

Chapter 2

Planning a control program

At a glance

- Planning helps to prioritise the actions needed to manage sagittaria infestations.
- Consideration of an infestation's size, location, density and proximity to other sagittaria infestations will help identify the most appropriate management objective.
- This chapter outlines considerations for planning a sagittaria control program and how to choose a control method that complies with these considerations.

A sagittaria control program requires a planned approach to ensure the best possible results are achieved with minimal cost and effort. This is particularly important given that sagittaria:

- can spread by seed and plant parts
- produces large numbers of seed and
- grows in aquatic environments, which presents a range of management challenges.

Aquatic weeds spread across boundaries and to ensure that control efforts are effective, they must be long term, planned, coordinated and adequately resourced across regions (Osmond and Petroeschevsky, 2013). The most appropriate management strategy for sagittaria will depend on the situation. Factors such as the nature and use of the waterway; climate; size and age of the infestation; presence or absence of an upstream infestation; and current and ongoing resources available need to be considered in the control and management of sagittaria (Osmond and Petroeschevsky, 2013).

A good understanding of the situation, management options, available resources and management objectives will support a systematic and responsive approach to sagittaria management.

Setting management objectives

Identifying a management strategy based on the level of weed invasion is a common practice in weed control programs. This involves identifying whether the objective is one of prevention, eradication, containment or asset protection (Table 2.1). Determining the objective provides a good framework for planning and designing sagittaria control programs.



Sonia Jordan

Assessing infestations in waterbodies presents management challenges

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Table 2.1 Weed management objectives and actions based on stage of weed invasion.

Management objective	Description
Prevention	<p>This aims to prevent a weed from arriving and/or establishing in a new area.</p> <p>Actions taken for prevention may include surveillance, movement controls at borders, machinery and equipment hygiene, awareness and education.</p> <p>Return on investment is much greater for a prevention strategy than for managing weeds after they establish in a new area.</p>
Eradication	<p>This aims to eradicate a weed from a geographic area, requiring elimination of all plants and propagules (seeds, tubers, stolons) where there is limited or no potential for reinvasion.</p> <p>Actions taken for eradication may be similar to those adopted for prevention, but also include determining the extent of infestation and eliminating all plants and reproductive plant parts (e.g. through herbicide control or other methods).</p> <p>Eradication programs have a high upfront cost because surveillance and control activities are more intensive and frequent than they are for weed control programs for other objectives, such as asset protection.</p> <p>Return on investment is much greater for an eradication strategy than for ongoing management of weeds because recurring costs of control and ongoing weed impacts are avoided in the long term.</p>
Containment	<p>This aims to prevent an infestation expanding beyond a defined area, effectively using the approaches of ‘asset protection’ inside the containment area and ‘eradication’ outside of it.</p> <p>Actions taken may include those used for eradication and asset protection objectives.</p> <p>This is used where an infestation has become too established to attempt eradication, but nearby areas remain free of the weed.</p>
Asset protection (suppression)	<p>This aims to reduce the abundance of a weed such that its impacts are reduced.</p> <p>Actions taken may include surveillance, identification of priority assets for protection and weed control at priority assets (e.g. through herbicide, mechanical or biological methods).</p> <p>This is the most commonly applied weed control strategy and has a high recurring cost in the long term.</p>

The identification of management objectives can occur on multiple scales. Figure 2.1 identifies sagittaria management objectives at the national scale, based on its national distribution. In this scenario, areas of potential habitat are targeted for prevention activities; outlier infestations are targeted for eradication; and core infestations (e.g. those in the Murray and Goulburn rivers) are managed to reduce the impact on key assets (asset protection) by reducing infestation densities and their potential to spread.

Objectives may change at the local or regional scale. For example, a weed manager may wish to contain sagittaria to certain waterways even though the infestation falls within a national asset protection zone.

When setting a management objective, weed managers should also consider the assets and communities affected by sagittaria. For example, an irrigation authority is responsible for maintaining unobstructed channels and will therefore prioritise sagittaria management to protect this asset. In contrast, conservation managers may target sagittaria to maintain and protect the diversity of natural aquatic environments.

