Innovative methods of water hyacinth removal in tropical coastal wetlands – cutting the costs

Vern Veitch[1], Damien Burrows[1] and David Hudson[2]
[1] Australian Centre for Tropical Freshwater Research, James Cook University, Townsville, Queensland 4811, Australia
[2] Conservation Volunteers Australia, 38 Haywood Street, Mooroobool, Queensland 4870, Australia
Email: Vern.Veitch@jcu.edu.au

Summary Blankets of aquatic weeds such as water hyacinth, forming over the top of freshwater wetlands are one of the major management issues facing floodplain wetlands in many parts of Australia. Recent projects that successfully removed floating weed mats from large coastal lagoons have resulted in dramatic improvements to water quality, fish diversity and productivity and public amenity. However, there is a need to reduce the costs of these harvesting operations. In a recent wetland rehabilitation project, we trialled a combination of three innovative methods to reduce the costs of initial weed removal and, potentially, long-term maintenance: bank-side herbicide application, aerial application of brine, and the use of modified small boats. The results successfully demonstrate simpler and more cost-effective means of removing large floating weed mats and improving water quality.

Keywords Water hyacinth, removal, cost-effective methods.

INTRODUCTION

The vast majority of literature on water hyacinth (*Eichhornia crassipes* (Mart.) Solms) control is focused on biological control (e.g. McFadyen 1998, Julien *et al*. 2001) as this is generally the cheapest option when it is successful. However, biocontrol has had mixed success with water hyacinth in many environments for a range of reasons including the need for intensive management of biocontrol agents and variable response of both the plant and the biocontrol agents to environmental factors such as drought, flood and nutrient inputs from adjacent land practices (Labrada 1995, NASA 2007, M. Julien pers. comm. 2007).

From a cost perspective (without considering environmental impacts) chemical control is the next cheapest method followed by habitat manipulation and mechanical control (Madsen 2000). Proponents of biological and chemical control often focus on the cost but for many wetlands it is critical that high biomass aquatic weeds such as water hyacinth are removed from the wetland, as a large biomass of decomposing plant material can create anoxic conditions and toxic levels of ammonia, causing significant harm to aquatic biota (Gutieerez *et al*. 1994, Lugo *et al*. 1998, Perna and Burrows 2005). Thayer and Ramey (1986) described the history of development of equipment for mechanical removal and identified that the biggest restriction on efficiency of equipment was transport of the weed to an extraction point. Most of the equipment has been large and designed for operation in navigable waters that restricted use in confined or isolated waterways. As the weeds have spread and awareness of their environmental impacts has increased, the need to design smaller equipment and use innovative control methods to help minimise costs has increased (Jones 2001, Greenfield *et al.* 2004).

Coastal freshwater wetlands in North Queensland have undergone a reduction of up to 80% of their original aerial extent and many of those that remain are under pressure from a range of factors that include changed hydrology, loss of riparian and buffer zones and elevated levels of nutrient loading as a result of adjacent landscape management such as intensive farming and residential and tourism development (Burrows and Butler 2007). One of the factors that contribute markedly to their degradation is exotic aquatic weeds, with water hyacinth arguably being the worst of these. The impact of water hyacinth has previously been studied in floodplain lagoons of the Burdekin Region, south of Townsville (Perna and Burrows 2005, Bohl *et al*. 2003) and include reductions of fish species richness and abundance, and anecdotal reports of adverse impacts on bird communities. Removal of these hyacinth mats resulted in a rapid and dramatic increase in dissolved oxygen content of the water, a doubling of fish species richness and a reduction in exotic mosquitofish (Perna 2003, 2004, Perna and Burrows 2005). The cost of mechanically removing extensive mats was considerable.

Here, we report on our recent trial of new, more cost-effective methods for water hyacinth removal in a large coastal floodplain lagoon system. In the case of Lagoon Creek, a tidal barrier separated tidal brackish waters from a freshwater lagoon. We hypothesised that with some intervention, flood flows could reduce the cost of weed control. We proposed to break the bind that the weed mat had on the banks with herbicide spraying and reduce the integrity of the mat with aerial brine application. As the project proceeded, we developed methods of using modified small boats to reduce the cost of mechanical removal of the remaining areas of weed mat. More detailed versions of this project can be found in Veitch and Burrows (2007) and Veitch *et al*. (2007).

MATERIALS AND METHODS

Lagoon Creek consists of a series of permanent deep water lagoons on the lower Herbert River floodplain, near Ingham, north Queensland. The lower-most lagoon, where most of this work occurred, is separated from normal, occasional estuarine influences by a bund wall. In 2006, we began a program to remove the extensive water hyacinth mats that had covered the entire surface of Lagoon Creek for many years. Extensive secondary colonisation of the hyacinth mats had occurred with grasses and vines growing out from the banks over the hyacinth, binding the mats together so that they retain their integrity during flood events. Even when water levels rose 2 m in a few hours, the mats were observed to rise with the floodwaters and then lower back into their original position, without any loss of weed material, when the floodwaters receded.

The first step in the weed removal process was to break these bindings and enable high flows to dislodge the mats. This was achieved by manually spraying weeds along the banks and in the main body of the lagoon with herbicide as these weeds helped bind the hyacinth mats together, and to the bank. We also trialled helicopter application of a brine solution which does not kill plants, but desiccates their leaves, temporarily shrivelling them and reducing the cohesion of the mats. Although the desiccation effect of the brine spray was evident within hours of application, the effect was short-lived and because the plants recovered from the desiccation in less than a week, we needed to apply the brine within days of anticipated rainfall in order for high flows to dislodge the now treated mats.

