Gnangara Sustainability Strategy

An across-government initiative

Groundwater – Biodiversity – Land use

RESTORATION OF BANKSIA WOODLANDS AFTER THE REMOVAL OF PINES AT GNANGARA: EVALUATION OF SEEDING TRIALS

A report prepared on behalf of the
Department of Environment and Conservation
for the Gnangara Sustainability Strategy

Kellie Maher, Rachel Standish and Lauren Hallett

Murdoch University

December 2008

Government of Western Australia
Department of Water
Department of Agriculture and Food WA
Department for Planning and Infrastructure
Department of Environment and Conservation
WATER CORPORATION
CSIRO
Forest Products Commission Western Australia

Restoration of Banksia woodlands after the removal of pines at Gnangara: Evaluation of seeding trials

Report for the Gnangara Department of Environment and Conservation

Kellie Maher, Rachel Standish and Lauren Hallett
Murdoch University

Gnangara Sustainability Strategy Taskforce
Department of Water
168 St Georges Terrace
Perth Western Australia 6000
Telephone +61 8 6364 7600
Facsimile +61 8 6364 7601
www.gnangara.water.wa.gov.au

2009

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

Restoration of Banksia woodland after the removal of pines at Gnangara: Evaluation of seeding trials

A report to the Department of Environment and Conservation

Kellie Maher, Rachel Standish and Lauren Hallett

December 2008

Murdoch UNIVERSITY

DISCOVERERS WELCOME

www.murdoch.edu.au

Restoration of *Banksia* woodland after the removal of pines at Gnangara: Evaluation of seeding trials

A report to the Department of Environment and Conservation

Kellie Maher, Rachel Standish and Lauren Hallett

Murdoch University

December 2008

Table of Contents

List of Tables

List of Figures

1 Introduction

Only 20% of the original *Banksia* woodlands on the Swan Coastal Plain remain. Continued urban development is likely to reduce their extent further and impact the health of the fragments that are left. The opportunity for large-scale restoration of *Banksia* woodland to Gnangara is especially significant given the ongoing clearing of *Banksia* woodland elsewhere within the region. However, it is important to note that both the protection of remaining woodlands and the restoration of degraded and cleared woodlands is critical for their conservation (Turner et al. 2006).

Unfortunately, the recruitment biology of *Banksia* woodland species is not well understood, providing limited opportunities for devising appropriate prescriptions for restoration and management of this plant community (Rokich et al. 2000, 2002). Many of the techniques for the restoration of *Banksia* woodland have been developed through research on sand-mining rehabilitation, where the approach has been to utilize soil seed banks to "inoculate" sites with seeds (e.g. Rokich et al. 2000, 2002). This technique has also been used to inoculate other sites on the Swan Coastal Plain using topsoil from recently cleared nearby sites (Dallas Lynch, Greening Australia, pers. comm. 2008). Although topsoil application is the most useful, reliable, and economical source of plants, it has limitations, particularly for species whose seeds are only released following fire or other major disturbances (Turner et al. 2006). As a result, these species must be returned to as either broadcast seeds or greenstock (seedlings).

Where topsoil is not available, broadcast seeding is the most cost-effective means of restoring native vegetation to degraded landscapes over large areas. Despite much local research into broadcast seeding for the restoration of jarrah forest and *Banksia* woodlands after mining, the success of this technique remains limited; usually less than 10% of the broadcast seeds germinate and establish (Bellairs and Bell 1993, Koch and Ward 1994, Rokich et al. 2002). In general, the two main factors that effect the recruitment of broadcast seeds are seed predation and rainfall after sowing (e.g. Turner et al. 2006). While these factors are difficult to control, it is possible to increase recruitment by adopting practices that lessen the impact of these factors. For example, seeding into a well-prepared seedbed can improve germination and seedling establishment, and similarly, covering broadcast seeds with soil can reduce the number lost to predation (Whisenant 1999).

The Department of Environment and Conservation (DEC) are faced with the challenging task of restoring native vegetation to the sand plains north of Perth after the removal of the exotic pine plantations that have occupied the site since 1925. Native vegetation within and adjacent to the plantation area is predominantly *Banksia* woodland, with the dominant overstorey species including *Banksia menziesii*, *B. attenuata*, and dominant understorey species including *Bossiaea eriocarpa* and *Leucopogon conostephioides* (Gibson et al. 1994). Since 2001, DEC has been trialling practices to improve the establishment of native vegetation from broadcast seeds. These trials provide a unique opportunity to compare different methods of seedbed preparation. In particular, the effect of burning prior to broadcasting has rarely been tested despite the importance of fire for the recruitment of sand plain vegetation. They also provide an opportunity to assess how rainfall after broadcasting affects establishment after ploughing, which is a technique favoured by DEC to prepare the

seedbed. Again, this information is critical for ongoing attempts to restore native sand plain vegetation in our drying climate. Lastly, there is some data on the seedling establishment within the trials initiated in 2001–2003 which can be used to determine how the species diversity and structure of the restored vegetation develops as it matures.

Key questions:

- Does burning the seedbed prior to broadcasting increase the establishment and diversity of the restored vegetation?
- How does rainfall after broadcasting affect the establishment and diversity of the restored vegetation? Is there a threshold (i.e., minimum rainfall) to establishment and does this differ among species?
- Does the species diversity and structure of the vegetation reflect the mix of the broadcast seeds?

2 Method

2.1 Banksia woodlands

Banksia woodlands are a widespread and common plant community of the Swan Coastal Plain in the southwest of Western Australia. The woodlands extend from Jurien to the north (200 km from Perth), Busselton to the south (250 km south of Perth), and Dandaragan Plateau to the east (Beard 1989). *Banksia* woodlands are floristically rich and taxonomically diverse (Dodd and Griffin 1989). *Banksia attenuata* (slender *Banksia*) and *B. menziesii* (firewood *Banksia*) dominate the overstorey, while *Eucalyptus todtiana* (coastal blackbutt), *E. gomphocephala* (Tuart), *E. marginata* (Jarrah), *Allocasuarina fraseriana* (Fraser's sheoak), *Nuytsia floribunda* (christmas tree) and other *Banksia* species occur less frequently. The understorey is represented by the dominant woody families Proteaceae, Myrtaceae, Papilionaceae, and Epacridaceae, and nonwoody understorey families Orchidaceae, Cyperaceae, Restionaceae, Haemodoraceae, and Anthericaceae (Beard 1989, Dodd and Griffin 1989).

2.2 Site description

The Gnangara Pine Plantation is located approximately 20 km north of Perth, extending further north for approximately 50 km. The original plantation covered an area of approximately 23 000 ha; since the development of the Gnangara Sustainability Strategy, pines have been harvested as they mature but not replaced, and this will continue over the next few decades. As each coupe is harvested, it will be set aside for different land uses such as housing, parklands or restoration to *Banksia* woodlands. The plantation is located on two main soil complexes: the Spearwood sand complex to the north and west and Bassendean sand complex to the east (Mattiske and Havel 1998). These deep sands are well drained but nutrient poor. The region experiences a Mediterranean climate, characterized by hot dry summers (December–February) and mild moist winters (June–August). The region receives approximately 773 mm (average) of rainfall annually but this varies considerably from year to year (Bureau of Meteorology 2008).

2.3 Species establishment and density

Species abundance was recorded in three 7 m × 7 m plots at 15 restoration trial sites in spring 2008. The plots were located about 10 m apart, were ploughed but not burned prior to seeding by hand. Seven of the sites also had an adjacent treatment area that was burned prior to seeding. Species abundance was also recorded in three 7 m × 7 m plots at each of these sites. The sites were located throughout the plantation area, on both soil complexes and were sown from 2002 to 2006 (Table 1). Sites 1 to 6 were located towards the southern end of the plantation (Gnangara); sites 7 to 11 were located in the middle of the plantation (Pinjar); and sites 12 to 15 were located at the northern end of the plantation (Yanchep).

Table 1: Characteristics of 15 sites where *Banksia* woodland restoration has been trialed at Gnangara.

Site	Location	Year	Soil type	Treatment	Seed Mix	Code
1	Payne	2002	Bassendean	Unburnt	1	Pa2
2	Amarante	2002	Spearwood	Unburnt	1	A2
				Burnt	1	A2B
3	Warbrook	2002	Bassendean	Unburnt	1	W2
4	Barlow	2003	Bassendean	Unburnt	2	B3
				Burnt	2	B3B
5	Barlow	2004		Unburnt	3	B4
				Burnt	3	B4B
6	Barlow	2005		Unburnt	4	B5
7	Pigeon	2004	Spearwood	Unburnt	5	Pi4
				Burnt	5	Pi4B
8	Kestral	2002	Spearwood	Unburnt	6	K2
9	Kestral	2004		Unburnt	7	K4
10	Tomar	2005	Spearwood	Unburnt	8	T5
11	Tomar	2006		Unburnt	9	T6
12	Callitris	2004	Spearwood	Unburnt	10	C4
				Burnt	10	C4B
13	Callitris	2005		Unburnt	11	C5
14	Stirlingia	2004	Spearwood	Unburnt	12	S4
				Burnt	12	S4B
15	Stirlingia	2005		Unburnt	11	S5
				Burnt	11	S5B

The percentage of species that established in each plot was calculated by dividing the number of species recorded by the number of species included in the seed mix and multiplying by 100. This measure was used rather than species diversity because the number and type of species planted at each site varied considerably, therefore diversity could not be used to accurately compare establishment success among the sites.

The density of each species was calculated for each plot and converted to stems per hectare per gram of seed planted. The seed rate was taken into account in the measure of density to enable a comparison of establishment densities among sites where the quantity of seed planted for each species was different.

2.4 Effect of site characteristics and treatments on species composition

Non-metric multidimensional scaling (NMS) was used to explore differences in the composition of the vegetation among plots. Species that were sown but did not establish anywhere were exluded from the analysis. NMS uses ranked distances to arrange plots along a number of axes based on the composition (presence/absence) of the vegetation within them. The placement of plots and number of axes in a NMS ordination are calculated as the solution minimizing the final stress between the dissimilarity in the original data matrix and that in the reduced ordination matrix. This ordination method is well-suited to data that are non-normally distributed and for this reason it is often used to explore ecological data (Clarke 1993, Warton 2008). Each NMS was based on a Bray-Curtis matrix of dissimilarities between sites. The program PC-ORD (McCune and Mefford 1999) was used for these analyses.

2.5 Effects of rainfall on species establishment and density

The mean percentage of species that established at each site and species density (stems per hectare per gram of seed planted) was calculated and the effects of rainfall on these measures were analysed using linear regression. The amount of rain that fell within five time-periods was calculated for each site: 30 days, 60 days, 90 days, one and two years after sowing. The species included in the density analysis were those sown at all 15 sites including *Acacia pulchella*, *Allocasuarina fraseriana*, *Allocasuarina humilis*, *Banksia attenuata*, *Banksia menziesii* and *Eucalyptus todtiana*. The variation in the establishment of these particular species provides the most appropriate data to answer this question because they were consistently sown and were therefore exposed to the full range of yearly variations in rainfall. Percentage values were converted to proportions and arcsine square root transformed and density values were cube root transformed. The analyses were undertaken using SPSS 15.0 (SPSS 2006).

2.6 Effects of weed cover on species establishment and density

Weed cover was visually estimated in each plot surveyed for species abundance and a value of 1–5 was recorded according to the weed cover within the plot: 1 = < 20 %; 2 = 21–40 %; 3 = 41–60 %; 4 = 61–80 %; 5 = 81–100 %. The effects of weed cover at each site on the mean percentage of species that established and species density (stems per hectare per gram of seed planted) at each site were analysed using linear regression, as described for rainfall.

3 Results

3.1 Species establishment and density

A total of 65 species were planted in the restoration trials from 2002 to 2006. Forty four of these species were planted at three or more sites, and twenty one species were planted at only one or two sites. The rate of success for the establishment of each species varied considerably (Table 2). Most species were generally successful and established at a moderate to high level i.e. at more than 50% of sites where they were sown. However, several species had low establishment rates (20–44%) and some were not recorded at any site. The success rates for the 21 species planted at only one or two sites is not a reliable indicator of how the species may perform at other locations.

The density at which individual species established was also variable (Table 2). However, it should be noted that these measurements are per hectare per gram of seed and are therefore not comparable among species due to the differences in seed masses.

Table 2: Establishment rates and density of 65 species seeded in *Banksia* woodland restoration trial sites at Gnangara, assessed three to six years after sowing.
*** species planted at only one or two sites**

Species planted	No. sites seeded	No. sites established	Mean establishment rate (%)	Density (plants/ha/gram of seed) mean and range
Acacia cyclops	1	1		0.2 (0.2–0.2)*
Acacia huegelii	10	5	50	1.0 (0.0–3.0)
Acacia pulchella	15	13	87	2.1 (0.0–7.3)
Acacia saligna	6	5	83	0.4 (0.0–0.5)
Acacia sessilis	12	7	58	0.7 (0.0–4.5)
Allocasuarina fraseriana	15	9	60	0.5 (0.0–2.7)
Allocasuarina humilis	15	9	60	0.4 (0.0–1.8)
Anigozanthus humilis	5	1	20	0.1 (0.0–0.5)
Anigozanthus manglesii	7	4	57	0.5 (0.0–1.8)
Banksia attenuata	15	13	87	1.2 (0.0–6.5)
Banksia grandis	9	5	56	0.8 (0.0–2.6)
Banksia littoralis	1	0		0.0 (0.0–0.0)*
Banksia menziesii	15	11	73	1.5 (0.0–4.1)
Beaufortia elegans	7	7	100	28.6 (0.9–122.4)
Bossiaea eriocarpa	6	4	67	1.0 (0.0–4.5)
Calothamnus quadrifidus	8	7	88	8.3 (0.0–29.1)
Calothamnus sanguineus	9	8	89	5.0 (0.0–23.5)
Daviesia divaricata	9	4	44	0.4 (0.0–2.0)
Dianella divaricarta	1	0		0.0 (0.0–0.0)*
Dianella revoluta	3	0	0	0.0 (0.0–0.0)
Diplolaena angustifolia	1	0		0.0 (0.0–0.0)*
Dryandra sessilis	1	1		1.8 (1.8–1.8)*
Eremaea asterocarpa	9	3	33	0.2 (0.0–1.0)
Eremaea pauciflora	14	10	71	3.4 (0.0–15.7)
Eremaea purpurea	1	1		19.0 (19.0–19.0)*
Eucalyptus decipiens	1	1		1.4 (1.4–1.4)*
Eucalyptus marginata	8	6	75	0.3 (0.0–0.9)
Eucalyptus rudis	1	0		0.0 (0.0–0.0)*
Eucalyptus todtiana	15	13	87	3.0 (0.0–20.0)
Gastrolobium capitatum	10	6	60	1.5 (0.0–8.7)
Gompholobium tomentosum	10	10	100	5.0 (0.3–16.3)
Hakea lissocarpha	1	1		2.7 (2.7–2.7)*
Hakea prostrata	9	9	100	6.1 (0.3–16.7)
Hakea ruscifolia	3	2	67	3.2 (0.0–9.5)
Hakea trifurcata	2	2		5.4 (1.4–9.5)
Hakea varia	1	0		0.0 (0.0–0.0)*

Hardenbergia comptoniana	7	3	43	0.1 (0.0–0.5)
Hovea pungens	14	7	50	0.4 (0.0–2.6)
Hypocalymma robustum	1	1		0.7 (0.7–0.7)*
Jacksonia calcicola	8	7	88	15.1 (0.0–89.8)
Jacksonia floribunda	3	3	100	3.5 (0.9–7.7)
Jacksonia furcellata	13	13	100	4.9 (0.5–18.7)
Jacksonia sternbergiana	7	6	86	7.2 (0.0–33.3)
Kennedia prostrata	5	4	80	0.9 (0.0–2.2)
Kunzea ericifolia	12	11	92	50.8 (0.0–322.4)
Lechenaultia floribunda	3	2	67	8.7 (0.0–21.8)
Macrozamia riedlei	5	2	40	0.0 (0.0–0.1)
Melaleuca huegelii	1	0		0.0 (0.0–0.0)*
Melaleuca preissiana	1	1		0.0 (0.0–0.0)*
Melaleuca scabra	10	6	60	5.8 (0.0–27.8)
Melaleuca seriata	3	3	100	7.9 (1.4–14.5)
Melaleuca systena	8	6	75	5.7 (0.0–20.4)
Melaleuca teretifolia	1	1		2.3 (2.3–2.3)*
Olearia axillaris	1	0		0.0 (0.0–0.0)*
Patersonia occidentalis	6	0	0	0.0 (0.0–0.0)
Petrophile brevifolia	5	0	0	0.0 (0.0–0.0)
Petrophile macrostachya	4	0	0	0.0 (0.0–0.0)
Petrophile serruriae	5	1	20	0.1 (0.0–0.5)
Pultenaea reticulata	1	1		2.7 (2.7–2.7)*
Regelia ciliata	1	1		68.8 (68.8–68.8)*
Regelia inops	7	6	86	4.6 (0.0–9.5)
Scholtzia involucrata	3	0	0	0.0 (0.0–0.0)
Verticordia nitens	2	1		0.5 (0.0–1.0)
Viminaria juncea	1	0		0.0 (0.0–0.0)*
Xanthorrhea preissii	1	0		0.0 (0.0–0.0)*

Species with high establishment rates (>75 %) that were sown at three or more sites, include:

- *Acacia pulchella*
- *Acacia saligna*
- *Banksia attenuata*
- *Beaufortia elegans*
- *Calothamnus quadrifidus*
- *Calothamnus sanguineus*
- *Eucalyptus marginata*
- *Eucalyptus todtiana*
- *Gompholobium tomentosum*
- *Hakea prostrata*
- *Jacksonia calcicola*
- *Jacksonia floribunda*
- *Jacksonia furcellata*
- *Jacksonia sternbergiana*
- *Kennedia prostrata*
- *Kunzea ericifolia*
- *Melaleuca seriata*
- *Melaleuca systena*
- *Regelia inops*

Species with low establishment rates (<35%) that were sown at three or more sites, include:

- *Anigozanthus humilis*
- *Petrophile serruriae*
- *Eremaea asterocarpa*

Species that did not establish and were sown at three or more sites, include:

- *Dianella revoluta*
- *Patersonia occidentalis**
- *Petrophile brevifolia**
- *Petrophile macrostachya*
- *Scholtzia involucrata*

**Patersonia occidentalis* was sown six times and did not establish and similarly *Petrophile brevifolia* was sown five times and did not establish. An alternate method of introduction is needed for these species.

A number of species were recorded in the plots that were not included in the seed mix. These 'volunteer' species that had most likely colonized from nearby bushland areas or were present in the soil seed bank include:

- *Adenanthos cygnorum*
- *Astroloma sp.*
- *Burchardia umbellata*
- *Conospermum sp.*
- *Conostylis sp.*
- *Dampiera sp.*
- *Daviesia decurrens*
- *Exocarpus sparteus*
- *Gonocarpus pithyoides*
- *Hibbertia sp.*
- *Hibbertia subvaginata*
- *Leucopogon sp.*
- *Macarthuria australis*
- *Nuytsia floribunda*
- *Petrophile linearis*
- *Phyllanthus calycinus*
- *Scaevola repens*
- *Stirlingia latifolia*
- *Thysanotus sp.*

There were a number of species that were recorded in the plots that were not included in the seed mix for that site, but were included in the seed mix at other sites. These species were not included in the above list because it is possible that there was some mixing of the seed mixes for different sites. However, a number of these species are common in the surrounding bushland and it is possible that they also 'volunteered'.

3.2 Effect of site characteristics and treatments on species composition

The NMS ordination recommended a 3-dimensional solution. The three axes cumulatively explained 87.8 % of the variation in species composition (Table 3). The final stress for the optimal 3-dimensional solution was 0.13, where 0 is minimal stress and 1 is maximal stress. The vegetation data (present/absent) were analysed once but displayed separately for each factor: one each for site, year, treatment and soil type (Figure 1a–d). Axis 1 was plotted against Axis 2 because these two axes explained most of the variation in the data (76.8 %).

Table 3: Individual and cumulative variation explained by the three axes of NMS ordination of the species assemblages at the trial sites at Gnangara.

	R Squared	
Axis	Increment	Cumulative
1	0.410	0.410
2	0.357	0.768
3	0.111	0.878

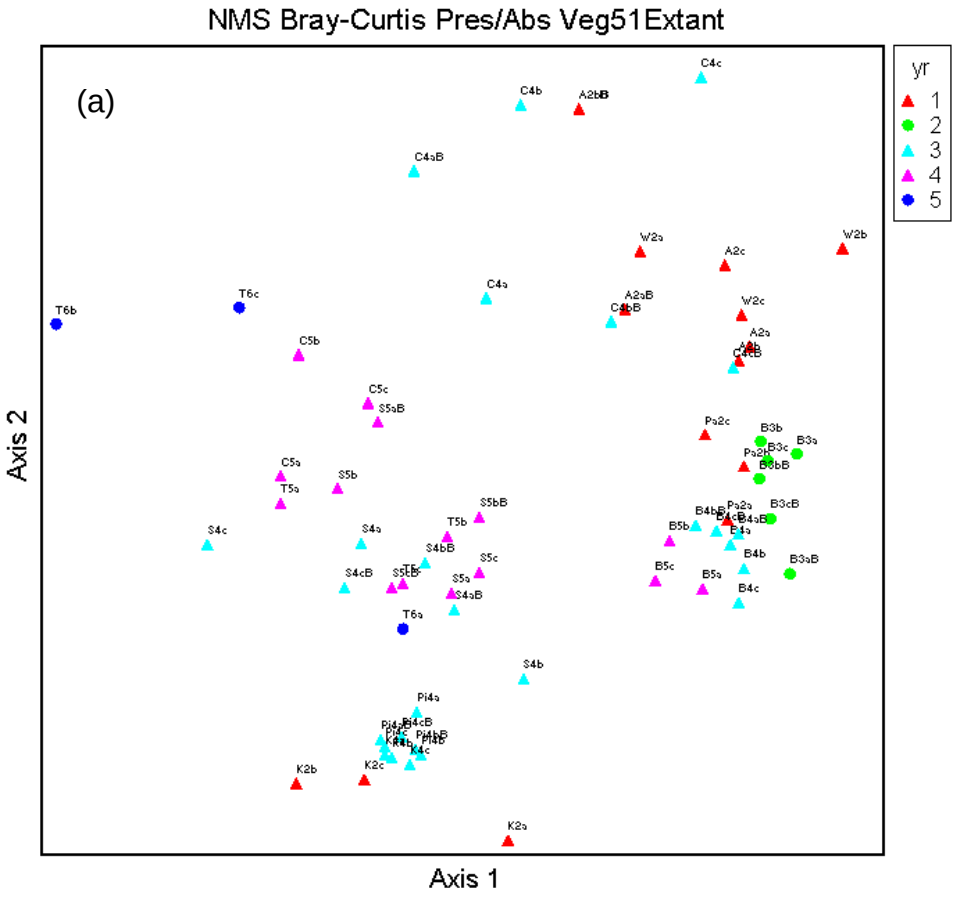
In each of the following ordination diagrams, plots close to one another in the ordination space are more similar, based on their species assemblages, than those further apart. Furthermore, if the factors that we considered had an ecologically significant and detectable effect on the restored assemblages, then we would expect plots to cluster into groups according to the levels within these factors (e.g., one cluster of burnt and one cluster of unburnt plots).

