

Implementation of the Aquatic Weeds of National Significance Strategic Plans

PROGRESS REPORT: 2003-2008



Alligator Weed

Cabomba

Salvinia

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Cover illustration: Conducting a salvinia weevil release in northern NSW (NSW DPI)

Contents

Letter from the Chair	4
About this report	5
Background	5
Progress over five years: 2003-2008	7
Coordination of control efforts	7
Preventing the spread	10
Controlling the vectors	10
Managing areas at risk of infestation	12
Management of infestations	13
Alligator weed	14
Cabomba	15
Salvinia	16
Research	18
Alligator Weed	18
Cabomba	19
Salvinia	20
Future efforts	21
Acronyms and short forms	23
Bibliography	24
Appendix 1: Spread of aquatic weeds	27
Appendix 2: Sample of extension activities	31
Appendix 3: The national aquatic weeds management group	33
Appendix 4: Review of key performance indicators	34
Appendix 5: National aquatic weeds management group action plan	39
Appendix 6: Papers written on aquatic weeds topics	42
Appendix 7: Declaration of the three aquatic weeds of national significance	43
Appendix 8: Distribution of aquatic weeds in Australia	45

Letter from the Chair

On behalf of the National Aquatic Weeds Management Group I am pleased to present this five year progress report (2003-2008) on the implementation of the national strategic plans for alligator weed, cabomba and salvinia. This report outlines some of the key achievements by many stakeholders in Australia over the last five years to reduce impacts, prevent spread and coordinate the management of these three aquatic Weeds of National Significance (WoNS).



Our management group consists of a wide range of representatives including government at all levels, aquarium industry, community, and research scientists. We are all stakeholders who either work to better manage these aquatic weeds or are directly affected by them.

It's been a privilege to serve as NAWMG's chair for the last five years and to note the many contributions to the implementation of the strategic plans by key stakeholders. We've seen a dramatic increase in the knowledge base for each weed and how to achieve strategic control of them. We've also initiated many education programs and successfully engaged the aquarium industry in helping reduce the threat of aquatic weeds. I believe that after five years of coordinated national management we are in an excellent position to further consolidate our efforts and achieve successful long term control to reduce the threat of these very invasive aquatic weeds and related species.

We know that much work remains to be done and there are still many hurdles to be overcome. This includes adapting to new government investment priorities and funding arrangements, engaging new stakeholders and overcoming new threats such as climate change or potentially stricter legislation on control methods.

I would like to take this opportunity to thank many of the key stakeholders for their support, involvement in and commitment to the national aquatic WoNS program. This includes the Australian, State and Local governments, research organisations, the Pet Industry Association of Australia and the aquatic plant trade, Regional Catchment Management organisations, water supply companies, community groups, and last but not least the local control authorities who continue the fight against these weeds at the coal face.

A handwritten signature in black ink that reads "N. Tweedie". The signature is written in a cursive, flowing style.

Neale Tweedie

About this report

This report is a summary of progress made by stakeholders over the past five years (2003-2008) in the implementation of strategies¹ aimed at controlling the spread of the three aquatic weeds of national significance (WoNS):

- Alligator weed (*Alternanthera philoxeroides*)
- Cabomba (*Cabomba caroliniana*)
- Salvinia (*Salvinia molesta*)

Information for this report is drawn primarily from annual reports² prepared by the National Aquatic Weeds Coordinator for the National Aquatic Weeds Management Group, though other sources were also consulted.

Overall, the summary shows that actions guided by the aquatic weeds strategies have provided a sound basis for achieving better control over the WoNS aquatic weeds. There is now better knowledge of their biology and ecology, and weeds managers are better informed about early detection, surveillance and control techniques, and planning processes to achieve ongoing control.

However more work needs to be done: this is particularly the case in the control of cabomba and alligator weed.

Based on increased understanding of the particular control challenges posed by each of the weeds, the Management Group have revised the Strategies to guide action over the coming five years

Background

In 1996 the Standing Committee on Agriculture and Resource Management, the Standing Committee on Conservation, and the Standing Committee on Forestry³ initiated the development of a national strategy to coordinate efforts to reduce the social, environmental and economic impact of weeds in Australia. The following year, federal, state and territory ministers responsible for agriculture and resource management, environment and conservation, endorsed the National Weeds Strategy and appointed a National Weeds Strategy Executive Committee (Executive Committee) to implement it.

The Executive Committee asked responsible authorities from Australian states and territories to nominate weed species that might benefit from a coordinated, national approach. Authorities submitted 73 individual weed species for consideration. The Executive Committee recommended that twenty of the total submitted be declared Weeds of National Significance (WoNS). The three Ministerial Councils unanimously adopted the recommendation⁴.

¹ Alligator Weed Strategy, 2000; Cabomba Strategy, 2000; Salvinia Strategy, 2001.

² See the 15 NAWMG reports, 2003-2008.

³ These Committees support the Ministerial Councils responsible for agriculture and resource management, environment and conservation, and forestry. Membership of the Standing Committees comprises the relevant departmental secretaries/chief executive officers of federal, state, territory and New Zealand government agencies.

⁴ Thorp, 2000

The Executive Committee oversaw the development of strategic plans for the coordinated control of each of the WoNS, including the three aquatic WoNS: alligator weed (*Alternanthera philoxeroides*)⁵, cabomba (*Cabomba caroliniana*)⁶ and salvinia (*Salvinia molesta*)⁷.

Refer to Appendix 7, notes A1 to A3 for an explanation of the WoNS status of the three aquatic weeds.

In line with all WoNS strategies, the aquatic weeds strategic plans emphasise:

- 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 deployed against weeds
- Successful weed management requires a coordinated national approach which involves all levels of government in establishing appropriate legislative, educational and coordination frameworks in partnership with industry, landholders and community
- The primary responsibility for weed management rests with landholders/land managers but collective action is necessary when the problem transcends the capacity of the individual landholder/land manager to address it adequately

Although each aquatic WoNS strategy differs in detail, they follow the same broad objectives:

- Coordination of efforts to effectively control aquatic weeds
- Prevention of spread – including through trade
- Management of infestations
- Research to develop better means of control

As well, many of the stakeholders and actions listed in the three aquatic WoNS strategies are common. The initial management groups for alligator weed and cabomba decided to implement the strategies as a group then included the Salvinia Strategy when it was adopted. In 2003 the Executive Committee appointed a National Aquatic Weeds Management Group (the Management Group) with representatives from government, community and industry, and a National Aquatic Weeds Coordinator (the Coordinator) to implement the aquatic weeds strategies.

5 Alligator Weed Strategy, 2000

6 Cabomba Strategy, 2000

7 Salvinia Strategy, 2001

Progress over five years: 2003-2008

Coordination of control efforts

Many groups, including landholder, voluntary and government groups, are involved in the management of aquatic weeds. In the early 2000s, when the aquatic weeds strategies were first launched, there was little communication between the groups and little cross learning. This situation was specifically recognised by the National Weeds Strategy, which established a number of initiatives to enable a more cooperative, coordinated approach to weeds management. The aquatic WoNS strategies were launched within a national framework where:

- A national electronic platform for sharing information already existed (www.weeds.org.au)
- Work had already begun with federal government authorities, such as the Australian Quarantine Inspection Service (AQIS) and Biosecurity Australia, to increase knowledge and vigilance regarding weeds in Australia
- Increased resourcing opportunities existed (even though bids for resources remained competitive), and
- National weeds awareness programs, including regular weeds forums, had been established



Members of the management group inspecting salvinia weevil breeding tank, Brisbane City Council (NSW DPI)

Although much had been achieved on a national scale, at the time the National Aquatic Weeds Management Group (the Management Group) was appointed, there still remained non-uniform legislation among states and territories on the status of cabomba. Uniformity of legislation was finally achieved in 2005 when the Victorian government amended the relevant state legislation to bring it into line with legislation in other states and territories, declaring cabomba a prohibited plant..

A number of the aquatic WoNS strategic actions were directed towards the coordinated collection of data to enable better national knowledge of infestations. Collecting such data had its challenges, especially in the early 2000s when there was considerable flux in the organisational regimes and attention of state, regional and local weed management authorities. Nevertheless, considerable information is now available.

The Coordinator now keeps a database of infestations, and maps showing regional locations of infestations and at risk areas for each of the weeds is available on the weeds website (see Appendix 8 for Maps 1 to 3). At risk areas become target regions for surveillance exercises.

There is now also an impressive range of publicly available information⁸. Significant among these are the best practice manuals for control of alligator weed⁹ and salvinia¹⁰. A similar manual for cabomba is due for publication in 2009.

The Management Group developed a media and communications strategy to ensure that information about aquatic WoNS was consistently delivered to the public. From 2003 to 2008, the Coordinator and other stakeholders developed a range of publications and conducted workshops, field days and seminars to increase stakeholder knowledge about aquatic weeds and their control. Appendix 2 lists a sample of such extension material and activities.

The accumulation of knowledge motivated by the aquatic WoNS strategies established the platform for focused action and greater capacity for obtaining resources for management and research. Although each of the strategies addressed a range of common issues, they also had separate foci:

- In the case of alligator weed, an important concept was the identification of core and non-core (outlier) areas: management of core areas emphasised control for prevention of spread and management of non-core areas emphasised control for eradication
- In the case of cabomba, the fact that there were neither effective herbicides nor biological controls encouraged intensive research into finding better management options
- In the case of salvinia, the fact of the existence of an effective biological agent motivated a strategy for increasing the distribution of biological control agents to improve control

Underpinning the WoNS strategies was a brief to ensure that coordination activities enhanced the capacity of those already involved in the management and control of aquatic WoNS while at the same time encouraging a broader range of stakeholders to become involved. This brief is being partly fulfilled through the representation of key stakeholder groups on the Management Committee: see Note 1. In addition, an ever-increasing range of stakeholders are consulted, supported and trained.

Achievements:

Maps of infestations and at-risk regions

Readily available information on aquatic WoNS, including control manuals

Training forums on identification and control

Coordinated research activities

Identification of key issues

Better resourcing for management and research

Increased set of informed and engaged stakeholders

Experienced Management group

⁸ A number of these are included in the bibliography of this report and Appendix 6 lists papers written on aquatic weeds topics.

⁹ van Oosterhout, 2007

¹⁰ van Oosterhout, 2006

Note 1: The National Aquatic Weeds Management Group

The National Aquatic Weeds Management Group was formed to plan and facilitate the implementation of the aquatic WoNS strategic plans. Its purpose was also to provide a forum for consultation and communication among those committed to aquatic weeds management, including state agencies, other agencies and the community.

Throughout its history, the Management Group comprised a wide range of stakeholders drawn from the community, aquarium and irrigation sector, research, and local and state government. Such diversity brought together a range of skills and expertise to the national program that significantly benefited implementation of the WoNS strategies. For example, the advice and input of aquarium industry representatives helped to: overcome technical issues associated with salvinia biological control facilities; and establish competition trials as part of the Aquatic Plants Weed Risk Assessment project.

A list of members as at 2008 is included in Appendix 3.

While stakeholder input and involvement is important, a significant achievement has been the stability in the working relationship between the Management Group and the Coordinator over the past five years (2003-2008). Such stability has enabled the Management Group to develop a depth of experience which helps to ensure that programs supported are likely to be strategically effective.

For example, familiarity with the three aquatic weeds strategies programs gave the Management Group the insight to support the development of surveillance protocols that could be applied across all aquatic weeds. Familiarity also enabled the Management Group to decide upon a variation to the Cabomba Strategy¹¹ that could prove beneficial for the prevention of other aquatic weed problems: the variation is to support a project to assess the weed risk of pond and aquarium species in the aquatic plants trade rather than identify safe alternatives to cabomba per se: see Note 2 for more details.

