The effect of soil moisture on the distribution of *Watsonia bulbillifera* in Serpentine National Park, Western Australia

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Introduction

Since Europeans settled in Australia 200 years ago, they have unwittingly introduced many species of exotic biota. This has included many species of plants that have become established in areas such as national parks and conservation reserves. Once established they have had a major impact on the ecology of these reserves that are often vested to conserve the inherent values of natural vegetation.

> "Amidst the public clamour for more national parks, nature reserves and wilderness area, almost nothing is heard of the danger of weeds, despite the fact that many of the most significant conservation areas will be irretrievably damaged unless action is taken immediately" (Australian Institute of Agricultural Studies 1976).

Watsonia was first introduced into Australia, during the 1800s, as horticultural specimens and were considered naturalized in Victoria by 1907. There was a rapid spread of their range in that state during the 1930s and 1940s (Parsons 1973).

The spread of *Watsonia* in Western Australia is poorly documented and is reliant primarily on anecdotal evidence. Diver (personal communication 1989) suggests that the spread of this plant in Western Australia occurred at a similar time as in Victoria. White (1989) recalls a rapid colonisation of Serpentine National Park by *Watsonia bulbillifera* during the late 1940s and 1950s. The first specimens of *Watsonia* were lodged at the State herbarium in 1949.

Whilst research into agricultural weeds has been ongoing, efforts to combat the threats of environmental weeds have been minimal. This can be attributed to the lack of financial incentives in researching control and management techniques for environmental weeds. Also control programs for environmental weeds are often difficult to initiate in conservation reserves due to financial, bureaucratic and environmental constraints that may be exacerbated by difficult site access. Thus control programs for environmental weed species are often ineffective or neglected. For these reasons, *Watsonia bulbillifera* in many conservation areas such as Serpentine National Park has been able to invade and dominate some areas.

It is commonly assumed that *Watsonia bulbillifera* is confined to areas of damp soils and this notion is echoed by Parsons (1973). Field observations at Serpentine National Park of *Watsonia bulbillifera* suggest that this plant is found in a diverse range of locations, often far removed from the damp soil regimes.

This paper investigates the effect of soil moisture on the distribution of *Watsonia bulbillifera* at Serpentine National Park.

Study area

Serpentine National Park, an irregular linear shaped area of approximately 4500 ha, is located approximately 50 km south east of Perth. The Park experiences a typical Mediterranean climate with hot dry summers, average temperature 29.1°C in December to February, and mild cool winters, average temperature 11.5°C, June to August. The average rainfall of 1212 mm falls on an average of 112 rainy days, mainly between May and August.

The terrain is steep, with slopes of >30 degrees being common in many areas of the Park. Height above sea level ranges from 30 to 300 m. The landscape is drained by the Serpentine River, and the Carralong and Gooralong Brooks.

Granite outcrops dominate the Darling Scarp landform, which delineates the western boundary of the Park. East of the scarp, lateritic outcrops are more common in the Darling Plateau landform area. The soils range from lateritic, rounded gravels to reddish clays in the granite areas. The riverine areas have rich dark alluvial soils. There is also a small section of lateritic sandy loam associated with the Ridge Hill Shelf System. *Watsonia bulbillifera* was located in all soil types within the Park.

Literature review

Extensive searches of library data bases in Australia and the United States, e.g. Australian Bibliography Network (Aust.), Environmental Bibliography, Institute of Environmental Studies, Santa Barbara revealed little information on the target species, highlighting the paucity of information on environmental weeds in general and this species in particular.

Pate and Dixon (1982), noted that in Western Australia there are approximately 750 alien species, which have established themselves in the native flora. Of these approximately 10% are tuberous, bulbous or cormous, e.g. *Watsonia* spp.

> "Amongst our most ubiquitous alien species bearing fleshy storage organ's one would list *Watsonia bulbillifera*, a species reproducing by aerial 'bulbils' as well as daughter corms" (Pate and Dixon 1982).

