
SPRAYING AS A SOLUTION

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Deborah leads research projects that focus on solutions for aquatic weed issues, such as screening aquatic herbicides for use in New Zealand, assessing the impacts of grass carp and the potential development and use of more selective bio-control agents. Trials have been completed on the efficacy of a range of products and weeds as well as a range of non-target native plant species. Research seeks to improve the tool-box for weed control options in New Zealand with new research on the use of grass carp, and the development of more selective bio-control options for New Zealand. Deborah contributes to the assessment of aquatic plant species that are new to New Zealand or in the aquarium trade to predict their potential threat to the environment, and inform legislation where appropriate, and she has a special interest in the conservation of native flora and fauna which can be better protected through understanding the consequences of aquatic weed invasions and management.

ABSTRACT

When invasive aquatic weeds establish in a lake, they usually result in detrimental effects on native biodiversity, amenity and utility values. Once a weed species or weed issue has been recognised control options are often sought to protect amenity and utility functions of aquatic systems. There is also a growing desire to control invasive plants to support the restoration of lakes, improving biodiversity and habitat values. The tools or methods that can be utilised for the control of invasive aquatic plants can be broadly described by the following categories; habitat manipulation; biological, chemical, mechanical and manual, and integrated weed control. The selection of which tool to use is primarily determined by the target weed, characteristics of the lake or waterbody and the management goals or desired outcome. Herbicides can be used to provide effective, selective and targeted weed control. This paper describes the products available, how they work and the environmental benefits that can be achieved with their use.

TRANSCRIPT

We really need to look at the necessity to control aquatic weeds and the control with herbicides in particular. This paper covers some information on products, testing, efficacy, selectivity possibilities and outcomes and the way forward.

Three species of submerged plants are of particular importance in the Rotorua Te Arawa Lakes:-

- *Egeria densa*,
- *Lagarosiphon major*
- *Ceratophyllum demersum*, (Hornwort) and one of the worst weeds shown here on Lake Rotoehu in a weed drift on the shore line.

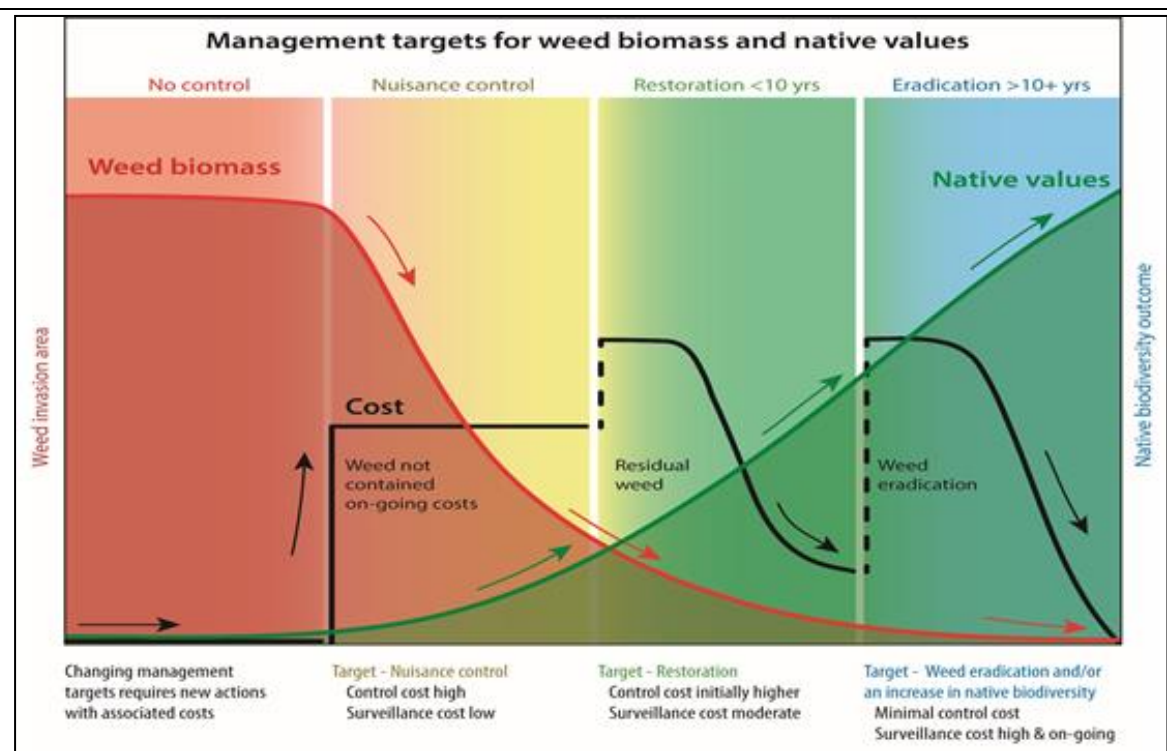
There is a fourth weed, *Elodea canadensis*, of lesser threat compared with the other three, but it is an invasive (non-native) plant species.



