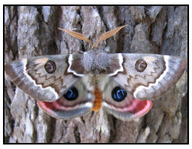
Department of Parks and Wildlife
Science and Conservation Division

FORESTCHECK

REPORT OF PROGRESS 2013








PARKS AND WILDLIFE

Produced by the Department of Parks and Wildlife, Kensington, Western Australia, July 2014

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This report highlights preliminary results for FORESTCHECK monitoring, determined by basic analysis and field observation, for the year 2013. This and previous FORESTCHECK Annual Reports should not be quoted or used as final results for the FORESTCHECK program. Publications based on detailed analyses using comprehensive statistical methods are published on a 5-year basis. All FORESTCHECK publications and reports are available on the DPaW web site at www.dpaw.wa.gov.au .

Cover photos: The filmstrip represents biota monitored in FORESTCHECK: *from left*, forest structure and coarse woody debris, reptiles, macrofungi, invertebrates, lichens, mammals, birds and vascular flora. *Main photo*: mature virgin reference forest at Carter forest block. *Above left*, undescribed hydnoid fungus, *Phellodon* sp.; *centre left*, southwestern four-toed Lerista, *Lerista distinguenda* and *bottom left*, pygmy possum, *Cercartetus concinnus*, represent some of the biota recorded on the Donnelly 2 FORESTCHECK grids in 2013 (photos: R. Robinson).

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EXECUTIVE SUMMARY

This report represents an annual summary of activities from the FORESTCHECK monitoring project. In 2013 FORESTCHECK entered a new phase with the addition of eight new monitoring grids in the Donnelly District that provide examples of silviculture implemented during the period of the Forest Management Plan 2004–2013. The grids were established within three locations in jarrah forest in the Donnelly District. Three grids were established south of Quinninup in Boyndaminup and Gobblecannup forest blocks, three north east of Donnelly Mill in Carter block, and two north west of One Tree Bridge in Lewin and Barlee blocks. Grids were established in forest stands that were either uncut or in forest subject to timber harvesting (shelterwood, selective cut and gap release treatments). The existing external reference grid in Easter block (established in 2001) was included as a reference for the Lewin and Barlee silviculture treatment grids.

All the monitoring grids are located in State forest or National park located within the Bevan 1 vegetation complex which occurs in tall open forests of marri-jarrah (*Corymbia calophylla-Eucalyptus marginata* subsp. *marginata*) on uplands in perhumid and humid zones. Harvested sites were matched to 2004, 2006 and 2007 harvest activities. Grids at harvested sites were subject to prescribed fire in either the year of harvest or the next (i.e. 6–9 years). Reference grids at Boyndaminup and Carter were prescribed burnt four and six years prior to monitoring, while the Easter reference grid was burnt by bushfire 18 years previously in 1995.

At all grids, forest attributes including forest structure, regeneration stocking, coarse woody debris and litter loads were measured and species richness and abundances of macrofungi, cryptogams (lichens and bryophytes), invertebrates, terrestrial vertebrates and vascular plants were recorded.

FORESTCHECK monitoring is contributing to increased knowledge of jarrah forest biodiversity and ecology, and underpins the concept of sustainable forest management in jarrah forest in Western Australia. Data collected in the first 10 years of FORESTCHECK monitoring is currently being analysed, while results presented here are from a preliminary analysis of data collected in 2013. Some highlights include:

- Very large trees (>100cm) retained on gap release grids at Carter and Lewin resulted in high basal areas. Neither grid achieved the current regeneration stocking standard of 65% of points stocked with ground coppice or saplings. In contrast, the shelterwood and selective cut grids exceeded the regeneration stocking standard, primarily through the contribution of sapling regeneration. Jarrah comprised >40% of the regeneration cohort on all grids.
- Repeated measurements of stand basal area at the Easter reference grid in 2002, 2008 and 2013 highlight the fact that old-growth stands are dynamic, and that the site may be responding to a variety of influences including climate variability and temporary disturbance from defoliation by gumleaf skeletoniser (*Uraba lugens*) during the summers of 2010–11 and 2011–12.
- Litter loads reflected time since fire, except on the Easter external reference grid which had a high litter and exceptionally high SWT load. This may be the result of defoliation and twig shedding following the gumleaf skeletoniser (*Uraba lugens*) outbreak.
- CWD load increased with the intensity of the harvest treatment and the time since treatment.
- The Jarrah South ecosystem has an extremely rich, diverse and abundant mycota. Macrofungal mean species richness per grid of was similar in all treatments. The mean abundance of fruit bodies was consistently lower in harvested grids, but not significantly lower than the reference treatment.
- The majority of cryptogams were crustose lichens and tufted mosses. Crustose lichens were more diverse on reference grids and tufted mosses had similar species numbers on all grids irrespective of treatment.
- The overall mean species richness of plants was similar in all treatments but the mean abundance of vascular plants was consistently lower in the external reference treatment

compared to the harvested treatments. The understorey vegetation was also denser on harvested grids.

- Birds like the scarlet robin, which prefers an open understordy and scrub layer, were mostly recorded in the external reference grids while birds like the white-browed scrubwren, which prefer thick scrub, were more common in harvested treatments.
- One half of the brush tail possum captures occurred in the shetterwood/selective cut treatment, with the remainder occurring almost equally in both the gap release and external treatments.
- All but one quokka captures were recorded in recently harvested grids. Quokkas normally inhabit forest in riparian zones but it appears that harvested grids also provided habitat with a similar understorey structure.

Laboratory sorting of the invertebrate captures is currently in progress and results will be published at a later date.

The FORESTCHECK team is to be commended for their commitment to the project. I also extend my sincere thanks to the many volunteers who have assisted with the project. In 2014 new monitoring grids will be established in the Blackwood District within the Sandy Basins forest ecosystem in forest harvested during the previous Forest Management Plan (2004–2013), under Sustainable Forest Management Guideline No. 1. This report, and previous reports, can be viewed and downloaded from the Department of Parks and Wildlife website at www.dpaw.wa.gov.au.

Dr Margaret Byrne
Director, Science and Conservation Division

July 2014

INTRODUCTION

Scope

This report represents an annual summary of activities from the FORESTCHECK monitoring project. The aim of the report is to detail activities carried out in 2013 in the Jarrah South forest ecosystem within the Donnelly District and to present preliminary descriptive interpretations and analyses of the data collected. More detailed and robust analyses are conducted on a five-year basis and following the peer-review process are published in relevant scientific journals. Previous reports and publications can be viewed at www.dpaw.wa.gov.au .

FORESTCHECK is an integrated monitoring system that has been developed to provide information to forest managers in the southwest of Western Australia about changes and trends in key elements of forest biodiversity associated with a variety of forest management activities. The initial focus of FORESTCHECK has been on timber harvesting and silvicultural treatments in jarrah (*Eucalyptus marginata*) forest, although the scale of monitoring over time may be extended to include other forest ecosystems, fire (prescribed and wildfire), mining, the effects of forest disturbance for utility corridors (e.g. roads, power transmission lines), and the impacts of recreation uses. (Note, however, that the Forest Products Commission only provides funding for FORESTCHECK that is specific to its activities).

FORESTCHECK was developed to meet a range of compliance conditions placed on the Forest Management Plan 1994–2003 through Ministerial Conditions and the Codd Report of 1999 (Codd 1999). It was included as an operational program in the previous Forest management Plan 2003–2013 and continues to be so in the current Forest Management Plan 2014–2023 (Conservation Commission 2014). Integrated monitoring is a fundamental component of ecologically sustainable forest management (ESFM), and is necessary for reporting against the Montreal Process criteria and indicators for ESFM. In addition, monitoring forms the basis for adaptive management and adaptive management is recognized as an appropriate strategy for managing under conditions of uncertainty and change.

The Science and Conservation Division in the Department of Parks and Wildlife has primary responsibility for the implementation of FORESTCHECK. The development of the program took place over 2 yrs and included input from scientists and managers within the Department (then Conservation and Land Management), and from a number of external scientific agencies. The background to this process is described in the FORESTCHECK Concept Plan, and details of methods are provided in the FORESTCHECK Operations Plan. Annual Progress Reports, the Concept Plan and Operations Plan may be viewed on the Department's website at www.dpaw.wa.gov.au, by searching on the term 'forestcheck'.

Monitoring strategy

Since 2004 timber harvesting in jarrah forests was undertaken according to Sustainable Forest Management Guideline No.1 (Anon. 2004), which recognizes three silvicultural objectives:

1. Thinning—to promote growth on retained trees.
2. The release of regeneration by gap creation, where existing advance growth is encouraged to develop unimpeded by the removal of competing overstorey.
3. Regeneration establishment by shelterwood, where seedlings are encouraged to establish and develop into the lignotuberous ground coppice stage. This is achieved by reducing the competition from the overstorey, but retaining sufficient overstorey to provide a seed source and maintain other forest values until the ground coppice is developed and capable of responding to release.

Due to past management practices or limits on culling of unmerchantable trees, some areas of jarrah forest are treated as 'selective cut'. Selective cut stands are prescribed burnt in conjunction with burns for other purposes.

Gap creation and shelterwood treatments are being given priority in the initial stages of FORESTCHECK as these are the most widespread operations and involve the greatest extent of disturbance to the forest. Selective cutting is also monitored where the structure of the forest dictates that this treatment is appropriate on a significant scale.

FORESTCHECK monitoring sites have been established at a number of locations throughout the jarrah forest, stratified according to recognized ecological gradients of rainfall, evapo-transpiration and soil fertility. Forest ecosystem mapping (Mattiske and Havel 1998, 2000) provides a systematic basis for stratification of sampling. Allocation of sites also takes account of scheduled future harvesting within the jarrah forest, with priority given to those ecosystems likely to be subject to harvesting on an extensive scale in the next decade.

Each FORESTCHECK site has up to four sampling grids. Grids have been established in forest subject to the following treatments:

1. gap release
2. shelterwood (and/or selective cut)
3. coupe buffer or internal reference forest i.e. temporary exclusion areas (TEAS) between adjacent gaps or shelterwood forest
4. external reference or control forest (i.e. not recently harvested, or has had minimal harvesting, and will not be subject to harvesting in the foreseeable future)

At each location, grids are closely matched in terms of site characteristics (climate, geomorphology, soils, topography, altitude, aspect), pre-harvest forest structure and vegetation attributes in order that differences between grids reflect the effects of harvesting, rather than inherent site differences. Not all treatment types are always present in the one locality and occasionally, external reference forest has been located some distance from their harvested counterparts. Also, it may not always be possible to find gap release and shelterwood treatments together, because underlying relationships between rainfall, soil fertility and jarrah lignotuber development influence the broad pattern of silvicultural treatment across the jarrah forest, as have previous silvicultural activities.

Methodology

Monitoring of biodiversity is based on a sampling grid (see Fig. 1). The main grid is 200m x 100m, with a central area of 100m x 100m. A range of ecosystem attributes are monitored on each grid including:

- forest structure and regeneration stocking
- foliar and soil nutrients
- soil disturbance
- coarse woody debris and leaf litter
- macrofungi
- cryptogams
- vascular flora
- invertebrate fauna
- vertebrate fauna (birds, herpetofauna, and mammals).

Sampling methodologies for each set of ecosystem attributes are described in the FORESTCHECK Operations Plan, together with examples of protocols for data collection and storage.

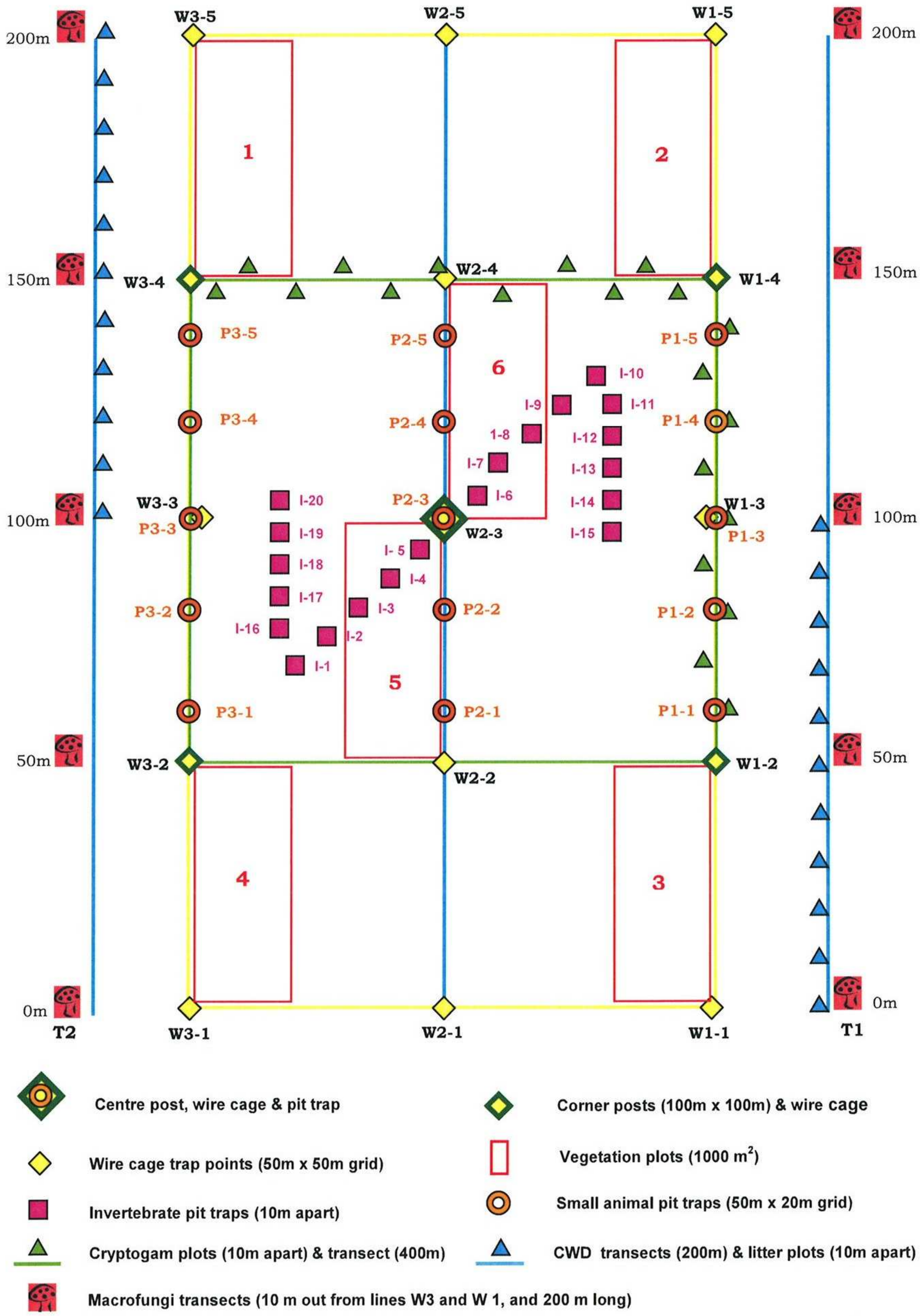

Figure 1. FORESTCHECK grid layout

Monitoring in the Donnelly District 2013

Eight FORESTCHECK monitoring grids were established within three locations in Jarrah South forest ecosystem in the Donnelly District in summer 2013. Three grids (FC49, FC50 and FC51) were established south of Quinninup in Boyndaminup and Gobblecannup forest blocks, three (FC52, FC53 and FC54) north east of Donnelly Mill in Carter block, and two (FC55 and FC56) north west of One Tree Bridge in Lewin and Barlee blocks (Figs 2–4). The existing external reference grid in Easter block (FC10) was included as a reference for the Lewin and Barlee silviculture treatment grids (Fig. 4).

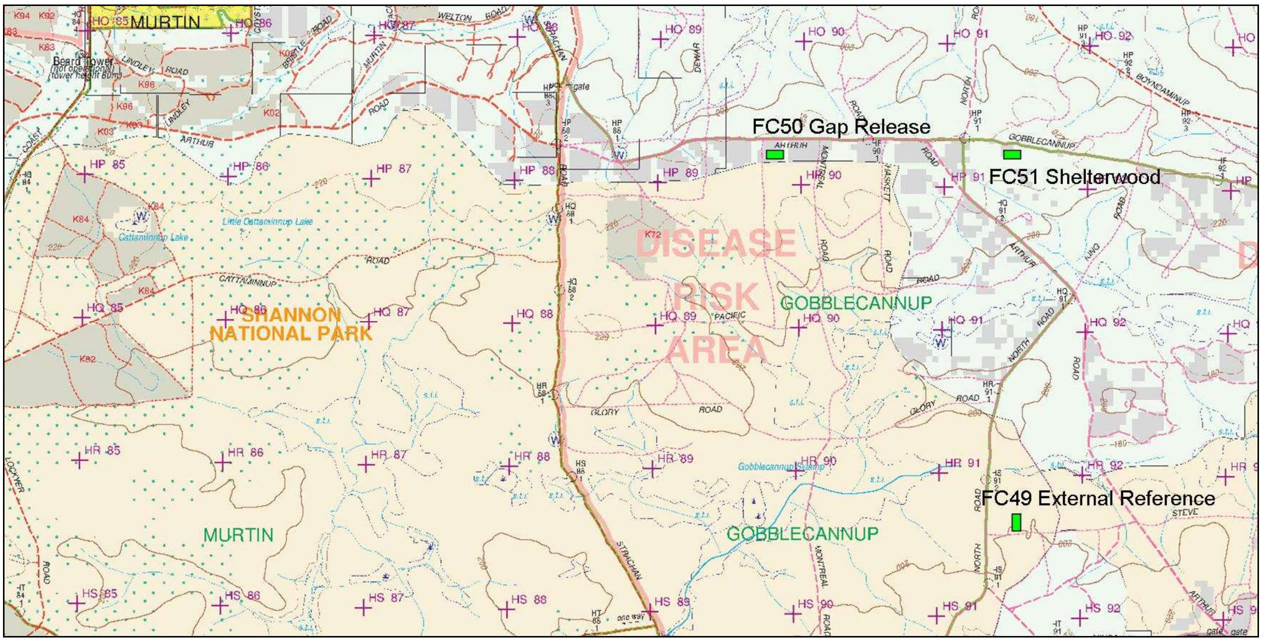

Figure 2. Locations of FORESTCHECK monitoring grids established in 2013 in Gobblecannup and Boyndaminup blocks

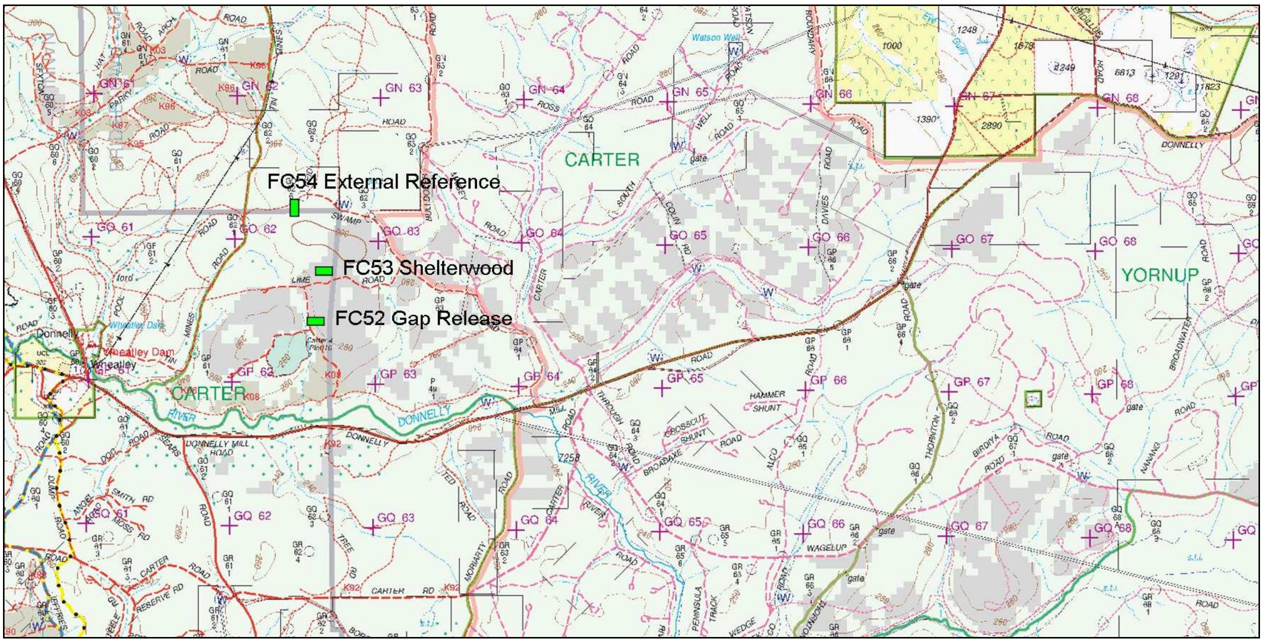

Figure 3. Locations of FORESTCHECK monitoring grids established in 2103 in Carter block

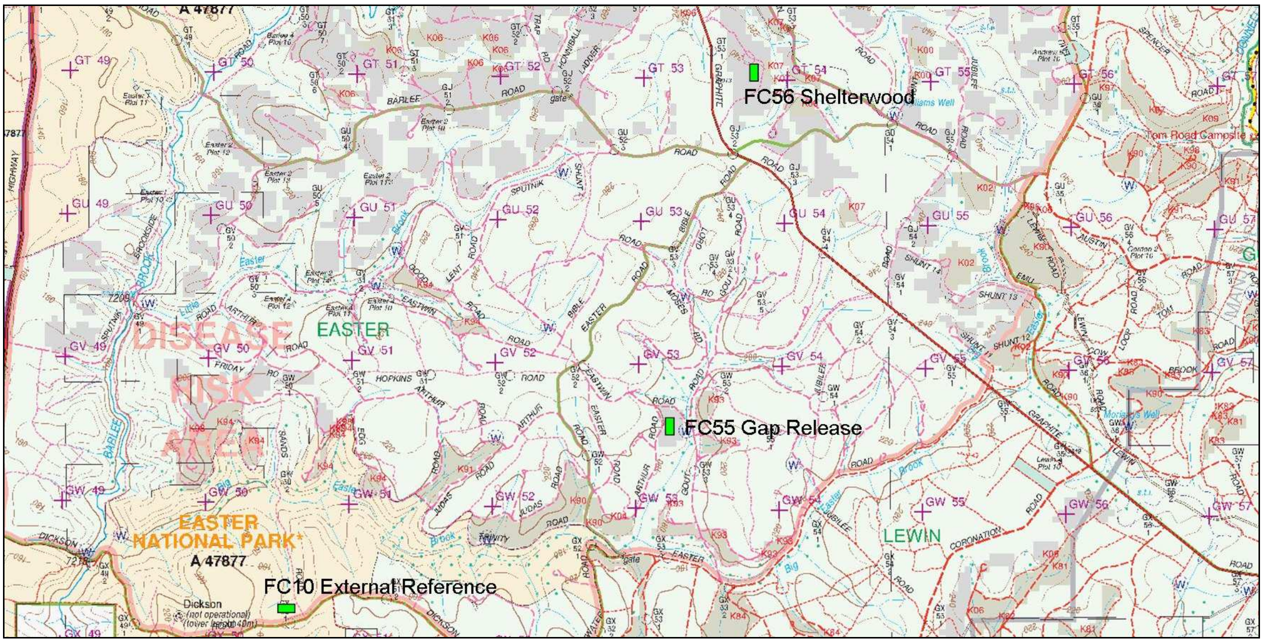

Figure 4. Locations of FORESTCHECK monitoring grids established in 2013 in Lewin and Barley blocks, and FC10 in Easter block

All nine grids are located within the Bevan 1 vegetation complex of Mattiske and Havel (1998). This complex is found in tall open forests of marri-jarrah (*Corymbia calophylla-Eucalyptus marginata* subsp. *marginata*) on uplands in perhumid and humid zones (Table 1).

Table 1. Location (forest block) and site attributes of each FORESTCHECK monitoring grid in the Donnelly District in 2013.

Treatment/grid location	Burnt		Harvested		Vegetation Complex[2]
	Year and type of burn[1]	Years since[2]	Year	Years since[2]	
External reference					
FC49 Boyndaminup	Sp 2009 (prescribed)	4	Uncut		Bevan 1
FC54 Carter	Sp 2007 (prescribed)	6	Uncut		Bevan 1
FC10 Easter	Su 1995 (Bushfire)	18	Uncut		Bevan 1
Shelterwood/selective cut*					
FC51 Boyndaminup*	Sp 2008 (prescribed)	5	2007	6	Bevan 1
FC53 Carter	Sp 2007 (prescribed)	6	2007	6	Bevan 1
FC56 Barlee	Sp 2004 (prescribed)	9	2006	7	Bevan 1
Gap release					
FC50 Gobblecannup	Sp 2008 (prescribed)	5	2006	7	Bevan 1
FC52 Carter	Sp 2006 (prescribed)	7	2006	7	Bevan 1
FC55 Lewin	Sp 2004 (prescribed)	9	2004	9	Bevan 1

[1] Su = summer, Sp= spring, Au = autumn
[2] The Bevan vegetation complex is found in tall open forests of marri-jarrah (*Corymbia calophylla-Eucalyptus marginata* subsp. *marginata*) on uplands in perhumid and humid zones (Mattiske and Havel 1998).

Two external reference grids (FC10 and FC49) are situated in uncut forest within Easter and Shannon National Parks respectively, but a small number of stumps is present in the Boyndaminup external reference grid (FC49) and records suggest that a number of trees had been selectively harvested in the decade 1960-69. The Carter external reference grid (FC54) is located within a fauna habitat zone adjacent harvested forest, and although there is no record of any cutting a small number of stumps is also present within the stand. The remaining grids are in forest that was harvested during the period of 2004–07 and were established at sites in stands with comparable management histories. The silvicultural outcome of the harvested grid at Boyandaminup (FC51) was selective cut, while all other harvested treatments were either shelterwood or gap release (Table 1). All grids were harvested during the period of the previous Forest Management Plan 2004–2013 (Conservation Commission 2004), under the Sustainable Forest Management Guideline No. 1 (Anon. 2004).

Grid photographs

Reference photographs of each grid (Figs. 5–13) were taken in June/July 2013 from a standard photo point at peg W2-1 looking towards the centre peg (W2-3) (refer to Fig. 1). Having a standard reference point allows for accurate changes in vegetation structure and condition to be observed in each subsequent photograph taken.

Gobblecannup/Boyndaminup Grids

Figure 5. FC49 Boyndaminup external reference

Figure 6. FC51 Boyndaminup selective cut

Figure 7. FC50 Gobblecannup gap release

Carter grids:

Figure 8. FC54 Carter external reference

Figure 9. FC53 Carter shelterwood

Figure 10. FC55 Carter gap release

Easter/Barlee/Lewin grids:

Figure 11. FC10 Easter external reference

Figure 12.FC56 Barlee shelterwood

Figure 13. FC52 Lewin gap release

Budget
The annual operational budget for the program is provided through the Forest and Ecosystems Management Division of the Department of Parks and Wildlife via a works agreement with the Forest Products Commission for $225,000. Salaries of all staff involved in the project are paid by the Department of Parks and Wildlife.

2014 Activities
Analysis of ten years of monitoring data collected between 2001 and 2012 is currently in progress. A comparison of the first (2001–2006) and second (2007–2012) rounds of monitoring will be undertaken as well as an analysis of the effects of timber harvesting on forest attributes and biodiversity using the combined data from the two rounds of monitoring.

It is proposed to install an additional set of monitoring grids in forest harvested under the guidelines of the Forest Management Plan 2004–2013 (Conservation Commission 2004). Monitoring on these grids is scheduled to commence in autumn 2014.

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FOREST STRUCTURE AND REGENERATION STOCKING

Lachlan McCaw and Verna Tunsell

Introduction

The adequacy of regeneration following harvesting and silvicultural treatment is one of the core indicators of ecologically sustainable forest management (ESFM). The current framework of regional level indicators provides for assessment of the area and per cent of harvested area of native forest effectively regenerated (Indicator 2.1.g). This is recognised as a Category A indicator that can be reported upon immediately (Commonwealth of Australia 1998). Regeneration outcomes have, for a number of years, been assessed as a matter of routine on a sample of the area subject to harvesting and silvicultural treatment in south-west forests.

Natural regeneration is the preferred method of regeneration in the jarrah forest. Silvicultural management encourages the production of seed crops *in-situ* and promotes the growth of existing lignotuberous seedlings, ground coppice and saplings where they exist. For uneven-aged stands, the current stand structure and stocking level of saplings and ground coppice will influence the silvicultural method applied (Department of Parks and Wildlife 2014).

Forest managers also require information about stand structure, species composition and rates of tree mortality so that future stand conditions can be projected over time. These attributes can affect the potential of forest stands to produce wood and other products, and to achieve ecological outcomes.

Field assessment

Forest structure and regeneration stocking were assessed on nine monitoring grids in jarrah forest in Donnelly District, including one grid (FC10) that had been assessed on two previous occasions in 2002 and 2008. The location of these grids is referred to as Donnelly 2. Field work was undertaken during winter and spring of 2013.

Assessment methods were as per the FORESTCHECK Operating Plan (DEC 2006), and included measurement of cut stumps and surveys of regeneration stocking density and species composition by the triangular tessellation method. All trees taller than 2 m were measured along transects 100 m long by 4 m wide located between marker pegs W1-2 to W1-4 and W3-2 to W3-4 (see Fig. 1 p.5). To improve the reliability of long term measurements of tree growth, mortality and tree fall all stems ≥20cm diameter at breast height were identified with a numbered tag. The height and species of regeneration was assessed at four locations on each grid to indicate the rate of regrowth.

Projected foliage cover was recorded in spring 2013 as part of the vegetation cover assessment during vascular plant surveys. Intercepts with foliage were recorded at 240 points around the perimeter of four 30m x 30m vegetation quadrats using a vertical periscope fitted with a fine crosshair. Intercepts were recorded as foliage present or absent in height classes of 2-15m and >15m. Contacts with eucalypt foliage were recorded separately to contacts with other plant species.

Data management

Stem diameter (overbark) measurements for individual trees were entered into the FORESTCHECK stand database. Individual tree basal areas were calculated and summed.

Preliminary results
Stand structure and species composition
Eucalypt basal area on external reference grids ranged from 55– 73m^{2}ha^{-1} with the highest basal area on the Easter external reference grid (FC10) (Table 1). Jarrah and marri contributed equally to basal area on the Easter external reference, whereas jarrah was dominant on the other two external reference grids. Basal area on the two shelterwood and the selective cut grids ranged from 21–33m^{2}ha^{-1}. Jarrah dominated the basal area on the shelterwood grids at Carter (FC53) and Barlee (FC56), but was matched by marri on the Boyndaminup selective cut (FC51). The Gobblecannup gap release grid had a total live basal area of 9m^2 ha^{-1}, and a moderate basal area of dead trees. Gap release grids at Carter (FC52) and Lewin (FC55) had a high basal area of marri (>23m^{2}ha^{-1}) that resulted in a high total basal area, particularly in the case of the Lewin grid. Several very large jarrah trees sampled on the transect between points W1.2 and W1.4 also resulted in a high mean basal area of jarrah for the Lewin grid, although this was reduced somewhat if only the data for the transect between points W3.2 and W3.4 were considered. The Carter shelterwood and Lewin gap release grids also had a substantial basal area of dead trees (>10m^{2}ha^{-1}).

Table 1. Basal area of eucalypts >2 m tall for nine FORESTCHECK grids at Donnelly 2 in 2013

Treatment/Grid	Basal area (m^2 ha^{-1})				
	Live			Dead	
	Jarrah	Marri	Total live	Jarrah	Marri
External reference					
FC49 Boyndaminup	32.11	23.40	55.51	0.36	0.05
FC54 Carter	36.06	21.78	57.84	0.04	0.06
FC10 Easter	35.13	37.39	72.52	0.19	4.30
Shelterwood/selective cut					
FC51 Boyndaminup	10.63	10.84	21.47	6.39	1.25
FC53 Carter	23.25	3.20	26.45	5.87	11.88
FC56 Barlee	27.39	5.68	33.07	1.39	0.31
Gap release					
FC50 Gobblecannup	5.16	4.04	9.20	1.06	2.73
FC52 Carter	15.33	23.55	38.88	0.01	0.02
FC55 Lewin[a]	16.20	34.88	51.08	0.15	0.80
FC55 Lewin	31.94	29.61	61.55	10.30	2.34

[a] Data for Sections 3.4-3.3 and 3.3.-3.2 only

Mid-storey species recorded included *Banksia grandis*, *Xanthorrhoea preissii* and *Persoonia elliptica* but their contribution to total basal area on eight of the grids was small (<1m^{2}ha^{-1}), except for the Carter external reference (Fig. 1).

Total live basal area on the Easter external reference had reduced slightly from 72.86m^{2}ha^{-1} in 2008 to 72.51m^{2}ha^{-1} in 2013, primarily due to the death of a mature marri tree. This was compensated by an increase in jarrah basal area of 1.53m^{2}ha^{-1} equivalent to an annual increment of 0.31m^{2}ha^{-1}.

Cut stumps from timber harvesting prior to 1970 were recorded on all grids except the Easter external reference, consistent with information available from the SILREC database (Table 2). Stumps from harvesting prior to 1970 were large (>1m diameter) with the estimated basal area removed being typically 10–15m^{2}ha^{-1} but as high as 35m^{2}ha^{-1} on the Carter external reference grid. Basal area removals resulting from harvesting between 2004 and 2013 were 8–12m^{2}ha^{-1}

for shelterwood and selective cut grids and 9–24m^{2}ha^{-1} for gap release grids. Only cut stumps of jarrah were encountered during the survey.

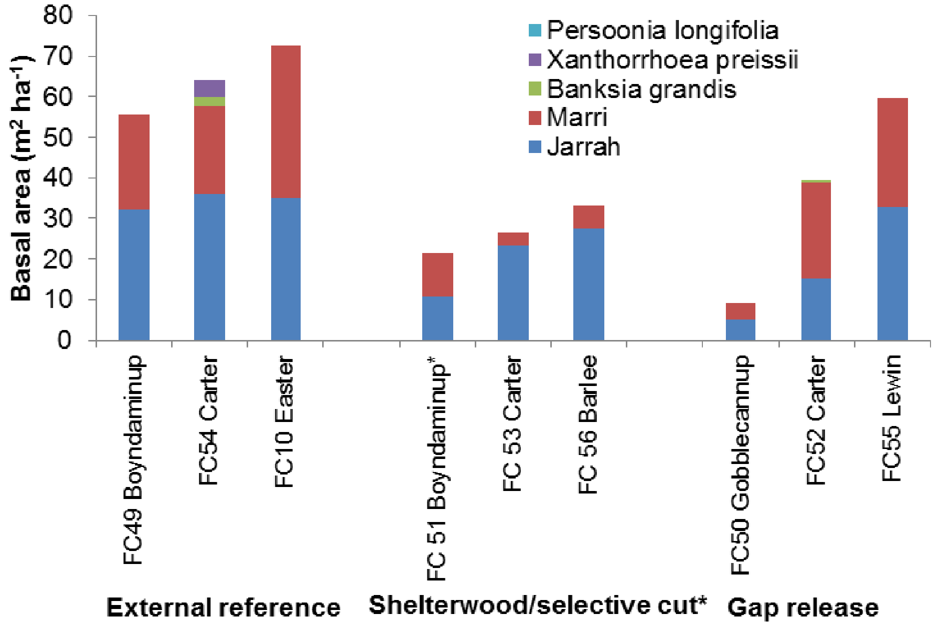

Figure 1. Basal area (m^{2}ha^{-1}) of jarrah, marri and mid-storey species on nine grids at Donnelly 2 in 2013

Table 2. Basal area (m^{2}ha^{-1}) of eucalypt cut stumps from recent and earlier harvesting on FORESTCHECK grids at Donnelly 2

Treatment/Grid	**Cut stump basal area (m^{2}ha^{-1})**				
	Harvesting 2004-2013		Earlier harvesting		
	Jarrah	Marri	Jarrah	Marri	Decade
External reference					
FC49 Boyndaminup	nil	nil	14.14	nil	1960-70
FC54 Carter	nil	nil	12.58	nil	1940-50
FC10 Easter	nil	nil	nil	nil	never
Shelterwood/selective cut					
FC51 Boyndaminup	12.00	nil	11.88	nil	1960-70
FC53 Carter	7.68	nil	35.53	nil	1940-50
FC56 Barlee	12.00	nil	6.29	nil	1950-60
Gap release					
FC50 Gobblecannup	22.14	nil	22.41	nil	1960-70
					1970-80
FC52 Carter	9.24	nil	0.01	0.02	1940-50
FC55 Lewin[a]	23.35	nil	nil	nil	1950-60
					1960-70
FC55 Lewin	14.63	nil	10.30	2.34	as above

[a] Data for Sections W3.4 - W3.3 and W3.3 - W3.2 only (see Fig. 1, p.5)

Stem diameter distributions of eucalypts and mid-storey trees on grids in each treatment are shown in Figures 2–4. Very large trees with diameter >100cm were recorded on external reference grids at Carter and Easter, and on gap release grids at Carter and Lewin. Very large trees included both marri and jarrah. The largest trees recorded on shelterwood and selective cut grids were up to 80cm in diameter. Saplings were the most frequent size class on all of the harvested grids, with the proportion of jarrah and marri saplings varying between grids. A notable feature of the Easter external reference grid was the presence of a dense stratum of marri and jarrah saplings, despite the absence of previous timber harvesting in this stand (Table 3, Fig. 2).

