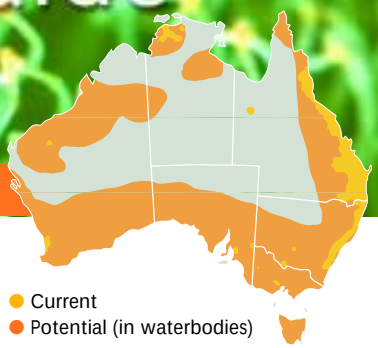
Weed Management Guide

Salvinia – *Salvinia molesta*



Salvinia (*Salvinia molesta*)

The problem

Salvinia is a *Weed of National Significance*. It is regarded as one of the worst weeds in Australia because of its invasiveness, potential for spread, and economic and environmental impacts.

Salvinia is an aquatic weed that can choke waterways. It floats on still or slow-moving water and can grow rapidly to cover the entire water surface with a thick mat of vegetation. This shades out any submerged plant life and impedes oxygen exchange, making the water unsuitable for fish and other animals. Salvinia infestations reduce the natural beauty and biodiversity of wetlands.

A salvinia infestation can reach up to 400 tonnes of wet weight per hectare. Infestations are a major obstacle to the enjoyment and use of water. They block irrigation, cause flooding, pollute drinking water, and prevent recreational activities such as swimming, fishing and boating. Infestations can be dangerous to animals and people because the mats look like solid ground, and they provide an ideal breeding environment for disease-carrying mosquitoes.

Salvinia forms dense mats that can cover entire waterbodies.
Photo: Colin G. Wilson

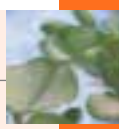
The weed

Salvinia is a free-floating fern that forms dense mats on water. It consists of many-branched horizontal stems, 1–2 mm in diameter, which float just below the water surface. At each node, or joint, on the stem is a pair of floating, green, oval-shaped hairy fronds. A brown frond, consisting of many hairy filaments, also occurs at each node and trails in the water, looking and acting like a root.

Salvinia changes as it matures and becomes more crowded. In low densities the primary invading plants have a few small floating fronds (10–15 mm wide) which lie flat on the water. However, in the dense infestations that cause mats, the many floating fronds are folded, up to 60 mm wide, overlapping and tightly packed together in a concertina-like fashion.

The surfaces of the floating fronds have numerous distinctive egg-beater-shaped hairs that repel water and assist floatation. This hair shape is characteristic of *Salvinia molesta*.

Key points



- Salvinia is a major aquatic weed threatening waterways around Australia.
- Infestations are widespread on the east coast of Australia but could spread elsewhere.
- Public education will help to prevent spread because infestations are caused by human activities.
- Because of salvinia's ability to rapidly spread from single plants, only small infestations are likely to be eradicated.
- In warm temperate, sub-tropical and tropical areas, biological control is very effective.
- Biological control can be integrated with chemical and physical control in cooler areas.

Natural Heritage Trust
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Growth calendar

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
New growth												
Active growth												
Spore formation	No viable spores yet found in Australia											
Spore drop												
Germination												

■ General growth pattern ■ Growth pattern under suitable conditions

Salvinia grows best when the water temperature is between 20 and 30°C; growth is limited or absent under 10°C. As salvinia is found throughout tropical, sub-tropical and temperate regions, these climatic conditions will occur at different times of the year. It grows faster when nutrients are abundant, often after rainfall has washed nutrients from the land into water bodies.

Salvinia is a fern and does not produce flowers. Although many ferns do produce spores, salvinia has never been known to produce spores in Australia and is considered to be a sterile clone.

Mature salvinia, showing the overlapping and deeply folded fronds.
Photo: Matthew Brown

How it spreads

Salvinia can increase its density by growth (stems can grow up to 300 mm long) or vegetative reproduction. It grows extremely quickly and infestations can double in size every two to three days. Uninfested areas can quickly become completely covered with salvinia, even when only small amounts are introduced to a waterway.

