia*, 497(1-3), 79-90.

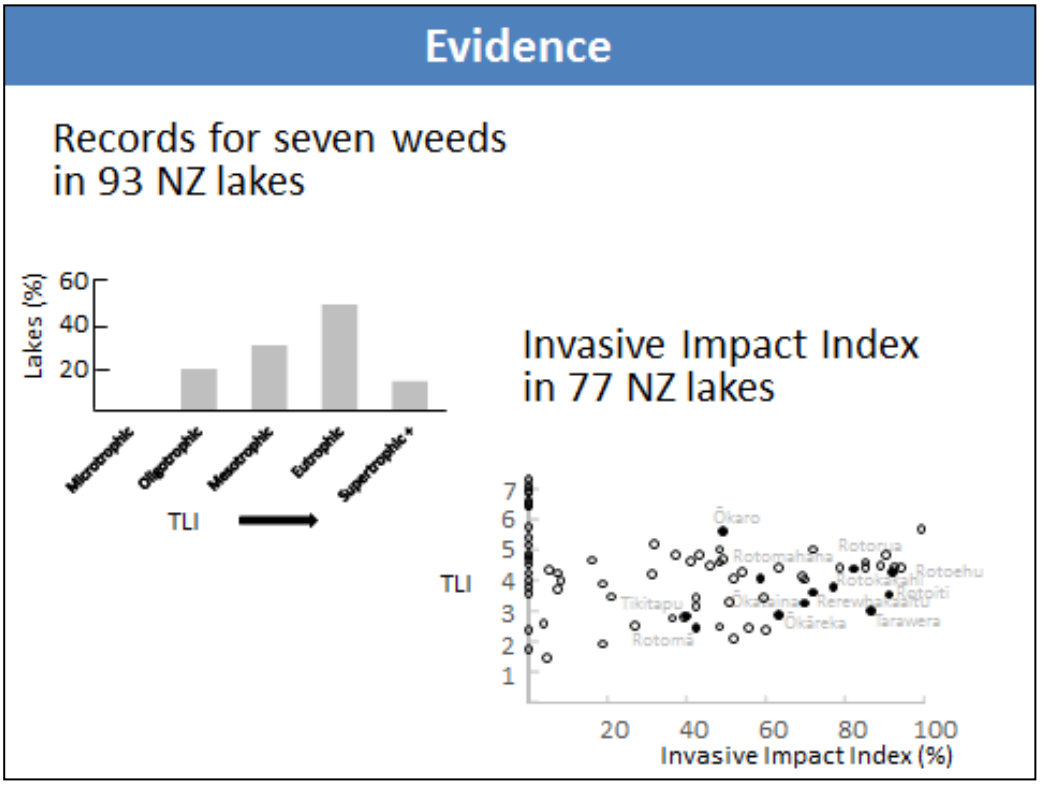
[12] Brown, J.M.A., Dromgoole, F.I. 1977. The ecophysiology of Lagarosiphon in the Rotorua Lakes. *Proceedings of the 30th New Zealand Weed and Pest Control Conference*, 130 – 134.

[13] Clayton, J.S. 1982. Effects of fluctuations in water level and growth of *Lagarosiphon major* on the aquatic vascular plants in Lake Rotoma, 1973-80. *New Zealand Journal of Marine and Freshwater Research*, 16:89-94.

[14] Rattray, M.R., C. Howard-Williams, Brown, J.M.A. 1991. Sediment and water as sources of nitrogen and phosphorus for submerged rooted aquatic macrophytes. *Aquat*. Bot. 40: 225–237.

[15] de Winton, M.D.; Champion, P.D.; Clayton, J.S.; Wells, R.D.S. 2009. Spread and status of seven submerged pest plants in New Zealand lakes. *New Zealand Journal of Marine & Freshwater Research*, 43: 547–561.

Slide 9



Looking at the overall measure of the invasive impact of weeds in 77 New Zealand lakes from LakeSPI data and how that relates to TLI[16], the higher TLI number means more enriched lake water conditions. The index captures proportion of vegetation dominated by weeds, their depth extent, height and canopy cover. The filled circles show the distribution of the Rotorua Te Arawa Lakes across these gradients. Results show little evidence of a role for nutrient enrichment in increasing the impacts by water weeds in lakes.

