Hygrophila costata demonstration and pilot eradication project

Phillip L. Moran and Vanessa Moscato
Noosa and District Landcare Group, PO Box 278, Pomona, Queensland 4568, Australia
Email: nrmanager@noosalandcare.org

Summary An innovative and integrated pest management approach was trialled on the Class 1 declared pest plant *Hygrophila costata* Nees (Acanthaceae), around Lake Macdonald in Noosa Shire. A combination of the gas burn method, follow up herbicide treatment and revegetation with native riparian species was used to control hygrophila and discourage recolonisation. Water quality monitoring and community awareness raising activities were conducted throughout the duration of the project.

Keywords *Hygrophila costata*, gas burn method, integrated pest management, Noosa Shire.

INTRODUCTION

Hygrophila was first noticed at Lake Macdonald in 1993. According to distribution maps prepared by Noosa Shire Council in February 2003, the infestation covered 52% of Lake Macdonald's 31.4 km perimeter, in a band approximately 4 m wide (Burrows 2003). Hygrophila has also invaded riparian areas both upstream and downstream of Lake Macdonald. The infestation is more extensive than any others known in Queensland or New South Wales. The spread of hygrophila within the Noosa River catchment and to adjacent catchments is considered inevitable unless adequate control programs are implemented.

Hygrophila is difficult to control due to its vegetative reproduction mechanism, dense adventitious root network, rapid growth and ability to grow both on land and water (McCartney 2006). Since Lake Macdonald is an important breeding habitat for fauna and a major recreational area for visitors, there are a number of environmental and social constraints imposed on what management methods can be used around it.

MATERIALS AND METHODS

Site description Lake Macdonald, a town water supply storage for Noosa Shire with a capacity of 8000 ML, is situated between Noosa and Cooroy. The project was conducted over a 4500 m^2 area of the upper reaches of the lake system, approximately 10 km from Cooroy, between Dath Henderson Rd and Sivyers Rd (26°24'3.31"S, 152°57'34.74"E) (Figure 1). Average water depth exceeds 2 m.

Gas burn treatment Burning was carried out from 15th January to 15th March 2007 in four stages (Figure 1). Emergent leaves, stems and flowers were burnt using a hand-held Weed Dragon Jet 4 Torch and a 13.5 kg gas cylinder. The flames were directed at the base of the plants where they emerge from the soil or water and were passed back and forth until the upper stems shrivelled and fell over. Areas that could not be safely accessed from the shore due bank instability were burnt from a floating pontoon. The high rate of consumption of gas caused the regulator to malfunction due to freezing around the outlet after periods of continuous use. This was overcome by floating the gas cylinders in the water. The timing of control work was dictated by wind and rain conditions, availability of fire permits from the Rural Fire Service, personal safety and concerns of neighbouring residents. Each gas bottle lasted for approximately three hours of continuous operation.

Manual removal of floating mats Floating mats that could not be reached with the jet torches were hand pulled using a dingy and pontoon. Floating mats ranged in size between 2 and 10 m^2 and occurred in close proximity to the shoreline. Harvested material was piled up on a sheet of black plastic and left to dry for a few weeks. New shoots were treated with herbicide as they emerged. As no viable seeds of this species are recorded in Queensland, dry material was reapplied as mulch.

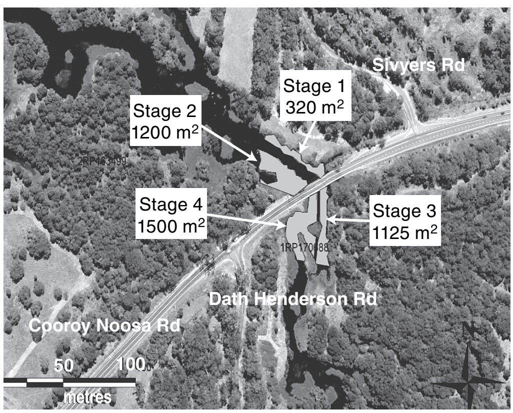

Figure 1. Map showing stages of work.

Herbicide treatment Foliar spray with Weedmaster Duo® (360 g a.i L^{-1} glyphosate) was carried out in all areas that were too unstable to access and where the water height prevented effective burning. Follow up spot spraying with 360 g a.i L^{-1} glyphosate was carried out as required where hygrophila reshooted from adventitious roots after gas burn control work. All spraying was carried out more than 5 km upstream of the water intake.

Revegetation A selection of riparian trees, shrubs and sedges representative of vegetation communities occurring naturally in the surrounding area were planted along the banks of the lake. Trees and shrubs were planted 1 m apart, while sedges were planted 300 mm apart. Where the bank was wide enough, multiple rows were planted.

