

WEEDS OF NATIONAL SIGNIFICANCE

Cabomba

(Cabomba caroliniana Gray)

strategic plan 2012–17

This publication is produced as part of the Weeds of National Significance initiative, a joint initiative between the Commonwealth of Australia and each of the Australian states and territories.

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An unpublished draft of the revised strategic plan has guided national coordination of this Weed of National Significance for the past two years. Before publishing the revised plan, the Australian Weeds Committee altered it because some actions had been completed, and then agreed to include a uniform monitoring, evaluation, reporting and improvement (MERI) template for all phase-3 Weeds of National Significance.

Supporting information about the Australian 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 and copies of the strategy. Comments and constructive criticism are welcome as an aid to improving the process and future revisions of this strategy.

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Summary

In 1999, cabomba (*Cabomba caroliniana*) was named as one of the inaugural 20 Weeds of National Significance because of its severe impacts on freshwater ecosystems. It has been detected in over 100 waterbodies in Australia. These isolated infestations represent only a small percentage of the potential range of cabomba. Further spread of cabomba could threaten waterways from Cape York to Hobart and from Sydney to Perth.

Cabomba is a fully submerged aquatic weed with prolific growth rates. The large biomasses produced by the fast-growing infestations impact on the capacity of water storages, reduce 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 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.

The original national cabomba strategic plan was developed in 2001 to establish a nationwide coordinated effort to help prevent further spread and reduce impacts. In 2003, a national coordinator and management group were appointed to oversee implementation of the plan.

In 2009, the implementation of the cabomba strategic plan was reviewed to assess the need for future national coordinated effort. The review found that considerable progress had been made towards achieving the goals and objectives of the plan and that, as a result, national coordination could be reduced.

This revised cabomba strategic plan aims to provide guidance to key stakeholders, from local to a national level, for the ongoing management of cabomba and to help build on the gains made since the release of the original plan in an era of reduced national coordination. A significant and ongoing commitment will be required from all key stakeholders to ensure that the goals and objectives of this strategic plan are met.

The three main goals and associated objectives of this plan are:

- 1 Prevent new cabomba infestations from establishing
 - Monitor waterways to enable early detection of new infestations.
 - Prevent spread from existing sites.
 - Reduce invasion pathways for cabomba.
 - Maintain and monitor eradication and containment programs for outlier infestations.
- 2 Strategically manage existing infestations
 - Identify key ecological assets at risk.
 - Pursue effective biological control agents and strategies for use against cabomba.
 - Strategically control areas to minimise impacts of existing infestations.

- 3 Increase the capability and willingness to manage cabomba
 - Collate national mapping data and provide decision support tools.
 - Develop effective techniques for managing cabomba.
 - Promote adoption of best-practice management.
 - Increase regulatory and community support for cabomba and submerged aquatic weed control programs.
 - Maintain capacity for coordinated management.

These goals deliver specific measurable outcomes and actions that complement the Australian Weeds Strategy.

Vision

Australia's waterways will be protected from the negative impacts of cabomba.

1 The challenge

Cabomba (*Cabomba caroliniana*) poses a significant threat to all waterways in Australia. The first national cabomba strategic plan was developed in 2001 to help direct management efforts towards preventing its spread and reducing its impact. The National Aquatic Weeds Management Group and a National Aquatic Weeds Coordinator oversaw the implementation of this plan, providing a coordinated and national approach to the management of cabomba, which have resulted in increased commitment to its management.

Early detection, eradication and control programs are under way across Australia. Eradication and containment programs are under way at selected priority outlier sites in the Northern Territory, Queensland and Victoria. More than 3000 people across Australia have been trained to identify and report the weed—a program that forms the basis of a nationwide passive detection network for cabomba. Consultation and awareness-raising initiatives with the aquarium industry have helped increase their understanding of why cabomba is banned from sale, and broader aquatic weed issues. In addition, other aquarium plants with weed potential have been identified and their removal from sale will help ensure that cabomba is not replaced in the trade by other aquarium plants with similar weed potential. Recent research and development initiatives have included biological control, ecological studies, and herbicide screening and testing. This research has substantially improved our knowledge of cabomba, the mechanisms behind invasion and how it is best managed.

The above initiatives have helped to prevent the spread and reduce the impacts of cabomba since 2003. However, national coordination for the cabomba strategic plan will end in June 2013. To ensure Australia's waterways remain protected from the adverse impacts of cabomba, an ongoing commitment to its management will be essential. This revised plan outlines the strategic goals and actions required to maintain this commitment beyond 2013. The challenge now lies with all stakeholders to accept responsibility for implementing these goals and actions, and work together to help ensure that the national effort continues.

2 Background

2.1 The biology of cabomba

Cabomba is a fully submerged aquatic plant except for occasional floating leaves and emergent flowers. It is a perennial, growing from short rhizomes with fibrous roots. The branched stems grow up to 10 m long and have scattered white or reddish brown hairs. The underwater leaves are finely branched, resulting in a feathery, fan-like appearance. These leaves are about 5 cm wide and secrete a gelatinous mucus that 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 2 cm across and range in colour from white to pale yellow and may also have a pink or purplish tinge. The flowers emerge on stalks from the tips of the stems.

Cabomba in Australia was originally thought to be sterile, but, in 2006, seeding populations were detected in the Northern Territory. With these exceptions, reproduction and dispersal appear to be entirely vegetative. Fragments may survive in water for 6–8 weeks, and a detached shoot with at least one pair of leaves is capable of growing into a mature plant. Fragments 1 cm or less may be viable. In north Queensland and the Northern Territory, cabomba grows and flowers continuously, but in southern Queensland it dies back in winter and settles on the bottom where the stems fragment, providing dispersal material.

Cabomba is sensitive to drying out and requires permanent shallow water, usually less than 3 m deep, although it can grow in water up to 6 m deep (Schooler & Julien 2006). Because cabomba grows quickly, it can respond to wide fluctuations in water depths. It can acquire nutrients from both the water column and from the sediment. Cabomba grows well on silty substrates, but its vigour is reduced on hard substrates.

Water quality affects the growth of cabomba. It grows well in slightly acidic conditions (pH 6), but above pH 8 the plant loses its leaves. High calcium levels also inhibit growth. In aquaria ponds, cabomba grows well in water with medium turbidity and in water with high turbidity, which is of concern because turbid water usually limits the growth of aquatic weeds. Other species of cabomba require more light than *C. caroliniana*. Cabomba can survive temperatures down to 4 °C and can survive under ice where water is still liquid, but it prefers a warm, humid climate with a temperature range of 13–27 °C.

Preliminary genetic analyses indicate that most cabomba infestations in Australia are a hybrid between *C. caroliniana* var. *caroliniana* and *C. caroliniana* var. *pulcherrima*. However, an infestation in the Northern Territory is more similar to *C. caroliniana* var. *caroliniana* and is the only population in Australia known to produce viable seed. Another infestation near Bucca, in northern New South Wales, appears to be a hybrid between *C. caroliniana* var. *caroliniana* and *C. aquatica* (A Weiss in Schooler, Cabrera Walsh & Julien 2010). This indicates that there have been at least three separate introductions of cabomba into Australia.

Cabomba may be confused with other introduced and native aquatic species. One other species from the genus, *C. furcata* (pink cabomba) is also sold in the aquarium trade but is considered to be rare. This species is often confused with ambusias (*Limnophila* spp.), which are commonly sold as aquarium plants, but can be distinguished by leaf form. Other submerged species, which can also be distinguished by leaf form, are the hornworts

(*Ceratophyllum* spp.), native limnophilas (*Limnophila* spp.) and the watermilfoils (*Myriophyllum* spp.).

