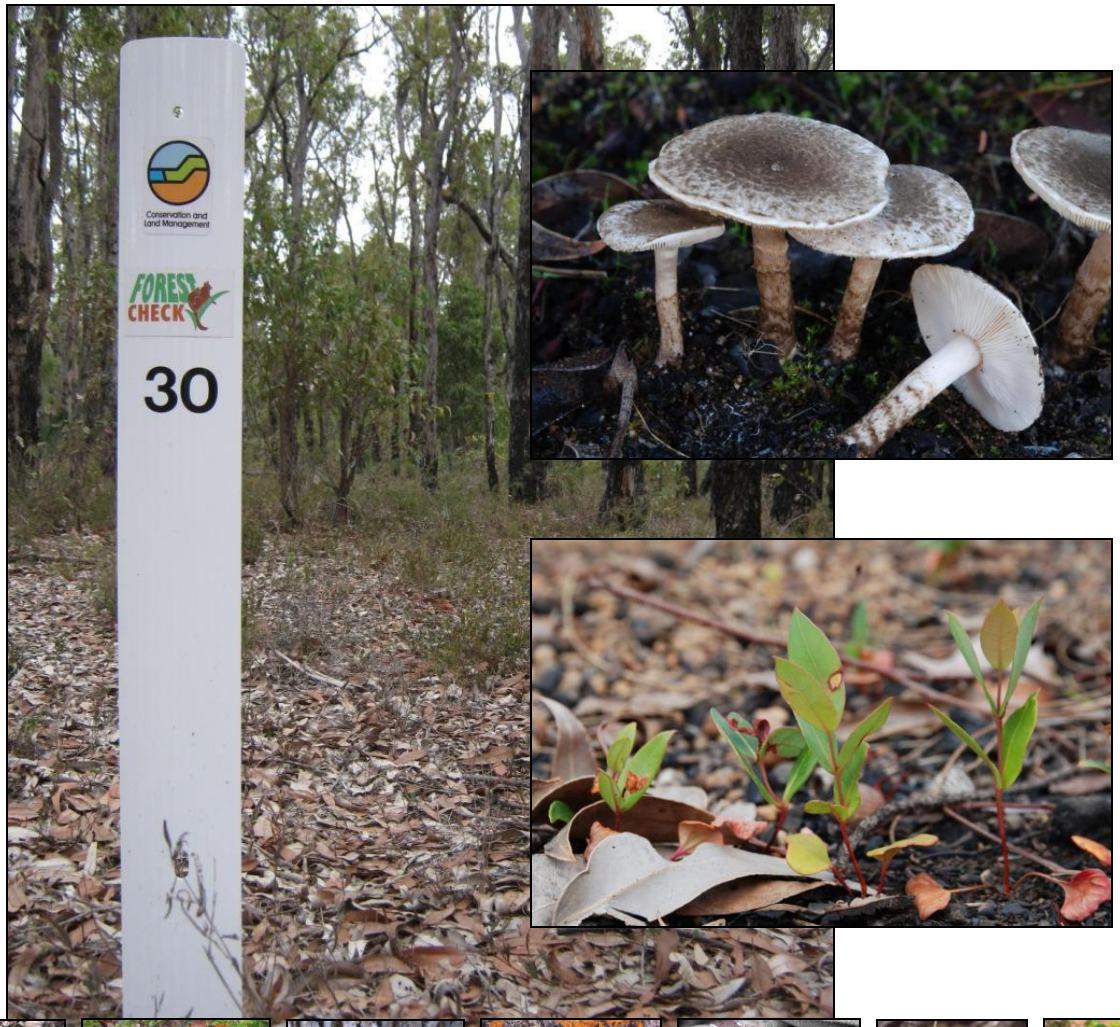
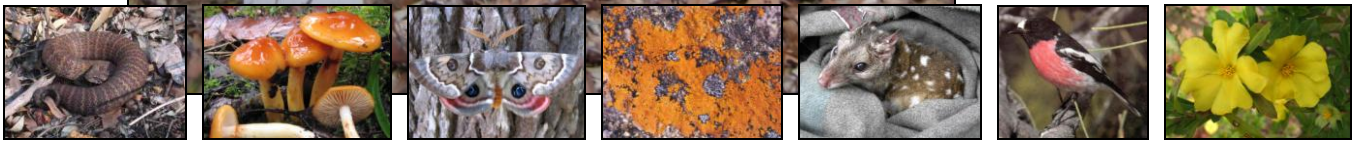
REPORT OF PROGRESS 2010-11

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, April 2012

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This report highlights preliminary results for FORESTCHECK monitoring, determined by basic analysis and field observation, for the year 2010-11. This and previous FORESTCHECK Annual Reports should not be quoted or used as final results for the FORESTCHECK program. Publications based on detailed analyses using comprehensive statistical methods are published on a 5-year basis. All FORESTCHECK publications and reports are available on the DEC web site at www.dec.wa.gov.au .

Cover photos: *Main photo*: Roadside location marker for FORESTCHECK grid in Godfrey forest block, *above right*: an undescribed species of *Lepiota* recorded in Bell block and *below right*: germination of jarrah (*Eucalyptus marginata*) seedlings was prolific 6 months after a prescribed burn in the Stockyard shelterwood grid (photos: R. Robinson).

TABLE OF CONTENTS

EXECUTIVE 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 ten Wellington East monitoring grids located in jarrah forest northeast of Collie. These grids were initially established in 2004 and monitored in 2004-05. 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 at Wellington East are located in State forest, National park or conservation parks in Dwellingup 4 vegetation complexes within the jarrah north-east ecosystem. Harvested sites were matched to 1996, 1998 and 2000 harvest activities. The range of time since the last fire was 2-8 years, except for one reference grid that was 23 years. Since the initial monitoring sessions in 2004-05, the three grids in stockyard block (FC32 external reference, FC33 shelterwood and FC 34 gap release) had a prescribe burn in spring 2008. The three Bell block grids (FC35 external reference, FC36 shelterwood and FC37 gap release) were burnt by wildfire in December 2005, between the spring and autumn sample sessions of 2004-05. At all grids, forest attributes including forest structure, regeneration stocking and litter loads were measured and species richness and abundances of macrofungi, cryptogams (lichens and bryophytes), invertebrates, terrestrial vertebrates and vascular plants were recorded. In 2010-11 the leaf area index of all 48 grids was also measured.

Knowledge regarding jarrah forest biodiversity and ecology continues to increase as the second round of FORESTCHECK monitoring proceeds. It is also noteworthy that monitoring at Wellington East took place following the driest 18 month period on record from August 2009 through to the end of 2010. During the late summer and autumn of 2011, jarrah forest on the Darling escarpment showed symptoms of severe drought stress with mortality of overstorey and mid-storey trees at scales of tens of hectares. Data collected from FORESTCHECK grids are therefore 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.

While the results presented here are from a preliminary analysis, highlights from the 2010-11 results and observations from comparisons with data from the same grids in 2004-05 include:

- Mean annual increments for shelterwood grids in Wellington East ranged from 0.30-1.16 m^2 ha^{-1} yr^{-1} and were similar to those reported for shelterwood grids in Donnelly (jarrah south ecosystem), Wellington 1 (jarrah north ecosystem) and Perth Hills (jarrah north west ecosystem);
- Seedling recruitment at the Stockyard shelterwood grid (FC33) following the 2008 prescribed fire is a significant finding because it demonstrates that the opportunity for recruitment remains open for at least a decade following silvicultural treatment;
- Small wood and twig loads were greater on all grids except the Stockyard shelterwood (FC33) compared to 2005 and may be due to accelerated small branch shedding following the long dry period from 2009-11;
- Leaf area index varied substantially across the FORESTCHECK grids and these variations appear to be independent of the treatments, or largely driven by other factors;
- Across all FORESTCHECK grids, leaf area index was reduced in 2011 compared to 2010;
- Macrofungal species richness was the same at Wellington east in 2011 (240 spp.) and 2005 (241 spp.). However, there was a large species turnover with only 130 species recorded in both sample years.

- The number of lichens recorded in 2010 was markedly lower (43% less) than in 2005;
- Lichen species richness was lowest on all the recently burnt grids in Stockyard block, regardless of treatment;
- Species richness and abundance of plants was lower than in 2004, which is most likely due to an excessively dry year in 2010;
- A large turn over of plant species occurred between 2004 and 2010 and was possibly due to successional trends following fire associated with six of the grids since 2004;
- A decrease in the diversity of invertebrates in 2010-11 indicates a dryer environment compared to that during the 2004-05 sample;
- Forty seven percent of invertebrate species recorded in 2010-11 were not recorded in 2004-05;
- There is little overall evidence of an effect due to silvicultural treatments on invertebrates;
- In 2010, numbers of individual honeyeaters and mid-storey feeders such as golden whistler and grey shrike thrush were greater than in 2004, but scarlet and western yellow robins decreased, reflecting changes in understory densities following fire;
- Captures of woylies were dramatically lower than in 2004-05 which coincides with a general decline of woylies across their range.
- Common brushtail possum captures were also lower than in 2004-05, but the reason for their decrease in abundance at Wellington East is uncertain as reduced numbers have not been observed at other FORESTCHECK locations; and
- Numbers of mardo in harvested grids had increased markedly at Wellington East compared to 2004-05.

The FORESTCHECK team is to be commended for their commitment to the project. In 2011-12 monitoring is being conducted in grids established in 2005 in the Blackwood Plateau in the Blackwood district and initially monitored in 2005-06.

Margaret Byrne

Dr Margaret Byrne
A/Director, Science Division

May 2012

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 eastern jarrah forest in the Wellington District during the 2010-11 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 2 yrs 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, but retaining sufficient overstorey to provide a seed source and maintain

[1] Codd, M. (1999) Forest management Plan 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.

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(Anon. 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 4 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. A range of ecosystem attributes are monitored on each grid including:

1. Forest structure and regeneration stocking
2. Foliar and soil nutrients

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

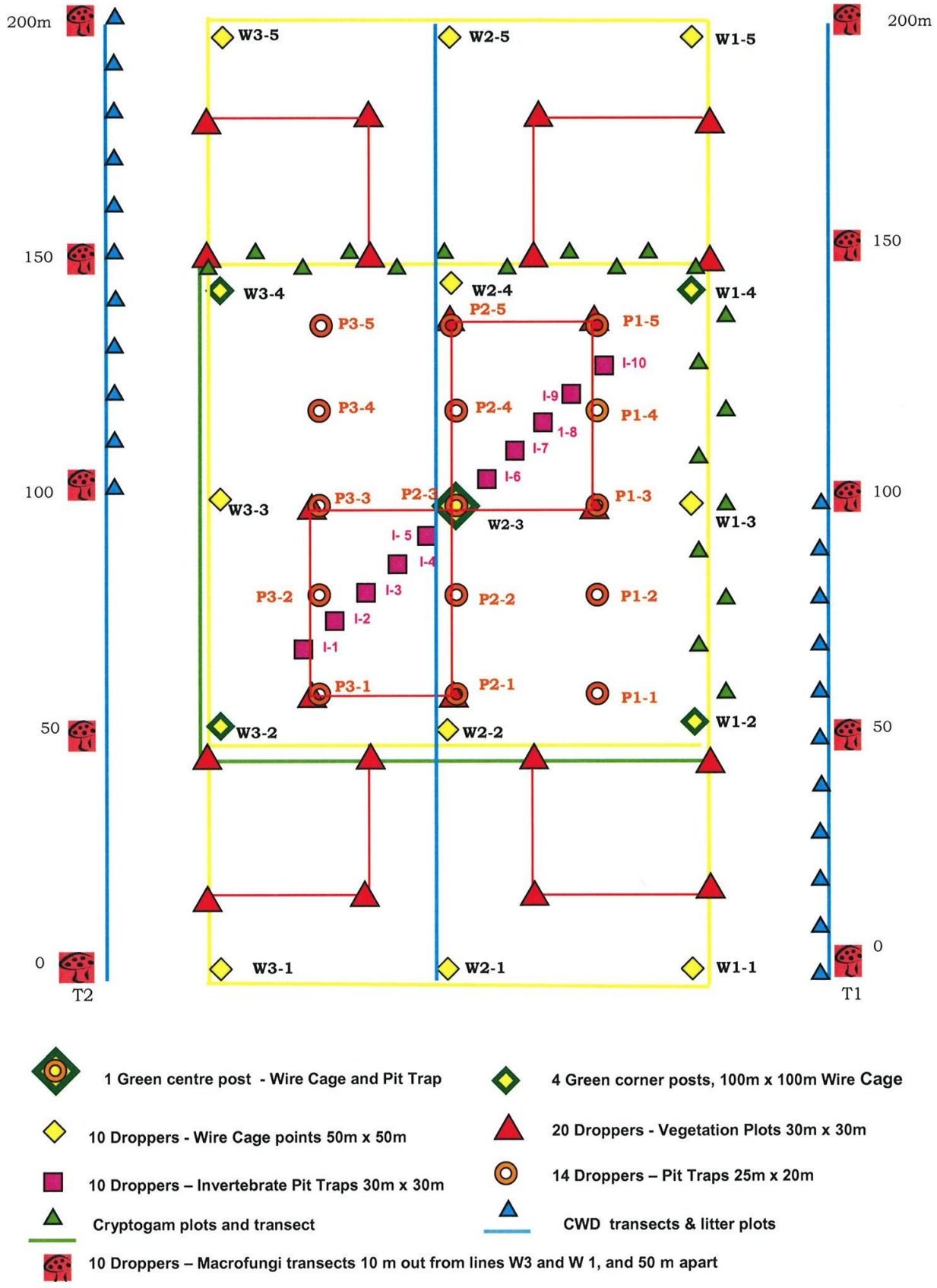


Figure 1. FORESTCHECK grid layout

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 2010-11

Ten FORESTCHECK monitoring grids were established in the Jarrah North East ecosystem of the Wellington District in 2004 (Table 1). The location encompassing the sites is referred to as Wellington East and grids are identified by alphanumeric codes FC28 to FC37 (Fig. 2). Four grids (FC28-31) were established in Nalyerin and Godfrey blocks (Figs 3 & 4), three (FC32-34) in Stockyard block (Fig. 5) and three (FC35-37) in Bell block (Fig. 6). All grids were located in areas of forest immediately east of the 800 mm annual rainfall isohyets and meet the definition of eastern jarrah forest outlined in SFM Guideline No 1 (CALM 2004).

Table 1. Location (forest block) and site attributes of each FORESTCHECK grid in the Perth Hills District in 2010-11

Treatment/	**Burnt**		**Logged**		**Vegetation Complex[3]**
Grid & location	Year and type of burn[1]	Years since[2]	Year	Years since	
External reference					
FC28 Nalyerin	Sp 1987 (prescribed)	(17) 23	Uncut	Uncut	Dwellingup 4
FC32 Stockyard	Sp 1998 (prescribed)/Au 2008 (prescribed)	(6) 2*	Uncut	50	Dwellingup 4
FC35 Bell	Sp 1997 (prescribed) /Su 2004 (Wild fire)	(7) 6*	Uncut	Uncut	Dwellingup 4
Coupe buffer					
FC29 Godfrey	Sp 2002 (prescribed)	(2) 8	Uncut	40	Dwellingup 4
Shelterwood					
FC30 Godfrey	Sp 2002 (establishment)	(2) 8	2000	(4) 10	Dwellingup 4
FC33 Stockyard	Sp 1988 (prescribed)/Au 2008 (prescribed)	(6) 2*	1998	(6) 12	Dwellingup 4
FC36 Bell	Sp 1997 (establishment)/Su 2004 (Wild fire)	(7) 6*	1996	(8) 14	Dwellingup 4
Gap release					
FC31 Godfrey	Sp 2002 (regen. release)	(2) 8	2000	(4) 10	Dwellingup 4
FC34 Stockyard	Sp 1988 (regen. release)/Au 2008 (prescribed)	(6) 2*	1996	(6) 12	Dwellingup 4
FC37 Bell	Sp 1997 (regen. release)/Su 2004 (Wild fire)	(7) 6*	1998	(8) 14	Dwellingup 4

[1] Sp = spring, Au = autumn and Su = summer.
* refers to grids that were burnt since they were first monitored in 2004-05.
[2] Number in bracket is the years since fire when monitored in 2005.
[3] Vegetation complexes are located in open forests or woodland jarrah (*E. marginata* ssp. *thalassica*) and marri (*Corymbia calophylla*), on semi-arid lateritic uplands (Mattiske and Havel 1998).

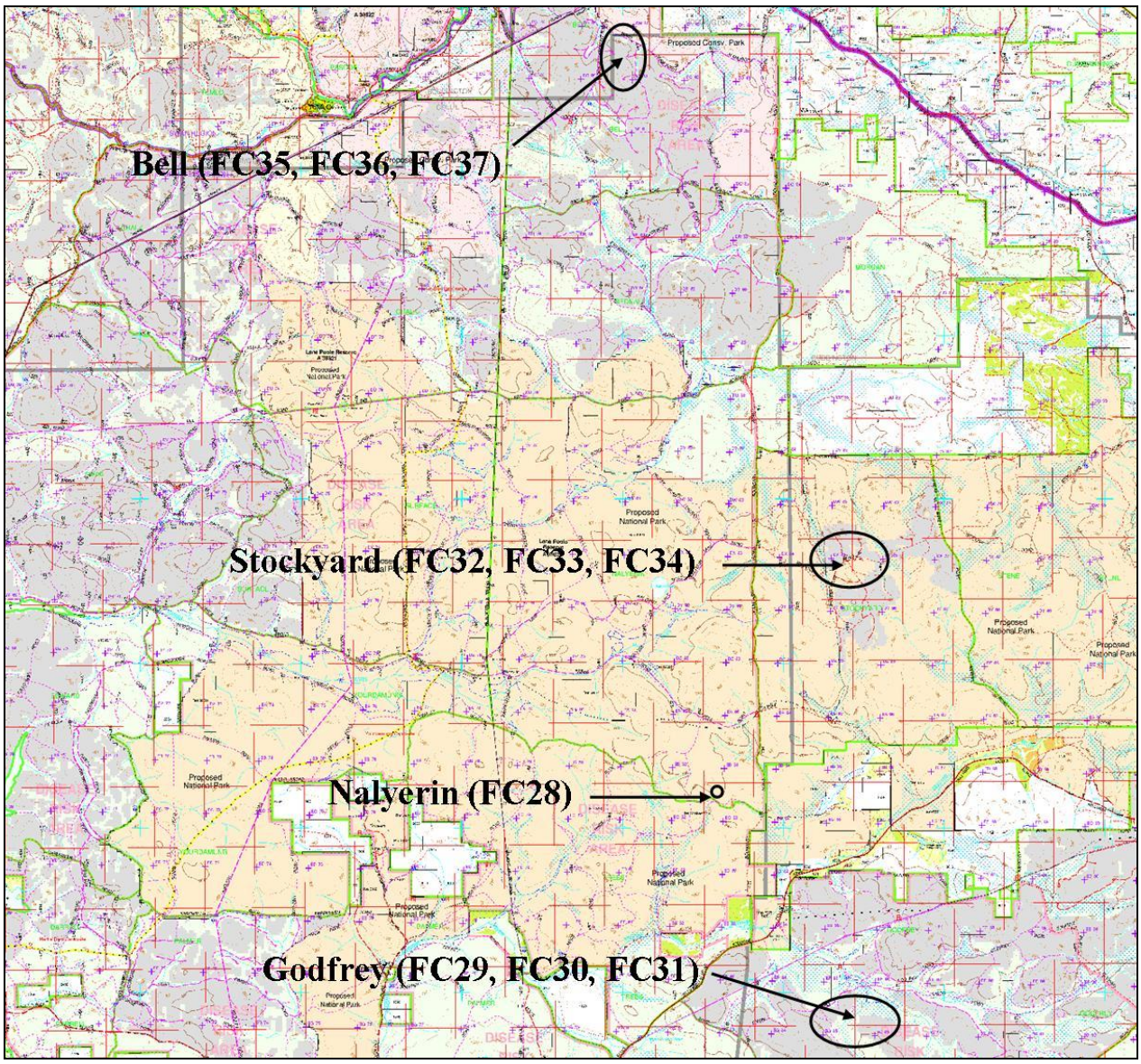


Figure 2. Locations of all FORESTCHECK monitoring grids at Wellington East

All monitoring grids are located within the Dwellingup 4 vegetation complex of Mattiske and Havel (1998) characterised by open forests or woodland jarrah (*E. marginata* ssp. *thalassica*) and marri (*Corymbia calophylla*), on semi-arid lateritic uplands. The three external reference grids are situated in virgin forest (but a small number of stumps present in the Stockyard grid suggest some trees were selectively harvested in the past). The Stockyard external control grid is situated in national park, the Bell grid in conservation park and the Nalyerin grid in the Lane-Poole Reserve. The remaining silvicultural treated grids are in forest that was harvested during the period of 1996-2000 and are matched by time since treatment.

The grids were initially monitored in spring 2004 and autumn 2005 and this second round of monitoring was conducted in spring 2010 and autumn 2011. In 2010-11, the range of time since the last fire was two to 23 years. The three Bell block grids were burnt by wildfire in December 2004, between the initial spring and autumn monitoring, and the three Stockyard block grids were prescribe burnt in autumn 2008 (Table 1).

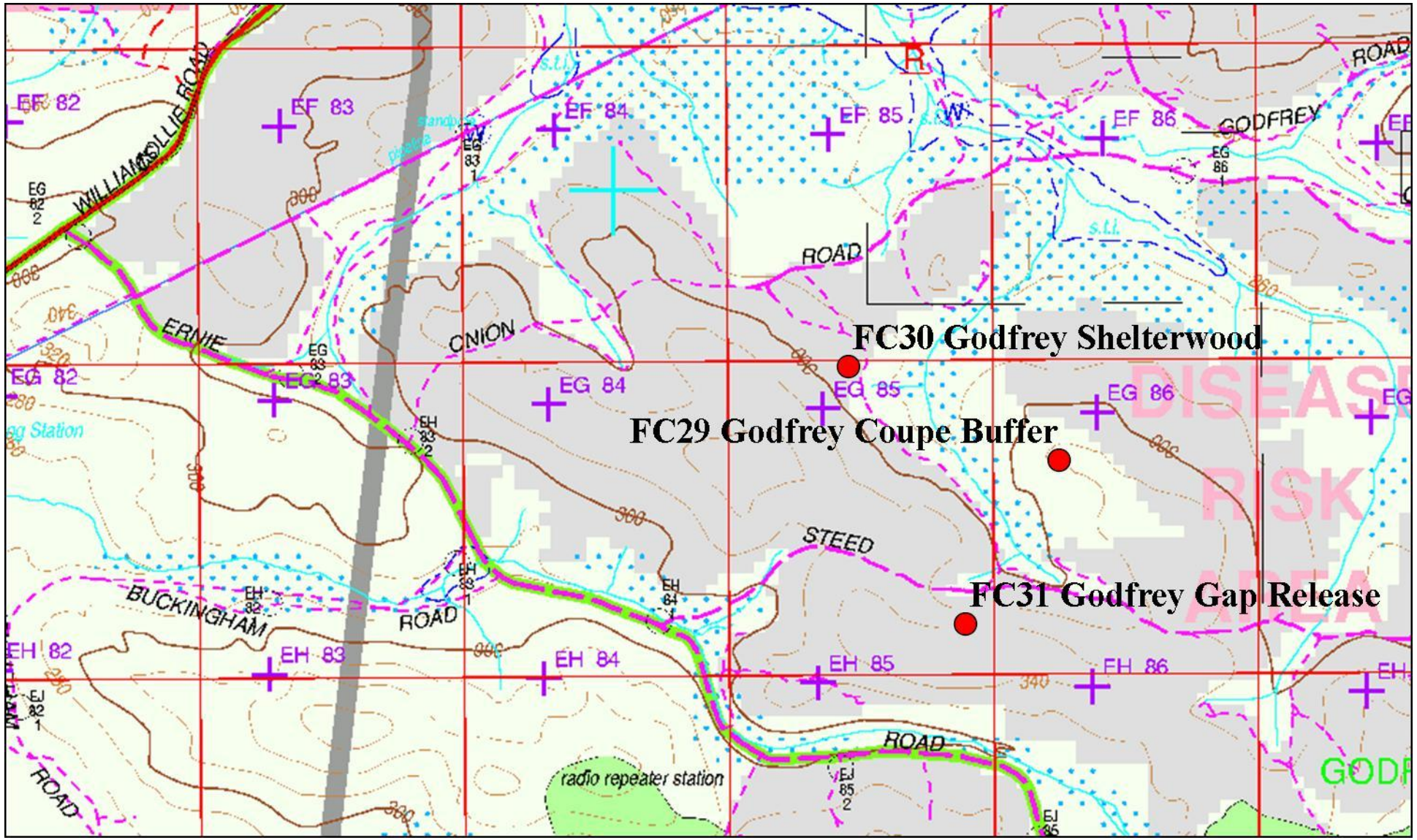


Figure 3. Locations of the three Godfrey block FORESTCHECK grids (FC29, FC30 & FC31) at Wellington East

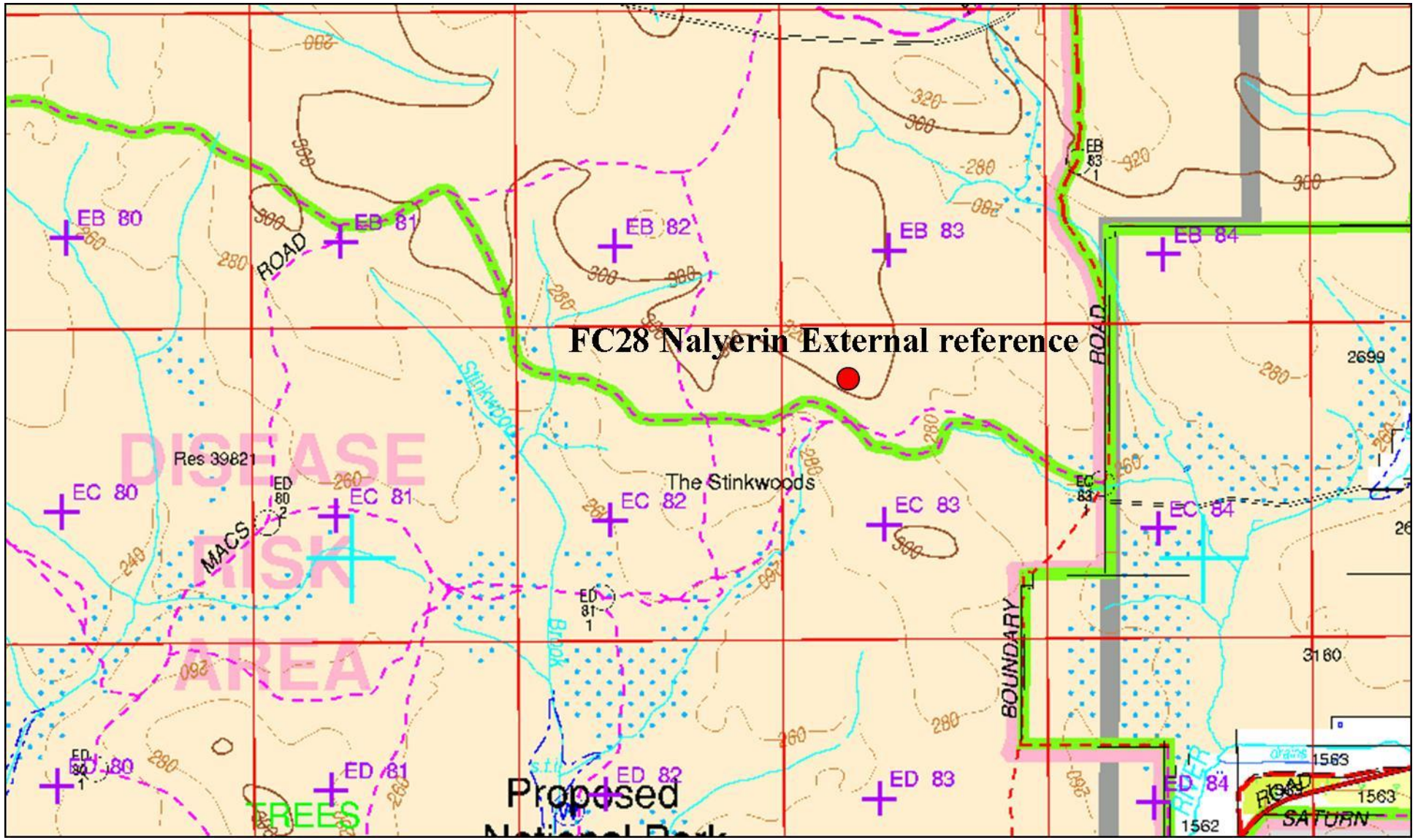


Figure 4. Location of the Nalyerin external reference FORESTCHECK grid (FC28) at Wellington East

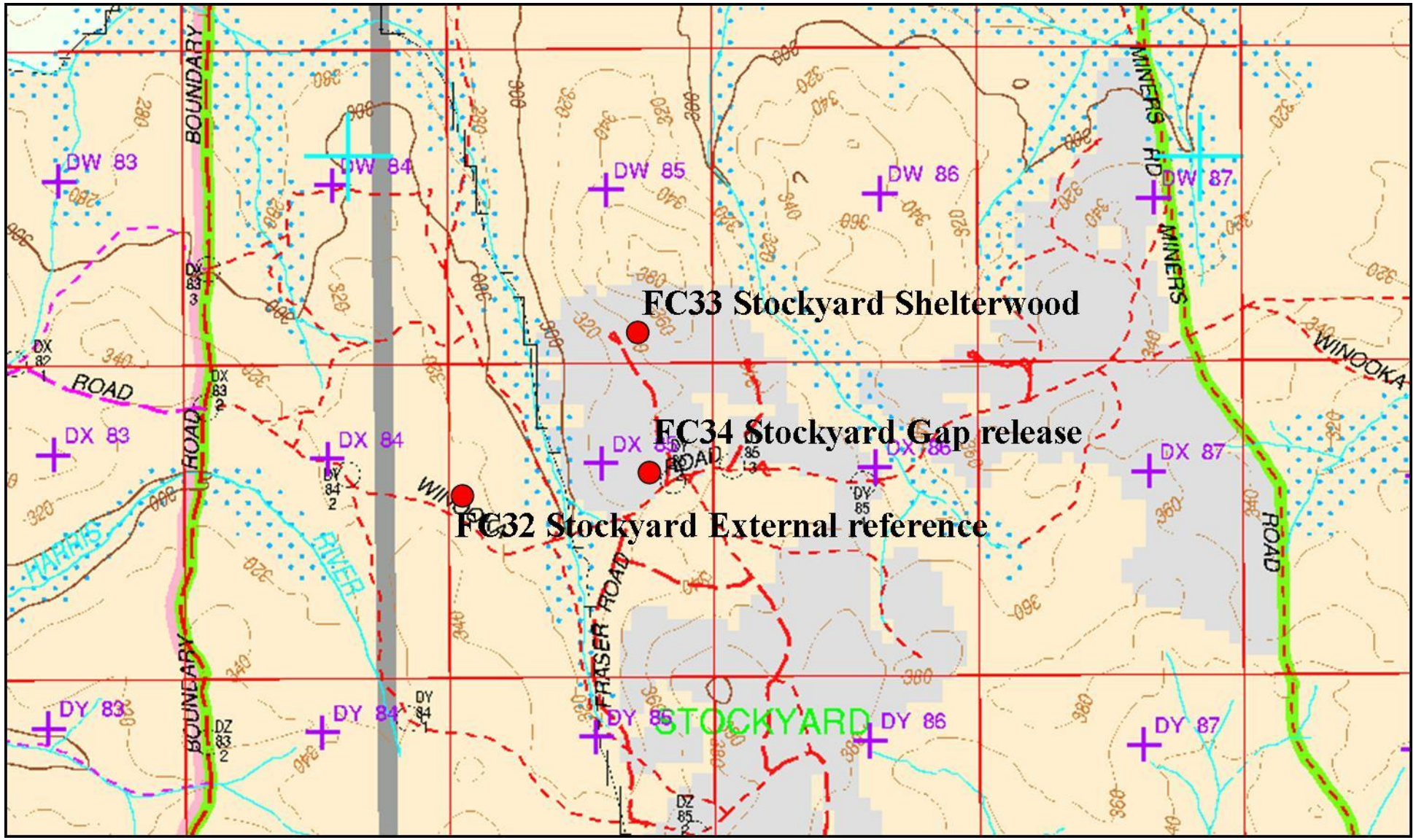


Figure 5. Location of the three Stockyard block FORESTCHECK grids (FC32, FC30 & FC34) at Wellington East

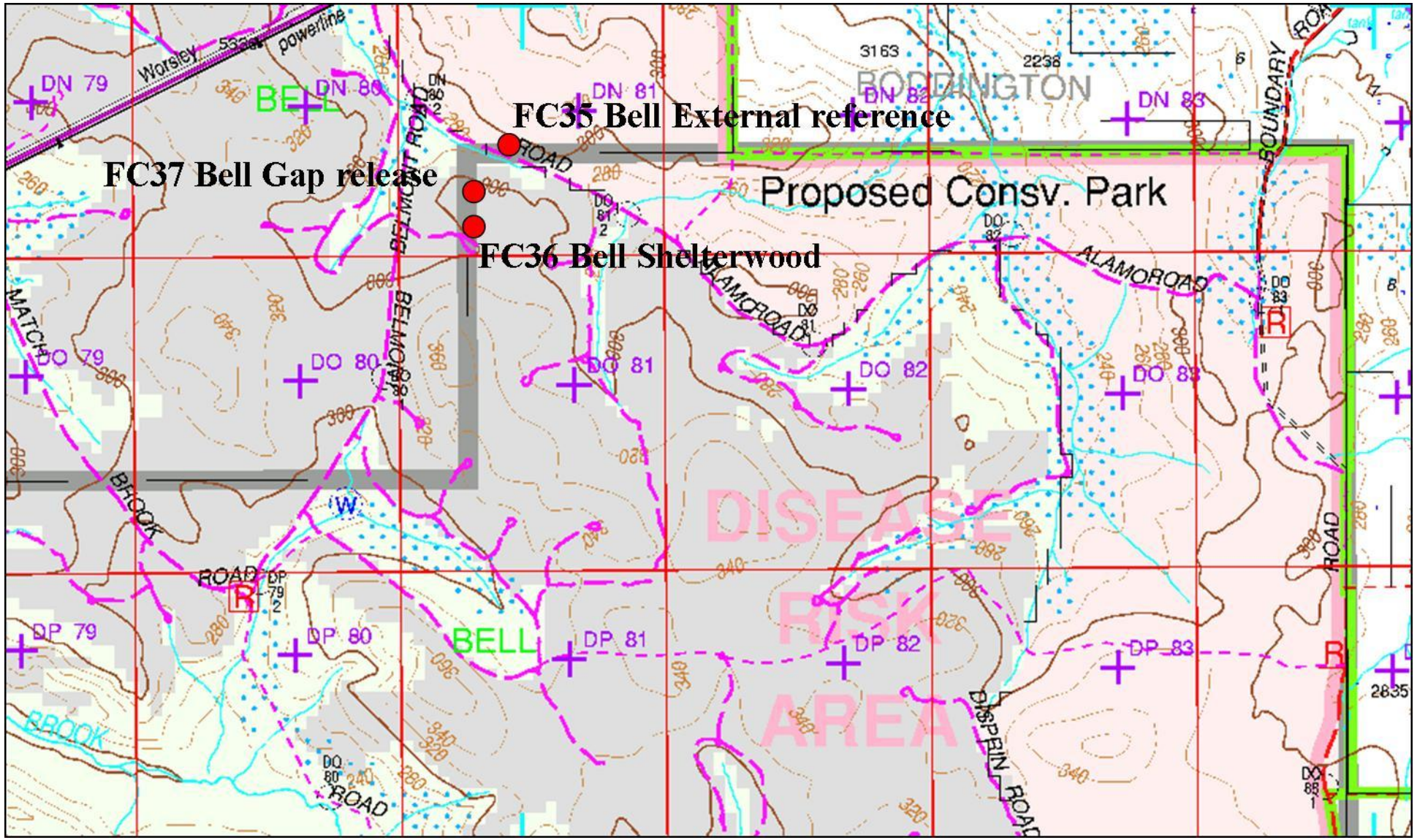


Figure 6. Locations of the three Bell block FORESTCHECK grids (FC35, FC36 & FC37) at Wellington East

On 16 May 2005, a mini tornado crossed the coast at Bunbury. The storm travelled inland and passed through forest north of Collie. Storm damage was clearly evident in the Godfrey gap release grid where many fallen trees and broken branches had affected the stand structure and the amount of coarse woody debris on site (see Fig. 14).

