Northern Territory Government

DEPARTMENT OF
NATURAL RESOURCES, ENVIRONMENT, THE ARTS AND SPORT

Northern Territory

Cabomba Eradication Program 2006/07 June 2009

Northern Territory Cabomba Eradication Program 2006/07

Department of Natural Resources, Environment, The Arts and Sport
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Disclaimer:

The information contained in this report comprises general statements based on scientific research and monitoring. The reader is advised that some of the information may be incomplete or unable to be applied in areas outside the Darwin River region. Some information may be superseded by future scientific studies, new technology and/or industry practices.

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Front cover: *Cabomba caroliniana*, in flower

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1. Introduction

Cabomba caroliniana (cabomba) is a fully submerged, aquatic plant native to South America. Cabomba was first recorded in Australia in 1967, probably introduced through the aquarium industry.

Since its introduction to Australia, cabomba has become established in various water storage facilities, farm dams and river systems in an area extending from Victoria to the Charters Towers/Townsville region in Queensland. Cabomba is often problematic in irrigation drains and channels where low flow rates facilitate rapid development and spread. Cabomba was first recorded in the Northern Territory (NT) in 1996.

Cabomba is a declared Weed of National Significance (WoNS species). The Northern Territory *Weeds Management Act*, administered by the Department of Natural Resources, Environment, the Arts and Sport (NRETAS), declares all plants within the genus *Cabomba* as Class A (to be eradicated) and Class C (not to be introduced to the NT).

Nationally, cabomba has proven to be a very difficult weed to manage effectively once established because of the rate at which it grows, the plant's ability to spread rapidly and the difficulty of managing off-target impacts.

The Cabomba Threat

Cabomba is a fast growing plant. Growth appears to positively correlate to increasing light, high temperature and elevated nutrients. These requirements indicate that most freshwater bodies in the Top End would be susceptible including floodplains, backflow billabongs and water reservoirs, including Darwin River Dam.

Infestations interstate have clearly demonstrated cabomba's capacity to reduce aquatic biodiversity and ecosystem functioning, adversely affect water quality, reduce water storage capacity of dams, block water distribution infrastructure, severely impede recreational activities (including fishing and boating) and create habitat suitable for mosquito breeding.

Cabomba spreads readily. Floating stem fragments, as short as 1cm, with only a pair of leaves, can take root and grow into new plants. Large infestations are also able to produce vast quantities of seed. Anything that moves through the water, including fishing lures, boats, trailers, outboard motors and animals, can act as vectors for the movement of either plant fragments or seeds.

As a result of these issues and associated costs, management programs in most jurisdictions target impact reduction rather than eradication. Given the currently limited range of cabomba in the NT, the enormous potential range and scope for extensive environmental, social and economic impacts (including the possible need to establish a drinking water supply treatment facility, in the event that Darwin River Dam became infested with cabomba), eradication was established as a priority.

Cabomba in the NT

Cabomba was first recorded in the NT in 1996 at Marlow's Lagoon, Palmerston. After multiple unsuccessful attempts at physical control, over a period of several years, a single application of the herbicide, *Agricrop Rubbervine Spray* (active ingredient - 2,4-D-n-butyl ester) resulted in the weed being eradicated in this isolated water body.

On 21 October 2004 the same species was reported and subsequently positively identified in the Darwin River area. Subsequent surveys identified cabomba at several locations along an 11 km stretch of the river. Chemical management of the Darwin River infestation commenced in November 2004 and provided satisfactory 'knock down' control results. The germination of seed after the 2004/2005 wet season has, however, resulted in re-establishment in multiple locations within Lok Landji Billabong.

An awareness campaign was launched following the discovery of cabomba at Darwin River which resulted in a number of cabomba populations being identified in confined urban aquariums and ponds. Notably, in December 2004, a resident of Pine Creek reported that cabomba was regenerating from seed in a fish pond. Cabomba plants were persisting despite the pond having been drained the previous month and the weed removed. Weed Management Officers visited the property and found seeds attached to the roots of seedlings pulled from the soil. This was the first evidence of viable seed production in Australia.

The Task Force

When cabomba was discovered in Darwin River in 2004, a taskforce was formed to direct, coordinate and oversee the Cabomba Eradication Program. Stakeholder groups, including Amateur Fisherman's Association of the Northern Territory (AFANT), Local Government and the NT Environment Centre were consulted.

During the 2006/07 reporting period the Task Force continued to provide support and guidance for the implementation of the eradication program, including management of the quarantine zone

Darwin River Quarantine

To minimise the chance of cabomba being spread further, the infested section of Darwin River was placed under quarantine in accordance with section 21 of the *Weeds Management Act*, for a period of two years from 9 November 2004 to 8 November 2006.

This quarantine order was extended for a further two years until 8 November 2008, and will remain in place until it is revoked or extended by the Minister for Natural Resources, Environment and Heritage. The area quarantined comprises the section of Darwin River between Cox Peninsula Road and Leonino Road.

The quarantine order prohibits the movement of people or any object, including boats, vehicles and fishing equipment, into or out of this section of river and the 5 metres of land adjacent to the water's edge, unless an appropriate permit has been obtained from NRETAS.

Vehicles are not to pass over causeways at Old Bynoe Road or Reedbeds Road if the river is flowing over these causeways. Non-compliance of this order is an offence with a maximum penalty of $50 000 for individuals and $250 000 for a body corporate. Minimum penalties of $5 000 or $25 000 respectively also apply.

Surveillance

Early detection of any new infestations is a vital part of the eradication program. NRETAS Weed Management Branch regularly monitors susceptible water bodies in the region including:

- unaffected reaches of the Darwin River;
- sections of the Blackmore River;
- Berry Springs Nature Reserve;
- Howard Springs Nature Reserve;
- McMinns Lagoon;
- Fairway Waters;
- Girraween Lagoon;
- Darwin River Dam;
- Manton Dam;
- Marlow Lagoon; and
- Knuckey Lagoon.

2. Purpose of the NT Cabomba Eradication Program

Overall the purpose of the Cabomba Eradication Program is to eradicate all known infestations of *Cabomba caroliniana* from the NT, and to prevent all future introductions of plants within the genus to the NT.

Seven specific objectives have been identified which guide the project and provide an avenue for monitoring and evaluation. This report details how each of these objectives were addressed during the 2006/07 year.