Note 2: Weed risk assessment of tradeable aquatic plants project

A weed risk assessment project for plants in the aquarium trade was successfully funded in 2005. The project aimed to remove high weed risk species from sale, to ensure aquatic WoNS are not replaced in the market by other weedy aquatic species. A project working group consisting of industry and government was formed and the National Institute of Water and Atmospheric Research (NIWA) from New Zealand was contracted to undertake the work. The project identified that of the 401 species in the trade in Australia, 54 have significant weed potential. Thirty-three of these were recommended for national ban after a weed risk assessment. A further evaluation is required on the remaining 21 before recommendations can be made. In addition, 25 aquatic plant species not yet naturalized in Australia pose a weed risk. On completion of the project, results were submitted to the Australian Weeds Committee for review and action.

¹¹ Cabomba Strategy, 2000

Another example of increased Management Group experience is a better understanding of the needs of various stakeholders. There is now an acknowledgement that to rely on self regulation in the aquarium and nursery industry to prevent the introduction of weeds will probably not be effective. The Management Group is now exploring ways to establish protocols that will encourage state authorities to communicate impending aquatic plant declarations to the industry, and encourage industry to report new plant sales and new species.

Preventing the spread

All three aquatic weed strategies recognise that prevention is the most effective way to manage a weed problem: eradication attempts are much more likely to be effective when a weed first begins to invade an area.

The three aquatic WoNS strategies all emphasise:

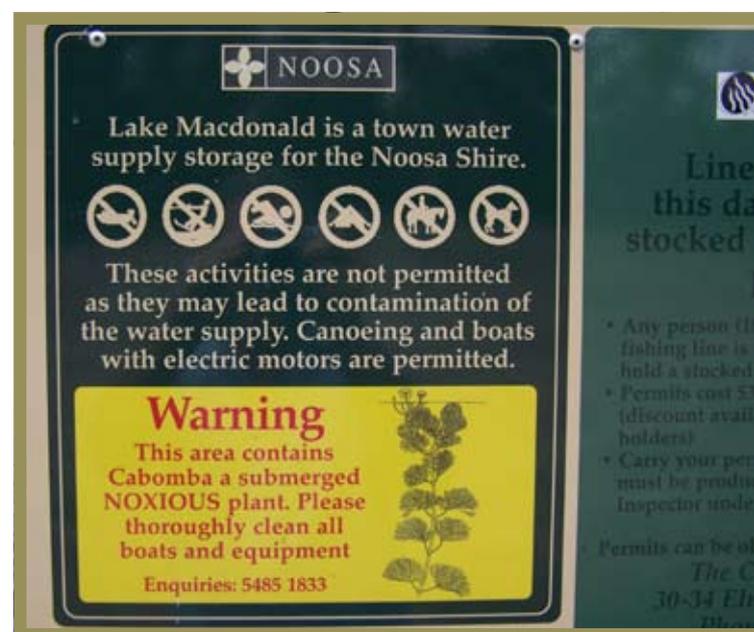
1. The need to prevent the spread of weeds – whether from core infestations or new introductions – by controlling the vectors of spread, and
2. Managing areas at risk of infestation through awareness, early detection initiatives and management of vectors.

Controlling the vectors

Table 1 lists the vectors for spread of each of the aquatic WoNS.

The number of programs targeting human vectors has been steadily growing over the last five years. Note 3, as well as parts of the list in Appendix 2, records just some of the extension material produced and media efforts. Some material is quite targeted, such as that focused on the provision of information about WoNS to the aquarium industry, eel gatherers and fishers. Other material is intended for a broader group.

All weeds can be spread downstream in running water, and by fragments attached to boating and fishing equipment, which are then transported to another waterway. The illegal sale and use as pond and aquarium plants are still vectors of spread for cabomba and salvinia. Although much reduced as a vector of spread, alligator weed's use as a garden vegetable continues to cause new infestations.



Cabomba awareness and prevention of spread signage at Lake MacDonald

Apart from encouraging people not to be vectors, some weed managers have quarantined infested areas to limit the possibility of inadvertent movement of plant fragments. For example, a section of the Darwin River infested with cabomba has been quarantined since 2004¹².

Another vector control technique has been the implementation of timely action after flood events. For example, after major floods in the Hunter Floodplain in 2007, weeds officers surveyed the plain for new alligator weed infestations, finding several emerging patches. Early detection enabled immediate and successful action to eradicate the new invasions.

How to prevent the downstream movement of weeds has involved a number of research projects, including those conducted by Vic. DPI on alligator weed fragmentation after herbicide applications. Weeds officers in a number of areas have also been proactive in the design and placement of booms and containment fences, particularly for limiting the drift of salvinia.

Not a vector of spread, but nevertheless an important consideration, are pollution points that increase nutrient levels in waterways. All aquatic WoNS thrive in nutrient rich waters. All three strategies encourage the implementation of actions that increase waterway health by reducing nutrient loads. Catchment Management Plans, motivated in part by the need to reduce weed threats, now incorporate a range of strategies to reduce nutrient levels in waterways.

Achievements:

Better understanding of vectors

More vectors being targeted through various programs

Catchment plans include strategies for reducing nutrient load in waterways

Better understanding of areas at risk of infestation

Protocols developed for early detection

Increased number of stakeholders involved in early detection

Note 3: Examples of targeted extension activities under the aquatic WoNS strategies

In cooperation with the PIAA, several activities have been focused on the aquarium and nursery industry. In 2003-2004, PIAA included instructions for the responsible purchase and sale of aquatic plants in its voluntary code of practice for pet and aquarium shops. In addition, the Coordinator contributed an article on the dangers of aquatic weeds and the weed risk assessment approach to the Nursery and Garden Industry Australia Paper series.

In 2006, a national poster was released to the aquarium and nursery industry on illegal aquatic plants, as well as an industry-developed DVD titled, 'Responsible Handling of Aquatic Plants'.

¹² DNRETA, 2008

Table 1: Aquatic weeds vectors of spread

Vectors	Alligator weed	Cabomba	Salvinia
Movement downstream in running water	A particular danger for infestations in the Murray Darling Basin	Has caused further spread of a number of infestations	Has caused further spread of a number of infestations
Fragments attached to earth moving equipment or other machinery then transported from waterbody to waterbody	Particularly responsible for the weed's widespread distribution in Australia	N/A	N/A
Fragments attached to boating and fishing equipment, and boat trailers	Potential cause of spread	Has been the cause of a number of infestations	Has been the cause of a number of infestations
Movement of contaminated soil and mulch	Has been the cause of a number of infestations	N/A	N/A
Use as a garden vegetable plant	Particularly responsible for the weed's widespread distribution in Australia	N/A	N/A
Sale or illegal use as an aquarium/ornamental plant	N/A	Particularly responsible for the weed's widespread distribution in Australia	Particularly responsible for the weed's widespread distribution in Australia

Managing areas at risk of infestation

To manage areas at risk of infestation requires a sound knowledge of the biology and ecology of the weed in question and, based on that knowledge, an identification of the regions in Australia where the weed could take hold. The Management Group has ensured that knowledge gained in the past five years, summarised in Table 2, has been translated into maps showing at-risk areas (Maps 1 to 3), and included in information about the characteristics of each of the aquatic WoNS.

Aquatic weeds identification workshops are now regularly held around Australia (Appendix 2 lists some of these extension activities). The workshops have increased the capacity of community and local government members to detect and report infestations. In 2005, the Management Committee developed an aquatic weeds surveillance and early detection methodology from local council areas, which formed the basis for a project titled, 'Early detection programs for high priority aquatic weeds'.

Table 2: Characteristics of areas at risk of infestation

Weed	Characteristics
Alligator weed	Grows: In waterways Along banks of waterways On floodplains On poorly drained land In drier situations above flood level (less commonly) In water with a salinity 30% of sea water Tolerates cool and warm temperate and subtropical climates Thrives in nutrient rich waters
Cabomba	In waterways (submerged weed) to 7 m Growth correlated to: Increasing light High temperature Elevated nutrients
Salvinia	Growth on still or slow-moving fresh water where nutrients are available Requires other vegetation to hold it if water is faster flowing Poor tolerance of water with a salinity 10 % of sea water Colonises all depths of water Survives on mud Enjoys nitrogen rich water Growth occurs between 5° C and 43° C

Management of infestations

Before the development of each of the aquatic WoNS strategies, management of infestations was ad hoc. If the need for management was recognised at all, it was often based on little knowledge of how the weeds could be controlled. Consequently, results of control efforts were frequently unsuccessful. There were, of course, exceptions to this, with some weeds authorities implementing well-researched, integrated and successful programs. But there were few national learning opportunities from these successful programs and an ongoing threat that weeds from uncontrolled infestations would re-infest controlled sites.

Through implementation of the weeds strategies, the situation has radically improved. As already noted:

- Information about best practice methods for each of the weeds is regularly collected, collated and made available to weed managers (see Note 4).
- Several field days and site visits have since been held at strategic locations to help weed managers gain and apply best practice methods (see Appendix 2).

Achievements

Management plans for most large and persistent infestations

Protocols for developing and implementing management plans

Increased, targeted resources for the management of strategic infestations

Increased sophistication in the use of controls that have been included in best practice manuals (except for cabomba)

In addition:

- Weed managers are encouraged (in extension material and in workshops) to develop strategies to ensure staged and integrated implementation of control programs that take account of the weed's: biology, context (including impact of the weed) in which it grows, and resources available for control.

The office of the Coordinator provides an important reference point for weed managers confronting difficulties. Because of the oversight of the three aquatic weeds, the Management Group also has the opportunity to exploit lessons learnt in the management of one aquatic weed to the management of another aquatic weed. For example, lessons learnt in establishing breeding facilities for the salvinia weevil could be useful if a biological control for cabomba is found.

Note 4: Best Practice Manuals

A key impediment to aquatic WoNS management was a lack of information on effective control techniques for the respective species.

Following the initiative of other WoNS programs, the Management Group supported the development of best practice (control manuals) for each of the aquatic WoNS. Manuals for salvinia and alligator weed are now available, with the manual for cabomba due for completion in 2009.

The manuals have helped increase the capacity of local control authorities to manage the weeds. They document and describe a range of key control methods for each aquatic WoNS, including recent developments and improvements such as herbicide efficacy, biological control approaches, physical control options and integrated approaches for each of the aquatic WoNS (*Alternanthera philoxeroides*, *Cabomba caroliniana* and *salvinia molesta*).

Alligator weed

Protocols are now in place for the treatment of the three categories of alligator weed infestations:

Core infestations: The Alligator Weed Strategy recognised the need to strategically manage core alligator weed infestations in the Sydney Basin and Hunter Floodplain to prevent further spread and reduce impacts on key assets. All core infestations are currently managed within strategies developed under regional plans (Table A1.1). In 2007, GHD Consultants commenced a study using a risk assessment matrix to identify the core infestations in the Sydney and Hunter regions that posed a high risk of further spread.¹³ Regional alligator weed technical groups are presently reviewing the assessment of the consultants to determine which on-ground priorities should be implemented to prevent further spread of infestations and protect key ecological assets. Outcomes from the review will form the basis of future funding applications and revised management plans.

Non-core infestations are treated within a plan that aims for eradication.

New infestations are immediately treated, also with an aim of eradication.

¹³ Beatentrack Group (BTG), 2007

Minor use permits for the herbicide 'metsulfuron methyl' have been obtained across all states to ensure weed managers of core and non-core infestations have access to a more effective herbicide than current registered versions. The Management Group is also exploring the potential for further minor use permits for high efficacy herbicides for strategic eradication programs.

Note 5: Significant among the achievements for controlling alligator weed are:

The early detection and removal of three new infestations on the NSW mid-north coast represents a major achievement in the ability of land managers to find and detect new infestations. Each site will be monitored for a period of five years to six years to ensure eradication.

In 2007-2008, a Defeating the Weeds Menace funded project implemented on-ground works to contain known alligator weed infestations in the Murray Darling Basin. Such works have helped to protect irrigation assets and prevented the spread of alligator weed into waterways within the basin.



