Trialling different low cost methods of water hyacinth removal in tropical coastal wetlands

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Abstract

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, demonstrating their value. Innovative methods trialled in this project to reduce costs of initial weed removal and, potentially, long-term maintenance, include aerial application of brine, and the use of small boats with and without special modifications. In addition to methods of weed removal, the environmental responses to weed removal are being studied. The results successfully demonstrate simpler and more cost-effective means of removing large floating weed mats and improving water quality.

Keywords

Water hyacinth, aquatic weed control, wetlands

Introduction

Prior to its degradation reaching a critical point during the 1990's, Lagoon Creek supported a healthy and diverse population of native fish and was an important nursery for barramundi (*Lates calcarifer*) and other commercially important anadromous fish species (Hogan & Graham, 1994). In 1996, local recreational and commercial fishers raised concerns that water quality in Lagoon Creek was so poor that it was a major source of contaminated water leading to fish kills in downstream areas after heavy rainfall events (Veitch, 1999). Other projects in Burdekin floodplain wetlands (south of Townsville) have shown rapid recovery of water quality and aquatic faunal communities following removal of water hyacinth (*Eichhornia crassipes*) (Perna, 2003; Perna & Burrows, 2005).

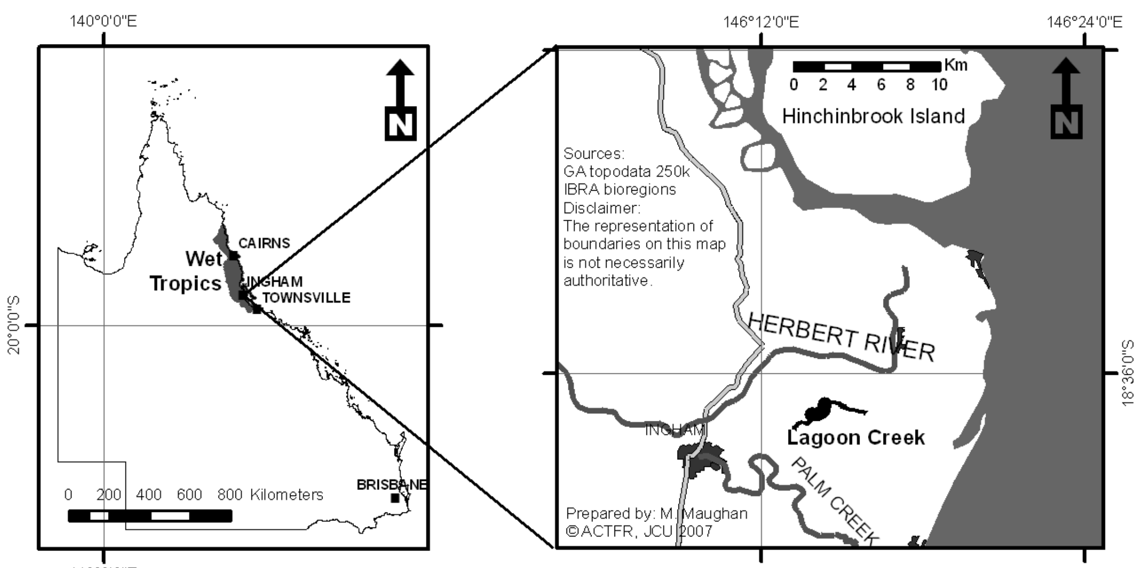

Figure 1. Map showing location of Lagoon Creek.

Lagoon Creek is a series of permanent deep water lagoons on the lower Herbert River floodplain. It drains a small floodplain catchment of approximately 18.5km^2 dominated by intense sugar cane growing and acts as an overflow path for Palm Creek and the Herbert River in major floods in the Ingham district (Figure 1).Lagoon Creek has a surface area of ~27 hectares and is impounded by a tidal barrier/weir which eliminates inflow of estuarine water to the downstream reaches of the creek and raises the water level by ~0.5 m above natural levels. The formerly degraded riparian vegetation has been extensively replanted along the banks in the lower half of the creek. The creek's water surface became progressively degraded due to water hyacinth domination along most of its length. A secondary invasion of introduced and native plants on top of the water hyacinth mats resulted in a complete blanket covering of what were previously open waters.

Due to the earlier riparian rehabilitation efforts, strong community support and the availability of baseline monitoring data from a previous research project, Lagoon Creek presented an ideal opportunity to demonstrate the benefits of aquatic weed removal. As such it was selected as one of a number of sites for the implementation of the Australian Government's Great Barrier Reef Coastal Wetlands Protection Programme – Pilot Programme, which funded the works described in this paper.

