A survey of *Sagittaria* spp. (Monocotyledons: Alismataceae) populations throughout the irrigation districts of northern Victoria

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**Summary**  *Sagittaria* spp. (sagittaria or arrowhead) are emergent aquatic perennials native to the Americas that have naturalised in Australia following introduction as ornamentals. The problems caused by *sagittaria* in the northern irrigation regions of Victoria and the extent of the infestations are increasing. Collation and mapping of distribution data was undertaken to determine the present distribution of *sagittaria* across northern Victoria. Additional field survey work was carried out in areas for which data were lacking. Herbarium specimens and plant tissue were collected for taxonomic studies. A distribution map of *sagittaria* has been produced that will provide a baseline for assessment of any future spread.

**Keywords** Arrowhead, aquatic weed, mapping.

**INTRODUCTION**

*Sagittaria* spp. are emergent aquatic macrophytes exotic to Australia. Although usually perennial they can behave as annuals (Sainty and Jacobs 2003). They were originally imported to Australia from North America for ornamental purposes as garden pond plants. During the last 40 years they have become naturalised in Australia in rice crops, irrigation channels, creeks, rivers, lakes and swamps, generally growing where water depths are less than a metre, and including places that are only periodically inundated. The taxonomy of *Sagittaria* spp. is problematic, and recent revisions have failed to agree. A number of different taxa have been listed as naturalised in Australia (Hnatiuk 1990, Sage *et al.* 2000), which are referred to by the common names ‘arrowhead’ or ‘sagittaria’

The species of *Sagittaria* common in northern Victoria is an erect plant, growing to 1.4 m in height at maturity. The leaves are lanceolate and are a distinctive dull green colour. The flowers are white, with yellow centres, and grow on fleshy triangular stems. Spread occurs through the production of floating seeds, of rhizomes and corms. *Sagittaria* grows best in static to slow moving water where there is a suitable silt substrate.

*Sagittaria* is an important problem in northern Victoria due to its rapid spread and capacity to quickly produce dense infestations. Each plant has the ability to produce many seeds, which can be spread downstream in water and also by birds. In the irrigation areas of northern Victoria, *sagittaria* blocks irrigation channels and drains, reducing the capacity of the water authorities to deliver their irrigation supplies effectively. Control of *sagittaria* costs Goulburn-Murray Water more than $250,000 a year and local landholders spend roughly an equivalent amount (M. Finlay, G-M Water pers. comm.). *Sagittaria* may also threaten biodiversity values in aquatic ecosystems when it infests rivers, creeks and wetlands, although its effects on these systems have not been quantified. It is a difficult plant to control; herbicides cause temporary dieback, but it re-grows from submerged rosettes. High rates of herbicides are required to maintain channels and drains; these uses and also treatment of *sagittaria* in Nine Mile Creek, Broken Creek and the Murray River are authorised under strict conditions by several Australian Pesticides and Veterinary Medicines Authority permits (APVMA 2006).

Attempts to mechanically remove the plants often result in the spread of plant fragments along the watercourse. *Sagittaria* is particularly problematic in irrigation channels where low flow has created silt sediment beds. While it usually grows in water less than 1 m deep, if the level rises beyond this it can persist as an underwater rosette form until the water level recedes.

The purpose of this project was to map the distribution of *sagittaria* across northern Victoria. This will assist in developing suitable management strategies to deal with its spread. Also, plant specimens were collected to provide herbarium specimens for taxonomic studies. Plant tissue samples were also collected for future molecular work. The survey was limited to northern Victoria and excluded adjacent areas of New South Wales, where is known to occur, due to the limited resources and time available for the project.
MATERIALS AND METHODS

Existing sagittaria distribution data were obtained from relevant waterways and wetlands managers including Goulburn-Murray Water, Goulburn Broken Catchment Management Authority and Parks Victoria. This information included known infestations in the Murray River, Broken Creek and within the Shepparton, Murray Valley and Central Goulburn Irrigation regions, and had been collected as a part of each organisation’s control strategy.