The remaining weed mats still needed to be mechanically removed. In the Burdekin district, 200 km to the south, harvesting of large hyacinth mats has been successfully undertaken, but in those situations, stream banks were low and lacked riparian vegetation. This enabled a floating weed harvester to cut the weed mat into floating islands and push them towards an excavator that moved along the banks in pace with the harvesting operations and removed the weeds progressively (Jones 2001).

In Lagoon Creek, the high stream banks limited the reach of the excavator's arm and the significant riparian vegetation limited access. Here, the excavator was positioned at one of two fixed points in each lagoon, created by hardening work platforms with rock. As the floating harvester moves slowly, this created a logistical problem of moving weed mats to the excavator. To overcome this problem we trialled the use of small boats to help move mats to the waiting excavator, and to access areas around snags. These boats were trialled in various combinations, including working in pairs with rope between them to pull weed mats, and also with the use of a security door fitted to the front of a boat in order to improve their ability to push mats to the excavator.

RESULTS AND DISCUSSION

Bankside spraying of plants binding the weed mats to the bank was trialled prior to the end of the wet season. 120 litres of Roundup® Bio-active was applied at a rate of 13 mL L^{-1} taking 23 man-days at a total cost of $9000. After an initial trial of aerial brine spraying that did not seem to affect water hyacinth, ground-based field trials were undertaken to determine appropriate application strengths and volumes. Brine spraying was subsequently undertaken in the most downstream lagoon using a helicopter fitted with spray booms for agricultural spraying. (Figure 1) The effective swath of the booms was 11 metres with 50 Teejet air injected nozzles on the booms. Ten loads of 450 litres per load containing about 100 kg of salt per load were applied over roughly 10 ha. The operation took three hours and cost $5000. While the observed impact on the water hyacinth was minor the brine had a greater effect on the secondary plant infestation binding the mat surface, reducing the integrity of the weed mat.

Herbicide spraying effectively killed the bankside weeds but none of the weed mat was lost during minor flooding six weeks after this treatment as the dead weeds had not decayed sufficiently to weaken their hold on the banks. However a second flood event a further four weeks later, when further breakdown had occurred and during which time aerial brine spraying

Figure 1. Lagoon 1 during brine spraying.

had also occurred, saw approximately 5 ha of weed mats flushed downstream (Figure 2). This indicated the success of the combined herbicide and brine-spraying program to break the integrity of the tightly held weed mats. The operation saved an estimated 10 days of mechanical harvesting that would have cost in the order of $30,000. Brine spraying can be effective in areas where aerial herbicide spraying is restricted and should be considered for future projects depending on the site, species and density of the weed infestation. The amount of salt used on the dense weed mat had no effect on water quality and it is probable that most brine remained on the weed mats, and did not reach the water surface anyway.

Mechanical removal of remaining weed mats in the downstream lagoon began mid 2006 with the Burdekin Shire Council's floating weed harvester and an excavator with a modified grab bucket sourced locally. The harvester worked alone for two days to break up the weed mat before being joined by the excavator. On the third day, two 4.1 metre plastic boats fitted with 25 hp motors were hired from local sources to join the operation. The harvester has previously been employed extensively working with excavators but not with the assistance of small boats. The harvester's ability to break up the weed mat was made easier by the earlier herbicide and brine spraying but we were unable to quantify any savings.

A number of methods were trialled with the small boats but dropping an anchor over the bow and using it to 'hook' weed islands and push or pull them with the bow of the boat overhanging the weed proved most successful in enhancing the operation of pushing weed mats (up to tennis court size or larger) cut by the floating harvester to where it could be reached by the excavator for removal. An important aspect of this operation was the use of prevailing winds to assist the boats and harvester in moving weed mats to the excavator.

Although precise quantification of costs is difficult, it was estimated that the small boats saved up to four additional days work for the harvester and excavator. Including operators, the costs for the weed harvester and excavator totalled $2500 per day compared with $720 per day for both boats. This suggests a cost saving of $2800 for weed removal from 5 ha of waterway. It was thought, however, that the boats could be more effective if fitted with a rake and a design was developed and built to trial in a second lagoon. Two small boats were fitted with mesh blades with one design constructed from a discarded security door (Figure 3). Construction and equipment costs for one boat totalled $200 plus one day's work by a local stakeholder and a cheap 2nd hand outboard motor costing $800. The small boats fitted with mesh rakes were then able to push much larger weed mats than those without rakes (Figures 3 and 4). Aquadozers were also effective in pulling weeds from the banks and in collecting smaller patches of weeds that neither the weed harvester nor unmodified boats were unable to clean up.

Figure 2. Lagoon 1 showing weed flushed out by a small flood after brine and herbicide treatment.

Figure 3. Aquadozer fitted with wings.

Figure 4. Aquadozer without wings pushing weed mat.

Limited trials have shown the small boats can pull weed mats out from the bank in areas inaccessible to the harvester. If maintenance is well managed and timely, the weed harvester may not be needed. In addition, small boats may make mechanical harvesting viable in small wetlands that cannot presently be targeted by the heavier equipment. Their basic design, ease of deployment and low operating costs also make ongoing maintenance control of weed mat regrowth simpler and more affordable. Now that the bulk of the dense weed mats have been removed, long-term maintenance will depend on regular herbicide spraying and small-boat harvesting of hyacinth regrowth, before large mats develop.

CONCLUSION

From the perspective of developing innovative methods for weed harvesting, we now have a suite of methods that reduce the cost of aquatic weed removal. It is important to identify the limitations of each site and implement techniques that minimise adverse impacts from intervention while at the same time, minimising costs. In addition, the use of low-cost options using small boats has also been proven successful.

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