Alligator weed with its distinctive ball-shaped flower (NSW DPI)

Cabomba

Both the Northern Territory (NT) and Queensland (Qld) governments have been particularly active in attempts to control the spread of cabomba well prior to the publication of the Cabomba Strategy. In the NT, the first infestation of cabomba recorded was in 1996 at Marlow Lagoon, Palmerston. Weed authorities used both physical control methods and herbicide applications to control the infestation, finally declaring eradication in 2002.

When cabomba was discovered growing in a part of the Darwin River in 2004, the NT government appointed a project officer to manage the infestation. By 2007-2008, the infestation had been reduced from 14 km of waterway to just 5 small active sites along a 2 km stretch, representing less than 0.01% of the original infestation size.¹⁴

In Qld, the active management of cabomba began in the Noosa Shire when an infestation in Macdonald Lake at the headwaters of the Mary River threatened the Noosa Shire water supply. Since 1994, a range of methods have been trialled in the Lake and surrounding areas¹⁵, many of which are to be included in the cabomba best practice manual.

¹⁴ NRETA, 2008

¹⁵ Mackey, 1996

Significant limiting factors in the control of cabomba are the lack of biological controls and effective herbicides. Physical removal (hand pulling or mechanical removal), shading, draining water bodies to dry out the plant and heat treatment are the primary control methods currently employed. Research is underway to find a biological control. There are also efforts underway to register another herbicide to replace 2,4-D,nbutyl ester (the only effective herbicide), which had its registration suspended in 2005.

Nevertheless, many lessons have been learnt from management efforts in the NT and Qld infestations as well as subsequent research under the Cabomba Strategy. A few large and strategic infestations are now being managed under a management plan, such as the infestations in the Lake Benalla and Broken River. A small infestation found in 2006 in a public park lake adjacent to the Murray River in Mildura, Vic., is under an eradication program: land managers have 'drawn down' (drained) the lake to dry out and eradicate the weed. The lake will be refilled during 2009 and monitored for re-emerging cabomba.

Table A1.2 summarises management initiatives. Generally, however, the lack of good control methods has inhibited the development of management plans.

Cabomba remains an extremely difficult weed to control. Although under development, there is as yet no control manual to guide best practice. Managing the vectors of spread is crucial for cabomba, as is managing public expectations of what can be achieved.

Salvinia

Although salvinia is a highly invasive aquatic plant with the potential to detrimentally impact waterways, options for its control are relatively good.

Biological controls, herbicide use, physical control (removal and booms) are all quite successful – as long as vigilance is maintained. Of the control methods available, the biological control provided by the salvinia weevil (*Cyrtobagous salviniae*) has had the biggest impact, decimating extensive infestations in northern parts of Australia.

A major thrust within the Salvinia Strategy has been to ensure that the weevil can be extensively utilised for control: research has shown that it is possible to increase the geographical range of the weevils' effectiveness; and plans to increase its availability are being progressively implemented (see Note 6 or more details).

*Inspecting plants for salvinia weevil
(Cyrtobagous salviniae) damage (NSW DPI)*



Note 6: *Cyrtobagous salviniae*: the salvinia weevil

The salvinia weevil is a small, dark, sub-aquatic weevil 2 to 3 mm long., originating in Brazil, CSIRO researchers brought it to Australia in 1980 and released 1500 individuals into lake Moondarra near Mount Isa. Within 11 months, the weevils had destroyed an estimated 50 000 tonnes of salvinia on the lake. To date the weevil continues to keep salvinia levels in the lake to low levels.

Two weevil-breeding facilities were established in Qld, one in Brisbane and one in Bundaberg, but they serviced only a limited region. In most areas, weed control authorities sourced weevils from wild populations, releasing weevil-infected plants into salvinia-contaminated waterways. This practice was unreliable and had the added danger of introducing other undesirable weeds.

Analysis has shown that weevil breeding facilities have a benefit cost ratio of 56:1. Increasing access to weevils for salvinia control is a priority for the Management Group.

In 2004, the Management Group helped establish systems to increase cross regional demand of weevils from the Brisbane facility, implementing a user pays system to ensure ongoing funding for the facility. In 2005, a weevil breeding facility was constructed at Grafton in the Northern Rivers to service NSW. NHT funds were used to set up the facility but it now operates on a user pays model. Smaller regional facilities in Qld have also been constructed at Lake Eacham, Townsville (but due to close), Yeppoon, Miriam Vale and Gympie. A small-scale facility has been constructed near Darwin in the NT.

When all facilities are fully operational, all weed control authorities will have access to a reliable and hygienic supply of salvinia weevils.

Management strategies for salvinia infestations are now the norm, with activities quickly targeted at emerging infestations. For example, in 2008 the Southern Cape York Catchments group began a program to eradicate salvinia from Honey Dam and upstream reaches of the Laura River (far north Qld). The infestations posed a major risk to wetlands in the downstream Lakefield National Park. To date the project has reduced the impact of salvinia from the 40 ha dam to just a few scattered plants. The dam is monitored weekly and emerging plants removed.

Eradication of outlier infestations remains a key priority for strategic efforts by local control authorities, such as the two outlier infestations at Bega, NSW and Kununurra, WA. These infestations have been removed and the area will continue to be monitored till it is clear that the weed has been eradicated from the waterways.

Increasing salvinia weevil availability

an additional six breeding stations to supplement the two that existed (location of facilities are Darwin, NT, Lake Eacham, Miriamvale, Gympie and Yeppoon QLD, and Grafton Vic).

Table A1.3 lists more examples of salvinia management.

Research

Research efforts into aquatic weeds have mostly been quite specific, the exception being a current investigation into the use of robotic surveillance for the detection of weeds¹⁶.

Robotic surveillance

This project was initiated by the University of Sydney's Australian Centre for Field Robotics. The project aimed to provide weed control authorities with a cost-effective surveillance tool for the detection of alligator weed and salvinia, utilising an autonomous hovering unmanned air vehicle (HUAV) – a robotic helicopter – fitted with low-cost sensor suites and intelligent aquatic weed detection algorithms. Such a system could provide coverage over large distances and over inaccessible aquatic habitats. (Australian Centre for field robotics, University of Sydney)



Alligator Weed

Much effort has been expended to find a biological agent to aid in the control of alligator weed infestations. As a result of research efforts begun by CSIRO in 2003, several possible agents have been identified, though none have yet proven useful (see Note 7). CSIRO are also studying the genetic origins of alligator weed in Australia. Preliminary indications are that the Australian populations have come from at least three separate locations in the weed's native range¹⁷.

Note 7: Finding a biological control agent for alligator weed

Surveys for potential biological control agents of alligator weed in the native range of the weed have revealed eleven potential agents, including ten insects and a rust fungus. It has been hard to find insect agents that are sufficiently host specific because there are native *Alternanthera* species in Australia that are closely related to alligator weed.

Nevertheless, host specificity testing is complete for the first three insect agents, a thrip, a leaf beetle, and a galling midge, but they were rejected because they are able to complete their life cycles on the native *Alternanthera* species. Work will soon be underway on a fourth and fifth insect agent, a leaf beetle and a leaf-mining fly.

¹⁶ Land, Water and Wool, 2009

¹⁷ NAWMG, 2007-2008

A range of fungi and a nematode have been isolated from alligator weed in the native range, and the most common species have been identified. One is a rust and is the fungus with most potential. Work on the biology and host range of this rust will be conducted in a quarantine facility.

There is also progress on the development of a mycoherbicide using a native *Nimbya* spp. as bioherbicide. A delivery mechanism is now being investigated.

Information adapted from Schooler, 2008

Other research projects have focused on better herbicide use, results of which have been incorporated into the Alligator Weed Control Manual¹⁸.

More recently, findings from alligator weed fragmentation studies by Vic. DPI confirm the need to utilize containment fences to prevent the pieces of weed that break off plants that have been treated by herbicide from spreading to other parts of the waterway. Containment strategies are now being incorporated into best practice management for alligator weed.

To date, research on alligator weed has focused predominantly on the better control of core infestations. However the Management Group now recognizes that strategies for eradicating alligator weed differ from those used for managing core infestation areas. Future research efforts will, therefore, be focused on developing successful eradication strategies.

Cabomba

Little was known about cabomba ecology and biology when the Cabomba Strategy was first launched. In 2003, CSIRO began a program to research cabomba ecology in Australia and find biological control agents.

The ecology research found that cabomba maintains high biomass throughout the year, which is a favourable condition for the establishment of biological control agents. In addition, research to date has shown that light intensity and substrate seem to be major factors that influence cabomba growth¹⁹. This information is helping in the design of 'shading' techniques to control, particularly, smaller infestations.

Researchers have found three biological agents in the native cabomba sites they surveyed. Of these, a small weevil (*Hydrotimetes natans*) seems a promising agent for biological control of cabomba in Australia. However, tests have yet to prove its host specificity.

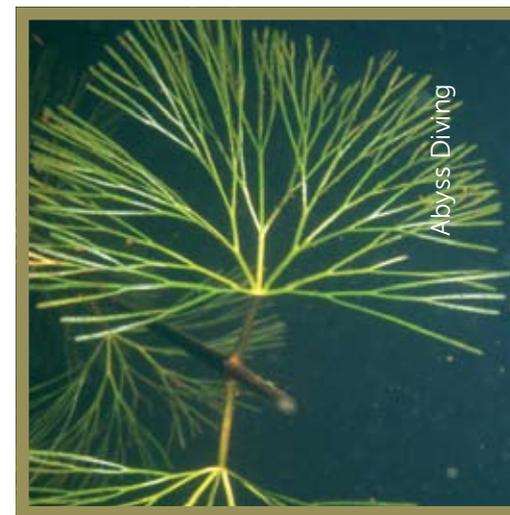
Achievements

Coordinated effort on research

Better understanding of biology and ecology of alligator weed

Better understanding of effects of various herbicides on alligator weed

Development of safe disposal techniques



Cabomba (*Cabomba caroliniana*)

¹⁸ van Oosterhout, 2007

¹⁹ Schooler and Walsh, 2007

NT research has focused, in part, on determining the viability of seed found in some cabomba infestations. Findings to date are that seeds are viable and viability rates can be quite high.²⁰

A data gathering exercise by NSW DPI and the former Qld DPI is also currently underway to establish another herbicide to replace the herbicide 2,4-D,nbutyl ester. Initial results are being used to support a label registration for carfentrazone ethyl whilst research continues into other products.

Another research activity was to investigate the possibility of composting harvested cabomba: an early finding is that worms do not absorb the heavy metals present in cabomba.

Salvinia

Research activities concerned with salvinia have focused predominantly on enhancing opportunities for using the salvinia weevil in temperate areas once considered outside the weevil's preferred climatic range. Studies show that weevils are even effective in cooler climates and are a useful control as far south as Sydney.

A research program being conducted by University of Wollongong is investigating the impacts of salvinia on at-risk native species in temperate climates. Results will help redefine salvinia management priorities and efforts in this climatic region. A current Qld DPI research project aims to quantify the impacts of salvinia and other floating aquatic weeds on evapotranspiration from water storage facilities.

