REPORT OF PROGRESS 2009-10

FOREST CHECK

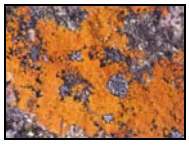
Department of Environment and Conservation

Science Division


Reptiles


Fungi


Invertebrates


Lichens


Mammals


Birds


Flora

Produced by the Department of Environment and Conservation, Kensington, Western Australia, January 2011

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This report highlights preliminary results for FORESTCHECK monitoring, determined by basic analysis and field observation, for the year 2009-10. 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 five-year basis. All FORESTCHECK publications and reports are available on the DEC web site at www.dec.wa.gov.au .

Cover photos: *Main photo*: Koomal (brushtail possum), *Trichosurus vulpecula hypoleucus* (photo: J. Dombrowski): *above right*: mouse spider, *Missulina* sp. (photo: R. Robinson) and *below right*: an un-named species of coral fungus, *Ramaria* sp. (photo: R. Robinson).

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SUMMARY

The first round of monitoring all 48 FORESTCHECK grids was completed in 2006. The second round of monitoring commenced in 2008 and this report covers the second session of monitoring at the eight Perth Hills monitoring grids located in the northern jarrah forest between Dwellingup and Mundaring. These grids were initially established in 2003 and monitored in 2003-04. This report, and previous reports, can be viewed and downloaded from the Department of Environment and Conservation website at www.dec.wa.gov.au .

All the monitoring grids in the Perth Hills district are located in State forest in Dwellingup 1 & 2 and Yarragil 1 & 2 vegetation complexes in the jarrah north-west ecosystem. Harvested sites were matched to 1988/89, 1995 & 1997 harvest activities. The range of time since the last fire was six months to 35 years Five grids had been burnt since the initial monitoring in 2003-04; four in the prescribed burn program and one by a severe bushfire in January 2005.

Knowledge regarding jarrah forest biodiversity and ecology continues to increase as the second round of FORESTCHECK monitoring proceeds. While the results presented here are from a preliminary analysis, highlights from the 2009-10 results and observations from comparisons with data from the same grids in 2003-04 include:

- Basal area increased by 0.25–0.75 m^2 ha^{-1} $year^{-1}$on all harvested grids, but loss of large trees due to fire resulted in a reduction of basal area on two external reference grids between 2004 and 2010.
- Data collected from FORESTCHECK grids are an important source of objective information that could be used to inform discussion on matters such as the effects of a drying climate on tree health, regeneration and stand growth.
- CWD loads on all grids are generally high, ranging from a mean of 140 tonnes ha^{-1} on grids in recently harvested treatments to 77 tonnes ha^{-1} on grids that have never been harvested.
- CWD volume increased with both the intensity of harvest and the number of times the stand has been harvested. Historical and recent harvesting increase the volume of smaller diameter CWD in the low to moderate decay classes (classes 2 to 5).
- Grids in Perth Hills have the lowest macrofungal diversity recorded in the four forest ecosystems sampled by the the FORESTCHECK project.
- Macrofungal species assemblages were considerably different in 2010 compared to 2004. Species richness and abundance was particularly low on gap release grids in 2009—likely a combination of recent fire and low rainfall.
- Monitoring a list of potential indicator species may be a viable alternative for assessing the impacts of forest management on cryptogam communities.
- The number of invertebrate morphospecies recorded in FORESTCHECK continues to increase. In 2009-10, 73% of species recorded were not captured in the previous 2003-04 sample.
- Increased numbers of striated pardalote, western gerygone, scarlet robin and broad-tailed (inland) thornbill since 2003-04 reflect changes in the structure of understory vegetation associated with time since disturbance. Increased numbers of honeyeaters in general is associated with the flowering cycle of plants.
- Amphibians have not been captured in large numbers because trapping in both 2003-04 and 2009-10 has not coincided with seasonal rains.
- Brush-tailed possums appear to be well established in both external reference and shelterwood treatments but were still absent from gap release treatments in 2009-10. Other mammals detected by trapping included mardo, chuditch, dunnart, pygmy possum and bandicoot.

- Changes associated with time since treatment resulted in an overall lower species richness and abundance of understory plants in 2009 compared to 2003—this is especially evident in the gap release treatment.

The FORESTCHECK team is to be commended for their commitment to the project. In 2010-11, the second round of monitoring will be conducted in grids which were established in 2004 in the eastern jarrah forest in the Wellington district and initially monitored in 2004-05.

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January 2011

INTRODUCTION

Scope

This report has been compiled from chapters prepared by Science Division research staff involved in the FORESTCHECK monitoring program. It represents a summary of monitoring activities completed in the central north-west jarrah forest in the Perth Hills District during the 2009-10 financial year.

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. Although the initial focus of FORESTCHECK will be on timber harvesting and silvicultural treatments in jarrah (*Eucalyptus marginata*) forest, the intention is to extend the scale of monitoring over time 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 provides funding for FORESTCHECK that is only 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[1] and is included as an operational program in the current Forest Management Plan 2004-2013[2]. 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 Division of the Department of Environment and Conservation has primary responsibility for the implementation of FORESTCHECK. The development of the program took place over two years and included input from scientists and managers within the Department of Environment and Conservation, 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.dec.wa.gov.au .

Monitoring strategy

Between 1995 and 2004 timber harvesting in jarrah forests was undertaken according to Silvicultural Guideline 1/95, which recognizes three silvicultural objectives:

(1) Thinning – to promote growth on retained trees,
(2) 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,

[1] Codd, M. 1999. Forest management Plans 1994-2003: Mid-Term EPA Report on Compliance
[2] Conservation Commission of Western Australia.2004. Forest management plan 2004-2013. Conservation Commission of Western Australia. 144p + maps.

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.

Silvicultural guidelines were revised in conjunction with the preparation of the Forest Management Plan (2004-2013) and are now available as SFM Guideline No. 1(CALM 2004[3]).

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. Thinning will also be monitored where the structure of the forest dictates that this treatment is appropriate on a significant scale.

FORESTCHECK 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[4], 2000[5]) 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 consists of up to four sampling grids. Grids have been established in forest subject to the following treatments:

(1) gap release,
(2) shelterwood (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 200 m x 100 m, with a central area of 100 m x 100 m. Four 30 m x 30 m vegetation sample plots are located external to and adjacent each corner of the central area.

[3] CALM 2004. Silvicultural practice in the jarrah forest. Dept. CALM, SFM guideline No. 1.
[4] Mattiske, E.M. and Havel, J.J. 1998. Regional Forest Agreement Vegetation Complexes, Collie, Western Australia [cartographic material – scale 1:250,000]. WA Department of Conservation and Land Management.
[5] Mattiske, E.M. and Havel, J.J 2000. Vegetation Mapping in the South West of Western Australia. CALM, Perth.

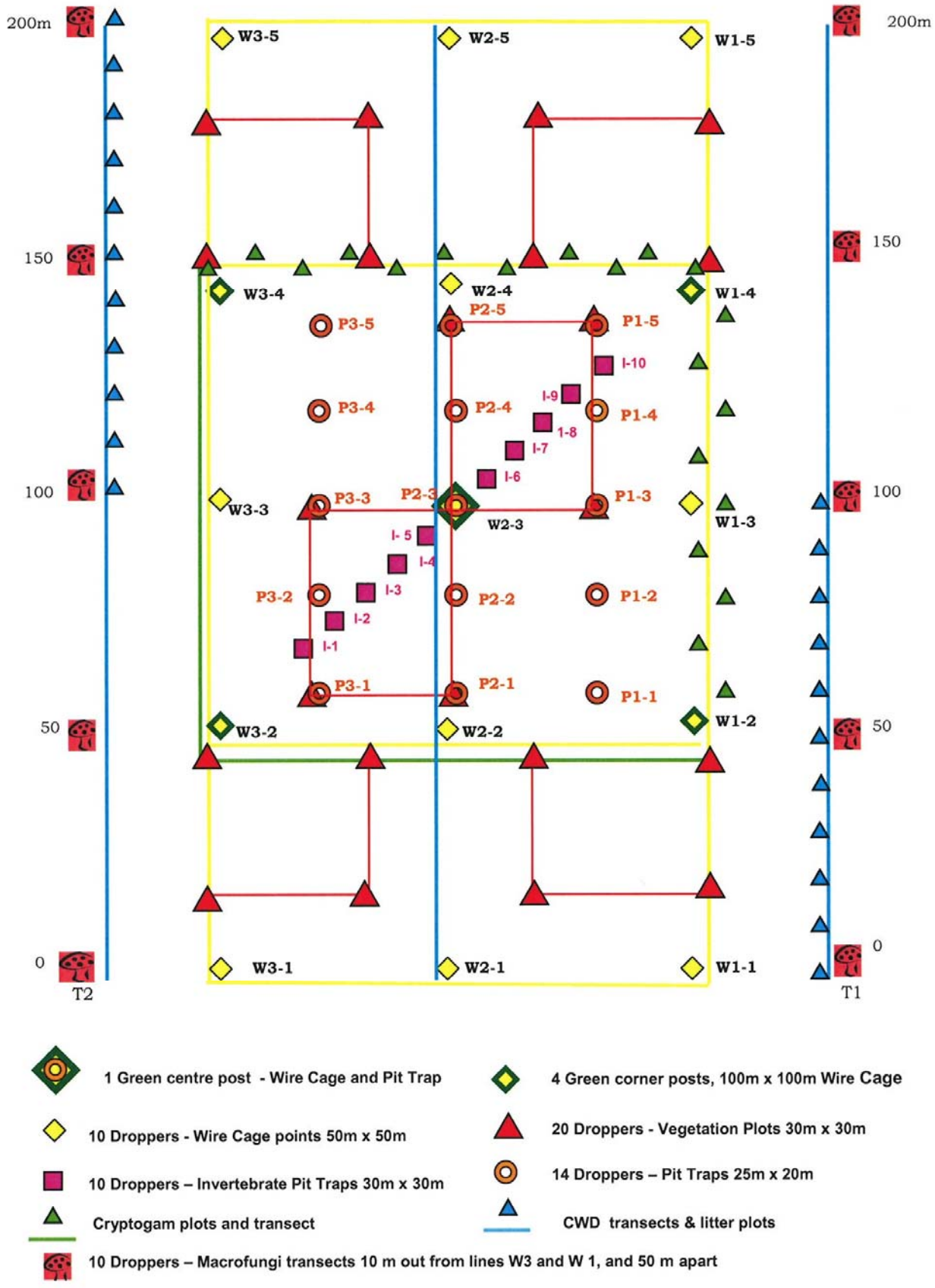

Figure 1. FORESTCHECK grid layout

A range of ecosystem attributes are monitored on each grid including:

1. Forest structure and regeneration stocking
2. Foliar and soil nutrients
3. Soil disturbance
4. Coarse woody debris and leaf litter
5. Macrofungi
6. Cryptogams
7. Vascular flora
8. Invertebrate fauna
9. 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.

Monitoring at Perth Hills 2009-10

Eight FORESTCHECK monitoring grids were established in the Perth Hills District in 2003 (Table 1). Grids were established in Occidental and Lesley forest blocks in the northern range of the district in the 900 mm rainfall zone and Holyoake, Kennedy and Cameron forest blocks east and northeast of Dwellingup in the 110-1300 mm rainfall zone. All the grids are located in state forest (Figs. 2-4). Harvested sites (shelterwood and gap release) were matched to 1988/89, 1995 & 1997 harvest activities. All external reference blocks were established in forest cut more than 70 years previously (Table 1). They were initially monitored in spring 2003 and autumn 2004 and this second round of monitoring was conducted in spring 2009 and autumn 2010. The grids are located in open *Eucalyptus marginata* subsp. *marginata* – *Corymbia calophylla* forest on either lateritic uplands in humid to subhumid (Dwellingup 1) and subhumid to semiarid (Dwellingup 2) zones or valley floors in humid to subhumid (Yarragil 1) and subhumid to semiarid (Yarragil 2) zones (Mattiske and Havel 1998). The range of time since the last fire was six months to 35 years, and five grids had been burnt since the initial monitoring in 2003-04, FC21, in the prescribed burn program in spring 2005, FC22, FC25 and FC26 in the prescribed burn program in October 2009 and FC27 by a severe wildfire in December 2004 (Table 1).

Reference photographs of each grid were initially taken in May 2004 and presented in the FORESTCHECK Report of Progress 2003-2004 (available at www.dec.wa.gov.au). In June 2010, reference photos were taken from a standard photo point at peg W2-1 looking towards the centre peg (W2-3) (see Fig. 1), which allow more accurate changes in vegetation structure and condition to be observed in each subsequent photograph (Figs. 6-13).

Table 1. Location (forest block) and site attributes of each FORESTCHECK grid in the Perth Hills District in 2009-10.

Treatment/Grid/Location	Burnt		Logged		Vegetation Complex[2]
	Year [1]	Years since	Year	Years since	
External reference					
FC 21 Holyoake	Sp 2005 (prescribed)*	4	Pre 1920	>90	Yarragil 1
FC 24 Kennedy	Au 1975 (prescribed)	35	1930-34	76	Dwellingup 1
FC 27 Occidental	Su 2005 (wildfire)*	5	1930-39	71	Dwellingup 2
Shelterwood					
FC 20 Holyoake	Sp 2001 (prescribed)	9	1995	15	Dwellingup 1
FC 23 Cameron	Sp 1983 (advance)	27	1989	21	Dwellingup 1
FC 26 Lesley	Sp 2009 (prescribed)*	0.5	1997	13	Dwellingup 2
Gap release					
FC 22 Kennedy	Sp 2009 (prescribed)*	0.5	1988	22	Yarragil 2
FC25 Lesley	Sp 2009 (prescribed)*	0.5	1997	13	Yarragil 2

[1] Sp= silvicultural burn carried out in the spring, Au = autumn and Su = summer.
* refers to sites that were burnt since they were first monitored in 2003-04.
[2] Vegetation complexes are located in open *Eucalyptus marginata* subsp. *marginata – Corymbia calophylla* forest on either lateritic uplands in humid to subhumid (Dwellingup 1) and subhumid to semiarid (Dwellingup 2) zones or valley floors in humid to subhumid (Yarragil 1) and subhumid to semiarid (Yarragil 2) zones (Mattiske and Havel 1998).

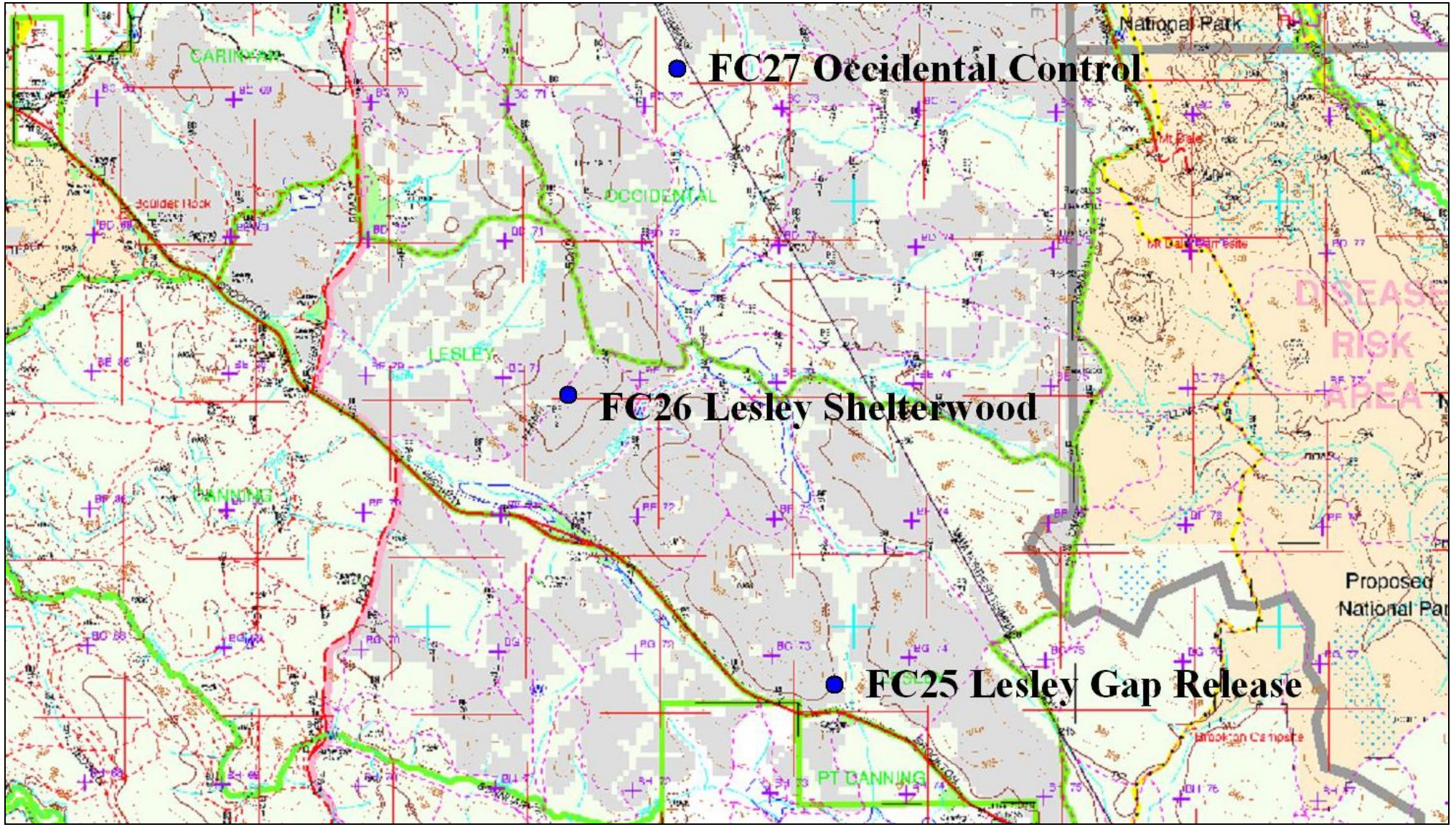

Figure 4. Location of the three 'northern' FORESTCHECK grids (FC25, FC26 & FC27) in the Perth Hills District

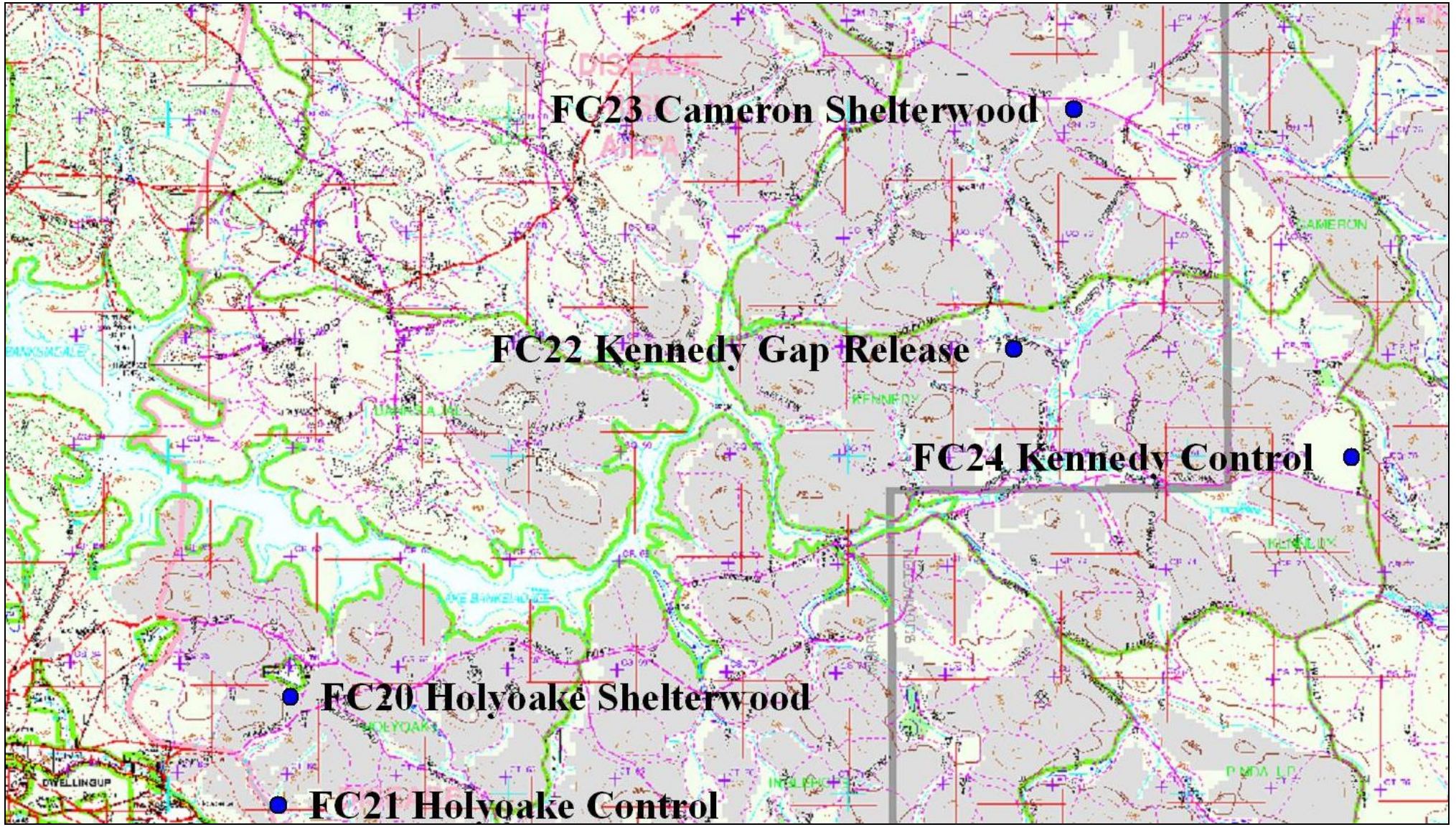

Figure 5. Llocation of the five 'southern' grids (FC20, FC21, FC22, FC23 & FC24) near Dwellingup in the Perth Hills District.

Figure 6. FC21 Holyoake external reference in 2004 (left) and 2010 (right).

Figure 7. FC24 Kennedy external reference in 2004 (left) and 2010 (right).

Figure 8. FC27 Occidental external reference grid when monitored in 2003-04 (top left), January 2005, one month after a severe wildfire in December 2004 (above right), coppice development in September 2005 (bottom left) and 5½ years after the fire in June 2010 (bottom right).

Figure 9. FC20 Holyoake shelterwood in 2004 (left) and 2010 (right).

Figure 10. FC23 Cameron shelterwood in 2004 (left) and 2010 (right).

Figure 11. F26 Lesley shelterwood in 2004 (left) and 2010 (right).

Figure 12. FC22 Kennedy gap release in 2004 (left) and 2010 (right).

Figure 13. FC25 Lesley gap release in 2004 (left) and 2010 (right).

Budget

The annual operational budget for the program is provided by the DEC's Sustainable Forest Management Division via a works agreement with the Forest Products Commission for $225,000. Salaries are funded throught a service agreement with the Sustainable Forest Management Division to an amount of approximately $200,000 per annum.

2010-11 Activities

In spring 2010 and autumn 2011 monitoring will be undertaken for the second time on ten grids (FC28 – FC37) established in 2004 in the eastern jarrah forest ecosystem in the Wellington District. These grids were initially monitored in 2004-05. The grids are located in Godfrey, Nalyerin, Stockyard and Bell forest blocks. All grids are within the Dwellingup 4 vegetation complex. External reference grids are all in uncut forest in national park, conservation park or reserve and treatment grids are in state forest that was harvested during the period 1996-2000.

FOREST STRUCTURE AND REGENERATION STOCKING

Lachlan McCaw and Julian Geisel

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 (Commonwealth of Australia 1998) that can be reported upon immediately.

Regeneration outcomes have for a number of years been assessed as a matter of routine on at least a portion of the area of forest subject to harvesting. For uneven-aged stands, there is a need to consider existing stand structure and whether there is sufficient sapling and advance growth present for re-establishment following harvesting. Under the current silvicultural guidelines for jarrah-marri forest, the decision as to whether the stand should be cut to gap release or shelterwood is determined by the density of existing lignotuberous advance growth (CALM 2004).

Forest managers also require information about growth rate and species composition 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.

A total of 48 FORESTCHECK monitoring grids were established between 2001-02 and 2005-06 across the geographic range of the jarrah forest. The distribution of grids stratified according to DEC administrative boundaries and forest ecosystems mapped for the Regional Forest Agreement (Mattiske and Havel 2000), and is as follows:

- Donnelly District (jarrah south), 10 grids;
- Wellington District (jarrah north west - central), nine grids;
- Perth Hills District (jarrah north west - north), eight grids;
- Wellington District (jarrah north east), 10 grids; and
- Blackwood District (jarrah Blackwood Plateau), 11 grids.

Eight monitoring grids established in Perth Hills District in 2004 were re-assessed in 2010 with the objective of describing changes in stand structure, species composition and developmental stage of tree species present over the previous six years.

Monitoring

Sampling techniques were as per the FORESTCHECK Operating Plan (DEC, 2006), except that cut stumps were not re-measured and triangular tessellation assessment of regeneration stocking was not repeated. All trees taller than 2 m were measured in transects 100 m long by 4 m wide located between marker pegs 1-2 to 1-4 and 3-2 to 3-4. To improve the reliability of long term measurements of tree growth, mortality and tree fall all stems ≥20 cm 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.

Crown condition of each tree on the Kennedy gap release (FC22) and Occidental external reference (FC27) grids was assessed to quantify recovery following fire using the following rating system: (1) primary crown intact (2) primary crown intact with epicormic shoots on stem (3) recovering from epicormic shoots on branches but not on stem (4) recovering from epicormic shoots on branches and on stem (5) primary crown dead, recovering only from epicormic shoots on stem (6) primary crown dead, sprouting from lignotuber below 1.3 m (7) tree completely dead.

Projected foliage cover was recorded in spring 2009 as part of the vegetation cover assessment during vascular plant surveys. Intercepts with foliage were recorded at 240 points around the perimeter of the four 30 m x 30 m vegetation quadrats using a vertical periscope fitted with a fine crosshair. Intercepts were recorded as foliage present or absent in height classes of 2-15 m and >15 m. Contacts with eucalypt foliage were recorded separately to contacts with other plant species.

Data management

Stem diameter measurements from 2010 were entered into the FORESTCHECK stand database and used to calculate current basal area and basal area increment for the period 2004-2010. Several inconsistencies in measurement between the 2004 and 2010 assessments were identified and taken into account in calculating stand increment over the intervening period:

- the basal areas of marri on Section 1-2 to 1-3 of FC20 had been incorrectly reported in 2004, and was in fact 5.3 m^2 ha^{-1} not 8.5 m^2 ha^{-1}. The database was amended to show the correct value;
- the diameter of a large hollow-butt jarrah on Section 3-4 to 3-3 of FC20 was reduced 120 cm in 2004 to 88 cm in 2010, probably as a result of uncertainty in the 2004 measurement. For the purposes of calculating increment it was assumed that no net growth took place on this section during the period;
- a jarrah tree on Section 3-4 to 3-3 of FC22 with a diameter of 45 cm in 2004 was found to fall outside of the measurement transect and so was not included in the 2010 assessment. For the purposes of calculating increment it was assumed that no net growth took place on this section during the period.

Permanent tagging of trees >20 cm diameter minimizes potential for errors of this kind during subsequent measurements.

Preliminary results

Stand structure and species composition

Basal area and basal area increment of jarrah and marri are summarised in Table 1. Stem diameter distributions by 10 cm classes are presented for each grid in Figs. 1, 2 & 3. Basal area declined slightly between 2004 and 2010 at external reference grids FC21 and FC27. At FC21 this reduction was attributed to tree fall following low intensity prescribed burning. Grid FC27 was burnt at very high intensity during the January 2005 Pickering Brook bushfire (Cheney 2010) leading to mortality of sapling and pole-sized trees, and also to a reduction in bark thickness which would have reduced measurements of basal area made overbark. In FC27 a large *Allocasuarina fraseriana* was killed by the fire, substantially reducing the basal area of the intermediate tree layer. As expected following temporary opening of the forest canopy in FC27 after fire the number of saplings <10 cm diameter increased over the period. Grid FC24 had a positive increment of 0.34 m^2 ha^{-1} yr^{-1} between 2004 and 2010 of which about two thirds was on jarrah. This grid was not burnt during the period.

Basal area increments in grids cut to shelterwood ranged from 0.30 to 0.60 m^2 ha^{-1} $year^{-1}$; with an average jarrah increment of about 0.27 m^2 ha^{-1} $year^{-1}$ on all three grids. Marri also contributed substantially to the increment in FC23 (Fig. 2). The stand structure of grids FC20 and FC26 revealed growth of the jarrah sapling cohort with an increase in the number of trees 10-19 cm dbh and a commensurate reduction in the number of trees <10 cm dbh. This transition was not as clearly evident at FC23, probably because this stand was harvested in 1989, a decade or more before the other two shelterwood grids and the initial phase of active sapling recruitment had concluded.

Gap release grid FC22 was burnt in October 2009 by moderate intensity fire sufficient to cause complete crown scorch of most of the sapling cohort less than 15 m tall (Fig. 4). Fire caused some mortality of saplings (<5 % of stems) but the majority re-sprouted from epicromic shoots on the stem or from basal lignotubers (Fig. 5). The stand structure of grid FC22 showed transition of jarrah from into larger size classes with an increase in the number of stems in the 10-19 cm and 20-29 cm classes, but an overall reduction in the number of marri saplings. This was reflected in a positive growth increment of jarrah but a negative increment of marri (Table 1). The stand structure of gap release grid FC25 changed little between 2004 and 2010 but a mean annual increment of 0.43 m^2 ha^{-1} $year^{-1}$, attributable to growth of individual trees, was measured.

Table 1. Basal area in 2010 and basal area increment of live eucalypts >2 m tall over the period autumn 2004-2010 for eight FORESTCHECK grids in Perth Hills District.

Treatment	Grid	Basal area 2010 (m^2 ha^{-1})			Basal area increment (m^2 ha^{-1})		Mean annual increment (m^2 ha^{-1} yr^{-1})
		jarrah	marri	total	jarrah	marri	
External reference	FC21	17.11	0.13	17.24	-1.00	-0.08	-0.18
	FC24	29.84	9.18	39.02	1.31	0.74	0.34
	FC27	27.10	4.99	32.09	-3.76	1.30	-0.41
Shelterwood	FC20	33.18	5.96	39.14	1.63	0.66	0.38
	FC23	32.03	3.80	35.83	1.60	1.93	0.59
	FC26	27.84	2.56	30.40	1.66	0.11	0.30
Gap release	FC22	14.44	0.26	14.70	0.69	-0.25	0.07
	FC25	10.05	0.30	10.35	2.39	0.17	0.43

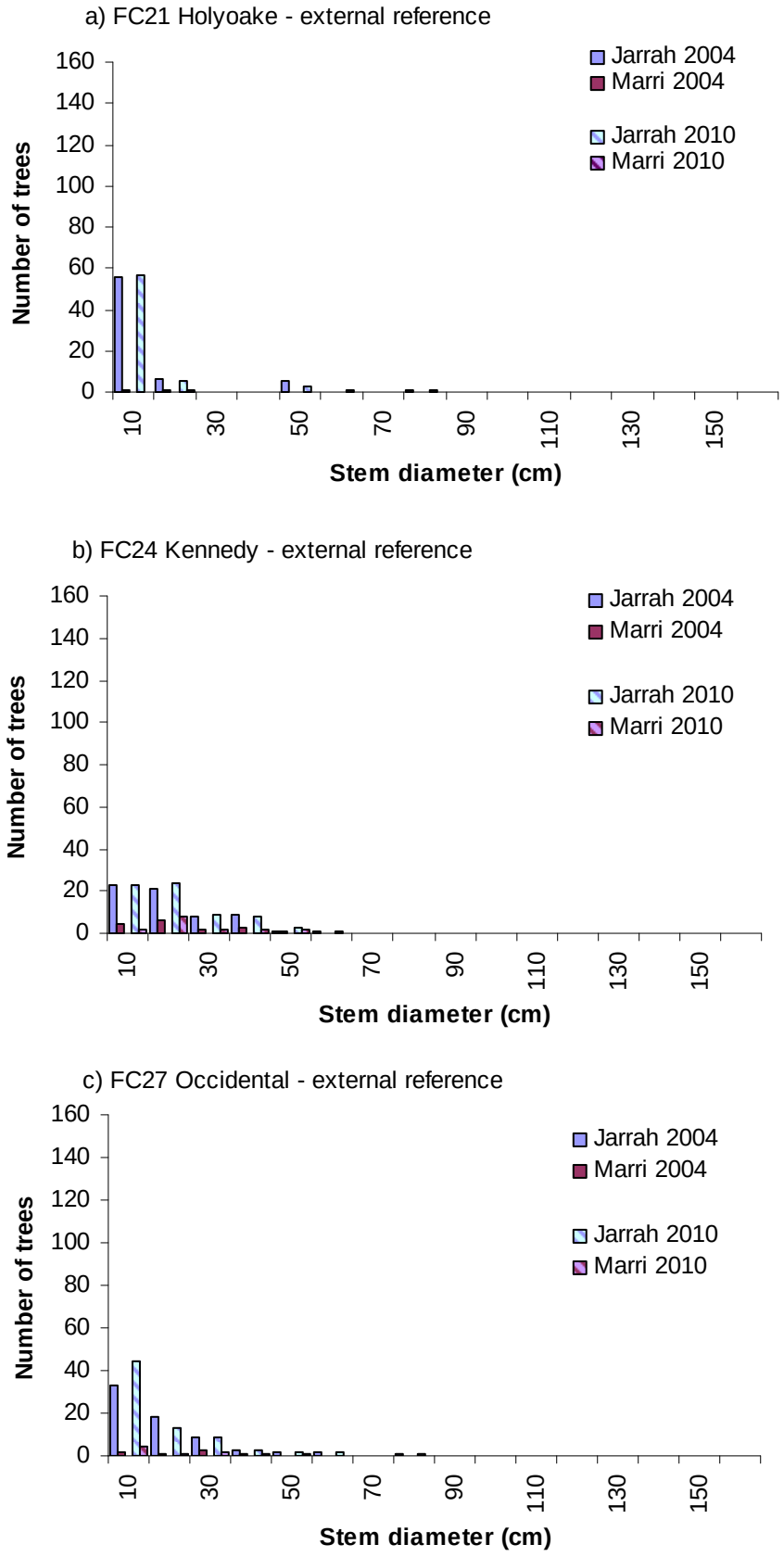

Figure 1. Stem diameter distribution by 10 cm classes for each external reference grid in classes 0-9 cm, 10-19 cm etc.

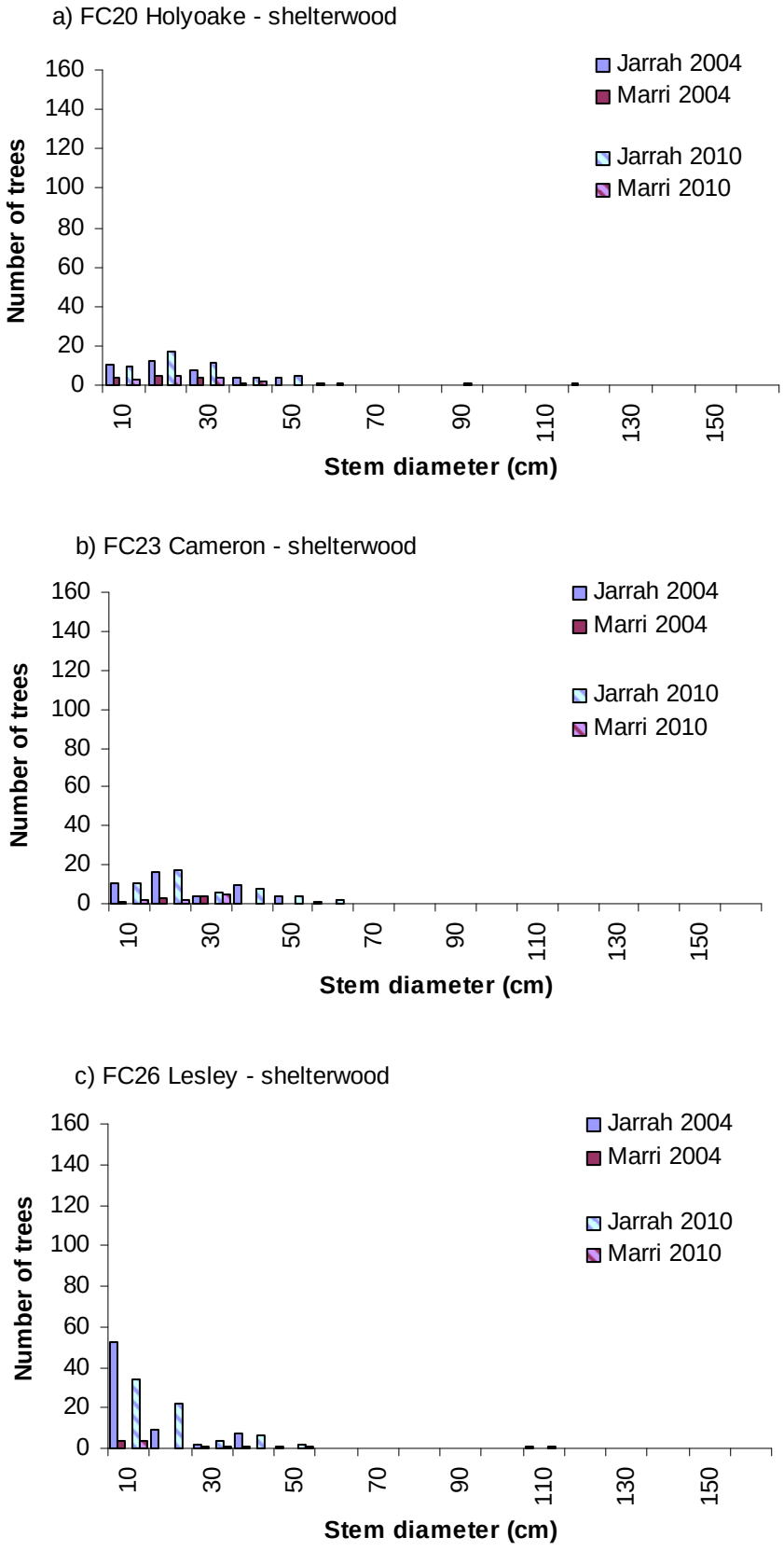

Figure 2. Stem diameter distribution by 10 cm classes for each shelterwood grid in classes 0-9 cm, 10-19 cm etc.

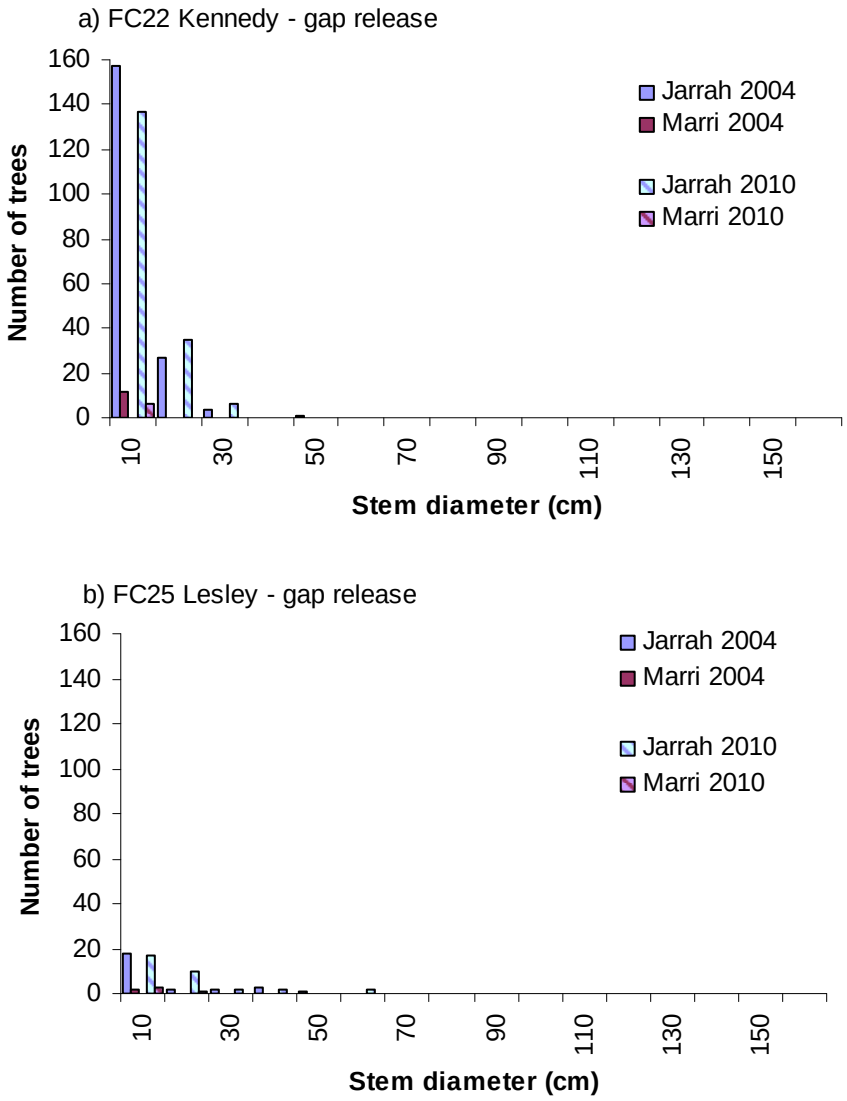

Figure 3. Stem diameter distribution by 10 cm classes for each gap release grid in classes 0-9 cm, 10-19 cm etc.

Figure 4. Sampling forest on FC22 scorched by fire in October 2009 showing vigorous resprouting from basal lignotuber and epicormic shoots in May 2010.

More than half of the jarrah trees <10 cm dbh were killed back to the basal lignotuber following the October 2009 moderate intensity fire in FC22, although only 4% of trees died completely (Fig. 5a). Trees >10 cm exhibited a strong ability to recover from epicormic shoots on the branches and stem, with no mortality recorded. The small number of marri trees on FC22 recovered readily from epicormic shoots (data not shown). Five years after complete defoliation by high intensity fire, grid FC27 included 338 stem ha^{-1} of jarrah <10 cm dbh that were completely dead (Fig. 5b). However, the number of live jarrah in this size class in 2010 actually exceeded the number recorded in 2004 indicating that additional saplings had recruited from lignotuberous ground coppice following the fire. Crowns of larger trees had re-established partially from epicormic shoots on branches and stems, but two jarrah >50 cm dbh re-sprouted only from the stem.

