Gnangara Sustainability Strategy

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Groundwater – Biodiversity – Land use

POST-FIRE JUVENILE PERIOD OF PLANTS IN *BANKSIA* WOODLAND ON THE NORTHERN SWAN COASTAL PLAIN

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Post-fire juvenile period of plants in *Banksia* woodland on the northern Swan Coastal Plain

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Gnangara Sustainability Strategy

This document has been commissioned/produced as part of the Gnangara Sustainability Strategy (GSS). The GSS is a State Government initiative which aims to provide a framework for a whole of government approach to address land use and water planning issues associated with the Gnangara groundwater system. For more information go to www.gnangara.water.wa.gov.au

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Introduction

As part of the Gnangara Sustainability Strategy (GSS), modifying the current burn regime by increasing the frequency of burning native vegetation on Crown land above the Gnangara groundwater system has been suggested as a cost effective technique that may increase groundwater recharge (Canci 2005; Yesertener 2007). CSIRO is undertaking an adaptive management project from 2008-2010 to examine the hypothesis that burning increases groundwater recharge. However, prior to the potential application of increased burn frequency as a management option, the biodiversity consequences of burning must be understood and the water yield and biodiversity balance quantified. DEC undertook a complementary project to assess the impacts of burning to the biodiversity of *Banksia* woodland, in particular the effect of fire and grazing on plant juvenile periods following a prescribed burn (this report) and the first time to flowering across a fire chronosequence (Mickle *et al.* 2010). A preliminary report by Reaveley *et al* (2009) discusses the set up of the UCL burn project.

The post-fire juvenile period (time to first flowering after fire) can be used to guide minimum intervals between fires to conserve plant diversity (Burrows *et al.* 2008). Burrows *et al.* (2008) defined the juvenile period as the time for at least 50% of a population of plants to have flowered following fire. Burrows *et al* (2008) suggests that the minimum fire interval be twice that of the juvenile period of the longest maturing plant species in South Western Australian Forest ecosystems, although this could be reduced with sufficiently patchy and low intensity burns to reduce the likelihood that all plants in a burn are scorched.

The aim of this project was to collect juvenile period (post-fire time to flowering) information for plants in *Banksia* woodland after a prescribed burn and to determine the effect of grazing after fire on the 'juvenile period'.

Methods

Study Site

CSIRO's trial site to measure the groundwater recharge hypothesis was in Unallocated Crown Land (UCL) (Caraban UCL) in the northern end of the GSS study area, in an area proposed for a prescribed burn by DEC's Swan Coastal District (Figure 1).

Caraban is located in the Swan Coastal Plain subregion (Drummond Botanical Subdistrict) (Beard 1990). The region is characterised mainly by low *Banksia* woodlands on leached sands with Melaleuca swamps in poorly drained areas (Beard 1990). Tuart (*Eucalyptus gomphocephala*), Jarrah (*E. marginata*) and Marri (*Corymbia calophylla*) woodlands occur where soils are less leached, while laterite pavement and gravelly sandplains support scrub heath (Beard 1990; Desmond 2001).

The climate of the area is described as warm Mediterranean with up to six dry months per year. Mean maximum temperatures range from 17.8°C in July to 33.3°C in January, while mean minimum temperatures reach 17.4°C in February and fall to 8.2°C in August (Beard 1990). Mean annual rainfall is approximately 750mm (Bureau of Meteorology 2009).

Experimental Design & Floristic Surveys

The total area of the trial site was 754 ha and 23 years had passed since the last fire. The eastern side of the site was burnt on 6 June 2008, leaving the western side unburnt as a control (Figure 1). Two adjacent pairs of 75 x 75 m plots were established, one pair on the burnt side, and one pair on the control/unburnt side, with one plot in each pair fenced to exclude grazing following the burn.

In May 2008, prior to the controlled burn, Mattiske Consulting Pty Ltd (2009) established and surveyed a total of twelve 10x10m vegetation monitoring quadrats, three in each of the four treatments; burnt/fenced, burnt/unfenced, unburnt/fenced and unburnt/unfenced (see inset diagram of site layout in Figure 1). Mattiske Consulting Pty Ltd conducted a follow-up survey in January 2009, six months following the controlled burn.