Table 3. Eucalypt regeneration stocking assessed by the triangular tessellation method on FORESTCHECK grids at Donnelly 2

Treatment/Grid	Per cent of sample points				
	Within 4 m of overwood tree	Stocked with saplings	Stocked with saplings and/or ground coppice	Stocked with lignotuberous seedlings	Not stocked to standard
External reference					
FC49 Boyndaminup	72	42	44	N/a	14
FC54 Carter	64	16	42	N/a	42
FC10 Easter	70	48	50	N/a	2
Shelterwood/selective cut					
FC51 Boyndaminup	60	60	38	0	2
FC53 Carter	34	46	28	8	18
FC56 Barlee	66	60	10	0	30
Gap release					
FC50 Gobblecannup	36	56	36	N/a	8
FC52 Carter	34	28	24	N/a	48
FC55 Lewin	48	46	8	N/a	46

N/a = not applicable

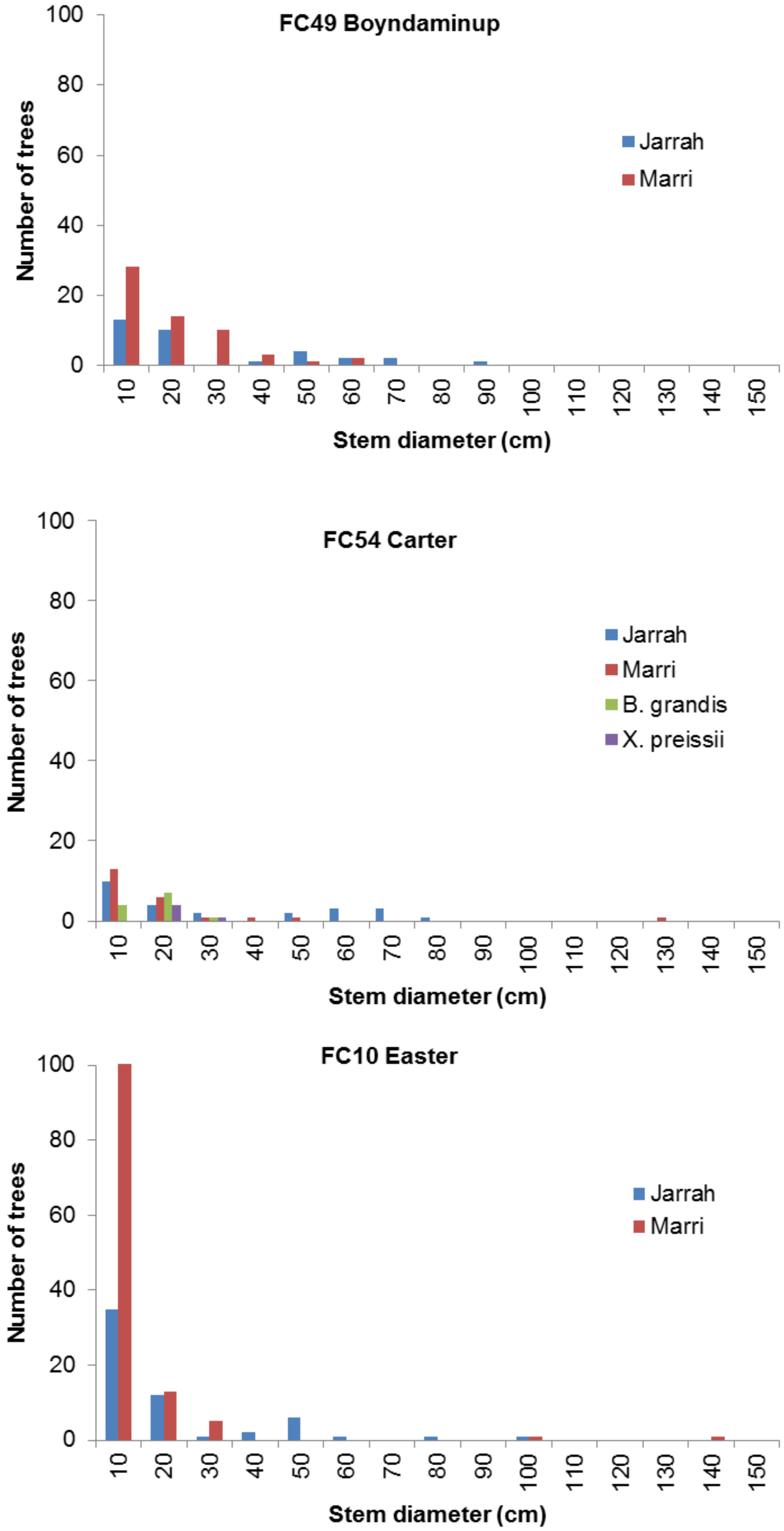

Figure 2. Stem diameter distribution by 10cm classes (0–9cm, 10–19cm etc.) for three external reference grids

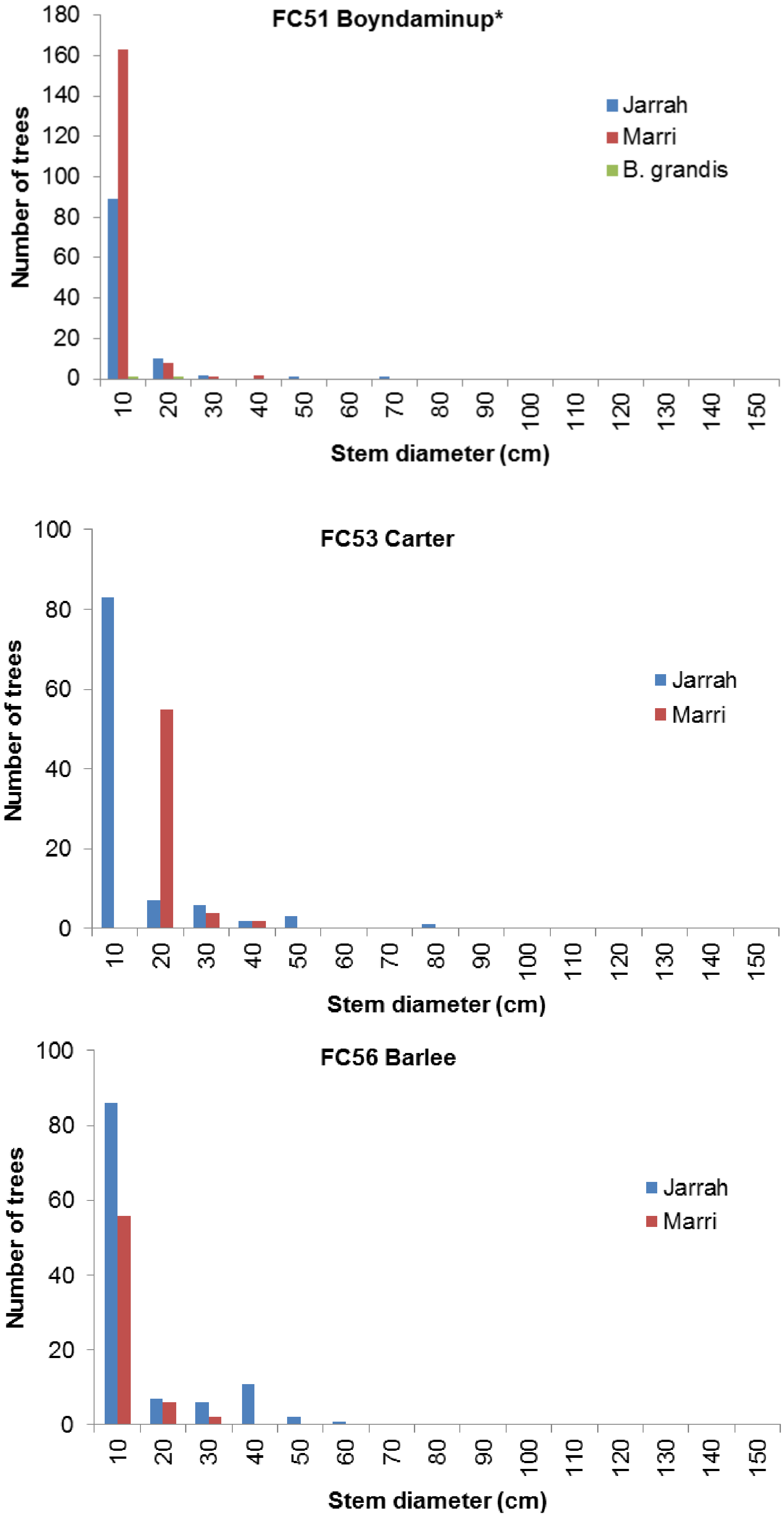

Figure 3. Stem diameter distribution by 10cm classes (0–9cm, 10–19cm etc.) for two shelterwood and one selective cut grid. Note the different scale on the vertical axis for the Boyndaminup selective cut.

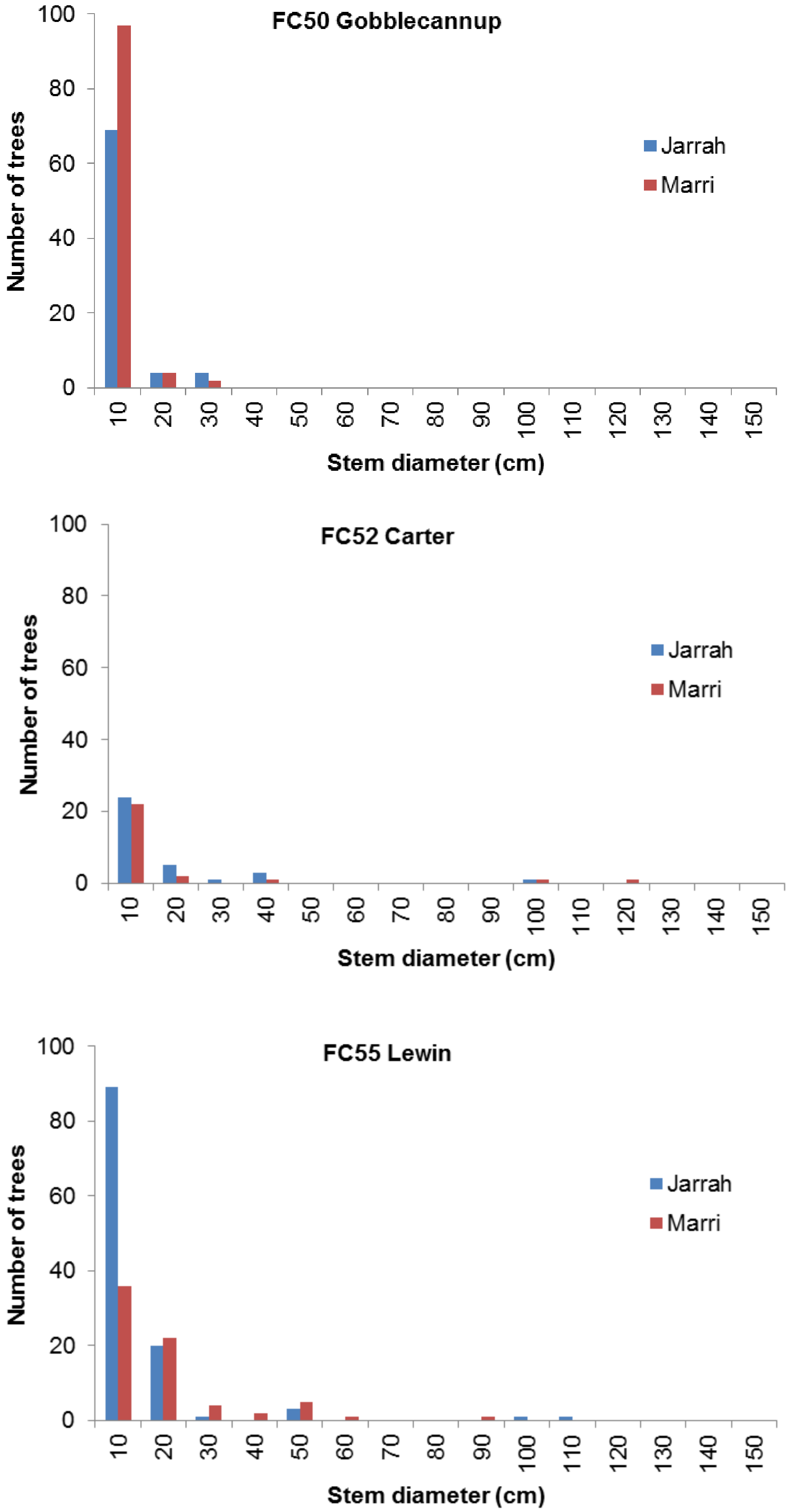

Figure 4. Stem diameter distribution by 10cm classes (0–9cm, 10–19cm etc.) for three gap release grids

Regeneration stocking surveys indicated that >70% of sample points in shelterwood and selective cut grids were stocked with saplings or a combination of saplings and ground coppice (Table 3). Lignotuberous seedlings also contributed to stocking at the Carter shelterwood. The Gobblecannup gas release was densely stocked with saplings and ground coppice (92%), but the Carter and Lewin gap release grids were stocked at only 52–54% of sample points. The proportion of sample points within 4m of an over-wood tree was generally lower in gap release than shelterwood or selective cut grids, consistent with the greater basal area reduction in gap release treatments. Jarrah comprised at least 40% of the regeneration cohort on all grids, and was generally more abundant on the harvested grids than on external reference grids (Fig.5).

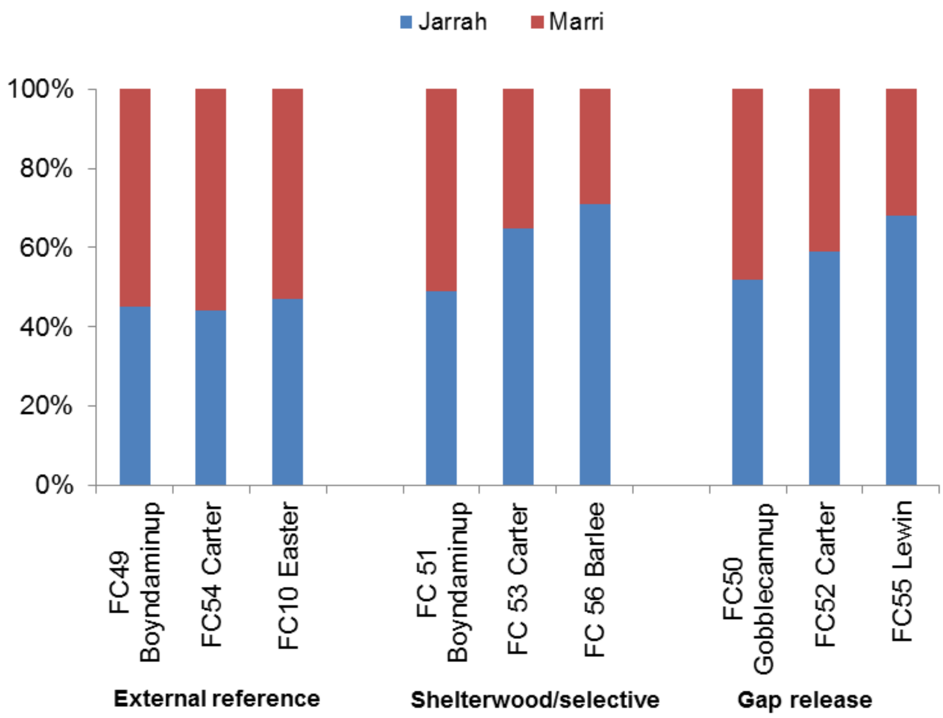

Figure 5. Species composition of sapling and ground coppice regeneration assessed by the triangular tessellation method.

Eucalypt foliage from the upper storey (>15m height) comprised the largest proportion of projected foliage cover on external reference grids (Fig. 6). Eucalypt foliage from the lower storey also contributed substantially to foliage cover on the Boyndaminup and Easter external reference grids, resulting in a combined cover of 90% or greater. Mid-storey trees also contributed 15% projected foliage cover on the Carter external reference grid, consistent with the higher basal area of mid-storey trees recorded on this grid. Eucalypt foliage from the lower storey (2–15m) contributed about 20% foliage cover on shelterwood and selective cut grids, but the upper canopy cover varied considerably being lowest at Boyndaminup and highest at Barlee. The projected cover of all layers combined was lowest on gap release grids. The Gobblecannup gap release, which had the lowest retained basal area, also had the lowest projected cover of upper storey foliage.

Figure 6. Projected foliage cover of eucalypts and other species divided into lower (2–15m) and upper (>15m) storeys

Discussion

All of the eight new grids established in 2013 had been harvested at least once prior to the harvesting and silvicultural treatment that took place under the silvicultural practices that applied during the Forest Management Plan 2004–2013 (Conservation Commission 2004). Surveys of cut stumps showed that the reduction in basal area resulted from removal of jarrah, with no marri stumps recorded. The Carter shelterwood grid had been heavily cut in the period 1940 to 1950, and this may partly explain the relatively small basal area reduction resulting from the 2007 treatment.

Very large trees (>100cm) retained on gap release grids at Carter and Lewin resulted in high basal areas. Neither grid achieved the current regeneration stocking standard of 65% of points stocked with ground coppice or saplings. In contrast, the shelterwood and selective cut grids exceeded the regeneration stocking standard, primarily through the contribution of sapling regeneration. Jarrah comprised >40% of the regeneration cohort on all grids.

Stand structure has been measured at the Easter external reference grid in 2002, 2008 and 2013. Total stand basal area has increased over this period, and the stand is developing a persistent cohort of sapling regeneration. This highlights the fact that old-growth stands are dynamic, and may be responding to a variety of influences including climate variability and temporary disturbance from defoliation by the gumleaf skeletoniser (*Uraba lugens*) outbreak in the summer of 2010–11; but which is gradually declining. Patterns of stand growth will be analysed in greater detail over the coming year. Where possible some of the initial 48 grids established between 2001 and 2006 should be included in the experimental design for future FORESTCHECK sampling so that periodic re-measurement is achieved.

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COARSE WOODY DEBRIS, SMALL WOOD AND TWIGS, AND LITTER

Kim Whitford, Richard Robinson and Lachie McCaw

Introduction

Wood and leaf litter on the forest floor provides habitat for many fungi, invertebrates, small reptiles, and mammals. The litter layer also affects soil moisture, and in conjunction with micro-organisms, influences soil structure. Coarse woody debris (CWD), small wood and twigs (SWT) and litter are important structural and biological components of forest ecosystems. Disturbances such as timber harvesting and fire affect the volumes and types of debris that occur in forests. This component of the FORESTCHECK monitoring program determines the amount of debris on each of the FORESTCHECK grids and monitors various attributes of this debris.

This component of FORESTCHECK is intended to:

- measure and record the amount of litter, SWT, and CWD on the ground in jarrah forest managed for silviculture (i.e. gap release and shelterwood treatments) and in uncut forest
- analyse trends within and between the treatments over time
- provide data for analysis of distribution patterns of other organisms such as invertebrates, small mammals, fungi and cryptogams.

Coarse woody debris is defined as woody plant material larger than 2.5cm in diameter. Small wood and twigs is woody material 1–2.5cm in diameter, and litter is dead leaves and other dead fine vegetative material less than 1cm in diameter.

Field and Laboratory Measurements

Coarse woody debris, small wood and twigs and litter assessments were undertaken on all nine FORESTCHECK grids, including three external reference (FC49, FC54 and FC10), two shelterwood (FC53, FC56), one selective cut (FC51) and three gap release grids (FC50, FC52 and FC55) in the Jarrah South ecosystem in Donnelly District (Donnelly 2) in 2013. The time since fire on the Easter external reference grid (FC10) was 18 years and on all other grids it ranged from 4–9 years. In earlier FORESTCHECK monitoring, the external reference grid at Easter block (FC10) was also sampled for litter and small twigs in 2002 and 2008; CWD measurements were also taken in 2008.

Small wood and twigs and litter assessments were undertaken from 2–6 December 2013. Twenty two samples each of SWT and litter were collected from each FORESTCHECK grid as per the methods detailed in the FORESTCHECK Operations Plan (DEC 2006). Briefly, on each grid, litter samples were collected from 11 plots, each $0.05m^2$, along each of two 100m transects. SWT samples were collected from $1m^2$ plots, directly adjacent each litter plot. All samples were oven dried for 24 hours and dry weights used to determine loads in tonnes per hectare ($t\ ha^{-1}$).

CWD was assessed along three 200 m long transects on each grid using the line intercept technique (van Wagner 1968). The assessment of CWD volume (m^3ha^{-1}) and condition followed the procedures described in Whitford *et al.* (2008). The Easter external reference site was originally assessed in 2008. It was not reassessed for CWD in 2013 as the site has not been burnt since the last assessment and there was no evidence of any substantial change in CWD load along transects.

Preliminary Results and Discussion

Litter

Litter accumulation is influenced by a variety of factors including stand structure and density, the extent of fuel consumption during previous fires, time since previous fire and reduction in canopy density by defoliating insects. In 2013, litter loads on grids within and between treatments were generally variable and reflected time since fire. The heaviest litter loads were recorded on the

Easter external reference (FC10), the Barlee shelterwood (FC56) and the Lewin gap release (FC55) grids, all of which had the longest time since fire (Fig. 1).

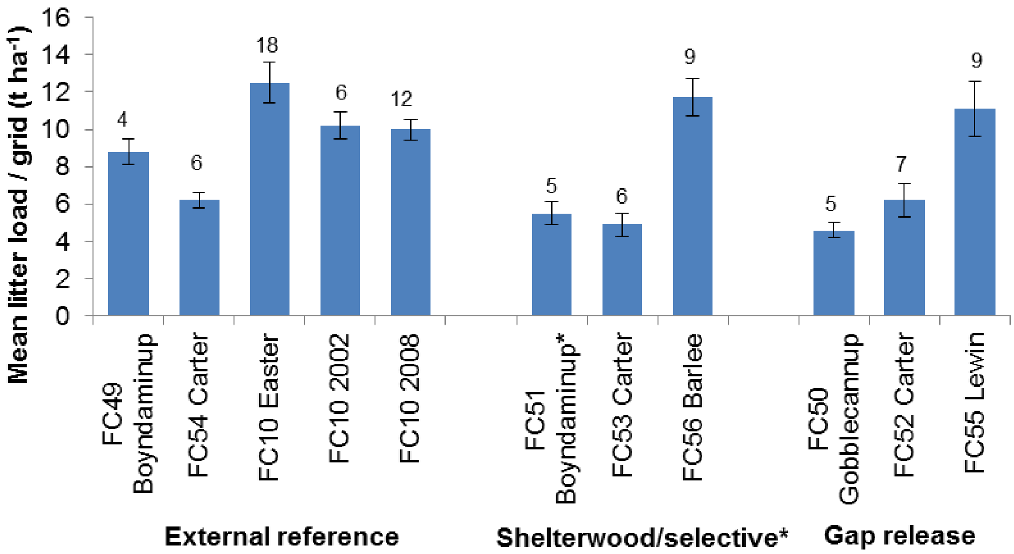

Figure 1. Mean litter loads (t ha^{-1} ± se) calculated at each FORESTCHECK grid at Donnelly 2 in 2013 and FC10 at Easter forest block in 2003, 2007 and 2013. Numbers above columns indicate years since fire.

Within each treatment, litter loads were generally related to time since fire. The Easter external reference had the highest litter load in 2013 (12.5 t ha^{-1}). The loads at the Easter external reference were similar in 2002 and 2007 (10.2 and 10 t ha^{-1} respectively) despite 6 years of accumulation from 2002–08 and suggests that 10 t ha^{-1} may be the stable litter load at this site in the absence of fire. The additional 2.5 t ha^{-1} recorded in 2013 may be due to extra leaf fall resulting from the gum leaf skeletoniser (GLS) outbreak during 2010–12, which was particularly severe at Easter forest block (Farr and Wills 2012).

Small wood and twigs

The amount of SWT on all sites was low (Fig. 2) compared to that of the litter (Fig. 1). The SWT load on the Easter external reference grid was exceptionally high and that on the Gobblecannup gap release (FC50) was noticeably low compared to other grids. The increase at Easter may be due to accelerated small branch and shedding as a result of severe defoliation by GLS during 2010–12. However, Carter forest block was also defoliated during the GLS outbreak and the external reference grid there has one of the lowest SWT loads measured. 2010 was also the driest year on record (BoM 2010) and was followed by a dry autumn in 2011 which may increase twig and small branch shedding (this trend was noted at the Wellington East grids in 2011 and the Blackwood Plateau grids in 2012—see FORESTCHECK Report of Progress 2010–11 and 2011–12). However, without previous measurements on the Donnelly 2 grids it is difficult to determine what effect these events had on the SWT loads there.

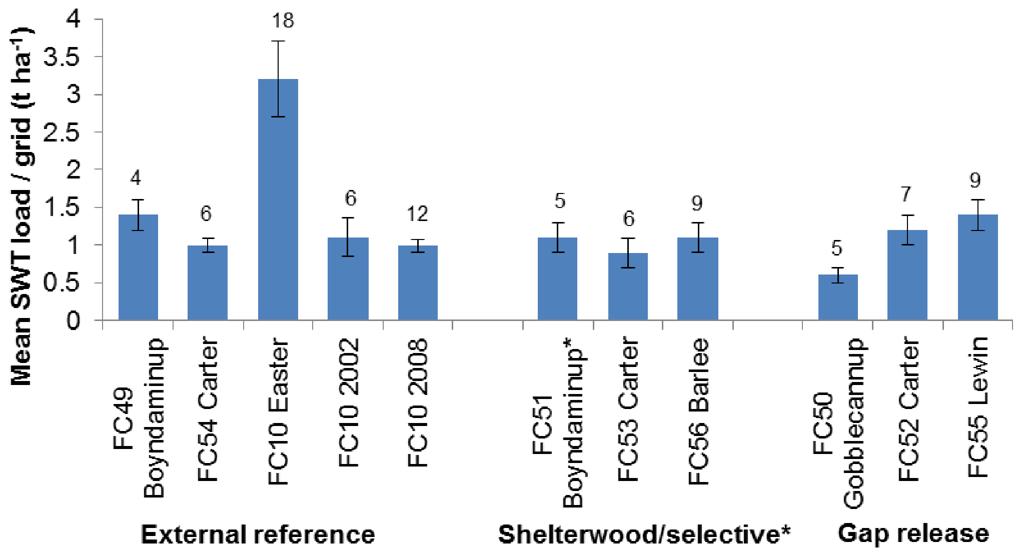

Figure 2. Mean loads (t ha^{-1}) of small wood and twigs measured at each FORESTCHECK grid at Donnelly 2 in 2013 and FC10 at Easter forest block in 2003, 2007 and 2013. Numbers above columns indicate years since fire.

Coarse woody Debris

The loads of CWD observed on the Donnelly 2 grids (mean 189 ± 16m^{3}ha^{-1}, range 108–247m^{3}ha^{-1}) (Table 1) were within the range of the loads observed and reported for the other 48 FORESTCHECK grids (see Forestcheck Report of Progress 2009–10), though slightly higher than the mean for these grids (mean 120 ± 11m^{3}ha^{-1}, range 26–407m^{3}ha^{-1}, n = 48). The CWD load carried on FC10, the Easter external reference (244m^{3}ha^{-1}) was relatively high when compared to the other 55 Forestcheck grids distributed across the SW jarrah forest. This grid also stands out as an outlier when compared to all other never harvested external reference grids (mean 64 ± 10m^{3}ha^{-1}, n = 14) and had a high CWD load compared to the other Donnelly 2 grids (mean 182 ± 16m^{3}ha^{-1}, n = 8) (fig. 3). The high CWD load on FC10 greatly increases the mean load for the never harvested class of external reference sites (fig. 4).

The post harvest silvicultural treatment on grids 50, 53, 55, and 56 included pushdown of smaller diameter cull trees. This increased the volume of CWD on these grids (mean 221 ± 10m^{3}ha^{-1}) compared to those harvested grids that did not have pushdown (mean 136 ± 16m^{3}ha^{-1}, n = 3). Consistent with observations on the previous 48 grids, the amount of CWD showing evidence of having been sawn increased as the intensity of the harvest treatment increased (Fig. 4).

The response across the harvested treatments was consistent with that observed for these treatments on the previous 48 grids, where the CWD load increased with the intensity of the harvest treatment and the time since harvest. The response on the never harvested treatments was not consistent with the trend previously observed. This was due to the very high CWD load observed on FC10, which substantially increased the mean for this treatment.

Table 1. The FORESTCHECK grids assessed in 2013 and the Easter grid assessed in 2008 for coarse wood debris (CWD) volume and condition. Grids are grouped by treatment type.

Grid	Location	Treatment	Year grid established	Year of most recent harvest	No. of cuts	Mean CWD volume (m^3ha^{-1} ± se)
FC54	Carter	external reference	2013	uncut	0	166 ± 96
FC49	Boyndaminup	external reference	2013	1960s*	1	108 ± 63
FC10	Easter	external reference	2001	uncut	0	244 ± 33
FC50	Gobblecannup	gap release	2013	2006	3	226 ± 130
FC52	Carter	gap release	2013	2006	2	164 ± 95
FC55	Lewin	gap release	2013	2004	3	248 ± 143
FC51	Boyndaminup	selective cut	2013	2007	2	135 ± 78
FC53	Carter	shelterwood	2013	2007	2	205 ± 118
FC56	Barlee	shelterwood	2013	2006	2	208 ± 120
All	**Mean**	**All treatments**				**189 ± 16**

* A small number of stumps on FC49 suggest that a number of trees were selectively harvested in the decade 1960-69

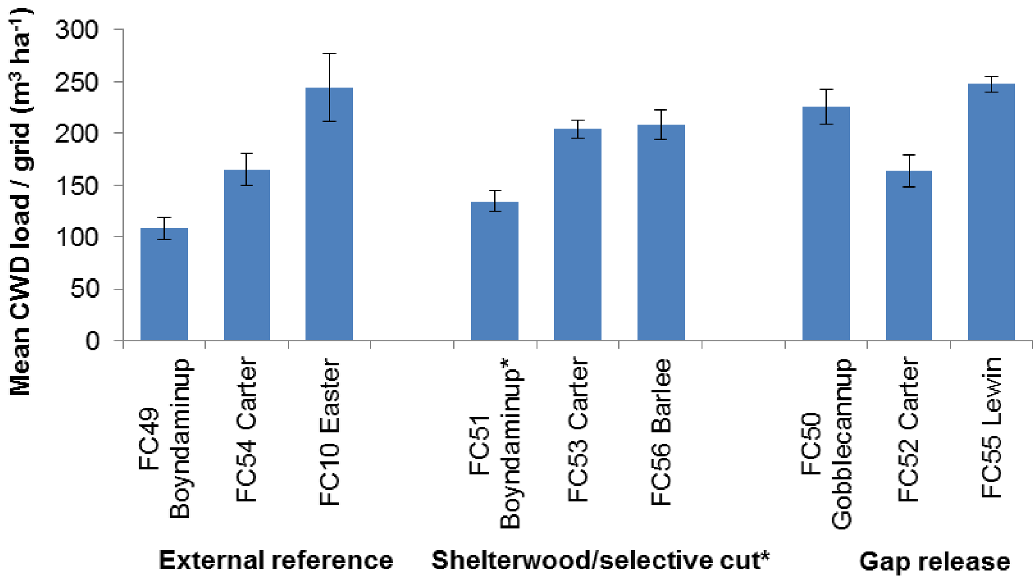

Figure 3. Mean loads (m^3ha^{-1} ± se) of coarse woody debris (CWD) > 2.5 cm in diameter at each FORESTCHECK grid at Donnelly 2 in 2013 and Easter block in 2008.

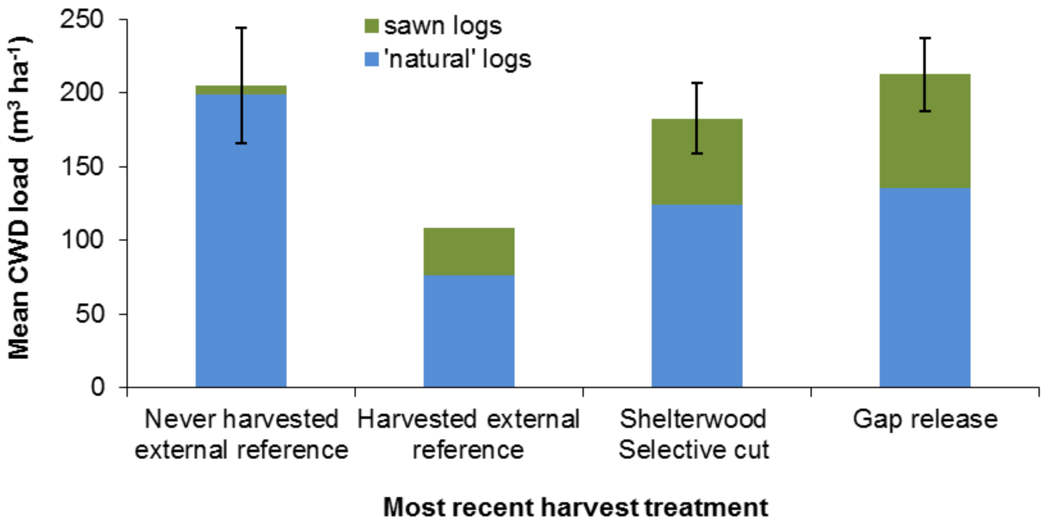

Figure 4. Mean loads ($m^3 ha^{-1}$ ± se) of coarse woody debris (CWD) >2.5cm in diameter derived from felled logs and from 'natural' logs on never harvested and various harvested FORESTCHECK treatments at Donnelly 2 in 2013.

Conclusions

Broad observations resulting from CWD, litter and SWT sampling at Blackwood Plateau in 2012 include:

- Litter loads reflected time since fire, except on the Easter external reference grid.
- SWT loads were similar on all grids and all treatments except for the Easter external reference grid.
- The Easter external reference grid had a high litter and exceptionally high SWT load, which may be the result of defoliation and twig shedding following a severe gumleaf skeletoniser outbreak in 2011–12.
- The CWD loads across the Donnelly 2 grids were generally high compared to the previous 48 FORESTCHECK grids.
- FC10, the Easter external reference grid, had a very high CWD load for this never harvested treatment. This is largely attributable to the very high stand basal area across this grid.
- Post harvest pushdown treatment appears to have increased the CWD loads on grids FC50, FC53, FC55, and FC56.
- CWD load increased with the intensity of the harvest treatment and the time since harvest. This was consistent with previous observations on FORESTCHECK grids. The very high CWD load on FC10 substantially increased the mean for the never harvested treatments and this response was not consistent with the trend previously observed for this treatment.

Acknowledgements

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MACROFUNGI

Richard Robinson, Sapphire McMullan-Fisher and Prue Anderson

Introduction

Fungi are considered one of the most important forest organisms in terms of both biodiversity and forest function. Soil, litter and wood inhabiting fungi play major roles in decomposition and nutrient cycling. Mycorrhizal fungi enhance nutrient uptake of plants and may enhance plant resistance to some pathogens. In addition, underground truffle-like fungi are an important food source for native animals, especially following disturbance such as fire.

Recent research on fungi in Western Australia's southern forests has shown that fungal communities respond to fire and other forest management activities and that species assemblages change with time since disturbance. Knowledge on fungal diversity and the ecological roles that fungi play is of vital importance to forest managers in making decisions regarding sustainable forest management.

The objective of this component of the FORESTCHECK program is to:

- monitor and record the species of macrofungi in the various silvicultural treatments of managed jarrah forest (shelterwood, selective cut and gap release) and in uncut reference forest
- analyse trends in species composition, richness and abundance and substrate utilization over time
- generate detailed descriptions of unknown or unnamed species.

Field Survey

Nine FORESTCHECK grids, including three external reference (FC49, FC54 and FC10), two shelterwood (FC53, FC56), one selective cut (FC51) and three gap release grids (FC50, FC52 and FC55), were monitored for macrofungi in the Jarrah South ecosystem in Donnelly District in 2013.

Two surveys were conducted, the first from 4–18 June and the second from 25 June–11 July. Surveys are conducted when the soil dryness index (SDI) indicates suitable conditions for fruit body development. SDI uses daily temperature, rainfall and evapotranspiration rates to determine a value that reflects the moisture content of surface soil, deep forest litter and woody debris (i.e. the major fungal habitats) and the value reflects the amount of rain (mm) needed to bring the soil back to field capacity (Burrows 1987). Prior research and previous FORESTCHECK surveys indicate that the soil dryness index (SDI) should be below 50 and falling to provide favourable conditions for the initiation of macrofungal fruit body development; and maximum species diversity is generally encountered when the SDI first falls to zero (Robinson 2007), indicating fully saturated conditions in the upper soil. During surveys, the SDI fluctuated around the 20 unit level for the first survey and around15 for the second, which implied ideal conditions for fruit body development. The SDI reached zero on 15 July (Fig 1).

In each survey, all nine grids were monitored. All macrofungal species and their abundance were recorded along 2 x 200m transects on each grid (see grid setup on p.5). All new or previously unrecorded taxa were photographed *in situ* and vouchers collected. For wood decay fungi such as *Stereum hirsutum*, individual hymenia (s. hymenium = spore-bearing layer of a fruit body) were counted irrespective of whether they arose from the same cluster or not, and for resupinate fungi such as *Mycoacea subceracea* or *Hypoxylon* spp., individual 'patches' of hymenium on the wood surface were counted irrespective of their size. For a small number of species that fruited in clusters, fruit bodies were counted up to 20 then visually estimated in steps of five up to 50. Larger clusters were scored at 75 or 100+. Substrates on which species were growing were also recorded and included: soil, leaf litter, bark, twigs (<2.5cm), branches

(2.5–5cm), wood (>5cm), dung, other fungi and fruits of vascular plants. Host species were also recorded for parasitic and saprotrophic fungi.