Grid photographs

Reference photographs of each grid were initially taken in August 2005 and presented in the FORESTCHECK Report of Progress 2004-05 (available at www.dec.wa.gov.au). In June 2011, 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).

Figure 7. FC28 Nalyerin external reference in 2005 (left) and 2011 (right)

Figure 8. FC29 Godfrey coupe buffer in 2005 (left) and 2011 (right)

Figure 9. FC32 Stockyard external reference grid in 2005 (left), 6 months following prescribed fire in 2008 (centre) and 2011 (right)

Figure 10. FC35 Bell external reference in 2005 (left), 1 month following wildfire in Dec. 2004 (centre) and 2011 (right)

Figure 11. FC30 Godfrey shelterwood in 2005 (left) and 2011 (right)

Figure 12. FC33 Stockyard shelterwood in 2005 (left), 6 months following prescribed fire in 2008 (centre) and 2011 (right)

Figure 13. FC36 Bell shelterwood in 2005 (left), 1 month following wildfire in Dec. 2004 (centre) and 2011 (right)

Figure 14. FC31 Godfrey gap release in 2005 (left), 2 months following mini tornado in May 2005 (centre) and 2011 (right)

Figure 15. FC34 Stockyard gap release in 2005 (left), 6 months following prescribed fire in 2008 (centre) and 2011 (right)

Figure 16. FC37 Bell gap release in 2005 (left), 1 month following wildfire in Dec. 2004 (centre) and 2011 (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 through a service agreement with the Sustainable Forest Management Division to an amount of approximately $200,000 per annum.

2011-12 Activities

In spring 2011 and autumn 2012 monitoring will be undertaken for the second time on 11 grids (FC38 – FC48) established in 2005 in the jarrah Blackwood Plateau forest ecosystem in the Blackwood District. These grids were initially monitored in 2005-06. The grids are located in Barrabup, St John, Layman and Cambray forest blocks. All grids are within the Kingia vegetation complex. External reference grids are all in uncut forest in national park, or conservation park and treatment grids are in state forest that was harvested during the period 1998-2002.

FOREST STRUCTURE AND REGENERATION STOCKING

Lachlan McCaw and Verna Tunsell

Introduction

The adequacy of regeneration following harvesting and silvicultural treatment is one of the core indicators of Ecologically Sustainable Forest Management (ESFM). The current framework of regional level indicators provides for assessment of the area and per cent of harvested area of native forest effectively regenerated (Indicator 2.1.g). This is recognised as a Category A indicator that can be reported upon immediately (Commonwealth of Australia 1998).

Regeneration outcomes have for a number of years been assessed as a matter of routine on a sample of the area 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 guideline 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 (Anon. 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), is as follows:

- Donnelly District (jarrah south), 10 grids;
- Wellington District (jarrah north west - central), 9 grids;
- Perth Hills District (jarrah north west - north), 8 grids;
- Wellington District (jarrah north east), 10 grids; and
- Blackwood District (jarrah Blackwood Plateau), 11 grids.

The ten monitoring grids established in low rainfall jarrah forest in the eastern part of Wellington District in were initially assessed in autumn 2005. They were re-assessed in autumn 2011 with the objective of describing changes in stand structure, species composition and developmental stage of tree species present over the previous six years. In addition to routine measurements, jarrah seedling establishment and survival in a shelterwood harvested grid at Stockyard block have also been monitored following a prescribed burn in April 2008.

Monitoring

Assessment methods at Wellington East in 2011 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 along 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.

Projected foliage cover was recorded in spring 2010 as part of the vegetation cover assessment during vascular plant surveys. Intercepts with foliage were recorded at 240 points around the perimeter of 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.

Stockyard block was burnt by prescribed fire in April 2008. The fire was of moderate intensity and caused complete crown scorch of forest on grids FC32, FC33 and FC34. Abundant regeneration of jarrah seedlings was observed on the Stockyard shelterwood grid (FC33) during a field visit in early December 2008, and four 100 m long x 1 m wide transects were established a week later with assistance from Edith Cowan University PhD candidate Jeff Cargill. Individual seedlings were identified according to their position along each transect and were marked with wire pegs. Seedlings were assessed for survival and height at six monthly intervals between December 2008 and July 2011.

Data management

Stem diameter measurements from 2011 were entered into the FORESTCHECK stand database and used to calculate current over-bark basal area and over-bark basal area increment for the 6-year-period from 2005 to 2011.

Validation of data in preparation for publication of the first five years of FORESTCHECK results revealed some errors in Table 1 of the Stand Structure and Regeneration Stocking section of the 2005 progress report. These included incorrect basal areas of jarrah on FC29, FC30 and FC34 to FC37, and incorrect basal areas of marri on FC29, FC30, FC31 and FC37. Errors related mostly to recording of particular trees as being alive or dead, and to mis-identification of jarrah as marri, or vice versa.

To minimise potential for errors of this kind during subsequent measurements, trees >20 cm diameter have now been numbered with permanent tags.

Results

Stand structure and species composition

Basal area and basal area increment of jarrah and marri are summarised in Table 1, and the basal area of eucalypts and mid-storey species are plotted in Figure 1. Total eucalypt basal area declined between 2005 and 2011 at the three grids in Stockyard block as a result of tree mortality and tree fall following the 2008 prescribed fire. The greatest change was at the Stockyard shelterwood grid (FC33) where a jarrah of 109 cm in diameter had fallen and mostly burnt away to ashbed. Basal area increased on the other seven grids, ranging from relatively small increments (<0.1 m^2 ha^{-1} yr^{-1}) on unharvested reference grids at Nalyerin (FC28) and Godfrey (FC29) blocks to an increment of 1.16 m^2 ha^{-1} yr^{-1} on the Godfrey shelterwood grid (FC30) that had a dense cohort of saplings. The greater proportion of this increment was on jarrah compared to marri. Increment at the Bell external reference grid (FC35) was greater than on other reference grids, probably because saplings exhibited dynamic growth following the December 2004 bushfire. Stem diameter distributions (by 10 cm classes) are presented for each grid in Figures 2-5.

Allocasuarina fraseriana contributed less than 4 m^2 ha^{-1} of basal area at the Nalyerin and Stockyard external reference grids, the, Godfrey coupe buffer and the Stockyard shelterwood (Figure 1). *Banksia grandis*, *Persoonia longifolia* and *Allocasuarina humilis* were also present at low density on some grids.

Table 1. Basal area in 2011 and basal area increment of live eucalypts >2 m tall over the period autumn 2005-2011 for ten FORESTCHECK grids at Wellington East

Treatment/Grid	**Basal area 2011 (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						
FC28	52.41	4.64	57.05	-0.04	0.53	0.08
FC32	8.75	1.81	10.56	2.19	-4.53	-0.39
FC35	16.75	9.69	26.44	0.95	1.59	0.42
Coupe buffer						
FC29	29.21	1.49	30.70	0.85	-0.36	0.08
Shelterwood						
FC30	19.18	1.88	21.06	5.91	1.04	1.16
FC33	11.53	0	11.53	-9.31	0	-1.55
FC36	17.56	1.78	19.34	1.78	0.98	0.46
Gap release						
FC31	22.16	1.23	23.39	1.95	0.61	0.43
FC34	17.65	1.41	19.06	-2.60	0	-0.43
FC37	8.08	3.71	11.79	2.73	1.00	0.62

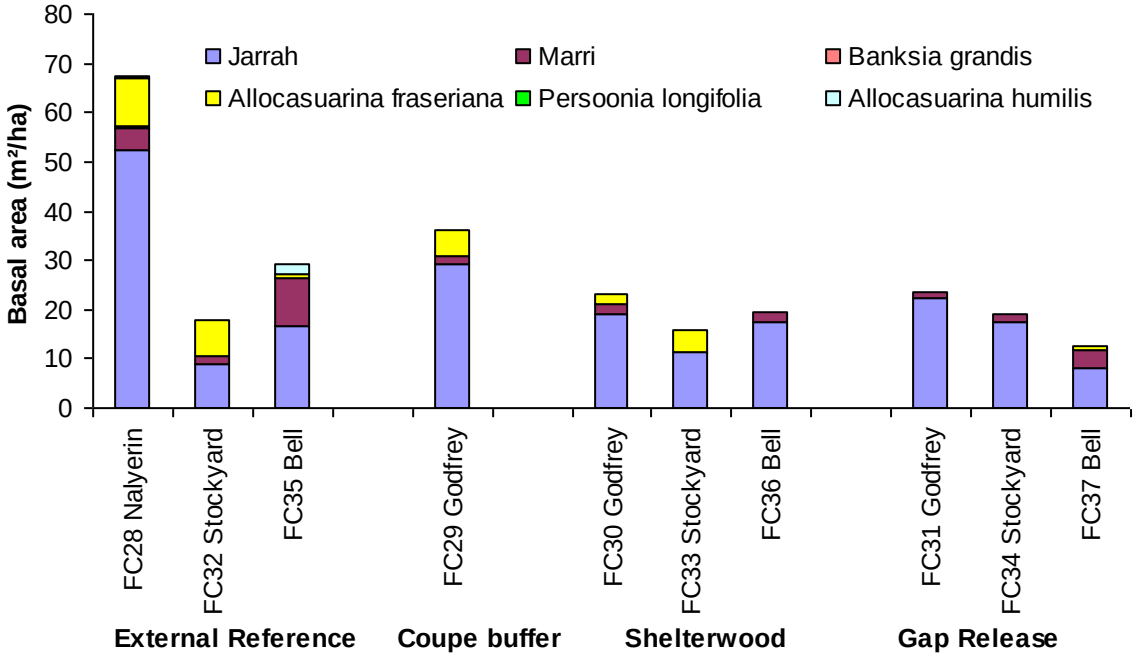


Figure 1. Basal area of jarrah, marri and mid-storey species on each grid at Wellington East in 2011

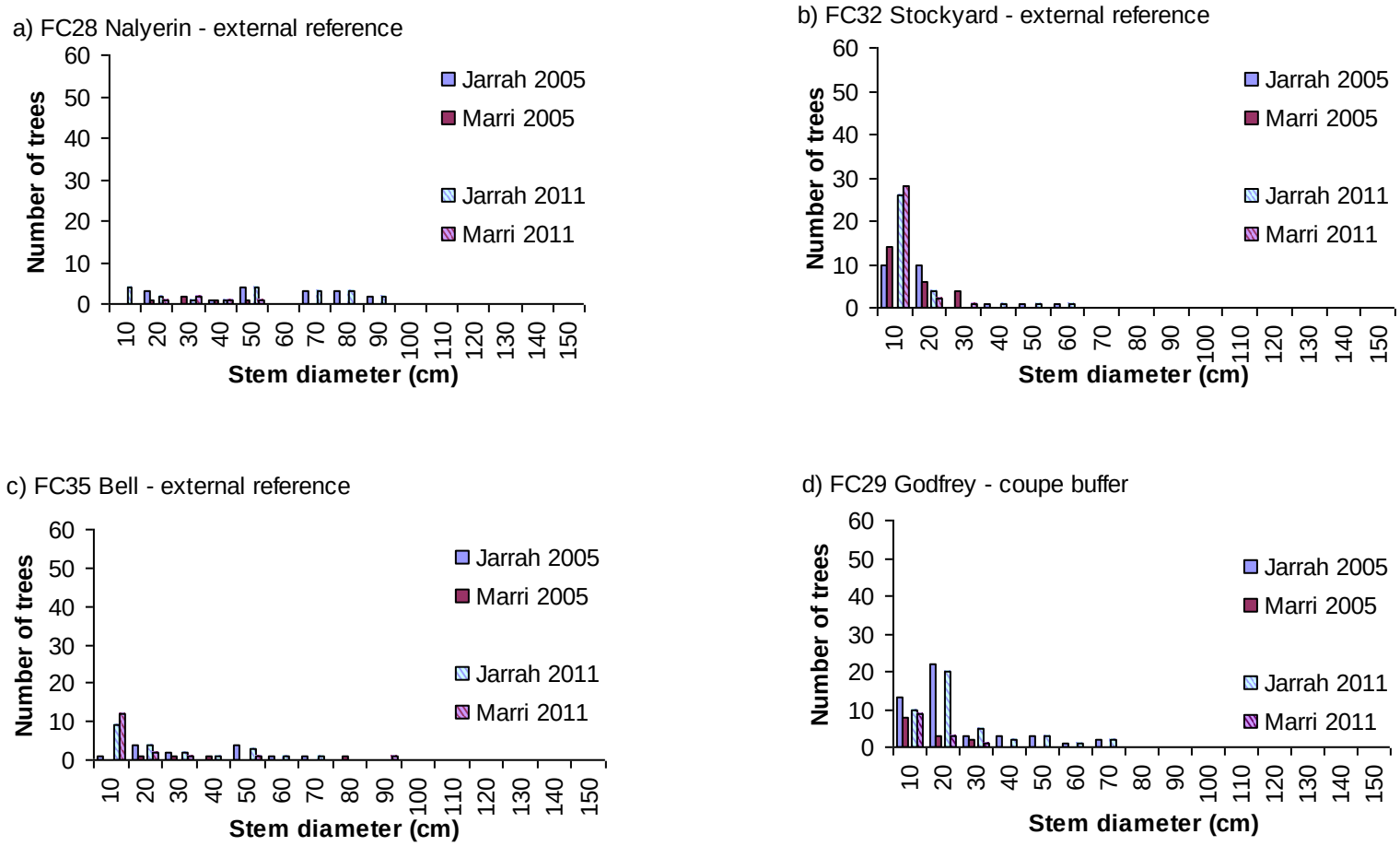


Figure 2. Stem diameter distribution by 10 cm classes (0-9 cm, 10-19 cm etc.) for three external reference grids and one coupe buffer grid. The vertical axis on this figure spans only half the range of the vertical axis on Figures 3 and 4.

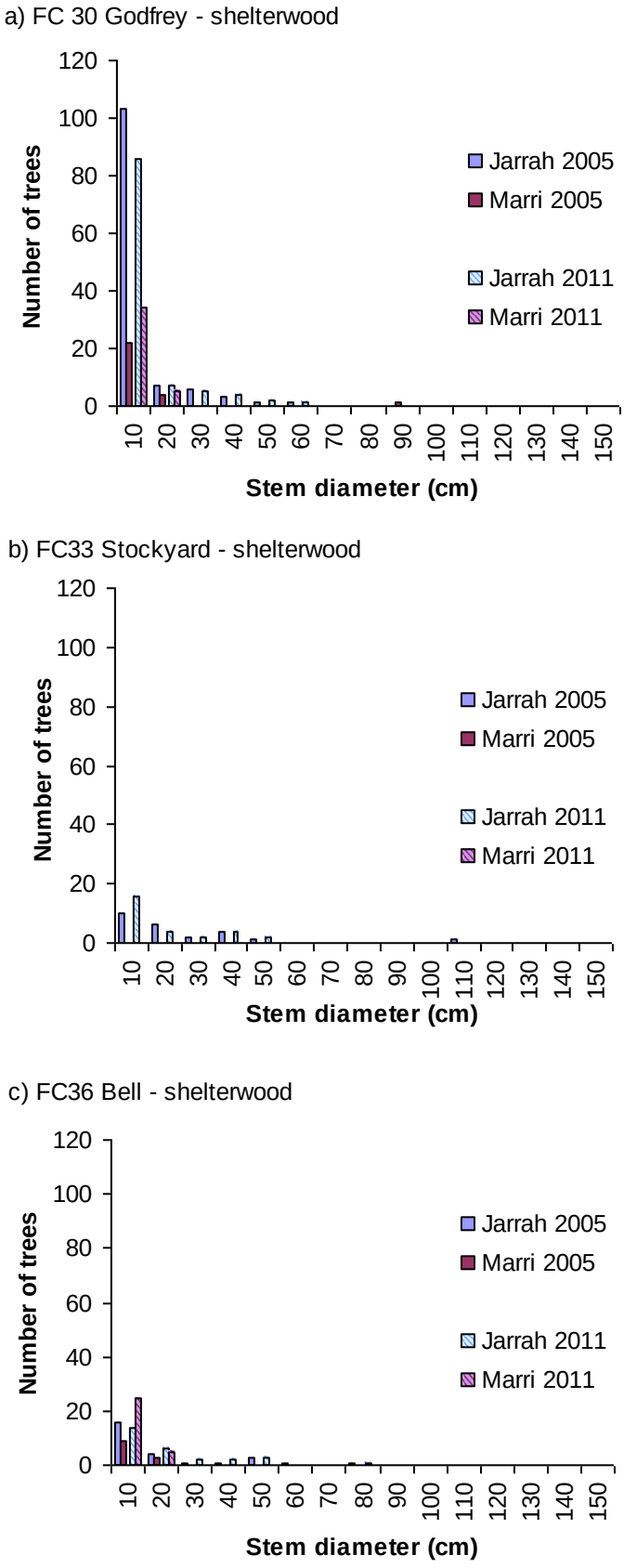
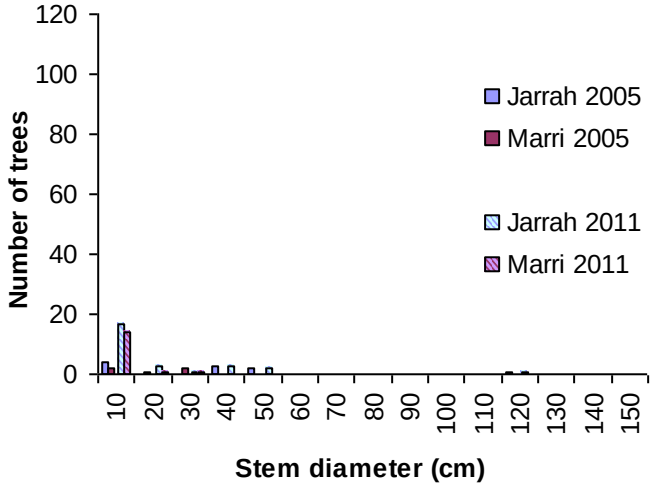
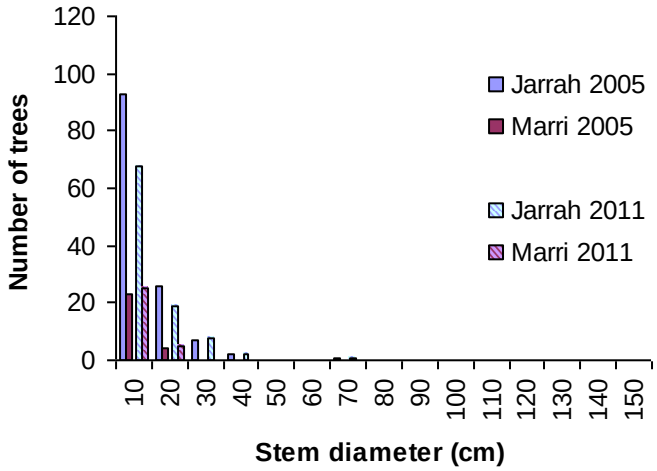


Figure 3. Stem diameter distribution by 10 cm classes (0-9 cm, 10-19 cm etc.) for three shelterwood grids

a) FC31 Godfrey - gap release



b) FC34 Stockyard - gap release



c) FC37 Bell - gap release

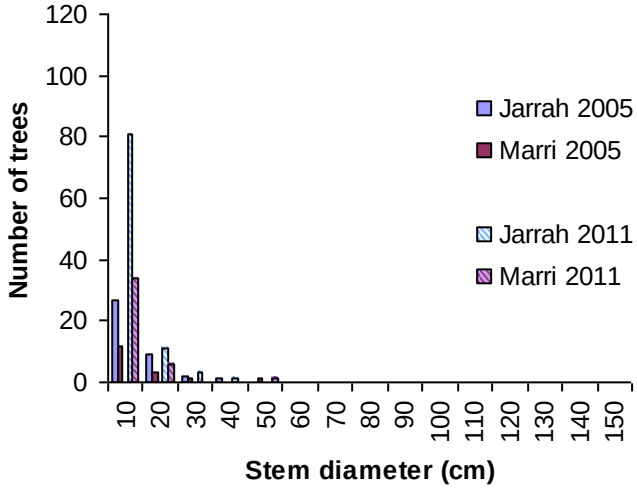


Figure 4. Stem diameter distribution by 10 cm classes (0-9 cm, 10-19 cm etc.) for three gap release grids

Eucalypt foliage from the upper storey (>15 m height) comprised the largest proportion of projected foliage cover on all grids (Figure 5). Eucalypt foliage from the lower storey (2-15 m) comprised >10% projected cover on the gap release grids and on the shelterwood grid FC36 Bell, reflecting the presence of a layer of young saplings. Non-eucalypt foliage comprised a significant proportion of the projected cover at the Nalyerin external reference and Godfrey coupe buffer grids due to a mid-storey of *A. fraseriana* and *B. grandis.*

Total projected foliage cover on harvested grids was generally greater than in 2004 (Figure 6). Unharvested reference grids showed increased cover (FC29 Godfrey), little change (FC35 Bell) or reduced cover (FC28 Nalyerin, FC32 Stockyard). The effect of fire on projected cover for unharvested grids was variable and appeared to depend on the time since last fire. The Bell external reference had similar foliage cover to the previous measurement in spring 2004, indicating that the canopy had recovered from complete scorch in December 2004. In contrast, projected cover at the Stockyard external reference was lower than in 2004 indicating incomplete recovery from canopy scorch in April 2008. The Nalyerin external reference showed a slight decline in projected cover despite having remained unburnt between 2004 and 2010.

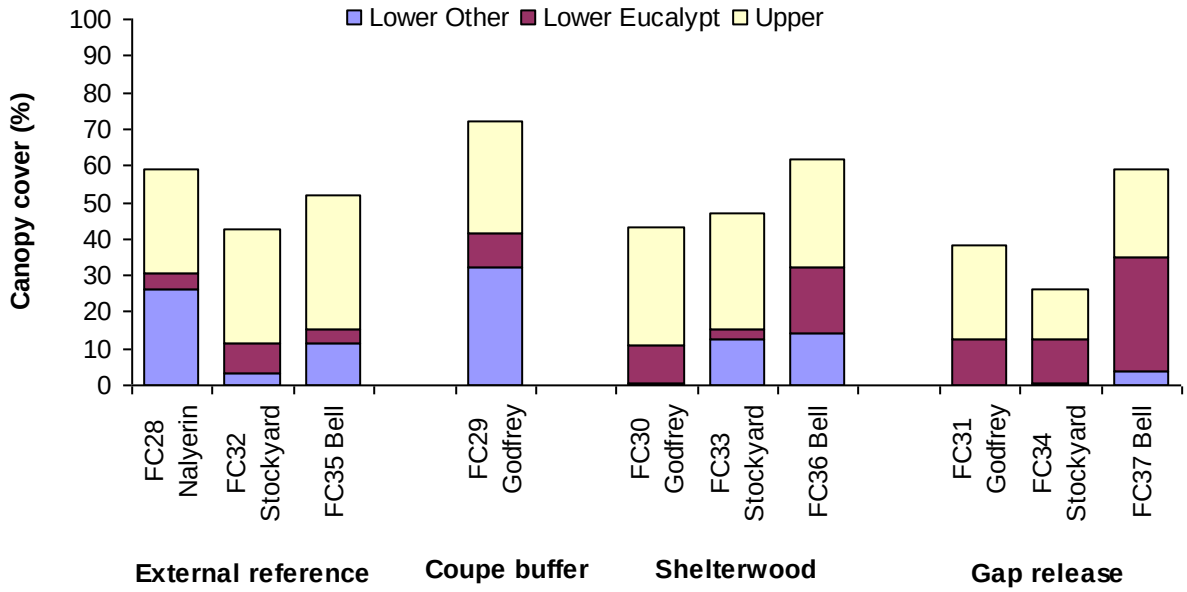


Figure 5. Projected foliage cover of eucalypts and other plants at Wellington East in 2010 divided into lower (2-15 m) and upper (>15 m) storeys

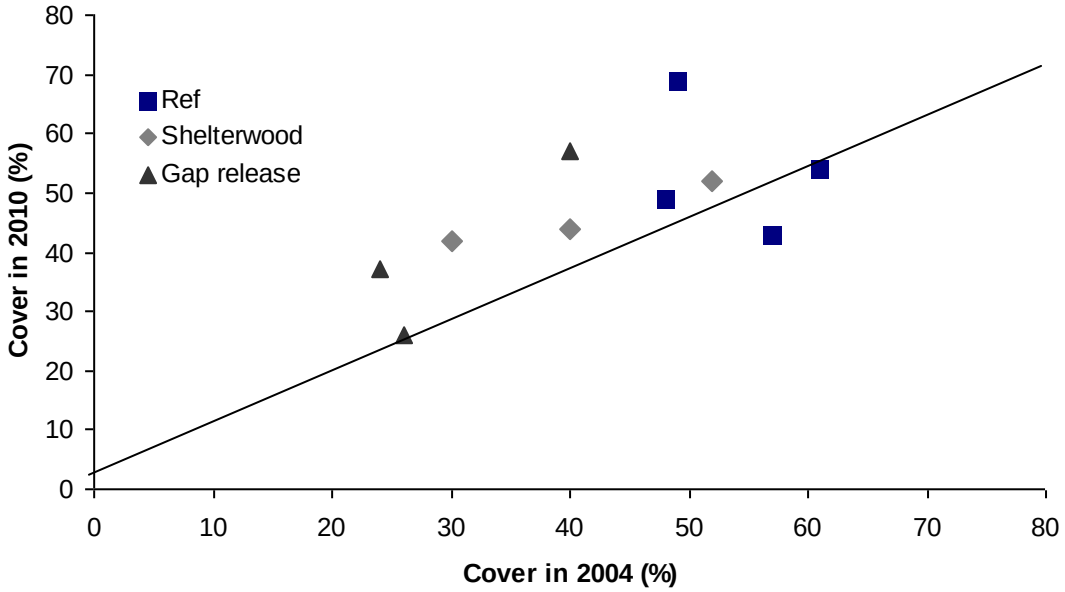


Figure 6. Scatterplot comparing projected foliage cover measured at Wellington East in 2004 and 2010

Jarrah seedling regeneration was widespread in shelterwood grid FC33 Stockyard in December 2008, with seedlings exhibiting dynamic growth on ashbeds (Figure 7).

Figure 7. Jarrah seedlings on mineral ashbed at the Stockyard shelterwood (FC33) in December 2008

Mean jarrah seedling density on the four 100 m^2 transects was 4000 ha^{-1} in December 2008 and 64% of these seedlings survived the summer and remained alive in June 2009 (Figure 8). By December 2010 seedling density had reduced to 1600 ha^{-1}, representing 43% survival of seedlings present at the initial assessment. A small number of seedlings assessed as being dead in June 2010 were in fact still alive and re-sprouted from basal shoots on developing lignotubers. As of June 2011 surviving seedling density remained at 1000 ha^{-1}.

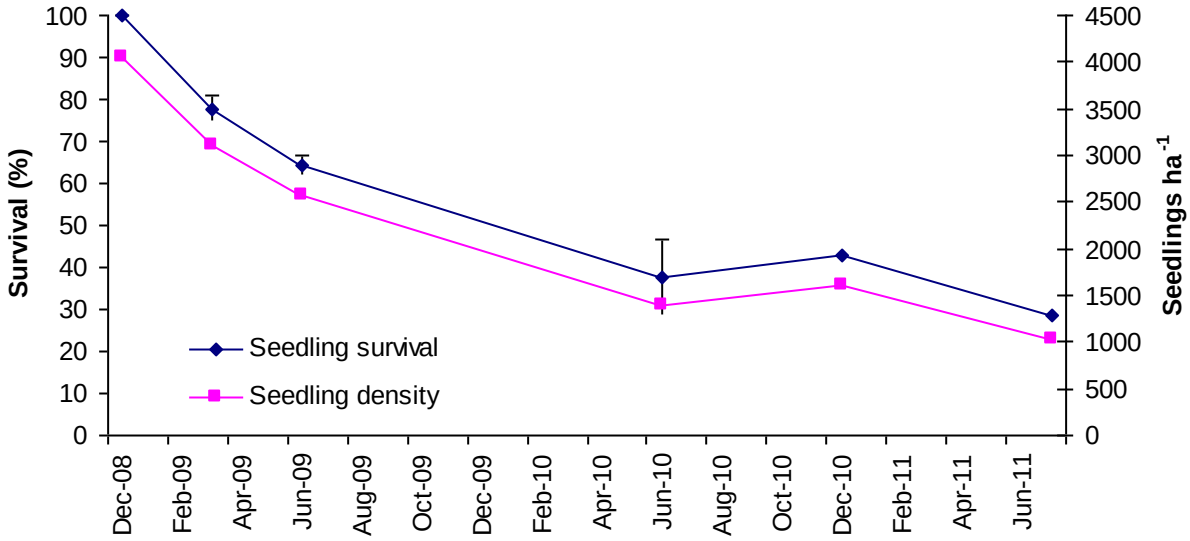


Figure 8. Jarrah seedling survival (%) and density (seedlings ha^{-1}) at the Stockyard shelterwood (FC33) between December 2008 and July 2011

Discussion

In the period from 2005 to 2011 at Wellington East, stand basal area increased on seven of the ten grids, with mean annual increments ranging from 0.08-1.16 m^2 ha^{-1} yr^{-1}. Basal area was reduced on three grids in Stockyard block as a result of tree mortality and tree fall following a prescribed fire in April 2008. Reduction in basal area was associated with lower projected foliage cover on external reference grid FC32, but not on shelterwood FC33 or gap release FC34 where foliage cover was maintained or slightly increased. This indicates that the sapling cohort has recovered since the fire, and will continue to contribute to the future growing stock of these stands. Mean annual increments for shelterwood grids in Wellington East were similar to those reported for shelterwood grids in Donnelly (jarrah south ecosystem), Wellington 1 (jarrah north ecosystem) and Perth Hills (jarrah north west ecosystem); and ranged from 0.30-1.16 m^2 ha^{-1} yr^{-1}. Gap release grids also exhibited annual increments in the range 0.4-0.6 m^2 ha^{-1} yr^{-1} over the period, despite the Bell block grid (FC37) being burnt by a moderate intensity fire in December 2004.

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). Issues relevant to the

forest structure component of the FORESTCHECK monitoring include the implications of a drying climate to the health of forest ecosystems, growth rates of potential commercial trees, and the effectiveness of regeneration following silvicultural treatment. Data collected from FORESTCHECK grids provide an important source of objective information that should be used to inform discussion of these matters. In relation to growth of commercial tree species, with the exception of the Stockyard shelterwood grid (FC33), all of the harvested grids had >350 stems ha^{-1} of single stemmed saplings in 2011 and therefore achieved the required minimum stocking standard. Stand structure charts demonstrated continuing recruitment into the sapling cohort at The Godfrey gap release grid (FC31), with 388 stems ha^{-1} of saplings recorded in 2011. This grid was post-harvest burnt in spring 2002 and at the time of initial assessment much of the ground coppice was less than 2 m tall and therefore not counted as part of the sapling cohort.

Seedling recruitment that has taken place at the Stockyard shelterwood grid (FC33) since 2008 is a significant finding because it demonstrates that the opportunity for recruitment remains open for at least a decade following silvicultural treatment. Crown expansion on retained trees in response to silvicultural treatment may have encouraged greater seed production, although this cannot be demonstrated here because no seed crop assessment had been undertaken prior to the 2008 prescribed burn. Monitoring has also demonstrated that young (1-2 year old) seedlings are resilient to moisture stress and can re-sprout and recover following desiccation.

It is also noteworthy that seedlings survived the driest 18 month period on record from August 2009 through to the end of 2010.

During the late summer and autumn of 2011, jarrah forest on the Darling escarpment showed symptoms of severe drought stress with mortality of overstorey and mid-storey trees at scales of tens of hectares. Worst-affected were sites with shallow soils, typically along the face of the escarpment, along the fringes of deeply incised streams, and adjoining granite monadnocks. In contrast to this, few areas of drought affected forest were observed in the eastern part of Wellington District during the field work program for FORESTCHECK.

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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LEAF AREA INDEX

Kim Whitford and Deb Feeniks,

Introduction

Leaves have a primary role in the transpiration, rainfall interception and photosynthesis of trees. In addition to strongly influencing growth and water use, tree leaf area also reflects tree health. Across a stand, leaf area is commonly measured as leaf area index (LAI) the one-sided area of foliage per unit ground area (Watson 1947). This key biophysical attribute of forests is valuable for modelling forest growth and water use, and for monitoring burn severity (Boer et al. 2008) and stand health.

Loneragan (1971) described the typical leaf cycle in *Eucalyptus marginata* (jarrah). Stand and tree leaf area follow a regular annual cycle dominated by a flush of new foliage in the spring continuing through into summer. A major flush follows a light flowering (typically in November) with a rush of new shoots and leaves in December and January from non-flowering branchlets. The first observed new leaves begin unfolding in August or September usually on coppice or sapling trees. Some of these leaves will have reached full size by December. Tiny new leaf buds begin to appear on healthy pole trees in November. Suppressed and decadent trees may show no further growth of new leaves while vigorous saplings can continue from spring through the summer period and in to autumn. Early in February, the last of the new tender leaves have grown to their full size. They mature, thicken and harden during the summer drought in March. Typically the growth of new leaves then recedes until the next spring (leaf-flushes have been observed in early spring following warm weather and in early autumn following good summer rains).

A stand loses about half of its leaves each year; with most of these leaves (54-69%) falling throughout summer while the new leaf-flush is maturing in January, February and March. The bulk of this leaf fall is one and two year old leaves, i.e. leaves aged from 12-15 or 24-27 months. Active leaves on the trees are rarely older than two years with less than 5% of the leaves living to be three years old.

It follows that the minimum in the annual leaf area cycle will occur in winter through to October, just prior to the new leaf flush. The maximum presumably occurs in January or February when the bulk of the new leaves are fully expanded and most of the summer leaf fall has occurred.

The objectives of this new component of the FORESTCHECK monitoring program are to:

- Determine the LAI of each FORESTCHECK grid;
- Provide annual monitoring of LAI for each FORESTCHECK grid;
- Monitor changes in LAI on each grid over time;
- Provide comparative measure LAI across the various silvicultural treatments (gap release and shelterwood) and in uncut forest;
- Analyse trends within and between the treatments over time and particularly with time since the last harvest; and
- Provide data for assessment of forest health.

LAI will be measured at the peak of the annual leaf cycle in late January to early February, and at the minimum in late winter through spring.

Field and Laboratory Monitoring

Direct non-destructive measurements of LAI are impractical. We used two indirect methods for estimating LAI; digital cover photography (DCP) (Macfarlane et al. 2007) and remote sensing of the normalized differential vegetation index (NDVI). DCP is suited to small plots with well defined boundaries and allows data collection on specific dates with a high degree of user control and fast data processing. In contrast, remote sensing offers less user control over data collection, it is best suited to large plots without distinct boundaries, and tends toward more complex data processing. However, remote sensing enables data collection over large and dispersed areas without the need for field access and can also provide historical data.

DCP consists of a set of vertically oriented photographs of the forest canopy analysed to determine canopy gaps. Digital photographs were taken with a Nikon D90 camera fitted with an AF-S Nikkor 18-55mm lens set to 50 mm and the following settings: ISO 400, F11, automatic exposure metered over the full image, aperture-priority mode, autofocus stationary (AF-S), white balance auto (WB auto), with the images stored as fine quality large jpeg files.

We took either 91 or 117 photographs (photo spacings of approximately 12.5 x 6.7 m and 8.3 x 6.7 m) over the central 100 x 100 m area of the FORESTCHECK grids. The closer photo spacing was used on grids with low tree canopies. The camera lens was pointed directly upwards and the camera levelled using a bubble level. Cover images were analysed using DCP software version 3.1 (Macfarlane pers. comm.) which identifies and computes the area of gaps in the canopy. Gaps larger than 1.3% of the total image area are classified as between-canopy gaps, all other gaps are classified as within canopy gaps.

Each photograph yields the following information:

Foliage cover	(FC)	=	Percentage of the ground covered by the vertical projection of foliage and branches (also known as foliage projective cover).
Gap fraction	(GF)	=	1 - foliage cover
Crown cover	(CC)	=	Percentage of the ground covered by the vertical projection of crowns assuming the crowns are solid.
Crown porosity	(CP)	=	Proportion of sky, or gaps, within the crown envelopes. CP = 1-(FC/CC)
Clumping index	(CI)	=	A function of CP and FC. Low CI indicates the clumped canopies.

