Report March 2000

Cabomba Pilot Study

An initiative of the

Lake Macdonald Catchment Care Group

Prepared for Noosa Shire Council

Appendix 1 Routine measurements taken during the study.
Appendix 2 Cabomba Action Plan
Appendix 3 Potable Water Quality Improved by Harvesting Cabomba

Summary

Cabomba is an exotic weed that infests Lake Macdonald. This pest plant is a threat to:
Nature conservation
Public safety
Water quality.

A pilot study was carried out by the Lake Macdonald Catchment Care Group from October 1999 to March 2000. Its aim was to evaluate mechanical control of cabomba.

The Queensland company, "Aquatic Weed Harvester Aust. Pty Ltd's" Model HV2600 performed well for 20 days straight with no problems.
At present, mechanical control is the only practical method of improving public safety, restoring recreational use, enhancing native vegetation and at the same time removing pollution.

Cabomba was sensitive to repeated cutting. The native plant *Hydrilla verticillata* reappeared after a six year absence. 1500 kg of nitrogen, 380 kg manganese and 216 g lead were removed in the 360 tonnes of cabomba that was cut in 20 days.

Photo 1.Harvester working near Botanical Gardens, showing clear water after cutting.

1.0 INTRODUCTION

In April 1999 the Lake Macdonald Catchment Care Group was formed to oversee activities on Lake Macdonald, a natural asset and potable water storage for Noosa Shire.

The exotic weed cabomba *Cabomba caroliniana* (Gray) infests the entire littoral zone of the dam. Noosa Council, in conjunction with the Alan Fletcher Research Station have been carrying out a research program on cabomba for the past 8 years. In October 1999 a pilot study into the effects of mechanical control of cabomba was completed.

The group will assess the pilot study report and make the necessary recommendations to Noosa Council.

1.1 Steering Group Members

Adrian Warner Community & Land Owner	Lew Brennan NSC Councillor	Bob Withers Cooloola Scouts
J & E Biersteker Community & Land Owner	Cameron Traill Maroochy Shire Rep.	Greg Dinsey Community Business
Richard Muhling Community	Dennis Riggs Community Dairy Farmer	Keith Garraty - NSC Noxious Plants
John Chandler – NSC Engineer	John Burrows Community SCEC Rep.	Brad Wedlock - MRCC DNR
Dave Burrows Landcare Rep.	Raul Weychardt NSC Director Environment and Planning	Vince Collis – Fish Hatchery & Breeder
Tom Anderson – DNR, AFRS District Experimentalist	Cr Ray Kelly NSC Councillor	Leisa Riggs – Mary River Cod Network
Becky Wandell Waterwatch & Landcare	Glenda Pickersgill WWF	Brian Stockwell - DNR ICM Rep.

Role of the Group

The group has decided to initially focus on the following tasks:-

1. **Raising Community Awareness**
   Involve Schools;
   Disseminate information.

2. **Promote Community Action**
   Organise and encourage rehabilitation projects;
   Hold Creek-Lake/Walks with people who have knowledge of the area/experts, etc
   Provide social events for information discussion of issues;
   Enhance image/profile of the assets of the Lake and surrounds.

3. **Co-ordinate recent research and its implementation**
   Acting as a community clearing house
   Assist scientists to get community involved in implementing the findings.

If you would like any further information contact Keith Garraty (5485 1833) or Tom Anderson (33750747). See Appendix 1.

1.2 Pilot study funding.

Agency	Amount $	Supplier	Purpose
Noosa Shire Council	$28,700	Aquatic Plant Harvesters Pty Ltd	Machinery hire
“	$ 9,000	Abyss Diving Services	Diving
DeptNaturalResources	$10,000	Alan Fletcher Research Station	Scientific
“	$ 3,000	Qld Health Laboratories	Analysis

1.3 Role of Water Plants

Aquatic plants are an important part of freshwater systems. They perform a wide variety of ecological functions. Plants provide nesting sites, cover and food for all kinds of aquatic life, including fish, waterfowl, insects and smaller animals. Plants invigorate the water body by increasing oxygen concentrations in the water and sediments. Rooted aquatic plant communities help secure and stabilise shorelines. In some cases aquatic plants help improve water clarity by competing for nutrients with algae. One major role of plants is to act as a buffer against pollution, soaking up inflows of chemicals. These are but a few of the beneficial roles that aquatic plants play.

Under certain conditions, however, aquatic plants can become a problem. Excess growth of aquatic plants can affect beneficial uses of a water body, such as recreational and aesthetic enjoyment, irrigation and water supply uses, and wildlife habitat. In addition, invasion by non-native (exotic) plant species, such as cabomba can seriously damage an aquatic ecosystem. Exotic weeds can choke out native vegetation, and can form dense stands that are a nuisance to humans, as in Lake Macdonald. Exotic weeds can also create poor habitat for fish and wildlife.

1.4 Cabomba

Cabomba is an American submerged water plant, introduced into Australia by the Pet Industry as early as 1930. It is a true aquatic and does not survive out of water. In recent years the plant has been recognised as a weed. Infestations range from Victoria

in the south to Papua New Guinea in the north. Its potential for spread is enormous as it can tolerate cold as well as tropical conditions. The problem caused are:-

- Degradation of water quality;
- Destruction of conservation/wildlife areas;
- Interference with recreational activities.
- Economic burden on the general community.

Depending on water quality, cabomba grows best at depths of 0.5-5m. It is a home in fast flowing or still waters. The main identifying feature is leaf insertion, ie two leaves are attached opposite each other at each node, also each leaf has a petiole. Its common name is 'fan wort', which refers to the leaf structure, as it resembles a flat fan made up of some 200 finely divided sections. Each plant has a growing point rooted in the bottom from which 3-90 reddish stems 2-6mm thick rise to the surface. Under water the plant forms an erect flexible bundle of strong stems capable of entangling a diver. The stems and leaves are covered in epiphytic algae and mud. Flowers are held above the water surface, and are white with 6 petals. Apparently Australian cabomba is sterile as no evidence of viable seed has been found yet. Propagation is by vegetative means only.

Photo 2. Submerged cabomba showing flower and leaf.

Cabomba's graceful foliage is attractive, it is easy to sell and has served the aquarium trade well. It is tough, easily propagated, transports well and tolerates fish molestation. These hardy characteristics also indicated weediness. First herbarium records in Australia are 1967; there seems to have been an initial lag period of a few decades before the plant escaped and naturalised in the wild. During this time it was probably planted in some creeks by unscrupulous dealers in water plants. During the 1980's reports of wild Cabomba trickled in from New Guinea to Victoria. In Queensland records of first detection include: 1985 the Caboolture River, 1989 Atherton, 1991 Lake Macdonald, 1992 Atherton, 1993 Ewen Maddock Dam and Cairns.

Cabomba is a declared pest plant throughout Queensland under the Rural Lands Protection Act 1985.

In the USA the plant has been reported as a weed, of little value to wildlife. Divers in Queensland have noticed few animals in the dense growths of Cabomba. It is a strong competitor, forming monocultures of serious concern to nature conservation. Also the risk of drowning through physical entanglement is a real danger to swimmers, fisherman and people working at an infested site.

Like many problem aquatic plants, cabomba can reproduce from small fragments. Cabomba stems become brittle in late summer, which causes the plant to break apart, facilitating its distribution and invasion of new water bodies. A conservative estimate of the money spent on cabomba in Australia since 1993 would be well over $1 Million.

