Wungong Catchment Trial

Flora Assessment 2011

Vegetation assessment of Treatment Area 4
Curtis Road, Bedfordale.

MATTISKE CONSULTING PTY LTD

Mattiske, L. et. al.

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1. SUMMARY

The Water Corporation has an ongoing commitment to managing and monitoring biodiversity within the Wungong Catchment. A component of this program is the long-term assessment of the vegetation in the catchment forest. In October 2010, Mattiske Consulting Pty Ltd was commissioned by the Water Corporation to establish six paired vegetation monitoring transects within selected sub-catchments of Treatment Area 4 of the Wungong Catchment. These transects are located in the forest along Curtis Road Bedfordale (Figure 1).

Half of the vegetation monitoring transects were established in areas which are dieback-free and half in dieback-affected areas of the forest. Subsequent to the initial monitoring of the vegetation along the transects in 2010, selected areas of the forest in which the transects are located were scheduled to undergo silviculture treatments to reduce the density of trees along selected transects. The vegetation at all transects is planned to be re-assessed on a regular interval to determine the effects of forest thinning on the vegetation in the forest, and to compare the silviculture techniques in the dieback-free and dieback-affected sections of the forest.

The survey of the understorey along the 12 transects established within Treatment Area 4 of the Wungong Catchment recorded a total of 139 taxa (including subspecies and varieties) representing 80 genera and 37 families. The majority of the taxa were recorded in the Asparagaceae (16 taxa), Fabaceae (16 taxa), Proteaceae (12 taxa) and Stylidiaceae (9 taxa) families.

During the survey two introduced (weed) species were recorded. These were *Hypochaeris glabra* and *Senecio diaschides.* Both taxa were recorded at one transect, Transect 11-2, a control transect established in a dieback-affected area. Neither taxon is listed by the Department of Agriculture and Food (2011) as a Declared Plant or a Pest Plant.

The baseline study of the understorey flora along transects within Treatment Area 4 has revealed that the species richness along transects established in the dieback-affected sections of the forest are statistically less species rich than at transects established in the dieback-free areas of the forest. The data on tree health, basal area and stem density when compared between the dieback-free and dieback-affected areas of the forest the results are less conclusive. Of the three parameters, a significant difference was only found to occur in the relative health of the dieback-free and dieback-affected areas of the forest where the transects had been established. Whilst statistically, the dieback-free transects were less healthy then the dieback-affected transects ($p<0.05$), both areas, with average health values of 2.47 and 2.64 respectively, are classed as stressed to slightly stressed. Both the tree basal area (m^2/ha) and stem density (stems/ha) did not show a statistically significant difference when the dieback-free and dieback-affected areas of the forest where the transects were established are compared. Future assessments of the flora along these transects may provide data which may make the differences in the dieback-free and dieback-affected areas of the forest where the transects have been established more conclusive.

The study of the effects of canopy thinning and dieback, on future changes in both the understorey and tree species components of the forest will require long term monitoring, with subsequent surveys of the flora transects undertaken on a regular basis. This is currently planned to be on a three year interval. A potential complicating factor in assessing data over the long term may occur should Jarrah Dieback spread from currently infected areas into the dieback-free areas of the forest. Hygiene measures will be undertaken to minimize this likelihood from operational activities.

2. INTRODUCTION

2.1 Background

The Water Corporation has an ongoing commitment to managing and monitoring biodiversity within the Wungong Catchment. A component of this program is the long-term assessment of the vegetation in the catchment forest. In October 2010, Mattiske Consulting Pty Ltd was commissioned by the Water Corporation to establish six paired vegetation monitoring transects within the Wungong Catchment. These transects are located in the forest along Curtis Road Bedfordale (Figure 1).

Half of the vegetation monitoring transects were established in areas which are dieback-free and half in dieback-affected areas of the forest. Subsequent to the initial monitoring of the vegetation at the transects in 2010, selected areas of the forest in which the transects are located were scheduled to undergo silviculture treatments to reduce the density of trees along selected transects. The vegetation at all transects is planned to be re-assessed on a regular (3 year) cycle to determine the effects of forest thinning on the vegetation in the forest, and to compare the silviculture techniques in the dieback-free and dieback-affected sections of the forest.

2.2 Location

Treatment Area 4 within the Wungong Catchment is located in Bedfordale, in the vicinity of Curtis Road, 11 km south of the intersection of the Albany Highway and the South-West Highway. The forest within the designated section of Treatment Area 4 contains both dieback-free and dieback-affected areas (Figure 1). In addition the southern section includes areas of rehabilitated forest previously mined by Alcoa. Flora monitoring transects were established in both dieback-free and dieback-affected areas of the forest, on mid to upper slope terrains. No flora monitoring transects were established in the rehabilitated areas of forest.

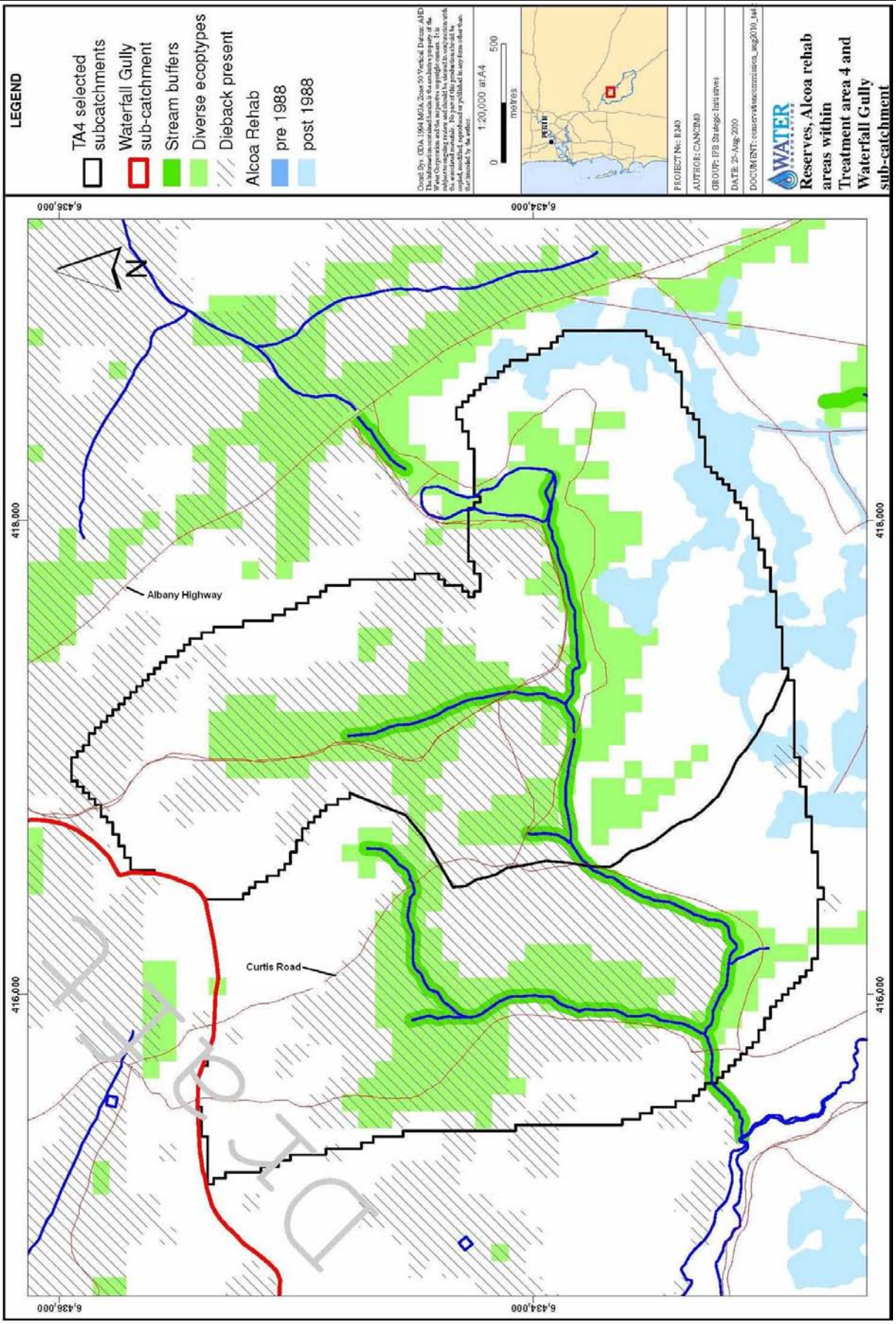

Figure 1: Treatment Area 4 and Waterfall Gully Sub-catchment Locality

2.3 Climate

The Wungong Catchment lies within the Darling Botanical District (Beard 1990). The Darling Botanical District is characterised by a dry Mediterranean climate, with winter rainfall of 600-1000mm and five to six dry months per year (Beard 1990). The Wungong Catchment area in the vicinity of Curtis Road lies approximately equidistant between the Karnet and Gosnells Bureau of Meteorology weather stations (Bureau of Meteorology 2011). The mean annual rainfall for Karnet is 1153.5mm (1963-2011) and that of Gosnells is 827.5mm (1961-2011). Figure 2 illustrates the average rainfall and temperature data for both Karnet and the City of Gosnells (Bureau of Meteorology 2011).

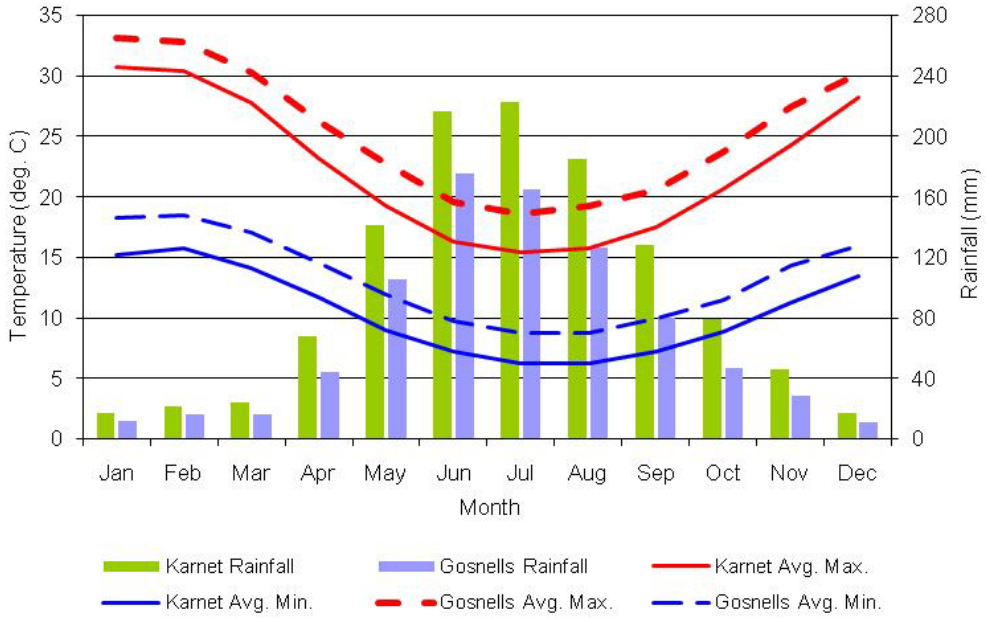

Figure 2: Long-term average rainfall, maxima and minima for Karnet and the City of Gosnells (Bureau of Meteorology 2011)

2.4 Topography and Soils

The Wungong Catchment is located on the western margin of the lateritic capped granite and igneous rocks of the Darling Plateau (Churchward and McArthur, 1980). The dominant soils are lateritic gravels consisting of up to 5 m or more of ironstone gravels in a yellow sandy matrix, and related lateritic podzolic soils with ironstone gravels in a sandy surface horizon overlying mottled yellow-brown clay subsoil. These materials frequently overlie a pallid zone up to 30m or more in thickness (Beard, 1990).

2.5 Flora and Vegetation

The survey area is located on the eastern section of the Darling Botanical District of the South-western Botanical Province as recognized by Diels (1906) and later developed by Gardner (1942) and Beard (1979, 1980).

Previous workers have stressed the significance of the climate, landforms and soils in determining the distribution of plant communities in this area (Diels 1906; Williams 1932, 1942; Speck 1958; Lange 1960; Churchill 1961, 1968; Smith 1974; Seddon 1972; Havel 1968, 1975a, 1975b; Heddle *et al*. 1980; Beard 1980, Mattiske and Havel 1998, Havel 2000).

The Wungong Catchment in its entirety is dominated by a mixture of *Eucalyptus marginata* (Jarrah), *Corymbia calophylla* (Marri) and Sheoak (*Allocasuarina fraseriana*). However, in wetter areas this association is replaced by one containing *Eucalyptus patens* (Blackbutt), *Eucalyptus megacarpa* (Bullich), *Melaleuca preissiana* (Paperbark) and *Banksia littoralis* (Swamp Banksia) (Batini *et al.* 1980).

Treatment Area 4 of the Wungong Catchment, in the vicinity of Curtis Road, comprises of the following four vegetation complexes as defined by Mattiske and Havel (1998):

Dwellingup 1 - Open forest of *Eucalyptus marginata* subsp. *marginata* – *Corymbia calophylla* on lateritic uplands in mainly humid and sub-humid zones.

Dwellingup 2 - Open forest of *Eucalyptus marginata* subsp. *marginata* – *Corymbia calophylla* on lateritic uplands in sub-humid and semiarid zones.

Murray 1 - Open forest *Eucalyptus marginata* subsp. *marginata* – *Corymbia calophylla* – *Eucalyptus patens* on valley slopes to woodland of *Eucalyptus rudis* – *Melaleuca rhaphiophylla* on the valley floors in humid and sub-humid zones.

Yarragil 1 - Open forest of *Eucalyptus marginata* subsp. *marginata* – *Corymbia calophylla* on slopes with mixtures of *Eucalyptus patens* and *Eucalyptus megacarpa* on the valley floors in humid and sub-humid zones.

The site-vegetation types defined by Havel (1975a, 1975b) for the northern Jarrah forest covered the variation of plant communities on this section of the Darling Range. Although the plant communities in this area form a continuum, it is possible to classify the site-vegetation types by incorporating site descriptions (e.g. soils, topography, slope, aspect, soil moisture regimes), floristic information and structural information.

In the last twenty years, subsequent studies by Mattiske and Havel in the northern Jarrah forest have recognised a series of new vegetation types not covered previously by Havel (1975a, 1975b). These include variations on the previously defined site vegetation types (e.g. PG, HS) as well as site-vegetation types, which were not covered by Havel.

3. OBJECTIVES

The objectives of the survey were to:

1. Establish flora monitoring transects and undertake baseline flora assessments, within both dieback-free and dieback-affected areas of the forest, in the selected sub-catchment of Treatment Area 4;
2. Assess the understorey flora along transects for growth, cover and health;
3. Assess the tree species along transects for growth, cover and health; and
4. Prepare a report summarising the findings of the survey.

4. METHODS

4.1 Establishment of Transects

Twelve transects, 120 m in length have been established in selected sub-catchments of Treatment Area 4 of the Wungong Catchment (Figure 1) in the vicinity of Curtis Road Bedfordale. The transects were set up in pairs and assigned the following names: 7-1, 7-2, 8-1, 8-2, 9-1, 9-2, 10-1, 10-2, 11-1, 11-2, 12-1 and 12-2. The location, bearing and dieback status of each transect is set out in Appendix A. The transects were established in October and November 2010.

The flora monitoring transects were marked with wooden pegs located every five metres along their length. Steel fence droppers have been used at the start and finish points of each transect. Tree assessment quadrats (10 m x 10 m) are located to the right of the transect centre line, when viewed from the transect origin. Understorey flora assessment quadrats (2m x 2m) are located to the left of the transect centre line. The transect layout is illustrated in Figure 3.