Over the narrow field of view utilized in DCP (approximately 15° from the zenith) LAI can be determined with a version of the Beer–Lambert law using the values of CC, CP, from DCP and an assumed value for the light extinction coefficient of k. Macfarlane et al. (2007) found that LAI of *E. marginata* forest was accurately estimated from cover by assuming k ~0.5 across the field of view of the 50 mm lens used in this photography (indicating a spherical leaf angle distribution for this vegetation type). Hence LAI, or more correctly LAI_t, which includes the small contribution to cover made by branches, can be estimated as:

$$LAI_t = - CC(\ln(CP)/k)$$

Landsat 5 Thematic Mapper (TM) imagery for the estimation of LAI was obtained from USGS EarthExplorer website (http://earthexplorer.usgs.gov/). We used cloudless summer scenes from path 112, rows 82, 83 and 84, typically collected in January or February but ranging from December 14 to March 3. Landsat TM scenes are processed with the Standard Terrain Correction (Level 1T) which incorporates ground control points and a Digital Elevation Model (DEM) for topographic accuracy. Landsat TM pixels are 30 x 30 m and we typically utilized 8 to 10 pixels to cover the 100 x 100 m FORESTCHECK grids. As grids were not oriented to align with the Landsat path, some data would have been obtained from outside the edges of the grid. As the area surrounding most grids was subject to the same harvesting treatment as the grid this contamination was not considered to be a great concern. Values for the Normalised Difference Vegetation Index (NDVI = (NIR - RED)/(NIR + RED)) were determined from these images. A regression model was applied to predict LAI from NDVI (LAI = 0.22 $e^{4.3(NDVI)}$, Macfarlane, pers. comm.). As this regression model was developed using DCP, these LAI values should be consistent with the DCP measurements taken in spring 2011. We estimated LAI from NDVI for all 48 FORESTCHECK grids in 1988, 1990, 2004, 2005, 2006, 2007, 2008, 2009, 2010 and 2011. Values for 1988 and 1990 are for periods before FORESTCHECK monitoring commenced and before any of the harvesting treatments occurred on these grids. These values provide some reference data for comparison with the post harvest data collected from 2004-2011. Future work will aim to assemble data for the period 1991-2003.

Results and discussion

Digital cover photography (DCP)

Table 1 shows the results from the cover photography of the 21 FORESTCHECK grids monitored between May and October 2011 to determine the minimum LAI for these grids in 2011 (referred to as 'spring 2011' LAI). LAI ranged from 0.49-1.62 with a mean of 1.14 ± 0.07.

Crown porosity ranged from 0.19-0.34 with a mean of 0.28 ± 0.01, consistent with the reported range for jarrah forest of 0.14-0.34 (Pekin and Macfarlane, 2009). Foliage cover ranged from 12-46% across the 48 grids with a mean of 32 ± 2%. Crown cover ranged from 15-65% with a mean of 45 ± 3%.

Normalized differential vegetation index (NDVI)

LAI was estimated from NDVI for each grid in 1988, 1990, and from 2004-2011. The LAI values across all the grids and all measured years were normally distributed (Chi-Square test = 46.18727, df = 16 (adjusted), p = 0.00009). Across these grids and years values of LAI ranged from 0.18-2.85 with a mean of 1.37 ± 0.02.

The minimum observed LAI occurred on the Occidental External reference grid (FC27), following a wildfire in January 2005 and the maximum LAI of 2.85 occurred on the Kingston gap release (FC2) in January 2006, ten years after it was harvested.

The grids show a general increase in LAI moving south along the central north to south axis: Perth Hills, 1.11 ± 0.03; Wellington 1, 1.45 ± 0.03; Donnelly, 1.74 ± 0.04; and a general decline in LAI moving east or west into lower rainfall areas; i.e. Wellington East, 1.06 ± 0.02 compared to Wellington 1, 1.45 ± 0.03; Blackwood, 1.44 ± 0.02 compared to Donnelly, 1.74 ± 0.04.

Table 1. Results from digital cover photography of 21 FORESTCHECK grids monitored in 2011. Grids are grouped by treatment type (LAI = leaf area index).

Grid	Location	Treatment	Year of most recent harvest	Date of photography	Crown porosity (CP)	Gap Fraction (GF)	Foliage cover (FC)	Crown cover (CC	LAI spring 2011
FC1	Winnejup	External reference	Uncut	6/10/11	0.33	0.59	0.41	0.61	1.36
FC5	Yornup	External reference	Uncut	5/10/11	0.28	0.66	0.34	0.48	1.21
FC10	Easter	External reference	Uncut	6/10/11	0.29	0.54	0.46	0.65	1.62
FC17	Surface	External reference	Uncut	4/10/11	0.25	0.57	0.43	0.57	1.57
FC19	Tumlo	External reference	Uncut	3/10/11	0.27	0.64	0.36	0.49	1.31
FC24	Kennedy	External reference	1935	13/09/11	0.28	0.69	0.31	0.43	1.09
FC27	Occidental	External reference	Uncut	30/09/11	0.27	0.73	0.27	0.37	0.95
FC28	Nalyerin	External reference	Uncut	7/10/11	0.34	0.67	0.33	0.50	1.07
FC32	Stockyard	External reference	Uncut	4/10/11	0.21	0.73	0.27	0.34	1.08
		Treatment mean							**1.25**
FC4	Kingston	Coupe buffer	1975	6/10/11	0.33	0.58	0.42	0.62	1.40
FC7	Thornton	Coupe buffer	1945	5/10/11	0.32	0.63	0.37	0.55	1.24
FC9	Carter	Coupe buffer	1945	5/10/11	0.22	0.60	0.40	0.51	1.55
		Treatment mean							**1.40**
FC3	Kingston	Shelterwood	1996	6/10/11	0.26	0.64	0.36	0.49	1.33
FC20	Holyoake	Shelterwood	1995	18/05/11	0.32	0.65	0.35	0.53	1.16
FC23	Cameron	Shelterwood	1989	3/06/11	0.33	0.65	0.35	0.51	1.18
FC33	Stockyard	Shelterwood	1998	28/09/11	0.24	0.74	0.26	0.34	0.99
		Treatment mean							**1.16**
FC2	Kingston	Gap release	1996	6/10/11	0.29	0.61	0.39	0.55	1.36
FC6	Thornton	Gap release	1991	5/10/11	0.29	0.69	0.31	0.44	1.09
FC11	Edward	Gap release	1994	14/09/11	0.28	0.78	0.22	0.31	0.77
FC22	Kennedy	Gap release	1988	19/05/11	0.22	0.85	0.15	0.19	0.58
FC25	Lesley	Gap release	1997	30/09/11	0.27	0.80	0.20	0.27	0.70
FC34	Stockyard	Gap release	1997	28/09/11	0.19	0.88	0.12	0.15	0.49
		Treatment mean							**0.83**
		Mean of all grids							**1.14**

The mean LAI for all grids that had been never harvested across all measured years was 1.34 ± 0.02 and the mean LAI for all grids that had been harvested was 1.36 ± 0.02 (excludes pre-harvest data from 1988 and 1990). Although this data set does not include values from the years immediately after harvest when the LAI would have been reduced by the harvest, this data does not indicate any long term change in LAI due to timber harvesting. Data covering the period immediately after the harvest treatments (1991-2003) will be extracted and reported next year.

We used the mean LAI measured before harvesting in 1988-1990 as reference values to examine the impact of harvesting on LAI. This exercise highlights the large annual variability in LAI. Gap release harvesting is the most intensive harvesting treatment and could be expected to produce the greatest long term impact on stand LAI. Of the 14 gap release treated grids two had not returned to the pre-harvest value of LAI by January 2011, eight had returned to the pre-harvest value of LAI by January 2004, and the remaining four reached the pre-harvest value at varying times after harvest (Table 2). Similar general trends can be observed in the shelterwood treated grids and, surprisingly, across the grids that had never been harvested; i.e. the variability

over time on the never harvested grids was sufficiently large that the LAI values from 1988 and 1990 could not be considered a meaningful baseline for assessing LAI in subsequent years (Fig. 1). There is large annual variability in LAI (Fig 2.). Consequently these pre-harvest values are not a useful baseline for considering the long-term effects of harvesting on LAI. A more detailed analysis that accounts for factors which affect forest wide variability in LAI across the years (e.g. annual rainfall) is needed to assess any impact of harvesting on LAI.

We found no relationship between LAI and total live stand basal area (as determined in McCaw 2011).

We identified 15 prescribed or wild fires that occurred on FORESTCHECK grids over the period 2004-2011 and examined subsequent changes in LAI (Table 2). Although LAI was reduced on some plots following fire (most notably the LAI determined on the Bell block grids, FC35, FC36 and FC37 in January 2005 was low due to a wild fire in December 2004) these occasional fires on a small number of plots did not drive the major annual trends in LAI across all plots in this study (Fig. 1 and Table 2) and the effects of fire appear to be short lived with LAI recovering within 12 months.

LAI on several of grids in Donnelly was low in January 2011 due to an outbreak of gum leaf skeletoniser (*Uraba lugens* Walker) in 2010. The DCP in spring 2011 shows a substantial recovery in LAI on the Carter coupe buffer (FC9) and Easter external reference (FC10), two grids that were badly affected by this outbreak. This recovery in LAI occurred as an irregular unseasonal leaf flush in winter.

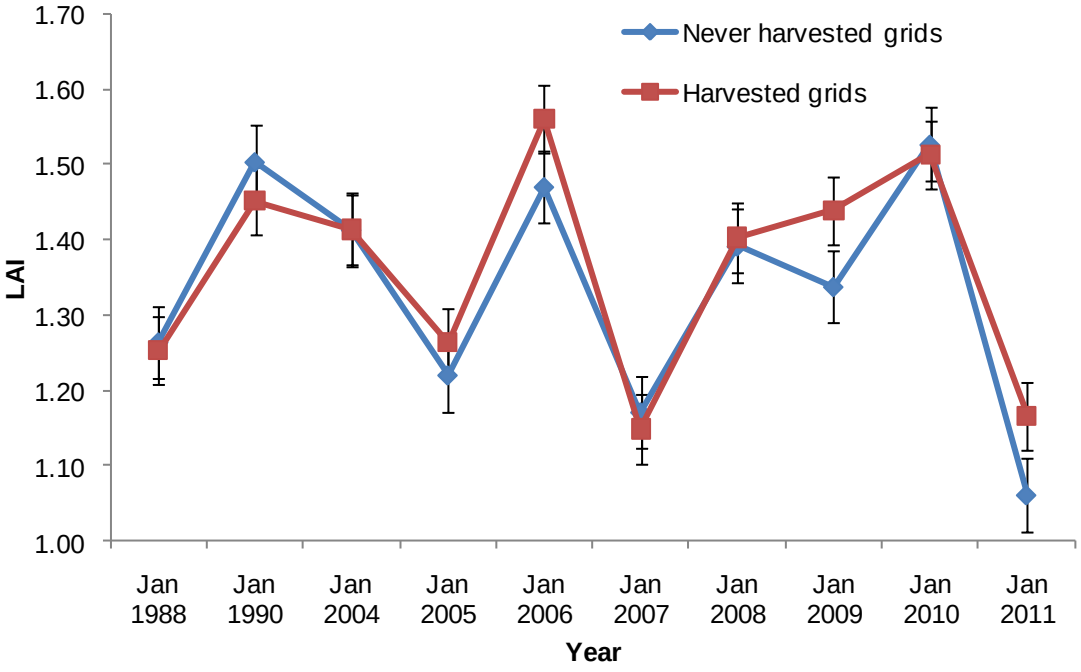

Figure 1. The annual mean leaf area index (LAI) in 1988, 1990, and from 2004 to 2011 for harvested FORESTCHECK grids and those grids that have never been harvested. LAI estimated from Landsat 5 Thematic Mapper imagery. Error bars are standard errors.

Table 2. The leaf area index (LAI) of FORESTCHECK grids estimated from normalised difference vegetation index (NDVI) extracted from Landsat 5 Thematic Mapper imagery from January of 1988, 1990, and 2004-2011. Spring 2011 values were estimated from Digital Cover Photography. Years where LAI may have been reduced by a preceding fire are bolded. Superscripts indicate the type of the fire: ^{S}, prescribed spring burn; ^{A}, prescribed autumn burn; and ^{W}, wildfire. ER = external reference, CB = coupe buffer, SW = shelyterwood, SC = selective cut and GR = gap release.

Grid	Location	Treat-ment	Year of most recent harvest	Jan. 1988	Jan. 1990	Jan. 2004	Jan. 2005	Jan. 2006	Jan. 2007	Jan. 2008	Jan. 2009	Jan. 2010	Jan 2011	Spring 2011	LAI 2004-11 (Mean ± SE)
FC1	Winnejup	ER	Uncut	1.36	1.59		1.38	2.23	1.42	1.40	1.81	1.74	1.25	1.36	1.60 ± 0.13
FC5	Yornup	ER	Uncut	1.17	1.59		1.44	1.99	1.31	1.52	1.70	1.42	1.38	1.21	1.54 ± 0.09
FC10	Easter	ER	Uncut	1.99	2.25	2.38	2.38	2.69	2.05	2.11		2.42	0.72	1.62	2.11 ± 0.24
FC16	Yourdamung	ER	Uncut	1.48	1.59	1.31	1.42	**1.15^{S}**	1.29	1.34	1.85	1.77	1.17		1.41 ± 0.09
FC17	Surface	ER	Uncut	1.39	1.75	1.46	1.30	1.58	**1.12^{W}**	1.71	1.16	1.78	1.32	1.57	1.43 ± 0.09
FC19	Tumlo	ER	Uncut	1.29	1.59	1.54	1.16	1.32	1.01	1.54	1.21	1.56	1.14	1.31	1.31 ± 0.08
FC21	Holyoake	ER	Uncut	1.15	1.31	1.29	1.02	0.55	1.05	1.21	1.21	1.23	1.01		1.07 ± 0.08
FC24	Kennedy	ER	1935	1.10	1.41	1.14	1.15	1.14	0.93	1.30	1.20	1.48	1.09	1.09	1.18 ± 0.06
FC27	Occidental	ER	Uncut	1.20	1.29	1.03	**0.18^{W}**	0.94	1.06	1.32	1.17	1.32	0.97	0.95	1.00 ± 0.13
FC28	Nalyerin	ER	Uncut	0.89	1.24	1.17	1.18	1.05	0.81	1.12	1.06	1.15	0.81	1.07	1.04 ± 0.05
FC32	Stockyard	ER	Uncut	0.89	1.29	1.33	1.14	1.05	0.80	1.19	**0.84^{A}**	1.13	0.95	1.08	1.05 ± 0.06
FC35	Bell	ER	Uncut	0.89	0.91	1.14	**0.40^{W}**	1.16	1.00	1.16	1.07	1.28	0.91		1.01 ± 0.10
FC38	Barrabup	ER	Uncut	1.32	1.64	1.37	1.21	1.86	1.22	1.31	1.20	1.57	1.18		1.36 ± 0.08
FC39	St John	ER	Uncut	1.32	1.75	1.53	1.55	1.68	1.39	1.40	1.62	1.66	1.31		1.52 ± 0.05
FC40	Layman	ER	Uncut	1.68	1.63	1.34	1.33	1.62	1.23	1.25	1.63	1.58	0.85		1.35 ± 0.09
Treatment mean															**1.32 ± 0.04**
FC4	Kingston	CB	1975	1.44	1.67	1.67	1.32	2.32	1.41	1.51	1.67	1.73	1.27	1.40	1.61 ± 0.12
FC7	Thornton	CB	1945	0.67	2.01	1.90	1.67	2.37	1.77	1.65	2.00	**1.65^{S}**	1.04	1.24	1.76 ± 0.13
FC9	Carter	CB	1945	1.28	1.68	2.05	1.92	2.36	1.76	1.54	2.25	1.58	0.73	1.55	1.77 ± 0.18
FC29	Godfrey	CB	Uncut	0.94	1.13	1.48	1.22	1.20	0.81	1.29	1.20	1.30	0.97		1.18 ± 0.07
Treatment mean															**1.58 ± 0.08**
FC43	Barrabup	SC	2002	1.36	1.76	0.94	1.49	1.87	1.41	1.50	1.69	1.64	1.18		1.47 ± 0.10
FC44	Cambray	SC	1995	1.53	1.81	1.60	1.52	1.87	1.40	1.32	1.62	1.83	1.41		1.57 ± 0.07
FC45	Butler	SC	1998	1.21	1.49	1.39	1.35	1.58	1.22	1.27	1.65	1.42	0.84		1.34 ± 0.09
Treatment mean															**1.46 ± 0.05**
FC3	Kingston	SW	1996	1.29	1.41		1.25	2.01	1.36	1.50	1.91	1.64	1.26	1.33	1.56 ± 0.12
FC13	Ross	SW	1992	1.35	1.60	1.26	1.17	1.28	0.97	1.25	1.33	1.43	1.13		1.23 ± 0.05
FC15	Surface	SW	1997	1.88	1.83	1.91	1.53	2.19	1.22	1.53	1.57	1.60	1.10		1.58 ± 0.12
FC18	Chalk	SW	1992	1.15	1.71	1.58	1.29	1.46	1.13	1.53	1.28	1.62	1.09		1.37 ± 0.07
FC20	Holyoake	SW	1995	1.21	1.48	1.31	1.24	1.41	1.36	1.64	1.62	1.61	1.18	1.16	1.42 ± 0.06
FC23	Cameron	SW	1989	1.12	0.79	1.24	1.30	1.32	1.03	1.50	1.35	1.60	1.23	1.18	1.32 ± 0.06
FC26	Lesley	SW	1997	1.08	1.13	1.00	0.94	0.96	0.91	1.17	1.03	**1.19^{S}**	1.11		1.04 ± 0.04
FC30	Godfrey	SW	2000	1.01	0.45	1.20	1.10	1.17	0.84	1.33	1.08	1.34	0.95		1.13 ± 0.06
FC33	Stockyard	SW	1998	0.95	1.29	1.16	0.97	0.97	0.73	1.06	**0.87^{A}**	1.06	0.87	0.99	0.96 ± 0.05
FC36	Bell	SW	1996	0.97	0.89	1.17	**0.56^{W}**	1.16	0.95	1.27	1.09	1.34	0.99		1.07 ± 0.09
FC41	Barrabup	SW	2002	1.24	1.71	1.21	1.22	1.54	1.26	1.37	1.51	1.44	1.17		1.34 ± 0.05
FC42	Cambray	SW	1995	1.46	1.83	1.44	1.50	1.83	1.35	1.39	1.23	1.58	1.27		1.45 ± 0.07
Treatment mean															**1.29 ± 0.03**
FC2	Kingston		1996	1.48	1.55	1.96	1.59	2.85	1.60	2.06	2.10	2.19	1.53	1.36	1.98 ± 0.15
FC6	Thornton	GR	1991	0.97	2.10	2.11	1.67	2.07	1.59	1.46	2.21	**1.44^{S}**	1.40	1.09	1.74 ± 0.12
FC8	Carter	GR	1995	1.60	2.15	2.55	2.16	2.13	1.67	2.21	2.52	2.34	1.82		2.18 ± 0.11
FC11	Edward	GR	1994	1.39	1.75	1.34	1.20	1.13	0.84	1.02	0.97	1.30	0.89	0.77	1.09 ± 0.07
FC12	Ross	GR	1992	1.29	1.51	1.53	1.52	1.62	**0.95^{S}**	1.42	1.46	1.75	1.21		1.43 ± 0.09
FC14	Surface	GR	1997	1.64	1.89	2.30	1.99	2.59	1.33	2.10	1.81	2.25	1.46		1.98 ± 0.15
FC22	Kennedy	GR	1988	1.04	0.91	1.08	0.92	0.85	0.86	1.11	1.03	**0.72^{S}**	1.07	0.58	0.95 ± 0.05
FC25	Lesley	GR	1997	1.17	1.14	0.72	0.75	0.71	0.66	0.81	0.81	**0.88^{S}**	0.79	0.70	0.77 ± 0.02
FC31	Godfrey	GR	2000	0.85	1.04	0.80	0.77	0.79	0.66	0.96	0.92	1.07	0.81		0.85 ± 0.05
FC34	Stockyard	GR	1998	0.97	1.38	1.41	1.23	1.42	0.92	1.31	**0.99^{A}**	1.41	1.08	0.49	1.22 ± 0.07
FC37	Bell	GR	1996	1.00	0.81	1.64	**0.37^{W}**	1.51	1.27	1.47	1.27	1.76	1.18		1.31 ± 0.15
FC46	Barrabup	GR	2002	1.37	1.82	1.09	1.12	1.54	1.24	1.45	1.62	1.53	1.25		1.35 ± 0.07
FC47	Cambray	GR	1996	1.29	1.75	1.31	1.49	1.79	1.31	1.30	1.62	1.67	1.37		1.48 ± 0.07
FC48	Butler	GR	1998	1.48	1.10	1.33	1.44	1.62	1.30	1.37	1.57	1.24	1.21		1.39 ± 0.05

Treatment mean	**1.41 ± 0.05**
Mean (all grids)	**1.37 ± 0.02**

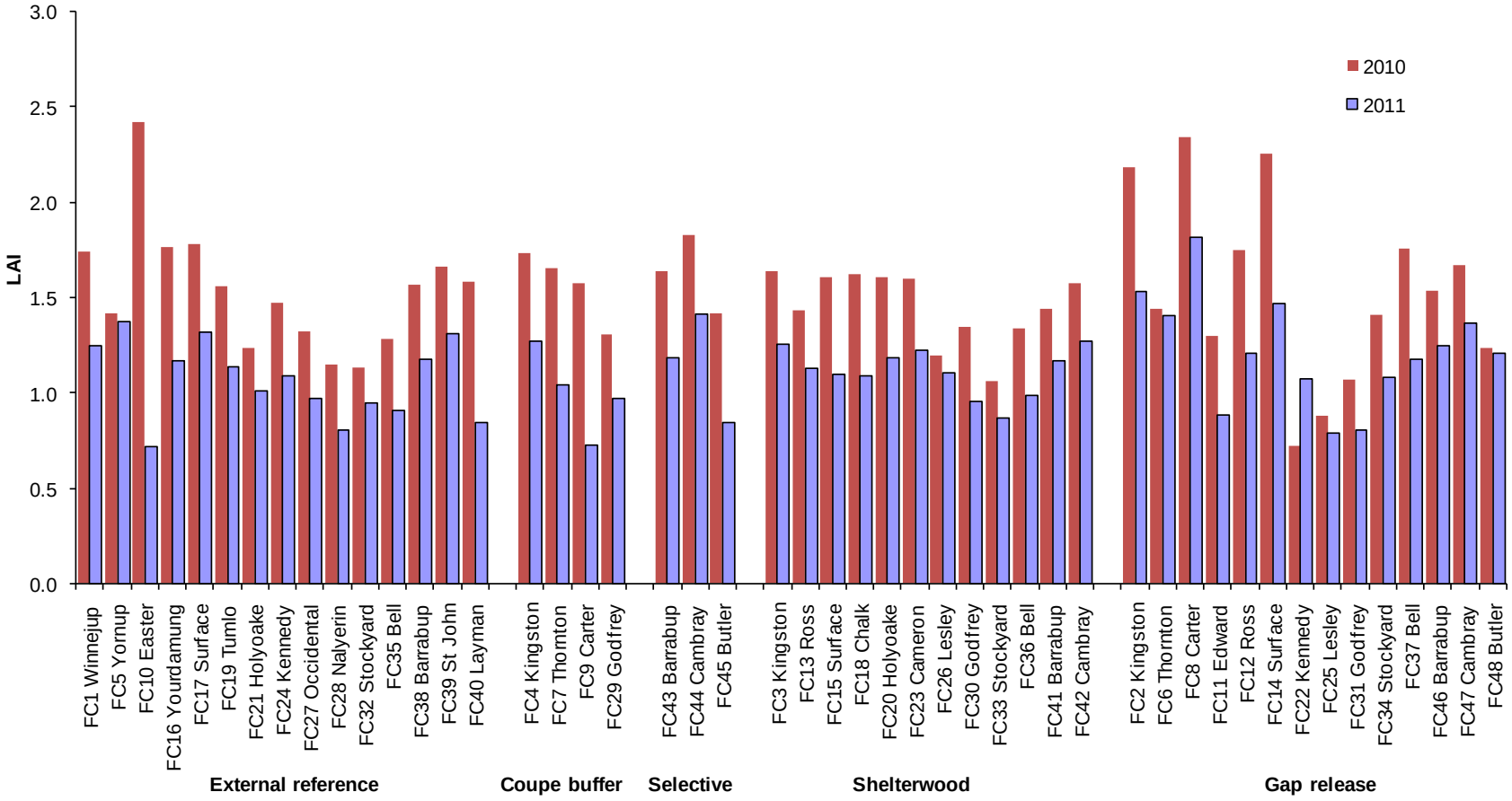

Figure 2. The leaf area index (LAI) of all FORESTCHECK grids in January 2010 and January 2011 estimated from normalised difference vegetation index (NDV derived from Landsat 5 Thematic Mapper imagery

CONCLUSIONS

- LAI varies substantially across the FORESTCHECK grids and these variations appear to be independent of the treatments, or largely driven by other factors.
- There are large forest wide annual variations in LAI. LAI declined substantially from 2010 to 2011.
- LAI increases moving from north to south and decreases as rainfall declines to the east and west.
- NDVI determined from remote sensing appears to provide sensible annual estimates of LAI.
- Canopy photography provides good data for tracking stand leaf area development and changes in canopy health over shorter time periods and should provide a sound basis for further calibration of remotely sensed LAI.
- DCP collected in 2011 on grids affected by gum leaf skeletoniser in 2010 indicates that LAI recovered substantially in an irregular, early season leaf flush.

Acknowledgements

We thank Craig Macfarlane for his substantial contribution in extracting NDVI data from the Thematic Mapper imagery, providing the DCP software, and advice on the DCP collection and analysis.

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COARSE WOODY DEBRIS, SMALL WOOD AND TWIGS, AND LITTER

Richard Robinson and Lachie McCaw

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 litter on the forest floor provides habitat for many fungi, invertebrates, small reptiles, and mammals. The litter layer also affects soil moisture, and in conjunction with micro-organisms, influences soil structure. 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 component of the FORESTCHECK monitoring program determines the amount of debris on each of the FORESTCHECK grids and monitors various attributes of this debris.

This component of FORESTCHECK is intended to:

- Measure and record the amount of litter, 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; and
- Provide data for analysis of distribution patterns of other organisms such as invertebrates, small mammals, fungi and cryptogams.

Litter samples are collected from 11 plots, each 0.05 m^2, along two 100 m transects on each grid (22 samples in total). SWT samples are collected from 22 plots, each 1 m^2, directly adjacent the litter plots. All samples are oven dried for 24 hrs and weights used to determine loads in tonnes per hectare. The CWD assessment was revised in 2008 (Whitford *et al*. 2008) in order to collect additional information. Amounts of CWD are determined along three 200 m transects on each grid using the methods of van Wagner (1968) and stages of decay for logs greater than 20 cm diameter are determines using the methods of Whitford *et al*. (2008). The re-assessment of all grids was commenced in 2008-09 (see FORESTCHECK 2008-09 Report of Progress) and completed in 2009-10. Six grids which had been burnt since their initial measurements were also re-assessed in 2009-10 (see 2009-10 FORESTCHECK Report of Progress).

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 measurements

No additional data on CWD was collected in 2011. Small wood and twigs and litter assessments were undertaken on the Wellington East grids from 29 April-1 May 2011. Twenty two samples each of SWT and litter were collected from each FORESTCHECK grid as

per the methods detailed in the FORESTCHECK Operations Plan (DEC 2006). Samples were oven dried, weighed in grams and then converted to tonnes per hectare (t ha^{-1}).

In 2005, the three Bell block grids (FC35, FC36 and FC37) had been burnt by wildfire six months prior to sampling. Prior to the 2011 sample, the three Stockyard grids (FC32, FC33 and FC34) had been burnt by prescribed fire in autumn 2008.

Results and discussion

Litter weights

In 2010, litter loads on grids within and between treatments were generally variable. Litter accumulation is influenced by a variety of factors including stand structure and density, the extent of fuel consumption during previous fires, time since previous fire and reduction in canopy density by defoliating insects. The three Stockyard grids (FC32, FC33 and FC34) had been prescribe burnt three years previously, and the relationship between litter loads on each of these and the other unburnt grids generally reflected time since fire (Fig. 1).

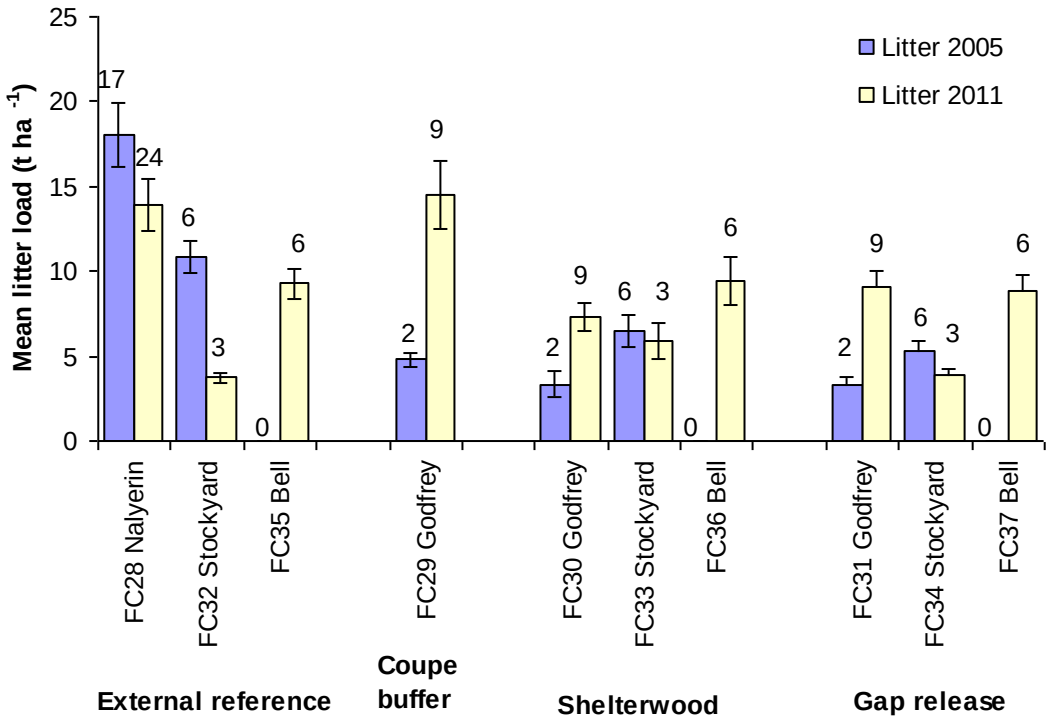

Figure 1. Mean litter loads (t ha^{-1} ± se) calculated at each FORESTCHECK grid at Wellington East in 2005 and 2011. Numbers above columns indicate years since fire.

However, the litter load on the long-unburnt external reference grid at Nalyerin (FC28) was lower by about 4 t ha^{-1} in 2011 despite not having been burnt in the interim since 2005. This may be due to the combined effects of mature crown development, a very dry period prior to measurement and a reduced leaf area index (see Whitford and Feeniks, this report) in 2011.

The Godfrey coupe buffer (FC29) had a similar litter load to that of the Nalyerin external reference in 2011 despite having 15 years less time for litter to accumulate. Both grids (FC28 and FC29) carried the heaviest litter loads and had dense mats of *Allocasuarina fraseriana* and *Banksia grandis* litter covering a significant area of the grid (Fig. 2). Litter loads on the

recently (3 years previously) burnt Stockyard shelterwood (FC33) and gap release (FC34) in 2011 were similar to those recorded in 2005, six years after fire. This likely reflects increased litter production by expanding canopies of retained trees and vigorous, well stocked regrowth compared to the more stable condition of canopies and lower numbers of seedlings and saplings on the external reference grid (FC32).

Figure 2.: General view (*left)* and showing thick build-up of *Allocasuarina fraseriana* and *Banksia grandis* litter and twigs (*right*) at the Nalyerin external reference grid (FC28).

Small wood and twigs

The amount of SWT on all sites was low (Fig. 3) compared to that of the litter (Fig. 1). SWT loads increased markedly on all grids except the Stockyard shelterwood (FC33) since 2005. The increase may be due to accelerated small branch shedding following the driest year on record occurring in 2010 (BoM 2010) followed by a dry autumn in 2011.

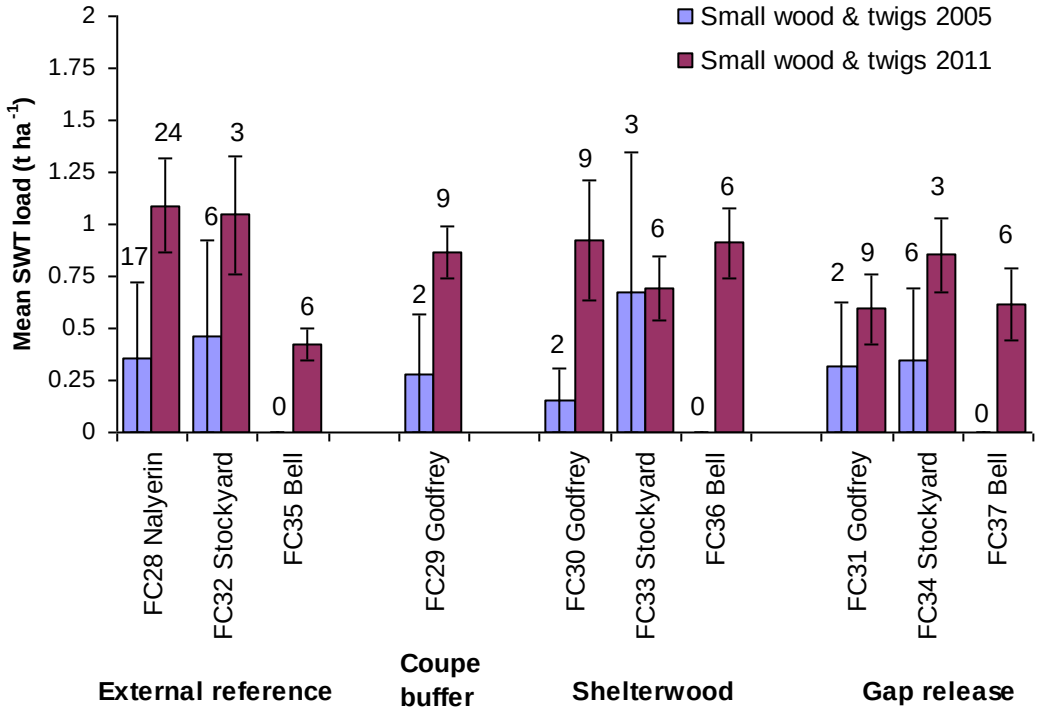

Figure 3. Average weights (t ha^{-1}) of small wood and twigs measured at each FORESTCHECK grid at Wellington East in 2005 and 2011. The numbers above the columns indicate years since burnt.

Conclusions

Broad observations resulting from litter and SWT sampling at Wellington East in 2010 include:

- Litter loads on harvested grids have generally increased since 2005;
- Generally litter loads reflect time since fire;
- SWT volumes have increased at least two- fold on all grids except the Stockyard shelterwood since 2005;
- Increased branch and twig shedding may be due to unprecedented low rainfall in 2010.

Acknowledgements

Thank you to Graeme (Tub) Liddelow and Neil Burrows for field assistance with sample collection.

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MACROFUNGI

Richard Robinson and Julia Bickle

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; and
- Generate detailed descriptions of unknown or unnamed species.

Field survey

Ten FORESTCHECK grids, including three external reference grids (FC28, FC32, FC35), one coupe buffer (FC29), three shelterwood (FC30, FC33, FC36) and three gap release treatments (FC31, FC34, FC37), were installed in the Jarrah North East forest ecosystem in the eastern region of the Wellington District in 2004. These plots were initially monitored for macrofungi in autumn 2005, and results were included in the FORESTCHECK Report of progress 2004-05.

The second round of macrofungal monitoring in Wellington east was undertaken in 2011. Two surveys were conducted, the first from 30 June-6 July and the second from 18-22 July 2011. 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). During a preliminary survey at Godfrey block on 14 June the SDI was at about 90 and very few fungi were encountered – except for a number of *Amanita* and *Boletus* species which are typical 'early' fruiting macrofungi. The SDI declined rapidly at the end of June and during the first survey it declined from 75 to 10. During the second survey, 2 weeks later, the SDI was steady between zero and 5 (Fig 1). During the first monitoring of the Wellington east grids in 2005 the SDI was steady at about 100 for the first survey (22-27 May 2005) zero during the second (30 June-8 July).