Water quality Physical and chemical water quality monitoring was carried out between 7.00 am and 9.00 am on three consecutive days every three months from the start of the project (07/12/06) to the end (16/05/06). Temperature, pH, electrical conductivity, turbidity and dissolved oxygen were monitored using a Hydrolab Quanta Water Quality Monitoring System. Filtered nitrates and reactive phosphorus were monitored using a Hach DR/890 Portable Datalogging Colorimeter. Dissolved oxygen levels were monitored weekly from 07/03/07 to 07/05/07 and expressed as percent saturation to provide a relative measure of oxygen availability to aquatic fauna. Herbicide levels in the waterway were also monitored by the Water Treatment Plant staff at the start and end of the project.

Communication strategy Throughout the duration of the project. an educational and awareness raising campaign delivered information about aquatic weed management to the local community in the form of press releases, newsletter articles, an informative brochure, a colour A3 poster, and an interpretative sign placed near the project area. Workshops were held to train local and state government officers, local school students and interested community group members in aquatic weed identification.

RESULTS

Gas burn treatment In areas where the bank was solid, dry and not too steep, gas burn treatment effectively reduced hygrophila biomass. The intense heat damaged the vascular system, leaves and flowers, and caused the stems to shrivel and collapse. It was difficult to burn in the wetter areas where more than half the plant height was submerged and where dense floating mats of hygrophila formed islands over deep water. The heat did not transmit well beneath the water and hygrophila reshooted from underground or underwater root systems within a few weeks. Walking on floating mats with 13 kg gas bottles caused the mats to become submerged and further impeded burning.

Manual removal of floating mats In comparison to the plants growing on the bank which have dense, tangled root systems that are almost impossible to pull out, the free floating emergent mats could be detached with relative ease. Approximately 1 t of hygrophila (wet weight) was harvested from Stage 1 and left to dry on the lake's edge. Although manual removal was effective, this method was not considered feasible for the entire project area and was discontinued due to the practical difficulties associated with transporting large amounts of a Class 1 Declared Plant from the other side of the bank across the body of water and because it was extremely labour intensive.

Herbicide treatment Application of herbicide was the most efficient control method with respect to time and labour (Table 1). Areas treated only with herbicide required less follow up spraying than those treated with

Table 1. Comparison of all control methods used on *Hygrophila costata* at Lake Macdonald.

	Manual removal of floating mats	Gas burn treatment	Herbicide treatment
Area treated (m^2)	80	1520	560
Material and labour required	Pontoon, boat, pitchforks, army of volunteers and two supervisors	Gas bottles, trailer, fire hose, fire permit, pontoon, hazard signs	Spray pack, herbicide, ACDC qualified staff
Time (h)	16	136	3
Cost ($)	320	5706	155
Value for money ($ m^{-2})	4	3.75	0.27
Value for time (h m^{-2})	0.20	0.09	0.005

the gas burn method. This may be because unburnt plants with intact leaves were able to absorb and translocate herbicide better than burnt ones which had less leaf surface exposed and consequently less capacity for foliar uptake of herbicide. Herbicide treatment was also required in areas where hygrophila occurred throughout dense *Setaria sphacelata* (Schumach.) Stapf & C.E.Hubb, as the setaria grew back vigorously after gas burn treatment. There is also a drain line beside the Cooroy-Noosa Road where *Sphagneticola trilobata* (L.C.Rich.) Pruski from the road shoulder began to colonise the drain after herbicide treatment of hygrophila. This weed could become more difficult to control than the hygrophila if allowed to invade this area (Geoff Black pers. comm.).

Revegetation Revegetation was carried out in all areas where the substrate was solid enough to support plant roots. Species included *Ficus coronata* Spin & Colla, *Eucalyptus grandis* W.Hill ex Maiden, *Commersonia bartramia* (L.) Merr., *Tristaniopsis laurina* (Sm.) P.G.Wilson & J.T.Waterh and *Melastoma malabathricum* L. Under the powerlines and near the road, short growing shrubs such as *Callicarpa pedunculata* R.Br, *Babingtonia bidwillii* A.R.Bean and *Lomandra longifolia* Labill. were planted to avoid obstructing the powerlines or the view of the lake. In total, 1200 trees, shrubs, rushes and sedges were planted.

Water quality The pH levels in the lake fluctuated between 5.67 and 6.20 over the project period, reflecting slightly more acidic conditions than those recommended by Queensland Water Quality Guidelines (QWQG; Environmental Protection Agency 2007). The pH decreased slightly over time at Stage 1; however, it remained relatively stable over all other sites.