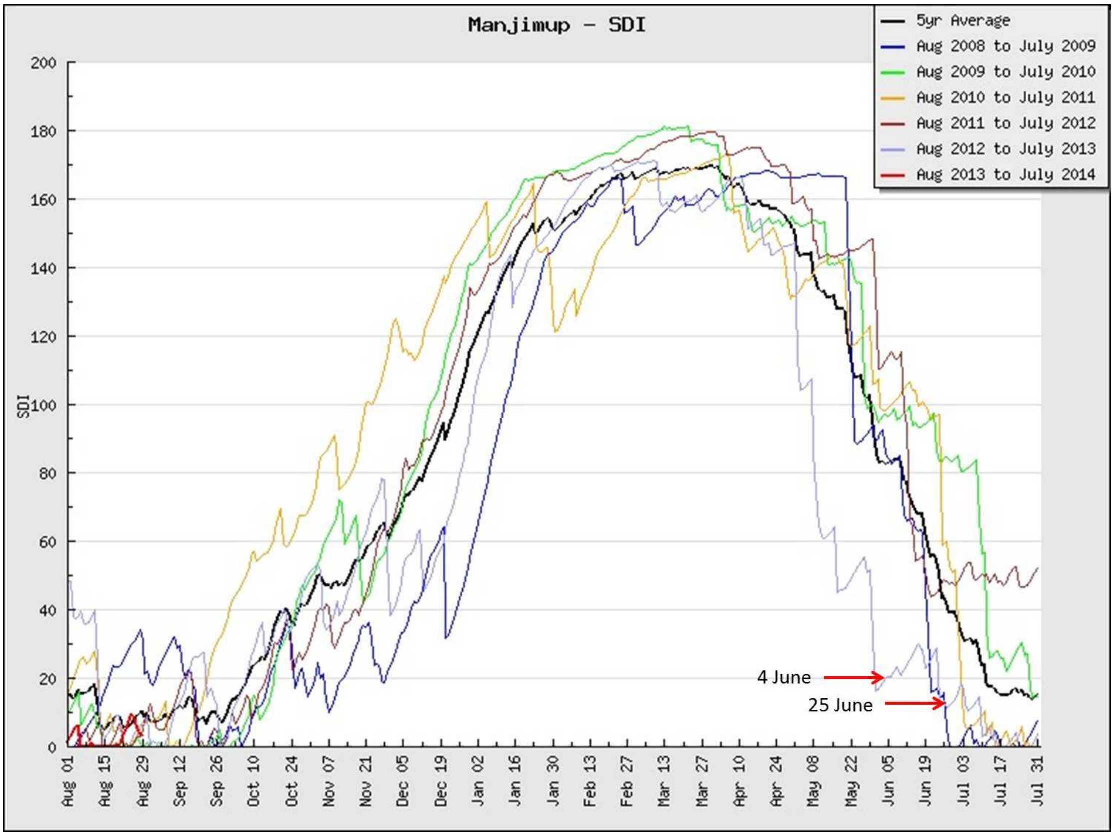

Figure 1. Daily soil dryness index (SDI) from the Manjimup automatic weather station during the period August 2009 to July 2013 (Bureau of Meteorology). The SDI at the start of each FORESTCHECK macrofungi monitoring period in 2013 is indicated by the red arrows.

Since 2002, a species list and field guide has been compiled from annual surveys and used to identify taxa based on morphological characteristics of fruit bodies. The list and field guide is reviewed annually, updating nomenclature and species determinations. In 2012-13, an extensive review of *Cortinarius* (including *Dermocybe*) species collected during the FORESTCHECK project was undertaken in collaboration with the Royal Botanic Gardens, Melbourne. ITS sequences were determined for 178 collections of *Cortinarius*, which represented 118 morpho-species recognisable on field characters. Eighty-six morpho-species were represented by single collections, and another 32 morpho-species by more than one collection. Analysis of ITS sequences (using a 98% similarity threshold) determined 94 molecular species (May *et al*. 2012, Robinson *et al*. 2013). This demonstrates a considerable variation in morphological characteristics for a number of *Cortinarius* species, and the difficulty of identifying them in the field. As a result of this study, the FORESTCHECK species reference list for *Cortinarius* was revised in 2013 to reflect the changes.

Preliminary Results and Discussion

Voucher specimen examination and processing

In the laboratory, voucher specimens were kept in a refrigerator at 5ºC. Processing of each voucher collection was completed on the day of collection or on the next morning. Detailed descriptions of the macroscopic characters of fresh specimens were compiled for each collection that represented a putative new species or represented noticeable variation in species concepts already determined. Following documentation, all collections were air dried at 35º C. At the completion of the field surveys, selected dried specimens were examined microscopically and detailed measurements of basidia, spore and hyphal structure were undertaken to either verify their identity or confirm undescribed species.

A species list has been compiled (Appendix 1). In total, 274 voucher collections were made representing 154 species. A total of 97 taxa were determined to be new records for FORESTCHECK. Voucher specimens are currently being entered onto the PERTH (WA Herbarium) database and are housed in the Tony Annells Herbarium at the Manjimup Research Centre. In order to verify identifications and keep pace with taxonomic revision of many species, taxonomic studies of specimens within the FORESTCHECK collection is an ongoing process.

Total species richness and abundance

A total of 460 species of macrofungi and 68,492 fruit bodies were recorded in the Donnelly 2 monitoring grids in 2013 (Appendix 1). Three hundred and fifty five species were recorded in the June survey and 365 in the second survey in July. Fifty seven per cent of the total species were recorded in both surveys (Fig. 2). This demonstrates the temporal differences in fruit body development throughout the fruiting season and the complications associated with analysing macrofungal communities in survey projects. It also demonstrates the importance of standardising survey methods and the value of intensive long-term survey for monitoring macrofungal communities.

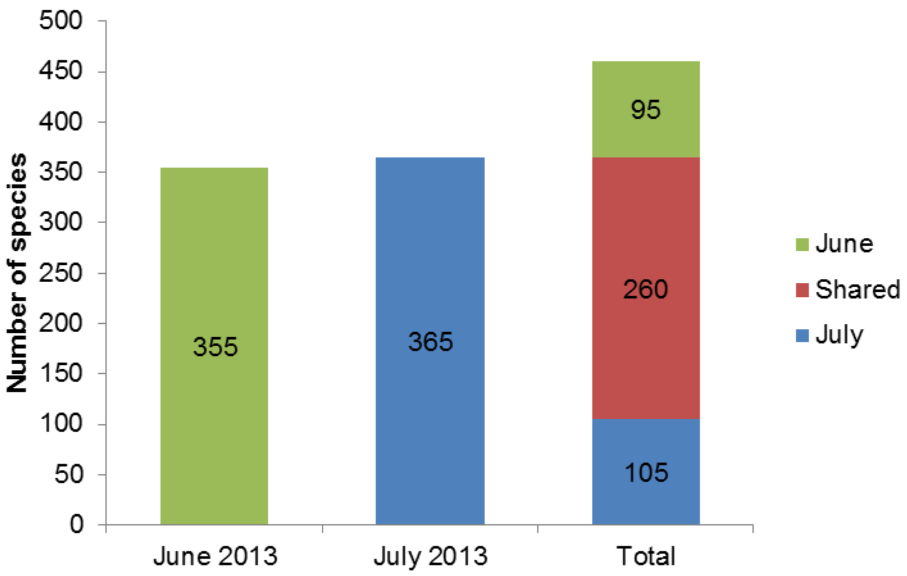

Figure 2. Total number of species recorded in June and July surveys on FORESTCHECK monitoring grids at Donnelly 2 in 2013.

Species richness on each grid was similar within and between treatments but abundance of fruit bodies on each grid varied. Total abundance on several harvested grids (FC50, FC51, FC55 and FC56) was noticeably lower than that on reference grids (Fig. 3). The length of time since fire did not appear to influence total species richness or abundance

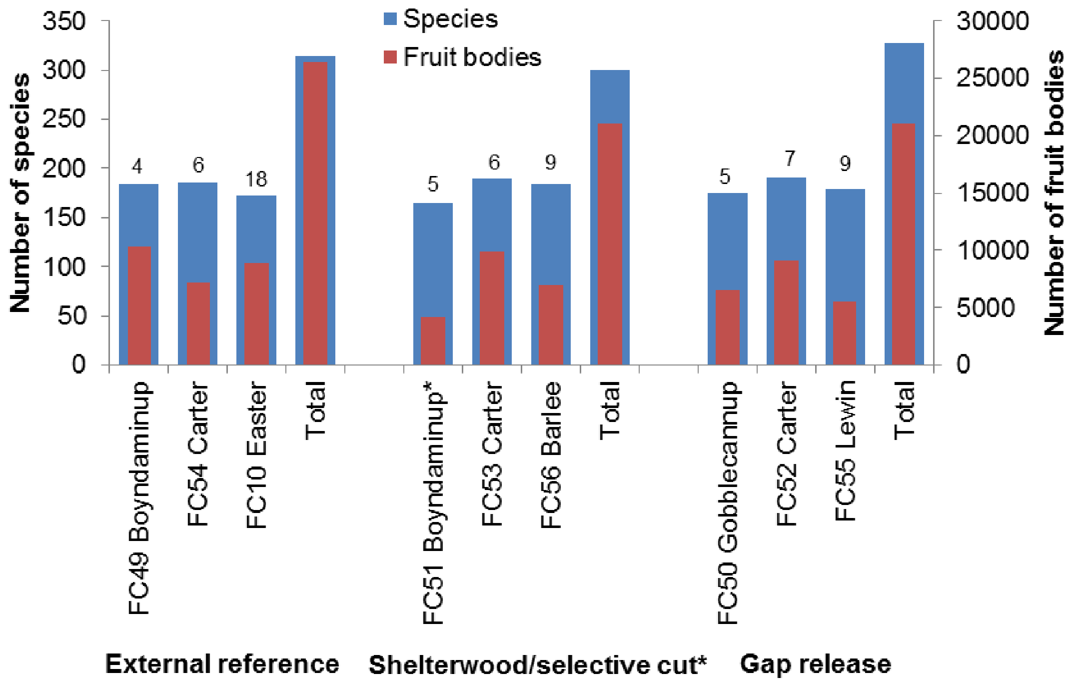

Figure 3. Total number of species and fruit bodies recorded on each FORESTCHECK monitoring grid at Donnelly 2 in 2013. Numbers above columns indicate years since the last fire.

Mean species richness and abundance per grid

Mean species richness and mean fruit body abundance per grid was similar in all treatments (Figs 4a and 4b). Although abundances recorded in harvested treatments were generally lower (Fig. 4b), it was not significant.

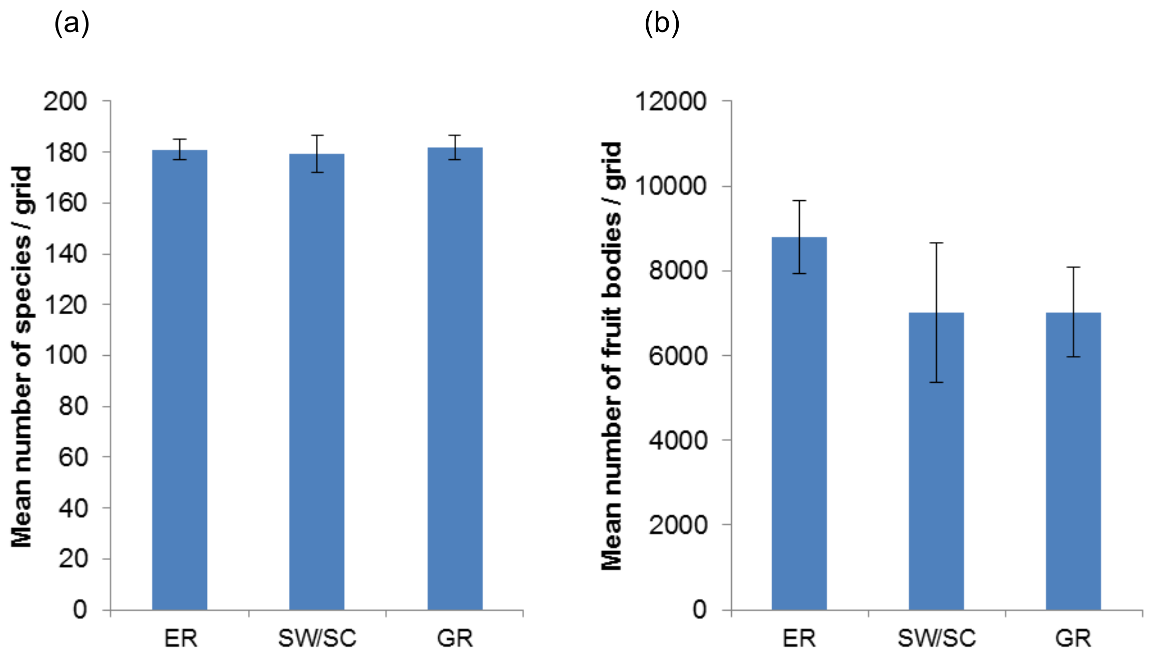

Figure 4. (a) Mean number of species of macrofungi per grid (± se) and (b) mean number of macrofungi fruit bodies per grid (± se) recorded in each treatment at Donnelly 2 FORESTCHECK monitoring grids in 2013. ER = external reference, SW/SC = shelterwood/selective cut and GR = gap release treatment.

Substrates
The three major habitats for fungi are soil, litter and wood. A small number of parasitic fungi fruit on their host and lichenised fungi fruit with their algal partner. The majority of macrofungi recorded at Donnelly 2 in 2013 fruited on soil. The mean number of species recorded on each substrate respectively was similar in each treatment (Fig. 5). Despite the larger amounts of coarse woody debris on harvested grids, mean species richness on wood was similar in both harvested and reference treatments.

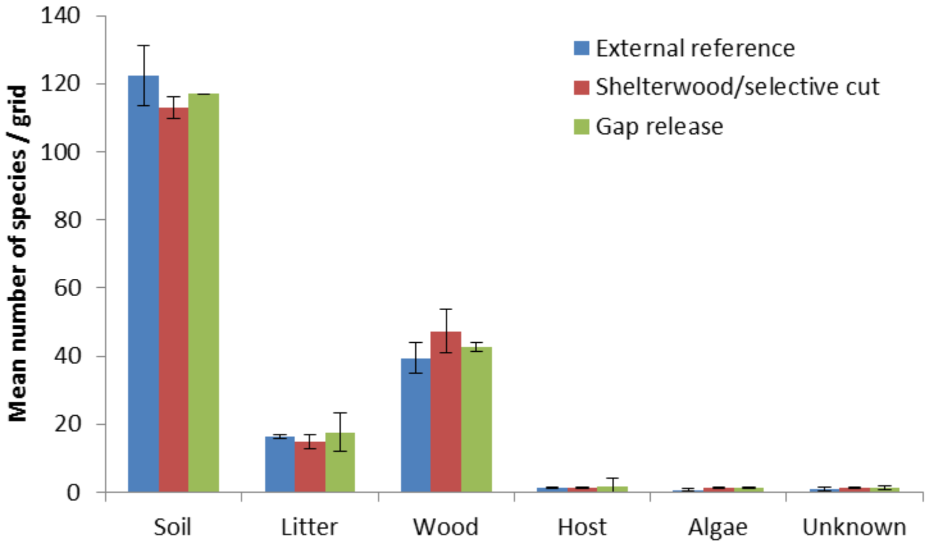

Figure 5. Mean number of species of macrofungi per grid (± se) recorded fruiting on soil, litter, wood and other substrates on the Donnelly 2 FORESTCHECK grids in 2013

Fruit body abundance recorded on soil litter and wood varied between treatments. More fruit bodies were recorded on soil and litter in reference treatments, and more were recorded on wood in harvested treatments (Fig. 6).

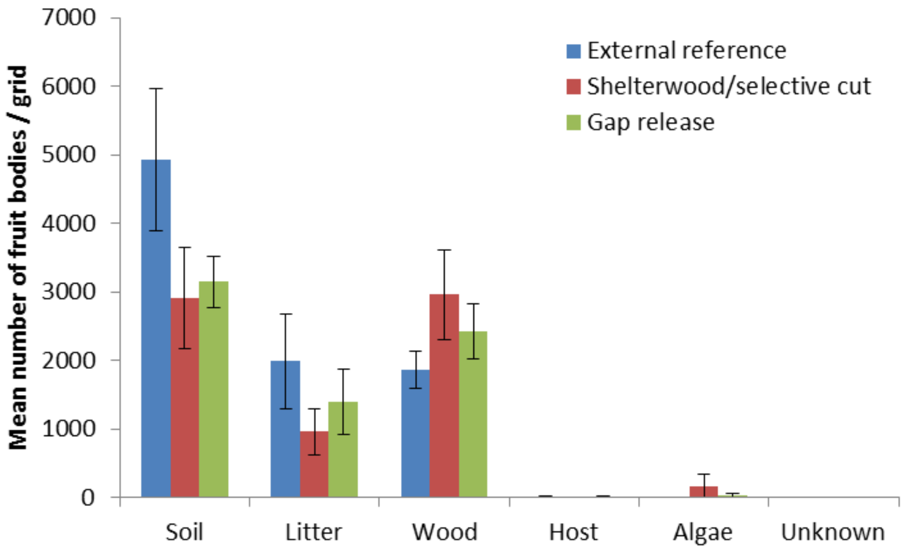

Figure 6. Mean number of macrofungi fruit bodies per grid (± se) recorded fruiting on soil, litter, wood and other substrates on the Donnelly 2 FORESTCHECK grids in 2013

Trophic status

Fungi are associated with two of the most beneficial ecological processes involved in ecosystem functioning; the formation of mycorrhizae, and decomposition. The vast majority (98%) of species recorded in 2013 were involved in these two roles (39% mycorrhizal, 59% saprotrophic). The mean number of mycorrhizal species per grid was higher in reference grids than in harvested grids, while the mean number of saprotrophic species was similar in each treatment (Fig. 7).

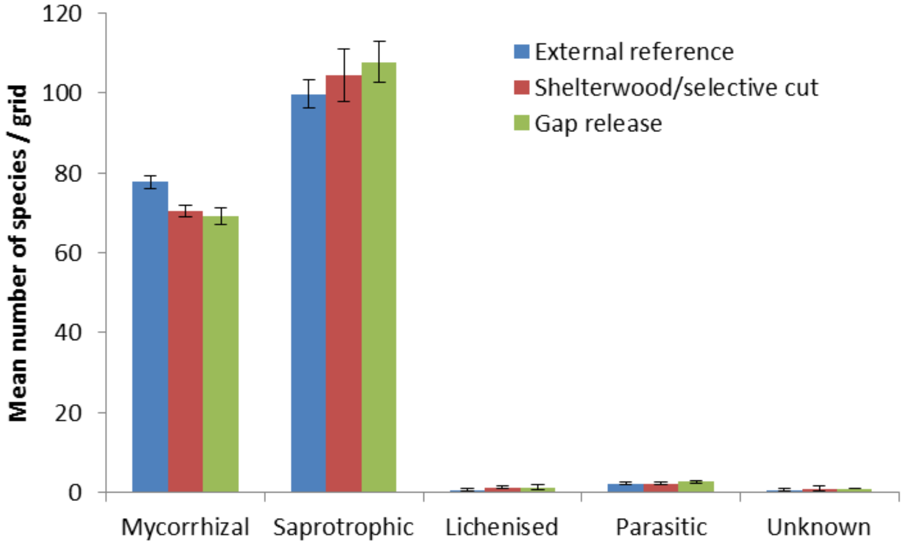

Figure 7. Mean number of mycorrhizal, saprotrophic, lichenised and parasitic species of macrofungi per grid (± se) recorded on the Donnelly 2 FORESTCHECK grids in 2013

The mean abundance of mycorrhizal fruit bodies per grid was higher on reference grids compared to harvested grids, but the abundance of saprotrophic fungi fruit bodies was similar in all treatments (Fig. 8).

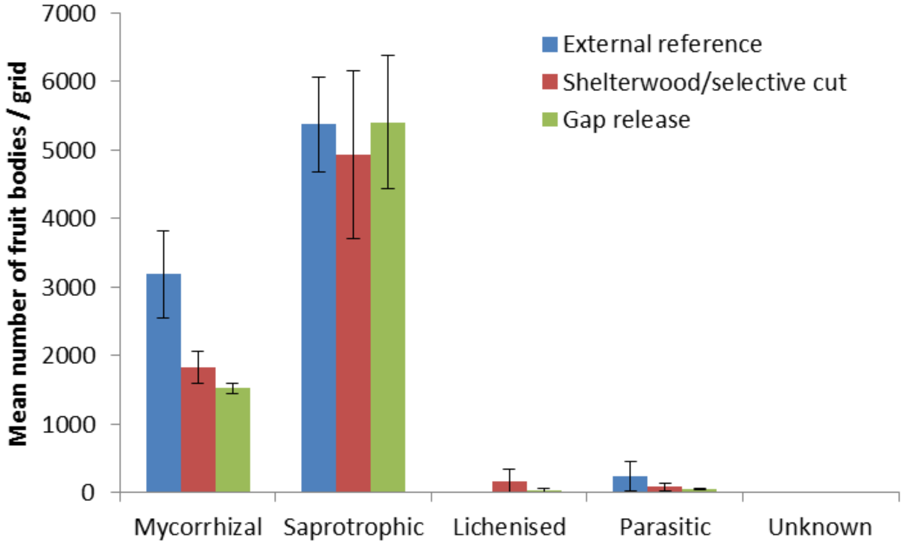

Figure 8. Mean number of mycorrhizal, saprotrophic, lichenised and parasitic macrofungal fruit bodies per grid (± se) recorded on the Donnelly 2 FORESTCHECK grids in 2013

Cortinarius (Fig. 9a and b) was the most common and diverse mycorrhizal genera, with a total of 62 species (including 10 species of *Dermocybe*) producing 4,627 fruit bodies. Other common mycorrhizal genera were *Inocybe* (12 spp.), *Russula* & Lactaruis (13 spp.) *Tricholoma* (11 spp.), *Boletus, Boletellus* & *Rubinoboletus* (11 spp.) and *Amanita* (9 spp.).

The most diverse saprotrophic genera were *Entoloma* (31 spp., see Fig. 9c) and *Mycena* (27 spp.). Species of Mycena produced 7,672 fruit bodies, but the most abundant taxa were species of *Gymnopilus* (see Fig. 9d), of which six species produced 5,410 fruit bodies.

Figure 9. Comon mycorrhizal fungi (a) *Cortinarius* (*Myxacium*) sp.146 'orange brown viscid cap' and (b) *Cortinarius* sp. 98 'pointy cap'; common saprotrophic fungi (c) *Entoloma* sp. 942 'light grey brown cap, tan gills, blue stem' and (d) *Gymnopilus alantopus*; (e) Coltricia cinnamomi infected with the parasitic fungus *Hypomyces* sp.729 'creamy pimples on coltricia', and (f) a lichenised fungus, *Lichenomphalia umbellifera* fruiting from an algal/moss mat on open sandy soil recorded on Donnelly 2 FORESTCHECK grids in 2013

Few macrofungi are parasitic or lichenised. *Armillaria luteobubalina* is a common parasitic species found throughout jarrah forest, being more prevalent in the wetter southern regions. It infects both tree and understorey species. Species of Hypomyces are also common parasites on other fungi, especially boletes and *Coltricia cinnamomi* (Fig. 9e). *Beauveria bassiana* is a common parasite on insect larvae. *Lichenomphalia unbellifera* (Fig 9f) and *L. chromacea* are common lichenised fungi that fruit prolifically from algal mats on either bare soil or on well-decayed wood and stumps. See Appendix 1 for data on these taxa.

Species richness and abundance at all locations from 2002–2013

Locations within the southern jarrah forest, i.e. Donnelly 1 and 2 (JS) and Blackwood Plateau (JB), are the most species rich in fungi. The drier Wellington East location (JNE) is also species rich, while the northern Perth Hills location (JNW-N) is the poorest for both species richness and abundance (Fig. 10). Abundance generally reflected species richness, except at Wellington 1 (JNW-C) in 2003, where abundance appeared to be higher in relation to the number of species recorded. In general, more species of large robust fungi were recorded at Wellington East, while very few smaller delicate species were found. This may be a reflection of the drier more open environment.

2013 appears to have been an exceptional year for macrofungal fruiting. In addition to the high number of species recorded, the total abundance was 2½ times more than the next most abundant years (2002-03 & 2008). The total number of fruit bodies recorded (68,492) represents

9.5 fruit bodies for each metre of survey conducted. The increased diversity and abundance in 2013 is likely due to the higher than average rainfall experienced in January, March and May (Fig 11)—conditions rarely experienced in the previous 10 years or so. This resulted in lower SDI throughout May and June than in the previous 5 years (see Fig. 1 for comparisons of SDI at Manjimup for 2008–2014).

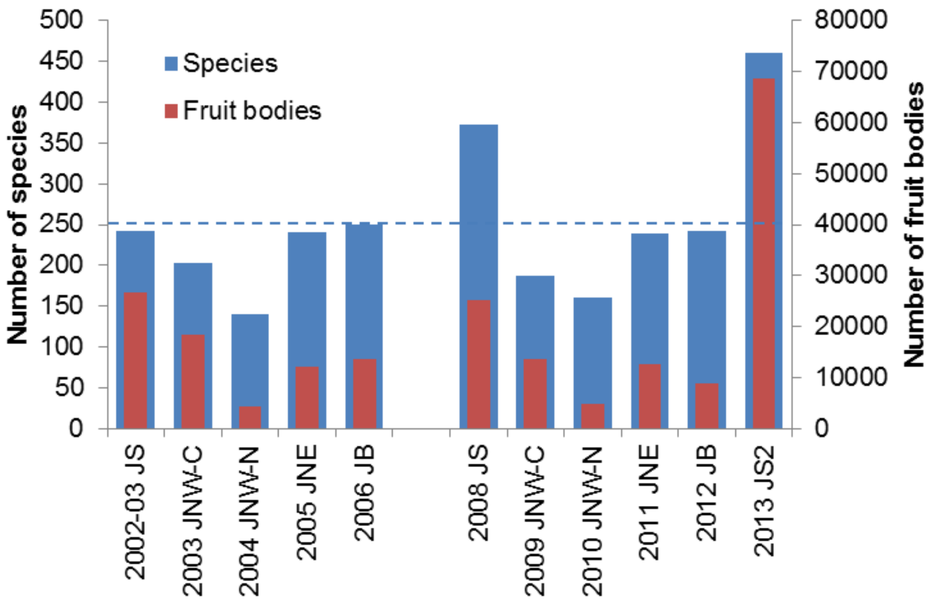

Figure 10. Total number of species and fruit bodies recorded at each FORESTCHECK location from 2002–2013. The dotted line represents the average number of species recorded per year (250). JS = Jarrah South, JNW-C = central region of the Jarrah North West, JNW-N = northern region of the Jarrah North West, JNE = jarrah North East and JB = Jarrah Blackwood Plateau ecosystem.

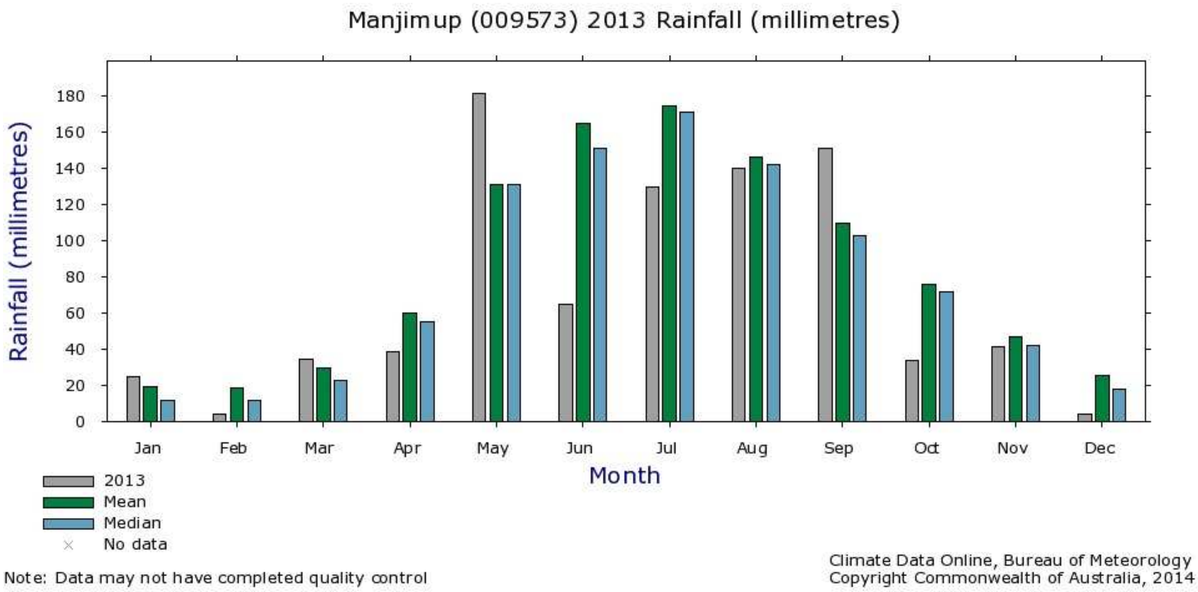

Figure 11. Total monthly rainfall for Manjimup in 2013, plotted against the long-term average monthly mean and median (Bureau of Meteorology http://www.bom.gov.au/climate/data/ [accessed on 2.5.2014])

In 2013, the fruiting of stipitate hydnoid fungi was exceptional. This is an artificial group of morphologically similar but unrelated mycorrhizal fungi. They are characterised by having typical caps and stems, but with spines on the underside of the caps. In Western Australia, the genera that make up this group consist of: *Auriscalpium*, *Hydnellum*, *Hydnum*, *Phellodon* and *Sarcodon* (Fig. 12). In Europe, species of *Hydnellum*, *Phellodon* and *Sarcodon* are Red Data listed and populations are declining in a number of countries. The declines are assumed to be due to artificially high nitrogen levels and loss of mature and ancient forest systems (Parfitt et al. 2007, Arnolds 2010). Their presence indicates that jarrah forest is able to support species sensitive to environmental change. In previous years, 1–5 species were generally recorded except in 2006 and 2008 where 8 and 12 species were recorded at the Blackwood Plateau (2008 JB) and Donnelly 1 (2008 JS) locations respectively (Fig. 13). In 2013, 19 species were recorded, including 13 species of *Phellodon*, three *Hydnellum*, two *Hydnum* and one *Sarcodon* species. All genera were represented equally in all treatments, except that only seven species of *Phellodon* were recorded in the gap release compared to 10 in both the reference and shelterwood treatments (Fig 14).

Figure 12. Species of stipitate hydnoid fungi from jarrah forest; (a) *Phellodon* sp. 634 ‘silver grey’, (b) *Phellodon* sp. 952 ‘small, orange spines’, (c) *Hydnellum* sp. 87 ‘red brown’, (d) *Hydnellum* sp. 480 ‘orange-tipped spines’, (e) *Sarcodon* sp. 263 ‘brown’ and (f) *Hydnum* aff. *repandum*

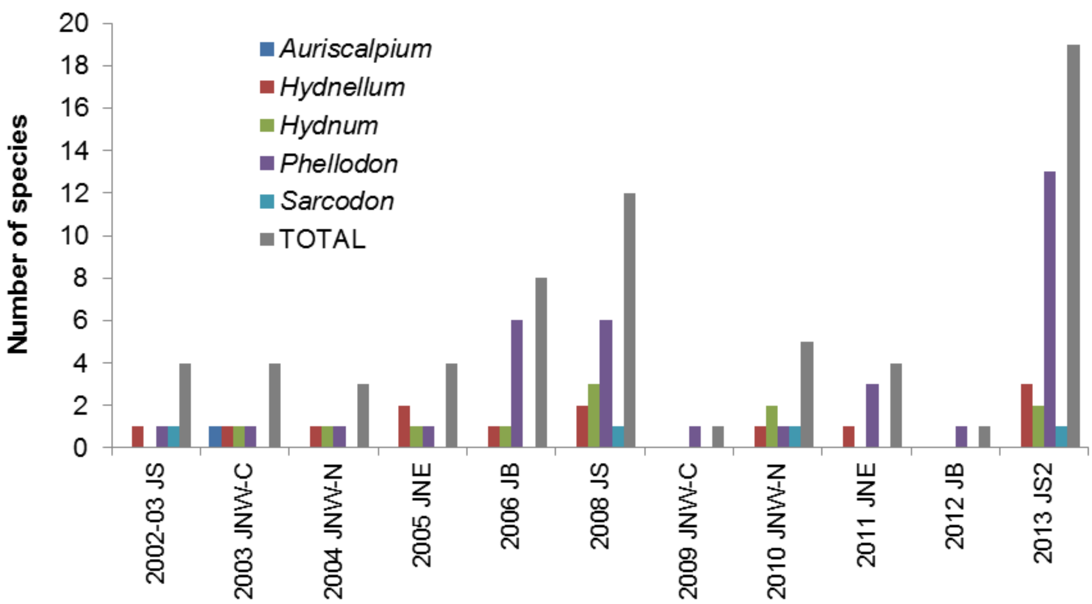

Figure 13. Number of stipitate hydnoid species recorded on FORESTCHECK monitoring grids from 2002–2013. JS = Jarrah South, JNW-C = central region of the Jarrah North West, JNW-N = northern region of the Jarrah North West, JNE = jarrah North East and JB = Jarrah Blackwood Plateau ecosystem.

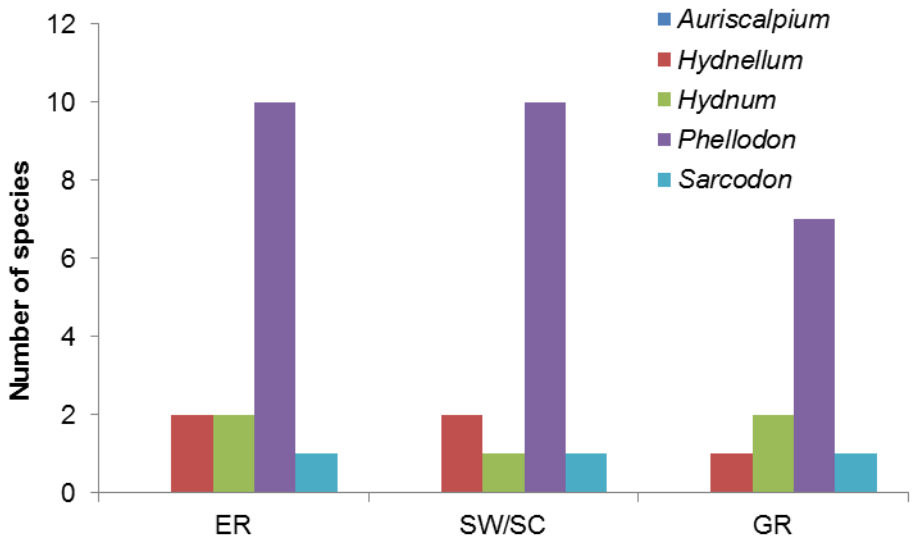

Figure 14. Number of stipitate hydnoid species recorded in silvicultural treatments on FORESTCHECK monitoring grids at Donnelly 2 in 2013. ER = external reference, SW/SC = shelterwood/selective cut and GR = gap release treatment.

Abundance declined with treatment intensity (Fig. 15). This is in accordance with the general belief that most stipitate hydnoid fungi prefer mature habitats. In jarrah forest, at least, most species were present in the gap release treatment, but they did not produce as many fruit bodies as in the less disturbed shelterwood/selective cut or undisturbed reference treatments. Further monitoring of disturbed sites over time will determine whether this is a short-term effect, or if fruit body production increases as sites regain mature attributes.

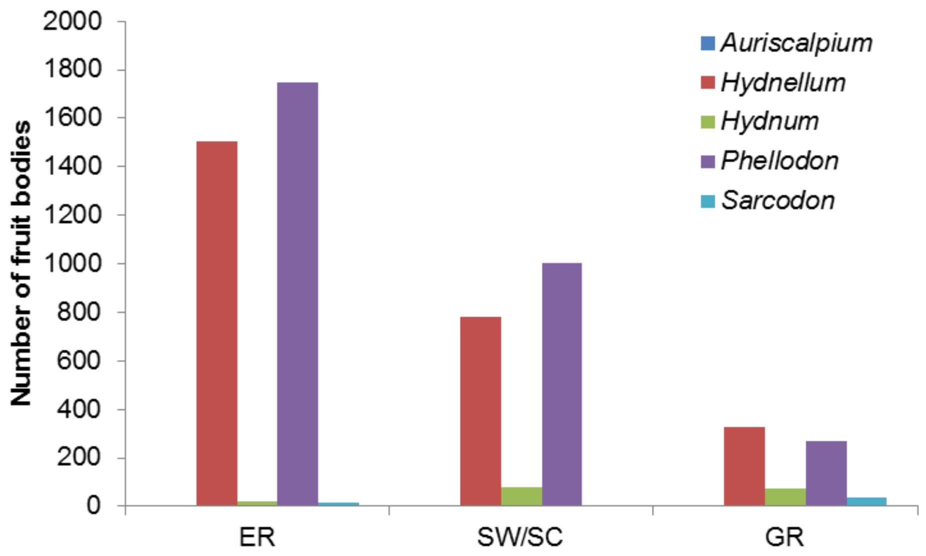

Figure 15. Number of stipitate hydnoid fruit bodies recorded in silvicultural treatments on FORESTCHECK monitoring grids at Donnelly 2 in 2013. ER = external reference, SW/SC = shelterwood/selective cut and GR = gap release treatment.

Species accumulation across all locations from 2002–2013

The total number of species of macrofungi recorded on FORESTCHECK monitoring grids between 2002 and 2013 is 770 (based on the recently revised species list). The number of species has steadily increased from 235 in 2002–03 by an average of 53.5 species per year. The largest increase was 97, experienced in both 2008 and 2013, and the lowest was 15 in 2010 (Fig. 16).