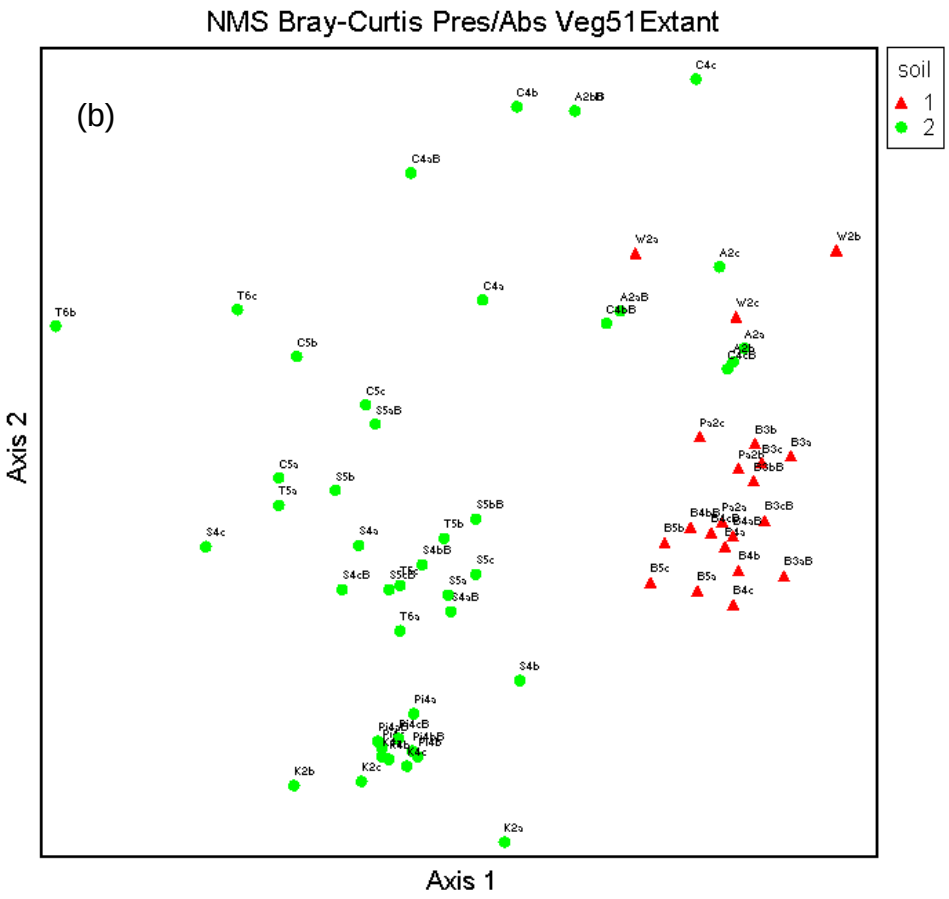
The assemblages that established in year 1 (2002), year 3 (2004) and year 5 (2006) were highly variable in species composition i.e. the distance between plots that were sown in these years were further apart than the distances between plots seeded in years 2 and 4 (Figure 1a).

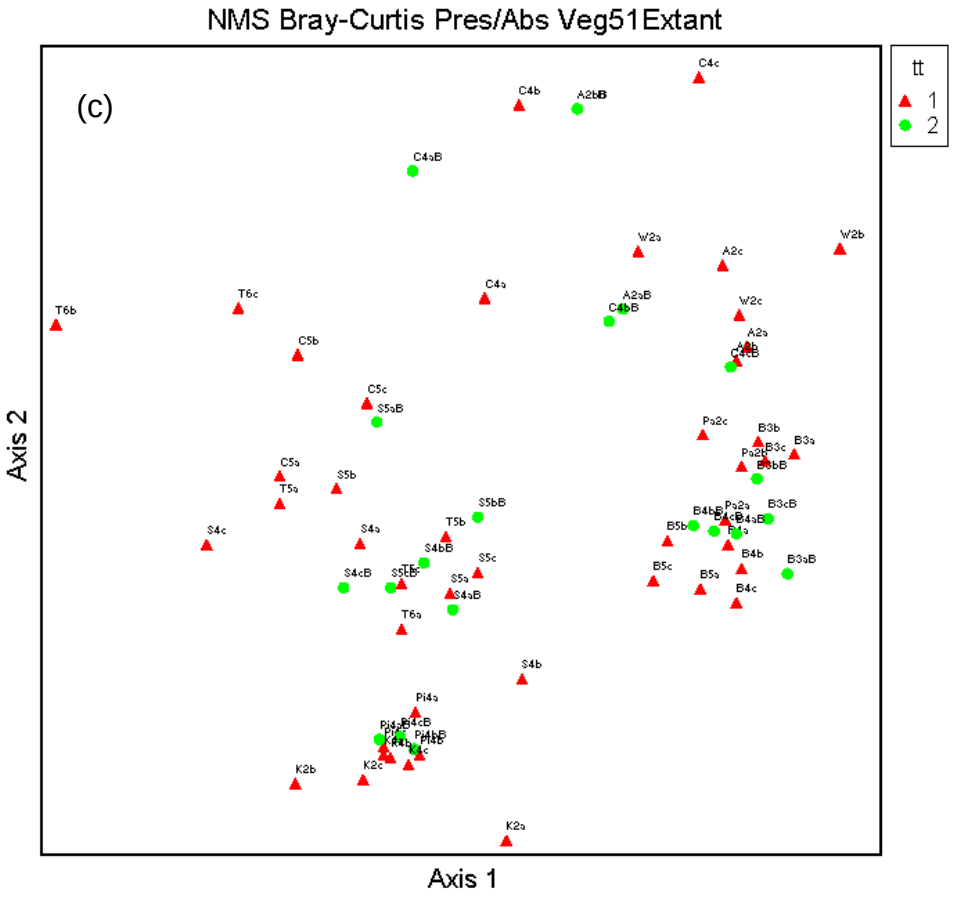
There is partial separation of assemblages with respect to their soil types, whereby most of the plots on soil type 1 (Bassendean sands) clustered together, with the exception of the W2 plots (Figure 1b). In comparison, plots on the second soil type (Spearwood sands) did not form a cluster. There was no difference between assemblages at unburnt (treatment 1) and burnt (treatment 2) sites (Figure 1c) and no clustering of the plots according to this treatment was apparent.

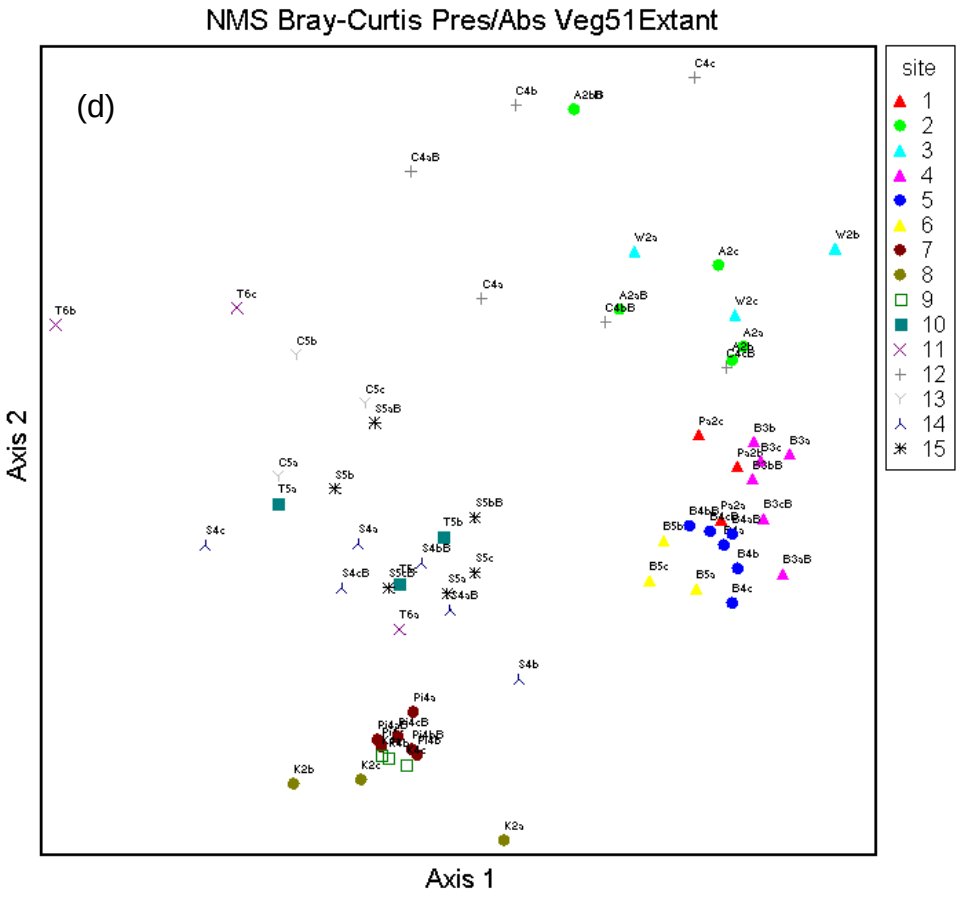
There was some grouping of plots within each site i.e. the species assemblages were more similar within each site than among different sites (Figure 1d). Sites located adjacent to each other (geographically) were generally clustered more closely than sites located further apart e.g. the Barlow 2003, 2004 and 2005 sites.

The grouping of plots for the seed mixes was very similar to the sites (Figure 1e) as few sites had the same seed mix. The sites at Payne, Amarante and Warbrook 2002 (seed mix 1); and Callitris and Stirlingia 2005 (seed mix 11) had the same seed mixes. However, plots seeded with these mixes did not cluster into groups.


NMS Bray-Curtis Pres/Abs Veg51Extant
(a)
yr
1
2
3
4
5
Axis 2
Axis 1


NMS Bray-Curtis Pres/Abs Veg51Extant
(b)
soil
1
2
Axis 2
Axis 1


NMS Bray-Curtis Pres/Abs Veg51Extant
(c)
tt
1
2
Axis 2
Axis 1


NMS Bray-Curtis Pres/Abs Veg51Extant
(d)
site
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Axis 2
Axis 1

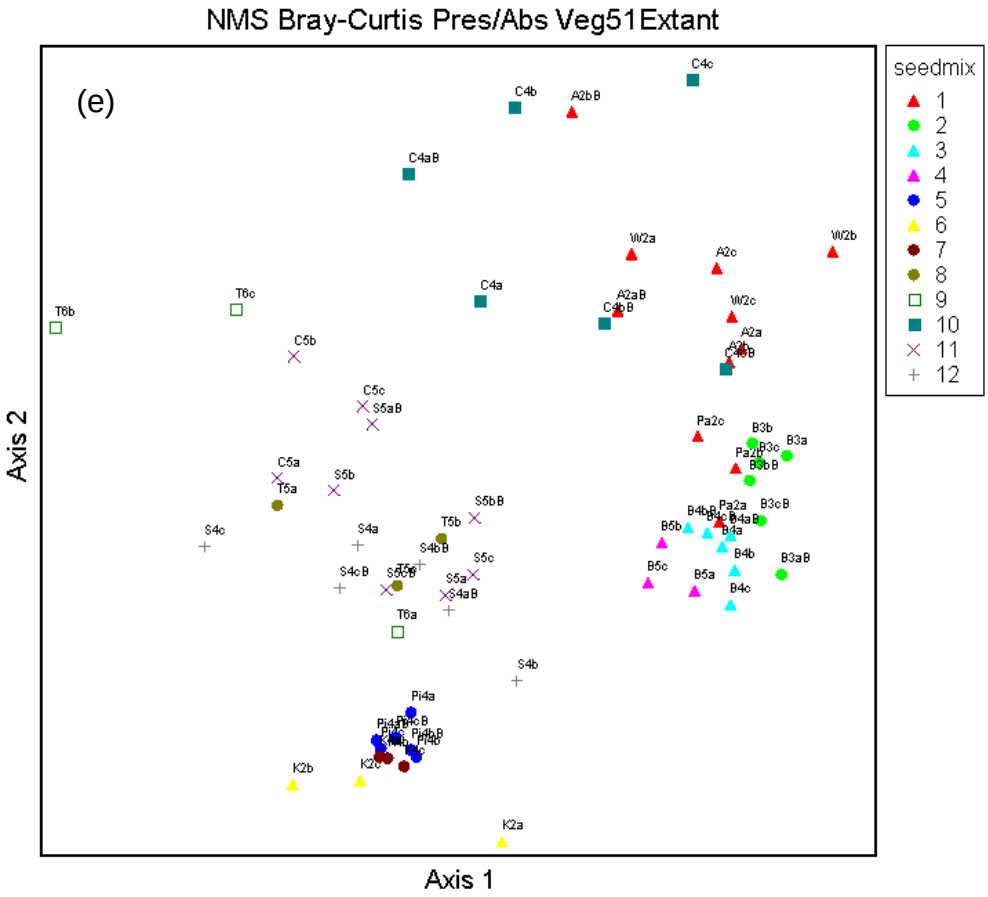


Figure 1 (a–e): NMS ordination of vegetation composition at *Banksia* woodland restoration trial sites. The cumulative variation explained by the two NMS axes is 76.8 %. Plot codes are listed in Table 1 and have a lower case a, b or c, which indicates the three plots sampled at each site. Legend codes: Year 1 = 2002; 2 = 2003, 3 = 2004; 4 = 2005; 6 = 2006. Soil type 1 = Bassendean; type 2 = Spearwood. Treatment 1 = Burned; treatment 2 = unburned. For seed mix and site codes see Table 1.

3.3 Effects of rainfall on species establishment and density

The mean percentage of species that established from the species seeded ranged from 12% of species (± 4.94 SE) at Callitris 2004, to 80% of species (± 5.00 SE) at Kestral 2004. Species establishment varied considerably among sites, including those sites that were seeded with the same seed mix, at the same time of year, in the same year, and located on the same soil type e.g. Payne, Amarante, and Warbrook 2002 (Figure 2). There does not appear to be any relationship with the geographical location of the sites and species establishment (south: Payne 2002–Barlow 2005; mid: Pigeon 2004–Tomar 2006; north: Callitris 2004–Stirlingia 2005).

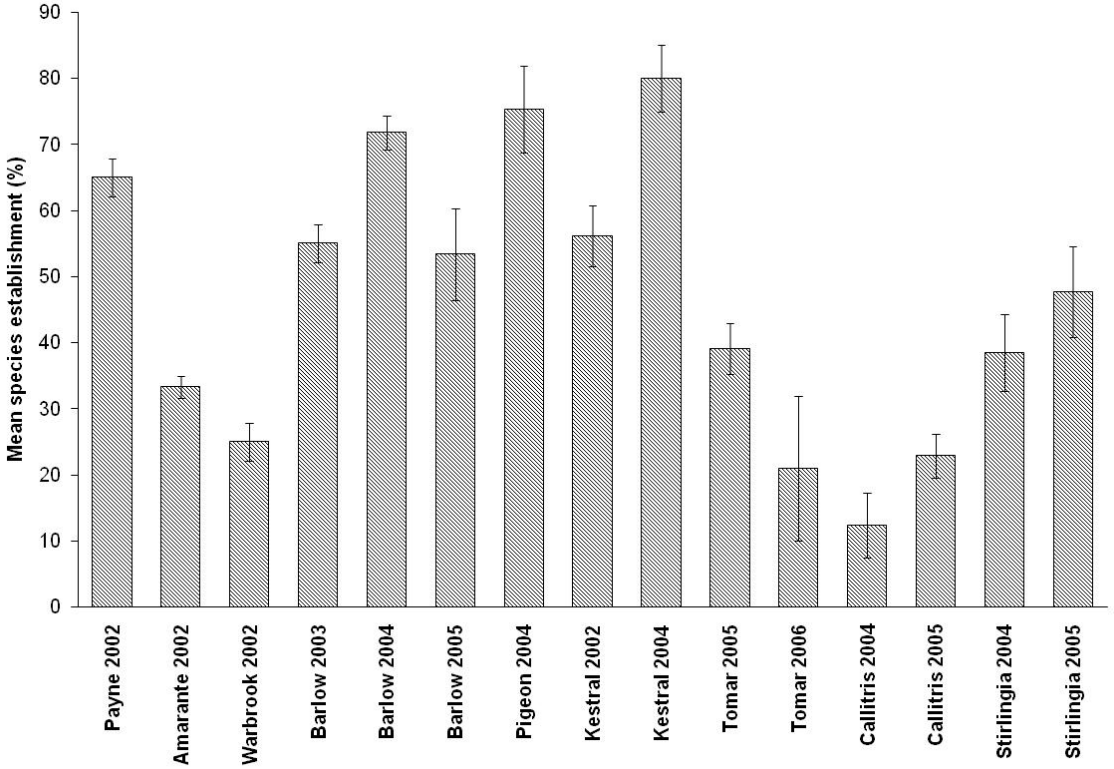


Figure 2: Mean percentage of species that established at 15 unburned trial sites at Gnangara assessed three to six years after sowing. Sowing dates are included with the x-axis site labels.

Six species were sown at all 15 sites including *Acacia pulchella*, *Allocasuarina fraseriana*, *Allocasuarina humilis*, *Banksia attenuata*, *Banksia menziesii* and *Eucalyptus todtiana*. The density of these species varied substantially among locations and within locations among years (Figure 3). These density figures do not indicate the actual number of plants at each site; they give some indication of the recruitment success at each site. For example, a gram of *Acacia pulchella* seed sown at Barlow in 2003 yielded no plants, whereas a gram sown at Barlow in 2005 yielded around three plants per hectare. Actual densities of *Acacia pulchella*, which does not take into account the amount of seed sown, was highest at Kestral 2002 (1769 stems/ha), Kestral 2004 (2381 stems/ha), and Tomar 2005 (2177 stems/ha). The size of the plants varied according to their age. The effects of rainfall on the density of recruitment (per gram of seed sown) was analysed to determine whether this factor explained some of the observed variation among sites and years.

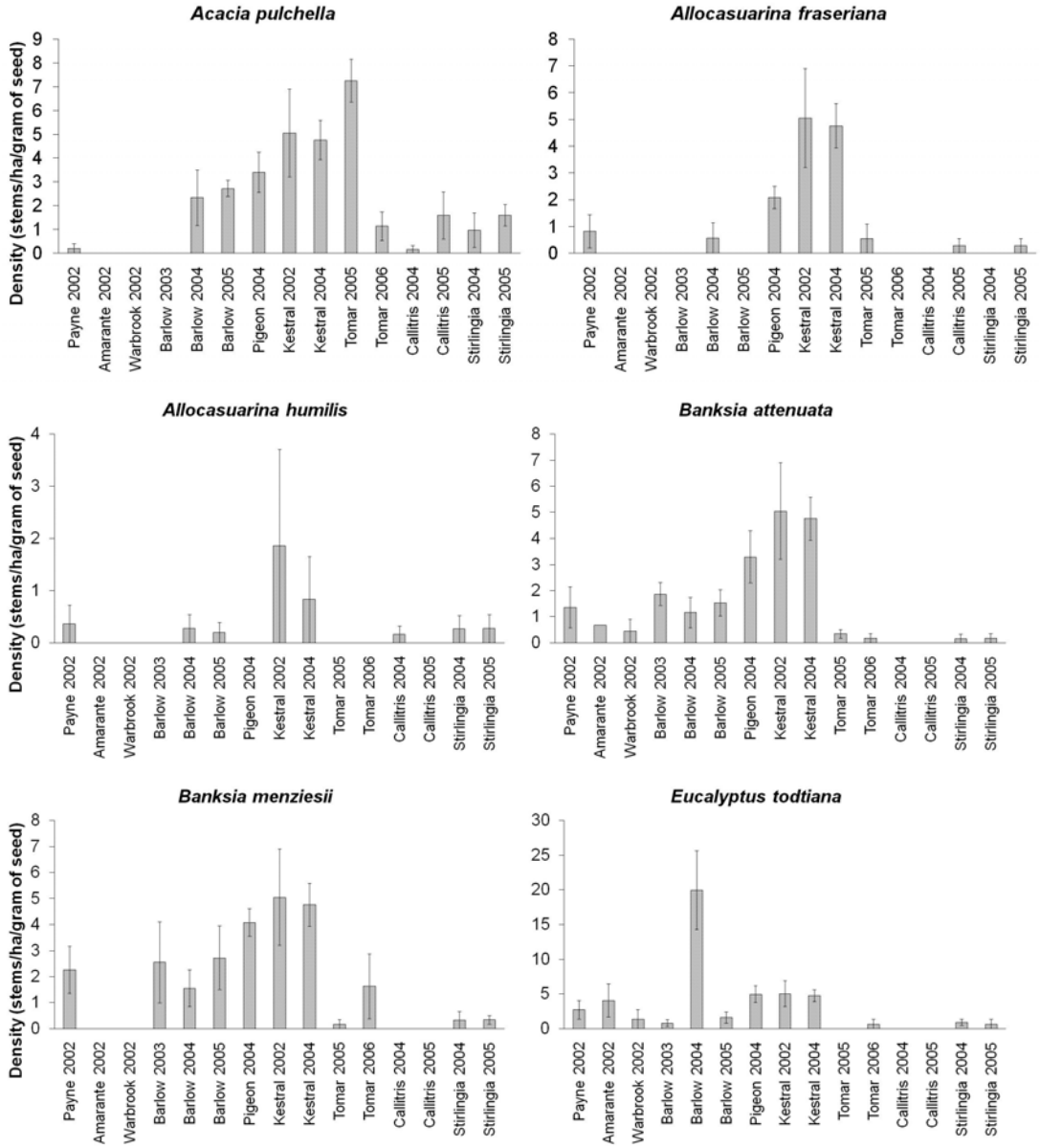


Figure 3 (a-f): Variation in density of the six species sown at all 15 restoration trial sites at Gnangara (from top left to bottom right): (a) *Acacia pulchella*, (b) *Allocasuarina fraseriana*, (c) *Allocasuarina humilis*, (d) *Banksia attenuata*, (e) *Banksia menziesii*, and (f) *Eucalyptus todtiana*.

