

WEEDS OF NATIONAL SIGNIFICANCE

SALVINIA

(Salvinia molesta)

Strategic Plan

ISBN 1 876977 17 5

This work is copyright. Apart from any use as permitted under the *Copyright Act 1968*, no part may be reproduced by any process without prior written permission from the National Weeds Strategy Executive Committee. Requests and inquiries concerning reproduction and rights should be addressed to the Project Manager, National Weeds Strategy Executive Committee.

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

This strategy was developed under the leadership of Agriculture Western Australia with full cooperation of all the States, Territories and Commonwealth of Australia.

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

Published by: National Weeds Strategy Executive Committee, Launceston

For further information contact:

John R Thorp, Project Manager

For the National Weeds Strategy Executive Committee

16 Flowers Court LAUNCESTON Tas. 7250

Telephone: (03) 6344 9657 Mobile: 0419 323 400 Fax: (03) 6343 1877

Email: jthorp@jta.com.au Web: www.weeds.org.au

Publication date: September 2000

Copies available from:

Agriculture W A

3 Baron-Hay Court

SOUTH PERTH, WA 6151

Preferred way to cite this publication:

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

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

The editors have tried to make the information in this product as accurate as possible. However, they do not guarantee that the information is totally accurate or complete. Therefore, you should not rely solely on this information when making a commercial decision.

CONTENTS

EXECUTIVE SUMMARY	1
THE CHALLENGE	2
1 BACKGROUND	3
1.1 Biology of <i>Salvinia molesta</i>	3
1.2 Spread and distribution in Australia	5
1.3 Environmental, social and economic impacts	5
1.4 Management to date	6
1.5 Control options	7
1.6 Principles	8
1.7 Strategy Development and Implementation	8
1.8 Relevance to other strategies	9
2 STRATEGIC PLAN	11
2.1 Prevent and/or reduce the introduction and spread of <i>salvinia</i>	11
2.2 Upgrade efforts to prevent the trading of <i>salvinia</i>	12
2.3 Minimise the impacts of <i>salvinia</i>	13
2.4 Coordinate management	14
3 MONITORING AND EVALUATION	15
4 STAKEHOLDER ROLES AND RESPONSIBILITIES	16
5 ACRONYMS	18
6 REFERENCES	19
7 APPENDIX 1: NATIONAL OVERVIEW - SALVINIA IN AUSTRALIA.	20

EXECUTIVE SUMMARY

Salvinia (*Salvinia molesta*) is a weed of national significance (WONS) because of its severe impacts in freshwater ecosystems. It adversely affects the biodiversity and functioning of wetland and riparian ecosystems, water quality, water storage and distribution infrastructure, recreation and amenity values. It has often been described as one of the world's worst weeds (Holm et al. 1977).

It is a commonly grown free floating aquatic fern that wreaks havoc wherever it naturalises. Promoted by various well meaning groups and individuals, its spread around the world has been rapid, taking less than 60 years. Production losses combined with the control and management costs it has incurred reach a multi-billion dollar figure world wide.

The cost to Australia is many millions of dollars when control social and environmental losses are accounted for. The environmental costs will never be known but would be well in excess of the management costs in dollar terms. In 1999 salvinia was named one of the inaugural 20 Weeds of National Significance. This strategy is the first step in creating a nation wide focus to reduce the impact of salvinia in Australia.

Despite being banned throughout Australia salvinia is a popular aquarium and pond plant grown in all States and Territories. From these ponds and fish tanks it continually re-infests local waterways and is now considered naturalised along most of the east coast of Australia from Cairns to Jervis Bay.

The impacts of salvinia are many and varied but essentially it reduces aquatic biodiversity by removing light from the water body killing all submerged plants and eventually their associated fauna. Hence fishing both commercial and recreational suffers dramatically with salvinia blocking nets and impeding the passage of boats.

The four main outcomes of this strategy are:

1 The rate of new salvinia infestations declines.

- Maintain natural characteristics of waterways

- Conduct regular monitoring of waterways for salvinia
- Change community attitudes and actions on salvinia
- Prevent importation of all *Salvinia* spp.
- Improve industry cooperation
- Improve cooperation from non-industry groups ie clubs, associations, societies
- Minimise potential for further spread

2 Nationwide ban on the trade in salvinia, and other aquatic WONS, to become widely recognised and accepted.

- Provide uniform regulations on trade of salvinia across Australia
- Enforce trade regulations
- Develop accreditation of exotic aquatic plant propagators
- Provision of alternative pond and aquarium plants

3 The impacts of existing infestations are removed or minimised.

- Strategic control of all infestations
- Improve the community's understanding of the ecology, biology and impacts of salvinia
- Implement biological control
- Investigate new potential control options
- Change community attitudes and actions on control

4 Commitment to coordination of the strategy exists at all levels.

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

Monitoring and evaluation of the strategy will be undertaken by a proposed Aquatic Weed Management group and will be reviewed after five years.

The vision for management of salvinia is:

To maintain the health of our waterways by limiting the impact and restricting the spread of salvinia.

THE CHALLENGE

Consumer demand for salvinia is being met through illegal operations despite Australia wide legislation.

Salvinia can be purchased through weekend markets, nurseries, pet shops and landscapers, with supplies coming from both growers and wild harvesters. It is very commonly traded amongst home gardeners, permaculturists and pond owners.

We need to raise community understanding about the dangers of salvinia in order to minimise further introduction and spread.

Land managers need to consider any activities that may impact on surrounding aquatic habitats.

Environmental impacts such as increased runoff, sedimentation and leaching of fertilisers can dramatically increase the establishment and spread of aquatic weed species.

There is a need to develop a set of catchment management protocols to minimise impacts in aquatic ecosystems.

Salvinia is widespread throughout Australia.

While not considered naturalised in several states, salvinia is present in all and new infestations are continually being found. Community surveillance programs such as Tasmania's Weed Alert and Western Australia's Weed Action Groups should be encouraged.