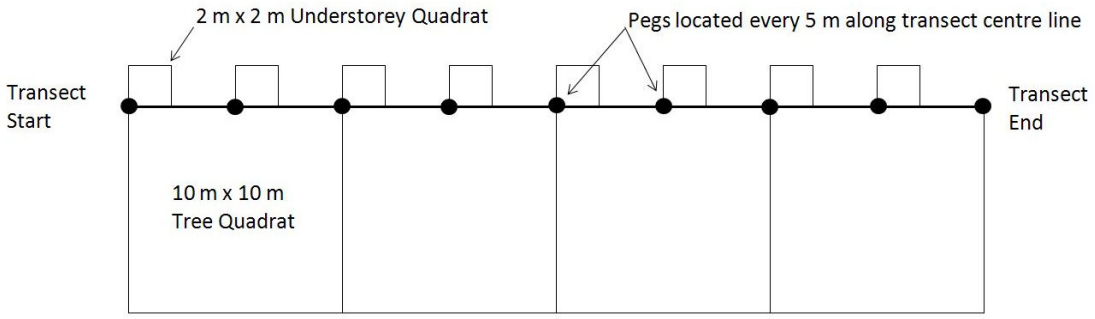

Figure 3: Flora Assessment Transect Design
Tree assessment quadrats (10m x 10m) are located to the right of the transect centre line. Understorey flora assessment quadrats (2m x 2m) are located every 5m and to the left of the transect centre line.

4.2 Assessment of Tree and Understorey Flora

Tree assessment quadrats (10 m x 10 m) were located to the right of the transect centre line (Figure 3). Trees (defined as 130 cm high or taller) were tagged with numbered aluminium tags, and were assessed for health, height, percentage (%) foliage healthy, percentage (%) canopy healthy and diameter at breast height (DBH). Tree health was assessed as being healthy (H), slightly stressed (SS), stressed (S), very stressed (VS), dead recent (DR, dead leaves and bark still retained in the canopy), dead medium (DM, dead leaves fallen from canopy, dead bark being shed) or dead old (DO; dead bark fallen from trunk and stems). For data analysis, health ratings were converted to numerical values. Conversions were as follows: H = 4, SS = 3, S = 2, VS = 1, DR, DM and DO = 0. The location of seedlings (<130cm in height) in relation to tagged trees was recorded in addition to their height and health status.

Understorey flora was assessed in 2 m x 2 m quadrats located every five metres on the left side of the transect centre line (Figure 3). Abundance and percentage cover of all vascular plants was recorded in each quadrat. Plants that could not be identified on site were collected and subsequently identified with the use of local and regional flora keys and by comparison with the named species held at the West Australian Herbarium. Where necessary, plant taxonomists with specialist knowledge were consulted. Nomenclature of species were recorded is in accordance with the Department of Environment and Conservation (2011a).

The conservation status of all recorded flora was also checked against current schedules and lists which conform to *Environmental Protection Act 1986*, *Environment Protection and Biodiversity Conservation Act 1999* and the *Wildlife Conservation Act 1950*. These include those of the Western Australian Herbarium (Department of Environment and Conservation 2011a), the Department of Environment and Conservation (2011b), the Department of Sustainability, Environment, Water, Population and Communities (2011a), The status of any introduced (exotic) and potential weed species was checked against the Declared Plants List (Department of Agriculture and Food 2011).

A photographic record was made of the start and end points of each transect. Photographs were taken along the centre line of each transect. Photos were taken so that the tops of the pegs marking the start and the end of the transect were within the lower portion of the photo to enable the same image to be taken during future assessments for comparison.

5. RESULTS

5.1 Photographic Record of Transects

A photographic record of the start and end points of each of the six pairs of transects was made. The photographs show the view along the transect centre line, from either the transect start or end pegs, and include a portion of the transect start or end pegs in the lower section of the photograph. The photographic record of the six pairs of transects is presented in Appendix D.

5.2 Tree Species

Five tree species were recorded along transects within the Treatment Area 4 sub-catchment within the Wungong Catchment. These were *Allocasuarina fraseriana*, *Banksia grandis*, *Corymbia calophylla*, *Eucalyptus marginate* and *Persoonia longifolia*. *Persoonia longifolia* was included in the tree statistics because it can be classified as a large shrub to small tree. For the purposes of the survey, trees were defined as having a height greater than 130 cm. All tree species with a height less than 130 cm were counted as seedlings. Only trees with a DBH > 10 cm were used for tree stem density calculations.

The average tree density, expressed as stems/ha, for all tree species, is illustrated in Figure 4. There was a wide range in stem densities within both the dieback-free and dieback-affected transects. The average stem density for all trees along the six dieback-free transects was 600 ± 40 stems/ha (mean ± s.e.m.). The average stem density for all trees along the six dieback-affected transects was 601 ± 72 stems/ha (mean ± s.e.m.). The difference in average stem densities between the dieback-free and dieback-affected transects was not statistically significant ($p>0.05$).

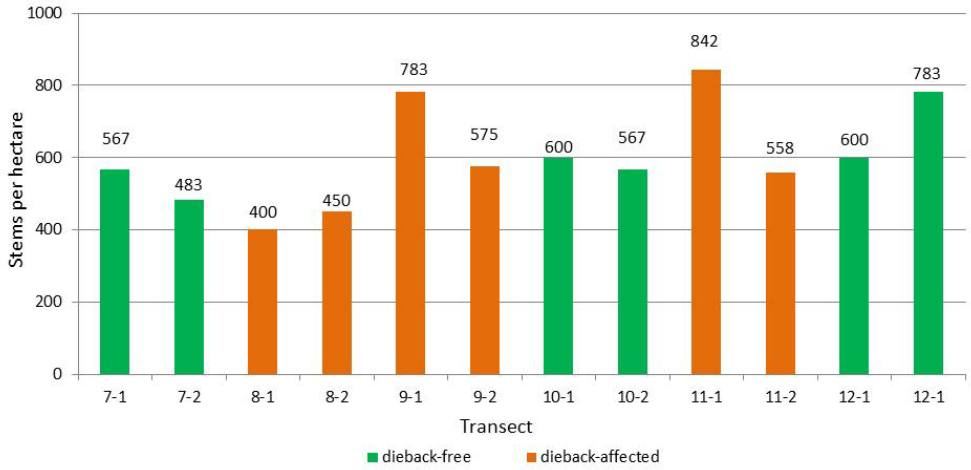

Figure 4: Average Tree Stem Density (stems/ha) Along Transects in Treatment Area 4 of the Wungong Catchment. The average stem density (stems/ha), for all tree species recorded along each transect, with a DBH > 10 cm is shown. The value associated with each bar in the graph is the average stem density for the transect.

The average basal area of all tree species along each transect, expressed as m^2/ha, is illustrated in Figure 5. The average basal area for all trees along the six dieback-free transects was 42.22 ± 4.12 stems/ha (mean ± s.e.m.). The average stem density for all trees along the six dieback-affected transects was 33.31 ± 2.81 stems/ha (mean ± s.e.m.). The difference in average basal area between the dieback-free and dieback-affected transects was not statistically significant ($p>0.05$).

On average, the basal area of trees along transects established in dieback-affected areas was 79% of the basal area of trees along transects established in dieback-free areas.

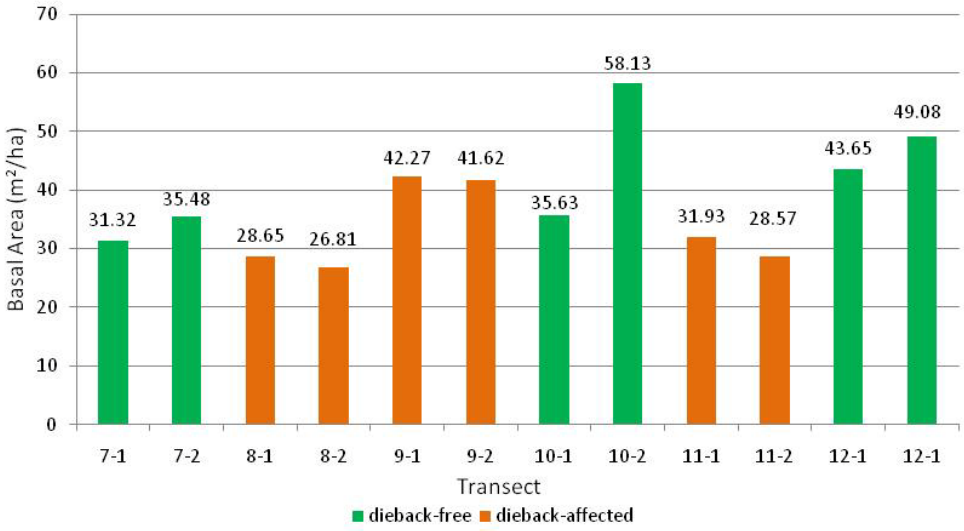

Figure 5: Average Tree Basal Area (m^2/ha) Along Transects in Treatment Area 4 of the Wungong Catchment. The average basal area (m^2/ha), for all tree species recorded along each transect is shown. The value associated with each bar in the graph is the average basal area for the transect. The data is colour-coded to indicate the dieback status of the transect.

The average health for all tree species is illustrated in Figure 6. The average health value for all trees along the six dieback-free transects was 2.47 ± 0.02 (mean ± s.e.m.). The average health value for all trees along the six dieback-affected transects was 2.64 ± 0.02 (mean ± s.e.m.). The difference in average tree health between the dieback-free and dieback-affected transects was statistically significant ($p<0.05$). Whilst statistically, the dieback-free transects were less healthy then the dieback-affected transects, both areas, with average health values of 2.47 and 2.64 respectively, are classed as stressed to slightly stressed.

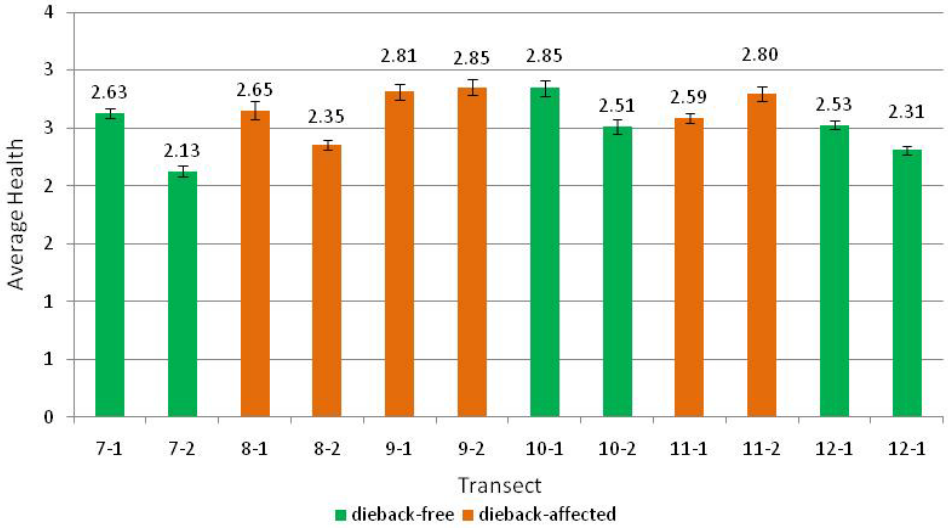

Figure 6: Average Tree Health Along Transects in Treatment Area 4 of the Wungong Catchment. The average health for all tree species recorded along each transect is shown. The value associated with each bar in the graph is the average basal area for the transect. Tree health codes: 0 = dead; 1= very stressed; 2 = stressed; 3 = slightly stressed; 4 = healthy.

The detailed results of the assessment of tree species physical and health parameters are set out in the following sections. In sections 5.2.1 through 5.2.12, stem density was calculated using two methods. Firstly, stem density was calculated based on trees with a stem diameter > 10 cm at breast height, a measure commonly used by foresters (F. Batini pers comm.). In addition, stem density was calculated using the data for all trees with a height > 130 cm at breast height. The former value is cited in the text, whereas the latter is only indicated within the tabular data.

5.2.1 Transect 7-1

Transect 7-1 consisted of an open forest dominated by *Eucalyptus marginata* (basal area = 10.6 m^2/ha, stem density = 216.7 stems/ha) mixed with *Allocasuarina fraseriana* (sub-dominant) (basal area = 15.4 m^2/ha, stem density = 208.3 stems/ha), *Banksia grandis*, *Corymbia calophylla* and *Persoonia longifolia*. The transect had a total basal area of 31.3 m^2/ha and a total stem density of 566.7 stems/ha, with *Banksia grandis* contributing the largest proportion of smaller stems.

Allocasuarina fraseriana was the tallest tree species, with an average height of 984 ± 67.2 cm. The mean health of trees was 2.6 ± 0.0 (Table 1). The seedlings (individuals less than 130 cm in height) of all five species found as trees were recorded along transect 7-1. Total stem density for seedlings was 2375.0 stems/ha with *Banksia grandis* being the most numerous (1716.7 stems/ha). *Allocasuarina fraseriana* seedlings were the tallest, averaging 106.7 ± 13.3cm and also the healthiest (4.0 ± 0.0) (Table 2).

Table 1: Summary of mean height, health, basal area and stem density for tree species recorded along Transect 7-1. Results are expressed as the mean ± s.e.m. Health codes: 0 = dead; 1 = very stressed; 2 = stressed; 3 = slightly stressed; 4 = healthy. Tree basal area was calculated from the diameter at breast height (DBH). Stem density (stems/ha) was calculated using either trees with stems > 10 cm diameter at breast height (130 cm), or all stems from trees with a height > 130 cm.

Species	Mean Height (cm)	Mean Health	Basal Area (m^2/ha)	Stems/ha	
				DBH > 10 cm	Height > 130 cm
Allocasuarina fraseriana	984.0 ± 67.2	2.3 ± 0.1	15.4	208.3	250.0
Banksia grandis	306.2 ± 16.3	2.7 ± 0.1	3.5	108.3	1150.0
Corymbia calophylla	1685.0 ± 248.0	1.5 ± 0.5	1.6	16.7	16.7
Eucalyptus marginata	644.3 ± 59.9	2.5 ± 0.1	10.6	216.7	500.0
Persoonia longifolia	350.0 ± 60.0	2.5 ± 0.5	0.2	16.7	16.7
Total	494.6 ± 26.6	2.6 ± 0.0	31.3	566.7	1933.3

Table 2: Summary of mean height, health and stem density for tree seedlings recorded along Transect 7-1. Results are expressed as the mean ± S.E.M. Health codes: 0 = dead; 1 = very stressed; 2 = stressed; 3 = slightly stressed; 4 = healthy.

Species	Mean Height (cm)	Mean Health	Stems/ha
Allocasuarina fraseriana	106.7 ± 13.3	4.0 ± 0.0	25.0
Banksia grandis	46.7 ± 2.27	2.8 ± 0.1	1716.7
Corymbia calophylla	30.0 ± 0.0	3.0 ± 0.0	8.3
Eucalyptus marginata	36.5 ± 3.9	1.8 ± 0.1	591.7
Persoonia longifolia	57.5 ± 13.8	3.8 ± 0.3	33.3
Total	44.9 ± 2.0	2.6 ± 0.1	2375.0

The majority of trees in transect 7-1 had a DBH between 5 and 15cm. Overall, frequency of trees declined with increasing DBH. *Allocasuarina fraseriana* was notable in having an even spread across DBH classes as was *Banksia grandis* for the large number of trees with a DBH less than 5cm (104). Five trees with DBH larger than 45cm were recorded (Table 3).

Table 3: Diameter at breast height (DBH) classes for trees recorded along Transect 7-1. The table shows the number of trees recorded with DBH values within the indicated DBH ranges.

Species	Diameter at Breast Height (cm)						
	< 5	5-15	15-25	25-35	35-45	> 45	Total
Allocasuarina fraseriana	0	8	9	6	4	3	30
Banksia grandis	104	29	4	1	0	0	138
Corymbia calophylla	0	0	0	1	1	0	2
Eucalyptus marginata	19	26	9	2	2	2	60
Persoonia longifolia	0	2	0	0	0	0	2
Total	123	65	22	10	7	5	232

5.2.2 Transect 7-2

Transect 7-2 consisted of an open forest dominated by *Allocasuarina fraseriana* (basal area = 18.1 m^2/ha, stem density = 258.3 stems/ha) mixed with *Eucalyptus marginata* (sub-dominant) (basal area = 13.6 m^2/ha, stem density = 141.7 stems/ha), *Banksia grandis* and *Corymbia calophylla*. The transect had a total basal area of 35.5 m^2/ha and a total stem density of 483.3 stems/ha with *Banksia grandis* contributing the largest proportion of smaller stems.

