

# Chapter 4

## Case study 1

### Goulburn-Murray Water glyphosate regime

Russel Talbot,\* Dannielle McMillan\* and Tony Dugdale

\* Goulburn-Murray Water



#### Key points

- *Sagittaria* is widespread and well established in waterbodies in northern Victoria.
- Drains and earthen irrigation channels provide a perfect environment for *sagittaria* to grow.
- Glyphosate applied at high rates (under permit) can reduce the size of infestations, thus restoring water flow.
- Treatments need to be repeated annually as regrowth is common.

#### The problem

*Sagittaria* grows prolifically in waterbodies with shallow water and silty sediments – exactly the habitat provided by drains and earthen irrigation channels. Plant parts (including rosettes, and stems and leaves of mature plants) obstruct water flow, resulting in reduced capacity to deliver irrigation water and to discharge drainage water. If left unmanaged, *sagittaria* can occupy the entire cross-section of drains and irrigation channels, severely compromising water carrying capacity.

#### The situation – core infestation

*Sagittaria* is widespread and abundant in waterbodies throughout Northern Victoria, where it has been established since the 1960s. These waterbodies include 10,900 km of irrigation channels, drains and pipelines managed by Goulburn-Murray Water.



Raelene Kwong

*An earthen irrigation channel infested with sagittaria.*

# Case study 1

## The approach

To maintain open channels and drains, Goulburn-Murray Water undertake an extensive control program to combat sagittaria. Glyphosate has been the most widely used herbicide to control sagittaria for decades and remains so. Table 4.1 details the typical treatments of sagittaria in irrigation channels and drains by Goulburn-Murray Water.

The regime provides substantial suppression of sagittaria; however, regrowth from existing plants and germination of new plants occurs after glyphosate application for several reasons:

- Crowns of adult emergent plants are not always killed outright, so these can regrow.
- Juvenile plants still in the rosette growth stage at the time of application are not exposed to lethal doses of glyphosate because they do not have emergent foliage.
- Anecdotal evidence suggests that tubers are not damaged by glyphosate application, even when they are still attached to the adult plant.
- Seeds remain in the substrate and subsequently germinate.

**Table 4.1** Typical treatments employed by Goulburn-Murray Water for sagittaria.

Product	Weedmaster Duo® Isopropylamine and mono-ammonium salts of glyphosate
Rate	* 27 L/ha (9.72 kg a.i./ha)
Mix & application	<b>Boom spray:</b> 200 L (173 L water + 27 L product)/ha <b>Handgun:</b> 600 L (573 L water + 27 L product)/ha No surfactant
Other information	Best applied when water levels are low to maximise the amount of foliage above the water, although this is often impractical because of limited control of water levels
Season	<b>Core infestations:</b> December (onset of substantial emergent foliage) to end of May for irrigation channels and rivers (senescence) Application in drains continues later in season
	<b>New or priority infestations:</b> November to end of May
Frequency	<b>Core infestations:</b> Once or twice per year. Ideally all infestations would be treated three times per year but more sagittaria exists than resources allow
	<b>New or priority infestations:</b> Three times per year

\* Permit required.

Note: Goulburn-Murray Water currently apply glyphosate at these rates under APVMA permit 13448, which restricts use to persons employed or contracted and supervised by Goulburn-Murray Water. A number of conditions are associated with this permit. Permit 13448 applies only to Victoria and New South Wales and is current until 30 April 2025.

Sagittaria infestations that are old, or have previously been treated with herbicide, have a narrow-leaf form. This form is not as susceptible to herbicide as the broad-leaf form, most likely because less surface area is available for herbicide capture and uptake.

It is thought that sagittaria in core infestations of northern Victoria has evolved tolerance to glyphosate, although evidence of this is lacking. Anecdotal observations indicate that populations that have not previously been exposed to glyphosate can be controlled with lower rates than the 27 L/ha specified above in Goulburn-Murray Water's glyphosate-based regime.