More effective surveillance and awareness operations need to be implemented. These would include community groups and local government.

Control of salvinia in southern Australia is difficult especially in high value wetlands which may contain endangered species.

While integrated use of biological control and herbicides is successfully used in northern Australia, there are fewer effective options in riverine and wetland habitats further south. Most efforts, therefore, involve methods that are time consuming, intensive and expensive.

Research into cheap and effective control methods for free floating aquatics is a high priority.

1 BACKGROUND

Salvinia (*Salvinia molesta*) is a weed of national significance (WONS) because of its severe impacts in freshwater ecosystems. It adversely affects the biodiversity and functioning of wetland and riparian ecosystems, water quality, water storage and distribution infrastructure, recreation and amenity values. It has often been described as one of the world's worst weeds (Holm et al. 1977).

Salvinia natans and *Salvinia cucullata* are closely related species that have also become weedy overseas.

1.1 Biology of *Salvinia molesta*

Salvinia molesta DS Mitchell was referred to as *Salvinia auriculata* Aubl. prior to its recognition as a separate species (Mitchell 1972). The biology of salvinia was most recently and comprehensively reviewed by Room & Julien (1995).

Salvinia molesta (salvinia) is a free-floating, sterile aquatic fern that reproduces by vegetative growth and fragmentation. Under normal conditions up to three lateral buds may develop on each node. However, with stress, predation and destruction of the apical buds, up to six buds may grow in compensation.

Salvinia typically passes through three vegetative growth forms starting with the primary juvenile or invasive form, followed by the secondary then tertiary forms (Fig. 1).

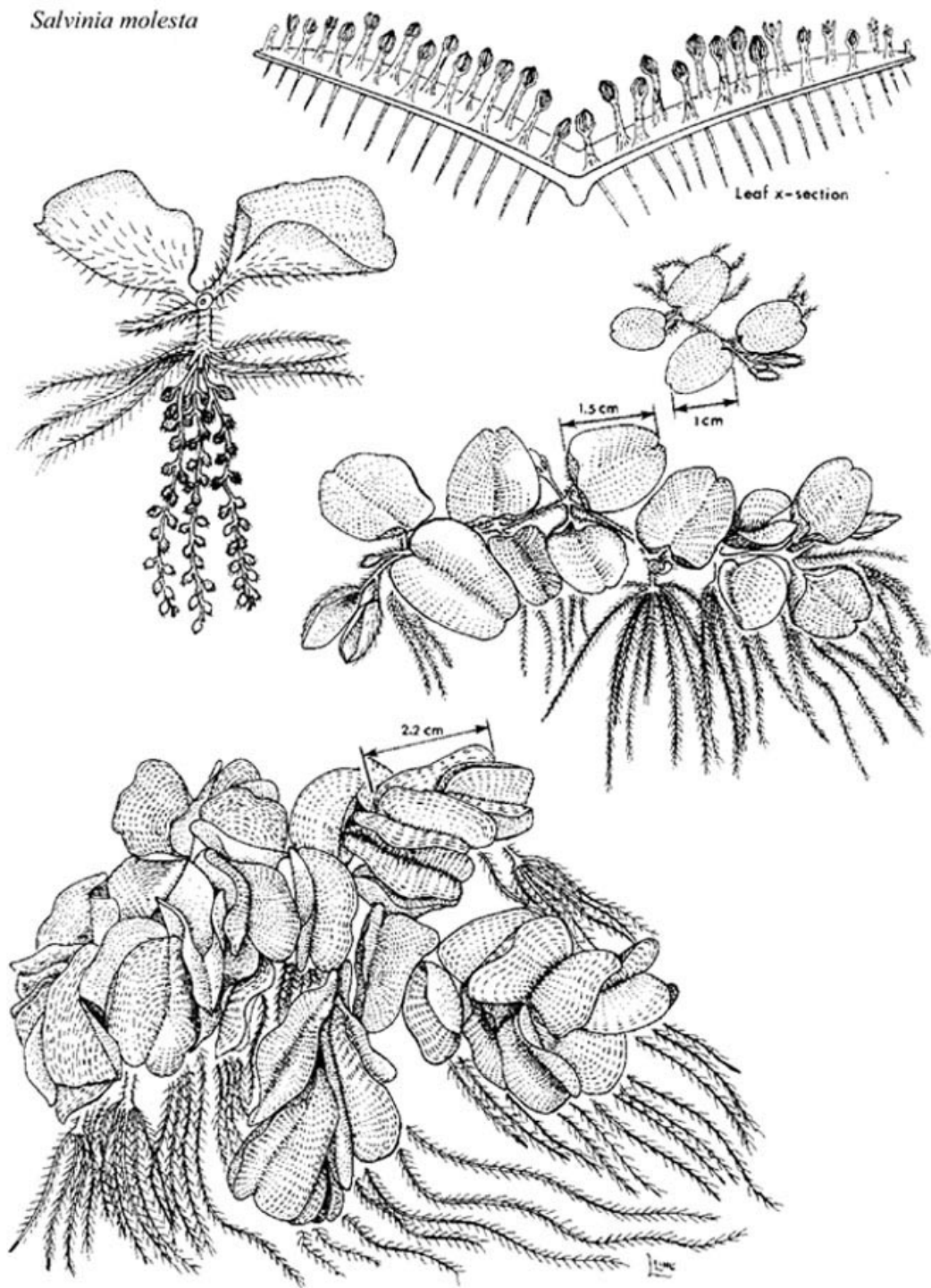
As growth progresses through each phase the leaves become larger, begin to fold upwards and the plants become more compact. While the primary phase is easily distinguished from the tertiary there are many factors that can affect the development of salvinia. In a rapidly expanding population it is quite easy to find all three forms present. Spore sacs develop amongst the roots of tertiary growth form plants (Fig. 1) but fertile spores have not been found (Room & Julien, 1995).