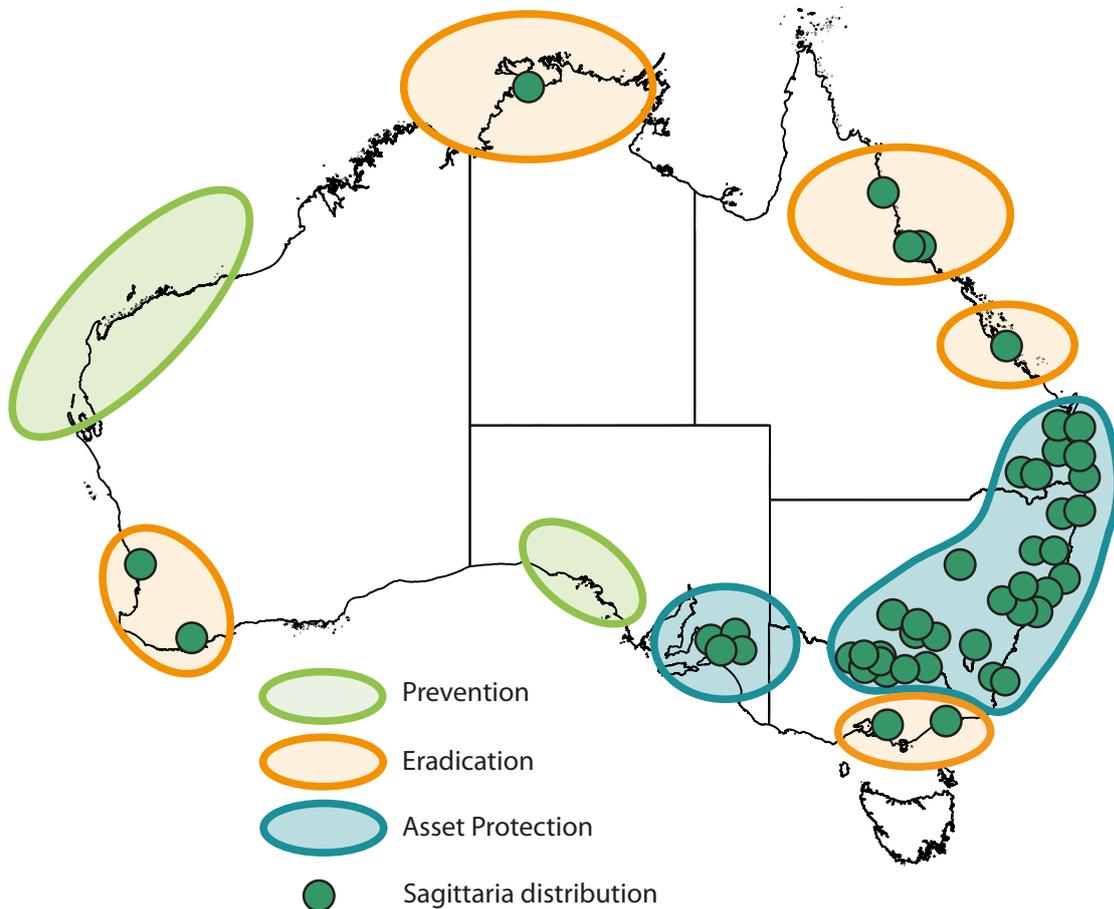


Figure 2.1 Distribution of sagittaria in Australia with idealised management objectives to consider for each infestation depending on their proximity to other known infestations.