Achievements

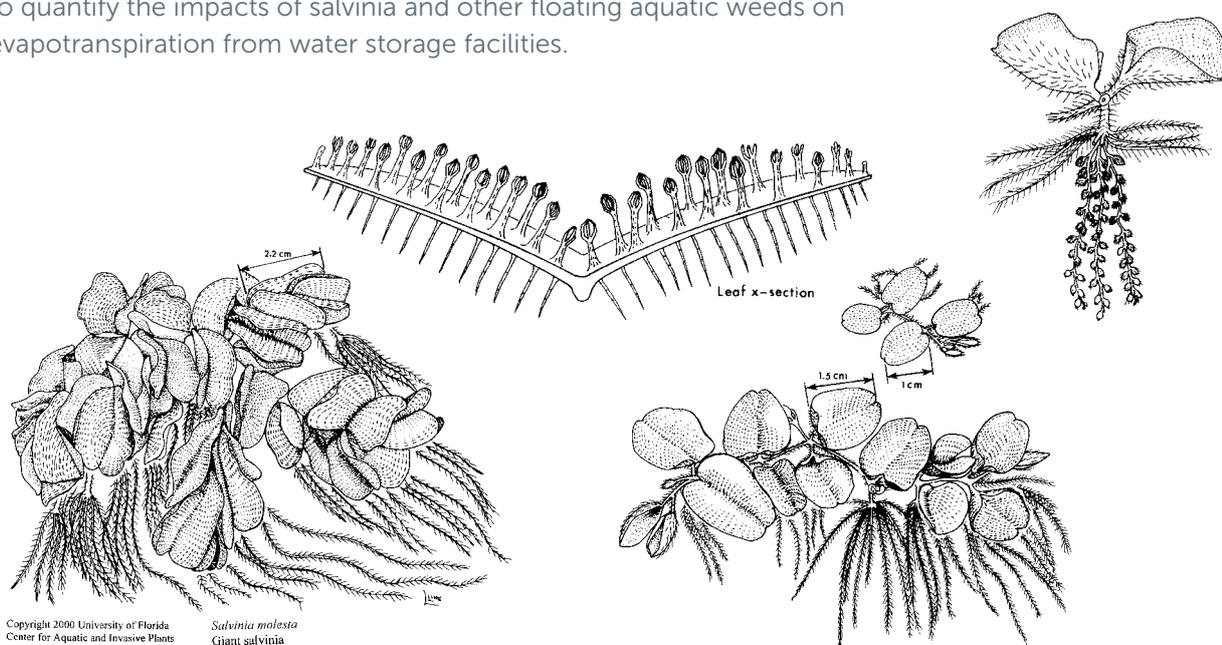
Better knowledge about the biology and ecology of cabomba

Increased number of physical control methods

Achievements

Methods for utilising salvinia weevil in cooler climates

Methods developed for best use of herbicides and physical weed removal and disposal



Future efforts

In general this summary of the aquatic WoNS annual reviews, together with a review of supplementary material, shows that the three aquatic WoNS strategies have been well conceived. The extent of the aquatic WoNS problem is now better understood, there are increased numbers of well-trained stakeholders, and increased resources have been targeted to manage the weeds. Appendix 4 contains summary tables of individual achievements against performance indicators.

Although much has been achieved, it is clear that aquatic weeds are continuing to spread and take hold in new areas in spite of management efforts. The exception is salvinia which has a good biological control agent that, when appropriately managed, can significantly reduce infestations.

In 2008, a report was commissioned by the Department of Agriculture, Fisheries and Forestry (DAFF) on behalf of the Australian Weeds Committee (AWC) to assess the progress of a number of the WoNS programs, among them, the aquatic weeds programs²¹. Overall, the assessment was positive, though the assessors made a number of recommendations to improve aspects of the programs.

In 2008, the Management Group incorporated a number of these recommendations into their planned priorities for the next five years (2008-2013). These priorities are reproduced in Appendix 5. Broadly, the priorities will be to:

- Continue coordination activities that support programs promoting weeds awareness at the national level, attract increased resources, and involved stakeholders.
- Continue work with government, industry and other stakeholders to minimise vectors of spread. The illegal and internet sale, and use of aquatic WoNS continues to be a problem, even though sales have been much reduced. There is still much work to do to educate human vectors to carry out hygiene procedures that will prevent spread of aquatic weeds. The ongoing use of salvinia as an ornamental plant for fishponds and property dams is of particular concern.



Working with stakeholders to minimise vectors of spread (NSW DPI)

²¹ Beatentrack Group (BTG), 2007

- Support key research projects that lead to the development of better control methods for each of the weeds. Particular focus to be on biological controls (with opportunities to implement the lessons learnt from expanding mass rearing facilities for the salvinia weevil), and better strategies to eradicate outlier infestations.
- Continue clarification and mapping of infestations of each of the aquatic WoNS.
- Increase efforts to encourage early detection regimes in areas at risk of infestation by aquatic weeds.
- Increase efforts to target critical infestations, such as those that threaten significant wetlands, or socially or economically important lands, or pose significant risk of further spread. At the very least, identify target areas to ensure that when better control methods are developed, control plans are in place.
- In the case of salvinia, encourage the development of plans that aim for eradication of the weed in non-core areas.
- Quantify the economic and ecological impact of aquatic WoNS weeds to enable cost/benefit analysis of management programs for each of the weeds.

One feature of the aquatic weeds program highlighted by the DAFF report is the significance of flow-on effects of aquatic WoNS programs to the management of aquatic weeds in general. There may be opportunities to capitalise further on this benefit, not only through the current program for assessing aquatic plants for weediness potential, but also in the collation and dissemination of information about control of weedy aquatic plants already in the environment.



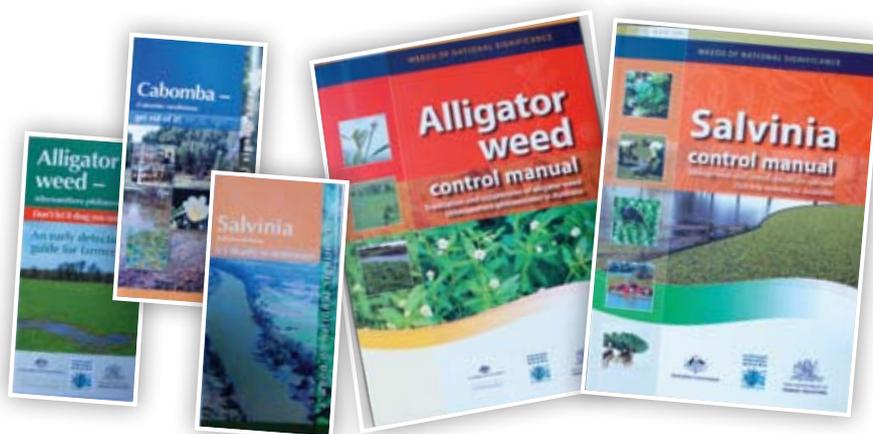
Support key research projects on biological controls

CSIRO entomology



Alejandro Sosa and Jimena Martinez searching for potential biological control agents on alligator weed

Shon Schooleer, CSIRO



Acronyms and short forms

ACT	Australian Capital Territory
APWRA	Aquatic Plant Weed Risk Assessment
AQIS	Australian Quarantine and Inspection Service
Coordinator	National Aquatic Weeds Coordinator
CRC	Cooperative Research Centre
DAFF	Australian Department of Agriculture, Fisheries and Forestry
DPI	Department of Primary Industries
DNRETA	Department of Natural Resources, Environment, The Arts and Sport, Northern Territory
Executive Committee	National Weeds Strategy Executive Committee
LMCCG	Lake Macdonald Catchment Care Group
Management Group	The National Aquatic Weeds Management Group (also known as, 'NAWMG')
NAWMG	The National Aquatic Weeds Management Group (also known as, 'Management Group')
NSW	New South Wales
NT	Northern Territory
PIAA	Pet Industry Association of Australia
Qld	Queensland
SA	South Australia
Tas.	Tasmania
Vic.	Victoria
WA	Western Australia
WoNS	Weeds of National Significance

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Appendix 1: Spread of aquatic weeds

Table A1.1 – History of alligator weed spread and treatment

ACT	
1994	Lake Ginninderra – probably introduced from backyard infestation via stormwater drain
2003-2004	Yerrabi Pond, three patches found – probably from backyard infestation via stormwater drain
2005-2006	Three backyard infestations – treated
2007-2008	Two backyard infestations – treated
NSW Central Coast	
1946	Carrington (Newcastle docks area) – may have been introduced in cargo or ballast
1946-2008	Hunter River (from Carrington in flood waters): Fullerton Cove, Williamstown, Raymond Terrace (in turf from Williamstown), Maitland – patches along 200 m of creek, Cessnock
1980s	Central Coast - Lake Macquarie, Gosford (in turf from Williamstown), Great Lakes, Wyong
1993	Paterson River and Williams River – spreading upstream at 1.5 km py on recreational craft
1996	Girvan – scattered plants along 8 km – not eradicable in the short term
1998	Wilsons River – More than 1 ha scattered along 75 km of river – potentially a 'core area'
2004-2005	Port Macquarie – about 30 m ² – now treated and less than 1 m ² being monitored
2004	Port Stevens – all near Grahamstown Dam (Medowie, Campvale, and Salamander) – Council together with aquatic club seeking to eradicate infestation
2006-2007	Forster
2004-2005	Taree – 15 plants found, all treated
2007-2008	Hunter River (Surveillance after 2007 floods) – ten new infestations treated
2007-2008	Hawkes Nest – infestation destroyed
NSW Sydney Region	
1969	Auburn (Duck Creek)
1970-2008	Botany wetlands to above Casula
1970-2008	Parramatta catchment (probably spread from Auburn infestation)
1981	Camden (probably introduced in sand from Chipping Norton)
1981-2008	Nepean River and downstream to Windsor – probably spread from Camden
1999	Wollongong - approximate density of 1% along 500 m watercourse
NSW Murray Irrigation Area	
1967	Albury (Woomargama) – a deliberate planting in a pond, spread 500 m downstream from the original infestation – infestation now contained but not eradicated
1994	Griffith (Barren Box Swamp and associated irrigation channels) – 250 ha – now 4 known plants
1994	Wah Wah - More than 1 ha over 9 properties
NSW North Coast	
1998	Byron Creek – spreading downstream – the weed is sold as a vegetable
2004-2005	Casino – 15 m ² – now treated and less than 1 m ²
2005	Coffs Harbour – Infestation over an approx 5 km ² area – now less than 1 m ² – being monitored
2006-2007	Lismore
2007-2008	Lismore Lakes – 20 m ² over three patches – destroyed, being monitored
NSW Other areas	
2007-2008	Backyard infestations

Table A1.1: History of alligator weed spread and treatment – cont.

Qld	South east
1994	Caboolture – 1 ha
1994	Rocklea – 1 ha
~ 1995	Brisbane – backyard infestations – reduced to 10% of original size
Pre 2000	Beenleigh – 0.5 ha
2005-2006	Currumbin – 0.5 ha – reduced to approx 50 1 m ² – being monitored
2005-2006	Mudgeeraba – 1 ha
~ 1995	Cairns – backyard infestation
Vic.	
~ 1995	Melbourne – backyard infestations and as a vegetable on sale
2000	Frankston (Ballarto Rd)– 20 m ² – now 0.3 m ² (2 patches)
2001	Dandenong (Trihatuan Park) – 1 m ² – now 10 m ²
2003	Yarra River – small patch
~ 2004	Mill Park - 109 m ² (20 infestations)
~ 2004	Edgars Creek – 10 m ² (1 infestation)
~ 2004	Eummerring Creek – 2780 m ² (35 infestations)
2004	Mill Park (subset Darebin Creek) – 20 m ² (3 patches) – 9 m ² (4 patches) detailed investigated
2004	Endeavour Hills (Frog Hollow) – 25 m ² – 2.2 m ² (11 patches) investigated in detail
2004	Endeavour Hills (remainder of site) – 25 m ² 2.2 m ² (11 patches)
2004	Hampton Park (subset Hallam Drain) – 200 m ² (20 patches) – now 18 m ² (16 patches) investigated in detail
2004	Hallam Drain - 100 m ² (12 infestations)
2004	Wantirna (Koomba Park) – 12 m ² – now 2 m ²
2005	Bendigo Creek – 10 m ² – Eradicated, being monitored
2006	Dandenong (Waterview Close) – 1000 m ² – 400 m ²
2006	Dandenong North (Healthy Bay) – 15 m ² – now 35 m ² (8 patches)
2006	Narre Warren (Centre Road) – 33 m ² (1 patch) – now 40 m ² (13 patches)
2007	Brunswick (Merri Creek) – 50 m ² (4 patches) – now 13 m ² (6 patches) detailed investigated
2007	Brunswick (Merri Creek) – now 25.7 m ² (14 infestations)
2007	Patterson River – 15 patches along 4 km of river – largest infestation in Vic. – under treatment
2007	Warragul (Stoddarts Road) – 200 m ² – 10 m ²
NT, Tas., SA, WA	
1995	Darwin
~ 1995	Adelaide –backyard infestation
~ 1995	Hobart - backyard
~ 1995	Perth – backyard infestations (subsequent infestations found in 2004 and 2005) – All treated

