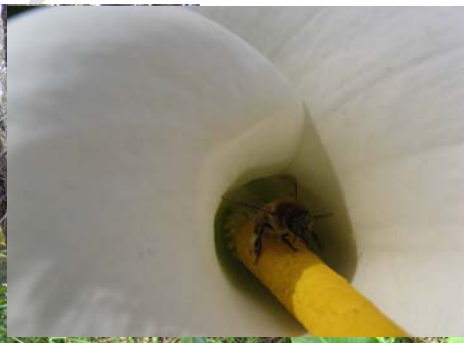
Arum Lily
Zantedeschia aethiopica

Strategic Plan for the Swan NRM Region

September 2008



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Department of Environment and Conservation

Australian Government

ACRONYMS

DEC – Department of Environment and Conservation
DAFWA – Department of Agriculture and Food Western Australia
SCC – Swan Catchment Council
LGA – Local Government Authority
NRM – Natural Resource Management
IBRA – Interim Biogeographic Regionalisation of Australia

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FOREWORD

Arum lily, pig lily, canna lily and lily of the Nile all refer to the well-known species *Zantedeschia aethiopica*. Arum lily was introduced to Australia from South Africa as a garden plant and has subsequently become a serious widespread environmental weed. In the Swan NRM Region of south west Western Australia, it is a common weed of freshwater wetlands, particularly on the Swan Coastal Plain. Many of these wetlands are important for biodiversity conservation and key components in maintaining ecological functions associated with the hydrological cycle. Arum lily is a major threat to these areas, as it rapidly reproduces to form dense monocultures and readily out-competes native under storey vegetation.

Arum lily was nominated in the list of 71 species for assessment as a Weed of National Significance (WONS), but was not included in the final list (Weeds Australia undated). Although it produces a popular cut flower, in areas near Perth it is a Declared weed because of its environmental impacts and the risk posed to children, as all parts of the plants are toxic. A Statewide ban on its sale and trade was introduced in 2006, after lobbying for it to be made illegal to sell, and for control to be required on private and public lands where it has established (DAFWA 2006).

As arum lily is widespread and abundant, management on a regional scale presents significant challenges. Some infestations are small and localized, however many are well-established and threaten high biodiversity values areas, including Regionally Significant Bushlands, Nationally Important Wetlands, Threatened Ecological Communites and Ramsar wetlands. As with many other weeds, it occurs across a range of tenures, making communication, coordination and cooperation integral in implementing an effective management program.

The priority of this strategy is to coordinate and implement on-ground actions to eradicate infestations which threaten high biodiversity assets in the Swan NRM Region. Providing appropriate resources to achieve this goal will help provide long-term protection of the Region's biodiversity. The strategy provides the following information on arum lily:

- biology and ecology;
- current distribution in Australia, Western Australia and the Swan NRM Region;
- impacts and threats;
- best practice control methods and
- management recommendations.

The purpose of this strategy is to:

- provide information essential for the strategic control of arum lily in the Swan NRM Region and
- facilitate, encourage and provide support to regional and local efforts for control of arum lily.

CONTENTS

1. CONTEXT AND PREPARATION

This strategy has been developed as an outcome of a Natural Heritage Trust-funded Invasive Environmental Weed Project for the Swan NRM Region. The project forms part of the 2006-2008 Swan Catchment Council Investment Plan, and is being completed by the Department of Environment and Conservation. Among the project's outcomes is the development of strategic plans for six of the Region's high priority environmental weeds, one of these being arum lily. Each of the species presents a major threat to the Region's rich biodiversity values. The six were selected to represent a range of life forms and different management objectives and approaches, so as much as possible the plans could be used as models to develop strategies for other environmental weeds within the Region and beyond.

2. AREA COVERED

This strategy centres on the Swan NRM Region in the southwest of Western Australia. It is made up of the Swan Coastal Plain and Jarrah Forest IBRA regions and numerous, overlapping management boundaries. These include NRM sub-regions, DEC regions and districts and Local Government Authority boundaries, as shown in Appendix 1.

3. DESCRIPTION

Taxonomic relationships

Arum lily belongs to the genus *Zantedeschia* in the family *Araceae* or Arum family. This family is made up of herbaceous monocots with 106 genera and about 4025 species (Aroid 2008). Members of the family are highly diverse in life forms, leaf morphology, inflorescence and other characteristics, with forms ranging from submerged or floating aquatics to tuberous terrestrials. The family is best charactersied by its distinctive inflorescence and includes other genera such as *Alocasia*.