Prevention

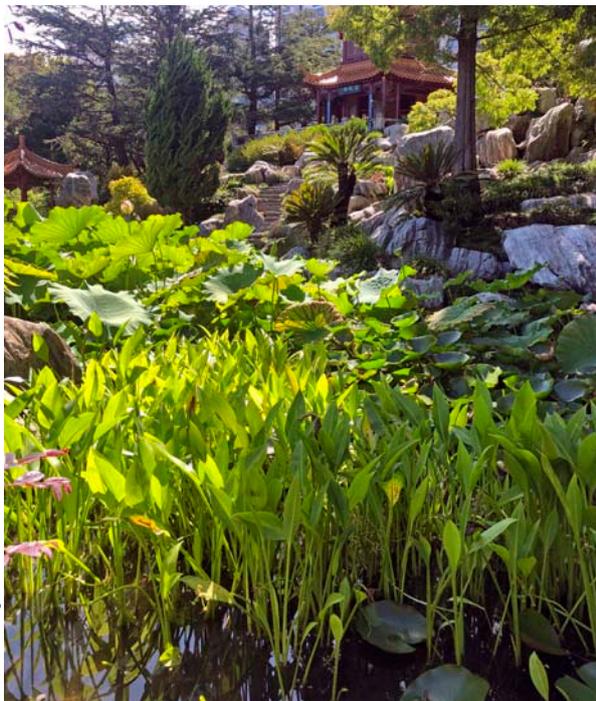
Although sagittaria is widespread in Australia, there are still many areas where it is not present. Thus, it is critical to implement measures to prevent it establishing in areas where it is currently absent. The most cost-effective way of dealing with any weed is to prevent its introduction, particularly through the sale and trade of plants among enthusiasts. Other likely sources of new infestations are the escape of cultured plants from ornamental ponds; natural downstream dispersal of upstream infestations via drift of seed and tubers; and dispersal of weed propagules (seed, tubers, plants) by waterfowl.

For sagittaria, the most obvious prevention measure is to ensure earth-moving machinery that is moved between waterbodies to excavate and maintain drains and irrigation channels is cleaned to remove soil and vegetation that might contain seeds and tubers or better still, to ensure that only local machinery is used.

Upstream infestations of sagittaria may pose a risk to clean areas downstream, particularly after flood events. Thus, it is important to consider the need for additional surveillance post-flood to increase the likelihood of detecting new infestations.

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For more information on weed hygiene, see Chapter 3 page 46 – *Disposal and site hygiene associated with mechanical and manual removal of sagittaria.*



Raelene Kwong

Ornamental plantings of sagittaria in public places pose a risk of escape. Chinese Friendship Garden, Darling Harbour, Sydney.



Raelene Kwong

Sagittaria seeds (achenes) are buoyant for several days and can float long distances downstream.

Eradication

Eradication means to eliminate all plants and propagules (includes seeds, stolons and tubers) in the infestation until sagittaria is locally extinct. To be successful there should be limited or no potential for sagittaria reinvasion from surrounding areas.

Eradication of weeds is often a desired outcome of weed control programs; however, in reality eradication is difficult to achieve. The best chance of success occurs when the control is conducted in the very early stages of invasion, when there are few plants and a limited seedbank. There is considerable expense associated with establishing an eradication program. The expenses are for delimitation surveys to determine the infestation's extent as well as equipment and chemical costs for initial and follow-up control. However, the payoff of a successful eradication program is that these costs do not continue into the future, and the area is free of the impacts of sagittaria.



Raelene Kwong

Sagittaria growing in a lake at Waring Gardens, Deniliquin New South Wales presents an opportunity for eradication. Eliminating this small infestation will prevent its expansion and the spread of propagules into the surrounding waterways.

The importance of early detection

Education and awareness raising among waterbody and land managers, contractors and the public is an important way to improve the chances of early detection of sagittaria. Early detection allows eradication programs to commence while infestations are small, thereby improving the chance of management success.

Outlier infestations of sagittaria were found in this wetland and targeted for eradication. Plants were carefully removed, reducing the likelihood of spread of sagittaria into the western half of Goulburn–Murray Water’s irrigation districts.

Early detection was achieved, with plants found before flowering and seeding had occurred, thus limiting the potential for re-establishment of sagittaria.



Russel Talbot



Russel Talbot

Eradication is usually only worth considering in the case of new infestations that represent significant range expansions. Formal responses to attempt sagittaria eradication have been initiated in Western Australia, South Australia, Queensland and the Northern Territory.

