

Where it grows

Both shallow water depth and slow flow are key requirements for establishment of sagittaria. It mostly inhabits waterways and or irrigation channels in water up to one metre deep or on the water edge, and prefers the muddy substrates associated with still or slow moving waterways. It can also survive in wet marshy soils near water. Fluctuating water levels can help establishment, as it allows greater access of sagittaria to shallow water.

In irrigation channels, sagittaria is best suited to the shallower and smaller channels where water is slow moving, warm and less turbid. In waterways, sagittaria establishes on shallow river backwaters and wetlands, and insides of river bends. It is less likely to establish in larger channels, and waterways, with high flow rates, greater depth and more stable water levels.

Potential distribution

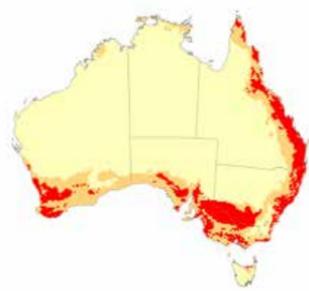
Modelling using Climatch software has demonstrated that tropical to temperate regions of Australia have climates that are highly suitable for sagittaria establishment. Based on these climatic tolerances the potential distribution of sagittaria includes still or slow moving freshwater bodies in every Australian state and territory. Sagittaria currently occupies only a small percentage of this predicted range.

Map 1: Current distribution of sagittaria in Australia



- Present and past reported occurrence
- No reported occurrence

Map 2: Potential distribution of sagittaria in Australia



- Low climate match
- Moderate climate match
- High climate match

Growth calendar

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												
Seed formation												
Seed drop												
Germination												
Regrowth from tubers and stolons												

■ General pattern of growth

In Victoria sagittaria flowers from August, peaking between November to February and finishes around May when the plants begin to be affected by cold weather. Fruits production and seed drop occurs from September. In south-east Queensland flowering occurs from November to January with seed maturation and drop in autumn. Seed germination can be immediate providing temperature, light and moisture conditions are favourable.

Legislation

Sagittaria is a declared noxious weed in New South Wales, South Australia, Tasmania and Western Australia. In these states it is an offence to grow, move or trade sagittaria. In Western Australia and some parts of New South Wales and South Australia infestations must be controlled.

The importation of sagittaria into Australia is prohibited by quarantine legislation.

Acknowledgements

This publication (and any material sourced from it) should be attributed as: *Weed Management Guide - Sagittaria*. Licensed from the Commonwealth of Australia under a Creative Commons Attribution 3.0 Australia Licence.

Compiled by Andrew Petroeshevsky, NSW Department of Primary Industries.

Information and guide revision: Tim Nitscke, Ross Gledhill (Goulburn-Murray Water), Keith Ward (Goulburn Broken Catchment Management Authority) and Paula Bosse (Eastern Riverina Noxious Weeds Advisory Group and Western Riverina Noxious Weeds Advisory Group).

Maps: Data provided by state and territory weed management agencies. Production by Chris Auricht. Potential distribution Climatch modelling by ABARES.

Photos: R.Gledhill; K.Ward

Key reference: Flower, G. (2004) *The Biology and Control of Sagittaria*, Goulburn Murray Water.

Forrest, L. Kahler, M. & van Oosterhout, E. (2011) *Fact Sheet - Sagittaria and Sagittaria*, NSW Department of Primary Industries, Orange.



Spraying is the most commonly used method for sagittaria control. Photo R Gledhill.

Case study: Preventing further spread of sagittaria on the River Murray

Sagittaria infests several irrigation districts, wetlands and river systems in northern Victoria, including the River Murray and Ramsar listed Barmah National Park. If left unmanaged, infestations are likely to spread further to downstream irrigation districts and important ecological communities.

In response the Sagittaria Management Plan for the River Murray was developed in 2007 by the Sagittaria Tri-State Working Group. A key element of this plan was to fund and implement an ongoing control program for all infestations on the River Murray with an aim to both reduce the size and prevent seeding of current infestations, in order to help prevent further downstream spread.