3. Report against Project Objectives

This section of the report is broken into four components which address prevention of further introduction of cabomba, the active control program, the seed research program and the various monitoring programs. Within these four sections, seven project objectives are reported against.

3.1 Prevention of further introduction

Objective 1: Prevent all future introductions of plants within the genus Cabomba to the NT.

During 2006/07 NRETAS Weed Management Officers visited and provided information to nurseries and aquatic plant retailers detailing the prohibition of import and subsequent sale of cabomba in the NT. It was noted that at this time no retailers were selling the plant. Significant effort was made with regards to increasing public awareness of cabomba (See 3.3 below).

3.2 Active Control Program

Objective 2: Eradicate all known infestations of the aquatic weed cabomba (Cabomba caroliniana) from the NT.

Objective 3: Prevent re-establishment of plants within the genus Cabomba at all sites where it has previously been recorded and subsequently been treated and/or removed.

Objective 4: Prevent the production of seed from all sites where cabomba is currently found.

Options available for reducing cabomba populations include biological control, water level manipulation, shading, physical removal of plants and herbicide application.

Water level manipulation and physical removal

To date, water level manipulation and physical removal have failed to eliminate major cabomba infestations in the NT or elsewhere in Australia. In the case of the Darwin River site, water level manipulation and physical removal are not viewed as viable options due to the extent and location of the infestation, size of affected waterholes and potential presence of saltwater crocodiles.

Biological control

It takes many years to comprehensively assess the suitability of potential biological control agents for weed control in Australia. CSIRO are in the process of assessing the suitability of several host-specific insects for use in cabomba control. Immediacy of risks in the Northern Territory ruled out waiting for biological control research.

Herbicide control

Application of *AF Rubbervine Spray* or *Agricrop Rubbervine Spray* (2,4-D n-butyl ester, 800g/L active ingredient) was the only herbicide control option previously registered in Australia. 2,4–D-n-butyl ester functions as a systemic herbicide and is used to control many types of weeds. It is used internationally in cultivated agriculture, rangeland applications and to control aquatic vegetation.

The Australian Pesticides and Veterinary Medicines Authority (APVMA) is the national independent regulator of pesticides and veterinary chemicals. As 2,4–D-n-butyl ester is not a registered herbicide for cabomba, any usage of 2,4–D-n-butyl ester can only be made with the successful application of an off-label permit from APVMA for use of the product, *Agricrop* or *AF Rubbervine spray*.

Comprehensive testing of 2,4–D-n-butyl ester has demonstrated that continued, direct exposure or ingestion can harm humans and animals. (See Table 2 for further explanation of possible off-target impacts). In aquatic environments, 2,4–D-n-butyl ester is broken down by micro-organisms. Increased nutrients, sediment load, high levels of oxygenation and dissolved organic carbon are conducive to more rapid breakdown.

The 1996 Australian Drinking Water Guidelines (Australian Government, 2004) contains specific recommendations for chemical concentrations in potable water. The Guidelines state, “2,4-D should not be detected in drinking water”. If present in drinking water, 2,4-D would not be a health concern unless the concentration exceeded 0.03mg/L. If detected then remedial action should be taken to stop contamination.” The Health Value of 0.03mg/L in drinking water is derived from the Australian ADI (acceptable daily intake based on daily lifetime exposure) of 0.01mg/kg/day for a 70kg adult with an average water consumption of 2 L/day.

Given earlier experience, reported in 2004/05 and 2005/06 the continued use of 2,4-D-n-butyl ester remained the preferred management option during 2006/07. As a result of this decision NRETAS applied successfully for an off-label permit from the APVMA to continue use the herbicide during 2006/07. The permit for use of 2,4-D-n-butyl ester stipulates spot application directly into cabomba infestations. Submerged nozzles are used to apply a mixture of the product and diatomaceous earth. This light silica soil absorbs the herbicide and makes it less mobile. This method of application ensures that the control is as targeted as possible and minimises extent of herbicide spread. Herbicide is primarily applied in the dry season when water is clear and flow is minimal. A high degree of sub-surface visibility is essential for targeted application and minimal flow allows herbicide will remain in the required area for sufficient time for the herbicide to take effect. Preferentially the herbicide should be applied prior to flowering to prevent seed production.

The herbicide is not allowed to be used in potable water supplies. This fact is one of the main drivers for effective control of cabomba. If it reached Darwin River Dam, control options would not be able to include herbicide use. It is noted that when the herbicide was first applied in 2004 alternate water supplies were provided by the Northern Territory Government to those who depended on Darwin River for drinking water and for irrigation.

Effective dilution and application of 2,4-D to Darwin River.

Target herbicide concentration: 10,000 g of 2,4-D ester per megalitre of water

Product chemical concentration : 800g active (2,4-D ester) per litre of raw product.

Label requirement: 12.5 L product + 5 kg diatomaceous earth mixed in 200 L water per a megalitre of water.

1 megalitre = 1,000,000 litres of water. This is calculated through a combination of water depth and surface area.

10,000 g of product per megalitre =1g per 100 litres of water.

1g per 100 litres of water =10 mg per litre of water.

Actual herbicide application is calculated considering water depth, width of spray boom/number of spray nozzles, speed of boat and pump rate (litre/min)

In 2006/07 chemical management of the Darwin River cabomba infestation involved applying 2,4–D-n-butyl ester to limited infestations in the Lok Landji Billabong. Chemical treatment for the reporting period commenced on 4 July 2006 (Table 1).

Table 1: Application of 2,4–D-n-butyl ester to Cabomba populations – Lok Landji Billabong 2006/07

Date	Amount (volume)
4-Jul-06	18 litres
19-Jul-06	18 litres
18-Aug-06	12 litres
12-Sep-06	18 litres
25-Sep-06	12 litres
29-Sep-06	12 litres
13-Oct-06	24 litres
31-Oct-06	12 litres
17-Nov-06	30 litres
23-Nov-06	30 litres
8-Dec-06	9 litres
15-Dec-06	15 litres
06/07 Wet Season	No herbicide required over wet
31-May-07	6 litres
22-Jun-07	6 litres

Note: herbicide volumes were in accordance with the off-label permit.