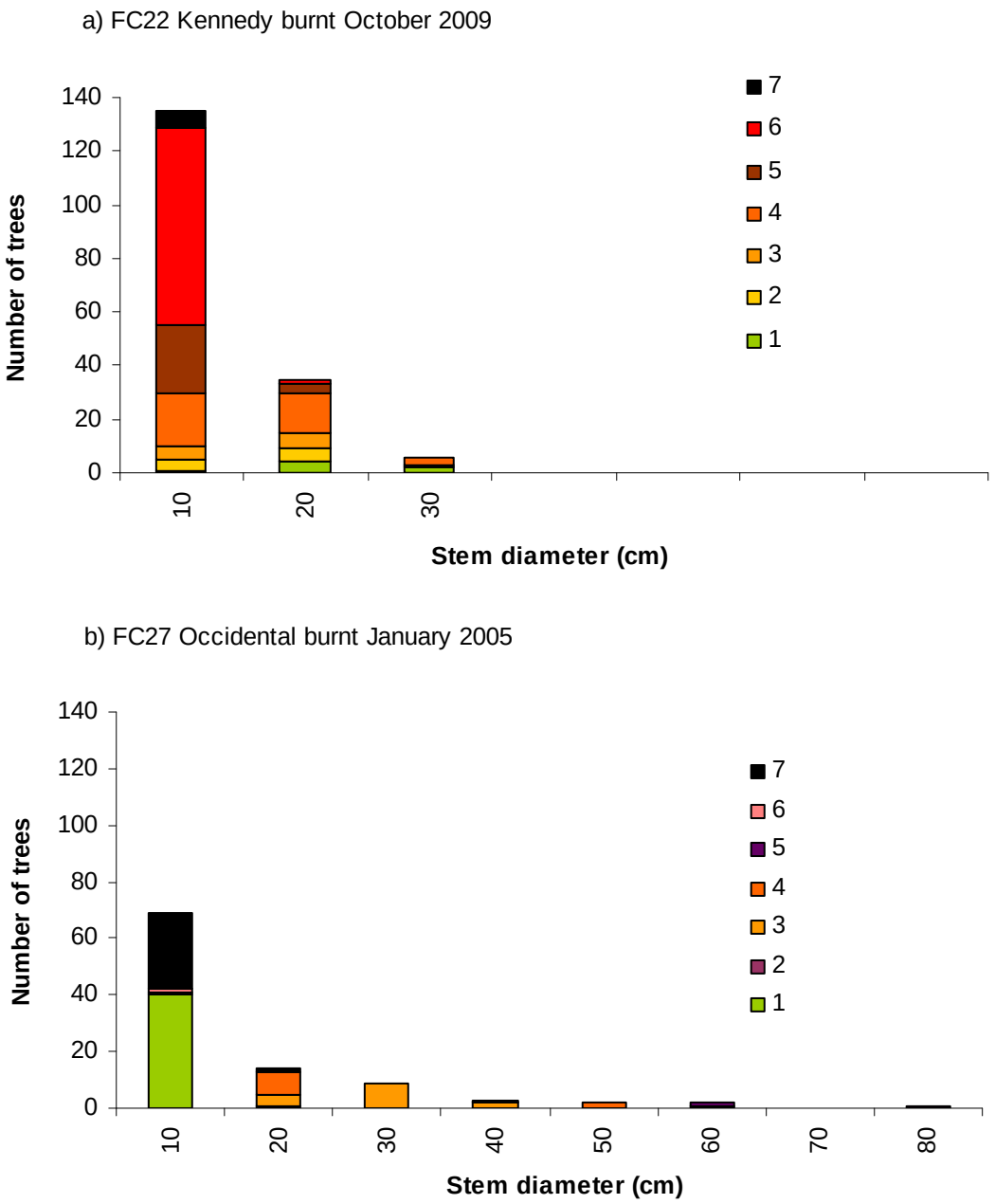

Figure 5. Crown ratings for jarrah trees on grids FC22 and FC27 burnt by moderate to high intensity fire. Classes descriptions: (1) primary crown intact (2) primary crown intact with epicormic shoots on stem (3) recovering from epicormic shoots on branches but not on stem (4) recovering from epicormic shoots on branches and on stem (5) primary crown dead, recovering only from epicormic shoots on stem (6) primary crown dead, sprouting from lignotuber below 1.3 m (7) tree completely dead.

Projected cover was dominated by eucalypts on all grids with foliage from the upper storey (>15 m dominant) on two external reference grids, one shelterwood grid and one gap release grid (Fig. 6). Eucalypt foliage from the lower storey (2-15 m) dominated the cover on external reference grid FC27 and gap release grid FC22, probably reflecting regrowth of saplings following fire. The high cover of non-eucalypt foliage on shelterwood grid FC23 resulted from a dense layer of *Allocasuarina*. Foliage cover in harvested grids had generally increased since 2003, and

remained relatively constant in external reference grids except FC27, which was defoliated by fire in 2005 (Fig. 7).

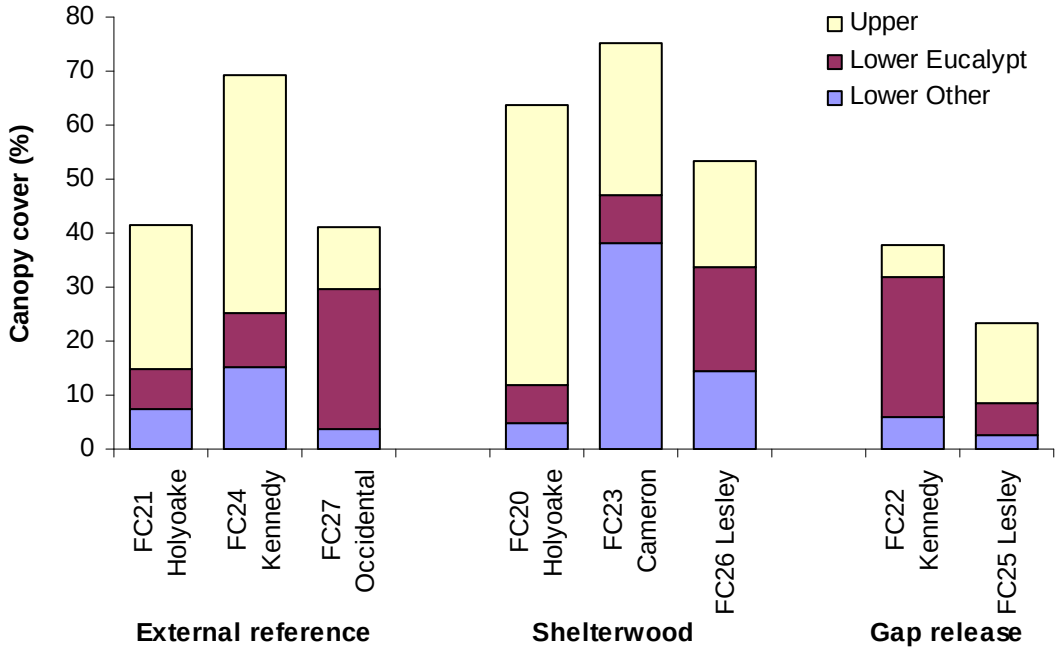

Figure 6. Projected foliage cover of eucalypts and other plants in 2009 divided into lower (2-15 m) and upper (>15 m) storeys.

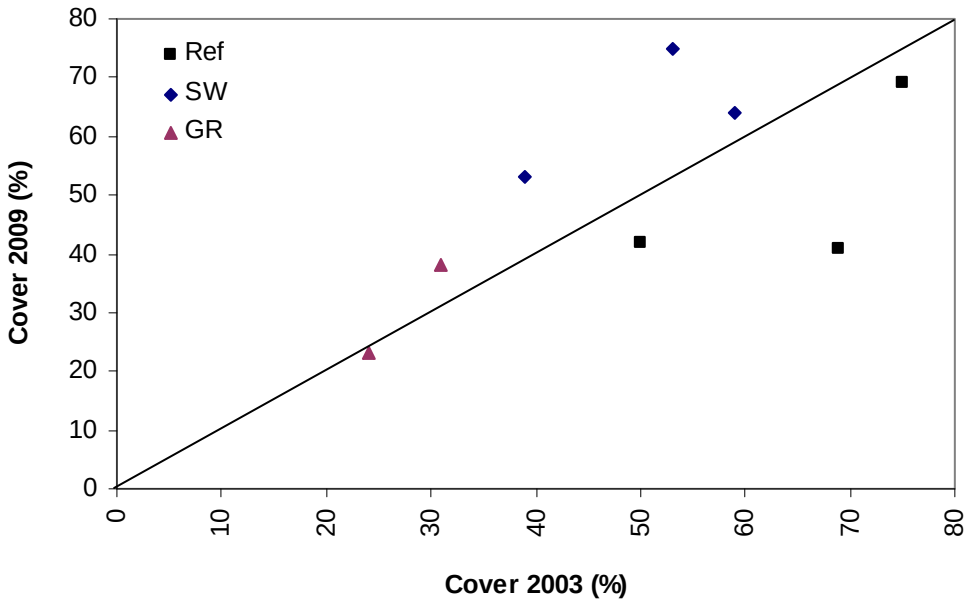

Figure 7. Scatterplot comparing cover measured in 2003 and 2009 (Ref = external reference, SW = shelterwood, GR = gap release).

Discussion

In the period from 2004 to 2010 stand basal area increased on six of the eight grids, including all of the grids harvested to shelterwood and gap release. Mean annual increments for the shelterwood grids in Perth Hills were similar to those reported for shelterwood grids in Donnelly (jarrah south ecosystem) and Wellington (jarrah north ecosystem) and in the range from 0.25 to 0.75 m^2 ha^{-1} $year^{-1}$. Both gap release grids exhibited positive growth over the period, despite grid FC22 being burnt by a moderate intensity fire that caused some mortality of smaller saplings. External reference grid FC24 had a similar stand basal area increment to the three shelterwood grids, while basal area reduced on grids FC21 and FC27 over the six year period. This reduction was attributed to loss of trees as a result of fire. Reduction in basal area was also observed on grids in Wellington District measured in 2009 where large mature trees fell down after burning through dead wood at the base of the stem.

Stand structure changes in shelterwood grids indicate that saplings released from competition following harvesting have continued to be recruited into larger size classes over the period from 2004 to 2010. The number of saplings recorded on grids FC20, FC23 and FC26 were respectively 425, 400 and 750 per hectare, approaching or exceeding the minimum stocking of 500 saplings ha^{-1} sought in higher rainfall forest under the current jarrah silvicultural guideline (CALM 2004). In drier eastern forest a stocking of 350 saplings ha^{-1} is considered sufficient for effective regeneration. These saplings are also supplemented by lignotuberous seedlings and ground coppice.

The remarkable ability of jarrah to recover following high intensity fire was clearly demonstrated at FC27 by re-establishment of crowns defoliated by the 2005 Pickering Brook bushfire. Bushfires of this intensity are undesirable for a variety of reasons, but it is fortunate that the main tree species are sufficiently adapted for fire that loss of forest cover is only temporary.

The Report and Recommendations of the Environmental Protection Authority on the Mid-term audit of performance of the Forest Management Plan 2004-13 identified a number of matters for consideration during preparation of the next management plan (EPA 2010). Amongst the issues relevant to the forest structure component of the FORESTCHECK monitoring are the implications of a drying climate for the health of forest ecosystems, growth rates of potential commercial trees, and the effectiveness of regeneration following silvicultural treatment. Data collected from FORESTCHECK grids are an important source of objective information that should be used to inform discussion of these matters. Periodic re-measurement of monitoring grids provides a valuable time series of rigorous and repeatable observations, and facilitates separation of the effects of seasonal conditions from the effect of geographical location. This should contribute to a better understanding of the response of jarrah forest ecosystems to climate and disturbance factors.

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COARSE WOODY DEBRIS, SMALL WOOD AND TWIGS, AND LITTER

Kim Whitford, Richard Robinson, Lachie McCaw and Deb Feeniks

Introduction

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

Wood and leaf debris 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. Consequently coarse woody debris (CWD), small wood and twigs (SWT) and litter are important structural and biological components of forest ecosystems. Disturbances such as logging and burning affect the volumes and types of debris that occur in forests. This part 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, small wood and twigs, and coarse woody debris on the ground in the various managed jarrah forest treatments (i.e. gap release and shelterwood) 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.

The CWD assessment was revised in 2008 (Whitford *et al*. 2008) in order to collect additional information. The re-assessment of all grids was commenced in 2008-09 (see FORESTCHECK 2008-09 Report of Progress) and completed in 2009-10.

Because fire has a major impact on CWD by consuming existing as well as creating additional CWD, the re-assessment of grids which had been burnt since their initial assessment was also commenced in 2009-10. Post-fire reassessment re-establishes the CWD baseline loads on recently burnt grids and will also aid in creating a dataset to assess the long-term impact of fire on CWD dynamics. Post fire re-assessment includes all measurements and attributes detailed in Whitford *et al*. (2008) plus assessment of scorch height, whether or not individual logs were burnt, and the degree of charring.

Field and Laboratory Monitoring

Coarse woody debris re-measurement was undertaken on 38 grids in 2008-09 (FC11 to FC48, see 2008-09 FORESTCHECK Report of Progress) and the remaining 10 grids (FC1 to FC10) completed in 2009-10. Six grids which had been burnt since their initial measurements were also re-assessed in 2009-10. Litter and SWT assessments were undertaken on the Perth Hills grids from 10-13 May 2010. Litter and small wood and twig samples were oven dried, weighed in grams and then converted to tonnes per hectare (t ha^{-1}). The volume of coarse woody debris was

determined using the line intersect method (Van Wagner 1968) and calculated to cubic metres per hectare (m^3 ha^{-1}).

Results and Discussion

Litter weights

In 2009, litter loads on grids within and between treatments were generally variable. Five grids had been burnt since the 2004 measurements (FC 21, FC22, FC25, FC26 & FC27), and in each treatment litter loads generally reflected time since fire (Fig. 1). However, only 13% of the Lesley gap release was burnt in spring 2009 (compared to 80% of the Lesley shelterwood and 100% of the Kennedy gap release) which likely accounts for the higher litter load on that grid. The Holyoak shelterwood (FC20) also a high load compared to other longer unburnt grids in both the external reference and shelterwood treatments and had the largest gain in litter load since 2004. All other unburnt grids experienced a reduction in litter load since the original 2004 assessment. The reason for this reduction is uncertain, but litter accumulation is influenced by a variety of factors including stand structure and density, the extent of fuel consumption during previous fires, and reduction in canopy density by defoliating insects.

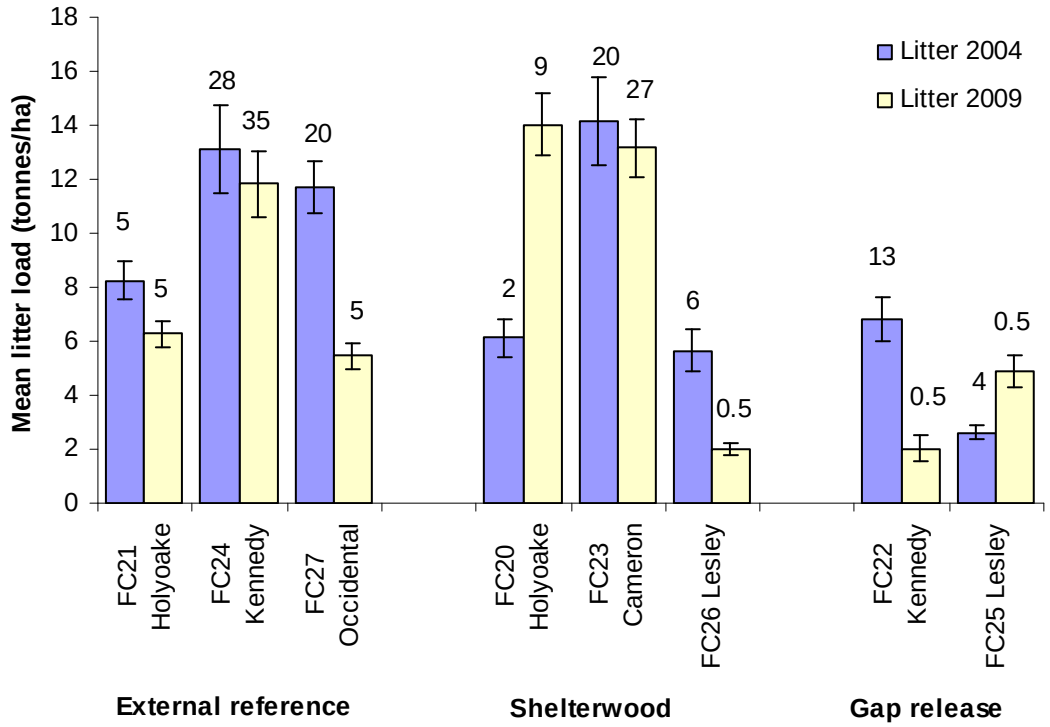

Figure 1. Mean litter loads (t ha^{-1} ± se) calculated at each FORESTCHECK grid at Perth Hills in 2004 and 2010. Numbers above columns indicate years since burnt.

Small wood and twigs

The amount of small wood and twigs on all sites was low (Fig. 2) compared to that of the litter (Fig. 1). Twig loads increased on all grids that had not been burnt since 2004 except on the Holyoak external reference (FC21). The amount of SWT was greatly reduced on all grids that had been burnt since 2004 (FC21 & FC 27 in 2005; FC26, FC25 & FC22 in 2009). On the

unburnt Cameron shelterwood (FC23) the SWT load had increased 2.5 times since 2004, which may be related to the long time since fire and senescence of the largely *Banksia grandis* understory (Fig. 3).

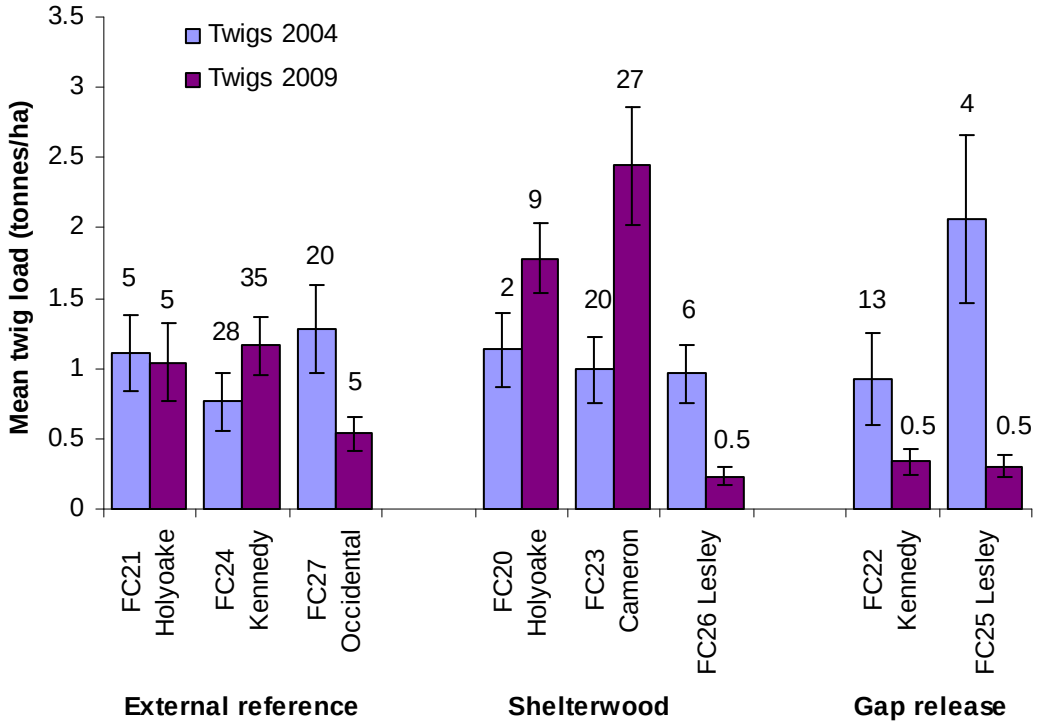

Figure 2. The average weights (t ha^{-1}) of small wood and twigs measured at each FORESTCHECK grid at Perth Hills in 2004 and 2010. The numbers above the columns indicate years since burnt.

Figure 3. Typical litter and twig structure on the Cameron shelterwood grid (FC23), with a large proportion being contributed by the *Banksia grandis* understory.

Coarse woody debris volumes

Table 1 lists the CWD volume on all of the 48 FORESTCHECK grids. Although CWD volume was highly variable across grids, some clear differences between the treatments emerged (Figs. 4 & 5). Volumes on external reference treatments that had never been harvested (77 ± 24 m^3 ha^{-1}) were relatively low compared to all of the harvested treatments (Fig. 4). CWD volume increased with the intensity of the most recent harvest, with the most intensive harvest treatment, (gap release) having the highest volumes of CWD (156 ± 25 m^3 ha^{-1}). Loadings of CWD in shelterwood (122 ± 16 m^3 ha^{-1}) and selectively harvested grids (127 ± 30 m^3 ha^{-1}) were not significantly different from one another and were lower than in gap release treatments (Fig. 4). The volume of CWD on previously harvested external reference and coupe buffer treatments (89 ± 14 m^3 ha^{-1}) was intermediate between those of the recently harvested and the never harvested treatments.

Factors affecting coarse woody debris volumes

The volume of coarse woody debris on the grids increased with the number of harvests and the intensity of the recent and historical harvests on the site. Figure 6 shows how the volume of CWD generally increases with the number of times that the site has been harvested. We determined the reduction in stand basal area produced by the most recent harvest and also the basal area of stumps from trees removed in previous harvests. The CWD volume is related to both the basal area removed in the recent harvest ($r^2 = 0.14$) and the total basal area removed in recent and historical harvests ($r^2 = 0.22$) (Fig. 7).

A substantial proportion of CWD on the recently harvested treatments is derived from harvesting (34%). This material derived from harvesting predominantly affects the volume of CWD between 10 to 50 cm in diameter (i.e. the 20 and 40 cm diameter classes, Fig. 8). This greater volume on the recently harvested stands is also the less decayed classes; the low to moderate log decay classes (classes 2 to 5). This is material that has been on the ground for approximately 10 to 60 years (Fig. 9), indicating that it is from both the most recent and previous harvest events. So harvested, and particularly recently harvested stands contain greater volumes of small diameter material in the less decayed classes.

Across all grids the small diameter material predominantly occurs in the less decayed classes (3 and 4); while the highly decayed classes (6, 7, and 8) predominantly consist of large diameter material (Fig.10). Smaller logs are more likely to ignite and sustain fire (Anderson, 1970; Brown *et al*. 1985; Burrows, 2001) and are thus less likely to persist on the ground over the longer term and reach advanced stages of decay.

Six grids that were burnt (either by wildfire or planned burning) since their original assessment were also reassessed. The fires had little impact on the volume of CWD on three of these grids, but reduced the volume of CWD on the remaining three grids (Table 1). The impact of fire on CWD will vary with fire intensity.

Table 1. The 48 FORESTCHECK grids reassessed in 2009 and 2010 for coarse wood debris (CWD) volume and condition. The grids are grouped by treatment type.

Grid	Location	Treatment	Year grid established	Year of most recent harvest	No. of cuts	Mean CWD volume (m^3 ha^{-1} ± se)	Mean CWD volume post burn (m^3 ha^{-1} ± se)
FC1	Winnejup	External reference	2001	Uncut	1	141 ± 26	
FC5	Yornup	External reference	2001	Uncut	1	87 ± 13	
FC10	Easter	External reference	2001	Uncut	0	244 ± 33	
FC16	Yourdamung	External reference	2002	Uncut	0	31 ± 7	
FC17	Surface	External reference	2002	Uncut	0	55 ± 24	50 ± 22
FC19	Tumlo	External reference	2002	Uncut	0	128 ± 28	
FC21	Holyoake	External reference	2003	Uncut	1	45 ± 8	
FC24	Kennedy	External reference	2003	Uncut	2	91 ± 7	
FC27	Occidental	External reference	2003	Uncut	2	26 ± 10	
FC28	Nalyerin	External reference	2004	Uncut	0	58 ± 29	
FC32	Stockyard	External reference	2004	Uncut	1	59 ± 12	
FC35	Bell	External reference	2004	Uncut	0	27 ± 6	
FC38	Barrabup	External reference	2005	Uncut	0	31 ± 14	
FC39	St John	External reference	2006	Uncut	0	39 ± 4	
FC40	Layman	External reference	2005	Uncut	0	80 ± 30	
FC4	Kingston	Coupe buffer	2001	Uncut	2	131 ± 63	
FC7	Thornton	Coupe buffer	2001	Uncut	1	154 ± 13	156 ± 12
FC9	Carter	Coupe buffer	2001	Uncut	1	196 ± 34	
FC29	Godfrey	Coupe buffer	2004	Uncut	1	64 ± 10	
FC43	Barrabup	Selective cut	2005	2002		163 ± 34	
FC44	Cambray	Selective cut	2005	1995		67 ± 15	
FC45	Butler	Selective cut	2005	1998		150 ± 50	
FC3	Kingston	Shelterwood	2001	1996	3	99 ± 15	
FC13	Ross	Shelterwood	2002	1992	2	152 ± 40	
FC15	Surface	Shelterwood	2002	1997	2	141 ± 18	
FC18	Chalk	Shelterwood	2002	1992	2 or 3	239 ± 41	
FC20	Holyoake	Shelterwood	2003	1995	2	110 ± 32	
FC23	Cameron	Shelterwood	2003	1989	2	182 ± 31	
FC26	Lesley	Shelterwood	2003	1997	2	71 ± 26	58 ± 22
FC30	Godfrey	Shelterwood	2004	2000	3	49 ± 8	
FC33	Stockyard	Shelterwood	2004	1998	2	114 ± 10	
FC36	Bell	Shelterwood	2004	1996	1	45 ± 20	
FC41	Barrabup	Shelterwood	2005	2002		155 ± 10	
FC42	Cambray	Shelterwood	2005	1995		109 ± 30	
FC2	Kingston	Gap release	2001	1996	3	208 ± 87	
FC6	Thornton	Gap release	2001	1991	2	407 ± 45	318 ± 70
FC8	Carter	Gap release	2001	1995	2	199 ± 36	
FC11	Edward	Gap release	2002	1994	2	113 ± 14	
FC12	Ross	Gap release	2002	1992	2	111 ± 34	
FC14	Surface	Gap release	2002	1997	2	107 ± 7	
FC22	Kennedy	Gap release	2003	1988	3	252 ± 39	194 ± 43
FC25	Lesley	Gap release	2003	1997	2	94 ± 14	95 ± 14
FC31	Godfrey	Gap release	2004	2000	2	61 ± 15	
FC34	Stockyard	Gap release	2004	1998	2	74 ± 15	
FC37	Bell	Gap release	2004	1996	1	67 ± 12	
FC46	Barrabup	Gap release	2005	2002		156 ± 63	
FC47	Cambray	Gap release	2005	1996		112 ± 39	

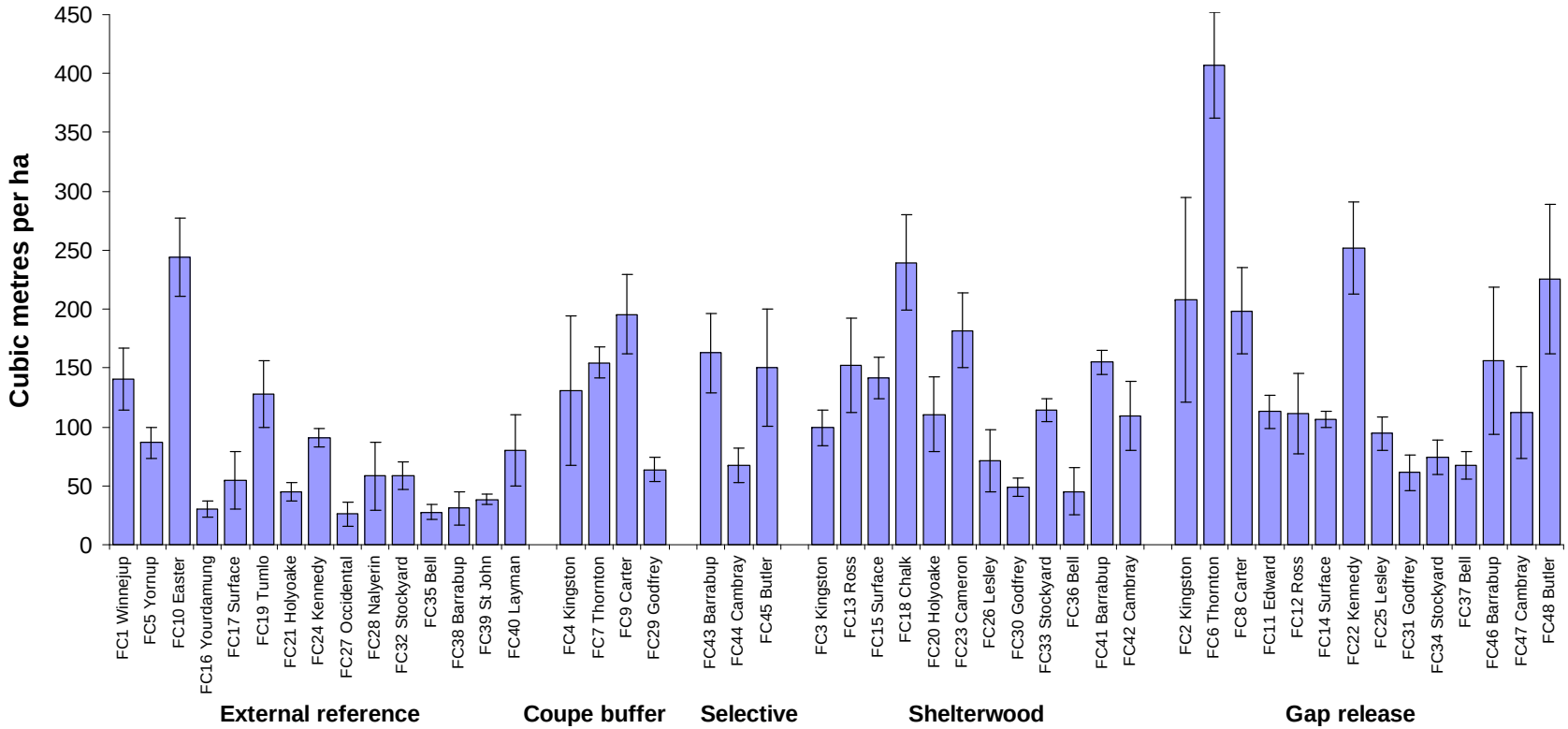

Figure 4. The volume of coarse woody debris (m^3 ha^{-1} ± se) measured at all FORESTCHECK grids in 2008 and 2009 using three 200 m transects on all grids except FC6, FC7 and FC17 which were burnt before the third transect could be added.

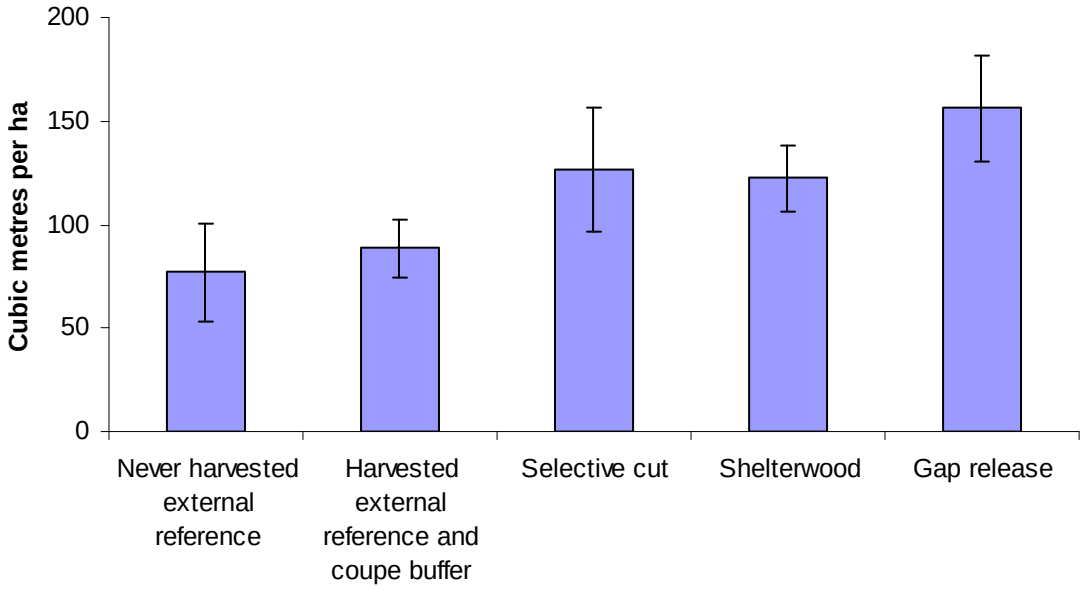

Figure 5. Treatment means for the volume (m^3 ha^{-1} ± se) of coarse woody debris on harvested and never harvested treatments measured across all 48 FORESTCHECK grids in 2008-09 and 2009-10.

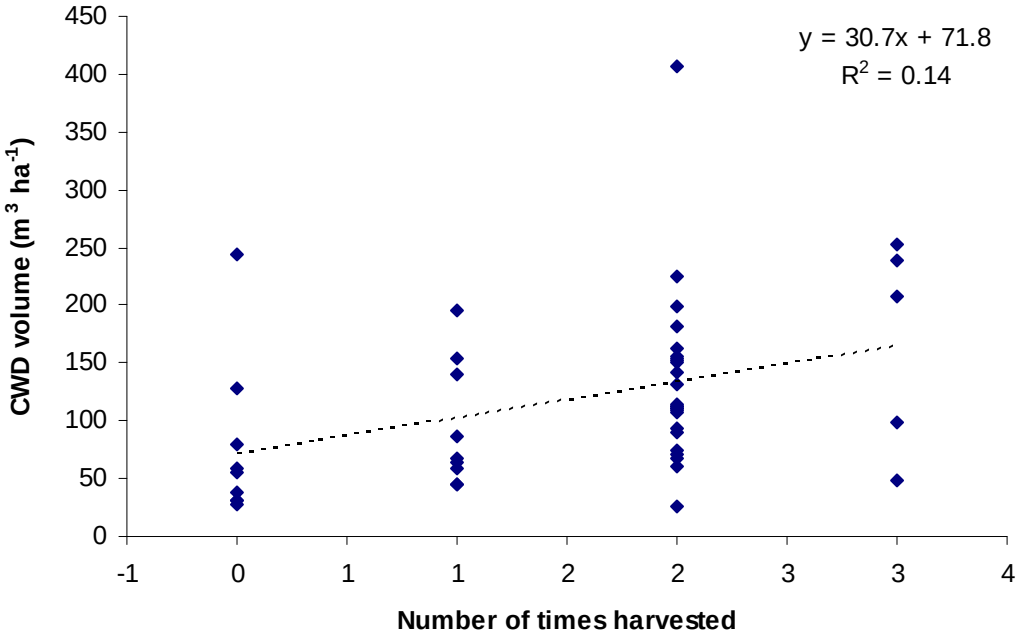

Figure 6. The relationship between the number of times a site is harvested and the volume of coarse woody debris on the site.

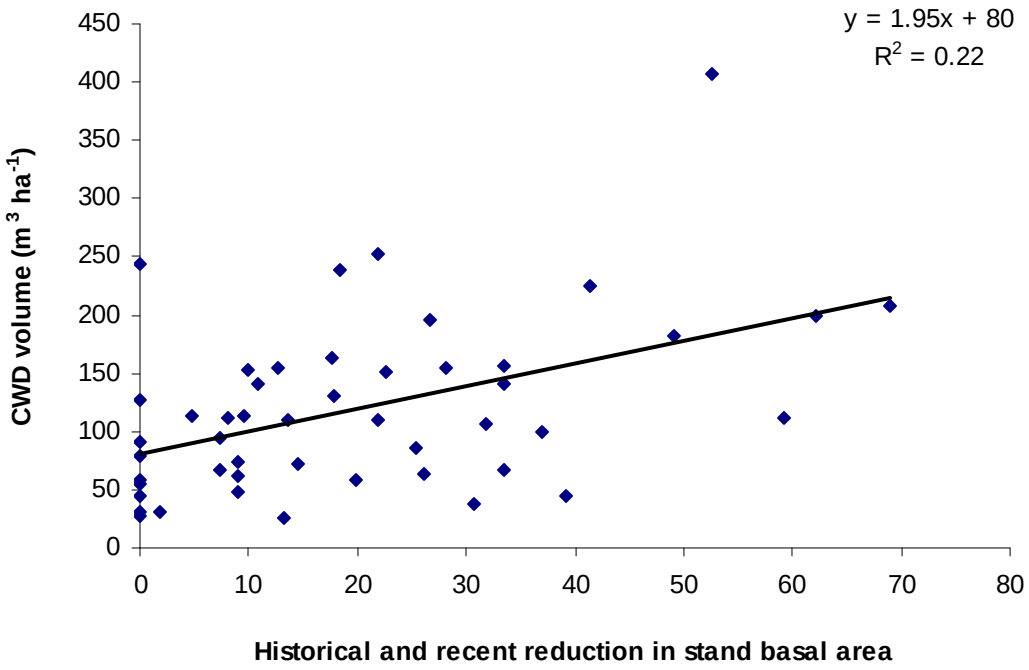

Figure 7. The reduction in stand basal area produced by the most recent and historical harvests was determined from the basal area of stumps left from the removal of trees during harvest. The volume of coarse woody debris on the site increased as the total basal area removed from the stand increased.

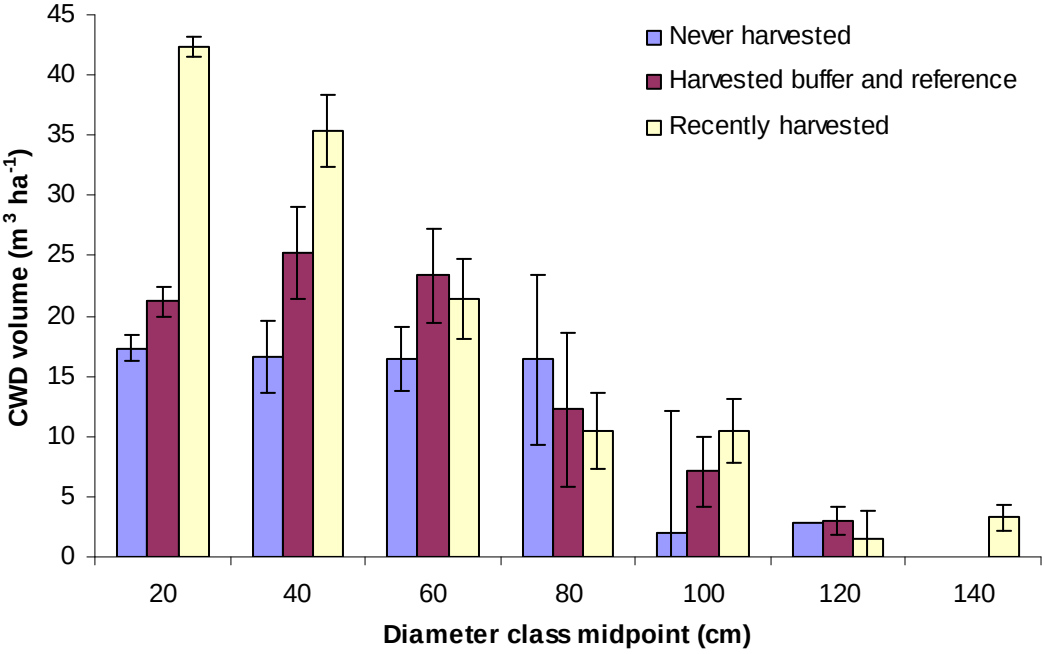

Figure 8. Means for the volume (m^3 ha^{-1} ± se) of coarse woody debris on never harvested, previously harvested coupe buffers and reference treatments, and recently harvested treatments. Mean volumes in each treatment were: never harvested, 77 m^3 ha^{-1}; previously harvested coupe buffers and reference treatments, 89 m^3 ha^{-1}; and recently harvested treatments, 140 m^3 ha^{-1}.

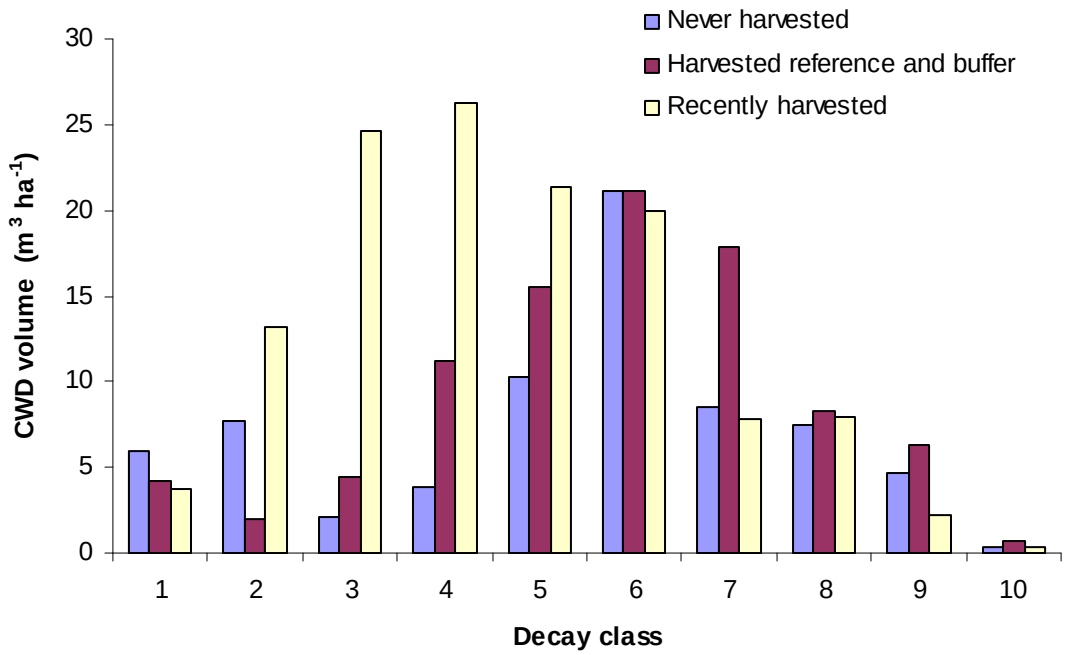

Figure 9. The volume (m^3 ha^{-1} ± se) of coarse woody debris in each of the 10 log decay classes. Treatments are never harvested, previously harvested coupe buffers and reference treatments, and recently harvested treatments. Total volumes in each treatment were: never harvested, 77 m^3 ha^{-1}; previously harvested coupe buffers and reference treatments, 89 m^3 ha^{-1}; and recently harvested treatments, 140 m^3 ha^{-1}.

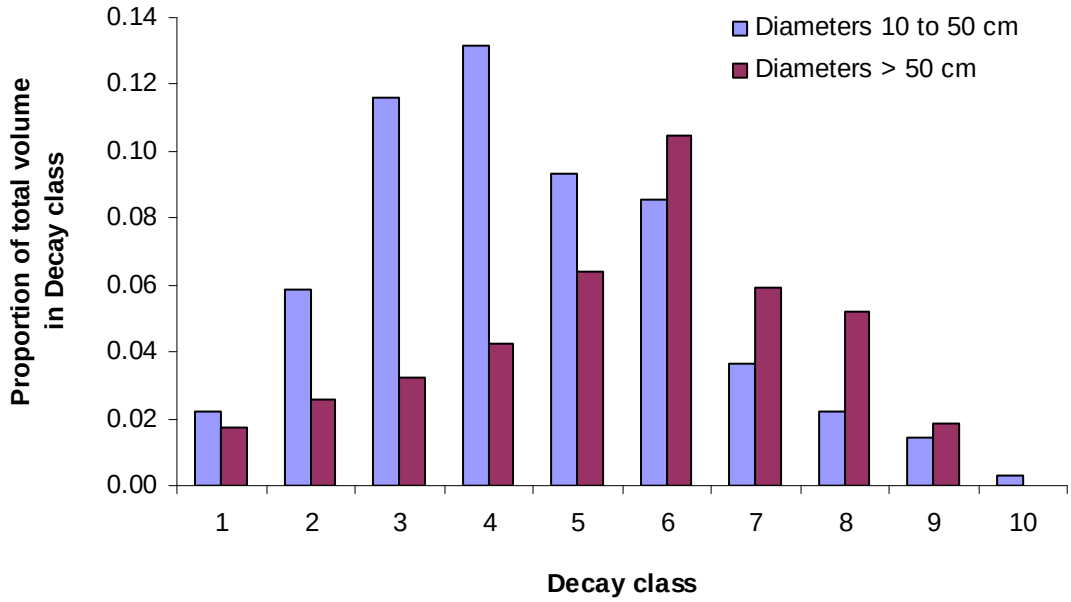

Figure 10. The proportion of the total coarse woody debris volume in each decay class, for large diameter (> 50 cm) and small diameter (10 to 50 cm) logs.