Survey and sampling design

The rationale for the survey and sampling undertaken was based on methods of Whittaker (1973), Gillison (1984) and Wood (1986). Three types of data sampling were considered, systematic, selected and random and systematic gradient sampling was selected as being the most appropriate. A systematic approach was chosen as the simplest method for sampling environmental gradients, such as slope or gradient of soil moisture. Selected sampling was rejected as it is considered to be a form of selected bias in favour of the average and random sampling was also rejected as being inappropriate for the project.

To assist in determining the relationship between soil moisture and the presence or absence of *Watsonia bulbillifera*, categories of soil moisture were used based on Heddles' (1980) model (Table 1).

Table 1. Categories of soil moisture used to describe soil samples at Serpentine National Park.

% soil moisture by weight	category
< 3	dry
3–10	moist
10–20	very moist
20	saturated, standing water

Methods

Locations and range of *Watsonia bulbillifera* for Serpentine National Park were determined from existing distribution data (Lamont 1987) and conducting field surveys. This data was used to choose study sites for the project. Three transects were established in areas where *Watsonia bulbillifera* was present over a range of elevations and aspect, to provide the greatest diversity of soil moisture. Quadrats of 2 m × 2 m were established at 20 m intervals along each of the transects.

The transects are described as follows:

- Transect 1. Orientation north-south on a south facing slope, 31 sample sites established from the crest of slope to littoral fringe of the Serpentine River.
- Transect 2. Orientation north-south along a north facing slope, 15 sample sites established from crest to littoral fringe of Serpentine River. This transect located approximately 1000 m east of Transect 1.
- Transect 3. Orientation east west along east facing slope , 10 sample sites established on this transect.

The number of *Watsonia bulbillifera*

plants present in each quadrat were counted. At each quadrat a soil sample of 500 grams was taken 15 cm below the soil surface. Soil samples were weighed in the field on household scales and placed in plastic bags to prevent evaporation. The samples were weighed again on an electronic scale in the laboratory, and then oven dried for 24 hours at 105°C. The dry weight was then subtracted from the initial weight and percentage moisture content for the sample calculated (data available on request from the author).

Population density data and soil moisture content were analysed using a chi-square test to determine whether there was a significant difference between an observed and expected frequency distribution (Levin and Ruben 1980). Mini-Tab statistical software was used to analyse the data.

Sampling for soil moisture and population of *Watsonia bulbillifera* was carried out on August 14 and 16 1989 from the 56 sites that had been establish along the transects. A decision was made to sample during a period of minimal precipitation. This was done in an endeavour to identify more accurately the moisture holding capabilities of the soil. In the fourteen days preceding sampling, 26.8 mm of rain were recorded, i.e. 16.0 mm on 5/8/89 and 10.8 mm on 13/8/89. At the time of sampling the cumulative annual total of 586.6 mm was considerably less than the average of 749.4 mm of the previous years.

Results

Results of sampling indicated that spatial distribution of *Watsonia bulbillifera* in transect one was clumped and some of the moist sites had instances of no *Watsonia bulbillifera* being present (Figure 1). These trends were less obvious in the other transects (Figure 1).

There was a considerable range of moisture content in the soil samples (Figure 2) and in population densities (Figure 3) of *Watsonia bulbillifera.*

The majority of sites with the higher densities of *Watsonia bulbillifera* were clumped in the 10–20% moisture content range. This result was to be expected as 64% of all sites were within this range.

It was anticipated that soil moisture would have been highest at the lower elevations adjacent to stream lines but this was not reflected in the results obtained. Analysis using chi-square techniques found no discernible correlation between soil moisture and the presence or density of *Watsonia bulbillifera* (results available on request from the author).

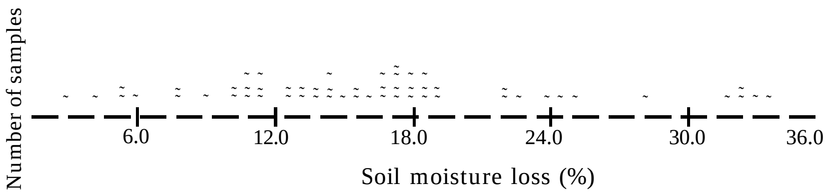

Figure 1. Moisture loss from soil samples for three transects at Serpentine National Park.