These invasive species have quite significant impacts, they displace native plants, they alter habitats for native fauna and they can reduce amenity/utility values in the lakes they have invaded. Weed control policies need to address management targets and outcomes for weeds in particular lakes. The challenge starts with key questions right at the beginning in terms of identifying weed issues and the required action. Is it a case of continuing to 'mow the lawns' thus providing control of nuisance weed beds? Or is restoration the long term goal to improve bio-diversity or native values, or weed eradication?

In **Slide 1**, the first panel on the left hand side of the diagram shows peak weed biomass which will continue if nothing is done. Between each panel on the diagram, new decisions are required to move to the next stage (to the right), and there are associated actions. If the aim is nuisance control, then that is like mowing lawns, a repeat action step. The red line (indicating weed biomass) will decline which is great if that is what the target is. But if the target is the improvement of native values and bio-diversity (green line), then a new decision that sustains a low level of that weed biomass is necessary so restoration can be considered. We have heard about the decline of native seed banks under dense weed beds. Thus consistently reduced weed biomass is necessary for restoration in lakes after having an invasive weed species. Eradication is another end point (fourth panel in the diagram) which is a much longer term goal. Again, further action steps are likely required to remove the last pieces of weed once the restoration goal is achieved.

The next question is how can this be achieved? There are three primary areas that are determinants in terms of how control tools are selected:

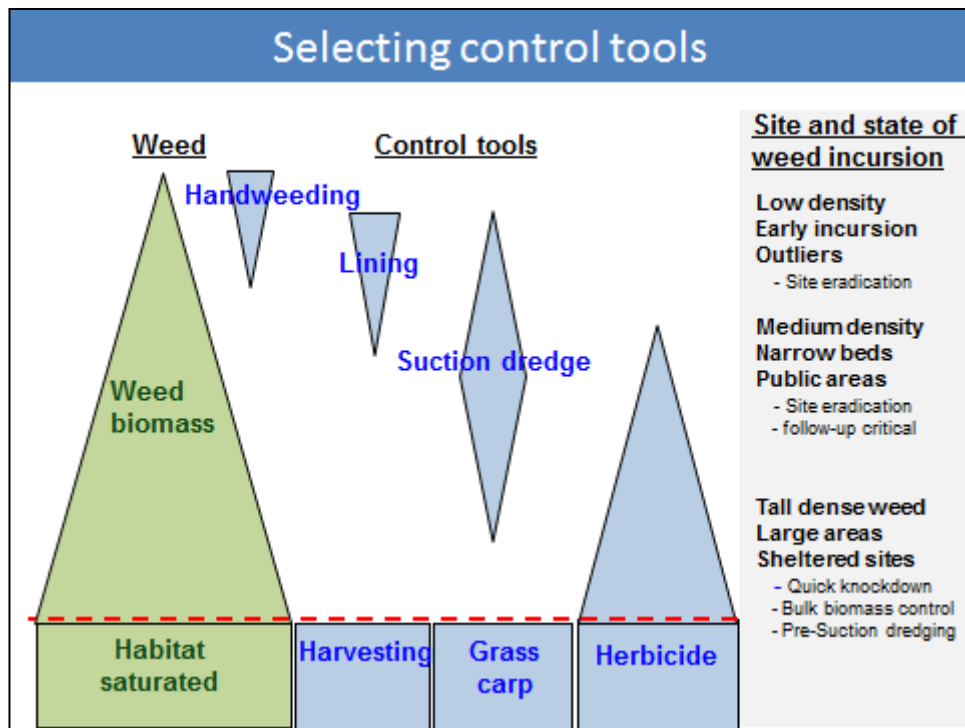


Slide 1

- (1) The target weed is important because there are specific things about the target weed that may determine why one tool is better than another. They can be factors like life form types that dictate when or how control can be targeted for that particular plant. For example, the particular submerged weed species in the Rotorua region (*E. densa*, *L. major*, *C. demersum*) do not have seeds, which enables a different approach compared with submerged weeds that do have seeds or similar long lived propagules (eg., the tubers of *hydrilla verticillata*).
- (2) The water body characteristics are important, size, shape, depth and water movement. For example, harvester use in a water body with strong currents, or submerged obstacles may not be suitable.
- (3) The third determinant, in terms of the selection of tools, is about management goals and the desired outcome. How is success to be measured? Is there a desired outcome with regard to bio-diversity, amenity, utility values? What are the time frames and costs for the required solution?

These important points are considered further in **Slide 2**. The green area indicates the weed biomass; in the top, of this green area, is the situation of a small amount of weed biomass where solutions like hand weeding can be the best tool from the weed-control tool box. These are situations of low weed density where for example, there might be an early incursion response or maybe there are smaller outlying populations after site eradication.




Slide 2



Where the habitat is saturated and there is a large amount of weed, the bottom of the diagram, control options of harvesting, grass carp or herbicides need to be considered. Water body specifics are really important here. As an example, grass carp are highly effective grazers and very effective at removing weeds. But if they cannot be contained in the water-body then they are unlikely to be a suitable control tool. So it really is about matching up the weeds, the site and the goals or targets.

Slide 3

Products

	Diquat	Endothall
	Targets Ec, Ed, Cd, Lm (not Hv)	Targets Cd, Lm, Hv (not Ec, Ed)
	Low impact on tall natives No impact on charophytes (Clayton and Tanner 1988)	Low impact on tall natives No impact on charophytes (Hofstra and Clayton 2001)
	Rat, acute oral LD50; 210 mg/kg (EXTOXNET)	Rat, acute oral LD50; 51mg/kg (EXTOXNET)

Considering herbicides and especially those for submerged weeds; we have two products in New Zealand that are registered for aquatic use; diquat and endothall. **(Slide 3)** Both of these products have a long history of use. Diquat has been used in New Zealand and the

Rotorua lakes since the 1960s. Endothall has an equally long history of use in the USA but has only been recently registered in New Zealand for use on submerged aquatic plants. For both of these products there is an extensive database on environmental safety and a snapshot of some of the information that is shown here.¹

Slides 3 compares the two products, and the different weeds here in New Zealand that they can be successfully used on. The slide shows that diquat works on *E. canadensis*, *E. densa* and *C. demersum*; Endothall is good for *C. demersum*, *L. major* and *H. verticillata*. Both of these products have comparatively less impact on our tall native plants and no impact on charophytes.

How do they work?

- Contact herbicides, desiccants, result in plant collapse
- Rapidly lost by deactivation, dispersion, uptake and breakdown by micro-organisms
- Short lived in the environment

What about toxicity?

- Both are diluted with water for the rate used to kill weeds (ca 1ppm for diquat, 5ppm or less for endothall).
- Field studies – no changes in kakahi, koura, inanga, shrimps and bullies
- No effect on fish or eels kept caged in treated areas
-

With regards to biota for New Zealand, a number of different field studies have been done that have looked at kakahi, koura, inanga, bullies, fish and eels in terms of impacts and there have been none¹.

Where does this information come from?

The information such as the toxicology data is generated by the companies or agencies who want to register their products with the likes of EPA, but we at NIWA also have a research facility. **Slide 4** shows some of NIWA's facilities and where we have carried out testing on aquatic plants; those which would be good targets, those native plants considered non-target species, and assessed what impacts are there likely to be on the plants. In these photographs there are a range of different tank sizes, from really small pots through to much larger tanks that have been used.

¹ Further info, see Clayton and Severne, 2005. Review of Diquat reports of relevance to iwi values in Lake Karapiro. HAM2005-136.