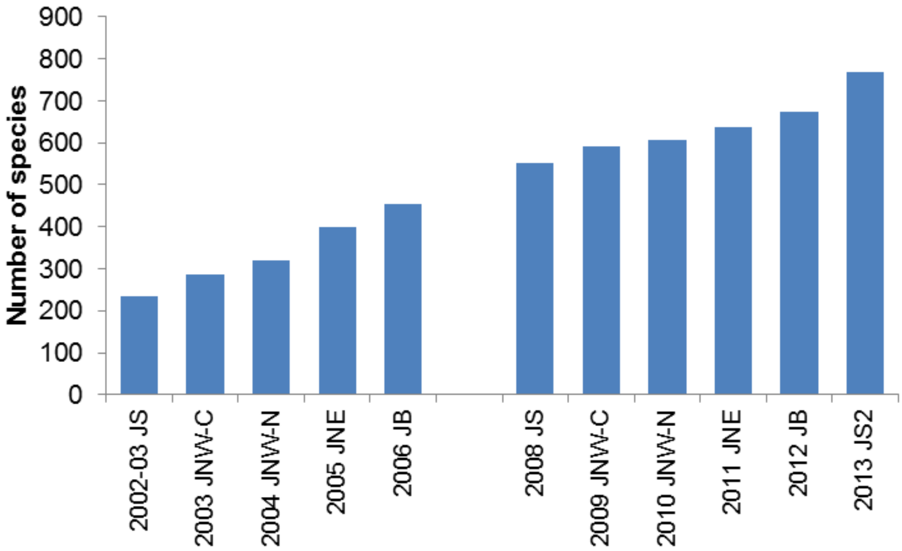

Figure 16. Species accumulation for macrofungi recorded on FORESTCHECK grids from 2002-2013. JS = Jarrah South, JNW-C = central region of the Jarrah North West, JNW-N = northern region of the Jarrah North West, JNE = jarrah North East and JB = Jarrah Blackwood Plateau ecosystem.

The accumulation curve appeared to plateau after 2009 at about 600 species, but it continued to rise again from 2011. The average annual increase from 2010 to 2012 was about 27 species per year compared to 59 per year for the period 2002 to 2009. The average annual accumulation during the first monitoring period of FORESTCHECK locations (2002–06) was 55 species per year and 44 during the second monitoring period (2008–12). In 2013, 97 new species were recorded.

The annual accumulation is closely related to survey intensity and is expected to decrease further (i.e. plateau) if monitoring continues on the same grids. However, as was the case in 2013, if new FORESTCHECK grids are introduced at different locations in different vegetation complexes, the accumulation would be expected to increase. As was also experienced in 2013, exceptional and favourable climatic conditions also contribute to extraordinary diversity and abundance.

Conclusions

The main observations made following monitoring of macrofungi in the Jarrah Blackwood Plateau ecosystem in the Blackwood District were:

- A total of 770 species of macrofungi have so far been recorded in FORESTCHECK and species accumulation continues to increase.
- The Donnelly 2 location in the Jarrah South ecosystem has a rich, diverse and abundant mycota, with a total of 460 species recorded, and 68,492 fruit bodies counted.
- Mean species richness per grid was similar in all treatments in 2013.
- The mean abundance of fruit bodies was consistently lower in harvested grids, but not significantly lower than the reference treatment.
- The majority of species fruited on soil, but their abundance was higher on soil and litter in the reference treatment and on wood in the shelterwood treatment.

- Saprotrophic fungi were more numerous and abundant than mycorrhizal fungi in 2013, and mycorrhizal fungi were more abundant on reference grids compared to shelterwood and gap release grids.
- Stipitate hydnoid fungi were common and abundant in 2013 compared to other years, but the abundance of *Hydnellum* and *Phellodon*, the two most common genera, was lower on harvested treatments.

Molecular determination of 118 putative morpho-species of *Cortinarius* collected from 2002 to 2012 revealed that they represented 94 molecular species. The species reference list for *Cortinarius* was reviewed and updated accordingly.

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APPENDIX 1. Species and number of fruit bodies recorded at Donnelly 2 FORESTCHECK grids in 2013. ER = external reference, SW/SC = shelterwood/selective cut and GR = gap release treatment.

Sp #	Species	ER	SW/SWC	GR	TOTAL
0	Agaric unidentified	9	3	29	41
894	Agaric. Olive to grey-brown, tough white stem (R.M. Robinson FC1767)		2		2
932	Agaric. White, burnt rubber, on wood (R.M. Robinson, S.J.M. McMullan-Fisher & P. Anderson FC1878)		3	6	9
39	*Agaricus austrovinaceous* Grgur. & T.W.May		1	2	3
71	*Agaricus* sp. small flat red stain (R.M. Robinson & R.H. Smith FC123)	3	1	10	14
240	*Agaricus* sp. small with red brown fibrils (R.M. Robinson & R.H. Smith FC407)	5	21	4	30
33	*Agaricus xanthodermus*Genev.			5	5
120	*Aleuria rhenana* Fuckel	113	70	69	252
126	*Aleurina ferruginea* (W. Phillips) W.Y. Zhuang & Korf	8		2	10
206	*Amanita ananiceps* (Berk.) Sacc.	7	5	15	27
395	*Amanita basiorubra* A.E.Wood - Not A. basiorubra - E.Davison			1	1
186	*Amanita brunneibulbosa* O.K.Mill.	2	5	25	32
875	*Amanita conicobulbosa* Cleland	1	1		2
269	*Amanita ochrophylloides*D.A.Reid		4	12	16
526	*Amanita* sp. small creamy white cap and stem with membranous ring (R.M. Robinson & R.H. Smith FC979)		6		6
531	Amanita spp. unidentified		1	4	5
196	*Amanita umbrinella* E.J.Gilbert & Cleland	2	4		6
6	*Amanita xanthocephala* (Berk.) D.A.Reid & R.N.Hilton	99	79	95	273
418	Amylotrama (Hysterogaster) sp citrus WFM153		1		1
629	*Amylotrama* (*Hysterogaster*) sp. yellow with olive gleba (R.M. Robinson & J. Fielder FC1190)		2	2	4
509	*Anthracophyllum archeri* (Berk.) Pegler		14	20	34
313	*Antrodiella citrea* (Berk.) Ryvarden	2			2
180	*Armillaria luteobubalina* Watling & Kile	666	236	127	1029
770	*Arrhenia* sp. (R.M. Robinson, K. Syme & J. Mccalmont WFM471)			19	19
714	*Asterostroma* sp. FC 1658	2			2
188	*Austroboletus laccunosus* (Kuntze) T.W.May & A.E.Wood	3		1	4
200	*Austroboletus occidentalis* Watling & N.M.Greg.	6		10	16
179	*Austropaxillus macnabbii* (Singer, J. García & L.D. Gómez) Jarosch	1	2		3
436	*Beauveria bassiana* (Bals.-Criv.) Vuill.		1	1	2
798	*Biscogniauxia plana* (Petch) Y.-M. Ju & J.D. Rogers FC1539	72			72
653	*Bjerkandera* sp WFM325	5	50		55
93	*Boletellus ananiceps* (Berk.) Singer	14	10	11	35
103	*Boletellus obscurecoccineus* (Höhn.) Singer	13	14	12	39
927	*Boletus sp* .nigerimus (R.M. Robinson, S.J.M. McMullan-Fisher & P. Anderson FC1882			3	3
29	*Boletus* sp. Boletus speciosa group - dull maroon, light stain (R.M. Robinson & R.H. Smith FC28)	2	4	1	7
253	*Boletus* sp. Boletus speciosa group - intense blue stain (R.M. Robinson & R.H. Smith FC439)	9	2	1	12
210	*Boletus* sp. Boletus speciosa group - orange pores (R.M. Robinson, R.H. Smith & K. Pearce FC344)		1	8	9
216	*Boletus* sp. 'brown' (R.M. Robinson, S.J.M. McMullan-Fisher & M. Read FC2051)			3	3
216b	*Boletus* sp. brown cap yellow pores which stain blue (R.M. Robinson, R.H. Smith & K. Pearce FC356)		5	25	30

Sp #	Species	ER	SW/SWC	GR	TOTAL
848	*Boletus* sp. brown cap, yellow pores (stain blue) flesh stains brown (R.M. Robinson, K.Syme, &P.Anderson WFM580)			11	11
607	*Boletus* sp. yellow brown, stains blue (R.M. Robinson & J. Fielder FC1102)	21	2	5	28
99	*Boletus* sp. yellow-red with blue staining flesh (R.M. Robinson & R.H. Smith FC398)	2	1	10	13
304	*Byssomerulius corium* (Pers. : Fr.) Parmasto	15	25	5	45
9	*Calocera guepinioides* Berk.	265	520	614	1399
557	*Camarophyllopsis sp. Napthalene*	1	71	12	84
187	*Campanella gregaria* Bougher	32	20	6	58
463	*Cantharellus concinnus* Berk.			1	1
265	*Cheilymenia coprinaria* (Cooke) Boud.	15	9	18	42
364	*Chlorociboria aeruginascens* subsp. *australis* P.R. Johnst.		2		2
573	*Chrysomphalina* sp. grey brown funnel, white decurrent gills, stippled stem WFM260		1	1	2
319	*Clavaria* (*Clavulinopsis*) sp. grey brown with black tips (R.M. Robinson & R.H. Smith FC758)	90		105	195
693	*Clavaria alboglobispora* R.H.Petersen FC1268			33	33
316	*Clavaria aurantia* Cooke & Massee	109	3	29	141
739	*Clavaria miniata* Berk. FC1375		2		2
81	*Clavulina* aff. *cinerea* (Bull. : Fr.) J.Schröt.	62	13	32	107
534	Clavulina amethystina (Bull. : Fr.) Donk / *Ramariopsis pulchella* (Boud.) Corner	7		1	8
344	*Clavulina* sp. cream, fluffy tips (R.M. Robinson & L. McGurk FC658)	13		1	14
700	*Clavulina* sp. fuzzy creamy white FC1297		2	2	4
458	*Clavulina* sp. pinkish brown, red-brown tips (R.M. Robinson & R.H. Smith FC805)	17		4	21
261	*Clavulinopsis* sp. cream (R.M. Robinson FC1390)	27	8	15	50
951	*Clavulinopsis* sp. grey brown with coral cystidia (R.M. Robinson, S.J.M. McMullan-Fisher & M. Read FC2026)		2		2
362	*Clavulinopsis* sp. grey brown, black tips (R.M. Robinson & R.H. Smith FC782)	3		6	9
660	*Clavulinopsis* sp. salmon-orange candles WFM355	8	27	12	47
143	*Clitocybe* aff. *clitocyboides* (Cooke & Massee) Pegler	5			5
197	*Clitocybe semiocculta* Cleland		3		3
950	*Clitocybe* sp. dark grey brown (R.M. Robinson, S.J.M. McMullan-Fisher & M. Read FC2022)	6			6
642	*Clitocybula* sp. khaki-yellow, moist BFF33	19	29	47	95
886	*Collybia* sp. dark brown, brown grey gills (R.M. Robinson FC1704)			1	1
880	*Collybia* sp. grey brown decurrent (R.M. Robinson FC1681)	2	12		14
15	*Coltricia cinnamomea* (Jacq.) Murrill	353	535	282	1170
128	*Coprinus* sp. basal hairs *sensu* Bougher & Syme			913	913
662	*Coprinus* sp. mealy scaled cap (on burnt soil)			1	1
394	*Coprinus* sp. roo poo			9	9
757	Corticioid blue grey crust WFM420			9	9
899	Corticioid. Black rubbery skin. (R.M. Robinson FC1786)	2			2
718	Corticioid. Creamy beige lumpy skin BFF157	3			3
973	Corticioid. *Phlebia* sp. greyish rose waxy skin (R.M. Robinson & S.J.M. McMullan-Fisher FC2132)		7		7
683	Corticioid. Thin creamy maze BFF0066 (Sp. 454a) FC1250	5			5
420	Corticoid. Salmon pink WFM76			3	3
617	*Cortinarius (Dermocybe)* sp. red brown, scurfy cap FC1129	29		3	32
702	*Cortinarius* (*Myxacium*) sp. khaki FC1299	3			3

Sp #	Species	ER	SW/SWC	GR	TOTAL
146	*Cortinarius* (*Myxacium*) sp. orange-brown viscid cap (R.M. Robinson & R.H. Smith FC223)	484	26	25	535
73	*Cortinarius* (*Phlegmacium*)sp. brown with purplish tints (R.M. Robinson & R.H. Smith FC434), FC1095, WFM406	26	29	10	65
314	*Cortinarius archerii* Berk.			1	1
207	*Cortinarius australiensis* (Cleland & Cheel) E.Horak	2			2
115	*Cortinarius austrofibrillosa* Grgur.	143	79	13	235
173	*Cortinarius basirubescens* (red cap/brown cap) Cleland & J.R.Harris	12	38	91	141
158	*Cortinarius microarcherii* Cleland (FC1183)	24	10	1	35
434	*Cortinarius rotundisporus Cleland & Cheel*	4		3	7
357	*Cortinarius sinapicolor* Cleland	18	2	1	21
279	*Cortinarius* sp. brown fibrillose (R.M. Robinson, R.H. Smith & K. Pearce FC521)		2		2
844	*Cortinarius* sp. brown moist cap, orange yellow gills, yellow stem (R.M. Robinson, K.Syme & P.Anderson WFM574)			3	3
928	*Cortinarius sp.* brown radial fibrils (R.M. Robinson, S.J.M. McMullan-Fisher & P. Anderson FC1871)	6	5	54	65
943	*Cortinarius* sp. brown suede domes (R.M. Robinson FC1960)		4	21	25
244	*Cortinarius* sp. brown umbonate (R.M. Robinson & R.H. Smith FC416), FC1050		2		2
154	*Cortinarius* sp. chestnut (R.M. Robinson & J. Fielder FC 1050), WFM110, FC918	105	62	102	269
382	*Cortinarius* sp. chestnut cap with yellow margin and yellow flesh (R.M. Robinson & R.H. Smith FC774)			1	1
201	*Cortinarius* sp. cream cap with orange gills (R.M. Robinson FC327)	15			15
303	*Cortinarius* sp. Creamy brown cap, lavender/brown gills (R.M. Robinson, K. Syme FC1485)	16	21	21	58
617	*Cortinarius* sp. dark brown scurfy cap, mustard gills (R.M. Robinson, S.J.M. McMullan-Fisher & M. Read FC2041)	36	10	296	342
934	*Cortinarius* sp. dark with tan margin (R.M. Robinson, S.J.M. McMullan-Fisher & P. Anderson FC1887)	6	19	42	67
252	*Cortinarius* sp. Golden tan, long stem, cob-web veil (FC504), FC669	27	15		42
941	*Cortinarius* sp. gun-metal green, in moss (R.M. Robinson & S.J.M. McMullan-Fisher FC1952)		5		5
68	*Cortinarius* sp. Honey brown (R.M. Robinson & R.H. Smith FC79)	4	38	10	52
935	*Cortinarius* sp. lavender all over (R.M. Robinson, S.J.M. McMullan-Fisher & P. Anderson FC1888)			16	16
646	*Cortinarius* sp. light brown, frosty BFF0058			7	7
898	*Cortinarius* sp. light brown, tan margin, ~viscid, white stem (R.M. Robinson, S.J.M. McMullan-Fisher & M. Read FC2006)	29	44	8	81
212	*Cortinarius* sp. orange brown (R.M. Robinson, R.H. Smith & K. Pearce FC371)	37	2		39
98	*Cortinarius* sp. pointy cap (R.M. Robinson & R.H. Smith FC134)	243	67	28	338
842	*Cortinarius* sp. purple veil (R.M. Robinson, K.Syme & P.Anderson WFM555)		7		7
881	*Cortinarius* sp. purple-brown cap , lavender stem, chocolate gills (R.M. Robinson FC1703)	2	1		3
626	*Cortinarius* sp. red brown pointy cap (R.M. Robinson & J. Fielder FC1181)			27	27
960	*Cortinarius* sp. slender green & gold (R.M. Robinson, S.J.M. McMullan-Fisher & M. Read FC2070)	5			5
670	*Cortinarius* sp. small fibrillose in moss (R.M. Robinson & J. Fielder BFF 84), WFM722	182	22	73	277

Sp #	Species	ER	SW/SWC	GR	TOTAL
230	*Cortinarius* sp. small orange brown viscid cap (R.M. Robinson & R.H. Smith FC390)	3	3	25	31
673	*Cortinarius* sp. small red-brown with tan margin BFF117	9	21	18	48
267	*Cortinarius* sp. snowy chestnut (R.M. Robinson & R.H. Smith FC478)	88	28	58	174
608	*Cortinarius* sp. sticky creamy beige	25			25
171	*Cortinarius* sp. vinaceus lilac (R.M. Robinson, R.H. Smith & K. Pearce FC543)	26	1	11	38
962	*Cortinarius* sp. viscid jarrah (R.M. Robinson, S.J.M. McMullan-Fisher & M. Read FC2077)	48		4	52
857	*Cortinarius* sp. viscid lavender with red-brown centre (R.M. Robinson WFM649)			10	10
270	*Cortinarius* sp. viscid red brown cap with white stem (R.M. Robinson & R.H. Smith FC482)	3	26	4	33
231	*Cortinarius* sp. yellow brown cap with tan margin (R.M. Robinson & R.H. Smith FC389)	16	10	17	43
237	*Cortinarius* sp. yellow with orange brown fibrils (R.M. Robinson & R.H. Smith FC403)	37	3	8	48
354	*Cortinarius* sp. yellow-brown cap with lavender/brown gills and white/lavender stem (R.M. Robinson & R.H. Smith FC698)			2	2
184	*Cortinarius* spp. (unidentified)	69	55	79	203
7	*Cortinarius sublargus* Cleland (FC6, FC431, FC1652)	25	112	31	168
584	*Cortinarius symeae* (Bougher, Fuhrer & E.Horak) Peintner			3	3
290	*Cortinarius violaceus* (L. : Fr.) Gray		8		8
953	*Cortinarous* sp. creamy domes with lavender gills (R.M. Robinson, S.J.M. McMullan-Fisher & M. Read FC2031)		5		5
909	*Cortinaruisaff. lavendulensis* Cleland - C. sp. Lilac (R.M. Robinson & P. Anderson WFM703)		31	197	228
16	*Cotylidia undulata* (Fr.) P. Karst.	38	203	444	685
118	*Crepidotus nephrodes* (Berk. & M.A.Curtis) Sacc.	32	21	3	56
619	*Crepidotus* sp. ginger with white margin and gills FC1146		10		10
83	*Crepidotus* sp. small creamy tan (R.M. Robinson & R.H. Smith FC99)	50			50
21	*Crepidotus* sp. small white NC		40	20	60
686	*Crepidotus* sp. white gelatinised FC1239		41		41
241	*Crepidotus variabilis* (Pers. : Fr.) P.Kumm.	1699	820	1226	3745
148	*Crucibulum laeve* (Huds. : Pers.) Kambly	2	26	20	48
625	*Cyphella*? sp. tiny white cups on marri nut (R.M. Robinson FC1174)	12			12
672	*Cystolepiota* sp. alba BFF116	1			1
106	*Dacryopinax spathularia* (Schwein.) G.W. Martin	347	3	48	398
289	*Dacrymyces capitatus* Schwein.		105	210	315
138	*Daldinia concentrica* (Bolton) Ces. & De Not. (D. childiea?)	3	10		13
124	*Dermocybe austroveneta* (Cleland) M.M.Moser & E.Horak	47	23	11	81
57	*Dermocybe clelandii* (white mycelium) (A.H.Sm.) Grgur.	55	31	62	148
172	*Dermocybe clelandii* (yellow mycelium - glutinous cap) (A.H.Sm.) Grgur.	2		2	4
172b	*Dermocybe clelandii* (yellow mycelium) (A.H.Sm.) Grgur.	27	26	6	59
944	*Dermocybe cramesina* E. Horak		5		5
768	*Dermocybe erethyrocephala* (Dennis) M.M.Moser	7			7
110	*Dermocybe kula* Grgur.	33		2	35
147	*Dermocybe* sp. 'green & gold' (R.M. Robinson & R.H. Smith FC226)			1	1
168	*Dermocybe* sp. jarrah (R.M. Robinson & R.H. Smith FC301)	119	140	83	342
310	*Dermocybe splendida* E.Horak	1			1
449	*Descolea maculata* Bougher	1			1
799	*Diatrypella* sp. on *Bossiaea* sp. (R.M. Robinson FC1539)	250			250
123	*Discinella terrestris* (Berk. & Broome) Denni	1902	182	873	2957

Sp #	Species	ER	SW/SWC	GR	TOTAL
622	*Discinella terrestris* (Berk. & Broome) Denni -white form (R.M. Robinson & R. Wittkuhn BFF107)*	845		110	955
243	Discomycete. Orange discs on marri nuts (R.M. Robinson & R.H. Smith FC798)		18		18
294	Discomycete. Small yellow on *Banksia grandis* leaves (R.M. Robinson, R.H. Smith & K. Pearce FC557)	180	76	805	1061
644	Discomycete. Tiny bright yellow on nuts and twigs BFF0047			40	40
508	*Discomycete.* Tiny cream disks on leaves (R.M. Robinson & F. Tovar FC1255)	645			645
462	Discomycete. Tiny white on marri nut			70	70
409	*Entoloma* i*ncanum* (Fr. : Fr.) Hesler	2	11	3	16
31	*Entoloma moongum* Grgur.	7	49	43	99
30	*Entoloma sericella* large (R.M. Robinson, S.J.M. McMullan-Fisher & P. Anderson FC1916)	12	12	6	30
792	*Entoloma* sp. (R.M. Robinson FC1450)		9	2	11
972	*Entoloma* sp. blonde cap, sinuate gills (R.M. Robinson, S.J.M. McMullan-Fisher & C. Newland FC2126)			12	12
939	*Entoloma* sp. bright green (R.M. Robinson & S.J.M. McMullan-Fisher FC1942)			5	5
194	*Entoloma* sp. brown (R.M. Robinson FC318) = Sp. 235	7	1	16	24
198	*Entoloma* sp. brown black cap tan gills blue stem (R.M. Robinson FC323)	2	3		5
530	*Entoloma* sp. brown black cap with marginate gills and bluish grey stem (R.M. Robinson, R.H. Smith & K. Syme FC1001)		1		1
227	*Entoloma* sp. brown black cap with tan gills (R.M. Robinson, R.H. Smith & K. Pearce FC378)			18	18
222	*Entoloma* sp. brown black with grey white gills (R.M. Robinson, R.H. Smith & K. Pearce FC374)	25	30	3	58
861	*Entoloma* sp. brown dimpled, tan gills, light brown stem (R.M. Robinson, K.Syme & P.Anderson WFM652)	1	18	53	72
347	*Entoloma* sp. brown striate cap (R.M. Robinson & J.E.Neal FC666)		2		2
967	*Entoloma* sp. brown velvet cap, blue stem (R.M. Robinson, S.J.M. McMullan-Fisher & M. Read FC2100)			2	2
820	*Entoloma* sp. brown with dimple & decurrent gills (R.M. Robinson & K. Syme WFM535)		15	1	16
858	*Entoloma s*p. conical grey brown, shiny cream srem (R.M. Robinson WFM623) - not an Entoloma			29	29
406	*Entoloma* sp. conical, brown		2		2
30b	*Entoloma* sp. creamy white (R.M. Robinson & R.H. Smith FC29)	6	12	100	118
167	*Entoloma* sp. dark grey cap with blue gill edge (R.M. Robinson & R.H. Smith FC410)	8	60	32	100
699	*Entoloma* sp. fawn scurfy cap (K. Syme & J. Fielder FC1285)			3	3
235	*Entoloma* sp. grey brown cap with grey stem (R.M. Robinson & R.H. Smith FC399) = Sp. 194	22	13	17	52
77	*Entoloma* sp. grey-brown with brown stem (R.M. Robinson & R.H. Smith FC92)			1	1
641	*Entoloma* sp. grey-brown with silver-blue stem BFF0031	5	15	29	49
25	*Entoloma* sp. grey-brown/blue stem (R.M. Robinson & R.H. Smith FC23)			2	2
936	*Entoloma* sp. indigo violet (R.M. Robinson, S.J.M. McMullan-Fisher & P. Anderson FC1884)		3	6	9
583	*Entoloma* sp. khaki brown cap with white stem (R.M. Robinson & J. Fielder FC1025)	4	13	13	30
942	*Entoloma* sp. light grey brown, tan gills, blue stem (R.R. Robinson FC1959)	27	11	20	58

Sp #	Species	ER	SW/SWC	GR	TOTAL
430	*Entoloma* sp. rosy rosy (R.M. Robinson & S.J.M. McMullan-Fisher FC1958)		7		7
278	*Entoloma* sp. suede grey brown cap with dimple (R.M. Robinson, R.H. Smith & K. Syme FC996)	2			2
606	*Entoloma* sp. tall velvet grey brown cap (R.M. Robinson & J. Fielder FC1100)		3	2	5
135	*Entoloma* sp. tall, grey-brown (R.M. Robinson & R.H. Smith FC207)	19	21	7	47
159	*Exidia glandulosus* (Bull. : Fr.) Fr.		60	9	69
926	*Favolaschia calocera*	45			45
41	*Fistulina spiculifera* (Cooke) D.A.Reid	6	7	8	21
91	*Fistulinella mollis* Watling	9	1	10	20
19	*Fomitopsis lilacinogilva* (Berk.) J.E.Wright & J.R.Deschamps	7	16	16	39
136	*Fuscoporia gilva* (Schwein.) T.Wagner & M.Fisch.	48	98	74	220
11	*Galerina* sp. hanging gills and conic (R.M. Robinson & R.H. Smith FC11)	484	810	604	1898
956	*Galerina* sp. orange brown cluster (R.M. Robinson, S.J.M. McMullan-Fisher & M. Read FC2045) - golden mycelium	78		56	134
957	*Galerina* sp. red brown cluster (R.M. Robinson, S.J.M. McMullan-Fisher & M. Read FC2052) - white basal mycelium	12		100	112
58	*Galerina* sp. small cap, eccentric stipe - on wood (R.M. Robinson & R.H. Smith FC63)	230	200	173	603
533	*Geoglossum* aff. *umbratile* Sacc. (R.M. Robinson, R.H. Smith & K. Syme FC997)	3		4	7
919	*Glonium circumserpens* (Nyl.) Kantvilas & Coppins	50			50
8	*Gymnopilus allantopus* (Berk.) Pegler	211	454	528	1193
690	*Gymnopilus ferruginosus* B.J.Rees	72	253	153	478
365	*Gymnopilus junonius* (Fr.) P.D. Orton			6	6
900	*Gymnopilus* sp. chestnut with yellow pale margin (R.M. Robinson FC1782)		4	1	5
174	*Gymnopilus* sp. red cap yellow gills red stem (R.M. Robinson, R.H. Smith & K. Pearce FC314)	19	69	7	95
85	*Gymnopilus* sp. slender (R.M. Robinson & R.H. Smith FC110)	1347	1292	994	3633
633	*Gymnopus dryophilus* (Bull. : Fr.) Murrill	2	1	5	8
931	*Gymnopus* sp. pinkish buff, hairy (R.M. Robinson, S.J.M. McMullan-Fisher & P. Anderson FC1876)		20	23	43
600	*Hebeloma aminophilum* R.N.Hilton & O.K.Mill.			2	2
96	*Hebeloma* sp. viscid pink (R.M. Robinson & R.H. Smith FC457)	14	13	6	33
56	*Heterotextus peziziformis* (Berk.) Lloyd	28	61	93	182
422	*Hohenbuehelia atrocaerulea* (Fr. : Fr.) Singer	42	20	10	72
541	*Hohenbuehelia* sp. dark brown	10			10
419	*Hpocrea gelatinosa* (Tode) Fr./*Creopus gelatinosus* (Tode) Link	40	8	60	108
480	*Hydnellum* sp. orange tipped spines (R.M. Robinson, R.H. Smith & K. Syme FC829)	40			40
87	*Hydnellum* sp. red brown (R.M. Robinson & R.H. Smith FC113)	1465	768	327	2560
704	*Hydnellum* sp. rubber FC1310		12		12
300	*Hydnoplicata convoluta* (McAlpine) Trappe & Claridge		2	1	3
297	*Hydnum repandum* L. : Fr.	18	81	69	168
380	*Hydnum* sp. chestnut (R.M. Robinson & J. Fielder FC1158)	2		4	6
476	*Hygrocybe* aff. *astatogala*	2	3	8	13
965	*Hygrocybe austropratensis*	10		1	11
381	*Hygrocybe cantharellus* (Schwein. : Fr.) Murrill	4	3	27	34
445	*Hygrocybe polychroma* Bougher & A.M.Young	19			19
599	*Hygrocybe* sp. olive yellow (R.M. Robinson & J. Fielder FC1058)	2			2
732	*Hygrocybe* sp. pallid with orange stem FC1426 - H. virguinea var. virginea?	33		1	34

Sp #	Species	ER	SW/SWC	GR	TOTAL
631	*Hygrocybe* sp. yellow orange with orange stem (R.M. Robinson FC1835)		4		4
564	*Hygrocybe* sp. yellow red	7		2	9
122	*Hygrocybe* sp. yellow-orange (R.M. Robinson & R.H. Smith FC858)	20	25		45
964	*Hygrophorus involutus*	1			1
416	*Hymenochaete semistupposa* Petch			9	9
711	*Hymenochaete* sp. chocolate BFF140	2			2
691	*Hyphodontia barba-jovis* (Bull.) J. Erikss. FC1265	20			20
100	*Hypholoma australe* O.K.Mill.	176	725	1167	2068
595	*Hypholoma* sp. (R.M. Robinson & J. Fielder FC 1049) - *H sublateritium* (Fr.) Quél.?	24	4	9	37
963	*Hypnoplicata* sp. greyish purple (R.M. Robinson, S.J.M. McMullan-Fisher & M. Read FC2081)	1			1
971	*Hypocrea* sp. copper green (R.M. Robinson, S.J.M. McMullan-Fisher & C. Newland FC2124)		30	83	113
108	*Hypomyces chrysospermus* Tul. & C. Tul.	21	10	33	64
268	*Hypomyces* sp. brown/yellow-orange on *C. cinnamoni* (R.M. Robinson, R.H. Smith & K. Pearce FC483)			1	1
726	*Hypomyces* sp. creamy pimples on Coltricia FC1329	17			17
933	*Hypoxylon* sp. tuncatum-type stroma (R.M. Robinson FC1886)			4	4
1	*Inocybe australiensis* Cleland & Cheel	836	180	214	1230
398	*Inocybe fibrillosibrunnea* O.K. Mill. & R.N. Hilton	28	3	16	47
790	*Inocybe mallocyboides* Matheny, Bougher, Robinson & Syme sp. nov. scaly orange brown cap, pink stem (R.M. Robinson & K. Syme WFM379)			14	14
948	*Inocybe* sp. (R.M. Robinson & S.J.M. McMullan-Fisher FC1994)	8		1	9
48	*Inocybe* sp. grey (R.M. Robinson & R.H. Smith FC52)	6	76	2	84
65	*Inocybe* sp. large scaly cap (R.M. Robinson & R.H. Smith FC74)	2	5		7
113	*Inocybe* sp. radially fibrillose with pink stem (R.M. Robinson & R.H. Smith FC162)	4		2	6
20	*Inocybe* sp. scaly cap (R.M. Robinson, R.H. Smith & K. Pearce FC334)	154	53	89	296
169	*Inocybe* sp. shaggy stem (R.M. Robinson & R.H. Smith FC306)		3		3
162	*Inocybe* sp. small light brown, fibrillose (R.M. Robinson & R.H. Smith FC261)	16			16
53	*Inocybe* sp. tan skirt (R.M. Robinson & R.H. Smith FC60)	77	60	6	143
286	*Inocybe* sp. umbonate, shaggy (R.M. Robinson & K. Pearce FC576) - check with sp. 486 (sp. 286 has larger spores)	34	13	29	76
74	*Laccaria* aff. *masoniae* G.Stev.	600	576	706	1882
36	*Laccaria lateritia* Malençon	107	11	38	156
765	*Laccaria* sp. burnt orange (R.M. Robinson, K. Syme & J. Mccalmont WFM460)	23			23
221	*Lactarius clarkeae* Cleland	18	3	1	22
142	*Lactarius eucalypti* O.K.Mill. & R.N.Hilton	24	50	52	126
245	*Lactarius* sp. creamy yellow (R.M. Robinson & R.H. Smith FC417)	47	10	41	98
185	*Lepiota* aff. *cristata* (Alb. & Schwein. : Fr.) P.Kumm.	37	18	15	70
76	*Lepiota alopochroa* (Berk. & Broome) Sacc.	2			2
735	*Lepiota* sp. amber drops FC1398	11		1	12
862	*Lepiota* sp. creamy brown with ring (R.M. Robinson, K.Syme & P.Anderson WFM597) - *Leucoagaricus* sp.	104	36	54	194
884	*Lepiota* sp. creamy brown with scaly stem (R.M. Robinson FC1721)	11	2		13
264	*Lepiota* sp. creamy grey (R.M. Robinson & R.H. Smith FC471)			2	2
760	*Lepiota s*p. creamy grey no ring (R.M. Robinson, K. Syme & J. Mccalmont WFM448)	26	16	39	81

Sp #	Species	ER	SW/SWC	GR	TOTAL
862	*Lepiota* sp. creamy yellow-brown (R.M. Robinson, S.J.M. McMullan-Fisher & P. Anderson FC1910)	3	1	6	10
246	*Lepiota* sp. purple grey (R.M. Robinson & R.H. Smith FC419)	2			2
958	*Lepiota* sp. red brown scales, yellow gills (R.M. Robinson & M. Read FC2059)	2	2	1	5
728	*Lepiota* sp. red-brown (R.M. Robinson & K. Syme FC1337)	4	4		8
166	*Lepiota subcristata* Cleland	6	1	2	9
214	*Leucopaxillus lilacinus* Bougher	9			9
112	*Lichenomphalia chromacea* (Cleland) Redhead, Lutzoni, Moncalvo & Vilgalys	11	4	47	62
127	*Lichenomphalia umbellifera* (L.) Redhead, Lutzoni, Moncalvo & Vilgalys	2	502	51	555
24	*Lycoperdon* sp. (R.M. Robinson & R.H. Smith FC22)	13	395	52	460
190	*Macrolepiota clelandii* Grgur.	2		3	5
561	*Macrotyphula* sp. simple white clubs	13	27	271	311
826	*Marasmiellus* sp. white fans on bark (R.M. Robinson & K. Syme FC1603)		3		3
55	*Marasmius crinisequi* F.Muell.	157		59	216
183	*Marasmius elegans* (Cleland) Grgur.	64		6	70
309	*Marasmius* sp. 223 (R.M. Robinson FF664)*	120	615	124	859
946	*Marasmius* sp. creamy tan on litter (R.M. Robinson & S.J.M. McMullan-Fisher FC1995)	268	21		289
720	*Marasmius* sp. garlic BFF179	4	8	6	18
443	*Marasmius* sp. tan (R.M. Robinson FF770, WFM129)*	50	28	20	98
341	*Marasmius* sp. tiny red on twigs (R.M. Robinson & K. Syme WFM 495)	240			240
507	*Meiorganum curtisii* (Berk.) Singer, Garcia & Gomez	4	11	17	32
529	*Melanoleuca* sp. grey brown cap with white gills and stem (R.M. Robinson, R.H. Smith & K. Syme FC994)	5	2		7
151	*Melanoleuca* sp. large (R.M. Robinson & R.H. Smith FC472)	2	1		3
22	*Melanotus hepatochrous* (Berk.) Singer	66	1	1	68
298	*Micromphale* sp. garlic (R.M. Robinson & K. Syme WFM11)			5	5
961	*Microphale* sp. Light brown on twigs (R.M. Robinson, S.J.M. McMullan-Fisher & M. Read FC2076)	18			18
912	*Mucronella pendula* (Massee) R.H.Petersen		15		15
64	*Mycena adscendens* (Lasch) Maas. Geest.	1	3	5	9
477	*Mycena* aff. *adonis* (Bull.) Gray	2	12	62	76
44	*Mycena* aff. *atrata* Grgur. & A.A.Holland. ex Grgur.		34	5	39
327	*Mycena* aff. *maldea* Grgur.		19		19
134	*Mycena albidocapillaris* Grgur. & T.W.May	102	139	126	367
80	*Mycena carmeliana* Grgur.	88	102	175	365
312	*Mycena fuhreri* Grgur.			37	37
372	*Mycena fumosa* Grgur.	7	43	68	118
144	*Mycena kuurkaceae*Grgur.	29	116	43	188
50	*Mycena mijoi* Grgur.	903	427	506	1836
66	*Mycena pura* (Pers. : Fr.) P.Kumm.	10	9	3	22
308	*Mycena* sp. grey brown cap no bleach (R.M. Robinson & J. Fielder FC1038)	22	23	7	52
18	*Mycena* sp. grey brown striate (R.M. Robinson & S.J.M. McMullan-Fisher FC1933)		13	5	18
658	*Mycena* sp. orange striate cap, dimpled WFM352	6	2	34	42
756	*Mycena* sp. orange striate on litter (R.M. Robinson & K. Syme WFM424)	63	7	50	120
565	*Mycena* sp. red gills (R.M. Robinson & K. Syme WFM374)		3	1	4
437	*Mycena* sp. rosy maroon cap with marginate decurrent gills	2			2
295	*Mycena* sp. small buff (R.M. Robinson & K. Pearce FC558)		48	31	79