Assessment of Juvenile Period

The pre burn floristic data collected by Mattiske Consulting Pty Ltd from the six 10x10m vegetation monitoring quadrats within burnt/fenced and burnt/unfenced sites was used as the baseline for this study on plant juvenile periods. DEC's Gnangara Sustainability Strategy team monitored the six burnt quadrats (quadrats 7 through 12, see Figure 1) monthly between August 2008 and November 2009.

Within each quadrat each flowering species was assigned to a flowering category based on a visual estimate of the proportion of plants flowering. Flowering categories ranged from 1 to 5 (Burrows pers. comm. 2009) where:

1 indicated default value for plants with no flowers (or none of the following),

2 indicated plants with some flowers on some plants,

3 indicated many flowers on some plants (approximately 50% flowering),

4 indicated some flowers on most plants, and

5 indicated many flowers on most plants.

Post-fire regeneration strategies were noted for a number of species and were based on Burrows *et al.* (2008, see Table 1).

Table 1 Regeneration Strategies (Reproduced from Burrows *et al.* 2008)

Seeders	**Resprouters**
(1) Stem girdling or 100% scorch kills, depends on canopy stored seed	(4) Survives stem girdling or 100% scorch, soil suckers (rhizome, corm, bulb, tuber)
(2) Stem girdling or 100% scorch kills, depends on soil stored seed	(5) Survives stem girdling or 100% scorch, basal sprouts (lignotuber)
(3) Stem girdling or 100% scorch kills, no stored seed	(6) Survives100% scorch, epicormic shoots
(8) Stem girdling or 100% scorch kills, any of 1,2,3 above	(7) Survives100% scorch, large apical bud
(10) Ferns and allies (spores)	(9) Survives100% scorch, any of 4,5,6,7 above