The trials at Gnangara were generally seeded in June and July, except in 2003, which was seeded in early May. Rainfall varied substantially among the years the trials were established, by up to 100 mm 30 days after seeding, 123 mm 60 days after seeding, 184 mm 90 days after seeding, 224 mm in the first year, and to 425 mm in the first two years.

Linear regression analyses found that the amount of rainfall after broadcasting had no significant effect on the mean percentage of species that established at each site or density of establishment of the six focal species at the five intervals tested (Table 4). At each interval, species establishment was consistently high for three sites after high rainfall, but then, establishment was low at sites receiving equal amounts of rainfall. There did not appear to be any threshold i.e. minimum rainfall required that resulted in a particular percentage of species establishment (Figure 4).

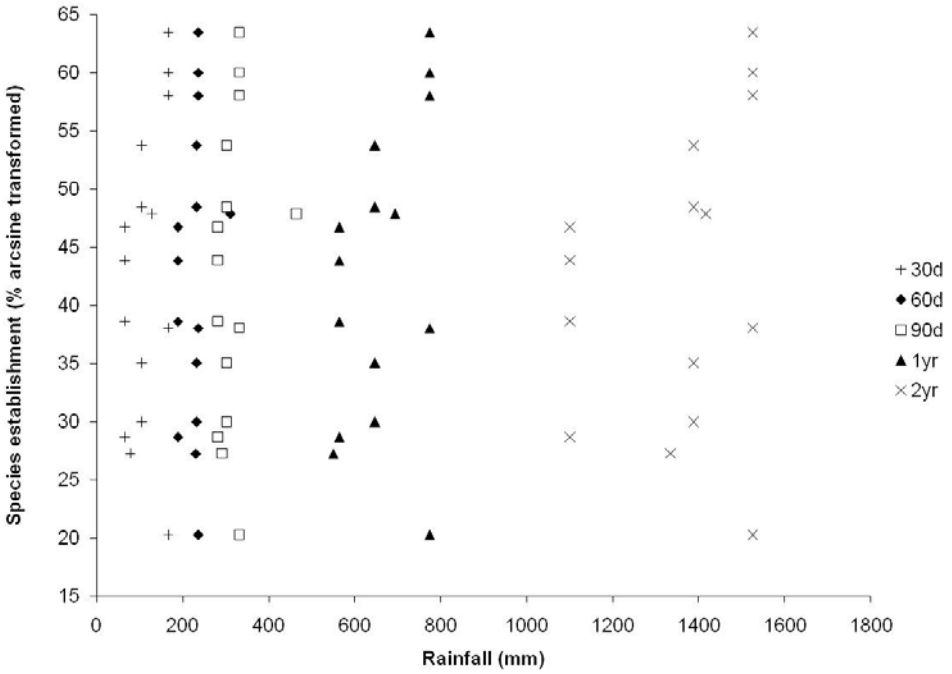


Figure 4: Scatter plot between rainfall (at five time intervals after sowing) and percentage species establishment assessed three to six years after sowing (arcsine transformed).

The amount of rainfall that occurred within the first 60 days after seeding significantly affected the density of *Acacia pulchella* (Table 4), which decreased with increasing levels of rainfall. However, the amount of variation explained was small (R^2 = 0.275) and the results were strongly affected by one site, Barlow 2003, which received the highest amount of rainfall and no *Acacia pulchella* plants were recorded there (Figure 5).

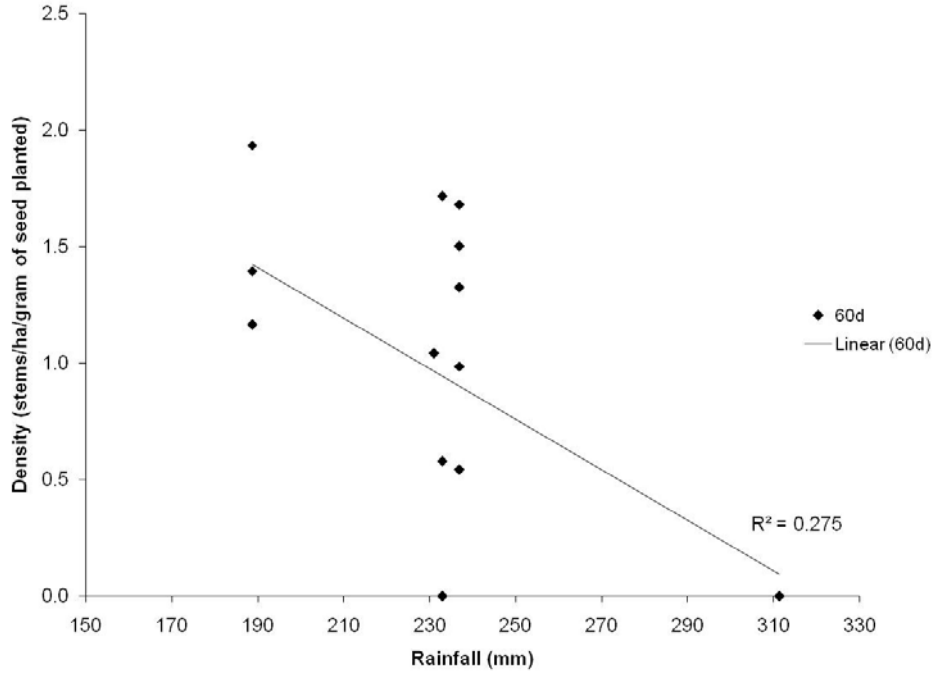


Figure 5: Scatter plot between rainfall that occurred 60 days after seeding and the density of *Acacia pulchella* seedlings (stems/ha/gram of seed planted) recorded at 15 trial sites.

Table 4: Results from linear regression analyses between the amount of rainfall during five intervals (predictor) and species establishment and density of six focal species at 15 restoration trial sites. For significant relationships: $P < 0.01$, $P < 0.05$*.**

Dependent Variable	Predictor	Sum of Squares	df	Mean Square	F	*P*
Establishment (%)	30d	285.91	1	285.91	1.79	0.204
	60d	90.08	1	90.08	0.52	0.485
	90d	143.96	1	143.96	0.84	0.375
	1yr	327.97	1	327.97	2.10	0.171
	2yr	166.55	1	166.55	0.99	0.339
Acacia pulchella (stems/ha/gram of seed)	30d	0.02	1	0.02	0.05	0.822
	60d	1.60	1	1.60	4.94	0.045*
	90d	0.96	1	0.96	2.58	0.133
	1yr	0.03	1	0.03	0.06	0.805
	2yr	0.32	1	0.32	0.76	0.398
Allocasuarina fraseriana (stems/ha/gram of seed)	30d	0.18	1	0.18	0.43	0.525
	60d	0.08	1	0.08	0.18	0.675
	90d	0.10	1	0.10	0.24	0.630
	1yr	0.23	1	0.23	0.55	0.473
	2yr	0.09	1	0.09	0.21	0.655
Allocasuarina humilis (stems/ha/gram of seed)	30d	0.78	1	0.78	2.26	0.157
	60d	0.00	1	0.00	0.00	0.960
	90d	0.02	1	0.02	0.05	0.832
	1yr	0.86	1	0.86	2.52	0.137
	2yr	0.56	1	0.56	1.54	0.236
Banksia attenuata (stems/ha/gram of seed)	30d	0.26	1	0.26	0.93	0.353
	60d	0.47	1	0.47	1.79	0.204
	90d	0.29	1	0.29	1.03	0.328
	1yr	0.29	1	0.29	1.05	0.324
	2yr	0.40	1	0.40	1.49	0.244
Banksia menziesii (stems/ha/gram of seed)	30d	0.26	1	0.26	0.59	0.455
	60d	0.47	1	0.47	1.10	0.313
	90d	0.43	1	0.43	1.02	0.331
	1yr	0.21	1	0.21	0.48	0.502
	2yr	0.30	1	0.30	0.69	0.421
Eucalyptus todtiana (stems/ha/gram of seed)	30d	1.40	1	1.40	2.86	0.115
	60d	0.71	1	0.71	1.31	0.272
	90d	0.16	1	0.16	0.27	0.614
	1yr	1.41	1	1.41	2.87	0.114
	2yr	1.98	1	1.98	4.44	0.055

3.4 Effects of weed cover on species establishment and density

Weed cover was generally higher at the northern sites (Tomar, Callitris and Stirlingia), which commonly had weed cover of greater than 3 (i.e. > 60 %), than sites locted towards the southern end of the plantation.

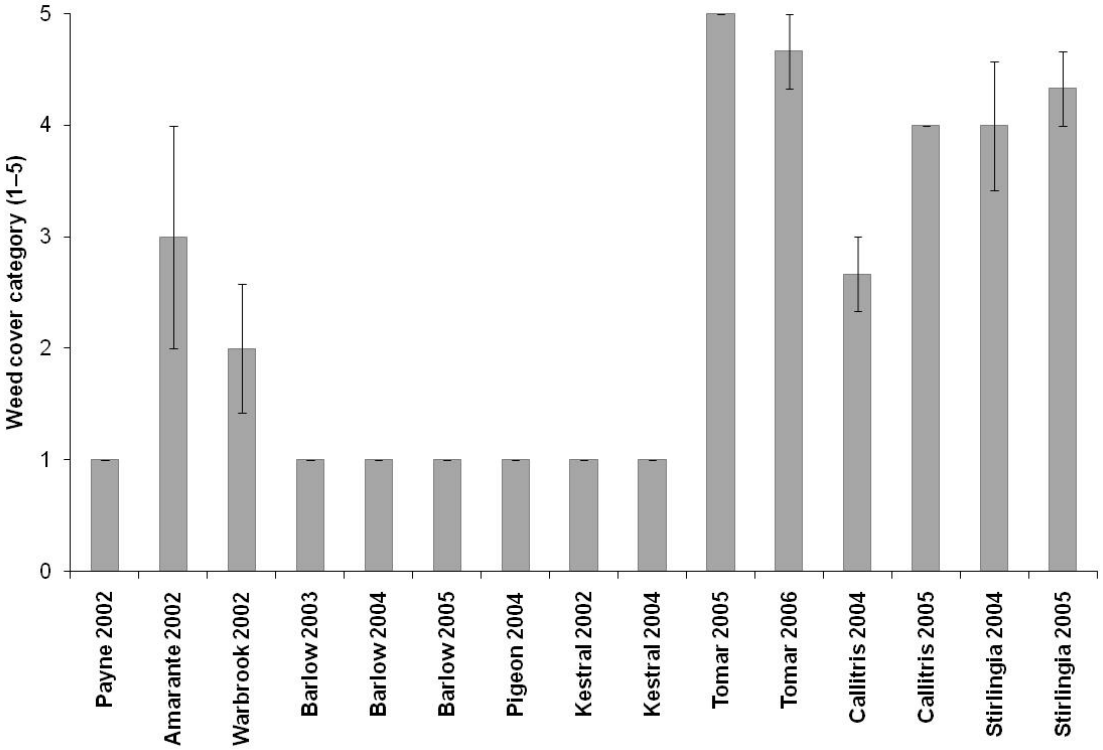


Figure 6: Mean weed cover (1 = < 20 %; 2 = 21–40 %; 3 = 41–60 %; 4 = 61–80 %; 5 = 81–100 %) at 15 unburned trial sites at Gnangara assessed three to six years after sowing. Sowing dates are included with the x-axis site labels.

Linear regression analyses found that the amount of weed cover had a significant effect on the mean percentage of species that established at each site and the density of establishment of *Banksia attenuata* and *Eucalyptus todtiana* (Table 5). Higher levels of weed cover reduced the percentage of species that establishment (Figure 7) and density of *Banksia attenuata* (Figure 8) and *Eucalyptus todtiana* (Figure 9) that established within the trial plots. The amount of variation explained by weed cover was moderate (R^2 = 0.461 for establishment; 0.396 for *Banksia attenuata* density; and 0.383 for *Eucalyptus todtiana* density).

Table 5: Results from linear regression analyses between the amount of weed cover (predictor) and species establishment and density of six focal species at 15 restoration trial sites. For significant relationships: *P* < 0.01, *P* < 0.05*.**

Dependent variable	Sum of Squares	df	Mean Square	F	*P*
Establishment (%)	1087.86	1	1087.86	11.12	0.005**
Acacia pulchella	0.16	1	0.16	0.37	0.556
Allocasuarina fraseriana	0.28	1	0.28	0.69	0.422
Allocasuarina humilis	0.72	1	0.72	2.06	0.175
Banksia attenuata	1.55	1	1.55	8.54	0.012*
Banksia menziesii	1.39	1	1.39	3.94	0.069
Eucalyptus todtiana	2.98	1	2.98	8.05	0.014*

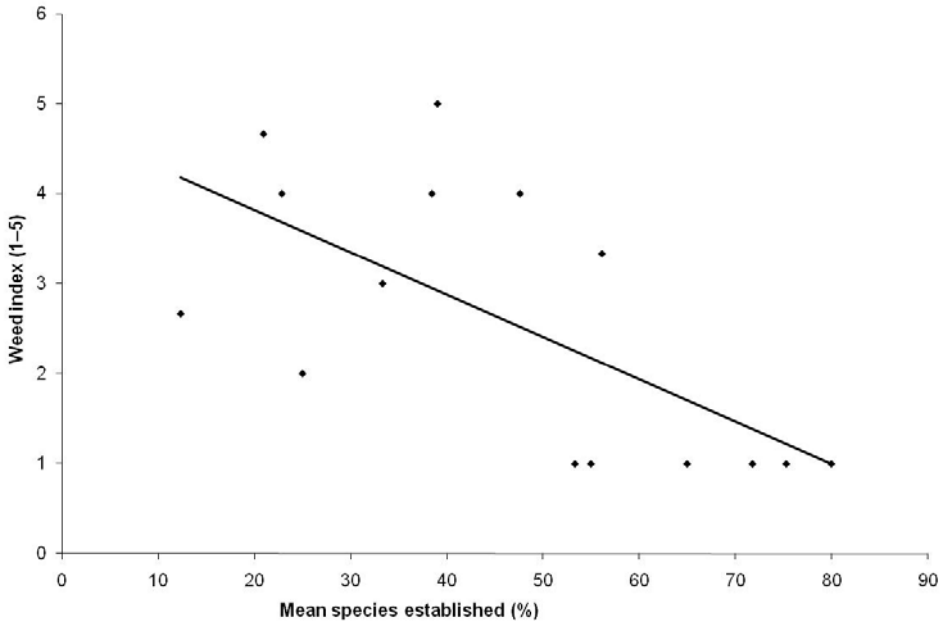


Figure 7: Scatter plot between weed cover and percentage species establishment assessed three to six years after sowing.

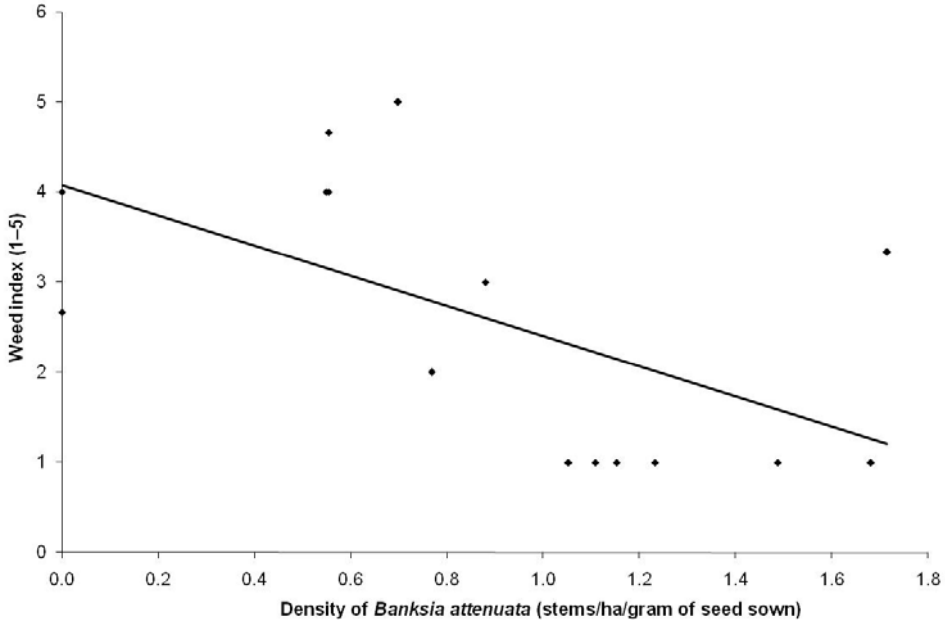


Figure 8: Scatter plot between weed cover and the density of *Banksia attenuata* (stems/ha/gram of seed sown) assessed three to six years after sowing.

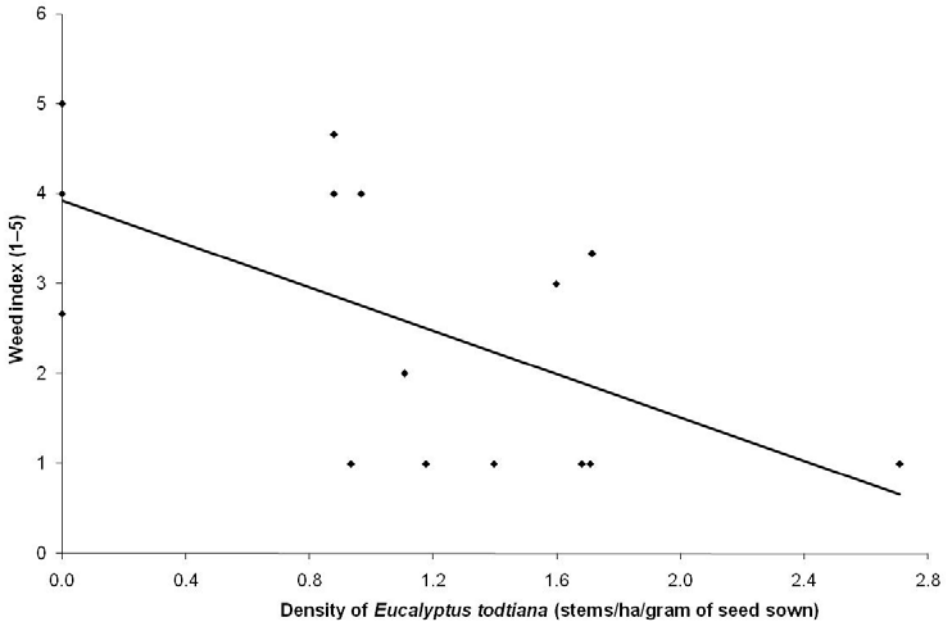


Figure 9: Scatter plot between weed cover and the density of *Eucalyptus todtiana* (stems/ha/gram of seed sown) assessed three to six years after sowing.

4 Discussion

Species establishment and density

The rate at which each species established and density of plants that established from each gram of seed planted (Table 2) provides a guideline to determine the approximate quantity of seed required to achieve the final density of plants desired in areas to be restored in the future. Although rates of establishment and density for each species are variable, the information gathered thus far on the 44 species planted at three or more sites is laudable. This information is more useful for some species than for others; for example, the density of seedlings that established per gram of *Beaufortia elegans* seeds varies by three orders of magnitude. In contrast, the densities of seedlings that established from *Acacia* seeds were less variable (i.e., consistent among sites, soil types, year and burning treatment). As the goals of the restoration programme become more refined and information continues to be gathered on the recruitment biology of these and other *Banksia* woodland species, then specific recommendations can be provided about the quantity, and therefore cost, of seeds required to achieve the desired species assemblages (see Section 5: Recommendations). It could take years of "tinkering"—using an adaptative management approach—to achieve this goal.

Many species had good established rates and 19 of the 44 species planted at three or more sites successfully established at more than 75% of the sites where they were sown. Species that failed to establish at any site include *Dianella revoluta, Patersonia occidentalis, Petrophile brevifolia, Petrophile macrostachya* and *Scholtzia involucrata.* Species that had low establishment rates (<35%) include *Anigozanthus humilis, Petrophile serruriae* and *Eremaea asterocarpa*. These species may have very low seed viabilities or complex dormancy mechanisms or other factors may be constraining their recruitment. Several of these species are known to have very low

germination rates, including *Patersonia occidentalis* (0.4% of viable seeds) and *Dianella revoluta* (6.3% of viable seeds) (Roche et al. 1997). However, the effects of smoke have been found to substantially promote germination of a number of species, including *Scholtzia involucrata* (Rokich et al. 2002), *Patersonia occidentalis* and *Dianella revoluta* (Dixon et al. 1995, Roche et al. 1997). Although *Anigozanthus humilis* had low establishment rates in the trial areas where its seed was planted, it was abundant bushland areas adjacent or near several trial sites, and was present at a number of sites where it had not been planted.

Purchasing sufficient quantities of seed of species that have low recruitment rates or failed to establish for effective levels of recruitment through broadcasting is not cost effective. These species therefore should not be planted at additional sites without further investigation into the factors responsible for their low establishment rates. If specifically required in restored areas, investigations should include seed viability, germinability and dormancy mechanisms. Such species may need to be planted as seedlings at a later stage of restoration.

Effect of site characteristics and treatments on species composition

The success and density of establishment for most species varied considerably among sites. Seed viability and germinability may have varied to some degree among years and contributed to the observed variation. However, these factors do not explain the variation among sites that utilised the same seed mix and were seeded in the same year. Other factors such as burning treatments and soil type did not explain the variation observed in the vegetation assemblages that have established at Gnangara.

Kasel (2004) reviewed a range of projects concerned with re-establishing native species on former pine plantations across Australia. The sizes of the areas ranged from 3 to 1850 hectares, and were located in alpine areas in the ACT and NSW; the coastal sands of Jervis Bay Territory; and low and high elevation sites across Victoria. Kasel (2004) found that the most successful techniques included those that used fire and additionally situations where the subsequent regenerating vegetation was of sufficient density to outcompete any regenerating pines. Burns were usually carried out to improve germination rates of broadcast seed through removal of slash and increase nutrient availability through physicochemical and other biological processes.

Immediate post-fire environments generally favour seedling establishment due to the ‘ash-bed effect’, which sterilises the soil through heat, removes growth-inhibiting chemicals and microbes, changes the soil microflora and provides a flush of nutrients, and is commonly recorded in Australian forest systems (Gill 1979, Khanna and Raison 1986, Chambers and Attiwill 1994, Cummings et al. 2007). Conditions are generally considered likely to be more favourable for recruitment following a fire and regeneration is likely to occur at a larger scale than in the absence of fire. It is therefore surprising that burning had little to no effect on the species assemblages that established at Gnangara.