Clayton, 2004. Diquat Summary – use and safety

Clayton and Tanner, 1988. Selective control of submerged aquatic plants to enhance recreational use of water bodies. *Verhandlungen des Internationalen Verein Limnologie* 23: 1518–1521.

Hofstra, D. E., J. S. Clayton & K. D. Getsinger, 2001. Evaluation of selected herbicides for the control of exotic submerged weeds in New Zealand: II. The effects of turbidity on diquat and endothall efficacy. *Journal of Aquatic Plant Management* 39: 25–27.

Slide 4



Slide 5 is an example of earlier work on *C. demersum* with endothall. *C. demersum* was growing in each of the small pots initially, but at the end of the study (after treatment with endothall), most pots have very little or no plants compared with the control pot (not treated). We also have larger tanks where we have assessed the efficacy of products. (**Slide 6**)



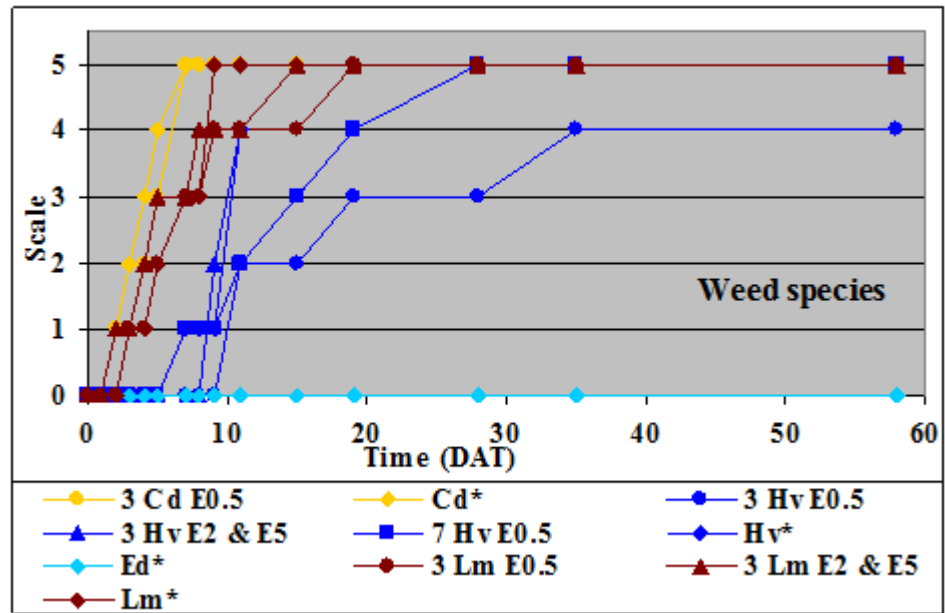
Slide 5



Slide 6

Experiments to evaluate efficacy

Slide 7

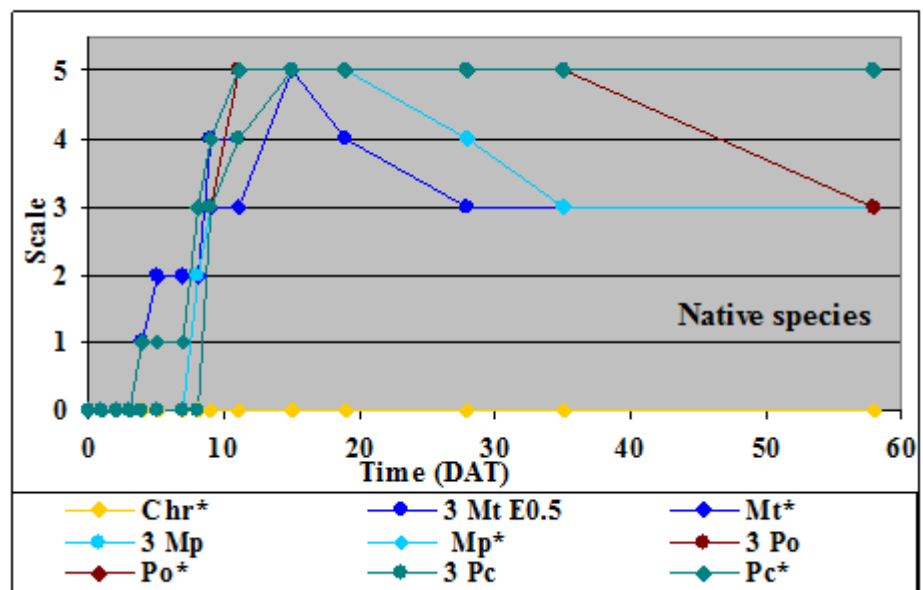


(Hofstra and Clayton, 2001)

