NSW GOVERNMENT Department of Primary Industries

FACTSHEET

Sagittaria and arrowhead

Invasive Species Unit

Introduction

Sagittaria (*Sagittaria platyphylla*, previously *S. graminea*) and arrowhead (*Sagittaria montevidensis*) are noxious aquatic weeds in New South Wales (NSW) capable of aggressive growth and rapid spread[1]. These weeds can block irrigation channels, impede water flows and choke natural watercourses and wetlands.

Distribution

Sagittaria is native to North America and was introduced to many continents as an ornamental plant. It was first identified in Australia in 1959 near Brisbane, and then in Victoria in 1962. During the 1980s sagittaria's distribution and density spread rapidly, and it is now widely dispersed in southern NSW, particularly in the Murray Irrigation District and is common in waterways around Sydney and Newcastle. It also occurs in waterways on the mid north and far north coasts and there is an isolated infestation in the northern inland region near Bingara. Recently two new infestations were recorded at Western Plains Zoo at Dubbo and another at Bega on the south coast. At present it is not widespread in other catchments, however it has the potential to spread and become extremely problematic.

Arrowhead is native to North and South America and was first recorded in Australia as a garden escape near Sydney in 1926. During the 1960's arrowhead spread to the Murrumbidgee Irrigation Area near Griffith, and now commonly occurs in rice crops and irrigation channels in the Murrumbidgee Valley. Its distribution is mostly contained to the inland waterways of the Riverina region.

Figure 1. Mature arrowhead leaves are distinctly arrow-shaped.

Figure 2. Sagittaria has oval-shaped leaves with pointed tips.

Habitat

Sagittaria grows in irrigation channels, drains, creeks, rivers, lagoons, dams and wetlands. Establishment is favoured by slow moving or static shallow water. Large channels and waterways with high flow rates, deeper water levels and little seasonal water level fluctuation are less at risk of sagittaria establishment.

[1] Please note *S. platyphylla* is commonly called 'arrowhead' in Victoria. In NSW, arrowhead refers to *S. montevidensis.*

Arrowhead is usually found in shallow flooded areas such as marshes and wetlands and is commonly found in crops such as rice. Drainage gullies, rice fields, permanent swamps and areas associated with irrigation drainage are favoured habitat.

Both sagittaria and arrowhead will establish easily along the edges of irrigation channels (berms).The water depth and flow rates allow seed to settle and plants to establish. The smaller channels provide ideal conditions for infestation, as the water is generally warmer, shallower and slower moving. Fluctuations in depth allow plants to establish while the water is shallow. Sagittaria prefers to grow where silt sediment accumulates such as in smaller channels and on the inside bends of larger channels. Once sagittaria is established in these areas further sediment is trapped, increasing the surface area that can be colonised by the plant's rhizomes.

Impact

In natural systems the vigorous, choking habits of sagittaria and arrowhead threaten native aquatic flora and fauna. Dense infestations restrict water flow and can substantially alter the flow regime of catchments and waterways affecting biodiversity and stream health.

In irrigation systems both species are capable of reducing flow and effectiveness of water delivery. The plant biomass fills the channel bed reducing the volume available for water storage and trapping silt, gradually reducing the capacity of the channel.

Infestations also have detrimental impacts on recreational activities such as fishing, boating and swimming, and reduce visual amenity of waterways.

Description

Sagittaria and arrowhead are emergent aquatic plants that belong to the Alismataceae family. Other similar-looking species in this family include alisma (*Alisma lanceolatum*), water plantain (*Alisma plantago-aquatica*) and star fruit (*Damasonium minus*). Table 1 (below) summarises the differences between sagittaria, arrowhead and these similar-looking species.

Sagittaria is a perennial herb and can grow up to 150 cm tall. Arrowhead acts as a fibrous-rooted annual reaching 100 cm in height.

Leaves and stems

Sagittaria has oval/linear shaped leaf blades with pointed tips, up to 25 cm long and 10 cm wide at the top of each stem (leaf stalk). It also has long narrow strap-like submerged leaves up to 50 cm long. Sagittaria stems are triangular in cross-section.

Arrowhead has broad, strongly arrow-shaped emergent leaves up to 25 cm long and 20 cm wide. It has narrow submerged leaves that can occasionally be slightly arrow-shaped. Arrowhead stems are round in cross-section.