Conclusions

- All 48 FORESTCHECK grids have now been reassessed for CWD using 3 x 200 m transects, except FC6, FC7 and FC17 which unfortunately were burnt before a third transect could be added.
- Six grids were reassessed (using 3 x 200 m transects) after they were burnt. These were FC6, FC7, FC17, FC22, FC25, and FC26.
- CWD loads were high, ranging from a mean of 140 tonnes ha^{-1} on grids in recently harvested treatments to 77 tonnes ha^{-1} on grids that have never been harvested.
- CWD volume increases with both the intensity of harvest and the number of times the stand has been harvested. This is shown by:
    - the general increase in CWD volume with the total number of historical harvests,
    - the relationship between the total amount of basal area that has been removed from the stand (determined from the remaining stumps) and the measured volume of CWD that remains and,
    - CWD volumes that increase with the intensity of the most recent harvest, and the most intensive harvest treatment (gap release) having the greatest volumes of CWD. External reference grids that have never been harvested have the lowest load of CWD.
- A substantial proportion of CWD on the recently harvested treatments is derived from harvesting (34%).
- Most of the difference in CWD volume between 'recently harvested' and 'never harvested' occurs in the 20 and 40 cm diameter classes (diameter range 10 to 50 cm).
- Historical and recent harvesting increase the volume of CWD in the low to moderate decay classes (classes 2 to 5).
- Harvested, and particularly recently harvested stands contain greater volumes of small diameter material in the less decayed classes.
- CWD load is also influenced by fire frequency and site factors such as stand density, shading and site moisture levels. These and other factors will be considered in subsequent analyses now that the entire data set is compiled.

Acknowledgements

Thank you to Julian Geisel, Daniella Stott, Tub Liddelow and Jamie Flett for field assistance with litter and twig sampling.

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MACROFUNGI

Richard Robinson, Katrina Syme and Julian Geisel

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 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 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 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.
- To generate detailed descriptions of unknown or unnamed species.

Field Survey

Eight FORESTCHECK grids, including three external reference grids (FC21, FC24, FC27), three shelterwood (FC20, FC23, FC26) and two gap release treatments (FC22, FC25), were installed in the northern region of the jarrah north-west forest ecosystem in the Perth Hills District in 2003. These plots were initially monitored for macrofungi in autumn 2004, and results were reported in the FORESTCHECK Report of progress 2003-04.

The second round of macrofungal monitoring in Perth Hills was undertaken in 2010. Two surveys were conducted, the first on 15-16 June and the second on 20-21 July 2010. Surveys are conducted in relation to the soil dryness index (SDI). 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). However, April and May were drier than average and consistent rains did not fall until mid-June. As a result the SDI during the first survey was at about 60 and fell to zero on 10 July, 10 days before the second survey (Fig. 1). In contrast the SDI in 2004 was zero by 8 June, and surveys were conducted from 21-23 June and 12-14 July.

During each survey, all eight grids were monitored. All macrofungal species and their abundance were recorded along 2 x 200 m transects on each grid (see plot layout on p. 5). All new or previously unrecorded taxa were photographed *in situ* and vouchers collected.

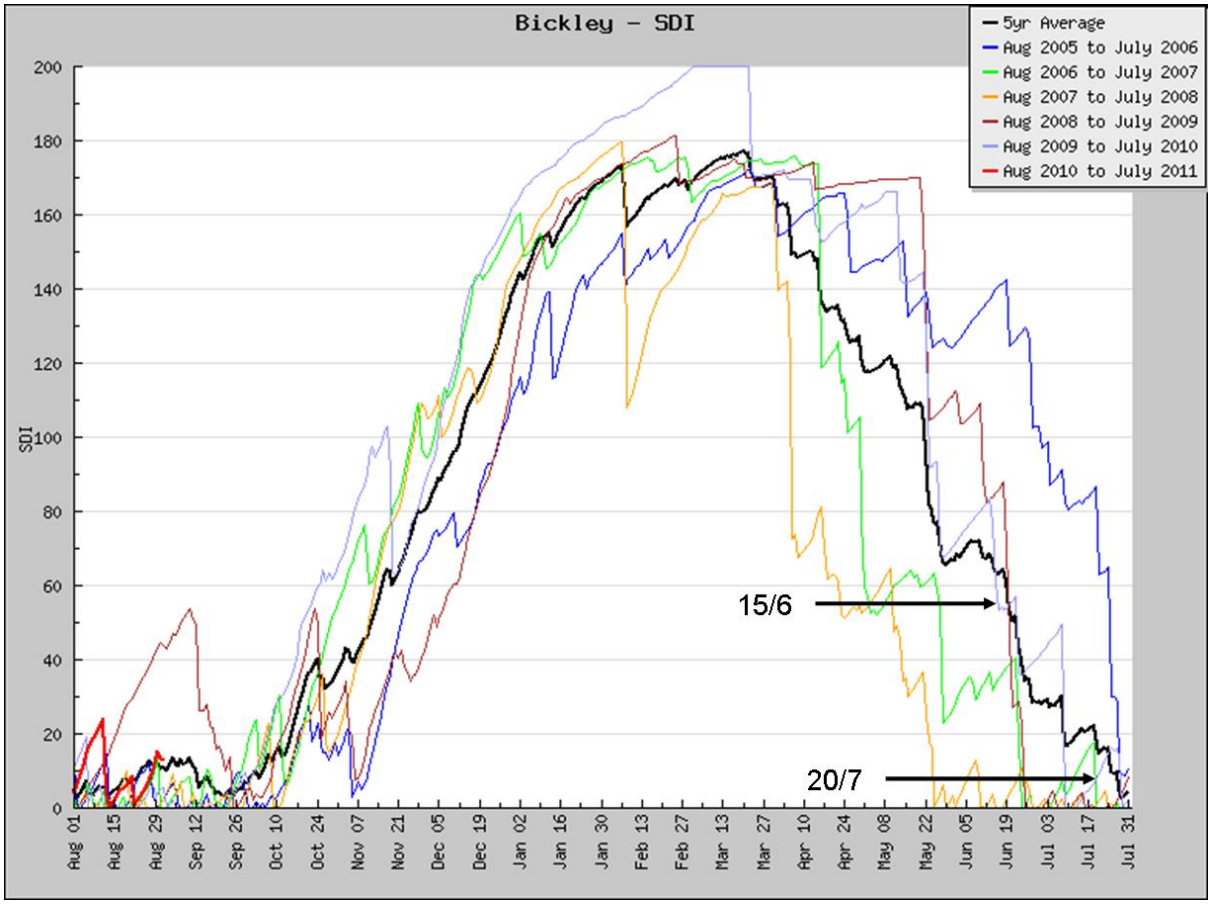

Figure 1. Daily soil dryness index (SDI) from the Bickley automatic weather station during the period August 2005 to September 2010 (Bureau of Meteorology). The SDI at the start of each FORESTCHECK macrofungi monitoring period in 2010 is indicated by the black arrows.

Preliminary Results and Discussion

Voucher specimen examination and processing

In the laboratory, voucher specimens were kept in a refrigerator at about 5º C. Processing of each voucher collection was completed on the day of collection or the next day. Detailed descriptions of the macroscopic characters of the fresh specimens were compiled for each collection that represented a putative new species or represented noticeable variation in species concepts already determined. All collections were then air dried at 35º C. At the completion of the field surveys, some dried specimens were examined microscopically and detailed measurements of basidia, spore and hyphal structure were undertaken to aid in verifying their identity and to confirm a number of other unnamed species. A species list has been compiled (Appendix 1). In total, 41 voucher collections were made representing 33 species. A total of 15 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 in 2010

A total of 161 species of fungi and 4,827 fruit bodies were recorded on the Perth Hills monitoring grids in 2010 (Appendix 1). Of these, 15 species (9.3%) were recorded for the first time in FORESTCHECK. Eighty three species were recorded and in the June survey and 119 in the July survey were. Only 25% of the total species were recorded in both surveys

(Fig. 2), thus demonstrating the temporal differences in fruit body development found in macrofungal communities throughout the fruiting season. There were almost twice as many 'new' species fruiting in July than in June, indicating that the July survey was likely conducted at the peak of the fruiting season.

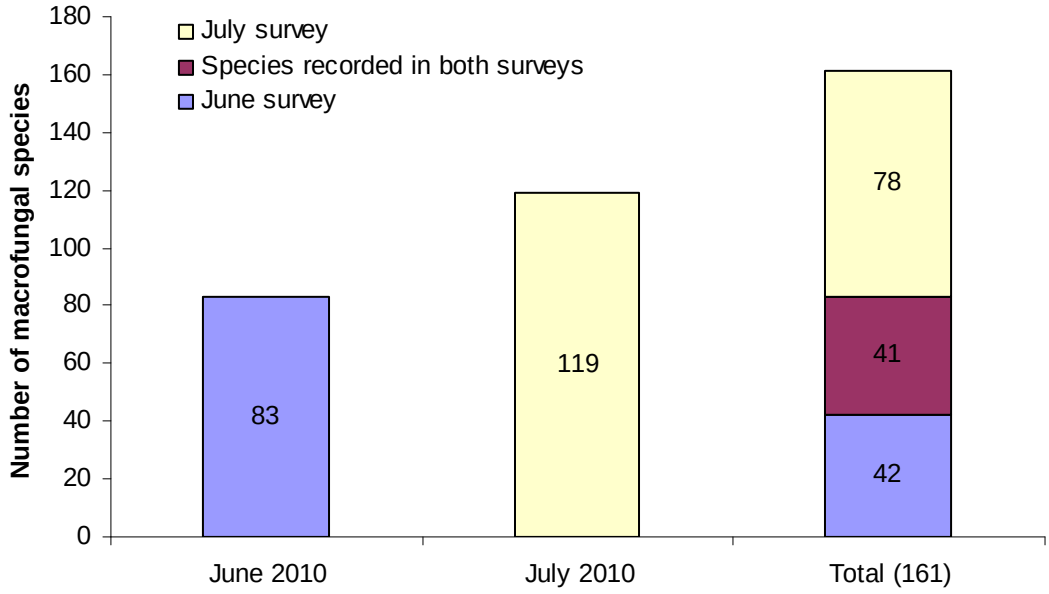

Figure 2. The total number of species recorded in June and July surveys on the Perth Hills FORESTCHECK monitoring grids in 2010.

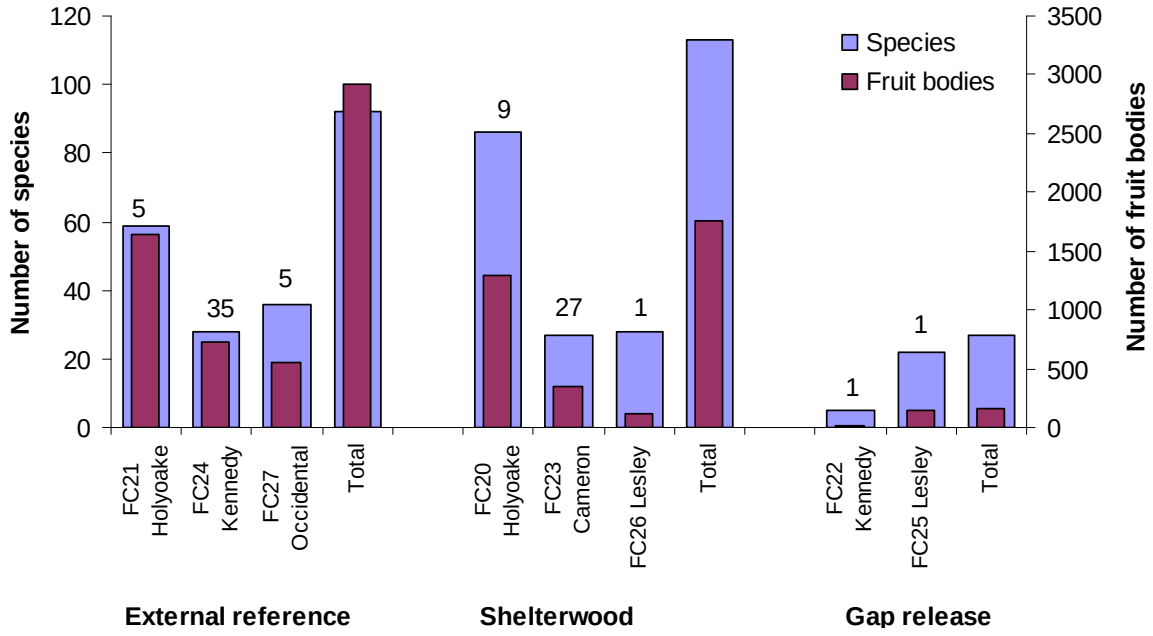

Figure 3. The total number of species recorded on each FORESTCHECK monitoring grid at Perth Hills in 2010. Numbers above columns indicate the years since the last fire.

Species richness and abundance of fruit bodies was variable within each treatment (Fig. 3). The Holyoake shelterwood (FC20) and the Holyoake external reference grid (FC21) had the highest number of species and fruit bodies. Both grids had an intermediate time since fire

(five - nine years). Both gap release grids, Kennedy (FC22) and Lesley (FC25), and the Lesley shelterwood (FC26) had been burnt the previous spring and very few species and fruit bodies were recorded. In the July survey, no species were recorded in the Kennedy gap release. The long-unburnt grids, Kennedy external reference (FC24) and Cameron shelterwood (FC23) also had low numbers of species and fruit bodies compared to those grids burnt 9-12 years previously.

The litter layer on both the long-unburnt grids was very thick, and likely masked any evidence of fruiting that may have occurred underneath. The Cameron shelterwood (Fig. 4) was dominated by thick *Banksia grandis* and *Allocasuarina fraseriana* leaf litter, sometimes up to 20 cm or more deep. In contrast the recently burnt Kennedy gap release (Fig. 4) had very little litter cover and the majority of small diameter wood was totally consumed or severely burnt (see section on woody debris and litter, pp. 27-37), leaving the site very open and with little habitat for litter and wood inhabiting fungi. Only five species were recorded on the Kennedy gap release grid, including a small *Amanita* sp. (Sp. 784), *Pholiota highlandensis* and *Ramaria capitata* (Appendix 1); the latter two known to inhabit burnt sites. However, no pyrophilous Ascomycetes, which are generally prolific on recently burnt sites, were recorded on either of the recently burnt gap release grids or the Lesley shelterwood.

Figure 4. *Left*, thick litter in the long-unburnt Cameron shelterwood (FC23); *right*, bare ground in the recently burnt Kennedy gap release grid (FC22).

The mean species richness and abundance per treatment and the mean number of species fruiting on the various substrates (soil, litter and wood) will be discussed in the following section.

Comparison with previous monitoring at Perth Hills and other regions

In this section, the 2010 results from monitoring at Perth Hills were compared with the initial 2004 monitoring results as well as those from other regions (Donnelly 2002, 2008, Wellington 2003, 2009, Wellington East 2005 and Blackwood Plateau 2006) where FORESTCHECK grids are established.

Species richness and abundance

Overall 232 species of macrofungi have been recorded on the Perth Hills grids, 140 in 2004 and 161 in 2010 (Fig. 5). Total abundance was similar in both 2004 and 2010 with fruit body counts of 4477 and 4827 respectively. Only 31% were common to both monitoring sessions. Mean species richness was similar in all treatments in 2004, and was also similar in the external reference and shelterwood treatments in 2004 and 2010. However, mean species

richness per grid in the gap release treatment was significantly lower on 2010 and contributed to it also being lower when both sets of data were combined (Fig. 6). In 2004, the highest mean number of fruit bodies per grid was recorded in the shelterwood treatment and in 2010 it was in the external reference treatment (Fig. 7). Again the low species richness in the gap release treatment was also reflected in the abundance in 2010 and in the total for the two monitoring sessions (Fig. 7). In all treatments there was a large range of variation in the total number of species and fruit bodies recorded, as indicated by the standard error bars in Figs. 6 & 7.

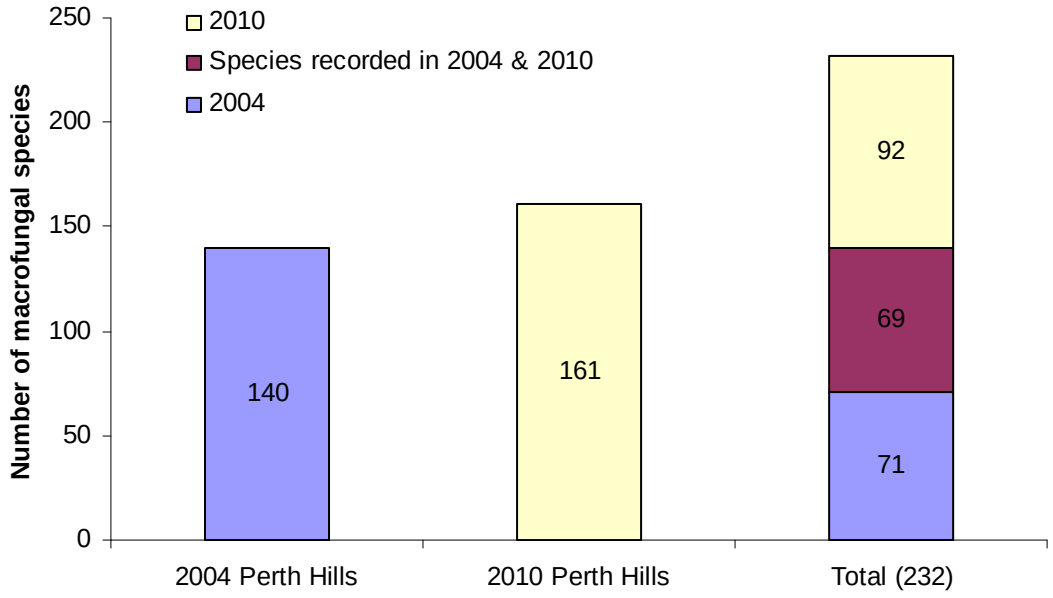

Figure 5. The number of species of macrofungi in FORESTCHECK monitoring at Perth Hills in 2004 and 2010.

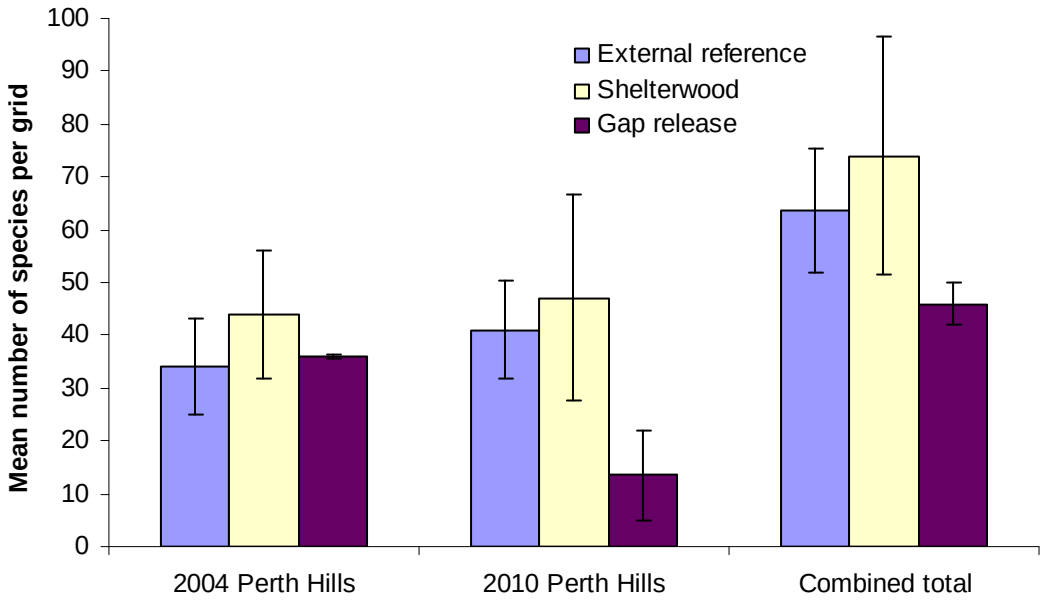

Figure 6. The mean number of species per grid (± se) in each treatment at Perth Hills in 2004 and 2010.

The Perth Hills appears to be the least species rich region within the FORESTCHECK monitoring project, and considerably fewer fruit bodies develop (Fig. 8). Donnelly appears to be the most species rich location, followed by the dry Wellington East location and the wet Blackwood Plateau where similar numbers of fungi were recorded in 2005 and 2006 respectively. Generally abundance has reflected species richness, except at Wellington in 2003, where abundance appeared to be higher in relation to the number of species recorded.

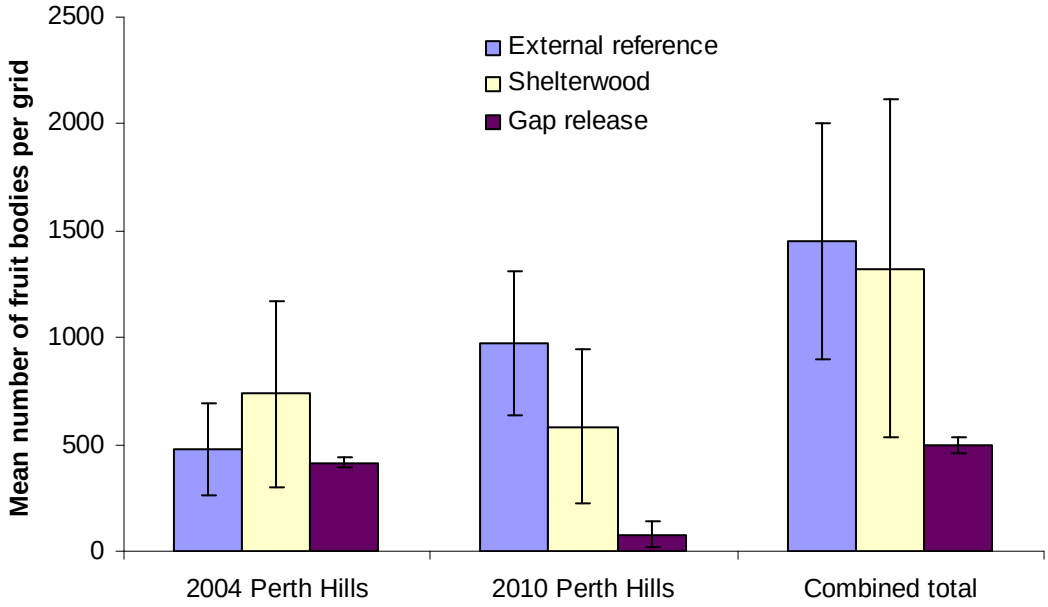

Figure 7. The mean number of fruit bodies per grid (± se) in each treatment at Perth Hills in 2004 and 2010.

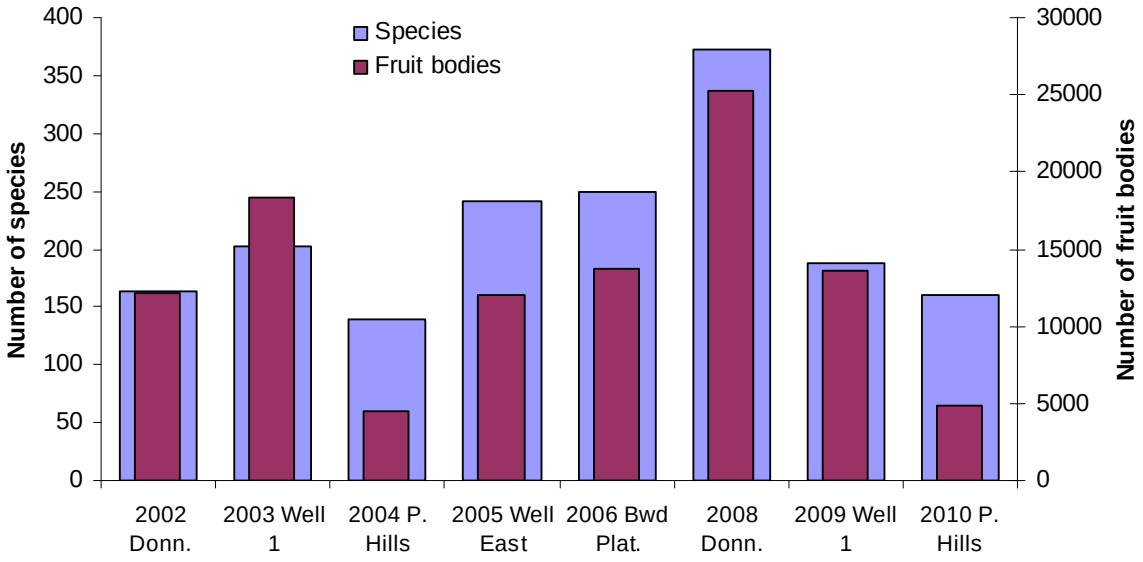

Figure 8. The total number of species and fruit bodies recorded at each FORESTCHECK location from 2002–2010.

The three major habitats for fungi are soil, litter and wood. Similar numbers of species were recorded on soil litter and wood both within and between external reference and shelterwood treatments in 2004 and 2010 (Fig. 9). In the gap release treatment however, fewer species were recorded on soil and wood in 2010 and fewer species were recorded on all three

substrates compared to the external reference and shelterwood treatments. In all treatments, soil recorded the highest number of species, but generally the highest number of fruit bodies was recorded on wood (Figs. 9 & 10). In 2010, mean abundance per grid on litter and wood was considerably higher in the external reference treatment, considerably lower on all three substrates in the gap release treatment and lower on wood in the shelterwood treatment.

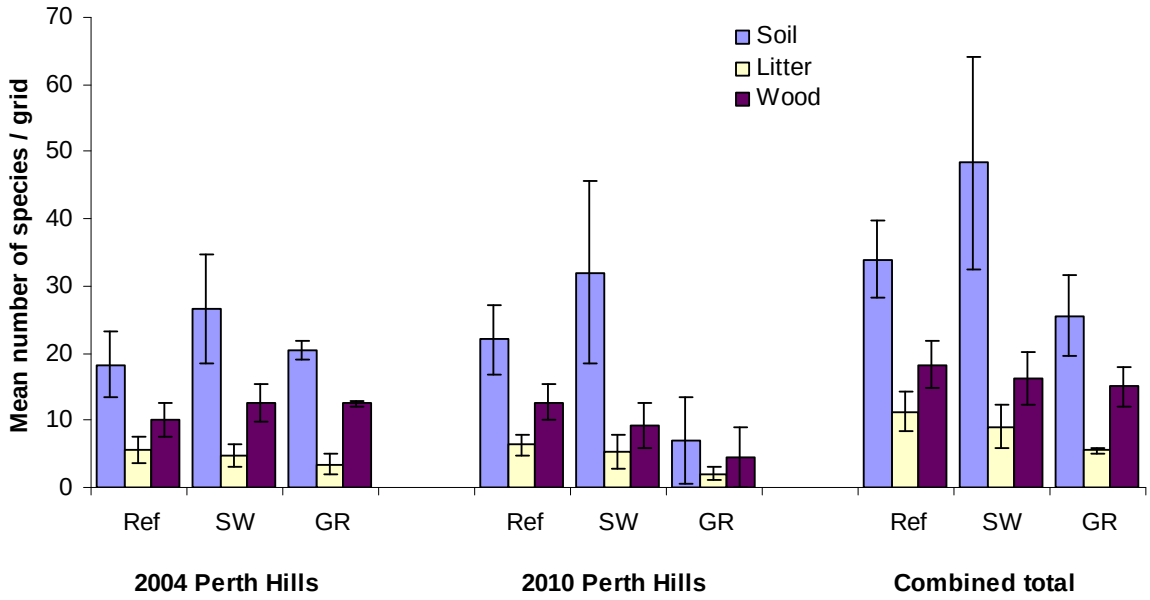

Figure 9. The mean number of species per grid (± se) recorded fruiting on soil, litter and wood on the Perth Hills FORESTCHECK grids in 2004 and 2010.

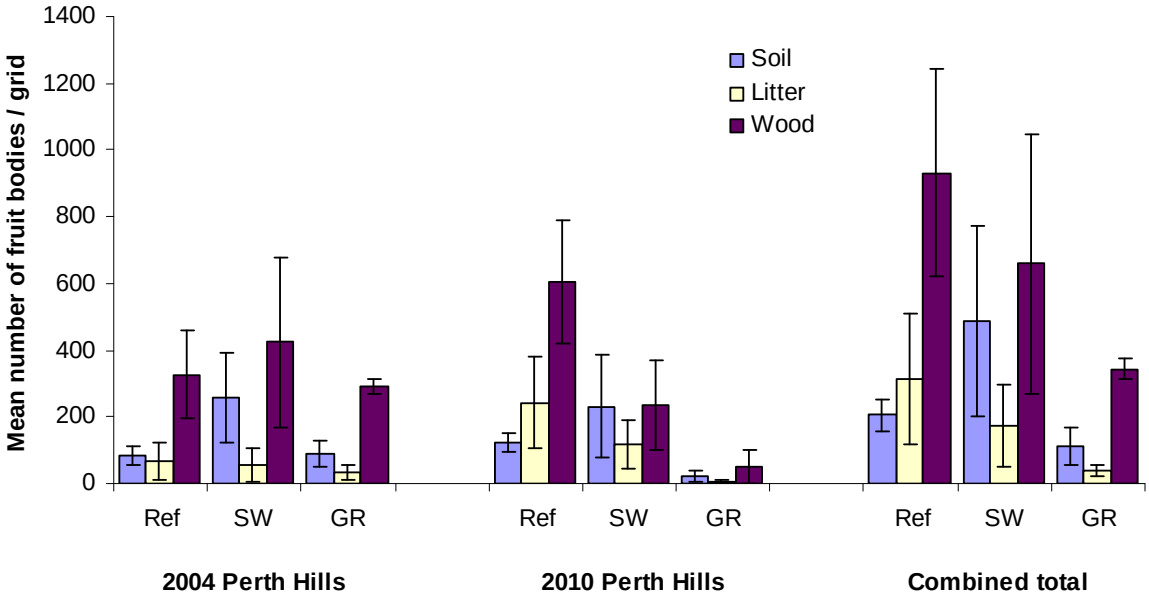

Figure 10. The mean number of fruit bodies per grid (± se) recorded fruiting on soil, litter and wood on the Perth Hills FORESTCHECK grids in 2004 and 2010.

The species responsible for the increased abundance on litter and wood in the external reference treatment in 2010 included: *Aleurodiscus* sp. which was very common on dead *Banksia grandis* cones (Fig. 11), *Excidia glandulosa*, *Heterotextus peziziformis*,

Hohenbuehellia bingarra, *Melanotus hepatochrous*, *Mycena subgallericulata*, *Resupinatus cinerascens*, *Tubaria cerulata* and four species of undetermined corticioid fungi (Sp. 751, Sp. 822, Sp. 710 and Sp. 582) (Appenxix 1). These 12 species of fungi all colonise and fruit on coarse woody debris, small diameter branch wood or twigs and produced in excess of 1800 fruit bodies. Only two of these species were recorded in 2004, *H. peziziformis* (Fig. 11) and *M. subgallericulata*, and they produced 94 fruit bodies (compared to 1127 in 2010).

Figure 11. *Left*, *Aleurodiscus* sp. on *Banksia grandis* cone; *right*, *Heterotextus peziziformis* on a small twig.

Species accumulation across all locations

The total number of species of macrofungi recorded in FORESTCHECK from 2002-10 is 621. The number of species has steadily increased from 160 by an average of 65 species per year (ranging between 15 and 113). The largest increase was 113 from 2006-08, and the lowest was 15 from 2009-10 (Fig. 12). The accumulation curve is starting to plateau at about 600 species, with an average annual increase since 2008 of only 30 species per year compared to that of 80 per year for the period 2002-08. However, the past two fruiting seasons have been unusual in that the autumn rains have been late, effectively delaying 'early' fruiting species and disrupting fruit body development of others. Further analysis of the effects of climate on the diversity and abundance of fruit body production needs to be undertaken.

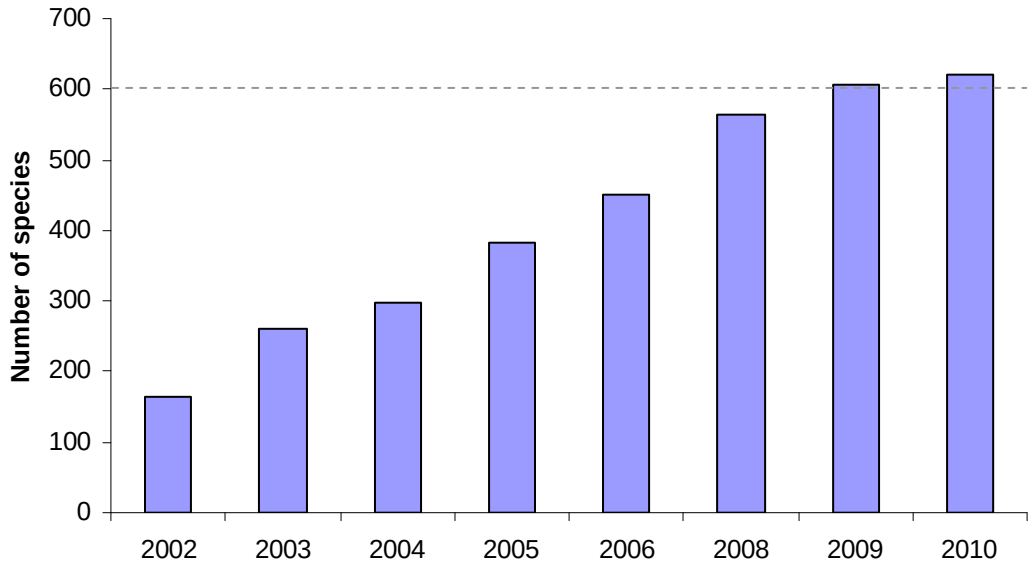

Figure 12. Species accumulation for macrofungi recorded on FORESTCHECK grids from 2002-2010.

Conclusions

The main observations made following monitoring of macrofungi in the jarrah north west ecosystem in the Perth Hills District were:

- A total of 621 species of macrofungi have so far been recorded in FORESTCHECK and species accumulation appears to be stabilising.
- The Perth Hills region appears to have the lowest macrofungal diversity of all the FORESTCHECK locations.
- 161 species were recorded at Perth Hills in 2010, 21 more than in 2004. Of these 92 were not recorded in 2004 and 15 were recorded for the first time in FORESTCHECK.
- Species assemblages were considerably different in 2010 compared to 2004.
- Overall, the external reference and shelterwood treatments had similar species richness.
- Species richness and abundance was considerably lower in the gap release compared to external reference and shelterwood treatments in 2010, and compared to the gap release in 2004. This is likely due to the combination of recent fire and low rainfall.
- Fruit body abundance was higher on wood and litter in 2010 compared to 2004.

Data Management

All data has been entered onto a Microsoft Excel worksheet. Species diversity and abundance on each grid and a frequency rating of one (rare) to eight (very common) for each species on each grid has been determined. The data includes a complete list of species recorded across all the sites, their life modes (mycorrhizal, saprotrophic, parasitic) and the substrate on which they were fruiting. Analysis is ongoing.

Acknowledgements

Thank you to Verna Tunsell for assistance with data entry, and for processing and data basing of voucher collections.

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APPENDIX 1. A list of species of macrofungi recorded at Perth Hills in 2010 and 2004.

		Treatments[2] 2010			2010	2004
Sp #	**Specie[1]s**	**ER**	**SW**	**GR**	**Total**	**Total**
0	Agaric unidentified		1		1	
831	Agaric unknown (R.M. Robinson & K. Syme FC1623)		5		5	
120	*Aleuria rhenana* Fuckel		5		5	8
126	*Aleurina ferruginea* (W. Phillips) W.Y. Zhuang & Korf					2
536	*Aleurodiscus* sp. apricot on B. grandis cone (R.M. Robinson & K. Syme FC1473)	495	110		605	
206	*Amanita ananiceps* (Berk.) Sacc.		2		2	
186	*Amanita brunneibulbosa* O.K.Mill.			1	1	8
360	*Amanita* sp. large, grey white cap, no veil (R.M. Robinson & R.H. Smith FC706)					1
218	*Amanita* sp. powdery cap and stem with long tapering base (R.M. Robinson, R.H. Smith & K. Pearce FC360)					4
784	*Amanita* sp. small brown, saccate base (R.M. Robinson, K. Syme FC1496)		1	11	12	
368	*Amanita* sp. white cap with mealy stem (R.M. Robinson & R.H. Smith FC735)					1
371	*Amanita* sp. white with saccate volva (R.M. Robinson & R.H. Smith FC741)					1
531	*Amanita* spp. (unidentified)	3	3	9	15	
196	*Amanita umbrinella* E.J.Gilbert & Cleland	4			4	1
6	*Amanita xanthocephala* (Berk.) D.A.Reid & R.N.Hilton	2	2		4	21
180	*Armillaria luteobubalina* Watling & Kile		10		10	20
770	*Arrhenia* sp. (R.M. Robinson & K. Syme WFM471)	32		1	33	
200	*Austroboletus occidentalis* Watling & N.M.Greg.		2		2	1
635	*Austrogautieria manjimupana* Trappe & E.L.Stewart		2		2	
522	*Austropaxillus* aff. *infundibuliformis* (Cleland) Bresinsky & M.Jarosch	1	2		3	
179	*Austropaxillus macnabbii* (Singer, J. García & L.D. Gómez) Jarosch	23	45		68	3
291	*Austropaxillus* sp. orange-brown (R.M. Robinson, R.H. Smith & K. Pearce FC 546)					4
356	*Austropaxillus* sp. robust with bulbous base (R.M. Robinson & R.H. Smith FC751)					3
103	*Boletellus obscurecoccineus* (Höhn.) Singer		4		4	4
29	*Boletus* sp. Boletus speciosa group - dull maroon, light stain (R.M. Robinson & R.H. Smith FC28)		1		1	1
210	*Boletus* sp. Boletus speciosa group - orange pores (R.M. Robinson, R.H. Smith & K. Pearce FC344)	1			1	
350	*Boletus* sp. pink maroon cap with yellow red stem (R.M. Robinson & R.H. Smith FC683)					2
358	*Boletus* sp. viscid brown cap with yellow marshmallow pores NC					1
99	*Boletus* sp. yellow-red with blue staining flesh (R.M. Robinson & R.H. Smith FC398)					1
304	*Byssomerulius corium* (Pers. : Fr.) Parmasto					7
9	*Calocera guepinioides* Berk.	150	140		290	730
187	*Campanella gregaria* Bougher					100
319	*Clavaria* (*Clavulinopsis*) sp. grey brown with black tips (R.M. Robinson & R.H. Smith FC758)					11
665	*Clavulicium* sp. yellow glue BFF NC	1			1	
344	*Clavulina* sp. cream, fluffy tips (R.M. Robinson & L. McGurk FC658)	15	5		20	
351	*Clavulina* sp. creamy white (R.M. Robinson & R.H. Smith FC690)					14
140	*Clavulina* sp. pink-buff coral (R.M. Robinson & R.H. Smith FC212)					2
458	*Clavulina* sp. pinkish brown, red-brown tips (R.M. Robinson & R.H. Smith FC805)	1			1	
261	*Clavulinopsis* sp. cream (R.M. Robinson FC1390)	4			4	
362	*Clavulinopsis* sp. grey brown, black tips (R.M. Robinson & R.H. Smith FC782)	4	6		10	
197	*Clitocybe semiocculta* Cleland	4			4	
370	*Clitocybe* sp. creamy beige (R.M. Robinson & R.H. Smith FC 739)					20
15	*Coltricia cinnamomea* (Jacq.) Murrill	20	4		24	40
532	*Coltriciella dependens* (Berk. & M.A.Curtis) Murrill		8		8	
832	*Coprinus* sp. parabolic scales (R.M. Robinson & K. Syme FC1622)		50		50	
823	*Cordyceps* sp. on meal worm (R.M. Robinson & K. Syme FC1569)	1			1	
373	Corticioid creamy yellow merulioid skin on jarrah stick (R.M. Robinson FC1531)					1
751	Corticioid pink black crust (R.M. Robinson & K. Syme WFM399)	6	3		9	
822	Corticioid pinkish ochre tuberculate crust (R.M. Robinson & K. Syme FC1568)	15			15	
710	Corticioid translucent blue grey (tuberculate) skin (R.M. Robinson & K. Syme BFF140)	18			18	
825	Corticioid waxy white crust (R.M. Robinson & K. Syme FC1572)		3		3	

		Treatments[2] 2010			2010	2004
Sp #	**Specie[1]s**	**ER**	**SW**	**GR**	**Total**	**Total**
582	Corticioid white parchment (R.M. Robinson & J. Fielder FC1047)	65	6	2	73	
775	Corticioid yellow ochre tuberculate crust on B. grandis cone (R.M. Robinson, K. Syme FC1474)		12		12	
158	*Cortinarius* aff. *microarcherii* Cleland	1	2		3	
115	*Cortinarius austrofibrillosa* Grgur.		12		12	3
173	*Cortinarius basirubescens* (red cap) Cleland & J.R.Harris					1
293	*Cortinarius rotundisporus* Cleland & Cheel	1	1		2	
357	*Cortinarius sinapicolor* Cleland					5
689	*Cortinarius* sp. (R.M. Robinson & K. Syme FC1247)	5	1		6	
355	*Cortinarius* sp. brown cap with lavender margin and stem (R.M. Robinson & R.H. Smith FC699)					6
154	*Cortinarius* sp. chestnut (R.M. Robinson & J. Fielder FC 1050)		21		21	28
382	*Cortinarius* sp. chestnut cap with yellow margin and yellow flesh (R.M. Robinson & R.H. Smith FC774)					1
500	*Cortinarius* sp. chestnut large (R.M. Robinson & R.H. Smith FC918)		15		15	
201	*Cortinarius* sp. cream cap with orange gills (R.M. Robinson FC327)	2		1	3	18
252	*Cortinarius* sp. glutinous cap with rooting stem (R.M. Robinson & R.H. Smith FC431)					22
374	*Cortinarius* sp. golden tan (R.M. Robinson & R.H. Smith FC748)		15		15	3
348	*Cortinarius* sp. golden tan cap with long stem (R.M. Robinson & J.E.Neal FC669)		2		2	
257	*Cortinarius* sp. honey brown (R.M. Robinson & R.H. Smith FC454)		2		2	4
369	*Cortinarius* sp. large red brown (R.M. Robinson & R.H. Smith FC738)					2
379	*Cortinarius* sp. lilac brown cap with yellow gills (R.M. Robinson & R.H. Smith FC767)					1
146	*Cortinarius* sp. Myxacium orange-brown viscid cap (R.M. Robinson & R.H. Smith FC223)					5
212	*Cortinarius* sp. orange brown (R.M. Robinson, R.H. Smith & K. Pearce FC371)	5	15		20	
778	*Cortinarius* sp. pinkish brown, pale stem (R.M. Robinson, K. Syme FC1480/1483)		1		1	
98	*Cortinarius* sp. pointy cap (R.M. Robinson & R.H. Smith FC134)	2	7		9	25
824	*Cortinarius* sp. rusty orange (R.M. Robinson & K. Syme FC1571)		12		12	
267	*Cortinarius* sp. snowy chestnut (R.M. Robinson & R.H. Smith FC478)		2		2	12
96	*Cortinarius* sp. viscid pink (R.M. Robinson & R.H. Smith FC457)					1
273	*Cortinarius* sp. white with deep rooting stem (R.M. Robinson, R.H. Smith & K. Pearce FC498)		3		3	
780	*Cortinarius* sp. yellow and lavender (R.M. Robinson, K. Syme FC1485)	1	1		2	
237	*Cortinarius* sp. yellow with orange brown fibrils (R.M. Robinson & R.H. Smith FC403)	13	10		23	11
354	*Cortinarius* sp. yellow-brown cap with lavender gills and stem (R.M. Robinson & R.H. Smith FC698)					12
184	*Cortinarius* spp. (unidentified)	6	12		18	58
7	*Cortinarius sublargus* Cleland	28	18	1	47	
171	*Cortinarius vinaceolamellatus* Cleland		4		4	
16	*Cotylidia undulata* (Fr.) P. Karst.	4			4	
118	*Crepidotus nephrodes* (Berk. & M.A.Curtis) Sacc.		1		1	12
83	*Crepidotus* sp. small creamy tan (R.M. Robinson & R.H. Smith FC99)					11
241	*Crepidotus variabilis* (Pers. : Fr.) P.Kumm.		25		25	
148	*Crucibulum laeve* (Huds. : Pers.) Kambly		20	10	30	131
307	*Cyathus* sp. (R.M. Robinson & K. Pearce FC591)	3	30		33	2
147	*Dermocybe austroveneta* (Cleland) M.M.Moser & E.Horak					2
57	*Dermocybe clelandii* (white mycelium) (A.H.Sm.) Grgur.	1	9		10	3
172	*Dermocybe clelandii* (yellow mycelium) (A.H.Sm.) Grgur.		3		3	
110	*Dermocybe kula* Grgur.	4			4	
168	*Dermocybe* sp. jarrah (R.M. Robinson & R.H. Smith FC301)	7	54		61	
310	*Dermocybe splendida* E.Horak			5	5	
123	*Discinella terrestris* (Berk. & Broome) Denni	3	10		13	28
243	Discomycete orange discs on marri nuts (R.M. Robinson & R.H. Smith FC798)					8
294	Discomycete small yellow on *Banksia grandis* leaves (R.M. Robinson, R.H. Smith & K. Pearce FC557)					5
508	*Discomycete* tiny cream disks on leaves (R.M. Robinson & F. Tovar FC1255)		10		10	
31	*Entoloma moongum* Grgur.					1
222	*Entoloma* sp. brown black with grey white gills (R.M. Robinson, R.H. Smith & K. Pearce FC374)		1		1	2
347	*Entoloma* sp. brown striate cap (R.M. Robinson & J.E.Neal FC666)		5		5	1
30	*Entoloma* sp. creamy white (R.M. Robinson & R.H. Smith FC29)					4