Table A1.2: History of cabomba spread and treatment*

1930	Anecdotal evidence of introduction to Australia
1967	In herbarium records
Qld	
1989	Leslie Creek (Atherton Tablelands)
1991	Avondale Creek (North of Cairns)
1991	Maria Creek and drainage channel at Goondi (near Innisfail)
1991	Caboolture River, (south Qld)
1991	Lake Tinaroo (Atherton Tablelands)
1991	Lake MacDonald (headwaters of Mary River, Noosa Shire) – Extensive management – mostly physical removal and community education underway
1996	Canal Creek (near Babinda), Diggers Creek, El Arish, the Ewen Maddock Dam and Cabbage Tree Creek
2003	Hinze Dam (Gold Coast)
2003	Townsville water impoundments – Management plan in place, mechanical harvesting
2005	Mackay City
Vic.	
1990	Lake Benalla – Management plan put in place in 2006 to control the infestation and prevent its spread to other areas of Murray Darling. Drawdown mostly used but other options are being considered
1996	South Gippsland and Lake Negambie
1997	Marlow Lagoon (Palmerston) – with perhaps another deliberate introduction some years later – Lagoon emptied and weed removed, then herbicide application for second infestation
1999	Farm dam in West Gippsland region – Eradicated
2003	Broken River – probably spread from the Benalla Lake infestation – Management plan put in place for Benalla
2006	Casey's Weir – probably from Lake Benalla infestation
NSW	
1996	Four Mile Creek (Dapto, Sydney), Glenbrook Lagoon, Burringbar Creek (at Mooball), Barrington, Eastlakes golf course, Griffith area and Bulahdelah (north of Newcastle)
2003	Taree
2003	Eastlakes (Sydney)
2003	Emigrant Creek Dam (near Alstonville)
2005	Hastings River (near Port Macquarie) – Management Plan in place – predominantly hand-pulling used
2005	Forster – several more private dams
2007	Tea Gardens – presence of other aquatic plants indicate the infestation could be a deliberate planting by an aquarium plant supplier
2004	Murwillumbah
2007	Nabiac – private dam
NT	
2004	Darwin River - Herbicide application and monitoring in place: quarantine order set in place from 9 November from 2005 to 2010. Infestation reduced to less than 0.01% of original size.

* Extent of infestation areas is probably greater than shown here but the table indicates a growing problem

Table A1.3: History of salvinia weed spread and treatment*

NSW	
1952	First recorded in Luddenham (near Sydney)
1973	<i>Found in farm dams, ponds and streams along coast from Ulladulla, NSW to Julatten, Qld</i>
1975	Found in a small farm dam near Deniliquin
1998	Infestation found in Myall Lakes National Park
2003-2004	Hawkesbury River – infestation along 50 km of river – integrated anagement plan in place and infestation reduced, however remains problematic due to reduced environmental flows
2003-2004	Wollombi Brook (near Cessnock) - 100 km infested, treatment hampered by a debate over who is responsible for management of the brook – Management plan now in place
2007-2008	2 infestations at Why Swamp and Malua Bay, Eurobodalla Shire, NSW - continue to be suppressed (one landholder fined for non compliance of a notice)
2007-2008	4 existing sites in the Shoalhaven Shire remain under containment
2007-2008	4 infestations n the Illawarra shire near Wollongong - eradicated (only 2 infestations left)
2007-2008	6 new infestations in the Wollombi Brook area but project officer working well
2007-2008	Hawkesbury River infestations continue to be managed.
2007-2008	Monitoring of eradicated sites in the Bega Shire found no regrowth of salvinia for 4 years.
Qld	
1953	Brisbane
1966	Roos River Weirs (Townsville)
1975	Lake Moondarra (near Mt Isa) – three decades of biological control
1995	Ewen Maddock Dam – washed down from infested farm dams
2004-2005	Infestation in central Qld.
2006-2007	Honey dam (near Cooktown)
2007-2008	Burnett Region (central Qld) infestations reduced by over 99% - project officer oversees sites
WA	
1973	Small infestation in Bunbury and Albany
2004-2005	6 infestations in WA reported
2004-2005	An infestation in north-west Perth – treated successfully
2004-2005	An infestation in Ord River catchment treated successfully
2004-2005	New infestation near Perth - treated and eradicated
2007-2008	An infestation in a water supply dam near Kununarra has recently been eradicated
NT	
1976	A nursery in Darwin
1976	In waters near Nhulunbuy
1980	Five infestations of salvinia eradicated in NT
1988	10 infestations in NT (one being Kakadu National Park)
1995	Introduced as ornamental plant in upper catchment, washed into Boolambayte Ck in floods.
Vic.	
2001	Vic. – salvinia eradicated from a dam

* Extent of infestation areas probably greater than shown but the table indicates a growing problem

Appendix 2: Extension activities

Table A2: Sample of aquatic weeds extension activities -2003-2008

Date	Extension activities on aquatic weeds
2003	Aquatic weed brochures developed in NSW and Qld
2003	Griffith - alligator weed, NSW – community forum
2003	Hunter region – 5 field days
2003	Qld Buddhist community - alligator weed awareness raising
2003	Speakers kits developed - aquatic weeds
2003	Wah Wah irrigation district - alligator weed field day
2003-2004	Aquatic weeds identification workshops - 3 in NSW, 4 in SA
2003-2004	Aquatic weeds training of parks and garden staff - Bankstown Council Sydney
2003-2004	Article written for Pet Industry News on national aquatic weeds declaration status, emphasising cabomba - National Coordinator & PIAA
2003-2004	Cabomba and aquatic pests display at 2004 Qld Pet and Animal Exp
2003-2004	Cabomba weed management guide printed
2003-2004	General aquatic weed awareness during Weedbuster Week
2003-2004	Much media attention to the salvinia outbreaks in Hawkesbury and Wollombi waterways
2003-2004	National exposure of cabomba management at Lake MacDonald
2003-2004	North coast weeds forum
2003-2004	NT brochure developed
2003-2004	Qld-wide weed spread campaign with TV and brochure
2003-2004	Reconnaissance surveys for early detection and reporting of aquatic weeds under development – National Coordinator & PIAA
2003-2004	Salvinia biological control and aquatic WoNS story published in BUSH magazine
2003-2004	Salvinia brochure under development
2004-2005	3 Field days and 3 visits to NT government agencies - cabomba
2004-2005	Aquatic weed workshop – 1 in Grafton and 3 Sydney
2004-2005	Cabomba display at Sydney boat show – preventing the spread
2004-2005	Identification brochure and banner produced and distributed to all states
2004-2005	Media attention to outbreak of cabomba in central Qld.
2004-2005	Murrumbidgee irrigation area – Bus tour to Raymond Terrace alligator weed infestation
2004-2005	National aquatic weeds declaration poster for aquarium industry under development
2004-2005	PIAA obtained weeds menace funding to produce DVD
2004-2005	Reconnaissance methods developed for cabomba and other aquatic weeds
2004-2005	Workshop on aquatic weeds at National Waterwatch conference – LMCCG
2005-2006	Aquatic weed identification training manual developed
2005-2006	Aquatic weed identification workshops held – 4 in NSW, 1 in Qld, 1 in SA, 1 in ACT
2005-2006	Best practice manual published – salvinia
2005-2006	DWM to implement aquatic weeds early detection programs in 3 priority regions - to link with Waterwatch Australia
2005-2006	Eel trappers in NSW written to and informed of measures to prevent spread of cabomba
2005-2006	National aquatic weeds declaration poster for aquarium industry produced

TableA2: Sample of aquatic weeds extension activities (2003-2008) – cont.

2005-2006	Workshop in Kakadu NP to determine management options for Salvinia in Kakadu National Park
2006-2007	1 aquatic weed identification workshop held in Grafton
2006-2007	10 newspaper articles - central Qld.
2006-2007	3 field days, central Qld
2006-2007	4 radio interviews, central Qld
2006-2007	9 aquatic weed identification workshops in south east Qld
2006-2007	Aquatic weed spread advertisement published in NSW Freshwater Anglers club annual report – distributed to 24,000 members.
2006-2007	Aquatic weed identification workshops in Qld and SA
2006-2007	Aquatic Weeds Early Detection training for Waterwatch in north central Vic.
2006-2007	Training sessions on Aquatic Weeds Early Detection project - weeds officers in northern NSW
2007-2008	2 weed surveillance training to weed control authorities in south east Qld
2007-2008	Aquatic weeds surveillance training by Aquatic Weed Early Detection project – 7 weed control authorities in northern NSW -
2007-2008	AWED project officer conducted 14 aquatic weed ID workshops
2007-2008	Cabomba stakeholder's information day – 50 people from south east Qld
2007-2008	3 aquatic weed ID workshops in WA and ACT by National Aquatic Weeds Coordinator
2007-2008	8 aquatic weed ID and 2 early detection workshops by Noosa Landcare

Appendix 3: The National Aquatic Weeds Management Group (2008)

Organisation	Name
Community (Hunter)	Margaret McMahon
CSIRO Entomology	Schon Schooler
Pet Industry Association of Australia	Ed Frazer
Community (Noosa & District Landcare Group)	Phil Moran (Vice Chair)
NSW Department of Primary Industries	Syd Lisle
Biosecurity Qld (Department of Employment, Economic Development and Innovation)	Jo Vitelli
Department of Primary Industries (Victoria)	Tony Dugdale
Community (Hawkesbury/Nepean)	Neale Tweedie (Chair)
Local Government	Paul Rasmussen
Technical advisors	
NSW Department of Primary Industries	Jessica Grantley
Maitland City Council	Brian Worboys
Coordinator	
NSW Department of Primary Industries	Andrew Petroschevsky
Corresponding members	
Department of Water and Biodiversity Conservation (SA)	Shauna Potter
Nursery and Garden Industry Australia	Robert Chin
ACT Parks, Conservation and Lands	Pest Species Coordinator (weeds & Invertebrates)
Department of Agriculture and Food (WA)	Sandy Lloyd
Department of Primary Industries, Water and Environment (Tas)	Vacant
Department of Environment and Arts (NT)	Steve Wingrave

Appendix 4: Key Performance Indicators

Table A4.1: Review of KPIs identified in Alligator Weed Strategy

KPI (alligator weed)	Progress	Measures
No new importations into Australia	✓	No importations reported
Increased Awareness of alligator weed by the community and reduced use as a vegetable.	✓ 80%	<ul style="list-style-type: none"> Overwhelming majority of Sri Lankans in Sydney are aware of issue and have stopped growing alligator weed. No Sri Lankans found growing alligator weed in Melbourne (Meyer et al, 2004) Targeted workshops for Sri Lankan communities Brochures on <i>mukunnawana</i> (alternative vegetable to alligator weed) produced in Sri Lankan and English
Increased reporting rate of new infestations	✓ 80%	<ul style="list-style-type: none"> Prior to the Strategy 10 non core infestations were reported dating back to 1970's. Since 2004 there have been 10 new infestations reported. Aquatic Weed ID training conducted in 6 states and territories (NSW, QLD, VIC, WA, SA, ACT) with aim to educate people to identify alligator weed (early detection) Local government weeds officers trained in alligator weed detection and surveillance in NSW and Qld.
Improved understanding of the social, economic and environmental impacts	➔ 40%	<ul style="list-style-type: none"> Application for study of economic impact submitted in round two of Defeating the Weed Menace but not funded. Very high priority task that requires further work
Improved understanding of biology and ecology of weed	➔ 60%	<ul style="list-style-type: none"> Better understanding of below/above ground biomass ratio and how herbicides impact on biomass Competition and reason for invasion studies in progress Genetic origin studies in progress Propagule size studies completed More work required on physiology (i.e. follow up work on herbicide translocation barriers)
Better treatment packages for eradication of small infestations	➔ 40%	<ul style="list-style-type: none"> Alligator weed control manual produced, which provides protocols Treatment packages available (i.e. integrated herbicide and mechanical removal) Off-label permits for Metsulfuron lodged in Qld, NSW and Vic. A range of options identified for various situations (as per control manual) Packages can be improved with further biology and integrated herbicides work
Improved biological control	➔ 50%	<ul style="list-style-type: none"> Potential agents identified Host specificity testing on three agents complete but all failed Needs integrated control research with other methods (such as are available to Salvinia) Future options include pathogens and Mycoherbicides <i>Strategy KPI is unrealistic for life of strategy as this is long term work (more than 5 yrs)</i>
Reduced rate of spread	➔	<ul style="list-style-type: none"> <i>Not easily measured – Impossible within project scope as it needs prior knowledge base</i> No benchmark available prior to start of project Benchmark (data of core infestation locations) available as of 2008 Vectors have been targeted through education and awareness Project underway to identify core infestation sites at high risk of further spread

✓ Completed ✓ Substantially completed ➔ Substantially completed but ongoing
 ➔ Towards completion ● Not begun ➔ Not measurable ✗ Not achievable

Table A4.1: Review of KPIs identified in Alligator Wed Strategy – Cont.