2.2 History of spread

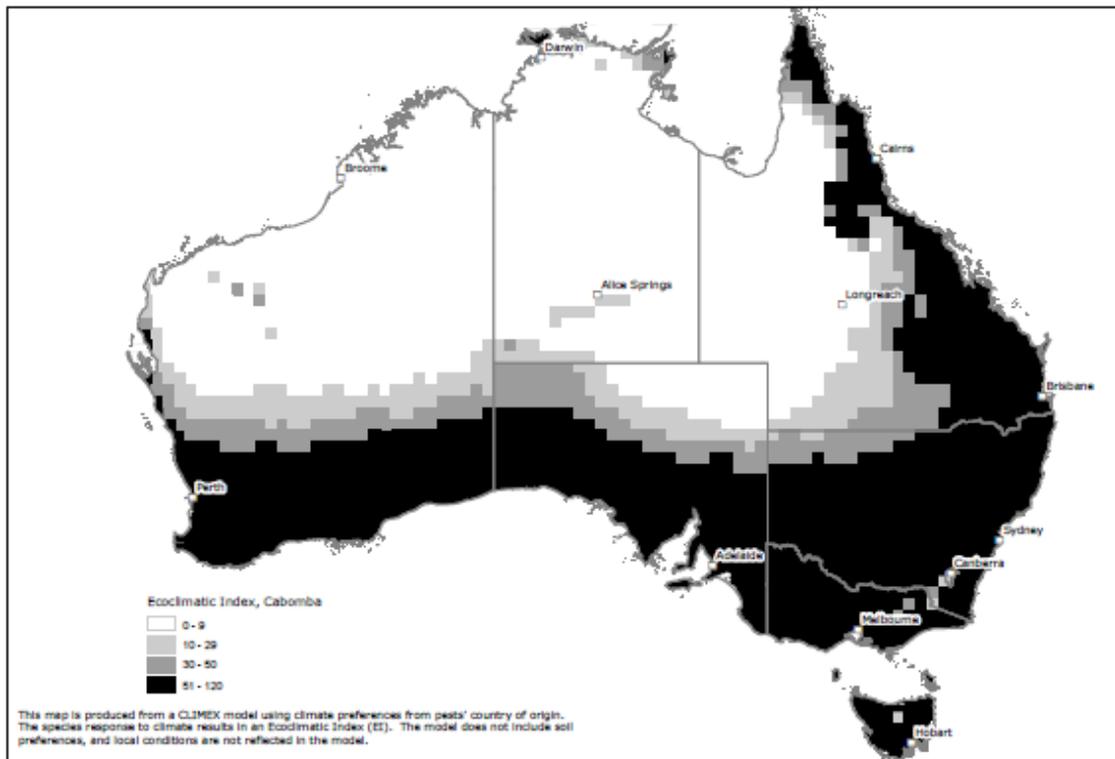
C. caroliniana is the only species of the genus *Cabomba* known to have naturalised in Australia, although there is at least one *C. caroliniana* × *C. aquatica* hybrid population on the North Coast of New South Wales.

C. caroliniana is native to southern Brazil, Paraguay, Uruguay, north-east Argentina and the south-east United States. Cabomba's popularity in the aquarium trade has resulted in its dispersal throughout the world. The first herbarium record of cabomba in Australia is dated 1967, but there is anecdotal evidence that it may have been introduced in the 1930s.

C. caroliniana was recorded in the flora of New South Wales 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 aquarium trade.

Cabomba is distributed across a wide climatic zone from Darwin to Victoria at more than 100 sites. In Queensland, it 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. In New South Wales it has naturalised in numerous creeks and river systems in the northern rivers, Hunter region, Central Coast and the Sydney Basin. In Victoria, infestations occur at Lake Nagambie (25 ha), Lake Benalla (20–25 ha) and Broken River in central Victoria. There is no record of naturalisation in the Australian Capital Territory, South Australia, Tasmania or Western Australia. Control efforts have successfully eradicated infestations in Marlow Lagoon near Darwin and in Mildura, Victoria.

The potential distribution of cabomba has been predicted using a CLIMEX model that is based on temperature tolerance found in its native range (Figure1). All states and territories potentially have favourable climatic conditions for cabomba, with excellent habitat conditions provided across southern and eastern Australia. Consequently, cabomba can potentially invade nearly all permanent, slow-moving or ponded waterways in Australia.



Ssource: Queensland Department of Agriculture, Fisheries and Forestry

Figure 1 Climex model predicted range of cabomba in Australia; the black area is considered to be highly suitable and the grey area marginally suitable

2.3 Summary of impacts

Cabomba is a Weed of National Significance (WoNS) because of its impacts on the biodiversity and function of freshwater, water quality, water storage and distribution infrastructure, and on recreational and amenity values.

The monoculture that results from fast-growing submerged cabomba infestations excludes native aquatic plants and alters the aquatic habitat for other organisms, ultimately reducing biodiversity. Light penetration is restricted, causing changes to food chain structures and species composition. Cabomba will out-compete many native plants, such as the pond weeds (*Potamogeton* spp.), stoneworts (*Chara* spp.), water nymph (*Najas tenuifolia*) and hornwort (*Ceratophyllum demersum*). There are examples where alterations to the native flora have affected populations of native fauna, including platypus, water rats and Mary River cod (van Oosterhout 2009).

Cabomba dies back at certain times of the year (depending on temperature), which can cause large amounts of decomposing vegetation, foul-smelling, oxygen-deficient water and an increase in the rates of release of some nutrients from bottom sediments.

Dense stands of cabomba can affect recreation, and create public safety concerns by interfering with the navigation and movement of water craft. Fishing is nearly impossible in heavy infestations because lines can become entangled in the weed. Cabomba is a potential drowning hazard for swimmers, and also creates a work place health and safety issue for local government, water engineers, weed managers, field staff and protected-area staff.

Severe infestations can also reduce the scenic amenity values associated with the waterbody. Clear rippled surfaces become darker, still and partially stagnant in the presence of a cabomba infestation.

Cabomba increases costs associated with managing irrigation and water supply equipment because it blocks the foot valves of pumps, resulting in continual and increased levels of maintenance and reduced pumping efficiencies.

2.4 Control to date

Current on-ground control of cabomba has been restricted because of a lack of biological control agents and registered herbicides. The process of registering safe and effective herbicides and finding potential biological control agents takes considerable time. These processes are currently under way. In the meantime, on-ground control is limited to physical control methods, which are documented in the cabomba control manual (van Oosterhout 2009). The physical control options contained in the manual and the current status of herbicide and biological control development are briefly summarised below.

2.4.1 Physical control

Physical control options include mechanical removal, hand removal, drawdown and shading.

Mechanical removal or harvesting, using either paddlewheel or suction-based harvesters, involves cutting cabomba underwater and removing it from a waterbody. It is mostly used in large, established infestations in closed waterbodies where other methods are not applicable (e.g. potable water supplies). It is expensive but deemed cost-effective in situations where cabomba needs to be suppressed (for either safety reasons or to limit spread). Disposal of harvested material and management of fragments generated by harvesting operations need to be considered when using this method. Regrowth of cabomba normally occurs so quickly after harvesting that areas treated with mechanical removal will retain a clear body of water for a short time (several weeks). Mechanical removal improves water quality once cabomba is removed.

Hand removal is best used to remove small infestations or sections of large infestations, or as a follow-up method in an eradication program. Cabomba plants are pulled out by the roots, either by wading through shallow water or by scuba diving. Hand removal is expensive and has limited application, but is highly thorough and target specific.

