Ecology, biology and management of invasive bulbs - Seminar program

8.15–8.45	Registrations
8.45–9.00	Welcome and Introduction Dave Coates, Department of Conservation and Land Management
9.00–9.35 (5 min questions)	Geophyte weeds of south-western Australia Greg Keighery, Department of Conservation and Land Management
9.35–10.10 (5 min questions)	Biology of the geophyte weeds in south-western Australia Kate Brown, Department of Conservation and Land Management
10.10–10.40	Morning Tea
10.40–11.20 (5 min questions)	Geophytes and fire in southern Africa Will Stock, Centre for Ecosystem Management, Edith Cowan University
11.20–12.00 (5 min questions)	Fire and the management of geophyte weeds in south-west Australia Bob Dixon, Botanic Gardens and Parks Authority
12.00–12.45	Lunch
Series of case studies looking at management of the geophyte weeds where they are invading native plant communities	
12.45–1.15 (5 min questions)	Ecology of *Lilium formosanum* and implications for management Susie Warner, CSIRO, Townsville
1.15–1.45 (5 min questions)	*Freesia* control in Kings Park bushland, Perth, Western Australia Bob Dixon, Botanic Gardens and Parks Authority
1.45–2.15 (5 min questions)	*Sparaxis bulbifera*; eight years of control and management in a threatened ecological community Kate Brown, Department of Conservation and Land Management
2.15–2.45 (5 min questions)	Watsonia; intelligent control John Moore, Department of Agriculture and Food, Western Australia
2.45–3.10	Afternoon Tea
3.10–3.40	Bulbous/geophyte weeds of the future Greg Keighery, Department of Conservation and Land Management
3.40–4.20	Where to from here? Priorities for research and management? General discussion
4.20	Closing

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Geophyte Weeds of south-western Australia

Greg Keighery
Principal Research Scientist, Science Division
Department of Conservation and Land Management
PO Box 51 Wanneroo WA 6946
Ph: (08) 9405 5100 Fax: (08) 9306 1641
gregk@calm.wa.gov.au

The term bulbous often is used to cover any plant that has an underground resting stage, be that a true bulb, a tuber, a fleshy rootstock or a corm. It is perhaps more informative to refer such plants as Geophytes.

Our 106 geophytic weeds come from 17 familes of plants both Monocots and Dicots, although nearly half are cormous Iridaceae from southern Africa (Table 1). Unlike many other areas of similar climates, Southern Western Australia is somewhat depauperate in geophytes, with about 200 species in our flora of c. 6,000 (less than 4%), compared to southern Africa with 1500 (17%). The greatest number of geophytes in WA are Tuberous Orchids, compared to other regions where species with true bulbs or corms predominate.

The "worst" geophytic weeds are from the Hyacinthaceae (*Lachenalia*), Araceae (*Zantedeschia*-Arum Lily), Asparagaceae (*Asparagus*), the Iridaceae (*Babiana*, *Freesia*, *Gladiolus*, *Moraea*, *Romulea*, *Sparaxis* and *Watsonia*) and the Oxalidaceae (*Oxalis*). Habitats impacted and potential impacts will be discussed for these weeds. Nearly all geophytic weeds were originally introduced as ornamentals.

Currently virtually all geophytic weeds are confined to the south west, especially around Perth where 98 species have been recorded. Most of these weeds are still actively expanding their ranges. There are currently none recorded for the Kimberley or Desert regions, although numerous species occur overseas in similar climates and several are locally naturalised on offshore islands (Cocos and Christmas).

Since nearly all were introduced as ornamentals and many highly desirable species are potentially weedy we need to be alert to limiting new introductions of geophytes to the Tropics and Desert regions. Eradicating new infestations to limit the spread and impact of serious geophytic weeds already naturalised in southern Western Australia should be priority.