During each survey in 2011, all ten grids were monitored. All macrofungal species and their abundance were recorded along 2 x 200 m transects on each grid. All new or previously unrecorded taxa were photographed *in situ* and vouchers collected.

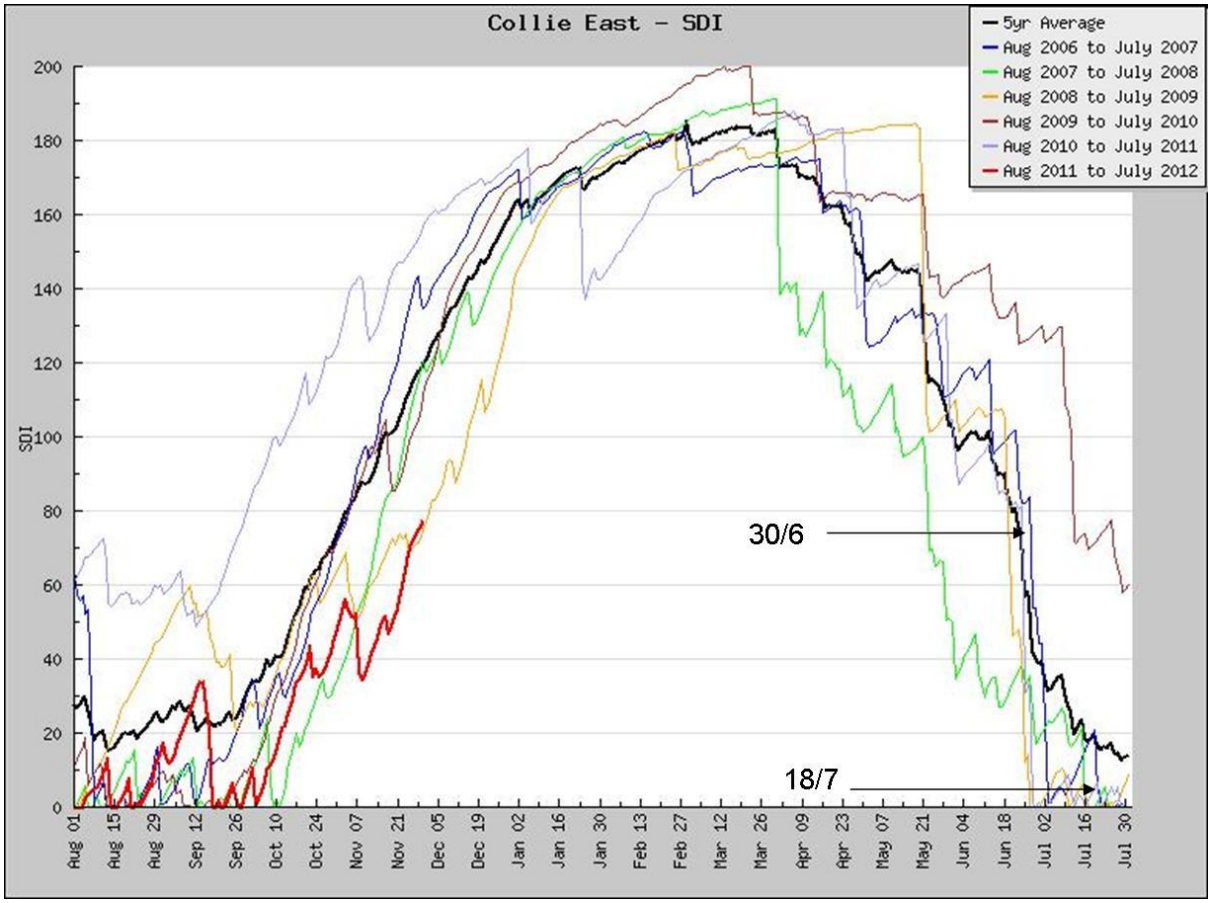

Figure 1. Daily soil dryness index (SDI) from the Collie East automatic weather station during the period August 2006 to November 2011 (Bureau of Meteorology). The SDI at the start of each FORESTCHECK macrofungi monitoring period in 2011 is indicated by the black arrows.

Results and discussion

Voucher specimen examination and processing

In the laboratory, voucher specimens were kept in a refrigerator at 5ºC. Processing of each voucher collection was completed on the day of collection. 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, 96 voucher collections were made representing 79 species. A total of 38 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 Annels 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 2011

A total of 239 species of macrofungi and 12,713 fruit bodies were recorded on the Wellington east monitoring grids in 2011 (Appendix 1). Of these, 38 species (16%) were recorded for the first time in FORESTCHECK. One hundred and eighty seven species were recorded in the late June/early July survey and 159 in the second July survey. Only 22% of the total species were recorded in both surveys (Fig. 2). This demonstrates the temporal differences in fruit body development throughout the fruiting season and the difficulties associated with analysing macrofungal communities in survey projects. It also demonstrates the importance of intensive long-term survey for monitoring macrofungal communities.

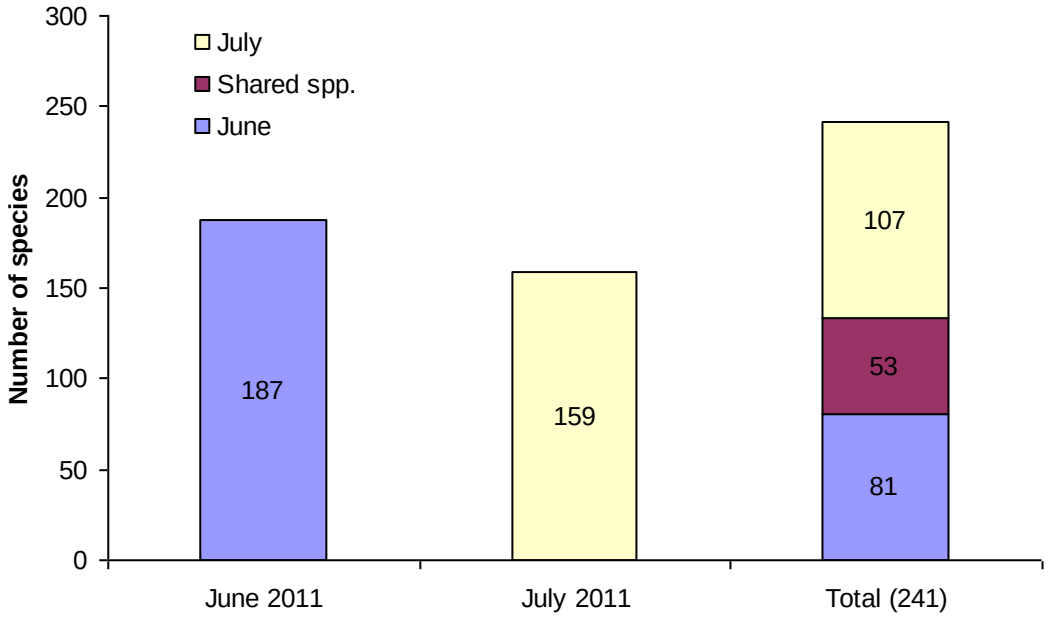

Figure 2. Total number of species recorded in June and July surveys on the Wellington east FORESTCHECK monitoring grids in 2011

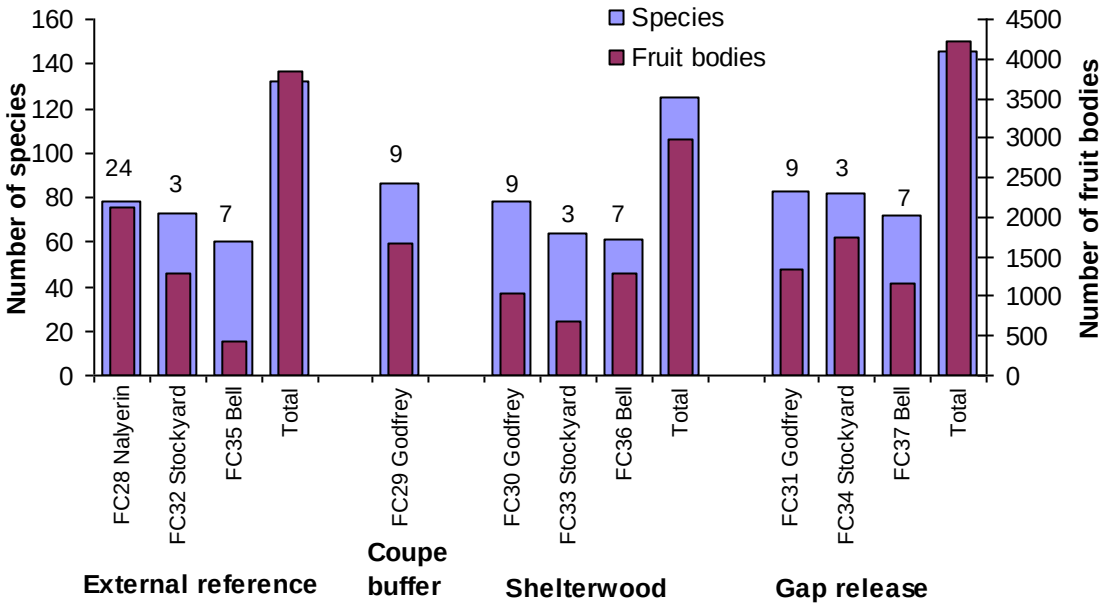

Figure 3. Total number of species recorded on each FORESTCHECK monitoring grid at Wellington east in 2011. Numbers above columns indicate the years since the last fire.

Total species richness and abundance of fruit bodies on each grid varied little within and between treatments (Fig. 3). Godfrey and Bell block grids had an intermediate time since fire (7-9 years) while Stockyard grids were the most recently burnt (3 years). There was no apparent effect of time since fire on either species richness or abundance. The Bell external reference (FC35) and Stockyard shelterwood (FC33) had unusually low abundances compared to the other grids.

The Nalyerin external reference (FC28) and the Godfrey coupe buffer (FC29) had high litter levels compared to other grids (see Fig. 1, p. 41 in section on Coarse Woody Debris, Small Wood and Twigs and Litter), principally consisting of a thick layer of *Allocasuarina fraseriana* needles. Generally thick *Allocasuarina* litter tends to limit the fruiting abundance of macrofungi and the high abundance recorded on the Nalyerin external reference was due to large numbers of *Ramaria* sp. 490 (459) which fruited within the mats of *Allocasuarina* needles and *Gymnopilus allantopus* (964) which fruited on decaying wood sitting above the litter (Fig. 4, Appendix 1). Ramaria sp. 459 appears to only be associated with *Allocasuarina* litter but has only ever been recorded on the Nalyerin external reference grid.

Figure 4. Left, *Ramaria* sp. 490 fruiting in *Allocasuarina* litter on the Nalyerin external reference grid. Right, *Gymnopilus allantopus* fruiting on decaying *Banksia grandis* wood.

Comparison with previous monitoring at Perth Hills and other regions

In this section, mean species richness and abundance per treatment and the mean number of species fruiting on the various substrates (soil, litter and wood) is analysed for Wellington east in 2011 and compared with the initial 2005 monitoring results as well as those from other regions (Donnelly 2002, 2008, Wellington 2003, 2009, Perth Hills 2004, 2010 and Blackwood Plateau 2006) where FORESTCHECK grids are established.

Species richness and abundance

Overall 348 species of macrofungi have been recorded on the Wellington east grids. The total number of species and total abundance was very similar in both 2005 (241 species, 12,053 fruit bodies) and 2011(239 species, 12,713 fruit bodies) (Fig. 5). About 54% were common to both monitoring years. Mean species richness was similar in all treatments in 2005 but variable within each treatment. In 2011, the mean species richness per grid was again similar in each treatment but with higher numbers of species per grid and less variable within treatments than that recorded in 2005 (Fig. 6). In both monitoring years, the total abundance of fruit bodies was similar in all treatments with external reference and gap release grids having similar and higher abundances than that recorded in shelterwood grids (Fig. 7). The

lower species richness in the shelterwood treatment was also reflected in the abundance in 2011 and in the total for the two monitoring sessions (Fig. 7). The single coupe buffer grid (FC29) in Godfrey block had the highest richness and abundance in both years (Figs. 6 and 7) but it is difficult to compare it with the other treatments which all had three monitoring grids. Generally at least one grid in each treatment had richness and abundances similar to the Godfrey coupe buffer (see Fig. 3).

Figure 5. Numbers of species of macrofungi in FORESTCHECK monitoring atWellington east in 2005and 2011

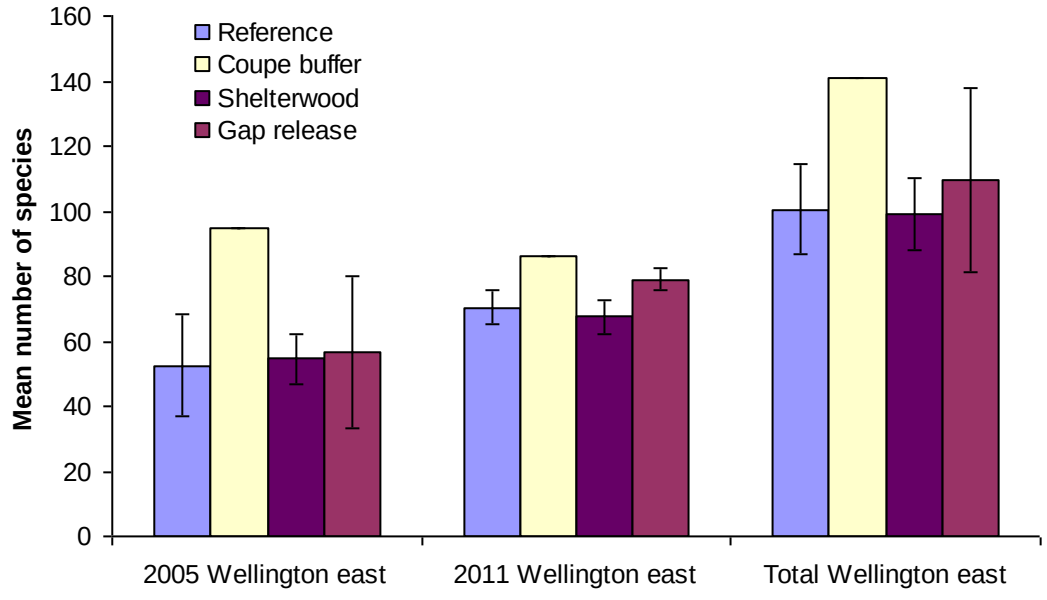

Figure 6. Mean numbers of species per grid (± se) in each treatment at Wellington east in 2005 and 2011

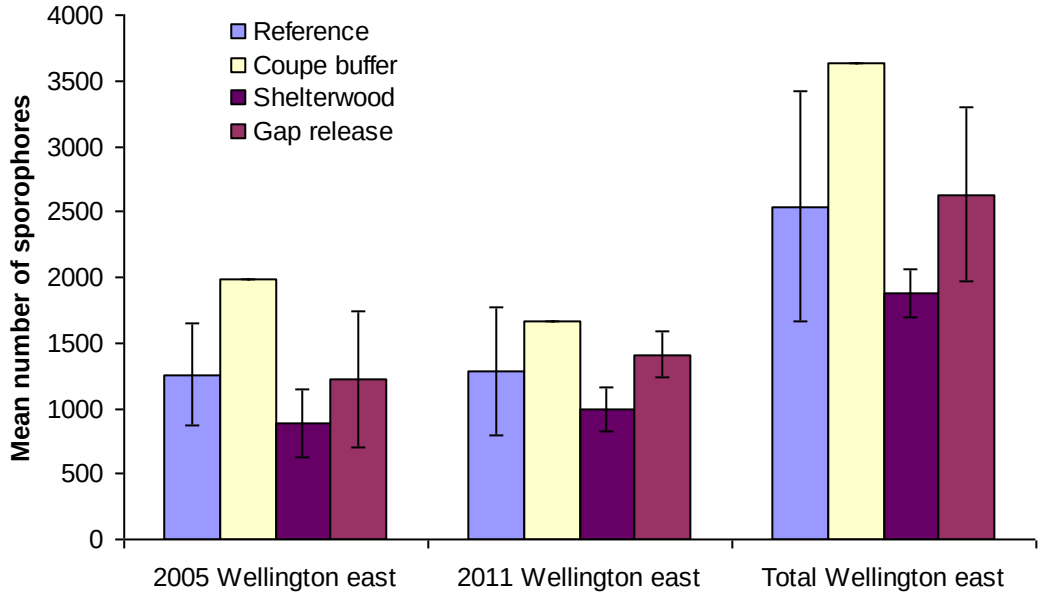

Figure 7. Mean numbers of fruit bodies per grid (± se) in each treatment atWellington east in 2005 and 2011

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, 2011 and 2006. The Perth Hills location is the poorest for both species richness and abundance (Fig. 8). Abundance has generally reflected species richness, except at Wellington 1 in 2003, where abundance appeared to be higher in relation to the number of species recorded. In general, we observed more species of large robust fungi in Wellington east and very few smaller delicate species were recorded. This may be a reflection of the drier more open environment.

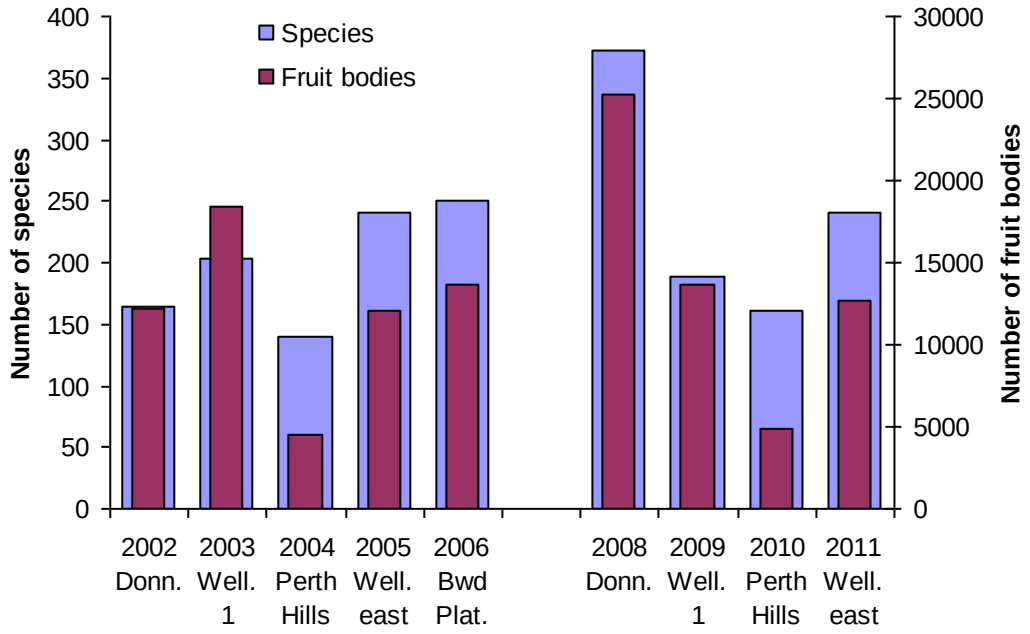

Figure 8. Total numbers of species and fruit bodies recorded at each Forestcheck location from 2002–2011

The three major habitats for fungi are soil, litter and wood. A small number of parasitic and lichenized fungi fruit on their host. The majority of macrofungi recorded at Wellington east fruited on soil, and more species were recorded on soil in 2011 that in 2005 (Figs 9 and 10). Litter was the least species rich substrate. For each substrate, the mean number of species per grid recorded in each year and in total was similar in each treatment.

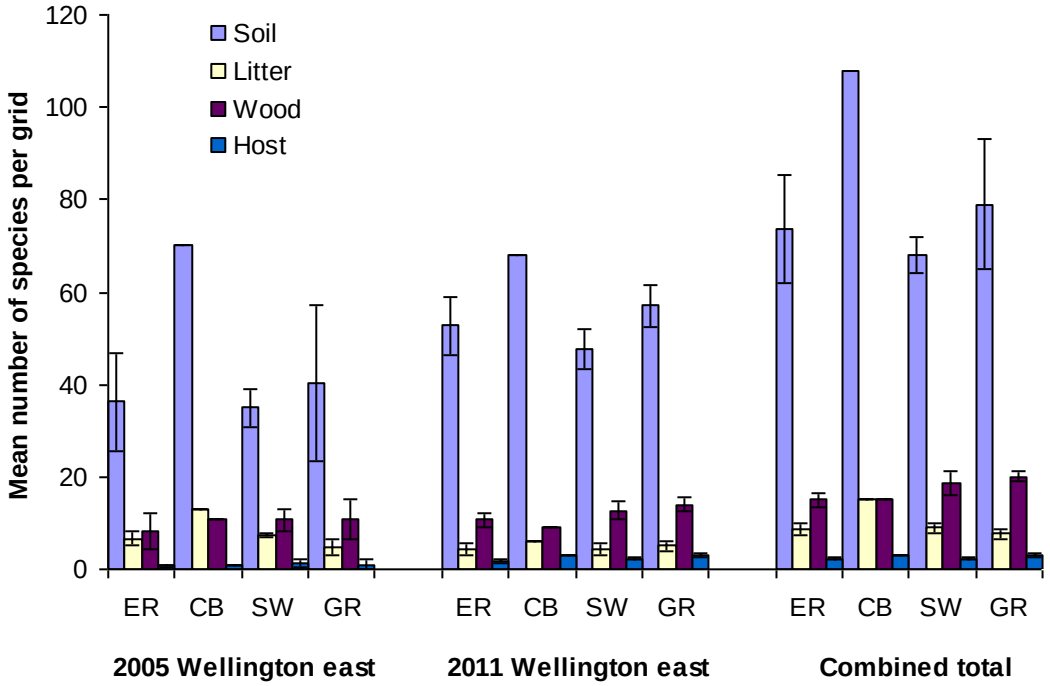

Figure 9. Mean numbers of species per grid (± se) recorded fruiting on soil, litter and wood on the Perth Hills FORESTCHECK grids in 2005 and 2011

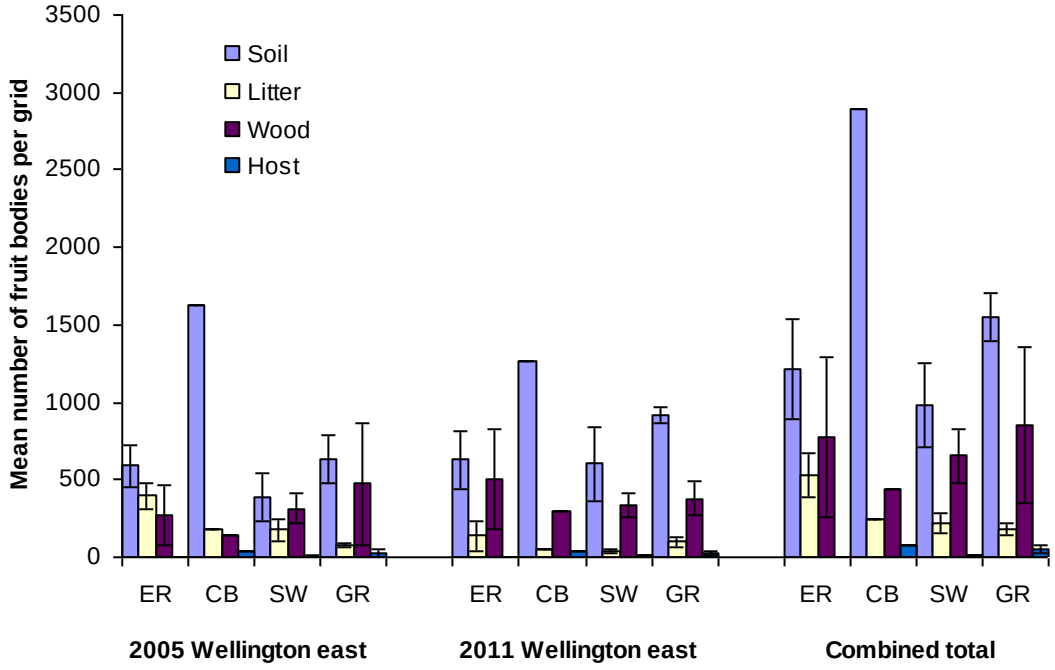

Figure 10. Mean numbers of fruit bodies per grid (± se) recorded fruiting on soil, litter and wood on the Perth Hills FORESTCHECK grids in 2005 and 2011

Fungi are associated with two of the most beneficial ecological processes involved in ecosystem functioning; the formation of mycorrhizae and decomposition. The vast majority (98%) of species recorded in 2011 were involved in these two roles. In 2011, the number of mycorrhizal and saprotrophic species was similar within and between treatments (Fig. 11). In 2005 there were generally fewer mycorrhizal species recorded in treatments compared to saprotrophic species and fewer mycorrhizal species than recorded in 2011. This was also reflected in the abundance of mycorrhizal species. Overall, saprotrophic species were more abundant than mycorrhizal species within treatments (Fig. 12).

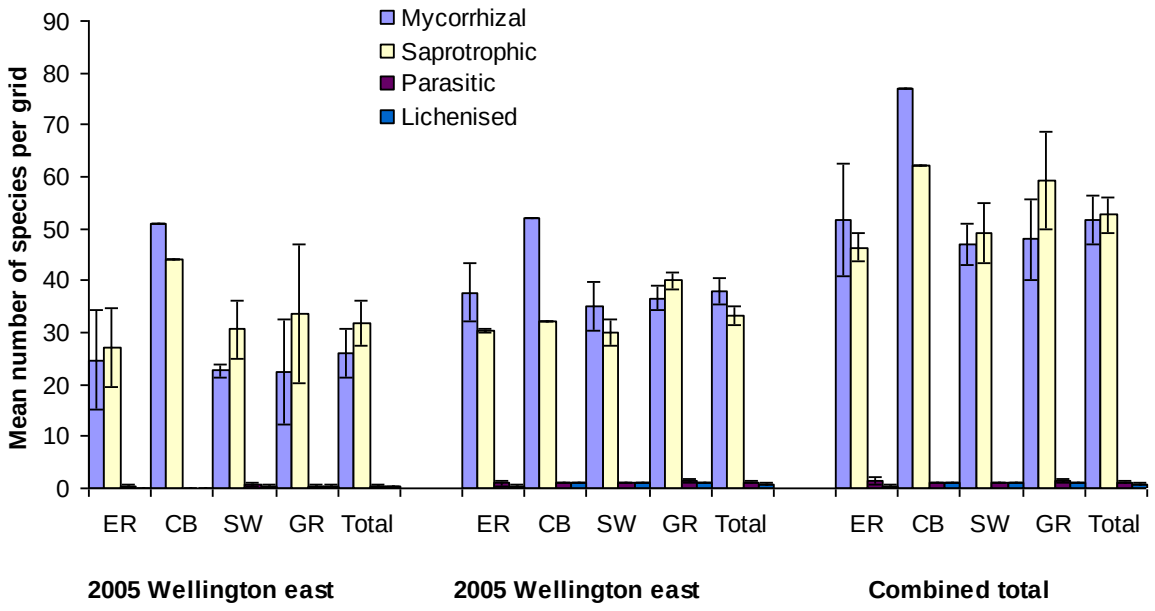

Figure 11. Mean numbers of mycorrhizal, saprotrophic, parasitic and lichenised species of macrofungi per grid (± se) recorded in the Perth Hills FORESTCHECK grids in 2005 and 2011

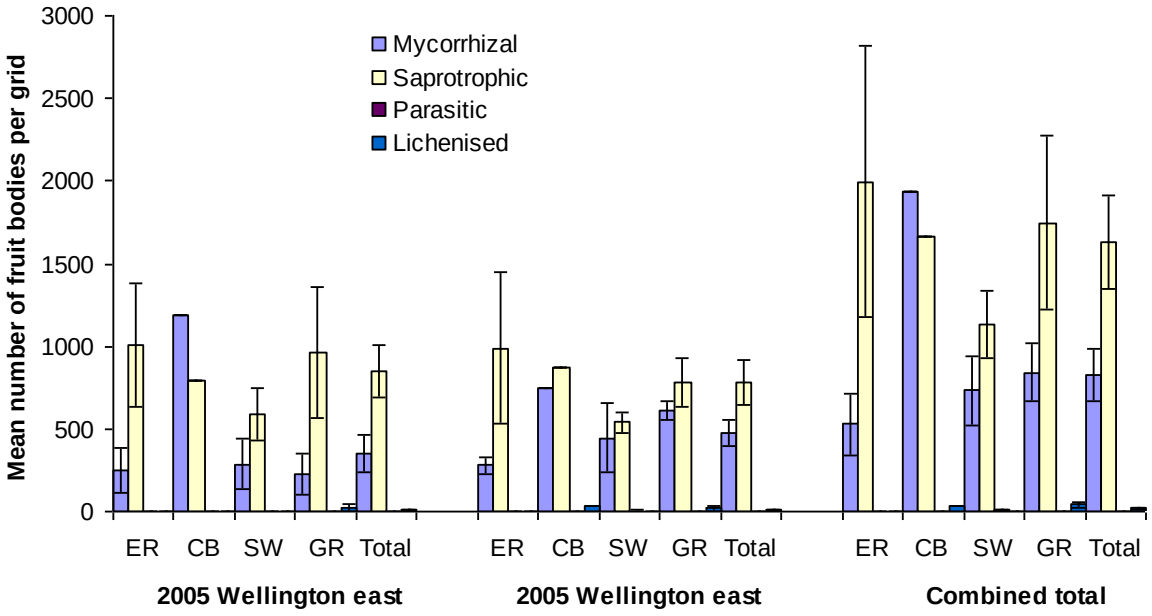

Figure 12. Mean numbers of mycorrhizal, saprotrophic, parasitic and lichenised macrofungal fruit bodies per grid (± se) recorded in the Perth Hills FORESTCHECK grids in 2005 and 2011

Cortinarius was the most diverse (41 species) and abundant (1617 fruit bodies) mycorrhizal genus. The two most common mycorrhizal species were *Cortinarius* sp. 201 and *Laccaria* aff. *masonii* (Fig. 13, left) (Appendix 1). *Mycena* and *Entoloma* were the most diverse (14 species each) genera and *Galerina* and *Gymnopilus* the most abundant (1112 & 2061 fruit bodies respectively). The most common saprotrophic species were *Gymnopilus alantopus* (Fig. 4, right) and *Galerina* sp. 58 (Fig. 13, right).

Figure 13. Left, *Laccaria* aff. *masonii*, the most abundant mycorrhizal species. Right, *Galerina* sp. 58, the second most abundant saprotrophic species, fruiting on a jarrah log.

Few parasitic and lichenised macrofungi were recorded. *Hypomyces chrysospermus* (Fig. 14, left), a parasite of *Boletus* spp. was common and recorded in all treatments in 2011 (Appendix 1) but was uncommon in 2005. In 2005 only 4 species of *Boletus* were recorded compared to 12 in 2011. The three most abundant species it was recorded on in 2011, *Boletus* sp. 49 (Fig. 14, right), *Boletus* sp. 99 and *Boletus* sp. 774 were not recorded in 2005. Species of *Boletus* are mycorrhizal and fruit on the soil.

Figure 14. Left, *Hypomyces chrysospermus* growing on *Boletus* sp. 774. The parasite consists of three stages, here the second yellow powdery and the third grey crust-like phases can be seen. Right, Healthy unparasitised *Boletus* sp. 49 fruit bodies.

Species accumulation across all locations

The total number of species of macrofungi recorded in FORESTCHECK from 2002-11 is 660. The number of species has steadily increased from 160 by an average of 62 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. 15). The accumulation curve is starting to plateau at about 600

species, with an average annual increase from 2008-10 of only 30 species per year compared to that of 80 per year for the period 2002-08. This was attributed to late autumn rains effectively delaying 'early' fruiting species and disrupting fruit body development of others. However, in 2011, despite seasonal rains not occurring until late June, 39 additional species were recorded in 2011, effectively stopping the plateau effect on species accumulation. Further analysis of the effects of climate on the diversity and abundance of fruit body production needs to be undertaken.

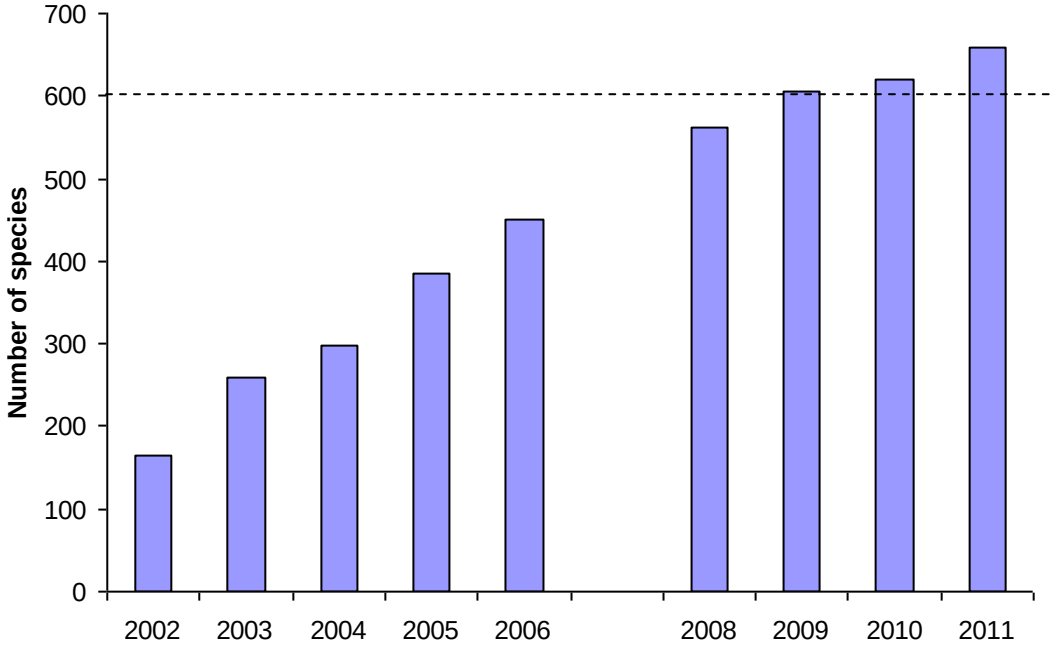

Figure 15. Species accumulation for macrofungi recorded on FORESTCHECK grids from 2002-2010

Conclusions

The main observations made following monitoring of macrofungi in the jarrah east ecosystem in the Wellington District were:

- A total of 660 species of macrofungi have so far been recorded in FORESTCHECK and species accumulation continues to increase.
- Wellington east has a rich and diverse mycota, with a total of 348 species so far recorded.
- 240 species were recorded at Wellington east in 2011, virtually the same as that recorded in 2005 (241). However, only 130 species were recorded in both years. Thirty nine species recorded in 2011 were recorded for the first time for FORESTCHECK.
- Mean species richness per grid was similar in all treatments in 2005, 2011 and overall.
- The majority of species fruited on soil in both years.
- There were similar numbers of mycorrhizal and saprotrophic species within and between treatments in 2011, and fewer mycorrhizal species were recorded in 2005 compared to 2011.