Flowers

Sagittaria flowers appear in whorls or coils. Male flowers are 3 cm across with three white petals and yellow centres. Female flowers have no petals, resembling flattened green berries. Flowers appear below the height of the leaves during spring and autumn.

Arrowhead flowers occur in whorls of 2-12 at the apex of a leafless stem. Female flowers are carried in groups of 3 around the stems, and male flowers occur in groups above the female flowers. There are 3 white petals, 2.5 cm in diameter.

Figure 3: Sagittaria flowers

Fruit/seeds

Sagittaria seeds occur in clusters, consisting of flattened and winged segments, 0.15-0.3 cm long with 1 seed in each segment.

Arrowhead seeds are laterally flattened, 0.15-0.3 cm long with wings.

	SAGITTARIA *S. platyphylla*	ARROWHEAD *S. montevidensis*	ALISMA *Alisma lanceolatum*	WATER PLANTAIN *A. plantago-aquatica*	STAR FRUIT *Damasonium minus*
Origin	North America	America	Europe, west Asia, north Africa	Native to Australia	Native to Australia
Height	150 cm	100 cm	100 cm	150 cm	100 cm
Distinguishing features	Larger flowers (3 cm wide), oval-shaped leaves with only one main mid-vein	Large flowers (2.5 cm wide), strongly arrow-shaped adult leaves	Narrow leaves and large inflorescence held above the height of the leaves, small flowers (10 mm wide)	Small flowers (10 mm wide), oval-shaped leaves with many veins	Small flowers (6 mm wide), large inflorescence held above leaves
Leaves	Emergent leaves: oval-shaped with a pointed tip; to 25 cm long and 10 cm wide. Submerged leaves: long, narrow strap-like without expanded blades; to 50 cm long	Emergent leaves: arrow-shaped; prominently veined; to 25 cm long and 20 cm wide; lobes to 15 cm long and 10 cm wide. Submerged leaves: strap-like, linear	Spear-shaped; to 20 cm long and 4 cm wide; up to 7 prominent veins connected by several transverse veins. Submerged leaves: strap-like	Oval-shaped; 10-25 cm long and 7-10 cm wide; usually 7 prominent parallel veins connected by numerous transverse veins	Oval-shaped; 5-10 cm long and 1.5-4 cm wide; 3-5 parallel veins connected by numerous finer transverse veins
Stems (leaf stalk)	Triangular in cross-section; to 80 cm long.	Round in cross-section	To 80 cm long; flattened on one side with small wings at the base	To 80 cm long, flattened on one side with small wings at the base	To 30 cm long
Flowers	Appear in whorls or coils. Male flowers: 3 white petals with yellow centre; 3 cm wide. Female: no petals; look like flattened green berries. Flowers appear below the height of the leaves during spring to autumn	Female flowers carried in groups of 3 ringing the stem, with male flowers in groups above them; all borne on a leafless stem. Petals are white. Flowers are 2.5 cm wide	Inflorescence (flower cluster) to 60 cm long and 40 cm wide. Flowers 10 mm diameter. Sepals to 2 mm long. Petals 4 mm long, white or pink. Flowers in summer	Wiry inflorescence (flower cluster), to 60 cm long and 40 cm wide. Flowers 10 mm diameter. Sepals to 2 mm long. Petals 4 mm long, pale pink or almost white. Flowers on long stems above height of leaves	Inflorescence (flower cluster) to 50 cm long. Flowers 6 mm in diameter. Sepals 1 mm long, green. Petals ovate 6 mm long, white or pink. Flowers early summer
Fruit/Seed	Cluster 0.5-1 0 cm across; 1 seeded segment flattened and winged 1.5-3 mm long. Each plant can produce up to 20,000 seeds	Clustered; laterally flattened, 1.5-3 mm long, beaked at the apex with dorsal wings	Triangular; 2-2.5 mm long. Each fruit contains 1 seed	2-2.5 mm long, falling singly	Star-shaped

Table 1. Distinguishing features of sagittaria, arrowhead and similar-looking species found in NSW.

Morphological forms

Sagittaria has three morphological growth forms: submerged rosette, broad-leaved emergent and narrow-leaved emergent. These forms play an important role in the life cycle allowing the species to adapt to varying environmental conditions.