Table One: Geophytic Weeds of Western Australia

BULBS
ALLIACEAE (ONIONS) - 6 SPECIES
AMARYLLIDACEAE - 9
COLCHICACEAE - 1
HYACINTHACEAE - 9

TUBERS
ALSTROEMERIACEAE - I

TUBEROUS RHIZOMES
ALISMATACEAE - 2
ARACEAE - 4
ASPARAGACEAE - 6
ASPHODELEACEAE - 2
IRIDACEAE - 2
NYMPHACEAE - 2
ORCHIDACEAE - 1
PASSIFLORACEAE - 1
PHYTOLACCACEAE - 1
STERCULIACEAE - 1

CORMS
IRIDACEAE - 50
TECOPHILACEAE – 1

CORMS/TUBERS/BULBS/RHIZOMES
OXALIDACEAE - 12

106 IN TOTAL

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Biology of the geophyte weeds in south-western Australia

Kate Brown
Urban Nature
Department of Conservation and Land Management
PO Box 1167, Bentley Delivery Centre, WA
katebr@calm.wa.gov.au

Knowing and understanding the life-cycles and reproductive biology of the bulbous weeds is an important part of knowing how to prevent spread and control and manage them where they are invading bushland. As a group they often share reproductive and life cycle traits.

Corms, bulbs and tubers/rhizomes

Corms

Corms comprise underground swollen stems or stem bases. Almost without exception the weedy cormous plants in south-west Western Australia are summer-dormant sending up their first shoots as the temperatures drop with the autumn rains. Almost all have annually renewed corms. *Ferraria crispa* (Black Flag) is an interesting exception. It has a column of persistent perennial corms to which a new corm is added each year. *Colocasia esculenta* (Taro), a native of south-east Asia, is another exception. It grows actively through summer and has a perennial corm. The naturalised genera *Babiana, Chasmanthe, Freesia, Gladiolus, Hesperantha, Watsonia, Moraea, Sparaxis* and *Ferraria* all die back to corms over summer.

Bulbs

Bulbs are made up of swollen leaf bases. They form the underground storage organs for many common weeds such as *Amaryllis, Allium, Lachenalia* and *Oxalis.* The bulbs of *Lachenalia, Oxalis* and *Allium* are annually renewed while others such as *Amaryllis* are perennial. Most bulbous weeds are summer dormant, sending up leaves as the temperatures drop with the first autumn rains. Flowering and seed set take place at the end of the growing season, in winter to late spring. However there are exceptions. The flowers of Easter Lily (*Amaryllis belladonna*) and some others in the family Amaryllidaceae emerge in early autumn, often long before the first rains with the leaves appearing after flowering has finished.

Tubers/Rhizomes

Tubers generally comprise swollen underground stems or roots. *Asparagus* (*A. asparagoides* - Bridal Creeper, *A. declinatus* - Bridal Veil, *A. densiflorus* - Asparagus Fern and *A. scandens* - Climbing Asparagus) arise from rhizomes (underground stems) supported by a dense tuberous root mat. Arum Lily (*Zantedeschia aethiopica*) arises from a large tuberous root sometimes referred to as a rhizomatous tuber.

Reproduction, dispersal and persistence

The majority of the geophyte/bulbous weeds reproduce both vegetatively and by seed. Seed is the major mechanism for dispersal into undisturbed bushland for many species and fire appears to play a significant role in seedling establishment. The seeds of species such as *Freesia, Sparaxis* and *Lachenalia* have no specialised adaptation for dispersal, relying mainly on water or soil movement. With their winged seed *Gladiolus*, and to a lesser degree *Watsonia* can also rely on wind for medium to long distance dispersal

Birds are the agents of medium to long distance dispersal of the fleshy berries of Arum Lily and the small red berries of Bridal Creeper.

Foxes (ingesting seed) also play a role in the dispersal of Arum Lily. Observations and a number of detailed studies suggest that seed of many of these geophytes do not persist for long, generally less than two years, in the soil.