In 2007-08, funding was obtained from the Dams Unit of Goulburn-Murray Water through the Murray Darling Basin Authority to expand existing control programs to cover all known infestations on the River Murray. This new project area included the entire stretch of the River Murray between the Hume Weir downstream to Barham. Goulburn-Murray Water led the control program due to their technical expertise with sagittaria management.

Glyphosate spraying was the sole control method selected, as it was considered to be the most efficient and effective tool for sagittaria control in the river. Due to the distances involved and shallow habitat of the River Murray, flat-bottomed boats with specialised spray equipment were used.

All infestations were sprayed three times during the 2007-08 growing season, which resulted in significant reductions in both infested areas and sites. By the end of the 2007-08 season, sagittaria had been reduced within the target area from approximately 16,500 square metres across 1088 active sites to just 815 square metres across 344 active sites, without any adverse impacts from the spraying program.

The control program has since expanded to cover all reaches between Hume Weir and Barham. So far the project has been highly successful in achieving its aim of preventing further spread, as recent surveys have not detected sagittaria infestations downstream of Barham.

Weed Management Guide

Weed of National Significance



CARING FOR OUR COUNTRY

Sagittaria (*Sagittaria platyphylla*)

Also known as Arrowhead.



Sagittaria flowers and fruit. Photo: A Petroeshevsky

Key points

- **Sagittaria is a highly invasive aquatic weed and is one of the most serious aquatic weed issues in the Murray Darling Basin.**
- **Severe infestations form dense monocultures that block irrigation channels and degrade natural wetlands.**
- **It is a prolific seed producer and can also be spread vegetatively through its tubers and stolons.**
- **Early detection is critical to the success of control programs.**
- **Control utilises specialist equipment and is best achieved through herbicides or mechanical removal.**
- **Ongoing control will be required in most situations.**

The problem

Sagittaria (previously *S. graminea*), also known as Arrowhead, is one of Australia's worst aquatic weeds.

Sagittaria causes significant impacts to irrigation channels, waterways and wetlands, particularly in the southern areas of the Murray Darling Basin. It is a highly invasive, rapidly growing plant that forms dense monocultures

in water bodies up to one metre deep. Severe infestations block irrigation channels and drains, leading to restricted flows and increased trapping of silt. It chokes wetlands and waterways, which adversely affects aquatic biodiversity. Infestations can also have detrimental impacts on recreational activities, such as boating, swimming and fishing, and reduce visual amenity of waterways.

Sagittaria is a difficult and expensive plant to control, particularly in irrigation districts. The continued spread of sagittaria threatens irrigation assets and aquatic biodiversity throughout the Murray Darling Basin and other waterways in Australia within its potential range. Ramsar wetlands at immediate risk include Barmah National Park, Kerang Wetlands and Gunbower Forest in Victoria and the Chowilla Floodplain in South Australia.

The weed

Sagittaria is an emergent aquatic plant that belongs to the Alismataceae family. It has three distinct growth forms: narrow-leaved emergent, broad-leaved emergent and submerged rosette.

The emergent forms grow up to 1.5 metres and tend to be found in water up to one metre deep. The broad leaf form tends to grow either from rosettes, energy rich stolons or seedlings. The narrow leaf form grows as a response to damage to broad leaved plants from herbicide applications, grazing or flooding. It is thought that these plants are derived from depleted root crowns and their narrow leaves give the plant a skinny and unhealthy appearance.

The submerged rosettes develop from seed germination, tubers or stolons. They may grow into the emergent form in shallow waters, but they can also grow to a large size and persist for long periods without producing

emergent stems. The rosette form is capable of growing in deeper waters than the emergent forms and can also be interspersed with emergent forms in dense stands.

Sagittaria is native to the southern states of North America. It was most likely introduced into Australia as an ornamental plant. It was first detected in Australia in 1959 in Ekibin Creek in Brisbane. Naturalised infestations were first detected in Victoria in 1962, New South Wales in 1973 and Western Australia in 1999.