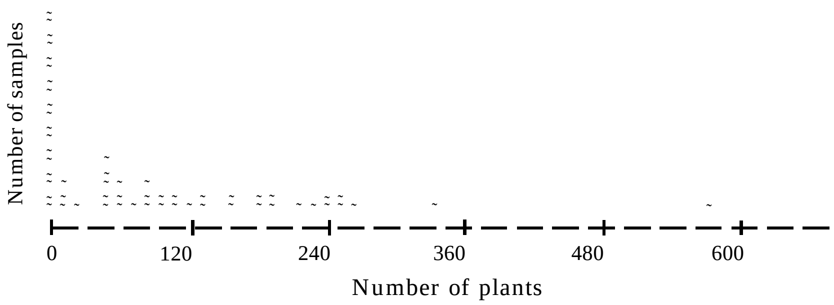

Figure 2. Numbers of *Watsonia bulbillifera* plants for samples along three transects at Serpentine National Park.

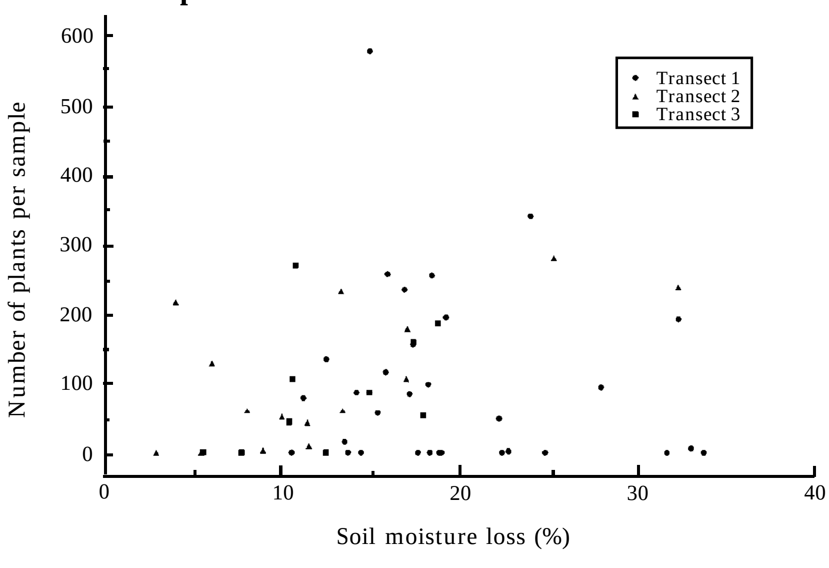

Figure 3. Poulation density of *Watsonis bulbillifera* for three transects at Serpentine National Park.

Discussion

Research into factors limiting the distribution of *Watsonia bulbillifera* has been negligible. Studies of native vegetation have shown that the soil moisture gradient has a considerable effect on its distribution (Heddle 1980). Therefore it seems reasonable to postulate that this could apply similarly to a weed species such as *Watsonia bulbillifera. Watsonia* spp. are generally considered to be plants of damp open places but this is not supported by the study or previous field observations at Serpentine National Park (Lamont 1986).

There was no relationship between population density and soil moisture. Elevation had little effect on soil moisture levels. Several sites with high population densities of *Watsonia bulbillifera* had relatively low levels of soil moisture. This study indicates that soil moisture is perhaps not as significant a factor in the distribution of this environmental weed as had been presumed.

Distribution is probably limited more by a lack of motility of propagules than by soil moisture. The dense colonisation of the littoral fringe of streams could be attributed more to the significance of the stream as a transport vector than the availability of moisture. This being the case, drier areas are equally at risk if reproductive material is introduced to them. At Serpentine National Park many granite outcrops have been heavily colonized by *Watsonia bulbillifera.* The discrete suite of specialized flora supported on granite outcrops is placed at risk by this weed.

With communities becoming more aware of the degrading effect of environmental weeds, there is an urgent need for the issue to be addressed. Failure to do so will allow spread of *Watsonia* spp. to continue unabated and increases the cost when eventually control and rehabilitation are attempted.

