WEEDS OF NATIONAL SIGNIFICANCE

CABOMBA

(Cabomba caroliniana)

Strategic Plan

ISBN 1 876977 05 1

Supporting information about the National Weeds Strategy, Weeds of National Significance and progress to date may be found at www.weeds.org.au where links and downloads provide contact details for all species, their management committees and copies of the strategy.

This strategy was developed under the leadership of the Dept of Natural Resources, Queensland with full cooperation of all the States, Territories and Commonwealth of Australia.

Comments and constructive criticism are welcomed as an aid to improving the process and future revisions of this strategy.

Published by: National Weeds Strategy Executive Committee, Launceston

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Publication date: December 2000

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Preferred way to cite this publication:

Agriculture & Resource Management Council of Australia & New Zealand, Australian & New Zealand Environment & Conservation Council and Forestry Ministers, (2000) *Weeds of National Significance Cabomba (Cabomba caroliniana) Strategic Plan.* National Weeds Strategy Executive Committee, Launceston.

Cover design by: Simone Chown and Grant Flockhart, Queensland Department of Natural Resources

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EXECUTIVE SUMMARY

Protect our waterways from cabomba

Most Australians are not yet familiar with cabomba - a fully submerged aquatic weed naturalised in some east-coast waterways. Infestations are currently isolated and confined to relatively few water bodies but potentially, it could impact on waterways from Cape York to Hobart and from Sydney to Perth.

The large biomass produced by the fast-growing infestations of cabomba impact on the capacity of water storages, reduce the water quality and increase the maintenance costs of water delivery systems. Infestations develop as monocultures, reducing the abundance and species richness of aquatic plants and indirectly impacting on associated aquatic fauna. Fishing, swimming and boating are all impeded by the dense biomass to the point of posing a safety hazard.

Weed control in aquatic environments has inherent difficulties and control options are very limited by social and environmental pressures. An effective control option is not currently available for large infestations.

Cabomba has been successfully marketed throughout Australia as an aquarium plant but this is now restricted in some States. As a plant with commercial value its management required unique solutions.

In April 2000, the Queensland Department of Natural Resources brought together the practical experience of industry, community and government to develop the National Strategy for Cabomba Weed Management.

The vision for of the strategy is:

To stop cabomba destroying our waterways.

The Strategy aims to deliver four desired outcomes to be achieved through a range of strategies and actions:

1 No new cabomba infestations develop

- Prevent importation of cabomba
- Change community attitudes and actions on cabomba
- Conduct regular monitoring of waterways for cabomba
- Improve aquarium plant industry cooperation
- Minimise potential for further spread
- Maintain natural characteristics of waterways.

2 Stop the trade in cabomba

- Provide uniform regulations on cabomba trade across Australia
- Provision of alternative aquarium plants
- Develop accreditation regime for aquatic plants
- Enforce trade regulations.

3 The impacts of existing cabomba infestations are minimised

- Strategic control of all infestations
- Improve the understanding of the ecology and biology of cabomba
- Implement biological control
- Quantify the impacts of cabomba
- Change community attitudes and actions on control.

4 Commitment to coordination of the strategy exists at all levels

- National assessment of the distribution and impacts of cabomba
- Manage implementation of the plan
- Maximise the availability and use of resources
- Provide cooperative management frameworks.

The extent to which these outcomes are met will be evaluated as part of a five-year cycle of review and will determine the success of the strategy.

THE CHALLENGE

To define the problem, the community needs to be aware of cabomba.
Waterways around Australia are under threat from infestations of cabomba (*Cabomba caroliniana*), a submerged aquatic weed that grows well in shallow, slow moving, nutrient-rich water. Cabomba may have been present in Australia for more than seventy years but it has only been identified as a significant potential weed in the last ten to fifteen years. Infestations go unnoticed because of cabomba's submerged growth habit and the limited public knowledge of the weed and its potential impacts. Most infestations occur in the northern NSW and southern Queensland hinterlands, however, infestations have been recorded from as far apart as Darwin and central Victoria.

Consumer demand for cabomba is being met through wild harvest operations and loopholes in the legislation.
Cabomba's fine, feathery, green foliage make it a desirable aquarium plant and it has been traded through for many years. Declaration of cabomba in all States and Territories, except South Australia and Victoria, has restricted the trade of cabomba, however, the inconsistent regulations have made enforcement very difficult. Cabomba can still be purchased through weekend markets and pet shops, with supplies coming from both growers and wild harvesters. Some plant suppliers use natural waterways to grow cabomba and other aquatic plants, harvesting 'wild stocks' for markets.

The potential impacts of cabomba on the community and the environment are wide and varied.
Infestations have the ability to significantly reduce the capacity for water storage thereby limiting the availability for town water supplies. If the storage is for potable water, tainting from cabomba will significantly increase the cost of treatment. If the storage is for irrigation, increased costs are incurred for maintenance of the pumping and water delivery infrastructure. Infestations also pose a safety hazard to swimming, fishing and boating enthusiasts and local authorities are under pressure on how best to manage recreational use of the areas. Cabomba also affects native aquatic vegetation, through competition and allelopathic activity. Indirectly this must influence the aquatic fauna, but the extent is unknown.

Future control and management practices depend on a much better understanding of the biology and ecology of cabomba.
Cabomba appears to behave differently in Australia compared to its native range. The reason is not understood and its biology and ecology have not been studied. The development of efficient and effective control measures will, however, depend on identifying and exploiting a weakness(es) within its lifecycle.

Current and potential impacts cannot be readily managed in isolation.
Containing and reducing the level of cabomba infestations is not easy as there are significant social or environmental limitations to the traditional weed control techniques and no effective control technique is currently available. Because cabomba grows well in nutrient rich waters it flourishes in degraded waterways. Management aimed at the catchment level offers considerable scope because it identifies the community as both part of the problem and the solution.

1 BACKGROUND

Cabomba (*Cabomba caroliniana*) is a weed of national significance (WONS) because of its potential impact on the biodiversity and function of wetland and riparian ecosystems, water quality, water storage and distribution infrastructure and its impact on recreation and amenity values.

Cabomba may be confused with other aquatic species both introduced and native. One other species from the genus *C. furcata* (pink cabomba) is also sold in the trade. Other submerged species, which can be separated by leaf form, are the hornworts (*Deratophylum* spp.) and the watermilfoils (*Myriophyllum* spp.).