Sp #	Species	ER	SW/SWC	GR	TOTAL
938	*Mycena* sp. small buff with distant gills - on *Banksia grandis* bark (R.M. Robinson, S.J.M. McMullan-Fisher & P. Anderson FC1911)	35	9	25	69
352	*Mycena* sp. small creamy yellow white (R.M. Robinson & R.H. Smith FC695)		3		3
165	*Mycena* sp. small grey - bleach (R.M. Robinson & R.H. Smith FC394)	2	32	8	42
386	*Mycena* sp. tiny white sticky cap (R.M. Robinson & K. Syme WFM6, WFM305)	90	55	41	186
88	*Mycena* sp. tiny white with decurrent gills (R.M. Robinson & R.H. Smith FF61)		15	2	17
182	*Mycena* spp. (unidentified)	1	7	1	9
163	*Mycena subgallericulata* Cleland	480	901	370	1751
51	*Mycena yirukensis* Grgur.	639	575	587	1801
238	*Mycena yuulongicola* Grgur.	189	114	98	401
703	*Nectria* aff. *cinnabarina* (Tode) Fr. (FC1305)	3			3
667	*Nectria* sp. rusty nuts BFF 80		3	50	53
104	*Panellus ligulatus* E.Horak	30	3	23	56
311	*Panus fasciatus* (Berk.) Pegler	1	10	64	75
968	*Peziza* sp. pitted and wrinkled (R.M. Robinson & S.J.M. McMullan-Fisher FC2111)	3			3
37	*Phellinus* sp. yellow rim (R.M. Robinson, R.H. Smith & K. Pearce FC515)		10		10
70	*Phellodon* aff. *niger* (Fr. : Fr.) P.Karst.	59	6	7	72
84	*Phellodon* sp. black slender (R.M. Robinson & J. Fielder FC1189)	273	293	77	643
621	*Phellodon* sp. black with silvery margin and brown grey spines (R.M. Robinson & J. Fielder FC1159)	26	73	21	120
479	*Phellodon* sp. black, brown spines (R.M. Robinson & R.H. Smith FC844)	696	346	135	1177
435	*Phellodon* sp. brown (R.M. Robinson, R.H. Smith & K. Syme FC827)	60			60
874	*Phellodon* sp. drab grey brown spines, olive mycelium (R.M. Robinson, K.Syme & P.Anderson WFM683)	530	69	12	611
716	*Phellodon* sp. feathery, purple black BFF148		25		25
634	*Phellodon* sp. flimsy silver grey (R.M. Robinson & J. Fielder FC1204)		31	8	39
621	*Phellodon* sp. grey spines (R.M. Robinson & S.J.M. McMullan-Fisher FC2115)	8			8
563	*Phellodon* sp. olive brown spines	37	5	8	50
70b	*Phellodon* sp. P. niger-like, feathery soft margin (R.M. Robinson & S.J.M. McMullan-Fisher FC2109)	28			28
447	*Phellodon* sp. silver-blue (R.M. Robinson RR844WA)		54		54
952	*Phellodon* sp. small orange spines (R.M. Robinson, S.J.M. McMullan-Fisher & M. Read FC2030)	30	100		130
101	*Phlebia rufa* (Pers. : Fr.) M.P.Christ.	1	9		10
101	*Phlebia rufa* 'blonde' WFM329			2	2
160	*Pholiota communis(Cleland & Cheel) Grgur.*		23		23
160	*Pholiota highlandensis* (Peck) Quadr.	54	102	124	280
119	*Pholiota multicingulata* E.Horak	354	983	608	1945
363	*Piptoporus australiensis* (Wakef.) G.Cunn.	1			1
353	*Pisolithus* sp. small stalked (R.M. Robinson & R.H. Smith FC697)		12	15	27
133	*Pluteus atromarginatus* (Konrad) Kühner		11	17	28
47	*Pluteus flammilipes* E.Horak var. *depauperatus* E.Horak	1	2	1	4
47b	*Pluteus lutescens* (Fr.) Bres.	4	29	16	49
659	*Pluteus nanus* (Pers. : Fr.) P.Kumm. WFM354			1	1
4	*Pluteus* sp. brown velvet (R.M. Robinson & R.H. Smith FC4, BFF150)	2		4	6
157	*Podoserpula pusio* (Berk.) D.A.Reid	8	28	3	39
204	Polypore. Beige resupinate, stains brown (R.M. Robinson FC1553)	1			1

Sp #	Species	ER	SW/SWC	GR	TOTAL
868	Polypore. Dark grey (R.M. Robinson, K.Syme & P.Anderson WFM670)	3			3
930	Polypore. Honeycomb pores (R.M. Robinson, S.J.M. McMullan-Fisher & P. Anderson FC1930)			2	2
3	Polypore. Long white shelf (R.M. Robinson & R.H. Smith FC3)	6	24	28	58
746	Polypore. Shelving tiers BFF223		3	3	6
940	Polypore. White irpicoid maze on burnt bark (R.M. Robinson & S.J.M. McMullan-Fisher FC1951)		64		64
585	Polypore. White floccose resupinate (R.M. Robinson & J. Fielder FC1027)	16	31	29	76
116	Polypore. White resupinate (R.M. Robinson & J. Fielder FC1197)	2			2
361	Polypore. White resupinate on twig (R.M. Robinson & R.H. Smith FC708)	6			6
494	*Polyporus* sp. brown stalked (R.M. Robinson & R.H. Smith FC901)			2	2
929	*Polyporus* sp. velutina-like (R.M. Robinson, S.J.M. McMullan-Fisher & P. Anderson FC1874)			6	6
145	*Poronia erici* Lohmeyer & Benkert	20			20
632	*Porostereum crassum* (Lév.) Hjortstam & Ryvarden	2	5	13	20
236	*Postia peliculosa* (Berk.) Rajchenb.	4	17	20	41
155	*Protubera canescens* G.W.Beaton & Malajczuk			1	1
59	*Psathyrella echinata* (Cleland) Grgur.	58	271	169	498
250	*Psathyrella* sp.	1			1
337	*Psathyrella* sp.		2		2
17	*Psathyrella* sp. (R.M. Robinson & R.H. Smith FC15)		30		30
359	*Psathyrella* sp. brown with white skirt (R.M. Robinson & R.H. Smith FC707)	4			4
550	*Pseudobaeospora* sp. blue grey	1	11	27	39
650	*Pseudobaeospora* sp. maroon or red gills WFM320	4	20	95	119
955	*Pseudobeaospora* sp. red brown (R.M. Robinson, S.J.M. McMullan-Fisher & M. Read FC2039)			18	18
177	*Psilocybe coprophila* (Bull. : Fr.) P.Kumm.	11	29	41	81
349	*Psilocybe musci* Cleland & Cheel	9	4	10	23
280	*Pulvinula* sp. (R.M. Robinson, R.H. Smith & K. Pearce FC526)		8		8
129	*Pulvinula tetraspora* (Hansf.) Rifai	75	63	8	146
748	*Punctularia strigoszonata* (Schwein.) P.H.B.Talbot / *Steruem illudens* complex, grey-white hymenium FC1317)			10	10
176	*Pycnoporus coccineus* (Fr.) Bondartsev & Singer	25	44	62	131
72	*Ramaria australiana* (Cleland) R.H.Petersen	37	1	3	41
52	*Ramaria capitata* (Lloyd) Corner	6	5	1	12
52	*Ramaria capitata* 'burnt'	5		3	8
377	*Ramaria lorithamnus* (Berk.) R.H.Petersen	253	116	109	478
102	*Ramaria ochroceosalmonicolor* (Cleland) Corner	53	135	160	348
833	*Ramaria* sp. orange pink (R.M. Robinson & K. Syme FC1624)		7	1	8
86	*Ramaria* sp. orange-red with yellow stem (R.M. Robinson & R.H. Smith FC112)	23	19	7	49
767	*Ramaria* sp. yellow flat (burnt ground) (R.M. Robinson, K. Syme & J. Mccalmont WFM464)	8		3	11
254	*Ramaria versatilis* Quél.		12		12
970	*Ramariopsis* sp. creamy yellow forks (R.M. Robinson, S.J.M. McMullan-Fisher & C. Newland FC2121)			12	12
79	*Resupinatus cinerascens* (Cleland) Grgur.	10	53	3	66
181	*Rhodocollybia butyracea* (Bull. : Fr.) Lennox	8	4	15	27
811	*Rhodocybe* sp. grey with decurrent gills R.M. Robinson & K. Syme WFM508	7	7	8	22
966	*Rhodocybe* sp. brown (R.M. Robinson, S.J.M. McMullan-Fisher & M. Read FC2095)			4	4

Sp #	Species	ER	SW/SWC	GR	TOTAL
969	*Rhodocybe* sp. brown convex cap (R.M. Robinson & S.J.M. McMullan-Fisher FC2114)	13			13
397	*Rhodocybe* sp. grey (R.M. Robinson & K. Syme WFM35)	1	1	1	3
209	*Rickenella fibula* (Bull. & Vent. : Fr.) Raithelh.	137	1	1	139
305	*Rubinoboletus phaseolisporus* T.-H. Li, R.N. Hilton & Watling [*Tylopilus* sp. yellow] (R.M. Robinson & J. Fielder FC1015)	8	4	24	36
69	*Russula adusta* (Pers. : Fr.) Fr.	32	28	9	69
90	*Russula* aff. *cyanoxantha* creamy grey-green (R.M. Robinson FC1565)	2			2
89	*Russula clelandii* complex O.K.Mill. & R.N.Hilton	378	31	32	441
202	*Russula flocktoniae* Cleland & Cheel	11	4	2	17
90	*Russula kalimna* Grgur.	59	1	5	65
92	*Russula neerimea* Grgur.	251	44	50	345
178	*Russula persanguinea* Cleland	2	6	3	11
107	*Russula* sp. grey-white (R.M. Robinson & R.H. Smith FC168)	2	3		5
10	*Russula* sp. small white-white-white (R.M. Robinson RR921WA)		3		3
10	*Russula* sp. tiny, white-white-white - hypogeous?			18	18
10	*Russula* sp. white white white (R.M. Robinson & R.H. Smith FC 8)	116	11	17	144
342	*Ryvardenia campyla* (Berk.) Rajchenb	64			64
263	*Sarcodon* sp. brown (R.M. Robinson, R.H. Smith & K. Syme FC791)	17	6	35	58
806	*Schizopora* sp. A (R.M. Robinson & K. Syme WFM477)			5	5
12	*Simocybe tabacina* E. Horak		5		5
306	*Sphaerobolus stellatus* Tode : Pers.			112	112
94	*Steccherinum* sp. tiered white shelves (R.M. Robinson & R.H. Smith FC128)	162	174	96	432
62	*Stereum hirsutum* (Willd. : Fr.) Pers.	268	917	283	1468
149	*Stereum illudens* Berk. - brown hymenium		107	11	118
773	Stereum sp. black with purple brown merulioid hymenium (R.M. Robinson, K. Syme FC1458)	153	467	246	866
5	*Stereum* sp. grey brown, hirsute, white margin, purple hymenium (R.M. Robinson & R.H. Smith FC468)		115	3	118
974	*Stereum* sp. light brown hymenium (R.M. Robinson & S.J.M. McMullan-Fisher FC1945)		39		39
949	*Stereum* sp. light brown with pink hymenial margin (R.M. Robinson, S.J.M. McMullan-Fisher & M. Read FC2008)	50			50
67	*Stropharia semiglobata* (Batsch : Fr.) Quél.	3		4	7
587	*Tephrocybe* sp. dark brown with grey brown gills (R.M. Robinson & J. Fielder FC1036)		13	3	16
301	*Tephrocybe* sp. dark grey with dimpled cap (R.M. Robinson & K. Pearce FC580)	2		1	3
233	*Tephrocybe sp.* grey brown dimpled cap (R.M. Robinson & R.H. Smith FC 391)			15	15
945	*Tephrocybe* sp. grey brown funnel (R.M. Robinson & S.J.M. McMullan-Fisher FC1982)	495			495
153	*Tephrocybe* sp. small dark grey-brown (R.M. Robinson & R.H. Smith FC242)	8			8
402	*Tephrocybe*? sp. brown - burn (R.M. Robinson & K. Syme WFM-044)		8		8
266	*Thelephora* sp. white with orange margin (R.M. Robinson & R.H. Smith FC476)	18	58	70	146
669	*Trametes velutina* (Pers. : Fr.) G.Cunn.	41	27		68
63	*Trametes versicolor* (L. : Fr.) Lloyd	70	76	343	489
959	*Tremella foliacea* Pers.	4			4
287	*Tremella globispora* D.A.Reid	25	124	84	233
60	*Tremella mesenterica* Retz. : Fr.		7	4	11

Sp #	Species	ER	SW/SWC	GR	TOTAL
109	*Trichaptum byssogenum* (Jungh.) Ryvarden	1		1	2
446	*Tricholoma* aff. *austrocollossum* Grgur.	23			23
54	*Tricholoma eucalypticum* A.Pearson	137	36	19	192
855	*Tricholoma* sp. creamy brown with waxy gills (R.M. Robinson, K.Syme & P.Anderson WFM613)	2	1	2	5
736	*Tricholoma* sp. creamy tan (K. Syme & J. Fielder FC1422)	7			7
872	*Tricholoma* sp. creamy tan with orange veil (R.M. Robinson, K.Syme & P.Anderson WFM696) = 446 T. austrocolossum?		10	3	13
733	*Tricholoma* sp. olive green (R.M. Robinson & R.S. Wittkuhn FC 1427)		182		182
375	*Tricholoma* sp. orange cap with orange ring on stem (R.M. Robinson & R.H. Smith FC 753)	6			6
736	*Tricholoma* sp. 'sticky beige' (R.M. Robinson, S.J.M. McMullan-Fisher & M. Read FC2087)			3	3
560	*Tricholoma* sp. tan gills, ring (R.M. Robinson & K. Syme WFM220)	1			1
863	*Tricholoma* sp. virgatum mini (R.M. Robinson, K.Syme & P.Anderson WFM654)		5		5
161	*Tricholoma virgatum* (Fr.) Gillet	1	8	2	11
189	*Tubaria rufofulva* (Cleland) D.A.Reid & E.Horak	11			11
111	*Tubaria serrulata* (Cleland) Bougher & Matheny	1		13	14
910	Unknown. Plant snot (R.M. Robinson & P. Anderson WFM712)		11		11
651	Unknown. White mycelium on bark and litter WFM323	5	3	15	23
2	*Xerula mundroola* (Grgur.) R.H.Petersen	1	12	1	14
175	*Xylaria hypoxylon* (L.) Grev.			4	4
828	*Zelleromyces* sp. (R.M. Robinson & K. Syme FC1612)			2	2
	Total number of species	315	300	328	460
	Total number of fruit bodies	26387	21027	21078	68492

CRYPTOGAMS

Ray Cranfield, Sapphire McMullen-Fisher, Richard Robinson and Verna Tunsell

Introduction
Lichens, mosses and liverworts are collectively known as cryptogams. Some species of lichens are important indicators of ecosystem health, being sensitive to changes and disturbance in the environment in which they grow. Many colonise primary substrates such as rocks and decaying organic matter and are active in the initial breakdown of these materials. Mosses also play an important role in the stabilization of bare soil. Lichens, mosses and liverworts are a major component of the biodiversity of forest ecosystems, and most species in Western Australia have poorly known distributions and many are yet to be named.

The object of this component of FORESTCHECK is to:

- record all species of lichen, moss and liverwort present on each FORESTCHECK grid
- record species habitat and substrate preference
- analyse trends in species composition and richness and over time.

Additional objectives are to:

- monitor the presence of 41 monitoring (or indicator) species
- determine successional trends in communities.

Field survey
Nine FORESTCHECK grids, including three external reference grids (FC49, FC54 and FC10), three shelterwood (FC51, FC53 and FC56) and three gap release treatments (FC50, FC52 and FC55) were monitored in the Jarrah South jarrah forest ecosystem in the Donnelly District in 2013. The location is referred to as Donnelly 2.

Survey was conducted in late winter from 17 June to 13 August, when most species of cryptogams are well hydrated and actively growing. In this state they are more easily found and identification is not as difficult as for desiccated specimens.

In 2013, the survey method for cryptogams was reviewed and simplified into a foray-type survey following a 400m transect around the perimeter of the central 1ha area of each grid. (see grid layout on p.5). All species of lichen, moss and liverwort encountered in each 50m section of transect were recorded. This frequency statistic (a score out of 8 on each grid) demonstrates how common a species is on each grid. Those species that could not be identified positively in the field were collected and examined in detail in the lab. An illustrated field guide, compiled from previous FORESTCHECK surveys, was used to facilitate the recognition of species encountered. The field guide is continually updated to include new taxa identified during the surveys.

Vouchers specimens were extensively collected during the 2013 monitoring. Specimens were collected to verify species identifications and to voucher new species records. All specimens collected in 2013 have been identified to species or given informal field names. Advances in taxonomy, and re-examination of specimens collected during previous FORESTCHECK surveys has resulted in few name changes but several new species were recorded during this survey which required updating the FORESTCHECK and Western Australian Herbarium databases. All new collections have been processed and prepared for submission into the WA Herbarium.

Preliminary Results and Discussion

Species richness

A total of 106 species of cryptogams were recorded from all the monitoring grids; including 66 lichens, 27 mosses and 13 liverworts. Three new liverwort species were identified and a number of moss species were re-determined. One of the liverworts was a new record for WA and one moss is considered new and is awaiting expert confirmation.

Lichens were the most common group on all grids (Fig. 1). More species of lichens were recorded in the external reference grids and the numbers recorded on the Boyndaminup selective cut, the Barlee shelterwood and the Lewin gap release were noticeably lower. Similar numbers of mosses were recorded on all grids in each treatment. Only 3–8 species of liverworts were recorded on each grid, but similar numbers were recorded in each treatment.

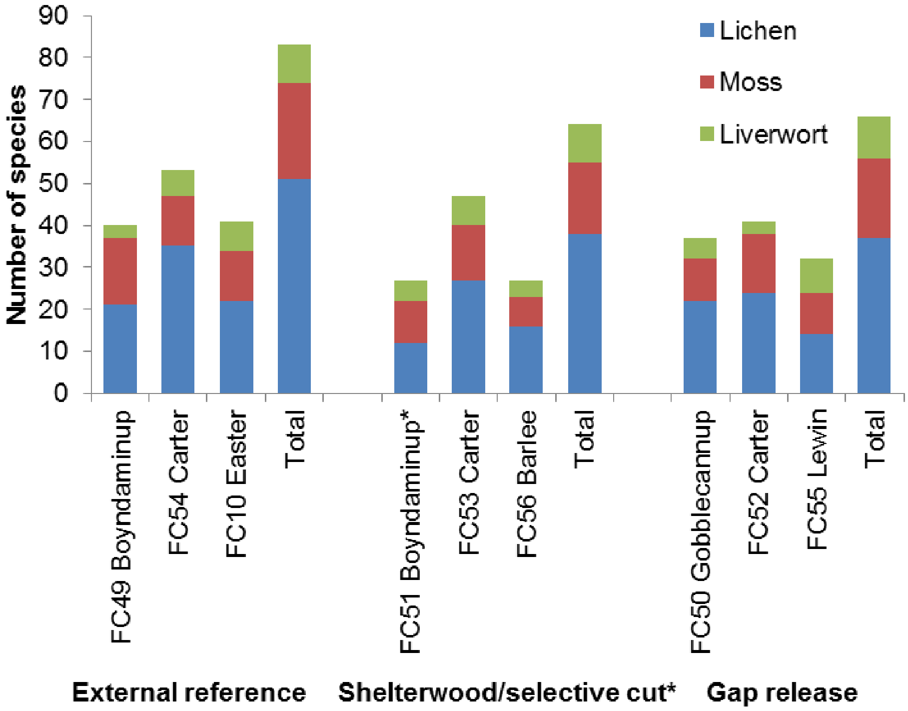

Figure 1. Total number of lichens, moss and liverwort species recorded on each FORESTCHECK monitoring grid at Donnelly 2 in 2013

The mean species richness of mosses and of lichens was similar in each treatment, but the mean richness of lichens was higher in the external reference treatment (Fig. 2). The frequency, or how common each species was on each grid, was not analysed in detail for this report.

Five lichens; *Cladia aggregata*, *C. schizopora*, *Pannoparmelia wilsonii*, *Thysanothecium scutellatum* and *Usnea inermis*, four mosses; *Barbula calycina*, *Campylopus bicolor*, *C. introflexus* and *Rosulabryam capillare*, and one liverwort; *Cephaloziella exilliflora*, were recorded on all nine grids (Appendix 1).

A number of unusual and interesting species were recorded during surveys. *Peltigera dolichorrhiza* (Fig. 3) was recorded on the Gobblecannup gap release grid growing on a log in an ashbed. It has previously been recorded in the Donnelly area, but it is normally associated with logs in hyper wet areas. The liverwort, *Enigmella thallina* (Fig. 3) was recorded on two grids, the Easter external reference and Lewin gap release. It has previously been recorded for WA but these are the first collections to be lodged in the WA Herbarium.

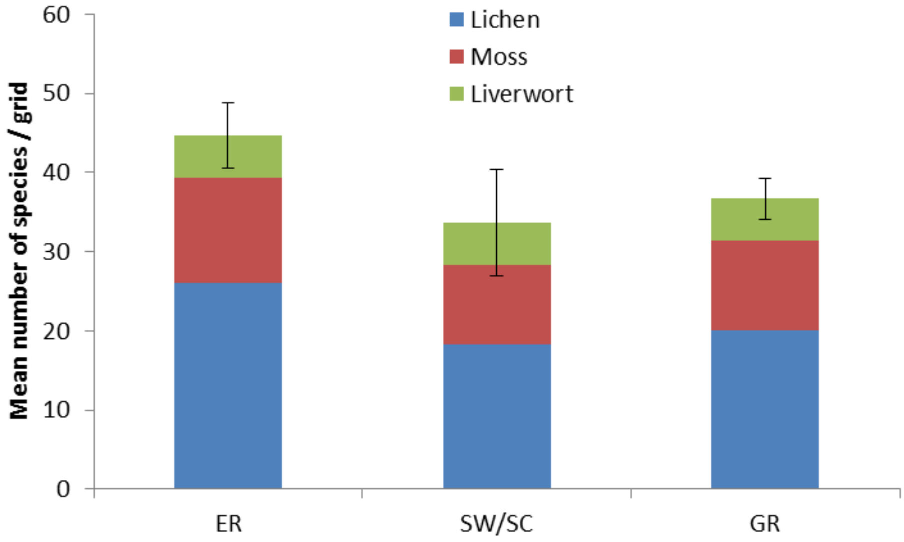

Figure 2. Mean number of lichen, moss and liverwort species per grid recorded in each treatment on Donnelly 2 FORESTCHECK monitoring grids in 2013. ER = external reference, SW/SC = shelterwood/selective cut and GR = gap release treatment.

Figure 3. *Left*: *Peltigera dolichorrhiza* was only recorded in one gap release grid (FC50) in 2013. *Right*: *Enigmella thallina* was a new liverwort recorded in 2013.

Substrate utilisation

Most substrates needed for the establishment and maintenance of cryptogam communities were available on the majority of grids; but not all substrates were consistently colonised (Fig. 4). The majority of cryptogams were recorded on soil. Time since treatment (harvesting and fire) has an influence on the condition of substrates and their consequent colonisation by cryptogams. On external reference grids and the gap release, soil and wood were the most frequently colonised habitats. On shelterwood grids soil was well utilised but few species were recorded on bark. Although termite mounds were present on most grids, cryptogams were only recorded growing on them on the three Boyndaminup/Gobblecannup grids.

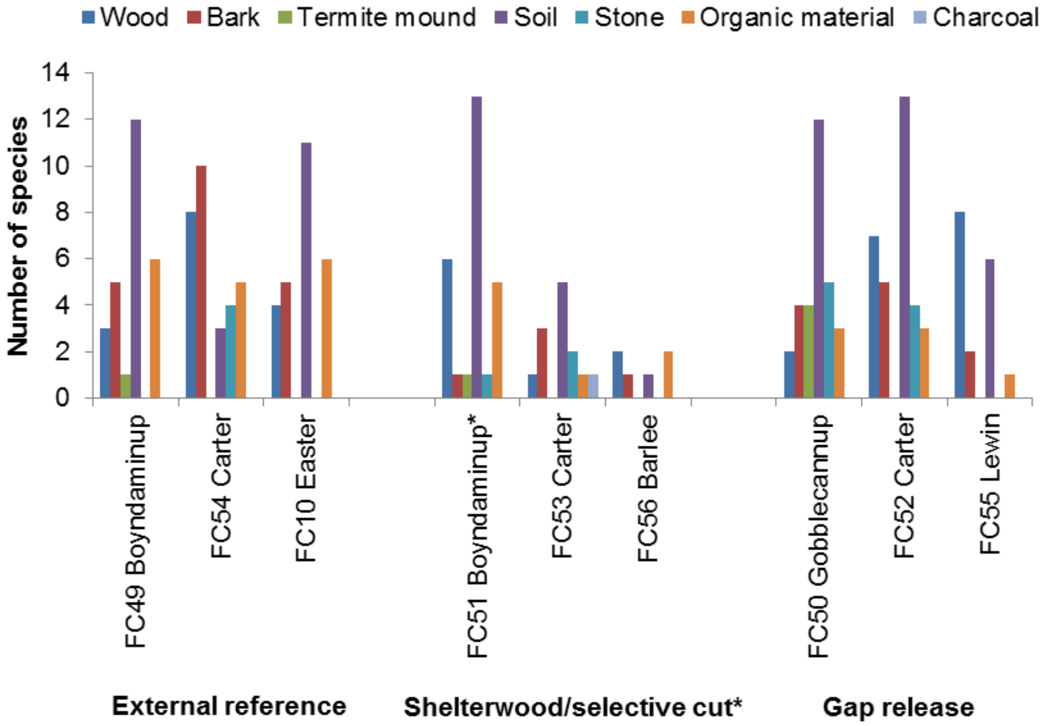

Figure 4. Number of substrates and their utilization by cryptogams on each Jarrah South Donnelly 2 FORESTCHECK grids in 2013

Colonisation of strata layers

The presence of cryptogams at different levels in the strata depends on the availability of suitable substrates at each level. Of the three strata layers investigated, the ground layer (0–30cm) was the most utilised on every grid except the Carter external reference where the shrub layer (31cm-3m) was highly utilised (Fig. 5). More species occupied the shrub layer on grids in the gap release treatment than in the shelterwood or on the other two external reference grids. The epiphytic tree layer (>3m) is difficult to examine and surveys depend on recording material which has fallen from tree crowns, and as such the results do not reflect the true extent of tree crown colonisation. Most species associated with tree crowns were recorded near mature trees, whether on the unharvested external reference grids or on grids in the harvested treatments. The retention of mature habitat trees in harvested treatments is important for the retention of crown dwelling cryptogams, especially lichens.

Heavy or constant litter cover appears to affect the presence and growth of a number of cryptogams. Lichens growing on soil or stones rapidly decline when covered by litter. However, in areas where litter is temporary or able to be moved by wind and not become trapped, some can withstand short periods of being covered without being totally excluded. Ground dwelling mosses and lichens were less frequent on plots with dense litter cover. Grids with dense coverage of *Bossiaea aquifolium* subsp. *laidlawiana* tended to have a reduction in abundance of cryptogams (Barlee shelterwood and Lewin gap release).

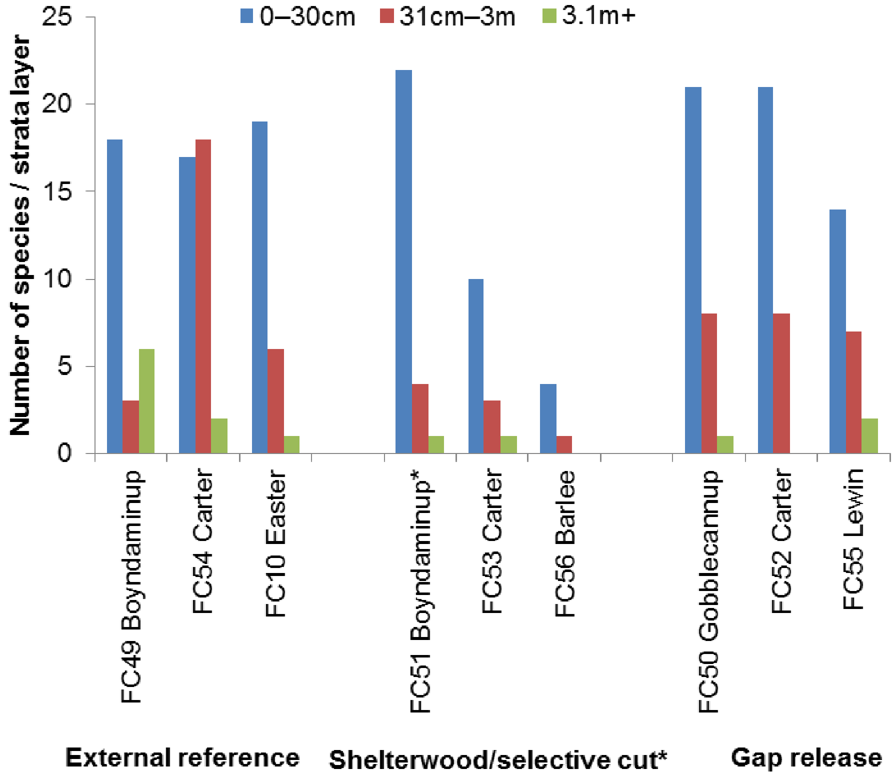

Figure 5. Number of different strata levels occupied by cryptogams on each Jarrah South Donnelly 2 FORESTCHECK grid transects in 2013 (NB: 4 x 100m transects)

Life forms

The majority of cryptogams can be artificially grouped according to their morphology. Most lichens are foliose (leaflike, with flat sheets of tissue not tightly bound), crustose (crustlike, growing tight against the substrate), fruticose (free-standing branching tubes) and a few can be leprose (powdery) or squamulose (tightly packed pebble-like mass); mosses are creeping or tufted and liverworts are thallose or leafy. These groups are referred to as life or growth forms, and species in each group generally have similar life strategies. Crustose and fruticose lichens, tufted mosses, and leafy liverworts were the most common types recorded (Figs 6 and 7). Tufted mosses, *Barbula calycina* and *Ceratodon purpureus* were regularly recorded on all treated grids. Thallose liverworts were recorded on six grids and leafy liverworts recorded on all grids, *Cephaloziella exiliflora and C. hirta*, were regularly found on all grids, with *Chaetophyllopsis whiteleggei* only on one grid and *Enigmella thallina* on two grids.

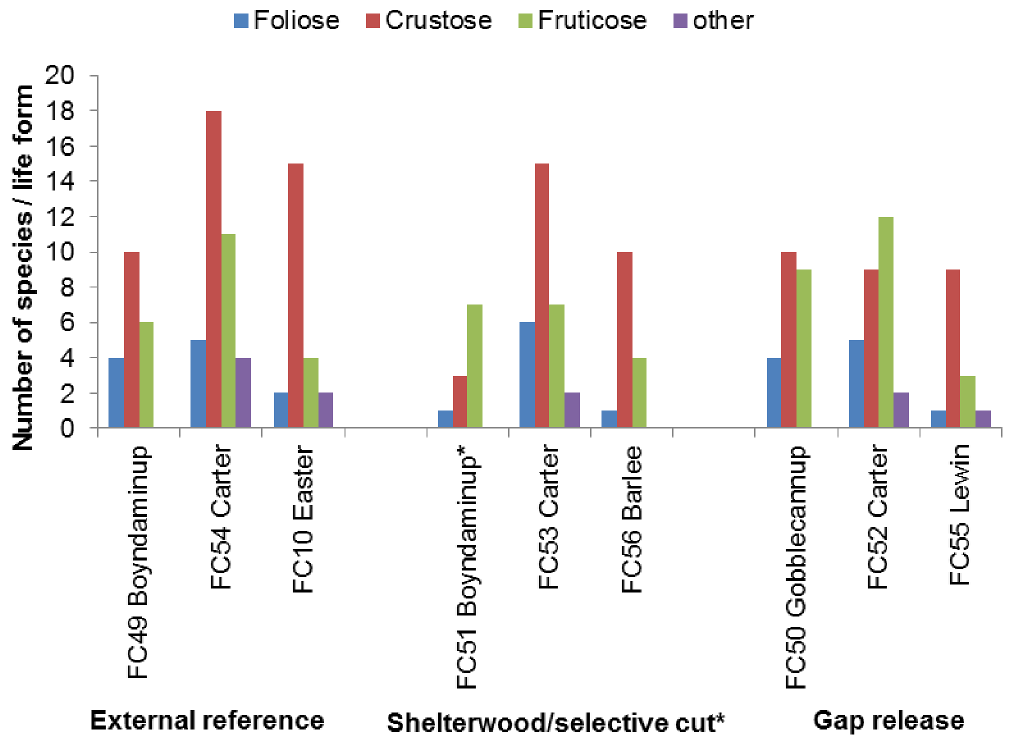

Figure 6. Number of each lichen life form was recorded on each Jarrah south Donnelly 2 FORESTCHECK grid transects in 2013 (NB: 4 x 100m transects)

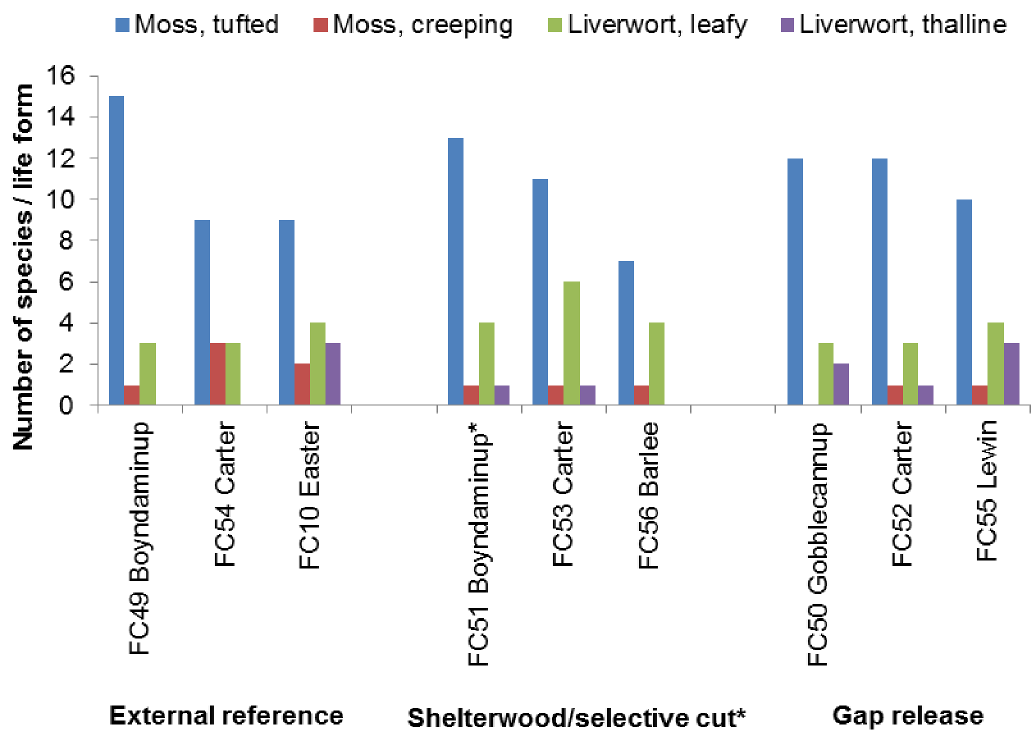

Figure 7. Number of moss and liverwort life forms was recorded on each Jarrah South Donnelly 2 FORESTCHECK grid in 2011 (NB. 4 x 100m transects)

Monitoring potential indicator species
Thirty five taxa were initially selected to monitor as potential indicator species (see FORESTCHECK Report of Progress 2011–12, p. 61–62); this was recently increased to 41. Species were selected on the basis of the substrates and strata layers they occupied, and on their perceived resilience and response to environment and physical changes. They now include 28 lichens, eight mosses and five liverworts. The new species added include two lichens (Genus sp. grey green slick and *Ainoa mooreana*), three mosses (*Rosulabryum capillare*, *Campylopus bicolor* and *Orthodontion lineare*) and a liverwort (*Fossombronia altilamellosa*)

In 2013, a total of 31 monitoring species were recorded during the Donnelly 2 surveys; 21 lichens, seven mosses and three liverworts (Appendix 1). To test the reliability of this list of (monitoring) species to pick up trends or differences between treatments, the proportion of all lichen, moss and liverwort species in each treatment was determined and compared to that for the selected monitoring species recorded (Fig. 8). The proportion of each group was similar in all treatments when either all cryptogams or just the monitoring species were analysed. However, the proportion of lichens was larger in all treatments when only the monitoring species were considered, compared to all species.

When a similar comparison was done using mean species richness per grid, the trend was similar when all cryptogams were recorded or just the selected monitoring species. The number of monitoring species recorded was similar in all treatments (Fig. 9). Overall, however, the number of cryptogam species recorded in the external reference treatment was higher than that in harvested grids. In harvested treatments there was no relationship associated with the intensity of treatment.

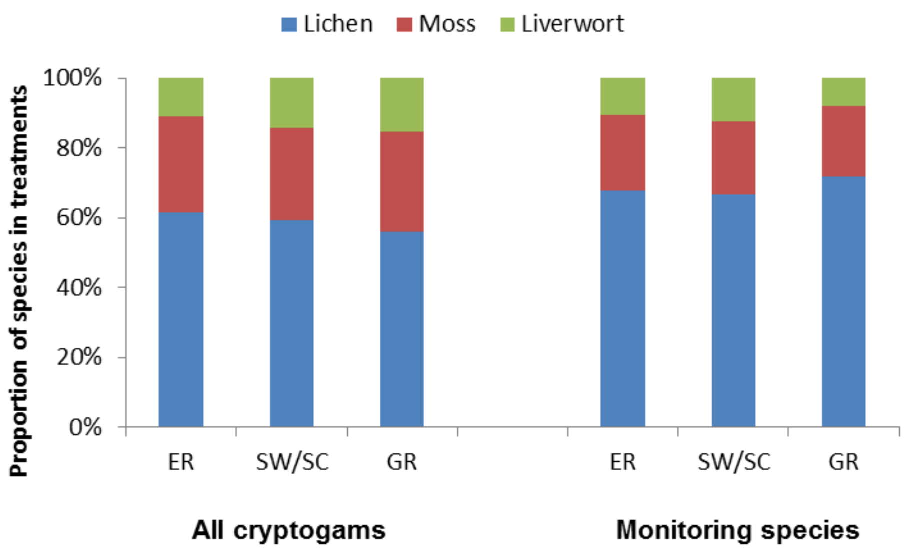

Figure 8. Proportion of lichen, moss and liverwort species in each treatment when considering all cryptogams (left) and only the selected list of potential indicator species recorded at the Donnelly 2 FORESTCHECK grids in 2013. ER = external reference, SW/SC = shelterwood/selective cut and GR = gap release treatment.