Case studies describing early detection and eradication programs in the Northern Territory and in North Queensland are provided in Chapter 4.

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Reduced sagittaria dispersal associated with the Ross River eradication program

The sagittaria infestation in the Ross River, North Queensland, is part of an ongoing eradication program. As described, eradication programs are difficult to achieve and require time and perseverance. While eradication may take a long time, the benefits of control efforts may be realised sooner.

In 2019, the Ross River experienced a severe flood event that affected the site of the sagittaria infestation that was subject to eradication. In the four years prior to the flood, land managers had successfully reduced the sagittaria infestation from 560 square metres to 50 square metres. Frequent spraying and plant removal further reduced seed and tuber production. This management led to a reduction in the number of propagules in the environment and a depleted propagule bank in the river sediments, limiting the potential for dispersal and establishment of new infestations.

The flood caused major scouring and changes to the watercourse in the section where sagittaria had previously been located. Without the control efforts in the four years prior to the flood, this would have resulted in significant downstream dispersal of sagittaria plants, seeds and tubers and an associated increase in sagittaria infestations. Instead, post-flood surveying downstream of the original infestation has shown limited spread, which has been attributed to the successful management in the four years prior to the flood event.

Containment

Containment refers to situations where sagittaria is too well established in a particular area for eradication to be feasibly achieved but other nearby areas are free of sagittaria. In such a situation, establishing a containment zone could reduce further spread of sagittaria into clean areas. In these situations, sagittaria would be managed within the containment zone to reduce its local impact (i.e. managing to achieve the objective of asset protection); while outside of the containment zone, sagittaria would be managed to achieve eradication. Management of containment zones is costly because of the need for ongoing control works and coordination of management activities undertaken by multiple landholders and agencies.

Containment programs are worth considering at catchment or sub-catchment scales, for example, where there are heavy infestations of sagittaria in one catchment, but it is absent or sparse in a nearby catchment. This situation exists in the western part of Goulburn–Murray Water's irrigation districts, where sagittaria is managed to kill every plant, compared with the suppression approach (asset protection) used in the east, where sagittaria is widespread.

Asset protection

Asset protection, or suppression, refers to management activities to reduce the impact of sagittaria and is the most common weed management strategy. For sagittaria, asset protection may include controlling infestations to reduce obstruction of drains and irrigation channels or to allow greater growth of native aquatic plants in wetlands. The latter approach was undertaken by Parks Victoria in Barmah National Park. Asset protection also has the benefit of reducing propagule load, and thus the potential for spread of sagittaria.

Chapter 4 (case study 1) has an example of sagittaria management for asset protection.



Raelene Kwong

Controlling sagittaria infesting this drain leading into Reedy Swamp will protect a significant wetland asset near Shepparton, Victoria.



Hasan Rahmani

Biological control is often utilised in asset protection control programs because other control methods may not be cost effective for these widespread infestations.

Full details of where and how to make releases of the sagittaria fruit feeding weevil can be found in Chapter 3.

Developing a management plan

This section describes considerations for preparing a management plan for sagittaria infestations. It is adapted from Osmond and Petroseschevsky (2013).

Management of sagittaria requires careful planning and coordinated activities over several years because of:

- the rapid growth of sagittaria
- the ability of sagittaria to quickly form seed and tuber banks within the sediments of waterbodies
- the interconnectedness of waterbodies, which allows sagittaria to spread and establish throughout suitable habitats within a region.

The factors to consider when preparing a management plan are discussed in Table 2.2.



Raelene Kwong

Sagittaria infestations occurring in remote and difficult to access locations can go unnoticed, hampering eradication and control programs. In the shallow 'everglades' section of the Murray River, upstream from Lake Mulwala, sagittaria surveys can be conducted only by boat, which hampers early detection and eradication.

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Table 2.2 Factors to consider when preparing a management plan.