1.1 The biology of cabomba

Cabomba, is a fully submerged aquatic plant except for the occasional floating leaves and emergent flowers. It is a perennial, growing from short rhizomes with fibrous roots. The branched stems can grow up to 10m long and are scattered with white or reddish-brown hairs. The underwater leaves are divided into fine branches, resulting in a feathery fan-like appearance. These leaves are about 5cm across and secrete a gelatinous mucous which covers the submerged parts of the plant. The floating leaves, however, are small, diamond-shaped, entire, and borne on the flowering branches. The solitary flowers are less than 2cm across and range in colour from white to pale yellow and may also include a pink or purplish tinge. The flowers emerge on stalks from the tips of the stems. Cabomba is not seen as desirable for propagation by all aquarists as its rapid growth make it difficult to maintain and the foliage becomes “stingy” reducing its ornamental value.

Cabomba in Australia may be sterile; it produces flowers but fertile seed/fruit have not been recorded even though pollinators are plentiful. Although most reproduction is asexual hybrids of *C. furcata* have been found which does not exclude cabomba hybridizing with other species. Reproduction and dispersal appear to be entirely vegetative; fragments may survive in water for 6 to 8 weeks and a detached shoot with at least one pair of leaves is capable of growing into a mature plant. Fragments as small as 1cm may be viable. In north Queensland, cabomba grows and flowers continuously but in southern Queensland it dies back in the winter period and lays on the bottom where the stems fragment, providing dispersal material (Figure 1).

Cabomba is sensitive to drying out and requires permanent shallow water, usually less than 3m deep, although it can grow in water up to 10m deep producing stems that reach the surface. With the ability to grow quickly, cabomba can respond to wide fluctuations in water depths. It is a water column feeder. It grows well on silty substrates, but its vigour is reduced on hard substrates. Cabomba extracts have an allelopathic effect, inhibiting vegetative growth of some aquatic plants. This may be a mechanism for invading new habitats and competing with other plants.

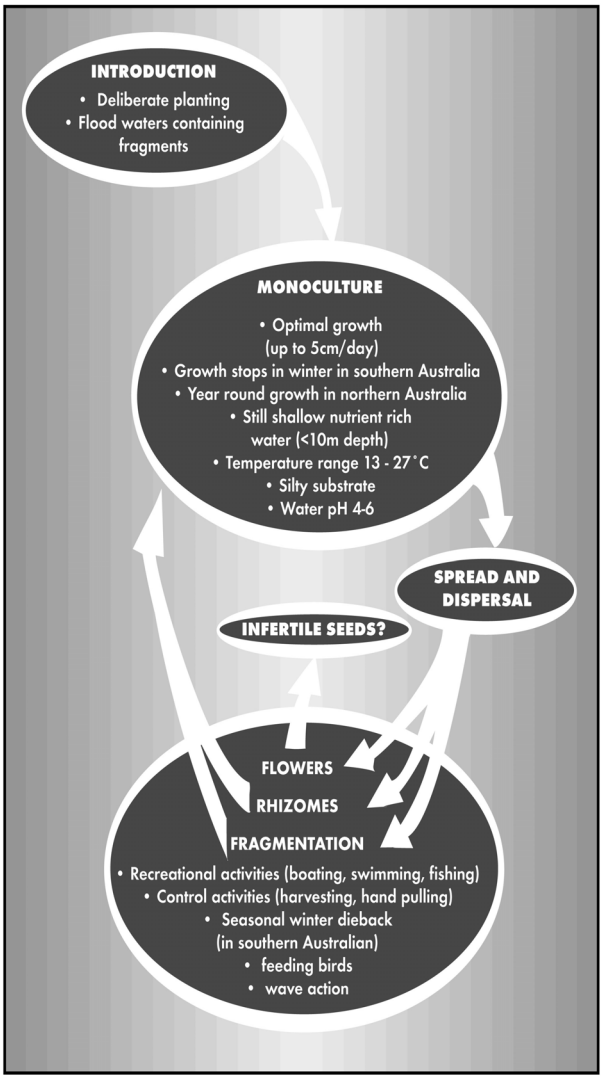

Figure 1. Life cycle of cabomba

Water quality affects the growth of cabomba. It grows well in eutrophic conditions with low pH but conditions above pH 8 tend to defoliate the stems. High calcium levels also inhibit growth. In aquaria ponds, cabomba not only grows well in water with medium turbidity, but also in waters with high turbidity. This characteristic is of concern, as turbid water usually limits the growth of aquatic weeds. Other species of cabomba, however, require more light than *C. caroliniana.* Cabomba can survive temperatures of less than 0°C, but it prefers a warm, humid climate with a temperature range of 13-27°C.

1.2 History of spread

C. caroliniana is the only species of the genus *Cabomba* known to have naturalized in Australia. It is native to southern Brazil, Paraguay, Uruguay, and northeast Argentina. It is also widely naturalised in the south east of the USA and has been dispersed throughout the world by the aquarium trade.

The first herbarium record of cabomba in Australia is dated 1967, but there is anecdotal evidence that it may have been introduced in the 1930's. It was recorded in the flora of NSW in 1986 and soon after was found naturalised in many parts of eastern Australia. The spread of cabomba has been facilitated by the deliberate "seeding" of waterways to ensure a wild supply of cabomba for the aquarist trade. It is now distributed across a wide climatic zone from Darwin to Victoria.

In Queensland, cabomba occurs in shallow, permanently flowing creeks and deep, slow-flowing pools of coastal river systems. The heaviest infestations occur in shallow dams of the Sunshine Coast but significant infestations also occur in Far North Queensland. It has naturalised in numerous creeks and river systems of north coast NSW but is also recorded from Dapto and the Blue Mountains. Infestations occur at Lake Nagambie (20-25 ha) and Lake Benalla (2-3 ha) in central Victoria and in Marlow Lagoon at Palmerston (NT). There is no record of naturalisation in Tasmania, Western Australia or South Australia; however, aquarists in these States sometimes trade cabomba. For more details, refer to Appendix 1.

The potential distribution of cabomba has been predicted using a CLIMEX model that is based on temperature tolerance found in its native range (Figure 2). This prediction suggests that all States and Territories have favourable climatic conditions for cabomba with excellent habitat conditions provided across southern and eastern Australia. This model over-estimates the potential distribution because it focuses only on temperature and not the availability of water.

GARP is another prediction model that uses parameters based on the known existing distribution within in Australia. This model predicts that the potential distribution is limited only to the east coast with optimal habitat from southern Queensland to west coast Tasmania. The potential distribution is probably somewhere between the two models but the key feature of the two predictions is how extensive the potential range is.