Arrowhead generally has two growth forms, submerged rosette and emergent. Arrowhead does not produce rhizomes like sagittaria making it easier to manage.

Submerged rosette form of sagittaria

The submerged rosette form develops following germination and can persist for several years without producing erect emergent stems. The emergent form develops when conditions are suitable. The rosette form does not produce

flowers or seeds but can produce rhizomes and corms. This is one of the keys to the plant being able to survive and perpetuate without producing emergent stems.

The rosette form is commonly found in deeper water where conditions are unsuitable for the emergent forms. It can also be found interspersed with the emergent forms in dense stands.

Broad-leaved emergent form of sagittaria

Rosettes grow into emergent plants if water height is approximately less than one metre. This may be due to depth-related factors such as light reduction in deeper water which prevents emergent forms developing.

The broad-leaved emergent form arises from an energy-rich rhizome system. It tends to occur in slow-moving parts of channels and streams, along river banks and at the extremities of infestations. Infestations in drains tend to be established from seed, rather than from existing plants. The warm, shallow and slow flowing water in drains favours the settling and germination of seed and the growth of healthy, broad-leaved plants.

Figure 4: Broad-leaved emergent sagittaria

Narrow-leaved emergent form of sagittaria

The third form of sagittaria is an emergent form with narrow leaves and an almost grass-like appearance. Compared to the broad-leaved form, these leaves give plants an ‘unhealthy’ appearance, and are thought to arise from depleted rhizomes.

When broad-leaved plants are damaged by flooding, herbicide application or grazing they will re-emerge as the narrow-leaved form. The narrow leaves supply energy to the rhizome through photosynthesis until the rhizome is healthy enough to produce new broad-leaved plants.

Figure 5: Narrow-leaved emergent sagittaria

Lifecycle and spread

Sagittaria and arrowhead can reproduce via several methods. They are prolific seeders, with each plant having the ability to produce hundreds of thousands of seeds. They can also reproduce vegetatively by stem or root fragments, and sagittaria can reproduce from underground rhizomes and corms. These reproductive options allow both species to spread rapidly, survive adverse conditions and resume growth when conditions are more favourable.

Seed production occurs from September to May. Seed can either germinate immediately or remain dormant only germinating when conditions are favourable. Seed may be dispersed via animals such as stock and birds or by water currents.

Seed can float for up 3 weeks before sinking. This ability aids in dispersal. The stimulus for germination includes sufficient light and water absorption by the outer seed coat.

The corms produced by sagittaria are rounded fleshy organs that contain starch and form at the terminus of a rhizome. Corms can remain viable in the soil for many years. Observations from research suggest corms are produced in response to periods of stress such as the onset of winter, dry soils and herbicide application. However, corms can be observed in most infestations. The production of corms allows for rapid regeneration of sagittaria following periods of stress, rather than having to recruit from seed. Corms and rhizomes are dormant through winter and regenerate in spring.

After seeds germinate plants grow into grass-like seedlings which can mature into any of the morphological forms depending on conditions.

Sagittaria germinates from late winter to spring. If an emergent form develops, flowers appear soon after establishment and can continue until colder weather affects growth (around May or June).

Arrowhead seeds germinate in spring and plants mature during summer producing flowers from January to March. Seeds mature throughout autumn and adult plants die back during the colder months.

Control and management

There are limited effective herbicides available for sagittaria control and it therefore poses a greater threat to agricultural production and the environment. Arrowhead is more susceptible to herbicide treatments.

Chemical control

There are no chemicals registered for sagittaria control in NSW. Some agencies and organisations in the Riverina district of NSW hold off-label minor use permits issued by the APVMA (Permit number PER10712, Expiry June 2013) that enable them to use glyphosate in specific waterways. For further details go to the APVMA website www.apvma.gov.au

Often herbicides will only suppress infestations and regeneration will occur. Foliar applied herbicides act as a 'chemical mower', causing an abscission at the base of the stem resulting in the death of standing leaves and stems. Generally these herbicides are not translocated to the submerged rosettes or the underground corms and rhizomes. Often, the rosette plants growing within treated infestations are stimulated by the reduced competition and can transform into new emergent plants.

Water depth can affect efficacy as foliar applied herbicide must come in contact with a large surface area of the plant. In deeper water there is less exposed plant material to treat with herbicide.