Drawdown drains or lowers a waterbody to allow aquatic vegetation to be managed. It is only possible where water levels can be controlled through pumping and outflow—usually only in water storages, reservoirs and dams. To control cabomba the waterbody needs to be drained and the substrate dried enough to destroy the plants (including roots). If the soil remains damp there is a greater than 50% chance of cabomba returning. Draining the waterbody can spread cabomba fragments so this method should only be considered where the risk of spreading fragments can be minimised. In addition, the significant ecological and economic impacts that can result from draining a waterbody should also be considered. Drawdown is best used in regions where harsh climatic conditions (e.g. severe frosts, high summer temperatures) can help to kill the plants. A drawdown for 9 months during 2008–09, which included winter and summer months, occurred in a small lake near Mildura,

Victoria. The results appear promising, with ongoing monitoring revealing no regrowth of cabomba.

High levels of shade have been shown to destroy cabomba over a 3–4-month period; consequently, the use of either benthic or floating blankets can be a suitable control strategy for small strategic areas. Benthic blankets or mats sit over the substrate on the bottom of a waterbody and both compress the plant and block out sunlight. However, in turbid water, silt can cover the blanket within just a few weeks and if not removed can allow cabomba to recolonise. Floating blankets constructed from builders' black plastic have been successfully used to suppress cabomba patches in the Darwin River, Northern Territory, and in farm dams near Kin Kin, Queensland. Although effective, floating blankets are costly and logistically difficult to install and maintain.

2.4.2 Chemical control

Chemical control of cabomba can be problematic due to the difficulties associated with applying herbicides to the submerged foliage of the plant, risks of off-target damage and negative public perceptions surrounding use of herbicides in water. In 2004 the registration of 2, 4-D N-butyl ester was suspended and, as a result, there were no herbicides effective against cabomba registered for use. In 2011, following an extensive process to find an alternative herbicide, carfentrazone-ethyl (Shark[®]) was approved by the Australian Pesticides and Veterinary Medicines Authority for use against cabomba in non-flowing water bodies. The herbicide is applied to the water surface or below the water surface, with the intention to achieve a high enough concentration in the water column to control cabomba. The product is practically non-toxic to birds and mammals, does not bio-accumulate in fish and, due to its short half-life, does not persist in the environment. The herbicide is, however, considered moderately toxic to fish and, because of the way it is applied, there are risks of off-target damage to native vegetation. There are no herbicides registered for use in potable water supplies or flowing water.

2.4.3 Biological control

There are no biological control agents available for cabomba. However, researches have identified a small weevil, *Hydrotimetes natans*, as a promising biological control agent. Preliminary host-specificity testing showed the weevil was likely to be host specific but the weevil colony perished before studies could be completed. Future research aims to finalise this testing and to find other agents that may be viable for use in Australia. If suitable and safe biological control agents can be found they may provide a vital tool to control cabomba in potable water supplies, flowing water and other environments where physical and chemical methods are not feasible.

2.5 Socioeconomic factors affecting management decisions

Cabomba is highly destructive to waterways but due to the lack of effective control options a management program is not always feasible. Where control programs do exist they are mostly undertaken and funded by weeds or waterway managers. However, the prolific growth rate of cabomba, the limitations of control methods and the aquatic habitat cabomba invades often make these control programs extremely resource intensive.

Where a strategic need exists to manage cabomba to prevent further spread or reduce its impact, it is likely that control programs will require significant long-term funding to achieve the desired goals. It is likely that in most instances the costs associated with a control program will often be beyond what individual landholders or even a local government can afford. However, as there will almost certainly be considerable public benefit arising from the control program, government agencies should provide support and adequate funding where such benefits can be demonstrated.

2.6 Quarantine and legislative controls

Cabomba is prohibited from trade or sale in all states and territories. Its legal status in some states is somewhat restricted by the lack of broadscale and cost-effective control techniques and therefore declarations may change if such techniques become available. The legal status of cabomba is summarised in Table 1.

Table 1 Legislation related to *Cabomba caroliniana*

Jurisdiction	Legislation	Declaration	Action
Australian Capital Territory	<i>Pest Plants and Animals Act 2005</i>	Class 1—notifiable pest plant Class 4—prohibited pest plant	Presence must be notified to the Chief Executive Propagation and supply is prohibited
New South Wales	<i>Noxious Weeds Act 1993</i>	Class 5 (S)—restricted weed (statewide). Class 5 weeds are also notifiable weeds	Control is not required; sale and movement is restricted
Northern Territory	<i>Weeds Management Act 2001</i>	Class A,C—declared weed. Not to be introduced to the Territory	To be eradicated
Queensland	<i>Land Protection (Pest and Stock Route Management) Act 2002</i>	Class 2 plant—plants are established in the state and have, or could have, an adverse economic, environmental or social impact	Landowners must take reasonable steps to keep land free of Class 2 plants. It is an offence to keep or sell Class 2 plants without a permit
South Australia	<i>Natural Resource Management Act 2004</i>	Class 11+—restricted sale only	Control is not required
Tasmania	<i>Weed Management Act 1999</i>	Declared plants	Details on actual restrictions or measures for each declared weed is contained in the weed management plan for that weed
Victoria	<i>Catchment and Land Protection Act 1994</i>	R10—restricted weeds (i.e. weeds that are, or have or may have the potential to become, a serious threat to primary production, Crown land, the environment or community health in Victoria or in another state or a territory of the Commonwealth. They pose an unacceptable risk of spread if they were sold or traded)	
Western Australia	<i>Agricultural and Related Resources Protection Act 1976</i>	P1 and P2 The legislative arrangements are currently in a transition from the <i>Agriculture and Related Resources Protection Act 1976</i> to the <i>Biosecurity and Agriculture Management Act 2007</i> (BAM Act)	P1—prevention of trade, sale or movement P2—eradicate: serious weeds that are not yet widely established

2.7 Principles underpinning the plan

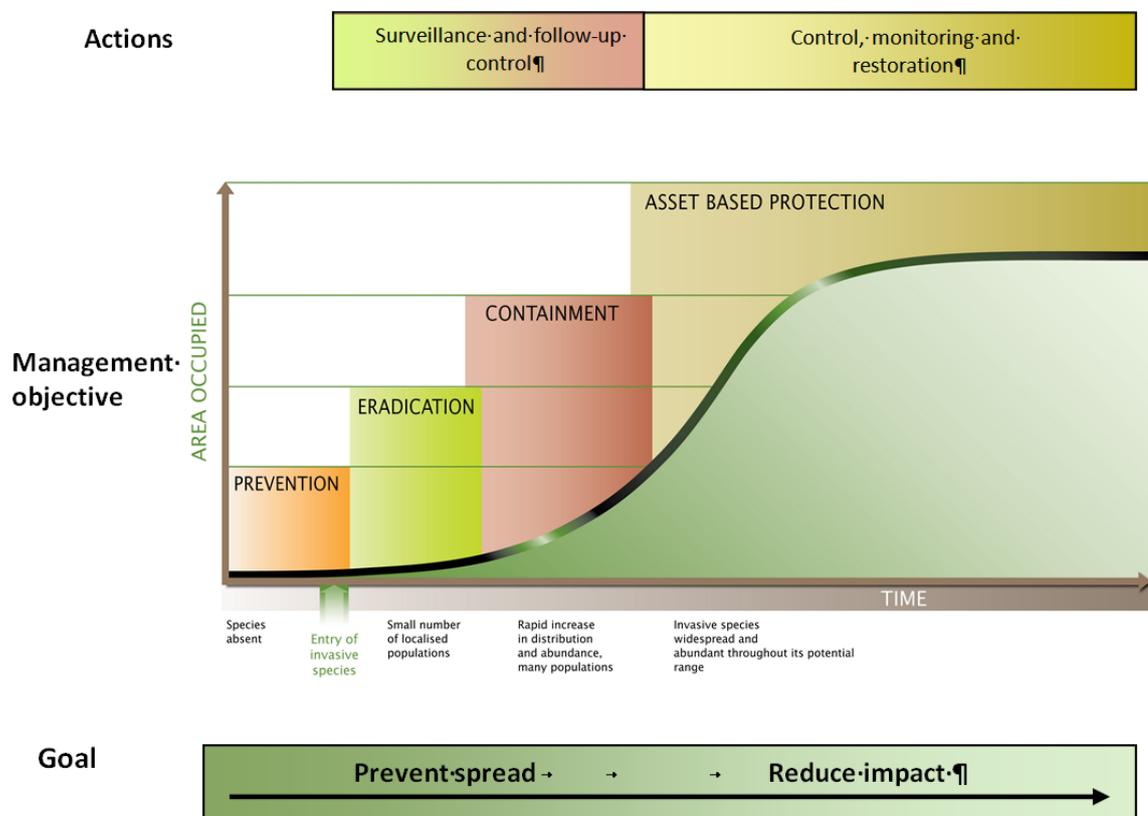
This strategic plan is based on the seven key principles of the Australian Weeds Strategy (NRMMC 2007):