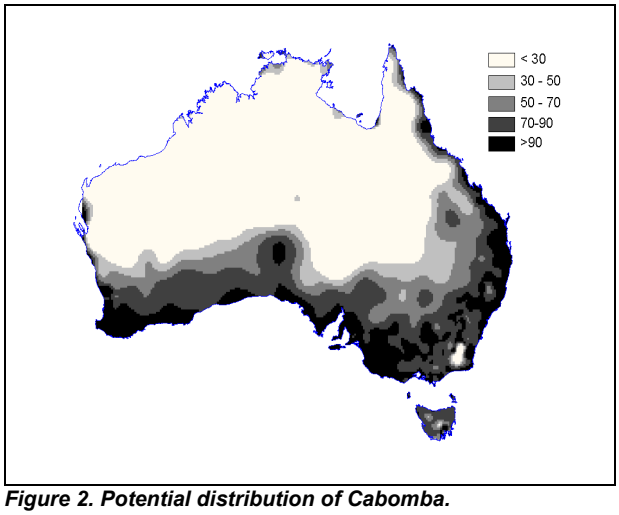

Figure 2. Potential distribution of Cabomba.
(Data is splined from a CLIMEX climate prediction. EI = Ecoclimatic index: EI<30 potential for a permanent population low; EI>70 potential for a permanent population is very high)

1.3 A Weed of National Significance

Cabomba is still in its early invasive stages and many of the impacts apparent overseas are not yet locally observable.

Environmental costs

Cabomba is an important potential environmental weed at the ecosystem level, such as the Wet Tropics World Heritage Area, where it may endanger native aquatic flora and fauna.

It is extremely persistent and can establish a monoculture by excluding native plant species. In Lake Macdonald, a community of hydrilla, Najas, Potamogetons and stoneworts was replaced. Monocultures also affect resident native fauna, the infestations in the Kenny-Leslie creek system in far north Queensland has resulted in reduced numbers of platypus and water rats. In Lake Macdonald, there has been an increase in shrimp numbers and in the density of native gudgeons and exotic small fish species. Native bass, stocked in the lake, are thriving on the increased food supply.

An increase in numbers of eels also indicates a change in the trophic structure and/or species composition of the lake. Not all species have increased, however, numbers of the endangered Mary River cod appear to have declined, with brood areas in the dam smothered by the weed. This dam is on the Six Mile Creek and is one of the major breeding sites for this fish.

Public safety

Dense stands of cabomba make it unsafe for swimming activities of any kind and have direct implications for associated water sports. It also creates a work place health and safety issue for local government, water engineers, weed managers, field staff and park managers.

Amenity

Infestations impact on the aesthetic and scenic values of the area with direct negative impacts on tourism opportunities and real estate values. Instead of clear water, rippled by the wind, a dense cabomba infestation can turn it into a still, partially stagnant, water body.

Recreation activities

Boating, sailing and canoeing activities are restricted by dense cabomba infestations by interfering with navigation and movement of watercraft. They may cause damage to outboard motors. Angling becomes impossible as the lines become completely tangled in the weed. In the USA, commercial fishing camps and waterside camp owners have had reductions in their income or have been forced to close. Cabomba infestations may also lead to a reduction in fish stocks through competition. Recreational equipment; eel traps, boat trailers and propellers may transport and spread cabomba fragments.

Water quality

Cabomba taints and discolours potable water, potentially increasing the cost of treatment by up to $50/megalitre. Cabomba dies back at certain times of the year (depending on temperature) and the massive amount of decomposing vegetation causes dramatic oxygen reductions. This results in foul-smelling, oxygen-deficient water that reduces water quality in the impoundment and further downstream. These anoxic conditions may have an adverse impact on the biological community and also increase the rate of release of some nutrients from the sediments, making them more available for plant growth. It has also been speculated that the decomposition process could release large amounts of iron, manganese and other metals, further reducing water quality.

Water storage and distribution infrastructure

Cabomba blocks the foot valves of pumps resulting in continual and increased levels of maintenance. It also interferes with the operation of dam machinery, such as the clogging of aerators. Extra costs are involved in extending the pump pickup lines into areas clear of cabomba and there are increased costs associated with unblocking fixed lines and gravel filters. A heavy infestation can also raise water levels to a point where overflows and heavy seepage losses occur.

Direct costs of management activities

Cabomba has been recognized as a pest plant for less than ten years yet conservative 1999 estimates place the national cost of cabomba control at over $0.5m. Cabomba control costs, borne by Local and State governments, include enacting policy and

legislation, inspection and enforcement, extension and education, planning, research and on-ground control programs. Refer to Appendix 1 for further details.
Weed management activities, particularly the use of herbicides in waterways, raise community angst about further loss of biodiversity, contamination and off-site impacts. Similarly, water level manipulation or draw down, may impact on off-take level requirements, site aesthetics, pumping requirements, stock access, recreational activities and biodiversity.

Benefits to the aquarium plant trade

Cabomba has ornamental value in aquaria and provides shelter for breeding exotic fish. It has been traded under the names *C. australis* and *C. pulcherrima* because there appear to be different forms, however, both are *C. caroliniana*.

Trade represents a $300,000 industry but it is restricted by legislation in most states. Cabomba can be cultivated and traded in Victoria and South Australia but is prohibited in all other States and Territories. It is, however, being traded from Queensland and New South Wales, to the markets in Victoria and South Australia and aquatic plant suppliers who do not supply cabomba, are being commercially disadvantaged by those who do. Most trade in this species is based on wild harvesting, rather than controlled commercial pond operations, and is made at markets and other backyard establishments. 'Rogue players' are undermining the regulations and industry by harvesting and trading wild grown cabomba (sourced from deliberate plantings in public waterways).

1.4 Legislative controls

The importation of all species of the genus *Cabomba* is prohibited under federal legislation managed by the Australian Quarantine and Inspection Service (AQIS). The Weed Risk Assessment system used by AQIS generates a score of 18 for this genus, on a scale where any plant with a score greater than 6 is considered a weed. There is anecdotal evidence, however, that some *Cabomba* species are imported illegally as *Limnophila* spp. or *Ambulia* spp.
Cabomba is not declared under legislation in Victoria, despite the infestations at Benalla and Nagambie, Australian Capital Territory or South Australia. Other States have a range of declarations:

Western Australia
C. australis, *C. caroliniana* and *C. gigantea*. Category P1 and P2 weed - To be eradicated and prevented from sale, trade or movement. Other species require assessment before importation.

Tasmania
Prohibited weed – Illegal to import, cultivate, sell or move from one place to another within the State.

Northern Territory
Class A Noxious Weed - To be eradicated;
Class C - not to be introduced.

Queensland
All Cabomba species are declared P3 (Plants are to be reduced in numbers and distribution throughout the State) and cannot be sold..

New South Wales
All cabomba except *C. furcata* (pink cabomba) Declared W4 - must not be sold, propagated or knowingly distributed.