How to identify sagittaria

These features will help distinguish sagittaria from similar looking native species, including *Damasonium minus* and *Alisma plantago-aquatica*, *Rumex*, and the introduced *Sagittaria montevidensis* spp:

- Narrow leaved emergent form is erect and narrowly tapered blades giving a grass like appearance.
- Flowers are between two and three centimetres in size in spirals of two to 12 at the top of a leafless stem.
- Male flowers with three white petals and a yellow centre, while female flowers have no petals and have the appearance of green berries.
- Flowers appear below the height of the leaves, which helps distinguish Sagittaria from similar native species.
- Stems grow up to 60 centimetres long with triangular cross sections.
- Rosettes with translucent and strap like leaves up to 50 centimetres long.

Native species tend to have smaller flowers which appear above the height of the leaves. *Sagittaria montevidensis* has stems with rounded cross sections and more distinct arrow-shaped adult leaves.

How it spreads

Sagittaria reproduces by both seeds and vegetative means, although seed production is only possible in emergent forms. They can be prolific seed



Narrow leaved emergent form – erect and narrowly tapered blades giving a grass like appearance. Photo: K Ward.

producers with one healthy emergent plant capable of producing up to 20,000 seeds. The small and buoyant seeds can float for up to three weeks and can be easily dispersed by relatively light water currents. Ducks appear to be another major cause of seed spread. Seeds can also potentially be spread by mud attached to boats, vehicles or other equipment, or by other birds. Seed germination occurs when light and moisture conditions are favourable.

Both the emergent and rosette forms reproduce vegetatively through their underground stolons and tubers. These vegetative parts can survive over winter and allow infestations to rapidly regenerate in spring or following periods of stress. Tubers are round and fleshy organs found at the end of the stolon. They can remain viable in the soil for several years and can be detached and dispersed downstream by strong water currents.

Its use as an ornamental plant can also aid the spread of sagittaria. New incursions can result from seeds or vegetative material spreading to waterways from ornamental plantings in upstream water gardens, fishponds and dams.

These reproductive traits and dispersal mechanisms have allowed sagittaria to survive adverse conditions and spread rapidly throughout its current range in Australia.

What to do about it

Prevent further spread

Sagittaria control is best achieved by preventing its entry into a water body. Sagittaria spreads to new catchments through human activities such as ornamental use. Education programs will assist in preventing further spread. Gardeners and property owners should be discouraged from using sagittaria as an ornamental plant in water gardens, fish ponds and dams. Although it can currently be legally traded in most states and territories, its sale as an ornamental plant is discouraged.



Sagittaria growing in a shallow waterway in the Ramsar listed Barmah National Park. Photo: K Ward.



Narrow leaved emergent form of sagittaria blocking flow in an irrigation channel in the Goulburn Murray Irrigation area. Photo: R Gledhill.

People who have cultivated sagittaria and wish to destroy it should contact weed control authorities for information on its disposal. Burial is the quickest means of disposal but drying in the sun and/or mulching are also acceptable providing there is no risk of seeds or plant fragments spreading to a waterway.

In catchments where sagittaria is already present the main goal is to prevent further downstream or inter catchment basin spread. Preventing downstream spread is a difficult task because the main causes of spread, floodwaters, ducks and possibly birds are difficult to control. However strategic control programs to prevent annual seeding of plants can help reduce the rate of downstream spread.

Hygiene measures, including inspection and wash down, should be implemented where machinery, such as excavators, have been working amongst sagittaria infestations. Such measures can significantly reduce the likelihood of the spread of sagittaria to new areas.

Early detection

Early detection is critical for the management of sagittaria as successful eradication or containment is normally only possible when infestations are small. Even in such cases a persistent seed bank means ongoing commitment will be required to ensure that previously destroyed infestations do not re-establish and spread further.

Monitoring for early detection should be conducted in catchments at high risk of sagittaria invasion, especially after floods where there is a high risk of plants washing out of backyard ponds or dams into downstream waterways. Weed officers, waterway managers, farmers and irrigation managers in such areas should familiarise themselves with sagittaria and its key identification features.