Under ideal growth conditions salvinia can achieve extraordinary growth rates, doubling its biomass in as little as two days (Parsons & Cuthbertson, 1992) and produce as much as 400 tonnes per hectare of fresh weight (Room & Julien, 1995).

Growth rates are significantly affected by nutrient availability, especially nitrogen. Even under low nutrient situations, densities of 2,500 large plants m^{-2} have been documented. In nutrient rich waters, densities of small plants can exceed 30 000 m^{-2} (Room & Julien, 1995).

Flotation and water repellency are facilitated by small 'egg-beater' shaped hairs on the upper surface of the leaves. These hairs are very effective air traps and maintain the correct orientation of the plant under most weather conditions.

Optimum growth occurs in water temperatures from 20-30°C. Plants are killed by constant temperatures that exceed 43°C or drop below -3°C for any extended period of time. However, salvinia survived when leaf temperatures exceeded 45°C, and water temperatures did not exceed 43°C in Kakadu National Park (Storrs & Julien, 1995). Salvinia can tolerate a low level of salinity and will grow in water that is one tenth as saline as seawater. This extreme tolerance allows salvinia to colonise almost any perennial water body it is introduced to within the temperate, subtropical and tropical regions of the world.



Copyright 2000 University of Florida
Center for Aquatic and Invasive Plants

Figure. 1. *Salvinia molesta*, (illustration by Line). Top to bottom (L-R) : Cross section of a leaf showing the flotation hairs, a single ramet with spore sacs, two connected ramets with long internodes (primary phase), a larger cluster of ramets (secondary phase), a tertiary phase phenet (With the permission of the University of Florida)

1.2 Spread and distribution in Australia

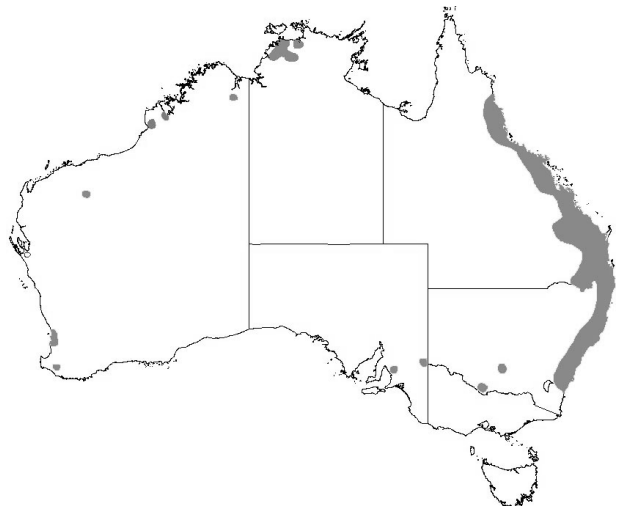
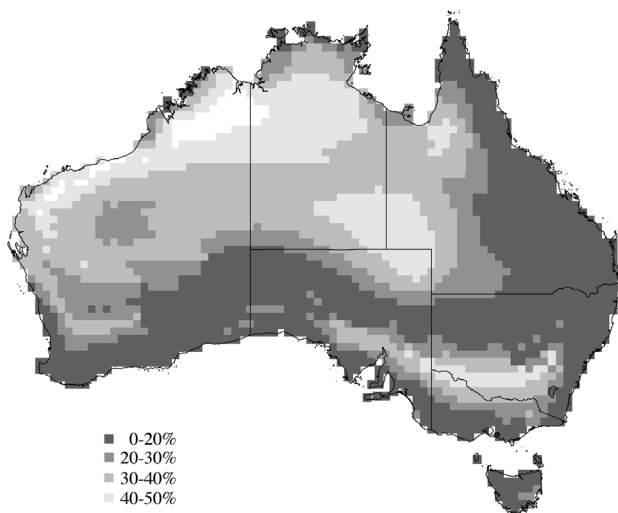
Salvinia molesta is the only naturalized species of the Family *Salviniaceae* in Australia. Its native distribution is described variously as "tropical Central America to southern Brazil". Forno and Harley (1979) determine its native range as southeastern Brazil.

Introduced to Australia in the early 1950s, most likely via the aquarium trade, salvinia soon established in dams, rivers and swamps around the country. The capacity of salvinia to invade new catchments is directly linked to human activities, and this is exacerbated by its ongoing popularity amongst pond and aquarium owners. Its floating habit and capacity for rapid increase has led to it escaping during floods or being discarded and resulting in new infestations. Naturalized salvinia is now found in all major capital cities and adjacent freshwater ecosystems around Australia, and most of the east coast. Incursions into natural habitats are almost certainly due to the cultivation of salvinia in

aquariums and backyard ponds, and this will continue to be the major source of infestations in the more densely populated States and Territories.

The potential distribution of salvinia has been determined using 'CLIMATE', a predictive model based on the temperature tolerances found in salvinia's native and introduced ranges. This prediction suggests that all States and Territories have favorable climatic conditions for salvinia with excellent habitat conditions provided across southern and eastern Australia (Fig. 2a).

The potential distribution of salvinia will therefore include any freshwater body within the two highest matching zones (\pm 0-30% of the ideal temperature conditions). It is within these two zones that salvinia would be expected to grow well and cause major problems. Outside these regions, salvinia could grow in protected micro-climates and potentially re-infest habitats further downstream.



Figures 2. a). Potential distribution of *Salvinia molesta* in Australia (\pm percent ideal temp °C) and **b).** Current distribution in Australia.

1.3 Environmental, social and economic impacts

Public safety and health

Salvinia is known to encourage breeding of disease carrying pests by providing a perfect habitat for larval development; these include mosquito vectors of malaria in Papua New Guinea and Ross River virus and encephalitis in Australia (Anon, 1997). The development of thick floating mats can provide a dangerous platform for children and animals. Animals frequently mistake the dense carpets

of salvinia for firm ground and fall into the water body underneath.