A lack of burning effect at Gnangara may be due to a time lag between burning and seeding. The effects of ash beds are only temporary and a large period of time between burning and seeding would mean that the positive ash bed effects are missed. However this information was not available. The fuel loads of the cleared pine plantations may be insufficient to create a substantial ash bed, and therefore would

minimise the effects of burning. Alternatively, the sample size (seven paired sites) may have been too small to detect the difference in burning, particularly with such strong site effects. The sample size was limited because only one treatment was conducted at all other sites i.e. the entire trial site was burned or not burned. Therefore comparisons could not be made between burnt and unburnt areas within the same site.

The general lack of effect of soil type on the vegetation assemblages that established was largely expected because both systems are composed principally of sand, with little structure, and are very infertile (McArthur 1991). The Spearwood dune system formed about 40,000 years ago, and comprises red/brown, yellow and pale yellow/grey sands. The sands are coated with both iron and aluminium oxides, which increases the capacity of the sands to retain phosphorus. The Bassendean dune system is about 800,000 years old, and is leached, infertile and acidic. The sands contain little silt or clay, and very low levels of nutrient elements, with any nutrient element content being associated with organic matter. Such differences in the two soil types may explain some of the clustering in the NMS.

The analysis of soil type only included the two broad soil types and did not include a range of soil physical and chemical properties such as organic matter, nutrients, pH or other properties that affect plant establishment and may be different among the sites. A range of projects aimed at restoring former pine sites in Australia have found that the plantations had modified soil conditions, associated biota and nutrient cycling processes (Kasel 2004). Addressing these issues has been a key challenge associated with restoring the sites. Further investigations of soil properties at Gnangara may indicate additional site differences, including inherent variation or modifications caused by former pine plantations, which may affect the vegetation assemblages that establish.

Effects of rainfall on species establishment and density

Abiotic factors such as temperature and rainfall are known to have an important effect on germination (Mott and Groves 1981) and plant establishment (Harper 1977). Germination in native species from the southwest of Western Australia generally occurs during winter (June–August), when ample moisture is available and temperatures rarely exceed 20 °C (Bell et al. 1995).

In developing seed-based rehabilitation techniques for *Banksia* woodland following sand mining at Banjup, 20 km south of Perth, Turner et al. (2006) found that the time of seed sowing had a significant effect on seedling emergence. More emerged seedlings were observed from the May sowing than from the July sowing. They suspected that this was due to greater amounts of rainfall immediately following the May sowing than the July sowing, which was followed by a period of 11 days without rainfall and then intermittent variable rainfall.

The substantial differences in rainfall that occurred over a range of time periods at the trial sites at Gnangara appeared to have little effect on the vegetation assemblages that established. These results were also evident in the large variation in success and density of establishment among sites that were seeded in the same year using the same seed mix. Site factors instead appear to have a greater impact on species establishment at Gnangara (discussed below).

Effects of weed cover on species establishment and density

Common herbaceous weed species in southwest Western Australia, particularly annual forbs and grasses, are fast growing and easily dispersed (Hobbs 2001; 2003). These species commonly establish after disturbances such as soil turnover, nutrient addition, or fire. Such disturbances are common site preparation treatments prior to seeding at Gnangara. Seedling establishment of many native woody species is significantly reduced in the presence of annual weed species (Hobbs 2001). Exotic grasses and herbs, which are often more vigorous and compete more effectively for limited soil water and nutrients (Humphries et al. 1991). Higher levels of weed cover reduced the percentage of species that establishment and density of *Banksia attenuata* and *Eucalyptus todtiana* that established within the trial plots at Gnangara. Although weed cover reduced the density of *Banksia attenuata* and *Eucalyptus todtiana*, it did not reduce the density of all species. These species may be more sensitive to competition from weeds than other species.

Although weed cover explained some of the variation observed in species establishment and density among sites, other site factors also appear to have a strong impact on these measures at Gnangara. Other site factors were not investigated, but establishment and density do not appear to be related to the soil type or to geographical (north–south) location of the sites. However, weed cover was generally higher in sites at the northern end of the plantation. It is not known whether all of trial sites were sprayed with herbicide to control for weeds. Other site factors such as soil organic matter, nutrients, pH, depth to groundwater, topography or other factors may explain some of the variation in the vegetation assemblages that established among the different sites.

An additional factor that was not investigated, but may contribute to the apparent site differences is the effect of browsing herbivores. Results from a previous study of the trial sites found that fencing from herbivores did not have a positive effect on early recruitment (Reid et al. 2004). Germination was actually reduced by fencing possibly as a consequence of poor fence design i.e. the fence was ineffective at keeping kangaroos out and once inside the fence they spent longer periods within the contained areas. Alternatively, reduced grazing of weeds inside the fenced areas increased competition from weeds and therefore inhibited recruitment.

Field observations suggest that plant cover and density were much greater in fenced areas at some sites, particularly Callitris and Stirlingia, which were located near Yanchep National Park. The kangaroo population may be greater in this part of Gnangara and therefore grazing may be greater at trial sites in these areas. Such effects may explain some of the variation in species assemblages that established at the trial sites. Numerous studies have also found kangaroos, which are present throughout Gnangara, and other native mammal herbivores to have a substantial negative effect on seedling recruitment (Abbot 1984, Cohn and Bradstock 2000, Meers and Adams 2003, Koch et al. 2004). To determine whether browsing herbivores are having a significant impact on recruitment and contributing to the strong individual site affect on establishment found in this study, further investigations are required.

Conclusions

- Burning the seedbed prior to broadcasting did not increase the establishment and density of the restored vegetation but this is worth re-testing as there may have been a delay between burning and seeding, which means that seeds were not exposed to the ash-bed effect.
- Rainfall after broadcasting did not appear to affect affect the establishment and density of the restored vegetation, and there did not appear to be a threshold of minimum rainfall required for establishment.
- Species diversity of the vegetation generally reflects the mix of the broadcast seeds at most sites. However, some sites had very low levels of species diversity in terms of the number of species that established of those that were seeded. Some species did not establish at any site or had very low establishment rates.
- Individual site characteristics appear to have the greatest influence on species establishment and density. Weed cover negatively affected species establishment and density, and explained some of the variation observed in these measures among sites. Other factors such as soil chemical and physical properties may also explain some of the site effects on species establishment and density.

5 Recommendations

1. Reducing weed cover should be a primary goal of restoration activities. Further investigations into the use of a non-residual herbicide following site preparation disturbances are recommended. However, the effectiveness of herbicides may be limited in trial areas that are small compared to the surrounding cleared area. These sites would be exposed to large quantities of weed seeds and herbicides are unlikely to substantially reduce weed cover in such areas. Herbicide spraying therefore needs to occur over larger areas to be effective in controlling weeds.

2. To accurately determine the effects of individual sites on establishment and density, effects of rainfall variation, and to obtain more accurate estimates of species establishment rates and densities the trial design needs to be modified so as to increase the replication of the factors of interest (e.g., burning) while keeping other factors, which are not of interest but can affect the outcome (e.g., sowing time) similar. This is particularly important at Gnangara because of the variation inherent among sites. Ideally:
   - A minimum of five trial sites should be established for three consecutive years at the same location. The species included in the seed mix and the quantities of seeds sown should be the same. We realize this is practically difficult to achieve given the variation in the availability and quantity of seeds each year, so perhaps a subset of species that are readily available each year could be used in the trial plots, while the full compliment of species available each year are seeded elsewhere. Seeding should occur at a similar time of year (± 2 weeks). Viability and germinability of each species contained within the seed mix should be tested each year as this may explain some of the variation in establishment. Soil samples should be collected across the site and tested for a range of chemical and physical properties, and depth to groundwater could be measured, as these variables may explain the differences between the assemblages that established on Spearwood and Bassendean sands.
   - All sites should be ploughed. Previous studies of the restoration trials Gnangara found that ploughing was a successful, cost-effective treatment compared with establishment in unploughed areas (Reid et al. 2004). Presumably ploughing improves the suitability of the soil as a bed for germination and seedling establishment.
   - Four 10 m^2 plots at each site should be permanently marked and surveyed, for each treatment e.g. ploughed, unburnt and unfenced; ploughed, burnt and unfenced; ploughed, unburnt and fenced; and ploughed, burnt and fenced. The plots should be located 5 m from the edge of the trial site and at least 10 m apart. This is possible with the current trial layout. Seeding should occur immediately after burning to ensure seeds are exposed to the ash-bed effect.
   - Note: to investigate the effects of burning and/or fencing, these treatments must be paired with adjacent unburnt/unfenced areas. In recent years all of the trial area has been burnt and fencing has not always occurred. Ideally fenced should be 1.8 m high to prevent kangaroos jumping over. However, as fencing is not a practical option for restoration of large areas, it is questionable whether it is really worth testing this factor.

3. Clearly defined and detailed end point goals need to be developed for the Gnangara restoration project with suitable and measurable indicators. Defining project objectives is the single most important step in the planning process as it provides a 'road map' for the project (Pastorok et al. 1997). Estimates of restoration costs, likely success etc. cannot be determined until specific goals at Gnangara are set. Objectives should be as specific as possible while recognising natural variability. Whisenant (1999) suggests that restoration projects should include objectives that specify: (i) goals for abiotic (non-living) functions (e.g. soil, water), performance of primary processes, species, communities, and landscape arrangements; (ii) land-use, habitat, and/or aesthetic goals; (iii) spatial scales and time period goals; and (iv) performance goals for all important objectives.

   Setting goals and objectives for restoring former pine plantation areas at Gnangara may require further surveys of surrounding *Banksia* woodland areas or the establishment of nearby reference systems. These systems may include a nearby 'intact' or recently burnt site. Surveys of *Banksia* woodlands located elsewhere on the Swan Coastal Plain may be useful in providing such information (e.g. Dodd and Griffin 1989; Gibson et al. 1994). For example, the vegetation structure of intact *Banksia* woodland, in terms of the ratio of trees to shrubs to herbs, might provide a simple goal for restoration. Restoring florisitic diversity similar to that of reference sites is another goal common to restoration projects (e.g. Koch and Hobbs 2007). The experience at Gnangara so far suggests that this goal will be difficult to achieve, and will probably require planting of species that do not establish from seeds (e.g. *Patersonia occidentalis*). Costing estimates for ongoing work at Gnangara could include scenarios whereby these more expensive "recalcitrant" species are both included and excluded in the restoration plan. These goals will provide targets against which the performance of the project can be assessed (see Section 6: Monitoring).

6 Monitoring and Evaluation

Monitoring is generally conducted within the context of an adaptive management framework and involves data collection, evaluation, and the analysis of that data to assess project success (Whisenant 1999). Monitoring and evaluation are a critical component of any restoration project as information gained through these activities can rectify deficits before they become large costly problems (Kasel et al. 2006). Short-term monitoring can assess the success of restoration and indicate areas where additional work is required, which allows the timely application of remedial works. Long-term monitoring provides information on the development of the restored site and is required to ensure that the project meets the completion criteria.

The success of a restoration project is usually assessed by comparing a range of indices of 'ecosystem health' of a target site with that of a reference system. It is important to select indices that are relevant to the system of interest and that can measure the success of pre-defined goals. Useful monitoring indices generally have the following features: (1) cost-effective; (2) readily measurable; (3) cause minimum disruption to the system; (4) at appropriate spatial and temporal scale; (5) biologically

and socially relevant; and (6) sensitive to stressors (Cairns et al. 2003). Potential indices that can be used to monitor the success of restoration projects may include:

- Germination rates and early survival
- Seedling size, density, cover and survival
- Colonisation rates by 'volunteer' species
- Soil seed bank, seed rain
- Permanent photo points
- Browsing damage
- Composition and abundance of exotic species including pine wildings
- Soil nutrient status, microbial biomass, pH
- Thickness of litter layer and composition and structure of woody debris
- Decomposer organisms and invertebrates
- Other desired fauna e.g. birds or mammals
- Evidence of self-sustaining assemblages eg seeding and recruitment

Example monitoring program for the Gnangara Restoration Program

Short term monitoring
All areas should be monitored in March following restoration activities to determine that *Banksia* (and other selected species) stocking rates are adequate, there are enough legume seedlings (so defined by comparison to reference sites) and weed invasions are minimal. The timing of this monitoring allows remedial work to be carried out prior to the second winter.

At each site 2m wide belt transects should be established across each site. Target species such as *Banksia* and *Eucalyptus* should be counted within the belts. Selected target legume species, understorey species and weeds should be counted in quadrats at an appropriate interval e.g. 20 m along the belt.
Criteria must be developed for the restored areas to meet at this stage. For example:

- A minimum number of *Banksia*, *Eucalyptus*, *Allocasuarina* (or other key species) stems per hectare;
- A minimum leguminous plant density per square metre.
- A maximum number of declared perennial weed plants per hectare.
- Remedial treatments should be applied to areas not meeting any of these criteria.

Mid-term monitoring
In the second spring after planting, species abundance surveys should be carried out to determine the species richness of the restored areas. The monitoring plots should be randomly located in the restored areas and nearby areas of *Banksia* woodland enable a comparison. The plots located in surrounding *Banksia* woodland should include sites of various ages, from recently burned through to long unburned areas.

The appropriate number and size of plots needs to be determined and will vary with the age of the vegetation. Within these plots the health and size of trees should be recorded and the abundance of all species present. Appropriate completion criteria for species richness also need to be set. For example, one goal might be that in the second

spring after planting the restored areas contain a specific minimum percentage of the species represented in the surrounding *Banksia* woodland.

Long-term monitoring
Some of the mid-term monitoring plots should be retained as permanent long-term monitoring plots and surveyed yearly. The purpose of these plots is to:

- Examine floristic and structural changes over time;
- Determine the factors affecting seeding success and vegetation development in restored areas as well as the reference sites;
- Provide baseline data from *Banksia* woodlands.

7 Acknowledgements

This research was funded by a DEC grant awarded to RJ Standish and RJ Hobbs. The authors wish to thank Tracy Sonneman, Clayton Sanders, DEC staff that assisted with field work and Paul Brown for their assistance with this research.

8 References

Abbot, I. 1984. Emergence, early survival and growth of seedlings of six tree species in Mediterannean forest of Western Australia. Forest Ecology and Management **9**:51–66.

Beard, J. S. 1989. Definition and location of the *Banksia* woodlands. Journal of the Royal Society of Western Australia **71**:85–86.

Bell, D. T., D. P. Rokich, J. A. Plummer, and C. J. McChesney. 1995. Effects of temperature, light and gibberellic acid on the germination of seeds of 43 species native to Western Australia. Journal of Vegetation Science **6**:797–806.

Bellairs, S. M., and D. T. Bell. 1993. Seed stores for the restoration of species-rich shrubland vegetation following mining in Western Australia. Restoration Ecology **1**:231–240.

Chambers, D. P., and P. M. Attiwill. 1994. The ash-bed effect in *Eucalyptus regnans* forest: chemical, physical and microbiological changes in soil after heating or partial sterilisation. Australian Journal of Botany **42**:739–749.

Clarke, K. R. 1993. Non-parametric multivariate analyses of changes in community structure. Australian Journal of Ecology **18**:117–143.

Cohn, J. S., and R. A. Bradstock. 2000. Factors affecting post-fire seedling establishment of selected mallee understorey species. Australian Journal of Botany **48**:59-70.

Cummings, J., N. Reid, I. Davies, and C. Grant. 2007. Experimental manipulation of restoration barriers in abandoned Eucalypt plantations. Restoration Ecology **15**:156–167.

Dixon, K. W., S. Roche, and J. S. Pate. 1995. The promotive effect of smoke derived from burnt native vegetation on seed germination of Western Australian plants. Oecologia **101**:185–192.

Dodd, J., and E. A. Griffin. 1989. Floristics of the *Banksia* woodlands. Journal of the Royal Society of Western Australia **71**:89–90.

Gibson, N., B. J. Keighery, G. J. Keighery, A. H. Burbidge, and M. N. Lyons. 1994. A floristic survey of the southern Swan Coastal Plain. Unpublished report for the Australian Heritage Commission prepared for the Department of Conservation and Land Management and the Conservation Commission of Western Australia (Inc.).

Gill, A. M. 1979. Fire in the Australian landscape. Landscape Planning **6**:343–357.

Harper, J. L. 1977. Population Biology of Plants. Academic Press, London.

Hobbs, R. J. 2001. Synergisms among habitat fragmentation, livestock grazing, and biotic invasions in southwestern Australia. Conservation Biology 15:1522–1528.

Hobbs, R. J. 2003. How fire regimes interact with other forms of ecosystem disturbance and modification. Pages 421–436 in I. Abbott and N. Burrows, editors. Fire in Ecosystems of South-West Western Australia: Impacts and Management. Backhuys Publishers, Leiden.

Humphries, S. E., R. H. Groves, and D. S. Mitchell. 1991. Plant invasions of Australian ecosystems. Pages 1–134 in D. W. Walton, B. Reville, J. Just, M. Forbes, M. Fagg, and R. Longmore, editors. Kowari 2, Plant Invasions - The Incidence of Environmental Weeds in Australia. Australian National Parks andWildlife Service, Canberra.

Kasel, S. 2004. Re-establishment of native vegetation on former pine plantations: an Australian Perspective. Department of Forest and Ecosystem Science, University of Melbourne, Creswick.

Kasel, S., C. Jewell, and K. Gosby. 2006. Rehabilitation of former pine plantations: a practitioners manual. Department of Sustainability and Environment, Melbourne.

Khanna, P. K., and R. J. Raison. 1986. Effect of fire intensity on solution chemistry of surface soil under a *Eucalyptus pauciflora* forest. Australian Journal of Soil Research **24**:423–434.

Koch, J. M., J. Richardson, and B. B. Lamont. 2004. Grazing by kangaroos limits the establishment of the grass trees *Xanthorrhoea gracilis* and *X. preissii* in restored bauxite mines in Eucalypt forest of southwestern Australia. Restoration Ecology **12**:297–305.

Koch, J. M., and S. C. Ward. 1994. Establishment of understorey vegetation for rehabilitation of bauxite mined areas in the jarrah forest of Western Australia. Journal of Environmental Management **41**:1–15.

Mattiske, E. M., and J. J. Havel. 1998. Perth, Western Australia: Regional Forest Agreement vegetation complexes. (Cartographic material). Department of Conservation and Land Management, Perth.

McArthur, W. M. 1991. Reference Soils of South-Western Australia. Department of Agriculture, Perth.

McCune, B., and M. J. Mefford. 1999. PC-ORD. Multivariate Analysis of Ecological Data, Version 4. MjM Software Design, Gleneden Beach, Oregon, U.S.A.

Meers, T., and R. Adams. 2003. The impact of grazing by Eastern Grey Kangaroos (*Macropus giganteus*) on vegetation recovery after fire at Reef Hills Regional Park, Victoria. Ecological Management and Restoration **4**:126-132.

Mott, J. J., and R. H. Groves. 1981. Germination Strategies. Pages 307–341 *in* J. S. Pate and A. J. McComb, editors. The Biology of Australian Plants. University of Western Australia Press, Nedlands.

Pastorok, R. A., A. MacDonald, J. R. Sampson, P. Wilber, D. J. Yozzo, and J. P. Titre. 1997. An ecological decision framework for environmental restoration projects. Ecological Engineering **9**:89-107.

Reid, R., K. Onton, and C. Sanders. 2004. Gnangara revegetation trials report 2001–2004. Department of Conservation and Land Management, Wanneroo.

Roche, S., K. W. Dixon, and J. S. Pate. 1997. Seed ageing and smoke: partner cues in the amelioration of seed dormancy in selected Australian native species. Australian Journal of Botany **45**:783-815.

Rokich, D. P., K. W. Dixon, K. Sivasithamparam, and K. A. Meney. 2000. Topsoil handling and storage effects on woodland restoration in Western Australia. Restoration Ecology **8**:196–208.

Rokich, D. P., K. W. Dixon, K. Sivasithamparam, and K. A. Meney. 2002. Smoke, mulch, and seed broadcasting effects on woodland restoration in Western Australia. Restoration Ecology **10**:185–194.

SPSS. 2006. SPSS for Windows rel. 15.0. SPSS Inc, Chicago.

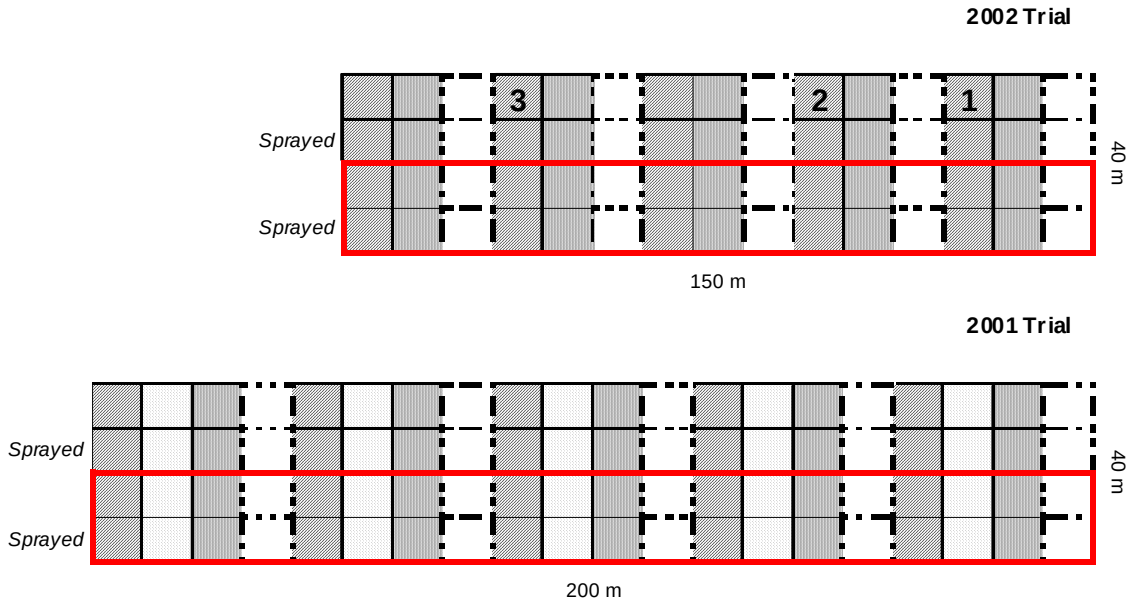
Turner, S. R., B. Pearce, D. P. Rokich, R. R. Dunn, D. J. Merritt, J. D. Majer, and K. W. Dixon. 2006. Influence of polymer seed coatings, soil raking, and time of sowing on seedling performance in post-mining restoration. Restoration Ecology **14**:267–277.