Slide 7 shows the score (vertical axis, 0 represent no impact, 5 represents large impact/plant death) given to plants over time (horizontal axis) representing their state of health or recovery following endothall treatment. All of the weed species, apart from the *E. densa* (Ed), were killed at the higher rates. *E. densa* was unaffected in all treatments (light blue line). *C. demersum*, *L. major* and *H. verticillata* were all susceptible to endothall, although for each of these species there was variation in the timing of plant death (DAT, days after treatment) and the rates or exposure periods used on the plants. The yellow line is the *C. demersum* result showing that it was highly impacted by endothall, which is a

Experiments to evaluate efficacy

Slide 8



(Hofstra and Clayton, 2001)

desirable outcome for a target weed species.²

Slide 8 graphs the score given to native plants over time representing their state of health or recovery following endothall treatment. The native milfoils (*Myriophyllum triphyllum* and *Myriophyllum propinquum*) here are represented by Mt and Mp, the P is native pondweed (*Potamogeton cheesemanii* and *Potamogeton ochreatus*). The milfoils and pondweeds varied in their susceptibility to endothall. For example *Potamogeton cheesemanii* (green line) was controlled at all rates, whereas some *Potamogeton ochreatus* (brown line) recovered. *P. ochreatus* is an example of how understanding the relationship between concentration and exposure time and plant susceptibility can provide selective weed control outcomes. The products can be used when their impact on one plant versus another is understood. They can be used at rates where impacting the weeds is known relative to the native species. It is also important to note that the native charophytes (represented by the yellow line) did not exhibit any endothall symptoms.

Another point is that these weed species may invade a lake with native plants, but once a dense weed bed is established, the native plants are replaced by the weeds. Long term native seed banks become depleted under alien weed beds.

Other than selectivity around the products in terms of their effectiveness (or not) on different plants, there is another suite of research being done on smarter use of products. Essentially this includes methods of application of the product, to get it where and when it is needed, and how a successful application can be predicted to achieve the desired outcome. It is also desirable to minimise the environmental load of the products being used, and there is an economic cost/benefit associated with that.

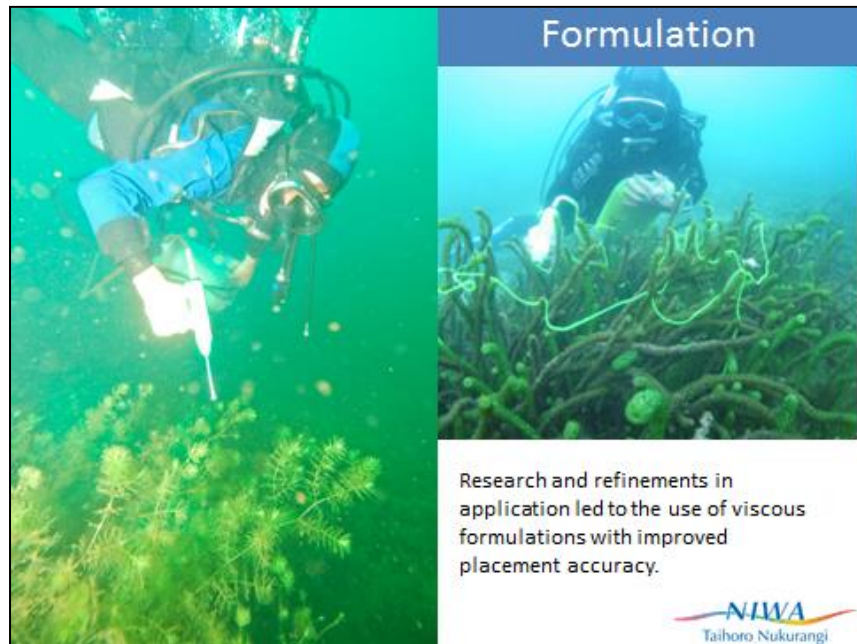
Selectivity
Target submerged plants <ul style="list-style-type: none">• Diquat – hornwort, lagarosiphon, elodea, egeria• Endothall – hornwort, lagarosiphon• Do not affect native charophytes (desirable plants)
Smarter use <ul style="list-style-type: none">• Application, product placement, tracking, predictors of success
Purpose <ul style="list-style-type: none">• to achieved desired outcome while minimising environmental load and economic costs