Decline in the number of small infestations in non core areas	●	<ul style="list-style-type: none"> Backyard infestations – over 50% of backyard infestations in Sydney eradicated. Nationally others under inspection and eradication program Three field sites eradicated but new sites discovered Now have knowledge that population can exist 3-5 years after last sighting at site Need to understand how long it can persist for Sites often reduce in overall size but not number of plants (infestation scatters)
Effective collaboration between Government agencies	✓ 75%	<ul style="list-style-type: none"> Four meetings a year of the NAWMG – continued membership Four coordinators reports per year distributed to NAWMG, each state government and key stakeholders Murray Darling Alligator Weed eradication has three participating state governments The production of the alligator weed manual involved members from state governments in three states Non core alligator weed review involved discussions between three states More efforts required in core areas
Cooperation and collaboration with community resulting in better education, surveillance and control	✓ 75%	<ul style="list-style-type: none"> Aquatic Weeds ID training package – accredited training package 441 people trained as part of AWED (community, Local Government, CMA – NSW, Qld and Vic.) 150 trained by Noosa District Landcare (Community – Qld and SA) 90 trained by National Coordinator (Local and State Government in NSW, SA, ACT and WA) Community representatives on two regional alligator weed taskforces in NSW New taskforce in Northern NSW has invited community members
Increased resources to develop the national strategy	✓ 75%	<ul style="list-style-type: none"> NAWMG reviews and refines the strategy, continually improving and amending where/when necessary This team discusses strategy regularly with mixed stakeholder members Resources have increased since commencement of strategy

Table A4.2: Review of KPIs identified in Cabomba Strategy

KPI (cabomba)	Progress	Measures
National Restrictions on the trade of cabomba	✓	<ul style="list-style-type: none"> Cabomba banned from all states and territories in 2006 Presentation at 2005 Victorian Weeds Conference aimed to raise awareness of weed in the only state it was not banned
Increased detection of cabomba imports	➔	<ul style="list-style-type: none"> This KPI is beyond the scope of the project and should not be a KPI There is no benchmark to work from
Alternative species available for the aquarium industry	✓ 75%	<ul style="list-style-type: none"> NAWMG discussed the merits of recommending 'safe alternative species' (as per the strategy) but decided this was not feasible. Any aquatic plant has potential to be a weed given the right circumstances, hence credibility could be at stake by recommending safe species NAWMG investigated and pursued concept of a Weed Risk Assessment of plants in the trade to identify and ban other weedy species. WRA project recommended 33 species be banned from sale nationally. 21 species in the trade still require risk assessments

✓ Completed ✓ Substantially completed ➔ Substantially completed but ongoing
 ➔ Towards completion ● Not begun ➔ Not measurable ✗ Not achievable

Table A4.2: Review of KPIs identified in Cabomba Strategy – Cont.

KPI Cabomba	Progress	Measures
Code of conduct for the aquarium industry	 40%	<ul style="list-style-type: none"> Pet Industry Association of Australia added additional tips on responsible plant handling into their 2005 National Code of Practice (under O.2.7 of the code of practice) PIAA produced the DVD – Responsible Handling of Aquatic Plants – and distributed it within industry. Need more understanding of effort from aquarium retailers Future measures include adoption of a plant labelling scheme
National Licensing Scheme developed		<ul style="list-style-type: none"> National accreditation schemes for industry not feasible or practical (state govt. will not endorse) KPI should be removed National labelling scheme would be a better KPI
Mapping and surveillance program completed	 60%	<ul style="list-style-type: none"> Map showing national distribution of cabomba compiled in 2006 Surveillance methodologies completed in 2005 Early detection project refined these methodologies and implemented in Northern NSW
Delivery of targeted extension material	 80%	<ul style="list-style-type: none"> Pull up display, cabomba brochure, aquatic weeds poster for aquatic plants industry, advertisements in the boating and fishing newsletters, aquatic plants ID manual and associated training, Waterwatch module on aquatic weeds and Waterwatch training, cabomba display at the International Sydney Boat Show, aquatic weeds display at 2005 International River Symposium (Brisbane), Noosa Festival of Water (3 times) and the 2005 cabomba stakeholders forum
Management plans for all infestation	 40%	<ul style="list-style-type: none"> Cabomba incorporated into general aquatic weed plans in NSW Specific management plans developed for Lake MacDonald (Qld) and Lake Benalla/Broken River (Vic.) Some regional plans at high priority sites in place <i>KPI should be changed to management plans for strategic infestations</i>
Reduction in nitrogen and phosphorous levels in waterways containing cabomba		<ul style="list-style-type: none"> <i>Well beyond the scope of the project</i>
Linkages developed to other NRM plans through cabomba actions	 40%	<ul style="list-style-type: none"> Mary Burnett, SEQ Catchments and Goulburn Broken (Vic.) regional bodies all have cabomba incorporated into their plans Cabomba linked to all NSW CMA plans due to its Class 5 status More work required to build further adoption into plans
Best Practice Management Package Developed	 80%	<ul style="list-style-type: none"> Cabomba control manual is under development Efficacy trials on one herbicide in progress whilst trials for other herbicides are proposed
Biological control program undertaken	 50%	<ul style="list-style-type: none"> Long term research but native range surveys complete and host specificity testing on one agent to be completed by December 2008
Impacts of Cabomba are Quantified		<ul style="list-style-type: none"> No work undertaken

 Completed
  Substantially completed
  Substantially completed but ongoing
 Towards completion
  Not begun
  Not measurable
  Not achievable

Table A4.2: Review of KPIs identified in Cabomba Strategy – Cont.

KPI Cabomba	Progress	Measures
National Weeds Strategy internet home page developed as a national database	✓ 75%	<ul style="list-style-type: none"> Evolving webpage Needs updating to include new extension material, national maps and strategy reports
Timely and adequate resources for actions	✓	<ul style="list-style-type: none"> All national and cross-regional cabomba projects (> \$50,000) proposed and endorsed by NAWMG successfully funded: <ul style="list-style-type: none"> Early detection of nationally significant aquatic weeds (05/06 DWM round) Weed Risk Assessment of tradeable aquatic plant species (05/06 DWM round) National Assessment and development of best practice information for cabomba 05/06 DWM round) Host specificity testing for cabomba biocontrol (06/07 DWM R&D round and Mary Burnett regional body) Cabomba native range surveys (stakeholder support and NHT2) NT Government funded \$500,000 to eradicate cabomba from Darwin River
Annual reports produced by the management group	✓	<ul style="list-style-type: none"> NAWMG have prepared and submitted the report 'review of progress toward the cabomba strategic plan' to the Australian Weeds Committee annually.

Table A4.3: Review of KPIs identified in Salvinia Strategy

KPI (salvinia)	Progress	Measures
Increased detection of salvinia imports	↘	<ul style="list-style-type: none"> <i>This KPI is beyond the scope of the project and should not be a KPI</i> <i>There is no benchmark to work from</i>
National Restrictions on the trade of salvinia	✓	<ul style="list-style-type: none"> Salvinia banned from sale in all states and territories prior to the existence of NAWMG Despite ban reports of illegal trading of salvinia continue
Code of conduct developed by industries involved in the plant sales	➔ 30%	<ul style="list-style-type: none"> Pet Industry Association of Australia added additional tips on responsible plant handling into their 2005 National Code of Practice (under O.2.7 of the code of practice) PIAA produced the DVD – responsible handling of aquatic plants and distributed it within Industry. No known progress with Nursery Industry regarding code of conduct Future measures include adoption of a plant labelling scheme
National accreditation developed by aquatic plant growers	✗	<ul style="list-style-type: none"> National accreditation schemes for industry not feasible or practical (state govt will not endorse) KPI should be removed National labelling scheme would be a better KPI

✓ Completed ✓ Substantially completed ➔ Substantially completed but ongoing
 ➔ Towards completion ● Not begun ↘ Not measurable ✗ Not achievable

Table A4.3: Review of KPIs identified in Salvinia Strategy – Cont.

KPI (salvinia)	Progress	Measures
Alternative species available for the industry	 80%	<ul style="list-style-type: none"> • NAWMG discussed the merits of recommending 'safe alternative species' (as per the strategy) but decided this was not feasible. Any aquatic plant has potential to be a weed given the right circumstances, hence credibility could be at stake by recommending safe species • NAWMG investigated and pursued concept of a Weed Risk Assessment of plants in the trade to identify and ban other weedy species. • WRA project recommended 33 species be banned from sale nationally. • 21 species in the trade still require risk assessments. • Future measures include adoption of a plant labelling scheme
Delivery of extension material specific to target groups and regions	 80%	<ul style="list-style-type: none"> • Pull up display, salvinia brochure, aquatic weeds poster for aquatic plants industry, Advertisements in boating and fishing media, aquatic plants ID manual and associated training, Waterwatch module on aquatic weeds and Waterwatch training, aquatic weeds display at 2005 international river symposium (Brisbane), Story in BUSH magazine regarding salvinia biological control. • More effort needed with water gardeners and farm dam owners
The Impacts of Salvinia are communicated to the community	 80%	<ul style="list-style-type: none"> • Salvinia received the highest number of weeds media stories in Qld over last 12 months • Social impacts can be quantified by the high number of community complaints • NAWMG measured other social impacts through media stories – salvinia attracts greatest media attention because it's visible i • More understanding of impacts needed by lifestyle property owners
Management plans for all infestations	 75%	<ul style="list-style-type: none"> • High priority infestations have specific plans (i.e. Kakadu, Honey Dam, eradication plan for WA) • NSW infestations linked to regional aquatic weeds plans
Linkages developed to other NRM plans through salvinia actions	 75%	<ul style="list-style-type: none"> • Three salvinia biological control facilities (Miriam Vale, Yeppoon and Bundaberg) funded by regional bodies • Other regional groups funding major salvinia programs (e.g. Hawkesbury Nepean, Southern Cape York Catchments, Mary Burnett and Fitzroy)
Biological control program extended	 80%	<ul style="list-style-type: none"> • 8 state/regional biological control facilities at present meaning all regions have access to biocontrol agents. 6 facilities constructed during duration of NAWMG term. Only 2 facilities operating prior to start of Strategy, both of which supplied only local needs. • NSW database shows 60 release sites from Grafton facility since 2004. This does not include releases made in the Hawkesbury nor sites where release forms were not submitted. • Further desired measures include increase adoption of weevils by weed control authorities
Timely and adequate resources for actions	 75%	<ul style="list-style-type: none"> • Have learnt from past mistakes • Rapid responses to new infestations now available in NSW and Qld (e.g. Roma), providing less than \$50,000 is required. • Follow up if Vic, WA and NT have rapid response measures • Follow up work the responsibility of local stakeholders and this is not always done well
Annual reports prepared by the management group		<ul style="list-style-type: none"> • NAWMG have prepared and submitted the report 'review of progress toward the salvinia strategic plan' to the Australian Weeds Committee annually
The Impacts of Salvinia are communicated to the community	 80%	<ul style="list-style-type: none"> • Salvinia highest no. Qld weed media stories in last 12 months • Social impacts estimate in high number of c'ty complaints • NAWMG measured other social impacts by examining media stories. Weed by far attracts the most media attention due to its visible impact • Need more understanding of impacts by lifestyle property owners