The data were collated using ArcView GIS mapping software and used as the base for a current sagittaria distribution map. Areas where gaps occurred in the data were subjected to field surveys to determine the presence or absence of sagittaria. This consisted of searching locations that were accessible and that local knowledge suggested might provide suitable conditions for sagittaria. During the growing season sagittaria is easily visible unless obscured by abnormally high water levels. The distinctive leaves and flowers make it readily identifiable. Additional mapping of the Murray River upstream of Echuca by boat was undertaken with assistance from Goulburn-Murray Water.

Sagittaria specimens were collected from across northern Victoria, with three plant press samples and a tissue sample taken at 41 sites visited across the region. The tissue samples were dehydrated with silica gel and frozen to await future molecular taxonomic work. Two of the three pressed samples from each site will be lodged with Australian herbaria, the third (the plant from which the tissue sample was taken) will be provided to the laboratory undertaking the molecular studies.

RESULTS

Distribution of sagittaria in the survey area is shown in Figure 1. There are heavy infestations of sagittaria throughout the Shepparton and Murray Valley irrigation areas. Isolated infestations occur across the Central Goulburn and Torrumbarry irrigation areas. The Rochester and Pyramid Boort irrigation areas appear to be free of sagittaria.

Infestations on natural waterways include the Murray River from Yarrawonga to downstream of the Torrumbarry Weir, the Broken Creek and Goulburn River. These infestations have the ability to cause continued spread further down the Murray River system.

Only small variation in the appearance of sagittaria across the region was observed. Plants in the natural waterway systems were larger with broader emergent leaves than the narrower strap-like leaf appearance.

Figure 1. Location of Sagittaria spp. in northern Victoria.
typical in the irrigation channels. Although detailed examination of all the specimens has not yet been completed, the sagittaria found in this survey appears to be consistent with descriptions of the taxon variously referred to as *Sagittaria graminea* var. *platyphylla* Engelm. or *Sagittaria platyphylla* (Engelm.) J.G.Sm. In New South Wales, *Sagittaria montevidensis* Cham. & Schlecht., a species with large arrowhead-shaped leaves to which the common name arrowhead is more appropriate, is a common weed of rice cultivation (Flower et al. 1999, Seal et al. 2004), but it does not appear to have been encountered here.

**DISCUSSION**

The constant threat of seed spread from areas of the Murray River upstream of Torrumbarry creates a requirement for ongoing control. At present Goulburn-Murray Water conduct a spraying program two or three times a year along the Murray River from Echuca to Torrumbarry to prevent sagittaria from spreading downstream to the Torrumbarry irrigation channels and South Australia. The failure to undertake control over a single year may result in establishment of the plant in new areas. Goulburn-Murray Water also conducts spraying of sagittaria in the channels and drains within the Central Goulburn, Shepparton and Murray Valley irrigation areas to allow for the delivery of water during the irrigation season.

Application of chemical control by Goulburn-Murray Water in natural waterways is highly restricted because the high rates required create problems with residues in the water. Some infestations observed had spread from both banks of the creek leaving only a narrow channel of open water, which, without intervention, would close completely. Oxygen concentrations may be seriously depleted below dense sagittaria beds, with serious consequences for aquatic invertebrates and, possibly, passage of native fish.

Areas for future surveying include detailed mapping of the Barmah State Forest, and surveys of the Ovens River, and Murray River upstream of Lake Mulwala. These areas could be potential sources of infestation for new areas. Numerous wetlands and creeks adjacent to the Murray River are also likely to be infested with sagittaria. Flooding regimes within the Barmah State Forest have provided suitable habitat for sagittaria to produce seeds to spread into the adjacent Murray River.

Prior to the commencement of this project, information regarding the distribution of sagittaria across northern Victoria had not been compiled. This project has produced a distribution map of sagittaria, which will provide a baseline for assessment of future spread. Pressed plant specimens from 41 locations have been collected to add to the five sagittaria specimens contained at the Melbourne Herbarium. Tissue samples have also been collected to enable further taxonomic resolution of sagittaria in this region, which will be an important step towards increased understanding of this weed, especially if biological control is contemplated.

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**REFERENCES**