Data management

All data has been entered onto a Microsoft Excel worksheet. Species diversity and abundance on each grid and a frequency rating of 1 (rare) to 8 (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
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Appendix 1. List of species of macrofungi species and their abundances recorded at Wellington East in 2005 and 2011

Species #	Species[1]	Treatments 2011[2]				2011	2005
		ER	CB	SW	GR	Total	Total
0	Agaric unidentified			3		3	
894	Agaric olive to grey-brown, tough white stem FC1767	2			2	4	
39	*Agaricus austrovinaceous* Grgur. & T.W.May				1	1	5
38	*Agaricus* sp. small (R.M. Robinson & R.H. Smith FC42)						1
240	*Agaricus* sp. small with red brown fibrils (R.M. Robinson & R.H. Smith FC407)	2		1	2	5	1
120	*Aleuria rhenana* Fuckel	3		16	53	72	68
126	*Aleurina ferruginea* (W. Phillips) W.Y. Zhuang & Korf	2			13	15	9
206	*Amanita ananiceps* (Berk.) Sacc.						5
186	*Amanita brunneibulbosa* O.K.Mill.	7		7	7	21	1
875	*Amanita conicobulbosa* Cleland	4	2	19	17	42	
283	*Amanita eucalypti* O.K.Mill.						2
518	*Amanita* sp. beige cap, membranous ring, saccate base (R.M. Robinson & R.H. Smith FC959)						1
493	*Amanita* sp. grey brown robust (R.M. Robinson, R.H. Smith & K. Syme FC891)						2
497	*Amanita* sp. grey brown with orange yellow veil (R.M. Robinson & R.H. Smith FC899)						1
496	*Amanita* sp. grey veil (R.M. Robinson & R.H. Smith FC911)						7
218	*Amanita* sp. powdery cap and stem with long tapering base (R.M. Robinson, R.H. Smith & K. Pearce FC360)	9	2	34	53	98	17
526	*Amanita* sp. small creamy white cap and stem with membranous ring (R.M. Robinson & R.H. Smith FC979)	1	2	2	1	6	1
520	*Amanita* sp. sticky creamy yellow cap (R.M. Robinson & R.H. Smith FC 961)						1
45	*Amanita* sp. white deeply rooted (R.M. Robinson, R.H. Smith & K. Pearce FC377)						2
525	*Amanita* sp. white with grey scales and silvery stem (R.M. Robinson & R.H. Smith FC978)						1
371	*Amanita* sp. white with saccate volva (R.M. Robinson & R.H. Smith FC741)						4
519	*Amanita* sp. yellow brown cap and long stem with constricted bulb (R.M. Robinson & R.H. Smith FC960)						2
320	*Amanita* sp. yellow buff robust fruit with bulbous base (R.M. Robinson & R.H. Smith FC592)						1
531	Amanita spp. (unidentified)	3				3	5
196	*Amanita umbrinella* E.J.Gilbert & Cleland	1		2	24	27	
6	*Amanita xanthocephala* (Berk.) D.A.Reid & R.N.Hilton	40	6	21	30	97	42
35	*Amanita xanthocephala (Berk.) D.A.Reid & R.N.Hilton* forma *macalpineana* (Cleland & Cheel) D.A.Reid						2
338	*Anthracobia muelleri*(Berk.) Rifai						362
338	*Anthracobia* sp. small yellow (R.M. Robinson FC 933)						130
188	*Austroboletus laccunosus* (Kuntze) T.W.May & A.E.Wood		3		3	6	2
522	*Austropaxillus* aff. *infundibuliformis* (Cleland) Bresinsky & M.Jarosch						13
179	*Austropaxillus macnabbii* (Singer, J. García & L.D. Gómez) Jarosch	6		5	6	17	1
291	*Austropaxillus* sp. orange-brown (R.M. Robinson, R.H. Smith & K. Pearce FC 546)	18	59	28	22	127	52
436	*Beauveria bassiana* (Bals.-Criv.) Vuill.						1
93	*Boletellus ananiceps* (Berk.) Singer	1				1	6
103	*Boletellus obscurecoccineus* (Höhn.) Singer	5	4	1		10	3
29	*Boletus* sp. Boletus speciosa group - dull maroon, light stain (R.M. Robinson & R.H. Smith FC28)		3	1	2	6	2
253	*Boletus* sp. Boletus speciosa group - intense blue stain (R.M. Robinson & R.H. Smith FC439)				4	4	1
885	*Boletus* sp. brown cap, olive pores, brown non-staining flesh FC1728			2		2	
774	*Boletus* sp. light brown cap yellow pores which stain blue (R.M. Robinson & K. Syme FC1463)			10	3	13	
879	*Boletus* sp. light brown, yellow - no stain FC1677	1		4	3	8	
195	*Boletus* sp. mustard brown cap with brown staining flesh (R.M. Robinson FC320)			1		1	
49	*Boletus* sp. red pores and stem (R.M. Robinson & R.H. Smith FC55)	11		8	9	28	
883	*Boletus* sp. red-yellow cap, bright yellow pores, stem and flesh (R.M. Robinson FC1713)	1				1	
607	*Boletus* sp. yellow brown, stains blue (R.M. Robinson & J. Fielder FC1102)	2		4	1	7	
99	*Boletus* sp. yellow-red with blue staining flesh (R.M. Robinson & R.H. Smith FC398)	14		4	1	19	
504	*Bortyobasidium* sp. creamy orange mycelium under well rotted litter (R.M. Robinson & R.H. Smith FC927)				2	2	119
503	*Botryobasidium* sp. creamy grey crust on charcoal and leaves (R.M. Robinson & R.H. Smith FC923)						23

Species #	Species[1]	Treatments 2011[2]				2011	2005
		ER	CB	SW	GR	Total	Total
304	*Byssomerulius corium* (Pers. : Fr.) Parmasto	4				4	17
9	*Calocera guepinioides* Berk.	85	40	92	85	302	785
319	*Clavaria* (*Clavulinopsis*) sp. grey brown with black tips (R.M. Robinson & R.H. Smith FC758)						4
81	*Clavulina* aff. *cinerea* (Bull. : Fr.) J.Schröt.						5
140	*Clavulina* sp. pink-buff coral (R.M. Robinson & R.H. Smith FC212)				33	33	2
458	*Clavulina* sp. pinkish brown, red-brown tips (R.M. Robinson & R.H. Smith FC805)			23	3	26	19
197	*Clitocybe semiocculta* Cleland			1		1	
48	*Clitocybe* sp. grey (R.M. Robinson & R.H. Smith FC52)						23
876	*Collybia* sp. dark brown with tan margin (R.M. Robinson FC1670)	6				6	
886	*Collybia* sp. dark brown, brown grey gills (R.M. Robinson FC1704)				11	11	
880	*Collybia* sp. grey brown decurrent (R.M. Robinson FC1781)				11	11	
15	*Coltricia cinnamomea* (Jacq.) Murrill	68	55	68	146	337	220
532	*Coltriciella dependens* (Berk. & M.A.Curtis) Murrill			24	3	27	3
32	*Coprinus* sp. (R.M. Robinson & R.H. Smith FC33)				26	26	
128	*Coprinus* sp. basal hairs *sensu* Bougher & Syme		50		8	58	
224	*Coprinus* sp. micaceus (R.M. Robinson, R.H. Smith & K. Pearce FC372)				2	2	
394	*Coprinus* sp. roo poo NC			1		1	
454	Corticioid creamy jagged ridged crust (R.M. Robinson, R.H. Smith & K. Syme FC795)						2
373	Corticioid creamy yellow merulioid skin on jarrah stick (R.M. Robinson FC1531)				5	5	
511	*Cortinarius* sp. multi red (R.M. Robinson, R.H. Smith & K. Syme FC941)						12
702	*Cortinarius* (*Myxacium*) sp. khaki (K. Syme & J. Fielder FC1299)	4				4	
753	*Cortinarius* (P*hlegmacium*) sp. small purple brown (R.M. Robinson & K. Syme WFM406)			1		1	
158	*Cortinarius* aff. *microarcherii* Cleland	8	27	25	8	68	6
676	*Cortinaruis* aff. *lavendulensis* Cleland BFF92			1		1	
314	*Cortinarius archerii* Berk.	9				9	
207	*Cortinarius australiensis* (Cleland & Cheel) E.Horak						1
115	*Cortinarius austrofibrillosa* Grgur.	1	2	7		10	
173	*Cortinarius basirubescens* (large brown) Cleland & J.R.Harris						1
173	*Cortinarius basirubescens* (red cap) Cleland & J.R.Harris	4	1	13	5	23	
173	*Cortinarius basirubescens*(brown cap) Cleland & J.R.Harris	12	10	10	7	39	5
293	*Cortinarius rotundisporus* Cleland & Cheel	16	32	2		50	1
357	*Cortinarius sinapicolor* Cleland	6	2			8	1
771	*Cortinarius* sp. bright lavender gills (R.M. Robinson, K. Syme & J. Mccalmont FC1446)	3			1	4	
68	*Cortinarius* sp. Brown (R.M. Robinson & R.H. Smith FC79)	1			1	2	1
421	*Cortinarius* sp. brown cap with lilac white stem (R.M. Robinson & J. Fielder FC1095)						16
279	*Cortinarius* sp. brown fibrillose (R.M. Robinson, R.H. Smith & K. Pearce FC521)	2				2	
154	*Cortinarius* sp. chestnut (R.M. Robinson & J. Fielder FC 1050)	50	14	9	12	85	61
500	*Cortinarius* sp. chestnut large (R.M. Robinson & R.H. Smith FC918)						101
299	*Cortinarius* sp. chocolate brown with mustard gills (R.M. Robinson & K. Pearce FC578)	20			19	39	13
201	*Cortinarius* sp. cream cap with orange gills (R.M. Robinson FC327)	15	6	630	43	694	
882	*Cortinarius* sp. creamy domes (R.M> Robinson FC1692)		9			9	
485	*Cortinarius* sp. creamy white with veil on stem (R.M. Robinson, R.H. Smith & K. Syme FC884)			10		10	4
878	*Cortinarius* sp. creamy yellow fibrillose cap, white bulbous stem (R.M. Robinson FC1743)			1	8	9	
453	*Cortinarius* sp. decurrent gills and deep stem with double ring (R.M. Robinson, R.H. Smith & K. Syme FC790)						12
611	*Cortinarius* sp. dry, purple grey (R.M.Robinson & J.C.Fielder FC1130)	4				4	
374	*Cortinarius* sp. golden tan (R.M. Robinson & R.H. Smith FC748)						2
348	*Cortinarius* sp. golden tan cap with long stem (R.M. Robinson & J.E.Neal FC669)	6		6		12	
887	*Cortinarius* sp. greyish dark brown cap, light purple grey stem FC1744				10	10	
257	*Cortinarius* sp. honey brown (R.M. Robinson & R.H. Smith FC454)		2			2	
146	*Cortinarius* sp. Myxacium orange-brown viscid cap (R.M. Robinson & R.H. Smith FC223)						12
223b	*Cortinarius* sp. orange (R.M. Robinson & J. Fielder FC1016)				10	10	
212	*Cortinarius* sp. orange brown (R.M. Robinson, R.H. Smith & K. Pearce FC371)	4			12	16	

Species #	Species[1]	Treatments 2011[2]				2011	2005
		ER	CB	SW	GR	Total	Total
205	*Cortinarius* sp. orange cap with yellow flesh and yellow gills (R.M. Robinson FC331)						2
404	*Cortinarius* sp. orange cap, with white floccose stem (R.M. Robinson & K. Syme WFM45)						1
893	*Cortinarius* sp. pale orange yellow, tan margin (R.M. Robinson FC1765)				39	39	
891	*Cortinarius* sp. pink-brown, mauve (R.M. Robinson FC1762)	1				1	
98	*Cortinarius* sp. pointy cap (R.M. Robinson & R.H. Smith FC134)	5		8	2	15	46
888	*Cortinarius* sp. purple brown cap, lavender stem (R.M. Robinson FC1747)				6	6	
881	*Cortinarius* sp. purple-brown cap , lavender stem, chocolate gills (R.M. Robinson FC1703)		1		15	16	
515	*Cortinarius* sp. red brown cap with slender lavender stem (R.M. Robinson, R.H. Smith & K. Syme FC952)		2			2	5
626	*Cortinarius* sp. red brown pointy cap (R.M. Robinson & J. Fielder FC1181)	14				14	
670	*Cortinarius* sp. small fibrillose in moss (R.M> Robinson & J. Fielder BFF 84)				4	4	
232	*Cortinarius* sp. small orange viscid cap (R.M. Robinson & R.H. Smith FC390)				1	1	1
267	*Cortinarius* sp. snowy chestnut (R.M. Robinson & R.H. Smith FC478)	17	2			19	13
432	*Cortinarius* sp. tan cap with chocolate gills (R.M. Robinson & K. Syme WFM110)						4
171	*Cortinarius* sp. vinaceous lilac (R.M. Robinson, R.H. Smith & K. Pearce FC543)						5
270	*Cortinarius* sp. viscid red brown cap with white stem (R.M. Robinson & R.H. Smith FC482)						1
273	*Cortinarius* sp. white with deep rooting stem (R.M. Robinson, R.H. Smith & K. Pearce FC498)		1			1	
231	*Cortinarius* sp. yellow brown cap with tan margin (R.M. Robinson & R.H. Smith FC389)	2	67	24	16	109	2
492	*Cortinarius* sp. yellow cap with yellow stem (R.M. Robinson, R.H. Smith & K. Syme FC889)						7
892	*Cortinarius* sp. yellow cap, white lavender tinted stem (R.M. Robinson FC1764)	12				12	
237	*Cortinarius* sp. yellow with orange brown fibrils (R.M. Robinson & R.H. Smith FC403)	31	12	4	4	49	5
354	*Cortinarius* sp. yellow-brown cap with lavender gills and stem (R.M. Robinson & R.H. Smith FC698)	3	5			8	4
184	*Cortinarius* spp. (unidentified)	84	27	31	43	185	23
7	*Cortinarius sublargus* Cleland			30		30	2
889	*Cotylidia* sp. brown (R.M. Robinson FC1748)				25	25	
16	*Cotylidia undulata* (Fr.) P. Karst.	3		3	259	265	67
118	*Crepidotus nephrodes* (Berk. & M.A.Curtis) Sacc.	4		3	1	8	4
21	*Crepidotus* sp. small white NC						75
241	*Crepidotus variabilis* (Pers. : Fr.) P.Kumm.	50			4	54	215
148	*Crucibulum laeve* (Huds. : Pers.) Kambly	131	1	29	84	245	332
307	*Cyathus* sp. (R.M. Robinson & K. Pearce FC591)			12		12	30
296	*Cyathus* sp. roo poo (R.M. Robinson & K. Pearce FC559)			2		2	80
289	*Dacrymyces capitatus* Schwein.						412
147	*Dermocybe austroveneta* (Cleland) M.M.Moser & E.Horak			3		3	
340	*Dermocybe clelandii* "mini" (A.H.Sm.) Grgur.		2			2	42
57	*Dermocybe clelandii* (white mycelium) (A.H.Sm.) Grgur.						15
57b	*Dermocybe clelandii* "olive brown" (A.H.Sm.) Grgur				2	2	
172	*Dermocybe clelandii* (yellow mycelium) (A.H.Sm.) Grgur.	13	3	1	3	20	1
172b	*Dermocybe clelandii* (yellow mycelium - glutinous cap) (A.H.Sm.) Grgur.	7				7	
168	*Dermocybe* sp. jarrah (R.M. Robinson & R.H. Smith FC301)	28	33	6	22	89	16
486	*Dermocybe* sp. yellow stipe with yellow mycelium (R.M. Robinson, R.H. Smith & K. Syme FC881)		2		1	3	
123	*Discinella terrestris* (Berk. & Broome) Denni	12			6	18	133
528	Discomycete yellow discs on Emu poo (NC)						150
409	*Entoloma incanum* (Fr. : Fr.) Hesler						6
31	*Entoloma moongum* Grgur.			2	2	4	6
811	*Entoloma* sp. grey with decurrent gills R.M. Robinson & K. Syme WFM508)			4	2	6	
410	*Entoloma* sp. blue-black, marginate gills (R.M. Robinson & K. Syme WFM53)						1
194	*Entoloma* sp. brown (R.M. Robinson FC318)	4				4	
198	*Entoloma* sp. brown black cap tan gills blue stem (R.M. Robinson FC323)						1
530	*Entoloma* sp. brown black cap with marginate gills and bluish grey stem (R.M. Robinson, R.H. Smith & K. Syme FC1001)			5		5	2
227	*Entoloma* sp. brown black cap with tan gills (R.M. Robinson, R.H. Smith & K. Pearce FC378)			4		4	6
222	*Entoloma* sp. brown black with grey white gills (R.M. Robinson, R.H. Smith & K. Pearce FC374)		2			2	

Species #	Species[1]	Treatments 2011[2]				2011	2005
		ER	CB	SW	GR	Total	Total
859	*Entoloma* sp. brown funnel (R.M. Robinson WFM625)				1	1	
347	*Entoloma* sp. brown striate cap (R.M. Robinson & J.E.Neal FC666)				1	1	
471	*Entoloma* sp. buff with dimple (R.M. Robinson, R.H. Smith & K. Syme FC849)	1				1	
30	*Entoloma* sp. creamy white (R.M. Robinson & R.H. Smith FC29)		1		7	8	11
235	*Entoloma* sp. grey brown cap with grey stem (R.M. Robinson & R.H. Smith FC399)	2		9	2	13	17
272	*Entoloma* sp. grey brown with dimple (R.M. Robinson, R.H. Smith & K. Pearce FC497)				2	2	8
25	*Entoloma* sp. grey-brown/blue stem (R.M. Robinson & R.H. Smith FC23)						1
812	*Entoloma* sp. sticky cream cap R.M. Robinson & K. Syme WFM512)	1				1	
278	*Entoloma* sp. suede grey brown cap with dimple (R.M. Robinson, R.H. Smith & K. Syme FC996)				1	1	6
606	*Entoloma* sp. tall velvet grey brown cap (R.M. Robinson & J. Fielder FC1100)	1				1	
135	*Entoloma* sp. tall, grey-brown (R.M. Robinson & R.H. Smith FC207)						9
514	*Entoloma* sp. very large brown grey (R.M. Robinson, R.H. Smith & K. Syme FC951)						1
274	*Entoloma viridomarginatum* (Cleland) E.Horak						5
159	*Exidia glandulosus* (Bull. : Fr.) Fr.	3				3	
41	*Fistulina spiculifera* (Cooke) D.A.Reid		1			1	2
19	*Fomitopsis lilacinogilva* (Berk.) J.E.Wright & J.R.Deschamps	6		8	1	15	11
11	*Galerina* sp. hanging gills and conic (R.M. Robinson & R.H. Smith FC11)	112	110	115	187	524	449
58	*Galerina* sp. small cap, eccentric stipe - on wood (R.M. Robinson & R.H. Smith FC63)	29	30	284	245	588	109
533	*Geoglossum* aff. *umbratile* Sacc. (R.M. Robinson, R.H. Smith & K. Syme FC997)						1
8	*Gymnopilus allantopus* (Berk.) Pegler	1043	113	200	254	1610	582
591	*Gymnopilus* sp. purple maroon (R.M. Robinson & J. Fielder FC1078)	2		3	14	19	
517	*Gymnopilus* sp. red cap with yellow gills and yellow stem (R.M. Robinson, R.H. Smith & K. Syme FC957)						1
174	*Gymnopilus* sp. red cap yellow gills red stem (R.M. Robinson, R.H. Smith & K. Pearce FC314)			1		1	
85	*Gymnopilus* sp. slender (R.M. Robinson & R.H. Smith FC110)	72	30	119	210	431	158
498	*Hebeloma* sp. small (R.M. Robinson & R.H. Smith FC922)						14
433	*Hebeloma westraliensis* Bougher, Tommerup & Malajczuk						1
56	*Heterotextus peziziformis* (Berk.) Lloyd	2		15	31	48	57
422	*Hohenbuehelia atrocaerulea* (Fr. : Fr.) Singer						14
877	*Hohenbuhellia* sp (R.M. Robinson FC1676)			1		1	
480	*Hydnellum* sp. orange tipped spines (R.M. Robinson, R.H. Smith & K. Syme FC829)						1
87	*Hydnellum* sp. red brown (R.M. Robinson & R.H. Smith FC113)		1			1	1
300	*Hydnoplicata convoluta* (McAlpine) Trappe & Claridge		1			1	6
297	*Hydnum repandum* L. : Fr.						3
381	*Hygrocybe cantharellus* (Schwein. : Fr.) Murrill						1
281	*Hygrocybe virginea*(Wulfen : Fr.) P.D. Orton & Watling var. *virginea*				1	1	
691	*Hyphodontia barba-jovis* (Bull.) J. Erikss.			3		3	
108	*Hypomyces chrysospermus* Tul. & C. Tul.	5	1	13	3	22	6
640	*Hypomyces* sp - on *Lactarius clarkeae* (R.M. Robinson & R.S. Wittkuhn BFF0027)	1				1	
697	*Hypomyces* sp. - on *Ramaria* sp. (K. Syme & J. Fielder FC1295)				1	1	
268	*Hypomyces* sp. brown/yellow-orange on *C. cinnamoni* (R.M. Robinson, R.H. Smith & K. Pearce FC483)				1	1	
516	*Ileodictyon gracile* Berk.			11		11	5
1	*Inocybe australiensis* Cleland & Cheel	33	1	1	39	74	473
398	*Inocybe* fibrillosibrunnea O.K. Mill. & R.N. Hilton [large scaly umbonate cap (R.M. Robinson & K. Syme WFM36)]				23	23	1
487	*Inocybe* sp. brown fibrillose cap with yellow gills (R.M. Robinson, R.H. Smith & K. Syme FC883)	4	7	11	57	79	32
65	*Inocybe* sp. large scaly cap (R.M. Robinson & R.H. Smith FC74)				1	1	
484	*Inocybe* sp. large umbonate firillosecap with yellow-tan gills (R.M. Robinson, R.H. Smith & K. Syme FC880)						6
20	*Inocybe* sp. scaly cap (R.M. Robinson, R.H. Smith & K. Pearce FC334)	8	1		9	18	35
169	*Inocybe* sp. shaggy stem (R.M. Robinson & R.H. Smith FC306)		16			16	4
162	*Inocybe* sp. small light brown, fibrillose (R.M. Robinson & R.H. Smith FC261)			1		1	
53	*Inocybe* sp. tan skirt (R.M. Robinson & R.H. Smith FC60)	9	8	4		21	26

Species #	Species[1]	Treatments 2011[2]				2011	2005
		ER	CB	SW	GR	Total	Total
286	*Inocybe* sp. umbonate, shaggy (R.M. Robinson & K. Pearce FC576)						9
203	*Inocybe violaceocaulis* Matheny & Bougher		4			4	5
74	*Laccaria* aff. *masoniae* G.Stev.	79	243	64	806	1192	1347
36	*Laccaria lateritia* Malençon	5	1	9	7	22	90
765	*Laccaria* sp. burnt orange (R.M. Robinson & K. Syme WFM460)	1				1	
221	*Lactarius clarkeae* Cleland	9	1		1	11	15
142	*Lactarius eucalypti* O.K.Mill. & R.N.Hilton	1		2	1	4	2
215	*Lactarius* sp. cream custard (R.M. Robinson, R.H. Smith & K. Pearce FC365)						3
245	*Lactarius* sp. creamy yellow (R.M. Robinson & R.H. Smith FC417)	3	20	37	63	123	150
478	*Laetiporus potentosus* (Berk.) Rajchenb.						6
185	*Lepiota* aff. *cristata* (Alb. & Schwein. : Fr.) P.Kumm.			16		16	
76	*Lepiota alopochroa* (Berk. & Broome) Sacc.	5		3	55	63	5
862	*Lepiota* sp. creamy brown with ring (R.M. Robinson, K.Syme & P.Anderson WFM597)	23	53	6	13	95	
884	*Lepiota* sp. creamy brown with scaly stem (R.M. Robinson FC1721)	1	1	3	20	25	
264	*Lepiota* sp. creamy grey (R.M. Robinson & R.H. Smith FC471)	2		1		3	1
760	*Lepiota* sp. creamy grey no ring (R.M. Robinson, K. Syme & J. Mccalmont WFM448)			1		1	
246	*Lepiota* sp. purple grey (R.M. Robinson & R.H. Smith FC419)				1	1	
728	*Lepiota* sp. red-brown (R.M. Robinson & K. Syme FC1337)	5	2	2	1	10	
166	*Lepiota subcristata* Cleland						12
214	*Leucopaxillus lilacinus* Bougher	5				5	
127	*Lichenomphalia umbellifera* (L.) Redhead, Lutzoni, Moncalvo & Vilgalys	5	35	8	56	104	74
24	*Lycoperdon* sp. (R.M. Robinson & R.H. Smith FC22)		9	6	31	46	22
190	*Macrolepiota clelandii* Grgur.	2	2			4	
191	*Marasmiellis* sp. "white umbrella" (NC)	2				2	
55	*Marasmius crinisequi* F.Muell.	4				4	
443	*Marasmius* sp. tan (R.M. Robinson FF770, WFM129)			4	4	8	
529	*Melanoleuca* sp. grey brown cap with white gills and stem (R.M. Robinson, R.H. Smith & K. Syme FC994)				1	1	3
151	*Melanoleuca* sp. large (R.M. Robinson & R.H. Smith FC472)			1		1	1
489	*Melanoleuca* sp. large brown cap with tan gills (R.M. Robinson, R.H. Smith & K. Syme FC894)						2
64	*Mycena adscendens* (Lasch) Maas. Geest.						3
44	*Mycena* aff. *atrata* Grgur. & A.A.Holland. ex Grgur.				8	8	52
327	*Mycena* aff. *maldea* Grgur.						7
134	*Mycena albidocapillaris* Grgur. & T.W.May				31	31	31
80	*Mycena carmeliana* Grgur.	2	25	10	9	46	73
144	*Mycena kuurkaceae*Grgur.	83	2	7	27	119	375
50	*Mycena mijoi* Grgur.			2	5	7	122
66	*Mycena pura* (Pers. : Fr.) P.Kumm.	2		1	1	4	41
491	*Mycena* sp. brown pointy cap (R.M. Robinson, R.H. Smith & K. Syme FC897)						156
521	*Mycena* sp. brown pura-like (R.M. Robinson & R.H. Smith FC963)						15
523	*Mycena* sp. brown striate cap with dark umbo (R.M. Robinson & R.H. Smith FC966)						29
308	*Mycena* sp. grey brown cap no bleach (R.M. Robinson & J. Fielder FC1038)	1		1	2	4	13
285	*Mycena* sp. light brown striate cap with white stem - on wood (R.M. Robinson, R.H. Smith & K. Pearce FC495)						12
756	*Mycena* sp. orange striate on litter (R.M. Robinson & K. Syme WFM424)			6		6	
295	*Mycena* sp. small buff (R.M. Robinson & K. Pearce FC558)				35	35	46
165	*Mycena* sp. small grey - bleach (R.M. Robinson & R.H. Smith FC394)				1	1	2
502	*Mycena* sp. striate cap with decurrent gills, on burnt ground (R.M. Robinson & R.H. Smith FC932)						7
88	*Mycena* sp. tiny white with decurrent gills (R. Robinson & R.H. Smith FF61)				1	1	
456	*Mycena* sp. viscid with brown grey conic cap (R.M. Robinson & R.H. Smith FC801)						5
182	*Mycena* spp. (unidentified)	18				18	11
163	*Mycena subgallericulata* Cleland	126	34	85	2	247	13
51	*Mycena yirukensis* Grgur.	62	38	58	55	213	746

Species #	Species[1]	Treatments 2011[2]				2011	2005
		ER	CB	SW	GR	Total	Total
238	*Mycena yuulongicola* Grgur.	14			8	22	73
164	*Nidula niveotomentosa* (Henn.) Lloyd	3	12	12		27	19
413	*Nidularia deformis* (Willd. : Pers.) Fr.						29
213	*Omphalotus nidiformis* (Berk.) O.K.Mill.		1	2	6	9	
705	*Panaeolus sp. Cortinarius* sp delicate brown bells FC1314	1				1	
311	*Panus fasciatus* (Berk.) Pegler			6	10	16	9
277	Perenniporia sp. beige (R.M. Robinson, R.H. Smith & K. Pearce FC510)						1
332	*Peziza praetervisa* Bres.						243
499	*Peziza* sp. dark brown burgandy cup with tan underside (R.M. Robinson & R.H. Smith FC930)						39
501	*Peziza* sp. flat black (R.M. Robinson & R.H. Smith FC936)						2
527	*Peziza* sp. smooth dark brown cup (R.M. Robinson & R.H. Smith FC982)		1		1	2	2
330	*Peziza tenacella* W. Phillips						87
524	*Peziza thozetii* Berk.						1
488	*Phaeocollybia ratticauda* E.Horak						14
479	*Phellodon* sp. black, brown spines (R.M. Robinson & R.H. Smith FC844)		8			8	12
874	*Phellodon* sp. drab grey brown spines, olive mycelium (R.M. Robinson, K.Syme & P.Anderson WFM683)			5		5	
447	*Phellodon* sp. silver-blue (R.M. Robinson RR844WA)				1	1	
101	*Phlebia rufa* (Pers. : Fr.) M.P.Christ.						2
160	*Pholiota highlandensis* (Peck) Quadr.	33	251	255	89	628	144
119	*Pholiota multicingulata* E.Horak	6	19	93	21	139	
636	*Phylloporus* sp. (R.M. Robinson & R.S. Wittkuhn BFF0010)	1				1	
481	*Phylloporus* sp. (R.M. Robinson, R.H. Smith & K. Syme FC876)						1
403	*Pisolithu arhizus* (Scop. : Pers.) Rauschert	22				22	1
4	*Pluteus* sp. brown velvet (R.M. Robinson & R.H. Smith FC4 (BFF150))						1
321	*Pogiesperma* sp. pink gleba (R.M. Robinson & L. McGurk FC596)						1
204	Polypore beige resupinate, stains brown (R.M. Robinson FC1553)	3				3	
333	Polypore on dead waterbush (R.M. Robinson & R.H. Smith FC626)						1
585	Polypore white floccose resupinate (R.M. Robinson & J. Fielder FC1027)				11	11	
116	Polypore white resupinate (R.M. Robinson & J. Fielder FC1197)						2
494	*Polyporus* sp. brown stalked (R.M. Robinson & R.H. Smith FC901)						1
145	*Poronia erici* Lohmeyer & Benkert	132		1		133	8
236	*Postia peliculosa* (Berk.) Rajchenb.	8		5	1	16	3
155	*Protubera canescens* G.W.Beaton & Malajczuk						3
59	*Psathyrella echinata* (Cleland) Grgur.				3	3	
17	*Psathyrella* sp. (R.M. Robinson & R.H. Smith FC15)	5				5	
229	*Psathyrella* sp. (R.M. Robinson & R.H. Smith FC386)						3
177	*Psilocybe coprophila* (Bull. : Fr.) P.Kumm.	44	1	10	39	94	159
349	*Psilocybe musci* Cleland & Cheel				9	9	8
331	*Pulvinula archerii* (Berk.) Rifai						218
129	*Pulvinula tetraspora* (Hansf.) Rifai	235			19	254	15
176	*Pycnoporus coccineus* (Fr.) Bondartsev & Singer	9		26	9	44	76
366	*Pyronema omphalodes* (Bull.) Fuckel						1
72	*Ramaria australiana* (Cleland) R.H.Petersen			1		1	1
52	*Ramaria capitata* (Lloyd) Corner			10		10	
52b	*Ramaria capitata* (Lloyd) Corner 'burnt'						69
247	*Ramaria citrinocuspidata* A.M. Young & N.A. Fechner	6	7	1	36	50	18
377	*Ramaria lorithamnus* (Berk.) R.H.Petersen		5			5	4
102	*Ramaria ochroceosalmonicolor* (Cleland) Corner	24	2	22	31	79	90
242	*Ramaria* sp. cream (R.M. Robinson & R.H. Smith FC414)		1		2	3	1
86	*Ramaria* sp. orange-red with yellow stem (R.M. Robinson & R.H. Smith FC112)						3
490	*Ramaria* sp. tan, in *Allocasuarina* litter (R.M. Robinson, R.H. Smith & K. Syme FC896)	459				459	291
534	*Ramariopsis pulchella* (Boud.) Corner						1
79	*Resupinatus cinerascens* (Cleland) Grgur.						5

Species #	Species[1]	Treatments 2011[2]				2011	2005
		ER	CB	SW	GR	Total	Total
181	*Rhodocollybia butyracea* (Bull. : Fr.) Lennox			2		2	
397	*Rhodocybe* sp. grey (R.M. Robinson & K. Syme WFM35)*			1		1	1
69	*Russula adusta* (Pers. : Fr.) Fr.	3			1	4	
89	*Russula clelandii* complex O.K.Mill. & R.N.Hilton	20	5	7	1	33	18
202	*Russula flocktoniae* Cleland & Cheel	1	1	5	30	37	79
90	*Russula kalimna* Grgur.						1
92	*Russula neerimea* Grgur.		1		5	6	2
178	*Russula persanguinea* Cleland	1		1		2	
107	*Russula* sp. grey-white (R.M. Robinson & R.H. Smith FC168)		1	4		5	1
890	*Russula* sp. lavender (R.M. Robinson FC1761)	2				2	
10	*Russula* sp. white white white (R.M. Robinson & R.H. Smith FC8)	2	1	2	3	8	35
315	*Scleroderma cepa*Pers. : Pers.	17				17	
306	*Sphaerobolus stellatus* Tode : Pers.						20
132	*Steccherinum* sp. creamy yellow crust (R.M. Robinson & J. Fielder FC1080)						1
94	*Steccherinum* sp. tiered white shelves (R.M. Robinson & R.H. Smith FC128)						5
62	*Stereum hirsutum* (Willd. : Fr.) Pers.			26	73	99	181
149	*Stereum illudens* Berk. - brown hymenium						228
5	*Stereum* sp. grey brown, hirsute, white margin, purple hymenium (R.M. Robinson & R.H. Smith FC468)			9	108	117	
67	*Stropharia semiglobata* (Batsch : Fr.) Quél.	40	8	5	44	97	7
402	*Tephrocybe* ? sp. brown – burn (R.M. Robinson & K. Syme WFM044)	18				18	
301	*Tephrocybe* sp. cark grey with dimpled cap (R.M. Robinson & K. Pearce FC580)				3	3	2
587	*Tephrocybe* sp. dark brown with grey brown gills (R.M. Robinson & J. Fielder FC1036)			1	1	2	
513	*Tephrocybe* sp. dark grey brown convex (R.M. Robinson, R.H. Smith & K. Syme FC948) - check with sp.512						5
249	*Tephrocybe* sp. grey (R.M. Robinson & R.H. Smith FC423)						13
233	*Tephrocybe sp.* grey brown dimpled cap (R.M. Robinson & R.H. Smith FC 391)						1
512	*Tephrocybe* sp. small grey brown (R.M. Robinson, R.H. Smith & K. Syme FC945)						66
266	*Thelephora* sp. white with orange margin (R.M. Robinson & R.H. Smith FC476)	1	5	3	3	12	51
482	*Torrendia arenaria* f. *lutescens* (R.M. Robinson, R.H. Smith & K. Syme FC877)						44
63	*Trametes versicolor* (L. : Fr.) Lloyd	35				35	22
287	*Tremella globispora* D.A.Reid						2
60	*Tremella mesenterica* Retz. : Fr.	6				6	
288	*Tremella* sp. yellow buttons (R.M. Robinson, R.H. Smith & K. Pearce FC540)				15	15	81
446	*Tricholoma* aff. *austrocollossum* Grgur.						3
54	*Tricholoma eucalypticum* A.Pearson	17	25	53	6	101	1
483	*Tricholoma* sp. (R.M. Robinson, R.H. Smith & K. Syme FC878)						2
872	*Tricholoma* sp. creamy tan with orange veil (R.M. Robinson, K.Syme & P.Anderson WFM696)	12	16	8	46	82	
733	*Tricholoma* sp. olive green (R.M. Robinson & R.S. Wittkuhn FC 1427)			1		1	
375	*Tricholoma* sp. orange cap with orange ring on stem (R.M. Robinson & R.H. Smith FC 753)		2			2	
495	*Tricholoma* sp. orange with white stem (R.M. Robinson & R.H. Smith FC903)						4
189	*Tubaria rufofulva* (Cleland) D.A.Reid & E.Horak						9
305	*Tylopilus* sp. yellow (R.M. Robinson & J. Fielder FC1015)		3	1	2	6	2
440	White mycelium on roo poo (R.M. Robinson & K. Syme WFM118)						1
2	*Xerula mundroola* (Grgur.) R.H.Petersen	1				1	
348	**Number of species**	**132**	**86**	**125**	**146**	**239**	**240**
	Number of sporophores	**3843**	**1658**	**2978**	**4234**	**12713**	**12053**

[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. NC -= not collected or vouchered. **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

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

The object of this component of FORESTCHECK is to:

- Record 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;
- Record the presence of 35 monitoring (or indicator) species; and
- 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

Ten Forestcheck grids, including three external reference grids (FC28, FC32 & FC35) and one coupe buffer (FC29), three shelterwood (FC30, FC33 & FC36) and three gap release treatments (FC31, FC34 & FC37) were established in the eastern jarrah forest ecosystem in the Wellington District in 2004. All the grids were initially surveyed for cryptogams in spring 2004. They were surveyed again in spring 2010 and the results are presented in this report. Since the previous report (2005) the Bell block grids were burnt by wildfire in December 2005 and the Stockyard blocks were prescribe burnt in spring 2008.

Following a review of survey methods outlined in the Forestcheck Operations Plan, updated survey methods were developed and are described in the 2007-08 Forestcheck report. 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 were assessed in 20 1x1 m plots along a 200 m transect. To assess the impact of litter coverage on cryptogams, litter cover 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 was 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 field guide featuring monitoring species was used to facilitate the recognition of species encountered.