Project design

The focus of the project was removal of water hyacinth from three large, deep downstream lagoons which constitute the majority of aquatic habitat in the creek system. Management methods to enhance weed removal were determined prior to the start of the project. Large-scale herbicide spraying of the weed mat was rejected due to the potential for severe adverse impacts on water quality and biota as experienced in other tropical environments where this method has been used extensively. The risks of post-spraying oxygen depletion and potential for ammonia toxicity caused by large volumes of decaying weed mats represented unacceptable threats (Gutieerez *et al*., 1994; Lugo *et al*. 1998).

Due to extensive secondary colonisation of the hyacinth mats, and grasses and vines growing out from the banks over the hyacinth mats, the weed mats retained their integrity during flood events. During one storm event when the project was being designed, water levels rose 2m in a few hours, but the mats merely rose as the floodwaters passed underneath. When floodwaters receded, the mats lowered back into their original position without any loss of weed material. It was clear that floodwaters by themselves would be unable to shift the mats. Thus, the first step in the plan was to break the bindings with the banks and on the weed mat surface prior to the onset of the wet season, to see if that would make the mats more prone to dislodgement and passage downstream during high flows. Manual bankside herbicide spraying was undertaken to break the bank-bindings. In lieu of aerial herbicide spraying, we trialled aerial application of a brine solution which does not kill the plants, but desiccates them, temporarily shrinking their leaves and reducing their cohesion. The bankside herbicide spraying was conducted some weeks before rain to enable the affected plants to decompose to break their binding. However, because of the temporary effect of the brine, it was intended to apply it within days of anticipated rainfall.

Despite being hopeful the spraying program would dislodge some of the weed mats, it was always probable that some of the weed mats would have to be manually removed. In the Burdekin district to the south, harvesting of large hyacinth mats has been successfully undertaken, but in those situations, the banks were smaller and lacked riparian vegetation, making it easy for a floating weed harvester to cut up the weed mat and push them towards an excavator that moved along the banks in pace with the harvesting operations and removed the weeds. In Lagoon Creek, the same operation was planned, but the high banks limited the reach of the excavator's arm and the significant riparian vegetation limited excavator access, meaning that it would have to be positioned at one or two fixed points in each lagoon, created by hardening work platforms with rock. As the floating harvester moves slowly, this created a logistical problem. To save time and work around large snags in the water, we trialled the use of small boats to help move mats to the waiting excavator, and to access areas around snags. Ecological monitoring was also undertaken, including surveys of fish and wetland dependant birds, nutrient measurements in both the water and the weed mat and water quality monitoring before and after weed removal.

Project implementation

Bankside spraying of weed mats

Bankside spraying of plants binding the weed mats to the bank was undertaken progressively by two workers using a vehicle mounted spray unit. They started with the downstream lagoon, working their way upstream to maximise the potential for flushing out weeds after breaking the grip on the banks. 4.7km of bank was sprayed prior to the first rains in January 2006, after which spraying was suspended until the end of the wet season. 120 litres of Roundup Bi-active was applied at a rate of 13ml/L taking 23 man-days at a total cost of $9000.

Herbicide spraying effectively killed the bankside weeds but six weeks later the dead weeds had not decayed sufficiently to break the hold on the banks, enabling them to resist movement with minor flooding. However a 2nd event 10 weeks after spraying resulted in approximately 5 ha being flushed downstream.

Aerial application of brine
After an initial trial of aerial brine spraying that did not seem to affect the water hyacinth, ground-based field trials were undertaken on 10 February 2006 to determine appropriate application strengths and volumes. Brine spraying was subsequently undertaken on 22 February 2006 in the most downstream lagoon using a helicopter fitted with spray booms for agricultural spraying. 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 ~100Kg of salt/load were applied over ~ 10 ha. The operation took ~ three hours including an unexpected ~30 minute rain shower and cost $5000.

Figure 2a. Lagoon Creek prior to treatment.

Figure 2b. Effect of bankside herbicide spraying.

Figure 2c. Brine spraying.