There has been research on the use of gelling agents seen here (**Slide 9**) being applied specifically to the plant.³ Other examples show the use of containment nets to contain an

² Hofstra, D. E., J. S. Clayton & K. D. Getsinger, 2001. Evaluation of selected herbicides for the control of exotic submerged weeds in New Zealand: I. The use of endothall, triclopyr and dichlobenil. *Journal of Aquatic Plant Management* 39: 20–24.

³ Clayton, J., 1986. Review of diquat use in New Zealand for submerged weed control. In *Proceedings of EWRS/AAB 7th Symposium on Aquatic Weeds*, Loughborough, UK: 73–79.

Slide 9



application in a particular target weed bed and within a larger water body (**Slide 10**).⁴ Again this is about maintaining that contact time to ensure a result and minimise dispersion of product. Herbicides can be applied by helicopter or by boat with underwater booms or submerged trailing hoses to optimise product placement on the weed bed.⁵

Slide 10

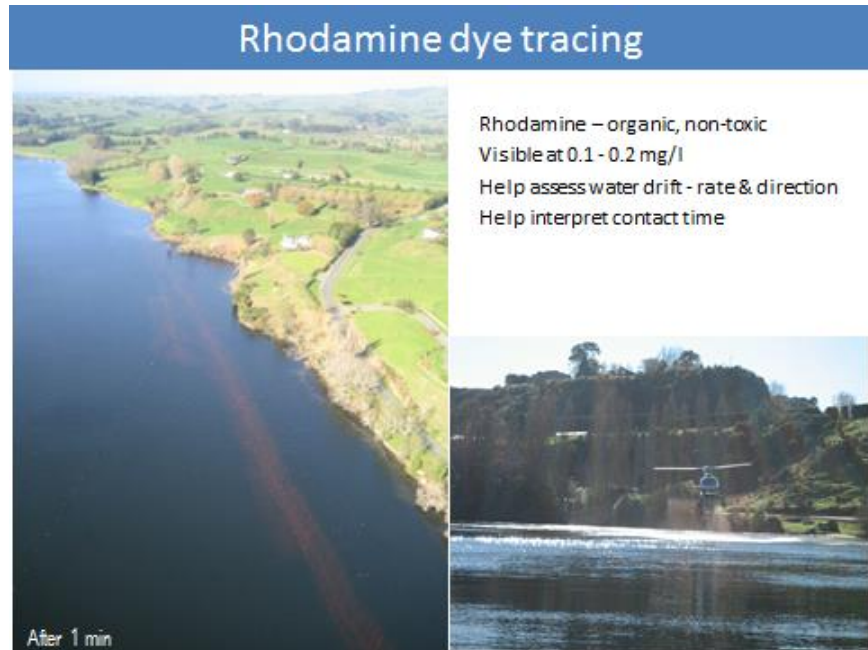


⁴ Clayton and Matheson 2008. *Partial treatments in New Zealand Lakes*. Aquatic Plant Management Society Conference, Charleston, South Carolina.

⁵ Clayton, J., Matheson, F (presenter). 2014. *Improving Underwater Herbicide Placement*. NZ Biosecurity Institute NETS conference. New Plymouth, 30 July-1 August 2014.