Voucher Specimen Processing

Vouchers were extensively collected during the 2005 survey. In 2010, voucher specimens were restricted to a small number of samples needed to verify species identifications and to voucher new species records. All specimens collected in 2010 have been identified to species or given informal field names. Advances in identification, and re-examination of previously collected specimens has resulted in name changes for a number of species which required

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

Results and discussion

Previous surveys were conducted in spring from 5-20 September 2005. The 2010 Wellington East survey was conducted in the spring; during 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 2005 and 2010 survey, it needs to be noted that methods were reviewed and modified in 2007 (see 2007-08 FORESTCHECK report).

Transect surveys

Species richness

A total of 77 species of cryptogams were recorded from transects; 67 lichens, nine mosses and one liverwort. Lichens were the most common group on all grids, but fewer were recorded on the recently burnt (2 years previously) Stockyard external reference grid (FC32). The number of mosses was low but similar on all grids except the Bell external reference (FC35) where two to three more species were recorded. The single liverwort species, *Cephaloziella exiliflora*, was only recorded on two grids; the Stockyard (FC33) and Bell block (FC36) shelterwoods (Fig. 1). The mean species richness per grid of mosses was similar in all treatments (Fig. 1) but total lichen richness was lower on the recently burnt Stockyard grids (FC32, FC33 & FC34) (Fig. 1) and mean lichen species richness per grid was lower on the gap release grids (Fig. 2).

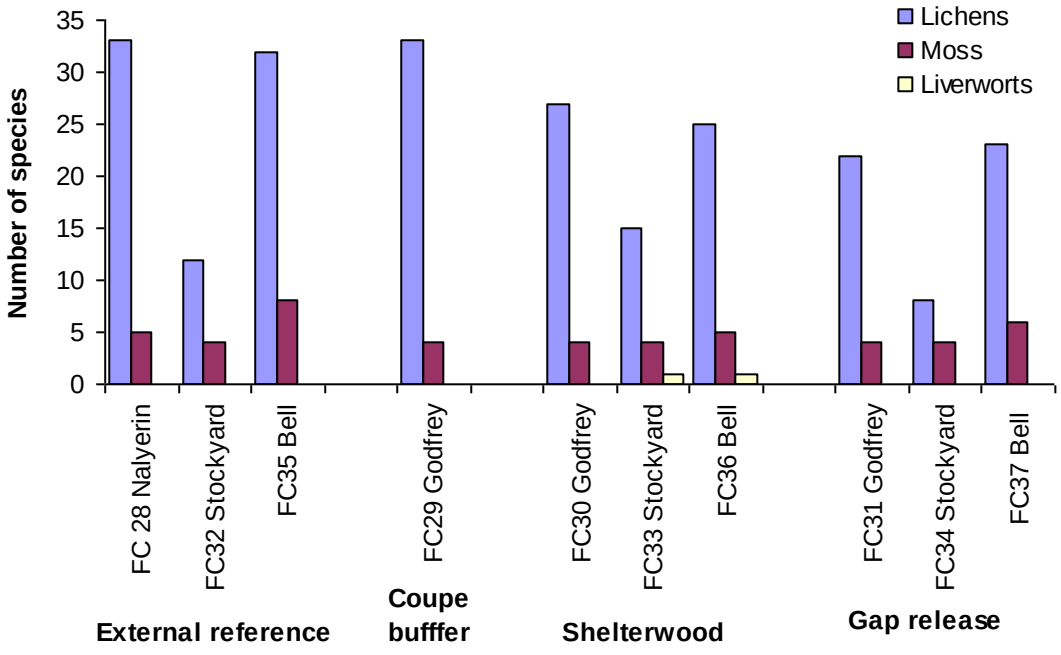

Figure 1. Total number of lichens, moss and liverwort species recorded from transects on each grid in each FORESTCHECK treatment in Wellington East in 2010

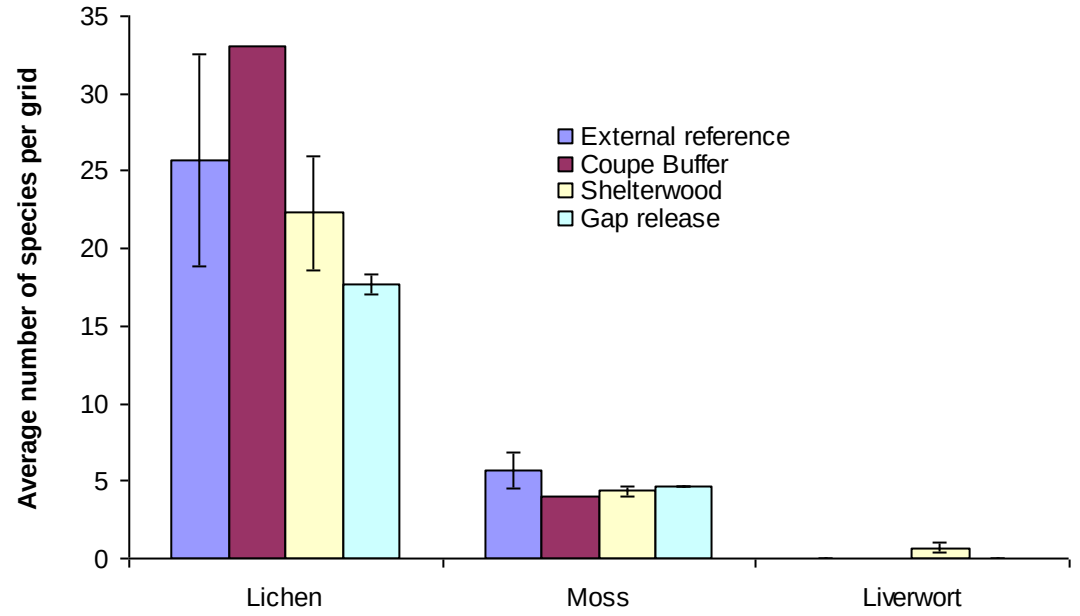

Figure 2. Mean number of lichen, moss and liverwort species per grid recorded from transects in each treatment in Wellington East FORESTCHECK grids in 2010

In 2010, the number of lichens recorded was half (51%) that recorded in 2004 (Fig. 3). Although two more lichens were recorded in the Nalyerin coupe buffer in 2010, numbers in the external reference and shelterwood treatments were 38% lower and in the gap release treatment 20% lower than those recorded in 2004. Whether this is related to the revised survey methods, natural changes within species complexes over time or other effects such as drought needs to be investigated further.

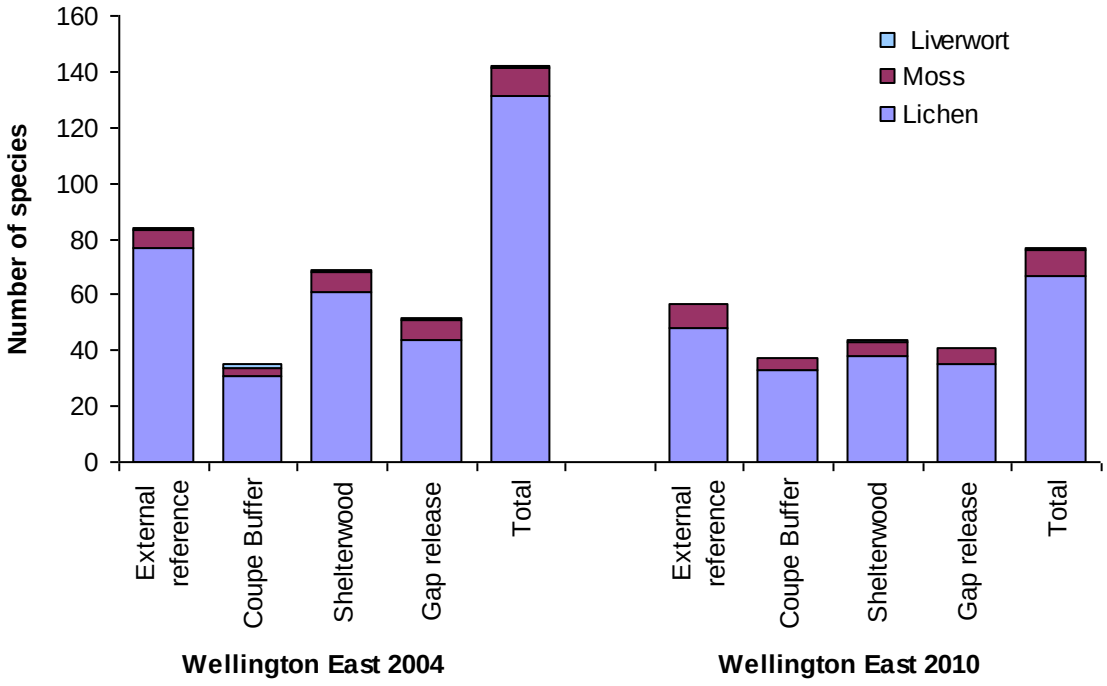

Figure 3. Total number of lichen, moss and liverwort species per grid recorded from transects in each treatment in Wellington East FORESTCHECK grids in 2005 and 2010

Cephaloziella exiliflora (Fig. 4 *left*) was the only liverwort recorded in both survey years. The number of moss species recorded was similar in 2004 and 2010 (Fig. 3). Only one species of lichen known to colonise tree crowns was recorded, *Tephromela alectoronica* (Fig. 4 *right*). It was recorded on fallen branch material on two grids, the Godfrey coupe buffer (FC29) and the Bell external reference (FC35) and is known as being associated with mature trees.

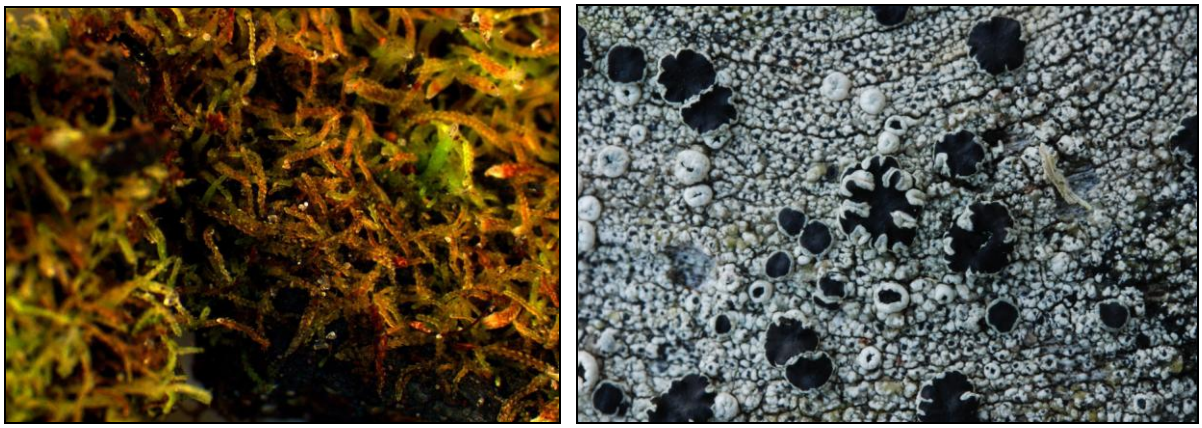

Figure 4. Left: *Cephaloziella exiliflora* was the only liverwort recorded in 2010. Right: *Tephromela alectoronica* was only recorded in external reference and coupe buffer grids in 2010.

Plot surveys

Plot surveys were not conducted at Wellington East in 2005, having only been introduced to the FORESTCHECK protocol in 2007. The following results are therefore from 2010 data 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. 5). Time since treatment has an influence on the condition of substrates and their consequent colonisation by cryptogams. On external reference grids and the coupe buffer, bark and stone were the most frequently colonised habitats. Similarly on shelterwood grids bark and stone was well utilised and on gap release grids soil and stone were the most utilised substrate.

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 on every grid (Fig. 6). The shrub layer (31 cm-3 m) was only colonised on one reference grid and two shelterwood grids and not colonised on any of the 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. No species from the tree layer (>3m) was recorded in 1x1 m plots on any grids.

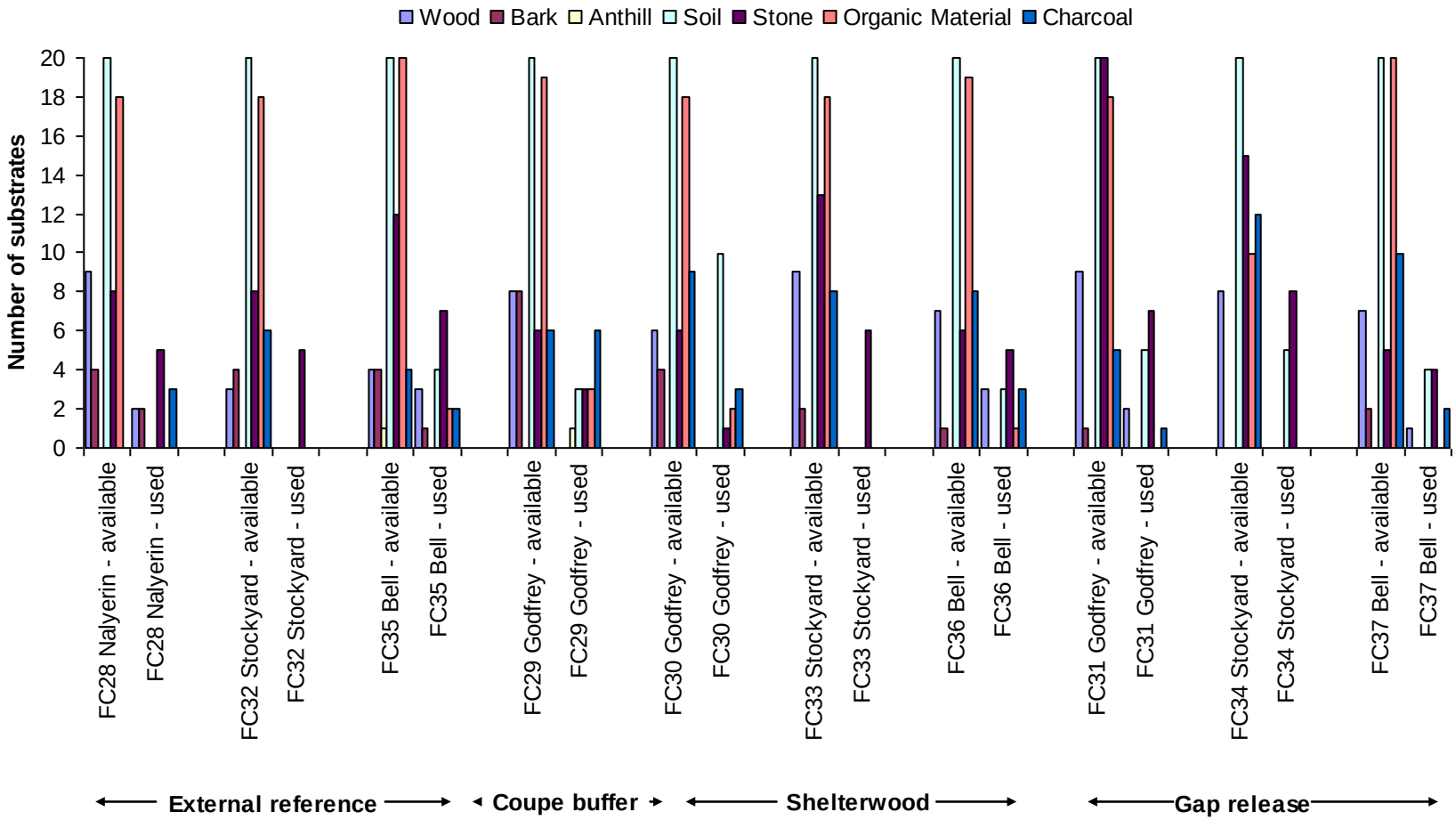

Figure 5. Number of plots with substrates available for colonization and their utilization by cryptogams on each Wellington East FORESTCHECK grid in 2010.

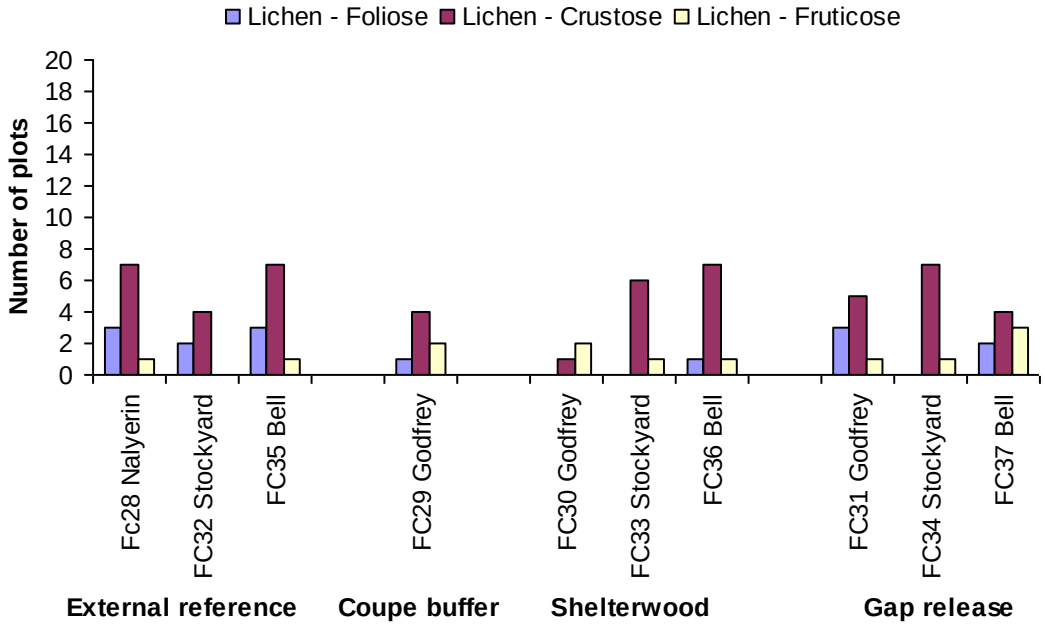

Figure 6. Number of 1x1 m plots with different strata levels occupied by cryptogams on each Wellington East FORESTCHECK grid in 2010 (NB. 20 plots per grid)

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 group generally have similar life strategies. Crustose and foliose lichens and tufted mosses were the most common types recorded (Figs 7 and 8). Only two creeping mosses, *Sematophyllum subhumile* and *Thuidopsis sparsa* were recorded in two reference grids and one shelterwood. The single leafy liverwort recorded, *C. exiliflora*, was only found on the Godfrey shelterwood (FC30) grid.

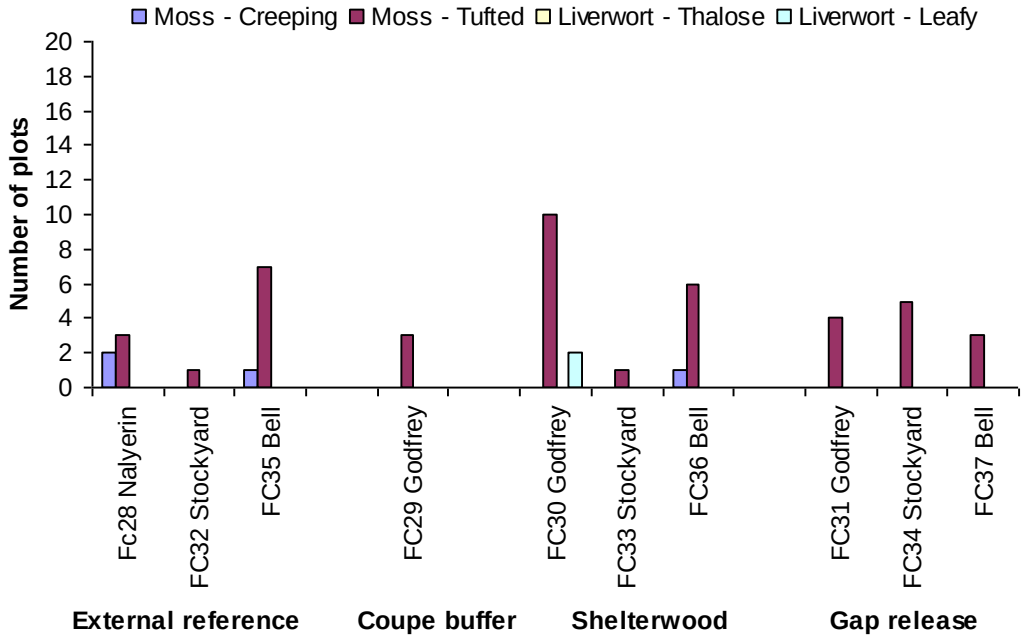

Figure 7. Number of 1x1 m plots in which each lichen life form was recorded on each Wellington East FORESTCHECK grid in 2010 (NB. 20 plots per grid)

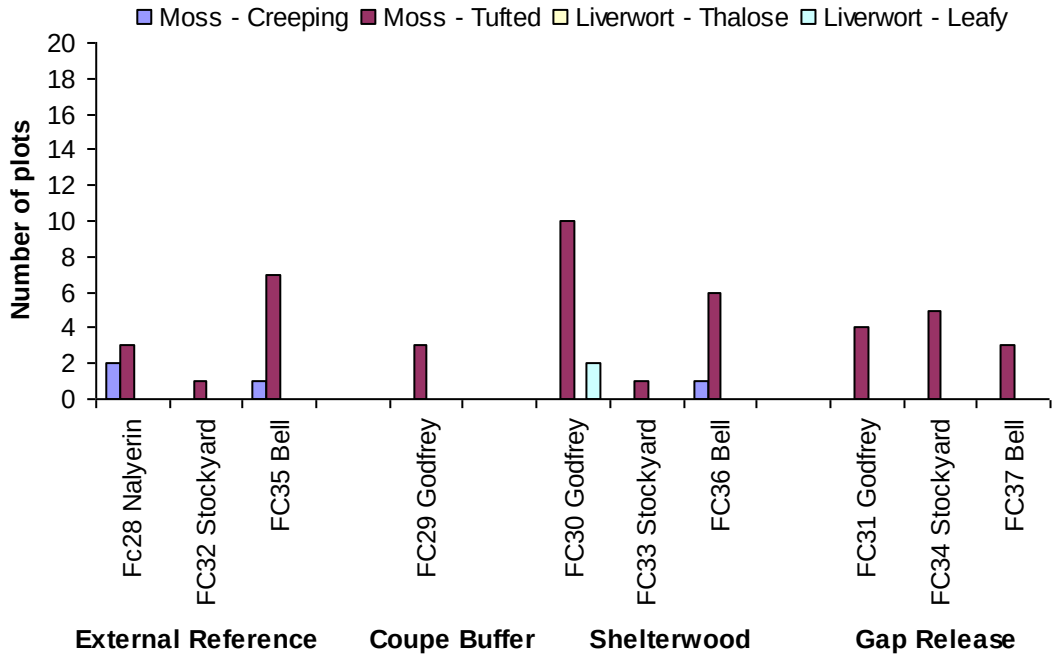

Figure 8. Number of 1x1 m plots in which each moss and liverwort life form was recorded on each Wellington East FORESTCHECK grid in 2010 (NB. 20 plots per grid)

Litter cover on individual 1x1 m plots

Heavy or constant litter cover appears to affect the presence and growth of a number of cryptogams. Lichens growing on soil or stones rapidly decline when covered by litter. However, in areas where litter is temporary or able to be moved by wind and not become trapped, some can withstand short periods of being covered without being totally excluded. At Wellington East in 2010, the majority of plots had a dense (< 75% cover) to moderate (26-75% cover) cover of litter (Fig. 9), especially on the external reference and coupe buffer grids. Litter cover on the recently burnt (2008) Stockyard grids (FC32, FC33 & FC34), was generally sparse to moderate. Litter coverage on the gap release grids was variable. Ground dwelling mosses and lichens were less frequent on plots with dense litter cover.

Monitoring potential indicator species recorded in plots 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 survey method to assess them and to assess changes withinin the cryptogam community.

The lichens *Cladia schizopora*, *Cladonia rigida*, *Cladonia sulcata* and *Thysanothecium scutellatatum* were recorded in most treatments using both survey methods (Table 1). *Thysanothecium hookerii*, a common termite mound specialist, was more commonly recorded on transects than in plots. Although termite mounds occurred within some plots (see Fig. 5),

most were observed on transects. Two other licens, *Pannoparmelia wilsonii and Cladia aggregate*, were recorded on transects but not in plots.

Most species of the selected mosses were recorded in both plot and transect surveys. *Campylopus introflexus* and *Funaria hygrometrica* were the main 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 Wellington East survey. One species was recorded, *C. exiliflora* (Table 1). It occurred only on the Godfrey (FC30) and Stockyard shelterwoods (FC33) in both plot and transect surveys (more frequent on transects.

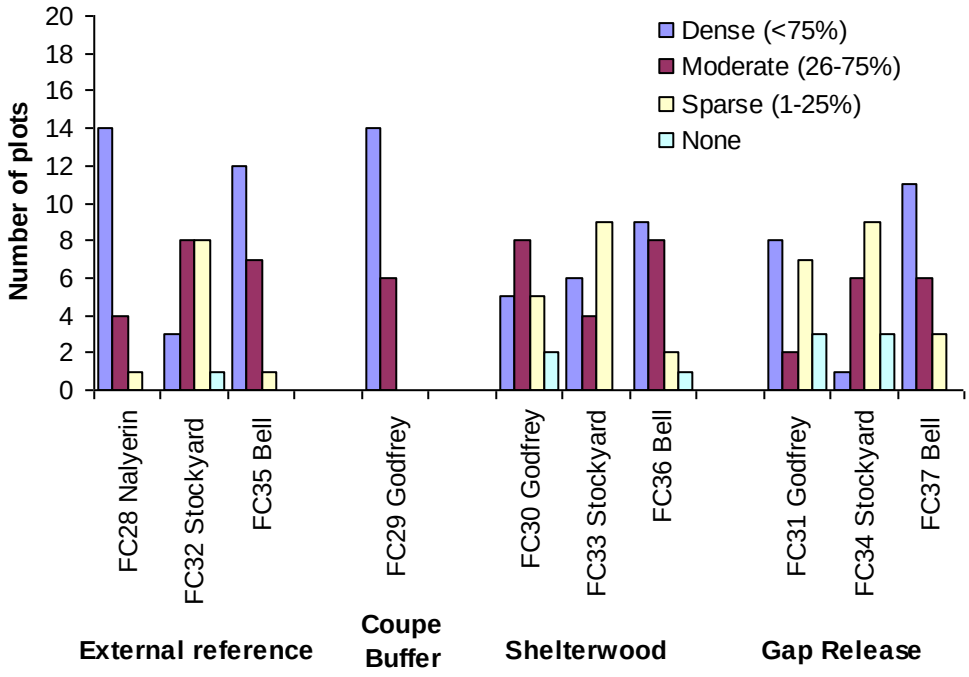

Figure 9. Number of 1x1 m plots with sparse, moderate and dense litter cover on each Wellington East FORESTCHECK grid in 2010 (NB. 20 plots per grid)

Table 1. Frequency of potential indicator species in plots and on transects for each treatment in the Wellington East FORESTCHECK grids in 2010

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 were recorded[3]			
				External reference	Coupe Buffer	Shelter-wood	Gap release	External reference	Coupe Buffer	Shelter-wood	Gap release
	Lichen										
1	*Cladia aggregata*	L	Fruticose					2	1	4	2
2	*Cladia schizopora*	L	Fruticose	1		1		7	1	3	1
3	*Cladonia cervicornis var. verticellata*	L	Fruticose								
4	*Cladonia krempelhuberi*	L	Fruticose					4		6	4
5	*Cladonia rigida*	L	Fruticose			1		10	1	7	2
6	*Cladonia sulcata*	L	Fruticose		2	1	2	1	1	7	5
7	*Calicium glaucellum*	L	Crustose						1	3	1
8	*Diploschistes sticticus*	L	Crustose								
9	*Flavoparmelia haysonii*	L	Foliose					4			
10	*Hypocenomyce foveata*	L	Crustose			1		3		5	2
11	*Hypocenomyce scalaris*	L	Crustose	1	1	1		8	1	10	3
12	*Hypogymnia subphysodes var. subphysodes*	L	Foliose	1				1		1	
13	*Menegazzia platytrema*	L	Foliose	1				6	1		
14	*Glonium circumserpens*	L	Crustose					2		4	
15	*Ochrolechia* sp. (G.S. Kantvilis 306/92)	L	Crustose				1	1		1	1
16	*Pannoparmelia wilsonii*	L	Foliose					7	1		1
17	*Paraporpidia glauca*	L	Crustose							1	
18	*Parmotrema reticulatum*	L	Foliose								
19	*Ramboldia stuartii*	L	Crustose				2	6	1	4	3
20	*Tephromela alectoronica*	L	Crustose					2	1		
21	*Thysanothecium hookeri*	L	Fruticose	1				1		4	3
22	*Thysanothecium scutellatum*	L	Fruticose	3	1	1	2	8	1	14	8
23	*Usnea inermis*	L	Fruticose	1		1		10	1	9	3
24	*Usnea* sp. leuco (R.J. Cranfield 20195)	L	Fruticose					3			1
25	*Xanthoparmelia isidiigera*	L	Foliose								
26	*Xanthoparmelia notata*	L	Foliose	2							

Table 1. Cont.

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 were recorded[3]			
				External reference	Coupe Buffer	Shelter-wood	Gap release	External reference	Coupe Buffer	Shelter-wood	Gap release
	Liverwort										
27	*Cephaloziella exiliflora*	H	Leafy			2				3	
28	*Chiloscyphus semiteres*	H	Leafy								
29	*Fossombronia intestinalis*	H	Thallose								
30	*Frullania prohosciphora*	H	Leafy								
	Moss										
31	*Barbula calycina*	B	Tufted	1			1	2		1	
32	*Campylopus introflexus*	B	Tufted	4	2			22	1	16	13
33	*Dicranoloma diaphanoneum*	B	Tufted								
34	*Funaria hygrometrica*	B	Tufted	4	1	14	8	12	1	19	21
35	*Sematophyllum subhumile*	B	Creeping	1				4	1		
	Total number of species [4]			14	5	11	6	24	16	21	18
	Total Lichen species			8	3	7	4	19	12	16	15
	Total Moss species			6	2	3	2	5	4	4	3
	Total Liverwort Species					1				1	

[1]L = lichen, B = bryophyte (moss) and H = heptophyte (liverwort)
[2] Max score = 60 for the external reference, shelterwood and gap release (20 plots x 3 grids each) and 20 for the coupe buffer (20 plots x grid)
[3] Max score = 12 for external reference, shelterwood and gap release (4 x 50 m sections x 3 grids each) and 4 for the coupe (4 x 50 m sections x 1 grid)
[4] There were a total of 21 species of 'monitoring' cryptogams recorded in plots and 27 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. 10). The proportion of each group was similar in all treatments when all cryptogams were monitored. However, when only the monitoring species were considered, mosses were proportionally larger and there was variation between results from the plots and transects.

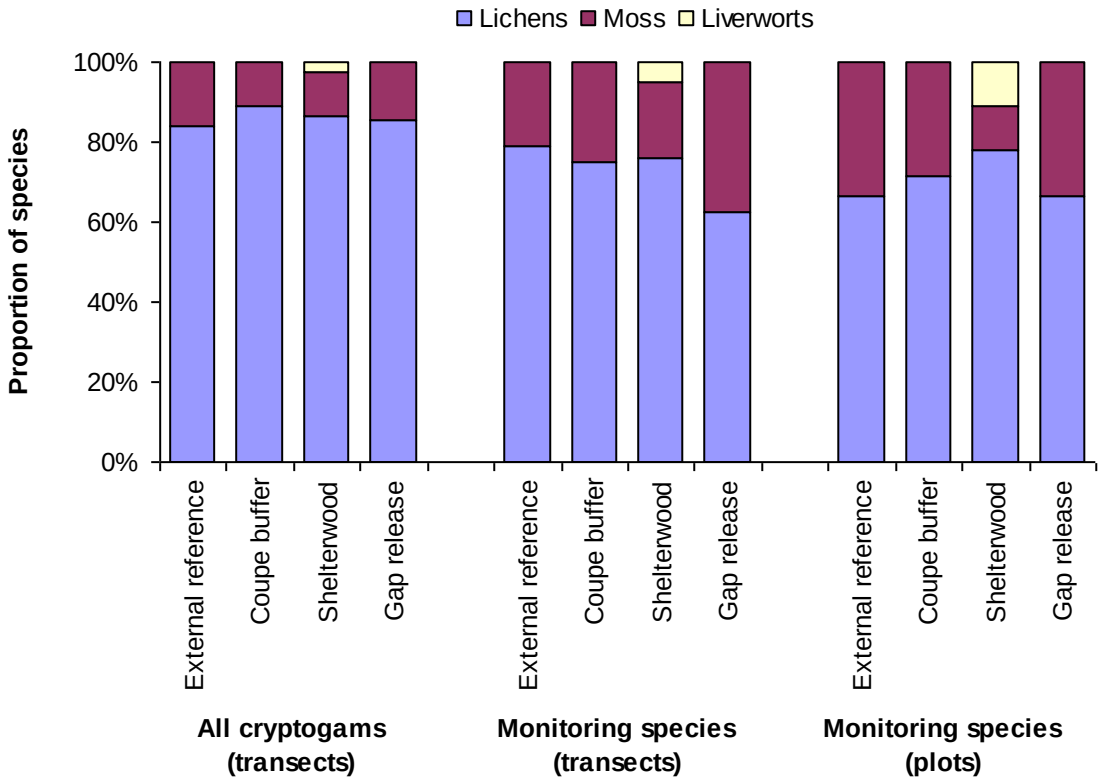

Figure 10. Proportion of lichen, moss and liverwort species in each treatment when considering all cryptogams (left) and only the selected list of potential indicator species (right) recorded in the Wellington East FORESTCHECK grids in 2010

The mean species richness per grid of all cryptogams recorded on transects was lower in the gap release treatment (Fig. 11). When only the monitoring species were considered, the means species richness per grid was similar in each treatment, for both transect and plot surveys, but fewer species were recorded in the plots. At Wellington East, therefore, the 'indicator' species did not show the trend for fewer species in the gap release treatment.

Because the jarrah forest covers a large region encompassing a variety of ecosystem types (as represented by the five established FORESTCHECK locations; Donnelly, Wellington 1, 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.

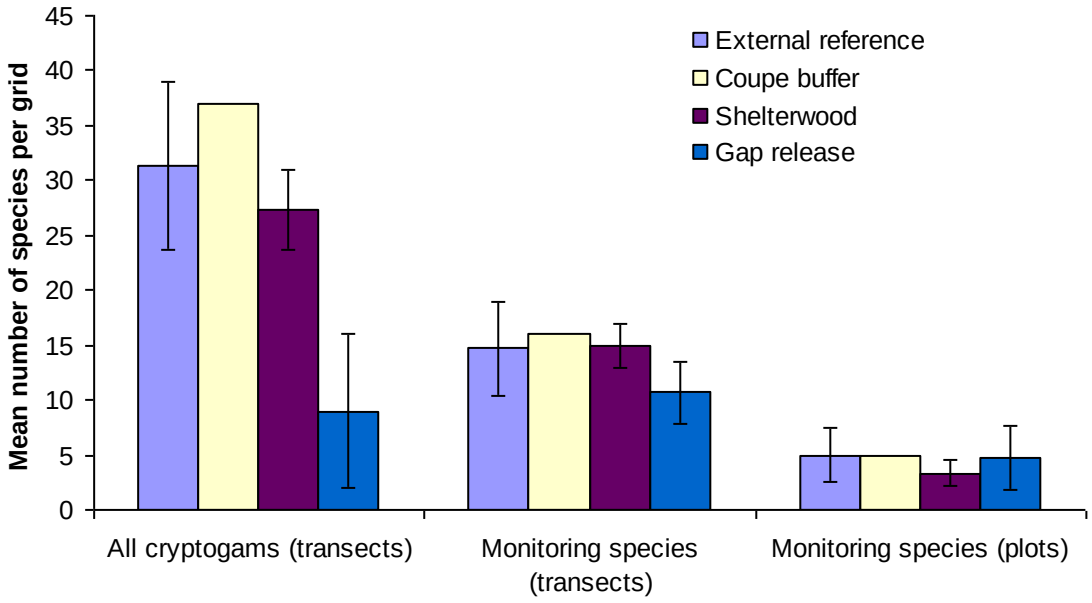

Figure 11. Mean species richness per grid for all cryptogams (left) and only the selected monitoring species (right) recorded in the Wellington East FORESTCHECK grid in 2010

Conclusions

The revised survey techniques failed to record many species of lichens that were recorded in the Wellington East grids in 2005. The same problem was encountered in previous when comparing results from the first and second rounds of monitoring at Donnelly, Wellington 1 and the Perth Hills. From 2009-2011, additional monitoring was conducted on the Donnelly, Wellington 1 and Perth Hills grids that included surveying an additional 200 m of transect. In 2010, the Wellington East grids were also monitored using the revised 400 m of transects (increased from the previous 200 m) to determine species richness. All previous results from the second round of monitoring will be analysed to determine if the additional 200 m of transect is adequate.