Treatments are best applied when water levels are lowest and plant growth is highest to enable maximum uptake of the herbicide. Sagittaria grows actively and rapidly in autumn (around March and April) and these months may be optimum times for herbicide applications, however this is also the middle of the irrigation season when water levels are high and infestations are largely submerged. Risks of herbicide residues in irrigation water are also higher at this time. It is currently thought herbicide treatments on sagittaria at the end of the irrigation season are less effective as plants are beginning to overwinter.

Arrowhead does not appear to be as persistent as sagittaria. A number of herbicides are registered to control arrowhead. To view the list of products visit the APVMA website at www.apvma.gov.au

Recent developments in applied steam technology may provide an alternative to the use of herbicides in sagittaria control. In theory the application of steam would have the same role as herbicide, as an initial treatment to kill the above ground plant material. This method is being trialled throughout Australia and specifically on sagittaria in Victoria.

Physical removal

Physical removal involves excavation with machinery or manual digging by hand. Physical removal allows water movement to be restored quickly in waterways blocked by infestations. It is also a technique used in areas where herbicide use is inappropriate, such as near sensitive waterways or irrigation channels under continual use.

Appropriate hygiene and containment measures must be applied during manual removal to ensure plant fragments do not float downstream and establish elsewhere. It is also important when excavating to ensure the root and rhizome fragments in the soil are removed to avoid future regeneration.

Excavation can be labour intensive and costly and is generally avoided in irrigation channels where it interferes with the engineering structure of the drain. However in new and isolated infestations where eradication is possible mechanical and manual removal should be considered. By removing all viable plant material and following up with removal of regrowth, eradication is possible. Physical removal can be particularly effective to control isolated or new infestations.

Legislation

Sagittaria and arrowhead are declared noxious weeds under the *NSW Noxious Weeds Act* 1993. Sagittaria is declared a Control Class 5 noxious weed throughout the state. Sagittaria is also a Control Class 4 noxious weed in certain areas of the state see Figure 6.

Arrowhead is declared a Control Class 4 throughout the entire state.

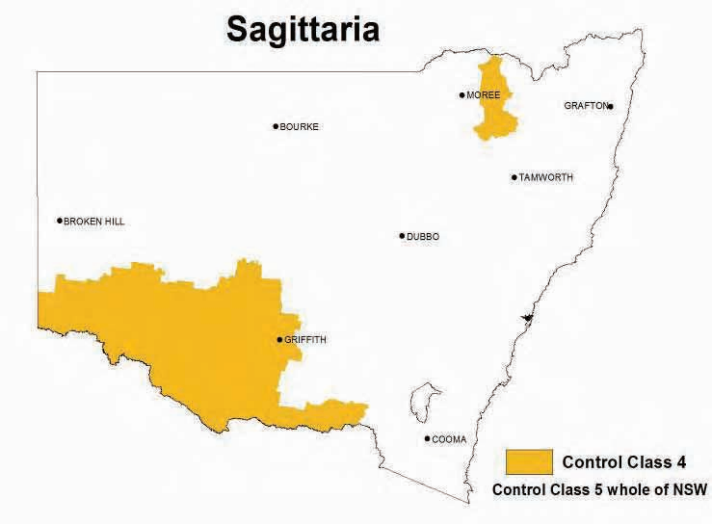

Figure 6: Declaration of sagittaria in NSW.

The declared Control Class defines how the weed needs to be managed in your area. Contact your local council weeds officer or refer to the NSW DPI weeds website www.dpi.nsw.gov.au/weeds for further details.

The responsibility for control of noxious plants and appropriate disposal of plant material on private land rests with the owner or occupier of the land. Failure to do so could result in the local control authority issuing a weed control notice, court action and/or a fine.

Local control authorities must adequately control noxious weeds on land under their control to prevent them from spreading to and infesting adjoining land.

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Figure 1. Graham Prichard, Lake Macquarie Council

Figure 2. Rebecca Coventry, NSW DPI

Figure 3. Graham Prichard, Lake Macquarie Council

Figure 4. Graham Prichard, Lake Macquarie Council

Figure 5. Melissa Kahler, NSW DPI

Figure 6. produced by Alan Maguire, NSW DPI

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