Early intervention	Commencing control activities as soon as possible after infestations establish (i.e. while they are small) increases the likelihood of success, reduces the cost of control programs, and reduces the likelihood of dispersal from the site. Early intervention requires regular formal monitoring of waterbodies. It can also be assisted by working with local communities such as citizen scientists and natural resource management organisations.
Map and record	Record the location and extent of the infestation. This can be achieved via a sketch or by recording geographic data with a GPS. The purpose of this step is to estimate extent of the infestation so that progress can be measured. Keeping such records also allows evaluation of how well the control methods are working and if changing the approach will result in improved control. Maps should be updated each time the site is monitored, and each map should have a date. It is also useful to record control methods used; presence of flowers, fruit and seed; and water levels (or flooding or drying events) and to keep photos of the site over time.
Identify the weed source	For new infestations, the source of the infestation is likely to be nearby. It is important to check upstream areas of the same waterbody first, along with nearby waterbodies such as billabongs, drains, garden ponds and farm dams. Accessing aerial imagery (where available) can be highly effective for this purpose. Implementing sagittaria management at the source infestations should be a high priority to prevent reinvasion.
Physically contain the infestation	For small new infestations, it may be possible to contain the infestation by installing floating booms, closing flow-regulating structures or constructing earthen bund walls. Such measures reduce the risk of spread and are particularly important if there are no nearby sagittaria infestations or where downstream locations have high environmental values.
Plan ongoing management and obtain resources	After control work has been conducted, sagittaria can repopulate a site from seeds and tubers buried in the sediment, damaged crowns of emergent plants, and submerged juvenile rosettes. Therefore, successful control requires repeated management over long periods, which in turn requires a long-term budget for monitoring and control. The high cost and difficulty of sustaining long-term management necessitates taking a strategic approach by determining whether eradication, containment or asset protection should be targeted for the infestation.
Check for permits	Permits may be required if sagittaria control tools are likely to cause disturbance to the aquatic environment, or where modifications to the banks of waterways are required to allow access for machinery. It is important to check with local and state governments before commencing control programs.
Decide which control method to use	Control methods are described in detail in Chapter 3. The characteristics of the waterway and access to it will influence which control method to use. See the section titled 'Choosing a control method' in Chapter 3 for more information.
Prevent seed and tuber set	To prevent seed and tuber formation, control should be applied early in spring before flowers have set seed, with follow-up control required at least once more during the growing season. Frequent monitoring (ideally monthly) will help determine when control tools should be applied before the next round of seed set. Control may need to be conducted throughout the year in some situations, such as where eradication is the target and in tropical and sub-tropical areas where vegetative growth and seed set can occur throughout the year.
Have hygiene measures in place	Weed control programs should include hygiene practices to prevent further spread of sagittaria associated with movement of material attached to equipment and personnel. Boats, excavators, trailers and footwear should be washed down to remove plant material and mud that could harbour seeds and propagules.
Monitor and adapt	Utilise the information collected above in the 'Map and record' step to review the success of the control tools and management plan. Changes to the management plan should be made in an adaptive management context and the suitability of the following should be considered: control methods used; timing of application of control methods; frequency and timing of monitoring events; and future extent of management at the site compared with the available budget.

Monitoring and surveillance

Monitoring of areas where sagittaria control works have been undertaken is critical to determine success and guide further management.

Sagittaria is usually monitored via bankside surveys, on foot or in all-terrain or utility vehicles, with surveys sometimes undertaken in boats. The location of each patch should be recorded with a GPS device, along with an indication of its size and maturity.

The frequency of surveys should be varied according to the aim of the control program. Surveys at intervals of two to four weeks are required where local eradication is sought to ensure new plants are detected and controlled before they set seed or grow tubers. In this situation, surveys need to be highly intensive to detect all plants. Where the control program aims for asset protection or suppression, annual or biannual surveys may be sufficient to demarcate the extent of heavy and light infestations. This allows weed managers to evaluate past control measures and plan future ones.

Other planning considerations associated with aquatic environments

Control methods

A range of control options for sagittaria are outlined in Chapter 3. In addition to considering the type of control method to use, it is also important to consider herbicide requirements (e.g. what the herbicide label permits); potential off-target impacts; and whether a site requires regular control and site access (see Table 2.3).