Reproduction occurs when mature plants produce buds at the stem node (the join between sections of the stem) which develop to form daughter plants. It may also occur if a part of the stem containing a node breaks away from the main plant and grows into a new plant. One pair of fronds can start an entire new infestation.

Salvinia spreads easily downstream during flooding, but moves into new catchments by human activities. It has been intentionally spread throughout the world as an ornamental pond or aquarium plant, and has escaped or been placed into waterways on numerous occasions. It can also be unintentionally introduced into new catchments attached to boats and other aquatic equipment.

Where it grows

Salvinia grows best in still or slow-moving fresh water. It can survive being frozen and water temperatures up to 43ºC, and salinities up to one-tenth that of sea water. Additionally, plants protected as part of dense mats can survive for many months if the water body dries up, particularly in shaded environments or on soils that hold water. Salvinia also thrives in nutrient-rich waters such as agriculture run-off or wastewater. These attributes allow it to colonise most water bodies.

Salvinia is a native of southeastern Brazil. It has become a serious weed throughout Africa, India, Sri Lanka, South-East Asia, the Philippines, Papua New Guinea, New Zealand, Fiji, Hawaii and mainland United States.

In Australia it was recorded as a weed near Sydney in 1952, and a year later near Brisbane. Since then it has infested most coastal streams from Cairns in northern Queensland to Moruya on the south coast of New South Wales. It has spread from backyards in all capital cities, and remote infestations affect the Top End of the Northern Territory and regions of Western Australia. There is a belief that many infestations have been deliberately spread in order to harvest the plants for sale in the aquarium and horticulture industries.

The submerged frond is feathery and acts like a root.
Photo: NSW Dept of Agriculture

Potential distribution

Based on its temperature tolerance, the potential distribution of salvinia includes waterbodies in every Australian state and territory. Although the climate would not be suitable for rapid growth, salvinia could probably survive in Tasmania and Victoria, which are currently free from major infestations.

Still or slow-moving waterways are threatened by salvinia: Finniss River, NT, in November.
Photo: Colin G. Wilson

What to do about it

Prevention of spread

Preventing the further spread of salvinia outside core infestations is a key management objective. It is far easier and cheaper to prevent the introduction of a weed than to try and control it, particularly something that is as difficult to eradicate as salvinia.

Preventing salvinia's spread will only be achieved by educating the public, as it is most commonly spread (either deliberately or accidentally) by people. Although it is illegal to import salvinia or to sell it in Australia, both of these activities occur. The sale or dumping of the weed should be reported to the authorities, and people who have unknowingly cultivated it should contact local councils or state/territory weed management agencies for information on how to properly dispose of salvinia. Burial is the quickest means of disposal. Drying in the sun and/or use as garden mulch is also suitable, providing there is no risk of accidental spread into a waterway.

Alternative species

In ornamental situations such as ponds and aquariums, use local native species instead of salvinia because they are unlikely to cause problems if they escape cultivation. However, in confined, nutrient-rich areas, these native species may also completely dominate the water surface of ponds, dams or wetlands. Check with your local council or weed management agency about alternatives to salvinia.

Controlling salvinia

Because of its extremely rapid growth rate, eradication of salvinia is only likely very early in its spread. Therefore, monitoring and early detection should be undertaken in catchments at risk from salvinia invasion, especially after floods because this is one way it spreads to new areas.

Smaller infestations – a chance of eradication

Although the success rate of eradication attempts is very low, best results are achieved with an integrated mechanical and herbicide control program. Careful removal of all salvinia by hand is particularly useful for clearing irrigation blockages. Any material physically removed from the water should be left to dry and preferably burnt or buried some distance from the water. Floating booms or nets can be used in the short term to restrict small infestations, although these are likely to be breached during floods.

Manual removal of salvinia also has the advantage of removing nutrients from the water, in comparison to herbicide control in which the nutrients from dead salvinia are released into the water, potentially affecting water quality and helping to fertilise new salvinia growth. Herbicides are effective however, and there are several that are registered for spraying on salvinia. Some herbicides act by reducing salvinia's buoyancy, causing it to immediately sink just below the surface. The plants darken, die and sink completely after several days.