1.5 Control to date

Cabomba management must address a wide range of community issues and values and is therefore best dealt with by the community to ensure that the benefits and risks of management decisions are shared in a partnership.

Research
Little research work is currently being done on cabomba:

- DNR is conducting pond trials to investigate cabomba's impacts on water quality and has undertaken considerable chemical screening trails;
- The Noosa Shire Council (Qld) are carrying out a pilot study on the potential of mechanical removal of cabomba; and,
- Caloundra City Council is working on a pilot study for revegetation of the bed of Ewen Maddock Dam.

Lake Macdonald Action Plan

The complexity and difficulties of cabomba management are well demonstrated at Lake Macdonald in southeast Queensland. The lake has been infested with cabomba for about ten years and now has seventy-five per cent of its area covered by cabomba (approx 180ha). Noosa Council is hampered in its control options as herbicides can not be used on the town water supply and draw down is not an option because the lake is habitat for the endangered Mary River cod as well as providing local recreational opportunities, including boating and fishing.
A holistic approach was adopted, focusing on actions to reduce impacts and prevent the spread:
Lake Macdonald Catchment Care Group established;
Sealed boat ramps constructed to prevent snagging of cabomba on boat trailers;
Education campaigns to promote decontamination of vehicles and equipment;
Restore and maintain riparian vegetation (nutrient traps, exclusion of stock, shading);
Investigating mechanical removal;
Limiting the generation and flow of nutrients into the system from catchment land-uses;
Lobbying for biological control; and,
Supporting initiatives of local Landcare and environmental groups.

This group provides an excellent model of community action in affected water bodies.

Extension and Education

There is limited knowledge on the existing level and distribution of cabomba because detection is difficult and identification skills and awareness have not yet developed within the community. Limited information material has been produced and made available to the community; for example a poster on weeds in waterways was developed for Weedbuster Week in 1999.

Control methods

In many situations it should be possible to contain cabomba because it mostly inhabits shallow nutrient rich impoundments, and cannot readily spread upstream, and it is difficult for cabomba to become established in fast flowing water downstream. There are, however, presently no effective control options for large infestations. Most methods are only useful for small or confined infestations.

Mechanical

Mechanical removal. The physical cutting and removal of vegetative material of cabomba is most applicable to closed water bodies, with established heavy infestations. Cabomba grows so quickly that treatment by this method is only likely to maintain a clear water surface for several weeks. Trials of mechanical removal in Lake Macdonald showed that two treatments over a month resulted in increased water clarity and some re-growth of other aquatic species. Rigorous hygiene protocols are required for operators and their equipment to ensure the risk of spread to clean sites is minimised. The movement of the plant material and nutrient rich water from this material also requires control. A concern with this option is that cabomba easily fragments from disturbance and so this process may assist the weed spread.
A venturi dredge (vacuum) was used in Ewen Maddock Dam which minimised fragmentation and also extracted the root ball.

Hand pulling. The success of hand pulling is yet to be fully evaluated, but it is probably suitable for isolated plants and small areas. A 100m strip was hand pulled in Lake Macdonald to allow a fishing workshop but within 2 weeks it was difficult to find a trace of the cleared area. Hand pulling by divers in Ewen Maddock Dam has been quite successful.

Habitat modification

Drawdown. The deliberate lowering of the water body may be the best option for potable water supplies if the water body can be taken “off line”. If the hydrosoil dries out completely then there is minimal chance of cabomba surviving but if the soil remains damp then there is greater than 50% chance of cabomba returning. Drawdown is not as useful when the bed has a gradual slope and better results are achieved when there are steep banks that can be flooded to maximum depth very quickly.
Drawdown has been recommended for the infestations in Victoria; the lack of water, in association with harsh environmental

conditions (winter frost and high summer temperatures), should be adequate to kill the plants. Three successive dry-season drawdowns and dredging have been carried out in Marlow Lagoon (NT), however, monitoring continues to assess results.

Weed mats /shading. Shading has been used for small strategic areas. At Lake Macdonald, builder's plastic was placed on the lakebed to keep the plant away from Mary River cod brood pipes and achieved good success. The cost is, however, prohibitive for large-scale programs. Also in turbid water, a silt substrate may cover the weed mat, which would enable the shallow rooted cabomba to colonise the matting.

Re-establishment of riparian vegetation may offer some control as cabomba does not tolerate shade. Long-term benefits are expected from maintaining tree cover along the edges of creeks and rivers to discourage cabomba establishing in the less swiftly flowing areas.

Chemical

Chemical control of this plant is problematic because of the difficulties associated with chemical applications in aquatic habitats (especially flowing water) and the potential to impact on non-target species and sites. A chemical control method for strongly flowing waters is not yet available, although granulated or pelletised herbicides can be strategically placed on the hydrosoil of still water bodies. A slow action herbicide is needed to help prevent oxygen depletion of the water resulting from massive decomposition of huge volumes of dead vegetation.

In non-potable water, 2,4-D N-butyl ester (Nufarm AF Rubber Vine Spray®) and diatomaceous earth is registered for cabomba in Queensland, Northern Territory and New South Wales. The 2,4-D ester is not water-soluble and is adsorbed onto the diatomaceous earth, so it does not disperse very far. This mixture is not persistent in the environment and does not accumulate in food chain but it does not have high public acceptance.
There is no herbicide registered for cabomba control in potable water. Trial results have been erratic and often required re-treatment. The most promising results were achieved with fluridone (Sonar®), however this chemical is being removed from the marketplace. Fluridone also produced some adverse impacts on emergent native species such as*, Hydrilla* and *Ludwigia*. Diquat, 2,4-D, copper sulphate and dichlorprop have been used with limited success overseas.

Biological control

Biological control has been developed for some floating weeds and for some partially submerged species, however, biological control of cabomba has not been attempted and surveys for potential agents have not been conducted in cabomba's native range. It is generally considered that submerged plants have a lower diversity of natural enemies because of their specialised environment also most herbivores that feed on submerged aquatic plants are generalists and may not offer a similar degree of specialisation e.g. grass carp. There may be specialists that offer potential as biological control agents but this is yet to be investigated. There is only one native member of the *Cabombaceae* family in Australia, *Brasenia schreberi*, which may mean agents may not affect native relatives.

Substitutes for cabomba

A number of aquatic species can offer potential as substitutes but their commercial value is probably limited. The two main groups of plants with similar features to cabomba are *Limnophila heterophyla or L. indica* (common name ambulias.) and *Myriophyllum* species, such as *M. variifolium* (watermilfoils). Other native aquatic species including, *Ceratophyllum* spp*,* and *Hydrilla* spp may provide suitable alternatives but these species may also be weedy and so should not be endorsed unless there weed potential has been assessed.