Amenity

Salvinia disrupts use of waterways for recreation, boating, fishing and swimming. It reduces the aesthetic value of water bodies by an accumulation of litter, water stagnation and development of fetid odours. Increased numbers of mosquitoes and midges, aside from any public health issue, can severely reduce visitor numbers and length of stay at aquatic venues.

Recreation activities

Heavy infestations prevent access by boats and recreational fishing is impeded. Swimming is dangerous if not impossible in dense infestations.

Water quality

Salvinia degrades water quality through decomposing plant material and dramatically increases water loss through transpiration. This leads to a reduction in water oxygen levels and consequent fish deaths.

Water storage and distribution infrastructure

Blocking of irrigation channels and pump intakes can increase pumping times and costs, and can lead to expensive repairs or significantly reduced maintenance intervals.

Environmental costs

Salvinia modifies the environment by shading out submerged aquatic plants and lowering oxygen levels causing animal deaths. Dense infestations could eventually kill most vascular plant life normally found below water level and much aquatic fauna will either die out, or move to better conditions if possible.

This loss of aquatic biodiversity has been documented in Kakadu where bird species that used open water were excluded from heavily infested billabongs and small fish and file snake numbers were reduced (Storrs & Julien, 1995). Salvinia has negatively impacted on one RAMSAR wetland and nine nature reserves in Queensland.

Direct costs of control and management activities

Some Queensland local government authorities keep breeding tanks of the leaf eating weevil called *Cyrtobagous salviniae* (introduced by CSIRO) to assist in dealing with salvinia infestations in their region.

Brisbane City Council (BCC) and Redlands Shire Council maintain pools for production of *Cyrtobagous salviniae*. BCC has sent weevils to a number of councils across the state but will only send insects to landholders on receipt of a sample to confirm that the weed is salvinia. The Far North Coast County Council (NSW) has three collection sites and also supplies agents to councils in its state.

In northern NSW it is estimated *Cyrtobagous* weevils have saved in excess of \$100,000 a year in chemical and mechanical control costs. This figure may increase in future as the weevils continue to acclimatise and their use increases. Chemical and mechanical costs incurred Councils, government agencies and private landowner control programs are likely to be in excess of \$250,000 per annum.

1.4 Management to date

Research

Very effective biological control methodologies have been developed for salvinia. These have dramatically reduced the impact of this weed in tropical and sub tropical environments. However, in cooler southern areas *Cyrtobagous salviniae* is less effective due to lower temperatures.

For a detailed salvinia management plan see: "***A handbook for the integrated Control of Salvinia molesta in Kakadu National Park***" Storrs, M.J. & Julien, M.H. Northern Landscapes Occasional Papers, Paper N° 1, 1996

In these cooler regions further research is needed to develop integrated strategies including an assessment of the contribution of biological control, particularly in areas where herbicides are either environmentally or socially unacceptable. In addition, better techniques and equipment should be developed for manual removal to be used in integrated strategies and where neither chemical nor biological techniques are effective or appropriate.

Extension and Education

This is the area where most effort needs to be extended by government and industry.

Legislation

The legal status of salvinia is summarised in Table 1. The importation of all species of the genus *Salvinia* is prohibited under commonwealth quarantine legislation on the basis of their weed risk assessment.

State	Declaration Status of <i>Salvinia molesta</i>
ACT	Pest Plant, Class C , under the Land (Planning And Environment) Act 1991 Declaration Of Pest Plants, Declaration No. 1 Of 1999.
New South Wales	W1-Notifiable weed: The presence of this species must be notified to the local control authority in parts of NSW and the weed must be fully and continuously suppressed and destroyed throughout the state
Northern Territory	NT Noxious Weeds Act Class A,B,C Noxious Weed - to be eradicated - growth and spread to be controlled - not to be introduced to the Territory & the Northern Territory Parks and Wildlife Act, 2000 salvinia is a "prohibited entrant" that cannot be imported.
Queensland	Plants that are to be DESTROYED throughout the State or relevant parts thereof or plants whose numbers and/or distribution are to be REDUCED throughout the State or the relevant parts thereof. Sale is also Prohibited.
South Australia	Proclaimed plant: To be destroyed throughout the State. Sale and transport prohibited. Notifiable throughout the State.
Tasmania	Declared weed under the Weed Management Act 1999.
Victoria	State Prohibited Weeds: (Do not occur in Victoria, or is reasonable to expect that they can be eradicated from the state)
Western Australia	Category P1 and P2 Declared Plant: - prohibited from sale, trade or movement throughout the state and to be eradicated where found.

Table 1. Legal status of salvinia in Australia.

1.5 Control options

Reference should be made to any state-based river corridor management policies, guidelines and legislation.

Biological control

Effective biological control was achieved in warm temperate, subtropical and tropical Australia with the release of the weevil *Cyrtobagous salviniae* in 1981. Throughout the world where this weevil has been released the impact of salvinia has been significantly reduced. For example in Papua New Guinea, where the impacts of salvinia were catastrophic, salvinia is now only occasionally a localised problem. Julien & Griffiths (1998) cite twelve countries where excellent control has occurred. Good control has been achieved in cool locations near Sydney, NSW, but not in other sites in the region. The limiting factors and appropriate release strategies have not yet been determined. In mid to southern NSW, salvinia control is enhanced by the use of *Cyrtobagous* in inundative releases at critical times of the year.

Physical control

Mechanical or manual removal of salvinia is only appropriate if it is part of a continual

campaign of removal or follow up treatments. Regrowth from tiny fragments left behind is rapid and, with no follow up work salvinia can rapidly re-establish to pre-treatment populations. Physical removal of salvinia is usually carried out to alleviate water blockage, rather than as part of a long term control program.