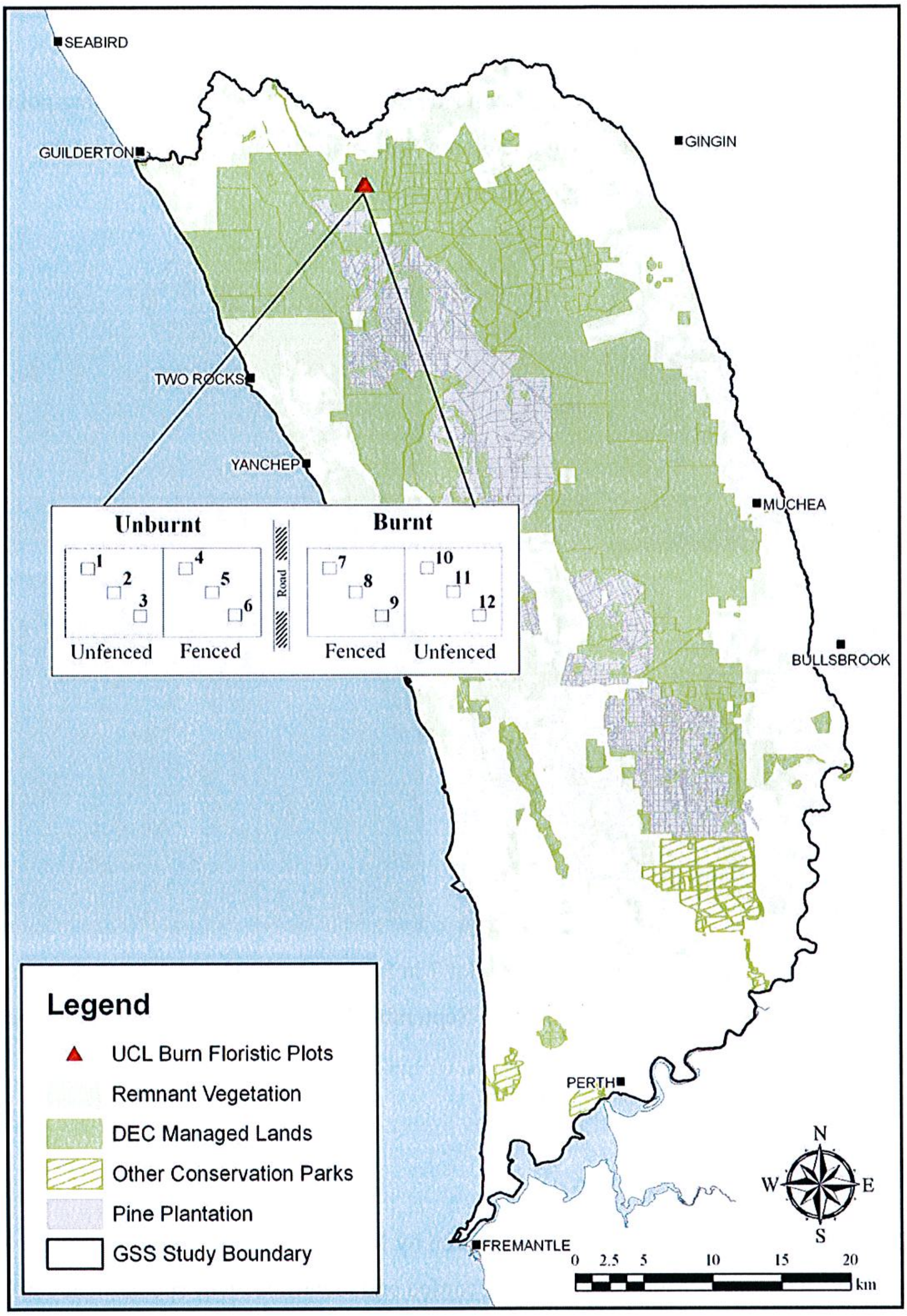

Figure 1. Location of juvenile period study site and layout of quadrats. Only burnt sites 7 through 12 were surveyed for 'juvenile period'.

Photographic monitoring

Digital photographs were taken at each quadrat as a visual record of condition. Photographs were taken from the northern side of the quadrat at each monitoring point in time. Figure 2 shows site photos at one month following the burn and at 12 months following the burn for a fenced and unfenced site.

Figure 2. Photos of a fenced quadrat: a) plot 7 in September 2008, b) plot 7 in September 2009; and unfenced quadrat: c) plot 12 in September 2008 and d) plot 12 in September 2009.

Analysis

During the initial flora assessment undertaken by Mattiske Consulting Pty Ltd in the winter of 2008 all vascular plant species were recorded and identified. This species list, combined with any other species found by DEC monitoring between August 2008 and November 2009 was used to create a total species list for each site and hence find the total species count for each 10x10m quadrat. This total was used to calculate the cumulative proportional percentage of plants that reached 'juvenile period' where plants having reached 'juvenile period' is defined as being the time for at least 50% of a population of plants to reach flowering age following fire (Burrows *et al.* 2008) or any species with a flowering category of 3 or greater.

Estimates of juvenile period of plants at each site were determined using all plant species that had reached at least 50% of the population flowering. Each quadrat did not contain the same number of species so each percentage was unique to its own quadrat. To examine patterns in data, one-way ANOVAs (using SPSS 2008, version 17) were used to examine fencing treatment and time since fire. Post-hoc Tukey HSD tests were used to determine differences among vegetation types where applicable. We conducted a two-way ANOVA using the grazing treatment (fenced vs unfenced) and time since fire at 6 months, 10 months and 17 months.

Results

Floristics

In the six quadrats that underwent the prescribed burn, pre and post-fire floristic surveys and observations recorded a total of 107 species from 32 families, the dominant families being Proteaceae, Myrtaceae and Stylideaceae (Table 2).

Table 2. Plant families surveyed ranked by number of species in each family.

Family	No. Genera	No. Species
Stylideaceae	2	10
Proteaceae	6	10
Myrtaceae	7	10
Papillionaceae	6	7
Haemodoraceae	4	7
Cyperaceae	5	7
Restionaceae	5	5
Dilleniaceae	1	5
Asteraceae	3	5
Asparagaceae	3	5
Droseraceae	1	4
Poaceae	3	3
Orchidaceae	3	3
Epacridaceae	3	3
Xanthorrhoaceae	1	2
Mimosaceae	1	2

Family	No. Genera	No. Species
Goodeniaceae	2	2
Dasypogonaceae	2	2
Apiaceae	2	2
Thymelaeaceae	1	1
Rutaceae	1	1
Polygalaceae	1	1
Loranthaceae	1	1
Loganiaceae	1	1
Lauraceae	1	1
Iridaceae	1	1
Hemerocallidaceae	1	1
Haloragaceae	1	1
Colchicaeae	1	1
Centrolepidaceae	1	1
Casuarinaceae	1	1
Ameranthaceae	1	1
Total	73	107

Post-fire Regeneration Strategies

The post-fire regeneration strategies were noted for 101 of the 107 plant species observed (Table 3). Twenty four species (22%) were recorded as being seeders (killed by fire), the remainder resprouted from a variety of underground structures (soil suckers or lignotubers), epicormic or apical growth. Of the other six species, four were observed by Mattiske Consulting Pty Ltd (2009) pre-burn survey but where not recorded during the post-burn DEC-GSS survey (this study). Consequently the regeneration strategy of these species was estimated from the Vegetation Species List and Response Database (DEC 2008). The remaining two species presented a variety of regeneration strategies and as such where not able to be confidently assigned to any particular regeneration strategy.