Some trends observed in 2010 were:

- The number of lichens recorded in 2010 was markedly lower (43% less) than in 2005;
- The external reference and coupe buffer grids had more species of lichens than those in harvested grids, except they were very low in the recently burnt Stockyard external reference grid (FC32);
- The number of lichens was lowest on all the recently burnt grids in Stockyard block, regardless of treatment;
- The vast majority of cryptogams were recorded in the 0-30 cm strata layer;
- The majority of cryptogams were crustose lichens and tufted mosses;
- 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. The frequency of all cryptogam species recorded from transects at the Wellington East FORESTCHECK grids in 2010. Numbers in treatment columns indicate the number of 50 m sections (max. = 24 in external reference, and shelterwood and gap release treatments and 8 in coupe buffer) of transect that each species was recorded in

Species Number	Monitor Species Number	Species	Group[1]	Treatment[2]				Total
				ER	CB	SW	GR	
363		*Acarospora citrina*	L				1	1
360		*Buellia cranfieldii*	L	4		1	8	13
249		*Buellia* sp. sparse (R.J. Cranfield 20619)	L	1		1		2
279		*Buellia tetrapla*	L	5	1	1		7
5	7	*Calicium glaucellum*	L		1	3	1	5
6		*Calicium salicinum*	L	1				1
148		*Calicium tricolor*	L	1				1
7		*Calicium victorianum* subsp. *victorianum*	L	2		1		3
250		*Caloplaca marina*	L				2	2
150		*Candelariella xanthostigmoides*	L				1	1
16	1	*Cladia aggregata*	L	2	1	4	2	9
17	2	*Cladia schizopora*	L	7	1	3	1	12
18		*Cladonia chlorophaea*	L	1	1			2
24		*Cladonia crispata* var. *cetrariiformis*	L		1			1
26	4	*Cladonia krempelhuberi*	L	4		6	4	14
19		*Cladonia praetermissa*	L	1				1
30	5	*Cladonia rigida*	L	10	1	7	2	20
255		*Cladonia* sp. Stockyard (R.J. Cranfield 20737)	L			1		1
37	6	*Cladonia sulcata*	L	1	1	7	5	14
159		*Cladonia ustulata*	L		1		1	2
94		*Dictyographa* sp. brown lips (R.J. Cranfield 17791)	L	2	1	4		7
365		*Diploschistes conceptionis*	L	1				1
220		*Diploschistes scruposus*	L	11		10	12	33
142	9	*Flavoparmelia haysomii*	L	4				4
272		Genus sp. grey (R.J. Cranfield 20915)	L	1				1
344		Genus sp. grey green slick	L	3	1	6	1	11
72		Genus sp. lead grey (R.J. Cranfield 18098)	L	1				1
345		Genus sp. mustard	L	1		1		2
93	14	*Glonium circumserpens*	L	2		4		6
96		*Hypocenomyce australis*	L		1	1	2	4
61	10	*Hypocenomyce foveata*	L	3		5	2	10
78	11	*Hypocenomyce scalaris*	L	8	1	10	3	22
330		*Hypogymnia subphysodes*	L	5	1			6
103	12	*Hypogymnia subphysodes* var. *subphysodes*	L	1		1		2
364		*Lecidea capensis*	L				2	2
54		*Lecidea sarcogynoides*	L	5	1	3	2	11
346		*Lecidea* sp.	L				1	1
282		*Lecidea* sp. Godfrey (R.J. Cranfield 20657)	L		1			1
350		*Lepraria coriensis*	L			1		1
107	13	*Menegazzia platytrema*	L	6	1			7
115	15	*Ochrolechia* sp. (G.S. Kantvilis 306/92)	L	1		1	1	3
240		*Ochrolechia* sp. (R.J. Cranfield 20178A)	L		1			1
111		*Ochrolechia subrhodotropa*	L	2	1			3
118	16	*Pannoparmelia wilsonii*	L	7	1		1	9
119	17	*Paraporpidia glauca*	L			1		1

Species Number	Monitor Species Number	Species	Group[1]	Treatment[2]				Total
				ER	CB	SW	GR	
241		*Parmelina conlabrosa*	L	2	1			3
122		*Parmotrema tinctorum*	L	2	1			3
277		*Pertusaria georgeana* subsp. *occidentalis*	L	2	1	1		4
349		*Pertusaria subarida*	L	4	1			5
198		*Pyrenopsis* sp. (R.J. Cranfield 18998)	L	14	1	6	7	28
290		*Ramboldia laeta*	L			3		3
52	19	*Ramboldia stuartii*	L	6	1	4	3	14
361		*Rhizocarpon obscuratum*	L	4	1	1		6
127		*Rhizocarpon* sp. grey (R.J. Cranfield 17914)	L			1	1	2
292		*Rhizocarpon tinei*	L	1			1	2
79	20	*Tephromela alectoronica*	L	2	1			3
64	21	*Thysanothecium hookeri*	L	1		4	3	8
132	22	*Thysanothecium scutellatum*	L	8	1	14	8	31
362		*Thysanothecium sorediatum*	L	1		3	2	6
178		*Trapelia coarctata*	L	13	1	6	8	28
298		*Trapelia* sp. Bell (R.J. Cranfield 20850)	L				1	1
299		*Trapelia* sp. Godfrey (R.J. Cranfield 20612)	L			1		1
136	23	*Usnea inermis*	L	10	1	9	3	23
208	24	*Usnea* sp. leuco (R.J. Cranfield 20195)	L	3			1	4
309		*Xanthoparmelia mexicana*	L				3	3
213		*Xanthoparmelia mougeotina*	L	5	1	4	3	13
355		*Xanthoparmelia notata*	L	8	1	2	8	19
2	31	*Barbula calycina*	B	2		1		3
9		*Campylopus bicolor*	B	5		3	3	11
10	32	*Campylopus introflexus*	B	22	1	16	13	52
44		*Fissidens tenellus* var. *tenellus*	B	1				1
50	34	*Funaria hygrometrica*	B	12	1	19	21	53
366		*Grimmia laevigata*	B	1			1	2
40		*Orthodontium lineare*	B	11	1	12	5	29
336		*Rosulabryum capillare*	B	1			1	2
128	35	*Sematophyllum subhumile* var. *contiguum*	B	4	1			5
12	27	*Cephaloziella exiliflora*	H			3		3
		Number of species		**57**	**37**	**44**	**41**	**77**
		Total Lichen species		48	33	38	35	67
		Total moss species		9	4	5	6	9
		Total Liverwort species		0	0	1	0	1
		Monitoring species (Transects)		16	10	13	10	27
		Total Lichen species		11	6	8	7	21
		Total moss species		5	4	4	3	5
		Total Liverwort species		0	0	1	0	1

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

VASCULAR PLANTS

Bruce Ward and Ray Cranfield

Introduction

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

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

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

- Determine species richness and abundance in the various silvicultural treatments of managed jarrah forest (shelterwood, selective cut and gap release) and in uncut reference forest;
- Compare species richness, abundance and composition recorded within and between silvicultural treatment grids to those in uncut reference grids; and
- Compare results from Wellington in 2004 with those from 2010.

Monitoring

Ten FORESTCHECK monitoring grids were established at Wellington East in 2004. They included three external reference grids (FC28, FC32, FC35), one coupe buffer (FC29), three shelterwood (FC30, FC33, FC36) and three gap release treatments (FC31, FC34, FC37). All are established in the Dwellingup 4 vegetation complex (Matiske and Havel 1998) and located on mid to upper slopes. The initial monitoring of grids was undertaken in October 2004 and they were subsequently re-measured in 2010. In the time between the two monitoring events, the Bell block grids (FC35, FC36, FC37) were burnt by wildfire in summer 2005 and the Stockyard grids (FC32, FC33, FC34) were subject to prescribed fire in spring 2008.

Flora surveys on the Wellington East FORESTCHECK grids were undertaken in spring (October) of 2010, coinciding with the peak flowering time for most plants. 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 the total contacts that have a 'yes' (Y). Cover was divided into mid and upper storey ratings. The mid storey was further split into eucalypt and other species so that the structure of the developing stand could be tracked as it progressed from saplings into poles and from poles to mature trees. Detailed descriptions of all monitoring methods including abundance, cover and frequency ratings is documented in the FORESTCHECK Operations Plan (DEC 2006).

The area around each grid was used to voucher flowering plant specimens to aid in species identification. During the original assessment in 2004, 127 vouchers were collected representing 58% of the species recorded then. In 2010, a further 26 voucher collections were added. In order to achieve a complete set of voucher specimens for the Wellington East grids, species that have not yet been collected will be added opportunistically during future visits.

Results and duscussion

Species richness

In 2010, a total of 150 vascular plant species were recorded on the Wellington East grids. This is a reduction of 38 species from the 2004 assessment (Table 1) and may be due to an excessively dry year. The coupe buffer appears to have lower species numbers but is represented by only one grid where all other treatments have three grids. Weed species were also lower in this assessment with only two weed species being recorded from all treatments; down from 10 species recorded in 2004.

Mean species richness per treatment was similar across all treatments in both 2004 and 2010 but markedly lower overall in 2010 (Fig. 1). Although plants usually follow successional trends peaking in richness 2-3 years after fire, plant species richness was lower across all grids regardless of the time since fire (Fig. 2). Drought or other low rainfall-associated factors is the most likely cause. In 2010, the annual rainfall at Lake Yourdamung, NE of Collie, was only about 50% of the mean 1995-2010 average (Fig. 2)

Table 1. Comparison of total plants recorded for silvicultural treatments for the 2004 and 2010 sampling sessions (ER = external reference, CB = coupe biffer, SW = shelterwood, GR = gap release)

Number of species	Wellington East 2004					Wellington East 2010					Wellington East 2004-2010				
	ER	CB	SW	GR	Total	ER	CB	SW	GR	Total	ER	CB	SW	GR	Total
Total	137	84	141	132	188	111	61	104	107	150	205	126	208	198	297
Unique to treatment	26	5	15	12		17	3	11	13		28	5	26	20	
Common to all					66					52					102
Exclusive to year					79					41					
Recorded in both years										109					
Weeds	6	2	5	5	9	2	1	2	1	2	7	2	6	5	10

Table 2. Number of plants in each life-form category recorded exclusively in each treatment for both sampling sessions2004 and 2010 in the Wellington East grids

Lifeform	External reference				Coupe Buffer				Shelterwood				Gap Release				All treatments combined			
	2004 only	2009 only	shared	Total	2004 only	2009 only	shared	Total	2004 only	2009 only	shared	Total	2004 only	2009 only	shared	Total	2004 only	2009 only	shared	Total
Tree	0	0	4	4	0	0	4	4	0	0	4	4	0	0	4	4	0	0	4	4
Shrub	15	15	28	58	5	5	15	25	10	13	20	43	10	12	25	47	20	22	34	76
Dwarf shrub	11	4	27	42	10	8	10	28	9	9	25	43	11	7	25	43	12	11	34	57
Herb	12	2	3	17	10	1	2	13	13	2	5	20	8	1	11	20	14	1	11	26
Geophyte	16	3	9	28	15	1	2	18	16	2	6	24	12	1	5	18	25	3	9	37
Grass	2	2	4	8	3	1	3	7	2	2	5	9	2	3	3	8	2	2	5	9
Cycad	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1
Vine	2	2	0	4	0	1	0	1	1	0	3	4	1	1	1	3	2	0	3	5
Grass tree	1	0	1	2	0	1	0	1	0	0	2	2	0	1	1	2	0	0	2	2
Sedge	1		5	6	0	1	4	5	1	1	5	7	0	2	4	6	1	2	4	7
Fern	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rush	0	0	0	0	1	0	0	1	2	0	0	2	1	0	0	1	2	0	0	2
Parasite	0	0	0	0	1	0	0	1	1	0	0	1	0	1	0	1	1	0	1	2
Unknown	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	1	0	1
Total	60	28	82	**170**	45	20	41	**106**	55	29	76	**160**	45	29	80	**154**	79	42	108	**229**

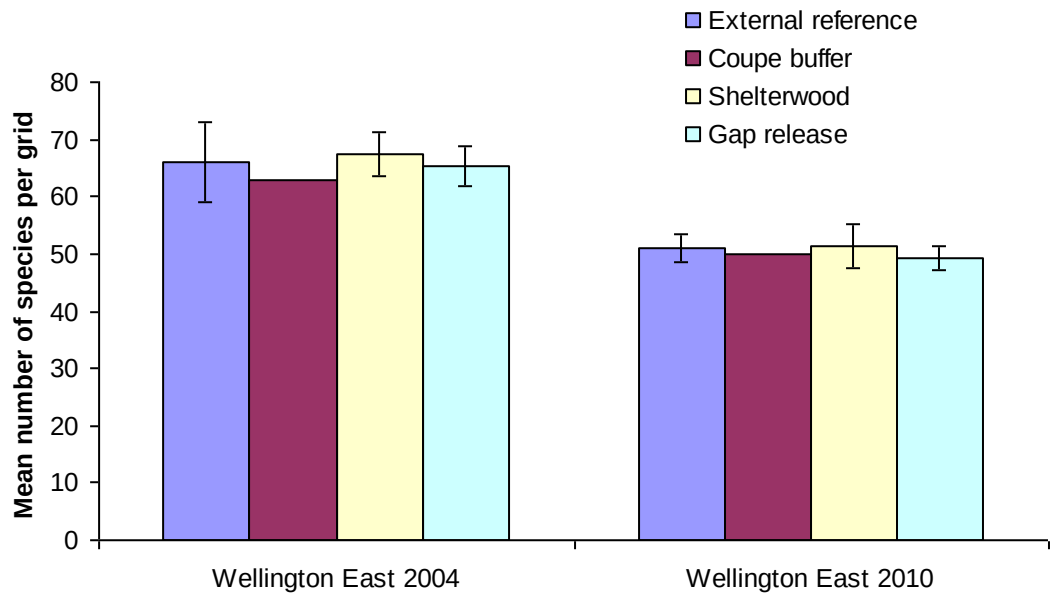

Figure 1. Mean species richness of plants per grid at Wellington East FORESTCHECK grids in 2004 and 2010

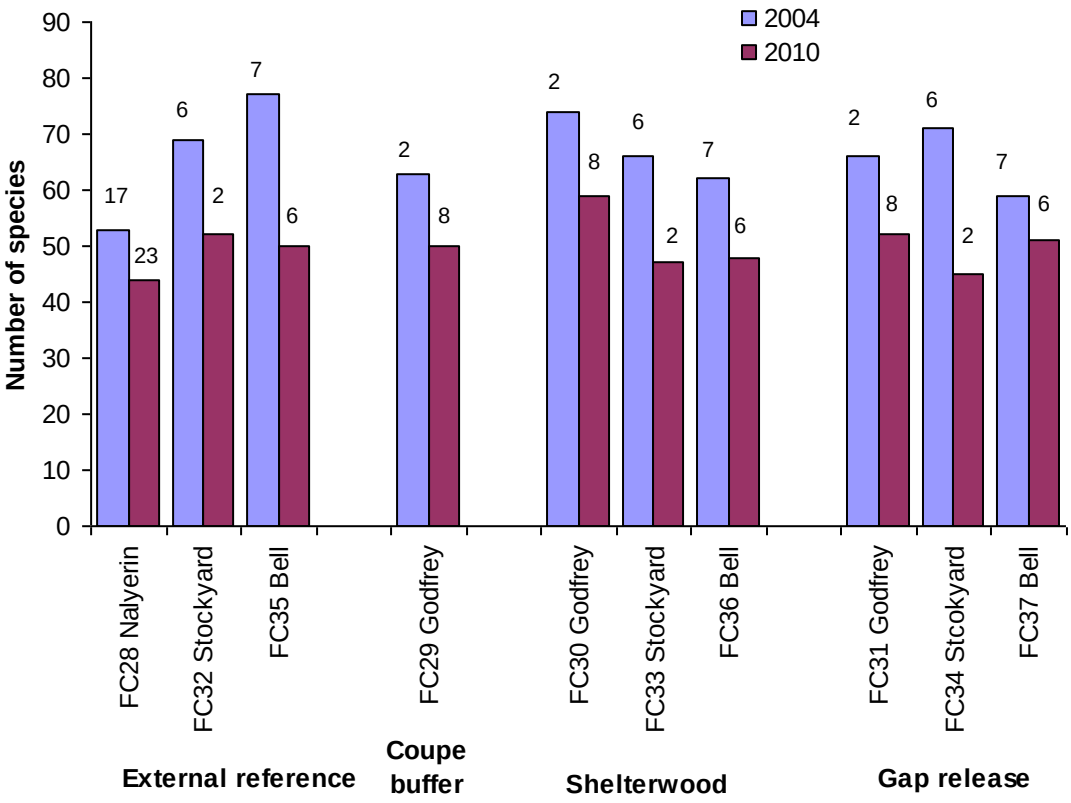

Figure 2. Number of plant species in each monitoring grid recorded at Wellington East FORESTCHECK grids in 2004 and 2010 (numbers above columns indicate the number of years since last fire)

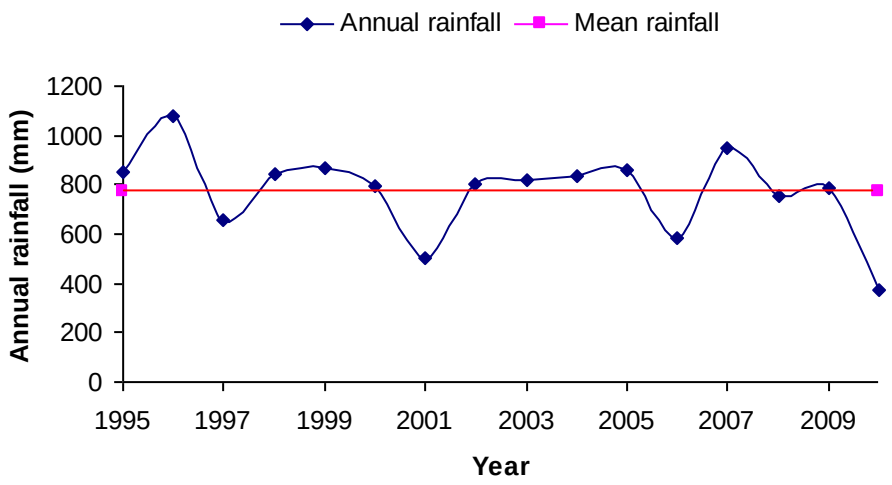

Figure 3. Annual rainfall since 1995 from Lake Yourdamung weather station close to monitoring grids with the mean annual rainfall line plotted. The 2010 rainfall was only 50% of the mean annual rainfall for the 15 year period

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 2004 and 2010 sampling sessions (Appendix 1) (Table 2 and Fig. 4). This is not surprising given that four of the grids remained unburnt since 2004 and the other six have had fire, three burnt by wildfire in 2005 and three with prescribed fire in 2008. This highlights differences in seral stages within treatments and between sampling sessions. A noticeable change in species assemblage was due to fewer species of dwarf shrubs, herbs and geophytes in all treatments (Fig 3). In contrast, tall shrubs and grass species increased in shelterwood and gap release treatments. This may be due to larger shrubs which dominated sites having better access to moisture and nutrients making them more capable of surviving harsh conditions, while the seeds of grasses are able to blow in from some distance and establish on gaps between the shrubs.

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. It is likely that the dryness of the 2010 year may have influenced plant development and many of the annual species had completed their cycle before the October assessment. Timing of assessments is a critical factor and the months of August to October are generally targeted to capture the flowering and spring development of most species.

Almost 60% of all species were recorded in both 2004 and 2010. The remaining 40% were either missed because of the timing of measurement or short lived species having died out prior to 2010 or they were promoted by fire since 2004. It is this stable core of species that allows for robust analysis of species data.

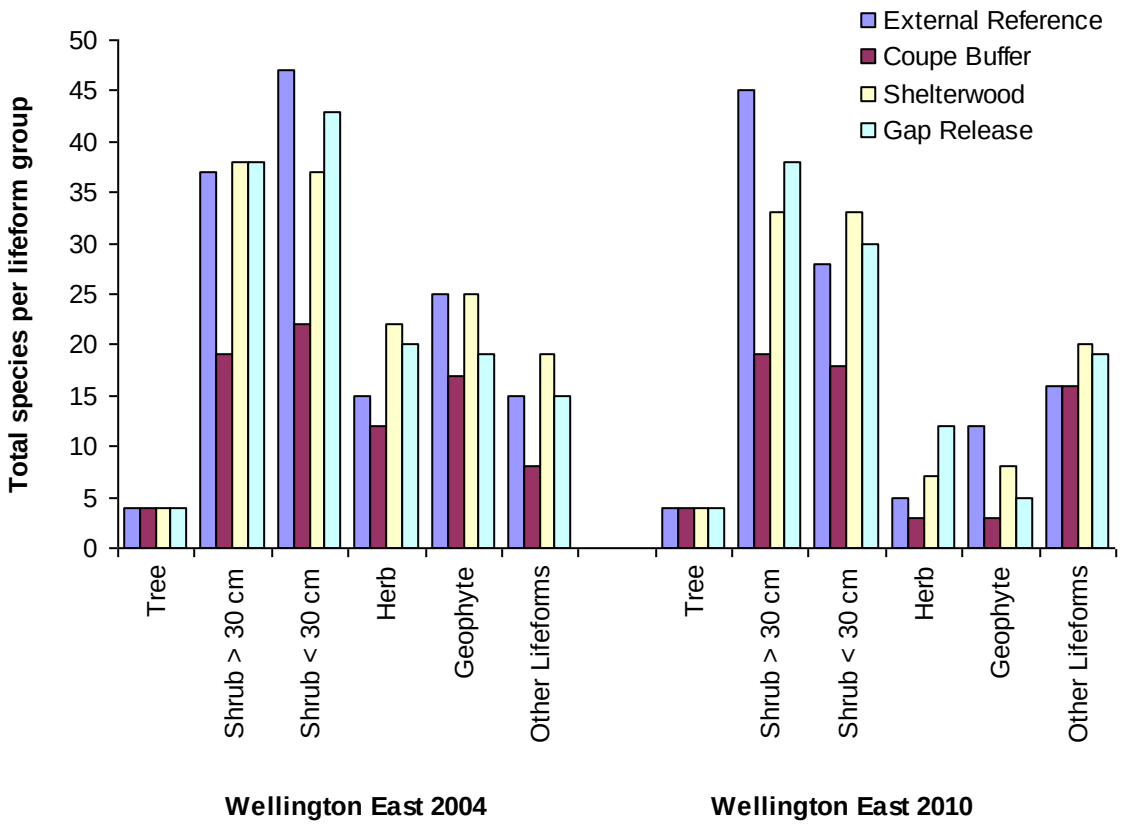

Figure 4. Total number of species in each life-form category for each treatment at Wellington East in 2004 and 2010

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 then converted to plants m^{-2} for each grid. Plant abundance has dramatically declined in all grids since 2004 and may be indicative of the effects of drought. The low abundances in the Stockyard block (grids FC32, FC33 and FC 34) also goes against normal trend of increasing in the first few years following fire (Fig 5.).

Vegetation structure

There appeared to be no obvious relationship between mean understory shrub height and treatments (either silvicultural or time since fire) on any grids in 2010 (Fig. 6). However, the mean shrub height on the Bell gap release grid (FC37) was higher than the other grids. The more recently burnt grids at Stockyard block (FC32, FC33 and FC34 – burnt 2 years previously) had a less complex structure than other grids (Fig. 7).There was more dead material within the understory structure on the long-unburnt Nalyerin external reference (FC 28) which is likely related to the stage of development and age of plants. However, there were also low levels of dead material within the understory of more recently burnt grids (Fig. 7), suggesting that drought is having an impact on the vegetation.

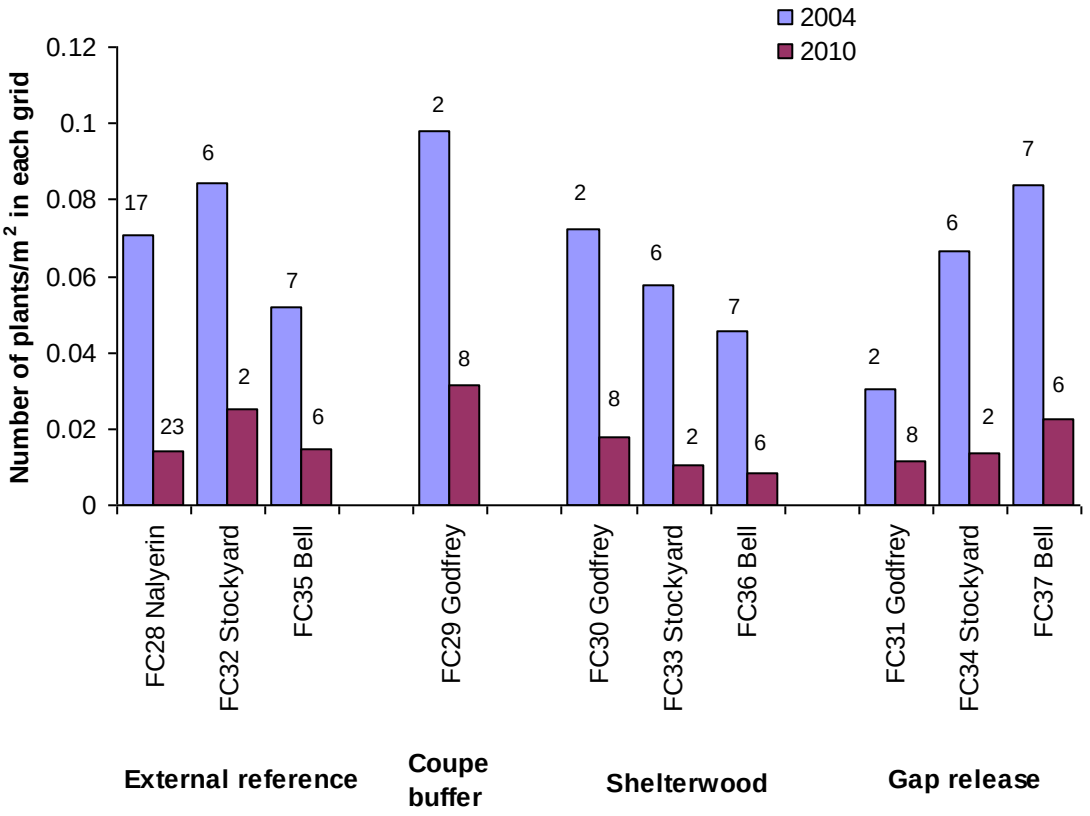

Figure 5. Plant abundances at Wellington East FORESTCHECK grids in 2004 and 2010 (numbers above columns indicate the number of years since fire)

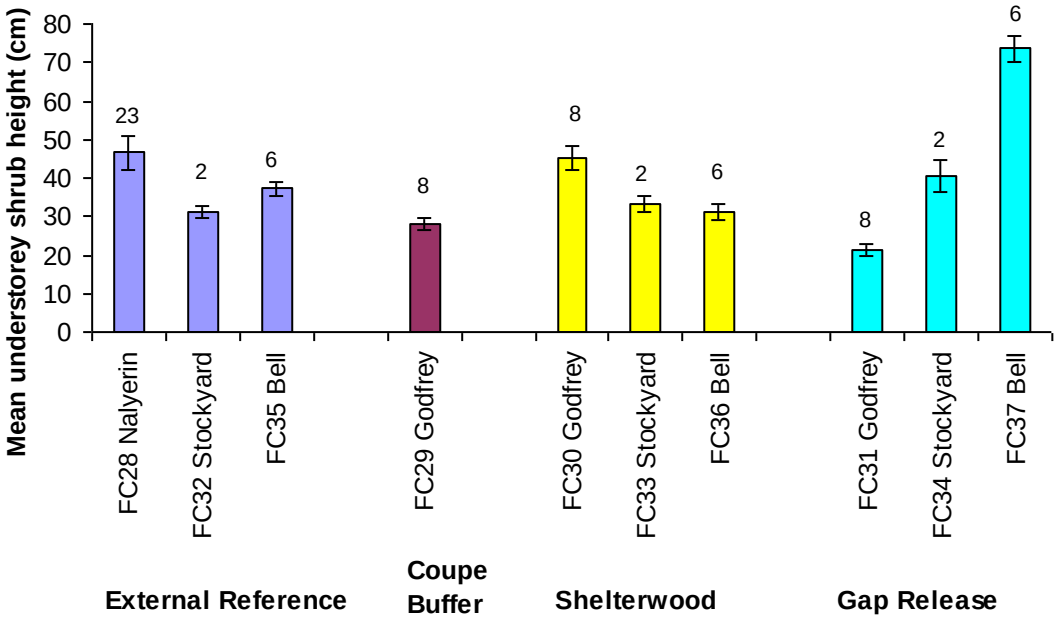

Figure 6. Mean understorey shrub height (±se) at Wellington East FORESTCHECK grids in 2010 (numbers above columns indicate the number of years since fire)

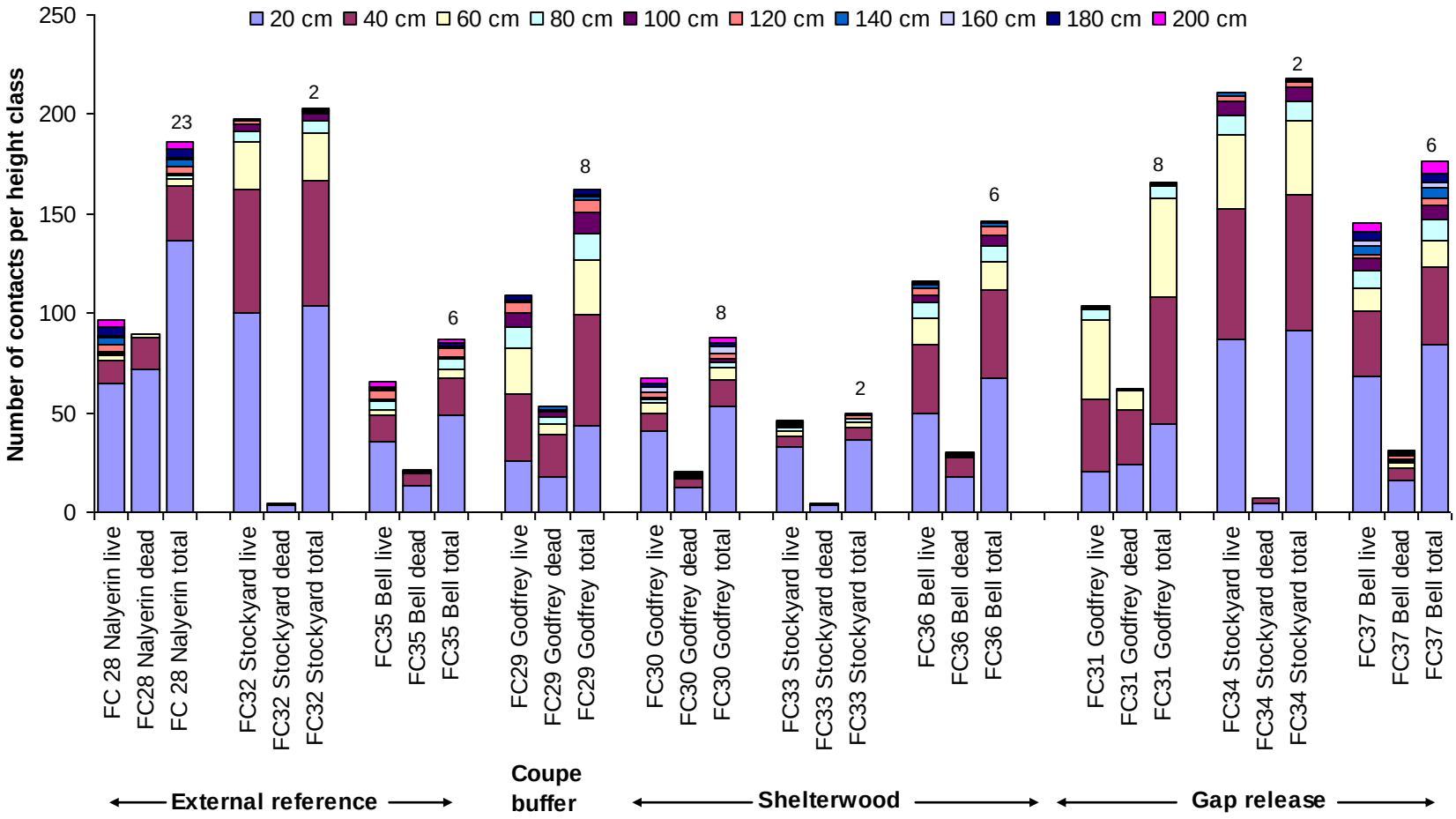

Figure 6. Numbers of live, dead and total vegetation contacts within 20cm height classes up to 2m at each Wellington East FORESTCHECK grid in 2010. Numbers above the 'total' bars indicate the time since last fire for that grid (legend displays the upper limits of each 20 cm class).

Conclusions

The main observations made following monitoring of vascular plants and measurement of plant structure at theWellington East FORESTCHECK location include:

- Few weed species were recorded at Wellington East grids and they have reduced from 10 to two over the period 2004-10.
- Species richness and abundance of plants has fallen since 2004, which is most likely due to an excessively dry year in 2010.
- A large turn over of plant species was detected between the 2004 and 2010 assessments and was possibly due to successional trends following wildfire in Bell and prescribed fire in Stockyard forest blocks.
- The long unburnt Nalyerin external control has a two-tiered understory structure compared to the other grids which have all been burnt within the past eight years and have a continuous understory profile.
- Many annuals such as geophytes have a short vegetative period and timing of surveys needs to coincide in order to capture data on these species.
- Flowering vouchers need to be collected to determine some species varieties.