1.5 Lake Macdonald

Lake Macdonald is a man made impoundment on Six Mile Creek located at the head waters of the Mary River system. The storage supplies potable water to Noosa shire.

Its catchment is zoned 'Rural Catchment', however some 'Rural Residential' zoning and the town of Cooroy are within this area. Activities allowed on the dam are recreational with restrictions on power boats. Hydrological data relevant to the lake is summarised as:-

Photo3. Noosa Shire's potable water storage, Lake Macdonald.

- Mean annual catchment rainfall 1614mm,
- Catchment area of 49.4 km^2, surface area 250 ha;
- Storage volume 8000 ML;
- Resultant annual catchment runoff 297mm;
- Net utilisation of stream flow 22.5%;
- Storage water can be described as slightly eutrophic with a pH of 6.5 to 7.0, highly coloured, high in organic content, low hardness and low alkalinity. During the warmer months of the year the lake experiences several 'turn-overs', induced by thermal and chemical stratification.

Noosa Shire Council has promoted the interests of native fish by funding the Gerry Cook Hatchery, resulting in the successful stocking of the lake. Today the lake is a popular spot for anglers where good catches of yellow belly, silver perch, mary river cod and saratogas are taken. Lake Macdonald Amateur Fishing Club hosts regular fishing competitions.

In April 1991 the pest plant Cabomba was reported at Lake Macdonald. By 1995 cabomba had invaded most of the shallow littoral zone which covers an extensive area of the lake. Submerged species replaced by cabomba were; hydrilla, *Hydrilla verticillata*, thin leaf naiad, *Najas tenuifolia*, pondweed, *Potamogeton javanicus*, and bladderwort, *Utricularia sp*. Emergent species consist of water snowflake *Nymphoides indica,* tall spikerush *Eleocharis sphacelata*, hygrophila *Hygrophila costata*, and knotweeds *Polygonum spp.*

1.6 Management

Noosa Shire Council and the Alan Fletcher Research Station (AFRS) have a joint research project investigating the plants biology/ecology and its impact on water quality. The aims are to gather data which will provide an understanding of this pest, enabling informed decisions to be made about its management. Australia's National Weeds Strategy lists 20 very serious weeds. Cabomba is on that list as a' Weed of National Significance'

It is important to carefully evaluate any cabomba control options. In the past cabomba eradication programs have not worked. This project places great emphasis on ecological and biological control methods, that have long term benefits and are not environmentally disruptive.

There is very little information available in the world literature which deals with cabomba control or its impacts. Therefore the data gathered from Lake Macdonald is of great interest to science and the rest of the world.

1.6.1 Management Options

Drawdown

Drawdown or the deliberate lowering of water levels is a management tool widely used in the USA. Man made dams and weirs can have stable water levels, that stay near full for long periods. Many exotic water plants thrive in stable impoundments. By reducing water levels between 1-3m and allowing the exposed banks to dry out, true aquatics like Cabomba are adversely affected. The overall impact of drawdown on Australian native plants is minimal. Australian wetlands have evolved in a drought, flood cycle. Accordingly most native water plants have survival strategies to overcome drawdown.

A severe drought at the end of 1994 caused water levels in Lake Macdonald to be drawn down by 1.2m. As the exposed Cabomba infestation dried out 60 plant bases were tagged. Ten weeks after reflooding, divers located 36 of the 60 tagged plants. None of the tagged bases had regrowth, indicating the dried plants were dead. However, free floating Cabomba fragments (30cm in length) originating from plants growing in deeper water reinfested the drawdown area within 10 weeks to a density of 3 plants per m^2. 100 random grapple samples from the area scored 55% live Cabomba hits. Clearly, drawdown by itself would not provide long term control of Cabomba.

In an integrated pest management strategy drawdown is a very useful method of killing Cabomba in shallow areas. Also it reduces the area of infestation needing further treatment.

Understandably, in a dry country water engineers resist using drawdown, preferring to keep dams full.

Drawdown	
Advantages	**Disadvantages**
Economical	Wastes water
Pollution free	Weather dependent
Safe	Unsightly

Chemical

Herbicides are useful tools of food and fibre farming. They are an integral part of pest eradication programs. Provided the weed has been detected early in its spread, an

appropriate chemical could be used to destroy the new colony. However once a weed has become a permanent resident, the chances of eradication are slim.

Cabomba has formed a monoculture over the entire littoral zone of Lake Macdonald. It is here to stay and eradication is not possible.

Cabomba is a difficult plant to control using herbicides. Screening trials conducted by the Alan Fletcher Research Station reveal only a few molecules have any activity against cabomba. The plant is protected by a mucilage film that stops chemical penetration. The most effective chemical against cabomba is 2, 4-D ester.

Public concern about the use of chemicals, especially in water storages and densely populated areas means any chemical program would be subject to controversy and just plain foolish. Eradication is not a management goal for Lake Macdonald; therefore herbicides should not be considered at all.

Chemicals	
Advantages	**Disadvantages**
Economical	Public opposition
Effective	Pollution
	Risky politics
	Non-target damage

Biological Control

Classical biological control involves reuniting the plant with its natural enemies. In cabomba's case, the plant has been spread as an aquarium specimen and its pathogens and insect fauna have been left behind in the country of origin, Guyanna. This type of scientific research is very expensive and there are no guarantees of success. Other South American water plants have been controlled using biological agents, for example Alligator weed, Salvinia and water hyacinth. Other submerged plants eg hydrilla and Eurasian milfoil have also been controlled by insect enemies. Introducing natural enemies is a long term solution and one can only hope that CSIRO is funded to carry out a cabomba program in the near future. The Lake Macdonald Catchment Group favours environmentally friendly technology, making biological control one of the group's long term goals.

Biological Control	
Advantages	**Disadvantages**
Pollution free	Expensive approx ($600,000)
On-going self sustaining	May not work at all
Natural	Only controls one weed species
Safe	

Mechanical management

Special machines designed to cut, load, carry and unload water weeds are common in the USA. In Louisiana 2200 machines help keep the state's waterways clean. The appeal of mechanical removal is the results are immediate, instant clearing of the weed giving water managers complete control. Another important consideration in polluted waters is the removal of nutrients from the system which enhances water quality. A machine is not selective. It removes all weeds leaving clear water behind, whereas other methods such as chemical and biological control are specific to some plant species.

One drawback is that plants need repeated cuttings, but this could be viewed as an employment opportunity.

Mechanical Removal	
Advantages	**Disadvantages**
Economical	Needs repeated cuttings
Available now	Disposal of weeds
Nutrient removal	Machine maintenance
Pollution free	Stump relocation
Addresses public safety	Removes all plants
Improved aesthetics	

Scuba Diving

Cabomba can be effectively removed by hand using professional divers. The plant is a herb, it has the same growth habit as land herbs such as thistles, rag weed, or a cabbage ie. a main stem and a single root system. It has no runners or rhizomes which are characteristics of grasses. Cabomba can be grabbed by the stem and pulled out entirely. Diver removal would be applicable to small infestations or as a window dressing operation. It is extremely expensive and very dangerous. There are two laws controlling diving in the work place. Code of practice for recreational Diving at a Workplace, and Code of practice for Recreational Snorkelling at a Workplace.