Corymbia calophylla was the tallest tree species, with an average height of 1508.1 ± 0.0cm. The mean health of trees was 2.1 ± 0.1 (Table 4). The seedlings (individuals less than 130 cm in height) of all four species recorded as trees and *Persoonia longifolia* were recorded along transect 7-2. Total stem density for seedlings was 2533.3 stems/ha with *Banksia grandis* being the most numerous (2200.0 stems/ha). *Allocasuarina fraseriana* seedlings were the tallest, averaging 90.0 ± 0.0cm, and also the healthiest (4.0 ± 0.0) (Table 5).

Table 4: Summary of mean height, health, basal area and stem density for tree species recorded along Transect 7-2. Results are expressed as the mean ± s.e.m. Health codes: 0 = dead; 1 = very stressed; 2 = stressed; 3 = slightly stressed; 4 = healthy. Tree basal area was calculated from the diameter at breast height (DBH). Stem density (stems/ha) was calculated using either trees with stems > 10 cm diameter at breast height (130 cm), or all stems from trees with a height > 130 cm.

Species	Mean Height (cm)	Mean Health	Basal Area (m^2/ha)	Stems/ha	
				DBH > 10 cm	Height > 130 cm
Allocasuarina fraseriana	933.7 ± 58.4	1.9 ± 0.1	18.1	258.3	291.7
Banksia grandis	343.4 ± 18.1	2.0 ± 0.1	3.1	75.0	991.7
Corymbia calophylla	1508.1 ± 0.0	2.0 ± 0.0	0.6	8.3	8.3
Eucalyptus marginata	771.9 ± 78.7	2.6 ± 0.1	13.6	141.7	366.7
Persoonia longifolia	0.0	0.0	0.0	0.0	0.0
Total	548.9 ± 29.2	2.1 ± 0.1	35.5	483.3	1658.3

Table 5: Summary of mean height, health and stem density for tree seedlings recorded along Transect 7-2. Results are expressed as the mean ± S.E.M. Health codes: 0 = dead; 1 = very stressed; 2 = stressed; 3 = slightly stressed; 4 = healthy.

Species	Mean Height (cm)	Mean Health	Stems/ha
Allocasuarina fraseriana	90.0 ± 0.0	4.0 ± 0.0	8.3
Banksia grandis	37.3 ± 1.9	2.9 ± 0.0	2200.0
Corymbia calophylla	20.0 ± 10.0	3.0 ± 1.0	16.7
Eucalyptus marginata	27.0 ± 5.0	2.3 ± 0.2	266.7
Persoonia longifolia	54.0 ± 5.8	3.8 ± 0.2	41.7
Total	36.6 ± 1.7	2.9 ± 0.0	2533.3

The majority of trees in transect 7-2 had a DBH between 5 and 15cm. Overall, frequency of trees declined with increasing DBH. *Banksia grandis* was notable for the large number of trees with a DBH less than 15cm (115), as was *Allocasuarina fraseriana* in having a relatively even spread across DBH classes. Three trees with DBH larger than 45cm were recorded (Table 4).

Table 6: Diameter at breast height (DBH) classes for trees recorded along Transect 7-2. The table shows the number of trees recorded with DBH values within the indicated DBH ranges.

Species	Diameter at Breast Height (cm)						
	< 5	5-15	15-25	25-35	35-45	> 45	Total
Allocasuarina fraseriana	0	10	10	7	6	2	35
Banksia grandis	78	37	4	0	0	0	119
Corymbia calophylla	0	0	0	1	0	0	1
Eucalyptus marginata	9	20	9	0	5	1	44
Persoonia longifolia	0	0	0	0	0	0	0
Total	87	67	23	8	11	3	199

5.2.3 Transect 8-1

Transect 8-1 consisted of an open forest dominated by *Allocasuarina fraseriana* (basal area = 16.0 m^2/ha, stem density = 108.3 stems/ha) mixed with *Eucalyptus marginata* (sub-dominant) (basal area = 10.4 m^2/ha, stem density = 241.7 stems/ha), *Banksia grandis* and *Corymbia calophylla*. *Persoonia longifolia* was absent from this transect. The transect had a total basal area of 28.6 m^2/ha and a total stem density of 400.0 stems/ha with *Banksia grandis* contributing a large proportion of smaller stems.

Allocasuarina fraseriana was the tallest tree species, with an average height of 1049.9 ± 57.7 cm. The mean health of trees was 2.6 ± 0.1 (Table 7). The seedlings (individuals less than 130 cm in height) of all four species present as trees were recorded along transect 8-1. Total stem density for seedlings was 1125.0 stems/ha with *Eucalyptus marginata* being the most numerous (550.0 stems/ha). *Allocasuarina fraseriana* seedlings were the tallest, averaging 70.0cm ± 0.0cm and also the healthiest (4.0 ± 0.0) (Table 5).

The majority of trees in transect 8-1 had a DBH between 5 and 15cm. Overall, frequency of trees declined with increasing DBH. *Eucalyptus marginata* comprised the majority of trees with DBH less than 15cm (42) while *Allocasuarina fraseriana* was notable in having an even spread across DBH classes. Two trees with DBH larger than 45cm were recorded (Table 6).

Table 7: Summary of mean height, health, basal area and stem density for tree species recorded along Transect 8-1. Results are expressed as the mean ± s.e.m. Health codes: 0 = dead; 1 = very stressed; 2 = stressed; 3 = slightly stressed; 4 = healthy. Tree basal area was calculated from the diameter at breast height (DBH). Stem density (stems/ha) was calculated using either trees with stems > 10 cm diameter at breast height (130 cm), or all stems from trees with a height > 130 cm.

Species	Mean Height (cm)	Mean Health	Basal Area (m^2/ha)	Stems/ha	
				DBH > 10 cm	Height > 130 cm
Allocasuarina fraseriana	1049.9 ± 57.7	2.3 ± 0.1	16.0	108.3	233.3
Banksia grandis	397.7 ± 46.7	2.5 ± 0.1	1.1	25.0	175.0
Corymbia calophylla	652.4 ± 124.0	2.7 ± 0.2	1.1	25.0	83.3
Eucalyptus marginata	862.1 ± 66.1	2.8 ± 0.1	10.4	241.7	508.3
Persoonia longifolia	0.0	0.0	0.0	0.0	0.0
Total	788.9 ± 42.3	2.6 ± 0.1	28.6	400.0	1000.0

Table 8: Summary of mean height, health and stem density for tree seedlings recorded along Transect 8-1. Results are expressed as the mean ± S.E.M. Health codes: 0 = dead; 1 = very stressed; 2 = stressed; 3 = slightly stressed; 4 = healthy.

Species	Mean Height (cm)	Mean Health	Stems/ha
Allocasuarina fraseriana	70.0 ± 0.0	4.0 ± 0.0	8.3
Banksia grandis	54.8 ± 5.3	3.0 ± 0.1	350.0
Corymbia calophylla	37.7 ± 2.5	2.7 ± 0.1	216.7
Eucalyptus marginata	47.1 ± 4.2	2.5 ± 0.1	550.0
Persoonia longifolia	0.0	0.0	0.0
Total	47.9 ± 2.7	2.7 ± 0.1	1125.0

Table 9: Diameter at breast height (DBH) classes for trees recorded along Transect 8-1. The table shows the number of trees recorded with DBH values within the indicated DBH ranges.

Species	Diameter at Breast Height (cm)						
	< 5	5-15	15-25	25-35	35-45	> 45	Total
Allocasuarina fraseriana	1	7	10	5	3	2	28
Banksia grandis	9	10	1	1	0	0	21
Corymbia calophylla	1	7	1	1	0	0	10
Eucalyptus marginata	8	34	9	9	1	0	61
Persoonia longifolia	0	0	0	0	0	0	0
Total	19	58	21	16	4	2	120

5.2.4 Transect 8-2

Transect 8-2 consisted of an open forest dominated by *Eucalyptus marginata* (basal area = 16.1 m^2/ha, stem density = 308.3 stems/ha) mixed with *Corymbia calophylla* (sub-dominant) (basal area = 7.1 m^2/ha, stem density = 66.7 stems/ha), and *Banksia grandis*. *Allocasuarina fraseriana* was absent from this transect. The transect had a total basal area of 26.8 m^2/ha and a total stem density of 450.0 stems/ha with *Banksia grandis* contributing a large proportion of smaller stems.

Corymbia calophylla was the tallest tree species, with an average height of 1297.8 ± 218.0 cm. The mean health of trees was 2.3 ± 0.0 (Table 10). The seedlings (individuals less than 130 cm in height) of all three species present as trees plus *Persoonia longifolia* were recorded along transect 8-2. Total stem density for seedlings was 3441.7 stems/ha with *Banksia grandis* being the most numerous (2391.7 stems/ha). *Persoonia longifolia* seedlings were the tallest, averaging 61.0 ± 12.2 cm, and also the healthiest (3.3 ± 0.5) (Table 11).

Table 10: Summary of mean height, health, basal area and stem density for tree species recorded along Transect 8-2. Results are expressed as the mean ± s.e.m. Health codes: 0 = dead; 1 = very stressed; 2 = stressed; 3 = slightly stressed; 4 = healthy. Tree basal area was calculated from the diameter at breast height (DBH). Stem density (stems/ha) was calculated using either trees with stems > 10 cm diameter at breast height (130 cm), or all stems from trees with a height > 130 cm.

Species	Mean Height (cm)	Mean Health	Basal Area (m^2/ha)	Stems/ha	
				DBH > 10 cm	Height > 130 cm
Allocasuarina fraseriana	0.0	0.0	0.0	0.0	0.0
Banksia grandis	296.0 ± 10.3	2.2 ± 0.0	3.5	75.0	1883.3
Corymbia calophylla	1297.8 ± 218.0	2.5 ± 0.2	7.1	66.7	75.0
Eucalyptus marginata	805.5 ± 65.4	2.5 ± 0.1	16.1	308.3	658.3
Persoonia longifolia	0.0	0.0	0.0	0.0	0.0
Total	453.6 ± 24.0	2.3 ± 0.0	26.8	450.0	2616.7

Table 11: Summary of mean height, health and stem density for tree seedlings recorded along Transect 8-2. Results are expressed as the mean ± S.E.M. Health codes: 0 = dead; 1 = very stressed; 2 = stressed; 3 = slightly stressed; 4 = healthy.

Species	Mean Height (cm)	Mean Health	Stems/ha
Allocasuarina fraseriana	0.0	0.0	0.0
Banksia grandis	55.2 ± 2.2	2.8 ± 0.0	2391.7
Corymbia calophylla	28.4 ± 3.7	2.8 ± 0.1	375.0
Eucalyptus marginata	41.1 ± 3.5	2.3 ± 0.1	633.3
Persoonia longifolia	61.0 ± 12.2	3.3 ± 0.5	41.7
Total	49.7 ± 1.7	2.7 ± 0.0	3441.7

The majority of trees in transect 8-2 had a DBH less than 15cm. Overall, frequency of trees declined with increasing DBH. *Banksia grandis* comprised the majority of trees with DBH less than 15cm (221) while *Eucalyptus marginata* was notable for having trees in each DBH class. Four trees with DBH larger than 45cm were recorded (Table 12).

Table 12: Diameter at breast height (DBH) classes for trees recorded along Transect 8-2. The table shows the number of trees recorded with DBH values within the indicated DBH ranges.

Species	Diameter at Breast Height (cm)						
	< 5	5-15	15-25	25-35	35-45	> 45	Total
Allocasuarina fraseriana	0	0	0	0	0	0	0
Banksia grandis	179	42	4	1	0	0	226
Corymbia calophylla	1	1	3	0	2	2	9
Eucalyptus marginata	20	36	15	4	2	2	79
Persoonia longifolia	0	0	0	0	0	0	0
Total	200	79	22	5	4	4	314

5.2.5 Transect 9-1

Transect 9-1 consisted of an open forest dominated by *Eucalyptus marginata* (basal area = 24.8 m^2/ha, stem density = 566.7 stems/ha) mixed with *Allocasuarina fraseriana* (sub-dominant) (basal area = 9.2 m^2/ha, stem density = 175.0 stems/ha), *Corymbia calophylla* and *Banksia grandis*. *Persoonia longifolia* trees were absent from this transect. The transect had a total basal area of 42.3 m^2/ha and a total stem density of 783.3 stems/ha. *Banksia grandis* contributed a minor percentage of the total basal area. Consequently, its individual basal area value has to be presented as a category (<0.1m^2/ha). Both *Allocasuarina fraseriana* and *Eucalyptus marginata* contributed large numbers of smaller diameter stems to the transect.

Eucalyptus marginata was the tallest tree species, with an average height of 837.8 ± 51.3 cm. The mean health of trees was 2.8 ± 0.1 (Table 13). The seedlings (individuals less than 130 cm in height) of the three species present as trees were recorded along transect 9-1 with *Banksia grandis* being absent. Total stem density for seedlings was 1275.0 stems/ha with *Eucalyptus marginata* being the most numerous (750.0 stems/ha). *Allocasuarina fraseriana* seedlings were the tallest, averaging 70.0 ± 6.2 cm and also the healthiest (4.0 ± 0.0) (Table 14).

The majority of trees in transect 9-1 had a DBH between 5 and 15cm. Overall, frequency of trees declined with increasing DBH. *Eucalyptus marginata* comprised the majority of trees in this class (48) and was also the only species represented in all classes. *Allocasuarina fraseriana* had a similar distribution of DBH values. Five trees with DBH larger than 45cm were recorded (Table 15).

Table 13: Summary of mean height, health, basal area and stem density for tree species recorded along Transect 9-1. Results are expressed as the mean ± s.e.m. Health codes: 0 = dead; 1 = very stressed; 2 = stressed; 3 = slightly stressed; 4 = healthy. Tree basal area was calculated from the diameter at breast height (DBH). Stem density (stems/ha) was calculated using either trees with stems > 10 cm diameter at breast height (130 cm), or all stems from trees with a height > 130 cm.

Species	Mean Height (cm)	Mean Health	Basal Area (m^2/ha)	Stems/ha	
				DBH > 10 cm	Height > 130 cm
Allocasuarina fraseriana	571.3 ± 41.5	3.7 ± 0.1	9.2	175.0	500.0
Banksia grandis	200.0 ± 0.0	3.0 ± 0.0	<0.1	0.0	8.3
Corymbia calophylla	532.8 ± 107.2	2.8 ± 0.2	8.3	41.7	225.0
Eucalyptus marginata	837.8 ± 51.3	2.4 ± 0.1	24.8	566.7	1008.3
Persoonia longifolia	0.0	0.0	0.0	0.0	0.0
Total	719.8 ± 36.0	2.8 ± 0.1	42.3	783.3	1741.7

Table 14: Summary of mean height, health and stem density for tree seedlings recorded along Transect 9-1. Results are expressed as the mean ± S.E.M. Health codes: 0 = dead; 1 = very stressed; 2 = stressed; 3 = slightly stressed; 4 = healthy.

Species	Mean Height (cm)	Mean Health	Stems/ha
Allocasuarina fraseriana	70.0 ± 6.2	4.0 ± 0.0	58.3
Banksia grandis	0.0	0.0	0.0
Corymbia calophylla	46.4 ± 4.4	2.3 ± 0.1	466.7
Eucalyptus marginata	47.3 ± 3.1	1.9 ± 0.1	750.0
Persoonia longifolia	0.0	0.0	0.0
Total	48.0 ± 2.5	2.1 ± 0.1	1275.0

Table 15: Diameter at breast height (DBH) classes for trees recorded along Transect 9-1. The table shows the number of trees recorded with DBH values within the indicated DBH ranges.