Consequences of control

Cabomba provides the usual benefits of aquatic plants in aquatic systems by removing nutrients from the water, protecting against bank and bed erosion and providing shelter for some organisms. Any control measure aimed at cabomba must consider the whole water body ecosystem to prevent shifting the potential photosynthetic biomass from submerged macrophyte to phytoplankton that could result in algal blooms. Impacts of control options on bank

and channel stability, water quality and the aquatic ecosystem must be considered.

1.6 Principles underlying the strategy

This strategy is based on the recognition and acceptance of four principles outlined in the National Weeds Strategy:

- Weed management is an essential and integral part of the sustainable management of natural resources and the environment, and requires an integrated, multidisciplinary approach.
- Prevention and early intervention are the most cost-effective techniques that can be employed against weeds.
- Successful weed management requires a coordinated national approach, which involves all levels of government in establishing appropriate legislative, educational funding and coordination frameworks in partnership with industry, landholders and the community.
- The primary responsibility for weed management rests with the landholders/land managers but collective action is necessary where the problem transcends the capacity of the individual landholder/land manager to address it adequately.

1.7 Process followed

Participation and consultation of all stakeholders is paramount in the development of a successful strategy. The Cabomba National Strategy is a product of 5 months of planning and public consultation. The Cabomba National Strategy Workshop (Brisbane, 13-14th April 2000) was attended by twenty-seven government and community representatives from Victoria, New South Wales, Queensland and the Northern Territory. Representatives represented; industry groups (Murray-Goulburn Water, Pet Industry Joint Advisory Committee, Aquarium Trade Association), research (CSIRO, FRC Environmental Consultants, DNR Alan Fletcher Research Station, Royal Botanic Gardens Sydney), local government (Caloundra City Council, Hawkesbury River County Council, Noosa Shire Council), state government (Northern Territory DPIF, NSW Agriculture, Department of Natural Resources, Queensland Department of Health, Queensland EPA Parks and Wildlife Service), Commonwealth government (Environment Australia) and community groups (Freshwater Fish Stockists Association of Qld, Mary River ICM Coordinator, Wildlife Preservation Society of Queensland, Sunfish Queensland Inc).

The Workshop was advertised electronically via the electronic list server, ENVIROWEEDS, which reaches over 400 people involved in weed management nationally. A notice was also placed in the March edition of *Petletter*, a monthly newsletter of the Pet Industry Joint Advisory Committee. A questionnaire was distributed to obtain information on cabomba distribution and impacts and over seventeen replies and submissions were received.

Draft strategies were forwarded electronically to nearly 80 individuals who expressed interest during the development process. Many of these individuals provided links to major stakeholder networks through their membership databases. Six weeks were provided for consultation on the draft strategy. Comments on the draft strategy were received from over 20 stakeholder groups and these were included in the final document.

The Strategy will be implemented through a Cabomba Management Group who will provide the management framework for cabomba as a Weed of National Significance and advise the National Weeds Strategy Executive Committee on progress (terms of reference are available from the National Weeds Executive Committee).

1.8 Relevance to other strategies

The National Cabomba Weed Management Strategy has been established to provide a framework for coordinated management of cabomba across the country. Complementary linkages can be found in a range of existing resource management initiatives at all jurisdictional levels (Table 1).

Scope Scale	Natural Resource Management	Pest Management	Weed Species Management
National	National Strategy for Conservation of Australia's Biological Diversity National Strategy for Ecological Sustainable Development	National Weeds Strategy	Cabomba WONS Strategy
State	State Biodiversity and Natural Resource Management Strategies Forest, River, Estuary and Wetland policies	State weeds strategies (Qld, NT, WA, NSW, Vic, Tasmania)	NSW Cabomba Management plan
Regional	Regional NRM Plans	Regional Pest Management Strategies	
Catchment	Catchment Management Strategies	ICM Pest Management Strategies	
Local	Landcare plans; conservation corridor plans; riparian vegetation management plans	Local Government Pest Management Plans (Qld.) Weed Management Strategy Lake Benalla (Vic) Aquatic Weeds in Lake Nagambie (Vic)	Marlow Lagoon Cabomba Management Plan
Property	Property Management Plans National Park Plans of Management (NT)	Property Pest Management Plans National Park Weed Management Strategy (NT)	

Table 1. Policy and strategy linkages

2 STRATEGIC PLAN

VISION

To stop cabomba destroying our waterways.

2.1 Prevent the introduction and spread of cabomba

Desired outcome

No new cabomba infestations develop.

Background

Prevention is the most effective way to manage any weed problem. Quarantine represents the first line of defense against incursions of weeds and the reports of continued importation need to be followed up. One of the most effective ways to prevent further distribution is through education. An informed community will have an understanding of the importance of catchments, freshwater ecology, the impacts of aquatic weeds as well as the specific problems and nature of cabomba. Understanding why weeds are able to invade, or what processes promote weed invasions is also important to catchment management and a wide range of natural resource issues. There have been no systematic waterway surveys to verify cabomba's distribution. There are a number of national monitoring programs that provide opportunities for education and monitoring linkages e.g. Tasmanian Weed Alert Network. The earlier cabomba naturalisation is detected, the easier it will be to control.

The retail supply of cabomba (section 3.2) is driven by market demand. Stopping demand is a major objective for this strategy as enforcement will only be useful as a last line of action. Apart from deliberate plantings it is assumed that the many recreational activities also lead to proliferation and transfer of vegetative particles to other areas. Local agencies need the ability to be able to close waterways to prevent spread but also to reduce their liability should accidents happen in the dense weed mats. Protocols for ensuring washdown of boats, trailers and fishing equipment can assist in preventing spread.

Strategy	Actions	Responsibility	Priority
2.1.1 Prevent importation of cabomba	Maintain AQIS quarantine provisions. Improve AQIS inspectors' ability to identify cabomba and other aquatic weeds in plant consignments. Promote correct labeling of imports.	AQIS, PIJAC, Aquarium Trade Assoc.	High
2.1.2 Change community attitudes and actions on cabomba	Develop and target a multi-media education and extension campaign at all stakeholder groups. Develop professional robust extension and education material on the; identification of cabomba impacts of cabomba community actions that can be taken regulations, penalties and enforcement alternative aquarium plants freshwater ecology.	DLWC, Agriculture Dept's (QLD, NT, NSW, Vic), DNRE, DNR, ICMC	High
2.1.3 Conduct regular monitoring of waterways for cabomba	Undertake reconnaissance surveys. Identify potential sources or areas of cabomba. Develop protocols for detection. Link with other programs such as Streamwatch, Waterwatch.	DLWC, local governments, DNRE, DNR, ICMC	High
2.1.4 Improve aquarium plant industry cooperation	Adoption of self-regulation by the aquarium plant industry (refer 3.2).	PIJAC, Aquarium Trade Assoc.	High
2.1.5 Minimise potential for further spread	Use quarantine protocols to manage activities, access and use of waterways containing infestations.	ICMC, local govt	High
2.1.6 Maintain natural characteristics of waterways	Ensure appropriate land use patterns. Identify and reduce diffuse and point sources of nutrient inflow. Maintain riparian vegetation.	DLWC, DUAP, Agriculture (QLD, NSW, NT, Vic), DNRE, DNR, local govt	Medium

2.2 Prevent the trade in cabomba

Desired outcome

Stop the trade in cabomba.