Scuba Diver Removal	
Advantages	**Disadvantages**
Effective	Very costly
Instant result	Extremely dangerous
	Slow

Do Nothing

To do nothing is an easy option, but would be totally inappropriate because:-

- It promotes spread of the weed
- It ignores public safety issues
- It destroys recreational and nature conservation values
- Cabomba being a Weed of National Significance has a high profile
- Cabomba is a declared pest plant.

The legislative structure in Queensland clearly outlines the obligations of Local Government to control pest plants. It is listed as priority P3 in the declared plants schedule of the Rural Lands Protection Act 1985. This means that infestations must be reduced and it is illegal to sell or keep the plant throughout the state.

1.7 Mechanical Control history on Lake Macdonald

The only manufacturer of aquatic weed control machinery is (Aquatic Plant Harvesters Australia Pty Ltd) based in Brisbane.

In 1994 Noosa Shire trialed the HV3000 Model, it was a large machine with a 3.0m wide x 3.0m deep cutting mouth. The cut weeds were lifted by a conveyor onto a storage area, when full they were transported to the bank and disposed of by a back hoe.

Problems encountered in 1994 were:-

- Machine was too large
- Damaged its cutting teeth on submerged objects
- The conveyor mesh stretched and caused drive break downs

The overall exercise showed that Cabomba could be controlled and that there was an improvement in water quality. (See Appendix 2.)

In 1999 the Lake Macdonald Catchment Care Group commissioned a pilot study into the effectiveness of a new machine the HV/2600. This pilot study involved a much larger area and looked at the problem of weed disposal.

Photo 4. Recreational hygiene, cleaning cabomba from a boat trailer.

Photo 5, 6. Infrastructure improvements to help quarantine cabomba.

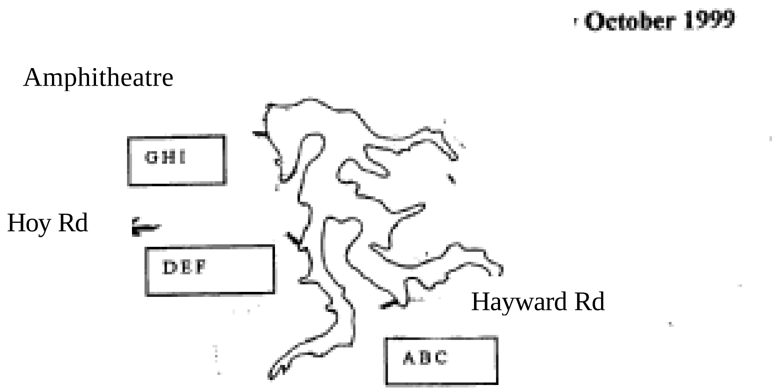
2.0 METHOD

2.1 Experimental design for the current study

Three separate inlets of the dam were chosen as pilot study sites, they are:-

- Hayward Road;
- Hoy Road;
- Amphitheatre.

Lake Macdonald Pilot Study



There were three treatments: 1 single cut, 2 cuts (letting the plants regrow then repeating the cut) plus a control. (control is an undisturbed site.)

The experimental design used was a randomised block with three replicates. The experimental unit was a 1.0m² quadrat used to gather plants from three separate sub-sites at each location.

Location	Treatment codes		
	Control	**Cut once**	**Cut twice**
Hayward Rd	A	B	C
Hoy Rd	D	E	F
Amphitheatre	G	H	I

2.2 Scuba Divers & Measurements

Plant data was gathered using scuba divers. A one square metre quadrat was used to gather the plant samples.

Samples were assessed for plant fresh weight, species composition, plant number, plant length, stem brittleness, %flower and %leaf.

Records were taken of water depth, water appearance, wave height, temperature, dissolved oxygen and seechi disc readings. Water surface samples were forwarded to the Queensland Health Laboratories for water quality analysis.

Observations were carried out on a weekly basis from 19/10/99 to 01/03/00.

2.3 Machine HV2600

Mechanical control using model HV2600 started on 18th October 1999 and finished work on 11th November 1999 (19 working days).
The second cut started on 8th November at Hayward Rd and on 10th November at the Ampitheatre site.

Weeds were cut and transported to a compactor truck, then moved to a bunded area at a disposal site in Cooroy, specially formed for this operation.

The average depth of cut was 0.8m below the water surface.

The machine HV2600 has a capacity of $5m^3$ and removed 159 loads in 19 days. Cabomba waste was loaded into a garbage compactor truck with a tare of $19m^3$. In all 18 truck loads totalling $342m^2$, ie 360 tonnes were removed from the test sites.

Photo 7. Aquatic weed harvester HV 2600.

3.0 RESULTS and DISCUSSION.

3.1 Plant growth.

Conditions on the lake during the pilot study were not favourable for optimum cabomba growth. Inflows of rain caused dirty water and water temperatures were low. Cabomba was also observed to be sensitive to winds and waves, particularly at the Hoy Rd. site where he inlet has a south east alignment and waves over 100mm. were frequent. Wind causes the leaves to be stripped from the plant.

Table 1.

Cabomba response to mechanical control (fresh weight kg/m^2)

Treatment	6th Oct	19th Oct	26th Oct	2nd Nov	9th Nov	16th Nov	23rd Nov	30th Nov	1st Mar
Control	2.6	4.4	4.7	3.0	5.0	4.9	7.1	4.0	6.4
1 Cut	3.3	2.0	2.6	3.9	3.4	4.3	3.9	2.9	5.5
2Cuts	3.1	2.4	3.3	3.7	1.8	2.1	2.3	3.8	4.0

Plant weights per square metre are in Table 1. To convert these to tonnes per hectare they should be multiplied by ten. (4.4kg/m^2 becomes 44 tonnes per hectare).
Cabomba standing crop for the study averaged 47 tonnes per hectare, which was down on previous years measurements of about 77 tonnes per hectare. The highest crop weights were recorded in late November at 71 tonnes per hectare.
Each figure in Tables 1-3 is the average of 9 samples gathered from three subsites at each of three replications. Mechanical removal started on the 19th October for the single cut and was repeated on the 8th November for the second cut of the 2 cut treatment. Observations taken on the 1st March are 19 weeks after the first cut.

Table 2.

Cabomba response to mechanical control (plant number /m^2)

Treatment	6th Oct	19th Oct	26th Oct	2nd Nov	9th Nov	16th Nov	23rd Nov	30th Nov	1st Mar
Control	4.3	5.3	7.0	7.3	6.4	7.7	5.6	6.2	6.2
1 cut		9.3	6.7	5.9	6.6	7.2	6.0	6.7	7.9
2 cuts		4.5	4.3	5.2	5.4	6.0	5.2	4.9	4.9