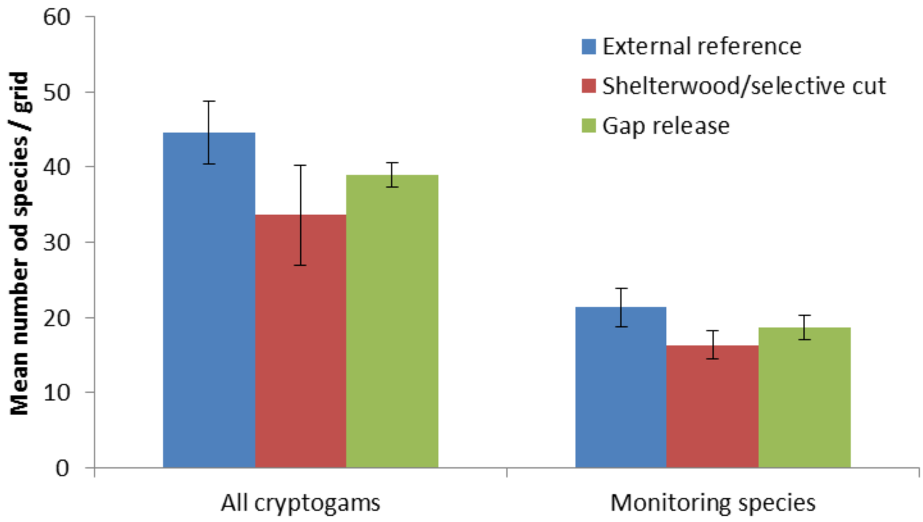

Figure 9. Mean species richness per grid for all cryptogams (left) and the selected monitoring species (right) recorded on the Donnelly 2 FORESTCHECK grids in 2013

The suitability of monitoring this short list of species is continually under review. Jarrah forest covers a large region encompassing a variety of ecosystem types and vegetation complexes (as represented by the six established FORESTCHECK locations; Donnelly 1, Wellington 1, Perth Hills, Wellington East, Blackwood Plateau and Donnelly 2) a number of monitoring species have specific environmental requirements and do not occur in all locations. Others occur in all locations, and in all treatments, and their suitability is as indicators of change are continually being assessed. However, the use of 'indicator' species to monitor changes in cryptogam communities following disturbance appears to have potential, but there is still much to learn about the ecology of many Australian species.

Conclusions

A revised survey procedure was used to record the cryptogam species on the Donnelly 2 FORESTCHECK monitoring grids. The survey has been modified to a foray-type transect over 400m around the perimeter of the central 1ha area on each monitoring grid. Determination of the presence of species within each 50m section of transect provides a frequency statistic to demonstrate how common each species is on each grid.

Some trends observed in 2013 were:

- The external reference grids had more species of crustose lichens than those in harvested grids.
- Tufted mosses were the most common mosses and had similar number of species on all grids irrespective of treatment.
- The number of lichens was low on the Boyndaminup selective cut, the Barlee shelterwood and the Lewin gap release grids.
- The vast majority of cryptogams were recorded in the 0-30cm strata layer.
- The majority of cryptogams were crustose lichens and tufted mosses.

Other observations

- The use of monitoring species may be a viable alternative for assessing the impacts of timber harvesting and silviculture on cryptogam communities, future monitoring will help to determine whether this is the case.

Appendix 1. Species of cryptogams recorded and their frequency in each treatment at Donnelly 2 Forestcheck monitoring grids. Species in bold type are the potential monitoring species (PMS).

Sp. No.	PMS No.	Taxon	Life-form[2]	Treatment[1] ER	SW/SC	GR	Total
2	**31**	***Barbula calycina***	B	18	24	22	64
10	**32**	***Campylopus introflexus***	B	21	24	22	67
39	**33**	***Dicranoloma diaphanoneuron***	B	8			8
128	**35**	***Sematophyllum subhumile var. contiguum***	B	8	4	4	16
336	**37**	***Rosulabryum capillare***	B	16	23	21	60
9	**38**	***Campylopus bicolor***	B	17	21	23	61
40	**40**	***Orthodontium lineare***	B	1			1
392		*Barbula* sp. fine (R.J. Cranfield 26794)	B	5	10	6	21
395		*Barbula* sp.(R.J. Cranfield 26752)	B	2		5	7
396		*Bryum* sp. (R.J. Cranfield 26797)	B			1	1
13		*Ceratodon purpureus* subsp. *convolutus*	B	3	7	11	21
396		*Entosthodon* sp. (R.J. Cranfield 26751)	B	5	2	5	12
401		*Fissidens* sp. (R.J. Cranfield 26848)	B		2	1	3
405		*Fissidens* sp. on rock (R.J. Cranfield 26923)	B	1			1
394		*Fissidens* sp. smooth (R.J. Cranfield 26764)	B	4	3	1	8
393		*Fissidens* sp. toothed (R.J. Cranfield 26763)	B	5			5
44		*Fissidens tenellus* var. *tenellus*	B	3			3
402		*Genus* sp. (R.J. Cranfield 26863)	B		3	1	4
387		*Genus* sp. small ceratodon (R.J. Cranfield 26748)	B	2			2
388		*Orthodontium pallens*	B	6	3	7	16
125		*Racopilum cuspidigerum* var. *convolutaceum*	B	3	4	5	12
295		*Rosulabryum billarderi*	B	11	17	13	41
390		*Rosulabryum microrhodon*	B	3	1	1	5
389		*Rosulabryum* sp. tight (R.J. Cranfield 26745)	B	3			3
391		*Rosulabryum subtomentosum*	B	4	9	9	22
337		*Sematophyllum homomallum*	B	10	4	4	18
403		*Tayloria octoblepharum*	B	1		1	2
12	**27**	***Cephaloziella exiliflora***	H	14	23	24	61
15	**28**	***Chiloscyphus semiteres***	H	7	2	3	12
47	**41**	***Fossombronia altilamellosa***	H	1	1		2
386		*Cephaloziella hirta*	H	9	14	16	39
380		*Chaetophyllopsis whiteleggei*	H	1			1
406		*Enigmella thallina*	H	1		4	5
46		*Fossombronia pusilla*	H	1	1		2
368		*Kurzia hippurioides*	H	4	13	3	20
332		*Lethocolea pansa*	H	8	6	10	24
407		*Lunularia cruciata*	H			1	1
1		*Phaeoceros laevis*	H		1	1	2
404		*Riccardia* c.f. *aequicellularis*	H	3		1	4
398		*Riccardia cochleata*	H		2	2	4
16	**1**	***Cladia aggregata***	L	12	18	21	51

Sp. No.	PMS No.	Taxon	Life-form[2]	Treatment[1]			Total
				ER	SW/SC	GR	
17	**2**	***Cladia schizopora***	L	16	14	13	43
23	**3**	***Cladonia cervicornis* var. *verticellata***	L			1	1
26	**4**	***Cladonia krempelhuberi***	L	5	1	9	15
30	**5**	***Cladonia rigida***	L	21	4	16	41
37	**6**	***Cladonia sulcata***	L	1	3	1	5
5	**7**	***Calicium glaucellum***	L	4	1		5
221	**8**	***Diploschistes sticticus***	L	1	2		3
61	**10**	***Hypocenomyce foveata***	L	1			1
78	**11**	***Hypocenomyce scalaris***	L	5	4	9	18
103	**12**	***Hypogymnia subphysodes* var. *subphysodes***	L	8	3	3	14
107	**13**	***Menegazzia platytrema***	L	7	2	4	13
115	**15**	***Ochrolechia* sp. (G.S. Kantvilis 306/92)**	L	4		3	7
118	**16**	***Pannoparmelia wilsonii***	L	21	9	7	37
119	**17**	***Paraporpidia glauca***	L	11		8	19
52	**19**	***Ramboldia stuartii***	L	10	1	3	14
79	**20**	***Tephromela alectoronica***	L	2	1	3	6
64	**21**	***Thysanothecium hookeri***	L		1	1	2
132	**22**	***Thysanothecium scutellatum***	L	10	14	17	41
136	**23**	***Usnea inermis***	L	19	9	7	35
344	**36**	***Genus sp. grey green slick***	L	13	12	12	37
241		*Austroparmelina conlabrosa*	L	9	3	3	15
334		*Austroparmelina pseudorelicina*	L	3			3
400		*Bacidia* sp. termite mound	L		1	1	2
4		*Buellia cranfieldii*	L	1		1	2
313		*Buellia homophylia*	L		1		1
279		*Buellia tetrapla*	L	4	1	3	8
148		*Calicium tricolor*	L	1		1	2
7		*Calicium victorianum* subsp. *victorianum*	L	2			2
149		*Caloplaca elixii*	L	1	1	5	7
152		*Cladonia calyciformis*	L	1			1
252		*Cladonia capitellata*	L	3	3	2	8
18		*Cladonia chlorophaea*	L			1	1
154		*Cladonia merochlorphaea*	L	4			4
385		*Cladonia nudicaulis*	L	3			3
29		*Cladonia ramulosa*	L			5	5
31		*Cladonia scabriuscula*	L		7		7
38		*Cladonia tessellata*	L		1	6	7
399		*Diploschistes diploschistoides*	L		1		1
222		*Ephebe lanata*	L	2		1	3
378		*Genus* sp. mustard	L	6	4	4	14
327		*Genus* sp. termite mound (R.J. Cranfield 21529)	L	1			1
373		*Halegrapha mucronata*	L	4			4
96		*Hypocenomyce australis*	L	2	1	2	5
330		*Hypogymnia subphysodes*	L	7		1	8

Sp. No.	PMS No.	Taxon	Life-form[2]	Treatment[1] ER	SW/SC	GR	Total
104		*Imshaigia aleurites*	L	4			4
364		*Lecidea capensis*	L	1	5		6
54		*Lecidea sarcogyunoides*	L	2			2
376		*Lecidea* sp.	L			1	1
333		*Megularia grossa*	L		1		1
408		*Menegazzia caesiopruinosa*	L	1			1
291		*Notocladonia cochleata*	L	1			1
112		*Ochrolechia* sp. tan doughnuts (R.J. Cranfield 18163)	L		1		1
384		*Ochrolechia subpallescens*	L	8	1	2	11
111		*Ochrolechia subrhodotropa*	L	2	1	1	4
293		*Parmotrema reticulatum*	L		1		1
346		*Peltigera dolichorriza*	L			1	1
114		*Pertusaria* sp. white pustules (R.J. Cranfield 17911)	L	1			1
326		*Pertusaria thiophanica*	L	3	4		7
196		*Pertusaria trachyspora*	L	3			3
409		*Pterygiopsis* spp.	L	1			1
198		*Pyrenopsis* sp. (R.J. Cranfield 18998)	L		6		6
163		*Ramboldia sorediata*	L	3	2	2	7
362		*Thysanothecium sorediatum*	L	1	1	1	3
178		*Trapelia crystallifera*	L	3	5	4	12
367		*Lichenomphalia chromacea*	LF	2			2
		Total number of species		**85**	**65**	**69**	**106**
		Total Lichens		51	39	39	66
		Total Mosses		24	17	20	27
		Total Liverworts		10	9	10	13
		Total number of monitoring species		**29**	**25**	**25**	**31**
		Monitoring lichens		19	17	18	21
		Monitoring mosses		7	5	5	7
		Monitoring liverworts		3	3	2	3

[1] L = lichen, B = bryophyte (mosses) and H = heptophyte (liverwort, hornwort)
[2] ER = external reference, SW/'SC = shelterwood/selective cut, GR = gap release

VASCULAR PLANTS

Bruce Ward and Ray Cranfield

Introduction

Understorey plants are key organisms for monitoring impacts of commercial timber harvesting in jarrah (*Eucalyptus marginata*) forest. FORESTCHECK utilises data on species richness and abundance to determine impacts across silvicultural harvesting treatments. One of the strengths of this monitoring is that it is applied at an operational scale under standard industry conditions providing results that are representative of forest management practices.

Disturbance associated with timber harvesting includes soil mixing and compaction, and direct physical impact on trees and shrubs during felling and extraction operations. These effects may reduce the abundance of some plant species, but can also provide opportunities for regeneration by creating mineral earth seedbeds and stimulating rootstocks and germination of seed stored in the soil. When analysing species richness data from harvest treatment sites it is important to also consider time since fire as observed differences may be due to succession following fire rather than a direct impact of timber harvesting. Vegetation complexes of the jarrah forest are considered to be relatively stable and resilient to natural disturbances such as fire. In most circumstances, and in time, species that were present before disturbance are generally present after the event, although abundances may temporarily change.

The specific aim of monitoring vascular plants for the FORESTCHECK project is to:

- determine species richness and abundance in the various silvicultural treatments of managed jarrah forest (shelterwood, selective cut and gap release) and in uncut reference forest
- compare species richness, abundance and composition recorded within and between silvicultural treatment grids to those in uncut reference grids.

Monitoring

Nine FORESTCHECK monitoring grids were measured in the Donnelly District during September and October of 2013. They included three external reference (FC49, FC54 and FC10), two shelterwood (FC53, FC56), one selective cut (FC51) and three gap release treatment grids (FC50, FC52 and FC55). All occur within the Bevan 1 vegetation complex (Matiske and Havel 2000) and are located on lateritic uplands in perhumid zones. The set of grids is referred to as Donnelly 2.

Species richness and understorey vegetation structure was determined, by recording each species, estimating its area of cover, frequency of occurrence and measuring its position in the understorey strata in six 1000m^2 plots for each grid. Vegetation structure was determined from Levy contact data at various height categories up to 2m in the understorey (Levy and Madden 1933). Point samples were taken at 1m intervals on three internal trap lines (for 100 point samples per line or 300 per grid) and numbers of contacts were used to describe the vertical profile of the vegetation. Canopy cover was also assessed at each point sample using a periscope with a vertical view set at eye level on the levy pole. Canopy was rated as present (Y) or not (N) with canopy cover calculated as a percentage of the total contacts that have a 'yes' (Y). Cover was divided into mid- and upper-storey ratings. The mid-storey was further split into eucalypt and other species so that the structure of the developing stand could be tracked as it progressed from saplings into poles and from poles to mature trees. Detailed descriptions of all monitoring methods including abundance, cover and frequency ratings is documented in the FORESTCHECK Operations Plan (DEC 2006).

Preliminary rResults
Species richness
A total of 171 vascular plant species were recorded at Donnelly 2 in 2013, including three weed species (Table 1 and Appendix 1).

Table 1 Total number of plant species recorded and the distribution of unique and shared species between treatments at the Donnelly 2 FORESTCHECK grids in 2013.

	Number of species in treatments[1]			Total
	ER	SW/SC	GR	
Total	121	116	118	171
Unique to treatment	26	16	21	
Common to all treatments				74
Common to ER + SW/SC				12
Common to ER + GR				10
Common to SW/SC + GR				12

[1] ER = external reference, SW/SC = shelterwood/selective cut, GR = gap release

Floristically, Carter block was the most species diverse (Fig. 1). Each of the treatments has a wide spread of ages since harvesting and fire treatment, with the youngest ages 4-5 years having the highest species richness and the oldest 9-14 years the lowest (Fig. 1). When the mean of species richness was calculated for each treatment there was virtually no difference between treatments (Fig. 2).

Plant abundance
Some plant species abundances can be influenced by disturbances associated with timber harvesting. However, not all species are equally affected by disturbances since effects depend on the type and intensity of disturbance. The density of plants from six plots on each grid was determined by summing the abundance class mid-point values for each species and then converting that figure to plants per square metre for each grid. Fire intensity can have a varying effect on understorey species. Peet (1971) showed in the northern jarrah forest that mild intensity fire promoted a richer ground flora, whereas high intensity fire resulted in a dominance of leguminous species such as *Bossiaea aquafolium* and *Acacia browniana.* Our results were consistent with these patterns. We found that those with the highest abundance contained hard seeded leguminous species, including *Bossiaea aquafolium and Acacia browniana*; whereas grids without fire-stimulated obligate seeders were dominated with resprouting species, including *Pattersonia umbrosia* (Fig. 3)*, Bossiaea ornata, Hibbertia commutata and Hibbertia amplexicaulis.* The highest abundance was measured in a five year old shelterwood grid (FC51) and the lowest a six year old reference forest grid (FC54) (Fig. 4).

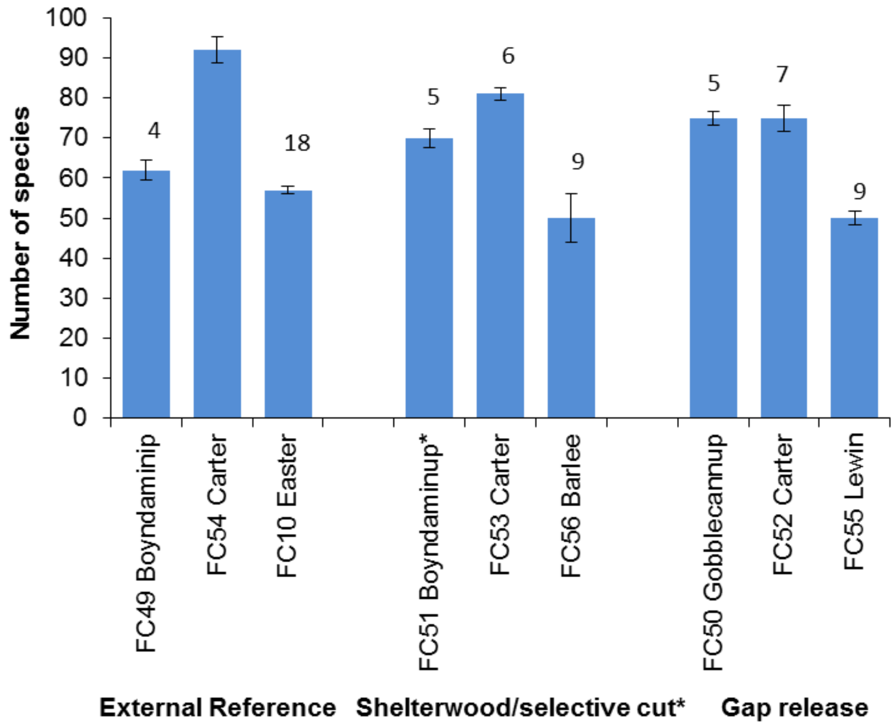

Figure 1. Mean number of plant species per plot recorded in each monitoring grid at the DONNELLY 2 FORESTCHECK grids in 2013. Numbers above columns indicate years since the last fire.

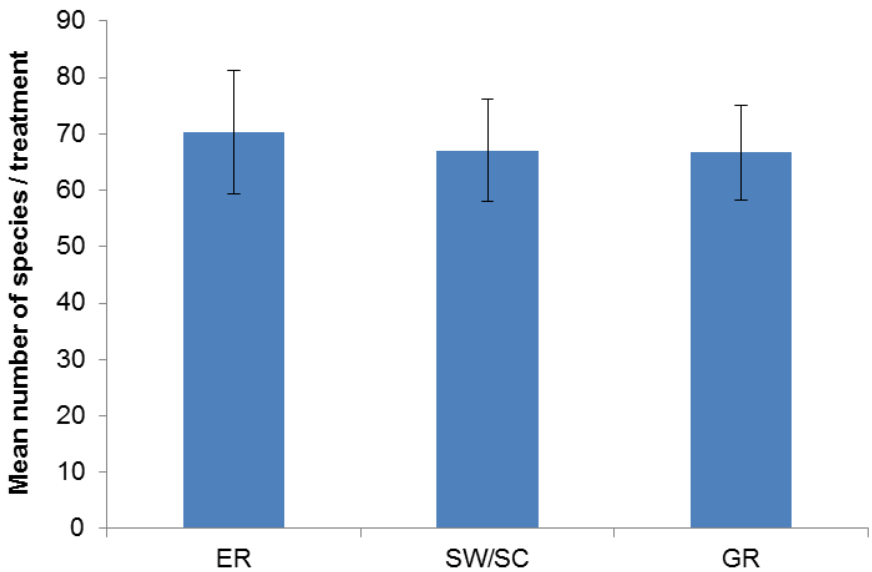

Figure 2. Mean species richness (±se) of plants in each treatment at the Donnelly 2 FORESTCHECK grids in 2013 (ER = external reference, SW/SC = shelterwood/selective cut, GR = gap release)

Patersonia umbrosia var *umbrosia* | *Pimelia rosea* | *Patersonia umbrosia* var *xanthina* | *Rhodanthe citrina* | *Thysanotus multiflorus*

Figure 3. Left to right: *Patersonia umbrosia* var *umbrosia* was found in all treatments with the highest abundance in the gap release treatment; *Pimelia rosea*, a tall perennial shrub > 30cm which relies on soil stored seed was only recorded in the gap release treatment; *Patersonia umbrosia* var *xanthina,* a close relative of *P. umbrosia* var. *umbrosia*, is a perennial shrub to 30cm which regenerates from a woody rootstock was only recorded in reference forest; *Rhodanthe citrina* is an annual herb which regenerates from soil stored seed was recorded in clumped but low abundances in disturbed areas of shelterwood grids and *Thysanotus multiflorus*, a geophyte which propagates from a fleshy underground tuber, was recorded in all treatments, but was most abundant in the shelterwood/selective cut treatments (see Appendix 1).

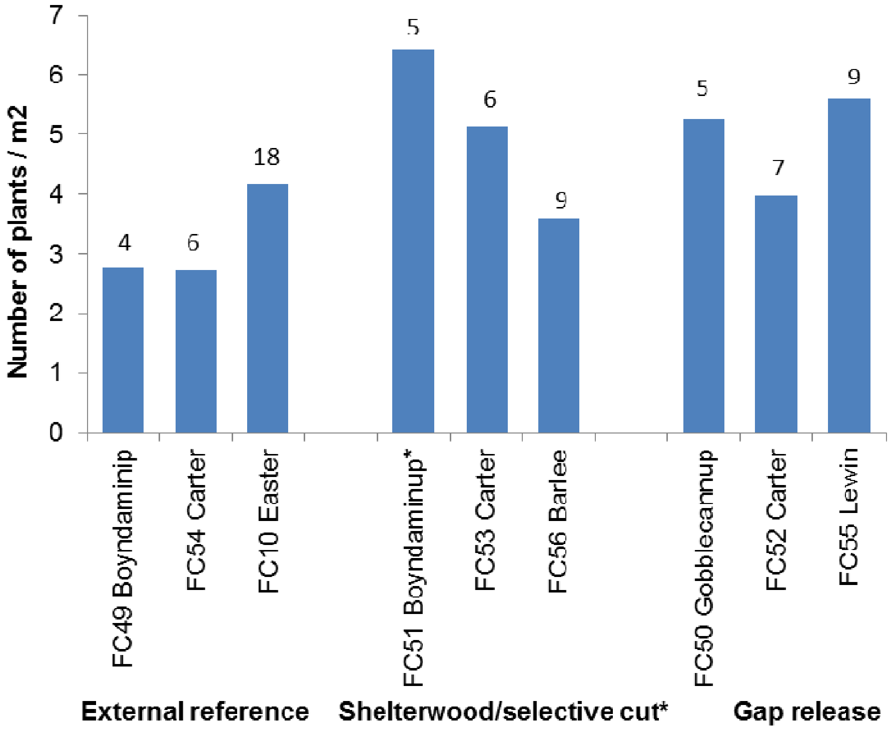

Figure 4 Total numbers of plants per square metre on each FORESTCHECK grid at Donnelly 2 in 2013. Numbers above columns indicate the time since last fire on each grid.

For plants, resource partitioning is considered an important determinant of species diversity in structuring plant communities. However, this aspect has been difficult to resolve due to problems in studying how plants compete for below ground resources (McKane *et al.* 2002). Often in communities, only a few species are very common (or dominant) while the majority of species occur at moderate or low abundances (subordinate or rare). Dominant species often take a disproportionate share of resources, contribute most to productivity and other ecosystem functions, and are consistently present in the community over time. Rare and uncommon species, on the other hand, are collectively the most diverse component of the community, but generally contribute less to ecosystem functioning and often experience high levels of species turnover.

The frequency with which plant species contribute to the community show that sites are dominated with a handful of species (<10) that are high in number with the majority having a low or moderate abundance (Fig. 5)

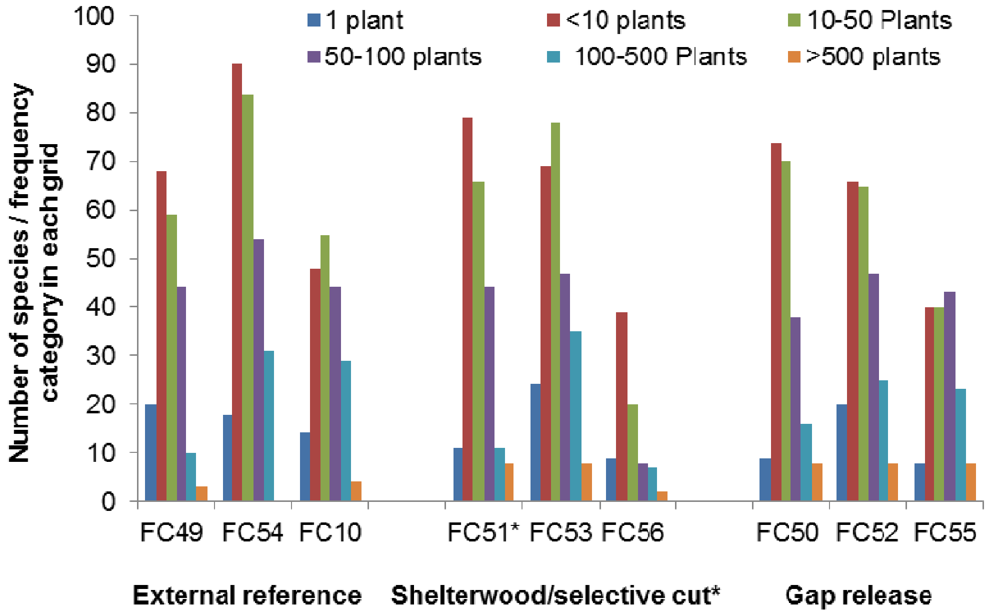

Figure 5 The number of plant species per frequency category in each Forestcheck monitoring grid at Donnelly 2 in 2013

Plant life forms and fire responses

In vegetation ecology, plants have been grouped into life- or growth-form categories on the basis of their similarity in structure and function, which also displays an obvious relationship to environmental influences. Here, life form groups were used to compare the effects of silvicultural treatments and determine if various sub groups are more vulnerable to silvicultural treatments than others. On the Donnelly 2 grids, the numbers of tall shrub (>30cm) and geophyte species declined slightly in the harvested treatments, whereas small woody shrubs (<30cm) increased by a few species (Fig. 6).

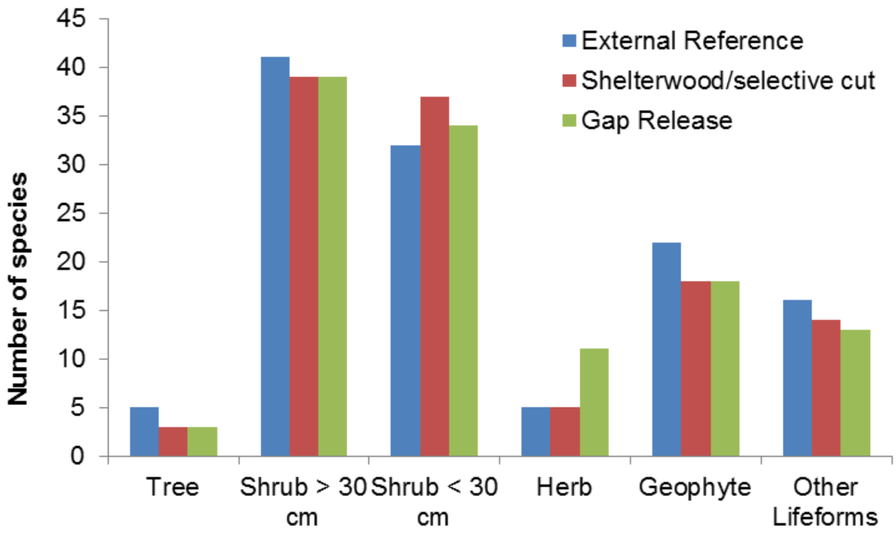

Figure 6 Number of species within each life form category in each treatment at the Donnelly 2 FORESTCHECK grids in 2013.

Plant structure

Vegetation Height and structure was used to describe the vertical profile of the vegetation (Fig 7). The amount of dead contacts (determined during Levy measurement—see methods), was also measured, to determine the level of senescence within the shrubs. It has been suggested that a shrub is senescent and in need of rejuvenation when 50% of the plant canopy is dead (Shedley 2007), although ongoing work in this area continues to develop our level of understanding. Structure is measured as vegetation layers on vertical plains and has value in estimating habitat condition for native animals and birds. It is also used to characterize ecosystems in order to assess changes in communities. Changes in vegetation structure between monitoring events will strongly reflect how disturbed sites are recovering or developing in terms of the functional role of the vegetation. At Donnelly 2, reference forest grids tend to be dominated by resprout species while harvest treatment grids are dominated by fire stimulated seeder species. Differences in plant regeneration and growth habits have had an effect on the vertical structure of the vegetation.

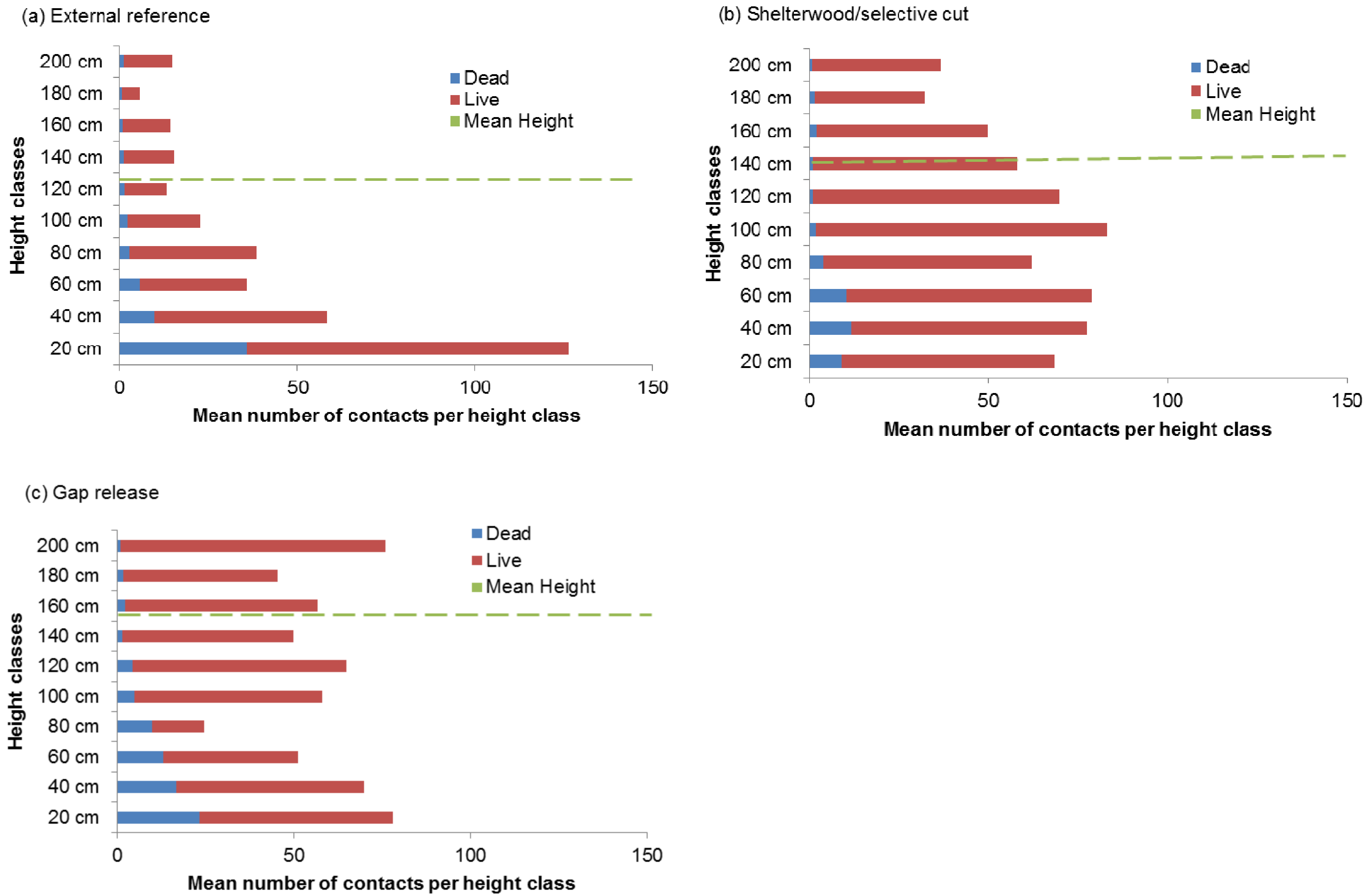

Figure 7. Vertical profile of the external reference (a), shelterwood/selective cut (b) and gap release (c) grids in Donnelly 2 shown by density of contacts in live and dead vegetation for 20cm height categories up to 2m in height. The green dashed line represents the mean height of all point samples for each treatment.

The height of vegetation is related to time since fire, and grids with the longest time since fire had the tallest shrubs. The Boyndaminup external reference grid (FC49) had the lowest vegetation and only 4 years since prescribed fire. The tallest vegetation was at the Barlee gap release (FC55), burnt 9 years previously, and the long-unburnt (18 years) Easter reference grid (FC10). However, the overall mean height for each treatment was similar (Fig. 8).

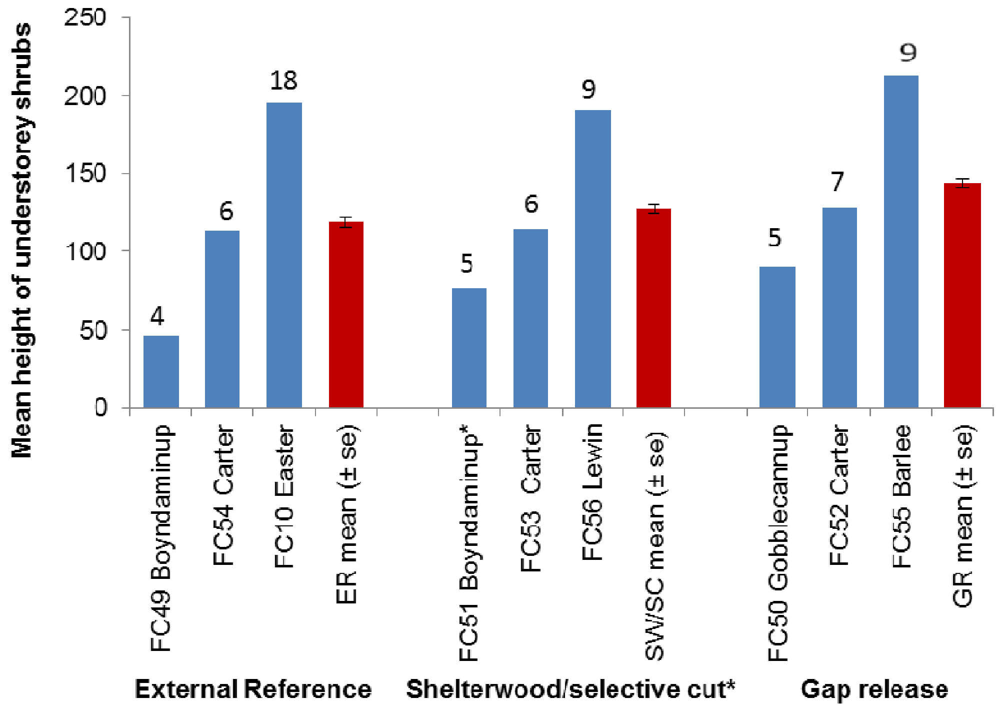

Figure 8 Mean height of understorey vegetation in each grid at the Donnelly 2 FORESTCHECK grids, showing the overall mean (± se) per treatment as red columns. Numbers above columns indicate time since the last fire on each grid.

Conclusions

The main observations made following monitoring of vascular flora on the Donnelly 2 FORESTCHECK grids in 2013 were that;

- The Jarrah South ecosystem, as represented by the Donnelly 2 FORESTCHECK monitoring grids, has a rich and diverse flora, with the highest local diversity occurring on the Carter forest block grids.
- A total of 174 species of vascular plants were recorded.
- The overall mean species richness of plants was similar in all treatments.
- The mean abundance of vascular plants was consistently lower in the external reference treatment compared to the harvested treatments.
- The understorey vegetation was denser on harvested grids, which may be important for native animal and bird habitat.