Plants now listed in the genus *Zantedeschia* were once all called arums, and were reclassified in the genus *Richardia*, but now reside in the genus *Zantedeschia*. The flowers of members of this genus are commonly known as arum lilies or calla lilies. Within the genus there are eight species, all of which are indigenous to southern Africa. Arum lily (*Z. aethiopica*) is the largest of the genus growing to a height of 1m and is most common of all the species in Southern Africa. Other species include *Z. albomaculata*, *Z. elliottiana*, *Z. jucunda*, *Z. odorata* (scented arum) which is similar in appearance to *Z. aethiopica* and restricted to the northern cape, *Z. pentlandii*, *Z. rehmannii* and *Z. valida*.

Arum lily features

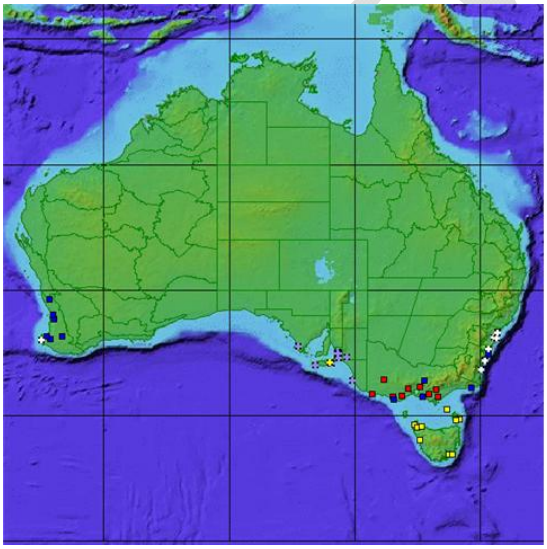
Arum lily is a robust clump-forming, dark green, perennial, succulent herb, with triangular-shaped leaves (Figure 1). It is rhizomatous, developing from a large tuberous root referred to as a rhizomatous tuber, with the above ground growth dying back over the warmer months (Brown and Brooks 2002). The petioles or leaf stalks are up to 0.4m long and smooth; the leaf blades are thick and fleshy, pointed at the apex with blunt lobes at the base. It has white to green-white tubular flowers which become funnel shaped at the top with a slit down one side. It flowers during late winter through spring and has 10mm long orange fleshy fruits and yellow-brown seeds 3mm in diameter. All parts of the plant including the tubers, leaves, flowers and fruit are poisonous.

Figure 1 (left to right): arum lily tuber with daughter tubers starting to develop, illustration by Libby Sandiford, reproduced from Brown and Brooks (2002); single plant growing to approximately 1m tall, close up of flower; mass of plants growing in understorey; single flower showing tubular form.

4. HABITAT AND DISTRIBUTION

Australia and Western Australia

Arum lily is found throughout southern temperate Australia, including coastal New South Wales, southern Victoria, south west Western Australia, Tasmania and South Australia (figure 2.1). It is found in open to semi-shaded conditions in damp areas, disturbed creeklines, waterways, floodways, drains, gullies, bushland and sand dune heath.



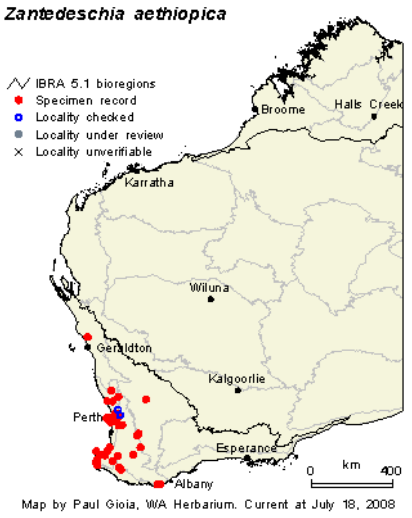


Figure 2.1 (left): distribution of arum lily in Australia based on herbarium collections (Australia's Virtual Herbarium 2008); **Figure 2.2:** distribution of arum lily in Western Australia based on State herbarium collections (WA Herbarium 2008).

In Western Australia arum lily occurs across the higher rainfall area of the south west corner of the State from Northampton to Albany, with outliers recorded from north of Geraldton and the Avon Wheatbelt, as shown in Figure 2.2 (WA Herbarium 2008).