Species	Diameter at Breast Height (cm)						
	< 5	5-15	15-25	25-35	35-45	> 45	Total
Allocasuarina fraseriana	17	30	9	3	0	1	60
Banksia grandis	1	0	0	0	0	0	1
Corymbia calophylla	15	8	1	1	0	2	27
Eucalyptus marginata	30	48	22	15	4	2	121
Persoonia longifolia	0	0	0	0	0	0	0
Total	63	86	32	19	4	5	209

5.2.6 Transect 9-2

Transect 9-2 consisted of an open forest dominated by *Allocasuarina fraseriana* (basal area = 22.4 m^2/ha, stem density = 316.7 stems/ha) mixed with *Eucalyptus marginata* (sub-dominant) (basal area = 15.9 m^2/ha, stem density = 175.0 stems/ha), *Corymbia calophylla*, *Banksia grandis* and *Persoonia longifolia*. The transect had a total basal area of 41.6 m^2/ha and a total stem density of 575.0 stems/ha. *Banksia grandis* contributed a minor percentage of the total basal area. Consequently, its individual basal area value has to be presented as a category (<0.1m^2/ha).

Eucalyptus marginata was the tallest tree species, with an average height of 967.7 ± 114.0 cm. The mean health of trees was 2.9 ± 0.1 (Table 16). The seedlings (individuals less than 130 cm in height) of all five species present as trees were recorded along transect 9-2. Total stem density for seedlings was 1466.7 stems/ha with by *Allocasuarina fraseriana* being the most numerous (608.3 stems/ha). *Allocasuarina fraseriana* seedlings were the tallest, averaging 71.9 ± 3.1 cm while *Persoonia longifolia* were the healthiest (4.0 ± 0.0) (Table 17).

The majority of trees in transect 9-2 had a DBH less than 15cm. Overall, frequency of trees declined with increasing DBH. *Eucalyptus marginata* and *Allocasuarina fraseriana* had the greatest spread of values across classes. Twelve trees with DBH larger than 45cm were recorded (Table 18).

Table 16: Summary of mean height, health, basal area and stem density for tree species recorded along Transect 9-2. Results are expressed as the mean ± s.e.m. Health codes: 0 = dead; 1 = very stressed; 2 = stressed; 3 = slightly stressed; 4 = healthy. Tree basal area was calculated from the diameter at breast height (DBH). Stem density (stems/ha) was calculated using either trees with stems > 10 cm diameter at breast height (130 cm), or all stems from trees with a height > 130 cm.

Species	Mean Height (cm)	Mean Health	Basal Area (m^2/ha)	Stems/ha	
				DBH > 10 cm	Height > 130 cm
Allocasuarina fraseriana	648.4 ± 48.5	3.0 ± 0.1	22.4	316.7	750.0
Banksia grandis	195.5 ± 18.1	3.0 ± 0.2	<0.1	0.0	91.7
Corymbia calophylla	820.0 ± 157.9	2.9 ± 0.2	3.2	83.3	108.3
Eucalyptus marginata	967.7 ± 114.0	2.4 ± 0.1	15.9	175.0	366.7
Persoonia longifolia	290.0 ± 0.0	3.0 ± 0.0	0.1	0.0	8.3
Total	716.8 ± 46.2	2.9 ± 0.1	41.6	575.0	1325.0

Table 17: Summary of mean height, health and stem density for tree seedlings recorded along Transect 9-2. Results are expressed as the mean ± S.E.M. Health codes: 0 = dead; 1 = very stressed; 2 = stressed; 3 = slightly stressed; 4 = healthy.

Species	Mean Height (cm)	Mean Health	Stems/ha
Allocasuarina fraseriana	71.9 ± 3.1	3.9 ± 0.0	608.3
Banksia grandis	48.3 ± 17.4	3.7 ± 0.3	25.0
Corymbia calophylla	32.3 ± 3.2	3.0 ± 0.1	450.0
Eucalyptus marginata	28.9 ± 3.9	2.6 ± 0.2	375.0
Persoonia longifolia	40.0 ± 0.0	4.0 ± 0.0	8.3
Total	48.2 ± 2.4	3.3 ± 0.1	1466.7

Table 18: Diameter at breast height (DBH) classes for trees recorded along Transect 9-2. The table shows the number of trees recorded with DBH values within the indicated DBH ranges.

Species	Diameter at Breast Height (cm)						
	< 5	5-15	15-25	25-35	35-45	> 45	Total
Allocasuarina fraseriana	31	34	16	2	0	7	90
Banksia grandis	11	0	0	0	0	0	11
Corymbia calophylla	3	6	2	1	0	1	13
Eucalyptus marginata	14	12	8	5	1	4	44
Persoonia longifolia	0	1	0	0	0	0	1
Total	59	53	26	8	1	12	159

5.2.7 Transect 10-1

Transect 10-1 consisted of an open forest dominated by *Allocasuarina fraseriana* (basal area = 18.9 m^2/ha, stem density = 325.0 stems/ha) mixed with *Eucalyptus marginata* (sub-dominant) (basal area = 8.9 m^2/ha, stem density = 183.3 stems/ha), *Corymbia calophylla*, *Banksia grandis* and *Persoonia longifolia*. The transect had a total basal area of 35.6 m^2/ha and a total stem density of 600.0 stems/ha with *Banksia grandis* contributing a large number of small stems.

Corymbia calophylla was the tallest tree species, with an average height of 1334.3 ± 597.0 cm. The mean health of trees was 2.8 ± 0.1 (Table 19). The seedlings (individuals less than 130 cm in height) of the four species present as trees were recorded along transect 10-1 with *Persoonia longifolia* seedlings being absent.

Total stem density for seedlings was 1625.0 stems/ha with *Banksia grandis* being the most numerous (991.7 stems/ha) as well as being the tallest, averaging 35.0 ± 2.8 cm. *Banksia grandis* and *Persoonia longifolia* were the healthiest seedlings (2.9 ±0.1 and 2.9 ±02) (Table 20).

The majority of trees in transect 10-1 had a DBH less than 15cm. Overall, frequency of trees declined with increasing DBH. *Allocasuarina fraseriana* had the greatest spread of values across classes. Six trees with DBH larger than 45cm were recorded (Table 20).

Table 19: Summary of mean height, health, basal area and stem density for tree species recorded along Transect 10-1. Results are expressed as the mean ± s.e.m. Health codes: 0 = dead; 1 = very stressed; 2 = stressed; 3 = slightly stressed; 4 = healthy. Tree basal area was calculated from the diameter at breast height (DBH). Stem density (stems/ha) was calculated using either trees with stems > 10 cm diameter at breast height (130 cm), or all stems from trees with a height > 130 cm.

Species	Mean Height (cm)	Mean Health	Basal Area (m^2/ha)	Stems/ha	
				DBH > 10 cm	Height > 130 cm
Allocasuarina fraseriana	932.1 ± 59.7	3.2 ± 0.1	18.9	325.0	408.3
Banksia grandis	367.0 ± 28.0	2.7 ± 0.1	2.1	75.0	558.3
Corymbia calophylla	1334.3 ± 597.0	3.0 ± 0.0	5.7	16.7	25.0
Eucalyptus marginata	1182.0 ± 99.8	2.5 ± 0.1	8.9	183.3	216.7
Persoonia longifolia	320.0 ± 10.8	3.5 ± 0.3	0.2	0.0	33.3
Total	713.2 ± 41.7	2.8 ± 0.1	35.6	600.0	1241.7

Table 20: Summary of mean height, health and stem density for tree seedlings recorded along Transect 10-1. Results are expressed as the mean ± S.E.M. Health codes: 0 = dead; 1 = very stressed; 2 = stressed; 3 = slightly stressed; 4 = healthy.

Species	Mean Height (cm)	Mean Health	Stems/ha
Allocasuarina fraseriana	10.0 ± 0.0	2.5 ± 0.5	16.7
Banksia grandis	35.0 ± 2.8	2.9 ± 0.1	991.7
Corymbia calophylla	26.7 ± 4.3	2.9 ± 0.2	250.0
Eucalyptus marginata	23.4 ± 2.6	2.3 ± 0.2	366.7
Persoonia longifolia	0.0	0.0	0.0
Total	30.8 ± 2.0	2.8 ± 0.1	1625.0

Table 21: Diameter at breast height (DBH) classes for trees recorded along Transect 10-1. The table shows the number of trees recorded with DBH values within the indicated DBH ranges.

Species	Diameter at Breast Height (cm)						
	< 5	5-15	15-25	25-35	35-45	> 45	Total
Allocasuarina fraseriana	5	15	13	9	4	3	49
Banksia grandis	44	19	4	0	0	0	67
Corymbia calophylla	1	0	0	0	0	2	3
Eucalyptus marginata	1	11	7	5	1	1	26
Persoonia longifolia	0	4	0	0	0	0	4
Total	51	49	24	14	5	6	149

5.2.8 Transect 10-2

Transect 10-2 consisted of an open forest dominated by *Allocasuarina fraseriana* (basal area = 29.1 m^2/ha, stem density = 125.0 stems/ha) mixed with *Eucalyptus marginata* (sub-dominant) (basal area = 22.5 m^2/ha, stem density = 241.7 stems/ha), *Corymbia calophylla, Banksia grandis* and *Persoonia longifolia*. The transect had a total basal area of 58.1 m^2/ha and a total stem density of 566.7 stems/ha with *Banksia grandis* contributing many small stems. Transect 10-2 had the greatest total basal area of any of the 12 transects.

Eucalyptus marginata was the tallest tree species, with an average height of 1287.3 ± 107.2 cm. The mean health of trees was 2.5 ± 0.1 (Table 22). The seedlings (individuals less than 130 cm in height) of the three of the four species present as trees were recorded along transect 10-2. *Allocasuarina fraseriana* seedlings were not present. Total stem density for seedlings was 5083.3 stems/ha with *Banksia grandis* being the most numerous (2933.3 stems/ha). *Persoonia longifolia* seedlings were on average the tallest (40.0 ± 4.5 cm) as well as being the healthiest (3.8 ±02) (Table 23).

The majority of trees in transect 10-2 had a DBH less than 15cm. Overall, frequency of trees declined with increasing DBH. *Allocasuarina fraseriana* and *Eucalyptus marginata* had the greatest spread of values across classes. Twelve trees with DBH larger than 45cm were recorded (Table 24).

Table 22: Summary of mean height, health, basal area and stem density for tree species recorded along Transect 10-2. Results are expressed as the mean ± s.e.m. Health codes: 0 = dead; 1 = very stressed; 2 = stressed; 3 = slightly stressed; 4 = healthy. Tree basal area was calculated from the diameter at breast height (DBH). Stem density (stems/ha) was calculated using either trees with stems > 10 cm diameter at breast height (130 cm), or all stems from trees with a height > 130 cm.

Species	Mean Height (cm)	Mean Health	Basal Area (m^2/ha)	Stems/ha	
				DBH > 10 cm	Height > 130 cm
Allocasuarina fraseriana	1133.0 ± 121.5	3.1 ± 0.1	29.1	125.0	158.3
Banksia grandis	435.6 ± 23.0	2.2 ± 0.1	4.7	191.7	708.3
Corymbia calophylla	1166.0 ± 956.0	3.0 ± 0.0	1.8	8.3	8.3
Eucalyptus marginata	1287.3 ± 107.2	2.9 ± 0.1	22.5	241.7	308.3
Persoonia longifolia	310.0 ± 65.1	4.0 ± 0.0	0.1	0.0	25.0
Total	747.5 ± 47.8	2.5 ± 0.1	58.1	566.7	1208.3

Table 23: Summary of mean height, health and stem density for tree seedlings recorded along Transect 10-2. Results are expressed as the mean ± S.E.M. Health codes: 0 = dead; 1 = very stressed; 2 = stressed; 3 = slightly stressed; 4 = healthy.

Species	Mean Height (cm)	Mean Health	Stems/ha
Allocasuarina fraseriana	0.0	0.0	0.0
Banksia grandis	22.1 ± 0.9	2.6 ± 0.0	2933.3
Corymbia calophylla	18.5 ± 1.2	2.9 ± 0.1	891.7
Eucalyptus marginata	15.8 ± 1.2	3.0 ± 0.1	1216.7
Persoonia longifolia	40.0 ± 4.5	3.8 ± 0.2	41.7
Total	20.1 ± 0.6	2.7 ± 0.0	5083.3

Table 24: Diameter at breast height (DBH) classes for trees recorded along Transect 10-2. The table shows the number of trees recorded with DBH values within the indicated DBH ranges.

Species	Diameter at Breast Height (cm)						
	< 5	5-15	15-25	25-35	35-45	> 45	Total
Allocasuarina fraseriana	2	3	4	4	1	5	19
Banksia grandis	35	43	7	0	0	0	85
Corymbia calophylla	0	0	0	0	0	1	1
Eucalyptus marginata	2	12	10	4	3	6	37
Persoonia longifolia	1	2	0	0	0	0	3
Total	40	60	21	8	4	12	145

5.2.9 Transect 11-1

Transect 11-1 consisted of an open forest dominated by *Eucalyptus marginata* (basal area = 20.0 m^2/ha, stem density = 525.0 stems/ha) mixed with *Corymbia calophylla* (sub-dominant) (basal area = 8.5 m^2/ha, stem density = 216.7 stems/ha), *Allocasuarina fraseriana* and *Banksia grandis*. *Persoonia longifolia* trees were absent from this transect. The transect had a total basal area of 31.9 m^2/ha and a total stem density of 841.7 stems/ha.

Corymbia calophylla was the tallest tree species, with an average height of 1210.7 ± 84.1 cm. The mean health of trees was 2.6 ± 0.0 (Table 25). The seedlings (individuals less than 130 cm in height) of three of the five species present as trees were recorded along transect 11-1. *Allocasuarina fraseriana* and *Persoonia longifolia* seedlings were absent. Total stem density for seedlings was 3083.3 stems/ha with *Eucalyptus marginata* being the most numerous (2141.7 stems/ha) as well as the tallest, averaging 24.0 ± 1.6 cm. *Corymbia calophylla* were the healthiest seedlings (3.2 ±0.1) (Table 26).

The majority of trees in transect 11-1 had a DBH less than 25cm with most of these being *Eucalyptus marginata*. Overall, frequency of trees declined with increasing DBH. No trees with DBH larger than 45cm were recorded (Table 27).

Table 25: Summary of mean height, health, basal area and stem density for tree species recorded along Transect 11-1. Results are expressed as the mean ± s.e.m. Health codes: 0 = dead; 1 = very stressed; 2 = stressed; 3 = slightly stressed; 4 = healthy. Tree basal area was calculated from the diameter at breast height (DBH). Stem density (stems/ha) was calculated using either trees with stems > 10 cm diameter at breast height (130 cm), or all stems from trees with a height > 130 cm.

Species	Mean Height (cm)	Mean Health	Basal Area (m^2/ha)	Stems/ha	
				DBH > 10 cm	Height > 130 cm
Allocasuarina fraseriana	608.8 ± 88.4	3.1 ± 0.1	3.1	91.7	150.0
Banksia grandis	819.0 ± 0.0	3.0 ± 0.0	0.3	8.3	16.6
Corymbia calophylla	1210.7 ± 84.1	2.6 ± 0.1	8.5	216.7	241.7
Eucalyptus marginata	702.3 ± 39.1	2.5 ± 0.0	20.0	525.0	1441.7
Persoonia longifolia	0.0	0.0	0.0	0.0	0.0
Total	761.3 ± 35.1	2.6 ± 0.0	31.9	841.7	1850.0

Table 26: Summary of mean height, health and stem density for tree seedlings recorded along Transect 11-1. Results are expressed as the mean ± S.E.M. Health codes: 0 = dead; 1 = very stressed; 2 = stressed; 3 = slightly stressed; 4 = healthy.

Species	Mean Height (cm)	Mean Health	Stems/ha
Allocasuarina fraseriana	0.0	0.0	0.0
Banksia grandis	20.0 ± 0.0	3.0 ± 0.0	8.3
Corymbia calophylla	17.7 ± 1.2	3.2 ± 0.1	933.3
Eucalyptus marginate	24.0 ± 1.6	3.0 ± 0.1	2141.7
Persoonia longifolia	0.0	0.0	0.0
Total	22.1 ± 1.2	3.1 ± 0.0	3083.3

Table 27: Diameter at breast height (DBH) classes for trees recorded along Transect 11-1. The table shows the number of trees recorded with DBH values within the indicated DBH ranges.