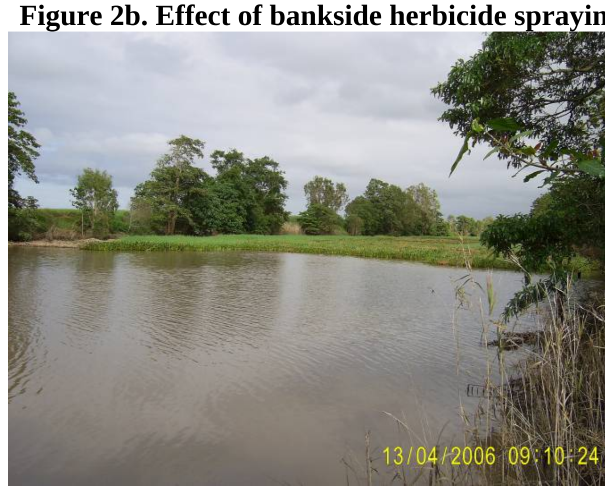

Figure 2d. Weed flushed from lower half of lagoon after aerial brine spraying.

The brine was not intended to kill the water hyacinth but to desiccate the leaves, causing them to shrink and/or burn. While the observed impact on the hyacinth was minor it killed the secondary infestation of plants (mostly sedges) that were binding the mat surface, which proved successful in reducing the integrity of the underlying weed mat. A subsequent rain event in April 2006 caused water in the lagoons to rise ~2 metres above normal height and this flushed out ~5ha of weeds in the downstream half of the lower lagoon though the remaining mats remained intact (Figure 2d). This second rain event cleared out 5ha of water hyacinth when the previous similar-sized event 5 weeks earlier had no effect, indicating the success of this method when combined with bank-side spraying. It saved an estimated 10 day harvesting operation with an estimated additional cost of $30 000. The series of images at Figure 2 shows progress made on weed removal prior to harvesting.

Brine spraying was considered to be moderately successful, saving an estimated $25 000 in harvesting costs. It can be effective in areas where aerial herbicide spraying is restricted and should be considered for future projects depending on the site and density of the weed infestation. The amount of salt used on the dense weed mat did not change water quality – it is probable that most brine remained on the weeds, and did not reach the water. In any case, the amount of salt applied was small in relation to the water volume present and it was calculated that there would be no measurable impact on conductivity. Some difficulty was experienced in mixing the salt in sufficient strength, but warming the water would improve its ability to dissolve the salt at high concentrations.

Mechanical removal of weed mats

Mechanical removal of remaining weed mats in the downstream lagoon began mid 2006 with a floating weed harvester hired from Burdekin Shire Council and an excavator with a modified grab bucket sourced locally. The harvester and excavator were transported to the site on low loaders and the harvester was unloaded with two large industrial cranes. The harvester worked alone for 2 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 25hp 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.

Methods trialled with the small boats included using a net to encircle weed "islands" cut by the harvester, and towing captured weed mats with one or both boats; using a net draped over a plastic floating pipe and pushing the pipe; or 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 (Figure 3a). The latter two methods proved successful in enhancing the operation of pushing weed mats (up to tennis court size or larger) 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 weeds to the excavator. Although precise quantification of costs is difficult, it was estimated that the small boats saved up to 4 additional days work for the harvester and excavator. Including operators, the costs for the weed harvester and excavator totalled $2500/day compared with $720/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 (Figure 3b). Two small boats were fitted with mesh blades with one design constructed from a discarded security door. Construction and equipment costs for one boat totalled $200 plus one day's work by a local stakeholder and a cheap second hand outboard motor costing $800. The small boats fitted with mesh blades were then able to push much larger weed mats than those without rakes. Rake boats were also effective in pulling weeds from the banks and in collecting smaller patches of weeds that unmodified boats were unable to clean up.

Figure 3a. Small (4.3 m) boats without rakes pushing weed to the excavator.

Figure 3b. Punt with rake pushing weed mat.

There has not yet been an opportunity to employ rake boats in regular maintenance of regrowing weed mats but limited trials have shown they 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 make maintenance simpler and more affordable.

Small boats have a range of advantages and disadvantages that include:
- they can be used in shallow waters;
- they are easily transported and can access wetlands more easily than heavy equipment;
- they are cheap to buy and operate compared with the aquatic weed harvester;
- despite small motors they can push weed mats at similar speeds to the harvester;
- they can pull weed out from the bank around snags and are highly manoeuvrable;
- they may require special motors due to water pump clogging and prop fouling;
- they cannot cut through or push heavily matted weed; and,
- they still need land based equipment such as an excavator to remove weed from the water body.

Monitoring ecological responses of weed mat removal
Monitoring of the response of Lagoon Creek to weed removal is ongoing and it is still too early to see any change to aquatic faunal communities. Preliminary water quality results are encouraging, with dissolved oxygen levels showing dramatic improvements from chronic anoxic conditions that restricted fish diversity to only six hypoxic tolerant species (unpublished data). Dissolved oxygen saturation (DO) has increased from less than 1% at 10cm below the surface prior to weed removal, to a minimum of 51.2% in the early morning at the same site and with similar weather after weed removal (Figure 4). This level of DO should be sufficient to support the full range of normally expected fish species. However recruitment of new species is only possible during high flow events (e.g. the 2007 wet season). Fish communities at Lagoon Creek will be monitored throughout 2007.