Table 3: Species list of all species recorded during either the pre-burn survey by Mattiske or the post-burn juvenile period survey. Post-fire regeneration strategies are based on (Burrows *et al.* 2008, see Table 1). * denotes regeneration strategies that were not observed during the post-burn DEC-GSS survey but estimated from the Vegetation Species List and Response Database (DEC 2008). † denotes regeneration strategies that were unable to be positively identified in the field.

Family	Species	Burrows Regeneration Strategies
Ameranthaceae	*Ptilotus manglesii*	5
Apiaceae	*Trachymene pilosa*	2
	Xanthosia huegelii	5
Asparagaceae	*Laxmannia ramosa subsp. ramosa*	2
	Lomandra caespitosa	4
	Lomandra hermaphrodita	4
	Lomandra preissii	4
	Thysanotus sp	4
Asteraceae	*Hypochaeris sp*	2
	Podotheca angustifolia	2
	Podotheca crysantha	2
	Podotheca gnaphalioides	2
	Sonchus oleraceus	2
Casuarinaceae	*Allocasuarina fraseriana*	6
Centrolepidaceae	*Centrolepis drummondii*	2
Colchicaeae	*Burchardia congesta*	4
Cyperaceae	*Isolepis marginata*	2
	Lepidosperma leptostacyum	4
	Lepidosperma pubisuameum	4
	Mesomelaena psuedostygia	4
	Schoenus clandestinus	2
	Schoenus curvifolius	4
	Tetraria capillaris	4
Dasypogonaceae	*Calectasia naragarra*	2 or 5 †
	Dasypogon bromeliifolius	4

Family	Species	Burrows Regeneration Strategies
Dilleniaceae	*Hibbertia acerosa*	5*
	Hibbertia huegelii	5
	Hibbertia hypericoides	5
	Hibbertia racemosa	5
	Hibbertia subvaginata	5
Droseraceae	*Drosera erthrorhiza*	4
	Drosera macrantha subsp. macrantha	4
	Drosera menziesii	4
	Drosera parvula	4
Epacridaceae	*Conostephium pendulum*	5
	Leucopogon conostephoides	2
	Lysinema ciliataum	2
Goodeniaceae	*Dampiera linearis*	2
	Scaevola repens	2
Haemodoraceae	*Anigosanthus humilis subsp. humilis*	4
	Conostylis aculeata	4
	Conostylis juncea	4
	Conostylis setigera	4
	Haemodorum paniculatum	4
	Haemodorum spicatum	4
	Phlebocarya ciliata	4
Haloragaceae	*Gonocarpus pithyroides*	5
Hemerocallidaceae	*Arnocrinum preissii*	4
Iridaceae	*Patersonia occidentalis*	4
Lauraceae	*Cassytha sp*	2
Loganiaceae	*Phyllangium paradoxum*	2
Loranthaceae	*Nuytsia floribunda*	6
Mimosaceae	*Acacia extensa*	2
	Acacia stenoptera	5
Myrtaceae	*Baeckea camphorosme*	5*
	Beaufortia squarrosa	5
	Calytrix flavescens	9
	Calytrix fraseri	5
	Eremaea asterocarpa subsp. asterocarpa	5
	Eremaea beaufortioides	5
	Eremaea pauciflora	5
	Eucalyptus todtiana	9
	Melaleuca trichophylla	5
	Scholtzia involucrata	5
Orchidaceae	*Caladenia flava subsp. flava*	4
	Paracaleana nigrita	4
	Pyrorchis nigricans	4
Papillionaceae	*Bossiaea eriocarpa*	9
	Bossiaea ornata	2*
	Daviesia decurrens	2
	Daviesia nudiflora	5
	Gastrolobium capitatum	5
	Gompholobium tomentosum	5
	Hovea trisperma	5
Poaceae	*Amphipogon turbinataus*	4
	Austrodanthonia occidentalis	2
	Austrostipa compressa	2