Warton, D. I. 2008. Raw data graphing: an informative but under-utilized tool for the analysis of multivariate abundances. Austral Ecology **33**:290–300.

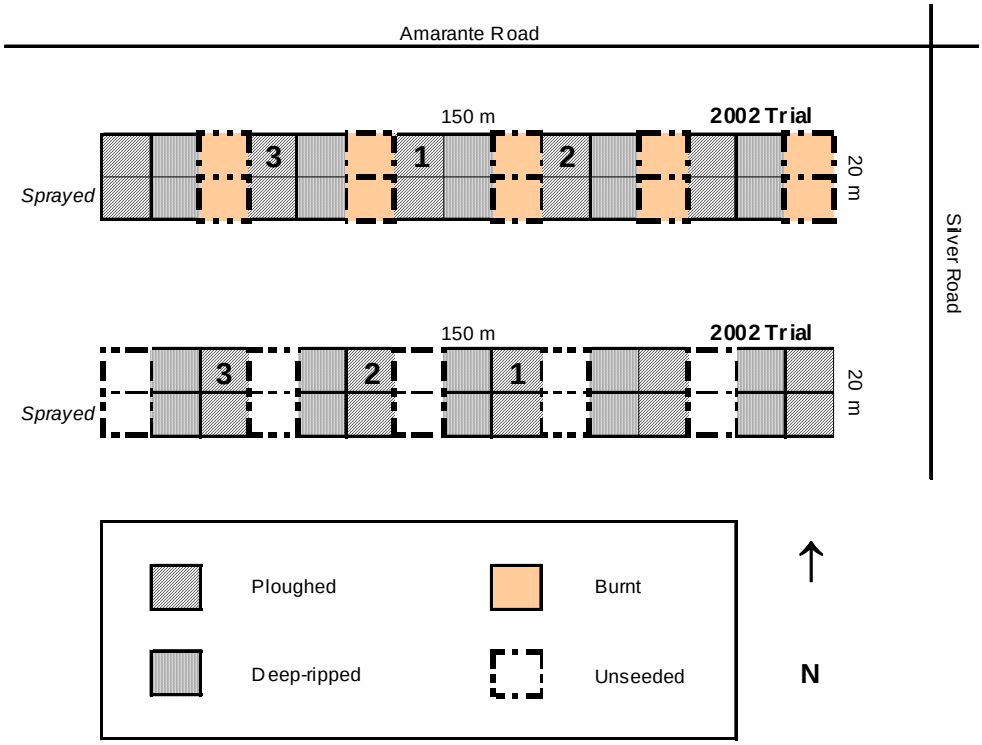
Whisenant, S. G. 1999. Repairing damaged wildlands: a process-orientated, landscape-scale approach. Cambridge University Press, Cambridge.

Appendix 1: Plots surveyed

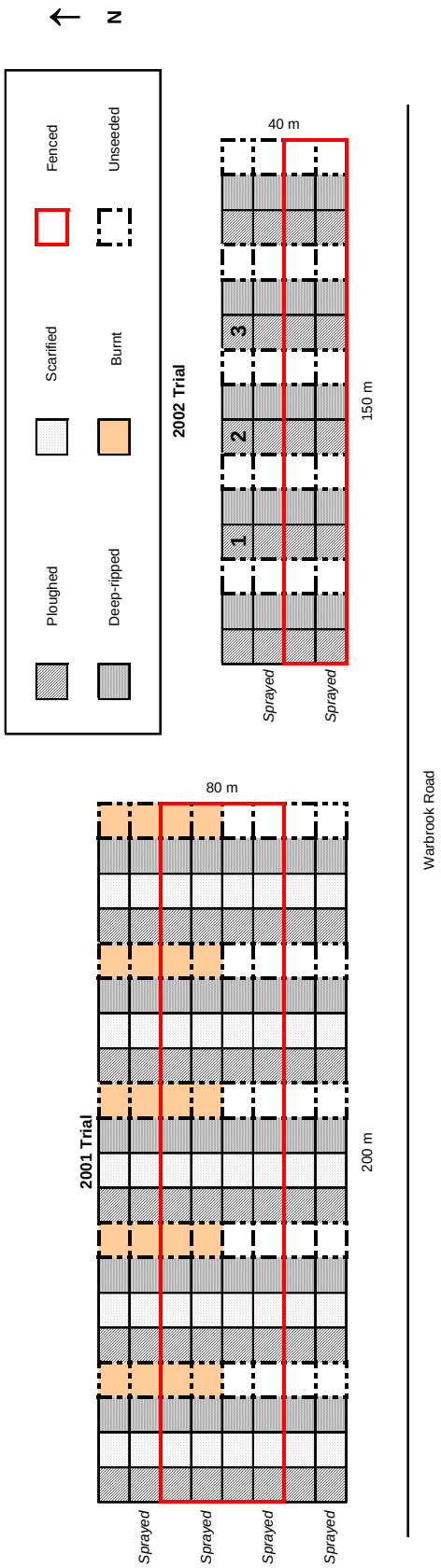
Payne 2002



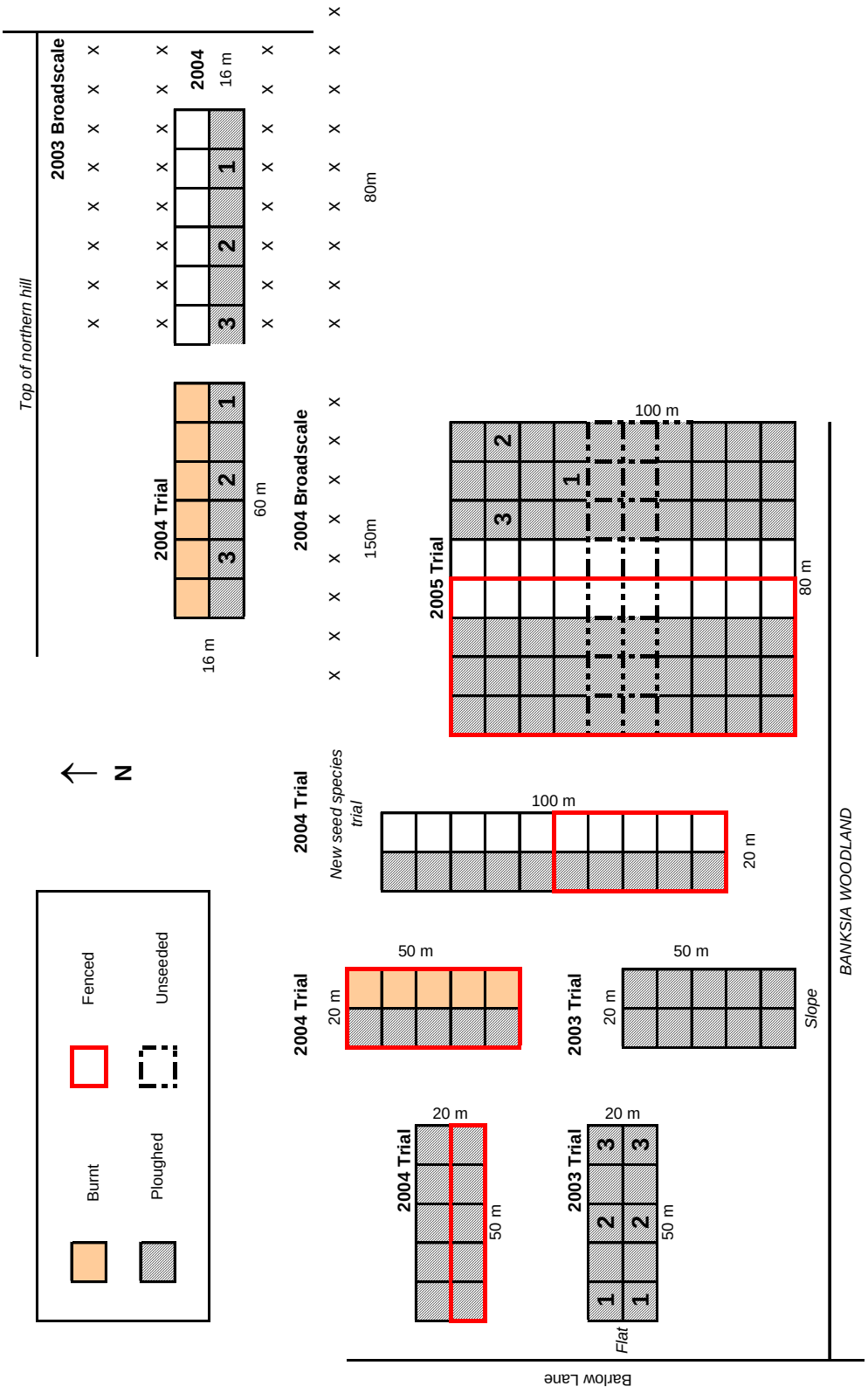
Amarante 2002



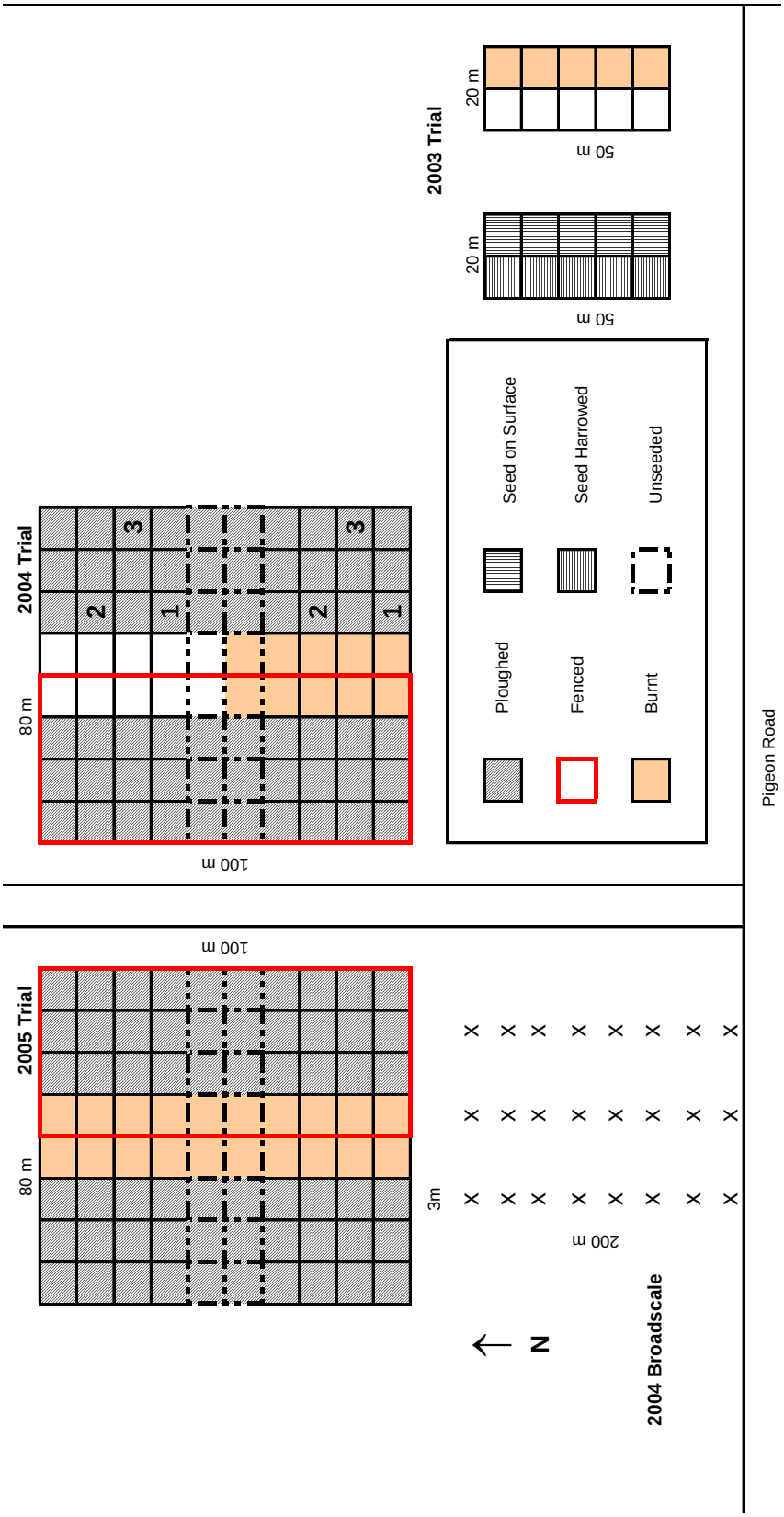
Warbrook 2002



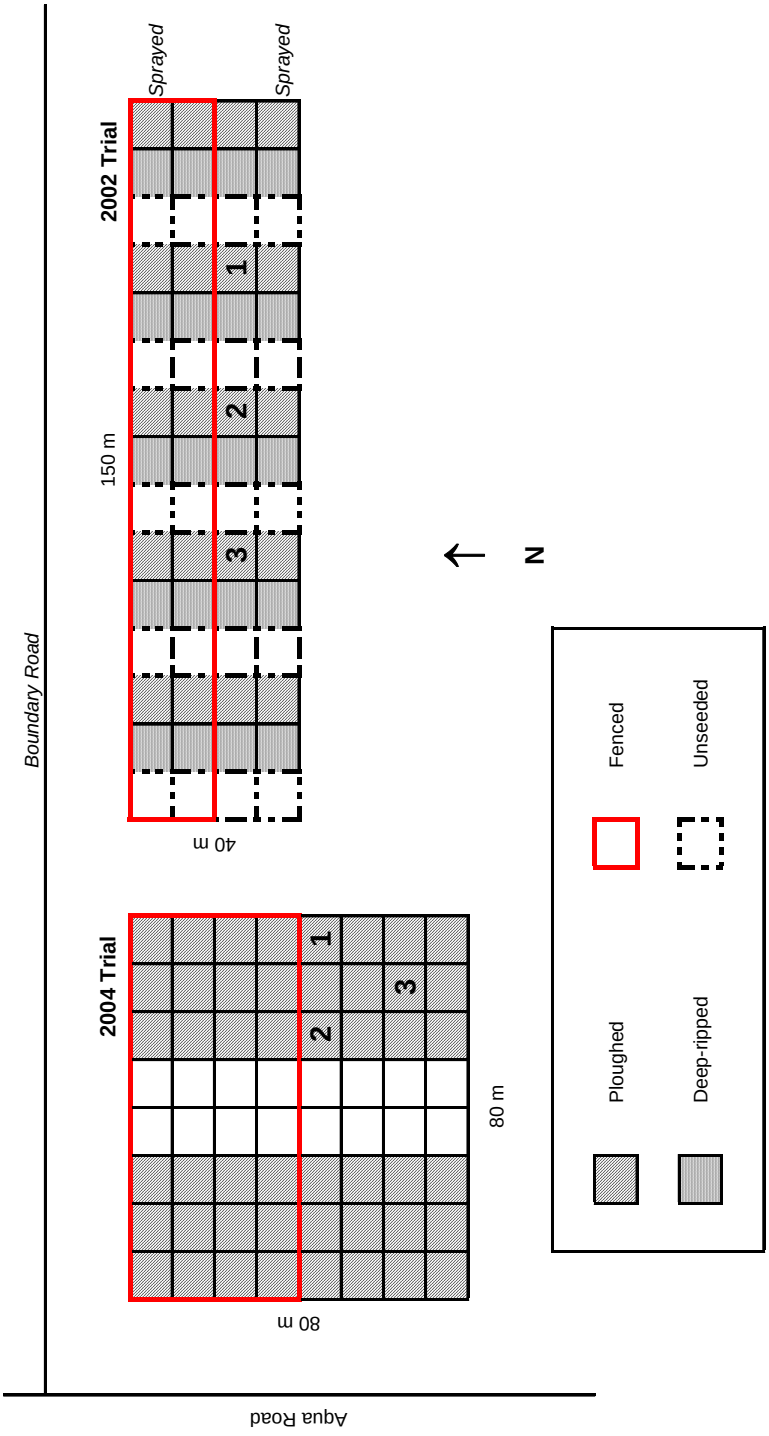
Barlow 2003, 2004 and 2005



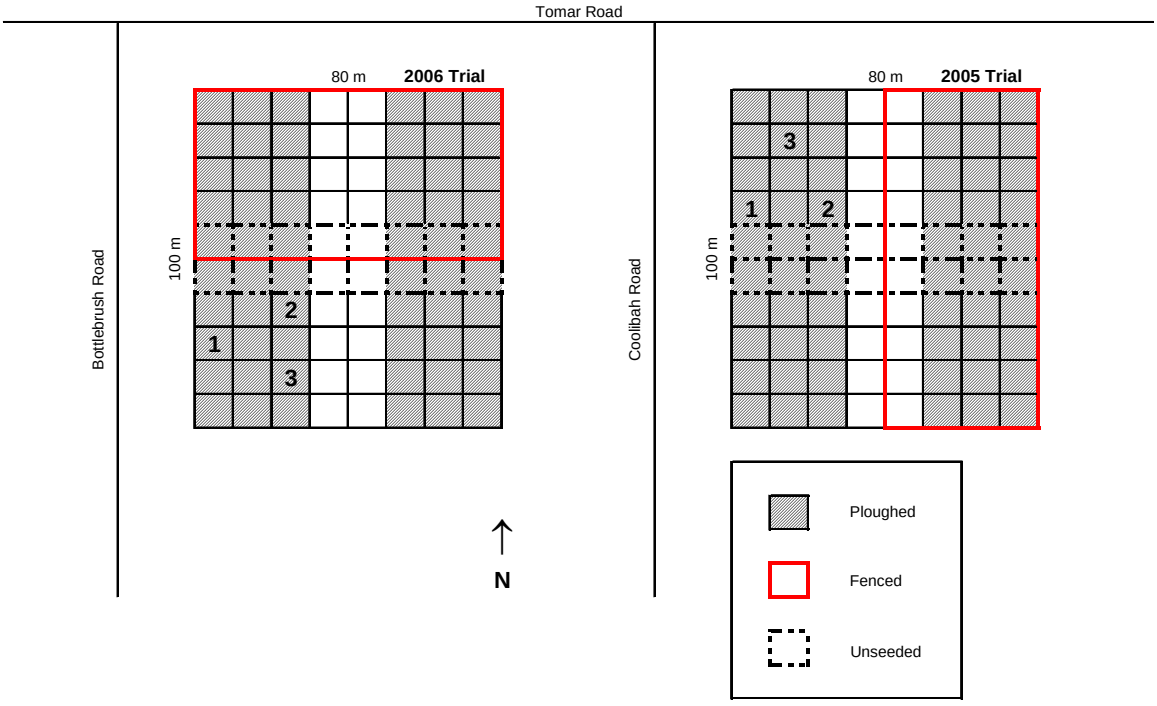
Pigeon 2004


2003 Trial
20 m
50 m
20 m
50 m
Seed on Surface
Seed Harrowed
Unseeded
Ploughed
Fenced
Burnt
2004 Trial
3
2
1
3
2
1
80 m
100 m
Pigeon Road
2005 Trial
100 m
80 m
3m
200 m
N
2004 Broadscale