Appendix 5: National Aquatic Weeds Management Group Action Plan 2008-2013

Table A5.1: Action Plan (April 2008) – aquatic weeds knowledge base (including research)

Strategy/Action	Outputs and outcomes	Australian Weeds Strategy links
Quantify impact of aquatic weeds to Australia's economy and environment	<ul style="list-style-type: none"> The aquatic weed threat is more understood Improved ability to identify 'assets at risk' from aquatic weeds 	2.3.1
Continue studies into the translocation of herbicides through alligator weed roots	<ul style="list-style-type: none"> Understanding of the fate of herbicides Understanding of optimal growth stages of plants for herbicide treatments leading to increased kill 	3.2.3
Continuation of Autonomous Arial Vehicle development for detection of aquatic weeds (if concept shows merit)	<ul style="list-style-type: none"> Surveillance and detection tool for high priority aquatic weeds, enabling inspection of larger and inaccessible areas Infestations detected and treated earlier 	3.2.3
Alligator weed adaptive management trials for eradication (including herbicide, surfactant and optimisation trials, below ground biomass depletion studies)	<ul style="list-style-type: none"> Tools available to destroy alligator weed infestations in shorter time period – hence cheaper and faster eradication of non core alligator weed infestations 	2.2.2, 2.3.4
Assessment of new non herbicide technologies for alligator weed control/eradication	<ul style="list-style-type: none"> Efficacy and costs of steaming & flame quantified Tools available to treat alligator weed in potable water supplies and sensitive environmental areas 	2.2.2, 2.3.42
Cabomba adaptive management trials Integration of herbicides and mechanical harvesting	<ul style="list-style-type: none"> A range of tools available to manage cabomba in differing environments (ie flowing water, rivers, lakes) 	2.2.2, 2.3.4
Salvinia herbicide development and integration with biological control	<ul style="list-style-type: none"> Strategies available to maximise control works whilst minimising Biological Oxygen Demand on water column Data available to support minor use permit applications for preferred herbicides 	2.2.2, 2.3.4
Continue host specificity testing of cabomba and alligator weed biocontrol agents (including alligator weed pathogens)	<ul style="list-style-type: none"> Host specific agents ready for mass rearing and release. 	2.2.2
Mass rear, release and monitor new alligator weed biological control agents (if host specific)	<ul style="list-style-type: none"> Biological control agents mass reared and released. Effectiveness of agent quantified 	2.2.2
Re-examine salvinia biological control – review native range data from previous Australian and International research	<ul style="list-style-type: none"> Identify if other potential agents capable of complementing current biocontrol (ie assist with multi layered mats) may exist 	2.2.2
Mass rearing of cabomba biological control agents	<ul style="list-style-type: none"> Capacity to mass rear and monitor effectiveness of cabomba biological control agents 	2.2.2
Annual or biannual aquatic weeds research forum	<ul style="list-style-type: none"> Identification of research priorities Key stakeholders involved Greater support from Australian Weeds Research Centre and industry for aquatic weeds research. 	

Table A5.2: Action Plan – stakeholder engagement

Strategy/Action	Outputs and outcomes	Australian Weeds Strategy links
Development of plant labelling scheme for aquatic plant industry Consider recommendations from Vic. Department of Primary Industries scoping study on industry	<ul style="list-style-type: none"> Reduced likelihood of industry mislabelling leading to declared species been sold 	3.1.5
Evaluation of remaining 21 species requiring evaluation as part of the Weed Risk Assessment project. A combination of field inspections and competition trials	<ul style="list-style-type: none"> Further aquatic plants with significant weed potential are removed from sale nationally 	2.1.1
Engage companies to pursue registration of additional aquatic herbicides	<ul style="list-style-type: none"> Registration of effective herbicides for cabomba and salvinia by companies Support for field trials from companies 	
Improve registration/permit process for aquatic Herbicides Liaise with Australian Pesticides and Veterinary Medicines Authority and state agencies	<ul style="list-style-type: none"> Discussion paper on future directions for aquatic herbicides Guidance from APVMA and better support for registrations and minor use permits for aquatic herbicides 	

Table A5.3: Action Plan – program management

Strategy/Action	Outputs and outcomes	Australian Weeds Strategy links
National Aquatic Weeds Coordination and National Aquatic Weeds Management Group for aquatic WoNS, high priority aquatic weeds and aquatic weeds issues.	<ul style="list-style-type: none"> National Coordination of national aquatic weeds strategies continues Employment of fulltime National Coordinator and full/part time project officer. 	2.2.1 and others
Audit of on ground control works for aquatic WoNS Annual inspection of all alligator weed non core sites by outside parties.	<ul style="list-style-type: none"> Effectiveness of current efforts (including resources, site management and tools used) are measured Progress towards eradication of alligator weed non core sites is measured annually. Deficiencies identified and rectified (eg salvinia biocontrol in farm dams) Effective methods trialled and utilised elsewhere Increase in effectiveness of management 	
*New aquatic weed species for national action	<ul style="list-style-type: none"> Potential species for future national action identified and evaluated Action plans and/or strategies for new nationally significant aquatic weeds developed 	2.1.1

Table A5.3: Action Plan – onground works and education

Strategy/Action	Outputs and outcomes	Australian Weeds Strategy links
National Aquatic Weeds Extension – incorporating early detection, prevention of spread, and knowledge transfer communication	<ul style="list-style-type: none"> • Early detection procedures and effort are in place, thus increasing likelihood of early detection and eradication of new infestations • Target audiences (ie fishing and boating, water gardeners) do not contribute to further spread of aquatic WoNS and high priority aquatic weeds • 1-2 best practice field days held annually in key states to improve ability of weed control authorities to manage aquatic WoNS 	3.1.2, 3.1.5, 2.3.3
High priority sites for treatment identified	<ul style="list-style-type: none"> • Methodology for prioritising sites (based on impacts, management feasibility and potential for further spread) developed • Key environmental and economic assets at threat identified 	
Eradication/containment of non core alligator weed high priority infestations	<ul style="list-style-type: none"> • Sites deemed to be high risk (in terms of potential impact and spread) are contained and eventually eradicated 	2.3.2, 2.3.1
Eradication/containment of high priority cabomba/salvinia infestations	<ul style="list-style-type: none"> • Sites deemed to be high risk (in terms of potential impact and spread) are contained and eventually eradicated 	2.3.2, 2.3.1
Intensive treatment of core alligator weed infestations that pose risk of spread or impact to key ecological assets Formation of project committee to oversee core alligator weed management	<ul style="list-style-type: none"> • High risk sites (potential to spread, as identified in previous work) are contained, thus preventing likelihood of new alligator weed outbreaks • Increased stakeholder support and involvement in core alligator weed management 	1.3.1
Continual update of aquatic WONS national maps and surveillance of high risk catchments (incorporate management objectives where feasible)	<ul style="list-style-type: none"> • Inspection of high risk catchments and Murray Darling Basin for aquatic WONS • Maps provide decision support for identifying future management options 	3.4.2
Floodplain modelling of key alligator weed catchments to predict post flood spread	<ul style="list-style-type: none"> • Improved accuracy and reduced cost of post flood reconnaissance programs 	

Appendix 6: Papers written on aquatic WoNS topics

- Cook, T & Storrie, A, 2008, 'Tactics for the control and possible eradication of terrestrial alligator weed (*Alternanthera philoxeroides*)', *Proceedings of the 16th Australian Weeds Conference*, Cairns, Australia, Weed Society of Queensland, Brisbane, 469-471.
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Appendix 7: Declaration of the three aquatic weeds of national significance

Note A1: WoNS status of alligator weed (*Alternanthera philoxeroides*)

Alligator weed was first detected in 1946 near Newcastle, NSW. Native to South America, the weed was originally thought to have been brought to Australia in ships' ballast. Recent, preliminary results from genetic studies indicate that there have been at least three separate introductions into Australia. By 2000, alligator weed could be found in all Australian states.

Alligator weed displaces other more favourable plants and can be harmful to animals. In fresh water the weed can cover the entire surface; preventing flow, blocking drainage channels and potentially increasing flood damage. Efforts to control the weed from the 1950s to 2000 were sporadic and, with a few exceptions, unsuccessful.

Although some biological agents are known to attack alligator weed, none are effective at controlling it, especially in controlling the terrestrial form of the weed and infestations outside of warm temperate and sub tropical areas.

The Australian Commonwealth, states and mainland territories governments agreed that alligator weed should be declared a Weed of National Significance (WoNS) because of its impacts, its invasiveness, its capacity to spread and regenerate from single plant fragments, and its ability to tolerate a range of control treatments, including herbicides. Table A1.1 in Appendix 1 shows the capacity of alligator weed to spread quickly from place to place.

It is now prohibited to import, trade or cultivate the plant, and efforts must be made to control infestations and, if possible, to eradicate them.

Note A2: WoNS status of cabomba (*Cabomba caroliniana*)

Cabomba is native to southern Brazil, Paraguay, Uruguay, and north-east Argentina. It has become a problem weed in many countries, including the USA, Malaysia, India, Japan, China and New Guinea.

Cabomba was probably first brought to Australia for the aquarium trade via the USA (Mackey, 2006) then dispersed by 'seeding' of waterways, both deliberately to ensure a wild supply and accidentally (Cabomba Strategy, 2000). Recent studies have shown that the Australian variety is a hybrid between cabomba species found in south eastern USA and South America. The studies also show that there have been at least three separate introductions into Australia.

Cabomba forms dense underwater thickets that adversely affect the biodiversity and functioning of aquatic ecosystems, water quality, water storage facilities, and recreation and amenity values. Cabomba spreads by fragments and there is some evidence that it may also spread by seed. There are no biological controls for cabomba and no effective herbicides.

In April 2000, following a report on the status of cabomba and its declaration by the Australian Commonwealth, states and mainland territories governments as a weed of national significance (WoNS), 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.

Note A3: Status of Salvinia (*Salvinia molesta*)

Salvinia is a weed of national significance (WoNS) because of its severe impacts in freshwater ecosystems. It was first noticed growing in a water body near Luddenham (Sydney) in 1952. After that records show infestations occurring in almost every state in Australia. Table A1.3 in Appendix 1 provides information on some of the infestations.

In some places, the weed was controlled and even successfully eradicated, but such success stories were the exception rather than the rule. In most water bodies where salvinia had taken hold, the weed quickly overpowered control efforts.