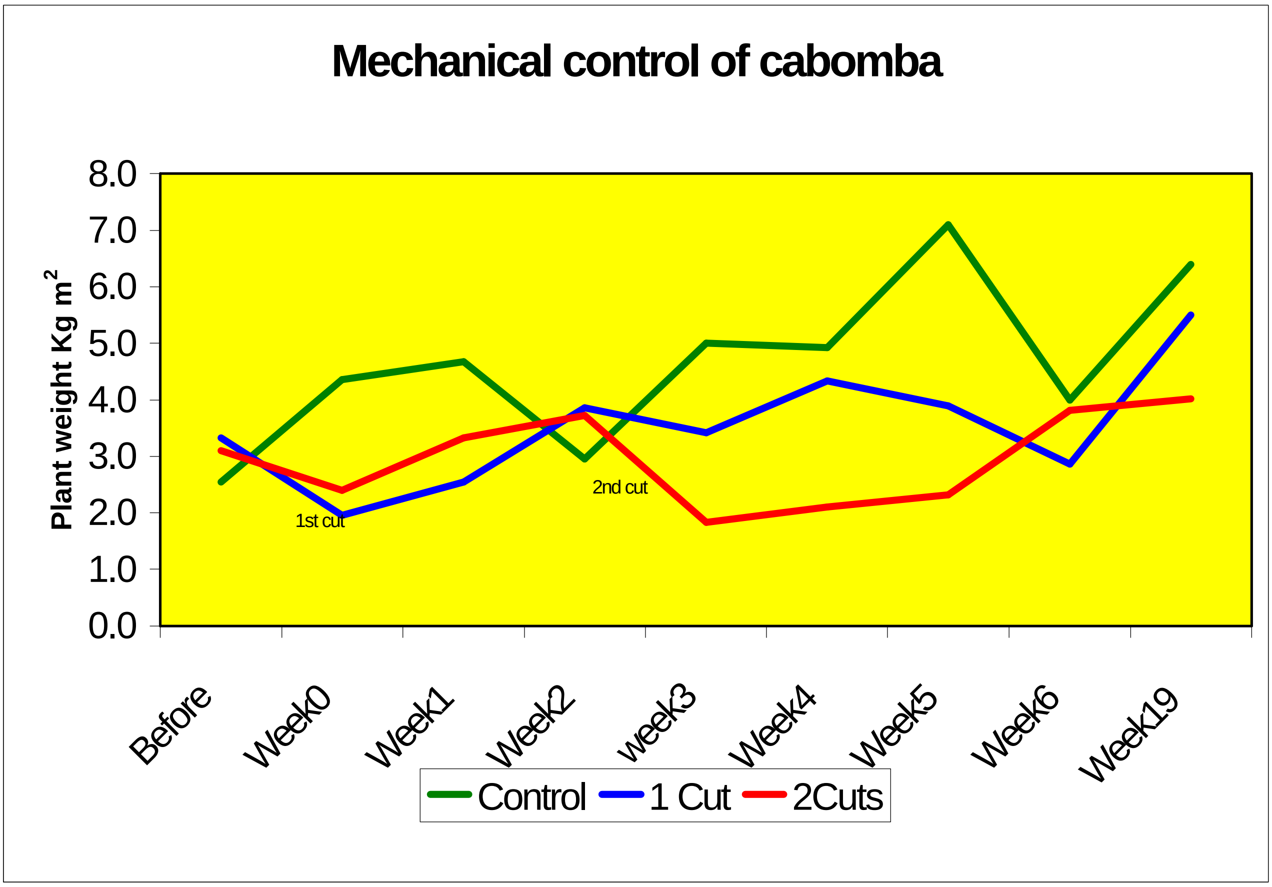
Results in Table 2 show no effect on plant number per square metre. Diver's observations were that the plants in the cut areas had increased in number but the figures don't support these observations.
The red line in Figure 1. represents a cut twice treatment which shows that the cabomba infestation took a long time to recover after the second cut.

Table 3.

Cabomba response to mechanical control (plant length m)									
Treatment	6th Oct	19th Oct	26th Oct	2nd Nov	9th Nov	16th Nov	23rd Nov	30th Nov	1st Mar
Control		2.5	2.8	1.8	2.0	2.7	2.3	2.2	2.2
1 cut	2.5	1.3	1.6	1.4	1.8	1.5	2.1	1.1	
2 cuts	2.5		1.3	2.2	1.2	1.7	1.6	2.0	

Photo 8. Collection of data.

Figure1. The effect of mechanical control of cabomba on plant biomass.



The red line in figure 1. represents the cut twice treatment, which shows that the cabomba infestation took a long time to recover after the second cut.

Table 4. The effects of mechanical control of cabomba on plant biomass.

Cabomba response to mechanical control, fresh weight kg/m^2										
Site	**Rep**	**6th Oct**	**19th Oct**	**26th Oct**	**2nd Nov**	**9th Nov**	**16th Nov**	**23rd Nov**	**30th Nov**	**1st Mar**
Control	A1	1.9	2.3			3.9	4.1	7.1	3.5	
Hayward	A2	2.1	3.3			1.9	7.5	6.9	3.5	
	A3		3.2			4.8	5.8	7.2	5	6.4
	Av	**2.0**	**2.9**			**3.5**	**5.8**	**7.1**	**4.0**	**6.4**
Ampi	G1			7.5	3.4	2.9	10.9	2.7	8.0	1.3
	G2			6.9	2	5.5	6	6.7	7.7	
	G3			4.6	3	2.8	10.6	4.6	5.7	
	Av			**6.3**	**2.8**	**3.7**	**9.2**	**4.7**	**7.1**	**1.3**
Hoy Rd	D1				2.2	6.8	2.2	1.1	4.3	
	D2				5.3	10.1	2.4	1.2	3.1	
	D3				3.9	8	2.1	4.7	5.5	
	Av				**3.8**	**8.3**	**2.2**	**2.3**	**4.3**	
Average control		**2.0**	**2.9**	**6.3**	**3.3**	**5.2**	**5.7**	**4.7**	**5.1**	**3.9**
One cut	B1		1.7	1.3	1.2	2.1	2.4	2.2	2.6	5.3
Hayward	B2		1.8	3.5	1.3	1.4	2.2	2.4	1.8	5.7
	B3		3.4	1.4	1.1	1.9	2.3	2.3	4.2	
	Av		**2.3**	**2.1**	**1.2**	**1.8**	**2.3**	**2.3**	**2.9**	**5.5**
One cut	H1			1.2	2.2	4.7	8.1	7.6	2.7	
Ampi	H2			2	3.5	8.8	4.8	7	9.2	
	H3			1.5	2.8	5.7	5	5.3	4.6	
	Av			**1.6**	**2.8**	**7.3**	**6.0**	**6.6**	**5.5**	
One cut	E1				1.5		3.9	2	3	
Hoy Rd	E2				2.4	2.9	4.2	2.8	4.9	
	E3				2.1	2.6	3.8	2.6	4.3	
	Av				**2.0**	**2.8**	**4.0**	**2.5**	**4.1**	
Average 1 cut			**2.3**	**1.8**	**2.0**	**3.9**	**4.1**	**3.8**	**4.1**	**5.5**
Two cuts	C1		2.4	2.8	2.2	1.6	1.6	1.6	1.3	4.9
Hayward	C2		2.4	3.6	2.6	2.6	1	1.9	3.1	
	C3		1.3	3.2	7	2.1	3.4	1.7	3.8	3.1
	Av		**2.0**	**3.2**	**3.9**	**2.1**	**2.0**	**1.7**	**2.7**	**4.0**
Ampi	I1	3.2		3.6	3.8	1.6	2.5	2.3	6.5	4.2
	I2	3			2.5	1.1	1.6	1.9	3.6	6.9
	I3			1.8	4.1	2	2.5	4.5	4.6	1
	Av	**3.1**		**2.7**	**3.5**	**1.6**	**2.2**	**2.9**	**4.9**	**4.0**
Average 2 cuts		**3.1**	**2.0**	**3.0**	**3.7**	**1.8**	**2.1**	**2.3**	**3.8**	**4.0**

Table 5. shows all the plant weight data collected from individual locations. This information is summarised in Table1 and Figure1.