Vegetative material including daughter corms, bulbs, tubers and 'seed like' cormels or bulbils produced around the base of the parent corm or along stems or roots can also play a significant role in reproduction dispersal and persistence of these weeds. This material can sometimes have greater persistence in the soil than seed. For example the cormels of Two-Leaf Cape Tulip (*Moraea miniata*) are known to remain viable in the soil for at least eight years and cormels from Bulbil Watsonia also remain viable for many years. Interestingly Two-Leaf Cape Tulip and *Gladious undulatus* (Wavy Gladiolus) produce masses of cormels but rarely produce viable seed.
Corm dormancy where there is a large population of dormant corms lying beneath the soil in any one growing season has been reported in *Moraea, Gladiolus* and *Watsonia.*

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Geophytes and fire in southern Africa

Professor William D. Stock
Director, Centre for Ecosystem Management, School of Natural Sciences
Edith Cowan University, Joondalup 6027
wstock@ecu.edu.au

The vegetation of the winter-rainfall region of southern Africa contains the richest geophyte flora in the world with almost two thousand species in twenty families. Geophyte storage organs vary enormously in size and may be cormous, bulbous, tuberous or rhizomatous. Geophytes may be synanthous (leaves and flowers produced at the same time), hysteranthous (leaves produced after flowering) or even evergreen. Many Cape geophytes are also known to have a high incidence of post-fire flowering with some taxa only flowering directly after fire (‘fire-lilies’).

In this presentation I will give an overview of Cape geophyte diversity including the range and variation in characteristics of below ground storage. The geographical distribution and phylogenetic patterns of storage organ types and sizes will be discussed in relation to climate and fire disturbance. Seasonal patterns of flowering, pollination modes and seed features such as the lack of dormancy, in some taxa, will also be considered. I conclude by speculating on some of the important characteristics of Cape geophytes which have made them successful weeds in south-western Australia.

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Fire and the management of geophyte weeds in south-west Australia

Bob Dixon
Manager Biodiversity and Extensions
Botanic Gardens and Parks Authority
Kings Park and Botanic Garden
West Perth, WA 6005
bdixon@bgpa.wa.gov.au

Fire is part of natural ecosystems in the south-west of Western Australia, however the frequency and intensity of fire events have changed dramatically since European settlement. Compared to areas such as the Wheatbelt where fires are less frequent and small isolated remnants of natural long unburnt vegetation still exist, fire events in bushland in urban areas such as the Swan Coastal Plain are now more frequent. By clearing above ground biomass, recycling nutrients and reducing competition, fire creates favourable conditions for weed establishment. This has undoubtedly led to increased weed invasion. There are a number of flow-on effects, including an increased fuel load. It is thought prescribed burning reduces these fuel loads, however, fifty years of fire records in Kings Park Bushland shows regular prescribed burning does not significantly reduce wildfires and weeds can increase the flammability of bushland.

Many geophyte weeds will spread and establish readily without the aid of fire, eg. *Asparagus asparagoides* (Bridal Creeper) is spread by birds and *Sparaxis bulbifera* spread by water. Some of these weeds may also be significantly reduced by hot fire. Plants are killed and the soil seed bank is significantly reduced. Examples include *A. asparagoides*, *Freesia alba* x *leichtlinii (*Freesia*)* and *Sparaxis bulbifera.* The dormant cormlets of *Gladiolus angustus* in light sandy soils, especially where there is a thick mulch layer, are very close to the surface and can be incinerated by hot fire. Therefore an occasional hot fire can aid in the control of these species. It also allows easier targeting of the weeds. They are easier to see when in leaf and many species flower prolifically after fire. Some species may have dormant corms that fire stimulates into growth, eg. Cape tulip and *Gladiolus caryophyllaceous*. Knowing the biology of the species enables you to make informed decisions on the best time for control. A good cost effective strategy is to be flexible with your weed control programme; if you have a wildfire you should be able to redirect your resources to these areas.

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Ecology of *Lilium formosanum* and implications for management

Susie Warner
Weeds CRC
CSIRO & UNE
Susie.Warner@csiro.au

Lilium formosanum (Formosa lily) is an invasive geophyte introduced to eastern Australia from its native Taiwan. Formosa lily is a herbaceous perennial that survives over winter as an underground bulb. It is fast growing with high morphological and physiological plasticity. Plants are self-fertile and prolific seeders with efficient dispersal. In its native range, Formosa lily tends to grow in disturbed fields amongst tall grasses, on bare cliff walls prone to landslips and grassy highlands disturbed by strong winds above the forest limit. Similarly in countries such as Japan, Norfolk Island, New Zealand, South Africa, Southern America and eastern Australia where it has become naturalised, it is present in the same environments.