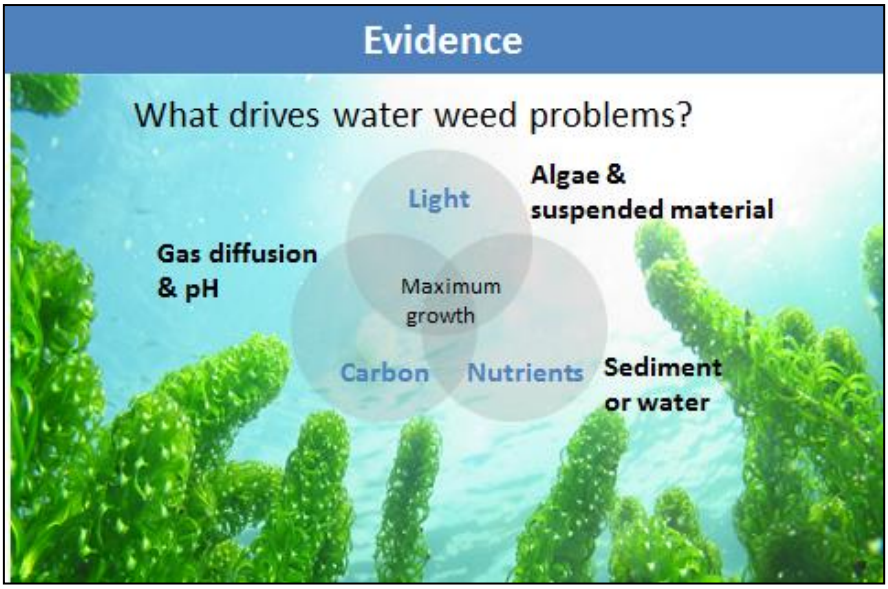
We can also note that none of the eight lakes with a TLI of 6 or more registered an invasive impact index, this is because these extremely enriched systems become dominated by phytoplankton or epiphytes at the expense of plants. Even the worst weed is not competitive against sustained algal blooms.

Why are weed problems seemingly uncoupled from lake trophic status? The answer is that nutrients supplied by sediment and/or water are not the only things driving weed biomass development. **(Slide 10)**

Submerged plant growth also needs adequate levels of light, so high levels of algae and suspended material can limit growth substantially, especially highly nutrient enriched lakes. Submerged plants also need a dissolved inorganic carbon source for photosynthesis, with availability limited by lack of gas diffusion and different forms of carbon influenced by pH. High rates of growth will occur in the 'sweet spot' where all these conditions are supplied in sufficient levels for high growth. Add to this self-shading within big weed beds, respiratory losses and physical disturbance of beds. So growth does not determine the final standing crop.

[16] de Winton M.D., Clayton J. S., Edwards, T. 2012. Incorporating invasive weeds into a plant indicator method (LakeSPI) to assess lake ecological condition. *Hydrobiologia*: Volume 691, Issue 1 (2012), Page 47-58 *Hydrobiologia* (DOI) 10.1007/s10750-012-1009-0.

Slide 10



What are the important conclusions from busting this nutrient myth? Firstly, water weeds are not merely passengers of environmental degradation. They do not respond to degradation in the form of nutrient enrichment. Lakes protected from eutrophication are not protected from invasion. Improvements in water quality of eutrophied lakes might actually increase weed problems. Weed problems need to be managed by other means than eutrophication management.

I would like thank the NIWA Freshwater Biosecurity team from whom I have shamelessly stolen images for this talk and a lot of the ideas and also the Bay of Plenty Regional Council's lakes' data. I would also like to make special thanks to the LakesWater Quality Society for putting on this Lake Weed and Wallabies Symposium. As John Green mentioned, there was a bit of an in-house joke as to what the solution might be for both of these. So I will leave you with this.

QUESTIONS

Paul Scholes, BOPRC: (The full question not tapped). …avian effects in small lakes. How do you explain weeds in remote lakes?

Mary de Winton, NIWA: Definitely recreational boating is one of the key vectors of weed spread in smaller lakes without road access. There are other vectors which can be involved such as ditch drain clearage machinery that has been working in a contaminated drain. It can introduce weeds to a new area. Weeds can also spread on eel fishing nets and other fishing equipment which is used from lake to lake. For the larger lakes with boats ramps with good road access it is primarily boating traffic which is the main vector.

Pauline Keen, Federated Farmers: I was wondering about the swans and the bird life on the lake that you said grazed weeds. Do they cause a lot of break up and spread from grazing?

John Clayton, NIWA: Yes that is a good question. Generally when there is enough weed at the surface for a swan to graze there would be enough natural fragmentation from wave action and people with their jet skis to spread it around. If it was eelgrass it would not spread because they need basal stem material but the oxygen weed could spread from fragmentation for sure. The question is whether it is a risk? Put it in the context of how much habitat saturation there is already for that particular weed. Quite often if a weed has got that far developed it has already had opportunity to spread by other means.