Eradication of smaller infestations is possible but requires a concerted effort with vigilant follow-up. The follow-up control should be conducted soon after the initial treatment, and repeated and monitored regularly until no salvinia is left.

Larger infestations – biological control in warm climates

Large infestations are virtually impossible to eradicate. Biological control with the salvinia weevil *Cyrtobagous salviniae* is very effective in warm temperate, tropical or sub-tropical climates. Following research by CSIRO, the 2 mm long weevil was first released in 1980 into Lake Moondarra near Mount Isa. It was a spectacular success – an estimated 800 ha infestation weighing tens of thousands of tonnes was reduced to less than one tonne in a little over a year. This weevil has since been released from Sydney to Kakadu and elsewhere around the world, providing very successful control of salvinia in specific climates.

Weevil larvae feed inside the stems and adults feed on buds, both contributing to plant death. Eventually the whole mat turns brown and begins to sink and decompose; this process generally takes between one and three years to control an infestation.

The Howard River near Darwin, NT. (*Left*) Before salvinia infestation in July 1984. (*Centre*) One month after salvinia infestation. (*Right*) The infestation dying after attack by the salvinia weevil *Cyrtobagous salviniae* in February 1985.
Photos: Colin G. Wilson

Weed control contacts

State / Territory	Department	Phone	Email	Website
ACT	Environment ACT	(02) 6207 9777	EnvironmentACT@act.gov.au	www.environment.act.gov.au
NSW	NSW Agriculture	1800 680 244	weeds@agric.nsw.gov.au	www.agric.nsw.gov.au
NT	Dept of Natural Resources, Environment and the Arts	(08) 8999 4567	weedinfo.nreta@nt.gov.au	www.nt.gov.au
Qld	Dept of Natural Resources and Mines	(07) 3896 3111	enquiries@nrm.qld.gov.au	www.nrm.qld.gov.au
SA	Dept of Water, Land and Biodiversity Conservation	(08) 8303 9500	apc@saugov.sa.gov.au	www.dwlbc.sa.gov.au
Tas	Dept of Primary Industries, Water and Environment	1300 368 550	Weeds.Enquiries@dpiwe.tas.gov.au	www.dpiwe.tas.gov.au
Vic	Dept of Primary Industries/Dept of Sustainability and Environment	136 186	customer.service@dpi.vic.gov.au	www.dpi.vic.gov.au www.dse.vic.gov.au
WA	Dept of Agriculture	(08) 9368 3333	enquiries@agric.wa.gov.au	www.agric.wa.gov.au
Australia wide	Australian Pesticides and Veterinary Medicines Authority	(02) 6272 5852	contact@apvma.gov.au	www.apvma.gov.au

For up-to-date information on which herbicides are registered to control salvinia and the best application methods and dosages, contact your state or territory weed management agency or local council. This information varies from state to state and from time to time. Contact details are listed above, including contacts for the Australian Pesticides and Veterinary Medicines Authority, which hosts the PUBCRIS database. This database contains information on all herbicides that are registered for use on weeds in each Australian state and territory.

When using herbicides always read the label and follow instructions carefully. Particular care should be taken when using herbicides near waterways because rainfall running off the land into waterways can carry herbicides with it. Permits from state or territory Environmental Protection Authorities may be required if herbicides are to be sprayed directly onto water.

Salvinia in open water can be difficult to reach with conventional herbicides.
Photo: Scott Robinson, Georgia (USA) Dept of Natural Resources

However, the weevil does not perform as well in cooler climates; in Australia it is effective about as far south as Grafton on the New South Wales coast. Spring is the best time to introduce weevils to a new infestation of salvinia in cooler climates. This gives them the chance to breed up to take advantage of the warmer weather in summer. Their life cycle lasts only about 6 weeks at 30°C, but is longer at lower temperatures.