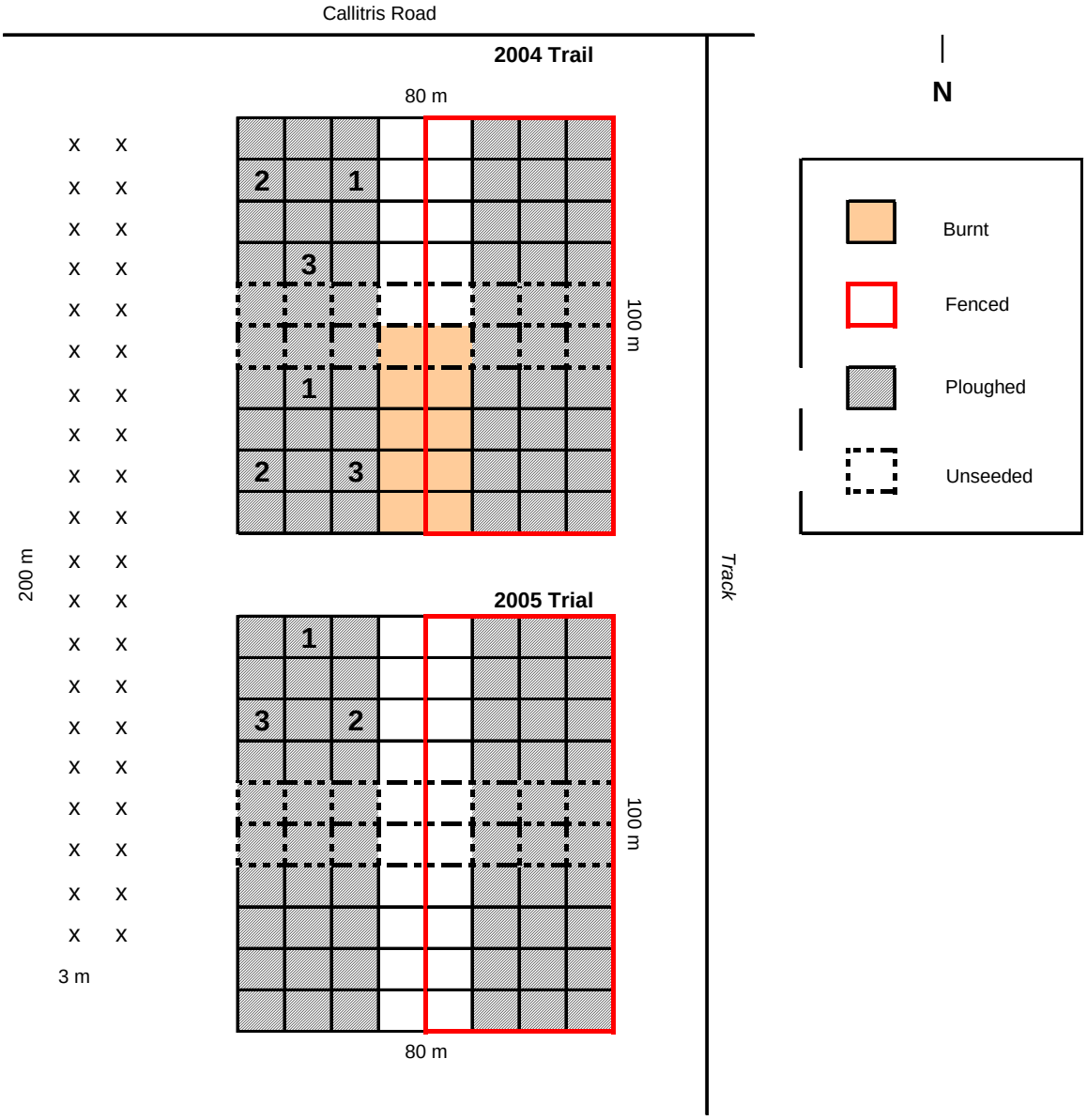
Kestral 2002 and 2004



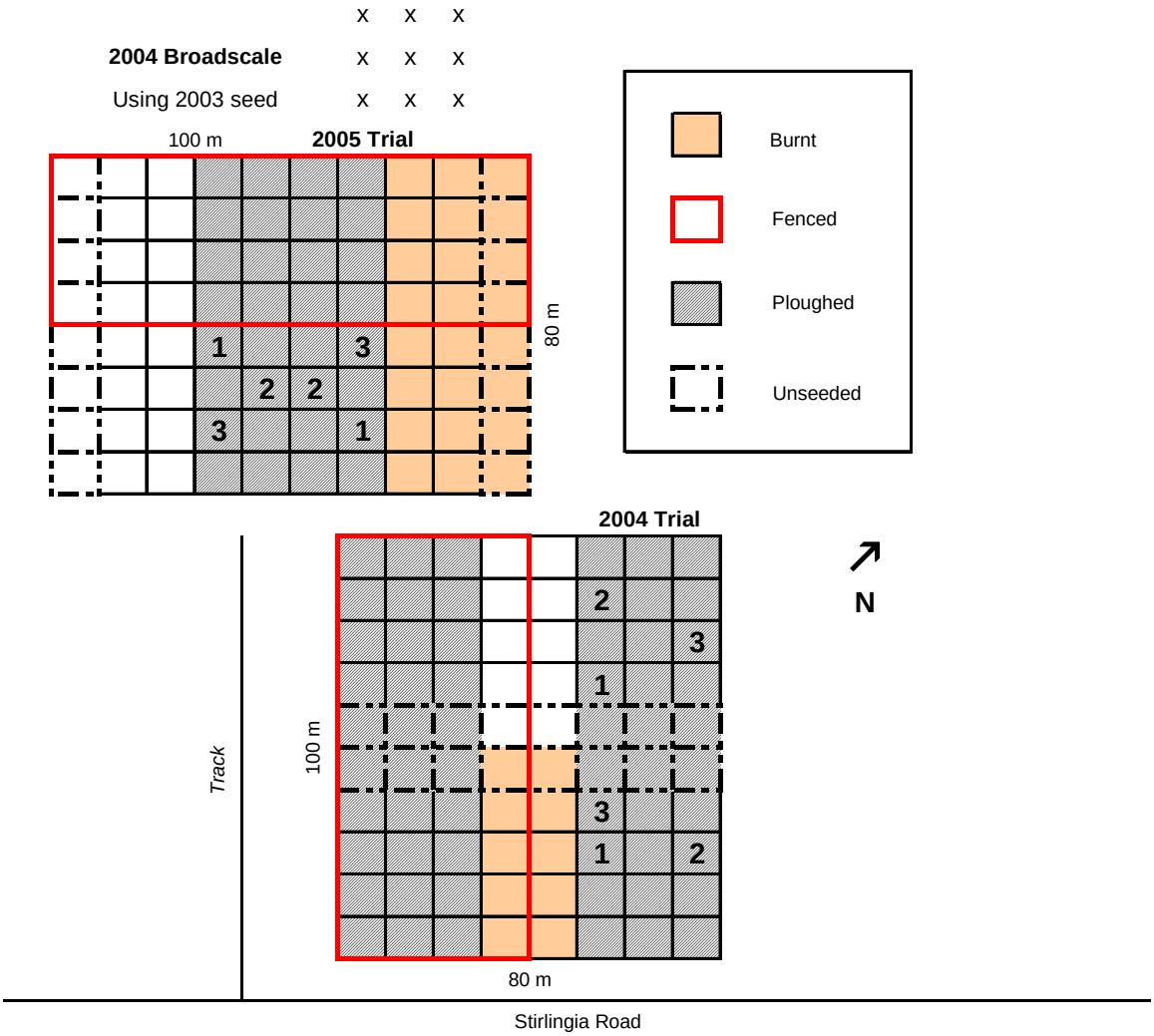
Tomar 2005 and 2006



Callitris 2004 and 2005



Stirlingia 2004 and 2005



Appendix 2: Species abundance in 49 m^2 plots

Payne 2002

Species	Seed mix (grams/ha)	Unburnt		
		Plot 1	Plot 2	Plot 3
Acacia huegelii	50	0	0	0
Acacia pulchella	350	0	0	1
Acacia saligna	150	0	0	1
Allocasuarina fraseriana	500	1	5	0
Allocasuarina humilis	500	2	4	1
Banksia attenuata	300	4	2	0
Banksia menziesii	300	2	2	6
Beaufortia elegans	80	14	28	12
Bossiaea eriocarpa	150	2	6	2
Daviesia divaricata	60	0	0	0
Eremaea pauciflora	30	0	0	0
Eucalyptus todtiana	50	1	0	1
Gastrolobium capitatum	250	1	5	3
Gompholobium tomentosum	170	4	6	2
Hovea pungens	90	1	0	0
Jacksonia furcellata	80	2	13	7
Kunzea ericifolia	70	9	9	11
Lechenaultia floribunda	300	1	11	7
Regelia inops	200	9	10	9
Scholtzia involucrata	400	0	0	0

Amarante 2002

Species	Seed mix (grams/ha)	Unburnt			Burnt		
		Plot 1	Plot 2	Plot 3	Plot 1	Plot 2	Plot 3
Acacia huegelii	50	0	0	0	0	0	0
Acacia pulchella	350	0	0	0	0	0	0
Acacia saligna	150	1	0	0	0	1	1
Allocasuarina fraseriana	500	0	0	0	0	0	0
Allocasuarina humilis	500	0	0	0	0	0	0
Banksia attenuata	300	1	1	1	1	0	0
Banksia menziesii	300	0	0	0	0	0	0
Beaufortia elegans	80	1	4	2	0	0	0
Bossiaea eriocarpa	150	0	0	0	0	0	0
Daviesia divaricata	60	0	0	0	0	0	0
Eremaea pauciflora	30	0	0	0	0	0	0
Eucalyptus todtiana	50	2	1	0	1	0	0
Gastrolobium capitatum	250	0	0	0	0	0	0
Gompholobium tomentosum	170	0	1	2	0	0	0
Hovea pungens	90	0	0	0	0	0	0
Jacksonia furcellata	80	3	4	2	3	2	4
Kunzea ericifolia	70	11	23	26	23	17	17
Lechenaultia floribunda	300	0	0	96	0	0	0
Regelia inops	200	1	4	0	0	0	0
Scholtzia involucrata	400	0	0	0	0	0	0

Warbrook 2002

Species	Seed mix (grams/ha)	Unburnt		
		Plot 1	Plot 2	Plot 3
Acacia huegelii	50	0	0	2
Acacia pulchella	350	0	0	0
Acacia saligna	150	0	1	0
Allocasuarina fraseriana	500	0	0	0
Allocasuarina humilis	500	0	0	0
Banksia attenuata	300	0	0	2
Banksia menziesii	300	0	0	0
Beaufortia elegans	80	0	1	0
Bossiaea eriocarpa	150	0	0	0
Daviesia divaricata	60	0	0	0
Eremaea pauciflora	30	0	0	0
Eucalyptus todtiana	50	1	0	0
Gastrolobium capitatum	250	0	0	0
Gompholobium tomentosum	170	5	6	8
Hovea pungens	90	0	0	0
Jacksonia furcellata	80	2	0	6
Kunzea ericifolia	70	7	7	14
Lechenaultia floribunda	300	0	0	0
Regelia inops	200	0	1	3
Scholtzia involucrata	400	0	0	0

Barlow 2003

Species	Seed mix (grams/ha)	Unburnt			Burnt		
		Plot 1	Plot 2	Plot 3	Plot 1	Plot 2	Plot 3
Acacia huegelii	300	0	0	0	1	1	2
Acacia pulchella	500	0	0	0	1	0	0
Acacia saligna	250	1	0	0	3	1	1
Acacia sessilis	200	0	0	0	0	0	0
Allocasuarina fraseriana	500	0	0	0	2	0	0
Allocasuarina humilis	500	0	0	0	0	0	0
Banksia attenuata	400	2	4	5	0	1	4
Banksia menziesii	400	3	1	11	3	2	2
Beaufortia elegans	200	3	17	38	19	7	17
Bossiaea eriocarpa	400	3	0	0	1	1	5
Eremaea pauciflora	200	1	0	0	1	4	2
Eucalyptus todtiana	250	0	1	2	2	5	8
Gastrolobium capitatum	400	0	0	5	0	0	5
Gompholobium tomentosum	250	12	12	31	5	9	19
Hovea pungens	350	0	0	0	0	0	1
Jacksonia floribunda	100	1	4	1	2	0	1
Jacksonia furcellata	100	1	1	2	0	6	3
Kunzea ericifolia	150	7	44	43	38	30	44
Melaleuca seriata	250	20	4	5	4	7	3
Regelia inops	300	5	7	26	6	3	5

Barlow 2004

Species	Seed mix (grams/ha)	Unburnt			Burnt		
		Plot 1	Plot 2	Plot 3	Plot 1	Plot 2	Plot 3
Acacia huegelii	250	3	4	4	8	2	5
Acacia pulchella	350	2	8	2	2	1	3
Acacia saligna	250	1	1	0	0	0	0
Acacia sessilis	200	0	0	1	0	0	0
Allocasuarina fraseriana	480	0	4	0	0	0	0
Allocasuarina humilis	500	0	0	2	0	0	0
Anigozanthus manglesii	500	0	0	4	0	0	0
Banksia attenuata	350	1	4	1	6	6	5
Banksia littoralis	50	0	0	0	0	0	0
Banksia menziesii	350	1	2	5	7	2	3
Beaufortia elegans	100	64	64	52	34	51	32
Bossiaea eriocarpa	300	2	1	0	0	0	0
Eremaea pauciflora	100	4	4	1	0	4	1
Eucalyptus todtiana	150	10	23	11	15	18	7
Gastrolobium capitatum	250	7	16	9	8	5	6
Gompholobium tomentosum	150	13	19	4	18	11	10
Hovea pungens	200	1	0	0	1	0	0
Jacksonia floribunda	80	0	1	0	1	0	2
Jacksonia furcellata	80	1	2	0	2	4	4
Kunzea ericifolia	100	235	117	122	116	271	226
Melaleuca seriata	160	5	22	7	7	9	4
Melaleuca teretifolia	150	0	3	2	0	0	0
Pultenaea reticulata	250	4	4	2	3	5	4
Regelia ciliata	250	109	109	35	75	112	60
Regelia inops	200	7	10	5	1	4	1
Viminaria juncea	200	0	0	0	0	0	0

Barlow 2005

Species	Seed mix (grams/ha)	Unburnt		
		Plot 1	Plot 2	Plot 3
Acacia huegelii	300	5	0	0
Acacia pulchella	400	6	4	6
Acacia saligna	100	0	0	0
Acacia sessilis	200	0	0	0
Allocasuarina fraseriana	200	0	0	0
Allocasuarina humilis	350	1	0	0
Anigozanthus humilis	150	0	1	0
Anigozanthus manglesii	200	0	0	0
Banksia attenuata	400	5	2	2
Banksia menziesii	400	10	2	4
Beaufortia elegans	200	5	2	0
Bossiaea eriocarpa	250	2	0	0
Eremaea pauciflora	150	13	2	6
Eremaea purpurea	100	13	6	9
Eucalyptus todtiana	250	4	1	1
Gastrolobium capitatum	300	1	1	0
Gompholobium tomentosum	200	5	2	0
Hovea pungens	250	2	0	0
Hypocalymma robustum	100	0	1	0
Jacksonia floribunda	100	2	0	0
Jacksonia furcellata	200	11	1	3
Kennedia prostrata	250	0	0	0
Kunzea ericifolia	50	5	1	3
Macrozamia riedlei	2500	0	0	1
Melaleuca scabra	50	2	3	2
Melaleuca seriata	150	2	0	1
Patersonia occidentalis	200	0	0	0
Regelia inops	200	8	1	2
Verticordia nitens	200	2	0	1
Xanthorrhea preissii	100	0	0	0

Pigeon 2004

Species	Seed mix (grams/ha)	Unburnt			Burnt		
		Plot 1	Plot 2	Plot 3	Plot 1	Plot 2	Plot 3
Acacia pulchella	400	5	5	10	22	47	16
Acacia sessilis	150	0	1	1	3	1	0
Allocasuarina fraseriana	425	4	6	3	9	5	2
Allocasuarina humilis	450	4	4	4	0	3	0
Banksia attenuata	475	4	12	7	4	12	5
Banksia grandis	300	1	0	6	3	5	3
Banksia menziesii	450	7	11	9	8	11	11
Calothamnus quadrifidus	212.5	14	42	35	25	12	6
Calothamnus sanguineus	212.5	0	0	0	1	0	0
Dryandra sessilis	150	0	2	2	3	3	1
Eremaea asterocarpa	200	0	2	1	0	0	0
Eremaea pauciflora	200	1	5	10	4	5	3
Eucalyptus decipiens	100	1	1	0	0	0	0
Eucalyptus marginata	350	0	0	2	1	0	1
Eucalyptus todtiana	150	2	5	4	3	3	4
Hakea lissocarpha	100	0	0	4	3	1	0
Hakea prostrata	212.5	7	15	16	9	12	6
Hakea ruscifolia	100	5	5	4	5	4	2
Hakea trifurcata	100	4	3	7	1	3	2
Hardenbergia comptoniana	250	0	0	1	0	0	0
Hovea pungens	212.5	0	3	5	2	2	2
Jacksonia calcicola	100	3	5	7	2	5	6
Jacksonia furcellata	100	2	4	5	4	3	3
Jacksonia sternbergiana	100	4	1	10	3	1	26
Melaleuca scabra	100	0	0	0	18	7	5
Melaleuca systena	250	10	31	25	18	7	5
Petrophile serruriae	150	0	1	0	0	0	0

Kestral 2002

Species	Seed mix (grams/ha)	Unburnt		
		Plot 1	Plot 2	Plot 3
Acacia cyclops	450	1	0	0
Acacia pulchella	350	3	9	14
Acacia sessilis	100	0	1	0
Allocasuarina fraseriana	1200	1	9	7
Allocasuarina humilis	500	0	1	2
Banksia attenuata	300	2	0	2
Banksia grandis	300	3	6	0
Banksia menziesii	300	3	11	3
Calothamnus quadrifidus	100	0	5	7
Calothamnus sanguineus	110	0	7	5
Diplolaena angustifolia	600	0	0	0
Eremaea asterocarpa	250	0	1	1
Eucalyptus todtiana	50	1	0	0
Hakea prostrata	100	4	7	6
Jacksonia calcicola	25	13	7	13
Melaleuca huegelii	75	0	0	0
Melaleuca scabra	50	0	12	2
Melaleuca systena	85	0	0	0
Olearia axillaris	400	0	0	0

Kestral 2004

Species	Seed mix (grams/ha)	Unburnt		
		Plot 1	Plot 2	Plot 3
Acacia pulchella	500	12	15	8
Acacia sessilis	200	2	1	0
Allocasuarina fraseriana	400	3	10	3
Allocasuarina humilis	500	0	2	0
Banksia attenuata	400	11	14	13
Banksia grandis	400	4	6	5
Banksia menziesii	400	6	6	8
Calothamnus quadrifidus	200	15	25	4
Calothamnus sanguineus	200	19	27	23
Eremaea asterocarpa	400	0	0	0
Eremaea pauciflora	160	7	9	21
Eucalyptus marginata	550	4	3	0
Eucalyptus todtiana	160	3	6	6
Hakea prostrata	200	11	21	17
Hardenbergia comptoniana	440	0	0	0
Hovea pungens	320	0	2	3
Jacksonia calcicola	100	7	4	5
Jacksonia sternbergiana	100	0	14	35
Melaleuca scabra	120	22	16	11
Melaleuca systena	250	38	21	16

Tomar 2005

Species	Seed mix (grams/ha)	Unburnt		
		Plot 1	Plot 2	Plot 3
Acacia huegelii	150	0	0	0
Acacia pulchella	300	8	12	12
Acacia sessilis	150	3	3	4
Allocasuarina fraseriana	250	0	0	2
Allocasuarina humilis	250	0	0	0
Anigozanthus humilis	150	0	0	0
Anigozanthus manglesii	150	0	1	0
Banksia attenuata	400	0	1	1
Banksia grandis	400	0	0	1
Banksia menziesii	400	0	1	0
Calothamnus quadrifidus	200	10	1	3
Calothamnus sanguineus	200	0	0	10
Daviesia divaricata	100	0	3	0
Dianella divaricarta	200	0	0	0
Eremaea asterocarpa	100	0	0	0
Eremaea pauciflora	100	0	0	3
Eucalyptus marginata	200	0	0	0
Eucalyptus todtiana	100	0	0	0
Gastrolobium capitatum	200	1	2	0
Gompholobium tomentosum	200	0	1	1
Hakea prostrata	250	5	6	7
Hardenbergia comptoniana	150	0	0	0
Hovea pungens	100	0	0	0
Jacksonia calcicola	100	1	1	1
Jacksonia furcellata	150	3	1	5
Jacksonia sternbergiana	150	1	5	0
Kennedia prostrata	250	3	3	2
Kunzea ericifolia	50	3	9	12
Macrozamia riedlei	2187.5	0	0	0
Melaleuca scabra	100	0	0	0
Melaleuca systena	200	2	0	1
Patersonia occidentalis	100	0	0	0
Petrophile brevifolia	50	0	0	0
Petrophile macrostachya	50	0	0	0
Petrophile serruriae	100	0	0	0

Tomar 2006

Species	Seed mix (grams/ha)	Unburnt		
		Plot 1	Plot 2	Plot 3
Acacia huegelii	106.25	0	0	0
Acacia pulchella	300	3	0	2
Acacia sessilis	150	0	0	0
Allocasuarina fraseriana	250	0	0	0
Allocasuarina humilis	250	0	0	0
Anigozanthus humilis	150	0	0	0
Banksia attenuata	400	1	0	0
Banksia grandis	400	4	0	0
Banksia menziesii	250	5	0	1
Calothamnus quadrifidus	200	0	0	0
Calothamnus sanguineus	200	1	0	0
Daviesia divaricata	100	1	0	0
Dianella divaricarta	200	0	0	0
Eremaea asterocarpa	100	0	0	0
Eremaea pauciflora	100	0	0	0
Eucalyptus marginata	200	1	0	0
Eucalyptus todtiana	100	1	0	0
Gastrolobium capitatum	200	0	0	0
Gompholobium tomentosum	200	1	0	0
Hakea prostrata	250	4	0	0
Hardenbergia comptoniana	150	0	0	0
Hovea pungens	100	0	0	0
Jacksonia calcicola	50	3	0	0
Jacksonia furcellata	150	5	0	1
Jacksonia sternbergiana	150	0	7	0
Kennedia prostrata	250	1	1	1
Kunzea ericifolia	50	0	0	0
Macrozamia riedlei	2187.5	1	1	0
Melaleuca scabra	100	1	0	0
Melaleuca systena	200	0	0	0
Patersonia occidentalis	100	0	0	0
Petrophile brevifolia	50	0	0	0
Petrophile macrostachya	50	0	0	0
Petrophile serruriae	100	0	0	0

Callitris 2004

Species	Seed mix (grams/ha)	Unburnt			Burnt		
		Plot 1	Plot 2	Plot 3	Plot 1	Plot 2	Plot 3
Acacia pulchella	425	1	0	0	2	0	0
Acacia sessilis	100	0	0	0	0	0	0
Allocasuarina fraseriana	337.5	0	0	0	0	0	0
Allocasuarina humilis	425	1	0	0	1	0	0
Anigozanthus manglesii	300	0	0	0	0	0	0
Banksia attenuata	450	0	0	0	0	0	0
Banksia grandis	300	0	0	0	0	0	0
Banksia menziesii	450	0	0	0	0	0	0
Beaufortia elegans	137.5	5	0	1	0	0	2
Calothamnus sanguineus	150	0	0	0	0	0	0
Daviesia divaricata	150	0	0	0	0	0	0
Eremaea asterocarpa	225	0	0	0	0	0	0
Eremaea pauciflora	337.5	0	0	0	0	1	1
Eucalyptus marginata	250	0	0	0	0	0	0
Eucalyptus rudis	87.5	0	0	0	0	0	0
Eucalyptus todtiana	125	0	0	0	0	1	1
Hakea prostrata	200	1	0	0	0	0	0
Hakea ruscifolia	200	0	0	0	0	0	0
Hakea varia	100	0	0	0	0	0	0
Hovea pungens	150	0	0	0	0	0	0
Jacksonia furcellata	100	1	1	0	0	0	0
Kunzea ericifolia	100	25	4	1	1	2	1
Melaleuca preissiana	125	0	0	0	0	0	1
Melaleuca scabra	125	0	0	0	0	0	0
Patersonia occidentalis	200	0	0	0	0	0	0
Regelia inops	200	0	0	0	0	0	0
Verticordia nitens	250	0	0	0	0	0	0

Callitris 2005

Species	Seed mix (grams/ha)	Unburnt		
		Plot 1	Plot 2	Plot 3
Acacia huegelii	150	0	0	0
Acacia pulchella	300	0	2	5
Acacia sessilis	150	0	0	0
Allocasuarina fraseriana	250	1	0	0
Allocasuarina humilis	250	0	0	0
Anigozanthus humilis	150	0	0	0
Anigozanthus manglesii	150	0	1	0
Banksia attenuata	400	0	0	0
Banksia grandis	400	0	0	0
Banksia menziesii	400	0	0	0
Calothamnus quadrifidus	200	0	1	2
Calothamnus sanguineus	200	1	0	1
Daviesia divaricata	100	0	0	0
Dianella revoluta	200	0	0	0
Eremaea asterocarpa	100	0	0	0
Eremaea pauciflora	100	0	0	1
Eucalyptus marginata	200	1	1	0
Eucalyptus todtiana	100	0	0	0
Gastrolobium capitatum	200	0	0	0
Gompholobium tomentosum	200	0	1	1
Hakea prostrata	250	1	0	0
Hardenbergia comptoniana	150	0	0	1
Hovea pungens	100	0	0	0
Jacksonia calcicola	100	0	0	0
Jacksonia furcellata	150	0	0	1
Jacksonia sternbergiana	150	0	0	0
Kennedia prostrata	250	0	1	2
Kunzea ericifolia	50	4	5	11
Macrozamia riedlei	2187.5	0	0	0
Melaleuca scabra	100	0	0	0
Melaleuca systena	200	2	1	4
Patersonia occidentalis	100	0	0	0
Petrophile brevifolia	50	0	0	0
Petrophile macrostachya	50	0	0	0
Petrophile serruriae	100	0	0	0