All application of 2,4-D-n-butyl ester was in accordance with the standards imposed by the APVMA, with specific reference to location, concentration, application technique and frequency of application. The application regime at Darwin River, as determined by the off-label permit, was not expected to have a significant impact on the ecology of Darwin River, given the highly targeted mode of application.

Precautions, including the provision of an alternate water supply where necessary and a comprehensive communication program, ensured no impact to human health or industry eventuated.

On-site inspections conducted during 2006/07 indicated that infestation levels in Lok Landji Billabong were always less than 1% of those found in November 2004. These inspections support observations that flower and seed production were prevented during the 2005/06 reporting period.

Shading and Booms

As well as applying herbicide to Lok Landji Billabong, NRETAS Weed Management Officers established shades over all plants in infestations upstream to limit plant growth and prevent flower and seed production in areas where chemical control could not occur due to water supply issues. Shading was not considered feasible in Lok Landji Billabong due to the extent of the infestation.

Weed Management Officers also constructed floating 'booms' to prevent viable fragments moving downstream into unaffected areas. These structures are essentially a floating net extending 30 cm below the water surface supported by a length of poly pipe. An inspection of these structures and survey of the surrounding water body on 23 August 2006 indicated that these structures met the objective of limiting plant growth, preventing seed production and also preventing the spread of viable plant material.

All shading and floating "booms" were removed at the end of the 2006 dry season prior to the commencement of high level wet season flows. These were not replaced in the 2007 dry season as cabomba did not reappear at any site upstream of Lok Landji billabong.

Plate 1. Floating boom constructed to prevent spread of viable fragments

Capacity Building – NRETAS staff and public

Staff training continued to be recognised as a vital component of addressing Objectives 2, 3 and 4. Constant communication has also been maintained with interstate government agencies to ensure NRETAS staff have access to the most up to date information. All staff have been involved in regular inspections of all previously recorded sites.

3.3 Public Awareness and Education Strategy 2006/07.

Objective 5: Educate the NT community as to the identification of plants within the genus Cabomba and their potential negative impacts.

NT Cabomba Eradication Communication Strategy

A Communication Strategy was developed in 2004 as an integral part of the NT Cabomba Eradication Program. This strategy was developed through significant consultation with all stakeholders. The NT Cabomba Eradication Communication Strategy aims to:

- ensure the public understands the implications of cabomba establishment and spread in the NT, and is consequently prepared to undertake measures required to eradicate the weed;
- enlist the public as the 'eyes and ears' to aid early identification of any spread or new outbreaks;
- educate the public about the danger of using species such as cabomba in private aquarium collections;
- reassure the public that authorities are dealing with the threat in an efficient and effective manner; and
- allay any concerns about the ramifications of treatment.

In 2006/07 the program included:

- the production of media releases communicating eradication efforts;
- TV advertisements;
- quarantine awareness advertisements;
- information sites at shows and field days;
- website information;
- on-site quarantine signage;
- the continued administration of the *Cabomba Hotline*, allowing members of the public to contact NRETAS Weed Management Officers as required; and
- dissemination of water quality monitoring results (herbicide levels) in Darwin River, with particular reference to observed impacts on the Darwin River ecosystem and aquaculture establishments as necessary.

3.4 Seed research program 2006/07

Objective 6: Determine the viability and longevity of Cabomba seed in the NT.

An increased understanding of cabomba reproduction in the NT's environments will greatly benefit continued management, eradication and monitoring programs.

Seed Production

Seed production research was not continued during 2006/07 as potential production levels were ascertained during 2005/06.

Seed Viability

Seed viability research was not undertaken during 2006/07 as seed viability was determined during 2005/06.

3.5: Monitoring potential off-target impacts

Objective 7: Monitor the impacts of all management activities and provide an 'early warning' mechanism in order to avoid potential off-target impacts to the environment, community and industries of the NT.

The significant economic, environmental, cultural and social implications of further cabomba infestations in the NT were key factors in the Task Force's decision to attempt to control cabomba with herbicide in 2004. The decision to use herbicide meant that a program was put in place to monitor the potential of, and to avoid impacts on the Darwin River environment, surrounding industry or on human health.

In 2006/07 monitoring included:

- surface water quality assessments included testing for 2,4-D-n-butyl ester, and dissolved oxygen; and
- macro-invertebrates as biological indicators of river health.

Appendix 1 provides a brief overview of the monitoring programs and findings.

Water quality monitoring program

Surface water samples were collected from four sites, identified as Sites A-D, for analysis of the herbicide 2,4-D-n-butyl ester. Site locations are described below and shown in Figure 1.

- Site A is in the lower freshwater reach of Darwin River below all infestations of Cabomba.
- Site B is in the estuarine section of Darwin River just upstream of its confluence with the Blackmore River.
- Site C is downstream of the Darwin-Blackmore Rivers confluence adjacent to the intake for an aquaculture operation.
- Site D is the intake pond for that operation.

Three additional sites would be monitored if herbicide was detected at Site B.