Acknowledgements

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Appendix 1 Species of vascular plants and their mean abundances recorded in treatments at the Donnelly 2 FORESTCHECK grids in 2013 (ER = external reference area, SW = shelterwood/selective cut areas and GR = gap release areas, bold* type indicates weed species)

Current Species Name	Treatment		
	ER	GR	SW/SC
Acacia browniana	53.0	5756.0	7964.5
Acacia extensa	1.8		4.0
Acacia myrtifolia	1.8	1.8	2.2
Acacia pulchella	43.7	11.0	6.2
Acacia urophylla	15.7		
Agonis flexuosa	0.3		
Aira cupaniana*		842.0	
Allocasuarina fraseriana	0.3		
Amphipogon amphipogonoides	3.8	11.8	83.5
Andersonia caerulea			146.8
Asterolasia pallida			1.8
Astroloma drummondii		47.0	3.7
Astroloma pallidum	1.8	0.3	12.0
Astroloma spp.		0.3	1.8
Banksia grandis	153.5	166.5	93.0
Banksia littoralis		1.8	
Billardiera floribunda	1.8		0.3
Billardiera variifolia	5.5		0.3
Boronia gracilipes		27.3	12.3
Boronia megastigma	25.2		
Boronia spathulata			3.7
Bossiaea aquifolium subsp. *laidlawiana*	582.5	564.8	4112.8
Bossiaea linophylla	58.7		
Bossiaea ornata		922.3	36.7
Caladenia flava	15.0	11.7	63.8
Caladenia macrostylis	2.2		0.3
Caladenia reptans	41.2	38.7	6.2
Calytrix leschenaultii			1.8
Centaurium erythraea*		52.2	1.8
Chamaescilla corymbosa	37.5	1872.3	1252.3
Chorilaena quercifiola	9.8		
Chorizema retrorsum	2.2		
Clematis pubescens	24.7	27.0	
Comesperma calymega			0.3
Comesperma confertum			0.3
Comesperma virgatum	0.3		
Conostylis setigera			1.8
Corymbia calophylla	1633.2	3221.7	1539.0
Cyanicula sericea	12.3	36.8	62.0
Cyathochaeta avenacea		11.7	
Cyrtostylis huegelii	2373.2	994.8	1.7
Damperiea alata	0.3		
Dampiera hederacea		3.7	
Dampiera linearis	3.7		0.3
Daucus glochidiatus	9.8	0.3	
Desmocladus fasciculatus	11.7		

Current Species Name	Treatment		
	ER	GR	SW/SC
Desmocladus flexuosus	3.7	1.8	27.0
Dianella revoluta		2.2	
Drosera erythrorhiza	0.3		35.3
Drosera huegelii	12.3	26.3	51.0
Drosera menziesii	7.7	1.8	5.5
Eucalyptus marginata	123.0	127.3	3211.3
Euchiton collinus		12.2	1.2
Gastrolobium bilobum	1.8	1.8	
Geranium solanderi		0.3	
Gompholobium capitatum			9.8
Gompholobium ovatum	7.3		
Gompholobium preissii	9.8		0.3
Gonocarpus benthamii		19.0	
Goodenia eatoniana	1.8		
Grevillea centristigma			27.0
Grevillea pulchella	1.8	1.8	1.8
Hakea amplexicaulis	14.7	57.0	52.2
Hakea cyclocarpa			1.8
Hakea lissocarpha	1.8	3.7	13.5
Hakea prostrata	17.2		9.8
Hardenbergia comptoniana	23.3		
Hemigenia pritzelii		2.2	0.7
Hibbertia amplexicaulis	527.7	87.2	486.5
Hibbertia commutata	651.2	266.5	767.3
Hibbertia cuneiformis		9.8	
Hovea chorizemifolia	19.0	11.7	0.3
Hovea elliptica	276.8	74.3	43.0
Hovea trisperma	9.8		
Hybanthus debilissimus	5.3	2.2	
Hydrocotyle alata		25.2	
Hypocalymma cordifolium		85.3	
Hypochaeris glabra*	0.3	31.0	29.2
Isopogon sphaerocephalus			3.7
Isotoma hypocrateriformis		9.8	
Isotropis cuneifolia	11.7		
Johnsonia lupulina	1.8		
Kennedia coccinea	5.5	28.8	7.2
Lagenophora huegelii	916.7	393.8	197.2
Lasiopetalum floribundum		22.7	
Lechenaultia biloba	1.8		
Leptomeria cunninghamii	15.7	2.2	39.3
Leucopogon australis	116.7	343.5	97.0
Leucopogon capitellatus	1192.0	44.0	24.7
Leucopogon pendulus	28.8	37.2	21.7
Leucopogon propinquus	42.3	13.5	12.8
Leucopogon pulchellus	63.8	9.8	1187.2
Leucopogon obovatus subsp. *revolutus*		25.2	
Leucopogon verticillatus	115.5	191.7	15.0
Levenhookia pusilla	9.8	54.7	172.0
Lindsaea linearis	959.8	1136.8	85.3
Logania serpyllifolia	2.2	157.8	17.2

Current Species Name	**Treatment**		
	ER	GR	SW/SC
Logania vaginalis	11.7		
Lomandra caespitosa	71.8	94.2	296.2
Lomandra drummondii	5.5	5.7	29.8
Lomandra hermaphrodita		9.8	1.8
Lomandra integra	85.7	16.8	35.0
Lomandra pauciflora	5.5	128.2	5.8
Lomandra sericea	11.2	2.2	13.8
Lomandra sonderi		13.5	47.0
Macrozamia riedlei	75.5	7.3	13.2
Melaleuca thymoides		9.8	
Microlaena stipoides		9.8	3.7
Millotia tenuifolia	0.3	111.8	25.2
Mirbelia dilatata			9.8
Monotaxis occidentalis	156.7	12.8	1.2
Opercularia hispidula	433.7	298.0	46.0
Orthrosanthus polystachyus	25.2		
Oxalis corniculata*		1.8	
Paraserianthes lophantha		0.3	
Patersonia babianoides	13.5	2.2	1.8
Patersonia occidentalis	54.7	11.7	38.7
Patersonia umbrosa	8.7	44.8	2163.0
Patersonia umbrosa var. *xanthina*	967.2		
Pentapeltis peltigera	11.7		1.8
Pentapeltis silvatica	5.5		0.3
Persoonia longifolia	84.0	72.2	199.3
Petrophile diversifolia	2.2		5.5
Phyllangium paradoxum		1.8	
Pimelea rosea			5.5
Platysace filiformis	0.3	1.8	
Platysace tenuissima	11.7	39.3	32.0
Podocarpus drouynianus	119.5	14.0	129.0
Poranthera huegelii		1.8	
Pteridium esculentum	148.0	85.3	38.7
Pterostylis barbata	2.5		
Pterostylis pyramidalis	1692.8	121.0	52.8
Pterostylis vittata	2.8	25.5	1.3
Ptilotus manglesii			1.8
Rhodanthe citrina		25.2	
Rytidosperma caespitosum	1.8	49.2	2.8
Scaevola striata	5.5	17.2	
Senecio hispidulus	3.2	1.7	2.2
Sphaerolobium medium	13.8	5.5	79.5
Stackhousia monogyna	0.3	1.8	9.8
Stylidium amoenum	3.7	42.3	48.5
Stylidium brunonianum	35.0		
Stylidium calcaratum		25.2	
Stylidium ciliatum	35.0	15.5	79.8
Stylidium luteum		127.2	38.7
Stylidium rhynchocarpum	76.2	44.8	226.0
Stylidium spathulatum	0.3		
Stylidium spp.		1.8	1.8

Current Species Name	**Treatment**		
	ER	GR	SW/SC
Taxandria parviceps	15.0	588.0	495.2
Tetraria capillaris	164.0	116.0	27.3
Tetraria octandra	0.3		1.8
Tetrarrhena laevis	157.8	237.0	85.3
Tetratheca affinis		0.3	
Thelymitra crinita	5.8		
Thelymitra spp.		0.3	
Thysanotus manglesianus	2.5	2.2	
Thysanotus multiflorus	2.2	23.3	5.5
Thysanotus sparteus			1.8
Thysanotus tenellus	0.3	1.8	3.7
Tremandra diffusa	143.7	89.0	44.2
Tremandra stelligera	275.8	12.0	
Trichocline spathulata	17.2	15.0	169.5
Trymalium odoratissimum subsp. *trifidum*	7.0	28.8	
Velleia trinervis	11.7	2.2	
Veronica calycina	282.0	54.7	7.3
Xanthorrhoea gracilis	74.7	64.8	171.3
Xanthorrhoea preissii	36.8		
Xanthosia atkinsoniana	2.2	15.3	1.8
Xanthosia candida	168.8	118.5	75.5
Xanthosia huegelii	15.3	13.8	3.7
Xylomelum occidentale			3.7
Number of species in each treatment	121	116	118

INVERTEBRATES

Janet Farr, Allan Wills and Paul Van Heurck

Introduction

Invertebrates, including class Insecta, comprise over 95% of the planet's biodiversity and therefore represent a crucial component in any ecosystem. Invertebrates play a major role in decomposition, nutrient recycling, plant pollination, and provide an important food source for vertebrates. In addition, a wide range of species are already known to be exclusive to the southwest forests of Western Australia, and some of these are Gondwanan relics. Despite this, current knowledge of the invertebrate taxa present in the jarrah forest is limited.

The objectives of this component of FORESTCHECK monitoring are to:

- monitor and record the species of invertebrates in various silvicultural treatments of managed jarrah forest and corresponding uncut forest
- analyse trends in species composition, richness and abundance
- monitor the presence of Gondwanan relic and affinity invertebrate species with respect to the above treatments
- monitor the presence of known insect pest species.

Field Survey and Laboratory Procedure

Sampling of 12 FORESTCHECK grids in the Jarrah South ecosystem in Donnelly District was carried out in March (autumn) 2013 and November (spring) 2013, using protocols outlined in the FORESTCHECK Operating Plan (revised 2006) with minor alterations. Grids FC1, FC2, FC3 and FC10 had been previously sampled in 2001; grids FC49–FC56 were newly established in 2013. To briefly summarise the sampling protocol, active capture samples (hand sampling) involving sweeping, beating, and habitat searches of coarse woody debris (CWD) and litter were conducted once at each grid for a total time of one-person-hour per capture/habitat method. Light traps were run for three nights, simultaneously at each grid achieving one trap night per week for three weeks. In 2013, pit fall trap numbers were doubled to 20 traps per grid arranged in a "Z" pattern across the central grid area (see grid layout on p.5) and opened for 10 consecutive days simultaneously at each grid. Doubling pit fall traps from from 10 to 20 has been shown to be more effective in capturing a wider diversity of the ground invertebrate fauna (van Heurck, unpublished data). Captures were bagged and labelled with site and other capture details in the field and stored in a portable freezer. At the conclusion of a sampling period, specimens were then transported to the laboratory where they were sorted and compared to an extensive collection of voucher specimens.. Vouchers for each new morphospecies were erected as necessary and labelled according to site, date of capture and capture method then preserved as either pinned or alcohol specimens. To constrain sample processing times only macro-invertebrates are recorded, that is, invertebrates with a body length 10mm or greater and Lepidoptera with a wing length of 12mm or greater. Highly distinctive or relictual morphospecies, smaller than these sizes, were also recorded. Samples waiting to be processed were stored either frozen or in 80% ethanol.

Preliminary Results

In the autumn sample period, there were five light trap failures, and the mean minimum overnight temperature was 12°C. Sorting, specimen identification and cataloguing is completed for the autumn light trap and hand samples. Spring samples and all pit fall samples are yet to be sorted (Table 1). This report therefore summarises sampling results for autumn 2013 only.

Table 1. Sample sort summary for Donnelly 2013 grouped by sample method and season. A tick indicates sorting and morphospecies allocation completed, a cross indicates sorting and morphospecies allocation yet to be done. Sp. = spring, Au = autumn sampling.

		Sample method					
Grid	**Location**	**Light trap**		**Pit fall trap**		**Active capture**	
		Sp	Au	Sp	Au	Sp	Au
FC01	Kingston	X	✓	X	X	X	✓
FC02	Kingston	X	✓	X	X	X	✓
FC03	Kingston	X	✓	X	X	X	✓
FC10	Easter	X	✓	X	X	X	✓
FC49	Boyndaminup	X	✓	X	X	X	✓
FC50	Gobblecannup	X	✓	X	X	X	✓
FC51	Boyndaminup	X	✓	X	X	X	✓
FC52	Carter	X	✓	X	X	X	✓
FC53	Carter	X	✓	X	X	X	✓
FC54	Carter	X	✓	X	X	X	✓
FC55	Lewin	X	✓	X	X	X	✓
FC56	Barlee	X	✓	X	X	X	✓

Following the 2013 monitoring (given that sorting is still yet to be completed) the number of morphospecies recorded for FORESTCHECK is presently 2,286 (Fig. 1), with a total of 92,612 individual specimens. The number of morpohospecies up to and including the Blackwood Plateau 2011–12 sample was 2221. Morphospecies assignment may change following data refinement from progressive taxonomic evaluation and will continue to be influenced by minor adjustments in the future as morphospecies assignment is further refined.

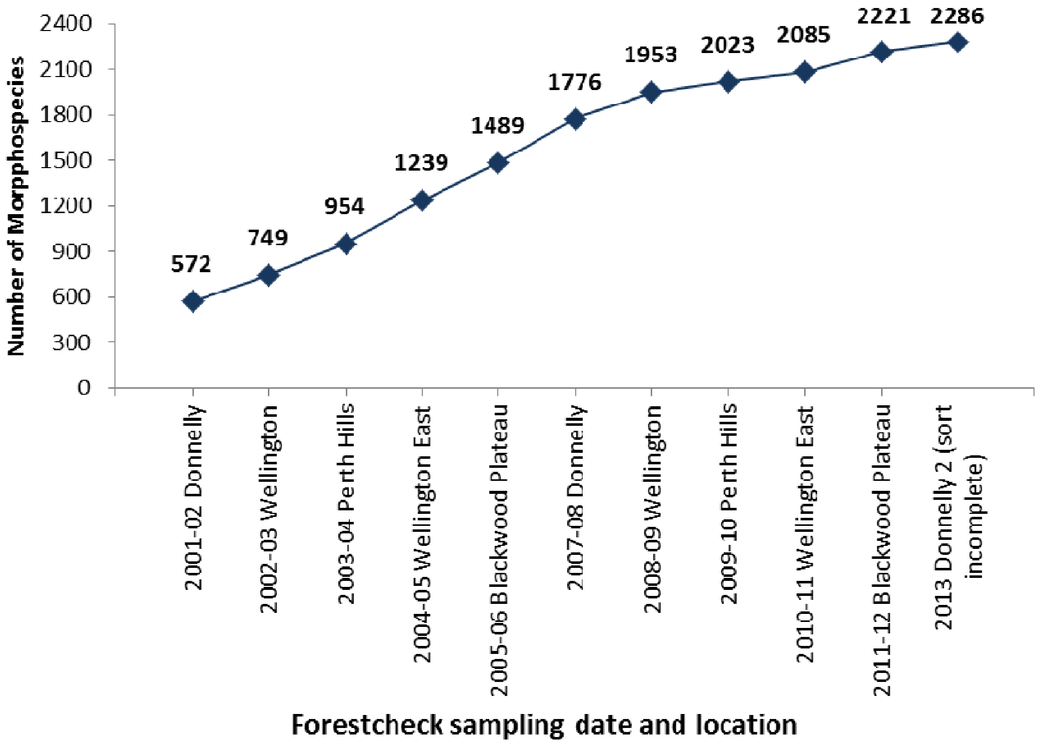

Figure 1. Cumulative morphospecies for 2001–2013 excluding spring 2013 captures and all pit fall captures for 2013.

A full report will be published as a supplement to the FORESTCHECK Report of Progress 2013 later in 2014 and will include a full species list for the FORESTCHECK invertebrate sample collected in 2013.

Data base

The invertebrate data bases have been checked, validated and updated including an additional field identifying trophic guild (according to Basset 2008) has been added for all species.

Acknowledgements

We thank Andy Young and Kerry Ironside for assistance in both the field and laboratory.

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DIURNAL AND NOCTURNAL BIRDS

Graeme Liddelow and Verna Tunsell

Introduction

Studies on the response of birds to disturbance in eucalypt forests and woodlands have demonstrated that deforestation (permanent removal of forest) has the largest impact on bird species (Catterall *et al.* 1998). The object of recording birds in FORESTCHECK is to monitor the impacts of logging and associated burning on bird species composition and abundance. This is achieved by:

- recording species richness and abundance within each silvicultural treatment (external reference, shelterwood, selective cut and gap release)
- comparing species richness and abundance between treatments
- analysing trends within species between treatments.

Monitoring

Nine FORESTCHECK monitoring grids, three external references, three shelterwood and three gap release were monitored for birds at Donnelly 2 in 2013. Birds were identified on both sight and sound and census techniques are detailed in the FORESTCHECK Operating Plan (DEC 2006). Briefly, for diurnal birds each grid was monitored five times during the spring of 2013, with at least seven days between each census. Monitoring commenced at sunrise and continued for four hours after sunrise in fine still weather. The central one hectare area at each grid is monitored for 20 mins before moving on to the next grid.

Preliminary Results and Discussion

Diurnal birds

A total of 35 species of birds comprising 790 individuals were recorded in 2013, with 14 species having 10 or more individuals (Table 1). There were 26 species (252 individuals) in the external reference, 28 species (259 individuals) in the shelterwood/selective cut and 27 species (279 individuals) in the gap release treatment. Similar numbers of species and individuals were recorded in each grid (Fig. 1).

Eight species of birds were recorded in only one treatment (either external reference, shelterwood or gap release—see Table 1). However, none would be expected to be restricted to that particular treatment, including the forest red-tailed black cockatoo—which was only recorded in the external reference site at Easter block, as there appeared to be adequate nesting and feeding sites in all areas.

There were six species of bird that were recorded 50 times or more. The most common birds recorded were the broad-tailed thornbill (*Acanthiza apicalis*) with a count of 174; the striated pardalote (*Pardalotus striatus*), 61; the golden whistler (*Pachycephala pectoralis*), 58; the white-browed scrubwren (*Sericornis frontalis*), 57; the grey fantail (*Rhipiduraq fuliginosa*), 53 and the red wattlebird (*Acanthochaera carunculata*), 50. These six species account for 57% of the total records for the 2013 survey (453 of 790). Three other species were recorded 40 times or more; the red-winged fairy-wren (*Malurus elegans*), 48; the western gerygone (*Gerygone fusca*), 44 and the western white-naped honeyeater (*Melithreptus chloropsis*) 41. Overall, these 9 species accounted for almost 74% of the total individuals recorded (586 of 790).

Table 1. Species list and the number of birds recorded in each treatment at Donnelly in 2013

RAOU N^o.1	Species name	Common name	External reference	Shelterwood/ selective cut	Gap release	Total
34	*Phaps chalcoptera*	Common bronzewing		1	1	2
35	*Phaps elegans*	Brush bronzewing	1		1	2
264	*Calyptorhynchus banksii naso*	Forest red-tailed black cockatoo	4			4
266	*Calyptorhynchus baudinii*	Baudins cockatoo	4		2	6
289	*Platycercus icterotis*	Western rosella	7	2		9
290	*Platycercus spurius*	Red-capped Parrot		1		1
294	*Barnardius zonarius semitorquatus*	Australian ringneck parrot	4	7	8	19
322	*Dacelo novaeguineae*	Laughing kookaburra	2	2	4	8
338	*Cacomantis flabelliformis*	Fan-tailed cuckoo	2	5	2	9
342	*Chrysococcyx basalis*	Horsefield's bronze-cuckoo	1	2	2	5
344	*Chrysococcyx lucidus*	Shining bronze-cuckoo		2	1	3
359	*Hirundo nigricans*	Tree martin			4	4
361	*Rhipidura fuliginosa*	Grey fantail	21	15	17	53
380	*Petroica multicolor*	Scarlet robin	4	3	1	8
387	*Eopsaltria georgiana*	White-breasted robin	10	12	11	33
398	*Pachycephala pectoralis*	Golden whistler	19	18	21	58
408	*Colluricincla harmonica*	Grey shrike-thrush	6	8	6	20
424	*Coracina novaehollandiae*	Black-faced cuckoo shrike	2	4	3	9
445	*Pomatostomus superciliosus*	White-browed babbler			4	4
463	*Gerygone fusca*	Western gerygone	12	16	16	44
476	*Acanthiza apicalis*	Broad-tailed thornbill	57	60	57	174
488	*Sericornis frontalis*	White-browed scrubwren	8	21	28	57
538	*Malurus elegans*	Red-winged fairy-wren	12	13	23	48
556	*Climacteris rufa*	Rufous treecreeper	4	1		5
565	*Pardalotus punctatus*	Spotted pardalote	6	10	9	25
574	*Zosterops lateralis lateralis*	Silvereye	8	4	3	15
578	*Melithreptus chloropsis*	Western white-naped honeyeater	15	13	13	41
592	*Acanthorhynchus superciliosus*	Western Spinebill		2		2
597	*Lichmera indistincta*	Brown honeyeater		2	1	3
631	*Phylidonyris novaehollandiae*	New holland honeyeater		2	2	4

Table 1. Continued......

RAOU N°[1]	Species name	Common name	External reference	Shelterwood/ selective cut	Gap release	Total
638	*Anthochaera carunculata*	Red wattlebird	19	14	17	50
697	*Sterpera versicolor*	Grey currawong		1		1
710	*Anthochaera lunulata*	Western little wattlebird	1			1
930	*Corvus coronoides*	Australian raven	2			2
976	*Pardalotus striatus*	Striated pardalote	21	18	22	61
	Total Species		26	28	27	**35**
	Total Individuals		252	259	279	**790**

[1] RAOU = Royal Australian Ornithologists Union

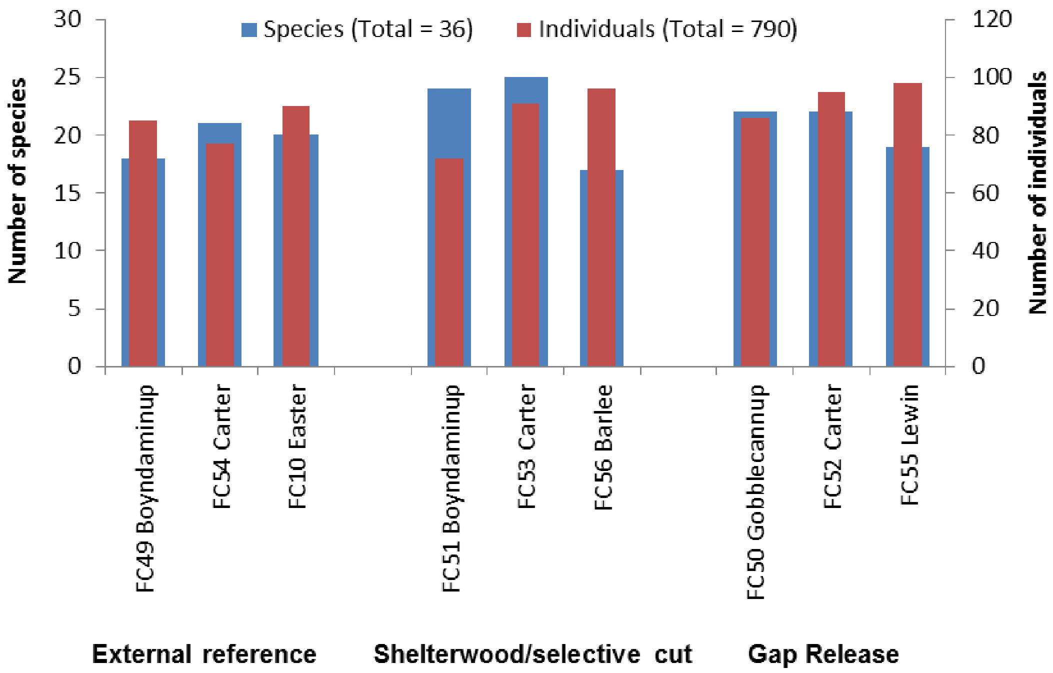

Figure 1. Number of bird species and individuals recorded in each FORESTCHECK grid at Donnelly 2 in 2013

The average density of birds within treatments was 17.6 birds ha^{-1} (Fig. 2), which is more than the long-term Kingston Study (see Abbott *et al*. 2003, 2009) in the southern jarrah forest region where the yearly average density is 10.4 birds ha^{-1} (Liddelow, unpublished). The densities recorded in each treatment were 16.8, 17.3 and 18.6 birds ha^{-1} in the external reference shelterwood/selective cut and gap release treatments respectively.

The white-browed scrubwren, was recorded in favorable numbers in the shelterwood/selective cut and gap release treatments (21 and 28 respectively), but was low in the external reference treatment (8 records). This is not surprising as the 'scrub' structure of the logged treatments has regenerated well with shrub and tree regeneration forming suitable habitat, whereas the external reference grids had a more open scrub structure and therefore less suitable.

Five different leaf gleaning and trunk and branch feeding species were recorded; the western gerygone (*Gerygone fusca*), broad-tailed thornbill, rufous treecreeper (*Climacteris rufa*), and spotted (*Pardalotus punctatus*) and striated pardalotes. The total number of these birds was 309, making up 39% of the total. Scrub birds, including the scarlet robin (*Petroica multicolor*), white-breasted robin (*Eopsaltria georgiana*), white-browed scrub wren and the red-winged fairy-wren (*Malurus elegans*) had 146 individuals comprising 18.5% of the total records. The mid canopy birds were recorded in similar numbers, including the grey fantail (*Rhipidura fuliginosa*), golden whistler (*Pachycephala pectoralis*), grey shrike-thrush (*Colluricincla harmonica*) and silvereye (*Zosterops lateralis*). Six species of honeyeater comprised 12.9% of the total with 102 individuals of these the western white-naped honeyeater (*Melithreptus chloropsis*) and the red wattle bird (*Anthochaera* carunculata) were the most abundant with 91 individuals. Parrots, even though five species were recorded; the forest red-tailed black cockatoo (*Calyptorhynchus banksii naso*), baudins cockatoo (*Calyptorhynchus baudinii*), western rosella (*Platycercus icteratis*), red-capped parrot (*Platycercus spurius*) and the australian ringneck parrot (*Barnardius zonarius*), only accounted for 4.9% of the total with 39 individuals.

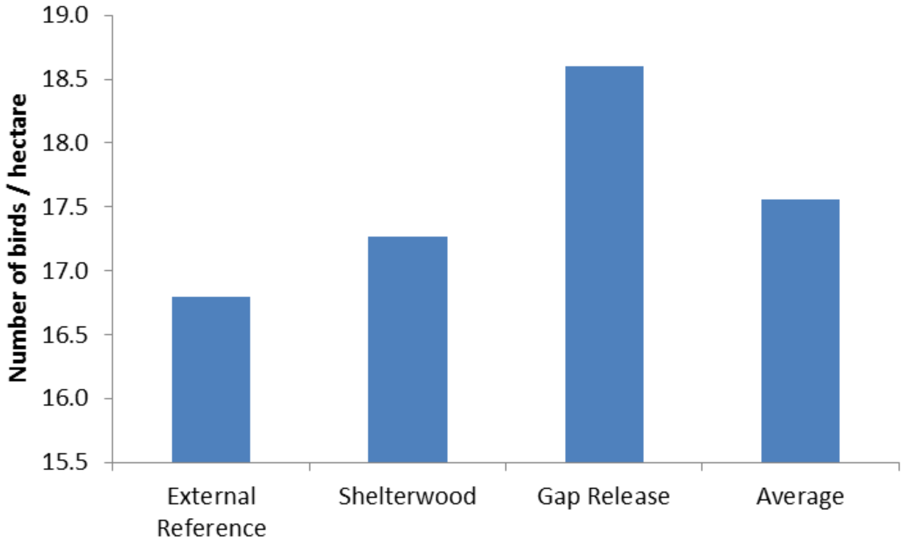

Figure 2. Bird densities recorded in each treatment at Donnelly 2 FORESTCHECK grids in 2013

No comparison can be made between any of the logged treatments as this was the first time these grids have been monitored. However, this was the third time that the site at Easter Block (FC10) has been surveyed. In 2001, 15 species and 85 individuals were recorded (17 birds ha^{-1}) on the grid. In 2008, 17 species and 67 individuals (13.4 birds ha^{-1}) and in 2013, 20 species and 90 individuals (18 birds ha^{-1}) were recorded. Overall, a total of 242 individuals comprising 24 species of birds have been recorded at FC10.

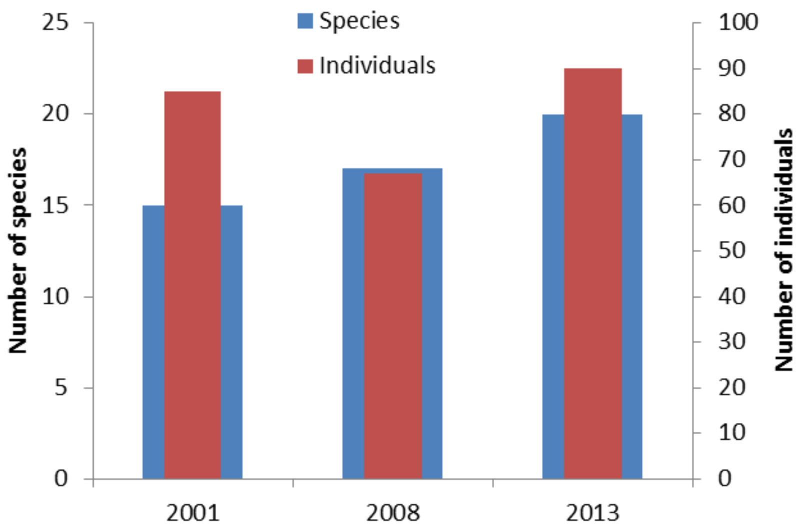

Figure 3. Numbers of species and individual birds at the Easter external reference grid (FC10) over three sample years

Nocturnal birds

Due to constraints on time and personnel, no systematic survey of nocturnal birds was undertaken in 2013. However, opportunistic records were kept when possible (e.g. during spotlight surveys for mammals in autumn and spring 2013), and studies by Liddelow *et.al.* (2002) would suggest that most species of nocturnal birds should be encountered in the Donnelly 2 locations.

Southern boobook owls (*Ninox novaeseelandiae*) were heard at all sites during mammal spotlight surveys and are generally common in this type of forest. Australian owlet-nightjars (*Aegotheles cristatus*) and tawny frogmouths (*Podargus strigoides*) were also commonly seen at night when travelling on roads between grid locations undertaking mammal spotlight surveys. Both species appear to be common in this type of forest habitat.

Conclusions

Bird species composition and abundances change continuously as the understorey density and fuel ages vary. These changes occur in harvested areas as the vegetation structure changes over time and through crown separation in regrowth trees and understorey shrubs, and in uncut forest as structural and successional changes occur in the understorey with time since fire. Changes in population also occur with variation in flowering cycles in plant species. Observations in 2013 related to these changes are:

- Two species of honeyeater, the western white-naped and the red wattlebird, were among the most common birds recorded due mainly to bull banksia (*Banksia grandis*) flowering during the survey period.
- Scarlet robins were mostly recorded in the external reference grids, which had a more open understorey and less dense scrub layer than silviculturally treated grids.
- White-browed scrubwrens were significantly more common in the thick scrub in shelterwood/selective cut and gap release treatments than in the open external reference treatment. Leaf gleaning birds (inland thornbill, western gerygone and striated pardalote) were constant over all treatments as the regenerating trees in the shelterwood/selective cut and gap release grids and virgin forest of the external references all had healthy crowns.
- Although no systematic survey was carried out for nocturnal birds, opportunistic records confirmed the presence of three species that would be expected to be present in this forest type.

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MAMMALS AND HERPETOFAUNA

Graeme Liddelow and Verna Tunsell

Introduction

The object of recording mammals and herpetofauna in FORESTCHECK is to monitor the impacts of timber harvesting and associated prescribed fire on species status and abundance. This is achieved by:

- trapping and recording medium and small sized mammals, reptiles and amphibians on each FORESTCHECK grid
- comparing species richness, abundance, sex ratio and trap percentages between grids and treatments at each location and between FORESTCHECK locations
- recording the presence of larger mammals along set transects that cover all treatments of the FORESTCHECK location on a landscape basis
- recording the presence of nocturnal mammals by spotlighting along set transects that cover all treatments of the FORESTCHECK location.

Monitoring

This report details preliminary results from monitoring nine FORESTCHECK grids located in Donnelly District. They include three unlogged external reference (FC10, FC49 and FC54), three Shelterwood (FC51, FC52 and FC56), and three gap release grids (FC50, FC53 and FC55). The group of grids is referred to as Donnelly 2. Trapping was conducted over two sessions, of four nights each, one month apart in both autumn and spring 2013; using protocols outlined in the FORESTCHECK Operations Plan. Briefly on each two hectare grid, 15 wire cage traps (20cm x 20cm x 45cm) and 15 20-litre pit fall traps (25cm dia. X 40cm deep) were set-up in a 50m x 50m grid pattern. Trapping sessions were conducted in April (15th–19th) and May (13th– 17th) in autumn and October (28th Oct.–1st Nov.) and December (2nd–6th) in spring.

Voucher Specimens

No specimens were logged with the Western Australian Museum from this trapping session

Preliminary Results

Trapping

The 2013 autumn and spring trapping sessions both consisted of a total of 4320 trap nights. This included 2160 trap nights for pit fall traps and 2160 trap nights for wire cages. The overall capture rate was 29.5 animals per night (cpn); 23.5 in autumn and 35.4 in spring (Fig. 1).

A total of 471 captures were recorded over the two sessions (Table 1, Figs 2 and 3); 188 in autumn and 283 in spring. Thirteen species of mammals were recorded with a total of 357 captures, 10 species of reptiles with 64 captures and seven species of amphibians with 50 captures over both seasons.

The most common mammal captured was the brushtail possum (*Trichosurus vulpecular*) with 21 individuals and 105 total captures; 28 of these were in autumn (13 individuals) and 77 in springs (15 individuals). Next was the black rat (*Rattus rattus*) with 49 individuals and 69 total captures, the mardo (*Antechinus flavipes*) with 47 individuals and 57 total captures, the dunnart (*Sminthopsis* sp.) 31 individuals and 32 individuals and the woylie (*Bettongia penicillata*) nine individuals and 31 captures.