Habitat modification

In man-made lakes and canals modification of banks and removal of edging vegetation can facilitate easy removal of salvinia. This option is useful where re-infestation occurs and the use of herbicides is unacceptable.

In cases where the water level of the infested area can be manipulated, such as in ornamental lakes and ponds, the water can be drained and the ponds allowed to dry sufficiently to kill any remaining salvinia plants. This drawdown option can also be used in larger water bodies, such as dams, where the salvinia plants are stranded on the shore line and allowed to dry out. Drawdown, however, is not likely to be a preferred option due to the amount of water that can potentially be wasted.

Chemical Control

Herbicide usage around and within any waterbody in Australia is strictly regulated. For all registered herbicides in Australia that can legally be used for *Salvinia molesta* control, the National Registration Authority's online database PUBCRIS should be consulted.

URL: www.affa.gov.au/nra/pubcris.html

A key part of the NRA registration process is the setting of label directions, which provide information to the user on how the pesticide can be used to effectively treat the weed or pest while avoiding possible health, environmental and trade impacts.

Any State-based guidelines for the use of herbicides in or near waters should be referred to; chemical use in or near waters should be managed appropriately by following the labels of registered chemical products and consulting relevant agencies on any legislative requirements such as: the need for a water licence; the need to notify water users of a proposed application; the need to notify the relevant authority if there is a pollution incident; or any other requirements, such as training and record keeping for chemical use near waters.

Substitutes for salvinia

There are several aquatic species that can be used in place of salvinia in ponds and aquaria. None reaches the same size or causes quite the same problems in ponds, but all provide an attractive surface covering.

Species already used in Australia include *Lemna* spp., *Spirodela* spp., *Azolla filiculoides*, *Azolla pinnata*, and a native liverwort, *Ricciocarpus natans*.

Though these plants are considered 'safe', it must be stressed in any extension or education material that pond and/or aquarium plants and fish must never be dumped in or near any waterway.

Pond, aquarium and nursery plant trade

The aquarium industry could benefit from actively promoting the use of safe alternative floating aquatic species, such as native *Azolla* species, that are similar in appearance and use to salvinia. The thrust of the sales pitch would be on environmental grounds and

could elevate the industry profile at the same time.

THE STRATEGY

To ensure that weeds of national significance are effectively managed the National Weeds Strategy outlines the need for the development, implementation and evaluation of a management program for each species.

1.6 Principles

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

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

1.7 Strategy Development and Implementation

Work began on the salvinia strategy in late July 2000, with a first draft distributed and commented on by a small weeds research and policy group in late September. A later release was sent to a much larger group of correspondents in early December 2000 and their comments and suggestions were incorporated over December and into January 2001. A teleconference was held at the end of January to work through this last draft before submission to the WONS executive.

1.8 Relevance to other strategies

The National Strategy for Salvinia Management has been established to provide a framework for coordinated management of salvinia across the country. There should be an Australia wide coordinated approach for all aquatic WONS as these plants are so often sold, utilised and distributed by the same people. A combined targeting of aquatic WONS species will provide a greater impact across Australia.

Scope Scale	Natural Resource Management	Weed Management	Weed Species Management
National	National Strategy for Conservation of Biodiversity; National Strategy for NRM; National Strategy for Ecological Sustainable Development	National Weeds Strategy	National Strategy for salvinia Management
State		Various State/Territory weed management plans NT Weeds Management Strategy 1996-2005, NSW Weeds Strategy etc	
Regional	Regional NRM Plans	Regional Pest Management Strategies	Various NSW regional salvinia management plans
Catchment	Catchment Management Strategies	ICM Pest Management Strategies	Kakadu integrated management strategy for salvinia (Storrs & Julien)
Local	Landcare, conservation corridor & riparian vegetation management plans	Local government and community groups	Moruya Y-Swamp salvinia management plan
Property	Property Management Plans	Private property, National Parks, government & Crown land and private landowners National Park Weed Management Strategies (NT).	

Table 2. Policy and strategy linkages

2 STRATEGIC PLAN

VISION

To maintain the health of our waterways by limiting the impact and restricting the spread of salvinia.

2.1 Prevent and/or reduce the introduction and spread of salvinia

Desired outcome

The rate of new salvinia infestations declines.

Background

Prevention is the most effective way to manage any weed problem. Quarantine represents the first line of defence against incursions of weeds. Reports of continued importation need to be followed up. One of the most effective ways to prevent further distribution is through education. An informed community will have an understanding of the importance of catchments, freshwater ecology and the impacts of aquatic weeds, as well as the specific problems and nature of salvinia.

Understanding why weeds are able to invade, or what processes promote weed invasions is also important to catchment management and a wide range of natural resource issues.

The retail supply of salvinia (section 3.2) is driven by market demand. Eliminating demand is a major objective for this strategy as enforcement will only be useful as a last line of action.

Apart from deliberate releases, it is assumed that numerous recreational activities also lead to proliferation and transfer of plant fragments to other areas. Local agencies need the ability to be able to close waterways to prevent spread, and also to reduce their liability should drownings or other accidents happen in dense infestations.