Species	Diameter at Breast Height (cm)						
	< 5	5-15	15-25	25-35	35-45	> 45	Total
Allocasuarina fraseriana	3	7	6	2	0	0	18
Banksia grandis	0	0	2	0	0	0	2
Corymbia calophylla	0	10	11	6	2	0	29
Eucalyptus marginate	47	88	26	9	3	0	173
Persoonia longifolia	0	0	0	0	0	0	0
Total	50	105	45	17	5	0	222

5.2.10 Transect 11-2

Transect 11-2 consisted of an open forest dominated by *Eucalyptus marginata* (basal area = 15.5 m^2/ha, stem density = 383.3 stems/ha) mixed with *Corymbia calophylla* (sub-dominant) (basal area = 13.1 m^2/ha, stem density = 175.0 stems/ha), and *Allocasuarina fraseriana*. *Banksia grandis* and *Persoonia longifolia* trees were absent from the transect. The transect had a total basal area of 28.6 m^2/ha and a total stem density of 558.3 stems/ha. *Allocasuarina fraseriana* contributed a minor percentage to the total basal area. Consequently, its individual basal area value has to be presented as a category (<0.1m^2/ha).

Corymbia calophylla was the tallest tree species, with an average height of 1009.6 ± 107.8 cm. The mean health of trees was 2.8 ± 0.1 (Table 28). The seedlings (individuals less than 130 cm in height) of the three species present as trees were recorded along transect 11-2. Total stem density for seedlings was 2333.3 stems/ha with *Eucalyptus marginata* being the most numerous (1616.7 stems/ha). *Allocasuarina fraseriana* were the tallest, averaging 90.0 ± 0.0 cm, as well as the healthiest seedlings (4.0 ± 0.0) (Table 29).

Table 28: Summary of mean height, health, basal area and stem density for tree species recorded along Transect 11-2. Results are expressed as the mean ± s.e.m. Health codes: 0 = dead; 1 = very stressed; 2 = stressed; 3 = slightly stressed; 4 = healthy. Tree basal area was calculated from the diameter at breast height (DBH). Stem density (stems/ha) was calculated using either trees with stems > 10 cm diameter at breast height (130 cm), or all stems from trees with a height > 130 cm.

Species	Mean Height (cm)	Mean Health	Basal Area (m^2/ha)	Stems/ha	
				DBH > 10 cm	Height > 130 cm
Allocasuarina fraseriana	320.0 ± 20.0	4.0 ± 0.0	<0.1	0.0	16.6
Banksia grandis	0.0	0.0	0.0	0.0	0.0
Corymbia calophylla	1009.6 ± 107.8	2.9 ± 0.1	13.1	175.0	283.3
Eucalyptus marginata	706.5 ± 42.4	2.8 ± 0.1	15.5	383.3	1083.3
Persoonia longifolia	0.0	0.0	0.0	0.0	0.0
Total	764.8 ± 41.0	2.8 ± 0.1	28.6	558.3	1383.3

The majority of trees in transect 11-2 had a DBH less than 15cm. Overall, frequency of trees declined with increasing DBH. *Corymbia calophylla* had the greatest spread of values across classes. Four trees with DBH larger than 45cm were recorded (Table 30).

Table 29: Summary of mean height, health and stem density for tree seedlings recorded along Transect 11-2. Results are expressed as the mean ± S.E.M. Health codes: 0 = dead; 1 = very stressed; 2 = stressed; 3 = slightly stressed; 4 = healthy.

Species	Mean Height (cm)	Mean Health	Stems/ha
Allocasuarina fraseriana	90.0 ± 0.0	4.0 ± 0.0	8.3
Banksia grandis	0.0	0.0	0.0
Corymbia calophylla	28.2 ± 2.4	2.7 ± 0.1	708.3
Eucalyptus marginate	36.3 ± 2.0	2.6 ± 0.1	1616.7
Persoonia longifolia	0.0	0.0	0.0
Total	34.0 ± 1.6	2.6 ± 0.0	2333.3

Table 30: Diameter at breast height (DBH) classes for trees recorded along Transect 11-2. The table shows the number of trees recorded with DBH values within the indicated DBH ranges.

Species	Diameter at Breast Height (cm)						
	< 5	5-15	15-25	25-35	35-45	> 45	Total
Allocasuarina fraseriana	1	1	0	0	0	0	2
Banksia grandis	0	0	0	0	0	0	0
Corymbia calophylla	4	15	7	3	1	4	34
Eucalyptus marginate	25	78	15	11	1	0	130
Persoonia longifolia	0	0	0	0	0	0	0
Total	30	94	22	14	2	4	166

5.2.11 Transect 12-1

Transect 12-1 consisted of an open forest dominated by *Eucalyptus marginata* (basal area = 22.3 m^2/ha, stem density = 325.0 stems/ha) mixed with *Allocasuarina fraseriana* (sub-dominant) (basal area = 15.7 m^2/ha, stem density = 133.3 stems/ha), *Corymbia calophylla*, *Banksia grandis* and *Persoonia longifolia*. The transect had a total basal area of 43.6 m^2/ha and a total stem density of 600.0 stems/ha with *Banksia grandis* contributing many small stems. *Corymbia calophylla* contributed a minor percentage to the total basal area. Consequently, its individual basal area value has been presented as a category (<0.1m²/ha).

Allocasuarina fraseriana was the tallest tree species, with an average height of 1052.1 ± 87.6 cm. The mean health of trees was 2.5 ± 0.0 (Table 31). The seedlings (individuals less than 130 cm in height) of the three species present as trees were recorded along transect 12-1. Seedlings of both *Allocasuarina fraseriana* and *Persoonia longifolia* were absent. Total stem density for seedlings was 1900.0 stems/ha with *Banksia grandis* being the most numerous (966.7 stems/ha). *Eucalyptus marginata* seedlings were the tallest, averaging 48.5 ± 3.2 cm and *Corymbia calophylla* the healthiest seedlings (2.5 ± 1.5) (Table 32).

Table 31: Summary of mean height, health, basal area and stem density for tree species recorded along Transect 12-1. Results are expressed as the mean ± s.e.m. Health codes: 0 = dead; 1 = very stressed; 2 = stressed; 3 = slightly stressed; 4 = healthy. Tree basal area was calculated from the diameter at breast height (DBH). Stem density (stems/ha) was calculated using either trees with stems > 10 cm diameter at breast height (130 cm), or all stems from trees with a height > 130 cm.

Species	Mean Height (cm)	Mean Health	Basal Area (m^2/ha)	Stems/ha	
				DBH > 10 cm	Height > 130 cm
Allocasuarina fraseriana	1052.1 ± 87.6	3.0 ± 0.1	15.7	133.3	158.3
Banksia grandis	350.1 ± 16.8	2.4 ± 0.0	4.7	141.7	1366.7
Corymbia calophylla	213.3 ± 37.6	3.0 ± 0.0	<0.1	0.0	25.0
Eucalyptus marginata	602.5 ± 43.1	2.6 ± 0.1	22.3	325.0	1050.0
Persoonia longifolia	436.0 ± 121.7	4.0 ± 0.0	0.9	0.0	41.7
Total	491.5 ± 22.4	2.5 ± 0.0	43.6	600.0	2641.7

Table 32: Summary of mean height, health and stem density for tree seedlings recorded along Transect 12-1. Results are expressed as the mean ± S.E.M. Health codes: 0 = dead; 1 = very stressed; 2 = stressed; 3 = slightly stressed; 4 = healthy.

Species	Mean Height (cm)	Mean Health	Stems/ha
Allocasuarina fraseriana	0.0	0.0	0.0
Banksia grandis	47.6 ± 3.4	2.4 ± 0.1	966.7
Corymbia calophylla	15.0 ± 5.0	2.5 ± 1.5	16.7
Eucalyptus marginata	48.5 ± 3.2	2.1 ± 0.1	916.7
Persoonia longifolia	0.0	0.0	0.0
Total	47.7 ± 2.3	2.3 ± 0.0	1900.0

The majority of trees in transect 12-1 had a DBH less than 15cm. Overall, frequency of trees declined with increasing DBH. *Allocasuarina fraseriana* had the greatest spread of values across classes while Banksia grandis was notable for the large number of trees with DBH less than 5cm (101). Nine trees with DBH larger than 45cm were recorded (Table 33).

Table 33: Diameter at breast height (DBH) classes for trees recorded along Transect 12-1. The table shows the number of trees recorded with DBH values within the indicated DBH ranges.

Species	Diameter at Breast Height (cm)						
	< 5	5-15	15-25	25-35	35-45	> 45	Total
Allocasuarina fraseriana	1	4	3	3	4	4	19
Banksia grandis	101	55	8	0	0	0	164
Corymbia calophylla	3	0	0	0	0	0	3
Eucalyptus marginata	51	47	14	7	2	5	126
Persoonia longifolia	1	3	0	0	1	0	5
Total	157	109	25	10	7	9	317

5.2.12 Transect 12-2

Transect 12-2 consisted of an open forest dominated by *Eucalyptus marginata* (basal area = 30.2 m^2/ha, stem density = 500.0 stems/ha) mixed with *Corymbia calophylla* (sub-dominant) (basal area = 10.1 m^2/ha, stem density = 100.0 stems/ha), *Allocasuarina fraseriana*, *Banksia grandis* and *Persoonia longifolia*. The transect had a total basal area of 49.1 m^2/ha and a total stem density of 700.0 stems/ha). *Persoonia longifolia* contributed a minor percentage to the total basal area. Consequently, its individual basal area value has been presented as a category (<0.1m^2/ha).

Allocasuarina fraseriana was the tallest tree species, with an average height of 770.1 ± 121.0 cm. The mean health of trees was 2.3 ± 0.0 (Table 34). The seedlings (individuals less than 130 cm in height) of all five species present as trees were recorded along transect 12-2. Total stem density for seedlings was 3058.3 stems/ha with *Eucalyptus marginata* being the most numerous (1658.3 stems/ha). *Allocasuarina fraseriana* seedlings were the tallest, averaging 100.0 ± 20.0 cm and *Persoonia longifolia* were the healthiest (3.8 ± 02) (Table 35).

Table 34: Summary of mean height, health, basal area and stem density for tree species recorded along Transect 12-2. Results are expressed as the mean ± s.e.m. Health codes: 0 = dead; 1 = very stressed; 2 = stressed; 3 = slightly stressed; 4 = healthy. Tree basal area was calculated from the diameter at breast height (DBH). Stem density (stems/ha) was calculated using either trees with stems > 10 cm diameter at breast height (130 cm), or all stems from trees with a height > 130 cm.

Species	Mean Height (cm)	Mean Health	Basal Area (m^2/ha)	Stems/ha	
				DBH > 10 cm	Height > 130 cm
Allocasuarina fraseriana	770.1 ± 121.0	3.0 ± 0.2	7.7	83.3	158.3
Banksia grandis	345.7 ± 111.0	2.5 ± 0.2	1.1	16.7	50.0
Corymbia calophylla	386.9 ± 49.9	2.0 ± 0.1	10.1	100.0	575.0
Eucalyptus marginata	462.6 ± 21.0	2.3 ± 0.0	30.2	500.0	2400.0
Persoonia longifolia	350.0 ± 0.0	4.0 ± 0.0	<0.1	0	8.3
Total	460.2 ± 19.6	2.3 ± 0.0	49.1	700.0	3191.7

Table 35: Summary of mean height, health and stem density for tree seedlings recorded along Transect 12-2. Results are expressed as the mean ± S.E.M. Health codes: 0 = dead; 1 = very stressed; 2 = stressed; 3 = slightly stressed; 4 = healthy.

Species	Mean Height (cm)	Mean Health	Stems/ha
Allocasuarina fraseriana	100.0 ± 20.0	3.0 ± 1.0	16.7
Banksia grandis	42.4 ± 5.8	2.9 ± 0.1	316.7
Corymbia calophylla	53.8 ± 3.1	2.5 ± 0.1	1016.7
Eucalyptus marginata	59.8 ± 2.5	2.3 ± 0.1	1658.3
Persoonia longifolia	68.3 ± 13.0	3.8 ± 0.2	50.0
Total	56.4 ± 1.9	2.4 ± 0.0	3058.3

The majority of trees in transect 12-2 had a DBH less than 15 cm. Overall, frequency of trees declined with increasing DBH. *Eucalyptus marginata* and *Allocasuarina fraseriana* had the greatest spread of values across classes but *Eucalyptus marginata* was well represented in the <5cm and the 5-15 cm classes (140 and 123 respectively). Six trees with DBH larger than 45cm were recorded (Table 36).

Table 36: Diameter at breast height (DBH) classes for trees recorded along Transect 12-2. The table shows the number of trees recorded with DBH values within the indicated DBH ranges.

Species	Diameter at Breast Height (cm)						
	< 5	5-15	15-25	25-35	35-45	> 45	Total
Allocasuarina fraseriana	7	4	2	3	0	3	19
Banksia grandis	4	0	1	1	0	0	6
Corymbia calophylla	49	9	8	1	0	2	69
Eucalyptus marginata	140	123	18	4	2	1	288
Persoonia longifolia	0	0	0	1	0	0	1
Total	200	136	29	10	2	6	383

5.3 Understorey Species

The survey of the 12 transects established within Treatment Area 4 of the Wungong Catchment recorded a total of 139 taxa (including subspecies and varieties) representing 80 genera and 37 families. The majority of the taxa were recorded in the Asparagaceae (16 taxa), Fabaceae (16 taxa), Proteaceae (12 taxa) and Stylidiaceae (9 taxa) families. A full list of taxa recorded during the survey is presented in Appendix B. A list of taxa recorded along each transect is presented in Appendix C.

During the survey two introduced (weed) species were recorded. These were *Hypochaeris glabra* and *Senecio diaschides.* Both taxa were recorded at one transect, Transect 11-2, a control transect established in a dieback-affected area. Neither taxon is listed by the Department of Agriculture and Food (2011) as a Declared Plant or a Pest Plant.

The average species richness for each transect was calculated. The results are presented in Figure 4, and represent the mean ± standard error of the mean (s.e.m.) for the 24 quadrats of understorey data recorded at each transect. Paired transects 7-1 and 7-2 showed the highest species richness (15.08 ± 0.59 and 15.25 ± 0.51 respectively). The lowest species richness was that of transect 11-2 (8.17 ± 0.71). The largest difference in species richness within a paired transect set was that between transects 9-1 and 9-2 (13.54 ± 0.83 and 9.29 ± 0.35 respectively).

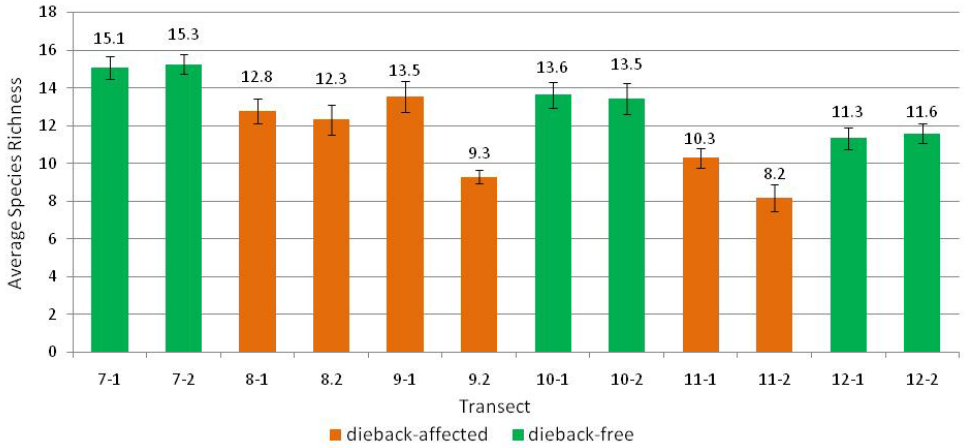

Figure 7: Average Species Richness of Understorey Species Recorded at Transects in Treatment Area 4 of the Wungong Catchment. The average species richness for each transect is indicated. The data is displayed as the mean ± s.e.m. for the 24 quadrats of understorey data recorded for each transect.

The average species richness for all dieback-free transects was 13.39 ± 0.28. The average species richness for all dieback affected transects was 11.06 ± 0.31. There was a significant difference ($p < 0.01$) in species richness between the dieback-free and dieback-affected areas, indicating that the dieback-affected areas are less species rich than the dieback free areas.

A detailed description of the results for each transect is presented in the following sections.