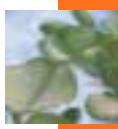
The weevils will be most effective on a healthy population of salvinia, so control with other methods is not desirable unless the weed is so dense it has become multi-layered. In such situations the mats should be thinned (eg strip sprayed) to encourage the rapid new growth that is preferred by the weevil. About 100 weevils should be released in the same warm, sunny spot in permanent water. In the tropics this release site should start to turn brown after 4–5 months, equivalent to two life cycles. Most of the remainder of the infestation, at least in warm environments, should then quickly turn brown and die within a year to 18 months. Not all salvinia will be killed, which will ensure that some weevils remain to prevent significant regrowth of the weed. Eventually, a balance of sorts is reached, and the weevil numbers will cycle with the amount of salvinia.

Control using other methods should not be attempted where biological control is contributing to significant reduction of salvinia, because most herbicides kill the weevils. Eradication is rarely achievable and the attempt may merely disrupt the biological control, allowing the weed to regrow.

Weevils are established in salvinia infestations throughout the Northern Territory, Queensland and New South Wales. Although the weevil can fly, it will probably need to be introduced into a new infestation. Local councils and state/territory weed management agencies in affected areas will either be able to provide the weevils for release, or advise where to find them and how to translocate them. If weevil-bearing salvinia is translocated, care must be taken that other weeds are not also spread.

Other methods will be required in climates not suited to the weevil

Mechanical and chemical control techniques should be integrated to manage large salvinia infestations where biological control is less effective. This may be necessary in the cooler climate of parts of New South Wales; and in some shallow tropical freshwater systems which can heat up to over 40°C, killing the weevil eggs. Mechanical methods, as previously outlined, can help to remove blockages and contain infestations. Herbicides, though relatively expensive, can be very effective.



...case study

Eradication of salvinia in Kununurra, Western Australia, on track

In 2000 salvinia was discovered by a resident in Lily Creek Lagoon, Kununurra, probably after being dumped into a drain, or the lake itself, from a fish tank. The weed posed a significant risk to the horticulture industry, which extracts water downstream of the lake via the Ord River Irrigation Scheme. It also threatened the Ramsar-listed Ord River Floodplain, which is a wetland of international significance supporting saltwater crocodiles and a large number and diversity of waterbirds.

Fortunately, the salvinia infestation was relatively small, occupying only about 15 square metres. A naturally occurring barrier of cumbungi reeds (*Typha* species, considered to be weedy itself) had helped to contain it by separating the salvinia from the rest of the waterway. It is probable that the salvinia would have escaped from this contained area if it had not been found and controlled before the next wet season.

The effort to eradicate the salvinia involved cooperation from a range of government agencies and community groups including the Department of Agriculture, Water Corporation, Waters and Rivers Commission, Department of Conservation and Land Management, Shire of Wyndham East Kimberley, and the environment groups Save Endangered East Kimberley Species and Ord Land and Water.

Firstly, booms were used to further contain the infestation and prevent spread. The next stage involved removing as much salvinia as possible by hand, using flat bottomed boats to help reach the infestation. Approximately 100 kg of weed removed in this initial attempt was spread out and dried in the sun for one week before burial in a safe place.

Follow-up control has been ongoing, involving regular monitoring (initially every fortnight, then on a monthly basis) and the use of chemicals to spray any material that was not collected by hand. Biological control was not considered because the aim was to eradicate the infestation quickly. An education program targeted the general community via press releases and displays throughout the project.

The results so far have been the prevention of salvinia spread, an enhanced public awareness of the threats posed by salvinia and other aquatic weeds, and the almost complete eradication of the infestation. This project has been successful because of the involvement of a wide range of organisations, early detection of the problem, and the natural barrier that initially prevented the salvinia's spread.

case study

Herbicide application

Herbicides that reduce buoyancy are most effective on light infestations because salvinia plants must be in contact with the water. The mixture should be applied at low pressures to ensure that droplets are kept as large as possible. One of the drawbacks of the use of chemicals is that water quality can be detrimentally affected if a large amount of salvinia is killed and decomposes at once.