Swan NRM Region

Arum lily is abundant in freshwater wetlands, creeks, river margins, shaded upland areas and degraded low-lying seasonally inundated sites on the Swan Coastal Plain. Fewer populations are recorded from the forest areas east of Perth in the Jarrah Forest IBRA Region (Figure 3). Keighery (1997) suggests this may reflect a true absence of arum lily from these habitats, as the majority of the area may be too dry for arum lily to establish. Arum lily in this area is otherwise restricted to disturbed creeklines at forest edges, especially near towns and old settlements along the western edges of the jarrah forest.

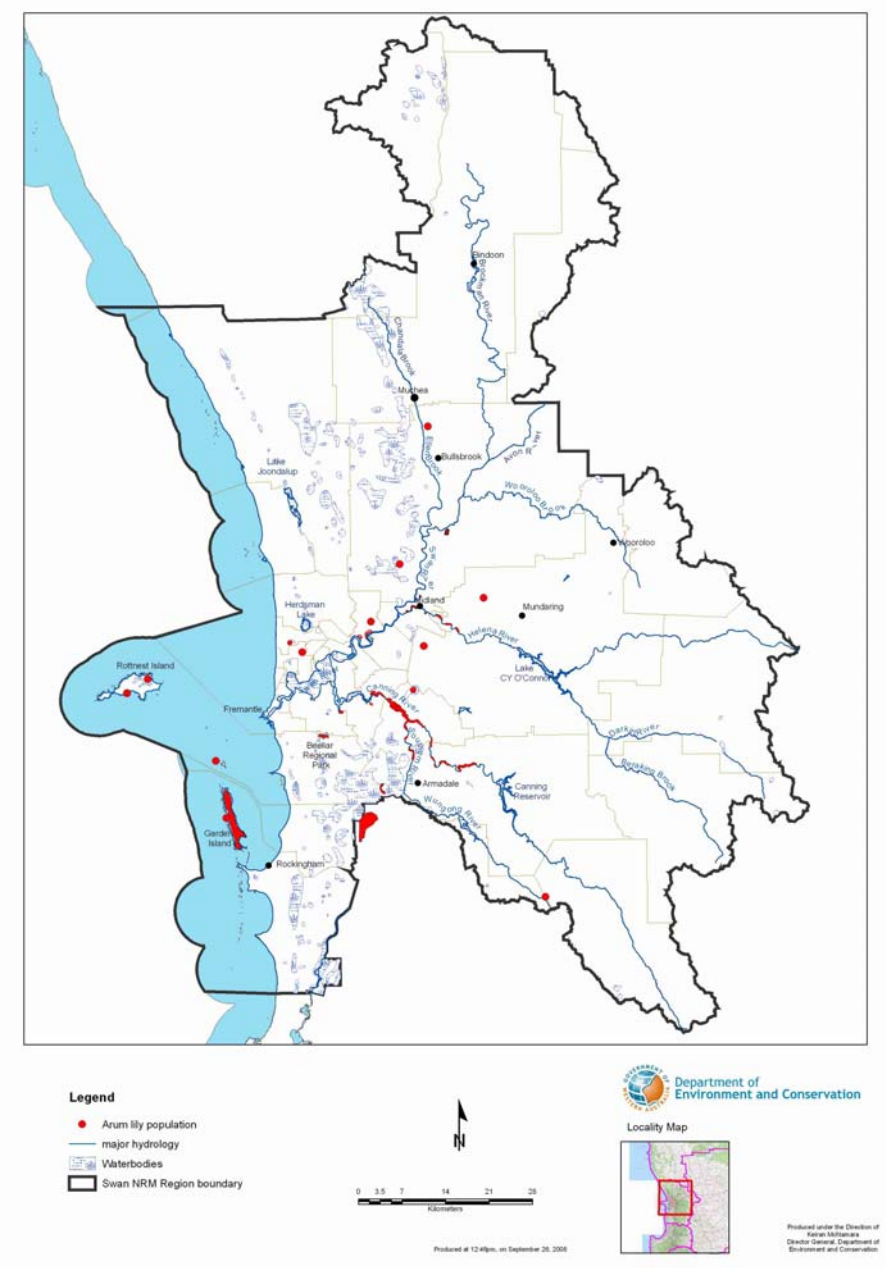


Figure 3: distribution of arum lily in the Swan NRM Region against major hydrology and waterbodies, based on SRT data (2007), Herbarium records (Western Australian Herbarium 2007) and Keighery (1997).