Background

Enforcement of bans on the sale of cabomba have been ineffective because inconsistent regulations between States have created the window of opportunity for wild harvesting and the continuation of illegal trade.

The plant industry is constantly on the lookout for new plants that may provide alternatives for cabomba. Preference would be given to native species, but this may involve changes to legislation governing the harvest of native species and some natives may pose weedy risks along with exotic species. A large number of plants are currently permitted imports but only a small number of these are commercially grown.

The aquarium plant industry supports the development of uniform legislation, the licensing and accreditation of growers (similar to that used for aquarium fish) and the establishment of a list of species that can be traded (similar to that used by Western Australia). This could provide benefits for other aquatic WONS and ensure that retailers only purchase supplies from regulated traders.

Strategy	Actions	Responsibility	Priority
2.2.1 Provide uniform regulations on cabomba trade across Australia	Introduce national uniform regulations preventing trade and distribution of cabomba Investigate effectiveness of domestic and international legislation covering cabomba Develop consultation processes with industry and community Provide penalties consistent with other flora/fauna regulation.	SCARM, NWSEC	High
2.2.2 Provision of alternative aquarium plants	Develop an appropriate process for selecting alternative species Develop a list of appropriate alternative, non-weedy plants (including natives) Investigate changes in legislation to enable trade in native species.	All State Dept's Agriculture, DNRE, DNR, EPA, NIA PIJAC, Aquarium plant trade assoc's,	Medium
2.2.3 Develop accreditation regime for aquatic plants	Develop a national licensing regime and code of practice to cover all aquatic plant growers and traders.	Industry, DNR, All State Dept's Agriculture, DNRE	Medium
2.2.4 Enforce trade regulations	Provide advice on regulation and responsibilities Provide adequate enforcement resources Involve the industry in a self-regulation and accreditation scheme Regularly audit retailers and wholesalers Provide consistent legal training procedures to enforcement agencies.	Agriculture Dept's (QLD, NT, NSW, Vic, Tas), local governments, DNR, EPA, DNRE, Industry	Medium

2.3 Minimise the impacts of cabomba

Desired outcome

The impacts of existing infestations are minimised.

Background

To minimise the impacts of cabomba there must be a reduction in the level of infestations. At this stage this is difficult to achieve because there are limited control methods available, and those that are available, are perceived as having too great a risk. Mechanical and hand removal appear to be the most effective at present. Some available methods have received negative publicity, herbicide control methods, but may be applicable in different situations.

Effective weed control is based on an understanding of the ecology and biology of the weed and relies on an intervention attacking at a weak or vulnerable point in the life cycle. Not enough information is known about cabomba to adequately develop a best practice management manual.

There is considerable interest and support for biological control of cabomba. There are still options for further development of mechanical and chemical control methods. It is unlikely that any one of these techniques will provide adequate control over the range of the weed in Australia, hence emphasis should be on the development of a suit of controls and integrating them to appropriate for best results. Local stakeholders are ideally located to assist in the development, implementation and assessment of integrated strategies.

Strategy	Actions	Responsibility	Priority
2.3.1 Strategic control of all infestations	Develop management plans with stakeholder participation and community based management groups. Map the extent of infestations and priority areas. Prepare a risk analysis and prioritize actions to prevent further spread. Treat infestations using approved methods.	ICMC, DLWC, DNRE, DNR, Agriculture Dept's (QLD, NT, NSW, Vic)	High
2.3.2 Improve the understanding of the ecology and biology of cabomba and freshwater ecosystems	Define the limits to growth and reproductive biology. Define, develop and adopt best practice management. Investigate integrated management options. Evaluate the impacts of the control technology on and off site.	DNR, DNRE, CSIRO, Agriculture Dept's (QLD, NT, NSW, Vic),	High
2.3.3 Implement biological control	Confirm the taxonomic status of cabomba. Undertake native range studies on natural enemies of cabomba. Evaluate the natural enemies as potential biological control agents. Release, establish and monitor their impact.	Agriculture Dept's (QLD, NT, NSW, Vic), CSIRO, DNRE	High
2.3.4 Quantify the impacts of cabomba	Establish the socio-economic impacts of cabomba: Water quality, quantity and delivery Biota Ecosystem function Safety. Identify if cabomba is a threatening process under federal biodiversity legislation.	DLWC, Agriculture Dept's (QLD, NT, NSW, Vic), ICMC, DNR, DNRE, EPA, Local govt.	Medium
2.3.5 Change community attitudes and actions on control	Identify community expectations of management Promote realistic expectations of control practices.	DLWC, DNR, DNRE, Agriculture Dept's (QLD, NSW, NT, Vic)	Low

2.4 Coordination of management

Desired outcome

Commitment to coordination of the strategy exists at all levels.

Background

Field experience with cabomba has highlighted the need for stakeholder involvement at all levels of decision-making and implementation. This approach enables a three-way flow of information between industry, government and community. The process achieves greater success through giving responsibility to those affected by the problem.

Community-based natural resource management is not new and a similar coordinated approach to cabomba could piggy-back on the successes of related programs such as integrated catchment management or Landcare.

Substantial resources are required to prevent the introduction and spread of cabomba and there is a need to ensure that these resources are used efficiently and effectively. Approaches for funding should be coordinated to highlight the level of commitment and to maximise the chance of funding support. The development of a management group will enable such coordination.