- Weed management is an essential and integral part of the sustainable management of natural resources for the benefit of the economy, environment human health and amenity.

- Combating weed problems is a shared responsibility that requires all parties to have a clear understanding of their roles.
- Good science underpins the effective development, monitoring and review of weed management strategies.
- Prioritisation of, and investment in, weed management must be informed by a risk management approach.
- Prevention and early detection are the most cost-effective techniques for managing weeds.
- Weed management requires coordination among all levels of government in partnerships with industry, land and water managements, and the community, regardless of tenure.
- Building capacity across government, industry, land and water managers, and the community is fundamental to effective weed management.

The WoNS initiative establishes national priorities and facilitates action where there is a significant national or cross-jurisdictional benefit to be gained. These strategic plans do not specifically address resourcing; however, they aim to identify efficiencies and ensure existing resources can be allocated to achieve the most strategic management outcomes.

Effective broadscale management of WoNS and other weeds requires an integrated approach that includes prevention and eradication programs, establishment and implementation of management zones, and the protection of key environmental, social and economic assets in areas where the weeds are already widespread (Figure 2).



Source: Modified from Hobbs & Humphries (1995) and DPI (2010).

Figure 2 Stages of weed invasion with corresponding goals, management objectives and actions at each stage

2.7.1 The national program—progress to date

The first national cabomba strategic plan was developed in 2001 with the aim of delivering four key outcomes: i) prevent the introduction and spread of cabomba, ii) prevent the trade in cabomba, iii) minimise the impacts of cabomba and iv) coordinate management. In 2003, a National Aquatic Weeds Coordinator was appointed and a National Aquatic Weeds Management Group (NAWMG) was convened to implement the cabomba strategic plan, and the alligator weed and salvinia strategic plans.

In 2009, the Natural Resource Management Ministerial Council (Resolution 15.7, 21 May 2009) endorsed a three-phased approach to national management of WoNS species (Appendix 1). In August 2009, a panel from the Australian Weeds Committee reviewed the implementation of the cabomba strategic plan to:

- assess progress towards implementation of the goals and actions of the strategic plan
- assess the need for future national coordinated effort
- propose changes to the strategic plan
- make recommendations as to the appropriate level of future support and coordination.

The review found that, from a base of very little knowledge, significant progress had been made towards implementing the strategic plan. Key achievements include:

- implementation of awareness and early detection initiatives, which has resulted in the doubling in the number of known cabomba sites in Australia
- national mapping of occurrence and management actions (Appendix 2)
- a ban from sale in all states and territories, which has effectively removed a major invasion pathway
- using a weed risk assessment approach to recommend banning 33 other aquatic plant taxa from sale in all states and territories, which helps address the risk of cabomba been replaced by other aquarium species with similar weed potential
- significant involvement of the aquarium industry in the national aquatic WoNS initiative, including their development of the 'responsible handling of aquatic plants' DVD and their involvement on the technical panel for the aquatic plants weed risk assessment project
- successful eradication or containment of some outlier infestations in the Northern Territory and Victoria
- a significant increase in knowledge of cabomba as a result of research.

Despite these achievements, the review concluded that progress towards managing infestations has been limited because of a lack of suitable control techniques, in particular herbicide and biological control. The review recommended that cabomba remains in an early phase of implementation (phase 1) and that a revised strategic plan be developed.

In February 2011, the NAWMG, in conjunction with key stakeholders, drafted a revised strategic plan, which was later released for public comment. All submissions received were supportive of the draft plan and were considered during preparation of this final version.

2.8 Relevance to other strategies

The WoNS Cabomba Strategic Plan 2012–17 has been developed to provide a framework for coordinated management of cabomba across the country. Complementary links can be found in a range of existing resource management initiatives at all jurisdictional levels, as shown in Table 2.

Table 2 Strategies and plans for the management of cabomba

Scale	Strategy and plans
National	Australian Weeds Strategy 2007, National Strategy for the Conservation of Australia's Biodiversity 2010, Draft Basin Plan—Murray–Darling 2012
State	State and territory biodiversity conservation strategies, invasive species and biosecurity strategies, Northern Territory Weed Management Plan for Cabomba 2011
Regional	Natural resource and catchment management plans, wetland and water quality management plans, invasive species plans, Mary River Aquatic Weeds Strategy 2010–14
Local	Weed control plans, creek and catchment plans, local government weed plans

3 Strategic goals

Revised actions to protect Australia's waterways from the impact of cabomba are described in Sections 3.1–3.3.

3.1 Goal 1: Prevent new cabomba infestations from establishing

Prevention is the most effective way to manage any weed problem. The goal is to project clean areas in Australia by preventing the introduction of cabomba and rapidly responding to new incursions (Table 3). Monitoring of waterways and invasion pathways helps ensure that new infestations are detected and destroyed early. A range of early detection tools are available to help build the capabilities of weed managers, waterway managers and the community to monitor waterways for cabomba, including identification resources, early detection survey guidelines and aquatic weed identification training.

Containment programs should be implemented at all sites posing a high risk of further spread. This can involve strategic control of cabomba at boat ramps to prevent accidental spread by boating and fishing equipment, or control at other sites where high-risk vectors are present (see Appendix 3). Targeted awareness and education campaigns will also help reduce the risk of further spread by boating and fishing enthusiasts.

The nationwide ban on the sale of cabomba has been highly effective in preventing further spread of cabomba through the aquarium trade. To ensure that cabomba is not replaced in the trade by other aquatic plants with similar weed potential, efforts to identify and ban from sale other aquatic plants with high weed risk need to continue. Awareness initiatives with the aquatic plant trade to increase their understanding of the impacts of aquatic weeds and their legislative status have been highly effective and such initiatives should continue.

Eradication and containment programs need to continue for all outlier sites otherwise they are likely to rapidly spread and become widespread. However, for many sites such programs will only be possible once effective herbicide options are available.