Arum lily is known to thrive in sandy soils with a periodically high water table (Sainty and Associates 2003) and to prefer calcareous soils in higher rainfall areas of the State (Keighery 1997). Conditions on the Leeuwin-Naturaliste Ridge in the southwest and on the Swan Coastal Plain make these areas highly susceptible arum lily invasion, and these areas appear the most heavily infested by arum lily.

Arum lily is often recorded from wetlands, old home sites, road verges, paddocks and second order streams such as Bennett Brook (Keighery 1997). It has been recorded from many conservation areas, including Nature Reserves, National Parks, Regional Parks, Local Government Reserves and other Conservation Reserves, listed in Table 1.

Most of these invasions are in wetland areas (swamp, creeks, rivers, lakes and seeps) under *Melaleuca* and/or flooded gum (*Eucalyptus rudis*) woodlands or in low sedgelands of *Juncus* species or *Baumea juncea*. SRT foreshore assessment survey of the Swan River and major tributaries undertaken in 2007 indicates arum lily is abundant in the middle and upper Canning River through to Armadale and Southern River, present in the middle and upper Swan River and throughout the Helena River. Populations are recorded in Midland, Guildford and Caversham in the east. It has been collected from Bullsbrook Nature Reserve north of Muchea, but is likely to be common in the general Bullsbrook area through to EllenBrook, Brockman River and lower Avon River.

On the lower Swan River, a population occurs in Alfred Cove in the Swan River Estuary Marine Park adjacent to Tompkins Park, and in the lower Canning River there is an isolated population in Yagan wetland, Bullcreek. There are other more fragmented occurrences in bushland throughout the northern coastal plain. These include localised infestations in tuart *(Eucalyptyus* gomphocephela), jarrah (*E. marginata*) or Banksia woodland in Shenton Bushland, Yanchep National Park, and Kings Park and Bold Park in the west.

Arum Lily is also present in limestone heath and *Acacia* shrubland on offshore islands: it widespread on Garden Island, and infestations have been recorded on Rottnest Island and Carnac Islands.

Table 1: Occurrences of arum lily in conservation reserves across the Coastal Plain, based on Keighery (1997), WA Herbarium collections (WA Herbarium 2008), 2007 SRT survey data and recent survey (DEC).

National Parks
Yanchep National Park
Nature Reserves
Attadale Nature Reserve
Bullsbrook Nature Reserve
Forrestdale Lake
Regional Parks
Herdsman Lake Regional Park
Canning River Regional Park
Beeliar Regional Park – Spectacles, Yangebup, Bibra Lake, North Lake, Market Garden Swamp, Brownman Swamp and Mount Brown Swamp)
Local Government Reserves
Lake Gwelup
Bennett Brook
Yagan Wetland, Bullcreek
Shenton Bushland
Other Conservation Reserves
Garden Island
Rottnest Island Reserve
Kings Park and Bold Park
Greater Brixton St Wetlands
Whiteman Park

5. BIOLOGY AND ECOLOGY

A calendar of arum lily growth, flowering, seed production and germination times in south west Western Australia is presented in Table 2. Table 2 also shows the optimum times for control measures based on its biology and ecology.

Table 2: Calender of arum lily biology and management.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Dormant												
Growth												
Flowering												
Seed production												
Germination												
Physical removal												
Herbicide application												

Arum lily spreads vegetatively from tuber fragments as well as from seed. It produces large amounts of viable seed, which germinates in late autumn to winter and remains viable for approximately four months (Panetta 1988). Plants can flower and set seed after three or four years. Established plants initiate leaves and flowers each year approximately at the same time, usually in late winter to early spring. The flower stems collapse after flowering and the seed ripen as the spathe dries out.

Much of the longer distance spread of arum lily has been the result of its use as an ornamental (Parsons and Cuthbertson 1992). Birds are also a major dispersal agent. Natural spread by offsets from the perennial tubers is very localized and is less than 30cm per year (Moore 1997). Other methods of dispersal, including foxes, stock, water movement, and rhizome spread by dumping of garden waste accounts for other short to medium distance spread.

The biology and ecology of arum lily has been the subject of several studies and is documented elsewhere in detail. Further information on its toxicity is provided by the US Food and Drug Administration Poisonous Plants Database.