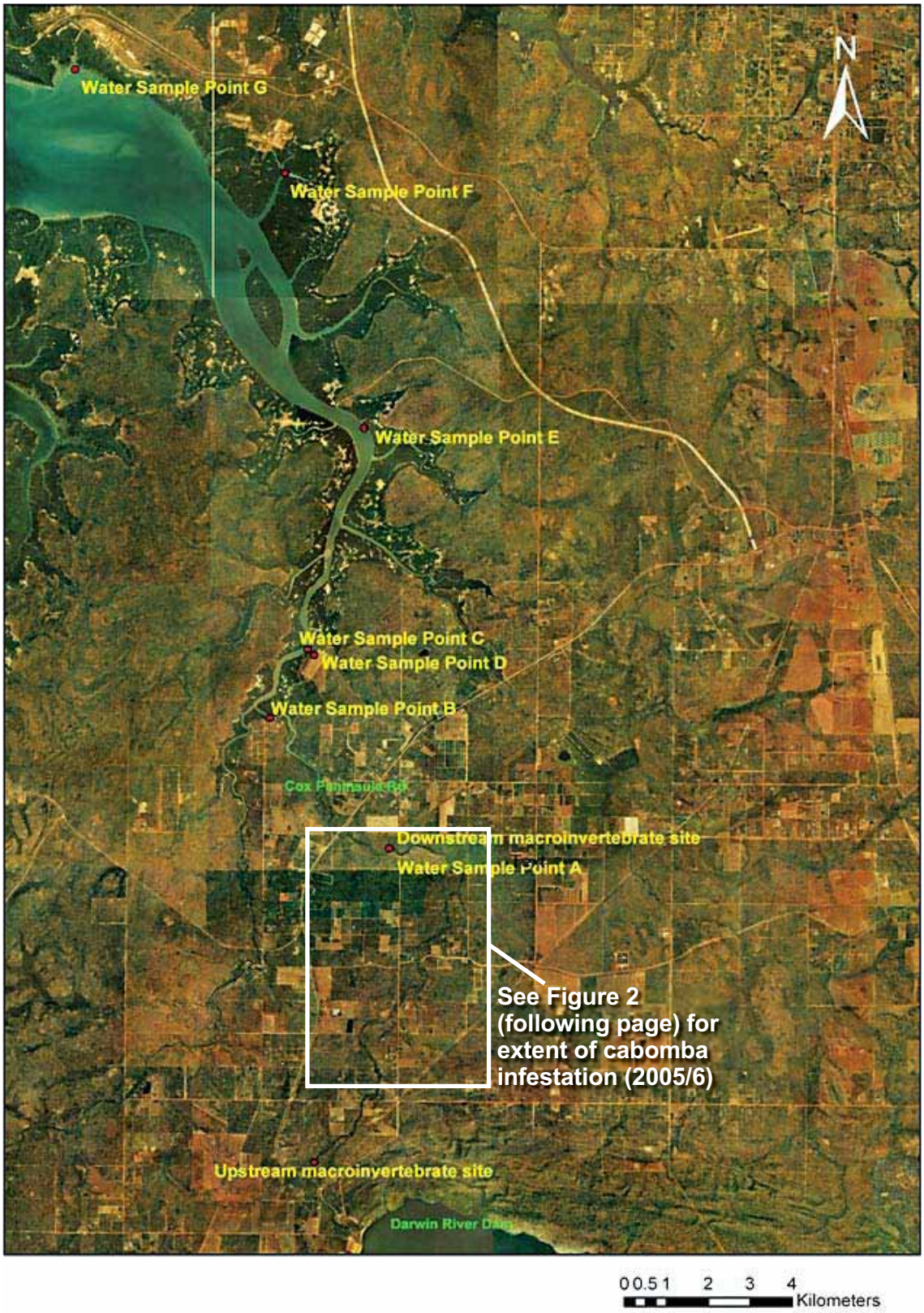


Figure 1. 2006/07 Water quality monitoring sites in Darwin River Catchment.

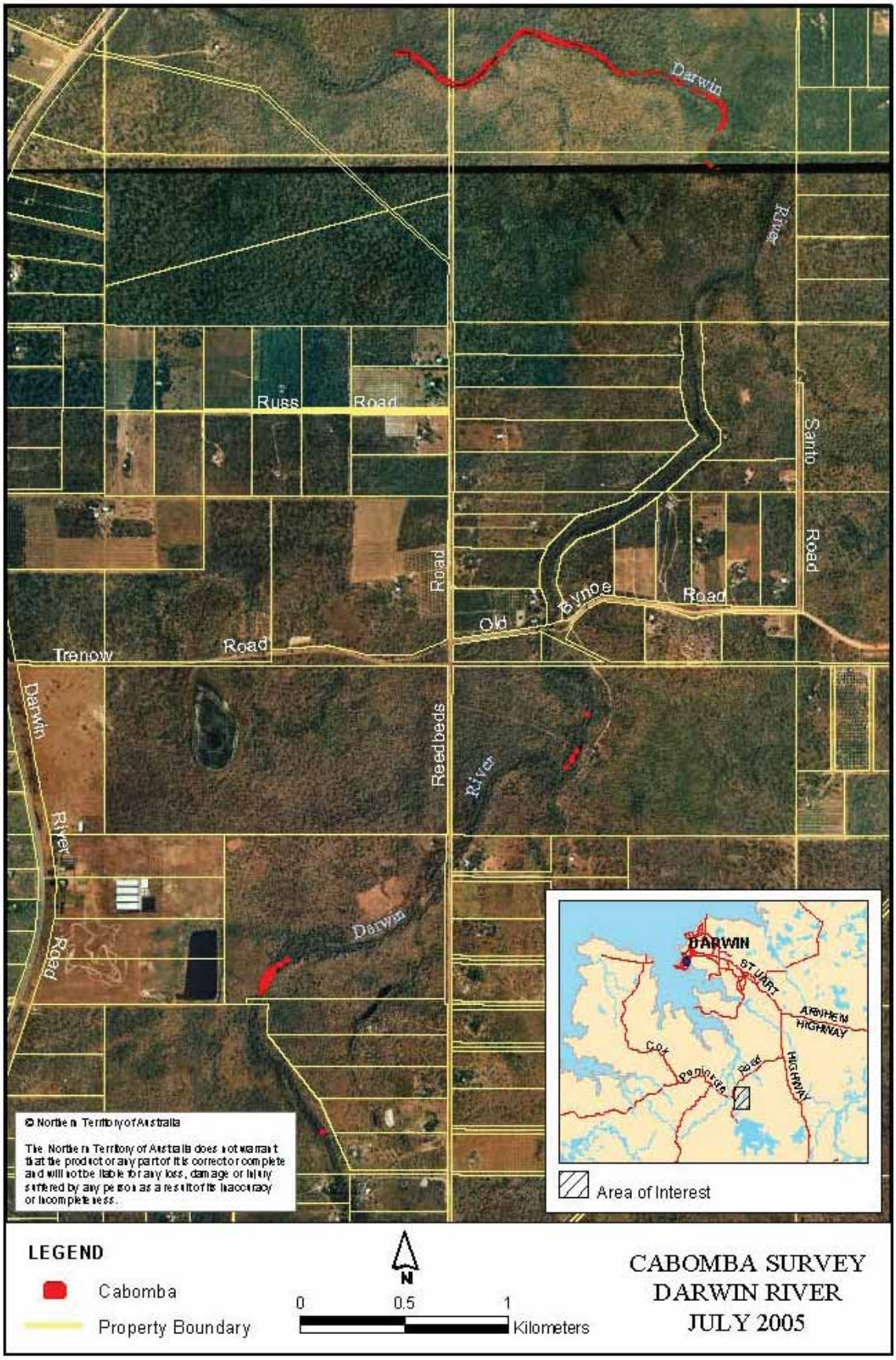


Figure 2. Cabomba Survey July 2005

It was predetermined that if the concentration of 2,4-D-n-butyl ester exceeded a 'trigger value' concentration of 1.0 mg/L at Site A, action would immediately be taken to prevent any further increase (e.g. reduce/cease application volumes) or spread to downstream areas. Action would also be taken if herbicide was detected at any of Sites B, C or D (Figure 3).