Peter Cole

*Foliar spray of sagittaria with handgun.*



Peter Cole

*Foliar spray of sagittaria with boom spray.*

## The outcome

When glyphosate is applied according to the approach described here, sagittaria abundance can be substantially reduced in irrigation channels and drains, thus restoring water movement. However, for well-established core infestations, this glyphosate-based regime needs to be continued annually in perpetuity.

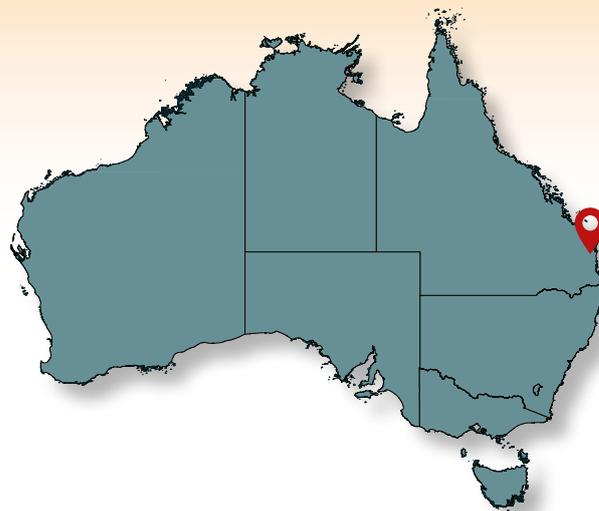
For new infestations given priority, sagittaria can be suppressed to extremely low levels of abundance with the intensive regime described, but breakouts can be rapid if scheduled monitoring and applications are missed.

# Case study 2

## Development of flumioxazin to control sagittaria

Tobias Bickel\* and Tony Dugdale

\*Invasive Plant Science, Department of Agriculture and Fisheries, Queensland Government



### Key points

- **Sagittaria is widespread and well established in waterbodies in south-east Queensland.**
- **There are concerns sagittaria could impact on water supply, native aquatic plants and drain function.**
- **Management with glyphosate has limited effectiveness, however alternative herbicides are lacking.**
- **A new herbicide, Clipper®, has now been registered for use on sagittaria in a range of situations.**

### The situation – core infestation

Sagittaria was first detected in Brisbane in 1959 and since then has spread, predominantly in coastal areas. Sagittaria has only become a management issue in the last 10 years and is well established in waterbodies of south-east Queensland. Queensland authorities are concerned about sagittaria's ability to interfere with drinking water and irrigation water supplies, obstruct drainage and displace native aquatic plants.

### The problem

Glyphosate is the main management tool used for sagittaria, though it has limited effectiveness, for reasons similar to those described in Chapter 3 (page 39). This prompted the Queensland Department of Agriculture and Fisheries to initiate a program to develop other control options.

### The solution

A research program was established to screen and test herbicides for potential use against sagittaria and other important aquatic weeds. Flumioxazin was selected for further investigation because it is capable of controlling a variety of key aquatic weeds. A series of laboratory and shade house trials were conducted to determine herbicide efficacy (i) at a range of rates, (ii) when sprayed on the emergent foliage or applied directly to the water, and (iii) under varying pH levels of the receiving waterbody.

When applied directly to the water column, damage to sagittaria was noted within a week of flumioxazin application. The extent of plant damage continued to increase over the 12-week duration of the



Tobias Bickel

Experimental research facility with tanks under shade cloth for growing aquatic weeds, including sagittaria.

experiment, such that at the end of the experiment biomass was reduced by approximately 70–90% relative to untreated plants. Efficacy was best when applied to water between 6 and 8 pH, and reduced at 8.5 pH. Both foliar and water column application of flumioxazin provided similar levels of sagittaria control.

The information collected in the research program was used to undertake field trials to test the effectiveness of flumioxazin against sagittaria and other aquatic weeds in natural water bodies, with promising results. Flumioxazin was applied as a foliar spray (210 g a.i./ha) to a dense sagittaria patch in a small water body located in a suburban park. The herbicide removed the entire emergent foliage within 60 days and greatly reduced plant density. However, there was still a large amount of submersed growing rosettes remaining in the site, which will be controlled with a future subsurface application of flumioxazin. The rate of 210 g a.i./ha was between the upper and lower bounds of flumioxazin's subsequent label rate for application to foliage via surface spray.