6. ECOLOGICAL IMPACTS AND THREATS

Arum lily is highly invasive, can reproduce rapidly, form dense monocultures and severely impact on a range of wetland and terrestrial communities on the Swan Coastal Plain, forest areas and offshore Islands. It is most abundant on the Coastal Plain; however this contains key areas of biodiversity and other values.

Wetlands and river foreshore areas of the Swan Coastal Plain are widely recognized as important areas of biodiversity, linkages and as key components in maintain ecological function and stability. They also provide areas of public open space and landscape diversity.

Arum lily also presents a major threat to the plant communities of the offshore islands. In the case of Garden Island, arum lily has been identified as the highest weed threat to the island's ecological integrity, with its management consuming significant time and budget allocations to weed environmental management. The problems posed have been identified as:

- ability to displace native plant species;
- invasiveness into undisturbed vegetation;
- ability to change the vegetation structure;

- alter wildlife habitat;
- toxicity and resulting of reduction of food sources available to native fauna and
- impact on aesthetic values (Wykes 1997).

There are likely to be many locally significant sites where arum lily presents a threat and where control programs have local benefits; however the values of Regionally Significant areas, including many Bush Forever sites are under greatest risk. These values at particular threat from arum lily may be used as criteria for prioritizing sites for protection. On a regional scale the values at risk from arum lily are listed in Appendix 2.

The Regionally Siginificant areas (including Bush Forever Sites) with these values at risk from arum lily, where arum lily is present is shown in Table 3.

Table 3: Regionally Siginificant areas (including Bush Forever Sites) with fore mentioned values at risk where arum lily is present.

SUBREGION	AREA/SUB-CATCHMENT	SITE	BFS Site number	VALUES	SIZE	Level of Infestation	Priority for management
South	Beeliar	The Spectacles	269	Directory of Important Wetlands			
		Bibra Lake, North Lake	244	Significant flora and fauna, EPBC Act	128.2	moderate	
	Swan River foreshore	Attadale Nature Reserve				low	
Southeast	Brixton St	Greater Brixton St Wetlands	387	TEC (3a,10a,7,80,) Directory of Important Wetlands, Significant flora and fauna, EPBC Act	126.7	low	
	southeast	Forrestdale Lake	345	Ramsar wetland, Directory of Important Wetlands		high	
		Canning River Regional Park	224	Significant fauna, contains 1181m of regionally significant river	161.2	high	
Coastal – offshore islands	west	Rottnest Island	-	Directory of Important Wetlands		medium	
	south	Garden Island	63	TEC (30a), Significant flora and fauna, JAMBA/CAMBA species, EPBC Act	956.9	high	
		Carnac Island	473	Significant fauna, JAMBA/CAMBA species, EPBC Act	19.6	low	
North		Herdsman Lake	281	Directory of Important Wetlands		moderate	
		Bold Park, Kings Park	312,317	Significant flora and fauna, JAMBA/CAMBA species, EPBC Act	316.7, 320.8	low	
		Lake Joondalup		Directory of Important Wetlands		moderate	
		Yanchep National Park	288	TEC (19,26a0, Significant flora and fauna, Directory of important wetlands, EPBC Act,	2706	high	
		Lake Gwelup	212	Significant bird species,		moderate	

		Reserve		EPBC Act			
		Yellagonga Regional Park	299	Directory of important wetlands, Significant flora and fauna, JAMBA/CAMBA species, EPBC Act	380.9	moderate	
Northeast	Bullsbrook	Bullsbrook Nature Reserve	292	TEC (7), Significant flora, EPBC Act,		unknown	high

There are a number of other large regionally significant areas with these values, where the status of arum lily is unknown. However, given the plant communities invaded by arum lily, these areas are all at high risk (Table 4).

As invasion and reinvasion can occur by water and by birds and management needs to be planned on an area or catchment basis, these sites have been grouped into landform elements, sub-catchments and subregions. These sites require further survey and assessment before management recommendations and strategies can be developed.

Table 4: high biodiversity value sites where the status of arum lily is unknown, but are at high risk and requires further assessment in lieu of protection, based on Bush Forever (WA Government 2000).