5.3.1 Transect 7-1

The mean species richness for transect 7-1 was 15.08 ± 0.59 (mean ± s.e.m.). The maximum species richness recorded was 20 species in quadrats 1 (0 m) and 19 (90m). The lowest species richness was ten species recorded in quadrats 11 (50 m) and 15 (70m) (Figure 5). Transect 7-1 is dominated by P site vegetation types, based on the site vegetation types defined by Havel (1975a and 1975b).

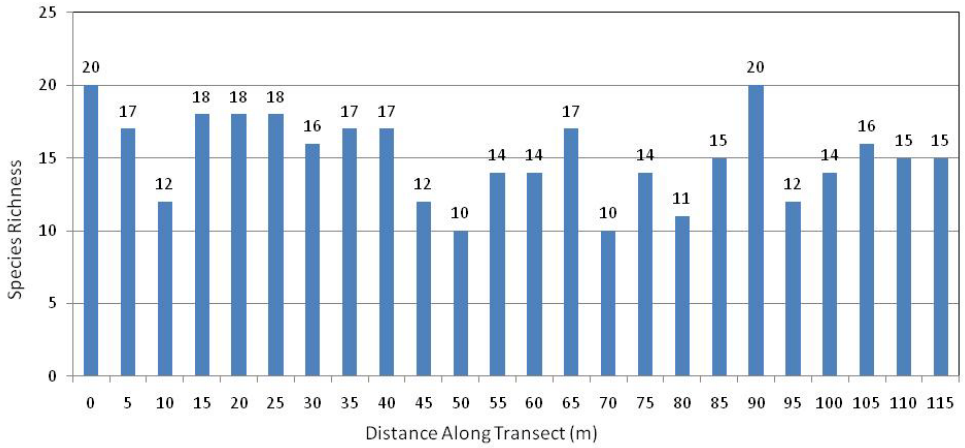

Figure 8: Species Richness Recorded along Transect 7-1. Species richness was recorded in 2 m x 2 m quadrats, every 5 m along the transect, from the transect origin. The value associated with each bar in the graph is the species richness for the quadrat.

5.3.2 Transect 7-2

The mean species richness for transect 7-2 was 15.25 ± 0.5 (mean ± s.e.m.). The maximum species richness recorded was 20 species in quadrats 14 (65 m) and 16 (75m). The lowest species richness was eight species recorded in quadrat 22 (105m) (Figure 6). Transect 7-2 is dominated by P site vegetation types, based on the site vegetation types defined by Havel (1975a and 1975b).

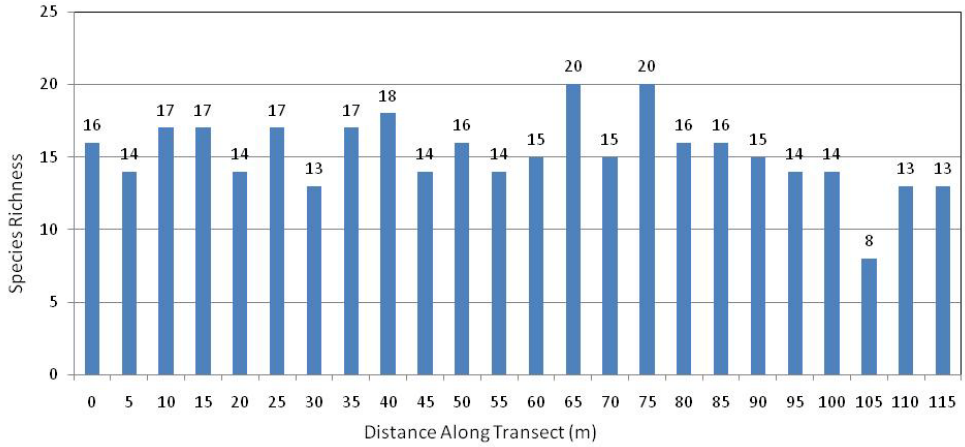

Figure 9: Species Richness Recorded along Transect 7-2. Species richness was recorded in 2 m x 2 m quadrats, every 5 m along the transect, from the transect origin. The value associated with each bar in the graph is the species richness for the quadrat.

5.3.3 Transect 8-1

The mean species richness for transect 8-1 was 12.79 ± 0.66 (mean ± s.e.m.). The maximum species richness recorded was 18 species in quadrats 2 (5m) and 10 (45m). The lowest species richness was five species recorded in quadrat 23 (110m) (Figure 7). Transect 8-1 is dominated by P site vegetation types, based on the site vegetation types defined by Havel (1975a and 1975b).

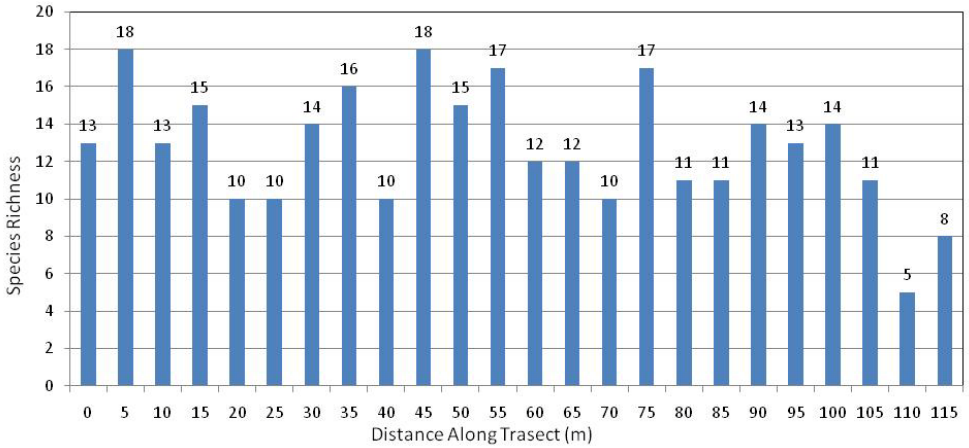

Figure 10: Species Richness Recorded along Transect 8-1. Species richness was recorded in 2 m x 2 m quadrats, every 5 m along the transect, from the transect origin. The value associated with each bar in the graph is the species richness for the quadrat.

5.3.4 Transect 8-2

The mean species richness for transect 8-2 was 12.33 ± 0.79 (mean ± s.e.m.). The maximum species richness recorded was 20 species in quadrat 10 (45m). The lowest species richness was four species recorded in quadrat 21 (100m) (Figure 8). Transect 8-2 is a mixture of both P and T site vegetation types, based on the site vegetation types defined by Havel (1975a and 1975b).

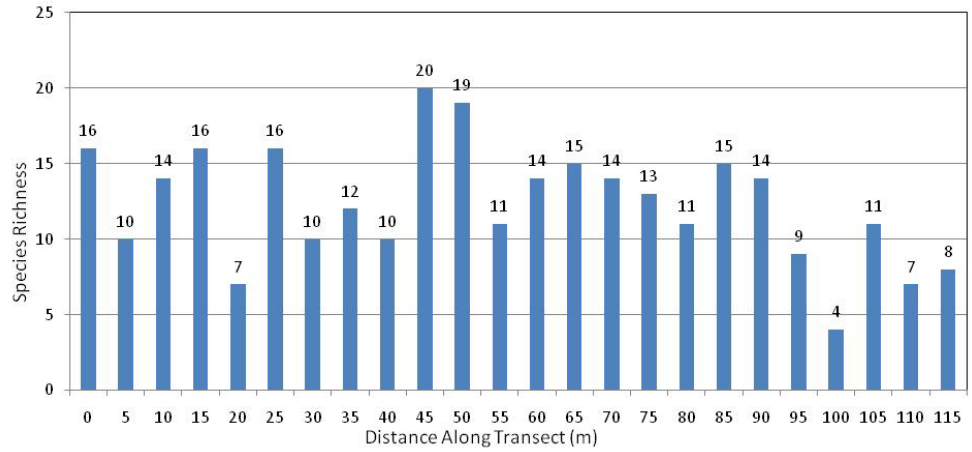

Figure 11: Species Richness Recorded along Transect 8-2. Species richness was recorded in 2 m x 2 m quadrats, every 5 m along the transect, from the transect origin. The value associated with each bar in the graph is the species richness for the quadrat.

5.3.5 Transect 9-1

The mean species richness for transect 9-1was 13.54 ± 0.83 (mean ± s.e.m.). The maximum species richness recorded was 17 species in quadrat 13 (60 m). The lowest species richness was seven species recorded in quadrat 10 (45 m) (Figure 9). Transect 9-1 is completely dominated by T site vegetation types, based on the site vegetation types defined by Havel (1975a and 1975b).

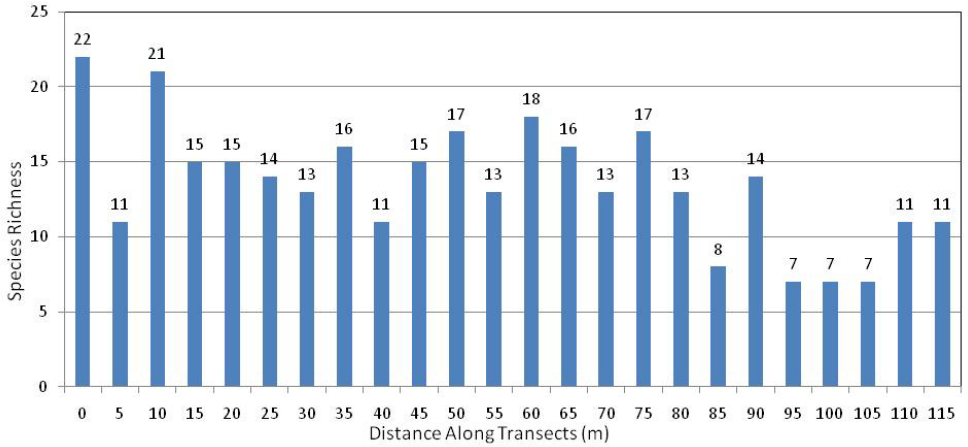

Figure 12: Species Richness Recorded along Transect 9-1. Species richness was recorded in 2 m x 2 m quadrats, every 5 m along the transect, from the transect origin. The value associated with each bar in the graph is the species richness for the quadrat.

5.3.6 Transect 9-2

The mean species richness for transect 9-2 was 9.29 ± 0.35 (mean ± s.e.m.). The maximum species richness recorded was 12 species in quadrats 4, 14 and 23 (15m, 65m and 110m). The lowest species richness was five species recorded in quadrat 18 (85m) (Figure 10). Transect 9-2 is a mixture of both P and T site vegetation types, but dominated by the P site vegetation type, as defined by Havel (1975a and 1975b).

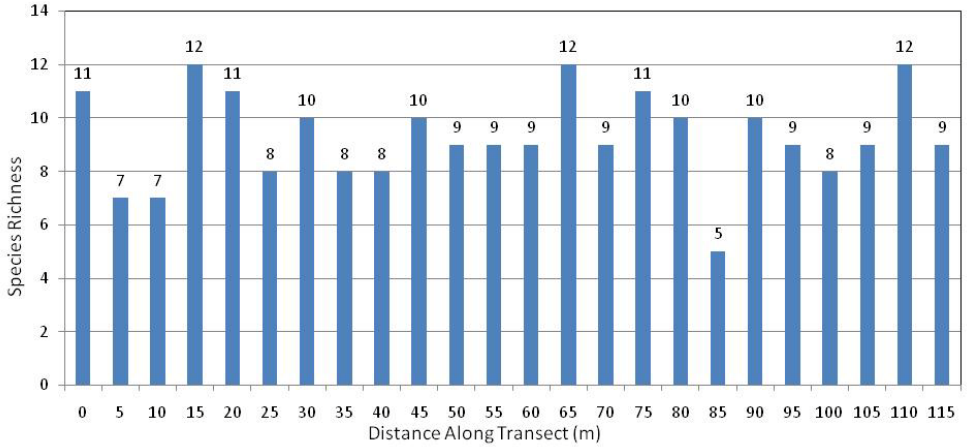

Figure 13: Species Richness Recorded along Transect 9-2. Species richness was recorded in 2 m x 2 m quadrats, every 5 m along the transect, from the transect origin. The value associated with each bar in the graph is the species richness for the quadrat.

5.3.7 Transect 10-1

The mean species richness for transect 10-1 was 13.63 ± 0.71 (mean ± s.e.m.). The maximum species richness recorded was 20 species in quadrat 3 (10m). The lowest species richness was six species recorded in quadrat 10 (45m) (Figure 11). Transect 10-1 is dominated by S site vegetation types, based on the site vegetation types defined by Havel (1975a and 1975b).

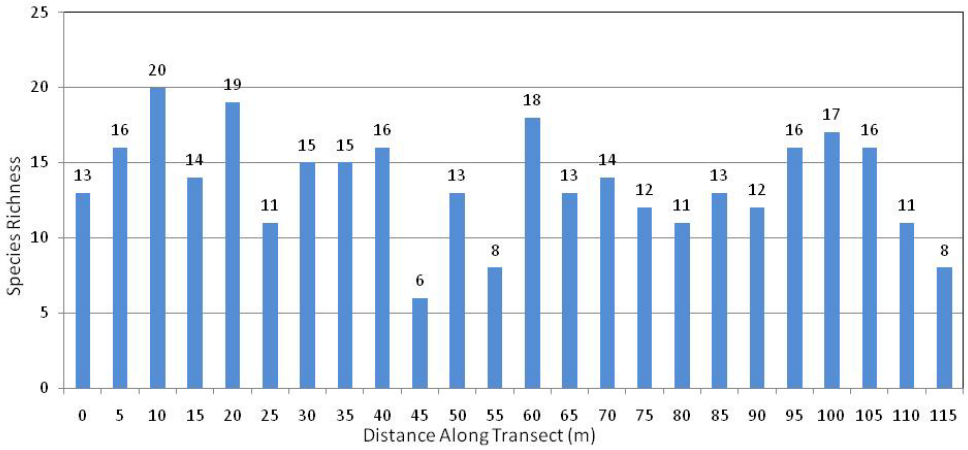

Figure 14: Species Richness Recorded along Transect 10-1. Species richness was recorded in 2 m x 2 m quadrats, every 5 m along the transect, from the transect origin. The value associated with each bar in the graph is the species richness for the quadrat.

5.3.8 Transect 10-2

The mean species richness for transect 10-2 was 13.46 ± 0.82 (mean ± s.e.m.). The maximum species richness recorded was 20 species in quadrats 10 and 19 (45m and 90m). The lowest species richness was six species recorded in quadrats 4 and 22 (15m and 105m) (Figure 12). Transect 10-2 is dominated by S site vegetation types, based on the site vegetation types defined by Havel (1975a and 1975b).

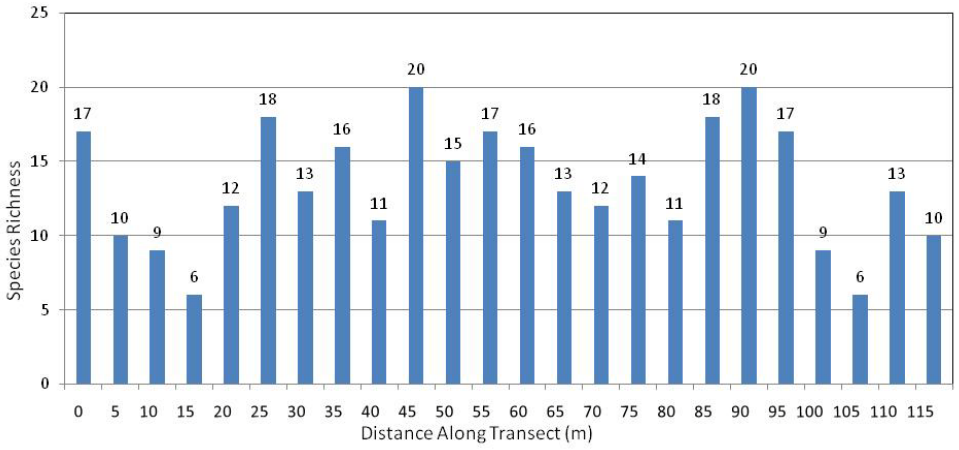

Figure 15: Species Richness Recorded along Transect 10-2. Species richness was recorded in 2 m x 2 m quadrats, every 5 m along the transect, from the transect origin. The value associated with each bar in the graph is the species richness for the quadrat.