Results:

3.2 Native plants

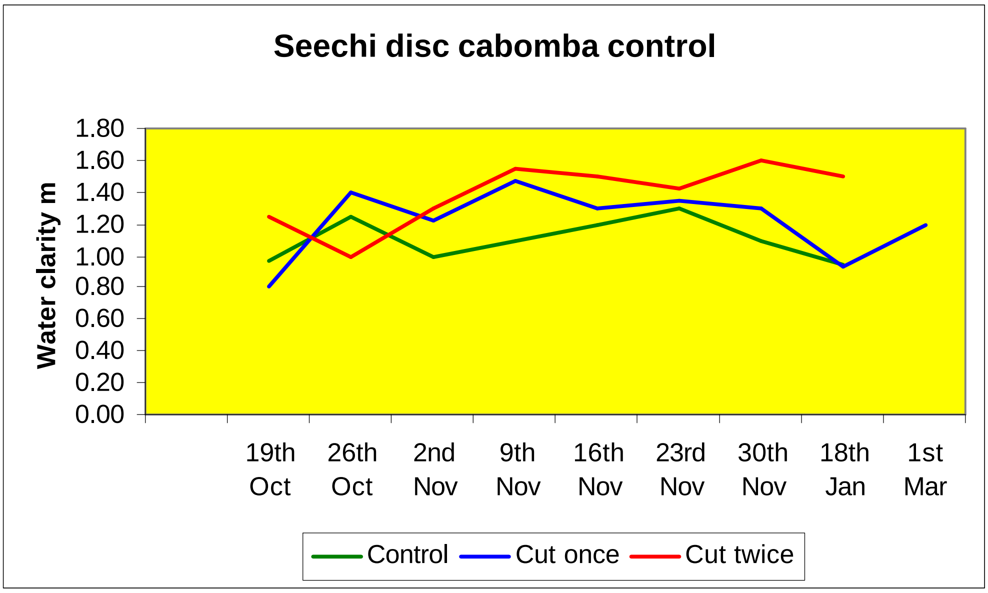
Plant samples have been gathered from the lake for the last 6 years. In that time no native submerged plants have been observed. There once was an underwater plant community of Hydrilla, Najas, Potamogetons, bladderworts and stoneworts. Towards the end of this study 2 Hydrilla plants were brought up in the diver's samples. These plants were in the cut twice areas, which is very encouraging.

3.3 Machine HV2600

The machine operated for 20 days without any breakdowns, a big improvement since the 1994 trials. The operators lowered the cutting mouth as deep as possible but cutting depth depends on the likelihood of hitting underwater stumps and understandably divers were cautious in new territory. The average cut was 0.8m depth and removed about 13 tonnes of cabomba per hectare. The machine became difficult to manoeuvre in winds over 30 knots.

A safer walkway between the machine and the compactor truck would be an improvement. However the use of a compactor is a big step forward in handling of cut material and it overcomes the legal obligations for secure and safe transport of a declared pest plant.

Figure 2. The effect of mechanical control on water clarity.



Water clarity is measured using a Seechi Disc; it is an optical evaluation of water quality. In the 1994 trial there was an improvement in water clarity after mechanical control. This effect was also recorded in the 1999 pilot study. The reasons for this clarity are not easily explained but in Figure 2 there is a clear trend. Mechanical control improves water clarity.

3.4 Cabomba chemical composition.

During the 19 days of mechanical control, 360 tonnes of cabomba was removed. Cabomba decomposes very quickly. When it is left in a heap for more than two days, the plant exudes a black liquid like molasses. Samples of cabomba were taken from the HV2600 machine and sent to Queensland Health Laboratories for analysis; results are in Table 6.

Cabomba has an epiphytic growth of algae and bacteria plus silt covering its surface. The plant is not affected or harmed by this muck, it may even be some sort of synergistic relationship. The high mineral content in the analytical results may be due to this epiphyte load. There clearly is biological amplification of heavy metals, as 380 kg of manganese and 216 g of lead were removed in the pilot study. Also 1,500 kg of nitrogen was accounted for.

Analysis of the liquid draining from cabomba under pressure in the compactor truck is presented in Table 7. Assay determined that the draining liquid is high in minerals and nitrogen when compared to the water the cabomba was growing in. This liquid could easily be caught and disposed of.

Table 5. Analysis of fresh air dried cabomba, and quantities removed from Lake Macdonald in pilot study, Nov 1999

Substance	Cabomba plant	Quantity/cut ha	Total for pilot study
Protein	13.3%	340.0kg	9,500kg
Nitrogen	2.13%	55.4kg	1,500kg
Phosphorus	0.17%	4.4kg	122.4kg
Potassium	1.77%	46.0kg	1,300kg
Calcium	0.53%	13.8kg	380.0kg
Magnesium	0.22%	5.6kg	158.0kg
Sulphur	0.41%	10.6kg	300.0kg
Sodium	2.17%	56.4kg	1,500kg
Chloride	1.27%	33.0kg	91.4kg
Copper	12.0mg/kg	31.2g	860g
Zinc	73.0mg/kg	189.8g	5.3kg
Manganese	5400mg/kg	14.0kg	380kg
Iron	19,000mg/kg	49.4kg	1,360kg
Boron	63.3 mg/kg	164.4g	4.5kg
Mercury	0.13mg/kg	0.3g	9.4g
Lead	3.0mg/kg	7.8g	216.0g
Cadmium	0.47mg/kg	1.2g	33.8g
Minerals total	32%	4.1tonnes	23,000kg

Quantity of elements removed per hectare were calculated on the average cut of 13 tonnes per hectare being removed.
Values in column (cabomba plant) in Table 6 are for air dried cabomba, and in column quantity cut/ha. And Total for the pilot study are as fresh weight.

Table 6. Analysis of liquid draining from cabomba under pressure in compactor truck compared to dam water.

Analyte	Truck liquid	Dam water
Conductivity	520	120
pH	6.6	6.7
Total diss. solids	260	63
Colour	210	74
Turbidity	59	3
Total sus. solids	130	<10
Sodium mg/kg	53	15
Potassium	25	1.7
Calcium	8.1	2.6
Magnesium	8.2	2.7
Chloride	63	22.5
Nitrate	<0.5	1.5
Iron	4.2	0.5
Manganese	1.8	<0.02
Zinc	0.14	0.06
Aluminium	<0.05	<0.05
Boron	0.1	<0.1
Copper	<0.05	<0.05
Nitrogen mg/L	22.0	0.49
Phosphorus mg/L	1.6	0.027

Photo 9. HV2600 transferring cabomba load to compactor truck.

5.0 Conclusions.

Lake Macdonald is no different to many fresh water lakes in south-eastern Queensland, that have a history of use and abuse. We can't simply lock up these natural assets or pretend that they are in pristine condition. The big challenge for the future is to manage our resources better. Mechanical control is one management tool that will correct some of the abuse and provide wiser water use.

The pilot study indicated that:

- Cabomba can be effectively controlled using mechanical means.
- Results showed that cabomba is sensitive to repeated cuttings.
- Native plant species ***Hydrilla verticillata*** appeared in the second cut areas after a six year absence.
- Aesthetic improvements to the dam after cutting brought about favourable community comments.

- Public safety issues were addressed by mechanical removal of the weed.
- Significant amounts of nutrients and heavy metals were removed from the cut areas.