SUBREGION	AREA/SUB-CATCHMENT	SITE	BFS site number	VALUES	Size (HA)	Priority
South	Beeliar	Thomsons Lake	391	Ramsar wetland, JAMBA/CAMBA species, Siginifcant flora and fauna, Directory of Important Wetlands	366.7	
		Booragoon Lake	337	Directory of Important Wetlands		
Southeast	Brixton St/Airport woodland	Perth Airport and adjacent Bushland	386	TEC (20a,b,7,15), Significant flora and fauna, Directory of Important Wetlands	629.5	
		Brixton St Wetlands		Directory of Important Wetlands, TEC, Significant flora and fauna		High
	Southeast	Jandabup Lake and adjacent bushland	324	JAMBA/CAMBA species, EPBC Act	107.5	
		Gibbs Rd Wetlands	344	Directory of Important Wetlands		
Northeast	Bullsbrook/Ellenbrook	North East Ellenbrook bushland	2	Significant flora, contains 1828m of regionally significant river	50.8	
		Pearce Aerodrome and adjacent bushland	294	TEC (3c,8,15), Significant flora, EPBC Act	213.5	
		Maroubra Ave Bushland	89	TEC (3c), EPBC Act	10.2	
		Twin Swamps Nature Reserve and Adjacent bushland	400	Directory of Important Wetlands	170.7	
		Ellenbrook Nature Reserve and adjacent bushland	301	TEC (3c,8), Directory of Important Wetlands, EPBC Act	63.6	
		Kirkby Rd Bushland	97	TEC (Community of Tumulus Springs), EPBC Act	440.7	
		Whiteman Park	304	Significant flora and	1547.9	

				fauna		
North	Middle/Upper Swan River	RAAF Caversham,	200	Directory of Important Wetlands, Significant flora,	97	
		Palmer Barracks, Guidlford	-	Directory of Important Wetlands		
South	Rockingham lakes Regional Park	Paganoni Bushland	395	Significant flora and fauna	705.5	
	Coastal	Port Kennedy, Becher Point wetlands	377	Directory of Important Wetlands, TEC (19), Significant flora and fauna, EPBC Act	674.9	
		Point Peron and adjacent bushland	355	Significant fauna	107.1	
Offshore islands	south	Penguin, seal , bird and gull islands, shag rock	367	JAMBA/CAMBA species, EPBC Act	6.1	

Size of these areas has been a consideration in determining the priority sites for survey and protection. It is generally accepted that large consolidated areas are the best options for viable conservation of natural ecosystems and populations. Within the Perth Metropolitan Region many of the Bush Forever Sites are small in size (less than 100 hectares) and isolated from other conservation areas (WA government 2000) however the focus will be on the few large areas that are still available for conservation.

In parts of the region and in other areas in south west Western Australia, arum lily is encroaching into upland plant communites. This includes jarrah and Banksia woodland of Lowlands on the Serpentine River and Acacia shrublands and heaths of Garden Island. Given the range of plant communities it is invading and the potential range of sites it could occur on the Coastal Plain and western forest edges, it is difficult to accurately predict all of the sites arum lily could invade. It is therefore safer to presume that all areas of these parts of the Region are susceptible to invasion.

Climex modeling of the potential distribution of arum lily undertaken by CSIRO suggests that few new areas are expected to be colonized by arum lily in the south west of Western Australia (Scott 1997). As such the main aim of the strategy should be to determine where it actually occurs and focus on eradicating at important sites.

7. LEGISLATION

Arum Lily is a P1 and P4 Declared plant for the whole of the State. Its P1 listing prohibits movement of plants or their seed is prohibited within the State. P4 listing prohibits the movement of contaminated machinery and produce including livestock and fodder, and aims to prevent infestation spreading beyond existing boundaries of infestation.

Sale and trade of arum lily was banned from September 2006 throughout Western Australia under changes to the State's Declared Plants list, which extended the ban already in place in parts of the south west. The ban included trading or selling of arum lily in weekend markets, as well as in nurseries. The declaration does not require gardeners to remove their plants, but rather they will no longer be allowed to plant more arum lily (DAFWA 2006).

8. CONTROL METHODS

The development of best control methods of arum lily to date have concentrated on herbicide treatment, as physical removal can impact on native vegetation, cause excessive soil disturbance and

be unviable in the case of large infestations. While there has been investigation into the potential for biological control agents, there is no program currently underway.

There are several herbicides suitable and effective for use on arum lily. Metsulfuron or chlorsulfuron at a rate of 0.4g/15L of water plus Pulse applied between June and September is recommended herbicide treatment, however early applications prevents flowering and seed set but may miss later sprouting tubers (Peirce and Randall 1998). Use of metsulfuron methyl at 0.4g/L or ~10g/hectare plus glyphosate at 15ml/L plus Pulse 2ml/L has been found to be effective both early and late in the season.