To expedite analysis, water samples collected from Sites A-C were analysed at a local NT Government laboratory where the detection limit, or minimum detectable concentration, is 0.02 mg/L. Samples from Site D were sent interstate to a National Association of Testing Authorities (NATA) accredited laboratory with a lower detection limit of 0.001 mg/L to provide additional reassurance that the herbicide was not likely to affect aquaculture operations.

2,4-D-n-butyl ester was not detected at the Darwin River monitoring sites in the 2006/07 year. This result was expected given the relatively low volumes of herbicide used. As a consequence of sampling results in 2006 and the limited herbicide application it was deemed unnecessary to continue sampling at sites D in 2007.

Table 2: Water monitoring schedule and results for 2,4-D-n-butyl ester testing at Darwin River monitoring sites, 2006/0

2006 sampling period:

Sample date	22 May 2006	30 May 2006	06 June 2006	13 June 2006	19 June 2006	26 June 2006	03 July 2006	10 July 2006	18 July 2006	25 July 2006	31 July 2006	08 August 2006	15 August 2006
Site A (mg/L)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Site B (mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Site C (mg/L)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Site D (µg/L)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

2007 sampling period:

Sample date	25 May 2007	01 June 2007	06 June 2007	13 June 2007	22 June 2007	09 July 2007	16 July 2007	31 July 2007	16 August 2007	24 August 2007	08 October 2007	19 October 2007
Site A (mg/L)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Site B (mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Site C (mg/L)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02

Notes: Sites A-C are analysed at Berrimah Farm DPIFM labs where detection limit is 0.02 mg/L. <0.02 mg/L means 2,4-D was below detection.

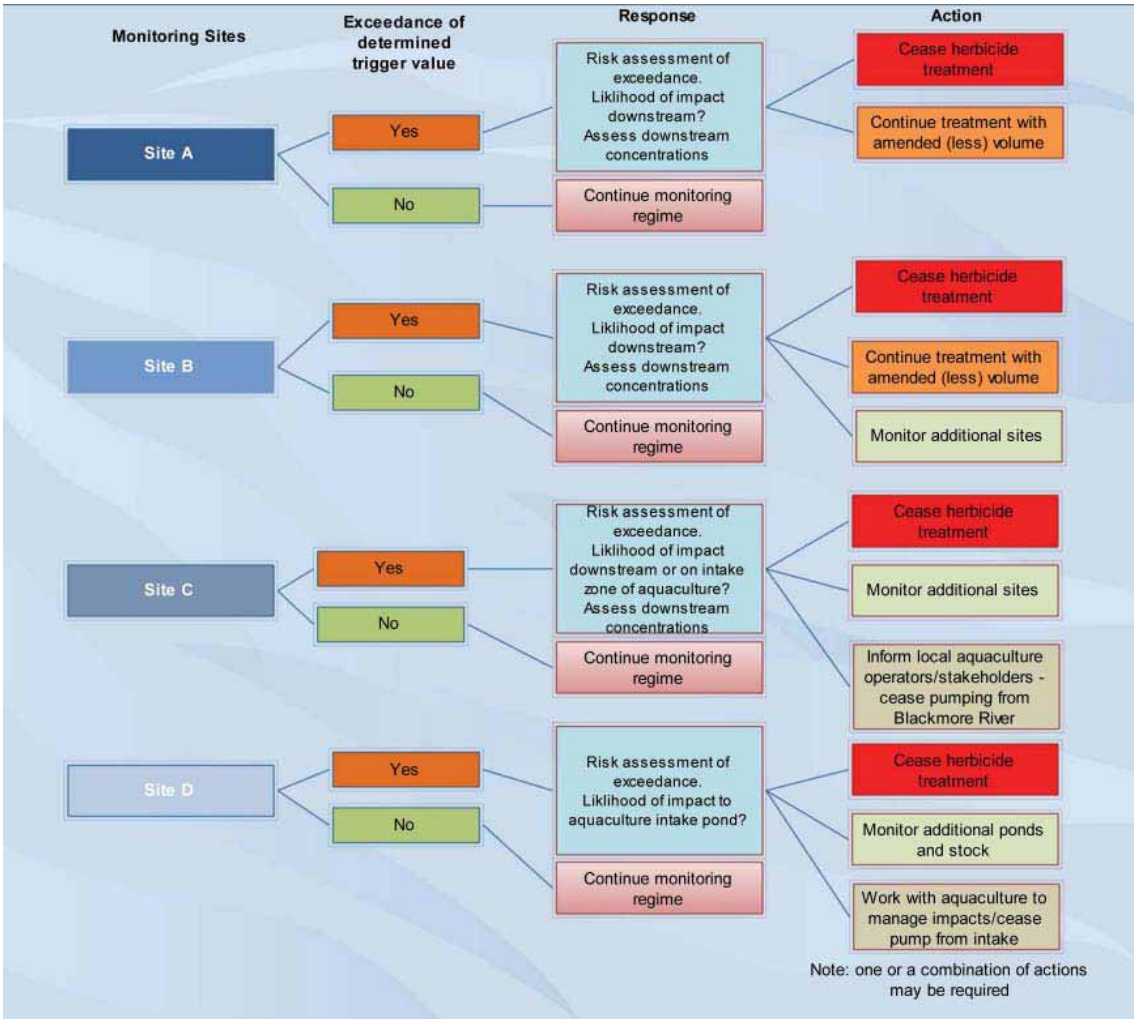


Figure 3. Adaptive assessment approach: water quality monitoring, response and management actions

Volumes of herbicide being applied would be reassessed if it was observed that site A recorded a departure from the determined trigger value (> 1 mg/L), or if 2,4-D is detected at Site B, C or D (Figure 3). A range of responses and actions would be initiated as a consequence of 2,4-D detection. These are broadly based on a risk assessment approach and would initiate further monitoring effort and management action as a consequence of where the herbicide is detected and its concentration.