Family	Species	Burrows Regeneration Strategies
Polygalaceae	*Comesperma calymega*	5
Proteaceae	*Adenanthos barbiger*	5*
	Adenanthos cygnorum	2
	Banksia attenuata	9
	Banksia dallanneyi subsp dallanneyi	9
	Banksia menziesii	9
	Persoonia comata	5
	Petrophile linearis	5
	Petrophile macrostachya	5
	Petrophile serruriae	5
	Stirlingia latifolia	5
Restionaceae	*Alexgeorgea nitens*	4
	Desmocladus flexuosus	4
	Hypolaena exsulca	4
	Loxocarya cinerea	4
	Lyginia barbata	4
Rutaceae	*Philotheca spicata*	5
Stylideaceae	*Levenhookia stipitata*	2
	Stylidium adpressum	2
	Stylidium araeophyllum	4
	Stylidium bicolour	4
	Stylidium brunonianum	4
	Stylidium carnosum	4
	Stylidium diuroides	2 or 4 †
	Stylidium piliferum	2
	Stylidium repens	4
	Stylidium sp Kalbarri	4
Thymelaeaceae	*Pimelea sulphurea*	5
Xanthorrhoaceae	*Xanthorrhoea brunonis*	7
	Xanthorrhoea preissii	7

Juvenile Periods (time to first flowering)

Out of 107 observed plant species, a total of 71 (66%) species from 28 families reached juvenile period in the 18 months following a prescribed burn in *Banksia* woodland in the GSS study area. Of the species that had reached their post-fire flowering period within 6 months of the burn, most (81%) were resprouters (based on our field observations and the Vegetation Species List and Response Database). Only 19% were annual seeders, and no perennial seeders had reached their juvenile period. Within 18 months of the burn, the proportion of seeders (20%) and resprouters (80%) reaching juvenile period had not changed, however some perennial seeders had reached juvenile period (n = 4).

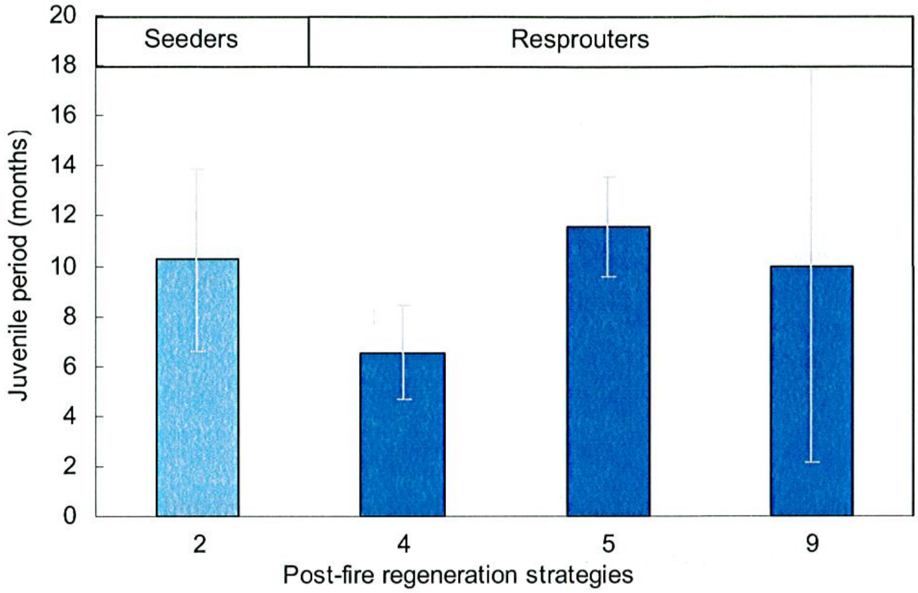

Figure 3. Mean juvenile period for plant species categorised according to post fire regeneration strategy based on Burrows *et al* (2008, see Table 1).