Table 3 Objectives and strategic actions to achieve goal 1 of the Cabomba Strategic Plan 2012–17

Objective	Strategic actions	Action level ^a	Responsibility
1.1 Monitor waterways to enable early detection of new infestations	Maintain cabomba (and high-priority aquatic weed) identification training initiatives for weeds staff, community members and waterway managers	1	State and territory governments, regional NRM groups
	Promote surveillance activities for cabomba in priority regions (as indicated in the national map, Appendix 2)	1	State and territory governments, regional weed committees, LCAs, regional NRM groups
	Link passive surveillance activities to fisheries, water quality and riverine monitoring programs, and community-based NRM reporting		
	Ensure the supply of cabomba identification and awareness information is ongoing	1	State and territory governments
	Review the effectiveness of existing aquatic weed early detection guidelines and revise where necessary	2	NAWMG
1.2 Prevent spread from existing sites	Implement strategic control programs at infested boat ramps and other sites at high risk of spread	1	State and territory governments, LCAs
	Implement awareness programs for boating and fishing audiences to promote hygiene and other measures that reduce spread of cabomba (and other aquatic weeds)	2	State and territory governments, regional weed committees, LCAs
1.3 Reduce invasion pathways for cabomba and other ornamental aquatic plants with weed risk	Ban from sale all species of <i>Cabomba</i> (other than <i>C. furcata</i>) that have a high weed risk potential, as recommended by the Aquatic Plants Weed Risk Assessment project	2	State and territory governments
	Maintain cabomba and aquatic weed awareness initiatives with aquatic plant wholesalers and retailers	2	NAWMG, state and territory governments, PIAA
	Inspect aquatic plant retail outlets	2	State and territory governments, LCAs
	Scope the potential of a species-labelling scheme for aquarium and aquatic ornamental plants at retail outlets	3	PIAA, NAWMG, aquatic plant wholesalers
1.4 Maintain and monitor outlier eradication and containment programs	Continue cabomba eradication and containment programs at existing strategic locations	2	State and territory governments, regional weed committees, LCAs, regional NRM groups
	Assess the feasibility of eradicating and containing cabomba at priority outlier sites in response to the availability of new or improved control methods (see Strategic actions 3.2.1 and 3.3.1)	1	NAWMG, regional weed committees LCAs
	Develop and implement management plans for priority eradicable/containable outlier infestations	1	State and territory governments, regional weed committees, LCAs regional NRM groups

LCA = local control authority; NAWMG = National Aquatic Weeds Management Group; NRM = natural resource management;
PIAA = Pet Industry Association of Australia

a The Australian Weeds Committee (AWC) applied three action levels that reflect jurisdictional commitment to implementing actions:

Level 1 = Highly beneficial as a national action that is critical to success of the WoNS revised strategic plan and all relevant AWC jurisdictions have committed resources to implementing this action.

OR

Highly beneficial to a particular jurisdiction and the responsible party/ies have committed resources to implement this action.

Level 2 = Highly beneficial at national and/or jurisdictional level, but implementation will be subject to resource availability and investment priorities.

Level 3 = Desirable and still beneficial to improving uptake and efficiency of on-ground action, but not critical to success.

3.2 Goal 2: Strategically manage existing infestations

Three objectives aim to reduce the impact of established cabomba infestations (Table 4). An asset-based protection approach shifts the focus of control programs to protecting economic assets and aquatic habitats of national, state or regional significance cabomba. Research to better quantify the ecological and economic impacts of cabomba and other submerged aquatic weeds will help this process.

Research into biological control needs to continue because biological control agents could be a cost-effective tool to reduce the impact of cabomba infestations that cannot be feasibility controlled with current options. If host-specific agents are found and approved for release, a biological control release and monitoring program for core areas will need to be established.

Table 4 Objectives and strategic actions to achieve goal 2 of the Cabomba Strategic Plan 2012–17

Objective	Strategic actions	Action level ^a	Responsibility
2.1 Identify key ecological assets at threat from cabomba and prioritise them at national, state and regional levels.	Compile a database of key national, state and regional ecological assets threatened or impacted by cabomba and other WoNS, and develop management actions and strategies to protect assets	3	National Aquatic Weeds Management Group, state and territory governments, regional natural resource management groups, regional weed committees, LCAs
	Quantify the impacts of submerged aquatic weeds to aquatic ecology	2	Research organisations, international collaborators
2.2 Pursue effective biological control agents and strategies for use against cabomba	Continue host specificity testing of potential biological control agents and seek approval for release of host-specific agents	2	CSIRO
	Implement rearing, release and monitoring programs for approved biological control agents	2	State and territory governments, local control authorities
	Continue to survey the native range of cabomba for potential biological control agents	3	CSIRO
2.3 Use strategic control measures to minimise the impacts of existing infestations	Develop and implement site-specific management plans (in addition to goal 2.1) that protect key assets and values at priority infestations	2	State and territory governments, regional weeds committees, LCAs

CSIRO = Commonwealth Scientific and Industrial Research Organisation; LCA = local control authority

a The Australian Weeds Committee (AWC) applied three action levels that reflect jurisdictional commitment to implementing actions:

Level 1 = Highly beneficial as a national action that is critical to success of the WoNS revised strategic plan and all relevant AWC jurisdictions have committed resources to implementing this action.

OR

Highly beneficial to a particular jurisdiction and the responsible party/ies have committed resources to implement this action.

Level 2 = Highly beneficial at national and/or jurisdictional level, but implementation will be subject to resource availability and investment priorities.

Level 3 = Desirable and still beneficial to improving uptake and efficiency of on-ground action, but not critical to success.

3.3 Goal 3: Increase capability and willingness to manage cabomba

Strategies need to be in place to ensure the capacity and willingness to manage cabomba continues to increase with reduced and eventual absence of national coordination (Table 5). Maintenance of the national cabomba map (Appendix 2) and strategic actions will help ensure the ongoing communication of national priorities.

The limitations of current control options means that further research and development is needed to identify cost-effective and sustainable management techniques for cabomba and other submerged aquatic weeds. Further research is needed into biological control (objective 2.2), physical control methods and herbicides, including testing new herbicides and herbicide and application technologies. Obtaining regulatory acceptance and approval for the use of additional aquatic herbicides in Australia will help the development of improved management techniques.

Ongoing provision of best-practice advice and materials will be critical for maintaining the skills base required for effective cabomba management. This advice and information will need to be updated if improvements in best practice are found. Finally, integration of the key priorities from this plan with state and regional weeds and natural resource management plans will help ensure that commitment to cabomba management continues.

Table 5 Objectives and strategic actions to achieve goal 3 of the Cabomba Strategic Plan 2012–17

Objective	Strategic actions	Action level ^a	Responsibility
3.1 Collate national mapping data and provide decision support tools	Maintain and update national distribution and density maps	1	State and territory governments
	Use a national online data storage and mapping tool for ongoing reporting and to access the cabomba dataset	2	State and territory governments
3.2 Develop effective techniques for managing cabomba and other submerged aquatic weeds	Implement research and development programs to investigate new control techniques or refine existing approaches. Priority areas include: <ul style="list-style-type: none"> evaluating new aquatic herbicide formulations improving herbicide delivery techniques to submerged weeds improving the cost-effectiveness of current non-herbicide techniques developing integrated control strategies 	2	Research organisations, state and territory governments, LCAs international collaborators
	Investigate impacts of submerged aquatic weed control measures on non-target organisms	2	Research organisations, international collaborators
	Maintain or establish networks and information sharing with cabomba (or submerged aquatic weed) managers and researchers from other countries	2	Research organisations, international collaborators