Tobias Bickel

A range of submersed aquatic weed species in pots arranged on the bottom of one of the tanks prior to dosing with flumioxazin.



Tobias Bickel

Sagittaria infestation in a suburban park in south-east Queensland (prior to foliar herbicide application).



Tobias Bickel

Same infestation 60 days later after spraying with flumioxazin. Note emergent sagittaria has disappeared.

# Case study 2

Flumioxazin was also applied as either a subsurface application (400 ppb) or combination of subsurface (200 ppb) and foliar (210 g a.i./ha) application to a slow-flowing drainage channel dominated by emergent sagittaria and Amazon frogbit. As performed at the other site, all the emergent sagittaria was removed within four weeks. The remaining subsurface rosettes were still present but showed considerable herbicide damage and potentially may die (results pending). There was no visual difference in control efficacy between the high subsurface or combination treatments. The subsurface applications of 200 and 400 ppb represent the upper and lower bounds of flumioxazin's subsequent label rate for subsurface application.

## The outcome

Flumioxazin was granted APVMA registration for use in Australia in December 2020, under the trade name Clipper®. It can now be used to control sagittaria in a range of situations, including non-flowing freshwater bodies and the margins of slow-moving streams, lakes, dams and channels. This provides an additional tool to complement glyphosate and provide managers with different mode of action to use against sagittaria to limit potential development of herbicide resistance.

Further trials are underway to determine if its registration can be extended to irrigation channels.



Tobias Bickel

*Foliar application of flumioxazin to sagittaria in a drainage channel (SEQ, September 2022).*



Tobias Bickel

*All emergent sagittaria removed about four weeks after treatment.*



Tobias Bickel

*Remaining submersed rosettes (four weeks after treatment) are brown and affected by herbicide.*

# Case study 3

## Eradication from Ross River, Burdekin Dry Tropics Natural Resource Management region

Tony Dugdale and Melissa Green\*

\*Technical Biosecurity Officer, Townsville City Council



### Key points

- Discovery of sagittaria in the Ross River threatened the environmental, economic and recreational values of the area.
- A control program was instigated to suppress reproduction and prevent spread.
- A combination of herbicide control and manual removal has been successful in preventing spread from the Ross River.
- Early intervention and rapid response are critical success factors.

### The situation – outlier infestations

Sagittaria was discovered in the Ross River at Townsville in December 2011. This discovery represented a major expansion of its range in Australia, approximately 1000 km north from known populations in south-east Queensland (Calvert, 2015).



Melissa Green



Melissa Green

*Sagittaria growing in the Ross River, Townsville.*

# Case study 3

## The problem

Sagittaria was immediately recognised as a threat to the ecology and recreational use of the Ross River and, more importantly, the other wetlands of the region and the nearby Burdekin irrigation areas, which are free of sagittaria. In particular, managers were concerned about sagittaria's potential to: reduce water flow in the region's extensive network of irrigation channels and drains; entrap silt, leading to increased flooding risk; and displace native aquatic species.

## The solution

A control program in the Ross River was immediately enacted by Townsville City Council. The program employed herbicide application (glyphosate) and manual removal, guided by an intensive monitoring and survey program. The aim of the control works was to suppress flowering and seed production and thereby minimise the source of propagules that could spread to other parts of North Queensland.

## Forming a regional working group

A regional sagittaria working group was formed around 2015 to formalise the management of sagittaria in the Burdekin Dry Tropics Natural Resource Management region. Since then, sagittaria in the Ross River has been subject to intensive treatment with glyphosate and regular surveys at two-to-four-week intervals. The short time between surveys is required so that the control program can keep pace with sagittaria's rapid growth in the Dry Tropics, allowing plants to be detected and treated before they flower and seed. In extreme situations, plants at this site have been recorded transitioning from juvenile to seeding in only one week.