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The effect of slashing on the growth of *Watsonia meriana* (L.) Mill. cv *bulbillifera* in the Adelaide Hills

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Summary

In order to control *Watsonia meriana* cv *bulbillifera* by slashing, it is necessary to prevent flowering and bulbil production, as well as reduce the strength of the corm. The effects of slashing at a number of heights, and at a range of times throughout the plant's life-history were investigated both for mature plants and those derived from bulbils. Plants derived from bulbils require slashing prior to their thirteenth week of growth if cormlet production towards the next season's growth is to be significantly affected. Mature plants should be slashed below the most basal node (about 15 cm or less) at the first appearance of the inflorescence if both bulbil and corm production are to be minimized.

Introduction

The introduction of exotic and ornamental plants to South Australia over the past 157 years has resulted in several garden escapees finding the climate and ecological conditions of the state ideal in which to establish (Kloot 1987a,b,c). Among the numerous introduced South African taxa, *Watsonia meriana* (L.) Mill. cv *bulbillifera* has invaded the foothills and pasture lands of the state's southern areas with remarkable speed and strength.

Species description and distribution

Watsonia meriana cv *bulbillifera* is a cormous perennial native to Southern Africa and is also known as *W. bulbillifera* J. Mathews and L. Bolus. Its common names are bulbil watsonia, bugle lily, wild watsonia (Cooke 1986) and Merian's bugle lily (Parsons and Cuthbertson 1992). Goldblatt (1989) considers the taxon to be a cultivar of *W. meriana*, believing it to have developed independently the ability to grow reproductive propagules (bulbils) a number of times. *Watsonia meriana sens. str.* often produces bulbils within the axils of the lower leaves and branch axils, although not to the extent of *W. meriana* cv *bulbillifera*, which develops bulbils at all nodes along the flower spike (Figure 1).

The natural distribution of *W. meriana* is the Cape winter rainfall area of Southern Africa in seasonally moist areas with sandy or thin rocky soils. The distribution of cv *bulbillifera* is not described (Goldblatt 1989) and, as no collections exist prior to the 19th century, Goldblatt suggested that it is merely a local sport which has been introduced into cultivation. Currently *Watsonia meriana* cv *bulbillifera* is considered a weed in Australia, Mauritius, Réunion (Goldblatt 1989) and New Zealand (Parsons and Cuthbertson 1992). The earliest record in South Australia dates from 1842 at Camden Park, Adelaide (Parsons and Cuthbertson 1992). The species' extent within Australia has been described by the Animal and Plant Control Commission (1991), Cooke (1986), Parsons and Cuthbertson (1992) and to a lesser extent Dashorst and Jessop (1990). It tends to infest pastures and natural reserves, and proliferates within unused land. It is a declared weed in South Australia, Victoria (Carr *et al.* 1992) and New South Wales. Within South Australia, it occurs most extensively from Victor Harbour to the Barossa Valley and within the South East. Dashorst and Jessop (1990) describe approximately the areas of infestation, although more accurate survey data are needed. Within the Adelaide hills, the weed is evident along roadsides, heavily invading natural vegetation, and forms stands which are generally impenetrable by other herbs and shrubs, either native or introduced. Agriculturally viable land is made redundant by *Watsonia* infestation.

Life history

Watsonia meriana cv *bulbillifera* is a cormous perennial, sprouting in mid Autumn after sufficient rain. Flowering occurs from October to mid-December, with aestivation (die-back) by late January. The corm remains dormant over the dry season within an outer tunic of coarse matted fibres. The root system is relatively simple and does not penetrate the soil much beyond 12 cm from the corm. The shoot arises from the corm apex and extends through the tunic before emergence. As the shoot elongates, its base swells at the point of junction with the parent corm and develops into the next season's corm. The parent corm shrinks as the stem grows, forming a hard, dead plate-like structure attached to the base of the new corm. Plants generally consist of the current year's corm with a series of plates stacked beneath. In the field, some corms have been observed with thirty-five plates, indicating the minimum age of some *Watsonia* stands.