- Aquatic Weed Harvester Aust. Pty Ltd's model HV2600 performed well.
- Improvements to the machine since 1994 are substantial. (Working for 20 days continuously without any breakdowns.)
- Wind speeds above 25knots interfered with the machine's operation.
- Accreditation required by a HV2600 operator is a current 'Speed Boat Driver's Licence' as issued by Queensland Transport.
- Transport and weed disposal regulations were covered by using a garbage compactor truck.
- Mechanical control offers an environmentally friendly weed removal system.
- Wind and dirty water inflows had a detrimental effect on cabomba growth.
- Water clarity improved after mechanical control.
- Dissolved oxygen levels improved after cabomba removal.
- Wave height increased in cut areas, which increases oxygen and reduces algal blooms.

6.0 Recommendations.

The Lake Macdonald Catchment Care group recommends to the Noosa council that the mechanical harvesting of cabomba is an urgent and only currently feasible management priority, in order

- to meet council's legislative responsibility
- to reduce risks to human safety
- to reduce the chance of spreading cabomba through transport by boat trailers
- to increase potential for natural revegetation of native macrophytes, to compete against cabomba.

Date 1st. May 2000

T Anderson
Alan Fletcher Research Station

K A Garraty
Noosa Shire

Photo 10,11. Cabomba is a hazard to recreation and the workplace.

Appendix 1.

Secchi disc, water depth, wave height,watertemperature,wind,cloud,plant fragments,specific gravity

Site		6th Oct	19th Oct	26th Oct	2nd Nov	9th Nov	16th Nov	23rd Nov	30th Nov	18th Jan	1st Mar
Control	Secchi	0.65m	0.95m	1.4m			1.0m	0.5m		0.9m	
Hayward Rd	Depth	3m	2.5m				2.0m	2.5m	2.5m	2.6m	
	Wave		20mm	2mm				0			
	Temp sur	21C				29C		24C	cold		
	Temp bot			24C		22C		22C			
	Wind	windy	no	no				8kts			
	Cloud	overcast	sunny	sunny				cloudy		medium	
	Fragments	brittle	brittle			strong			strong		
	Epiphyte	light	clean	clean							
	Color plants		green	green						red	
	SG		0.92						0.93		
	Natives		nil	nil		snowflake		nil			
	Behaviour	lying flat								healthy	
Hoy Rd	Secchi						1.5m	2.1m	1.1m	1.0m	
	Depth					3.3		3.5m	2.5m	2.9m	2.1m
	Wave							100mm	100mm	100mm	
	Temp sur				25C		28C		23C		24C
	Temp bot				21C		26C		21C	cold	
	Wind						windy	12kts	15kts	15kts	
	Cloud							cloudy	cloudy		
	Fragments									brittle	
	Epiphyte				clean						
	Color plants				green			green			
	SG										
	Natives				nil						

Secchi disc, water depth, wave height,watertemperature,wind,cloud,plant fragments,specific gravity

	Behaviour					wind striped	stripped	lying down			
Ampi	Secchi	1.4m	1.0m	1.1m	1.0m	1.1m	1.1m				
Site		**6th Oct**	**19th Oct**	**26th Oct**	**2nd Nov**	**9th Nov**	**16th Nov**	**23rd Nov**	**30th Nov**	**18th Jan**	**1st Mar**
	Depth	4m	3.5m	2.2m	2.4m	2	4.0m				
	Wave		40mm	10mm		10mm	100mm				
	Temp sur	21C	26C	26.5C	21C					24C	
	Temp bot		24C	24C	20C			24C		22C	
	Wind				windy		fine				
	Cloud			cloudy							
	Fragments		firm	firm	brittle	brittle					britle
	Epiphyte	nil	nil		medium	heavy	clean	medium	heavy		
	Color plants	dark	red	green/red	purple		red				
	SG	1.03									
	Natives		nil	nil	sn/flake						
	Behaviour	Laying down	normal	normal						entangled	
Cut once		**6th Oct**	**19th Oct**	**26th Oct**	**2nd Nov**	**9th Nov**	**16th Nov**	**23rd Nov**	**30th Nov**	**18th Jan**	**1st Mar**
HaywardRd	Secchi		0.8m	1.4m	0.95m	1.1m		1.3m	1.4m	1.0m	
	Depth		1.6m					1.3m	1.8m		1.8m
	Wave		20mm	20mm	50mm	75mm		20mm			
	Temp sur						27C		22C		24C
	Temp bot			24C				22C	21C		
	Wind		no	no	25kts	20knts					
	Cloud		sunny	sunny	cloudy	fine		cloud			
	Fragments					strong					
	Epiphyte			clean	clean	clean					
	Color plants			green		blue					purple
	SG										

Secchi disc, water depth, wave height,watertemperature,wind,cloud,plant fragments,specific gravity

	Natives			nil	nil	snowflake	snowflake		hydrilla	5snows	
	Behaviour			normal	normal	underwater					
	cut depth			0.4m	0.3m	0.2m					
Hoy Rd	Secchi				1.3m	1.7m		1.4m		0.8m	
Cut once		**6th Oct**	**19th Oct**	**26th Oct**	**2nd Nov**	**9th Nov**	**16th Nov**	**23rd Nov**	**30th Nov**	**18th Jan**	**1st Mar**
	Depth				3m			2.5m			2.5m
	Wave				100mm		50mm				
	Temp sur				24C			24C		28C	24C
	Temp bot				21C			24C		22C	
	Wind				25kts						windy
	Cloud										
	Fragments										
	Epiphyte				clean	clean					
	Color plants				green						
	SG										
	Natives						nil			nil	
	Behaviour							weak			
	cut depth				0.5m	0.5m				.3m	
Ampi	Secchi			1.4m	1.4m	1.6m	1.3m		1.2m	1.0m	1.2m
	Depth			3.4m		3					2.9m
	Wave			100mm	50mm	75mm					
	Temp sur			24C			28C				26C
	Temp bot			26C			22C				
	Wind			windy			5kts				
	Cloud			sunny			cloudy		cloudy		cloud
	Fragments			brittle			strong				
	Epiphyte			medium	clean	heavy		heavy	heavy		clean
	Natives										
	cut depth			0.7m	.4m				.45m		

Appendix 2.

CABOMBA ACTION PLAN

LAKE MACDONALD / SIX MILE CREEK

CONTENTS

Cabomba Action Plan

1. STATEMENT OF ISSUE

Cabomba is a threat to:-

- potable water quality;
- natural area conservation, eg habitat of cod;
- public health and safety; and
- efficient operation of water treatment equipment.

Cabomba is an invasive submerged water weed, which is indicative of high nutrient waters where it replaces native aquatic plants and in Australia grows to a depth of 4 to 5 metres. The Cabomba infestation in Lake Macdonald is considered to be both the first and the worst in a potable storage in Australia.

Failure to take appropriate management actions may lead to:-

- deterioration of water quality;
- significant depletion and loss of recreational fish stocks in the lake; and
- loss of environmental values that currently provide recreational opportunities.

2. GOAL

To manage the impact of Cabomba on water supplies, aquatic habitats and recreational uses.

3. OBJECTIVES

(a) To prevent the spread of Cabomba from the current infestation to new water storages or waterways as a result of physical transfer.

(b) To implement an action plan to reduce the extent and potential impact of the current infestation in Lake Macdonald.

(c) To eradicate existing Cabomba infestation in Six Mile Creek, downstream from the dam wall.