## Achieving control with glyphosate

Like elsewhere in Australia, glyphosate's effectiveness on sagittaria is limited. Glyphosate application in the Ross River kills the above-water foliage, but the plants survive via the network of stolons and tubers. Further, submersed rosettes are not damaged at all



*A patch of sagittaria invading a backwater after glyphosate application, Ross River, Townsville. Note narrow leaf blades, undamaged rosettes visible beneath the water, and presence of few flowers.*

Melissa Green

by the herbicide applications. The emergent foliage that regrows after glyphosate application has shorter and slimmer leaves than prior to application, such that after multiple applications the leaves are only marginally wider than the stems.

Repeated control in this way has resulted in significant reduction in infestation size, with the area of infestation reduced from 560 square metres in 2015 to just 50 square metres in 2019. As of 2023 the total area infested remains approximately 50 square metres. Tubers are now rare, and stolons have reduced from an average of 17 to 2 per plant. The typical size of the stolons has also reduced, from 6 mm diameter to 3 mm.

### Manual control of small infestations

On occasions when new infestations are discovered early while they are small, manual removal of sagittaria occurs. Although time consuming and difficult to achieve, this method provides a way to eliminate new infestations. Newly formed tubers remain attached to stolons, so careful tracing and removing of these can eliminate these propagules, which herbicide application does not achieve.

Where intensive control with glyphosate has reduced the size of infestations, manual removal is also used in the Ross River. This final, intensive push allows sagittaria patches to be eradicated.

Manual removal of existing patches occurs on a weekly basis. The size and number of patches targeted is balanced between the growth of the sagittaria (several sites totalling less than 10 square metres in the cooler months compared to 40 square metres in the warmer months) and the time that the sagittaria removal crew has available.

### The outcome

The outcome of the management program in the Ross River infestation is that 11 years after detection, sagittaria has not spread beyond the Ross River – a big win. This success would not have been achieved without the rapid response from Townsville weed officers, who recognised the threat posed by sagittaria and enacted and resourced an appropriate management program. Ongoing investment of resources is required to ensure this success is sustained.



Melissa Green

Crew returning from controlling sagittaria on Ross River. Note bags of manually removed sagittaria in the boat.

# Case study 4

## Rapid response to sale and propagation in the Northern Territory

Roni Opden,\* Thomas Price,\* Christopher Collins\* and Tony Dugdale

\*Weed Management Branch, Rangelands, Department of Environment, Parks and Water Security, Northern Territory Government



### Key points

- Mislabeled sagittaria plants were being sold at hardware stores.
- A rapid response by weed officers traced and recovered most of the plants sold.
- Two backyard infestations were found and treated.
- Media campaigns and cooperation from hardware stores, wholesalers and consumers contributed to the success of the response.

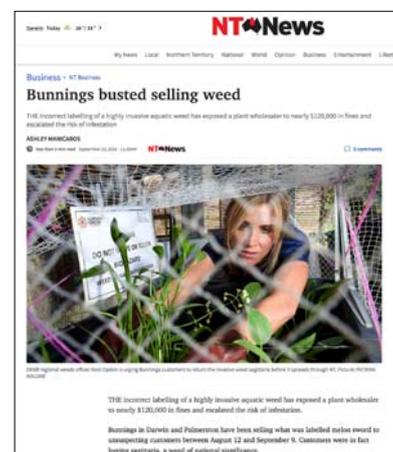
### The situation – outlier infestation

Sagittaria was not known to be present in the Northern Territory until 2016, when it was found being sold at hardware stores in Darwin and Katherine. Establishment of sagittaria in the Northern Territory would represent a substantial expansion of its range in Australia.

### The problem

The Northern Territory is renowned for its freshwater wetlands, which is just the habitat in which sagittaria thrives. In addition, parts of the Northern Territory also match sagittaria's climatic preference. Invasion of sagittaria into such habitats poses a serious threat, particularly to iconic wetlands such as Kakadu.

In 2016, sagittaria was detected for sale at a hardware store by an off-duty Northern Territory Government officer. The sagittaria was labeled Melon Sword (*Echinodorus osiris*).



A news article was part of the media campaign and recall of sagittaria (Source: NT News).

## The solution

A trace-back and trace-forward response was immediately initiated by the Northern Territory Government. This included an extensive media campaign for members of the public to report and return purchased sagittaria, and a rapid response to search the properties at which sagittaria had been reported. A compliance investigation was also launched as sagittaria is a declared weed under the Northern Territory's *Weed Management Act 2001*.