Control

Sagittaria is a difficult plant to control due to its aquatic nature, resistance to herbicide treatments and persistent seed bank. Most control programs aim to either reduce the impact of sagittaria or to contain and prevent further spread. Eradication is often only feasible in small outlier areas.

Control options are limited to herbicide application and physical removal. Currently there are no biological control agents, however a research program to identify potential agents has commenced.

Herbicide control

There are no registered herbicides for use against sagittaria in Australia. However several herbicides, including glyphosate, dichlobenil, and arsenal express (an imazapyr/glyphosate formulation) can be used under minor use permits issued by the Australian Pesticides and Veterinary Medicines Authority for sagittaria control in specific areas.

The use of herbicides in or near water bodies is strictly regulated. Always use herbicides strictly in accordance with the directions specified under permit.

Herbicide control is difficult and will often only provide limited and temporary control of sagittaria. Foliar applications of herbicide helps remove the standing biomass of emergent plants but the herbicides, available under permit, don't sufficiently relocate to the underground tubers or stolons, nor do they come into contact with the submerged rosettes. Regrowth from the rosettes, tubers and stolons can form new emergent plants in as little as six to 12 weeks after treatment. Herbicide control of emergent foliage before the plant flowers significantly reduces seed production, hence it can be a useful method to help prevent further spread of established infestations.

Spraying provides best results when water levels are low and plant growth is highest, which maximises the uptake of the herbicide. However, in irrigation districts spraying can be complicated as the plants optimal growth rates occur in March and April, which coincides with the irrigation season when water levels in channels tend to be at their highest.

Despite the above difficulties, herbicides still provide the most cost effective means for controlling emergent sagittaria in irrigation channels and restoring channel flow. In addition, there are some promising herbicide strategies under development, which may provide improved suppression tools for infestations, including submerged rosettes in irrigation channels.

Physical removal

Physical removal involves either digging by hand or mechanical removal through use of machinery. It is best used where there is a need to quickly restore hydrological function of irrigation channels or drains. It is also used where herbicide applications are not suitable or where the channels are in continual use and cannot be shut down for control. Viable plant fragments,

such as tubers and stolons, often remain after mechanical excavation, so follow up treatment is often required. Physical removal may also be a suitable tool for eradicating small infestations, providing all viable plant material can be removed.

Physical removal is costly and, can also damage irrigation channels. There is also, there is a high risk of spread associated with physical removal resulting from dislodgment of roots tubers and stolons, and movement downstream. Suitable hygiene and containment measures are required to ensure these fragments don't float downstream and cause new infestations.



The dense foliage of sagittaria can choke wetlands and slow moving waterways. Photo: R Gledhill.

Other control strategies

In irrigation districts careful channel redesign or maintenance strategies to manage water depth can prevent growth of emergent sagittaria forms and help maintain water flow. This mostly involves re-profiling and/or de-silting of channels to maintain water levels above one metre deep, which is considered too deep for formation of emergent vegetation. Prevention of emergent growth also prevents flowering and subsequent seed production. Although rosettes can still be present they will not develop emergent stems.

Weed control contacts

Contact the weed control authority in your state for up to date information on pesticides and legislation.

	Department	Phone	Website
National	Australian Pesticides and Veterinary Medicines Authority	02 6210 4701	www.apvma.gov.au
ACT	Department of the Environment and Sustainable Development	13 22 81	www.environment.act.gov.au
NSW	Department of Primary Industries	1800 680 244	www.dpi.nsw.gov.au
NT	Department of Natural Resources, Environment, the Arts and Sport	08 8999 4567	www.nt.gov.au
Qld	Department of Agriculture, Fisheries and Forestry	13 25 23	www.daff.qld.gov.au
SA	Department of Primary Industries and Regions SA	08 8303 9620	www.pir.sa.gov.au
Tas	Dept of Primary Industries, Parks, Water and Environment	1300 368 550	www.dpipwe.tas.gov.au
Vic	Department of Primary Industries	13 61 86	www.dpi.vic.gov.au
WA	Department of Agriculture and Food	08 9368 3333	www.agric.wa.gov.au