5.3.9 Transect 11-1

The mean species richness for transect 11-1 was 10.29 ± 0.52 (mean ± s.e.m.). The maximum species richness recorded was 15 species in quadrat 19 (90 m). The lowest species richness was six species recorded in quadrats 5, 6 and 7 (20m, 25 m and 30 m) (Figure 13). Transect 11-1 is dominated by P site vegetation types, based on the site vegetation types defined by Havel (1975a and 1975b).

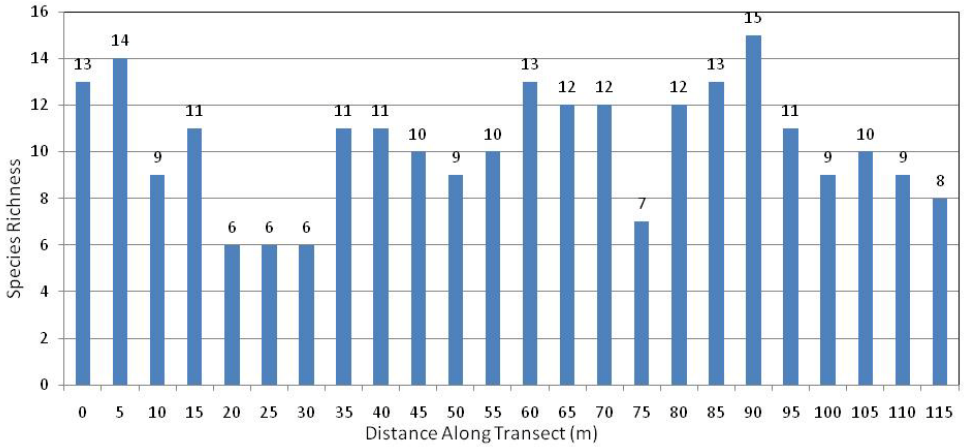

Figure 16: Species Richness Recorded along Transect 11-1. Species richness was recorded in 2 m x 2 m quadrats, every 5 m along the transect, from the transect origin. The value associated with each bar in the graph is the species richness for the quadrat.

5.3.10 Transect 11-2

The mean species richness for transect 11-2 was 8.17 ± 0.71 (mean ± s.e.m.). The maximum species richness recorded was 17 species in quadrat 16 (75m). The lowest species richness was four species recorded in quadrats 5, 7, 9, and 19 (20m, 30m, 40m and 90m) (Figure 14). Transect 11-2 is dominated by P site vegetation types, based on the site vegetation types defined by Havel (1975a and 1975b).

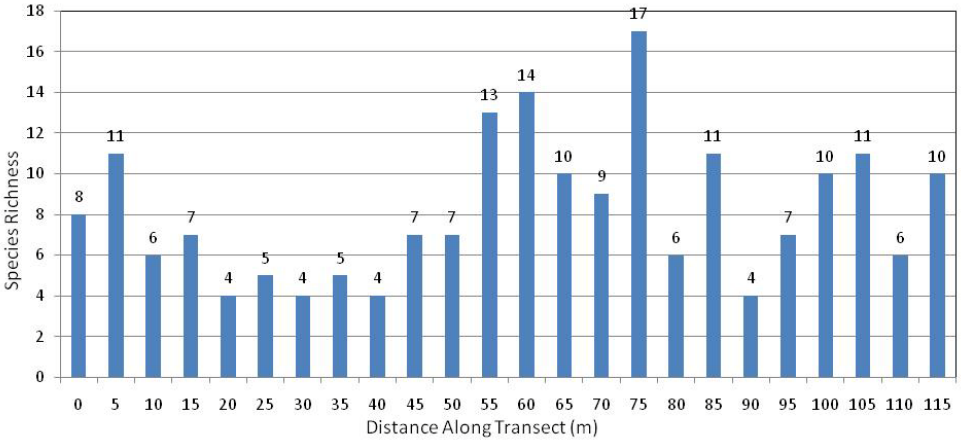

Figure 17: Species Richness Recorded along Transect 11-2. Species richness was recorded in 2 m x 2 m quadrats, every 5 m along the transect, from the transect origin. The value associated with each bar in the graph is the species richness for the quadrat.

5.3.11 Transect 12-1

The mean species richness for transect 12-1was 11.33 ± 0.59 (mean ± s.e.m.). The maximum species richness recorded was 16 species in quadrat 9 (40 m). The lowest species richness was five species recorded in quadrat 5 (20 m) (Figure 15). Transect 12-1 is dominated by S site vegetation types, based on the site vegetation types defined by Havel (1975a and 1975b).

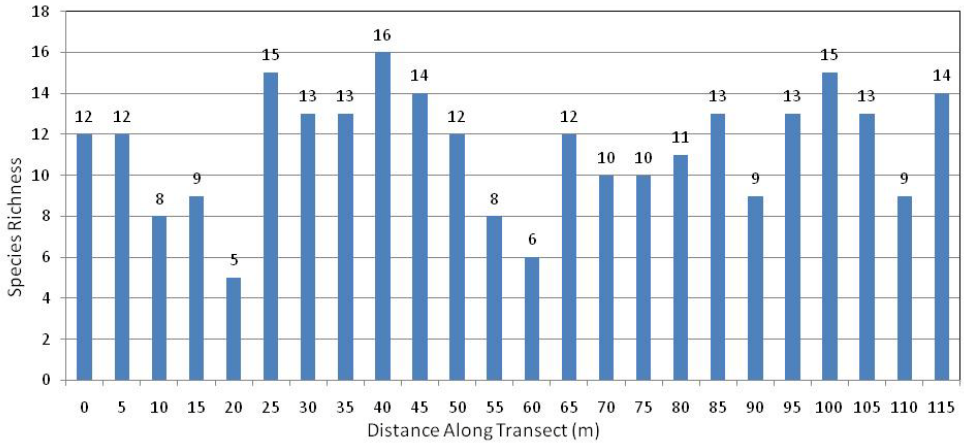

Figure 18: Species Richness Recorded along Transect 12-1. Species richness was recorded in 2 m x 2 m quadrats, every 5 m along the transect, from the transect origin. The value associated with each bar in the graph is the species richness for the quadrat.

5.3.12 Transect 12-2

The mean species richness for transect 12-2 was 11.58 ± 0.53 (mean ± s.e.m.). The maximum species richness recorded was 16 species in quadrats 2 and 8 (5m and 35m). The lowest species richness was six species recorded in quadrat 12 (55m) (Figure 16). Transect 12-2 is dominated by S site vegetation types, based on the site vegetation types defined by Havel (1975a and 1975b).

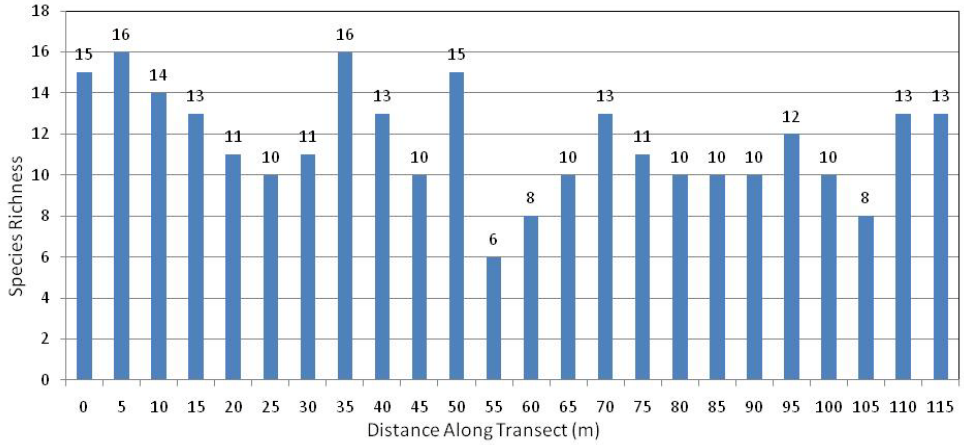

Figure 19: Species Richness Recorded along Transect 12-2. Species richness was recorded in 2 m x 2 m quadrats, every 5 m along the transect, from the transect origin. The value associated with each bar in the graph is the species richness for the quadrat.

6. DISCUSSION AND CONCLUSION

A baseline survey of tree and understorey species along transects established in Treatment Area 4 of the Wungong Catchment was carried out in October and November 2010. The transects were established in both dieback-free (six transects) and dieback-affected (six transects) sections of the Jarrah forest, on mid to upper slope terrains, in selected sub-catchments of Treatment Area 4 (Figure 1). Two transects, in both the dieback-free (Transects 12-1 and 12-2) and dieback-affected (Transects 11-1 and 11-2) areas of the forest will form control transects. The areas of the forest in which the remaining transects have been established were scheduled for selective thinning, by notching and poisoning in early 2011, in order to thin the tree canopy in those areas of the forest.

The purpose of establishing the transects in Treatment Area 4 was to investigate the effects of selective forest thinning on the biodiversity of the flora in the forest. In addition, due to the mix of dieback-free and dieback-affected areas of the forest within Treatment Area 4, the second aim of the study was to investigate the influence of dieback on biodiversity, compared to the dieback-free areas, subsequent to selective canopy thinning.

The results presented in this report form the baseline survey data for the 12 transects established in Treatment Area 4. Future surveys will permit comparisons with the present data to determine if any effects can be measured, and attributed to the selective canopy thinning. The opening up of the forest canopy is likely to stimulate increased recruitment of flora. The long term study may also provide some indications as to the influence Jarrah Dieback may have on such recruitment. The present study has demonstrated that Treatment Area 4 contains species typical of the northern Jarrah forest.

The baseline study of the understorey flora along transects within Treatment Area 4 has revealed that the species richness along transects established in the dieback-affected sections of the forest are statistically less species rich than at transects established in the dieback-free areas of the forest. When the data on tree health, basal area and stem density are compared between the dieback-free and dieback-affected areas of the forest where the transects have been established, the results are less conclusive. Of the three parameters, a significant difference was only found to occur in the relative health of the dieback-free and dieback-affected areas of the forest where the transects had been established. Whilst statistically, the dieback-free transects were less healthy then the dieback-affected transects, both areas, with average health values of 2.47 and 2.64 respectively, are classed as stressed to slightly stressed. Both the tree basal area (m^2/ha) and stem density (stems/ha) did not show a statistically significant difference when the dieback-free and dieback-affected areas of the forest where the transects were established, are compared.

Future assessments of the flora along these transects will provide data which may make the differences in the dieback-free and dieback-affected areas of the forest where the transects have been established more conclusive.

The study of the effects of canopy thinning and dieback, on future changes in both the understorey and tree species components of the forest will require long term monitoring, with subsequent surveys of the flora transects undertaken on a regular basis. This is currently planned to be on a three year interval. A potential complicating factor in assessing data over the long term may occur should Jarrah Dieback spread from currently infected areas into the dieback-free areas of the forest.

7. LIST OF PARTICIPANTS

The following Mattiske Consulting Pty Ltd personnel were involved in this project:

Name	Position	Project Involvement	Flora Collection Permit
Dr E.M. Mattiske	Managing Director & Principal Ecologist	Planning, Management & Auditing	
Mrs B. Koch	Senior Botanist	Plant identification	
Mr D. Angus	Botanist	Planning, fieldwork, data interpretation and report preparation	SL008896
Mr R. Dharmarajan	Botanist	Planning, fieldwork, plant identification, data interpretation and report preparation	SL008915
Ms F. Riviera	Botanist	Fieldwork, data interpretation and report preparation	SL009276
Ms M. Barrett	Botanist	Fieldwork	SL009184
Ms C. Bryan	Botanist	Fieldwork	SL009086
Ms L. Cockram	Botanist	Fieldwork	SL008895
Ms F. De Witt	Botanist	Fieldwork	SL008909
Ms J. Ellery	Botanist	Fieldwork	SL008892
Mr J. Freeman	Botanist	Fieldwork	SL008916
Ms F. Gambie	Botanist	Fieldwork	SL008913
Ms C. Graham	Botanist	Fieldwork	SL008890
Ms M. Hocking	Botanist	Fieldwork	SL008911
Ms J. Jones	Botanist	Fieldwork	SL008905
Ms T. Laslett	Botanist	Fieldwork	SL008912
Ms Shibi Chandran	Botanist	Plant identification	

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APPENDIX A: GEOGRAPHIC LOCATIONS OF FLORA MONITORING TRANSECTS IN TREATMENT AREA 4 OF THE WUNGONG CATCHMENT IN THE VICINITY OF CURTIS ROAD, BEDFORDALE

(Geographical coordinates are based on the GDA 94 datum, Zone 50)

Transect Reference	Transect Length (m)	Transect Start		Transect End		Bearing (degrees)	Dieback Status
		Easting (mE)	Northing (mN)	Easting (mE)	Northing (mN)		
7-1	120	416882	6435693	416789	6435662	260	Dieback free
7-2	120	416907	6435664	416801	6435646	260	Dieback free
8-1	120	416945	6435751	417074	6435765	90	Dieback affected
8-2	120	416954	6435807	417064	6435800	90	Dieback affected
9-1	120	416479	6434138	416431	6434032	210	Dieback affected
9-2	120	416438	6434171	416398	6434070	210	Dieback affected
10-1	120	416034	6435122	416127	6435169	80	Dieback free
10-2	120	416070	6435052	416180	6435109	80	Dieback free
11-1	120	417019	6435040	417126	6435047	90	Dieback affected (control)
11-2	120	417056	6435134	417175	6435141	90	Dieback affected (control)
12-1	120	416179	6435430	416290	6435442	85	Dieback free (control)
12-2	120	416100	6435488	416211	6435500	85	Dieback free (control)

APPENDIX B: SUMMARY OF VASCULAR PLANT SPECIES RECORDED AT FLORA MONITORING TRANSECTS IN TREATMENT AREA 4 OF THE WUNGONG CATCHMENT

Note: * denotes introduced species

FAMILY	SPECIES
DENNSTAEDTIACEAE	*Pteridium esculentum*
ZAMIACEAE	*Macrozamia riedlei*
POACEAE	*Amphipogon amphipogonoides*
	Austrodanthonia caespitosa
	Neurachne alopecuroidea
	Tetrarrhena laevis
CYPERACEAE	*Cyathochaeta avenacea*
	Lepidosperma pubisquameum
	Lepidosperma squamatum
	Lepidosperma tenue
	Mesomelaena tetragona
	Tetraria capillaris
	Tetraria octandra
RESTIONACEAE	*Desmocladus fasciculatus*
	Desmocladus flexuosus
	Hypolaena exsulca
	Loxocarya cinerea
ASPARAGACEAE	*Chamaescilla corymbosa*
	Lomandra brittanii
	Lomandra caespitosa
	Lomandra drummondii
	Lomandra hermaphrodita
	Lomandra ? *micrantha*
	Lomandra ? *nigricans*
	Lomandra purpurea
	Lomandra sonderi
	Sowerbaea laxiflora
	Thysanotus dichotomus
	Thysanotus fastigiatus
	Thysanotus ? *manglesianus/patersonii*
	Thysanotus multiflorus
	Thysanotus thyrsoideus
	Thysanotus sp.
DASYPOGONACEAE	*Kingia australis*
XANTHORRHOEACEAE	*Xanthorrhoea gracilis*
	Xanthorrhoea preissii
COLCHICACEAE	*Burchardia congesta*

APPENDIX B: SUMMARY OF VASCULAR PLANT SPECIES RECORDED AT FLORA MONITORING TRANSECTS IN TREATMENT AREA 4 OF THE WUNGONG CATCHMENT