4. ACTIONS

ACTION 1:

Action 1A: The Noxious Plants Supervisor be responsible for the overall implementation of the Cabomba Action Plan.

Responsibility: NSC

Action 1B: To temporarily exclude commercial and recreational aquatic uses on the lake until such time as the Cabomba infestation is controlled to a point that minimises public safety hazards and risks to physical transfer to other areas.

Responsibility: NSC

However, if this is considered impractical, measures need to be introduced to minimize risks, including:-

(a) To construct compacted/sealed boat ramps to prevent the snagging of Cabomba on boat trailers.

(b) Education campaigns for recreational and commercial users regarding appropriate de-contamination procedures.

ACTION 2:

Action 2A: To promote riparian restoration of headwaters and lake shores, to increase nutrient trapping and shading by both private land-holders and Council, including exclusion of stock from riparian areas.

Responsibility: NSC & MRCCC

Action 2B: To establish a Lake Macdonald catchment care group, to promote educational awareness and local action plans for better resource management.

Responsibility: DNR & ICM

Action 2C: To investigate funding options for purchase of weed harvester for Sunshine Coast Council impoundments.

Responsibility: NSC & SEQPAF

Action 2D: Pursue sponsorship of Lake Macdonald actions from an appropriately names corporate sponsor.

Responsibility: Lake Macdonald Catchment Care Group

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Cabomba Action Plan

Action 2E: To limit the generation and flow of nutrients into the dam as a result of catchment land-use, eg implementing recommendations of the Lake Macdonald Water Quality Study.

Responsibility: NSC

Action 2F: To conduct log and fence removal during natural or programmed draw-downs to facilitate efficient harvesting operations.

Responsibility: NSC

Action 2G: To support and endorse moves to commence a biological control program for Cabomba.

Responsibility: NSC, SEQPAF & MRCCC

Action 2H: To commence an active monitoring program of potential high nutrient-generating sites, eg septic tanks, dairies, nurseries, botanical gardens, etc.

Responsibility: NSC

ACTION 3:

Action 3A: Commence a research project to scientifically eradicate existing infestation below dam wall, initially focussing on non-chemical methods (investigate linkage with bridge construction program).

Responsiblity: DNR & AFRS

Action 3B: Declare all Lake Macdonald lands (between Gumboil Road, Noosa Cooroy-Road and Lake Macdonald Drive, and Six Mile Creek riparian vegetation under Council's tree preservation local law to ensure current shaded stream conditions are maintained.

Lake Macdonald Catchment Care Group, pilot study on cabomba.

Responsibility: NSC

Action 3C: Promote revegetation of Six Mile Creek riparian corridor through schemes such as the MRCCC Voluntary Riverbank Restoration Grants Scheme.

Responsibility: NSC & MRCCC

Action 3D: Support Noosa Landcare initiatives to maintain and enhance habitat values of Six Mile Creek to minimize potential for degradation which may lead to conditions being suited to Cabomba infestation.

Responsibility: N D L G

Abbreviation	**Organisation**
NSC	Noosa Shire Council
DNR	Department of Natural Resources
ICM	Integrated Catchment Management
AFRS	Alan Fletcher Research Station
NDLG	Noosa District Landcare Group
MRCCC	Mary River Catchment Coordinating Committee
SEQPAF	South East Queensland Pest Advisory Forum

APPENDIX 3.

POTABLE WATER QUALITY IMPROVED BY HARVESTING THE WEED CABOMBA.

T. Anderson and G. Diatloff, Alan Fletcher Research Station,
PO Box, Sherwood, Queensland 4075, Australia.

K. Garraty, Noosa Shire Council,
PO Box 141, Tewantin, Queensland 4565.

Summary
An improvement in water quality was measured during a field exercise which studied the impact of harvesting cabomba. Dissolved nitrogen was reduced by 25% and phosphorus by 33%. A difference of 53 true colour units was recorded in favour of the harvested site. The cut cabomba regrew to original infestation density within 3 weeks. Data gathered highlights the economic degradation of water storages caused by cabomba.

INTRODUCTION

The National Water Management Strategy for ecologically sustainable development states its overall water policy .....*is to achieve the sustainable use of the nation's water resources by protecting and enhancing their quality while maintaining economic and social development*. To achieve this objective the economic and environmental values of water resources need to be defined and protected from the effects of degradation.

This paper is about an exercise which explores the impact of removing a relatively new weed called cabomba, *Cabomba caroliniana* Gray and the after effects on water quality. Water is an essential service, our present consumption rate is 350-700 litres of water per capita per day. Producing this water requires a significant investment of public money (4). Some idea of the money spent on producing water is outlined in table 1. The figures are only an indication of the cost or value of a commodity many people regard as plentiful and cheap. Comparing one storage to another is pointless as each system has different accounting and costing procedures.

Table 1. Water statistics, consumption and costs.

Supply	Capacity (ML)	Annual Consumption (ML)	Raw-water costs ($/ML)	Treatment Costs ($/ML)	Total Value ($M)
SEQWB*	1,721,000	248,703	110.56	84.0	48.3
Hinze	163,500	60,217	45.30	65.0	6.5
Enoggera		960		175.0	
Lesley Harrison	24,000	8,205			

Lake Macdonald	8,000	5,610	22.00	100.0	0.68
Mary R.		2,078	180.0	100.0	0.58

* SEQWB = South East Queensland Water Board 3 dams, Wivenhoe, Sommerset and North Pine.

** Raw-Water cost = sky to treatment plant. Treatment costs are water purification costs including labour, chemicals, power but does not include capital costs, raw water costs or distribution.

Lake Macdonald study site. Lake Macdonald is a 250ha manmade impoundment on Six Mile Creek located at the head waters of the Mary River system. The storage supplies potable water to Noosa Shire. Its catchment (area 49.4 km^2) is zoned 'Rural Catchment' however some 'Rural Residential' zoning and the town of Cooroy are within this area. Storage water can be described as slightly eutrophic with a pH of 6.5 to 7.0, highly coloured, high in organic content, low hardness and low alkalinity. During the warmer months of the year the lake experiences several 'turn-overs', induced by thermal and chemical stratification.

In April 1992 the pest plant cabomba was reported at Lake Macdonald. By 1995 cabomba had invaded most of the shallow littoral zone which covers an extensive area of the lake. Submerged species replaced by cabomba were: hydrilla, *Hydrilla verticillata*, thin leaf naiad, *Najas tenuifolia*, Pondweed, *Potamogeton javanicus*, bladderwort, *Utricularia sp.*. Emergent species consist of water snowflake *Nymphoides indica,* tall spikerush *Eleocharis sphacelata, Hygrophila angustrifolia,* and knotweeds *Polygonum spp.*

METHOD

In 1994 the Brisbane based company 'Water Weed Control Pty Ltd.' built a weed harvester. A versatile machine capable of cutting submerged plants, loading and dumping on shore payloads of upto 12 tonnes. Noosa Shire's Water and Sewage Department engaged this harvester to remove an area of cabomba from Lake Macdonald. Two inlets of the lake with similar cabomba infestations were selected. Gumboil Rd. inlet was harvested and compared with Hayward Rd. inlet which was left untouched.