Objective	Strategic actions	Action level ^a	Responsibility
3.3 Adopt best-practice management	Promote adoption of new control methods (including new herbicides approved for use) and evaluate their effectiveness in control programs	1	NAWMG, state and territory governments, LCAs
	Ensure ongoing availability of cabomba best-practice information, including best-management practice manuals	1	State and territory governments
	Update awareness and management information to reflect new developments in best practice	1	State and territory governments
	Seek appropriate declaration status of cabomba in response to future availability of effective control options	2	State and territory governments, regional weed committees
	Develop training initiatives for weed managers on submerged aquatic weed management and aquatic herbicide use	3	State and territory governments
3.4 Increase regulatory and community support for cabomba and submerged aquatic weed control programs	Increase cooperation with herbicide regulatory authorities to seek approval for use of additional aquatic herbicides (through minor use permits or similar) against cabomba and other high-priority aquatic weeds	1	NAWMG, state and territory governments, herbicide companies, APVMA and other herbicide regulatory agencies
	Establish and maintain cooperative relationships with waterway regulators to seek support for cabomba and other strategic aquatic weed management programs	2	State and territory governments, LCAs
	Promote the importance of cabomba management to the community and seek acceptance for the use of best-practice methods (herbicides, drawdown, shading)	2	State and territory governments, LCAs
3.5 Maintain capacity for coordinated management	Maintain existing cabomba management networks, from local to national level	1	State and territory governments, regional weed committees, LCAs, regional NRM groups
	Integrate national strategic plan objectives throughout regional and state policy and planning approaches	1	State and territory governments, regional weed committees, LCAs, regional NRM groups

APVMA = Australian Pesticides and Veterinary Medicines Authority; LCA = local control authority; NAWMG = National Aquatic Weeds Management Group; NRM = natural resource management

a The Australian Weeds Committee (AWC) applied three action levels that reflect jurisdictional commitment to implementing actions:

Level 1 = Highly beneficial as a national action that is critical to success of the WoNS revised strategic plan and all relevant AWC jurisdictions have committed resources to implementing this action.

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Highly beneficial to a particular jurisdiction and the responsible party/ies have committed resources to implement this action.

Level 2 = Highly beneficial at national and/or jurisdictional level, but implementation will be subject to resource availability and investment priorities.

Level 3 = Desirable and still beneficial to improving uptake and efficiency of on-ground action, but not critical to success.

4 Monitoring, evaluation, reporting and improvement framework

The Australian Weeds Strategy (NRMMC 2007) gives the Australian Weeds Committee (AWC) responsibility for monitoring and evaluating the management of national priority weeds, including WoNS. The AWC is therefore responsible for monitoring and reporting on progress under this strategic plan.

This strategic plan is subject to a five-year review; however, mechanisms must also be put in place to allow the goals and actions to be evaluated throughout this period. This enables ongoing assessment of progress towards intermediate and long-term outcomes, and, ultimately, helps to determine the effectiveness of individual actions. It also helps to identify program improvements, and provides evidence to stakeholders and funding bodies that they are getting value from their investment.

Individual jurisdictions and/or organisations responsible for weed management and conservation will need to develop their own monitoring strategies. They should, where possible, coordinate actions to implement this plan, and monitor and evaluate progress towards its goals in conjunction with existing state, regional or local plans. While individual actions should be monitored at the jurisdictional level, data or evidence collected as a part of state, regional and local activities or plans should be provided to the AWC and collated so that it can be assessed each year within the national context. This will help to build a comprehensive overview of the plan's delivery. Table 6 lists key evaluation questions that should be assessed by the AWC each year at the national level to ensure progress against strategy goals, and which should be used to provide the basis for an annual report to the AWC.

This monitoring, evaluation, reporting and improvement (MERI) framework lists the basic reporting information that should be collected for the life of the strategic plan—including during phase 3 delivery (see Appendix 1). This will ensure that sufficient data are collected to identify successes and failures, and provide the opportunity for improvement where outcomes are not being achieved. Annual MERI plans may be developed to follow activities in more detail.

Although performance indicators or other ways of measuring progress are not provided in this strategic plan, a scoring system could be appropriate.

A generic program logic model (Appendix 4) was developed by WoNS coordinators in 2010. This shows the relationship between strategic actions and the objectives and goals they achieve. The program logic is one way to communicate the links between activities, their intermediate and long-term outcomes, and the vision of the strategic plan.

Table 6 Suggested monitoring and evaluation questions to measure progress under the phase 3 Cabomba Strategic Plan 2012–17

WoNS:		Jurisdiction:	Date:
Goal	Key evaluation questions	Data or evidence required	Consider
1 Prevent new infestations from establishing	To what extent have new infestations been prevented from establishing?	1.1 National distribution data: Has the national distribution map been reviewed and/or updated? Has the Priority Management Action spreadsheet been updated?	<ul style="list-style-type: none"> • Are these documents publicly available? • Have stakeholders been advised of any changes? • Where is this data or information stored? • Does this information capture national priorities?
		1.2 New infestations: Number of new infestations recorded Percentage of known infestations actively controlled	<ul style="list-style-type: none"> • Are any new infestations occurring in areas identified as a high priority in the national strategy? • How were infestations detected (passive or active surveillance, community reporting etc.)? • Have high-risk pathways been adequately identified? • Have threats been minimised?
		1.3 Eradication and containment programs: Percentage of eradication and/or containment programs being maintained	<ul style="list-style-type: none"> • What percentage of programs identified in the national strategy are being actively managed? • Is there a plan in place for ongoing management? • How is progress being monitored and reported to stakeholders? <p>(Examples using case studies can be included)</p>
		1.4 Legislation: Legislation or policy changes for this species Legislative change has been identified by stakeholders	<ul style="list-style-type: none"> • What legislative changes have been made? • Are minimum requirements being maintained (e.g. ban on sale, trade, movement)? • Is control required throughout or in part of the jurisdiction? • Is compliance actively enforced?
			Score:

Table 6 *continued*

WoNS:		Jurisdiction:	Date:
Goal	Key evaluation questions	Data or evidence required	Consider
2 Strategically manage existing infestations	To what extent is integrated weed management effectively managing core infestations?	2.1 Integrated weed management: Effectiveness of integrated weed management programs	<ul style="list-style-type: none"> Are existing tools providing adequate control of WoNS? Have new advances or technologies been developed and are they incorporated into best-practice management information? Are there barriers to adoption of best-practice management? Are research programs addressing any observed gaps (e.g. herbicide trials, biocontrol, restoration requirements post-control)?
	To what extent are assets being protected through strategic management?	2.2 Asset protection: Number of priority assets identified as 'at risk' from WoNS Percentage of priority assets being protected (e.g. assessed against relevant threat abatement plans) Percentage of state and regional invasive species plans that identify priority assets at risk from WoNS	<ul style="list-style-type: none"> Methods by which assets are being protected (e.g. targeted annual spray programs, high-risk pathway surveillance, strategic plans) Are long-term monitoring programs in place to detect change? To what extent is management leading to an improvement in asset condition? <p>(Response should include status report on progress towards asset-protection programs)</p>
			Score:
3 Increase capability and commitment to manage WoNS	To what extent has the capability and commitment to manage WoNS increased?	3.1 Community engagement and awareness: What is the status of best-practice information? Are partnerships being maintained to ensure collaboration on WoNS? Number and type of media activities	<ul style="list-style-type: none"> Is best-practice information up to date and readily available? Is this information and/or advice being targeted to priority regions? Is training being delivered to meet the needs of weed managers (including the community)? Are networks and groups being supported (e.g. through dissemination of research outcomes,

Table 6 *continued*

WoNS:	Jurisdiction:	Date:	
Goal	Key evaluation questions	Data or evidence required	Consider
			funding opportunities, control options etc.)? <ul style="list-style-type: none"> Has awareness and engagement in WoNS management been raised effectively?
		3.2 Resourcing: From what sources are programs being funded?	<ul style="list-style-type: none"> Number of projects funded by Australian Government, jurisdictions, industry, etc.
		3.3 Policy and planning: Are the objectives of the strategy being integrated into Australian Government/state/regional plans, policies and programs? Has cross-border collaboration occurred?	<ul style="list-style-type: none"> How are priorities reflected in planning and policy approaches (e.g. weed risk assessments, invasive species plans, asset-protection plans, district plans, weed spread prevention activities, management programs, incentive programs, state working groups)? How are national priorities being maintained (e.g. containment lines, eradication targets, training and awareness raising, research projects)?
			Score:
Continuous improvement	Are there any unexpected outcomes that have been identified through implementation of strategy?	Barriers: <ul style="list-style-type: none"> Have any other management issues or impediments been identified? 	