Stirlingia 2004

Species	Seed mix (grams/ha)	Unburnt			Burnt		
		Plot 1	Plot 2	Plot 3	Plot 1	Plot 2	Plot 3
Acacia pulchella	425	5	0	1	2	3	3
Acacia sessilis	110	0	0	0	1	0	1
Allocasuarina fraseriana	337.5	0	0	0	0	0	0
Allocasuarina humilis	525	2	0	0	0	0	0
Banksia attenuata	412.5	0	1	0	1	1	0
Banksia grandis	300	0	0	0	0	0	0
Banksia menziesii	412.5	0	2	0	1	0	1
Calothamnus quadrifidus	120	5	1	1	0	0	2
Calothamnus sanguineus	120	2	0	0	0	0	0
Daviesia divaricata	150	0	0	1	1	1	2
Eremaea asterocarpa	250	0	0	0	0	0	0
Eremaea pauciflora	200	1	1	1	1	0	0
Eucalyptus marginata	400	1	0	0	0	0	1
Eucalyptus todtiana	150	1	1	0	2	5	1
Hakea prostrata	300	2	1	5	4	5	3
Hakea ruscifolia	212.5	0	0	0	2	4	1
Hakea trifurcata	150	2	0	1	3	1	2
Hardenbergia comptoniana	312.5	0	1	0	1	0	0
Hovea pungens	225	0	1	0	0	2	0
Jacksonia calcicola	50	1	0	0	1	3	2
Jacksonia furcellata	100	1	0	3	1	1	1
Jacksonia sternbergiana	100	0	1	0	0	3	0
Kunzea ericifolia	100	10	1	0	15	3	10
Melaleuca scabra	125	0	1	0	0	0	0
Melaleuca systena	287.5	0	0	0	3	0	2
Petrophile brevifolia	125	0	0	0	0	0	0

Stirlingia 2005

Species	Seed mix (grams/ha)	Unburnt			Burnt		
		Plot 1	Plot 2	Plot 3	Plot 1	Plot 2	Plot 3
Acacia huegelii	150	1	3	2	0	2	1
Acacia pulchella	300	3	1	3	3	3	9
Acacia sessilis	150	0	0	1	0	1	1
Allocasuarina fraseriana	250	1	0	0	0	0	3
Allocasuarina humilis	250	1	2	1	0	1	6
Anigozanthus humilis	150	0	0	0	0	0	0
Anigozanthus manglesii	150	2	1	1	0	0	1
Banksia attenuata	400	0	0	1	0	0	1
Banksia grandis	400	0	0	0	0	0	0
Banksia menziesii	400	1	0	1	0	0	0
Calothamnus quadrifidus	200	6	4	3	0	0	4
Calothamnus sanguineus	200	1	3	20	1	1	11
Daviesia divaricata	100	1	0	0	2	0	2
Dianella revoluta	200	0	0	0	0	0	0
Eremaea asterocarpa	100	0	0	1	0	0	0
Eremaea pauciflora	100	4	2	3	0	0	3
Eucalyptus marginata	200	0	0	0	0	0	2
Eucalyptus todtiana	100	1	0	0	0	0	0
Gastrolobium capitatum	200	3	0	1	1	3	1
Gompholobium tomentosum	200	2	0	1	1	3	0
Hakea prostrata	250	3	9	11	4	2	5
Hardenbergia comptoniana	150	0	0	0	0	0	0
Hovea pungens	100	0	0	0	0	0	0
Jacksonia calcicola	100	4	0	0	0	0	0
Jacksonia furcellata	150	3	3	4	4	0	9
Jacksonia sternbergiana	150	1	0	0	1	1	1
Kennedia prostrata	250	1	1	1	1	0	2
Kunzea ericifolia	50	7	5	11	1	2	3
Macrozamia riedlei	2187.5	0	0	0	0	0	0
Melaleuca scabra	100	0	0	0	0	0	0
Melaleuca systena	200	5	1	5	1	0	8
Patersonia occidentalis	100	0	0	0	0	0	0
Petrophile brevifolia	50	0	0	0	0	0	0
Petrophile macrostachya	50	0	0	0	0	0	0
Petrophile serruriae	100	0	0	0	0	0	0

Appendix 3: Species cover and height along (approx.) 10m line transects.

Height class: 1 = <0.50m; 2 = 0.51–0.90m; 3 = 0.91–1.30m; 4 = 1.31m–1.70m; 5 = >1.70m.

Payne 2002

Unburnt

Plot 1			Plot 2			Plot 3		
Width	**Height**	**Species**	**Width**	**Height**	**Species**	**Width**	**Height**	**Species**
0.64	1	*Gompholobium tomentosum*	0.22	1	*Gompholobium tomentosum*	0.35	1	*Lechenaultia floribunda*
0.45	4	*Regelia inops*	0.44	2	*Banksia attenuata*	0.74	4	*Kunzea ericifolia*
1.28	3	*Regelia inops*	0.78	4	*Kunzea ericifolia*	0.35	1	*Beaufortia elegans*
0.44	2	*Regelia inops*	0.41	2	*Gastrolobium capitatum*	0.63	2	*Beaufortia elegans*
0.65	2	*Regelia inops*	0.12	3	*Kunzea ericifolia*	0.03	3	*Jacksonia furcellata*
0.27	4	*Regelia inops*	0.84	3	*Regelia inops*	0.04	3	*Jacksonia furcellata*
0.37	3	*Kunzea ericifolia*	0.51	5	*Kunzea ericifolia*	0.05	3	*Jacksonia furcellata*
0.47	3	*Regelia inops*	0.42	2	*Beaufortia elegans*	0.12	2	*Regelia inops*
1.01	4	*Kunzea ericifolia*	0.94	5	*Kunzea ericifolia*	0.03	3	*Jacksonia furcellata*
0.25	4	*Jacksonia furcellata*	1.04	2	*Beaufortia elegans*	2.04	5	*Kunzea ericifolia*
1.52	3	*Kunzea ericifolia*	0.28	1	*Beaufortia elegans*	1.09	2	*Regelia inops*
0.72	2	*Beaufortia elegans*	1.15	2	*Beaufortia elegans*	0.64	3	*Kunzea ericifolia*
0.19	3	*Kunzea ericifolia*	0.82	1	*Gastrolobium capitatum*	0.65	1	*Acacia pulchella*
10.66		**Transect length**	0.72	5	*Banksia menziesii*	9.90		**Transect length**
			0.82	3	*Regelia inops*			
			9.88		**Transect length**			

Amarante 2002

Unburnt

Plot 1			Plot 2			Plot 3		
Width	**Height**	**Species**	**Width**	**Height**	**Species**	**Width**	**Height**	**Species**
4.09	5	*Kunzea ericifolia*	0.16	2	*Kunzea ericifolia*	0.15	4	*Kunzea ericifolia*
0.22	2	*Jacksonia furcellata*	1.18	3	*Jacksonia furcellata*	2.02	4	*Kunzea ericifolia*
0.35	2	*Jacksonia furcellata*	0.29	2	*Jacksonia furcellata*	0.56	4	*Jacksonia furcellata*
9.90		**Transect length**	0.46	5	*Jacksonia furcellata*	2.48	5	*Kunzea ericifolia*
			0.81	5	*Kunzea ericifolia*	3.35	4	*Kunzea ericifolia*
			2.93	5	*Kunzea ericifolia*	9.90		**Transect length**
			1.17	2	*Regelia inops*			
			10.32		**Transect length**			

Amarante 2002

Burnt

Plot 1			Plot 2			Plot 3		
Width	**Height**	**Species**	**Width**	**Height**	**Species**	**Width**	**Height**	**Species**
1.43	5	*Kunzea ericifolia*	8.15	5	*Kunzea ericifolia*	0.07	3	*Kunzea ericifolia*
0.71	5	*Kunzea ericifolia*	0.84	3	*Jacksonia furcellata*	0.13	2	*Kunzea ericifolia*
0.32	5	*Jacksonia furcellata*	9.55		**Transect length**	0.46	3	*Jacksonia furcellata*
1.00	5	*Kunzea ericifolia*				4.70	5	*Kunzea ericifolia*
2.40	5	*Kunzea ericifolia*				9.70		**Transect length**
10.16		**Transect length**						

Warbrook 2002

Unburnt

Plot 1			Plot 2			Plot 3		
Width	**Height**	**Species**	**Width**	**Height**	**Species**	**Width**	**Height**	**Species**
0.32	5	*Kunzea ericifolia*	0.93	2	*Regelia inops*	1.69	5	*Kunzea ericifolia*
3.62	5	*Kunzea ericifolia*	0.02	1	*Regelia inops*	2.48	5	*Kunzea ericifolia*
0.63	2	*Gompholobium tomentosum*	0.04	1	*Beaufortia elegans*	0.35	1	*Acacia huegelii*
2.11	5	*Eucalyptus todtiana*	0.42	1	*Beaufortia elegans*	0.16	4	*Jacksonia furcellata*
0.84	3	*Gompholobium tomentosum*	1.42	3	*Kunzea ericifolia*	0.67	3	*Jacksonia furcellata*
0.60	2	*Gompholobium tomentosum*	0.92	5	*Kunzea ericifolia*	0.17	4	*Jacksonia furcellata*
9.98		**Transect length**	10.14		**Transect length**	0.17	1	*Jacksonia furcellata*
						0.03	2	*Kunzea ericifolia*
						0.02	1	*Kunzea ericifolia*
						0.02	1	*Kunzea ericifolia*
						0.01	1	*Kunzea ericifolia*
						0.07	1	*Kunzea ericifolia*
						0.30	2	*Kunzea ericifolia*
						9.93		**Transect length**

Barlow 2003

Unburnt

Plot 1			Plot 2			Plot 3		
Width	**Height**	**Species**	**Width**	**Height**	**Species**	**Width**	**Height**	**Species**
0.21	2	*Kunzea ericifolia*	2.21	3	*Kunzea ericifolia*	0.09	2	*Regelia inops*
0.55	3	*Banksia menziesii*	0.37	5	*Kunzea ericifolia*	1.84	4	*Kunzea ericifolia*
0.24	1	*Gompholobium tomentosum*	0.61	2	*Regelia inops*	0.43	2	*Beaufortia elegans*
0.82	5	*Acacia saligna*	0.40	4	*Kunzea ericifolia*	0.49	1	*Banksia attenuata*
1.06	4	*Regelia inops*	0.19	1	*Bossiaea eriocarpa*	0.49	3	*Banksia menziesii*
0.22	1	*Gompholobium tomentosum*	0.05	1	*Regelia inops*	1.07	4	*Kunzea ericifolia*
0.66	4	*Kunzea ericifolia*	0.08	1	*Regelia inops*	2.03	2	*Gompholobium tomentosum*
0.25	1	*Gompholobium tomentosum*	0.07	1	*Regelia inops*	2.29	4	*Kunzea ericifolia*
1.36	3	*Regelia inops*	0.77	2	*Acacia pulchella*	0.14	1	*Beaufortia elegans*
0.07	4	*Kunzea ericifolia*	9.46		**Transect length**	0.15	1	*Eucalyptus todtiana*
0.30	2	*Regelia inops*				0.88	2	*Gompholobium tomentosum*
0.31	2	*Banksia menziesii*				1.18	4	*Kunzea ericifolia*
0.19	1	*Kunzea ericifolia*				0.14	2	*Melaleuca seriata*
0.50	1	*Gompholobium tomentosum*				9.11		**Transect length**
0.10	3	*Kunzea ericifolia*						
0.41	3	*Kunzea ericifolia*						
0.34	2	*Eucalyptus todtiana*						
1.12	2	*Kunzea ericifolia*						
0.17	3	*Regelia inops*						
0.32	2	*Jacksonia floribunda*						
0.18	1	*Gompholobium tomentosum*						
9.40		**Transect length**						

Barlow 2003

Burnt

Plot 1			Plot 2			Plot 3		
Width	**Height**	**Species**	**Width**	**Height**	**Species**	**Width**	**Height**	**Species**
0.27	1	*Acacia huegelii*	0.06	1	*Gompholobium tomentosum*	0.08	2	*Regelia inops*
1.44	3	*Eucalyptus todtiana*	0.09	3	*Kunzea ericifolia*	0.20	1	*Beaufortia elegans*
0.25	1	*Melaleuca seriata*	1.11	3	*Kunzea ericifolia*	0.59	3	*Kunzea ericifolia*
0.33	2	*Beaufortia elegans*	0.81	5	*Kunzea ericifolia*	0.46	1	*Eucalyptus todtiana*
0.68	5	*Kunzea ericifolia*	1.02	3	*Kunzea ericifolia*	0.01	3	*Regelia inops*
0.37	1	*Banksia menziesii*	3.34	4	*Acacia saligna*	0.55	2	*Beaufortia elegans*
0.27	2	*Eremaea pauciflora*	0.38	1	*Beaufortia elegans*	0.41	2	*Kunzea ericifolia*
0.73	5	*Jacksonia furcellata*	0.93	3	*Kunzea ericifolia*	1.07	4	*Kunzea ericifolia*
1.81	5	*Acacia saligna*	0.83	4	*Regelia inops*	0.59	4	*Kunzea ericifolia*
1.44	5	*Kunzea ericifolia*	10.05		**Transect length**	1.53	4	*Kunzea ericifolia*
8.89		**Transect length**				10.61		**Transect length**

Barlow 2004

Unburnt

Plot 1			Plot 2			Plot 3		
Width	**Height**	**Species**	**Width**	**Height**	**Species**	**Width**	**Height**	**Species**
0.41	2	Banksia menziesii	0.11	1	*Regelia ciliata*	0.58	4	*Kunzea ericifolia*
0.08	2	Kunzea ericifolia	0.34	3	*Kunzea ericifolia*	0.49	1	*Beaufortia elegans*
0.34	1	Kunzea ericifolia	0.26	3	*Regelia ciliata*	0.14	1	*Regelia ciliata*
0.21	2	Kunzea ericifolia	0.27	3	*Kunzea ericifolia*	0.02	1	*Pultenaea reticulata*
0.06	3	Regelia ciliata	0.19	2	*Regelia ciliata*	0.61	3	*Kunzea ericifolia*
0.03	2	Regelia ciliata	0.12	1	*Melaleuca seriata*	0.3	2	*Kunzea ericifolia*
0.18	2	Kunzea ericifolia	0.37	2	*Regelia ciliata*	0.93	4	*Banksia menziesii*
0.38	3	Regelia ciliata	0.15	1	*Kunzea ericifolia*	0.18	2	*Kunzea ericifolia*
0.18	1	Kunzea ericifolia	0.16	1	*Kunzea ericifolia*	0.12	2	*Kunzea ericifolia*
0.39	2	Kunzea ericifolia	0.07	1	*Regelia ciliata*	0.09	2	*Kunzea ericifolia*
0.35	2	Banksia attenuata	0.87	3	*Pultenaea reticulata*	0.19	1	*Kunzea ericifolia*
0.1	1	Bossiaea eriocarpa	0.25	1	*Eucalyptus todtiana*	0.11	1	*Melaleuca seriata*
0.16	1	Kunzea ericifolia	0.13	1	*Gastrolobium capitatum*	0.01	2	*Regelia ciliata*
0.08	1	Beaufortia elegans	0.09	2	*Acacia saligna*	0.25	2	*Kunzea ericifolia*

0.04	1	Bossiaea eriocarpa	0.07	2	*Kunzea ericifolia*	0.41	2	*Regelia ciliata*
0.28	3	Regelia ciliata	0.01	2	*Acacia saligna*	0.49	3	*Kunzea ericifolia*
0.49	3	*Kunzea ericifolia*	0.15	2	*Acacia saligna*	0.04	4	*Regelia ciliata*
0.23	1	*Hovea pungens*	0.09	1	*Beaufortia elegans*	0.07	2	*Kunzea ericifolia*
0.2	1	*Gastrolobium capitatum*	0.22	2	*Regelia ciliata*	0.31	3	*Regelia ciliata*
0.07	1	*Eucalyptus todtiana*	0.16	2	*Regelia inops*	0.1	3	*Kunzea ericifolia*
0.07	2	*Regelia ciliata*	1.02	1	*Kunzea ericifolia*	0.13	1	*Melaleuca seriata*
9.90		**Transect length**	3.73	1	*Gastrolobium capitatum*	9.65		**Transect length**
			3.73	1	*Eucalyptus todtiana*			
			0.57	2	*Regelia ciliata*			
			0.04	1	*Beaufortia elegans*			
			0.08	1	*Kunzea ericifolia*			
			0.15	2	*Regelia ciliata*			
			0.41	2	*Kunzea ericifolia*			
			0.15	1	*Gastrolobium capitatum*			
			0.14	1	*Kunzea ericifolia*			
			0.19	2	*Regelia ciliata*			
			0.05	1	*Gompholobium tomentosum*			
			0.38	2	*Kunzea ericifolia*			
			0.35	1	*Eucalyptus todtiana*			
			0.31	3	*Regelia ciliata*			
			9.90		**Transect length**			

Barlow 2004

Burnt

Plot 1			Plot 2			Plot 3		
Width	**Height**	**Species**	**Width**	**Height**	**Species**	**Width**	**Height**	**Species**
1.03	3	*Kunzea ericifolia*	0.04	1	*Melaleuca seriata*	0.88	3	*Regelia ciliata*
0.14	1	*Acacia pulchella*	0.17	2	*Regelia ciliata*	0.26	2	*Kunzea ericifolia*
0.39	2	*Regelia ciliata*	0.16	1	*Kunzea ericifolia*	0.06	1	*Beaufortia elegans*
0.15	2	*Kunzea ericifolia*	0.67	2	*Regelia ciliata*	0.5	2	*Kunzea ericifolia*
0.26	3	*Kunzea ericifolia*	0.1	1	*Kunzea ericifolia*	0.24	1	*Acacia huegelii*
0.11	2	*Acacia huegelii*	0.31	1	*Gastrolobium capitatum*	0.28	2	*Kunzea ericifolia*
0.14	1	*Kunzea ericifolia*	6.08	1	*Kunzea ericifolia*	0.06	3	*Regelia ciliata*
0.22	3	*Regelia ciliata*	0.04	1	*Beaufortia elegans*	0.95	2	*Kunzea ericifolia*
0.24	2	*Regelia ciliata*	0.56	1	*Regelia ciliata*	0.82	2	*Regelia ciliata*
0.11	1	*Regelia ciliata*	0.19	2	*Kunzea ericifolia*	0.26	2	*Regelia ciliata*
0.18	2	*Kunzea ericifolia*	0.14	2	*Regelia ciliata*	0.01	2	*Kunzea ericifolia*
0.06	1	*Beaufortia elegans*	0.15	2	*Regelia inops*	0.05	2	*Kunzea ericifolia*
0.42	2	*Regelia ciliata*	0.18	2	*Regelia ciliata*	0.09	2	*Kunzea ericifolia*
0.37	2	*Kunzea ericifolia*	0.05	1	*Kunzea ericifolia*	0.46	2	*Kunzea ericifolia*
0.13	1	*Regelia ciliata*	0.08	1	*Gastrolobium capitatum*	0.12	1	*Gastrolobium capitatum*
0.47	1	*Gastrolobium capitatum*	0.1	1	*Beaufortia elegans*	9.67		**Transect length**
0.03	3	*Jacksonia furcellata*	0.08	1	*Regelia ciliata*			
0.3	2	*Regelia ciliata*	0.01	1	*Kunzea ericifolia*			
0.18	2	*Banksia menziesii*	0.03	1	*Regelia ciliata*			
0.24	3	*Regelia ciliata*	0.78	2	*Regelia ciliata*			
0.11	1	*Gompholobium tomentosum*	0.42	2	*Kunzea ericifolia*			
0.23	2	*Regelia ciliata*	0.52	2	*Regelia ciliata*			
0.66	3	*Kunzea ericifolia*	0.04	1	*Jacksonia furcellata*			
0.2	2	*Regelia ciliata*	0.2	1	*Beaufortia elegans*			
0.27	2	*Regelia ciliata*	0.04	1	*Jacksonia furcellata*			
0.51	2	*Kunzea ericifolia*	0.31	2	*Kunzea ericifolia*			
0.64	3	*Regelia ciliata*	9.17		**Transect length**			
0.18	1	*Gompholobium tomentosum*						
9.44		**Transect length**						

Barlow 2005

Unburnt

Plot 1			Plot 2			Plot 3		
Width	**Height**	**Species**	**Width**	**Height**	**Species**	**Width**	**Height**	**Species**
0.85	2	*Acacia pulchella*	0.20	1	*Melaleuca scabra*	0.86	2	*Eremaea purpurea*
0.03	4	*Jacksonia furcellata*	0.14	1	*Acacia pulchella*	0.11	1	*Banksia attenuata*
0.73	2	*Eremaea purpurea*	0.42	1	*Eremaea purpurea*	1.56	2	*Macrozamia riedlei*
0.21	1	*Eucalyptus todtiana*	9.90		**Transect length**	9.90		**Transect length**
0.37	2	*Kunzea ericifolia*						
0.08	1	*Acacia huegelii*						
0.95	2	*Acacia pulchella*						
0.03	1	*Regelia inops*						
0.28	1	*Eremaea pauciflora*						
9.90		**Transect length**						