Site selection. Before harvesting operations started a preliminary plant survey of Gumboil Inlet was made by scuba divers. The abundance and distribution of cabomba was not uniform. Variations in plant density were caused by water depth, hydrosoil type and the inlet's past history of land use. Cabomba did not grow well in shallow water below 0.5 m or at depths greater than 3.1 m. Bottom soils which were hard or stony also reduced the plant's vigour. To achieve precision and minimise variation in data, six random sub sites were selected. Each site had uniform cabomba growth, was at a depth of 1.5-2m and had a soft hydrosoil.

Scuba divers. Plant biomass and species composition were determined by scuba divers. Divers using 1 m^2 quadrats can only harvest 6-10 quadrats per day. While this limits the amount of information gathered the data is quantifiable, objective and appears to be the most reliable means of assessing infestations.

Water quality measurements of turbidity, colour, pH, dissolved oxygen, temperature, water levels, total nitrogen and total phosphorus were assayed by Noosa shire.

RESULTS

Cabomba growth. The summer standing crop of cabomba in each inlet was similar; Harvested Gumboil Rd inlet averaged 50 tonnes per ha. While the unharvested Hayward Rd inlet averaged 50.1 tonnes per ha. Biomass reduction due to harvesting and cabomba's subsequent regrowth are summarised in table 2.

Table 2. The growth rate of cabomba following harvesting
(Figures are an average of 6 subsites sd).

Standing crop (t/ha)		Net productivity (t/ha/wk)
Before cut	48.7 ±8.0	0
After cut	25.9 ±18.0	-22.8
week 1	29.0 ±10.0	3.1
week 2	34.1 ±17.0	5.1
week 3	51.9 ±19.0	17.8
week 10	49.1	0.3

Water quality. Water chemistry, temperature, drawdown levels and are summarised in table 3. Three weeks after cutting the infestation was expanding rapidly and bio mass production reached 17.8 tonnes, during this period a reduction in total nitrogen and total phosphorus was recorded. There is a marked difference in true colour between the two study sites following harvesting. There was no difference in pH. An improvement was measured in water dissolved oxygen at the harvested inlet.

Table 3. The effect of harvesting cabomba on water quality.

Harvested

Weeks after cutting	week 1	week 2	week 3	week 4
Total nitrogen (mg L^{-1})	0.67	0.62	0.50	0.66
Total phosphorus (mg L^{-1})	0.03	0.03	0.02	0.03
Turbidity (NTU)	3.70	4.60	3.30	4.10
Apparent colour (Co/Pt)	40.00	45.00	37.50	45.00
True colour (Co/Pt)	12.50	17.50	14.00	16.00
pH	7.30	7.10	7.60	7.40
Dissolved oxygen (mg L^{-1})				6.46
Temp ^{0}C				24.20
Draw down (m)	1.31	1.15	1.17	1.27

Unharvested

Weeks after cutting	week 1	week 2	week 3	week 4
Total nitrogen (mg L^{-1})	0.84	0.91	1.20	0.96
Total phosphorus (mg L^{-1})	0.04	0.06	0.04	0.04
Turbidity (NTU)	6.40	21.50	7.20	5.30
Apparent colour (Co/Pt)	75.00	165.00	90.00	75.00
True colour (Co/Pt)	47.50	75.00	67.50	52.50
pH	7.00	6.70	7.40	7.10
Dissolved oxygen (mg L^{-1})				5.50
Temp ^{0}C				24.30

DISCUSSION

Cabomba harvesting. The machine demonstrated that cabomba could easily be cut, loaded, carried and dumped on shore. Approximately 180 tonnes of cabomba was removed in 3 days.
Submerged stumps caused damage to the cutter bars and handicapped the exercise. Removal of the stumps would greatly improve overall efficiency.
Cabomba grew back to the original standing crop of 50 tonnes per ha in 3 weeks. The highest growth rate occurred in the third week when biomass production reached 17.8 t/wk.
Removing the cabomba increased surface wave action at Gumboil Inlet. An improvement in water dissolved oxygen levels from 5.5 -6.46 mg/L was noted.

Nutrients. EPA guidelines for nutrient levels in lake waters are:

total nitrogen 0.1- 0.5 mg/L
total phosphorus 0.005-0.05 mg/L

Lake Macdonald records from 1988 to 1994 average:

total nitrogen 0.83 mg/L
total phosphorus 0.03 mg/L

Indicating the water is slightly enriched or eutrophic. Literature suggests the best and most practical defence against nutrient enrichment is the natural filtering service performed by plant life (2). This knowledge has stimulated interest in wetland construction to treat effluent and waste waters. Other water weeds such as salvinia have demonstrated nutrient absorption (1). Anecdotal evidence of cabomba's ability to remove nutrients has been provided by nurserymen who are expert at growing cabomba. To maintain production of cut cabomba soluble nitrogen and phosphorus needs to be added weekly.
In this instance cabomba has been used as a sponge to soak up nutrients already present in Lake Macdonald. Three weeks after harvesting, cabomba was expanding rapidly, and a reduction in dissolved nitrogen (25%) and dissolved phosphorus (33%) was measured.

<u>Colour.</u> Water clarity was not visibly affected by the operation. Secchi disc readings of 0.85 m for the harvested site and 0.8 m for the unharvested area. Laboratory assay revealed substantial differences in water quality between the study sites, especially turbidity and colour. Turbidity in water is caused by suspended clay, silt, organic matter and plankton. Turbidity is an expression of the optical properties or clarity of the water(3). The harvested site produced the lowest turbidity figures indicating clearer water. Colour in water can originate from metallic ions, humus, peat, plankton and vegetation. It is quite different to turbidity. True colour refers to the colour of the water after turbidity has been removed. Colour is removed at the treatment plant to make the water suitable for general and industrial use. NHMRC guidelines for colour are set at 15 TCU (True Colour Units). The harvested site averaged 15 TCU, while the unharvested area averaged 60 TCU. Whether this is due to inherent factors at each site is unclear. Water chemists contacted agreed colour was caused by vegetation and its presence increased water treatment costs. eg. Enoggera reservoir with a colour of 20 TCU, has a chemical treatment cost of $40 per ML, compared to North Pine Dam with a colour of 3 TCU, costing $15 per ML to treat.

The differences in true colour measured at Lake Macdonald could mean a saving of $50/ML in water purification costs (G. Goss per comm.). Further trials under controlled conditions are needed to evaluate the linkages between cabomba and colour. Establishing a dollar value for the economic loss or cost of weeds can be difficult. Accurate procedures and costings exist within the water supply industry which should enable future research to define the cost of cabomba.

CONCLUSION

The exercise demonstrated that:

* cabomba can be efficiently harvested
* cabomba has a rapid growth rate with most production occurring in the third week after cutting
* cabomba soaks up nutrients as indicated by a reduction in nitrogen and phosphorus
* water colour may have been reduced by harvesting
* dissolved oxygen levels improved after harvesting
* operation of the machine had no adverse effects on water clarity or wildlife
* submerged stumps handicapped the machine's efficiency
* further laboratory research under controlled conditions is necessary to validate these field results.

This was an opportunistic exercise and as such can be criticised for a lack of careful planning.

However an improvement in water quality was measured as a result of harvesting. This information could be used to restore nitrogen and phosphorus levels. Caution is needed when interpreting these results. Cabomba is a serious weed. This paper does not promote the use of cabomba in any way. At the moment there are no control methods that are acceptable in potable water. Although cabomba may have beneficial effects through its nutrient uptake in eutrophic situations, the loss of biodiversity by far outweighs any perceived advantage.

Water chemists spoken to agreed the cleaner the water source the cheaper the water supplied to the end user.

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