Other management strategies

Reducing the amount of nutrients entering a water body will help to reduce salvinia growth. Agricultural run-off, sewage, stormwater and erosion run-off are the main preventable forms of nutrient input that could be targeted for control.

Salt water has been used to kill off salvinia in the Canning River, Western Australia. However, other impacts on the ecosystem must also be considered. Another possibility is to drain affected waterways and dry out the salvinia before refilling. Note, however, that densely matted salvinia can survive many months of dry conditions.

Legislation

Landholders across Australia are required by law to control salvinia when it occurs on their property. Most regions restrict its importation and sale. Check with your local council or state/territory government agency about its requirements for salvinia control.

Acknowledgments

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Maps: Australian Weeds Committee.

The different growth stages of salvinia: (*right*) primary invading form with small flat fronds, (*left*) open water secondary form with larger, slightly curved fronds and (*centre*) mat-forming tertiary plants with folded fronds.
Photo: Colin G. Wilson

How to control salvinia

Quick reference guide

Preventing salvinia's spread

Preventing salvinia's spread into uninfested catchments is the most cost-effective management strategy. As spread is mostly caused by people accidentally or deliberately releasing the weed, there needs to be greater public awareness about the problems it causes. Do not dump salvinia into drains or waterways. Small amounts should be buried, or dried and burnt. Check with your local council or state/territory weed management agency for advice about dealing with salvinia.

The aquarium and nursery industries must enforce the laws banning the sale and trade of salvinia, and encourage the use of alternative native species.

Eradication is rarely achievable…

It is extremely difficult to eradicate salvinia once it becomes established. Because it reproduces and grows so quickly, even small amounts can quickly take over large water bodies. Eradication is usually only possible in very small, accessible infestations.

…but salvinia can be managed with biological control…

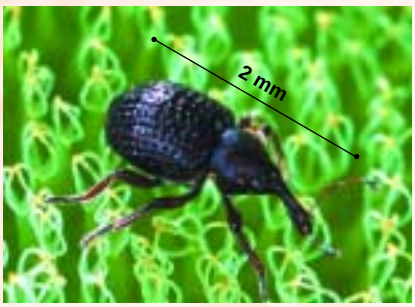
Very successful biocontrol of salvinia has been achieved in warm parts of Australia using the weevil *Cyrtobagous salviniae*.

…and/or integration with physical and chemical control

Physical and chemical controls are used in cooler areas where biological control is not effective. Manual removal may be used to clear small areas but extreme care must be taken not to leave behind any salvinia pieces. Herbicides can be quite effective but can cause water quality degradation if large amounts of salvinia are killed simultaneously.

Follow-up

Monitoring and vigilant follow-up control are required to contain salvinia where biological control is not effective.



The salvinia weevil *Cyrtobagous salviniae* and the egg-beater-shaped hairs that repel water from the upper surface of a salvinia frond.
Photo: Scott Bauer@USDA

Control options

Type of infestation	Physical	Mechanical	Chemical	Biological
Small (few plants, small area)	Manually remove by hand. Booms or nets can be used to prevent short-term spread.	Not suitable.	Several herbicides are registered for use on salvinia. Note: do not spray large infestations all at once, as this causes a mass die-off and pollutes water. Avoid this problem by removing most salvinia by hand or machine. All herbicides must be applied strictly in accordance with the directions on the label. Check with your local council or state/territory weed management agency for more details.	Biological control is unlikely to result in eradication, and is therefore not recommended for small infestations.
Medium (medium density, medium total area)	Not suitable.	Aquatic weed harvesters are available to regularly remove salvinia. However the results are similar to mowing a lawn, as it will regenerate.		The salvinia weevil *Cyrtobagous salviniae* is extremely effective in destroying the weed. In warm environments control should take 1–3 years. Cooler climates may require a longer time or repeated introductions, or may not be suitable for the weevil. Contact your local council or state/territory weed management agency for help in finding and releasing weevils onto salvinia.
Large (many plants, many ha)	Not suitable.			

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