Aquatic environment

Sagittaria grows in aquatic environments, which are sensitive to disturbance. Control programs can disturb the environment directly (e.g. entraining sediment in water associated with mechanical or manual removal of sagittaria) or indirectly by affecting fauna and flora through off-target effects of herbicides.

Table 2.3 Considerations when selecting a control option to manage sagittaria.

Herbicide label requirements	Consider whether the situation is compliant with the directions for use label. For example: restraints, do not statements, weed species, rate, critical comments and general instructions must all be appropriate for and compliant with the situation.
Potential for off-target impacts	This consideration will most often relate to the possible off-target impact of herbicides, but the impact of other control methods should also be considered. Examples of factors to consider include using excavators in high value areas such as national parks; co-existence of threatened species; impact of overspray; erosion when soil is exposed after control works; water quality during decomposition of dead plant material; and the disturbance of sediment and banks associated with excavation or manual removal.
Requirement for ongoing control	Sites where regular control activities are required to reduce sagittaria abundance are not suitable for releases of the fruit feeding weevil biocontrol agent because the use of herbicide will impede establishment of the biocontrol agent (see Chapter 3 'Implementing biocontrol as part of an integrated sagittaria management strategy' for more information).
Access	Herbicides require equipment to apply. Such equipment can range from small handheld devices to large machinery mounted devices. The method selected needs to be compatible with the water and mud associated with the aquatic habitats in which the sagittaria is found. Mechanical excavation and manual removal require disposal of material away from the excavation site, which means that a method of moving this heavy material is required. For manual removal, a boat can be used. For excavation, the reach of the excavator's arm is critical in efficiently accessing the sagittaria and accessing dry areas on the bank to dispose of it.

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Excavation of plants and associated sediment affects mud-dwelling fauna, with sediment plumes reducing water quality in the area in the short term. Although this is undesirable, the long-term benefits associated with removal of sagittaria infestations outweighs these effects.

Much like sediment can form a plume of turbid water, herbicide application to the water surface can cause a plume of herbicide that moves away from the treated area, with associated potential off-target impacts on the aquatic environment. Guidelines for use of herbicides around water have been developed (Ainsworth and Bowcher, 2005) and are discussed in Chapter 3: 'Herbicide use around water'.



Raelene Kwong

An example of a large, dense infestation that is suitable for biological control. In this case, the sagittaria infestation occurs in a disused irrigation channel in northern Victoria.

Health and safety

Working in aquatic environments presents challenges for health and safety. The risk of drowning is real, particularly where the water depth changes quickly, such as along riverbanks or where weed management personnel can suffer trauma that renders them unconscious or unable to stand (e.g. heatstroke, hypothermia and head injury by falling branches).

Aquatic environments are often underlain by deep muddy sediment, which can be extremely difficult to wade through, making people excessively tired and exacerbating any other personnel conditions. Without proper caution it can be very difficult for people to wade back to the safety of land.

Direct contact with waterbodies also presents the risk of infection or poisoning. Waterbodies can contain toxins (e.g. avian botulism and blue-green algae), and bacterial and viral pathogens associated with stormwater, sewage or animal faeces are also common.

The risks outlined above can be minimised by performing a risk assessment before undertaking any weed management activities and enacting a range of controls to reduce or remove any identified risks. The risk of drowning can be minimised by not working in water that is too deep; not working around water alone; and carrying a stick to use for balance and support. Where possible, all activities should be undertaken from the bank, rather than by entering the water.

Where accessing the water is required, or use of a boat is required, lifejackets should be worn. Medical advice should also be sought in relation to appropriate vaccinations for bacterial pathogens and viruses.

Where herbicide is being used, personnel should undertake training on the proper use, application, and disposal of herbicides and ensure they read and comply with the label. Refer to Chapter 3 for more information.

Permits to manage weeds in water

Weed managers should check with state authorities, such as environmental protection authorities and agriculture and environment departments, for permit requirements for managing weeds in water and for using herbicides in water. More information on permits is provided in Chapter 3.