The media campaign successfully generated public interest and triggered the return of at least 24 of the 28 plants that had been sold. Additionally, 109 plants were seized from the wholesaler.

Extensive surveys of constructed and natural waterways were carried out throughout Darwin and surrounds, with no sagittaria detected. Detections were made however, in several urban backyard ponds. One of the respondents to the campaign had an urban pond where sagittaria had been growing for at least 10 years. Associated searches found an additional urban pond where sagittaria had been known to be present for at least 17 years.

Sagittaria plants were removed manually by Northern Territory Government officers. Soil and sediment that could potentially contain seeds and tubers was also removed and the material was buried onsite to limit potential spread.

## The outcome

A compliance investigation found that the sagittaria plants had been misidentified and mislabelled, resulting the in plant wholesaler receiving a fine.

Backyard infestations of sagittaria were identified and plants and material removed. No further sagittaria plants were detected in the Northern Territory until 2022, when a single plant was found at one of the original urban ponds.



Northern Territory Weed Management Branch

*Sagittaria growing in a backyard pond, Northern Territory.*



Northern Territory Weed Management Branch

*The pond after Northern Territory weeds officers removed the sagittaria.*



Northern Territory Weed Management Branch

*Burial of sagittaria plants and associated sediment from the pond.*

# Case study 4

Recovery of 24 of the 28 plants known to be sold by the hardware stores is considered a significant success story. The response from the Northern Territory Government, and the resultant cooperation for hardware stores, wholesalers and consumers,

is a great example of the benefits of a coordinated and rapid response to eliminate the threat to the environment of a weed at a very early stage of invasion.

## Rapid response to the inadvertent sale and propagation of *sagittaria* (*Sagittaria platyphylla*), an aquatic Weed of National Significance

Louis Elliott and Roni Opden, Weed Management Branch, PO Box 496, Palmerston NT 081, Australia, email: roni.opden@nt.gov.au



### Summary

*Sagittaria* (*Sagittaria platyphylla*) is an aquatic Weed of National Significance and a declared Class A weed in the Northern Territory.

In 2016 it was misidentified, mislabelled, propagated and sold by a commercial plant wholesale nursery which triggered a rapid response with the aim to eradicate it in the Top End.

During the highly successful response, 109 potted plants were seized and destroyed prior to sale. Of the 28 plants sold to the public prior to detection, 23 plants have been

recovered. In addition, two historical pond plantings were discovered and controlled.

Surveys of surrounding land and native waterways failed to detect any wild populations.

The incident demonstrated the importance of correctly identifying and labelling plants prior to propagation and sale, and the vital role that government agencies play in reducing the risk of weedy garden and pond plants spreading into the natural environment.

### The Response

#### 1. Detection

An off-duty NT Government Officer detected *sagittaria* for sale in Bunnings in mid-2016, labelled Melon Sword (*Echinodorus osiris*).

Bunnings immediately removed the plants from sale, but 27 had already been sold to the general public.

Weed Management Officers seized 109 potted plants from the commercial plant wholesaler, and all remaining plants from Bunnings.

Several plants were also found at Mitre 10 in Katherine, of which one had been sold.



Photo: Sagittaria for sale labelled Melon Sword.

#### 2. Media campaign and recall

An intense media campaign commenced, alerting the general public to report and return any *sagittaria* purchased.

Many plants were reported and returned. One of these reports was a pond that was planted with *sagittaria* (more than 10 years old).

The pond discovery triggered a rapid response.

#### 3. Rapid response

Searching of residential blocks within 500 m of the historic pond detected a second pond cultivated for 17 years.

Extensive surveys of surrounding wetlands and potential habitat within 2.5 km of pond failed to detect any wild populations.

A compliance investigation was undertaken into the sale of a declared weed under the Weeds Management Act.

#### 4. Outcomes

The public recall raised community awareness, prompted the reporting of purchased plants and the discovery of two historic pond plantings, both of which have been controlled.