Although monitoring was conducted early in the morning and the results reflect minimum levels of dissolved oxygen (DO), DO levels were low overall compared with QWQG. Prior to hygrophila control activities, minimum DO levels ranged from 13.8–17.25% saturation. A notable decrease in DO occurred at all sites monitored in Stage 1, with minimum DO levels ranging from 1.2–8.8% after hygrophila control activities. DO levels in Stage 3 and 4 remained much more stable over the project period.

Electrical conductivity (EC) ranged from 161 uS cm^{-1} to 198 uS cm^{-1}, with a slight decrease at all sites over the project period. Overall the EC values were well within the range specified in the QWQG. Turbidity fluctuated greatly throughout the project period, ranging from 7.8 to 63.2 Nephelometric Turbidity Units. Marked increases in turbidity were recorded at Stage 1 and Stage 4, whereas turbidity remained relatively stable at Stage 3.

Surface water concentrations of nitrate-nitrogen and filterable reactive phosphorus (FRP) remained relatively stable over the project period at all sites. Nitrate-nitrogen ranged from 0.1–0.5 mg L^{-1} and FRP ranged from 0.03–0.18 mg L^{-1}.

DISCUSSION

This project demonstrated how gas burn treatment, chemical control and manual removal techniques can be used to reduce initial biomass and control subsequent regrowth. The success of the gas burn method was found to be influenced by bank topography, plant density and moisture content. Burning was much more effective in flatter, drier areas. In dense stands and in wet lower bank areas, it took longer to burn effectively. Steep banks proved too difficult or unsafe to access.

Manual removal was very effective on emergent rafts with free floating roots that were not embedded in the substrate. However, because of the large area covered by hygrophila at the lake, manual removal with a view to complete eradication may be unrealistic in terms of time and labour required.

Hygrophila is susceptible to very low concentrations of Roundup Biactive and this treatment was the most effective control method and the most efficient with respect to time and labour costs (Table 1). Herbicide treatment was equally effective on both land and water based hygrophila stands. However, this is not a realistic large scale option for several reasons. Firstly, there are significant community concerns regarding the broad-scale use of herbicides at Lake MacDonald and their effect on local fauna and water quality. Secondly, a large flood or very strong winds are needed to break up and remove the decomposing mats (Perna and Burrows 2005). Thirdly, the excess nutrients released as the plant matter breaks down *in situ* may promote the growth of other aquatic weeds such as *Cabomba caroliniana* A.Gray and floating macrophytes such as *Azolla pinnata* R.Br. that currently exist in the lake (Lombardo and Cooke 2003). The associated increase in biological oxygen demand as microbes decompose the plant matter may also lead to dissolved oxygen depletion and the subsequent release of sediment bound nitrogen and phosphorus. Low oxygen and high nutrient conditions are ideal for promoting the growth of toxic cyanobacteria. In future, harvesting treated mats and dead plant material from the lake should be considered to minimise the potential for toxic algal blooms.

The establishment of native riparian vegetation will in the long term create shade, prevent weeds from re-establishing, and filter sediment or nutrient inputs to the lake. Restoring floristic diversity to the riparian zone following removal of hygrophila will also provide fish, amphibians and waterbirds with cover, food and breeding sites in the future. Although a few plants succumbed to aphid attack, wind, mowing and extremely high temperatures, there was a high survival rate overall attributable to decent rainfall following planting and appropriate species selection. Further follow up herbicide treatment will be required to maintain the project site free of weeds for several years until the plants provide sufficient shade and successfully out compete the encroaching weeds. Noosa Council Environmental Services have given an undertaking that they will continue to maintain the site.

Containment in the form of multiple dense rows of low growing native shrubs and groundcovers to act as a physical barrier around the perimeter of the infestation may be an option in future to help prevent further spread. In addition, research into biological control agents is required for large scale water impoundments, given the constraints of each method outlined in this project. In future, to minimise the probability of large scale weed infestations occurring around dams, lakes, weirs and channels, as much mature native vegetation as possible should be retained and measures to exclude grazing from the riparian zone should be implemented at the outset.

Overall, the project has generated a lot of community interest and raised awareness about aquatic weed control and management. The local school students showed a great deal of interest in water quality and pest plant issues and a component of their school curriculum involved an assignment on aquatic weeds. The training in weed identification delivered to the staff of local councils, state government and community groups was positively received and enabled the sharing of hygrophila knowledge beyond shire boundaries to the Burnett Mary region, South East Queensland region and South Australia.

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