Note: * denotes introduced species

FAMILY	SPECIES
HEMEROCALLIDACEAE	*Agrostocrinum scabrum*
	Corynotheca micrantha
	Caesia sp.
	Dianella revoluta
	Tricoryne elatior
HAEMODORACEAE	*Conostylis serrulata*
	Conostylis setigera
	Conostylis setosa
	Haemodorum sp.
IRIDACEAE	*Patersonia occidentalis*
	Patersonia pygmaea
	Patersonia rudis
ORCHIDACEAE	*Caladenia* sp.
	Thelymitra sp.
	Orchidaceae sp.
CASUARINACEAE	*Allocasuarina fraseriana*
PROTEACEAE	*Adenanthos barbiger*
	Banksia dallanneyi var. *dallanneyi*
	Banksia grandis
	Banksia sessilis
	Grevillea pilulifera
	Grevillea synapheae subsp. *synapheae*
	Hakea ruscifolia
	Synaphea gracillima
	Synaphea petiolaris
	Synaphea spinulosa
	Synaphea sp.
	Persoonia longifolia
AMARANTHACEAE	*Ptilotus manglesii*
RANUNCULACEAE	*Clematis pubescens*
DROSERACEAE	*Drosera erythrorhiza*
	Drosera stolonifera
	Drosera sp.
FABACEAE	*Acacia browniana*
	Acacia extensa
	Acacia pulchella
	Acacia urophylla
	Acacia willdenowiana
	Bossiaea ornata
	Gompholobium knightianum

APPENDIX B: SUMMARY OF VASCULAR PLANT SPECIES RECORDED AT FLORA MONITORING TRANSECTS IN TREATMENT AREA 4 OF THE WUNGONG CATCHMENT

Note: * denotes introduced species

FAMILY	SPECIES
FABACEAE (continued)	*Gompholobium marginatum*
	Gompholobium polymorphum
	Gompholobium preissii
	Kennedia prostrata
	Sphaerolobium linophyllum
	Sphaerolobium medium
	Hovea chorizemifolia
	Hovea elliptica
	Hovea trisperma
	Viminaria juncea
RUTACEAE	*Boronia fastigiata*
	Boronia ovata
	Philotheca spicata
PHYLLANTHACEAE	*Phyllanthus calycinus*
CELASTRACEAE	*Stackhousia monogyna*
RHAMNACEAE	*Trymalium ledifolium*
ELAEOCARPACEAE	*Tetratheca hirsuta*
MALVACEAE	*Lasiopetalum floribundum*
DILLENIACEAE	*Hibbertia amplexicaulis*
	Hibbertia commutata
	Hibbertia hypericoides
	Hibbertia pachyrrhiza
VIOLACEAE	*Hybanthus debilissimus*
	Hybanthus floribundus subsp. *floribundus*
	Hybanthus sp.
THYMELAEACEAE	*Pimelea suaveolens*
MYRTACEAE	*Corymbia calophylla*
	Eucalyptus marginata
	Eucalyptus patens
	Hypocalymma angustifolium
	Pericalymma ellipticum
	Taxandria linearifolia
HALORAGACEAE	*Gonocarpus cordiger*
APIACEAE	*Pentapeltis peltigera*
	Platysace filiformis
	Xanthosia candida
	Xanthosia singuliflora

APPENDIX B: SUMMARY OF VASCULAR PLANT SPECIES RECORDED AT FLORA MONITORING TRANSECTS IN TREATMENT AREA 4 OF THE WUNGONG CATCHMENT

Note: * denotes introduced species

FAMILY	SPECIES
ERICACEAE	*Astroloma pallidum*
	Leucopogon capitellatus
	Leucopogon nutans
	Leucopogon propinquus
	Leucopogon verticillatus
	Styphelia tenuiflora
RUBIACEAE	*Opercularia echinocephala*
	Opercularia hispidula
GOODENIACEAE	*Dampiera linearis*
	Lechenaultia biloba
	Scaevola calliptera
STYLIDIACEAE	*Stylidium amoenum*
	Stylidium androsaceum
	Stylidium brunonianum
	Stylidium calcaratum
	Stylidium ciliatum
	Stylidium hispidum
	Stylidium piliferum
	Stylidium repens
	Stylidium schoenoides
ASTERACEAE	*Craspedia variabilis*
	* *Hypochaeris glabra*
	Lagenophora huegelii
	* *Senecio diaschides*
	Trichocline spathulata

APPENDIX C: SUMMARY OF VASCULAR PLANT SPECIES RECORDED AT EACH TRANSECT IN TREATMENT AREA 4 OF THE WUNGONG CATCHMENT

Note: * indicates introduced (weed) species

SPECIES	TRANSECT											
	7-1	7-2	8-1	8-2	9-1	9-2	10-1	10-2	11-1	11-2	12-1	12-2
Acacia browniana												x
Acacia extensa										x		
Acacia pulchella				x						x		
Acacia urophylla										x		
Acacia willdenowiana									x			
Adenanthos barbiger	x	x	x	x	x	x	x	x	x	x	x	x
Agrostocrinum scabrum											x	
Allocasuarina fraseriana	x	x	x		x	x	x	x	x	x	x	
Amphipogon amphipogonoides			x	x	x	x	x	x			x	x
Astroloma pallidum									x			
Austrodanthonia caespitosa	x											
Banksia dallanneyi var. *dallanneyi*	x	x	x		x		x	x	x	x		x
Banksia grandis	x	x	x	x		x	x	x			x	x
Banksia sessilis									x	x		
Boronia fastigiata	x	x	x	x	x	x	x	x	x	x	x	x
Boronia ovata											x	
Bossiaea ornata					x	x	x	x		x	x	x
Burchardia congesta	x		x		x				x	x	x	x
Caesia sp.											x	
Caladenia sp.	x	x	x	x	x	x			x	x	x	
Chamaescilla corymbosa	x	x	x					x				
Clematis pubescens			x	x								
Conostylis serrulata		x	x	x	x	x		x			x	x
Conostylis setigera									x	x		x
Conostylis setosa	x	x	x	x	x	x	x	x			x	x
Corymbia calophylla	x	x	x	x	x	x	x	x	x	x	x	x
Corynotheca micrantha						x						
Craspedia variabilis											x	
Cyathochaeta avenacea	x	x	x	x	x	x	x	x	x	x	x	x

APPENDIX C: SUMMARY OF VASCULAR PLANT SPECIES RECORDED AT EACH TRANSECT IN TREATMENT AREA 4 OF THE WUNGONG CATCHMENT

Note: * indicates introduced (weed) species

SPECIES	TRANSECT											
	7-1	7-2	8-1	8-2	9-1	9-2	10-1	10-2	11-1	11-2	12-1	12-2
Dampiera linearis	x	x	x								x	x
Desmocladus fasciculatus												x
Desmocladus flexuosus									x	x		x
Dianella revoluta	x											
Drosera erythrorhiza		x	x	x	x							
Drosera stolonifera	x	x	x				x					
Drosera sp.	x	x			x			x				
Eucalyptus marginata	x	x	x	x	x	x	x	x	x	x	x	x
Eucalyptus patens									x			
Gompholobium knightianum												x
Gompholobium marginatum							x	x	x		x	x
Gompholobium polymorphum	x	x							x			
Gompholobium preissii	x				x	x	x	x				
Gonocarpus cordiger					x							
Grevillea pilulifera					x							
Grevillea synapheae subsp. *synapheae*					x	x						
Haemodorum sp.								x				
Hakea ruscifolia					x		x	x			x	
Hibbertia amplexicaulis	x	x	x	x	x	x	x	x	x	x	x	x
Hibbertia commutata	x	x	x	x	x	x	x	x	x	x	x	x
Hibbertia hypericoides	x			x	x							
Hibbertia pachyrrhiza					x			x				x
Hovea chorizemifolia	x	x	x	x	x	x	x	x			x	x
Hovea elliptica						x						
Hovea trisperma									x	x		
Hybanthus debilissimus	x		x									
Hybanthus floribundus subsp. *floribundus*	x	x	x				x					
Hybanthus sp.									x			
Hypocalymma angustifolium					x							

APPENDIX C: SUMMARY OF VASCULAR PLANT SPECIES RECORDED AT EACH TRANSECT IN TREATMENT AREA 4 OF THE WUNGONG CATCHMENT

Note: * indicates introduced (weed) species

SPECIES	TRANSECT											
	7-1	7-2	8-1	8-2	9-1	9-2	10-1	10-2	11-1	11-2	12-1	12-2
**Hypochaeris glabra*										x		
Hypolaena exsulca									x	x		
Kennedia prostrata			x	x		x						
Kingia australis					x							
Lagenophora huegelii			x	x					x	x		
Lasiopetalum floribundum			x	x	x	x	x		x		x	
Lechenaultia biloba	x	x	x	x		x			x	x	x	x
Lepidosperma pubisquameum	x	x		x		x	x	x	x	x	x	
Lepidosperma squamatum					x			x	x		x	x
Lepidosperma tenue	x			x			x					x
Leucopogon capitellatus			x	x					x	x		
Leucopogon nutans	x				x		x		x	x		
Leucopogon propinquus	x	x	x		x	x			x			
Leucopogon verticillatus				x					x			
Lomandra brittanii									x	x		
Lomandra caespitosa									x	x		
Lomandra drummondii	x	x	x						x			
Lomandra hermaphrodita	x	x	x	x	x	x	x	x	x		x	x
Lomandra ? micrantha	x	x			x							
Lomandra ? nigricans	x	x	x	x	x	x	x	x			x	
Lomandra purpurea	x	x	x		x		x	x				x
Lomandra sonderi	x	x	x	x	x	x	x	x	x	x	x	x
Loxocarya cinerea	x	x	x	x		x					x	
Macrozamia riedlei			x	x	x		x		x	x	x	x
Mesomelaena tetragona									x			
Neurachne alopecuroidea	x									x	x	
Opercularia echinocephala		x			x				x	x		
Opercularia hispidula			x	x								
Orchidaceae sp.												x

APPENDIX C: SUMMARY OF VASCULAR PLANT SPECIES RECORDED AT EACH TRANSECT IN TREATMENT AREA 4 OF THE WUNGONG CATCHMENT

Note: * indicates introduced (weed) species

SPECIES	TRANSECT											
	7-1	7-2	8-1	8-2	9-1	9-2	10-1	10-2	11-1	11-2	12-1	12-2
Patersonia occidentalis	x	x			x						x	x
Patersonia pygmaea	x		x		x							
Patersonia rudis												x
Pentapeltis peltigera	x	x	x	x	x	x	x	x	x	x	x	x
Pericalymma ellipticum								x				x
Persoonia longifolia	x	x		x		x	x	x			x	x
Philotheca spicata					x							
Phyllanthus calycinus	x	x	x	x	x	x	x	x	x	x	x	x
Pimelea suaveolens		x			x	x			x			
Platysace filiformis			x	x			x	x				x
Pteridium esculentum			x	x					x			
Ptilotus manglesii					x			x				
Scaevola calliptera	x			x	x		x		x	x		
**Senecio diaschides*										x		
Sowerbaea laxiflora	x	x	x		x	x		x				
Sphaerolobium linophyllum											x	
Sphaerolobium medium					x							
Stackhousia monogyna								x				
Stylidium amoenum		x						x			x	
Stylidium androsaceum										x		
Stylidium brunonianum	x											
Stylidium calcaratum										x		
Stylidium ciliatum										x		
Stylidium hispidum									x	x		
Stylidium piliferum	x	x	x	x	x	x	x	x		x		
Stylidium repens					x							
Stylidium schoenoides	x											
Styphelia tenuiflora	x	x			x			x			x	x
Synaphea gracillima		x		x								

APPENDIX C: SUMMARY OF VASCULAR PLANT SPECIES RECORDED AT EACH TRANSECT IN TREATMENT AREA 4 OF THE WUNGONG CATCHMENT

Note: * indicates introduced (weed) species

SPECIES	TRANSECT											
	7-1	7-2	8-1	8-2	9-1	9-2	10-1	10-2	11-1	11-2	12-1	12-2
Synaphea petiolaris		x										
Synaphea spinulosa										x		
Synaphea sp.		x										
Taxandria linearifolia									x			
Tetraria capillaris	x	x	x	x	x	x	x	x	x	x	x	x
Tetraria octandra	x	x	x	x	x	x	x	x				x
Tetrarrhena laevis	x	x	x	x	x		x	x	x	x	x	x
Tetratheca hirsuta	x	x			x	x		x	x	x	x	
Thelymitra sp.										x		
Thysanotus ? *manglesianus/patersonii*	x	x	x			x		x				
Thysanotus dichotomus						x			x			
Thysanotus fastigiatus	x	x	x			x	x	x			x	x
Thysanotus multiflorus						x	x	x	x			
Thysanotus thyrsoideus							x	x		x	x	
Thysanotus sp.										x		
Trichocline spathulata	x	x	x	x	x	x	x	x			x	
Tricoryne elatior	x											
Trymalium ledifolium	x	x	x	x	x	x	x	x		x	x	x
Viminaria juncea										x		
Xanthorrhoea gracilis	x	x			x		x	x	x	x	x	
Xanthorrhoea preissii					x	x	x	x	x	x	x	x
Xanthosia candida	x	x		x		x		x		x	x	x
Xanthosia singuliflora	x	x										

APPENDIX D: PHOTOGRAPHIC RECORD OF TRANSECTS IN TREATMENT AREA 4 OF THE WUNGONG CATCHMENT

Photograph D1: Transect 7-1 – view from the beginning of the transect.

Photograph D2: Transect 7-1 – view from the end of the transect.

APPENDIX D: PHOTOGRAPHIC RECORD OF TRANSECTS IN TREATMENT AREA 4 OF THE WUNGONG CATCHMENT

Photograph D3: Transect 7-2 – view from the beginning of the transect.

Photograph D4: Transect 7-2 – view from the end of the transect.

APPENDIX D: PHOTOGRAPHIC RECORD OF TRANSECTS IN TREATMENT AREA 4 OF THE WUNGONG CATCHMENT

Photograph D5: Transect 8-1 – view from the beginning of the transect.

Photograph D6: Transect 8-1 – view from the end of the transect.

APPENDIX D: PHOTOGRAPHIC RECORD OF TRANSECTS IN TREATMENT AREA 4 OF THE WUNGONG CATCHMENT

Photograph D7: Transect 8-2 – view from the beginning of the transect.

Photograph D8: Transect 8-2 – view from the end of the transect.

APPENDIX D: PHOTOGRAPHIC RECORD OF TRANSECTS IN TREATMENT AREA 4 OF THE WUNGONG CATCHMENT

Photograph D9: Transect 9-1 – view from the beginning of the transect.

Photograph D10: Transect 9-1 – view from the end of the transect.

APPENDIX D: PHOTOGRAPHIC RECORD OF TRANSECTS IN TREATMENT AREA 4 OF THE WUNGONG CATCHMENT

Photograph D11: Transect 9-2 – view from the beginning of the transect.

Photograph D12: Transect 9-2 – view from the end of the transect.

APPENDIX D: PHOTOGRAPHIC RECORD OF TRANSECTS IN TREATMENT AREA 4 OF THE WUNGONG CATCHMENT

Photograph D13: Transect 10-1 – view from the beginning of the transect.

Photograph D14: Transect 10-1 – view from the end of the transect.

APPENDIX D: PHOTOGRAPHIC RECORD OF TRANSECTS IN TREATMENT AREA 4 OF THE WUNGONG CATCHMENT

Photograph D15: Transect 10-2 – view from the beginning of the transect.

Photograph D16: Transect 10-2 – view from the end of the transect.

APPENDIX D: PHOTOGRAPHIC RECORD OF TRANSECTS IN TREATMENT AREA 4 OF THE WUNGONG CATCHMENT

Photograph D17: Transect 11-1 – view from the beginning of the transect.

Photograph D18: Transect 11-1 – view from the end of the transect.

APPENDIX D: PHOTOGRAPHIC RECORD OF TRANSECTS IN TREATMENT AREA 4 OF THE WUNGONG CATCHMENT

Photograph D19: Transect 11-2 – view from the beginning of the transect.

Photograph D20: Transect 11-2 – view from the end of the transect.

APPENDIX D: PHOTOGRAPHIC RECORD OF TRANSECTS IN TREATMENT AREA 4 OF THE WUNGONG CATCHMENT

Photograph D21: Transect 12-1 – view from the beginning of the transect.

Photograph D22: Transect 12-1 – view from the end of the transect.

APPENDIX D: PHOTOGRAPHIC RECORD OF TRANSECTS IN TREATMENT AREA 4 OF THE WUNGONG CATCHMENT

Photograph D23: Transect 12-2 – view from the beginning of the transect.

Photograph D24: Transect 12-2 – view from the end of the transect.