Macroinvertebrate monitoring program

Macroinvertebrates are animals without backbones that are big enough to see with the naked eye. Macroinvertebrates form an integral part of the structure of most aquatic ecosystems, as they process and transfer organic material/nutrients and serve as a major food source for fish, water birds and other animals. Changes to macroinvertebrate community composition or populations can have significant implications for other organisms in the food web.

Many macroinvertebrates have limited mobility, meaning they are less able to avoid unfavourable environmental conditions. They are also sensitive to many environmental stressors. Consequently macroinvertebrate communities respond quickly to environmental changes. Monitoring of these communities can therefore tell us a great deal about the health of an ecosystem.

To evaluate whether the application of 2,4-D-n-butyl ester was having an impact on Darwin River health, a macroinvertebrate monitoring program was implemented by the Aquatic Health Unit of NRETAS. The program involved sampling in the early dry season, prior to the application of the herbicide 2,4-D-n-butyl ester and at the end of the dry season, when a possible impact would be more evident (Plate 3). The macroinvertebrate sampling sites are shown in Plate 2. The early dry season samples were examined using the national AUSRIVAS analysis system, whereas the late dry season samples were analysed using multivariate techniques. The results of macroinvertebrate monitoring were reported to the Cabomba taskforce when sample processing and data analysis was completed (Lamche 2006, Lamche 2007, Lamche 2008).

Early dry season monitoring

Using the 'Darwin-Daly region early dry season-edge habitat genus level AUSRIVAS model', results were calculated as OE50 scores. This score displays the number of observed to the number of expected or predicted taxa if the site was undisturbed. The OE50 score is related to a band, which enables easy interpretation of the results (Table 3).

Table 3: The bands provided through AUSRIVAS

Band	Description	Interpretation
X	More biologically diverse than reference	More families found than expected. Potential biodiversity "hot-spot" or mild organic enrichment. Continuous irrigation flow in a normally intermittent stream.
A	Similar to reference	Expected number of families within the range found at 80% of the reference sites. Reference sites are defined as pristine or least disturbed.
B	Significantly impaired	Potential impact either on water and/or habitat quality resulting in a loss of families.
C	Severely impaired	Many fewer families than expected. Loss of families from substantial impairment of expected biota caused by water and/or habitat quality.
D	Extremely Impaired	Few of the expected families and only the hardy, pollution tolerant families remain. Severe impairment.

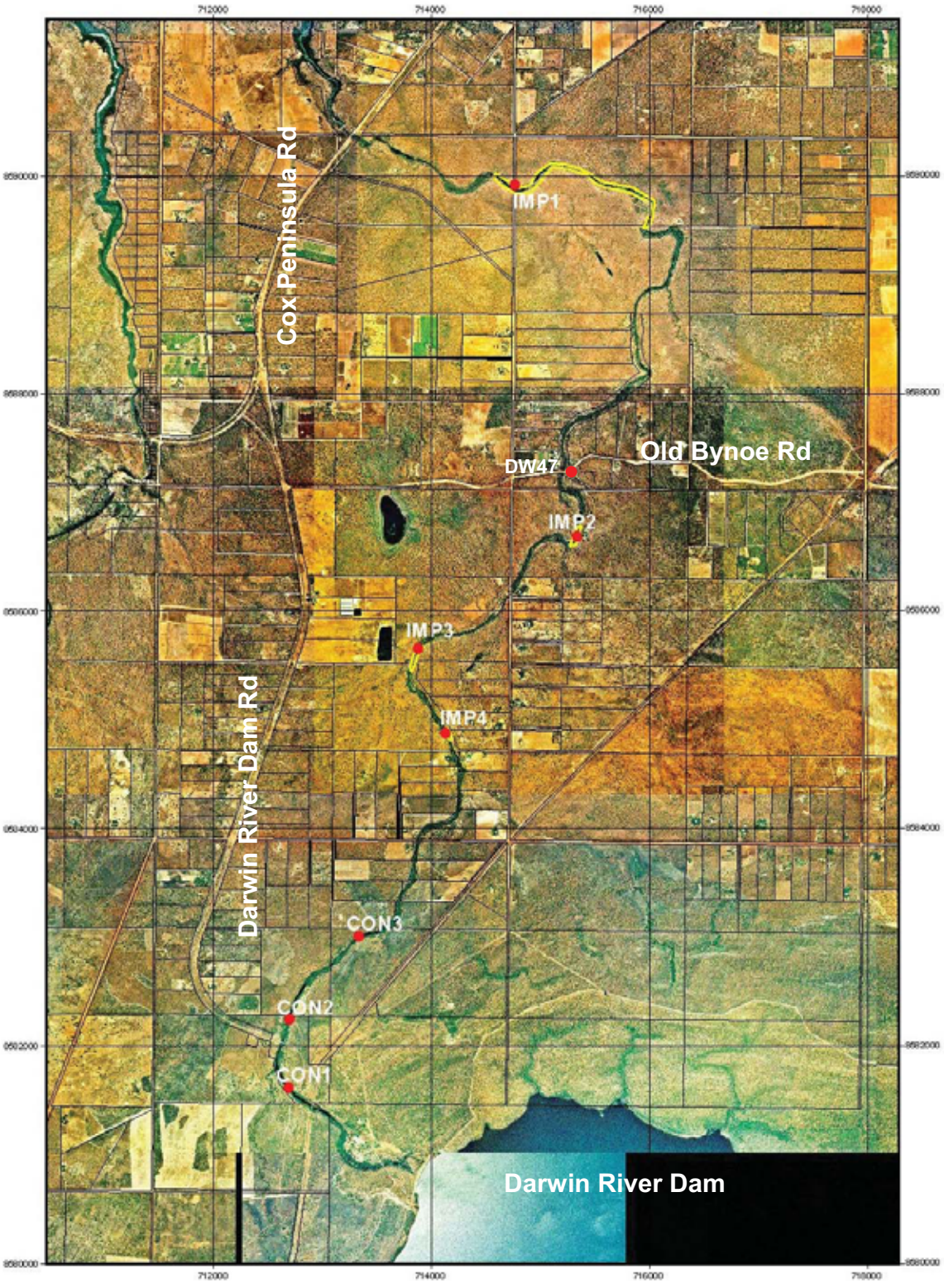


Figure 4: Aerial photograph of the Darwin River. The locations where Cabomba was detected in 2004 are marked yellow. Macroinvertebrate sample sites are shown in red

Table 4. AUSRIVAS modelling results for Darwin River sites using the Darwin-Daly-region Early-edge habitat genus-level AUSRIVAS model. Band A indicates ecological condition equivalent to reference condition, band B indicates significant impairment of ecological condition.