Sp #	Specie[1]s	Treatments[2] 2010			2010	2004
		ER	SW	GR	Total	Total
235	*Entoloma* sp. grey brown cap with grey stem (R.M. Robinson & R.H. Smith FC399)					8
135	*Entoloma* sp. tall, grey-brown (R.M. Robinson & R.H. Smith FC207)					5
159	*Exidia glandulosus* (Bull. : Fr.) Fr.	123			123	
41	*Fistulina spiculifera* (Cooke) D.A.Reid	1	2		3	6
19	*Fomitopsis lilacinogilva* (Berk.) J.E.Wright & J.R.Deschamps	1			1	7
136	*Fuscoporia gilva* (Schwein.) T.Wagner & M.Fisch.	4			4	16
11	*Galerina* sp. hanging gills and conic (R.M. Robinson & R.H. Smith FC11)	4	27	1	32	102
58	*Galerina* sp. small cap, eccentric stipe - on wood (R.M. Robinson & R.H. Smith FC63)	14	75		89	258
8	*Gymnopilus allantopus* (Berk.) Pegler	77	35		112	425
85	*Gymnopilus* sp. slender (R.M. Robinson & R.H. Smith FC110)	62	58		120	467
56	*Heterotexus peziziformis* (Berk.) Lloyd	734	113	55	902	72
422	*Hohenbuehelia bingarra* Grgur.	151			151	
87	*Hydnellum* sp. red brown (R.M. Robinson & R.H. Smith FC113)		22		22	5
297	*Hydnum repandum* L. : Fr.		4		4	
380	*Hydnum* sp. chestnut (R.M. Robinson & J. Fielder FC1158)	20			20	1
381	*Hygrocybe cantharellus* (Schwein. : Fr.) Murrill					2
122	*Hygrocybe* sp. yellow-orange (R.M. Robinson & R.H. Smith FC858)		1		1	
691	*Hyphodontia barba-jovis* (Bull.) J. Erikss.		3		3	
100	*Hypholoma australe* O.K.Mill.	1	92		93	87
595	*Hypholoma fasiculare* (Fr. : FR.) Kummer		7		7	
130	*Hypomyces* cf. *aurantius* (Pers.) Fuckel (*Cladobotryum varium*)					4
108	*Hypomyces chrysospermus* Tul. & C. Tul.	2	1		3	1
1	*Inocybe australiensis* Cleland & Cheel	10	5		15	195
378	*Inocybe* sp. chocolate umbonate (R.M. Robinson & R.H. Smith FC764)					3
48	*Inocybe* sp. grey (R.M. Robinson & R.H. Smith FC52)					1
484	*Inocybe* sp. large umbonate firillosecap with yellow-tan gills (R.M. Robinson, R.H. Smith & K. Syme FC880)	2	1		3	
113	*Inocybe* sp. radially fibrillose with pink stem (R.M. Robinson & R.H. Smith FC162)	1			1	1
20	*Inocybe* sp. scaly cap (R.M. Robinson, R.H. Smith & K. Pearce FC334)					2
53	*Inocybe* sp. tan skirt (R.M. Robinson & R.H. Smith FC60)					64
286	*Inocybe* sp. umbonate, shaggy (R.M. Robinson & K. Pearce FC576)					17
74	*Laccaria* aff. *masoniae* G.Stev.	8	12		20	52
36	*Laccaria lateritia* Malençon					6
765	*Laccaria* sp. burnt orange (R.M. Robinson & K. Syme WFM460)		2		2	
383	*Laccocephalum tumulosum* (Cooke) Núñez & Ryvarden			1	1	
221	*Lactarius clarkeae* Cleland	1			1	
142	*Lactarius eucalypti* O.K.Mill. & R.N.Hilton	6			6	2
245	*Lactarius* sp. creamy yellow (R.M. Robinson & R.H. Smith FC417)	12	43	3	58	
185	*Lepiota* aff. *cristata* (Alb. & Schwein. : Fr.) P.Kumm.		1		1	
246	*Lepiota* sp. purple grey (R.M. Robinson & R.H. Smith FC419)					1
166	*Lepiota subcristata* Cleland	1	7		8	
214	*Leucopaxillus lilacinus* Bougher		2		2	
127	*Lichenomphalia umbellifera* (L.) Redhead, Lutzoni, Moncalvo & Vilgalys					37
24	*Lycoperdon* sp. (R.M. Robinson & R.H. Smith FC22)					5
55	*Marasmius crinisequi* F.Muell.					28
443	*Marasmius* sp. small tan (R.M. Robinson FF770)*	1			1	
341	*Marasmius* sp. tny red on twigs (R.M. Robinson & K. Syme WFM 495)					12
61	*Melanotus hepatochrous* (Berk.) Singer	50			50	
80	*Mycena carmeliana* Grgur.		5		5	5
372	*Mycena fumosa* Grgur.					14
144	*Mycena kuurkaceae*Grgur.	13		1	14	51
50	*Mycena mijoi* Grgur.					2
308	*Mycena* sp. grey brown cap no bleach (R.M. Robinson & J. Fielder FC1038)	2			2	1
376	*Mycena* sp. small brown with decurrent gills (R.M. Robinson & R.H. Smith FC757)					6

Sp #	Specie[1]s	Treatments[2] 2010			2010	2004
		ER	SW	GR	Total	Total
326	*Mycena* sp. small buff on wood - bleach (R.M. Robinson & L. McGurk FC610)					1
352	*Mycena* sp. small creamy yellow white (R.M. Robinson & R.H. Smith FC695)					15
165	*Mycena* sp. small grey - bleach (R.M. Robinson & R.H. Smith FC394)					3
502	*Mycena* sp. striate cap with decurrent gills, on burnt ground (R.M. Robinson & R.H. Smith FC932)		1		1	
182	*Mycena* spp. (unidentified)			1	1	33
163	*Mycena subgallericulata* Cleland	101	124		225	22
51	*Mycena yirukensis* Grgur.	41	29		70	126
238	*Mycena yuulongicola* Grgur.		1		1	18
164	*Nidula niveotomentosa* (Henn.) Lloyd	12			12	
441	*Nothocastorium* sp. (R.M. Robinson & J. Fielder WFM243)		5		5	
535	*Nothojafnea thaxterii* (Cash) Gamundí		1		1	
213	*Omphalotus nidiformis* (Berk.) O.K.Mill.					5
311	*Panus fasciatus* (Berk.) Pegler			2	2	
37	*Phellinus* sp. yellow rim (R.M. Robinson, R.H. Smith & K. Pearce FC515)					6
70	*Phellodon* aff. *niger* (Fr. : Fr.) P.Karst.					18
479	*Phellodon* sp. black brown (R.M. Robinson & R.H. Smith FC844)	7	71		78	
101	*Phlebia rufa* (Pers. : Fr.) M.P.Christ.	17			17	5
160	*Pholiota highlandensis* (Peck) Quadr./*P. communis*(Cleland & Cheel) Grgur.	12	48	2	62	74
119	*Pholiota multicingulata* E.Horak	6	9	6	21	37
363	*Piptoporus australiensis* (Wakef.) G.Cunn.					1
353	*Pisolithus* sp. small stalked (R.M. Robinson & R.H. Smith FC697)					1
133	*Pluteus atromarginatus* (Konrad) Kühner			1	1	
47	*Pluteus lutescens* (Fr.) Bres. (yellow green)					2
4	*Pluteus* sp. brown velvet (R.M. Robinson & R.H. Smith FC4 (BFF150))					2
639	Polypore thick white resupinate on twigs R. M. Robinson & R. S. Whittkuhn BFF0023	2			2	
585	Polypore white floccose resupinate (R.M. Robinson & J. Fielder FC1027)	5			5	
116	Polypore white resupinate (R.M. Robinson & J. Fielder FC1197)		1		1	
361	Polypore white resupinate on twig (R.M. Robinson & R.H. Smith FC708)					1
830	Polypore yellow brown resupinate (R.M. Robinson & K. Syme FC1621)			12	12	
236	*Postia peliculosa* (Berk.) Rajchenb.	2			2	
17	*Psathyrella* sp. (R.M. Robinson & R.H. Smith FC15)		7		7	
359	*Psathyrella* sp. brown with white skirt (R.M. Robinson & R.H. Smith FC707)					7
763	*Psathyrella* sp. burnt ground (R.M. Robinson & K. Syme WFM455)		2		2	
177	*Psilocybe coprophila* (Bull. : Fr.) P.Kumm.	4			4	39
349	*Psilocybe musci* Cleland & Cheel					9
129	*Pulvinula tetraspora* (Hansf.) Rifai	33			33	
176	*Pycnoporus coccineus* (Fr.) Bondartsev & Singer	8		10	18	10
52	*Ramaria capitata* (Lloyd) Corner	2	1	2	5	4
247	*Ramaria citrinocuspidata* A.M. Young & N.A. Fechner		3		3	3
377	*Ramaria lorithamnus* (Berk.) R.H.Petersen	5	13		18	14
102	*Ramaria ochroceosalmonicolor* (Cleland) Corner	9	13		22	70
242	*Ramaria* sp. cream (R.M. Robinson & R.H. Smith FC414)					2
833	*Ramaria* sp. orange pink (R.M. Robinson & K. Syme FC1624)		4		4	
86	*Ramaria* sp. orange-red with yellow stem (R.M. Robinson & R.H. Smith FC112)	1	1		2	2
490	*Ramaria* sp. tan, in *Allocasuarina* litter (R.M. Robinson, R.H. Smith & K. Syme FC896)		46		46	
767	*Ramaria* sp. yellow flat (burnt ground) (R.M. Robinson & K. Syme WFM464)		1		1	
79	*Resupinatus cinerascens* (Cleland) Grgur.	57			57	
69	*Russula adusta* (Pers. : Fr.) Fr.		2		2	
89	*Russula clelandii* complex O.K.Mill. & R.N.Hilton	1	2		3	5
90	*Russula kalimna* Grgur.		1		1	1
92	*Russula neerimea* Grgur.		2		2	
178	*Russula persanguinea* Cleland	2			2	
559	*Russula* sp. peaches and cream (R.M. Robinson & K. Syme WFM186)	1			1	

Sp #	Specie[1]s	Treatments[2] 2010			2010	2004
		ER	SW	GR	Total	Total
10	*Russula* sp. white white white (R.M. Robinson & R.H. Smith FC8)		6		6	1
263	*Sarcodon* sp. brown (R.M. Robinson, R.H. Smith & K. Syme FC791)		4		4	
94	*Steccherinum* sp. tiered white shelves (R.M. Robinson & R.H. Smith FC128)					1
62	*Stereum hirsutum* (Willd. : Fr.) Pers.	61	26	2	89	349
149	*Stereum illudens* Berk. - brown hymenium	66	4	10	80	10
67	*Stropharia semiglobata* (Batsch : Fr.) Quél.	1			1	3
537	*Tephrocybe* sp. (R.M. Robinson & K. Syme WFM158)		8	2	10	
669	*Trametes velutina* (Pers. : Fr.) G.Cunn.		1		1	
63	*Trametes versicolor* (L. : Fr.) Lloyd	140			140	112
287	*Tremella globispora* D.A.Reid			5	5	6
685	*Tremella globispora* D.A.Reid	4			4	
60	*Tremella mesenterica* Retz. : Fr.					1
109	*Trichaptum byssogenum* (Jungh.) Ryvarden					3
54	*Tricholoma eucalypticum* A.Pearson	33	24	1	58	30
736	*Tricholoma* sp. creamy tan (K. Syme & J. Fielder FC1422)	8			8	
375	*Tricholoma* sp. orange cap with orange ring on stem (R.M. Robinson & R.H. Smith FC 753)					1
560	*Tricholoma* sp. tan gills, ring (R.M. Robinson & K. Syme WFM220)		14		14	
161	*Tricholoma virgatum* (Fr.) Gillet					3
829	Truffle (R.M. Robinson & K. Syme FC1625)		1		1	
111	*Tubaria serrulata* (Cleland) Bougher & Matheny	22	2		24	
2	*Xerula mundroola* (Grgur.) R.H.Petersen	1	1		2	
175	*Xylaria hypoxylon* (L.) Grev.					10
	Total species	**92**	**113**	**27**	**161**	**140**
	Total fruit bodies	**2916**	**1753**	**158**	**4827**	**4477**

[1] Undetermined species with informal names are accompanied by collector's names and a voucher collection which has been lodged at the Western Australian Herbarium. **Bold** species numbers indicate new FORESTCHECK species.
[2] ER = external reference treatment, SW = shelterwood treatment, GP = gap release treatment.

CRYPTOGAMS

Ray Cranfield, Richard Robinson and Verna Tunsell

Introduction

Lichen, moss and liverwort 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 bare 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 species richness and abundance in each FORESTCHECK grid and treatment
- Record species habitat and substrate preference, and
- Monitor the effect of disturbance on cryptogam communities
- To record the presence of 35 monitoring (or indicator) species
- To determine successional trends in communities and life-forms

Additional information is collected to:

- Monitor the availability and usage of suitable substrates and strata levels
- Determine the relationship of cryptogam presence with litter cover

Monitoring

Eight FORESTCHECK grids, including three external reference grids (FC21, FC24, FC27), three shelterwood (FC20, FC23, FC26) and two gap release treatments (FC22 and FC25) were established in the jarrah north west forest ecosystem in the Perth Hills District in 2003 and were initially surveyed for cryptogams in spring 2003. In spring 2009 they were monitored for the second time from 8-27 August.

Survey methods were as per the 2007-08 FORESTCHECK report, following modification in 2007. Briefly, the presence of 35 selected monitoring species, the total number of cryptogam species and life-forms present and the presence and use of substrates and strata are assessed in 20 1x1 m plots along a 200 m transect. Litter coverage impact assessment was also scored as either none, scarce (0-25% coverage), moderate (26-75% coverage) or dense (>75% coverage) in each 1x1m plot. The presence of all cryptogam species is also recorded in each 50 m section of a separate 200m transect; which extends around the perimeter of the central 1 ha area of each monitoring grid (see grid layout on p. 5). An illustrated monitoring species booklet for the area was used to facilitate the recognition of species encountered.

Voucher Specimen Processing

Vouchers were extensively collected in 2003. In 2009, specimen vouchering was restricted to a small number of samples that represented material needed to verify identifications and to voucher new species records. All specimens collected in 2009 have been identified or given informal names for ease of re-determination. Advances in identification, and re-examination of previously collected specimens has resulted in name changes previously used for a number of species. Recently name changes have been updated on the FORESTCHECK and Western

Australian Herbarium (PERTH) databases. All new collections have been prepared for database entry and label generation prior to submitting these vouchers to PERTH.

Preliminary Results and Discussion

Surveys were conducted in spring from 8-26 September. Both the 2003 and 2009 Perth Hills surveys were conducted in the spring; in 2003 it was done in August. Generally cryptogams grow in wetter months but their persistent nature allows their continued presence over extended periods throughout the year, independent of rain. Although fragile when desiccated, and easily damaged, they are still readily recognised. However when making comparisons between the 2003 and 2009 survey, it needs to be noted that methods were reviewed and modified in 2007 (see 2008-09 FORESTCHECK report).

Preliminary results for 2009 suggest that a further four species need to be included in the Perth Hills field guide as they appear to be more widespread than previously thought. They are mostly undescribed or recently described species but are reasonably well known and recognised. Taxonomic work to confirm their status is underway in collaboration with external colleagues.

Transect surveys

Species richness

A total of 55 species of cryptogams were recorded from transects; 44 lichens, nine mosses and two liverworts. Lichens were the most common group on all grids, but few were recorded on the Occidental external reference grid (FC27). The number of mosses was similar on all grids except for the Occidental external reference (FC27) and the Cameron shelterwood (FC23) where fewer species were recorded. Liverworts were consistently low in numbers or absent from some grids (Fig. 1). There was no difference in the mean species richness per grid of moss or liverwort species between treatments (Fig. 2) but lichen richness was lower on the gap release grids, and very variable on the external reference grids (Fig. 1 & 3).

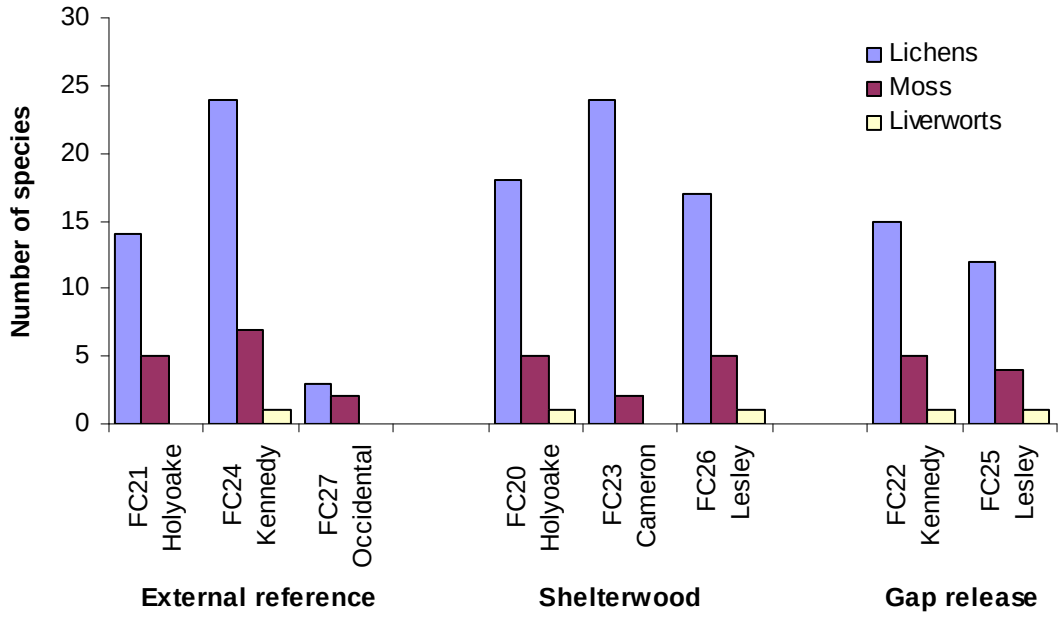

Figure 1. The total number of lichens, moss and liverwort species recorded from transects on each grid in each FORESTCHECK treatment in Perth Hills in 2009.

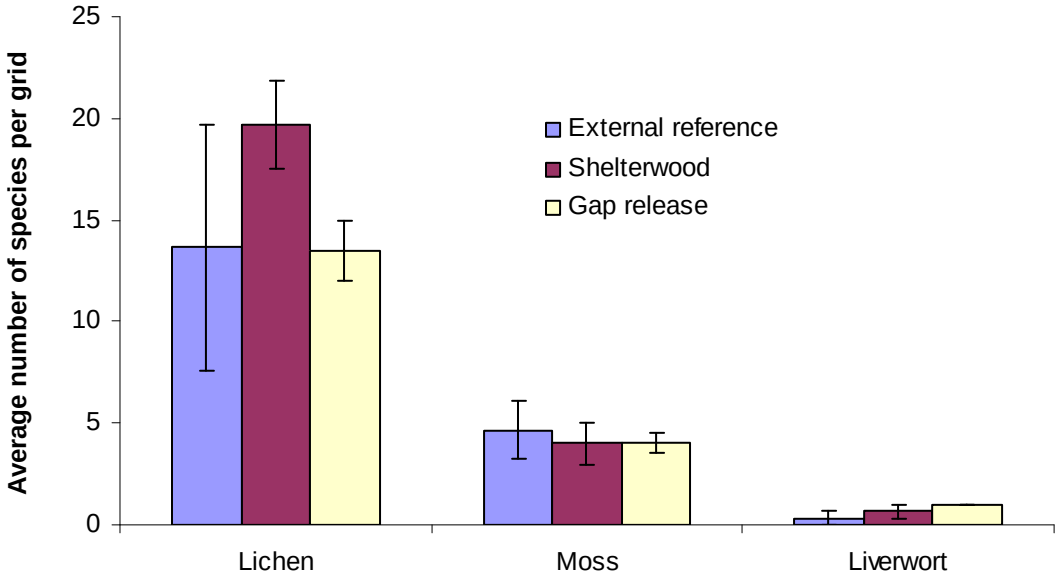

Figure 2. The mean number of lichen, moss and liverwort species per grid recorded from transects in each treatment in Perth Hills FORESTCHECK grids in 2009.

In 2009 the number of lichens was just over half (57%) of that recorded 2003 (Fig. 3). The trend was consistent between treatments for the two survey years and is likely related to the revised survey methods. In 2009, only two liverworts were recorded, *Cephaloziella exiliflora* recorded in all treatments (one external reference, two shelterwood and two gap release grids) and *Fossombronia intestinalis* in the Lesley gap release (FC25). In 2003, four liverworts were recorded, *C. exiliflora* in five grids, three external reference and two shelterwood gridss, *Fossombronia altilamellosa* in the Holyoake external reference grid (FC21), *Frullania probisciphora* in the Holyoake shelterwood (FC20) and *Austrofossombronia australis* in the Kennedy gap release (FC22). In both sample years, *C. exiliflora* was the only species consistently recorded in more than one grid. The number of moss species recorded was similar in 2003 and 2009 (Fig. 3).

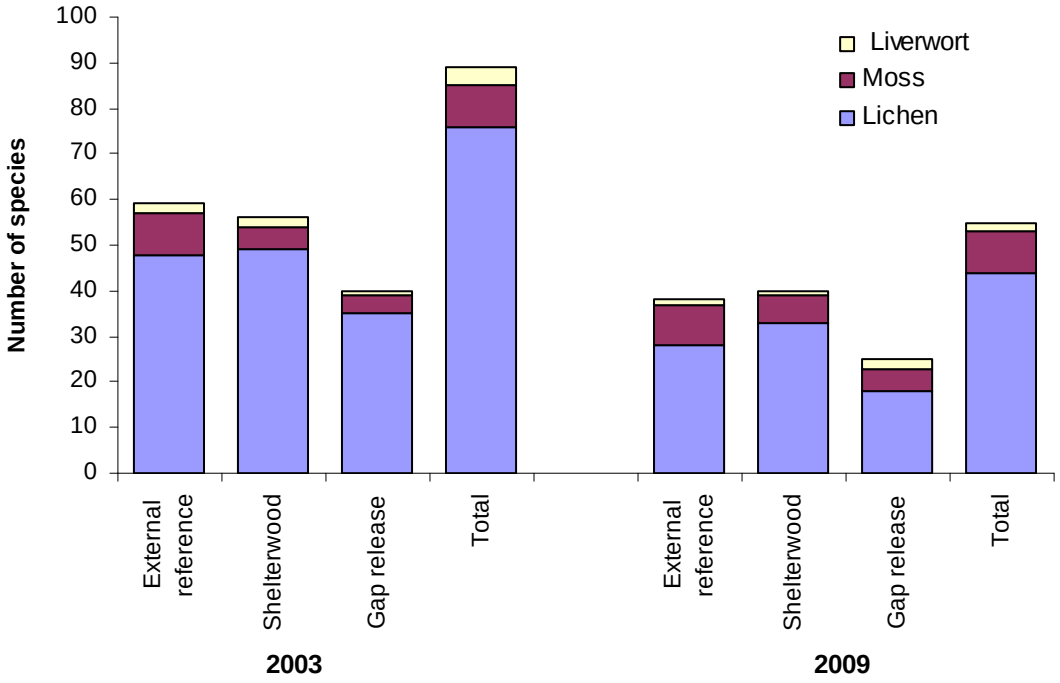

Figure 3. The total number of lichen, moss and liverwort species per grid recorded from transects in each treatment in Perth Hills FORESTCHECK grids in 2003 and 2009.

Plot surveys

Plot surveys were only introduced in 2007 and were therefore not conducted in 2003 at Perth Hills. The following results are from 2009 only.

Substrate availability and usage

Most substrates needed for the establishment and maintenance of cryptogams were available on the majority of grids; but not all substrates were consistently colonised (Fig. 4). Time since treatment has an influence on the condition of substrates and their consequent colonisation by cryptogams. On the external reference grids, soil and stone were the most frequently colonised habitats. On shelterwood grids stone, wood and charcoal was well utilised and on gap release grids charcoal and soil were the most utilised substrates. Other organic material was well utilised on the Kennedy gap release (FC22) but totally un-colonised on the Lesley gap release (FC25).

Strata layers and cryptogam colonisation

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 (0-30 cm) was the most utilised strata in every plot (Fig. 5). The shrub layer (31 cm-3 m) in the reference grids had lower rates of colonisation than both the shelterwood and gap release grids. The epiphytic tree layer (over 3 m) 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. Only three species of lichens known to colonise tree crowns were recorded; *Usnea inermus*, *Ochrolechia subpallens* and *Tephromela alectoronica*.

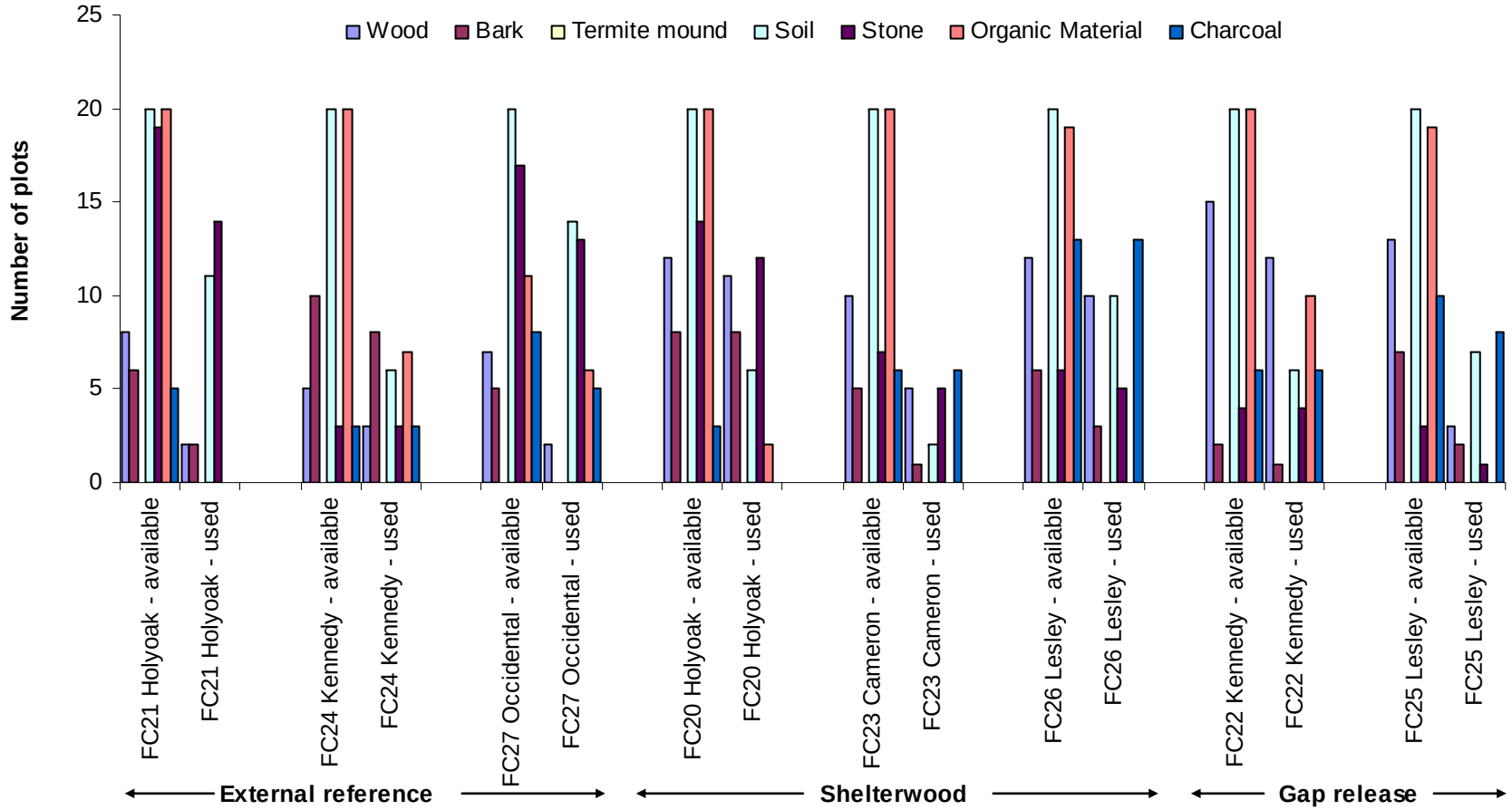

Figure 4. The number of plots with substrates available for colonization and their utilization by cryptogams on each Perth Hills FORESTCHECK grid in 2009.

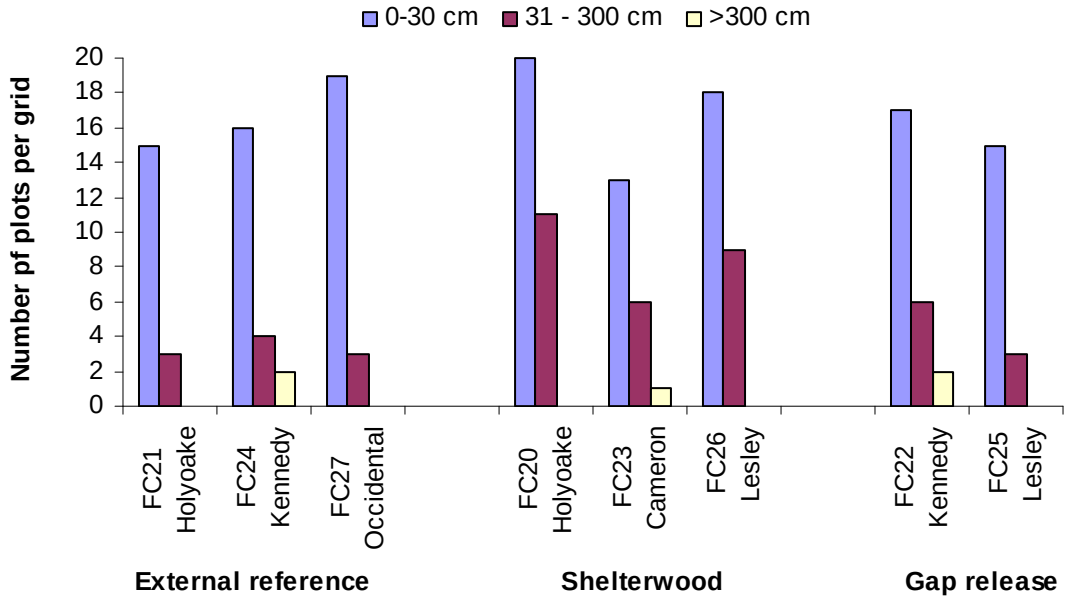

Figure 5. The number of 1x1 m plots with different strata levels occupied by cryptogams on each Perth Hills FORESTCHECK grid in 2009 (NB. 20 plots per grid).

Life forms and population structure

To simplify their identification, cryptogams can be artificially grouped according to their morphology. Lichens are foliose, crustose or fruticose; mosses are creeping or tufted and liverworts are thallose or leafy. These groups are referred to as life forms, and species in each of these groups generally have similar life strategies. Crustose and fruticose lichens and tufted mosses were the most common, being recorded in the highest number of plots on each grid (Fig. 6 & 7). Creeping mosses were only recorded in three plots on one grid, in the external reference FC24 Lesley. Thallose liverworts were absent in all treatments but the leafy liverwort *C. exiliflora* was recorded in Kennedy external reference (FC24) and gap release (FC22) grids (Fig. 8) (NB. It was recorded in all treatments in transect surveys – see Appendix 1).

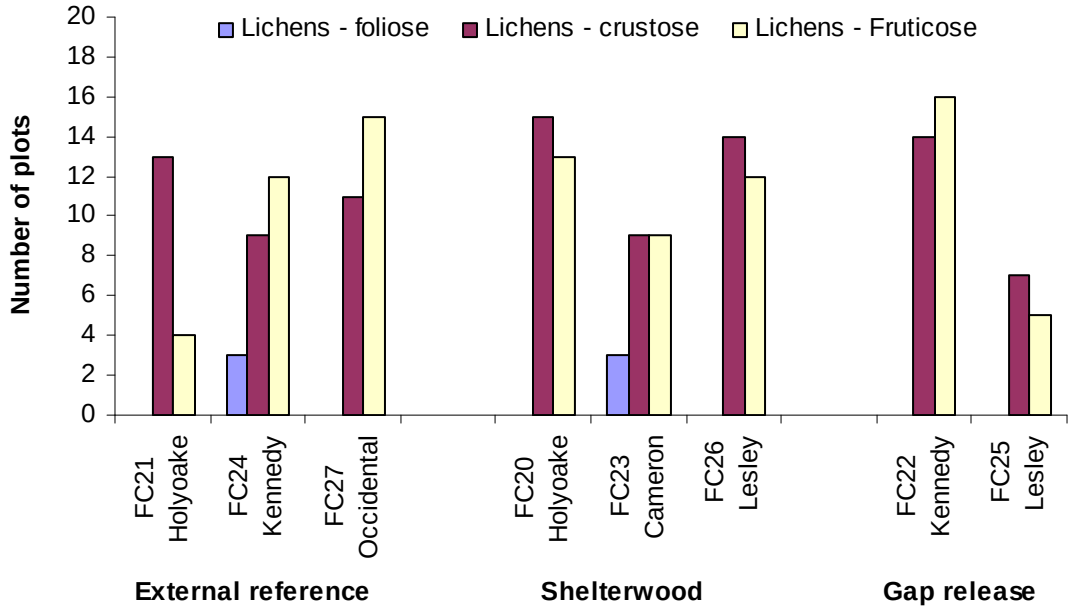

Figure 6. The number of 1x1 m plots in which each lichen life form was recorded on each Perth Hills FORESTCHECK grid in 2009 (NB. 20 plots per grid).

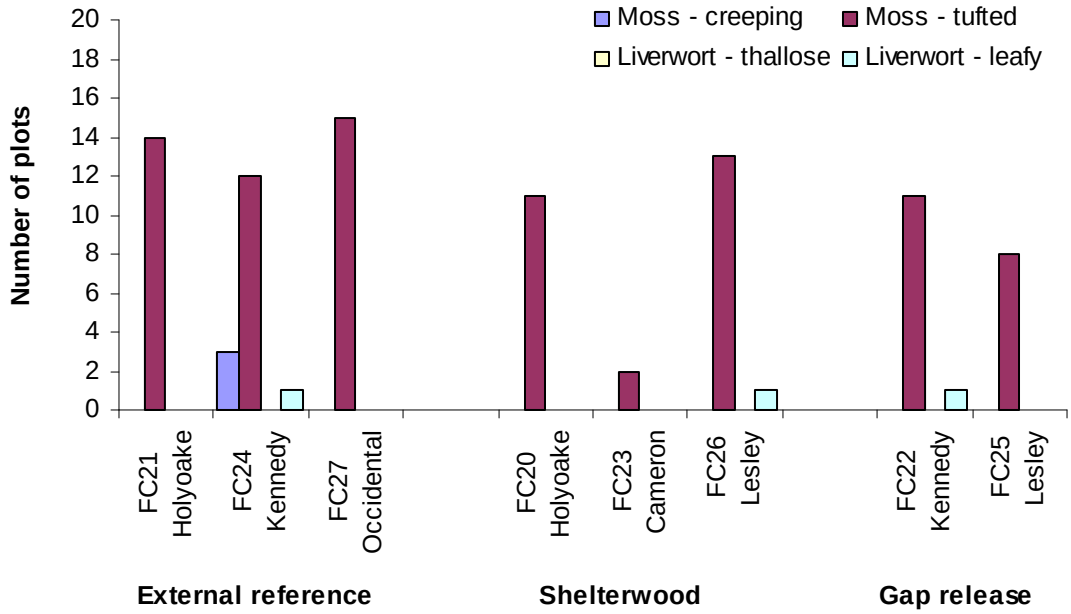

Figure 7. The number of 1x1 m plots in which each moss and liverwort life form was recorded on each Perth Hills FORESTCHECK grid in 2009 (NB. 20 plots per grid).

Litter cover on individual 1x1 m plots

In previous years we observed that litter cover appeared 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 cryptogams can withstand short periods of being covered without being totally excluded. Since 2007, a visual estimate of litter cover has been determined for each 1 x 1 m plot on each grid (Fig. 8). Overall, the majority of plots had a dense (< 75% cover) to moderate (26-75% cover) cover of litter, especially evident on the shelterwood

treatment grids. Litter cover on the external reference grids was variable with only spares to moderate coverage on the Holyoake grid (FC21); which was about 75% burnt in spring 2005. Moss, liverwort species and ground dwelling lichens were less frequent on plots with dense litter cover.

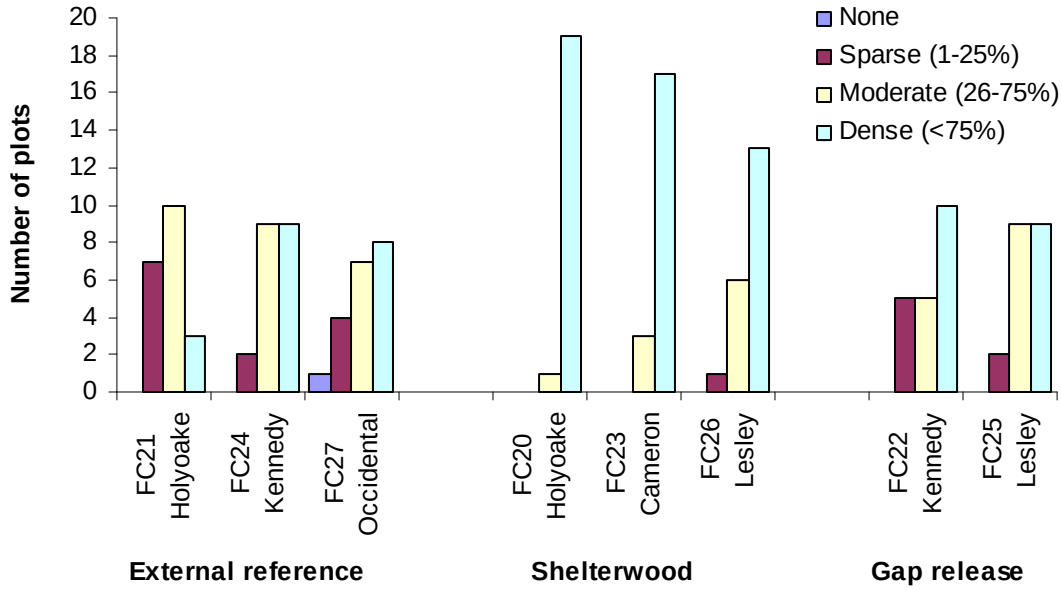

Figure 8. The number of 1x1 m plots with sparse, moderate and dense litter cover on each Perth Hills FORESTCHECK grid in 2009 (NB. 20 plots per grid).

Monitoring potential indicator species recorded in plot and on transect surveys

Thirty five taxa have been selected to monitor as potential indicator species (Table 1). 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. Their presence is recorded on each 1x1 m plot and in each 50 m section of the 200 m transect on each FORESTCHECK monitoring grid. Results from each method will be compared to test the most efficient method of monitoring them.

The lichens *Cladia aggregata*, *Cladia schizopora*, *Cladonia rigida*, *Cladonia sulcata* and *Thysanothecium scutellatatum* were recorded in all treatments using both plot and transect surveys. *Thysanothecium hookerii*, a common termite mound specialist, was not recorded in plots or on transects. Although no termite mounds occurred within the plots (see Fig. 4), they were observed on transects of some grids. *Diploschistes strictus* was recorded frequently in all treatments from plots but was the only lichen recorded that was not detected using transects. *Menegazzia platytrema*, *Paraporpidia glauca* and *Xanthoparmelia notata* were recorded on transects but not in plots.

All species of selected mosses were recorded in both plot and transect surveys. *Campylopus introflexus* and *Funaria hygrometrica* were the only mosses recorded by both survey methods in all treatments (Table 1). Liverworts are more common in the wetter southern regions of the jarrah forest and were rarely recorded in the Perth Hills. Two species were recorded; *C. exiliflora* was recorded in both plot and transect surveys (more frequent on transects) and *Fossembronia intestinalis* was recorded only once on transects; in the Kennedy gap release (FC22) (Table 1).