Herbicides should be applied when plants are actively growing, preferably August or September before flowering has finished. Earlier spraying can give poorer results while if left too late some viable seeds will be formed (APB 1995)

Treatment ideally should be followed up annually to control missed plants, new seedlings and daughter rhizomes. Because of the rapid spread of seed by birds, treatment and eradication needs to be done on a large scale, landscape level or where infestations are isolated, this is suggested to be at least 5 km from the closest infestation (Moore 1997).

9. MANAGEMENT

Vision

The main vision for management is to
Gain a better understanding of the extent of arum lily in prioritized areas of the region
Reduce the impacts, contain spread and eradicate arum lily at identified sites, thereby protecting the Region's high biodiversity value assets.

Targets

To fulfill the aims of the strategy, the following targets should be met within the Swan NRM Region by 2011, unless otherwise stated:
Survey of presence and extent of arum lily at identified priority areas (TABLE 4)
No nett increase in extent at representative sites in known high priority infested areas (TABLE 3)
Eradication of mature plants at selected high biodiversity value sites (To be determined)

Recommended actions

The following actions are recommended:

1. Seek funding to implement the strategy, including funds for coordination and on-ground activities

Funding is required in order for the strategy to be implemented and to coordinate and undertake onground activities (including survey, control work, monitoring and mapping). Priority: Very High

2. Facilitate, fund and provide assistance for strategic on-ground control work in priority areas with known infestations

Priority areas to undertake arum lily control has been identified in Table 3. Priority: Very High

3. Survey to understand the extent and distribution of arum lily in priority areas

These areas have been identified based on values listed in Bush Forever (WA Government 2000) and are outlined in Table 4. Priority: High

4. Obtain further biological and ecological information.

Information is needed particularly relating to restoring plant communities invaded by arum lily and preventing re-establishment of infestations. Priority: Medium

Stakeholders

Developing partnerships with the organizations involved with controlling arum lily and protecting priority areas is integral to achieving the desired outcomes of the strategy. The key agencies include:

- Swan Catchment Council (SCC)
- Department of Environment and Conservation (DEC);
- Local Governments;
- Department of Agriculture and Food Western Australia (DAFWA);
- Subregional Groups;
- Landcare Groups;
- WWF;
- Water Corporation;
- Department of Defence;
- Swan River Trust;
- Community members;
- Friends groups and
- Private landholders.

10. MONITORING AND EVALUATION

Monitoring and evaluation are key parts of measuring successful implementation of this strategy. New information can also provide the basis to adapt the management program. At the completion of three years (July 2011), the strategy should be reviewed and evaluated against the management targets. As further information is gathered, the strategy may be adapted.

Data needs to be recollected in 2011 to assess the spread/decline of arum lily and evaluate the success or progress toward management targets. Indicators to show this include:

- Mapping; spatial data can allow identifying new populations and changes in distribution and numbers of plants;
- Records of numbers of plants (separating adults, jeuveniles/seedlings) and
- Survey for expansions in existing populations and new populations.

11. CONTACTS

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12. ACKNOWLEDGEMENTS

Kate Brown, Greg Keighery, David Mitchell and Danielle Witham.