WoNS = Weeds of National Significance

Scoring:

- 1: Insufficient evidence to score
- 2: No progress has been made against this goal
- 3: Limited progress is being made against this goal
- 4: Reasonable progress is being made against this goal
- 5: Excellent progress is being made against this goal

5 Stakeholder responsibilities

Although landowners and managers have primary responsibility for the control of cabomba on their land, relevant agencies share responsibility for the actions listed in Sections 3 and 4. The effective implementation of this strategy requires the involvement of a range of stakeholders. Stakeholders' responsibilities may vary between jurisdictions: some actions may be optional while others are prescribed by legislation. The successful achievement of strategic actions relies on the development and maintenance of partnerships between community, industry and government, and recognition of the roles of each stakeholder. In particular, while the National Aquatic Weeds Management Group provided oversight for the original strategy, future coordination arrangements will evolve to maintain and build on past achievements. The Australian Weeds Committee, at a national level, and various agencies at the state and territory level will continue to provide a leadership role.

Appendix 1 The Weeds of National Significance initiative and its phases¹

In 2007, an independent review of the WoNS initiative concluded that the nationally strategic approach of WoNS was highly successful in leveraging consistent multijurisdictional activity on high-priority weed species. This initial review was followed by a detailed review of the inaugural WoNS species by the Australian Weeds Committee (AWC) in 2009–10. The AWC reviewed the implementation of the 20 WoNS national strategies and, in light of achievements for these 20 species, considered the capacity for national coordination of additional WoNS species.

Following the reviews, the Natural Resource Management Ministerial Council (Resolution 15.7, 21 May 2009) endorsed a three-phased approach to national management of WoNS species (Figure 3). This ‘phased approach’ aims to provide the most cost-effective use of limited ‘national coordination’ resources.

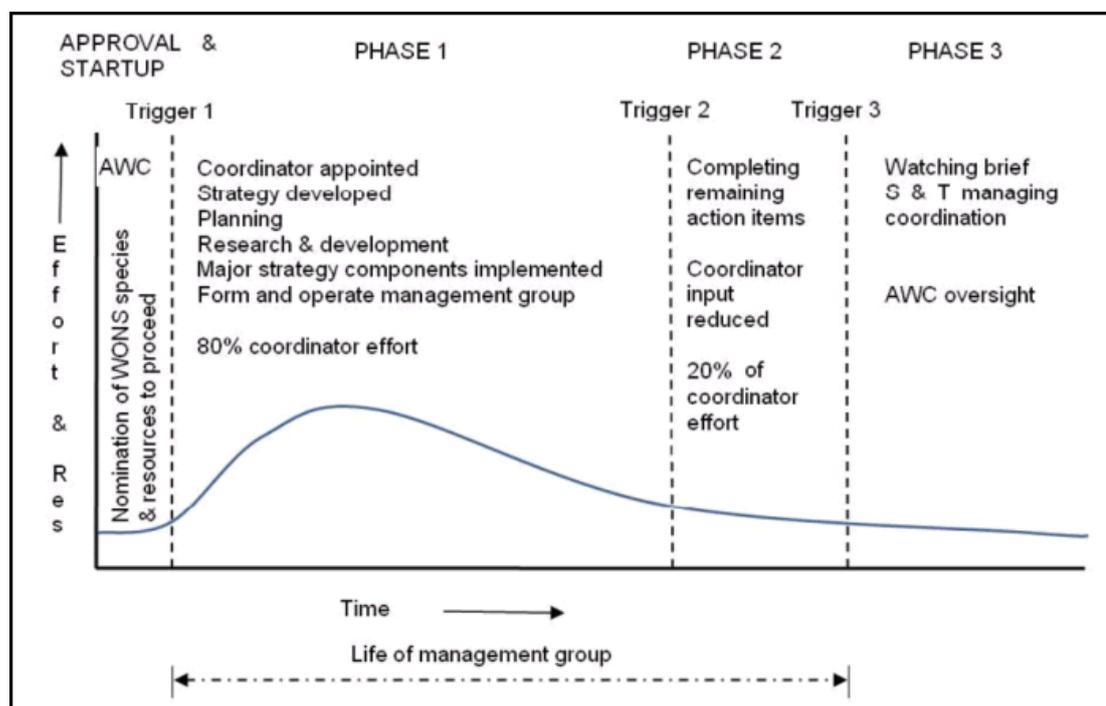


Figure 3 Australian Weed Committee diagrammatic representation of coordinator effort and resource use when implementing a Weeds of National Significance strategy

The phased approach recognises the need for reduced national coordination (‘phasing down’) of WoNS species that are under effective national management, and allows for further weed species to be nominated for consideration as additional WoNS. The AWC is implementing these reforms, and national coordination of the inaugural 20 WoNS species has already transitioned to phase 2 or 3, depending on the species. No species have yet been