Table 1. The frequency of potential indicator species in plots and on transects for each treatment in the Perth Hills FORESTCHECK grids in 2009

Monitoring number	Species name	Group[1]	Life form	Number of 1x1 m plots in which the species were recorded[2]			Number of 50 m sections of transect in which the species was recorded[3]		
				External reference	Shelter-wood	Gap release	External reference	Shelter-wood	Gap release
	Lichen								
1	*Cladia aggregata*	L	Fruticose	6	4	9	6	4	5
2	*Cladia schizopora*	L	Fruticose	7	10	2	10	12	4
3	*Cladonia cervicornis* var. *verticellata*	L	Fruticose						
4	*Cladonia krempelhuberi*	L	Fruticose	2	1	1	5		1
5	*Cladonia rigida*	L	Fruticose	2	14	2	2	6	5
6	*Cladonia sulcata*	L	Fruticose	1	1	3	2	4	5
7	*Calicium glaucellum*	L	Crustose	1	1		2		
8	*Diploschistes strictus*	L	Crustose	25	17	6			
9	*Favoparmelia haysonii*	L	Foliose						
10	*Hypocenomyce foveata*	L	Crustose	2			3	1	
11	*Hypocenomyce scalaris*	L	Crustose	1	2		5	6	
12	*Hypogymnia subphysodes* var. *subphysodes*	L	Foliose	3			3	4	
13	*Menegazia platytrema*	L	Foliose					1	1
14	*Opegrapha* sp.	L	Crustose		1			1	
15	*Ochrolechia* sp. (G. Kantavilis 306/92)	L	Crustose	1	2		1	4	1
16	*Pannoparmelia wilsonii*	L	Foliose		3		1	4	
17	*Paraporpidia glauca*	L	Crustose						3
18	*Parmotrema reticulatum*	L	Foliose						
19	*Ramboldia stuartii*	L	Crustose	2	1	2	4	1	3
20	*Tephromela alectoronica*	L	Crustose	1				2	
21	*Thysanothecium hookeri*	L	Fruticose						
22	*Thysanothecium scutellatum*	L	Fruticose	5	20	18	5	12	8
23	*Usnea inermis*	L	Fruticose	9	4	2	8	8	4
24	*Usnea* sp. (leuco)	L	Fruticose		1		1		
25	*Xanthoparmelia isidiigera*	L	Foliose						

Table 1. Continued.....

Monitoring number	Species name	Group[1]	Life form	Number of 1x1 m plots in which the species were recorded[2]			Number of 50 m sections of transect in which the species was recorded[3]		
				External reference	Shelter-wood	Gap release	External reference	Shelter-wood	Gap release
26	*Xanthoparmelia notata*	L	Foliose					2	
	Liverwort								
27	*Cephaloziella exiliflora*	H	Leafy	1		1	3	5	2
28	*Chiloscyphus semiteres*	H	Leafy						
29	*Fossombronia intestinalis*	H	Thallose						1
30	*Frullania prohosciphora*	H	Leafy						
	Moss								
31	*Barbula calycina*	B	Tufted	13	5		8	3	2
32	*Campylopus introflexus*	B	Tufted	10	16	8	7	7	7
33	*Dicranoloma diaphanoneum*	B	Tufted						
34	*Funaria hygrometrica*	B	Tufted	19	12	8	11	8	7
35	*Sematophyllum subhumile* var. *contiguum*	B	Creeping	1			4	4	
	Total number of species (23 & 26)[4]			**20**	**18**	**12**	**20**	**21**	**16**
	Total lichen			15	15	9	15	16	11
	Total moss			4	3	2	4	4	3
	Total liverwort			1		1	1	1	2

[1]L = lichen, B = bryophyte (moss) and H = heptophyte (liverwort)
[2] Max score = 60 for the external reference and shelterwood (20 plots x three grids each) and 40 for the gap release (20 plots x two grids)
[3] Max score = 12 for external reference and shelterwood (4 x 50 m sections x three grids each) and eight for the gap release (4 x 50 m sections x two grids)
[4] There were a total of 23 species of cryptogams recorded in plots and 26 on transects

To test the reliability of monitoring a list of indicator species to pick up trends or differences between treatments, the proportion of lichen, moss and liverwort species in each treatment, firstly for all cryptogams and then for only the monitoring species, was determined and compared (Fig. 9). The proportions were very similar, and there was no significant difference in the mean species richness between treatments for either all species (ANOVA $p = 0.6$) or monitoring species (ANOVA $p = 0.8$) (Fig. 10) showing that it is possible to determine trends in species richness between treatments using selected monitoring species.

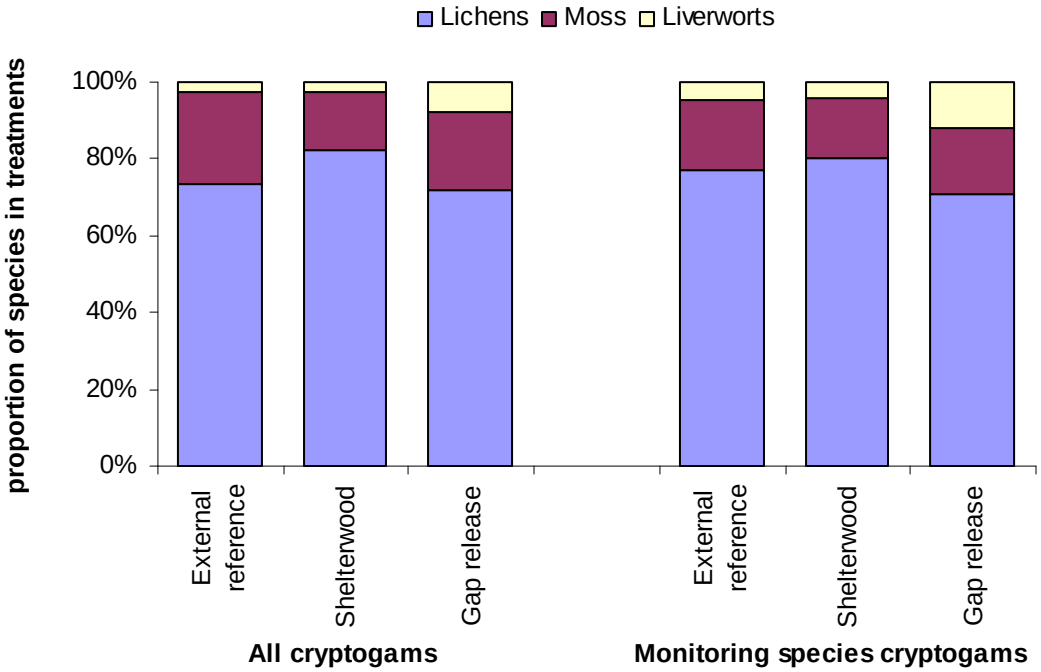

Figure 9. The proportion of lichen, moss and liverwort species in each treatment when considering all cryptogams (left) and only the selected list of potential indicator species (right) recorded in the Perth Hills FORESTCHECK grids in 2009.

Because the jarrah forest covers a large region encompassing a variety of ecosystem types (as represented by the five established FORESTCHECK locations; Donnelly, Wellington, Perth Hills, Wellington east and Blackwood plateau) several monitoring species do not occur in all locations (Table 1). The suitability of monitoring the existing list of potential indicator species will be tested further as the other FORESTCHECK locations are monitored over the coming years.

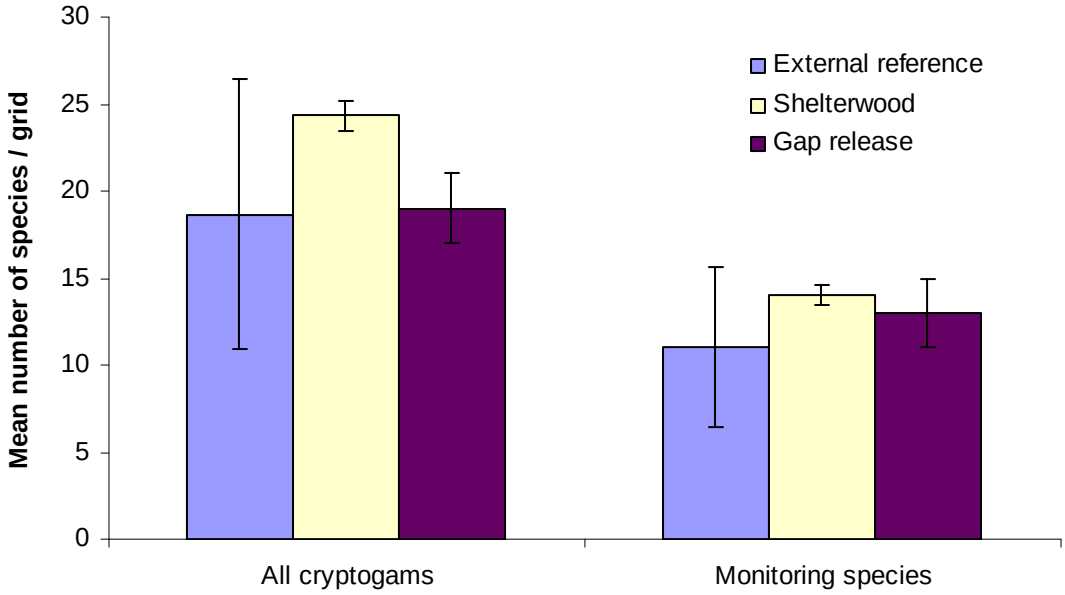

Figure 10. The mean species richness per grid for all cryptogams (left) and only the selected monitoring species (right) recorded in the Perth Hills FORESTCHECK grid in 2009.

Conclusions

The revised survey techniques failed to record many species of lichens that were recorded in the Perth Hills grids in 2003. The same problem was encountered in the previous two years. Over the next 12 months additional monitoring will be conducted on the Donnelly, Wellington and Perth Hills grids that will include an additional 200 m of transect. In 2010, the Wellington East grids will be monitored using 400 m of transects to determine species richness. All results will then be analysed to determine if the additional 200 m of transect is adequate.

Some trends observed in 2009 were:

- Lichen numbers were variable within the external reference treatment, and very low in the Occidental external reference grid (FC27)
- The number of lichens was lower in the gap release treatment
- The number of lichens recorded in 2009 was markedly lower (43% less) than in 2003, but the relative proportions recorded in each treatment was similar to 2003.
- More monitoring species were recorded on transects than in plots.

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.

Acknowledgements

Thank you to Bruce Ward for assistance with surveys.

Appendix 1. All cryptogam species recorded from transects at the Perth Hills FORESTCHECK grids in 2009 (numbers in treatment columns indicate the number of 50 m sections (max. = 12 in external reference and shelterwood and eight in gap release treatments) that each species was recorded in.

Species number	Monitor species number	Species	Group[1]	Treatment[2]			Total
				ER	SW	GR	
145		*Buellia* sp. (R.J. Cranfield 19106)	L		1	1	2
5	7	*Calicium glaucellum*	L	2			2
214		*Calicium victorianum* subsp. *desidiosum*	L	1	3		4
150		*Candelariella xanthostigmoides*	L	2			2
16	1	*Cladia aggregata*	L	6	4	5	15
17	2	*Cladia schizopora*	L	10	12	4	26
26	4	*Cladonia krempelhuberi*	L	5		1	6
30	5	*Cladonia rigida*	L	2	6	5	13
34		*Cladonia* sp. pipes (R.J. Cranfield 17710)	L	1			1
37	6	*Cladonia sulcata*	L	2	4	5	11
157		*Cladonia sulcata* var. *sulcata*	L		1		1
38		*Cladonia tessellata*	L	4			4
220		*Diploschistes scruposus*	L	12	12	4	28
229		*Genus* sp. grey crust (R.J. Cranfield 20361)	L	1			1
344		*Genus* sp. grey green slick	L	4	11	8	23
345		*Genus* sp. mustard	L		7		7
92		*Graphis* sp. tram lines (R.J. Cranfield 18165)	L		1		1
354		*Hafellia tetrapla*	L		1		1
351		*Heterodea muelleri*	L		1	1	2
96		*Hypocenomyce australis*	L		2		2
61	10	*Hypocenomyce foveata*	L	3	1		4
78	11	*Hypocenomyce scalaris*	L	5	6		11
103	12	*Hypogymnia subphysodes* var. *subphysodes*	L	3	4		7
346		*Lecidea* sp.	L	1	4		5
333		*Megularia grossa*	L	1			1
107	13	*Menegazzia platytrema*	L		1	1	2
115	15	*Ochrolechia* sp. (G.S. Kantvilis 306/92)	L	1	4	1	6
111		*Ochrolechia subrhodotropa*	L	1			1
93	14	*Opegrapha* sp. blackrays (R.J. Cranfield 17893)	L		1		1
118	16	*Pannoparmelia wilsonii*	L	1	4		5
119	17	*Paraporpidia glauca*	L			3	3
241		*Parmelina conlabrosa*	L		4		4
198		*Pyrenopsis* sp. (R.J. Cranfield 18998)	L	3			3
290		*Ramboldia laeta*	L		1	1	2
52	19	*Ramboldia stuartii*	L	4	1	3	8
127		*Rhizocarpon* sp. grey (R.J. Cranfield 17914)	L		3	3	6
79	20	*Tephromela alectoronica*	L		2		2
132	22	*Thysanothecium scutellatum*	L	5	12	8	25
352		*Thysanothecium* sp. brain-like	L	1	1		2
178		*Trapelia coarctata*	L	1	1	3	5

Species number	Monitor species number	Species	Group[1]	Treatment[2]			Total
				ER	SW	GR	
136	23	*Usnea inermis*	L	8	8	4	20
208	24	*Usnea* sp. leuco (R.J. Cranfield 20195)	L	1			1
355	26	*Xanthoparmelia notata*	L		2		2
247		*Xanthoparmelia* sp. (R.J. Cranfield 20150)	L		1		1
2	31	*Barbula calycina*	B	8	3	2	13
9		*Campylopus bicolor*	B	4	5	5	14
10	32	*Campylopus introflexus*	B	7	7	7	21
44		*Fissidens tenellus* var. *tenellus*	B	1			1
50	34	*Funaria hygrometrica*	B	11	8	7	26
40		*Othodontium lineare*	B	2	2	1	5
336		*Rosulabryum capillare*	B	1			1
128	35	*Sematophyllum subhumile* var. *contiguum*	B	4	4		8
353		*Triquetrella papillata*	B	1			1
12	27	*Cephaloziella exiliflora*	H	3	5	2	10
45	29	*Fossombronia intestinalis* (leafy)	H			1	1
		Total number of species		**38**	**40**	**25**	**55**
		Total Lichen species		28	33	18	44
		Total moss species		9	6	5	9
		Total Liverwort species		1	1	2	2
		Potential indicator species		20	21	16	26
		Lichen		15	16	11	20
		Moss		4	4	3	4
		Liverwort		1	1	2	2

[1]L = lichen, B = bryophyte (moss) and H = heptophyte (liverwort)
[2] ER = external reference, SW = shelterwood, GR = gap release

VASCULAR PLANTS

Bruce Ward, Ray Cranfield and Richard Robinson

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 making results 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 also important to consider time since fire as observed differences may be due to succession following fire rather than to direct impacts of timber harvesting. Vegetation complexes in the jarrah forest are considered resilient to fire, and in most circumstances species that were present before fire are present after the event, although abundances may change temporarily.

Monitoring of vascular plants on FORESTCHECK grids aims 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, and
- Compare results from Perth Hills in 2003 with those from 2009.

Monitoring

FORESTCHECK vascular flora surveys are undertaken in spring each year, to coincide with flowering of most species. Four 1000 m^2 vegetation plots were established on each of the Perth Hills grids and initially monitored in 2003. Following a review of methods in 2006, two additional 1000 m^2 plots were installed on all FORESTCHECK grids (increasing the flora survey area on each grid from 20% to 30%) in order to sample a higher percentage of the entire plant community and to assess canopy cover across a higher proportion of grid area.

Flora surveys on the Perth Hills FORESTCHECK grids were undertaken from 8-26 September 2009, and before prescribed burns were undertaken on the Kennedy gap (FC22), Lesley gap release (FC25) and the Lesley shelterwood (FC 26). Presence, abundance, cover and frequency were recorded in six 1000 m^2 plots on each grid (48 in total). Vegetation structure was determined from levy contact data at various height categories up to 2 m in the understorey (Levy and Madden 1933). Point samples were taken at 1m intervals on two internal sides of the 1000 m^2 plots (for 60 point samples per plot or 360 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 contacts with a 'yes' (Y) rating from the total number of contacts. 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).

One hundred and twenty three voucher specimens of plants in flower were collected around each grid during the initial monitoring assessment in 2003. This represents about 65% of species recorded. No voucher specimens were collected during this monitoring session as none of the species were flowering at the time of assessment. Species that have not yet been collected will be added opportunistically during future visits in order to achieve a complete set of voucher specimens for the Perth Hills grids.

Preliminary results and discussion

Species richness

A total of 156 taxa were recorded from the Perth Hills monitoring grids in 2009, compared to 201 in 2003 (Table 1). This was despite an increase of 2,000 m^2 in survey area in 2009. The reduction in species richness since the 2003 assessment is most probably due to changes associated with succession following harvesting and fire, and corresponding changes in species composition and abundance. Forty species recorded in 2009 were not recorded in 2003, but 85 species recorded in 2003 were not recorded in 2009 (Table 1). The number of weed species was similar in 2003 and 2009. In 2009, weeds were recorded in four out of the eight grids (compared to five in 2003), but with only one or two species in each (Table 1). Plant species recorded in both 2003 and 2009 in each treatment are listed in Appendix 1.

Mean species richness per grid was lower across all treatments in 2009 than in 2003 (Fig. 1). In 2003 there was a similar number of species recorded in the external reference and shelterwood treatments, but there was significantly more species recorded in the gap release treatment. In 2009 mean species richness was similar across all treatments.

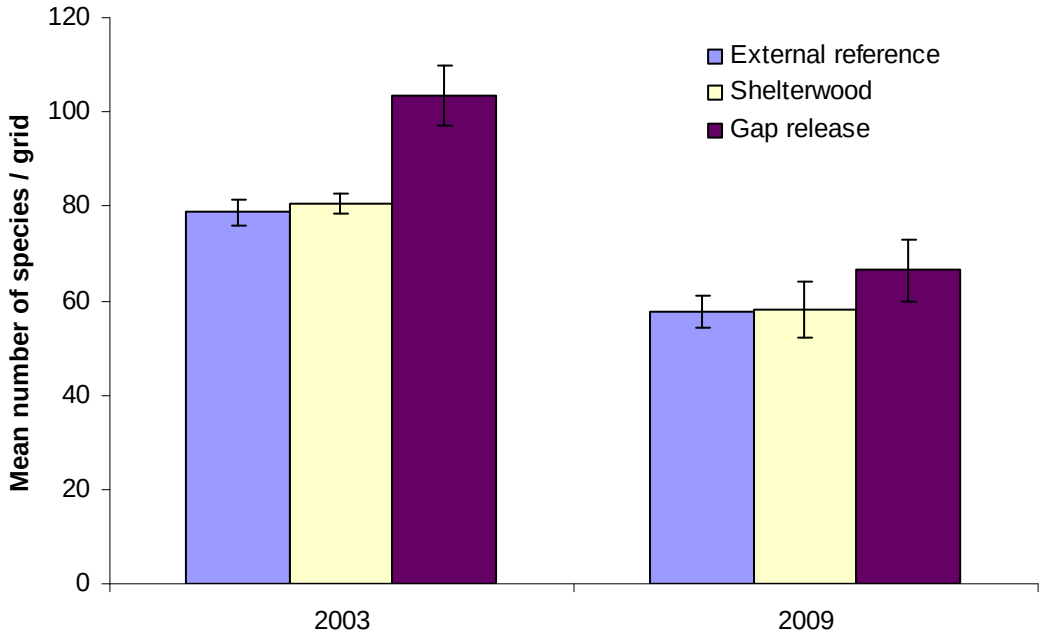

Figure 1. Mean species richness per grid recorded in each treatment in FORESTCHECK grids at Perth Hills in 2003 and 2009.

Table 1. Total numbers of plant species recorded in each treatment in FORESTCHECK monitoring grids in Perth Hills in 2003 and 2009.

	Perth Hills 2003				Perth Hills 2009				Perth Hills 2003+2009			
	ER	SW	GR	Total	ER	SW	GR	Total	ER	SW	GR	Total
Total (241)	137	134	147	201	104	100	99	156	162	158	166	241
Unique to treatment	22	16	38		26	15	23		30	23	40	
Common to all treatments				92				54				100
Exclusive to year				85				40				
Recorded in both years								116				
Weeds	3	2	1	4	2	2	1	4	4	4	2	7

Table 2. The number of plants in each life-form category recorded exclusively in each treatment in each year and in both years in the Perth Hills in 2003 and 2009.

Life form	External reference				Shelterwood				Gap release				Total for all treatments (2003+2009)			
	2003 only	2009 only	shared	Total	2003 only	2009 only	shared	Total	2003 only	2009 only	shared	Total	2003 only	2009 only	shared	Total
Tree	0	1	4	5	0	1	4	5	0	0	4	4	0	2	4	6
Shrub	14	12	27	53	14	9	27	50	18	12	32	62	27	19	44	90
Dwarf shrub	21	5	19	45	24	4	20	48	22	3	20	45	26	9	29	64
Herb	10	0	4	14	11	3	4	18	11	1	4	16	14	3	6	23
Geophyte	7	6	12	25	8	6	9	23	12	3	7	22	13	6	16	35
Grass	2	0	2	4	0	0	2	2	1	0	3	4	2	0	3	5
Cycad	0	0	2	2	0	0	1	1	0	0	1	1	0	0	2	2
Vine	2	1	4	7	0	0	3	3	1	0	3	4	1	1	5	7
Grass tree	0	0	2	2	0	1	1	2	0	0	2	2	0	0	2	2
Sedge	2	0	2	4	1	0	4	5	2	0	3	5	2	0	4	6
Fern	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1
Total	58	25	79	**162**	24	76	67	**158**	67	19	80	**166**	85	40	116	**241**

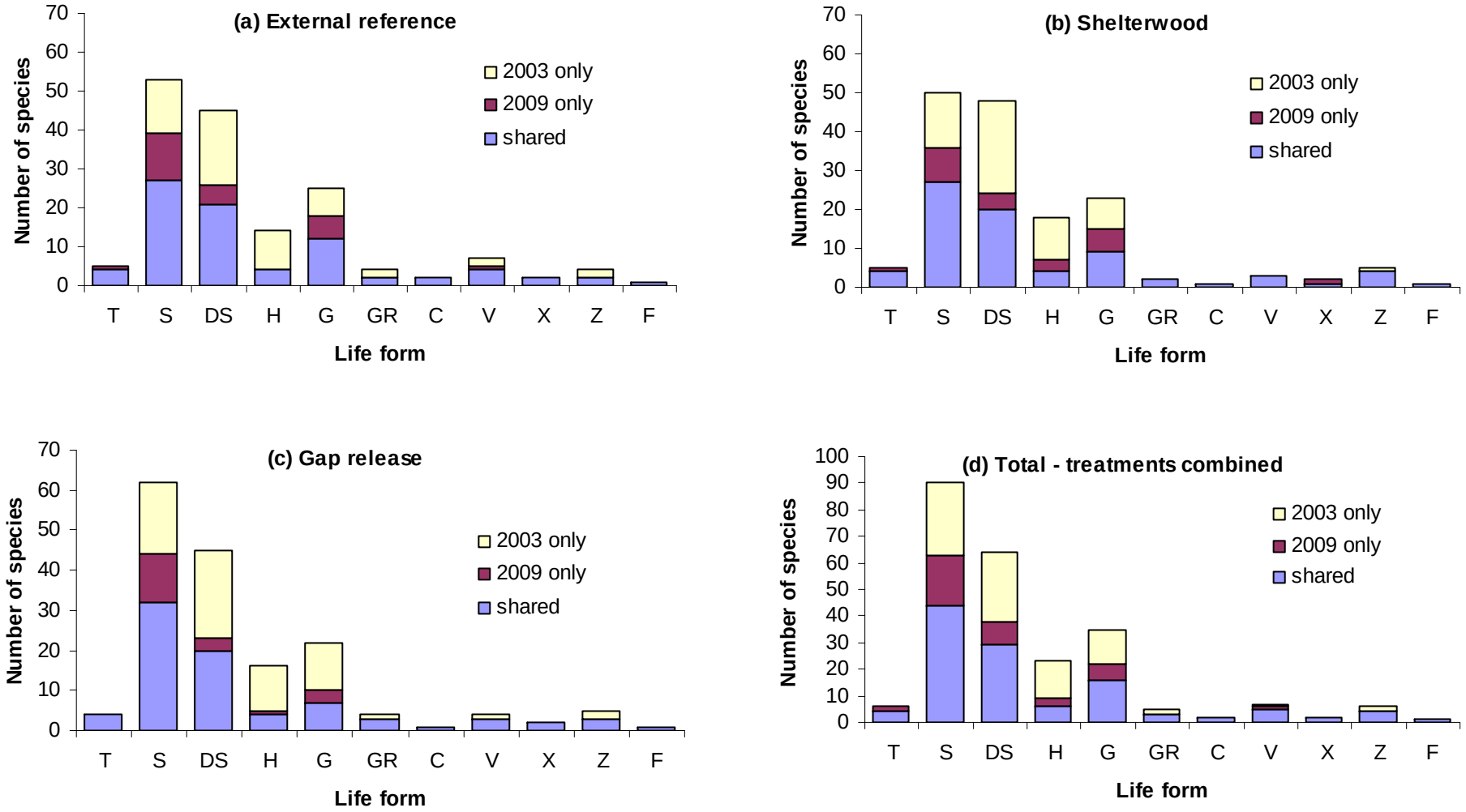

Figure 2. The number of plants in each life-form category recorded exclusively in each treatment in each year and in both years in the Perth Hills in 2003 and 2009. T = tree, S = shrub (31-200 cm), DS = dwarf shrub (0-30 cm), H = herb, G = geophyte, GR = grass, C = cycad, V = vine, X = grass tree, Z = sedge, F = fern.

Life form categories and fire response

In vegetation ecology, plants can be grouped into life form or growth form categories on the basis of their similarity in structure and function; which also often display an obvious relationship to environmental influences.

A high degree of species turn over was detected within life form categories between the two sampling periods (Appendix 1) (Table 2 and Fig. 2 – previous page). Changes in species assemblages was very noticeable within the shrub, dwarf shrub, herb and geophyte life form categories in all treatments (Table 2, Fig. 2, Fig. 3). Forty six species of plants that regenerate from seed and 39 species that regenerate by re-sprouting which were recorded in 2003 were not recorded in 2009. These included 55 species of shrubs and dwarf shrubs, 13 geophytes and 14 herbs. In 2009, these plants appeared to have been replaced by an additional 15 species of seeders and 25 species of re-sprouters, of which 28 were shrubs and dwarf shrubs, six were geophytes and three were herbs (Table 2).

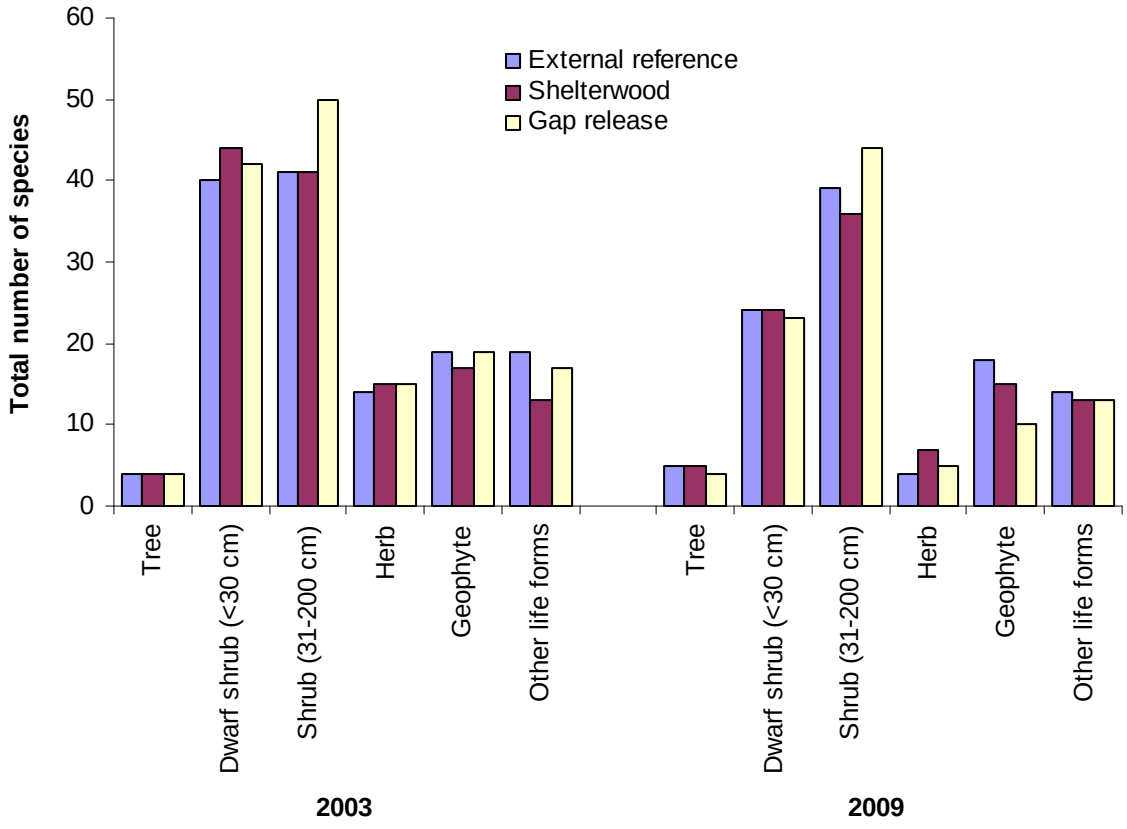

Figure 2. Total number of species in each life-form category for each treatment in 2003 and 2009

The timing of surveys may influence the ability to detect some plants including annual herbs, grasses and geophytes, but our data indicate that all plant life form groups showed changes in species numbers and assemblages. For example, geophytes such as *Drosera huegleii*, *D menzeisii*, *Pterostylis.pyramidalis* and *Thysanotus dichotomus* may have been missed on either survey because they had not yet emerged or were not flowering. However, other changes suggest that the plant community present in 2009 represents a different seral stage than that recorded in 2003. Short-lived disturbance-associated plants have likely been replaced by longer-lived plants associated with latter stages of understorey development. Herbs such as *Hydrocotyle callicarpa* , *Isotoma hypocrateriformis* and *Stylidium calcaratum* (= *S. androsaceum*) are short-lived and had likely been shaded out by the developing

understorey canopy in 2009. Similarly, *Corynotheca micrantha* is a short-lived shrub recorded in 2003 that was not recorded in 2009, and *Hibbertia glomerata* is a seeder that appears to have recolonised since 2003.

A number of species and varieties appear to have not been recognised in the field in 2009. These may include *Dianella revoluta* and *D. revoluta* var. *revoluta*, *Grevillea synapheae* and *G. synapheae* var. *synapheae*, and *Hovea trisperma*, *Hovea trisperma* var. *grandiflora* and *H. trisperma* var. *trisperma* (see Appendix 1). This can be overcome in the future by timing surveys to coincide more closely with flowering, and collecting vouchers to confirm identities.

Plant abundance

The total abundance of plants from all six plots on each grid was determined by summing the abundance class mid-point values for each species and was then converted to plants m^{-2} for each grid. Many individual plants were observed to be undergoing natural senescence, resulting in reduced abundances in the gap release and shelterwood grids since 2003. However, plant abundance had increased in the external reference grids (Fig. 3). The reduction in plant abundance in the gap release and shelterwood treatments may well be due to the increasing dominance of jarrah and marri regeneration on these grids and resultant shading of understorey plants. The reason for an increased abundance on the external reference grids is not obvious, but may be due to two of the grids, FC21 and FC 27, having been burnt four years prior to the 2009 assessment.

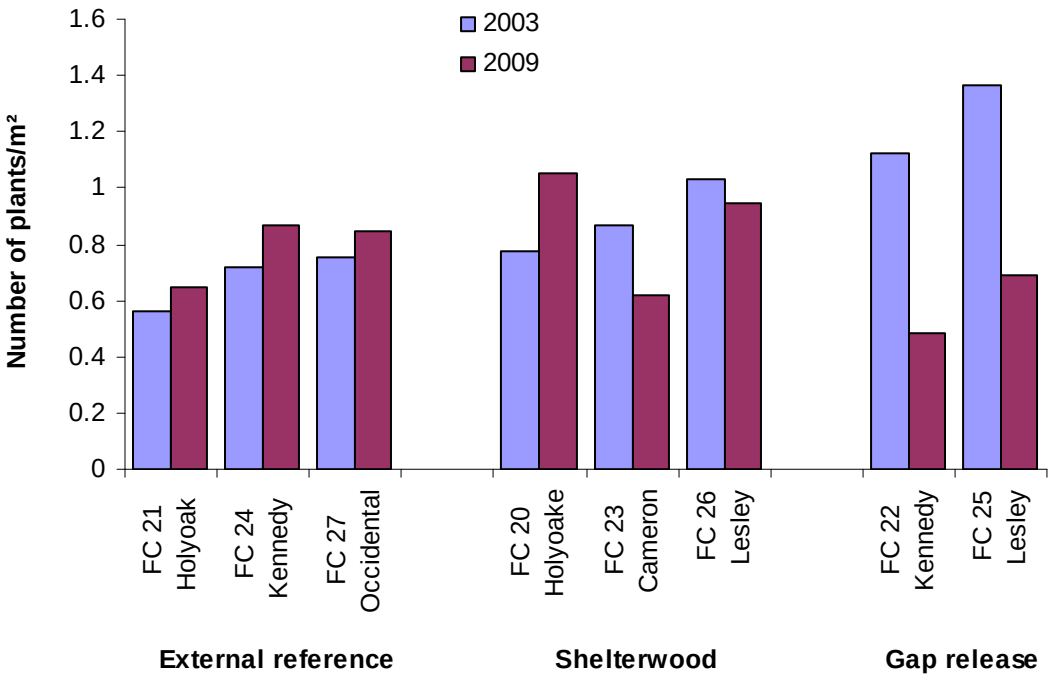

Figure 3. Plant density on each FORESTCHECK grid in the Perth Hills in 2003 and 2009.

Vegetation structure

Plant density at different heights up to 2 m was used to show a vertical profile of the vegetation within each grid (Fig. 4). Long-unburnt grids (≥ 10 yrs since fire) tended to be dominated by vegetation up to 40 cm tall, and those with more recent fire tended to have

about half of their contact points within the 0-60 cm profile and a more even distribution and larger representation of contacts from 60-200 cm. However, the Kennedy gap release site did not display the same trends but, generally, the vegetation structure on longer-unburnt grids had collapsed and had a lower mean height (Fig. 4).

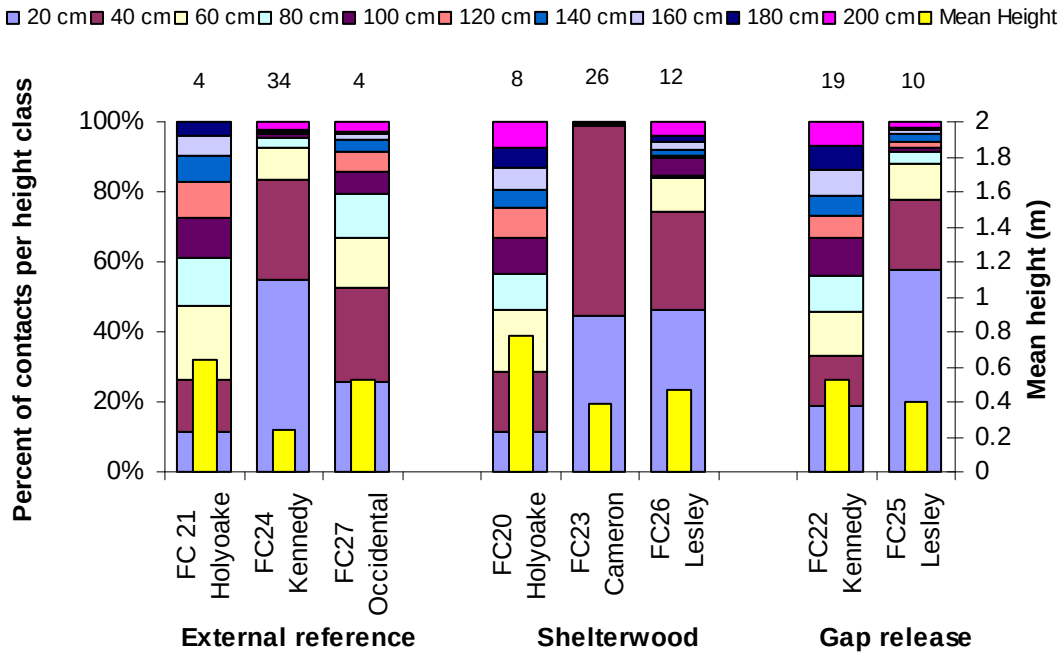

Figure 4. Profiles of vegetation structure from ground level to 2m on each grid in 2009. The yellow bars indicate the mean vegetation height while the stacked colour bars represent the percentage of contacts within each height class. Numbers above the columns indicate years since fire.

Conclusions

The main observations made following monitoring of vascular plants and measurement of plant structure at the Perth Hills FORESTCHECK location:

- The Perth Hills grids have a low infestation of weed species with only four out of the eight grids recording weeds in 2009.
- There was a drop in species richness and abundance which is most likely due to the advanced seral stage of the understorey.
- A large turn over of plant species was detected between the 2003 and 2009 assessments possibly due to the more advanced development of the forest since harvesting and the last fire.
- The structure of the understory vegetation also suggests that grids in stands with longer time since fire (≥ 10 years) are different to those with more recent (≥ 10 years) fire.
- Timing of surveys needs to be considered when monitoring geophytes and flowering vouchers need to be collected to determine some species varieties.

Acknowledgements

Thank you to Verna Tunsell for assistance with data entry, and for processing and data basing of voucher collections.

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Appendix 1. List of species recorded in each treatment in Perth Hills FORESTCHECK grids in 2003 and 2009.