Impact of fire and grazing on juvenile periods

The mean proportion of species that had reached juvenile period after 18 months following fire was 55% for the fenced treatment and 47% for the unfenced treatment. There was a significant difference in mean proportion of juvenile period over time between fenced and unfenced treatments (ANOVA: $F_{1,12} = 52.09$, $p<0.001$). From about 6 months post-burn, approximately 10% more species were flowering in the fenced ungrazed treatment. The time to flowering had significant differences between 6 months and 17 months post fire and between 10 months and 17 months post fire (ANOVA: $F_{2,12} = 177.154$, $p<0.001$). By 17 months 47.9% of species in unfenced and 55% species in the fenced treatment had reached juvenile period.

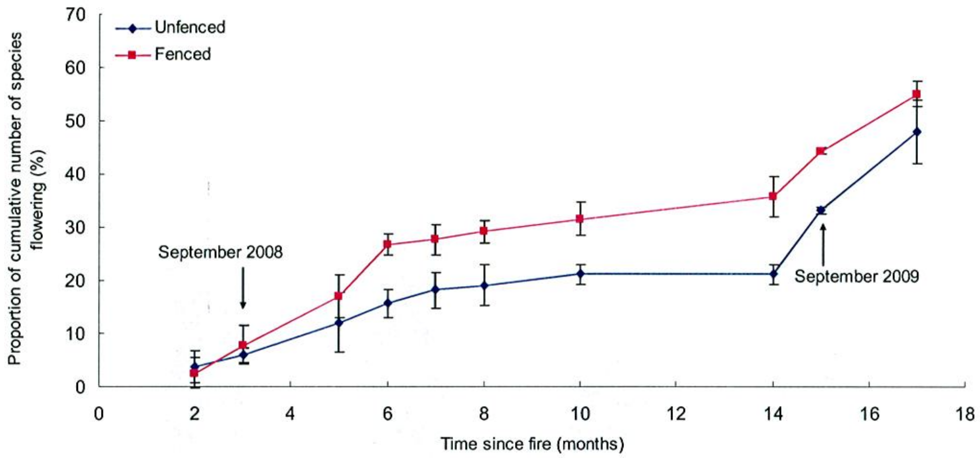

Figure 4. Proportion of plant species reaching juvenile period in fenced and unfenced burn treatments. Confidence interval 95%.

The unfenced treatment had initially a greater mean proportion (3.8%) of plants that had reached juvenile period, than the fenced treatment (2.6%). At three months post fire the fenced treatment consistently had greater mean proportion of plants reaching juvenile period with the fenced treatment having 55% of the plants having reached juvenile period at 17 months as opposed to the unfenced treatment having only 48% reaching juvenile period.

Discussion and Recommendations

Burrows *et al* (2008) suggests that the minimum fire interval be twice that of the juvenile period of the longest maturing plant species in South Western Australian Forest ecosystems, although this could be reduced with sufficiently patchy and low intensity burns.

This study highlights the need for a more extensive study of plant juvenile periods following fire in the Swan Region, particularly in *Banksia* woodland, but also utilising different vegetation complexes as a guide. Vegetation complexes were found to be the driver of the differences in the diversity in the GSS Study Area (Mickle *et al.* 2009).

This study was restricted to the *Banksia* woodland on the Spearwood dune landform. For this analysis there were only 3 replicates per treatment. The juvenile period was estimated over a limited time period of 18 months and was not monitored every month. This study is very limited by sample size since it is a preliminary study into the effect of grazing after fire on juvenile period of plants. It is recommended the sample size be increased in a larger study area.

While the data collected on juvenile periods and post-fire regeneration strategies are preliminary, this is the first step in the process of assessing the juvenile period of plant species in order to determine the appropriate fire interval for the *Banksia* woodland on the northern Swan Coastal Plain. To fully understand the effects of fire on juvenile period of *Banksia* woodland species, a much longer and broader study would need to be undertaken, and information gathered on key fire species – for example, species that have very long juvenile periods and species that require frequent fire. This study should ideally be long enough for a majority of species to have reached juvenile period. A period of 2-5 years was required by Burrows *et al.* (2008) to achieve this in the Jarrah forest. A comparison between the juvenile period of species found in both the Jarrah forest (Burrows *et al.* 2008) and *Banksia* woodlands from this study would be useful to gauge climatic variation within species. The study could include complete vegetation complexes across climatic gradients on the Swan Coastal Plain.

Another important aspect of this project is the consideration of it as a long-term site for monitoring vegetation condition on the Swan Coastal Plain, possibly as part of a long-term Adaptive Management Project (Reaveley *et al.* 2009).

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