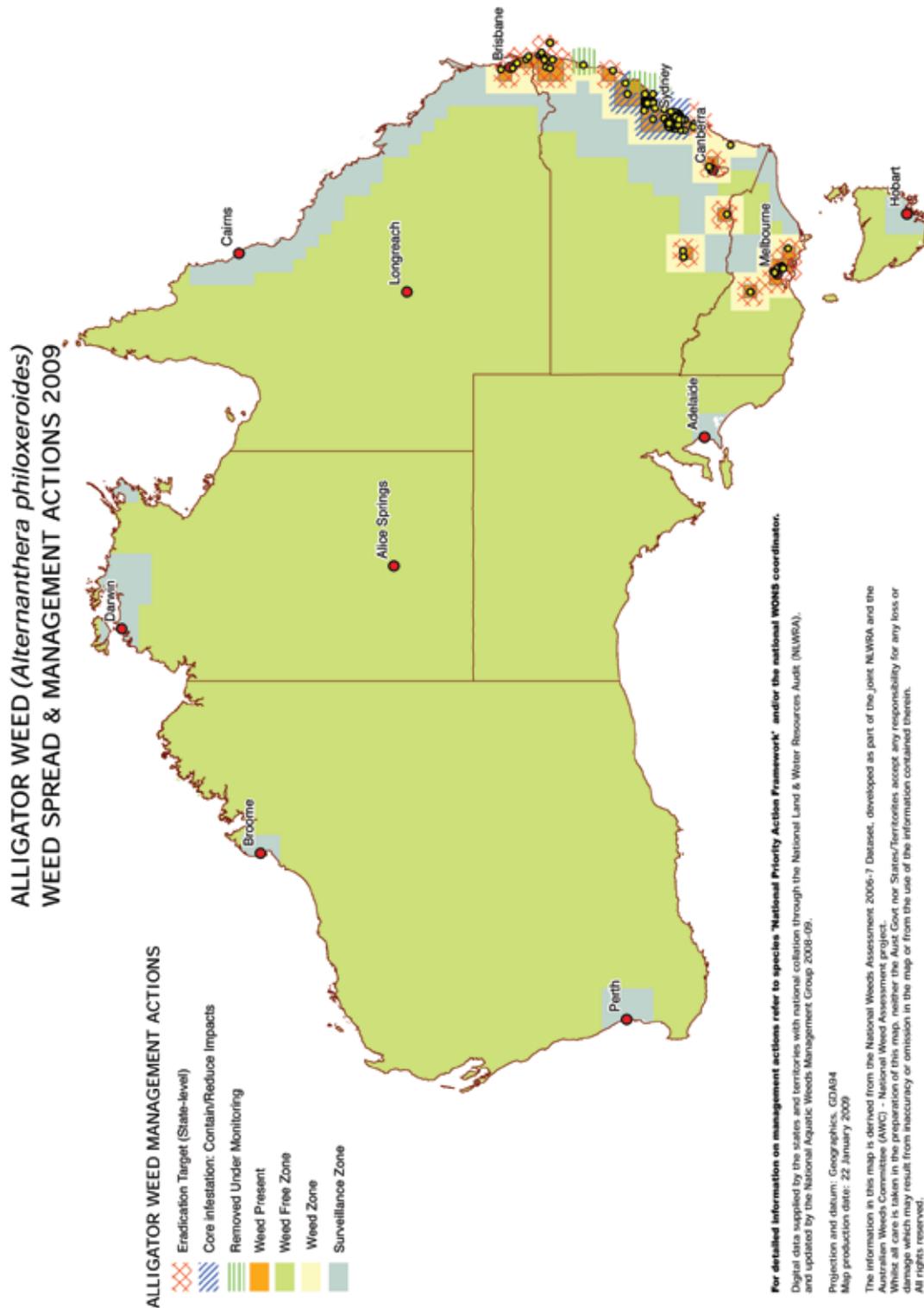
Three biological control agents were released by CSIRO: a moth (*Samea multiplicalis*) and a grasshopper (*Paulinia acuminata*), and the salvinia weevil (*Cyrtobagous salviniae*). Only the salvinia weevil provided significant control.

Unfortunately, the weevil seemed apparently less successful in areas where water temperatures fluctuated beyond the weevil's functional level (above 30 °C or below 13 °C). Infestations in significant areas such Kakadu National Park and the central and south coast of NSW became increasingly uncontrollable.

Development of the Salvinia Strategy was a direct recognition of the urgent need to implement a more coordinated effort to manage salvinia and reduce its impacts.

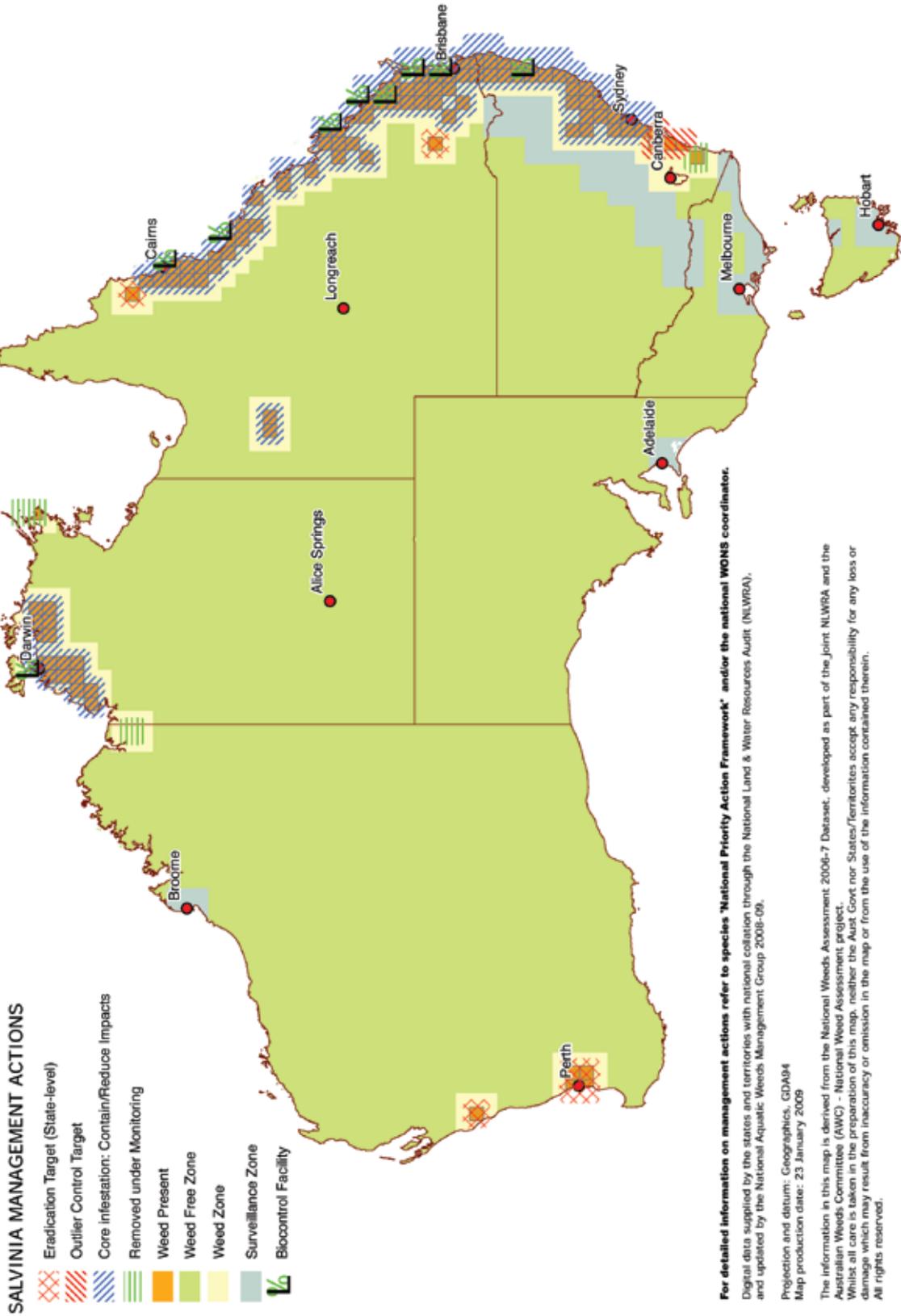
Appendix 8: Distribution of aquatic weeds in Australia

Map A1



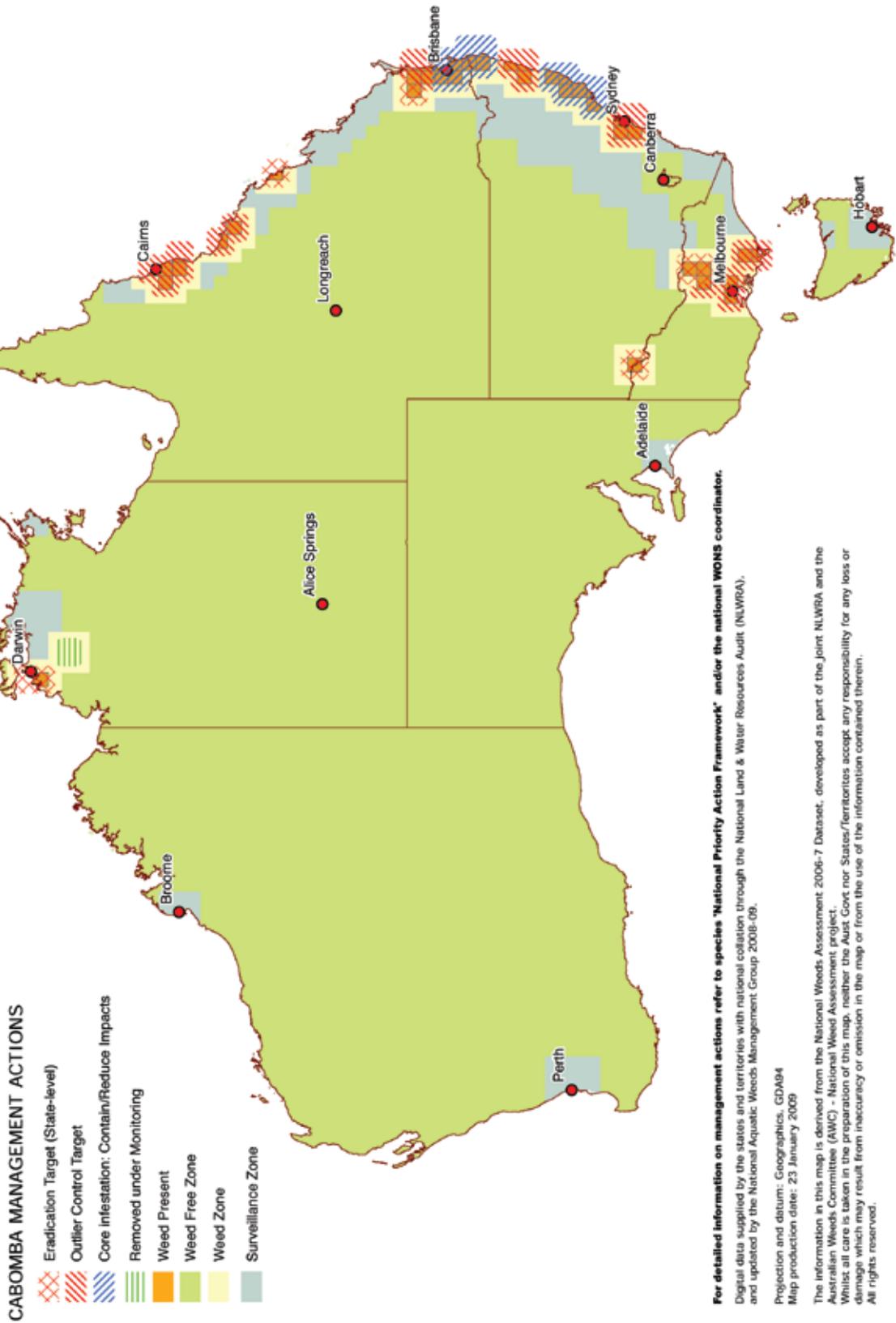
Map A2

**SALVINIA (*Salvinia molesta*)
WEED SPREAD & MANAGEMENT ACTIONS 2009**



Map A3

**CABOMBA (*Cabomba caroliniana*)
WEED SPREAD & MANAGEMENT ACTIONS 2009**





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