There are major gaps in our knowledge of the weeds' ecology and biology which makes it difficult to know what impacts it has, how serious they might be, and how to plan and implement successful control. My PhD project aims to fill in some of these knowledge gaps. My field work is based on World Heritage listed Lord Howe Island, NSW, where Formosa lily occurs in virtually all habitat types and poses a threat to the island's many endemic and other native species and unique habitats. I will quantify key aspects of the life cycle, recruitment and survival; responses to environmental variables; some aspects of impact on species richness; and response to physical damage.

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Freesia control in Kings Park Bushland

Bob Dixon
Manager Biodiversity and Extensions
Botanic Gardens and Parks Authority
Kings Park and Botanic Garden
bdixon@bgpa.wa.gov.au

Introduction

Freesias (*Freesia alba* x *leichtlinii*) have been a major weed in Kings Park bushland for many years. We do not know how or when it was introduced, and there appears to be no early records in Kings Park's Board Minutes (Wycherley pers. comm.). It is, however, likely freesias were introduced through rubbish dumping in the Crawley area or by planting around the base of the memorial trees (Wycherley pers. comm.).

Freesias are highly competitive weeds in Kings Park bushland and have spread rapidly at least since the mid 1970s. They thrive in degraded areas and move into good quality bushland with ease. Observations indicate they spread rapidly by cormlets forming dense populations (1500 or more per square metre) moving in a front. Plants produce copious amounts of seed, especially after fire and also on plants under canopy in shady conditions.

Herbicide trials

Many herbicide trials have been conducted in the bushland of Kings Park to control and eradicate freesias. Trials commenced in the early 1990s indicated the most effective herbicides are Brushoff and Ally (metsulfuron methyl 600g/kg) and Round-up (glyphosate 360 g/L). Round-up used at 1% gives up to a 100% kill rate and may be more useful than Brushoff or Ally, however it should only be used in degraded areas to avoid damaging native species.

In Brushoff and Ally trials rates of 2.5 to 5g/ha in 300 to 400L of water with the addition of a wetting agent (Agral at rates of 1m/L to 3.5mL/L) were used. These produced excellent results with up to 100% kill rates with minimal off-target damage. Off target damage may have been avoided because of foliage protecting plants, lower soil pH, a surface mulch layer and most species including sedges, rushes, native grasses and woody species, being resistant to low rates of this herbicide. Although there is occasional damage to softer species such as *Drosera erythrorhiza* and orchids, and *Templetonia retusa* on more alkaline soils, specifically targeting the freesia by careful spot spraying rather than blanket spraying can keep this to a minimum.

The freesia spraying program in Kings Park bushland has been very successful, however, more than one treatment is usually required. We make provision for follow-up spraying in the next year as well as monitoring new recruits from seed. Freesia was for many years regarded as the worst weed occurring in bushland. We now rate it along with *Sparaxis* - fairly easy to control and certainly not at the top of our 'worst weeds list'.

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Sparaxis bulbifera; eight years of control and management in a Threatened Ecological Community

Kate Brown
Bushland Management Advisor
Urban Nature
Department of Conservation and Land Management
PO Box 1167, Bentley Delivery Centre, WA
katebr@calm.wa.gov.au

The genus *Sparaxis* (15 species) is endemic to the winter rainfall areas of the Cape Province of South Africa. *Sparaxis bulbifera* is wide spread in the region occurring on wet sandy, limestone or granitic flats. In south-western Australia *S. bulbifera* is naturalised in bushlands on wetter sands, sandy loams or clay soils from Perth around to Albany. Specifically it is a serious threat to the plant communities that occur on the seasonally inundated clay soils of the Swan Coastal Plain. These soils have been heavily cleared for agriculture and the herb rich shrublands they once supported are now highly restricted and threatened. Where *S. bulbifera* invades these plant communities it displaces the diverse herb layer.

This presentation will cover the known biology of *S. bulbifera* including dispersal mechanisms and reproductive biology. The results of a long-term control program for *S. bulbifera* in the Brixton Street Wetlands will be presented.

Geophyte weeds -References and further reading

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Personal Communications

Paul Wycherley, former Director of Kings Park and Botanic Garden, Shenton Park, W.A.