FC No.	Species[1]	Life form[2]	Treatment 2003[3]			Total 2003[4]	Treatment 2009[3]			Total 2009[4]
			ER	SW	GR		ER	SW	GR	
3	*Acacia browniana*	S	+	+		2				
4	*Acacia browniana* var. *browniana*	S			+	1				
5	*Acacia celastrifolia*	S	+			1	+			1
8	*Acacia drummondii*	S	+	+	+	3	+			1
10	*Acacia drummondii* subsp. *elegans*	S	+			1				
11	*Acacia extensa*	S	+			1				
12	*Acacia huegelii*	S		+	+	2			+	1
13	*Acacia lateriticola*	S					+			1
15	*Acacia nervosa*	S			+	1				
18	*Acacia pulchella*	S	+	+	+	3		+	+	2
19	*Acacia pulchella* var. *pulchella*	S							+	1
22	*Acacia urophylla*	S	+			1				
26	*Actinotus omnifertilis*	DS							+	1
27	*Adenanthos barbiger*	S	+		+	2	+			1
31	*Agrostocrinum scabrum*	G			+	1				
32	***Aira cupaniana***	GR	+		+	2			+	1
33	*Allocasuarina fraseriana*	T	+	+	+	3	+	+	+	3
34	*Amperea ericoides*	DS		+		1				
35	*Amphipogon amphipogonoides*	DS	+	+	+	3				
36	*Amphipogon strictus*	GR	+			1				
463	*Astartea fascicularis*	S							+	1
49	*Astroloma ciliatum*	DS	+	+	+	3	+	+		2
51	*Astroloma pallidum*	DS	+	+	+	3			+	1
52	*Austrodanthonia caespitosa*	GR	+	+	+	3	+	+	+	3
54	*Baeckea camphorosmae*	S			+	1			+	1
58	*Banksia dallanneyi*	S	+	+	+	3	+	+	+	3
60	*Banksia grandis*	T	+	+	+	3	+	+	+	3
62	*Banksia sessilis*	S		+		1		+		1
456	*Banksia sessilis* var. *sessilis*	T						+		1
64	*Billardiera floribunda*	V	+			1	+			1
65	*Billardiera fusiformis*	S			+	1			+	1
67	*Billardiera variifolia*	V	+	+	+	3		+	+	2
68	*Boronia crenulata*	DS	+	+	+	3				
69	*Boronia denticulata*	DS		+		1				
464	*Boronia fastigiata*	S							+	1
70	*Boronia ovata*	DS			+	1				
72	*Boronia spathulata*	S	+	+	+	3	+	+	+	3
73	*Bossiaea aquifolium* subsp. *aquifolium*	S	+	+		2		+		1
75	*Bossiaea eriocarpa*	S		+		1				
77	*Bossiaea ornata*	S	+	+	+	3	+	+	+	3
78	*Brachyscome iberidifolia*	H	+			1				
80	*Burchardia congesta*	G	+			1				
81	*Caesia micrantha*	G	+			1				
83	*Caladenia flava*	G	+	+	+	3	+	+		2
84	*Caladenia flava* subsp. *flava*	G	+			1				
85	*Caladenia latifolia*	G			+	1				
87	*Caladenia reptans*	G	+			1	+	+		2
89	*Caladenia* spp.	G	+	+		2				
92	*Calytrix amethystina*	S			+	1				

FC No.	Species[1]	Life form[2]	Treatment 2003[3]			Total 2003[4]	Treatment 2009[3]			Total 2009[4]
			ER	SW	GR		ER	SW	GR	
93	*Calytrix leschenaultii*	S			+	1			+	1
449	**Undetermined weed**	S					+			1
97	***Centaurium erythraea***	H						+		1
102	*Chamaescilla corymbosa*	G	+	+	+	3	+	+	+	3
104	*Chorizema nanum*	DS	+	+		2				
105	*Chorizema rhombeum*	DS			+	1				
106	*Clematis pubescens*	V	+	+	+	3	+	+	+	3
107	*Comesperma calymega*	DS	+	+	+	3	+			1
111	*Conospermum capitatum*	S							+	1
113	*Conostylis aculeata*	DS	+	+	+	3	+	+	+	3
115	*Conostylis setigera*	DS	+	+	+	3	+	+	+	3
118	*Corymbia calophylla*	T	+	+	+	3	+	+	+	3
119	*Corynotheca micrantha*	S	+	+	+	3				
125	*Cyanicula gemmata*	G			+	1				
127	*Cyathochaeta avenacea*	Z		+		1				
130	*Dampiera linearis*	DS	+	+	+	3		+	+	2
135	*Daucus glochidiatus*	H	+	+		2	+	+		2
137	*Daviesia decurrens*	S		+	+	2		+	+	2
138	*Daviesia incrassata*	S		+	+	2		+	+	2
140	*Desmocladus fasciculatus*	Z	+	+	+	3		+		1
141	*Desmocladus flexuosus*	Z	+	+	+	3		+	+	2
142	*Dianella revoluta*	H	+	+	+	3				
457	*Dianella revoluta* var. *revoluta*	H						+	+	2
143	*Dillwynia* sp.	S			+	1				
458	***Disa bracteata***	S						+		1
146	*Diuris longifolia*	G			+	1				
148	*Diuris* spp.	G		+		1				
151	*Drosera bulbosa*	G	+	+	+	3	+			1
152	*Drosera erythrorhiza*	G	+	+	+	3	+	+	+	3
154	*Drosera huegelii*	G	+	+	+	3				
155	*Drosera menziesii*	G					+	+	+	3
157	*Drosera pallida*	G	+	+	+	3	+	+	+	3
158	*Drosera pycnoblasta*	G			+	1				
160	*Drosera* spp.	G		+		1				
161	*Drosera stolonifera*	G	+	+	+	3		+		1
462	*Eriochilus dilatatus*	H						+		1
164	*Eucalyptus marginata*	T	+	+	+	3	+	+	+	3
168	*Gastrolobium spinosum*	S			+	1	+		+	2
172	*Gompholobium capitatum*	DS		+		1				
174	*Gompholobium knightianum*	DS			+	1			+	1
175	*Gompholobium marginatum*	DS			+	1				
180	*Gompholobium* spp.	S			+	1				
181	*Gompholobium tomentosum*	DS		+	+	2	+			1
186	*Grevillea centristigma*	S						+		1
187	*Grevillea pulchella*	S		+	+	2				
450	*Grevillea synapheae*	S					+	+	+	3
188	*Grevillea synapheae subsp. synapheae*	S	+	+	+	3				
190	*Grevillea wilsonii*	S			+	1		+	+	2
191	*Haemodorum paniculatum*	H	+	+	+	3				
194	*Hakea amplexicaulis*	S	+			1	+			1
196	*Hakea lissocarpha*	S	+	+	+	3	+	+	+	3
451	*Hakea prostrata*	S					+			1

FC No.	Species[1]	Life form[2]	Treatment 2003[3]			Total 2003[4]	Treatment 2009[3]			Total 2009[4]
			ER	SW	GR		ER	SW	GR	
197	*Hakea ruscifolia*	S		+	+	2		+	+	2
202	*Hemigenia rigida*	DS	+	+		2				
205	*Hibbertia amplexicaulis*	S	+	+	+	3	+	+	+	3
206	*Hibbertia commutata*	S	+	+	+	3	+	+	+	3
209	*Hibbertia glomerata*	S					+	+	+	3
465	*Hibbertia huegelii*	DS							+	1
211	*Hibbertia hypericoides*	S			+	1				
212	*Hibbertia montana*	DS	+	+		2				
213	*Hibbertia quadricolor*	S					+		+	2
216	*Hibbertia* spp.	S			+	1				
466	*Hibbertia subvaginata*	DS							+	1
218	*Hovea chorizemifolia*	DS	+	+	+	3	+	+	+	3
220	*Hovea trisperma*	S	+	+		2	+			1
221	*Hovea trisperma* var. *grandiflora*	S	+	+	+	3				
222	*Hovea trisperma* var. *trisperma*	S					+	+		2
224	*Hyalosperma demissum*	H			+	1				
225	*Hybanthus debilissimus*	DS	+			1				
226	*Hydrocotyle callicarpa*	H	+	+	+	3				
229	*Hypocalymma angustifolia*	S			+	1			+	1
231	***Hypochaeris glabra***	H	+	+	+	3	+	+	+	3
233	*Hypoxis occidentalis*	H	+			1				
236	*Isotoma hypocrateriformis*	H	+	+	+	3				
240	*Kennedia carinata*	V	+			1				
241	*Kennedia coccinea*	V	+	+	+	3	+	+	+	3
452	*Kennedia microphylla*	V					+			1
242	*Kennedia prostrata*	V	+		+	2	+			1
245	*Labichea punctata*	DS	+	+	+	3			+	1
246	*Lagenophora huegelii*	G	+	+	+	3	+	+	+	3
247	*Lasiopetalum floribundum*	S	+	+		2	+	+		2
249	*Lechenaultia biloba*	S	+	+	+	3	+	+	+	3
250	*Lepidosperma leptostachyum*	Z	+	+	+	3	+	+	+	3
253	*Lepidosperma squamatum*	Z	+	+	+	3	+	+	+	3
254	*Leptomeria cunninghamii*	S	+	+		2	+	+	+	3
255	*Leucopogon australis*	S					+		+	2
256	*Leucopogon capitellatus*	S	+	+	+	3	+	+	+	3
258	*Leucopogon propinquus*	S	+	+	+	3	+	+	+	3
262	*Leucopogon verticillatus*	S	+	+	+	3	+	+	+	3
263	*Levenhookia pusilla*	H	+	+	+	3			+	1
266	*Logania serpyllifolia*	DS	+	+	+	3	+			1
267	*Logania serpyllifolia subsp. serpyllifolia*	DS						+		1
269	*Lomandra caespitosa*	DS	+	+	+	3	+	+	+	3
270	*Lomandra drummondii*	DS					+	+		2
271	*Lomandra hermaphrodita*	DS	+	+	+	3	+	+	+	3
272	*Lomandra integra*	DS	+	+	+	3	+	+	+	3
273	*Lomandra nigricans*	DS					+	+		2
276	*Lomandra purpurea*	DS	+			1				
277	*Lomandra sericea*	DS	+	+	+	3	+	+	+	3
278	*Lomandra sonderi*	DS	+	+	+	3	+	+	+	3
279	*Lomandra spartea*	DS	+	+	+	3				
280	*Lomandra* spp.	DS		+		1				
281	*Lomandra suaveolens*	DS	+	+		2				
285	*Macrozamia fraseri*	C	+			1	+			1

FC No.	Species[1]	Life form[2]	Treatment 2003[3]			Total 2003[4]	Treatment 2009[3]			Total 2009[4]
			ER	SW	GR		ER	SW	GR	
286	*Macrozamia riedlei*	C	+	+	+	3	+	+	+	3
290	*Millotia tenuifolia*	H	+	+	+	3		+		1
292	*Mirbelia dilatata*	S	+			1	+	+		2
293	*Monotaxis grandiflora*	DS			+	1				
296	*Neurachne alopecuroidea*	GR			+	1				
298	*Olax benthamiana*	S			+	1			+	1
299	*Opercularia hispidula*	S	+	+	+	3	+	+	+	3
301	***Orobanche minor***	H		+		1				
303	***Oxalis corniculata***	G	+			1	+			1
305	*Paraserianthes lophantha*	S			+	1				
307	*Patersonia babianoides*	G	+	+	+	3				
309	*Patersonia occidentalis*	DS	+	+	+	3	+		+	2
310	*Patersonia pygmaea*	DS	+	+	+	3		+	+	2
311	*Patersonia umbrosa*	DS		+	+	2				
315	*Pentapeltis peltigera*	DS	+	+	+	3	+	+		2
316	*Pentapeltis silvatica*	S					+	+	+	3
317	*Pericalymma ellipticum* var. *ellipticum*	S					+			1
319	*Persoonia elliptica*	T					+			1
321	*Persoonia longifolia*	S	+	+	+	3	+	+	+	3
322	*Persoonia saccata*	S			+	1			+	1
329	*Phyllangium paradoxum*	H		+	+	2				
330	*Phyllanthus calycinus*	DS	+	+	+	3	+	+	+	3
333	*Pimelea rosea*	S		+		1				
335	*Pimelea spectabilis*	S		+		1	+	+		2
336	*Pimelea* spp.	S		+		1				
337	*Pimelea suaveolens*	S	+		+	2	+		+	2
338	*Pimelea sylvestris*	S							+	1
339	*Platysace commutata*	S	+	+		2				
341	*Platysace filiformis*	S	+	+	+	3	+	+		2
342	*Platysace tenuissima*	DS						+		1
348	*Podotheca angustifolia*	H			+	1				
351	*Poranthera microphylla*	DS			+	1				
353	*Pteridium esculentum*	F	+	+	+	3	+	+	+	3
355	*Pterostylis pyramidalis*	G					+	+	+	3
356	*Pterostylis recurva*	G						+		1
359	*Ptilotus manglesii*	G			+	1			+	1
363	*Pyrorchis nigricans*	G	+	+	+	3	+	+		2
371	*Scaevola platyphylla*	S			+	1				
372	*Scaevola striata*	DS	+	+	+	3	+	+		2
375	*Senecio glomeratus*	H		+		1				
376	*Senecio hispidulus*	DS	+	+	+	3	+	+		2
377	*Senecio leucoglossus*	S		+		1				
382	*Sowerbaea laxiflora*	G		+		1	+			1
453	*Sphaerolobium fornicatum*	DS					+			1
384	*Sphaerolobium medium*	S	+			1				
385	*Sphaerolobium* spp.	S	+			1				
386	*Stackhousia monogyna*	S	+		+	2				
388	*Stylidium amoenum*	DS	+	+	+	3	+		+	2
390	*Stylidium calcaratum*	H	+	+	+	3				
391	*Stylidium cilatum*	DS	+	+	+	3	+	+	+	3
392	*Stylidium junceum*	H			+	1				
393	*Stylidium luteum*	DS	+	+		2		+		1

FC No.	Species[1]	Life form[2]	Treatment 2003[3]			Total 2003[4]	Treatment 2009[3]			Total 2009[4]
			ER	SW	GR		ER	SW	GR	
394	*Stylidium piliferum*	DS	+	+	+	3		+	+	2
397	*Stylidium schoenoides*	DS	+		+	2				
398	*Stylidium spathulatum*	DS			+	1			+	1
399	*Stylidium* spp.	DS	+	+		2				
401	*Styphelia tenuiflora*	S	+	+	+	3	+	+	+	3
403	*Synaphea petiolaris*	S			+	1			+	1
406	*Templetonia drummondii*	DS			+	1				
407	*Tetraria capillaris*	S	+	+	+	3	+	+	+	3
408	*Tetraria octandra*	Z			+	1				
409	*Tetrarrhena laevis*	GR	+	+	+	3	+	+	+	3
411	*Tetratheca hirsuta*	S	+	+	+	3	+	+	+	3
412	*Tetratheca hispidissima*	S		+	+	2				
413	*Tetratheca setigera*	S					+			1
414	*Thelymitra crinita*	G	+	+	+	3	+	+	+	3
454	*Thelymitra macrophylla*	G					+			1
416	*Thelymitra* spp.	G						+		1
417	*Thomasia foliosa*	S	+	+	+	3	+	+	+	3
455	*Thysanotus dichotomus*	G					+	+	+	3
418	*Thysanotus manglesianus*	G	+	+		2	+			1
419	*Thysanotus multiflorus*	G			+	1	+			1
423	*Thysanotus tenellus*	H	+	+	+	3	+		+	2
425	*Trachymene pilosa*	H	+	+	+	3	+	+	+	3
427	*Tremandra stelligera*	DS	+	+		2				
428	*Trichocline spathulata*	G	+	+	+	3	+	+	+	3
429	*Tricoryne elatior*	H	+	+	+	3				
430	*Tricoryne humilis*	DS	+	+	+	3				
432	*Tripterococcus brunonis*	DS	+	+	+	3				
433	*Trymalium floribundum*	S	+			1				
434	*Trymalium ledifolium*	S	+	+	+	3	+	+	+	3
461	*Trymalium ledifolium* var. *ledifolium*	S						+	+	2
442	*Xanthorrhoea gracilis*	X	+	+	+	3	+	+	+	3
443	*Xanthorrhoea preissii*	X	+		+	2	+	+	+	3
444	*Xanthosia atkinsoniana*	DS	+	+	+	3		+	+	2
445	*Xanthosia candida*	DS	+	+	+	3	+	+		2
447	*Xanthosia huegelii*	DS		+	+	2				
241	Total number of species		137	134	147	**201**	104	100	99	**156**
	Exclusive to treatment		22	16	38		26	15	23	
	Common to all treatments					92				54
	ER+SW					16				16
	ER+GR					7				8
	SW+GR					10				14

[1] Weed species are in bold font, common species recorded in all treatments one year and not the other are shaded
[2] T = tree, S = shrub (31-200 cm), DS = dwarf shrub (0-30 cm), H = herb, G = geophyte, GR = grass, C = cycad, V = vine, X = grass tree, Z = sedge, F = fern.
[3] ER = external reference, SW = shelterwood, GR = gap release, + = recorded in that treatment
[4] The number represents whether that species was recorded in 1, 2 or 3 treatments.

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

Field survey and laboratory procedure

Sampling at Perth Hills was carried out in November (spring) 2009 and April (autumn) 2010 using protocols outlined in the FORESTCHECK Operating Plan (DEC 2006). To briefly summarise: active capture samples, involving sweeping, beating, and habitat searches of coarse woody debris (CWD) and litter were conducted once at each site for a total time of one person hour per capture/habitat method. Light traps were run for three nights simultaneously at each site achieving one trap night per week for three weeks (there was one known light trap failure on 24/11/09 at grid FC27, however not all light trap samples have been processed); pitfall traps were opened for 10 days simultaneously at each site. Captures were bagged and labelled according to site and other capture details in the field, then transported in an insulated container back to a base camp were they were stored in a portable freezer. At the conclusion of a sampling period, specimens were then transported to the laboratory in Manjimup where they were sorted and compared to the extensive collection of voucher specimens held there. Morphospecies were assigned and vouchers for each morphospecies were erected as necessary and labelled according to site, date of capture and capture method and preserved as either pinned or alcohol specimens as a reference collection. To constrain sample processing times only macro-invertebrates are recorded, that is, invertebrates with a body length 10 mm or greater and Lepidoptera with a wing length of 12 mm 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 70% ethanol.

Sampling was conducted at all eight Perth Hill grids. Sorting, specimen identification and cataloguing have been completed for all hand, and pitfall samples. Part of the spring and the entire autumn light trap samples are yet to be processed. This report details sampling results for 2009-10 and also includes a brief comparison with the initial Perth Hills results for 2003-04. Note however, this is a preliminary report and results are from data as it exists for September 2010. 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. In addition since not all samples

have been processed, diversity will be lower than for previous reports. Consequently data comparisons will be confined to hand and pitfall captures.

Preliminary results

Species richness

Following the 2009-10 monitoring, the number of morphospecies recorded for FORESTCHECK increased to 1,991 (a total of 71,745 individual specimens), although this will increase once processing is complete. The total number of individual specimens captured at Perth Hills in 2009-10 was 3,091, comprising 376 morphospecies, this compares with 430 morphospecies (adjusted from original data for synonymy) captured in 2003-04 and an abundance level (number of specimens) of 4,885. So far there are 38 new morphospecies from Perth Hills that were not previously captured in any of the FORESTCHECK locations (although this figure will change following our morpho-species revision where synonymy is examined).

In 2008 we predicted (using a basic linear regression) there would be 156 new species in 2009-10. Figure 1 shows the current cumulative captures for the successive sampling locations. For the line including all capture methods (discounting the 2009-10 data), the graph's slope is consistent between successive sampling periods and shows no current trend of reduction indicating that, at this point, there is neither a sampling plateau nor an approach to one although there is a slight drop in species acquisition from the sample round of 2007-08. Once all samples are processed, a sample plateau will be approached should the total number of new species be considerably lower than the 156 predicted. The cumulative species curve for the hand capture and pitfall data across all sample periods from 2001 – 2009 (light trap captures removed) shows some slowing of the species accumulation (Fig. 1).

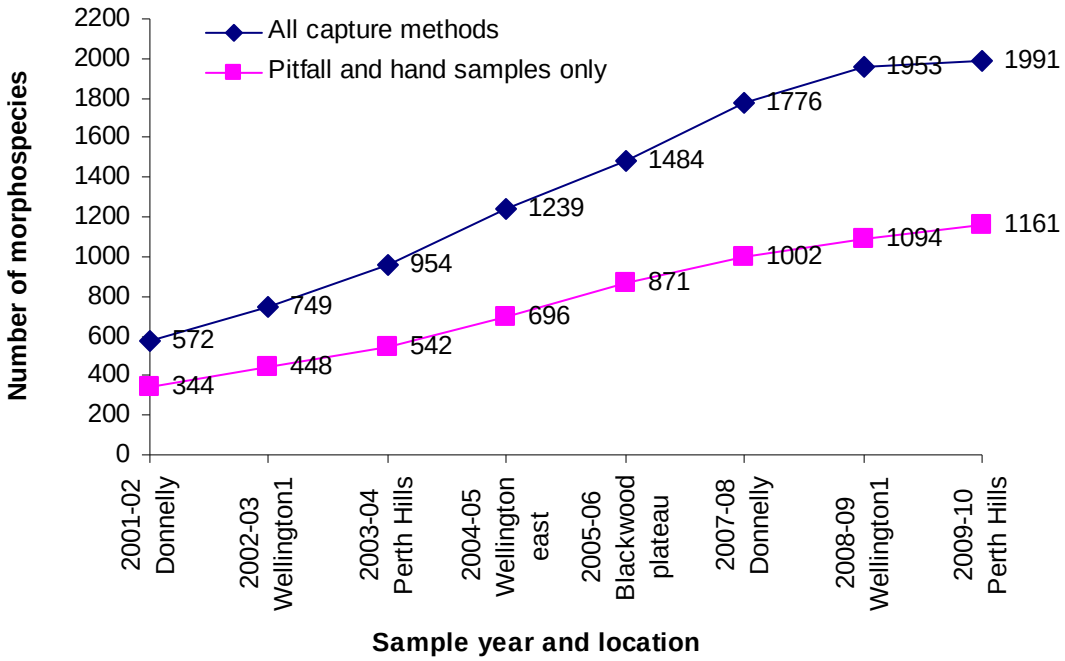


Figure 1. Cumulative morphospecies for 2001-02 (Donnelly) to 2009-10 (Perth Hills) for all capture methods (NB incomplete for Perth Hills 2009-10 data) and pitfall and hand captures only.

Table 1. Species richness (No. Spec.) and abundance (Abund.- number of individuals captured at each grid) for each capture method, season and site at each grid in Perth Hills for 2009-10.

				Active capture		Pitfall		UV light[1]		All capture methods	
Treatment	Grid No	Location	Season	No. spec.	Abund.	No. spec.	Abund.	No Spec	Abund.	No. Spe.c	Abund.
External reference	FC21	Holyoake	AU	12	20	9	13			33	21
External reference	FC21	Holyoake	SP	12	14	8	16	28	75	105	48
External reference	FC24	Kennedy	AU	16	20	2	3			23	18
External reference	FC24	Kennedy	SP	12	17	12	17	47	510	544	70
External reference	FC27	Occidental	AU	21	25	5	9			34	24
External reference	FC27	Occidental	SP	30	44	12	17	6	26	87	39
Gap release	FC22	Kennedy	AU	10	20	7	27			47	18
Gap release	FC22	Kennedy	SP	19	29	9	23	37	467	519	62
Gap release	FC25	Lesley	AU	19	29	7	12			41	24
Gap release	FC25	Lesley	SP	30	41	17	45	40	322	408	85
Shelterwood	FC20	Holyoake	AU	17	21	6	8			29	22
Shelterwood	FC20	Holyoake	SP	18	23	16	19	21	48	90	55
Shelterwood	FC23	Cameron	AU	15	25	9	14			39	24
Shelterwood	FC23	Cameron	SP	14	17	6	21	57	475	513	77
Shelterwood	FC26	Lesley	AU	15	22	7	15			37	21
Shelterwood	FC26	Lesley	SP	22	42	11	12	55	488	542	82

[1] Light trap samples were still being sorted and analysed when this report was written, and was incomplete for spring and unavailable for autumn.

A complete species list is included in Appendix 1 and summary of species richness and abundance (number of individuals captured at each grid) for each capture method, season and site for 2009-10 in Perth Hills is shown in Table 1.

Morphospecies capture for past sampling periods and districts are shown in Table 2. The Perth Hills 2009-10 sample is slightly higher in terms of diversity and abundance with the prior 2003-04 sample. Donnelly appears to be the most diverse site followed by Blackwood and Wellington east. Inclusion of past light trap data demonstrates that light trapping more than doubles diversity and is therefore a valuable capture technique.

Table 2. Morphospecies comparisons between sample regions.

District	Sample period	Number of morphospecies (hand & pit fall only)	Number of individuals (hand & pit fall only)	Number of morphospecies (+ light trap captures)
Donnelly	2001 – 02	344	NA	572
Wellington1	2002 – 03	208	763	373
Perth Hills	2003 – 04	175	619	428
Wellington east	2004 – 05	278	919	624
Blackwood	2005 – 06	319	1145	728
Donnelly	2007 – 08	302	1461	787
Wellington1	2008 – 09	248	930	592
Perth Hills	2009 - 10	222	680	NA

Figure 2 shows the numbers of morphospecies for invertebrate orders where 10 or more morphospecies have been assigned are compared for Perth Hills 2003-04 and 2009-10. The increased capture rates in 2009-10 are mostly within the Blattodea (cockroaches), Hymenoptera (wasps), Orthoptera (grasshoppers), Myglamorphae (trap door spiders) and Isopoda (slaters). The strong increases in myglamorphs, isopods and cockroaches are indicative of a damper environment. This is supported by the capture of some round and flat worms (Oligochaeta and Plathelminthes respectively) in the 2009-10 samples which were not found in 2003-04. Although Lepidoptera are a large order they do not feature in this graph since most species are captured using light trapping.

Comparing sample grids and silvicultural treatments

Figures 3 and 4 show comparisons between silvicultural treatments expressed as the total morphospecies and abundance for pitfall and hand captures; summed for spring and autumn seasons. In 2009-10, the Lesley gap release (FC25), Occidental external reference (FC27) and Holyoake gap release (FC20) grids had the greatest number of species (64, 52, and 51 respectively) in 2009-10. In both sample periods the Lesley gap release (FC25) had the highest diversity and the Kennedy external reference (FC24) the lowest (Fig. 3). In both sampling sessions the Kennedy reference grid (FC24) had the lowest abundance. The Holyoak external reference (FC21) had the highest abundance in 2003-04 and the Lesley gap release (FC25) the highest abundance in 2009-10 (Fig. 4).

Un-refined abundance data is best compared within the same sample year cohort as weather patterns for the influential seasons prior to the population sampled can strongly affect levels

and different invertebrates will respond in different ways. However combining the statistics of abundance and diversity for long term data (> three sample seasons can give insight into variations between grids regarding responses to environmental conditions.

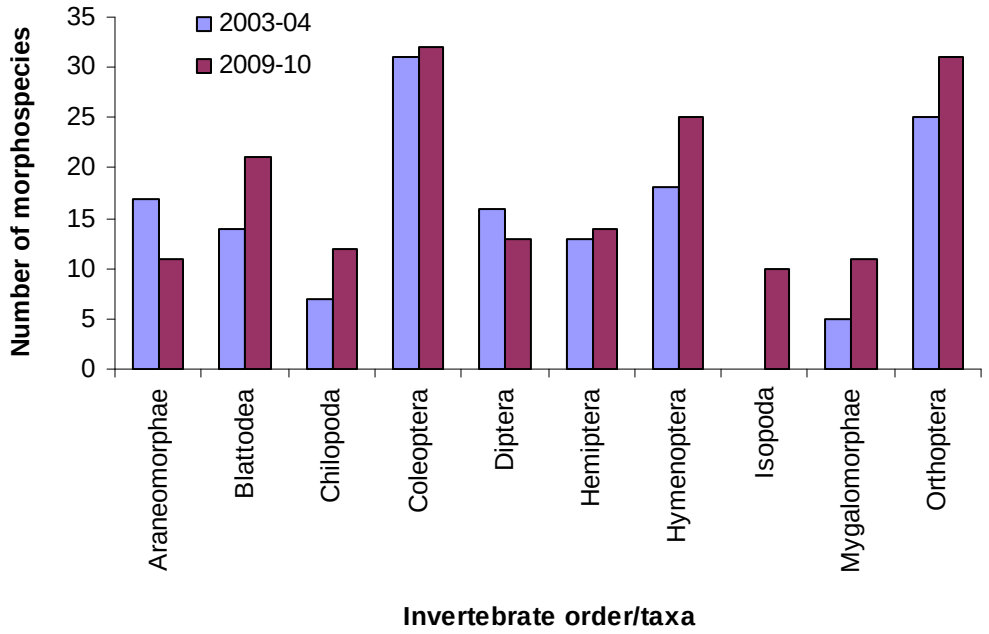


Figure 2. Comparison of Perth Hills 2003-04 and 2009-103 morphospecies numbers for invertebrate orders where ten or greater morphospecies have been assigned (light trap data excluded).

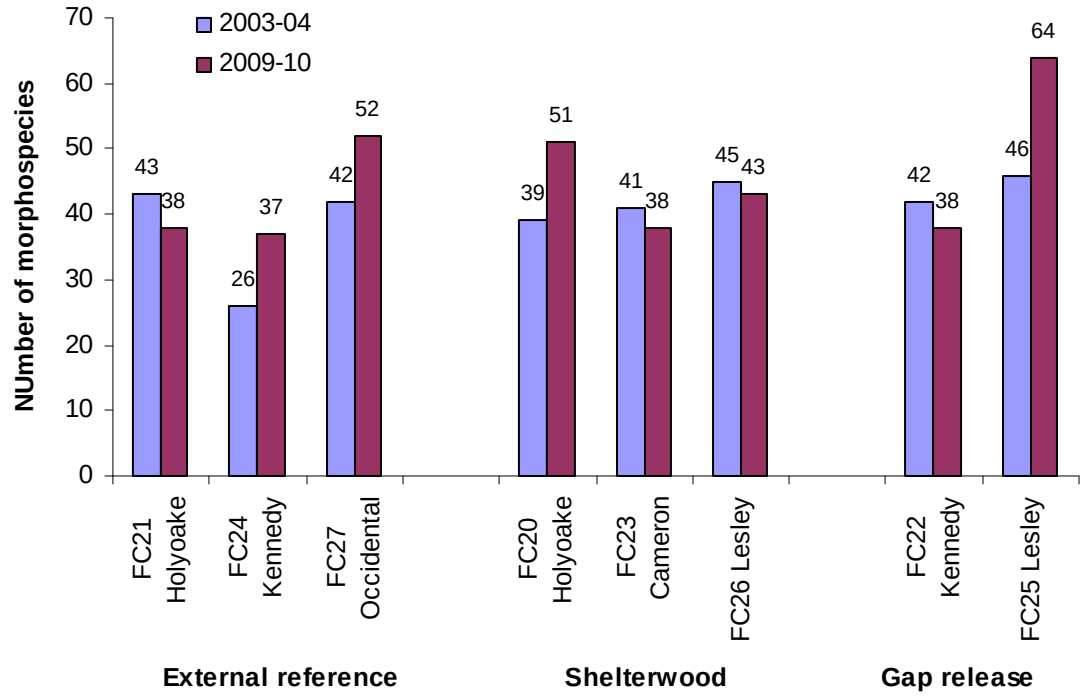


Figure 3. Comparison of individual Perth Hills treatment grids for total morphospecies, for pitfall and hand captures, combining both seasons.

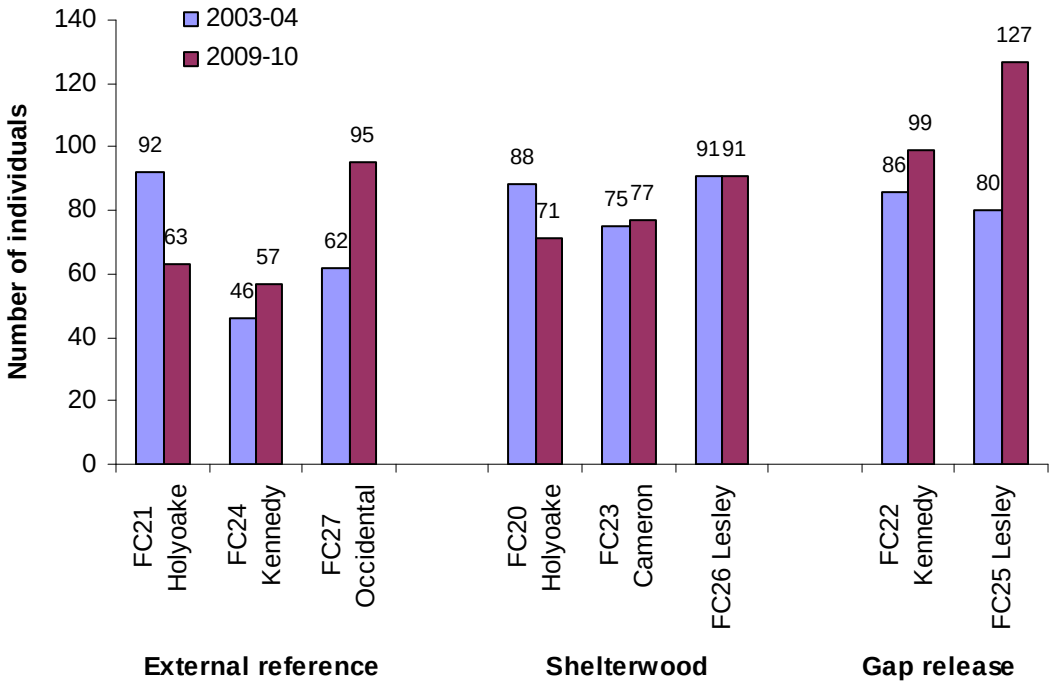


Figure 4. Comparison of individual Perth Hills treatment grids for abundance (number of individuals), for pitfall and hand captures, combining both seasons.

Comparison of means between treatments for Perth Hills 2009-10 (Fig. 5a) indicates the gap release treatment has higher species richness, however the standard errors show the mean is well within the range of the other treatments so differences are not significant. Nonetheless, comparison of the earlier 2003-04 samples show a consistent pattern for the Perth Hills data, with diversity highest in the gap release and lowest in the external control in both sample periods. However a similar pattern is not apparent in the comparable Wellington1 data (Fig. 5b) where there was little difference between treatments in the first sample period (2002-03) and in the second sample period the external reference had the highest diversity, with standard errors indicating a potential significance.

Species differences between localities

Table 3 shows the most frequent species captured for Perth Hills 2009-10, compared with another sample period and location. The ant *Camponotus* (species 423) was the most frequently captured species in Perth Hills 2009-10 and also featured in the top 10 most frequently sampled species for Perth Hills 2003-04 and Wellington1 2008-09. Only 42% of the top 10 Perth Hills 2003-04 sample featured in the current most frequently caught species and three of the most frequent species captured for 2003-04 (species 732, 482 and 484) were not captured in the most recent Perth Hills sample. For Wellington1, 33% of the most frequent species featured in the most frequent Perth Hills sample, with five of its top 10 species (species 221, 482, 3015, 153 and 473) not captured in the Wellington 2008-09 sample. However it needs to be pointed out at this stage that the morphospecies consolidation, where new species are examined and incorporated into the voucher collection, has as yet not been done for this sample and thus species such as 3324 and others may be synonymous with previous voucher IDs.

Looking at just the pitfall and hand capture data, of the 222 morphospecies found at Perth Hills in 2009-10, 162 had not been captured during the earlier sample period. In other words 73% of the current Perth Hills sample consisted of species not previously sampled in the

Perth Hills grids. Conversely 116 species from the initial Perth Hills sample were not present in the current sample (66%).

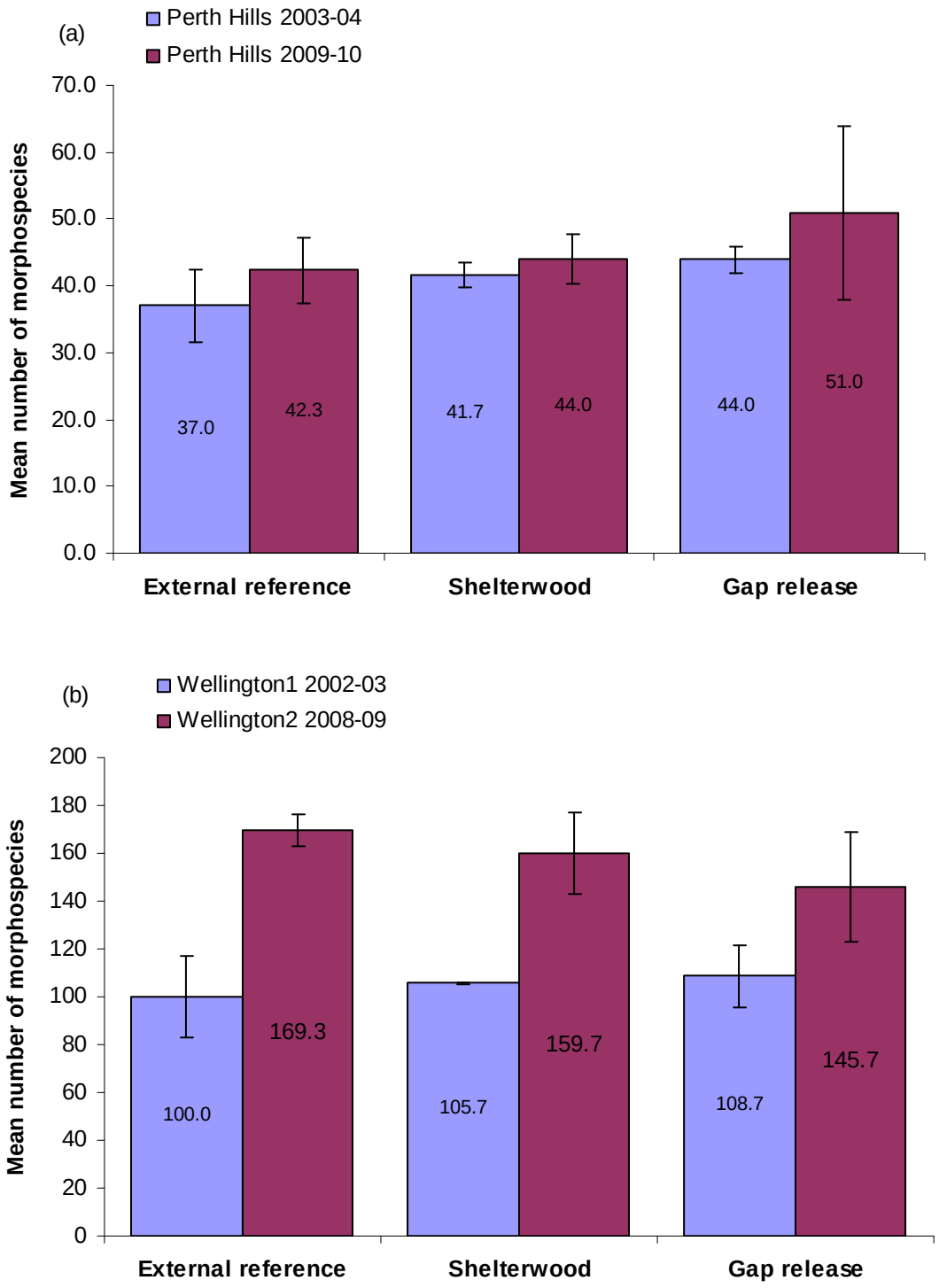


Figure 5. (a) Comparison of means for Perth Hills (n=3, ± SE, for each treatment except gap release where n=2, ± SE) for number of morphospecies in respect to silvicultural treatment and (b) Comparison of means for Wellington1 (n=3, ± SE) for number of morphospecies in respect to silvicultural treatment.

Table 3. Ten most frequent species captured for Perth Hills 2009-10, Perth Hills 2003-04 and Wellington 1 2008-9 for pitfall and hand capture only (light trap data is not included). Capture frequency is the number of times a specimen is collected over the sample grids in their respective locations and is listed from most frequent to least. It is not to be confused with abundance levels which refer to the total number of specimens collected. PH 09 capture frequency rank, refers to the frequency ranking of the same species as captured from Perth Hills in 2009-10, egg. a rank of six for a Perth Hills 2003-04 specimen means this species was the 6th most frequent species at Perth Hills 2009-10 Ranks > 16 indicate < three specimens of the respective species captured from Perth Hills 2009-10; a rank = 0 indicates no specimen captured in Perth Hills 2009-10.

Location	Species ID number	Capture frequency	PH 09 Capture Frequency Rank	Order	Family	Genus
Perth Hills 2009-10	423	37	1	Hymenoptera	Formicidae	Camponotus
	235	30	2	Orthoptera	Acrididae	Goniaea
	872	21	3	Orthoptera	Acrididae	Goniaea
	52	20	4	Hymenoptera	Apidae	Apis
	250	18	5	Mecoptera	Bittacidae	Harpobittacus
	98	15	6	Coleoptera	Curculionidae	Oxyops
	3324	14	7	Hymenoptera	Formicidae	Camponotus
	543	14	7	Hymenoptera	Formicidae	Rhytidoponera
	161	12	8	Coleoptera	Curculionidae	Oxyops
	223	11	9	Chilopoda	Scolopendridae	Ethmostigmus ?
	888	11	9	Hymenoptera	Formicidae	Rhytidoponera
	890	10	10	Orthoptera	Acrididae	Cedarinia
Perth Hills 2003-04	54	40	15	Diptera	Syrphidae	
	98	30	6	Coleoptera	Curculionidae	Oxyops
	161	20	8	Coleoptera	Curculionidae	Oxyops
	235	20	2	Orthoptera	Acrididae	Goniaea
	880	19	13	Scorpionida		
	872	17	3	Orthoptera	Acrididae	Goniaea
	52	16	4	Hymenoptera	Apidae	Apis
	732	16	0	Araneomorphae	Stiphidiidae	Baiami
	482	15	0	Hemiptera	Hyocephalidae	Hyocephalus
	258	14	18	Dermaptera	Anisolabididae	
	721	11	19	Mygalomorphae	Nemesiidae	Chenistonia
	423	11	1	Hymenoptera	Formicidae	Camponotus
	484	10	0	Dermaptera	Anisolabididae	
	526	10	17	Orthoptera	Stenopelmatidae	Onosandrus
Wellington1 2008-09	221	42	0	Hemiptera	Pentatomidae	
	250	36	5	Mecoptera	Bittacidae	Harpobittacus
	423	35	1	Hymenoptera	Formicidae	Camponotus
	161	24	8	Coleoptera	Curculionidae	Oxyops
	544	23	19	Isopoda		
	52	20	4	Hymenoptera	Apidae	Apis
	223	20	9	Chilopoda	Scolopendridae	Ethmostigmus ?
	54	15	15	Diptera	Syrphidae	
	482	15	0	Hemiptera	Hyocephalidae	Hyocephalus
	3015	13	0	Diplopoda		
	153	12	0	Hemiptera	Pentatomidae	
	712	12	12	Hymenoptera	Formicidae	Myrmecia
	713	12	14	Orthoptera	Acrididae	Ecphantus
	16	10	19	Diptera	Tipulidae	
	473	10	0	Diptera	Tabanidae	

Pest presence
Jarrah leaf miner (JLM) and gumleaf skeletonizer (GLS) were apparently absent from all sites (Table 4). Bullseye borer (BEB) was present at all grids and at high levels in FC24. Comparing the previous assessment in 2003-4, JLM and GLS were also absent in all grids, BEB was not observed in grid FC25 and was less abundant in FC24. Thus incidence of BEB has increased.

Table 4. Pest presence and abundance (0 = absent, 1 = present, 2 = abundant) assessment at each monitoring grid in the Perth Hills in 2009-10 (JLM = jarrah leaf miner; GLS = gumleaf skeletonizer; BEB = bullseye borer)

Treatment	Site No	Location	JLM	GLS	BEB
External reference	FC21	Holyoake	0	0	1
External reference	FC24	Kennedy	0	0	2
External reference	FC27	Occidental	0	0	1
Shelterwood	FC20	Holyoake	0	0	1
Shelterwood	FC23	Cameron	0	0	1
Shelterwood	FC26	Lesley	0	0	1
Gap release	FC22	Kennedy	0	0	1
Gap release	FC25	Lesley	0	0	1

Conclusions
In 2009-10 the Donnelly FORESTCHECK grids were re-sampled using the same sampling methods as for 2001-02.

- The total number of invertebrate morphospecies recorded for FORESTCHECK is now 1991 (however not all samples have been processed).
- Increases in diversity of myglamorphs isopods and cockroaches indicate a damper environment than in the earlier sample.
- From the raw data there is still little evidence of a treatment affect.
- In 2009-10, 73% of invertebrate species recorded were not captured in the previous 2003-04 sample.
- There is some indication of increased borer activity.
- The ant *Camponotus* 423 is consistently a frequent capture.

Acknowledgements
We thank our enthusiastic volunteers Neil Bartdot and Jacob Loughridge for sampling assistance in spring and autumn respectively. Julian Geisel also assisted us in the autumn 2010 field sampling. Both Julian Geisel and volunteer Neil Bardot participated in laboratory sorting.

References
DEC 2006. FORESTCHECK Operating Plan. Department of Environment and Conservation, Kensington, Western Australia.

Appendix 1. Species list including capture frequency (Cap freq) and abundances (Abund) for invertebrates collected at the Perth Hills Forestcheck grids in 2009-10.