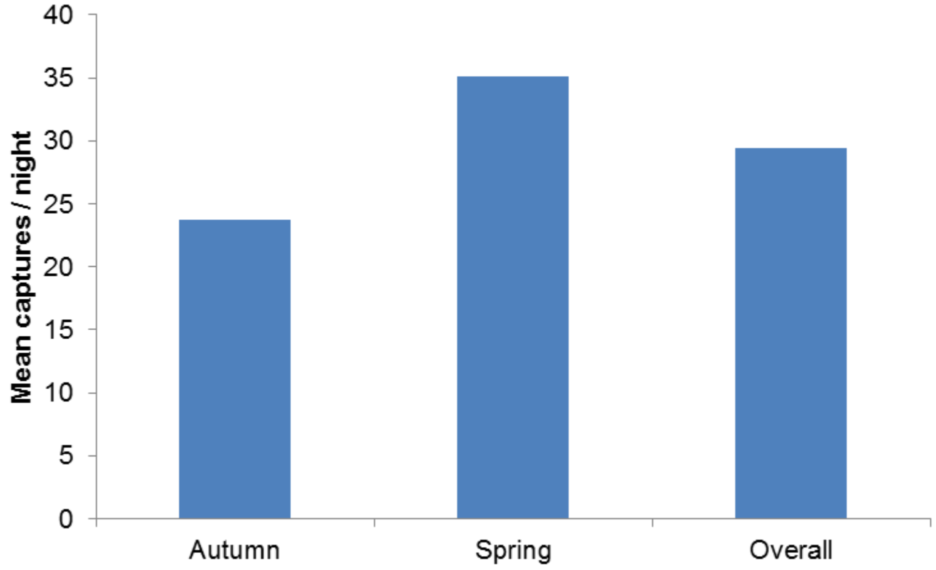


Figure 1. Mean number of animals captured per night (cpn) in Donnelly 2 FORESTCHECK grids in 2013

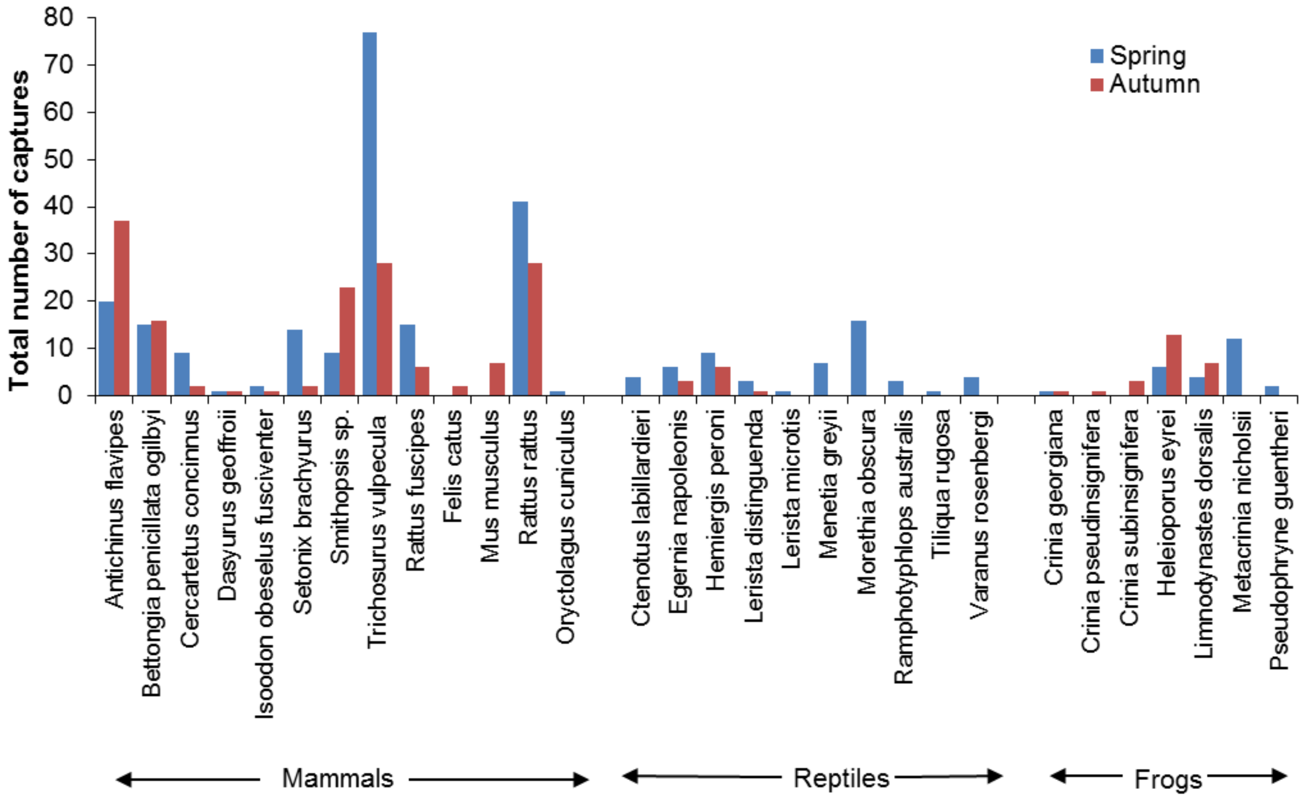


Figure 2. Total number of animal captured in Donnelly 2 FORESTCHECK grids in 2013

Table 1. Total number of animals captured in Donnelly 2 FORESTCHECK grids in 2013 (P = pit fall trap, W = wire cage trap)

Species	Common Name	External reference				Shelterwood/ Selective cut				Gap release				Total captures		
		Spring		Autumn		Spring		Autumn		Spring		Autumn		Spring	Autumn	Total
		P	W	P	W	P	W	P	W	P	W	P	W			
MAMMALS																
Antechinus flavipes	Mardo / Yellow-footed Antichinus		10		14		3		8		7		15	20	37	57
Bettongia penicillata	Woylie / Brush-tailed Bettong						7		16		8			15	16	31
Cercartetus concinnus	Mundarda / Western Pygmy-possum,	7		1		2						1		9	2	11
Dasyurus geoffroii	Chuditch		1		1									1	1	2
Isoodon obesulus	Quenda / Southern Brown Bandicoot				1		2							2	1	3
Setonix brachyurus	Quokka				1		4		1		10			14	2	16
Smithopsis sp.	Dunnart	5		13		2		8		2		2		9	23	32
Trichosurus vulpecula	Koomal / Common Brushtail Possum		14		10		44		8		19		10	77	28	105
Rattus fuscipes	Western Bush Rat						5				10		6	15	6	21
Felis catus	Cat								1				1		2	2
Mus musculus	House Mouse				4			1	1			1			7	7
Rattus rattus	Black Rat		18		17		6		8		17		3	41	28	69
Oryctolagus cuniculus	Rabbit										1			1		1
REPTILES																
Ctenotus labillardieri	Red-legged Ctenotus					2				2				4		4
Egernia napoleonis	Smith's Skink	1	2	1		3						2		6	3	9
Hemiergis peroni	Peron's (Lowland) Earless Skink	2		4		3		2		4				9	6	15
Lerista distinguenda	South Western Orange-tailed Slider	2				1						1		3	1	4
Lerista microtis	South western slider									1				1		1
Menetia greyii	Common Dwarf Skink	1				3				3				7		7
Morethia obscura	Southern Pale Flecked Morethia					10				6				16		16
Tiliqua rugosa	Bobtail / Shingleback		1											1		1
Varanus rosenbergi	Southern Heath Monitor		1				2				1			4		4
Ramphotyphlops australis	Southern Blind Snake	1				1				1				3		3
AMPHIBIANS																
Crinia georgiana	Quacking frog			1		1								1	1	2
Crinia pseudinsignifera	Bleating Froglet			1											1	1
Crinia subinsignifera	South Coast Froglet							3							3	3
Heleioporus eyrei	Moaning Frog	2		8		3		4		1		1		6	13	19

Species	Common Name	External reference				Shelterwood/ Selective cut				Gap release				Total captures		
		Spring		Autumn		Spring		Autumn		Spring		Autumn		Spring	Autumn	Total
		P	W	P	W	P	W	P	W	P	W	P	W			
Limnodynastes dorsalis	Pobblebonk / Western Banjo Frog / Bullfrog	1		2		2		2		1		3		4	7	11
Metacrinia nicholsii	Forest troadlet / Nicholl's Toadlet	3				2				7				12		12
Pseudophryne guentheri	Crawling Toadlet / Güther's Toadlet									2				2		2
Totals		**25**	**47**	**31**	**48**	**35**	**73**	**20**	**43**	**30**	**73**	**11**	**35**	**283**	**188**	**471**

(a)Autumn trapping

(b) Spring trapping

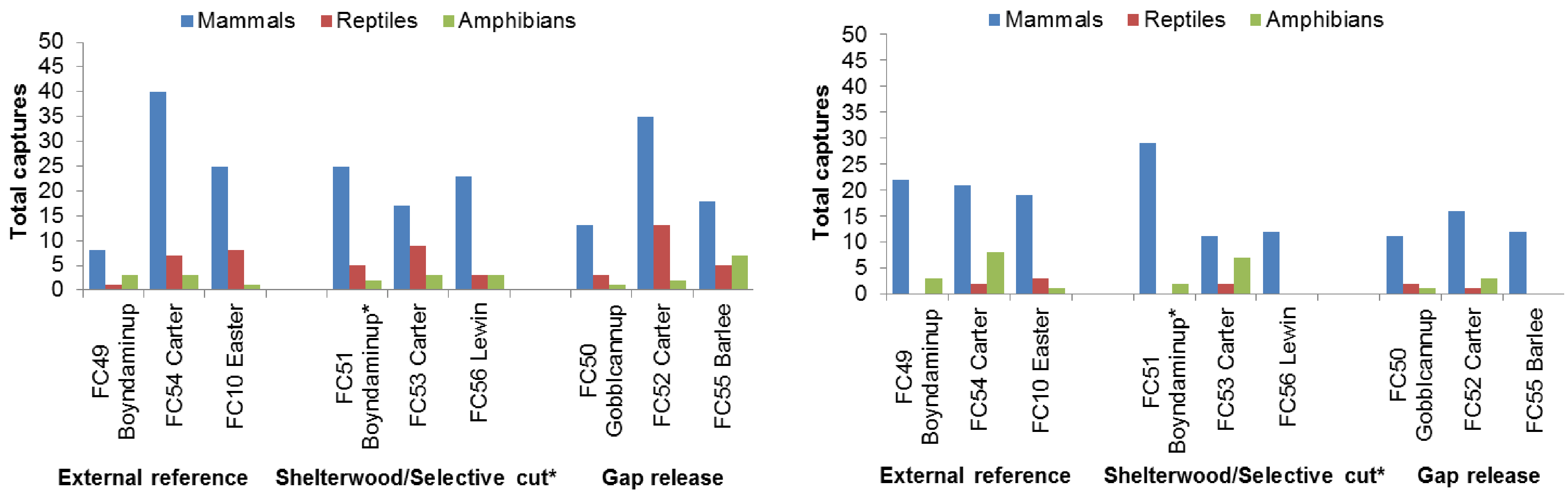


Figure 3. Total numbers of mammals, reptiles and amphibians captured in traps in (a) autumn and (b) spring in Donnelly 2 FORESTCHECK grids in 2013

Thirty nine possum captures were recorded in the external reference grids (4 individuals) and 66 in the silvicultural treatment areas, including 41 in gap release (7 individuals) and 25 in Shelterwood/selective cut (10 individuals). Of the 69 black rats captures, 35 occurred in the external reference (30 of these were in FC10 in Easter Block), 26 in the Shelterwood/selective cut (21 from FC56, the Barlee shelterwood) and eight in the gap release (seven from FC55 in Lewin) treatments. Twenty eight mardo (22 individuals) were trapped in the external reference grids, 23 (21 individuals) in the gap release grids and nine (seven individuals) in the Shelterwood/selective cut grids. The woylies were all trapped in two grids to the south-east of Manjimup with 30 captures (eight individuals) occurring in the Boyndaminup selective cut grid (FC51) and one in the Gobblecanup gap release (FC50). Other species trapped more than 10 times include the bush rat (*Rattus* fuscipes) with 21 captures, the quokka (*Setonix brachyurus*) 16 captures of which all but one were in silviculture treatment grids. This is because FORESTCHECK monitoring grids are not established in riparian zones and after silvicultural treatment, which includes follow up burning, the regenerating tree and understorey species are of similar structure to the creek systems that quokkas normally inhabit. The pygmy possum (*Cercartetus concinnus*) had a total of 11 captures, all in the Carter block grids including nine in the external reference grid (FC54) which, at the time of spring trapping, had numerous bull banksias (*Banksia grandis*) in flower.

As expected, most reptile captures occurred in spring. There were 64 reptile captures overall, with 54 occurring in spring. The most common species trapped were southern pale flecked Morethia (*Morethia obscura*) with 16 captures, all in spring, Peron's earless skink (*Hemiergis peroni*) with 15 captures, nine in spring and six in autumn and Smith's skink (*Egernia napoleonis*) with nine captures, six in spring and three in autumn. In all there were 10 species captured, seven of these were only recorded in the pit fall traps and the bobtail (*Tiliqua rugosa*) and the southern heath monitor (*Varanus rosenbergi*) were trapped in wire cages as were two Smith's skinks.

Seven species of amphibians were caught over the two trapping sessions. The total number of captures was 50 with 25 recorded in both autumn and spring. The moaning frog (*Heleioporus eyrei*) was the most common capture with a total of 19 captures, 13 in autumn and six in spring. Nicholl's toadlet (*Metacrinia nicholsii*) had all 12 captures recorded in spring and the western banjo frog (*Limnodynastes dorsalis*) had 11 captures, seven in autumn and four in spring. The other four species recorded three or less captures.

Wire Cage Traps

Total captures recorded from wire cages over the two sessions was 319 (19.9 cpn); including 126 captures (15.8 cpn) in autumn and 193 (24.1 cpn) in spring (Fig. 4 and 5).

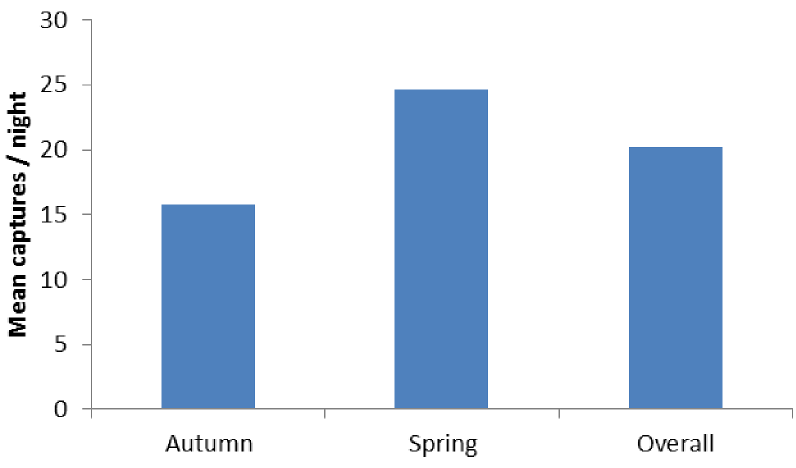
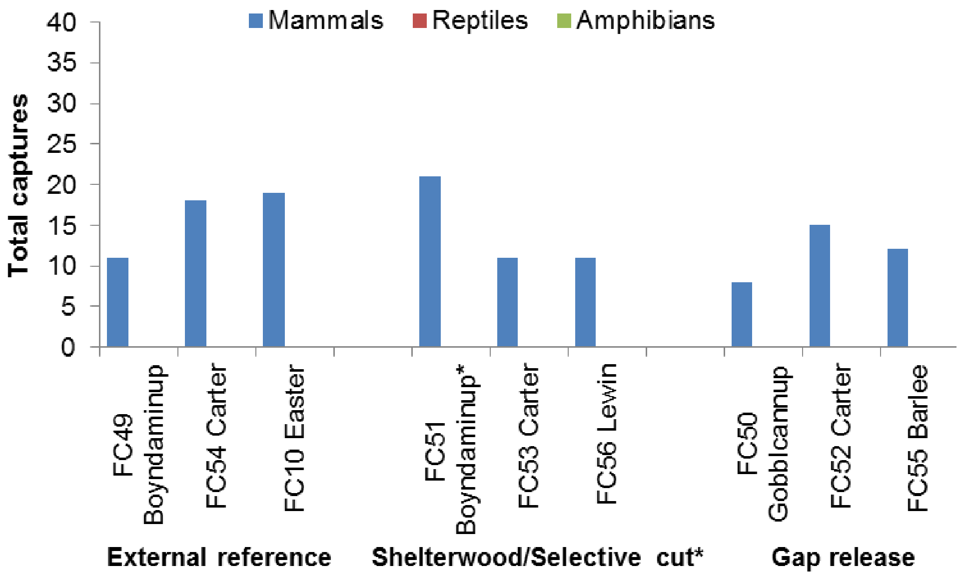


Figure 4. Mean number of animal captures per night in wire cage traps in Donnelly 2 FORESTCHECK grids in 2013

Mammals were the most common group of vertebrates captured in wire cages. All 126 captures in autumn and 186 of the 193 captures in spring were mammals. The seven remaining captures in spring were reptiles including two Smith's skinks, one bobtail and four heath monitors. The most common animal caught in wire cage traps was the brushtail possum, with 28 captures in autumn and 77 in spring. The black rat had 28 captures in autumn and 41 in spring and mardo captures were 37 in autumn and 20 in spring. Woylie captures were consistant with16 in autumn and 15 in spring but quokkas were only trapped twice in autumn and 14 times in spring.

(a) Autumn – wire traps



(b) Spring – wire traps

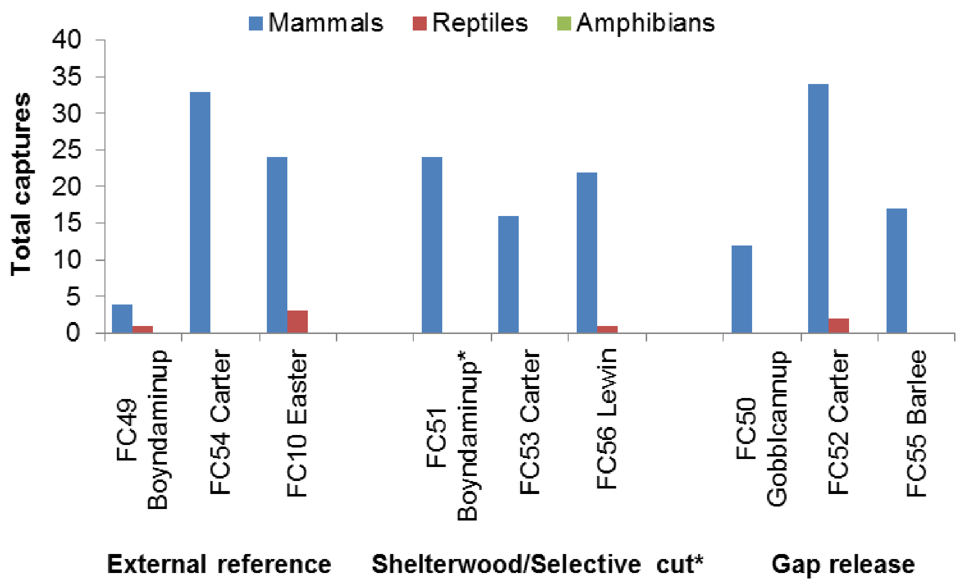


Figure 5. Total captures of mammals, reptiles and amphibians recorded in wire traps in (a) autumn and (b) spring in Donnelly 2 FORESTCHECK grids in 2013

Pit fall traps
One hundred and fifty two (9.5 cpn) of the 471 total captures occurred in pit fall traps. Sixty two captures were recorded in autumn (7.75 cpn) and 90 in spring (11.25 cpn) (Fig.6).

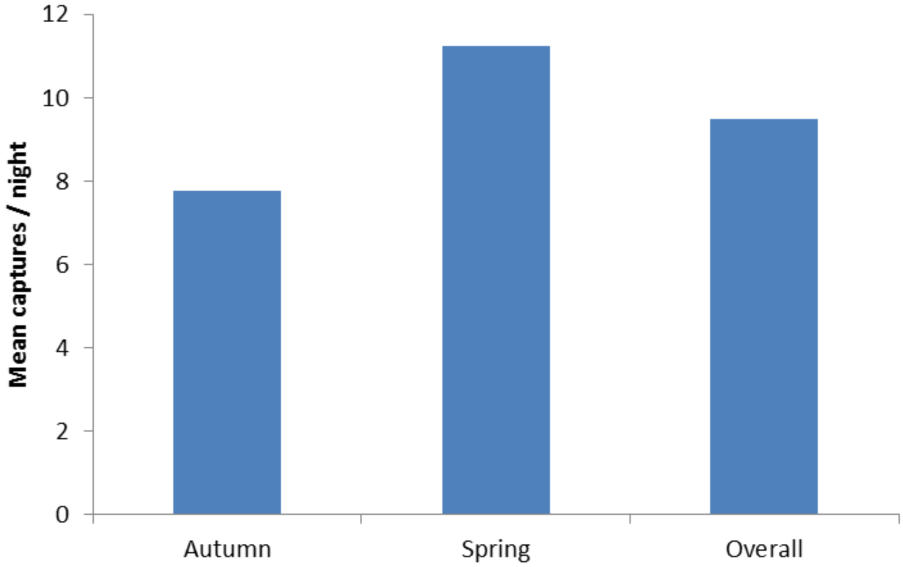


Figure 6. Mean number of animal captures per night in pit traps in Donnelly 2 FORESTCHECK grids in 2013

Almost 30% of the pit fall captures were mammals, including 32 captures of dunnart, 11 of pygmy possum and two house mice (*Mus musculus*). Eighteen of the 32 dunnarts were in the external reference, 10 in the shelterwood/selective cut and four in the gap release treatments. The majority (26 of 32) of the dunnart captures came from the Gobblecannup/Boyndaminup grids with15 recorded in the external reference grid (FC49).

Fifty seven of the 64 reptiles captures were recorded in pit fall traps, with only the bobtail and heath monitor exclusively caught in wire cages. The southern pale flecked Morethia was the most common skink recorded with 16 captures; all in silviculture treatments including 10 in the shelterwood/selective cut and six in the gap release. Peron's earless skink had 15 captures, six in external reference and nine in silviculture treatment grids. Smith's skink recorded nine captures, four in external reference and five in silviculture treatments.

All 50 captures of amphibians were recorded in the pit fall traps, with 25 recorded in both autumn and spring. There were 18 captures in the external reference (12 autumn and six spring), 17 in the shelterwood/selective cut (nine autumn, eight spring) and 15 in the gap release grids (four autumn, 11 spring). Forty two of the captures comprised just three species, the moaning frog, 19 captures, Nicholl's toadlet, 12 captures and the western banjo frog with 11 captures.

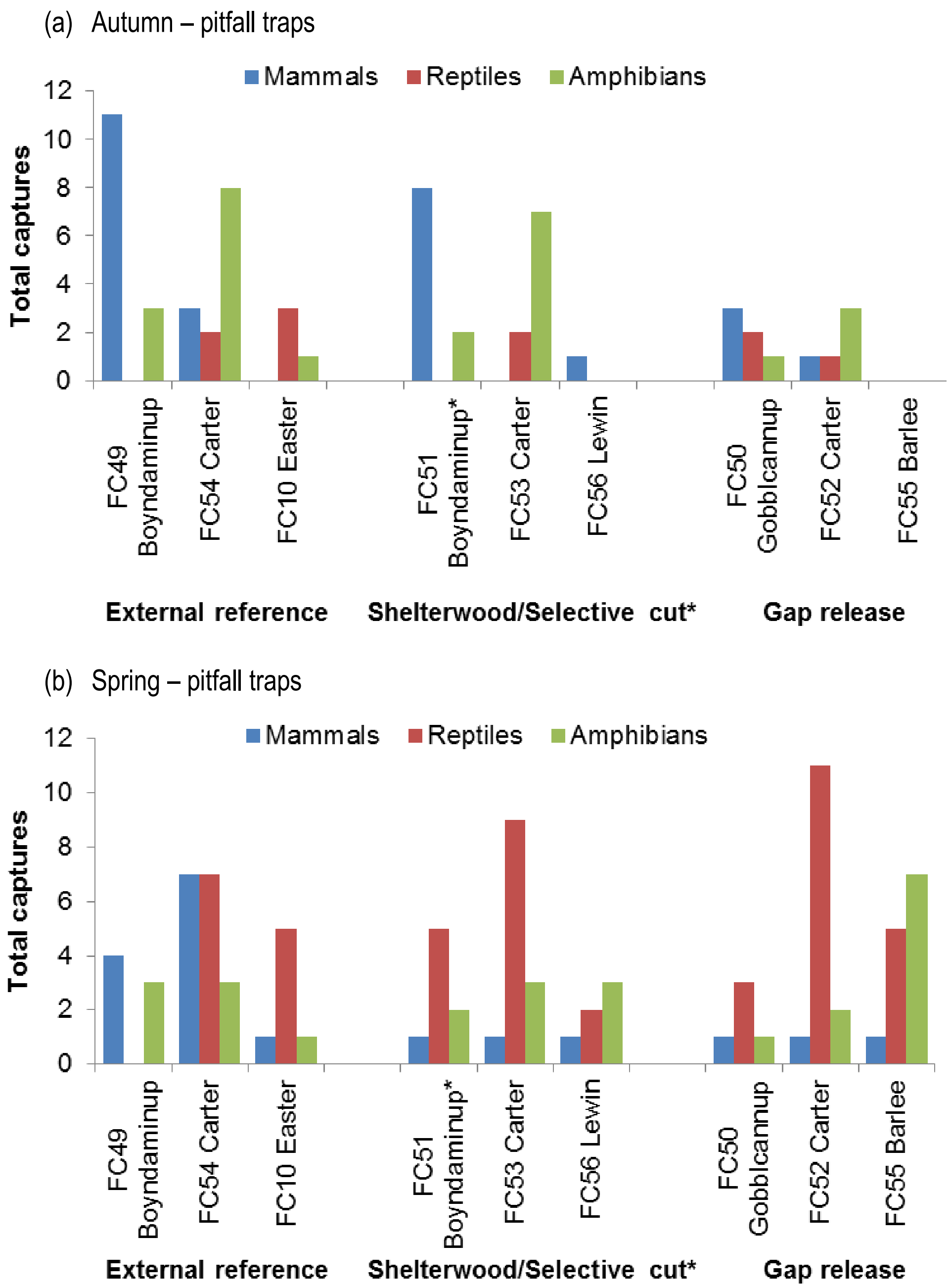


Figure 7. Total numbers of mammals, reptiles and amphibians recorded I pitfall traps in (a) autumn and (b) spring in Donnelly 2 FORESTCHECK grids in 2013

Other monitoring techniques

Besides trapping, spotlight surveys and road transect surveys were conducted in spring, as well as a trial use of remote sensor cameras.

Spotlight surveys

Spotlight surveys were only carried out over two nights in spring and seven species were recorded (Fig 8). The most common was the western grey kangaroo (*Macropus fuliginosus*) with 18 sightings, 12 at Gobblecannup/Boyndaminup blocks, two at Carter block and four at Easter/Barlee/Lewin blocks. There were also three brush wallaby (*Macropus Irma*), seven brushtail possum and one quokka. Three species of night bird were recorded, including four sightings of the tawny frogmouth (*Podargus strigoides*) and two each of the southern boobook owl (*Ninox novaeseelandiae*) and the owlet nightjar (*Aegotheles* cristatus).

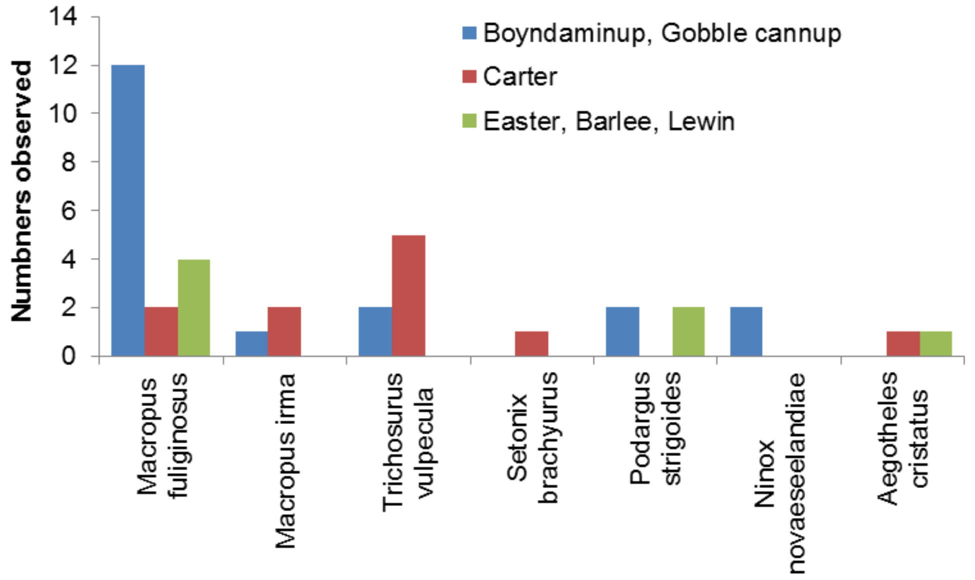


Figure 8. Total numbers for species seen on two spotlight surveys in spring 2013 in the areas surrounding the Donnelly 2 FORESTCHECK grids

Road surveys

Road transect surveys were conducted twice in spring with three species recorded (Fig. 9), the western grey kangaroo, western brush wallaby and the emu (*Dromaius novaehollandiae*). The kangaroo was recorded 32 times, 13 at Gobblecannup/Boyndaminup, 10 at Carter and nine at Easter/Barlee/Lewin Blocks. The western brush wallaby was recorded three times each at Gobblecannup/Boyndaminup and Carter and five times at Easter/Barlee/Lewin blocks. The emu was recorded four times at Carter and three times Easter/Barlee/Lewin. The species observed and the numbers recorded was consistent with the forest type traversed.

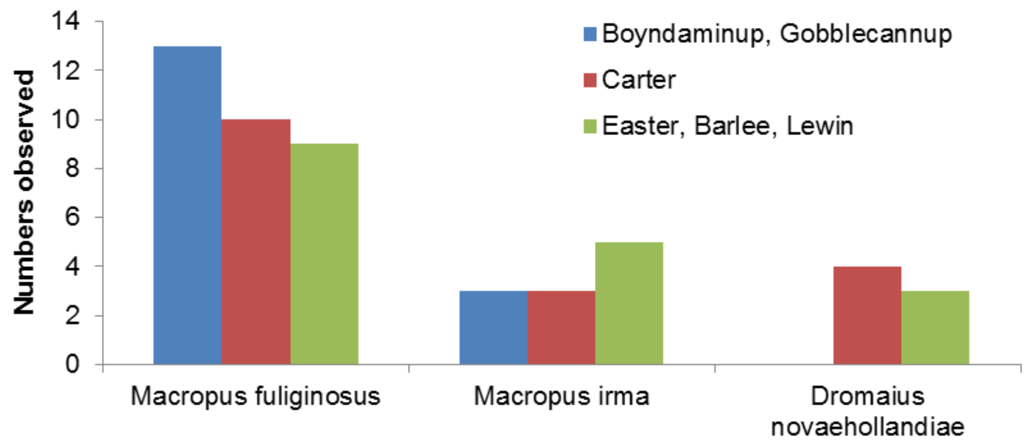


Figure 9. Total numbers of species seen on two road transects in spring 2013 in the areas surrounding the Donnelly 2 FORESTCHECK grids

Camera monitoring
Remote infra-red cameras (RECONYX HyperFire model HC600) were installed at two points in each grid, 1.4m above ground at an angle of 45°. They were operated for two two-week periods in the spring; 5–20 November and 6–20 December. A total of 17 species were recorded (Table 3) including 9 native and two introduced mammals, three reptiles and three birds. Animals were clearly seen on the images and in most instances individuals of the larger mammals including grey kangaroos, western brush wallabys and quokkas (Fig. 10) could be distinguished. Although echidnas (*Tachyglossus aculeatus*) were not trapped, they were recorded by cameras on the Boyndaminup selective cut grid (FC51) (Fig. 10). Small birds, including the red winged fairy wren (*Malurus elegans*) and white breasted robin (*Eopsaltria georgiana*), were clearly identified as well as small reptiles like the red-legged skink (*Ctenotus labillardieri*).

Figure 10. Remote camera photos of quokka (left) at the Gobblecannup gap release and an echidna (right) at the Boyndaminup selective cut.

The trial with the cameras was considered very successful and in future monitoring they will be deployed for a full month between the individual trap sessions in both autumn and spring. Methods for analysing data from the cameras are currently being investigated.

Table 3. Species and number of individuals that could be identified from remote cameras set in the Donnelly 2 FORESTCHECK grids in 2013 (ER = external reference, SW = shelterwood, SC = selective cut, GR = gap release treatments)

		Gobblecannup/Boyndaminup			Carter			Easter/Lewin/Barlee			Total
		FC49 ER	FC50 GR	FC51 SC	FC52 GR	FC53 SW	FC54 ER	FC10 ER	FC55 GR	FC56 SW	
Mammals											
Macropus fuliginosus	Grey kangaroo	1			1	1		2			5
Macropus irma	Western brush wallaby	1			1	1	1	1			5
Setonix brachyurus	Quokka	7	11	6	1				2	1	28
Bettongia penicillata oglibyi	Woylie		2	6							8
Trichosurus vulpecula	Common brushtail possum		1	1	7	2	5				16
Isoodon obesulus fusciventor	Quenda			1							1
Tachyglossus aculeatus	Short-beaked echidna			1							1
Antechinus flavipes	Mardo				1					3	4
Sminthopsis sp.	Dunnart			1							1
Rattus rattus	Black rat					1			5	7	13
Oryctolagus cuniculus	Rabbit		1								1
											0
Reptiles											
Varanus rosenbergi	Southern heath monitor		2	2	1				1	2	8
Egernia napoleonis	Smith's skink					1				1	2
Ctenotus labillardieri	Red-legged ctenotus			1							1
Birds											0
Phaps elegans	Brush bronzewing			1							1
Eopsaltria georgiana	White-breasted Robin					1					1
Malurus elegans	Red-winged Fairy-wren	1			2						3
Total records for each grid		10	17	20	14	7	6	3	8	14	99

Conclusions

Observations made following monitoring of terrestrial vertebrates at Donnelly 2 FORESTCHECK grids in 2013 were:

- Modifying the trapping routine to two 4-night sessions separated by a month in each season has reduced the number of recaptures, thus increasing the number of individuals recorded. It also reduces the pressure on animal handlers and assistants.
- Regenerating tree and understorey species in recently harvested grids provide habitat for quokkas, which normally inhabit forest in riparian zones with similar understorey structure.
- All the introduced black rats were trapped in grids from the higher rainfall zone west and north-west of Manjimup. The majority were recorded at the Easter reference grid, which is only 1.2km from cleared farm land.
- Mardo and dunnart males die after mating, which accounts for the higher capture rate in autumn (pre mating) than spring (post mating).
- Most mardo captures occurred on grids with deep litter loads in the higher rainfall zone, and dunnarts were more common on grids with lower rainfall, and lighter litter loads.
- Fifty per cent of the brush tail possum captures occurred in the shetterwood/selective cut treatment, with 27% and 23% in the gap release and external treatments respectively.
- Remote sensor cameras will continue to be investigated for future use in the FORESTCHECK project.

Acknowledgements

We would like to thank Science and Conservation staff Neil Burrows, Bruce Ward, Chris Vellios, Colin Ward, Marika Maxwell, Lachie McCaw, Richard Robinson, Madison Read and Jamie Flett and especially volunteers Karen Brown, Keith Liddelow and Eddie Liddelow for their assistance.

DATA MANAGEMENT AND STORAGE

Verna Tunsell

Introduction

The FORESTCHECK data management and storage service is responsible for entering and storing all data collected from the project into an electronic format, and databasing collected voucher specimens (flora, cryptogams and fungi) into the Western Australian herbarium (PERTH).

Data entry

All information from the field sheets are entered into individual Microsoft Excel® or Access® spreadsheets. The majority of the spreadsheets are formatted with drop down boxes for appropriate fields; e.g. scientific names. The spreadsheet is then checked and supplied to the leader of each individual monitoring group.

Data storage

The individual sampling data is saved and backed up as individual files on the network drive. The data are saved and secured when the Department's network drive is backed up daily. The final validated version is also backed up on an external hard drive, printed and filed and will be archived in the Conservation Science library at the completion of the project. All field data sheets are presently filed at the Manjimup Research Centre.

Voucher specimens

The vascular plant, fungi and cryptogam specimens collected during the period, have been identified (as far as possible) and curated. The vascular plants and cryptogams are lodged and housed at PERTH. The fungi collection is lodged at PERTH housed at the Tony Annels Herbarium in Manjimup, to enable work on descriptions and identification to be completed. Many of the lichen and fungi collections represent unnamed and previously unknown taxa.

Vascular plant specimens are pressed and dried, then mounted, with specialised herbarium tape, on card, and placed in separate folders. Cryptogams are dried (friable specimens are stabilised with emulsion), placed on a card with adhesive to keep the specimen together (mosses are washed prior to drying to remove debris). The specimens are then secured in cardboard boxes to prevent damage.

Fungi specimens are also dried, then wrapped in greaseproof paper inside zip-lock bags and put into boxes to prevent damage. Very large specimens remain unboxed but sealed in airtight plastic bags.

Each plant, cryptogam and fungi collection is allocated a unique barcode so that it is readily identified and easily located by electronic and physical means. Collections are data based on the Max system and submitted electronically to PERTH for incorporation into the herbarium database. Max was developed by Simon Woodman and Paul Gioia (Parks and Wildlife) and is used as the primary means of submitting specimen information to the WA Herbarium. While there are many facets to Max, the sections used for FORESTCHECK are the collecting book and reporting facilities.

Invertebrate voucher collections are housed at the Manjimup Insectary. The collection contains a large number of unnamed and previously unknown taxa. Specimens are either pinned or stored in 80% alcohol. Non voucher specimens are bulked according to site, date of capture and capture method. Light trap specimens are dried and stored in sealed plastic bags and pitfall and active capture samples are stored in alcohol. Therefore these specimens are available for further examination. The whole collection is managed using a Microsoft Access® database linked to photos, collection details and taxon descriptors. Taxa are reviewed annually to update and consolidate new taxa.

All collections (flora, cryptogams, macrofungi and invertebrates) are actively maintained including regular treatment (freezing) to minimize degradation and pest contamination. Descriptions of new taxa are compiled from fresh and then preserved collections to aid future taxonomic work.

Appendix 1. Example of flora collection labels generated in Max-V3

WESTERN AUSTRALIAN HERBARIUM, PERTH
Flora of Western Australia

Cassytha racemosa forma ***pilosa*** (Benth.) J.Z.Weber

Lauraceae

Identified by:

Parastitic perennial climber frequent. Hill to plain; gravelly brown sandy clay. Forest with associated vegetation of Corymbia calophylla and Eucalyptus marginata.

Loc.: Forestcheck monitoring site 5, N side of Wagelup Road 1.4 km W of railway line, Yornup Forest block

Lat.: 34°6'24.0" S **Long.:** 116°8'33.0" E (WGS84)

Coll.: R.J. Cranfield 23238 **Date:** /09/2008

Voucher: Forestcheck Monitoring Program

WESTERN AUSTRALIAN HERBARIUM, PERTH
Flora of Western Australia

Lomandra nigricans T.Macfarlane

Dasypogonaceae

Identified by:

Height to 20 cm, width to 15 cm; flowers white. frequent. Hill to plain; gravelly brown sandy clay. Forest with associated vegetation of Corymbia calophylla and Eucalyptus marginata. Percentage of population flowering: 10

Loc.: Forestcheck monitoring site 5, N side of Wagelup Road 1.4 km W of railway line, Yornup Forest block

Lat.: 34°6'24.0" S **Long.:** 116°8'33.0" E (WGS84)

Coll.: R.J. Cranfield 23239 **Date:** /09/2008

Voucher: Forestcheck Monitoring Program

WESTERN AUSTRALIAN HERBARIUM, PERTH
Flora of Western Australia

Leucopogon capitellatus DC.

Epacridaceae

Identified by:

Shrub, height to 30 cm, width to 40 cm; growth phase is active with flower buds, vegetative buds and flowers, white frequent. Hill to plain; gravelly brown sandy clay. Forest with associated vegetation of Corymbia calophylla and Eucalyptus marginata. Percentage of population flowering: 30

Loc.: Forestcheck monitoring site 5, N side of Wagelup Road 1.4 km W of railway line, Yornup Forest block

Lat.: 34°6'24.0" S **Long.:** 116°8'33.0" E (WGS84)

Coll.: R.J. Cranfield 23240 **Date:** /09/2008

Voucher: Forestcheck Monitoring Program

WESTERN AUSTRALIAN HERBARIUM, PERTH
Flora of Western Australia

Leucopogon pulchellus Sond.

Epacridaceae

Identified by:

Erect compact perennial shrub, height to 40 cm, width to 40 cm; flower buds white and pink frequent. Hill to plain; gravelly brown sandy clay. Forest with associated vegetation of Corymbia calophylla and Eucalyptus marginata. Percentage of population flowering: 30

Loc.: Forestcheck monitoring site 5, N side of Wagelup Road 1.4 km W of railway line, Yornup Forest block

Lat.: 34°6'24.0" S **Long.:** 116°8'33.0" E (WGS84)

Coll.: R.J. Cranfield 23241 **Date:** /09/2008

Voucher: Forestcheck Monitoring Program

Appendix 2. Example of flora report generated in Max V3.

27/02/2009 Forestcheck Donnelly 2007-2008 1

COLLECTOR_NO	SHEET_NO	GENUS	SPECIES	INFRA_RANK	INFRA_NAME
23250	6666795	Caladenia	arrecta		
23240	6666728	Leucopogon	capitellatus		
23243	6666752	Senecio	hispidulus		
23244	6666760	Senecio	hispidulus		
23249	6666787	Luzula	meridionalis		
23239	6666701	Lomandra	nigricans		
23241	6666736	Leucopogon	pulchellus		
23245	6666779	Senecio	quadridentatus		
23238	6666698	Cassytha	racemosa	forma	pilosa
23133	6667031	Cassytha	racemosa		
23251	6666809	Caladenia	reptans		
23242	6666744	Brachythecium	sp. FC5 (R.J. Cranfield 2324		
23133	6667023	Billardiera	variifolia		