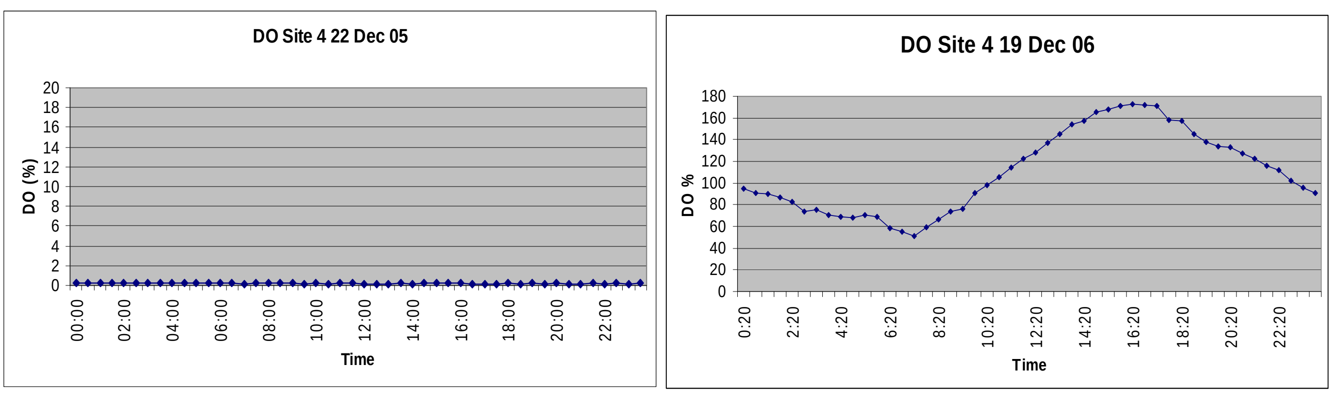

Figure 4. Dissolved Oxygen (DO) variation before and after weed harvesting (note difference in scale). All sites within the lagoons have shown similar improvements in dissolved oxygen.

Within the first 12 days after weed removal an apparent phytoplankton bloom occurred for about 7 days. Whilst no water samples were taken in this settling period, there were strong visual clues including a thick green/brown colour to the water. Prior to weed removal, water samples had very high levels of nitrogen and phosphorus and as there was almost no light reaching the water, limited productivity. After removal of the mat, it is likely that the phytoplankton responded to increased light and began using available nutrients. Subsequent water sample analysis has shown a ten-fold reduction in dissolved nutrient concentration from areas where the weed mat has been removed and the water is now a dark tannin colour. Further sampling planned throughout 2007 is necessary to draw any conclusions from the observations seen so far.

Potential uses of harvested weed mats

Investigation of potential uses of the weed mat included discussions with two commercial organisations that process various soil ameliorants including mulch, compost and organic fertilisers in various forms. Laboratory analysis revealed high levels of nitrogen and phosphorus in the weed mat and the stockpiled weed decomposes rapidly to a rich organic soil. Local farmers commented that they had previously used weed mats to spread on their paddocks complementing the views of some farmers from other weed removal operations elsewhere. This aspect of the project is still under investigation to determine if the weed removal costs can be offset to any degree by commercial uses of the waste product which would otherwise be left to decompose above the bank.

Conclusion

From the perspective of developing innovative methods for weed harvesting, Lagoon Creek has been an outstanding success. The creek system is now largely free of aquatic weeds throughout the lower and middle freshwater reaches and there has been a dramatic improvement in water quality. The flood removal of ~5ha of dense weed mat was assisted by bank-side herbicide and aerial brine spraying. Adequate lead time is critical to maximise assistance from natural events. The use of modified small boats reduced the time taken to remove the weeds from affected areas and simplified equipment requirements. Further investigation of the use of small boats in maintaining areas where aquatic weeds have been introduced needs to be undertaken but it is envisaged that with regular maintenance required to harvest regrowth of hyacinth mats, the need for an expensive aquatic harvester can be substantially reduced or eliminated.

Lagoon Creek now looks like a healthy floodplain wetland (Figure 5) although there is much more work to be done yet. Further monitoring after wet season rains will be necessary to measure the ecological responses to the improvements in visual and water quality aspects of weed removal, as well as faunal recovery.

Figure 5. Lagoon Creek with and without water hyacinth mats.

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