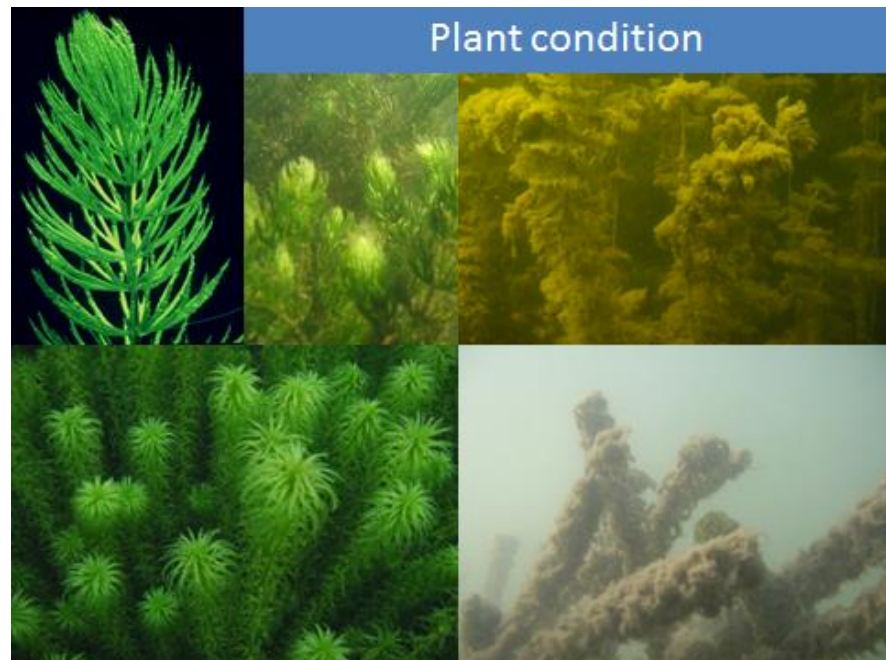
Slide 11 shows work done by Dr John Clayton and Dr Fleur Matheson using rhodamine dye. This is a product that can be used to assess the rate and direction of water movement and interpret contact time and the results of an application.

Slide 11



Slide 12 shows clean plants (left) versus really dirty plants (right) which is important with respect to diquat, because it will not work on dirty plants. **Slide 13** explains how dirty plants can be used to predict the right time to treat that particular weed with diquat, based on the state of the plants.⁶ Again this is about being able to predict success.

Slide 12



⁶ Clayton and Matheson, 2010. Optimising diquat use for submerged aquatic weed Management. *Hydrobiologia* (2010) 656:159–165
DOI 10.1007/s10750-010-0423-4.


Slide 13

Plant Condition – predicting success

Dirtiness scale (1-5) for lagarosiphon shoots

- 1 – Clean healthy shoots. Ideal for diquat treatment
- 2 – Slightly dirty. Light brown organic deposits. OK for diquat treatment
- 3 – Moderately dirty. Some reduction in diquat efficacy expected
- 4 – Quite dirty. Organic deposits interconnect between leaves.
High risk for diquat treatment i.e., reduced efficacy likely.
- 5 – Extremely dirty. Organic coating obscures species identity.
NOT suitable for diquat treatment.

(Clayton and Matheson, 2010)



Slide 14 shows the outcomes of a weed bed in Lake Wanaka, before and after treatment with diquat – from the green healthy plants to the total weed bed collapse.

Slide 14

Outcomes – lagarosiphon in Lake Wanaka



Slide 15 is an example from Lake Okataina where the diver is touching a piece of plant which at first looks to be intact, but it disintegrates readily when touched. It has no structure or integrity left in it. The bottom pictures shows native milfoils (left) and native pondweeds (right), which have recovered once that particular weedbed was removed. In the bottom right hand picture the lagarosiphon is re-sprouting. Once the weed biomass

Slide 15



has significantly declined, follow-up work is needed to support the continued regeneration of the native plants.

Slide 16 is a similar picture that shows results with diquat (left) and endothall (right). Both of these products work particularly well on *C. demersum*.⁷

Slide 16



⁷ Wells et al 2014. Potential for lake restoration using the aquatic herbicide endothall. Proceedings Nineteenth Australasian Weeds Conference.

We are always interested in evaluating new products that come on the market and what is happening in other countries. We look to see if there is a fit with a product that might give us a better solution here in New Zealand. We will evaluate those products that have better environmental properties. This comes down to expanding the toolbox so that we have options when it comes to weed beds, or to new incursions, and rapid response. The EPA recently modified approvals for the use of 4 products for marginal aquatic plants. It considers these substances beneficial in the control of aquatic pest plants and more effective than other methods of control (EPA, March 2013. Using herbicides to control aquatic pest plants).

Always at the end of the day it is about optimising the use, so that selective targeting and predictable outcomes for all weed control decisions are made.