Strategy	Action	Responsibility	Priority
2.1.1 Maintain natural characteristics of waterways	Ensure management programs are put in place for waterways Identify and reduce sources of nutrient inflow. Maintain or replace riparian vegetation.	Commonwealth & State Agencies Local Councils Community groups	1
2.1.2 Conduct regular monitoring of waterways for salvinia	Undertake prioritised reconnaissance surveys. Identify potential sources or areas of salvinia. Develop protocols for detection. Link with other programs such as Streamwatch, Waterwatch, Ribbons of Blue and catchment management organisations.	State Agencies Local Councils Community groups	1
2.1.3 Change community attitudes and actions on salvinia	Develop a multi-media education and extension campaign and target all stakeholder groups. Develop and distribute robust extension and education material on the: <ul style="list-style-type: none"> • identification and impacts of salvinia • community actions that can be taken • regulations, penalties and enforcement • alternative pond and aquarium plants • freshwater ecology information extension 	National Coordinator State Agencies such as: AGWEST, QDNR, NTFPIF etc.	3
2.1.4 Prevent importation of all <i>Salvinia</i> spp.	Maintain AQIS quarantine provisions. Improve AQIS inspectors ability to identify <i>Salvinia molesta</i> and other <i>Salvinia</i> spp. Routinely check for correct labelling of imports	AQIS, Aquarium Trade Assoc., nurseries, landscapers	2
2.1.5 Improve industry cooperation	Adoption of self-regulation by the aquarium plant industry (refer 2.2) and maintain the recognition of the legal status of many aquatic species still sold within the trade.	PIJAC, Aquarium Trade Assoc., NIAA, Landscape Industry Assoc.	2
2.1.6 Improve cooperation from non-industry groups ie clubs, associations, societies	Target specialist groups with the above mentioned extension and education materials; for example In Western Australia an aquatic weed brochure was sent out as a centrefold in the WA Trout and Freshwater monthly newsletter.	State and Local Government, Community groups.	3
2.1.7 Minimise potential for further spread	Use quarantine protocols to manage activities, access and use of waterways containing infestations.	ICMC, local govt	2

Table 2.1 Strategies to prevent and/or reduce the introduction and spread of salvinia

2.2 Upgrade efforts to prevent the trading of salvinia

Desired outcome

Nationwide ban on the trade in salvinia, and other aquatic WONS, to become widely recognised and accepted.

Background

The aquarium plant industry supports the development of uniform legislation, the licensing and accreditation of growers (similar

to that used for aquarium fish) and the establishment of a list of species that can be traded (similar to that used by Western Australia). This could provide benefits to other aquatic WONS and ensure that retailers only purchase supplies from regulated traders.

Other industries, such as landscaping and nurseries, should be included in this process.

Strategy	Action	Responsibility	Priority
2.2.1 Provide uniform regulations on trade of salvinia across Australia	Investigate effectiveness of domestic and international legislation covering salvinia. Introduce uniform regulations preventing trade and distribution of salvinia. Develop consultation processes with industry and community. Provide penalties consistent with other flora/fauna regulation.	SCARM, States/Territories	2
2.2.2 Enforce trade regulations	Advise of the new regulations and the responsibilities. Provide adequate enforcement resources. Involve all relevant industries in self-regulation. Regularly audit retailers and wholesalers. Pro-active inspection of retail outlets Provide consistent legal training to enforcement agencies.	State Depts of Agriculture and Environment, Industry, Local Councils and other State agencies	1
2.2.3 Develop accreditation of exotic aquatic plant propagators	Provide support to the nursery and aquarium trade to assist the development of a voluntary aquatic plant accreditation scheme and codes of conduct.	Industry, State Depts of Agriculture and Environment.	2
2.2.4 Provision of alternative pond and aquarium plants	Develop an appropriate process for selecting alternative species through collaboration. Develop a list of appropriate alternative, non-weedy plants that can be traded. Encourage the use of native or other non-invasive naturalised aquatic species.	All State Depts Agriculture, DNR, DNRE, EPA, NIA, PIJAC & Aquarium plant trade associations.	3

Table 2.2 Strategies to upgrade efforts to prevent the trading of salvinia

2.3 Minimise the impacts of salvinia

Desired outcome

The impacts of existing infestations are removed or minimised.

Background

To minimise the impacts of salvinia there must be a reduction in the level of infestations. At this stage this is difficult to achieve because there are limited control methods available, and those that are available are sometimes perceived as having too great a risk. Some of the methods available have received negative publicity or generate public concern.

Effective weed control is based on an understanding of the ecology and biology of the weed and relies on an intervention

attacking at a weak or vulnerable point in the life cycle. There is considerable interest and support for biological control in Australia and the successful work conducted here on salvinia should be capitalized on at all opportunities.

Integrated biocontrol is most effective in Queensland, Northern Territory and parts of northern New South Wales. Further south inundative release of *Cyrtobagous salviniae* is seasonally effective and local stakeholders are ideally located to assist in the process of using such control strategies.

Other options for integrated management and further development of physical and chemical methods should also be explored.

Strategy	Action	Responsibility	Priority
2.3.1 Strategic control of all infestations	Develop best management plans with stakeholder participation and community based management groups. Map the extent of infestations and priority areas. Prepare a risk analysis and prioritise actions to prevent further spread and reduce infestations (see 2.1.2)	CSIRO, State Agencies	1
2.3.2 Improve the community's understanding of the ecology, biology and impacts of salvinia	Disseminate this knowledge to the wider community through as many channels as possible. Implement aquatic weed training programs for community, recreational and industry groups	State Agencies, CSIRO, CRC for Weed Management Systems	1
2.3.3 Implement biological control	Release <i>Cyrtobagous salviniae</i> on infestations in as many suitable sites as possible.	Local government, community groups	1
2.3.4 Investigate new potential control options	<ul style="list-style-type: none"> • Trial new herbicide options and reassess current ones • Investigate biological control options for cooler climates • Investigate the further use of physical control options • Develop options for integrated control techniques 	State Agencies CSIRO, CRC for Weed Management Systems	2
2.3.5 Change community attitudes and actions on control	Identify community expectations of management. Promote realistic expectations of control practices.	Local government, community groups, catchment management groups	3

Table 2.3 Strategies to minimise the impacts of salvinia

2.4 Coordinate management

Desired outcome

Commitment to coordination of the strategy exists at all levels.

Background

Field experience with salvinia has highlighted the need for stakeholder involvement at all levels of decision-making and implementation. This approach enables a three-way flow of information between industry, government and community. The process achieves greater success through giving responsibility to those affected by the problem. Community-based natural resource management is not new and a similar

coordinated approach to salvinia could 'piggyback' on the successes of related programs such as integrated catchment management or Landcare.