Order	Family	Tax 3	Genus	Species	Spec ID#	Cap freq	Abund
Araneomorphae					3393	1	1
Araneomorphae	Araneidae		Phonographa	graeffei	1471	2	2
Araneomorphae	Lycosidae				1589	1	1
Araneomorphae	Lycosidae				741	1	2
Araneomorphae	Miturgidae				740	1	1
Araneomorphae	Miturgidae				1428	1	1
Araneomorphae	Miturgidae				3379	1	1
Araneomorphae	Miturgidae				3398	2	2
Araneomorphae	Miturgidae				794	1	1
Araneomorphae	Sparassidae				3397	1	1
Araneomorphae	Sparassidae		Olios		939	1	1
Araneomorphae	Zodariidae				972	1	1
Blattodea					3170	1	1
Blattodea					3231	1	1
Blattodea					3405	1	1
Blattodea					3417	1	1
Blattodea	Blaberidae				1101	1	6
Blattodea	Blaberidae				1115	2	2
Blattodea	Blaberidae				148	2	2
Blattodea	Blaberidae	Diplopterinae	Calolampra		147	6	8
Blattodea	Blaberidae	Epilamprinae	Laxta		2597	1	1
Blattodea	Blaberidae	Epilamprinae	Laxta		27	11	31
Blattodea	Blattelidae				926	2	2
Blattodea	Blattelidae				190	1	1
Blattodea	Blattellidae	Parcoblattini	Neotemnopteryx		591	1	1
Blattodea	Blattellidae	Parcoblattini	Neotemnopteryx		120	1	1
Blattodea	Blattidae				878	3	5
Blattodea	Blattidae				1559	1	1
Blattodea	Blattidae				2701	1	1
Blattodea	Blattidae				2970	1	2
Blattodea	Blattidae				3016	2	3
Blattodea	Blattidae				3151	2	2
Blattodea	Blattidae				3152	1	1
Blattodea	Blattidae				525	6	9
Blattodea	Blattidae	Polyzosteriinae	Platyzosteria		874	1	1
Blattodea	Blattidae	Polyzosteriinae	Platyzosteria		899	8	11
Blattodea	Blattidae	Polyzosteriinae	Platyzosteria		905	1	1
Blattodea	Blattidae	Polyzosteriinae	Platyzosteria		968	1	1
Blattodea	Blattidae	Polyzosteriinae	Platyzosteria		1474	1	1
Blattodea	Blattidae	Polyzosteriinae	Polyzosteria		592	1	2
Blattodea	Blattidae	Polyzosteriinae	Polyzosteria		2003	1	1
Chilopoda					2513	1	1
Chilopoda					3385	1	1
Chilopoda					3406	2	3
Chilopoda					3410	1	1
Chilopoda	Lithobiidae				228	1	1
Chilopoda	Lithobiidae				229	1	1
Chilopoda	Scolopendridae				586	1	1
Chilopoda	Scolopendridae				1767	1	1
Chilopoda	Scolopendridae				1882	4	6
Chilopoda	Scolopendridae				2050	1	1
Chilopoda	Scolopendridae				277	2	2
Chilopoda	Scolopendridae	Otostigminae	Ethmostigmus ?		223	11	16

Order	Family	Tax 3	Genus	Species	Spec ID#	Cap freq	Abund
Coleoptera					3227	2	2
Coleoptera	Carabidae				3419	1	1
Coleoptera	Carabidae				842	7	27
Coleoptera	Carabidae	Broscinae	Promecoderus		253	2	2
Coleoptera	Carabidae	Esydrinae			1442	1	1
Coleoptera	Carabidae	Lebiinae	Philophloeus	eucalypti	956	2	2
Coleoptera	Carabidae	Licininae	Dicrochile ?		914	1	1
Coleoptera	Cerambycidae		Coptocercus		3234	1	1
Coleoptera	Cerambycidae		Pytheus		3396	1	2
Coleoptera	Cerambycidae	Cerambycinae	Uracanthus	triangularis	351	1	1
Coleoptera	Chrysomelidae				3409	1	1
Coleoptera	Chrysomelidae	Chrysomelinae	Paropsisterna		463	1	1
Coleoptera	Cleridae?				3226	1	1
Coleoptera	Curculionidae				911	2	3
Coleoptera	Curculionidae				1110	1	1
Coleoptera	Curculionidae				368	1	1
Coleoptera	Curculionidae	Amycterinae			3395	1	1
Coleoptera	Curculionidae	Amycterinae			3407	1	1
Coleoptera	Curculionidae	Amycterinae	Acantholophus		869	1	3
Coleoptera	Curculionidae	Amycterinae	Acantholophus		1352	2	5
Coleoptera	Curculionidae	Amycterinae	Acantholophus		1486	1	1
Coleoptera	Curculionidae	Amycterinae	Acantholophus		1523	1	1
Coleoptera	Curculionidae	Amycterinae	Aedriodes	Mendosus?	744	1	1
Coleoptera	Curculionidae	Amycterinae	Aedroides?		3366	2	2
Coleoptera	Curculionidae	Amycterinae	Cucullothorax	horridus	1571	4	4
Coleoptera	Curculionidae	Amycterinae	Talaurinus		910	1	1
Coleoptera	Curculionidae	Amycterinae	Talaurinus		817	2	2
Coleoptera	Curculionidae	Aterpinae	Rhinaria ?		209	1	1
Coleoptera	Curculionidae	Entiminae	Mandalotus ?		2479	1	1
Coleoptera	Curculionidae	Gonipterinae	Oxyops	fasciata	161	6	17
Coleoptera	Curculionidae	Gonipterinae	Oxyops	pictipennis	98	3	3
Coleoptera	Curculionidae	Molytinae	Melanotranes	roei	290	4	4
Coleoptera	Curculionidae	Molytinae	Tranes	vigorsii	291	4	9
Coleoptera	Curculionidae	Rhadinosominae	Rhadinosomus	lacordaire	157	1	1
Coleoptera	Dytiscidae	Colymbetinae	Rhantus	suturalis	13	1	4
Coleoptera	Dytiscidae	Lancetinae	Lancetes	lanceolatus	850	1	2
Coleoptera	Dytiscidae	Lancetinae	Lancetes	lanceolatus	651	15	122
Coleoptera	Elateridae	Agrypninae	Chrostus		2186	1	1
Coleoptera	Elateridae	Agrypninae	Chrostyus ?		1121	1	1
Coleoptera	Elateridae	Agrypninae	Conoderus		444	6	12
Coleoptera	Elateridae	Agrypninae	Conoderus		595	1	3
Coleoptera	Elateridae	Agrypninae	Conoderus		1062	2	7
Coleoptera	Elateridae	Agrypninae	Conoderus		1109	7	8
Coleoptera	Elateridae	Agrypninae	Conoderus		1816	1	1
Coleoptera	Elateridae	Agrypninae	Conoderus		1818	2	19
Coleoptera	Elateridae	Agrypninae	Conoderus		2871	1	7
Coleoptera	Elateridae	Agrypninae	Conoderus		135	2	3
Coleoptera	Elateridae	Agrypninae	Drasterius ?		1120	2	2
Coleoptera	Elateridae	Agrypninae	Pseudaeolus		997	3	4
Coleoptera	Geotrupidae		Blackburnium	reichei	3425	1	1
Coleoptera	Gyrinidae		Macrogyrus		440	2	2
Coleoptera	Hydrophilidae				14	25	2824
Coleoptera	Lycidae				3008	1	1
Coleoptera	Scarabaeidae				3418	1	1
Coleoptera	Scarabaeidae		Onthophagus		3218	1	1
Coleoptera	Scarabaeidae	Dynastinae	Cryptodus		1160	2	2

Order	Family	Tax 3	Genus	Species	Spec ID#	Cap freq	Abund
Coleoptera	Scarabaeidae	Dynastinae	Cryptodus		189	4	4
Coleoptera	Scarabaeidae	Dynastinae	Semanopterus		824	1	1
Coleoptera	Scarabaeidae	Dynastinae	Semanopterus		1021	1	1
Coleoptera	Scarabaeidae	Geotrupiinae	Bolborhachium	dacoderum?	2625	1	1
Coleoptera	Scarabaeidae	Melolonthinae			1847	1	1
Coleoptera	Scarabaeidae	Melolonthinae			1926	1	1
Coleoptera	Scarabaeidae	Melolonthinae	Colpochila	antennalis	846	14	31
Coleoptera	Scarabaeidae	Melolonthinae	Colpochila	major	353	1	1
Coleoptera	Scarabaeidae	Melolonthinae	Heteronyx		347	3	5
Coleoptera	Scarabaeidae	Melolonthinae	Heteronyx		363	5	6
Coleoptera	Scarabaeidae	Melolonthinae	Maechidius		287	5	7
Coleoptera	Scarabaeidae	Rutelinae	Clilopocha		1846	1	1
Coleoptera	Scarabaeidae	Scarabaeinae	Onthophagus	ferox	17	1	2
Coleoptera	Silphidae	Silphinae	Ptomaphila		1656	1	1
Coleoptera	Silphidae	Silphinae	Ptomaphila	lacrymosa	924	1	1
Coleoptera	Staphylinidae				628	1	1
Coleoptera	Tenebrionidae	Heleini	Helea	perforata?	1389	1	1
Coleoptera	Tenebrionidae	Lagriinae	Adelium		904	3	4
Coleoptera	Tenebrionidae	Lagriinae	Metriolagria		192	3	3
Coleoptera	Tenebrionidae	Stenochiinae	Oectosis		1307	1	1
Coleoptera	Trogidae		Omorgus		1086	1	1
Dermaptera					1538	2	2
Dermaptera					3408	1	1
Dermaptera					734	1	1
Dermaptera	Anisolabididae				123	1	1
Dermaptera	Anisolabididae				258	1	1
Dermaptera	Anisolabididae	Anisolabidinae			257	1	1
Diplopoda					3020	2	2
Diplopoda					3367	1	1
Diplopoda					3368	1	1
Diplopoda					3378	1	1
Diplopoda					3388	1	3
Diplopoda					3401	5	14
Diplopoda	Julida				966	2	4
Diplopoda	Julida				260	7	20
Diptera	Acroceridae				1336	1	1
Diptera	Asilidae				1424	1	2
Diptera	Asilidae				1478	1	1
Diptera	Asilidae				2647	1	1
Diptera	Asilidae				217	1	2
Diptera	Asilidae				312	1	1
Diptera	Asilidae				313	1	3
Diptera	Asilidae				541	1	1
Diptera	Bombylidae				3233	1	1
Diptera	Bombyliidae				719	1	1
Diptera	Calliphoridae				1634	1	1
Diptera	Syrphidae				54	1	1
Diptera	Syrphidae				1421	1	1
Diptera	Tabanidae				126	2	2
Diptera	Tabanidae				466	1	1
Diptera	Tachinidae				3232	1	1
Diptera	Tachinidae				498	1	1
Diptera	Tachinidae				818	1	1
Diptera	Tipulidae				16	8	26
Gastropoda					969	1	1
Gastropoda					3412	1	1

Order	Family	Tax 3	Genus	Species	Spec ID#	Cap freq	Abund
Hemiptera	Cicadidae				916	1	1
Hemiptera	Cicadidae				3424	1	1
Hemiptera	Cicadidae	Tibicininae	Cicadetta	quadricinta?	207	1	1
Hemiptera	Coreidae	Coreinae	Amorbus	bispinus	700	5	12
Hemiptera	Fulgoridae				1090	5	8
Hemiptera	Fulgoridae				764	2	2
Hemiptera	Pentatomidae				599	2	2
Hemiptera	Pentatomidae				962	2	2
Hemiptera	Pentatomidae				251	8	10
Hemiptera	Pentatomidae				670	1	1
Hemiptera	Pentatomidae				680	2	2
Hemiptera	Pentatomidae				105	1	2
Hemiptera	Pentatomidae				513	1	1
Hemiptera	Reduviidae				3369	1	1
Hemiptera	Reduviidae				714	1	2
Hemiptera	Reduviidae				163	1	1
Hemiptera	Reduviidae	Emesinae			433	2	2
Hemiptera	Reduviidae	Emesinae			2065	2	3
Hemiptera	Reduviidae	Harpactorinae			863	2	2
Hemiptera	Reduviidae	Peiratinae?			2049	1	1
Hymenoptera	Anthophoridae				3386	2	3
Hymenoptera	Anthophoridae				203	5	7
Hymenoptera	Apidae		Apis	melifera	52	8	13
Hymenoptera	Braconidae				1258	1	1
Hymenoptera	Braconidae				3411	1	1
Hymenoptera	Colletidae				3383	1	1
Hymenoptera	Colletidae				3433	1	1
Hymenoptera	Formicidae				3382	1	1
Hymenoptera	Formicidae		Camponotus		3324	14	29
Hymenoptera	Formicidae	Formicinae	Camponotus		423	37	62
Hymenoptera	Formicidae	Myrmeciinae	Myrmecia		281	2	2
Hymenoptera	Formicidae	Myrmeciinae	Myrmecia		487	1	1
Hymenoptera	Formicidae	Myrmeciinae	Myrmecia		2046	1	1
Hymenoptera	Formicidae	Myrmeciinae	Myrmecia	vindex	712	2	2
Hymenoptera	Formicidae	Ponerinae	Rhytidoponera		543	14	18
Hymenoptera	Formicidae	Ponerinae	Rhytidoponera		888	11	43
Hymenoptera	Halictidae				3387	1	1
Hymenoptera	Ichneumonidae				1055	1	3
Hymenoptera	Ichneumonidae				1105	1	1
Hymenoptera	Ichneumonidae				1164	1	1
Hymenoptera	Ichneumonnidae				3420	1	1
Hymenoptera	Pergidae	Perginae	Perga		1550	1	1
Hymenoptera	Pompilidae				3374	1	1
Hymenoptera	Pompilidae				3376	1	1
Hymenoptera	Pompilidae				3377	1	1
Hymenoptera	Pompilidae				1017	1	1
Hymenoptera	Pompilidae				584	1	1
Hymenoptera	Tiphiidae				3404	1	1
Hymenoptera	Tiphiidae				3414	1	1
Hymenoptera	Tiphiidae				796	1	1
Hymenoptera	Vespidae	Polistinae	Polistes		2029	1	1
Isopoda					2968	1	1
Isopoda					3380	1	1
Isopoda					3389	1	2
Isopoda					3399	1	1
Isopoda					544	1	1

Order	Family	Tax 3	Genus	Species	Spec ID#	Cap freq	Abund
Isopoda					549	1	1
Isopoda					1305	1	1
Isopoda					1430	3	3
Isopoda					262	2	3
Isopoda					540	1	1
Lepidoptera					63	20	186
Lepidoptera					316	2	3
Lepidoptera					797	2	4
Lepidoptera					849	1	1
Lepidoptera					900	1	4
Lepidoptera					983	1	1
Lepidoptera					1031	1	1
Lepidoptera					1081	2	2
Lepidoptera					1129	1	1
Lepidoptera					1169	1	1
Lepidoptera					1488	2	10
Lepidoptera					1513	1	1
Lepidoptera					1870	1	2
Lepidoptera					2628	1	2
Lepidoptera					2631	1	1
Lepidoptera					2713	1	1
Lepidoptera					2884	1	1
Lepidoptera					2890	5	8
Lepidoptera					3068	1	1
Lepidoptera					3115	1	1
Lepidoptera					3117	1	1
Lepidoptera					3228	1	1
Lepidoptera					3229	1	1
Lepidoptera					3230	1	2
Lepidoptera					3237	1	1
Lepidoptera					3239	1	2
Lepidoptera					3240	1	1
Lepidoptera					3241	1	1
Lepidoptera					3413	1	1
Lepidoptera					3415	1	1
Lepidoptera					3422	1	1
Lepidoptera					3423	1	1
Lepidoptera					3426	10	81
Lepidoptera					3427	3	5
Lepidoptera					3428	4	6
Lepidoptera					3429	1	1
Lepidoptera					3430	1	1
Lepidoptera					3431	1	1
Lepidoptera					3432	1	1
Lepidoptera					3434	1	1
Lepidoptera					3435	1	1
Lepidoptera					3437	2	2
Lepidoptera					3438	1	1
Lepidoptera			the dart		322	9	27
Lepidoptera					48	22	189
Lepidoptera					411	1	1
Lepidoptera					420	2	5
Lepidoptera					428	1	1
Lepidoptera					459	1	1
Lepidoptera					760	1	2
Lepidoptera					657	1	1

Order	Family	Tax 3	Genus	Species	Spec ID#	Cap freq	Abund
Lepidoptera	Anthelidae	Anthelinae	Anthela	canescens	352	1	1
Lepidoptera	Anthelidae	Anthelinae	Anthela	ferruginosa?	457	6	20
Lepidoptera	Arctiidae				6	1	2
Lepidoptera	Arctiidae				44	1	3
Lepidoptera	Arctiidae	Arctiinae	Spilosoma		445	1	1
Lepidoptera	Arctiidae	Arctiinae	Utetheisa	pulchelloides	987	1	1
Lepidoptera	Carthaeidae		Carthaea	saturnioides	1	13	40
Lepidoptera	Depressariidae				324	3	8
Lepidoptera	Depressariidae		Thalamarchella	alveola	141	8	14
Lepidoptera	Gelechioidea	Gelechiidae ?			658	6	17
Lepidoptera	Geometridae				66	2	2
Lepidoptera	Geometridae				77	9	9
Lepidoptera	Geometridae				861	9	16
Lepidoptera	Geometridae				919	1	2
Lepidoptera	Geometridae				923	2	4
Lepidoptera	Geometridae				942	4	5
Lepidoptera	Geometridae				978	1	1
Lepidoptera	Geometridae				986	1	1
Lepidoptera	Geometridae				1030	1	2
Lepidoptera	Geometridae				1034	1	1
Lepidoptera	Geometridae				1155	2	3
Lepidoptera	Geometridae				1503	5	8
Lepidoptera	Geometridae				1516	1	1
Lepidoptera	Geometridae				1831	2	3
Lepidoptera	Geometridae				1876	2	2
Lepidoptera	Geometridae				2633	1	1
Lepidoptera	Geometridae				2925	1	1
Lepidoptera	Geometridae				3225	1	1
Lepidoptera	Geometridae				3416	1	3
Lepidoptera	Geometridae				3421	1	1
Lepidoptera	Geometridae				821	3	5
Lepidoptera	Geometridae				1036	1	1
Lepidoptera	Geometridae				1517	2	3
Lepidoptera	Geometridae		Poecilasthena		2630	1	1
Lepidoptera	Geometridae				417	3	4
Lepidoptera	Geometridae				20	1	1
Lepidoptera	Geometridae				47	1	1
Lepidoptera	Geometridae				61	2	2
Lepidoptera	Geometridae				67	1	1
Lepidoptera	Geometridae				82	1	1
Lepidoptera	Geometridae				86	1	1
Lepidoptera	Geometridae				95	1	1
Lepidoptera	Geometridae				317	1	2
Lepidoptera	Geometridae				318	1	1
Lepidoptera	Geometridae				326	18	38
Lepidoptera	Geometridae				382	1	1
Lepidoptera	Geometridae				395	1	1
Lepidoptera	Geometridae				407	2	2
Lepidoptera	Geometridae				422	1	1
Lepidoptera	Geometridae				434	1	1
Lepidoptera	Geometridae				438	1	2
Lepidoptera	Geometridae				634	1	1
Lepidoptera	Geometridae				638	6	10
Lepidoptera	Geometridae				646	1	2
Lepidoptera	Geometridae				655	2	2
Lepidoptera	Geometridae				691	8	15

Order	Family	Tax 3	Genus	Species	Spec ID#	Cap freq	Abund
Lepidoptera	Geometridae				694	1	1
Lepidoptera	Geometridae				754	1	2
Lepidoptera	Geometridae				757	4	4
Lepidoptera	Geometridae				758	6	15
Lepidoptera	Geometridae				759	1	1
Lepidoptera	Geometridae				24	1	1
Lepidoptera	Geometridae				41	2	2
Lepidoptera	Geometridae				375	1	1
Lepidoptera	Geometridae				389	1	1
Lepidoptera	Geometridae				424	8	25
Lepidoptera	Geometridae				436	15	35
Lepidoptera	Geometridae				451	3	3
Lepidoptera	Geometridae	Ennominae			83	1	1
Lepidoptera	Geometridae	Ennominae	Ectropis ?		23	3	3
Lepidoptera	Geometridae	Ennominae	Pholodes		384	3	3
Lepidoptera	Geometridae	Ennominae	Stibaroma	melanotoxa	858	3	4
Lepidoptera	Geometridae	Ennominae	Thalaina	clara	450	2	3
Lepidoptera	Geometridae	Geometrinae	Chlorocoma		22	13	16
Lepidoptera	Geometridae	Geometrinae	Chlorocoma	dicloraria	19	2	2
Lepidoptera	Geometridae	Geometrinae	Crypsiphona	ocultaria	330	5	6
Lepidoptera	Geometridae	Geometrinae	Heliomystis		663	1	1
Lepidoptera	Geometridae	Geometrinae	Prasinocyma		393	4	6
Lepidoptera	Geometridae	Larentiina	Xanthorhoe		455	2	3
Lepidoptera	Geometridae	Larentiinae			1029	1	1
Lepidoptera	Geometridae	Oenochrominae			72	8	12
Lepidoptera	Geometridae	Oenochrominae	Arcina	fulgorigera	631	7	25
Lepidoptera	Geometridae	Oenochrominae	Arhodia		2	7	9
Lepidoptera	Geometridae	Oenochrominae	Arhodia		79	2	2
Lepidoptera	Geometridae	Oenochrominae	Arhodia		320	9	43
Lepidoptera	Geometridae	Oenochrominae	Arhodia		820	1	6
Lepidoptera	Geometridae	Oenochrominae	Hypographa	aristarcha	1171	1	2
Lepidoptera	Geometridae	Oenochrominae	Lissomma	serpentaria	832	1	3
Lepidoptera	Geometridae	Oenochrominae	Oenochroma		31	3	3
Lepidoptera	Geometridae	Oenochrominae	Oenochroma	cerasiplaga	59	3	3
Lepidoptera	Geometridae ?				862	1	1
Lepidoptera	Geometridae ?				896	1	1
Lepidoptera	Geometridae ?				1056	1	1
Lepidoptera	Geometridae ?				2635	1	1
Lepidoptera	Geometridae ?				441	2	6
Lepidoptera	Geometridae ?				652	2	3
Lepidoptera	Geometridae ?				753	2	2
Lepidoptera	Hepialidae		Abantiades		761	1	1
Lepidoptera	Lasiocampidae				1657	1	1
Lepidoptera	Lasiocampidae				1832	1	1
Lepidoptera	Lasiocampidae				380	1	1
Lepidoptera	Lasiocampidae	Lasiocampinae	Entometa		426	1	1
Lepidoptera	Lasiocampidae	Lasiocampinae	Entometa	fervens	371	1	1
Lepidoptera	Lasiocampidae	Lasiocampinae	Porela?		749	4	22
Lepidoptera	Limacodidae				3235	1	1
Lepidoptera	Limacodidae		Doratifera		398	2	2
Lepidoptera	Noctuidae				556	1	1
Lepidoptera	Noctuidae				656	4	5
Lepidoptera	Noctuidae				1501	1	1
Lepidoptera	Noctuidae				1502	1	1
Lepidoptera	Noctuidae				1872	1	1
Lepidoptera	Noctuidae				2156	1	1

Order	Family	Tax 3	Genus	Species	Spec ID#	Cap freq	Abund
Lepidoptera	Noctuidae				2641	1	1
Lepidoptera	Noctuidae				2887	1	1
Lepidoptera	Noctuidae				2895	1	1
Lepidoptera	Noctuidae				345	1	1
Lepidoptera	Noctuidae				449	5	6
Lepidoptera	Noctuidae				25	5	7
Lepidoptera	Noctuidae				38	3	4
Lepidoptera	Noctuidae				133	1	1
Lepidoptera	Noctuidae				140	2	6
Lepidoptera	Noctuidae				383	1	1
Lepidoptera	Noctuidae				386	2	2
Lepidoptera	Noctuidae				391	2	5
Lepidoptera	Noctuidae				454	2	2
Lepidoptera	Noctuidae				642	1	1
Lepidoptera	Noctuidae	Amphipyrinae			523	3	3
Lepidoptera	Noctuidae	Amphipyrinae			414	1	1
Lepidoptera	Noctuidae	Amphipyrinae	Proteuxoa	pissonephra	39	15	117
Lepidoptera	Noctuidae	Amphipyrinae	Proteuxoa?		2752	1	1
Lepidoptera	Noctuidae	Catocalinae	Lyncestis	melanoschista	415	1	2
Lepidoptera	Noctuidae	Catocalinae	Pantydia		5	19	56
Lepidoptera	Noctuidae	Catocalinae	Pantydia		388	1	1
Lepidoptera	Noctuidae	Catocalinae	Pantydia		329	1	1
Lepidoptera	Noctuidae	Hadeninae	Persectania	ewingii	40	4	4
Lepidoptera	Noctuidae	Hypeninae	Sandava	scitisigna	43	5	5
Lepidoptera	Noctuidae	Noctuinae	Agrotis	munda	18	4	5
Lepidoptera	Noctuidae	Plusiinae	Chrysodeixis	argentifera	659	2	2
Lepidoptera	Noctuidae ?				766	1	1
Lepidoptera	Notodontidae				76	1	1
Lepidoptera	Notodontidae		Destolmia		4	13	22
Lepidoptera	Notodontidae				80	3	3
Lepidoptera	Notodontidae				374	1	1
Lepidoptera	Notodontidae		Sorama	bicolor	370	3	3
Lepidoptera	Oecophoridae				1840	1	4
Lepidoptera	Oecophoridae				1903	1	4
Lepidoptera	Oecophoridae				104	3	9
Lepidoptera	Oecophoridae				396	3	12
Lepidoptera	Oecophoridae ?				1626	1	1
Lepidoptera	Oecophoridae?				62	16	39
Lepidoptera	Pyralidae				333	7	20
Lepidoptera	Pyralidae				1051	16	66
Lepidoptera	Pyralidae				2901	1	1
Lepidoptera	Pyralidae				342	4	6
Lepidoptera	Pyralidae				397	1	1
Lepidoptera	Pyralidae	Crambinae	Hednota	recurvella	922	3	5
Lepidoptera	Pyralidae	Epipaschiinae			460	2	2
Lepidoptera	Pyralidae	Epipaschiinae ?			73	13	28
Lepidoptera	Pyralidae	Epipaschiinae ?			74	1	1
Lepidoptera	Pyralidae	Pyraustinae	Uresiphita	ornithopteralis	84	5	13
Lepidoptera	Pyralidae ?				837	3	4
Lepidoptera	Pyralidae ?				957	1	1
Lepidoptera	Pyralidae ?				661	4	4
Lepidoptera	Pyralidae?				3400	1	2
Lepidoptera	Thaumetopoeidae				32	3	5
Lepidoptera	Thaumetopoeidae		Ochrogaster		10	12	57
Lepidoptera	Thaumetopoeidae		Epicoma	melanostica	3	3	3
Lepidoptera	Thaumetopoeidae		Ochrogaster		7	3	5

Order	Family	Tax 3	Genus	Species	Spec ID#	Cap freq	Abund
Lepidoptera	Thaumetopoeidae ?				1084	1	1
Lepidoptera	Thaumetopoeidae ?				864	7	9
Lepidoptera	Tineidae		Moerarchis	clathrella	319	8	22
Lepidoptera	Tortricidae				92	2	9
Lepidoptera	unidentifiable		unidentifiable	unidentifiable	1172	21	163
Lepidoptera	Zygaenidae		Pollanisus		78	13	314
Lepidoptera	Zygaenidae		Pollanisus	cupreus	45	5	35
Mantodea	Amorphoscelidae	Paraoxypilinae			132	4	16
Mantodea	Mantidae				674	1	2
Mantodea	Mantidae				718	2	2
Mantodea	Mantidae				784	1	1
Mantodea	Mantidae	Mantinae			981	1	1
Mantodea	Mantidae	Mantinae			1001	2	3
Mecoptera	Bittacidae		Harpobittacus	phaeoscius	250	3	4
Mecoptera	Meropeidae		Austromerope	poultoni	89	1	1
Mygalomorphae					3156	1	1
Mygalomorphae					3365	1	1
Mygalomorphae					3381	1	1
Mygalomorphae					3403	1	1
Mygalomorphae	Nemesiidae				3162	9	9
Mygalomorphae	Nemesiidae				3371	1	1
Mygalomorphae	Nemesiidae				1401	1	1
Mygalomorphae	Nemesiidae				1560	2	2
Mygalomorphae	Nemesiidae		Chenistonia		581	4	4
Mygalomorphae	Nemesiidae				283	1	1
Mygalomorphae	Nemesiidae		Chenistonia		721	1	1
Neuroptera	Chrysopidae				2730	1	1
Neuroptera	Chrysopidae				2054	1	1
Neuroptera	Chrysopidae		Chrysopa		822	1	1
Neuroptera	Myrmeleontidae				400	1	1
Neuroptera	Myrmeleontidae?				3402	1	2
Neuroptera	Osmylidae				1938	3	14
Oligochaeta	Megascolecidae				3372	1	1
Orthoptera	Acrididae				1549	1	1
Orthoptera	Acrididae				3136	1	1
Orthoptera	Acrididae				3370	3	3
Orthoptera	Acrididae				3373	1	4
Orthoptera	Acrididae				3375	3	3
Orthoptera	Acrididae				3436	1	1
Orthoptera	Acrididae				738	1	1
Orthoptera	Acrididae				174	1	2
Orthoptera	Acrididae	Catantopinae	Adreppus		868	3	3
Orthoptera	Acrididae	Catantopinae	Cedarinia		890	10	17
Orthoptera	Acrididae	Catantopinae	Cedarinia		690	1	1
Orthoptera	Acrididae	Catantopinae	Coryphistes		231	3	3
Orthoptera	Acrididae	Catantopinae	Ecphantus	quadrilobus? sp nova?	713	3	3
Orthoptera	Acrididae	Catantopinae	Goniaea		871	1	1
Orthoptera	Acrididae	Catantopinae	Goniaea		872	20	36
Orthoptera	Acrididae	Catantopinae	Goniaea		235	6	8
Orthoptera	Acrididae	Catantopinae	Goniaea		256	1	1
Orthoptera	Acrididae	Catantopinae	Goniaea		272	1	1
Orthoptera	Acrididae	Catantopinae	Goniaea	vocans?	255	1	1
Orthoptera	Acrididae	Catantopinae	Goniaoidea		1261	1	2
Orthoptera	Acrididae	Catantopinae	Macrotona		2045	1	1
Orthoptera	Gryllidae				857	2	5

Order	Family	Tax 3	Genus	Species	Spec ID#	Cap freq	Abund
Orthoptera	Gryllidae				3390	1	1
Orthoptera	Gryllidae				608	4	5
Orthoptera	Gryllidae				609	3	3
Orthoptera	Gryllidae				180	2	2
Orthoptera	Pyrgomorphidae				883	1	1
Orthoptera	Stenopalmatidae?				3394	1	1
Orthoptera	Stenopelmatidae				524	1	2
Orthoptera	Stenopelmatidae				1582	1	2
Orthoptera	Stenopelmatidae	Henicinae	Onosandrus		526	3	4
Orthoptera	Tettigoniidae				1426	2	2
Orthoptera	Tettigoniidae				1884	1	1
Orthoptera	Tettigoniidae				2129	1	1
Orthoptera	Tettigoniidae				3189	1	1
Orthoptera	Tettigoniidae				3384	1	1
Orthoptera	Tettigoniidae	Phasmodinae			1080	1	1
Orthoptera	Tettigoniidae	Phasmodinae			1039	1	1
Phasmatodea	Phasmatidae				3392	1	1
Phasmatodea	Phasmatidae	Phasmatinae	Acanthomima	ripheus	3391	1	1
Platyhelminthes	Tricladida				1385	1	1
Platyhelminthes	Tricladida				1568	2	2
Platyhelminthes	Tricladida				521	3	3
Scorpionida					879	5	7
Scorpionida					880	7	11
Scorpionida					1451	2	2
Scorpionida					1600	1	1
Scorpionida					469	1	1
Trichoptera					2447	1	3
Trichoptera					2903	2	5
Trichoptera					2904	2	23
Trichoptera					1042	2	2
Trichoptera					1852	6	11
Trichoptera					144	13	148
Trichoptera					145	2	4
Trichoptera					151	1	1

DIURNAL AND NOCTURNAL BIRDS

G.L.Liddelow, Verna Tunsell and Chris Vellios

Introduction

Perth Hills FORESTCHECK grids were monitored for diurnal birds in the spring of 2009. 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 treatment (external reference, shelterwood and gap release)
- Comparing species richness and abundance between each treatment
- Analysing trends within species between treatments

Monitoring

There are eight FORESTCHECK grids in the Perth Hills District; three external reference grids, three shelterwood and two gap release grids. Diurnal bird census was undertaken on each grid in spring 2009. Both sight and sound were used to identify the birds as per the census technique (area search) outlined in the FORESTCHECK Operating Plan (DEC 2006).

A prescribed burn in spring 2009 in Lesley forest block burnt both the shelterwood (FC26) and gap release (FC25) grids prior to the census. Although the Kennedy gap release (FC22) was also prescribed burnt in spring 2009, the census was undertaken prior to the burn.

Surveys for nocturnal birds were also carried out in spring 2009 and autumn 2010 as outlined the FORESTCHECK Operating Plan (DEC 2006). Surveys are conducted using periods of listening (15 mins), playback (five mins per species) and spotlighting (10 mins) at each grid. The presence of bats and incidental sightings of other animals are also recorded.

Preliminary Results and Discussion

Diurnal birds

A total of 37 species of birds, comprising of 553 individuals, were recorded across all eight grids (Table 1 and Fig. 1). There were 28 species and 190 individuals in the external reference treatment, 26 species and 215 individuals in the shelterwood, and 27 species and 148 individuals in the gap release treatment grids, it must be remembered that there are only two gap release sites.

Fourteen of the 37 species recorded during this survey had 10 or more individuals. The most common bird recorded was the striated pardalote (*Pardalotus striatus*) with 79 records followed by the broad-tailed thornbill (*Acanthiza apicalis)* with 65 records, third was the western gerygone (*Gerygone fusca*) with 54, fourth was the western spinebill (*Acanthorhynchus superciliosus*) 44 records, fifth, the golden whistler (*Pachycephala pectoralis*) 32, sixth was the brown honeyeater (*Lichmera indistincta*) with 26, seventh was the western white-naped honeyeater (*Melithreptus chloropsis*) 25, eight the red wattlebird (*Anthochaera carunculata)*23, ninth the western thornbill (*Acanthiza inornata*) with 19, equal tenth were the grey fantail (*Rhipidura fuliginosa*) and the scarlet robin (*Petroica multicolor*) with 18 records, eleventh was

the twenty-eight parrot (*Barnardius zonarius semitorquatus*) 16, twelfth was the grey shrike-thrush (*Colluricincla harmonica*) with 14, and the last species with more than 10 records was the tree martin (*Hirundo nigricans*) with 18 (Table 1).

The prescribed burning of FC25 and FC26 just prior to the census in 2009 or the wildfire in FC27 in December 2004 did not appear to affect the overall diversity or abundance of birds recorded in these grids (Fig. 1)

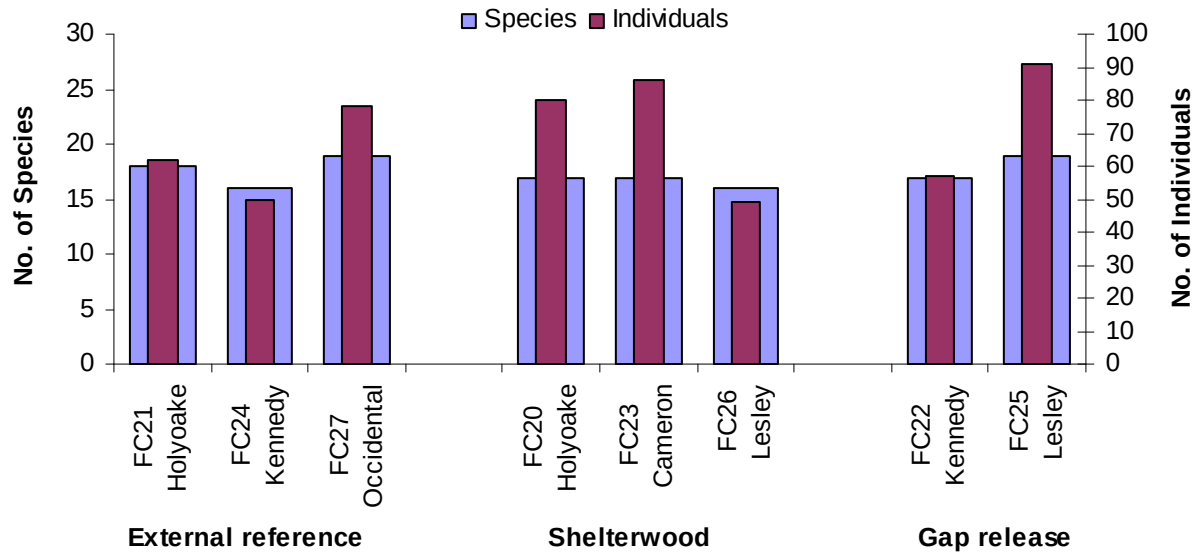


Figure 1. The number of bird species and individuals recorded in each Perth Hills FORESTCHECK grid in 2009.

The density of birds varied little between treatments in 2009 (Fig. 2) with the external reference having 12.7 birds ha^{-1}, the shelterwood had 14.3 ha^{-1} and the gap release had 14.8 ha^{-1}. Over all the treatments the density of birds was 13.8 birds ha^{-1}. The 2008 census at the Wellington sites showed an overall density of 12.9 birds ha^{-1} with the treatments varying from 13.6 ha^{-1} in the external controls, 15.5 birds ha^{-1} in the shelterwood and 9.6 birds ha^{-1} in the gap release. The Kingston Bird Study, which has been following the effects of logging on bird communities in the southern forest since 1996, has bird densities in all treatments varying from 10.4 to 13.4 ha^{-1}.

However, bird densities at Perth Hills increased between 2003 and 2009 (Fig. 2). The external reference increased from 11.1 ha^{-1} to 12.7 ha^{-1}, the shelterwood from 8.9 ha^{-1} to 14.3 ha^{-1} and the gap release from 9.6 ha^{-1} to 14.8 ha^{-1}. Total density increased from 9.9 birds ha^{-1} to 13.8 ha^{-1}. The only species that appears to have taken advantage of the increase in growth and density of the understory since the 2003 census appears to be the broad-tailed (inland) thornbill which increased from 25 records in 2003 to 65 in 2009; the largest change was in the external reference which increased from eight in 2003 to 31 in 2009, the shelterwood numbers for this bird increased from 11 in 2003 to 28 in 2009 and in the gap release they stayed the same at six each year. The group of birds that showed the largest change was the honeyeaters (Table 1); they increased from 54 in 2003 to 123 in 2009 or 128%. They increased in all treatments; the external reference increased from 18 in 2003 to 32 in 2009 (78%), shelterwood from 20 in 2003 to 51 in

Table 1. Bird species and number of individuals recorded in each treatment in the Perth Hills FORESTCHECK grids in 2003 and 2009.

RAOU	Species	Common name	Treatment [1] 2003			Total 2003	Treatment [1] 2009			Total 2009
			ER	SW	GR		ER	SW	GR	
1	*Dromaius novaehollandiae*	Emu						6	1	7
34	*Phaps chalcoptera*	Common Bronze-wing	2			2				
224	*Aquila audax*	Wedge-tailed Eagle			1	1				
259	*Glossopsitta porphyrocephala*	Purple-crowned Lorikeet	1			1				
264	*Calyptorhynchus banksii naso*	Forest Red-tailed Black Cockatoo	7	2	2	11	4	2	1	7
266	*Calyptorhynchus baudinii*	Baudin's Cockatoo		1	1	2				
289	*Platycercus icterotis*	Western Rosella	1		1	2	3	4		7
290	*Platycercus spurius*	Red-capped Parrot	7	4		11	3	2	4	9
294	*Barnardius zonarius semitorquatus*	Twenty-eight Parrot	5	5	1	11	6	3	7	16
322	*Dacelo novaeguineae*	Laughing Kookaburra	1	1		2	1	2	2	5
326	*Todiraphus sanctus*	Sacred Kingfisher			2	2			1	1
329	*Merops ornatus*	Rainbow Bee-eater					2		6	8
338	*Cacomantis flabelliformis*	Fan-tailed Cuckoo					1			1
344	*Chrysococcyx lucidus*	Shining Bronze-Cuckoo	5	2		7	1			1
359	*Hirundo nigricans*	Tree Martin					10		2	12
361	*Rhipidura fuliginosa*	Grey Fantail	10	5	3	18	8	8	2	18
380	*Petroica multicolor*	Scarlet Robin	2	1		3	7	5	6	18
381	*Petroica goodenovii*	Red-capped Robin						1		1
394	*Eopsaltria australis griseogularis*	Western Yellow Robin	6	6	4	16	3	6		9
398	*Pachycephala pectoralis*	Golden Whistler	14	10	4	28	14	11	7	32
401	*Pachycephala rufiventris*	Rufous Whistler	1	2	1	4				
408	*Colluricincla harmonica*	Grey Shrike-thrush	9	5	5	19	6	5	3	14
424	*Coracina novaehollandiae*	Black-faced Cuckoo Shrike		2		2	1	1		2
463	*Gerygone fusca*	Western Gerygone	11	15	10	36	19	22	13	54
465	*Smicrornis brevirostis*	Weebill		1		1				
472	*Acanthiza inornata*	Western Thornbill	6	10	7	23	8		11	19
476	*Acanthiza apicalis*	Broad-tailed (Inland) Thornbill	8	11	6	25	34	25	6	65
488	*Sericornis frontalis*	White-browed Scrubwren	4			4	2	2	2	6
532	*Malurus splendens*	Spendid Fairy-wren	1		1	2		3	6	9
538	*Malurus elegans*	Red-winged Fairy-wren	2			2	7			7
549	*Daphoenositta chrysoptera*	Varied Sittella	5		1	6		6	3	9

Table 1. Continued.....

RAOU	Species	Common name	Treatment [1] 2003			Total 2003	Treatment [1] 2009			Total 2009
			ER	SW	GR		ER	SW	GR	
565	*Pardalotus punctatus*	Spotted Pardalote	4	7	4	15			1	1
574	*Zosterops lateralis lateralis*	Silvereye	5	2	4	11	2	2		4
578	*Melithreptus chloropsis*	Western White-naped Honeyeater	4	5	2	11	7	14	4	25
592	*Acanthorhynchus superciliosus*	Western Spinebill	7	7	8	22	9	13	22	44
597	*Lichmera indistincta*	Brown Honeyeater	1	5	3	9	3	13	10	26
608	*Lichenostomus virescens*	Singing Honeyeater						4		4
631	*Phylidonyris novaehollandiae*	Yellow-winged (New Holland) Honeyeater	2			2	1			1
638	*Anthochaera carunculata*	Red Wattlebird	4	3	3	10	4	15	4	23
651	*Stagonopleura oculata*	Red-eared Firetail	1		1	2				
697	*Sterpera versicolor*	Grey Currawong	4	2	4	10		4	1	5
710	*Anthochaera lunulata*	Western Little Wattlebird	4	2	2	8	1		2	3
794	*Calyptorhynchus latirostris*	Carnaby's Cockatoo			1	1				
930	*Corvus coronoides*	Australian Raven	8	2	4	14			1	1
976	*Pardalotus striatus*	Striated Pardalote	15	15	10	40	23	36	20	79
		Total Individuals	167	133	96	396	190	215	148	553
		Total Species	33	27	28	39	28	26	27	37

[1] RAOU = Royal Australian Ornithology Union number
[2] ER = external reference, SW = shelterwood, GR = gap release

2009 (155%) and the gap release from 16 in 2003 to 38 in 2009 (138%). There were likely plant species flowering that these birds prefer to feed on.

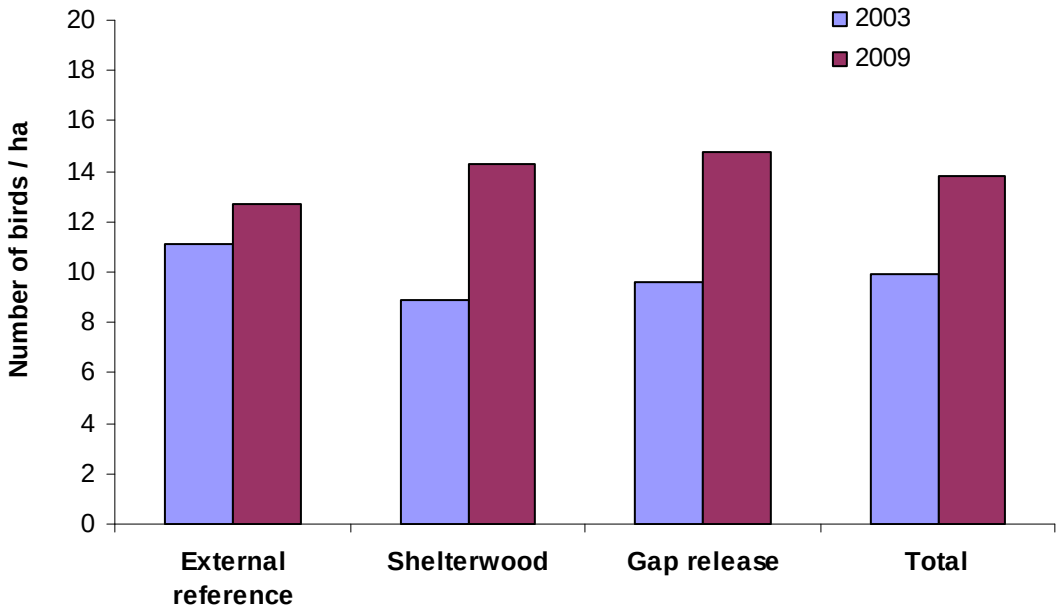


Figure 2. Bird density comparison between sample years and treatments at Perth Hills FORESTCHECK grids.

The striated pardalote was the most commonly recorded species in both censuses, with 40 in 2003 and 79 in 2009. The striated pardalote is an upper canopy leaf gleaning feeder and the greater the area of canopy, the more feeding area there is for this species. Increases occurred in all treatments with the greatest being 127% in the shelterwood, this was followed by the gap release with a 100% increase and finally the external control at 67%.

There were 37 species recorded in 2009 and 39 in 2003 and there were 157 more individuals in 2009 than 2003. There were eight species recorded in 2003 that were not seen in 2009 and there were six species in 2009 not seen in 2003 (Table 1). The eight species extra in 2003 amount to 13 individuals and the six extra in 2009 accounted for 33 individuals, these numbers account for only 0.33 birds ha^{-1} in 2003 and 0.83 ha^{-1} in 2009.

Of the species recorded in one sample year and not the other, over five different days separated by a minimum of seven days, you would expect to see one individual. The eight species from 2003 and the six from 2009 would be expected to be seen in either year. Those species are the emu, common bronzewing pigeon, purple-crowned lorikeet, Baudin's cockatoo, rufous whistler, weebill, red-eared firetail and Carnaby's cockatoo in 2003 and the emu, rainbow bee-eater, fan-tailed cuckoo, tree martin and singing honeyeater in 2009.

The yellow-winged honeyeater was conspicuous by their lack of numbers in both sample years. This species is usually relatively common in forest areas and feeds on nectar and insects associated with flowering plants.

Nocturnal Birds

A total of 63 individuals were seen or heard in spring including16 southern boobook owls *(Ninox novaeseelandiae*), six Australian owlet-nightjars (*Aegotheles cristatus*), seven tawny frogmouth (*Podargus strigoides*) and 33 bats. One brushtail possum (*Trichosurus vulpecula*) was also recorded. In autumn there were 55 individuals recorded including 13 southern boobook owls, three Australian owlet-nightjars, five masked owl (*Tyto novaehollandiae*) and 34 bats.