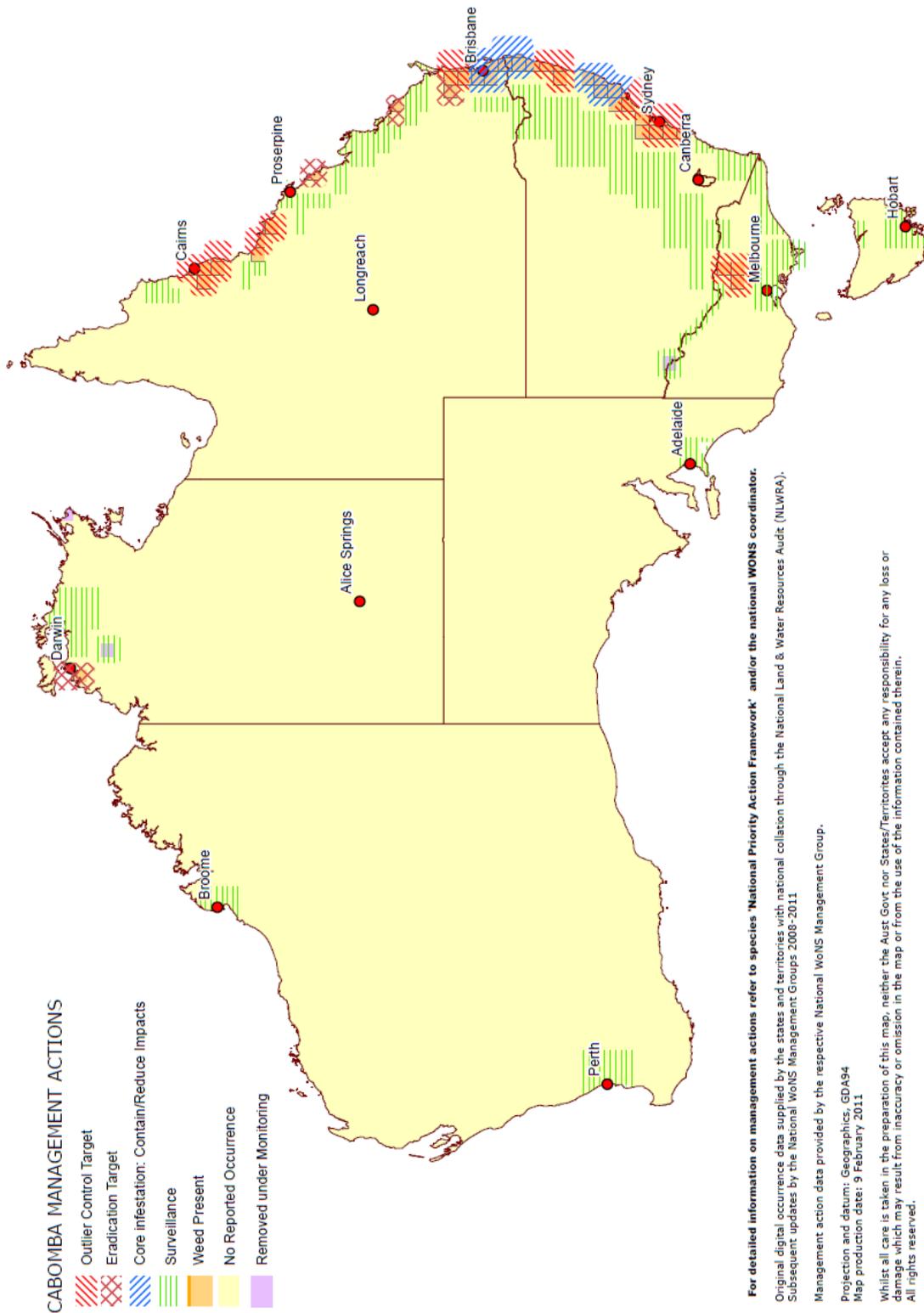
¹ Adapted from Thorp 2012, *Additional list of Weeds of National Significance*, <www.org.au/WoNS>.

removed from the WoNS list. The AWC is developing a protocol to guide future decisions about when this should occur on a case-by-case basis.

In 2010, jurisdictions nominated additional candidate WoNS species. These species were independently assessed, and the AWC endorsed 12 additional 'species' to be listed as WoNS. The AWC Chairman, Dr Jim Thompson, announced these additional plant species as WoNS on 20 April 2012. Additional information on the selection of these species and the phased approach is available on www.weeds.org.au/WONS.

Appendix 2 National cabomba distribution and management zone map, February 2011

The priority management actions for cabomba outlined in goals 1–3 of the strategic plan are reflected in the national weed spread and management map below.

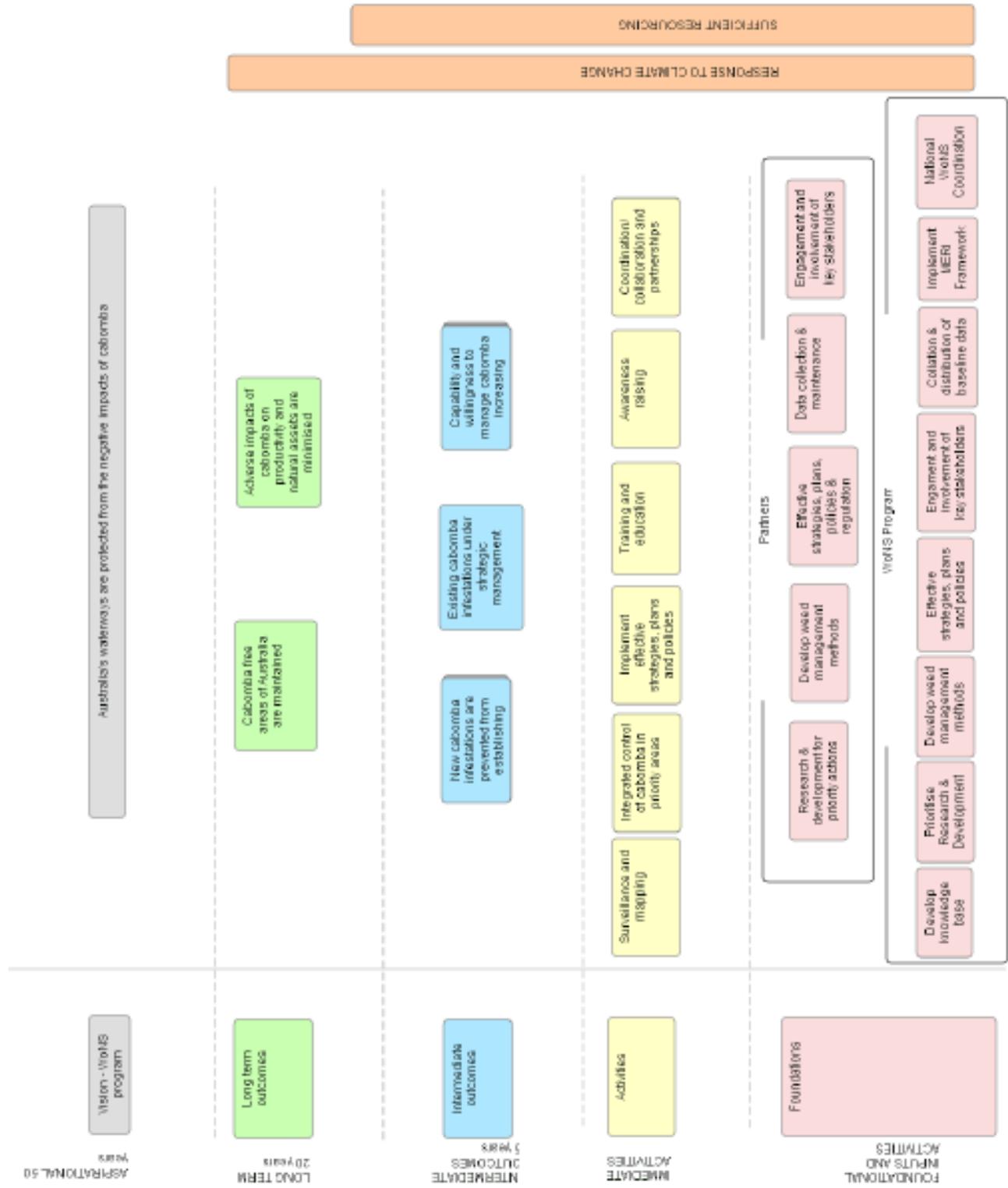


Appendix 3 Vectors for cabomba

Cabomba spreads through the movement of plant fragments from infested to uninfested waterways. The following potential vectors for the movement of cabomba plant fragments have been identified by the National Aquatic Weeds Management Group.

Vector	Risk factor
Boats and recreational craft	Medium
Boat trailers	High
Fishing nets and equipment	Medium
Aquarium/pond plant trading (including contaminations)	High
Floods	High
Wildlife (birds, mammals, etc.)	Low
Aquarium dumpings	Medium
Irrigation channels	High
Fire-fighting equipment (e.g. heletankers)	Low
Hobbyists (e.g. frog people, fish ponds)	Medium
Pumps and irrigation equipment	High

Appendix 4 Program logic model for the cabomba strategic plan



References and further reading

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