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

Strategy	Action	Responsibility	Priority
2.4.1 National assessment of the distribution and impacts of salvinia	Form regional assessment groups reporting to a national database.	Management Group	2
2.4.2 Provide cooperative management frameworks	Develop and implement management plans in partnership with all stakeholders. Link management into existing national, regional and local schemes between community, school, council, government department and industry, eg ICM, Streamwatch, Waterwatch, Landcare, Murray-Darling Basin.	Commonwealth, State and Local Government	1
2.4.3 Manage implementation of the plan	Evaluate the concept of an <i>AQUATIC WONS</i> Management Group for the joint management of salvinia and other aquatic weeds.	Workshop Steering Group Representatives of the other species	2
	Form an appropriate Management Group to implement and monitor this plan.	Workshop Steering Group	2
2.4.4 Maximise the availability and use of resources	Obtain adequate resources to implement the strategy (for education, enforcement, control and management).	All stakeholders	1

Table 2.4 Strategies for coordination of management

3 MONITORING AND EVALUATION

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

Monitoring will include a review of actions outlined and undertaken in:

- State weed management strategies;
- Catchment management plans;
- Local government pest management plans;
- Project plans developed from this strategy; and,
- State of the Environment reporting processes.
- Delivery of extension material specific to target groups and regions;
- The impacts of salvinia are communicated to the public;
- Management plans for all infestations;
- Linkages developed to other NRM plans through salvinia actions;
- Best practice management developed and packaged for use;

Performance indicators for the plan include:

- Increased detection of salvinia imports;
- National restrictions on trade in salvinia;
- Code of conduct developed by industries involved in plant sales;
- Industry accreditation developed by aquatic plant growers;
- Alternative species available for the industry;
- Biological control program improved and extended;
- National Weeds Strategy internet homepage developed as a national salvinia database;
- Timely and adequate resources for actions; and,
- Annual reports produced by the Management Group.

4 STAKEHOLDER ROLES AND RESPONSIBILITIES

Private Landholders

Prevent the introduction of salvinia onto their property:

- Do not stock salvinia in garden ponds, aquaria, farm dams, irrigation systems or other waterways;
- Be aware of the potential of salvinia to be introduced into farm dams; and,
- Alert the appropriate agency if salvinia is found.

Manage infestations on their own land/water:

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

Prevent the establishment of salvinia in local water bodies:

- Reduce their contributions to nutrient loading from septic systems, livestock, garden run-off and urban development;
- Alert appropriate agency of pollution sources; and,
- Report dumping, wild planting, sales and/or harvesting of salvinia.

Recreational groups

- Ensure members are aware of salvinia and can identify it;
- Educate members on quarantine and weed hygiene protocols;
- Do not undertake recreational activities or actions that will spread salvinia;
- Practice weed hygiene on recreational equipment (boats, nets etc);
- Observe and be aware of personal safety; and,
- Help monitor water bodies and report infestations of salvinia.

Pond, Aquarium, Nursery and Landscape and associated Industries

- Ensure respective industries continue to improve their responsibility for weed management;
- Actively discourage the importation, promotion and/or trade of salvinia and other prohibited aquatic weeds;
- Amongst their members create awareness of the legislation regarding weeds, including salvinia;
- Assist to develop and promote non-weedy alternatives to salvinia, particularly native aquatic species; and

- Promote compliance with state legislation governing noxious weeds among industry members.

Weed Science Societies and Conservation groups, including StreamWatch, WaterWatch, Ribbons of Blue, Frog Watch and other similar programs...

- Improve identification skills of members;
- Promote awareness of salvinia impacts on freshwater ecosystems;
- Report dumping, wild planting and harvesting or any other activities that spread salvinia; and
- Use weeds as indicators of water health.

Enthusiast groups such as permaculture, fern societies...

- Remove salvinia and other prohibited aquatic species from cultivation
- Do not promote salvinia or other prohibited/declared/noxious harmful species

Landcare and Catchment Management Groups

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

Local, State and Territory Governments

- Continue to research and develop efficient, effective and appropriate control techniques;
- Provide extension and education services to urban and industry stakeholders;
- Support enforcement of legislation and control measures;
- Ensure that salvinia is identified in local, regional and State level pest management plans;
- Liaise with landholder, community and industry interest groups to coordinate management and control of salvinia;

- Research and develop best practice management;
- Monitor water pollution;
- Periodically inspect all water bodies for salvinia; and
- Promote reporting of salvinia infestations.

State and Territory Government Departments

- Develop awareness campaigns to discourage cultivation and/or promotion of salvinia;
- Eradicate infestations where feasible; and,
- Enforce complementary legislation to prevent sale and distribution of salvinia.

Federal government departments and corporations

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

5 ACRONYMS

AQIS	Australian Quarantine and Inspection Service
AGWEST	Agriculture Western Australia
APCC	Animal and Plant Control Commission, South Australia
BCC	Brisbane City Council
CLIMATE	Climate modeling system developed by AGWEST from Climex and AnuClim.
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DLWC	Department of Land and Water Conservation (NSW)
DNR	Dept of Natural Resources (QLD)
DNRE	Department of Natural Resources and Environment (Victoria)
DPIF	Northern Territory Department of Primary Industries and Fisheries
DUAP	Dept of Urban Affairs and Planning (NSW)
EPA	Environmental Protection Agency (QLD)
ICMC	Integrated Catchment Management Committee
NIA	Nursery Industry Association
NRA	National Registration Authority
NRM	National Resource Management
NWSEC	National Weeds Strategy Executive Committee
PIJAC	Pet Industry Joint Advisory Committee
SCARM	Standing Committee on Agriculture and Resource Management
WONS	Weeds of National Significance