The distribution of the individuals within treatments in the spring included six southern boobook owls, three nightjars, two frogmouths, 11 bats and one brushtail possum in the external reference, seven southern boobook owls, two owlet-nightjars, four frogmouths and 15 bats in the shelterwood and three boobook owls, one owlet nightjar, seven bats and one frogmouth in the gap release treatments (23, 28 and 12 records respectively) (Fig. 3a).

Autumn counts comprised five southern boobook owls, three owlet nightjar's, three masked owl and 12 bats in the external reference, four southern boobook owls, two masked owls and 13 bats in the shelterwood and four southern boobook owls, and nine bats in the gap release treatments (23, 19 and 13 records respectively) (Fig. 3b).

All three external reference sites had a record of the masked owl in autumn and there were another two of this species recorded in the Lesley shelterwood grid (FC26). This species is not seen or heard often, so it is pleasing to have these records. Masked owls are now most often sighted in close proximity to farmland or open woodland where there is more food available such as the feral rabbit.

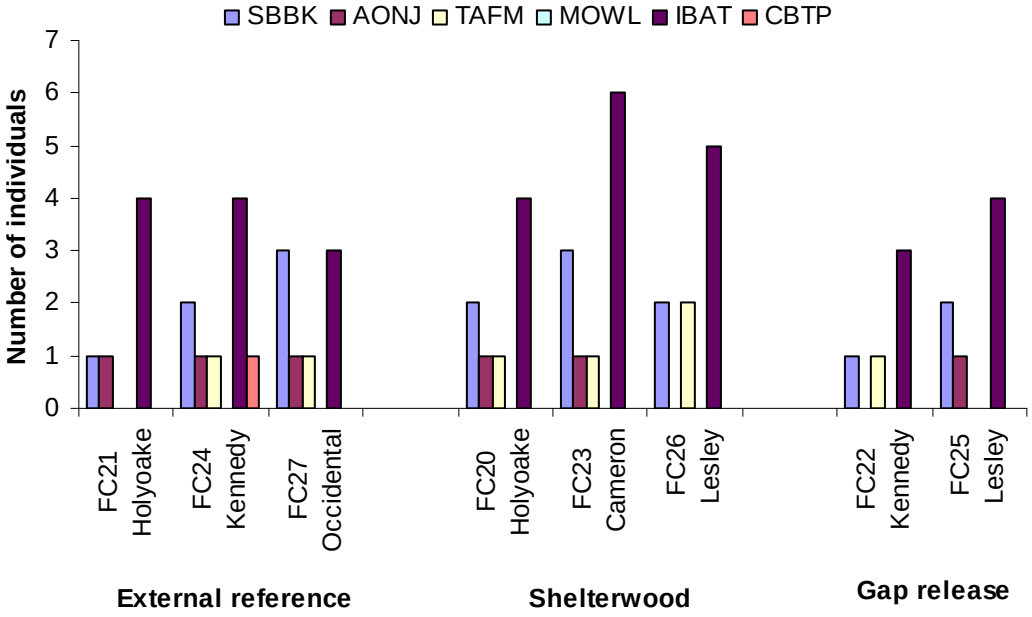
The most common species seen or heard on the 2009-10 surveys was the insectivorous bat which increased from 39 in 2003-04 to 67. Southern boobook owl recordings also increased in number since 2003-04 from 18 to 29. Owlet-nightjars stayed constant between the two sample sessions with eight and nine respectively. Similarly the tawny frogmouth also remained constant with seven each session. The masked owl sightings increased marginally from three in 2003-04 to five in 2009-10 (Table 2).

In treatments, southern boobook owl sightings increased by three, five and three in external reference, shelterwood and gap release respectively from 2003-04 to 2009-10.

Insectivorous bats increased 100% in the gap release from eight in 2003-2004 to 16 in 2009-2010. Similarly in the shelterwood and gap release they increased by 87% and 44% respectively.

Nocturnal bird census will continue throughout FORESTCHECK program. The information gained from these surveys continues to build on the knowledge jarrah forest biodiversity and adds information to the forest-wide survey of nocturnal birds carried out in the south-west in 1999-2000 (Liddelow *et al.* 2002).

(a) Spring



(b) Autumn

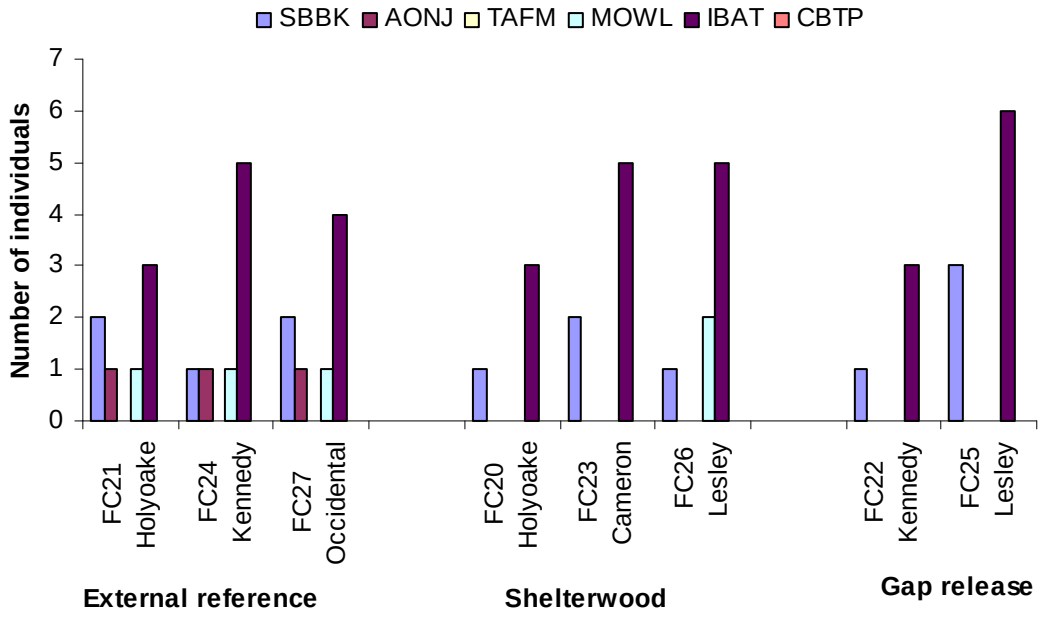


Figure 3. The number of nocturnal birds and other animals recorded in (a) spring and (b) autumn during night-time surveys at the Perth Hills FORESTCHECK grids in 2009-10. SBBK = southern boobook owl, AONJ = Australian owlet-nightjar, TAFM = tawny frogmouth, MOWL = masked owl, IBAT = insectivorous bat, CBTP = common brush tailed possum.

Table 2. Nocturnal birds and incidental sightings of other animals recorded in night-time surveys in the Perth Hills FORESTCHECK grids in 2003-04 and 2009-10.

Species (common name)	2003-04				2009-10			
	ER	SW	GR	**Total**	ER	SW	GR	**Total**
Australian owlet-nightjar	3	4	1	**8**	6	2	1	**9**
Masked owl	1	2		**3**	3	2		**5**
Southern boobook	8	6	4	**18**	11	11	7	**29**
Tawny frogmouth	3	1	3	**7**	2	4	1	**7**
Insectivorous bats	16	15	8	**39**	23	28	16	**67**
Brushtail possum	1	1		**2**	1			**1**
Chuditch	1	1		**2**				
Total	36	30	16	**79**	46	47	25	**118**

Conclusions

Bird species composition and abundances change continuously as the understory density and fuel ages vary. These changes occur in harvested areas as the vegetation structure changes over time through crown separation in regrowth trees and understory shrubs, and in uncut forest as structural and successional changes occur in the understory with time since fire. Changes in population also occur with variation in flowering cycles in plant species. Observations in 2009 related to these changes are:

- As a group, honeyeaters increased in number, likely reflecting the flowering cycle in plant species.
- Striated pardalote and western gerygone increased in numbers, likely reflecting the greater leaf area in all areas.
- Scarlet robin increased and western yellow robin decreased. Both prefer the more open understory of the northern jarrah forest and there seems to be no reason why one increased and the other decreased.
- Broad-tailed (inland) thornbill numbers increased in 2009, likely reflecting the increased density of understory plants.

References

DEC 2006. FORESTCHECK Operating Plan. Department of Environment and Conservation, Kensington, Western Australia.

Liddelow, G.L., Wheeler, I.B. and Kavanagh, R.P. 2002. Owls in the southwest forests of Western Australia. In Newton, I., Kavanagh, R., Olsen, J. and Taylor, I (eds) Ecology and Conservation of Owls. CSIRO Publishing, Collingwood, Victoria, pp. 233-241.

MAMMALS AND HERPETOFAUNA

G.L.Liddelow and Verna Tunsell

Introduction

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

- Trapping and recording the suite of medium and small sized mammals, reptiles and amphibians on each FORESTCHECK grid
- Recording the presence of small mammals in nest boxes placed within each grid
- Comparing species richness, abundance, sex ratios and trap percentages between grids and treatments at each location and between FORESTCHECK locations
- Recording the presence of the 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 the treatments of the FORESTCHECK location
- Recording feral animal species and abundance using sand pads placed at regular intervals along pre-determined tracks and roads within each FORESTCHECK location.

Monitoring

Trapping and spotlighting are conducted over a two week period in both spring and autumn as per the Forestcheck Operations Plan (DEC 2006). Briefly on each 2 ha grid, 15 wire cage traps (20 cm x 20 cm x 45 cm) are set-up in a 50 x 50 m grid pattern and 15 20 litre pit fall traps (25 cm diam. x 40 cm deep) are installed in a 20 x 20 m grid pattern. In addition spotlighting surveys are conducted to record macro vertebrates in the vicinity of each monitoring grid. Surveys are conducted by vehicle on two consecutive nights along a 40 km road transect driving at 20 kph from two hours before sunset to 15 minutes after sunset. The road transects cover the general area occupied by all the grids.

Monitoring for 2009-10 was conducted from 9-20 Nov 2009 and from 5-13 May 2010. There were no interruptions to trapping or spotlighting activities due to inclement weather. However, about fifteen percent of the Lesley gap release (FC25) and seventy percent of the Leslie shelterwood (FC26) were burnt in a prescribed burn just prior to the spring trapping session. Similarly the Kennedy gap release(FC22) was totally burnt in spring and was not sampled due to the fire burning at the time of trapping but trapping was conducted the following autumn.

Voucher Specimens

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

Preliminary Results

Trapping

A total of 238 individuals were trapped with 161 animals captured in spring and only 77 in autumn (Table 1and Figs. 1 & 2).

Table 1. The number of animals captured in each treatment, season and trap type at Perth Hills in 2009-10

Species	External reference				Shelterwood				Gap release				Total Spring	Total Autumn	TOTAL 2009-10
	Spring		Autumn		Spring		Autumn		Spring		Autumn				
	Wire	Pit	Wire	Pit	Wire	Pit	Wire	Pit	Wire	Pit	Wire	Pit			
MAMMALS															
Antichinus flavipes			5				1				7			13	**13**
Cercartetus concinnus		2				2		1					4	1	**5**
Dasyurus geoffroii			3		2		2				5		2	10	**12**
Isodon obeselus			1											1	**1**
Phascogale tapoatafa tapoatafa							1							1	**1**
Sminthopsis griseoventor		1				6					1		7	1	**8**
Trichosurus vulpecula	8		19				17						8	36	**44**
REPTILES															
Aprasia pulchella		1				2				3			6		**6**
Cryptoblepharus plagiocephalus		1											1		**1**
Ctentus catenifer						2							2		**2**
Ctenotus labillardieri						7				2			9		**9**
Egernia napoleonis		3				4		1					7	1	**8**
Hemiergis initialis		3											3		**3**
Hemiergis peroni		2				3		2					5	2	**7**
Lerista distinguenda		20				18				3			41		**41**
Lerista elegans										1			1		**1**
Menetia greyii		4		4		2				2		3	8	7	**15**
Morethia lineocellata		5		2		10				5			20	2	**22**
Morethia obscura								1						1	**1**
Pogona minor		1				1							2		**2**
Tiliqua rugosa	4				5								9		**9**
Varanus rosenbergi	1				1								2		**2**
Ramphotyphlops australis		5				5				3			13		**13**
Parasuta nigriceps												1		1	**1**
Psuedonaja affinis afinis					1								1		**1**
AMPHIBIANS															
Crinia georgiana		4				2							6		**6**
Heleioporus eyrei		1								2			3		**3**
AVIANS															
Corvus coronoides	1												1		**1**
TOTAL	14	53	28	6	9	64	21	5	0	21	13	4	161	77	**238**

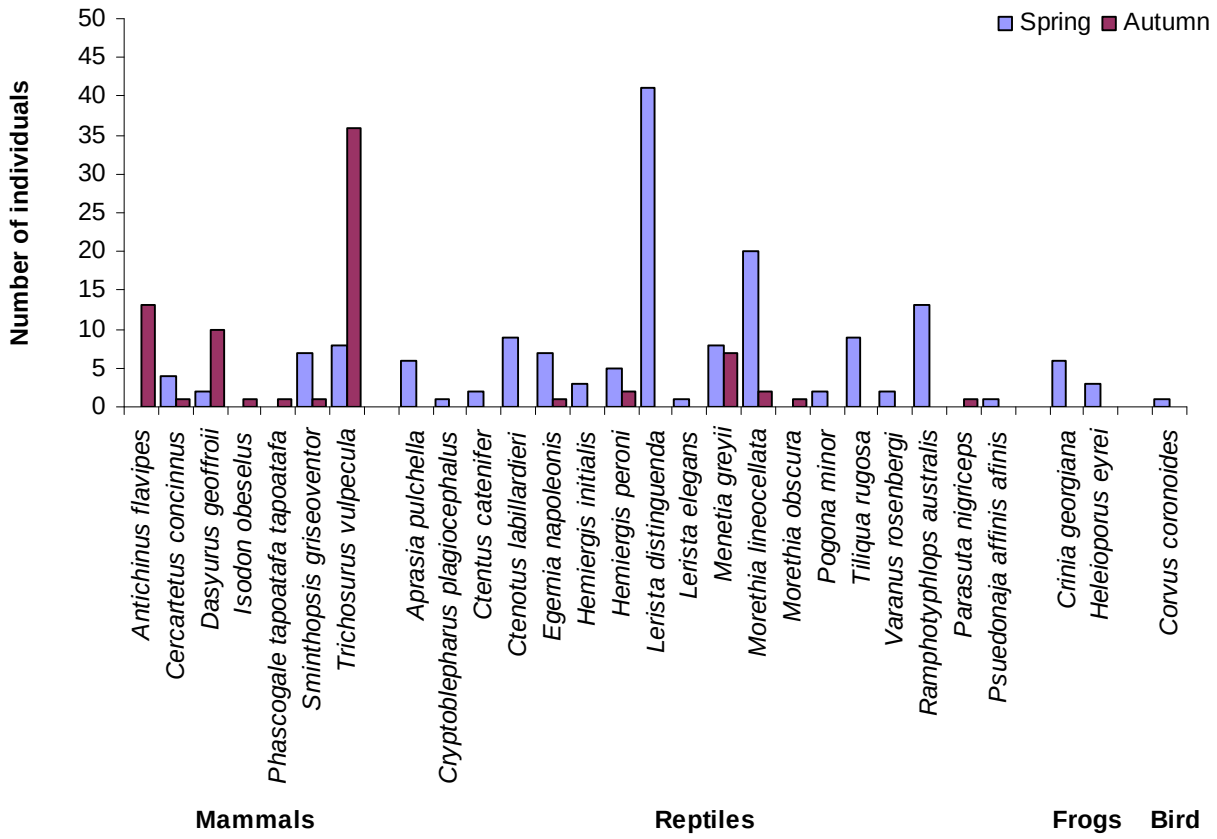


Figure 1. The number of animals captured in spring and autumn on Perth Hills FORESTCHECK grids in 2009-10.

Twenty one mammals, 130 reptiles, 10 amphibians and one bird were trapped in spring and 63 mammals and 14 reptiles trapped in autumn. No amphibians were recorded in autumn. The most common mammal captured was the brush-tailed possum (*Trichosurus vulpecula*) with 44 captures over the two seasons of which 36 occurred in autumn. Twenty-seven were in external reference grids and 17 in shelterwood grids. Thirteen mardos (*Antechinus flavipes*) were captured and all were trapped in autumn; five in the external reference, one in the shelterwood and seven in the gap release grids. Twelve chuditch (*Dasycercus geoffroii*) were captured; two in spring and 10 in autumn. Three were in the external reference, four in the shelterwood and five from the gap release grids. The next most commonly caught animal was the dunnart (*Sminthopsis* sp) with eight captures; seven in spring and one in autumn. Only one was captured in the external reference, six were from the shelterwood and one from the gap release. Five captures for Pygmy possums (*Cercatatus concinnus*) were recorded; four in spring (two each from the external controls and the shelterwood) and one in autumn in the shelterwood. There was also one quenda (*Isoodon obesulus*) in an external reference grid in autumn and one phascogale (*Phascogale tapoatafa*) in a shelterwood grid in autumn.

No feral mammals were captured in the Perth Hills in 2009-10 and notably, only one common rat (*Rattus rattus*) was captured during the 2003-04 session. This is very different to the Wellington grids (FC11-FC19) where 19 and 33 common rats were trapped in 2002-03 and 2008-09 respectively (see Forestcheck report of Progress 2009-09).

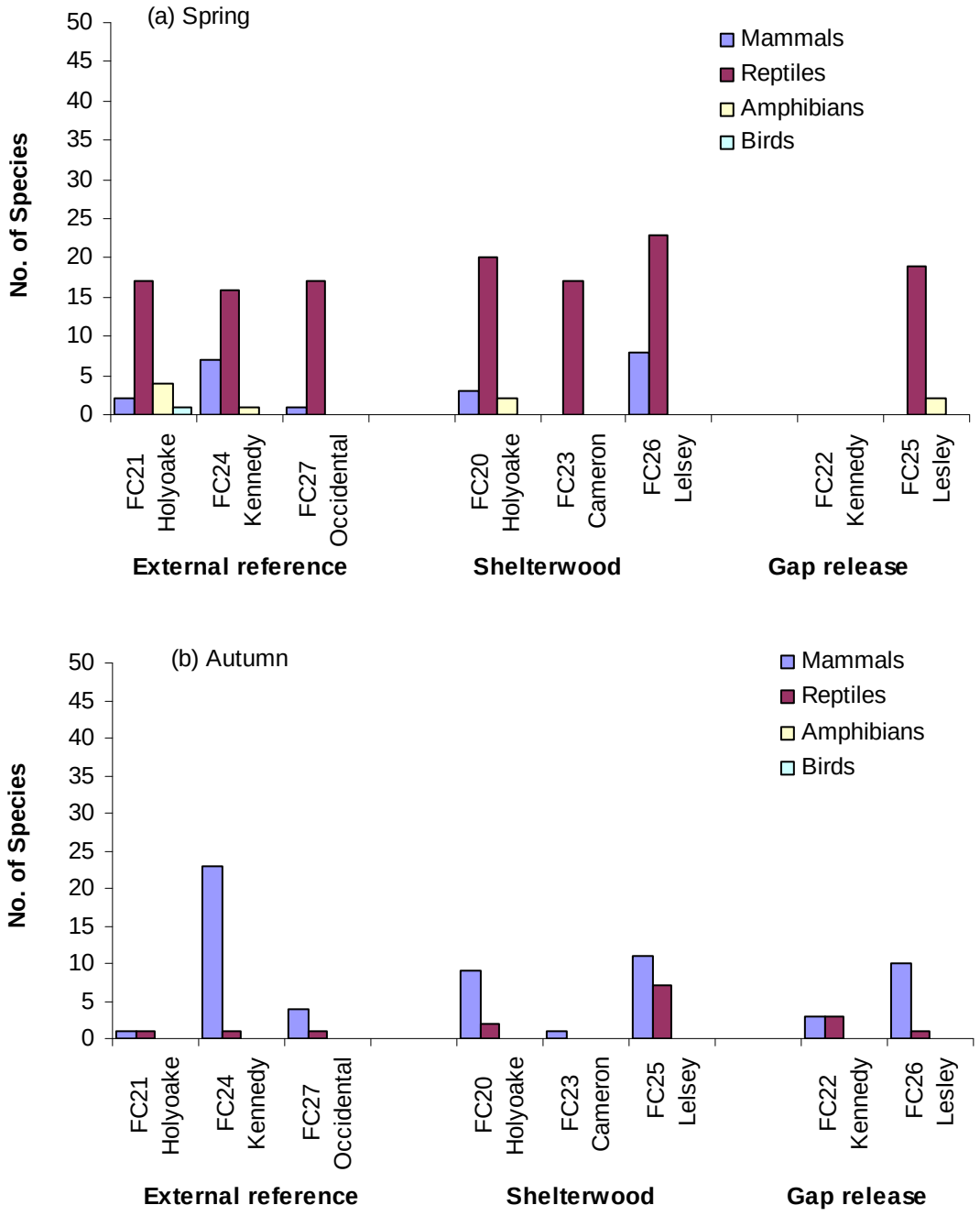


Figure 2. The number of mammals, reptiles and amphibians recorded in traps in spring (a) and autumn (b) on the Perth Hills FORESTCHECK grids.

The vast majority of reptiles were recorded in the spring, with 130 of the 144 captures occurring in this season. The most frequently encountered was *Lerista distinguenda* with 41 captures, all in spring; 20 in the external controls, 18 in shelterwood and only three in gap release grids. Next was *Morethia lineocellata* with 22 captures of which 20 were recorded in spring; 10 in shelterwood and five in gap release. The miniscule *Menetia greyii* was the next most commonly

encounted with 15; eight in the external reference, two in shelterwood and five in the gap release. The blind snake (*Rhamphotyphlops australis*) was also common with 13 captures, all in spring when the litter was moist; five came from the external reference, five from shelterwood areas and three from gap release areas. Only two snakes were caught a dugite (*Psuedonaja affinis affinis*) in spring and a black-backed snake (*Parasuta nigriceps*) in autumn.

Only nine amphibians were captured; six quacking frogs (*Crinia georgiana*) and three moaning frogs (*Heleioporus eyrei*). The same two species were caught in 2003-04 and in both trapping periods they were only caught in spring. Breaking autumn rains, which bring favourable conditions for amphibians, did not occur until late May and unfortunately commitments to other works programs meant that trapping was conducted prior to the seasonal rains.

Comparing trapping methods and seasons (Table 1, Fig. 3); 86 captures were in wire cages and 152 in the pits. There was a total of 101 captures in the external reference (42 wire cage, 59 in pits), 99 in the shelterwood (30 wire cage, 69 in pits) and 38 in the gap release (14 wire cage, 24 in pits) treatments. As mentioned earlier, the Kennedy gap release (FC22) grid was not trapped in spring 2009 due to fire and when it was trapped in May 2010 it was only six months since that fire.

Thirty six percent of the captures (86 of the 238) were in wire cage traps (Table 1, Fig. 3). Pit traps were most successful in spring. However, during the autumn session wire cages were the most successful with 62 of the 77 captures (80.5 %) in these traps. Brush-tailed possums, chuditch and mardos accounted for 59 of the 62 captures in wire traps in autumn.

Pit fall trapping was very successful accounting for 153 of the 238 total captures (64%). Only 12 mammals were trapped in pits and these comprised of two species, the pygmy possum with five captures and the dunnart with seven captures. Four of the five pygmy possums were caught in spring and all seven of the dunnarts were trapped in spring. One hundred and thirty one of the 144 reptiles recorded (91%) were caught in the pit traps. Only nine bobtail goannas, two heath monitors, a dugite and a black-backed snake were trapped in wire cages (Table 1, Fig. 3). No amphibians were caught in autumn in pit traps.

Comparisons of trapping results from 2003-04 and 2009-10 at the Perth Hills FORESTCHECK grids is shown in Table 3. Note that sampling in 2003-04 was conducted over a one week period and in 2009-10 it was conducted over a two week period. The two week trapping session is now the standard for all FORESTCHECK monitoring.

Mammal numbers increased overall from 23 in 2003-03 to 84 in 2009-10. Mardo numbers increased from three in 2003-04 to 13 in 2009-10 with five recorded in the external reference, one in the shelterwood and seven in the gap release treatments. All were caught in autumn in wire cage traps.

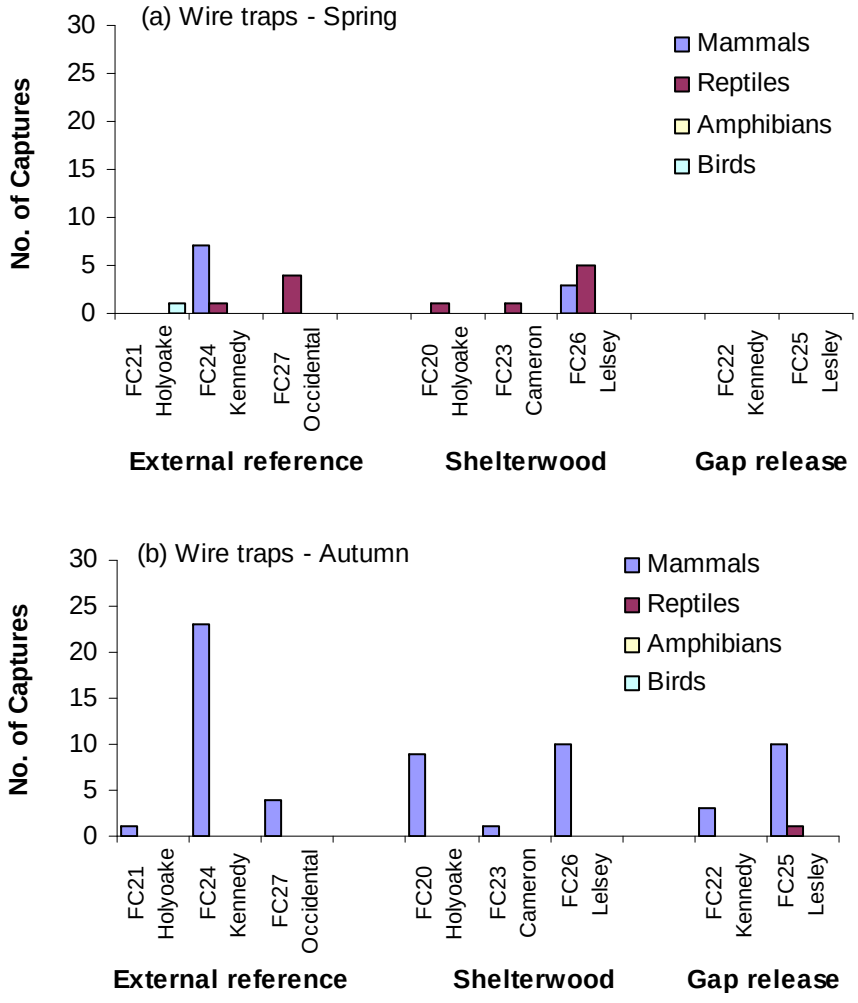
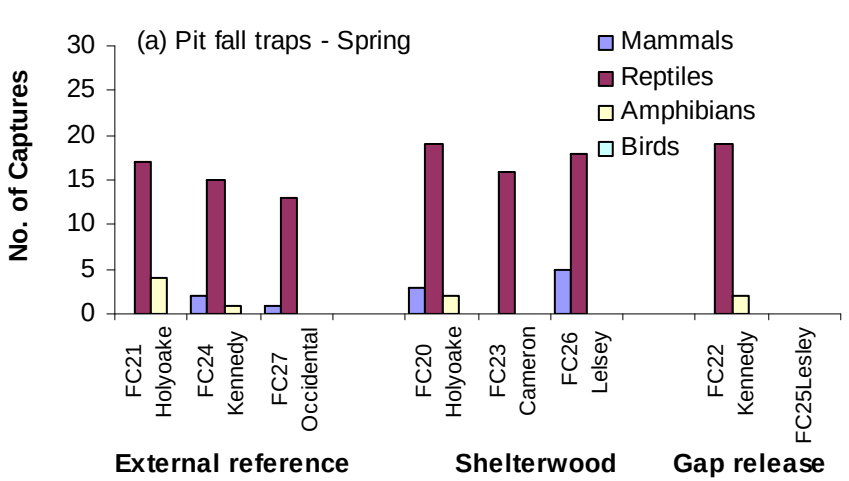


Figure 3. The number of individual mammals, reptiles and amphibians recorded in wire traps in (a) spring and (b) autumn at Perth Hills in 2009-10.



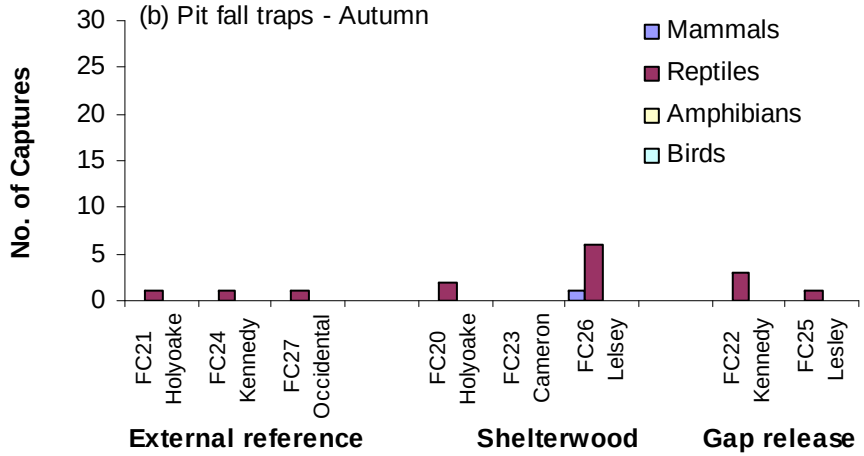


Figure 4. The number of individual mammals, reptiles and amphibians recorded in pit fall traps in (a) spring and (b) autumn at Perth Hills in 2009-10.

Chuditch captures also increased from four in 2003-04 to 12 in 2009-10. Three were trapped in the external reference, four in shelterwood and five in the gap release treatments. Two captures occurred in spring with the remaining ten in autumn.

Brush-tailed possums increased from 10 in 2003-04 to 44 in 2009-10. In 2009-10, 27 captures were in external reference grids and the remaining 17 came from the shelterwood grids of which eight were trapped in spring and 36 in autumn.

In contrast, reptiles were more abundant in 2003-04. In one week of trapping in 2003-04, 177 reptiles were caught, and in 2009-10 with two weeks of trapping 144 were captured. *Lerista distinguenda* had 78 captures in 2003-04 and only 41 in 2009-10 and *Menetia greyii* decreased from 29 to 15. *Morethia sp.* had 22 captures in both trapping sessions, but again the effort was doubled in 2009-10. Blind snakes, however, increased from eight to 13, and the bobtail goanna (*Tiliqua rugosa*) from one capture in 2003-04 to nine in 2009-10.

There were no adverse conditions prior to the trapping sessions in 2009-10. Although prescribed burning was carried on several treatment grids prior to trapping and the Kennedy gap release (FC22) was not trapped in spring, there is no obvious reason to explain why the reptile numbers were down in 2009-10.

In both 2004 and 2010 the season breaking autumn rains did not occur until well after the trapping session was completed which would explain why we no amphibians were recorded in autumn in both trapping years.

Table 3. Comparisons between the 2003-04 and 2009-10 trapping sessions at the Perth Hills grids.

	2003-2004			2009-2010		
Species	**Spring**	**Autumn**	**Total**	**Spring**	**Autumn**	**Total**
MAMMALS						
Antichinus flavipes		3	**3**		13	**13**
Cercartetus concinnus	5		**5**	4	1	**5**
Dasyurus geoffroii		4	**4**	2	10	**12**
Isoodon obesulus					1	**1**
Phascogale tapoatafa tapoatafa					1	**1**
Rattus rattus		1	**1**			
Sminthopsis griseoventor				7	1	**8**
Trichosurus vulpecula	3	7	**10**	8	36	**44**
REPTILES						
Acritoscincus trilineatum	1		**1**			
Aprasia pulchella	6		**6**	6		**6**
Christinus marmoratus	2		**2**			
Cryptoblepharus plagiocephalus				1		**1**
Ctentus catenifer				2		**2**
Ctenotus labillardieri	4		**4**	9		**9**
Diplodactylus polypthalmus	1	2	**3**			
Egernia napoleonis	8		**8**	7	1	**8**
Hemiergis initialis	8		**8**	3		**3**
Hemiergis peroni				5	2	**7**
Lerista distinguenda	67	11	**78**	41		**41**
Lerista elegans				1		**1**
Lialis burtonis	1		**1**			
Menetia greyii	15	14	**29**	8	7	**15**
Morethia lineocellata	8		**8**	20	2	**22**
Morethia obscura	9	4	**13**		1	**1**
Morethia sp.	1		**1**			
Pogona minor	1	3	**4**	2		**2**
Tiliqua rugosa	1		**1**	9		**9**
Varanus rosenbergi	1		**1**	2		**2**
Ramphotyphlops australis	8		**8**	13		**13**
Parasuta gouldii		1	**1**			
Parasuta nigriceps					1	**1**
Psuedonaja affinis afinis				1		**1**
AMPHIBIANS						**0**
Crinia georgiana	4		**4**	6		**6**
Heleioporus eyrei	3		**3**	3		**3**
Heleioporus sp.	2		**2**			
AVIANS						
Corvus coronoides				1		**1**
Total	159	50	**209**	161	77	**238**

Spotlighting

The results of spotlighting surveys are shown in Figure 5; they also include sightings of nocturnal birds. Twenty-three grey kangaroos (*Macropus fuliginosus*) and ten western brush wallabies (*Macropus irma*) were recorded in spring. There were only three grey kangaroos and one western brush wallaby recorded in autumn. One brush-tailed possum was recorded in spring and one in autumn (NB. 44 brush-tailed possums were trapped in 2009-10). One chuditch was seen in spring and none in autumn (NB. 12 were trapped in wire cages). Five tawny frogmouths (*Podargus strigoides*) were recorded; being the only nocturnal bird seen whilst spotlighting. Three feral pigs, (*Sus scrofa*) were recorded; all in Lesley block in spring.

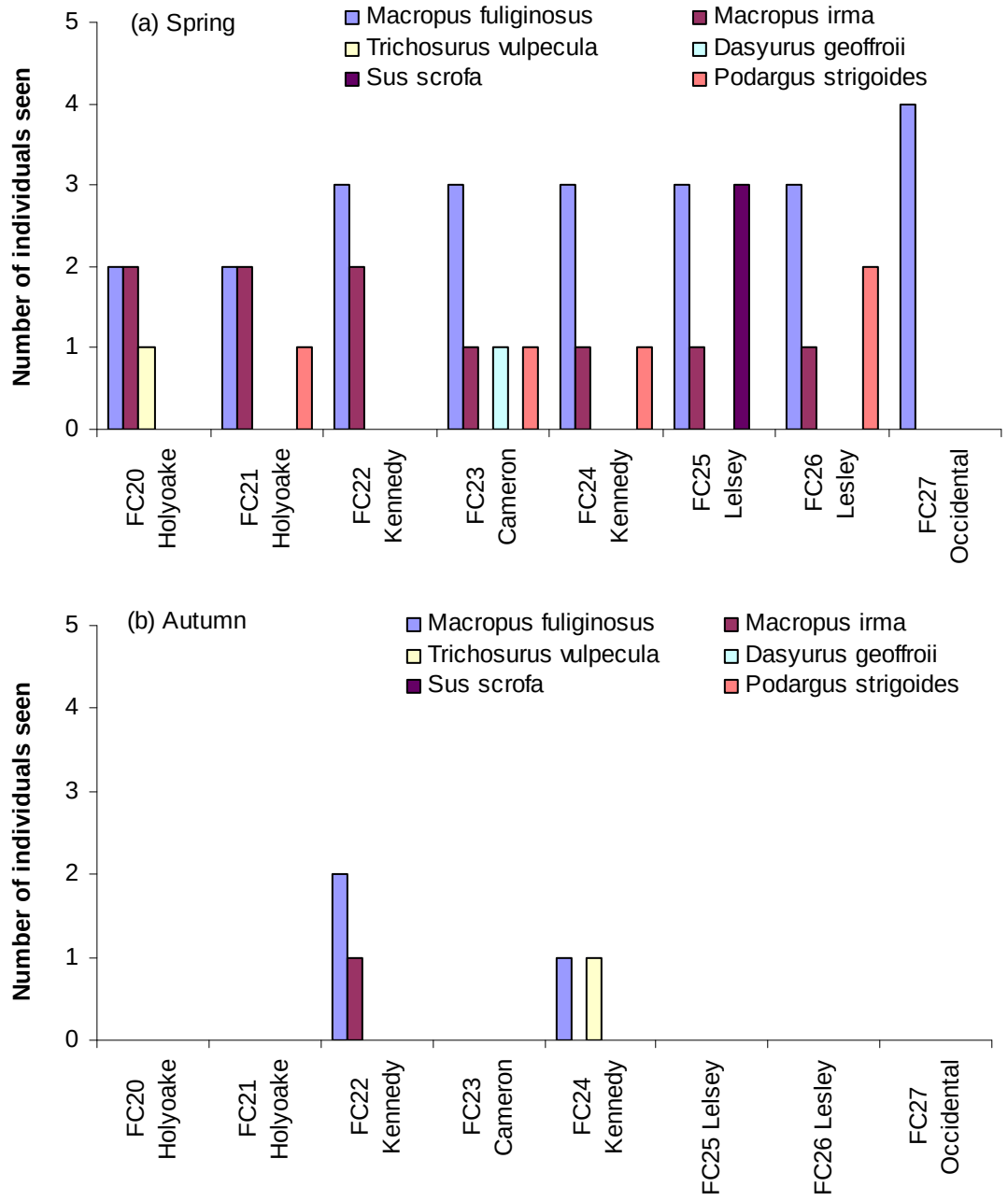
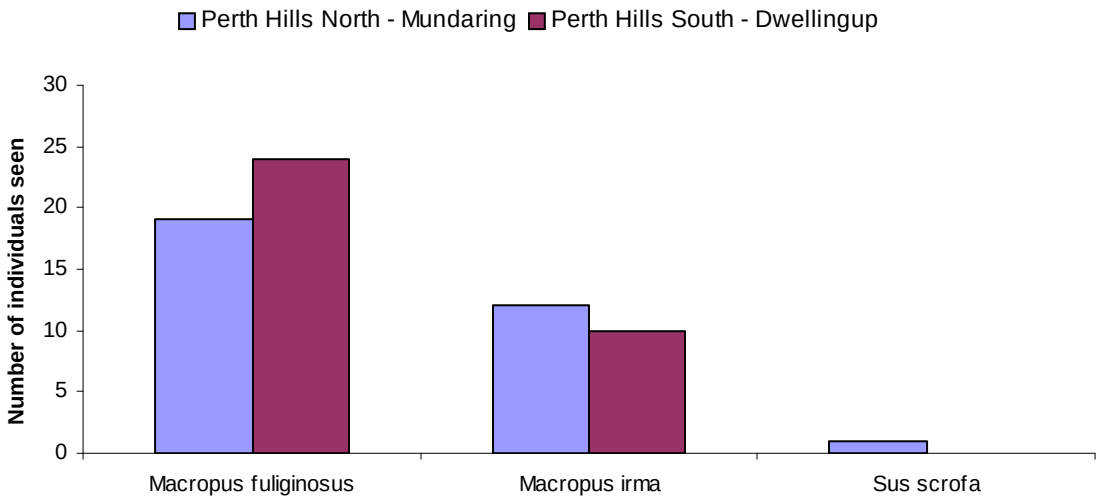


Figure 5. Species recorded in (a) spring and (b) autumn in vicinity of FORESTCHECK grids along spotlight transects in Perth Hills in 2009-10.

Road Transects

In Perth Hills, two 25 km road transects are utilized which cover the extent of the grids established in the northern region (Mundaring) and the southern region (Dwellingup) of the monitoring area. Each transect was driven on two consecutive nights in the spring and autumn. A total of 19 grey kangaroos, 12 brush-tailed wallabies and one feral pig were sighted on the Mundaring transect and 24 grey kangaroos and 10 western brush wallabies on the Dwellingup transect in the spring (Fig. 6a).

(a) Spring



(b) Autumn

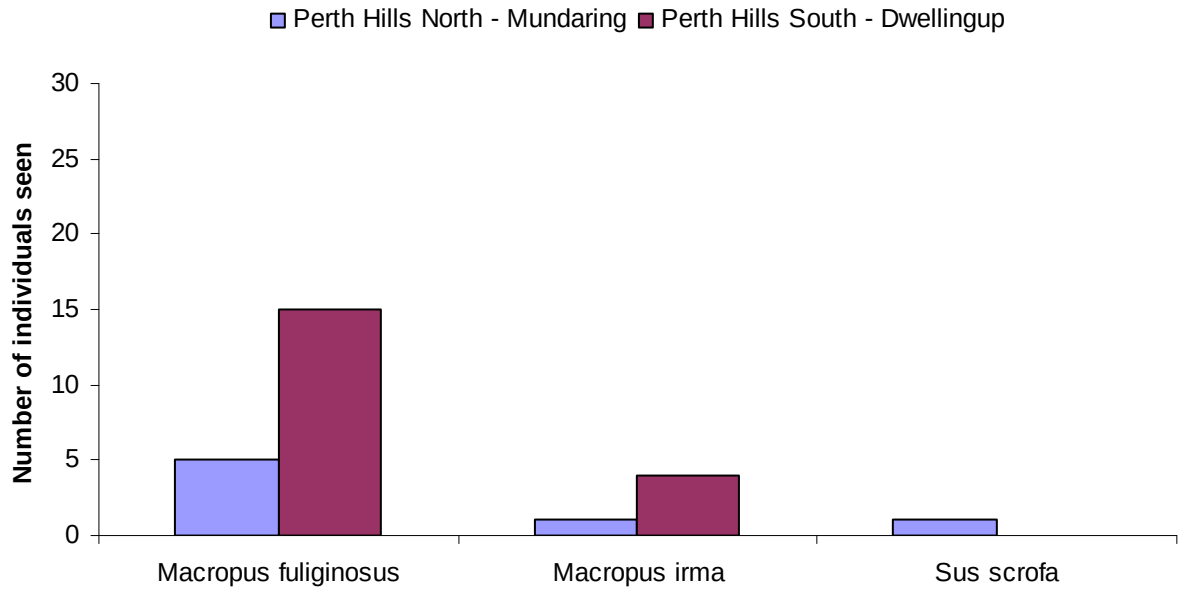


Figure 6. The numbers of macro fauna recorded in (a) spring and (b) autumn road surveys in the Perth Hills in 2009-10.

In autumn there were fewer sightings with five grey kangaroos, one western brush wallaby and a pig recorded on the northern (Mundaring) transect and 15 grey wallabies and four western brush wallabies on the southern (Dwellingup) transect. The total number of native animals recorded would be expected in these areas, but the feral pig numbers do not reflect how common this animal is in the area.

Conclusions

- The effect which extra trapping days in 2009-10 had on comparisons between 2003-04 and 2009-10 data needs to be analyzed further.
- Timing of trapping has not been favourable for capturing amphibians, as autumn rains have been occurring later than would be expected.
- Brush-tailed possums appear to be well established in both external reference and shelterwood treatments but are still absent from gap release treatments.
- Chuditch are well established in both harvested treatments and reference forest.
- Mardo, a species which generally prefers thicker litter in which it hunts for food, was also trapped in gap release grids; including one in the Kennedy gap release only six months after being burnt by intense fire.
- Reptile numbers were generally lower in 2009-10, despite doubling the trapping effort.

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References

DEC 2006. FORESTCHECK Operating Plan. Department of Environment and Conservation, Kensington, Western Australia.

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 DEC 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 (DEC) 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 collections are housed at the Manjimup Insectary. The voucher 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.

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		