To date, 23 *sagittaria* plants have been recovered, out of the 28 sold to the public.

The plant wholesaler was fined for selling declared weeds to the retailers.

The risk of spread to the natural environment of a new weed has been significantly reduced.

#### 5. What went wrong?

Putting up an unknown plant with weedy characteristics - not a good idea.

Not getting accurate identification prior to sale.

Plant labelled with a wrong name.

Biosecurity checks were then conducted on the wrong name and did therefore not pick up the error.

Nursery Industry Best Management Plant Labelling Guidelines are voluntary and not binding.



Photo: Sagittaria flyer distributed to the public.



Photo: Media coverage in the NT News.

### What is the problem?

*Sagittaria* (*Sagittaria platyphylla*), also known as arrowhead, is an ornamental aquatic plant that can invade waterways and native vegetation.

First reported naturalised in 1959 near Brisbane and spread rapidly in the 1970s in Victoria, New South Wales and Queensland.

Chokes wetlands and waterways and restricts waterflow, adversely impacting biodiversity and recreational activities such as boating and fishing.

Prolific seeder, producing up to 20,000 seeds per plant and can also spread through stolons and tubers.

Spread by humans as an ornamental plant and can be accidentally spread from ponds into native waterways.

Early detection is critical to successful control because *sagittaria* is difficult to control with herbicides.



Photo: Sagittaria infestation, Victoria (Raefene Keving, DEDJTR).

### How to distinguish sagittaria from other plants

- Aquatic herb.
- Flowers with 3 white petals and yellow stamens.
- Leaf form is variable with different submerged and emergent forms.
- Emergent leaves have stems that are triangular in cross section.
- Easily confused with sword plants (*Echinodorus* spp.) which are commonly cultivated in pots and ponds.
- Definitive method of distinguishing them requires flowers - *sagittaria* has separate male and female flowers, while sword plants have only one type of flower (with male and female parts).
- Sagittaria* can also be confused with other *sagittaria* species. The most common is 'arrowhead' (*Sagittaria sagittifolia*) which is also cultivated and traded. Arrowhead (*Sagittaria sagittifolia*) can easily be distinguished from *sagittaria* (*Sagittaria platyphylla*) by the long lobes on the leaves which resemble the barbs of an arrowhead.

## Sagittaria

### *Sagittaria platyphylla*



Weed Management Officers from the Weed Management Branch and private advice on all aspects of weed management including: weed identification, biological control, legislative responsibilities, policy advice, monitoring and reporting and signage and signage planning. For further information on weed management planning, signage costs, herbicide application techniques and monitoring please refer to the [www.wm.nt.gov.au](http://www.wm.nt.gov.au) website.

### References

Alex, R., Kewell, R., Keving, R., Saffigna, J. & Power, G. (2012). The Biology of Australian weeds: 03. *Sagittaria platyphylla* (English) and *Sagittaria sagittifolia* (English). Plant Protection Quarterly 27-47-58. Australian Weeds Committee (2012). Weeds of National Significance. *Sagittaria platyphylla* Strategic Plan. Australian Weeds Committee, Canberra.

Peterborough, A. (2012). Weed Management Guide - *Sagittaria*. Australian Government, Canberra.

## We still need your help

Although the recall and response from the general public has been successful, there may be up to five more mature *sagittaria* plants that were sold from Bunnings and Katherine Mitre 10 in 2016 still growing in gardens. We still need your help to locate them as well as any older plantings that may have gone undetected. If you see a plant that might be *sagittaria*, report it to the Weed Management Branch on 08 8999 4567.

Further information  
[weeds.ala.org.au/WoNS/sagittaria](http://weeds.ala.org.au/WoNS/sagittaria)  
[www.nt.gov.au/sagittaria](http://www.nt.gov.au/sagittaria)



### Acknowledgements

The Weed Management Branch would like to thank everyone who has reported suspected *sagittaria* plants during 2016-2017. The recall was immensely successful due to the high level of support from the general public. We would also like to particularly thank people that had *sagittaria* in their ponds for their support and help with its eradication.

Poster detailing the rapid response to the backyard incursion (Source: Northern Territory Weed Management Branch).