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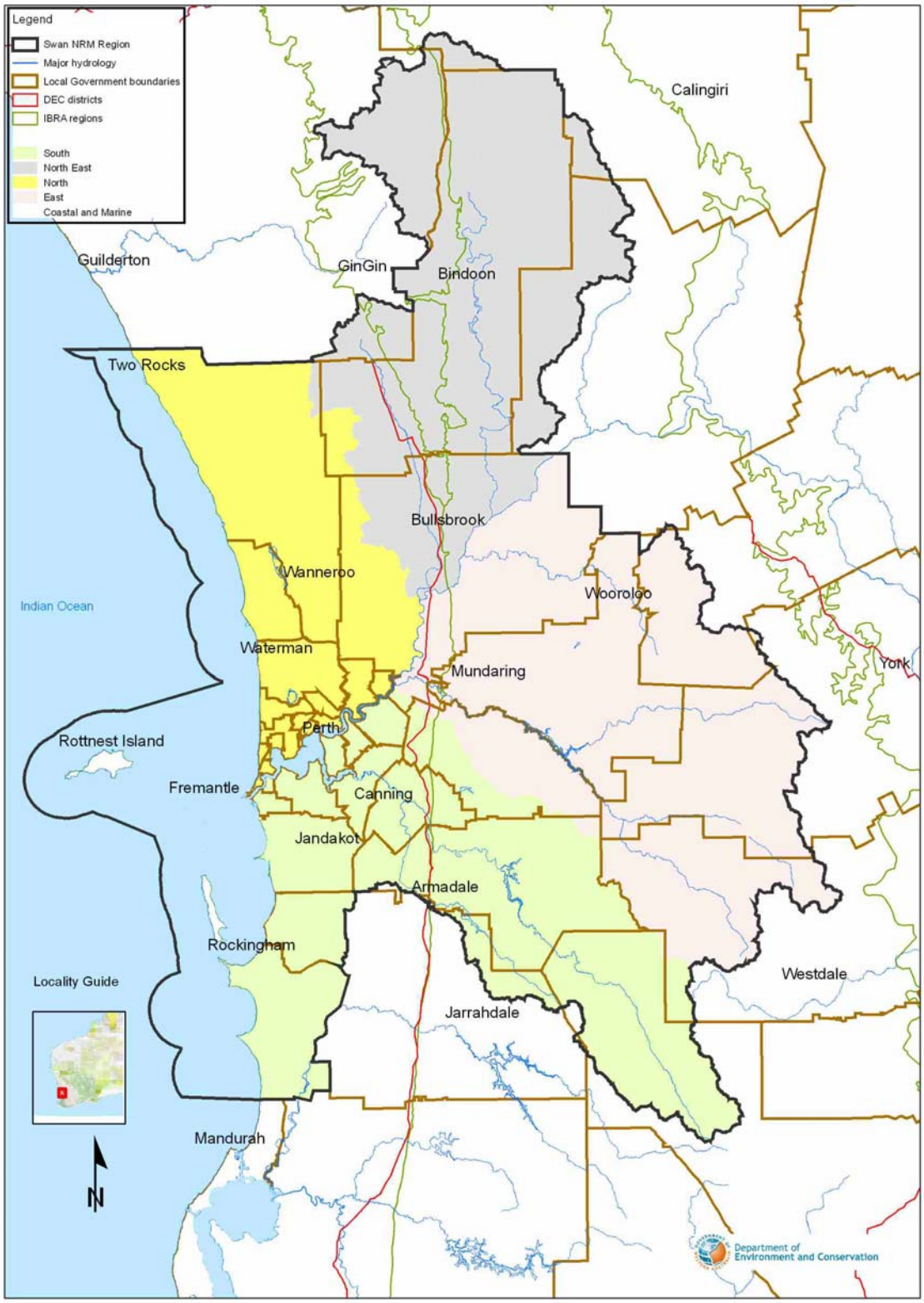
14. APPENDICES



Appendix 1: Map of the Swan NRM Region, showing NRM Sub-regions, DEC Regions, Districts and Local Government Authority boundaries.

Appendix 2

Regional scale values at risk from arum lily, adapted from *Bush Forever* (WA Government 2000);

- Significant flora (including those listed as DRF and Priority species);
- Significant fauna (EPBC Act 1999, Wildlife Conservation Notice , DEC Priority Fauna List (P1-P4));
- Significant birds of the Swan Coastal Plan portion of the Perth Metropolitan Region (species listed under the Wildlife Conservation Act 1950 coded 1, species listed under the JAMBA/CAMBA agreements –coded 2, habitat specialists with a reduced distribution on the SCP coded 3, wide-ranging species with reduced populations on the SCP locally extinct coded 4);
- Other special attributes (significance at a regional level by previous studies or identification processes (Classification by the National Trust of natural areas or landscapes, Threatened or Poorly Reserved Plant Communities);
- Wetlands of international and national significance (including Wetlands of International Importance or Ramsar wetlands, and those listed in the Directory of important wetlands in Australia);
- Migratory bird agreements (JAMBA and CAMBA) some of the BFS sites are visited by birds which migrate between hemispheres, conservation of these birds is supported by two international agreements covering these birds and their habitats and
- Commonwealth Environment Protection and Biodiversity Conservation Act 1999 listing (provides protection for matters of 'national environmental significance', these being World Heritage properties, Ramsar wetlands, nationally threatened andimal and plant species and ecological communities, internationally protected migratory species, Commonwealth marine areas).