Pigeon 2004

Unburnt

Plot 1			Plot 2			Plot 3		
Width	**Height**	**Species**	**Width**	**Height**	**Species**	**Width**	**Height**	**Species**
0.44	2	*Allocasuarina humilis*	1.47	4	*Acacia pulchella*	0.28	1	*Melaleuca systena*
0.05	1	*Calothamnus quadrifidus*	0.10	1	*Calothamnus quadrifidus*	0.52	1	*Calothamnus quadrifidus*
0.02	1	*Calothamnus quadrifidus*	0.08	1	*Jacksonia calcicola*	0.38	2	*Jacksonia furcellata*
0.81	2	*Calothamnus quadrifidus*	0.02	1	*Calothamnus quadrifidus*	0.31	2	*Melaleuca systena*
0.80	1	*Jacksonia calcicola*	0.10	1	*Calothamnus quadrifidus*	1.77	5	*Jacksonia sternbergiana*
0.95	5	*Eucalyptus decipiens*	0.07	1	*Calothamnus quadrifidus*	0.91	2	*Acacia sessilis*
0.09	1	*Allocasuarina fraseriana*	0.02	1	*Calothamnus quadrifidus*	0.11	1	*Melaleuca systena*
1.37	1	*Hakea prostrata*	0.03	1	*Calothamnus quadrifidus*	0.11	1	*Calothamnus quadrifidus*
2.43	2	*Jacksonia calcicola*	0.53	1	*Melaleuca systena*	0.13	1	*Hakea lissocarpha*
0.46	3	*Banksia menziesii*	0.31	1	*Calothamnus quadrifidus*	1.20	5	*Jacksonia sternbergiana*
1.36	3	*Acacia pulchella*	0.56	4	*Banksia attenuata*	0.08	1	*Melaleuca systena*
0.71	3	*Jacksonia sternbergiana*	0.55	3	*Acacia pulchella*	0.32	1	*Eremaea pauciflora*
0.50	1	*Hakea ruscifolia*	0.10	1	*Allocasuarina fraseriana*	0.10	1	*Jacksonia calcicola*
0.11	1	*Jacksonia calcicola*	0.14	2	*Eucalyptus todtiana*	0.02	1	*Jacksonia calcicola*
9.80		**Transect length**	0.48	2	*Banksia attenuata*	0.05	1	*Jacksonia calcicola*
			0.07	1	*Hakea prostrata*	0.28	2	*Jacksonia sternbergiana*
			0.37	2	*Banksia menziesii*	0.39	1	*Jacksonia calcicola*
			0.41	2	*Hakea prostrata*	0.33	1	*Hakea prostrata*
			0.45	1	*Calothamnus quadrifidus*	0.10	1	*Hakea prostrata*
			1.62	5	*Jacksonia sternbergiana*	0.24	2	*Melaleuca systena*
			0.68	2	*Melaleuca systena*	0.23	1	*Hakea prostrata*
			0.09	1	*Melaleuca systena*	0.82	2	*Calothamnus quadrifidus*
			0.49	1	*Jacksonia furcellata*	10.03		**Transect length**
			0.46	1	*Jacksonia calcicola*			
			0.07	1	*Calothamnus quadrifidus*			
			0.26	2	*Eucalyptus marginata*			
			0.08	1	*Calothamnus quadrifidus*			
			9.89		**Transect length**			

Pigeon 2004

Burnt

Plot 1			Plot 2			Plot 3		
Width	**Height**	**Species**	**Width**	**Height**	**Species**	**Width**	**Height**	**Species**
0.79	3	*Acacia pulchella*	0.97	2	*Hakea trifurcata*	1.78	3	*Jacksonia sternbergiana*
0.03	1	*Banksia grandis*	0.22	1	*Hovea pungens*	0.46	2	*Eucalyptus todtiana*
0.15	1	*Hakea prostrata*	0.19	1	*Banksia menziesii*	0.69	3	*Jacksonia furcellata*
0.35	2	*Acacia sessilis*	0.68	2	*Banksia attenuata*	0.28	2	*Acacia pulchella*
0.27	3	*Acacia pulchella*	0.70	2	*Jacksonia calcicola*	0.15	1	*Banksia attenuata*
0.35	3	*Acacia pulchella*	0.22	3	*Jacksonia sternbergiana*	0.64	4	*Banksia menziesii*
0.30	2	*Melaleuca systena*	0.47	2	*Banksia attenuata*	0.97	3	*Acacia pulchella*
0.14	1	*Hakea prostrata*	0.24	2	*Calothamnus quadrifidus*	0.79	3	*Jacksonia sternbergiana*
0.91	2	*Calothamnus quadrifidus*	0.22	1	*Melaleuca systena*	0.12	1	*Jacksonia sternbergiana*
0.14	2	*Melaleuca systena*	0.20	2	*Acacia pulchella*	0.20	1	*Banksia attenuata*
1.93	1	*Hakea prostrata*	0.72	3	*Banksia menziesii*	0.46	2	*Banksia menziesii*
0.85	3	*Acacia pulchella*	0.26	1	*Calothamnus quadrifidus*	0.63	5	*Jacksonia furcellata*
0.05	2	*Melaleuca systena*	1.05	1	*Hakea prostrata*	1.17	2	*Acacia pulchella*
0.52	2	*Acacia pulchella*	0.50	1	*Calothamnus quadrifidus*	2.61	5	*Jacksonia sternbergiana*
0.41	1	*Hakea ruscifolia*	0.30	1	*Banksia grandis*	0.22	1	*Allocasuarina fraseriana*
0.45	1	*Hakea lissocarpha*	1.33	2	*Hakea prostrata*	0.13	1	*Hakea prostrata*
0.69	4	*Banksia menziesii*	0.06	2	*Acacia pulchella*	9.97		**Transect length**
0.40	4	*Acacia pulchella*	0.09	2	*Acacia pulchella*			
0.27	3	*Banksia attenuata*	0.60	2	*Eremaea pauciflora*			
0.06	1	*Acacia pulchella*	0.38	2	*Calothamnus quadrifidus*			
0.36	1	*Hakea ruscifolia*	1.40	5	*Jacksonia sternbergiana*			
0.21	2	*Jacksonia calcicola*	0.14	2	*Acacia pulchella*			
0.13	3	*Acacia pulchella*	0.13	2	*Dryandra sessilis*			
0.26	1	*Calothamnus quadrifidus*	0.38	2	*Banksia menziesii*			
0.04	1	*Acacia pulchella*		9.28	**Transect length**			
0.02	1	*Calothamnus quadrifidus*						
9.82		**Transect length**						

Kestral 2002

Unburnt

Plot 1			Plot 2			Plot 3		
Width	**Height**	**Species**	**Width**	**Height**	**Species**	**Width**	**Height**	**Species**
0.53	1	*Jacksonia calcicola*	0.10	2	*Calothamnus quadrifidus*	1.62	3	*Acacia pulchella*
0.24	3	*Acacia pulchella*	0.32	2	*Allocasuarina fraseriana*	0.56	1	*Jacksonia calcicola*
0.09	1	*Jacksonia calcicola*	0.80	3	*Banksia menziesii*	0.03	1	*Calothamnus quadrifidus*
2.54	5	*Hakea prostrata*	0.23	5	*Banksia grandis*	0.05	2	*Allocasuarina humilis*
0.74	1	*Jacksonia calcicola*	0.03	2	*Acacia pulchella*	0.24	2	*Allocasuarina humilis*
0.06	2	*Hakea prostrata*	0.21	1	*Jacksonia calcicola*	1.03	3	*Calothamnus quadrifidus*
0.06	2	*Hakea prostrata*	0.31	2	*Acacia sessilis*	0.17	2	*Allocasuarina humilis*
0.06	3	*Acacia pulchella*	0.92	5	*Hakea prostrata*	0.70	2	*Acacia pulchella*
0.19	1	*Acacia pulchella*	0.69	3	*Acacia pulchella*	1.02	2	*Jacksonia calcicola*
9.81		**Transect length**	0.47	5	*Banksia attenuata*	9.90		**Transect length**
			0.85	5	*Banksia menziesii*			
			0.39	2	*Melaleuca scabra*			
			0.19	2	*Allocasuarina fraseriana*			
			0.19	1	*Acacia pulchella*			
			1.32	5	*Banksia menziesii*			
			0.04	1	*Hakea prostrata*			
			9.79		**Transect length**			

Kestral 2004

Unburnt

Plot 1			Plot 2			Plot 3		
Width	**Height**	**Species**	**Width**	**Height**	**Species**	**Width**	**Height**	**Species**
0.80	4	*Banksia menziesii*	0.34	2	*Hakea prostrata*	0.36	2	*Acacia pulchella*
0.45	2	*Banksia attenuata*	0.24	2	*Acacia pulchella*	0.45	1	*Eremaea pauciflora*
0.20	3	*Melaleuca systena*	0.09	1	*Calothamnus sanguineus*	0.16	1	*Calothamnus sanguineus*
0.40	3	*Acacia pulchella*	0.23	1	*Hakea prostrata*	0.29	2	*Hakea prostrata*
0.26	1	*Calothamnus quadrifidus*	1.11	1	*Hakea prostrata*	0.21	2	*Hakea prostrata*
1.79	2	*Hakea prostrata*	0.13	1	*Eucalyptus todtiana*	0.11	1	*Eucalyptus todtiana*
0.03	1	*Eremaea pauciflora*	0.05	1	*Melaleuca scabra*	0.15	1	*Calothamnus sanguineus*
1.26	3	*Acacia pulchella*	0.06	1	*Calothamnus sanguineus*	0.99	2	*Eremaea pauciflora*
0.18	1	*Calothamnus quadrifidus*	0.30	3	*Melaleuca systena*	0.29	4	*Melaleuca systena*
0.32	1	*Eremaea pauciflora*	0.04	1	*Melaleuca scabra*	0.04	1	*Jacksonia sternbergiana*
0.03	1	*Calothamnus quadrifidus*	1.65	2	*Acacia pulchella*	0.46	3	*Jacksonia sternbergiana*
0.03	1	*Calothamnus quadrifidus*	0.27	1	*Calothamnus sanguineus*	0.07	1	*Jacksonia calcicola*
0.36	1	*Calothamnus quadrifidus*	0.26	1	*Calothamnus sanguineus*	0.50	3	*Jacksonia sternbergiana*
0.04	1	*Eremaea pauciflora*	0.15	1	*Hakea prostrata*	0.03	1	*Hakea prostrata*
0.54	2	*Banksia menziesii*	0.31	1	*Eremaea pauciflora*	1.51	1	*Hakea prostrata*
1.05	2	*Acacia pulchella*	0.05	1	*Hakea prostrata*	2.01	3	*Melaleuca systena*
0.52	4	*Banksia menziesii*	0.32	3	*Melaleuca systena*	0.19	2	*Eremaea pauciflora*
0.41	1	*Melaleuca scabra*	0.32	1	*Hakea prostrata*	0.37	2	*Banksia grandis*
0.14	1	*Jacksonia calcicola*	0.04	1	*Calothamnus sanguineus*	0.74	1	*Eremaea pauciflora*
0.06	1	*Jacksonia calcicola*	0.15	2	*Melaleuca systena*	0.08	1	*Hovea pungens*
0.33	1	*Jacksonia calcicola*	0.09	1	*Melaleuca scabra*	0.20	1	*Calothamnus sanguineus*
0.14	2	*Acacia pulchella*	0.40	2	*Eucalyptus marginata*	0.25	1	*Jacksonia calcicola*
0.71	3	*Melaleuca systena*	0.29	2	*Hakea prostrata*	1.44	3	*Hakea prostrata*
0.25	1	*Calothamnus quadrifidus*	0.02	2	*Banksia menziesii*	0.40	3	*Acacia pulchella*
0.47	2	*Banksia grandis*	0.38	2	*Melaleuca systena*	1.74	5	*Jacksonia sternbergiana*
0.07	1	*Hakea prostrata*	0.47	1	*Calothamnus quadrifidus*	0.77	2	*Eremaea pauciflora*
1.12	1	*Hakea prostrata*	0.06	1	*Hakea prostrata*	0.40	1	*Calothamnus sanguineus*
0.14	1	*Melaleuca scabra*	0.06	1	*Eucalyptus todtiana*	0.12	1	*Jacksonia calcicola*
0.16	1	*Calothamnus sanguineus*	0.04	1	*Hakea prostrata*	0.28	1	*Eucalyptus todtiana*
0.18	1	*Acacia pulchella*	0.12	2	*Melaleuca systena*	10.38		**Transect length**

0.27	2	*Melaleuca systena*	0.06	2	*Hakea prostrata*			
0.18	1	*Melaleuca scabra*	0.13	1	*Calothamnus sanguineus*			
0.09	2	*Acacia pulchella*	0.19	1	*Calothamnus sanguineus*			
10.27		**Transect length**	0.11	1	*Melaleuca systena*			
			0.23	2	*Acacia pulchella*			
			0.48	1	*Calothamnus quadrifidus*			
			0.34	1	*Hakea prostrata*			
			0.07	2	*Melaleuca systena*			
			9.82		**Transect length**			

Tomar 2005

Unburnt

Plot 1			Plot 2			Plot 3		
Width	**Height**	**Species**	**Width**	**Height**	**Species**	**Width**	**Height**	**Species**
0.17	3	*Jacksonia furcellata*	0.07	1	*Hakea prostrata*	0.74	4	*Kunzea ericifolia*
0.02	3	*Jacksonia furcellata*	0.57	2	*Jacksonia sternbergiana*	0.72	1	*Acacia sessilis*
0.04	3	*Jacksonia furcellata*	0.83	2	*Hakea prostrata*	0.07	2	*Kunzea ericifolia*
0.54	1	*Acacia pulchella*	0.25	2	*Acacia pulchella*	0.08	2	*Kunzea ericifolia*
0.09	1	*Acacia pulchella*	1.60	4	*Jacksonia sternbergiana*	0.08	1	*Hakea prostrata*
0.33	1	*Melaleuca systena*	0.38	3	*Kunzea ericifolia*	1.01	2	*Acacia pulchella*
0.03	3	*Jacksonia sternbergiana*	0.30	2	*Acacia pulchella*	0.90	5	*Jacksonia furcellata*
0.37	3	*Jacksonia sternbergiana*	0.08	1	*Anigozanthus manglesii*	1.19	2	*Acacia pulchella*
0.07	4	*Jacksonia sternbergiana*	0.31	1	*Gompholobium tomentosum*	1.41	1	*Kennedia prostrata*
0.42	4	*Jacksonia sternbergiana*	0.42	5	*Jacksonia furcellata*	1.13	1	*Hakea prostrata*
0.42	2	*Acacia sessilis*	0.48	2	*Acacia sessilis*	0.31	2	*Kunzea ericifolia*
0.53	2	*Kunzea ericifolia*	0.06	1	*Kunzea ericifolia*	0.09	1	*Banksia attenuata*
0.01	1	*Acacia pulchella*	1.48	3	*Acacia pulchella*	0.08	1	*Kennedia prostrata*
0.07	3	*Kunzea ericifolia*	0.79	5	*Jacksonia sternbergiana*	0.21	1	*Calothamnus sanguineus*
9.85		**Transect length**	0.29	1	*Jacksonia sternbergiana*	9.78		**Transect length**
			0.64	5	*Jacksonia sternbergiana*			
			0.75	5	*Jacksonia sternbergiana*			
			9.81		**Transect length**			

Tomar 2006

Unburnt

Plot 1			Plot 2			Plot 3		
Width	**Height**	**Species**	**Width**	**Height**	**Species**	**Width**	**Height**	**Species**
1.06	3	*Macrozamia riedlei*	0.05	1	*Jacksonia sternbergiana*	9.64		**Transect length**
0.38	2	*Banksia menziesii*	0.16	1	*Jacksonia sternbergiana*			
2.31	5	*Eucalyptus todtiana*	2.13	5	*Jacksonia sternbergiana*			
0.16	2	*Acacia pulchella*	0.82	2	*Macrozamia riedlei*			
9.24		**Transect length**	1.16	5	*Jacksonia sternbergiana*			
			0.10	1	*Kennedia prostrata*			
			10.00		**Transect length**			

Callitris 2004

Unburnt

Plot 1			Plot 2			Plot 3		
Width	**Height**	**Species**	**Width**	**Height**	**Species**	**Width**	**Height**	**Species**
1.64	5	*Kunzea ericifolia*	0.05	3	*Kunzea ericifolia*	0.15	4	*Kunzea ericifolia*
0.86	5	*Kunzea ericifolia*	0.05	3	*Kunzea ericifolia*	0.75	4	*Kunzea ericifolia*
0.32	3	*Kunzea ericifolia*	0.10	3	*Kunzea ericifolia*	9.79		**Transect length**
0.52	5	*Kunzea ericifolia*	0.20	3	*Kunzea ericifolia*			
9.98		**Transect length**	0.71	2	*Kunzea ericifolia*			
			9.99		**Transect length**			

Callitris 2004

Burnt

Plot 1			Plot 2			Plot 3		
Width	**Height**	**Species**	**Width**	**Height**	**Species**	**Width**	**Height**	**Species**
0.33	1	*Acacia pulchella*	0.67	3	*Eucalyptus todtiana*	0.12	5	*Kunzea ericifolia*
0.03	4	*Kunzea ericifolia*	1.03	5	*Kunzea ericifolia*	0.03	3	*Kunzea ericifolia*
0.51	5	*Kunzea ericifolia*	0.01	3	*Kunzea ericifolia*	0.03	5	*Kunzea ericifolia*
0.07	5	*Kunzea ericifolia*	0.23	5	*Kunzea ericifolia*	0.07	1	*Beaufortia elegans*
0.06	5	*Kunzea ericifolia*	0.03	4	*Kunzea ericifolia*	9.73		**Transect length**
0.11	5	*Kunzea ericifolia*	0.07	3	*Kunzea ericifolia*			
9.85		**Transect length**	10.01		**Transect length**			

Callitris 2005

Unburnt

Plot 1			Plot 2			Plot 3		
Width	**Height**	**Species**	**Width**	**Height**	**Species**	**Width**	**Height**	**Species**
0.07	1	*Melaleuca systena*	0.05	2	*Kunzea ericifolia*	0.01	2	*Kunzea ericifolia*
0.23	2	*Kunzea ericifolia*	9.9		**Transect length**	0.64	3	*Kunzea ericifolia*
0.09	1	*Allocasuarina fraseriana*				0.57	2	*Acacia pulchella*
9.84		**Transect length**				0.01	3	*Kunzea ericifolia*
						0.11	4	*Kunzea ericifolia*
						0.02	3	*Kunzea ericifolia*
						0.10	1	*Jacksonia furcellata*
						0.68	2	*Kunzea ericifolia*
						0.06	1	*Kunzea ericifolia*
						0.08	1	*Kunzea ericifolia*
						9.93		**Transect length**

Stirlingia 2004

Unburnt

Plot 1			Plot 2			Plot 3		
Width	**Height**	**Species**	**Width**	**Height**	**Species**	**Width**	**Height**	**Species**
0.36	2	*Hakea prostrata*	0.64	3	*Banksia attenuata*	0.01	1	*Daviesia divaricata*
0.30	1	*Hakea prostrata*	0.14	1	*Hovea pungens*	0.41	1	*Acacia pulchella*
1.01	5	*Kunzea ericifolia*	9.90		**Transect length**	9.90		**Transect length**
0.06	3	*Kunzea ericifolia*						
0.19	2	*Kunzea ericifolia*						
0.03	1	*Acacia pulchella*						
0.01	1	*Acacia pulchella*						
0.04	1	*Calothamnus sanguineus*						
1.06	2	*Acacia pulchella*						
0.04	1	*Calothamnus quadrifidus*						
0.72	1	*Jacksonia calcicola*						
1.36	3	*Hakea trifurcata*						
9.88		**Transect length**						

Stirlingia 2004

Burnt

Plot 1			Plot 2			Plot 3		
Width	**Height**	**Species**	**Width**	**Height**	**Species**	**Width**	**Height**	**Species**
0.63	5	*Kunzea ericifolia*	0.64	5	*Kunzea ericifolia*	0.21	2	*Hakea trifurcata*
0.09	4	*Kunzea ericifolia*	0.63	2	*Eucalyptus todtiana*	0.09	1	*Hakea trifurcata*
0.09	4	*Kunzea ericifolia*	0.09	1	*Acacia pulchella*	0.01	3	*Kunzea ericifolia*
0.71	4	*Kunzea ericifolia*	0.44	1	*Hakea prostrata*	0.08	3	*Kunzea ericifolia*
3.10	5	*Kunzea ericifolia*	0.02	1	*Hakea prostrata*	0.13	3	*Kunzea ericifolia*
0.24	2	*Acacia pulchella*	0.61	3	*Kunzea ericifolia*	0.83	2	*Acacia sessilis*
1.04	2	*Jacksonia calcicola*	0.53	2	*Hakea ruscifolia*	0.61	3	*Kunzea ericifolia*
9.90		**Transect length**	1.05	5	*Jacksonia furcellata*	0.39	1	*Calothamnus quadrifidus*
			0.37	2	*Hakea trifurcata*	9.79		**Transect length**
			0.13	2	*Hakea trifurcata*			
			0.05	2	*Jacksonia sternbergiana*			
			0.49	5	*Jacksonia sternbergiana*			
			0.33	1	*Hakea prostrata*			
			0.19	1	*Hakea trifurcata*			
			9.97		**Transect length**			

Stirlingia 2005

Unburnt

Plot 1			Plot 2			Plot 3		
Width	**Height**	**Species**	**Width**	**Height**	**Species**	**Width**	**Height**	**Species**
0.03	5	*Jacksonia furcellata*	0.09	3	*Jacksonia furcellata*	0.29	1	*Hakea prostrata*
0.40	2	*Kunzea ericifolia*	0.04	3	*Jacksonia furcellata*	0.32	2	*Kunzea ericifolia*
0.31	1	*Gompholobium tomentosum*	0.13	1	*Calothamnus sanguineus*	0.08	1	*Hakea prostrata*
0.32	2	*Eucalyptus todtiana*	0.38	1	*Hakea prostrata*	0.13	1	*Gompholobium tomentosum*
0.03	1	*Kunzea ericifolia*	0.81	3	*Kunzea ericifolia*	0.84	1	*Hakea prostrata*
0.25	2	*Banksia menziesii*	0.26	1	*Kunzea ericifolia*	0.05	1	*Hakea prostrata*
9.92		**Transect length**	0.10	1	*Eremaea pauciflora*	0.07	1	*Calothamnus quadrifidus*
			9.92		**Transect length**	0.27	1	*Acacia pulchella*
						0.03	2	*Kunzea ericifolia*
						9.90		**Transect length**

Stirlingia 2005

Burnt

Plot 1			Plot 2			Plot 3		
Width	**Height**	**Species**	**Width**	**Height**	**Species**	**Width**	**Height**	**Species**
0.23	2	*Jacksonia furcellata*	0.26	1	*Gompholobium tomentosum*	0.15	1	*Calothamnus quadrifidus*
9.90		**Transect length**	1.85	4	*Jacksonia sternbergiana*	0.25	1	*Acacia pulchella*
			0.05	1	*Acacia pulchella*	0.02	1	*Acacia pulchella*
			10.04		**Transect length**	0.24	1	*Acacia pulchella*
						0.09	1	*Calothamnus sanguineus*
						0.13	1	*Hakea prostrata*
						0.91	5	*Jacksonia furcellata*
						0.23	3	*Jacksonia furcellata*
						1.40	3	*Daviesia divaricata*
						0.69	2	*Acacia pulchella*
						0.40	4	*Kunzea ericifolia*
						10.02		**Transect length**