Site	Date	OE50 score*	Band
DW47	20-May-2002	1.10	A
DW47	04-June-2003	0.8	B
DW47	29-April-2005	0.99	A
DW47	15-June-2006	0.95	A
DW47	06-June-2007	1.04	A
CON1	07-June-2005	1.10	A
CON2	08-June-2005	0.99	A
CON3	07-June-2005	1.06	A
IMP1	09-June-2005	0.79	B
IMP2	09-June-2005	1.01	A
IMP3	09-June-2005	0.90	A
IMP4	08-June-2005	1.09	A

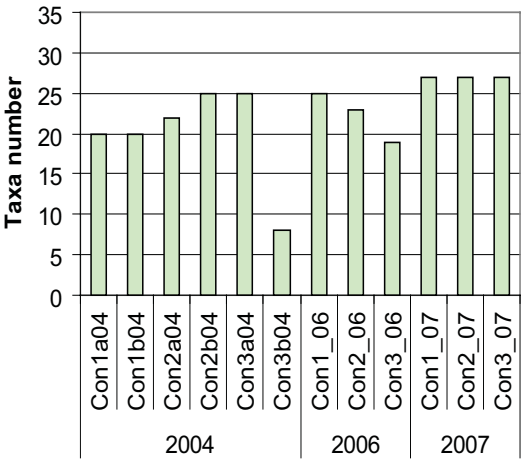
* OE50 scores might be slightly different to the ones reported (Lamche 2006) as an error in the database was discovered and subsequently fixed. Interpretation of results and conclusions remain similar.

The results of the early dry season sampling analysed with the Darwin-Daly genus level AUSRIVAS model revealed no significant change to the macroinvertebrate community at the regular monitoring site DW47 from 2002 to 2007 (Table 4) (Lamche 2006, Lamche 2007). Upstream control sites (CON) and downstream sites in Cabomba impacted reaches of Darwin river (IMP) were not significantly different in the early dry season 2005, after initial herbicide treatment in late 2004 and after a whole wet season had passed. From 2006 onwards, the monitoring of CON and IMP sites was carried out in the late dry season to allow for the assessment of the possible impact of Cabomba eradication measures before a wet season would have flushed all herbicide out and macroinvertebrate communities would have re-eastablished.

Plate 2 : Macroinvertebrate sampling, T. Boland and M. Majid, Aquatic Health Unit, NRETAS

Late dry season monitoring

The assessment was based on a BACI (before-after-control-impact) design using river edge mancroinvertebrate community abundance and taxa richness. Samples were collected at the end of the dry season in 2004, before application of any herbicide, and in 2006 and 2007, after several months of herbicide application when any impact was most likely to be detected. The communities at each of the sites have been shown to be similar at the beginning of each dry season (Lamche 2008).



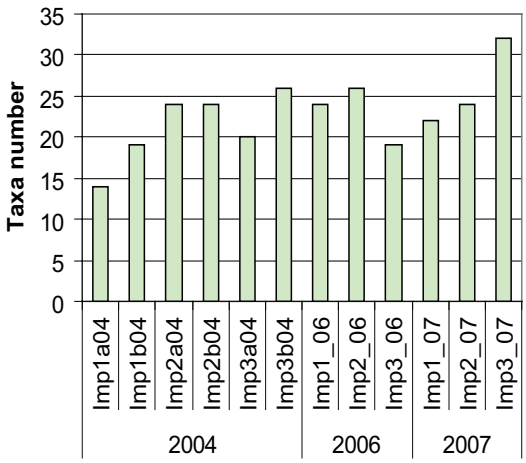


Figure 3a: Taxa number at control sites (2004-07). **Figure 3b:** Taxa number at impacted sites (2004-07). *Source: (Lamche 2008).*

The variability in taxa number was relatively low, with the control sites mainly having between 20 and 27 taxa per site with the exception of Con3b in 2004, which had a very low taxa number of 8, the lowest observed overall. The taxa number of impacted sites was also mainly between 19 and 26 with the highest number of 32 at Imp 3 (2007), a site which had a low overall abundance. The lowest taxa number of 14 was found at site Imp 1a (2004). Noting that all impacted sites had not been exposed to herbicide treatment in 2004, the taxa number data also do not display a trend distinguishing herbicide impacted or unimpacted sites, nor an up- and downstream trend or a trend over time. (Lamche 2008).

The macroinvertebrate monitoring carried out in the early and in the late dry season shows that communities have not been significantly impacted by the presence of Cabomba, nor by the Cabomba eradication measures.

Fauna monitoring program

Fauna surveys were initially undertaken in November and December 2004, pre and post treatment targeting birds, turtles and crocodiles.

All survey results indicate no measurable impact on any populations occurred as a result of the application of 2,4-D to Darwin river. No further survey occurred during the 2006/07 reporting period.

In 2004/05 the Department of Regional Development, Primary Industry, Fisheries and Resources (as the former Department of Primary Industry, Fisheries and Mines) conducted a series of fish surveys using gill nets and electro fishing techniques in both control and treatment sites. As no negative impacts were identified and herbicide applications dropped significantly since 2004/05 no further tests were deemed necessary in the 2006/07 period.

Incidental sightings during all site visits in 2006/07 included water monitors, northern water dragons, barramundi, garfish, mangrove jack, mullet, and rainbow fish. Crocodiles and turtles were also observed.

Flora Monitoring program

The application of herbicide has the potential to impact off-target species. Riparian plants with roots in the water, such as *Pandanus aquaticus* are also susceptible. Surveys assessing the vegetation cover from bank, dominants, vegetation cover from the top of water column and floristics were recorded before and after treatment in 2004/05. While localised and short term impacts were observed, including the temporary damage to individual trees there was no measurable impact on riparian vegetation or evidence that any irreversible impact on the vegetation structure and ecosystem function resulted.