Strategy	Actions	Responsibility	Priority
2.4.1 National assessment of the distribution and impacts of cabomba	Develop and maintain the National Weeds Strategy homepage. Form regional assessment groups reporting to a national database	NWSEC, Agriculture (QLD, NT, NSW,Vic), ICMC, DNR, DNRE	High
2.4.2 Manage implementation of the plan	Form a Management Group to implement and monitor the plan.	Workshop Steering Group	High
2.4.3 Maximise the availability and use of resources	Obtain adequate resources to implement the strategy (for education, enforcement, control and management).	Management Group, NWSEC	High
2.4.4 Provide cooperative management frameworks	Develop and implement management plans in partnership with all stakeholders. Link management into existing national, regional and local schemes between community, schools, councils, government departments and industry eg ICM, Streamwatch, Waterwatch, Landcare, Murray-Darling Basin.	DLWC, Agriculture (QLD, NT, NSW,Vic), ICMC, DNR, DNRE, local govt	Medium

3 MONITORING AND EVALUATION

This Strategy is subject to a 5-year review. The *Cabomba Management Group* will monitor the implementation of the plan as a component of its quarterly meetings. Annual reports will be forwarded to the National Weeds Strategy Executive Committee and made available to interest groups in the most cost effective way. Monitoring will include a review of actions outlined and undertaken in:

- State weed management strategies
- Catchment management plans
- Local government pest management plans
- Project plans developed from this strategy
- State of the Environment reporting processes..

Performance indicators for the plan include:

- National restrictions on trade in cabomba
- Increased detection of cabomba imports
- Alternative species available for the industry
- Code of conduct for aquarium plant industry
- National license scheme developed
- Mapping and surveillance program completed
- Delivery of targeted extension material
- Management plans for all infestations
- Reduction in nitrogen and phosphorus levels in water ways containing cabomba
- Linkages developed to other NRM plans through cabomba actions
- Best practice management package developed
- Biological control program undertaken
- The impacts of cabomba are quantified
- National Weeds Strategy internet homepage developed as a national cabomba database
- Timely and adequate resources for actions
- Annual reports produced by the Management Group.

4 STAKEHOLDER ROLES AND RESPONSIBILITIES

Private Landholders

Prevent the introduction of cabomba onto their lands:

- Do not stock cabomba in aquaria, garden ponds, farm dams or water ways
- Be aware of the potential of cabomba to be introduced into farm dams
- Alert government if cabomba is found.

Manage infestations on their own land/water:

- Eradicate infestations where feasible
- Maintain control pressure on other infestations.

Prevent the establishment of cabomba in local water bodies:

- Reduce their contributions to nutrient loading from septic systems, livestock, garden run-off and urban development
- Alert government of pollution sources and
- Report wild planting and harvesting of cabomba.

Recreational groups

- Members are aware and of can identify cabomba
- Educate members on quarantine and weed hygiene protocols
- Not to undertake recreational activities or actions that will spread cabomba
- Practice weed hygiene on recreational equipment
- Observe and be aware of personal safety
- Help monitor water bodies and report infestations of cabomba.

Aquarium industry

- Ensure the industry continues to improve its responsibility for weed management
- Discourage the importation, promotion or trade of cabomba
- Create awareness amongst their members of the legislation on cabomba
- Assist to develop non-weedy alternatives
- Develop code of practice and accreditation guidelines.

Conservation groups

- Improve identification skills of members
- Promote awareness of cabomba impacts on freshwater ecosystems
- Report wild planting and harvesting of cabomba.

Landcare and Catchment Management Groups

- Monitor for cabomba and report any findings
- Identify and reduce contributions to nutrient loading from septic systems, livestock, garden run-off and urban development etc
- Develop and employ hygiene protocols for local infestations and ‘clean’ water bodies
- Ensure catchment management plans incorporate cabomba management
- Seek funding for management programs.

StreamWatch, WaterWatch and other similar programs

- Monitor for cabomba and report any findings
- Use weeds as indicators of water health.

Local and State Government (Vic, NSW, Qld)

- Continue to develop efficient, effective and appropriate control techniques
- Provide extension and education services to urban and industry stakeholders
- Enforcement of legislation and control measures
- Ensure that cabomba is identified in local, regional and State level pest management plans
- Liaise with landholder, community and industry interest groups
- Liaise with industry on accreditation regimes
- Research and develop best practice management

- Monitor water pollution
- Periodically inspect all water bodies for cabomba
- Promote reporting of cabomba infestations.

Government Departments (WA, SA, Tas, NT)

- Develop awareness campaigns to discourage aquarium use of cabomba
- Eradicate infestations where feasible
- Enforce complementary legislation to prevent sale and distribution of cabomba
- Liaise with industry on accreditation regimes.

Federal government

- Ensure quarantine controls on entry of cabomba (AQIS)
- To ensure uptake by Departmental staff to restrict movement of weeds (agencies that manage land and travel on non-government land)
- To ensure cabomba control is undertaken on all federally managed lands (Defence, Environment Australia and other Commonwealth departments/ corporations that manage land)
- Oversee and manage federal funds including Natural Heritage Trust and National Weed Program (Environment Australia, Agriculture, Forestry and Fisheries – Australia).

5 ADDITIONAL READING

Anon (1999) Draft Marlow Lagoon Cabomba Management Plan. NTDPIF and Palmerston Town Council.

Anon (1998) State Weed Management Plan: Cabomba. NSW Agriculture.

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Mackey, A.P. & Swarbrick, J.T. (1998) Cabomba caroliniana. The Biology of Australian Weeds, Vol. 2. (edited by Panetta FD, Groves RH and Shepherd RCH). RG and FJ Richardson. P 19-36.

Parsons, W.T. & Cuthbertson, E.G. (1992) *Noxious Weeds of Australia.* Inkata Press Melbourne, p 354-5.

Randall, R (1997) Weed Potential of Cabomba, *Cabomba caroliniana* A Gray. Agriculture WA

Sainty and Jacobs (1988) *Water Plants in Australia: A Field Guide* (3rd ed.). CSIRO, p 22, 52-53.

Thorp, J R, & Lynch, R (2000) *The Determination of Weeds of National Significance.* National Weeds Strategy Executive Committee, Launceston.

6 GLOSSARY

AQIS	Australian Quarantine and Inspection Service
CLIMEX	Simulation modeling system developed by CSIRO
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DLWC	Department of Land and Water Conservation (NSW)
DNR	Dept of Natural Resources (QLD)
DNRE	Department of Natural Resources and Environment (Victoria)
DPIF	Northern Territory Department of Primary Industries and Fisheries
DUAP	Dept of Urban Affairs and Planning (NSW)
EPA	Environmental Protection Agency (QLD)
ICMC	Integrated Catchment Management Committee
NIA	Nursery Industry Association
NRA	National Registration Authority
NWSEC	National Weeds Strategy Executive Committee
PIJAC	Pet Industry Joint Advisory Committee
SCARM	Standing Committee on Agriculture and Resource Management
WONS	Weeds of National Significance

7 APPENDIX 1 National roundup - Cabomba in Australia

Queensland
Two main cabomba populations exist in Queensland:

Far North Queensland:
(a) Cabomba occurs in the small (4m wide, 2m deep), permanently flowing Kenney and Leslie Creek system, upstream of the Barron River and Lake Tinnaroo. Introduced as a food plant for red-claw crayfish, floodwaters washed it into the Leslie Creek. Chemical treatment with fluridone (under NRA permit) successfully reduced the biomass but it quickly recovered. The effectiveness of the slow release herbicide was hampered by the permanent flow of the creek. The Gwynne and Leslie Creeks Catchment Landcare Association planted trees for shading but it is too early to evaluate their effectiveness.