6 REFERENCES

- Forno, I.W. and Harley, K.L.S. (1979). The occurrence of *Salvinia molesta* in Brazil. *Aquatic Biology* 6, 186-7.
- Holm, L. G., Plucknett, D. L., Pancho, J. V. and Herberger, J. P. (1977). *The World's Worst Weeds*. University Press of Hawaii, Honolulu.
- Julien, M.H. and Griffiths, M.W. (1998). *Biological Control of Weeds. A world catalogue of agents and their target weeds*. Fourth Edition. ACIAR, Canberra.
- Parsons, W.T. and Cuthbertson, E.G. (1992). *Noxious Weeds of Australia*. Inkata Press, Melbourne & Sydney.
- PUBCRIS, (2000). National Registration Authority Agricultural and Veterinary Chemical Products Database. URL: <http://www.affa.gov.au/nra/pubcris.html>
- Room, P.M. and Julien, M.H. (1995) *Salvinia molesta* D.S. Mitchell. (in Groves, R.H., Shepherd, R.C.H. and Richardson, R.G. (Ed's) *The Biology of AUSTRALIAN WEEDS, Volume 1.*) R.G. and F.J. Richardson, Meredith Victoria.
- Storrs, M.J. and Julien, M.H. (1995). *Salvinia. A handbook for the integrated control of Salvinia molesta in Kakadu National Park*. Northern Landscapes Occasional Papers, N° 1. ANCA, Darwin.

7 APPENDIX 1: NATIONAL OVERVIEW - SALVINIA IN AUSTRALIA.

ACT

Salvinia has appeared in a number of ponds in the ACT and while most dies over winter some does survive in sheltered spots. The main source of salvinia is aquarium owners who quite happily grow it indoors. When the aquarium fills with salvinia they put it in their outside ponds or pass it on to friends. There is great potential for salvinia to spread from the ACT as there is a large transient population, eg Defence personnel who may be transferred to other areas of Australia where salvinia would be a problem.

NEW SOUTH WALES

Salvinia is common along the coast from Sydney north to the Queensland border. Here it is declared a W2 noxious weed. West of the Great dividing range and most areas south of Sydney, salvinia is rare, with only several small troublesome infestations on the south coast. In these areas salvinia is declared a W1 noxious weed.

Due to the difficulty of herbicide control (because of the issues of water contamination and effectiveness), more people are trying/experimenting with biological and physical control methods. Biological control produces reasonable results north from about Coffs Harbour; south of here results are less reliable. At the moment manual control in most situations is difficult, costly and needs continual follow-up work. Despite all efforts salvinia is still a common plant in the aquarium industry. It still can be found in nurseries and aquarium shops, particularly in the larger urban centres.

NORTHERN TERRITORY

Salvinia was first recorded in the Northern Territory in 1976. It currently infests eight creeks or river systems. It was eradicated from another five systems in the late 1970's and early 1980's. All existing infestations are under adequate control by *Cyrtobagous salviniae*. Monitoring of the *Cyrtobagous/Salvinia* system is being undertaken in Kakadu National Park by Parks Australia staff and at Mission Hole on the Daly River by Department of Primary Industry and Fisheries staff, with a view to integrating herbicide control with biological control if necessary.

QUEENSLAND

Salvinia extends from Cook Shire in the north to the south east of Queensland, with other infestations in the Mt Isa region. It is not yet found in all catchments; for instance, the Fitzroy and Lake Eyre Basins and the Bulloo and Northern Gulf Rivers are all free, however it has the potential to spread into all catchments and water bodies along the coast of Queensland and inland, where permanent water is found.

Priority for control in Queensland is in the Murray-Darling and Lake Eyre catchment since these areas currently contains only small infestations, which will expand considerably if left uncontrolled. Isolated infestations such as the Dawson River in Banana Shire should be controlled to prevent spread into salvinia free systems. Brisbane City Council keeps a population of salvinia in order to raise *Cyrtobagous salviniae* for the annual control of infestations. Some northern shires may also carry out dispersal of this agent, although most infestations are flushed into the sea by annual floods. Total eradication of salvinia from Queensland is not practical or economically feasible.

A strategic reduction in the plant's rate of spread and impact, however, is a realistic objective. Enforced control, using either chemical or physical removal, is required for isolated infestations up-stream from clean water bodies and for infestations in the Murray-Darling catchment. Biological control alone is not recommended for such infestations as it does not result in 100% control and may take time to suppress the population. Integrated control, incorporating biological control, can be used for contained infestations.

SOUTH AUSTRALIA

Salvinia is declared under the *Animal and Plant Control (Agricultural Protection and Other Purposes) Act, 1986* for destruction wherever found. It has never become naturalised in this State; there have been instances of plants dumped in the Torrens and other water bodies but these have not persisted. Salvinia is still grown in backyard pools and aquaria, but is confiscated whenever it comes to the attention of the APCC or local Board officers. The Act can also be used to prevent retailers selling or giving away salvinia.

TASMANIA

Salvinia auriculata and *S. molesta* are declared weeds under the Weed Management Act 1999. These plants are prohibited entry into Tasmania, and must not be sold or distributed in Tasmania. Salvinia has not been recorded wild in Tasmania. However, it has been grown as a cultivated plant.

VICTORIA

Salvinia is one of only 14 State Prohibited Weeds in Victoria. It is to be eradicated from the state if possible. Salvinia has been found as an ornamental in garden ponds in Melbourne and Ballarat.

WESTERN AUSTRALIA

Salvinia occurs sporadically throughout Western Australia and is declared P1, P2 (eradication) under the *Agriculture and Related Resources Protection Act 1976* for the whole state. Small infestations commonly occur throughout the Perth metropolitan area in swamps, ponds, lakes, streams and drains. Almost certainly all are the result of dumping from backyard ponds. In many cases these infestations are cleaned up by community groups or local government. Recently there have been significant finds in the Kimberley and Gascoyne in the north and some smaller finds south of Perth near Balingup and Bunbury.