The treatment areas are downstream of a four kilometre stretch of river which have not been impacted by cabomba or treated with herbicide. It is anticipated any aquatic and terrestrial plant communities harmed during the Cabomba Eradication Program will recover as native plant and seed material travels downstream and establishes in treated areas.

4. Conclusion

Public awareness, early detection, prevention of spread, prevention of seed production, prevention of establishment, the ability to manage with minimal off-target impacts, and targeted research are all components of an effective weed management program. Weed eradication may, as in this instance, require these components to be delivered concurrently.

The Cabomba Eradication Program has continued into 2006/07. Experiences to date have already resulted in further refinement of management techniques and further significant reductions in cabomba populations. Continued vigilance with respect to monitoring and surveillance will play a vital part in achieving eradication in the long term. The production of viable seed has continued to provide a challenge. The extension of the quarantine order until November 2008 will play an important part in preventing spread of viable plant material and seeds.

During the 2006/07 reporting period all objectives of the NT Cabomba Eradication Program were met, with success being measured through the following observations:

No new infestations in the NT were identified

The implementation of the Education and Awareness Program, while resulting in a number of reports of potential new infestations did not result in new positive records for the NT.

The spread of populations of Cabomba into new areas was prevented

Prevention of spread was effectively achieved through the implementation of quarantine restrictions in the project area, the establishment of floating 'booms' and also through active management of all sites where germination was detected.

Re-establishment at existing sites was prevented through management activity

Throughout the 2006/07 reporting period, all infestations were actively managed using either shades, herbicides, or a combination of both. These activities kept infestations to a level of at least 95% below those experienced in 2005/06. This reduced the potential for localised impact, further spread and subsequently reduced the requirement for herbicide application.

Seed production was prevented through the installation of shades

Once it had been determined that cabomba populations in the Darwin River were unfortunately producing viable seed every effort was made to prevent flower production, and therefore seed production, during the reporting period. The installation of shades limited infestation expansion and opportunity for seed transfer to into unaffected areas.

Monitoring programs did not indicate negative off-target environmental or economic impacts as a result of the implementation of the management program

Programs monitoring the effects of herbicide application on aquatic macro-invertebrates, riparian fauna and riparian vegetation failed to detect any measurable negative impacts resulting from management activities.

Water quality monitoring in both freshwater and saline ecosystems, did not indicate the presence of the herbicide 2, 4-D-n-butyl ester at detectable levels during the reporting period.

5. References

AusRivAS (Australian River Assessment System) is a prediction system used to assess the biological health of Australian rivers. More information is available from http://ausrivas.canberra.edu.au/Bioassessment/Macroinvertebrates/.

Australian Government – National Health and Medical Research Council and Natural Resource Management Ministerial Council, 2004, National Water Quality Management Strategy, Australian Drinking Water Guidelines 6 viewed 25 February 2008, <http://www.nhmrc.gov.au/publications/synopses/_files/adwg_11_06.pdf.

Lamche, G. (2006). Results of macoinvertebrate sampling on the Darwin River in the early dry season 2005 to assess the possible impact of Cabomba eradication program. Aquatic Health Unit, NRETA. Darwin, NT.

Lamche, G (2007). The ecological health of Darwin River in June 2007, after 3 years of eradication measures for Cabomba. October 2007. Aquatic Health Unit. Department of Natural Resources, Environment and the Arts.

Lamche, G (2008). Assessment of the Impact of Cabomba and its eradication on the Ecological Health of Darwin river. Report to the Cabomba Taskforce. Aquatic Health Unit. Department of Natural Resources, Environment and the Arts. Darwin, NT.

Northern Territory Government Department of Natural Resources Environment and the Arts, Cabomba Eradication Program Report for 2004/05, www.nretas.gov.au

United States Department of Agriculture 2008, United States Department of Agriculture, Washington DC, USA viewed 25 February 2008 <http://www.ars.usda.gov/research/publications/Publications.htm?seq_no_115=177040)

Appendix 1: Risk assessment and monitoring programs associated with use of 2,4-D-n-butyl ester in Darwin River

Risk Area	Potential for impact	Monitoring	Conducted by	Results – 2006-07
Human Health	Contamination of water used for drinking, washing and irrigation. Any contamination of water used for these purposes would require an alternative water supply to be secured.	2,4-D-n-butyl ester (trigger >1mg/L) Surface water - weekly samples collected from 4 monitoring sites on Darwin River.	NRETAS – Aquatic Health Unit	No detectable herbicide (>1mg/L) has been found in Darwin River surface water.
Environment	2,4-D-n-butyl is expected to kill cabomba and other plants in the immediate vicinity. The death of plants may deprive animals of food and cause anoxia in the water. Impacts on certain species can impact other animals, including higher order predators in the food web/chain. 2,4-D-n-butyl is also toxic to some animals, including fish. Macro-invertebrates are considered sensitive to certain chemicals and as such can be used as bio-indicators.	BACI design monitoring programs developed (Before-After Control-Impact), including: macro-invertebrates surveys; and physico-chemical parameters, including dissolved oxygen (DO) were measured during sampling.	NRETAS – Biodiversity Unit (Charles Darwin University – bird survey only) NRETAS – Aquatic Health Unit	*Crocodylus johnstoni* (freshwater crocodiles) were observed before and after treatment. Fish surveys in 04/05 indicated no significant difference between treated and untreated sites. Lower herbicide applications did not warrant further surveys. National methodologies did not indicate significant changes in macro invertebrate communities. DO levels did not fall below naturally observed minima. (NB: In 2004 low DO levels were detected and remediated using aerators.)
	Native Flora (riparian and aquatic) The application of herbicide has the potential to impact off-target species. Riparian plants with roots in the water, such as *Pandanus aquaticus* are also susceptible.	Twenty eight 5 m X 1 m deep, plots established. Depth, vegetation cover from bank, dominants, vegetation cover from the top of water column and floristics recorded before and after treatment.	NRETAS – Biodiversity Unit	No major changes were observed during the previous reporting period (2005/06). Monitoring of riparian vegetation was not undertaken due to the significant reduction in herbicide use during the reporting period.
Industry	Possible impacts on aquaculture facilities on the Darwin River, where estuary water is routinely pumped into production ponds.	As above - Monitoring sites established up-stream from aquaculture farm intake areas.	NRETAS – Aquatic Health Unit	No detectable herbicide has been found in the vicinity of aquaculture farms.