(b) Infestations have established on the coastal lowlands. Cabomba spread from a farm dam, where it was planted to attract invertebrates for platypus, into the upper reaches of the North Johnstone River. The stoney bed of the river at the site has probably prevented it spreading further. The infestation in the dam is being hand-pulled but the dam will be drained and chemically treated. Large infestations also occur in the deep (10m) and wide (100m) pools of the coastal Russell-Mulgrave river system. There are records of cabomba in Avondale Creek north of Cairns; a drainage channel at Goondi, near Innisfail; South Maria Creek near El Arish; and, Canal Creek, where it now threatens the Eubanangee Swamp National Park. Two small infestations occur in the Burdekin Shire.

South east Queensland:
Ewen Maddock Dam has a large infestation of cabomba. Control trials using 2,4-D and draw-down were halted because of community opposition. Mechanical harvesting has been blamed for spreading the weed. Hand-pulling by divers has been useful for small areas and isolated plants. Up until 1996, $250,000 - $300,000 had been spent in managing cabomba and $150,000 – 160,000 pa is still being spent on physical removal of the weed.
Cabomba was first identified in Lake Macdonald in 1991 and now covers approximately seventy-five per cent (180ha) of the lake area. Noosa Shire Council provides financial incentives and technical advice to landholders within the catchment, addressing issue of increased nutrient loading and declining water quality. The Lake Macdonald Catchment Care Group, formed in 1999, is actively looking at how best to manage the many and complex issues. In 1999, over $100,000 was spent for a pilot study on weed harvesting and for the construction of boat ramps to enable clean access to open water. This is being followed-up with an additional $12,000 from the Noosa Council for further research in 2000.

(c) There are many other smaller infestations in the creeks and rivers of the Sunshine Coast hinterland. These mostly appear to have been deliberately planted for wild harvesting operations.

The Queensland Department of Natural Resources is currently spending in excess of $58,000 annually in cabomba research and extension. At least $15,000 pa for the past 5 years has been spent in controlling the Far North Queensland infestations.

Western Australia
Cabomba has potential to cause problems in the Ord River irrigation system and is capable of invading wetlands in the south west of the State. It is not known if cabomba is being commercially traded.

South Australia
Cabomba has never been collected from the wild and is not known to have naturalised despite being used extensively in the aquarium industry. It is used as a substitute for the declared species: *Elodea canadensis, Egeria densa* and *Lagarosiphon major*. The presence of permanent water limits its potential distribution in the State. The shallow backwaters of the Murray River (from the NSW border downstream to Mannum) are considered at risk from cabomba but it is unknown how well cabomba might grow in the salinity levels now present in the Murray.

Victoria
Reports of cabomba being a problem weed come from Lake Nagambie (a diversion weir on the Goulburn River) and Lake Benalla (town park). Lake Nagambie provides irrigation water through over 2500km of channels and drains and Lake Benalla is

linked to the Broken River and Lake Mokoan (an off-line irrigation water storage). There is potential for significant economic and environmental damage if cabomba should spread into these irrigation systems and ultimately the Murray River.

Weed management on Lake Nagambie originally focussed on controlling *Nymphaea mexicana*, however, cabomba quickly emerged as a serious threat. There has been a ten-fold increase in the area of the Lake Nagambie infestation over the last 2 years and it now covers 50-60 hectares.

In both lakes, little has been done to control the weed. A limited herbicide trial has been conducted on Lake Benalla in 1999/00 using dichlobenil, simazine and chelated copper at a project cost of $15,000. Dichlobenil trials and water manipulation trials have also been established at Lake Nagambie. A management plan for Lake Nagambie has been developed through a community consultative committee and the local Catchment Management Board

Tasmania

There is no Tasmanian record of cabomba naturalisation. It is occasionally detected in pet shops and the most recent occurrence was in a water garden display in a plant nursery. Supplies appear to be sourced from Victoria but quarantine services screen out much of this supply. The GARP model of potential cabomba distribution includes Tasmania.

New South Wales

Cabomba can be found in weekend markets and is still available in some pet shops even though its weed profile has been raised with declaration. Pink cabomba, *C. furcata,* is legally traded in this state.

Through the Cabomba Weed Management Plan, NSW Agriculture aims to prevent cabomba from establishing in waterways through:

- minimising dispersal in aquaria and nursery trades;
- replacing existing plants with alternatives; and,
- identifying naturalised areas and development of containment strategies for each site.

Detailed records of infestations are not yet known and part of the Plan is to define the infested areas. Infestations are regularly being found along the north and central coasts. Many appear to have been deliberately planted for wild cultivation of cabomba. Infestations occur from the Blue Mountains (Glenbrook Lagoon) to the Tweed River town water supply. An infestation in the Richmond River may be up to 5km long. Other records come from creeks around Taree-Foster and Port Macquarie; lakes at Coffs Harbour; and a private dam at Grafton.

The infestation in the Glenbrook Lagoon restricts recreational activities. There is high community opposition to the use of herbicides in the lagoon and no control has been attempted because of the questionable efficacy of other available methods.

Hastings Council (Port Macquarie) have tried to control cabomba in a retention pond with herbicides but resorted to excavation at a cost of about $20,000. The Department of Agriculture is spending about $20,000 on cabomba related extension and inspection services.

Northern Territory

The only known infestation is believed to be the result of a deliberate release of a fish tank, complete with coloured rocks, into Marlow Lagoon, a 3.5 hectare, high-use, recreation lake at Palmerston.

The Marlow Lagoon Cabomba Management Plan, a collaboration between the Palmerston Town Council and the DPIF, aims to eradicate cabomba from the lagoon and to prevent the spread of cabomba into nearby waterways.

Since 1997, about $400,000 has been spent in controlling this infestation. The lagoon has been drained and dredged during the dry season so that the lagoon base can ‘bake’. The infestation has been reduced to isolated plants around the margins. No plants have been found in the nearby waterways. Monitoring continues and individual plants are being hand-removed.

DPIF Fisheries Division is increasing its monitoring for plants being brought into the NT in the aquarium trade.

Current distribution of Cabomba.
(Data was collected as part of the weeds of national significance assessment, Thorp and Lynch 2000)