Acknowledgements

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Appendix 1. List of species recorded from the Wellington East site for both monitoring sessions. A number 1 in the column indicates that the species was present and 0 indicates absent, those in bold type are weeds

FORESTCHECK species No.	Taxon No.	Species Code	Species	2004	2010
1	3207	ACAALA	*Acacia alata*	1	1
8	3311	ACADRU	*Acacia drummondii*	1	1
9	11661	ACADRUDRU	*Acacia drummondii* subsp. *drummondii*	1	0
11	3331	ACAEXT	*Acacia extensa*	1	1
14	3453	ACAMYR	*Acacia myrtifolia*	1	1
17	3496	ACAPRE	*Acacia preissiana*	1	1
18	3502	ACAPUL	*Acacia pulchella*	1	1
23	3593	ACAVAR	*Acacia varia*	0	1
24	**3184**	**ACAECH**	***Acaena echinata***	**1**	**0**
25	6203	ACTGLO	*Actinotus glomeratus*	1	1
31	1261	AGRSCA	*Agrostocrinum scabrum*	1	1
32	**185**	**AIRCUP**	***Aira cupaniana***	**1**	**1**
33	1728	ALLFRA	*Allocasuarina fraseriana*	1	1
34	4585	AMPERI	*Amperea ericoides*	0	1
35	194	AMPAMP	*Amphipogon amphipogonoides*	0	1
46	1411	ANIMAN	*Anigozanthos manglesii*	1	0
	7838	**ARCCAL**	***Arctotheca calendula***	**1**	**0**
49	6323	ASTCIL	*Astroloma ciliatum*	1	1
50	6325	ASTDRU	*Astroloma drummondii*	1	1
51	6334	ASTPAL	*Astroloma pallidum*	1	1
52	17950	AUSCAE	*Austrodanthonia caespitosa*	1	1
53	17233	AUSCAM	*Austrostipa campylachne*	1	1
515	17240	AUSFLA	*Austrostipa flavescens*	0	1
54	5336	BABCAM	*Babingtonia camphorosmae*	1	0
56	32677	BANBIP	*Banksia bipinnatifida*	0	1
58	32576	BANDAL	*Banksia dallanneyi*	1	1
537	32616	BANDALSYL	*Banksia dallanneyi* subsp. *sylvestris*	0	1
60	1819	BANGRA	*Banksia grandis*	1	1
62	32076	BANSES	*Banksia sessilis*	0	1
543	12111	BANSPHSPH	*Banksia sphaerocarpa* var. *sphaerocarpa*	1	1
64	3157	BILFLO	*Billardiera floribunda*	1	0
		BILFUS	*Billardiera fusiformis*	1	0
66	25796	BILHET	*Billardiera heterophylla*	0	1
67	3165	BILVAR	*Billardiera variifolia*	1	1
68	4413	BORCRE	*Boronia crenulata*	1	1
464	4420	BORFAS	*Boronia fastigiata*	0	1
71	4438	BORRAM	*Boronia ramosa*	1	0
72	4441	BORSPA	*Boronia spathulata*	1	1
539		BORSP.	*Boronia* spp.	0	1
75	3710	BOSERI	*Bossiaea eriocarpa*	1	0
77	3714	BOSORN	*Bossiaea ornata*	1	1
79	**245**	**BRIMIN**	***Briza minor***	**1**	**0**
80	12770	BURCON	*Burchardia congesta*	0	1
81	1276	CAEMIC	*Caesia micrantha*	1	0
83	1592	CALFLA	*Caladenia flava*	1	0
87	1613	CALREP	*Caladenia reptans*	1	0
94	2957	CASRAC	*Cassytha racemosa*	1	1
96		CASSP.	*Cassytha* sp.	1	0
97	**6539**	**CENERY**	***Centaurium erythraea***	**1**	**0**
102	1280	CHACOR	*Chamaescilla corymbosa*	1	0
106	2929	CLEPUB	*Clematis pubescens*	1	0

FORESTCHECK species No.	Taxon No.	Species Code	Species	2004	2010
107	4550	COMCAL	*Comesperma calymega*	1	1
108	4552	COMCON	*Comesperma confertum*	0	1
110	1862	CONCAE	*Conospermum caerulesens*	1	0
111	1863	CONCAP	*Conospermum capitatum*	0	1
113	1418	CONACU	*Conostylis aculeata*	1	1
114	1453	CONSER	*Conostylis serrulata*	1	0
115	1454	CONSET	*Conostylis setigera*	1	1
118	17104	CORCAL	*Corymbia calophylla*	1	1
120	13354	CRAVAR	*Craspedia variabilis*	1	1
126	15404	CYASER	*Cyanicula sericea*	1	0
128	10916	CYRHUE	*Cyrtostylis huegelii*	1	0
130	7454	DAMLIN	*Dampiera linearis*	1	1
135	6218	DAUGLO	*Daucus glochidiatus*	1	0
138	3816	DAVINC	*Daviesia incrassata*	1	1
139	3835	DAVPRE	*Daviesia preissii*	1	1
140	17691	DESFAS	*Desmocladus fasciculatus*	1	1
141	16595	DESFLE	*Desmocladus flexuosus*	1	1
142	1259	DIAREV	*Dianella revoluta*	1	1
146	1635	DIULON	*Diuris longifolia*	1	0
152	3095	DROERY	*Drosera erythrorhiza*	1	0
154	3102	DROHUE	*Drosera huegelii*	1	0
156	11853	DROMENMEN	*Drosera menziesii* subsp. *menziesii*	1	0
157	3118	DROPAL	*Drosera pallida*	1	0
161	3131	DROSTO	*Drosera stolonifera*	1	0
162	1643	ELYBRU	*Elythranthera brunonis*	1	0
164	5708	EUCMAR	*Eucalyptus marginata*	1	1
538	900	GAHARI	*Gahnia aristata*	0	1
487		GENSP.	*Genus* sp.	0	1
169		GENSP.	*Genus* sp. *orchid*	0	0
533	33620	GLIANG	*Glischrocaryon angustifolium*	0	1
171	6143	GLIAUR	*Glischrocaryon aureum*	1	1
173	10909	GOMCON	*Gompholobium confertum*	1	1
174	3950	GOMKNI	*Gompholobium knightianum*	1	1
175	3951	GOMMAR	*Gompholobium marginatum*	1	1
178	3955	GOMPRE	*Gompholobium preissii*	1	1
179	11083	GOMSCA	*Gompholobium scabrum*	1	0
192	1472	HAESIM	*Haemodorum simplex*	0	1
194	2128	HAKAMP	*Hakea amplexicaulis*	1	0
195	2152	HAKCYC	*Hakea cyclocarpa*	1	0
534	2170	HAKLAS	*Hakea lasianthoides*	0	1
196	2175	HAKLIS	*Hakea lissocarpha*	1	1
451	2197	HAKPRO	*Hakea prostrata*	0	1
542	2215	HAKUND	*Hakea undulata*	0	1
199	8027	HELMAC	*Helichrysum macranthum*	1	0
535	6838	HEMLIN	*Hemiandra linearis*	0	1
200	6839	HEMPUN	*Hemiandra pungens*	1	0
202	6868	HEMRIG	*Hemigenia rigida*	1	1
204	5108	HIBACE	*Hibbertia acerosa*	0	1
205	5109	HIBAMP	*Hibbertia amplexicaulis*	1	1
206	5114	HIBCOM	*Hibbertia commutata*	1	1
207	5117	HIBCUN	*Hibbertia cuneiformis*	0	1
211	5135	HIBHYP	*Hibbertia hypericoides*	1	1
491	5137	HIBINC	*Hibbertia inconspicua*	0	1
214	5162	HIBRAC	*Hibbertia racemosa*	1	1

FORESTCHECK species No.	Taxon No.	Species Code	Species	2004	2010
215	5171	HIBSPI	*Hibbertia spicata*	1	0
217	6222	HOMHOM	*Homalosciadium homalocarpum*	1	0
218	3964	HOVCHO	*Hovea chorizemifolia*	1	1
219	3965	HOVELL	*Hovea elliptica*	1	0
220	3968	HOVTRI	*Hovea trisperma*	1	0
223	12741	HYACOT	*Hyalosperma cotula*	1	1
225	5218	HYBDEB	*Hybanthus debilissimus*	0	1
227	6229	HYDDIA	*Hydrocotyle diantha*	1	0
229	5817	HYPANG	*Hypocalymma angustifolium*	1	1
231	**8086**	**HYPGLA**	***Hypochaeris glabra***	**1**	**1**
233	1503	HYPOCC	*Hypoxis occidentalis*	1	0
234	**917**	**ISOMAR**	***Isolepis marginata***	**1**	**0**
236	7396	ISOHYP	*Isotoma hypocrateriformis*	1	1
241	4037	KENCOC	*Kennedia coccinea*	1	1
242	4044	KENPRO	*Kennedia prostrata*	1	1
245	3669	LABPUN	*Labichea punctata*	1	1
246	18585	LAGHUE	*Lagenophora huegelii*	1	1
493	5026	LASCAR	*Lasiopetalum cardiophyllum*	0	1
247	5033	LASFLO	*Lasiopetalum floribundum*	1	0
532	1308	LAXSES	*Laxmannia sessiliflora*	0	1
249	7568	LECBIL	*Lechenaultia biloba*	1	1
250	936	LEPLEP	*Lepidosperma leptostachyum*	1	1
253	945	LEPSQU	*Lepidosperma squamatum*	1	0
254	2342	LEPCUN	*Leptomeria cunninghamii*	1	1
256	6367	LEUCAP	*Leucopogon capitellatus*	1	1
258	6436	LEUPRO	*Leucopogon propinquus*	1	1
263	7676	LEVPUS	*Levenhookia pusilla*	1	0
265	7405	LOBRAR	*Lobelia rarifolia*	1	1
266	6511	LOGSER	*Logania serpyllifolia*	1	1
269	1223	LOMCAE	*Lomandra caespitosa*	1	1
270	1225	LOMDRU	*Lomandra drummondii*	1	1
271	1228	LOMHER	*Lomandra hermaphrodita*	1	1
272	1229	LOMINT	*Lomandra integra*	1	1
275	1239	LOMPRE	*Lomandra preissii*	1	0
276	1240	LOMPUR	*Lomandra purpurea*	1	0
277	1243	LOMSER	*Lomandra sericea*	1	1
278	1244	LOMSON	*Lomandra sonderi*	0	1
279	1245	LOMSPA	*Lomandra spartea*	1	0
280		LOMSP.	*Lomandra* spp.	0	1
281	1246	LOMSUA	*Lomandra suaveolens*	1	0
284	1198	LUZMER	*Luzula merioionalis*	1	0
286	85	MACRIE	*Macrozamia riedlei*	1	1
290	8106	MILTEN	*Millotia tenuifolia*	1	1
296	492	NEUALO	*Neurachne alopecuroidea*	1	1
298	2365	OLABEN	*Olax benthamiana*	1	1
299	7348	OPEHIS	*Opercularia hispidula*	1	1
300	18255	OPEVAG	*Opercularia vaginata*	1	0
303	**4349**	**OXACOR**	***Oxalis corniculata***	**1**	**1**
306	**7089**	**PARLAT**	***Parentucellia latifolia***	**1**	**0**
307	1542	PATBAB	*Patersonia babianoides*	1	1
308	1546	PATJUN	*Patersonia juncea*	0	1
310	1551	PATPYG	*Patersonia pygmaea*	1	1
315	6245	PENPEL	*Pentapeltis peltigera*	1	1
321	2267	PERLON	*Persoonia longifolia*	1	1

FORESTCHECK species No.	Taxon No.	Species Code	Species	2004	2010
322	2273	PERSAC	*Persoonia saccata*	1	0
323	2293	PETDIV	*Petrophile diversifolia*	1	0
325	2309	PETSER	*Petrophile serruriae*	1	0
540	2312	PETSTR	*Petrophile striata*	0	1
326	20460	PHEDEF	*Pheladenia deformis*	1	0
329	16177	PHYPAR	*Phyllangium paradoxum*	1	1
330	4675	PHYCAL	*Phyllanthus calycinus*	1	1
331	5231	PIMANG	*Pimelea angustifolia*	1	0
332	5251	PIMIMB	*Pimelea imbricata*	1	0
333	5261	PIMROS	*Pimelea rosea*	1	1
335	5264	PIMSPE	*Pimelea spectabilis*	0	1
337	5266	PIMSUA	*Pimelea suaveolens*	1	1
345	573	POADRU	*Poa drummoniana*	1	0
347	8172	PODCAN	*Podolepis canescens*	1	0
541	8175	PODGRA	*Podolepis gracilis*	0	1
348	8182	PODANG	*Podotheca angustifolia*	1	0
350	4690	PORHUE	*Poranthera huegelii*	1	1
351	4691	PORMIC	*Poranthera microphylla*	1	0
356	1693	PTEREC	*Pterostylis recurva*	1	0
357	1698	PTEVIT	*Pterostylis vittata*	1	0
358	2718	PTIDRU	*Ptilotus drummondii*	1	0
359	2742	PTIMAN	*Ptilotus manglesii*	1	1
363	16367	PYRNIG	*Pyrorchis nigricans*	1	0
364	8195	QUIURV	*Quinetia urvillei*	1	0
365	2932	RANCOL	*Ranunculus colonorum*	1	0
366	13300	RHOCIT	*Rhodanthe citrina*	1	1
367	13234	RHOMAN	*Rhodanthe manglesii*	1	0
372	7646	SCASTR	*Scaevola striata*	1	1
375	8206	SENGLO	*Senecio glomeratus*	1	0
376	8208	SENHIS	*Senecio hispidulus*	1	1
381	**8231**	**SONOLE**	***Sonchus oleraceus***	**1**	**0**
382	1312	SOWLAX	*Sowerbaea laxiflora*	1	0
386	4733	STAMON	*Stackhousia monogyna*	1	1
388	7684	STYAMO	*Stylidium amoenum*	1	1
520	30278	STYAND	*Stylidium androsaceum*	1	1
389	7693	STYBRU	*Stylidium brunonianum*	1	0
391	7702	STYCIL	*Stylidium ciliatum*	1	1
393	7757	STYLUT	*Stylidium luteum*	0	1
394	7774	STYPIL	*Stylidium piliferum*	1	1
397	7798	STYSCH	*Stylidium schoenoides*	1	0
398	7799	STYSPA	*Stylidium spathulatum*	1	1
399		STYSP.	*Stylidium* spp.	0	1
400	1260	STYGLA	*Stypandra glauca*	1	0
401	6476	STYTEN	*Styphelia tenuiflora*	1	1
525	12914	SYNDEC	*Synaphea decorticans*	0	1
403	2324	SYNPET	*Synaphea petiolaris*	1	1
407	1034	TETCAP	*Tetraria capillaris*	1	1
408	1036	TETOCT	*Tetraria octandra*	1	1
409	667	TETLAE	*Tetrarrhena laevis*	1	1
411	4535	TETHIR	*Tetratheca hirsuta*	1	1
412	4536	TETHIS	*Tetratheca hispidissima*	0	1
531	1704	THECOR	*Thelymitra cornicina*	0	1
414	1705	THECRI	*Thelymitra crinita*	1	0
536	33488	THOSP.	*Thomasia* sp. Vasse (C. Wilkins & K. Shepherd CW 581)	0	1

FORESTCHECK species No.	Taxon No.	Species Code	Species	2004	2010
418	1338	THYMAN	*Thysanotus manglesianus*	1	1
419	1339	THYMUL	*Thysanotus multiflorus*	1	1
420	1343	THYPAT	*Thysanotus patersonii*	1	0
421	1351	THYSPA	*Thysanotus sparteus*	1	0
425	6280	TRAPIL	*Trachymene pilosa*	1	1
428	8251	TRISPA	*Trichocline spathulata*	1	1
429	1361	TRIELA	*Tricoryne elatior*	1	1
430	1362	TRIHUM	*Tricoryne humilis*	1	0
432	4737	TRIBRU	*Tripterococcus brunonis*	0	1
434	4842	TRYLED	*Trymalium ledifolium*	1	1
433	33418	TRYODOODO	*Trymalium odoratissimum* subsp. *odoratissimum*	0	1
435	7665	VELTRI	*Velleia trinervis*	1	0
441	1402	WURSIN	*Wurmbea sinora*	1	0
442	1253	XANGRA	*Xanthorrhoea gracilis*	1	1
443	1256	XANPRE	*Xanthorrhoea preissii*	1	1
444	6283	XANATK	*Xanthosia atkinsoniana*	1	1
445	6284	XANCAN	*Xanthosia candida*	1	1
447	6289	XANHUE	*Xanthosia huegelii*	1	1
Total				188	150

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;
- Monitor the presence of Gondwanan relic and affinity invertebrate species with respect to the above treatments; and
- Monitor the presence of known insect pest species.

Field survey and laboratory procedure

Sampling at Wellington East was carried out in November (spring) 2010 and April (autumn) 2011 using the protocol formerly established at Donnelly in 2001. 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 (no light trap failures) for each season, mean minimum overnight temperatures were 9.6 (±0.6) ºC in spring and 7.7 (±0.6) ºC in autumn; 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 and 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 10 Wellington East monitoring grids. Sorting, specimen identification and cataloguing have been completed for all light trap, hand, and pitfall samples. This report details sampling results for 2010-11 and also includes a brief comparison with the initial Wellington East results for 2004-5. Note however, this is a preliminary report and results are from data as it exists for November 2011. 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.

Results and discussion

Overall species accumulation

Following the 2009-10 monitoring, the number of morphospecies recorded for FORESTCHECK increased to 2,085 (a total of 84,847 individual specimens). To date, the number of individual specimens captured at Wellington East in 2010-11 was 8,040, comprising 524 morphospecies, this compares with 617 morphospecies (adjusted from original data for synonymy) captured in 2004-5 and an abundance level (number of specimens) of 28,625 (due to a high abundance of the Hydrophilidae coleopteran, species 14). There were 72 new morphospecies recorded from Wellington East that were not previously captured in any of the FORESTCHECK sites (although this figure will change following our morpho-species revision where synonymy is examined). From the 2009-10 data we predicted, using a basic linear regression, there would be a total of 2208 morphospecies. Figure 1 shows the current cumulative captures for the successive sampling locations. The slope of the graph is now decreasing between successive sampling periods and shows a current trend of reduction indicating that there is a slight drop in species acquisition since the 2007-08 monitoring event.

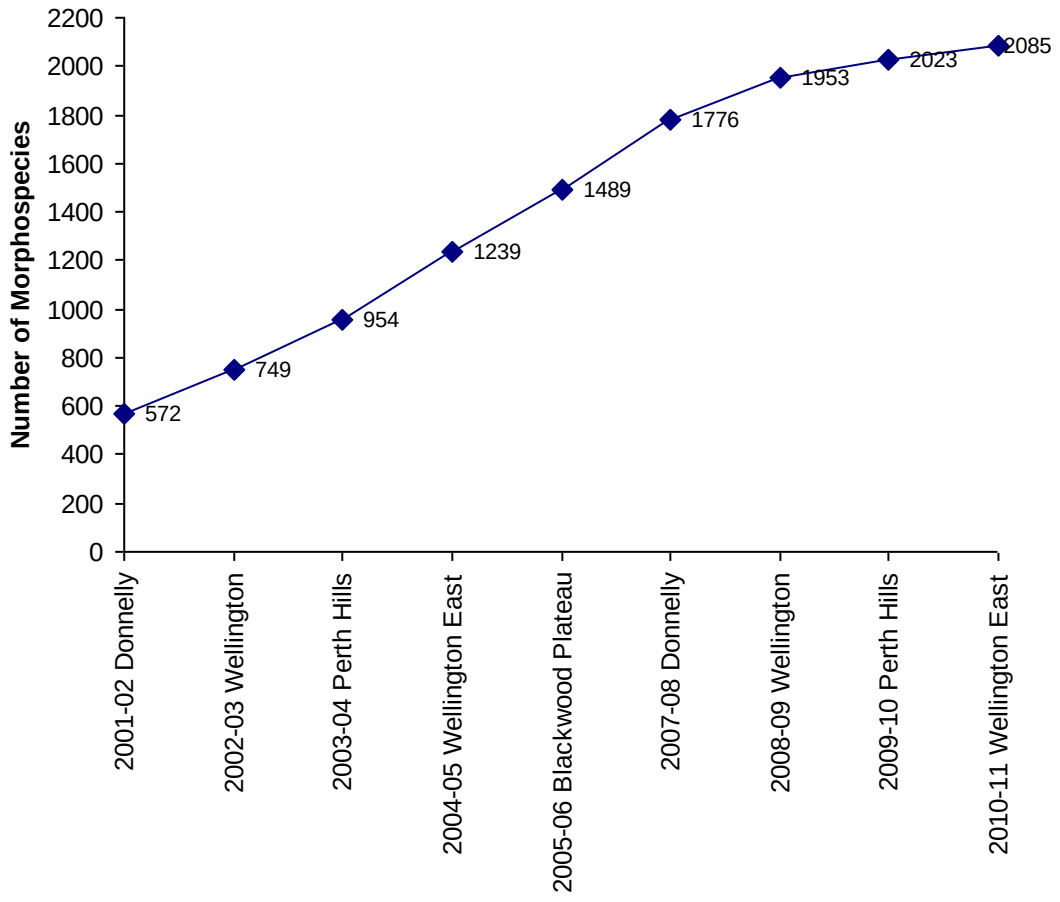

Figure 1. Cumulative morphospecies for 2001 (Donnelly) to 2010 (Wellington East) for all capture methods

Morphospecies captures for past FORESTCHECK sampling are shown in Table 1. The Wellington East 2010-11 sample is lower in terms of diversity and abundance compared with the prior 2004-05 sample. Donnelly still appears the most diverse site followed by Blackwood Plateau and Wellington East 2004-5.

Table 1. Morphospecies comparisons between sample regions

FORESTCHECK locations	Sample period	Number of Morphospecies	Number of individuals
Donnelly	2001-02	572	NA
Wellington 1	2002-03	373	3080
Perth Hills	2003-04	428	4883
Wellington East	2004-05	617	28625
Blackwood Plateau	2005-06	728	6959
Donnelly	2007-08	787	13581
Wellington 1	2008-09	592	5590
Perth Hills	2009-10	529	6439
Wellington East	2010-11	524	8040

The numbers of morphospecies for invertebrate orders where 10 or more morphospecies have been assigned are compared for Wellington East 2004-05 and 2010-11 in Figure 2. Diversity was similar for most orders between sample periods, slight differences were apparent in the Coleoptera, Hymenoptera, Lepidoptera and Orthoptera with the more recent sample (2010-11) being slightly less diverse. No Oligochaetae or Opiliones were captured in 2010-11, although species were present in the 2004-05 samples. However, Onychophora were found in both sample periods at the Nalyerin external reference grid (FC28).

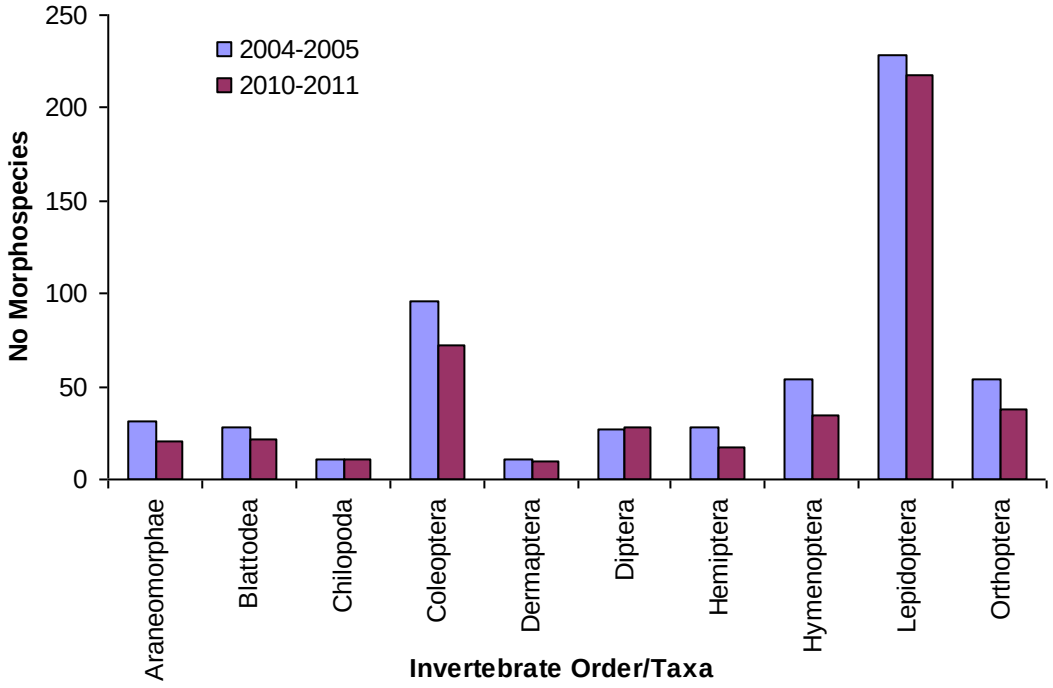

Figure 2. Comparison of Wellington East 2004-05 and 2010-11 morphospecies numbers for invertebrate orders where ten or greater morphospecies have been assigned

Comparing sample grids and silvicultural treatments

Wellington East grid comparisons for silvicultural treatments expressed as the total morphospecies and abundance for all capture methods and summed for spring and autumn seasons is shown in Figures 3 and 4. The Bell and Nalyerin external reference grids (FC35 &

FC28) and the Godfreey coupe buffer (FC29) had the greatest number of species (158, 148, 147 morphospecies respectively) in 2010-11. However, in the prior 2004-05 sample, the Godfrey and Bell shelterwoods (FC30 & FC36) and the Stockyard gap release (FC34) had the greatest diversity (190, 175 & 179 morphospecies respectively). Interestingly for both sample periods the Godfrey gap release (FC31) had the lowest diversity (120 in 2010-11 and 144 in 2004-05). Highest abundance for 2010-11 was in the Godfrey coupe buffer (FC29), followed closely by the Godfrey shelterwood (FC30) (1171 and 1004 individuals respectively). However, abundances were much higher in the earlier 2004-05 sample, with the Stockyard gap release (FC34) recording the highest number of individuals (4268). The variation in abundance levels between sample periods probably reflects differences in seasonal conditions such as rainfall. 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 (> 3 sample seasons) can give insight into variations between grids regarding responses to environmental conditions.

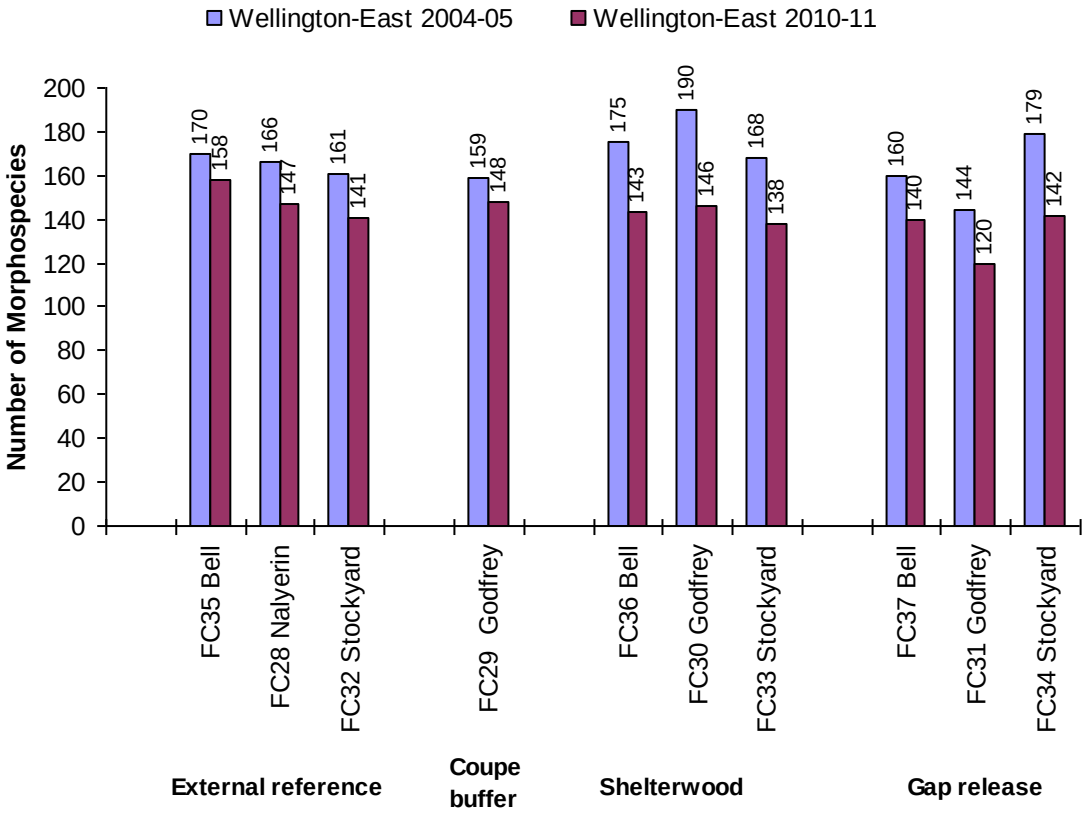

Figure 3. Comparison of individual Wellington East treatment grids for total morphospecies, for all capture methods, combining both spring and autumn samples

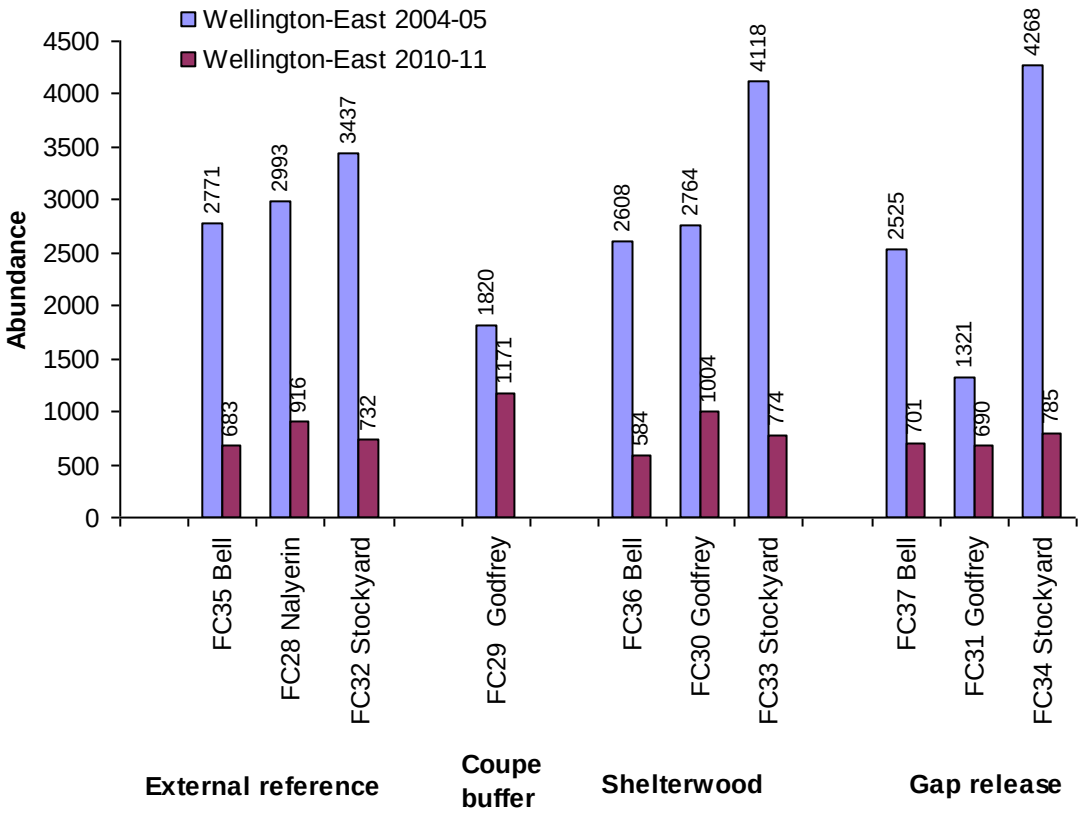

Figure 4. Comparison of individual Wellington East treatment grids for abundance (number of individuals), for all capture methods, combining both spring and autumn samples

Comparison of means between treatments for Wellington East 2010-11 (Fig. 5) indicates the reference treatment has higher species richness, and gap release is the least diverse. Comparison of the earlier 2004-05 samples show shelterwood is more diverse, with gap release consistently least diverse. A similar and slightly stronger pattern is apparent in the comparable Wellington 1 data for 2008-09 (Fig. 6) where the reference is the most diverse and gap release the least. However this pattern is not present in the earlier Wellington 1 2002-03 sample.

For the purpose of consistency and reference with past reports a summary of species richness and abundance (number of individuals captured at each grid) for capture methods, season and site are shown in Appendix I.

Species differences between localities

Table 2 shows the most frequent species captured for Wellington East in 2010-11, compared with the prior sample period in 2004-05. Comparison is also made with the sample region Wellington 1 2008-09 because of its close proximity to the Wellington East sites. The most frequently captured species in Wellington East for both 2010-11 and 2004-05 was the moth *Ochrogaster* (species 10). This species was also the second most frequent capture at Wellington 1 in 2008-09, indicating species 10 is very common in the Wellington area. Of the 10 most frequently captured species at Wellington East in 2004-05, fifty percent were included in the current most frequently caught species. In addition, all of the most frequent species captured in 2004-05 were captured in the current (2010-11) Wellington East sample. Comparing the nearby Wellington 1 location for 2008-09, 40% of the most frequent species featured in the most frequent Wellington East 2010-11. However, two of its top 10 species (species 221 and 333) were not present in the current Wellington East 2010-11 sample.

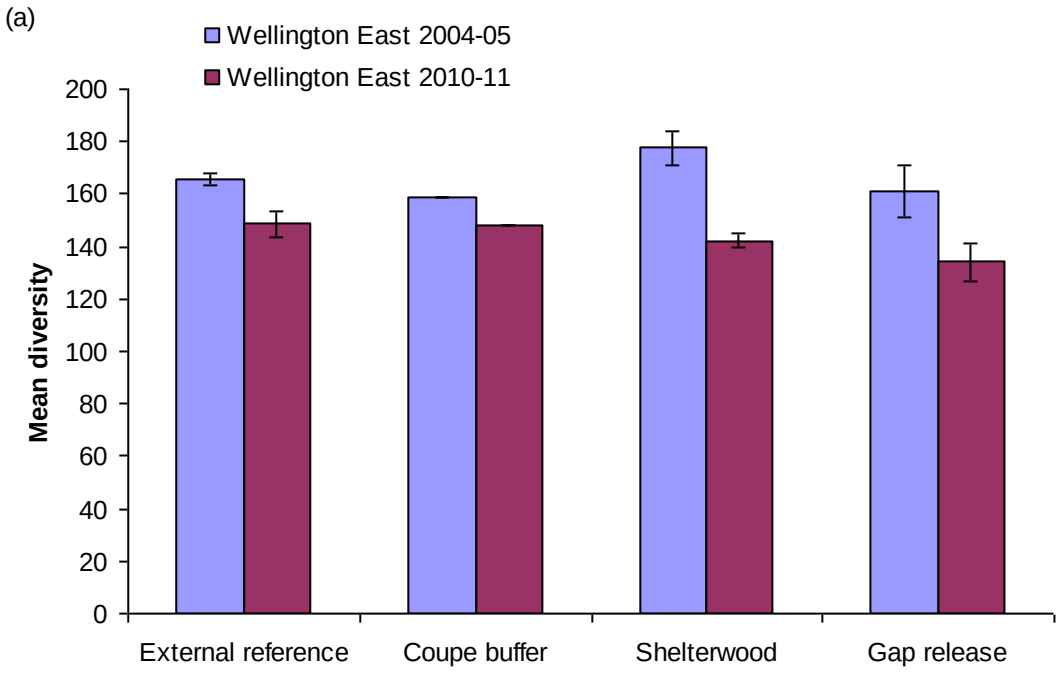

Figure 5. Comparison of means (± SE) for Wellington East (n=1 Coupe buffer, n=3 external reference, gap release and shelterwood,) for mean diversity (number of morphospecies) in respect to silvicultural treatment

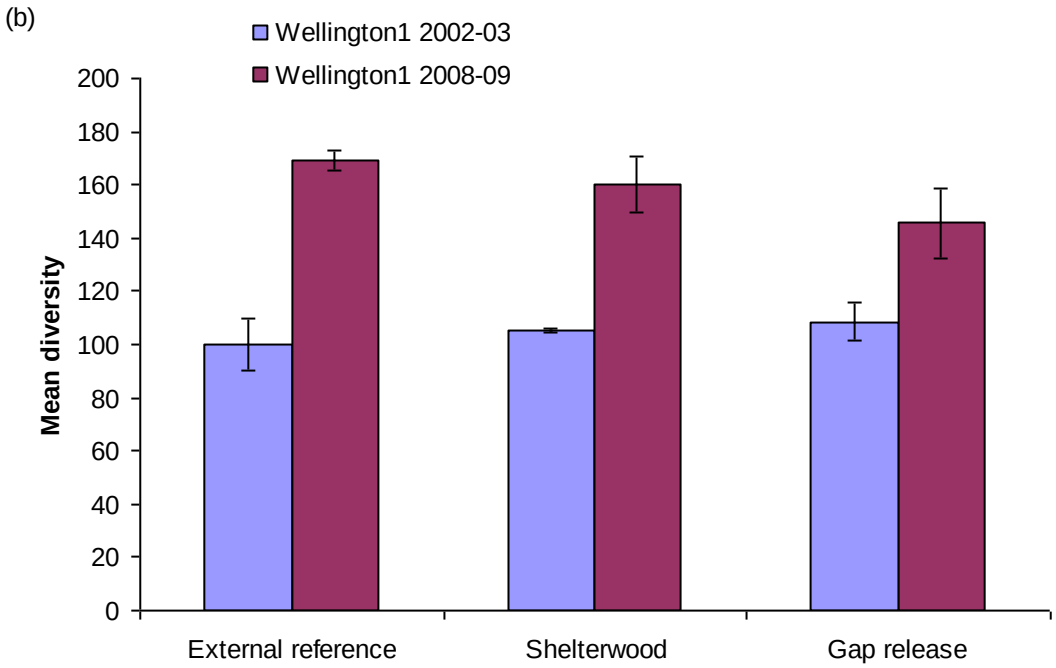

Figure 6. Comparison of means (± SE) for Wellington 1 (n=3 for all treatments) for mean diversity (number of morphospecies) in respect to silvicultural treatment

Furthermore, two species (23, 316) in Wellington 1 feature very low in frequency of occurrence in Wellington East 2010-11. This comparison demonstrates the differences between these two locations despite their close proximity. However, it needs to be pointed out that at this stage the morphospecies consolidation, where new species are examined and

incorporated into the voucher collection, is yet to be completed for the 2010-11 sample and thus some species may be synonymous with previous voucher IDs.

Table 2. Ten most frequent species captured for Wellington East 2010-11 (WE 10), Wellington East 2004-05 and Wellington 1 2008-9 for all capture methods combined. 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. WE 10 frequency rank, refers to the frequency ranking of the same species as captured from WE 10, e.g. a rank of 43 for a Wellington East 2004-05 specimen means this species was the 43rd most frequent species at WE 10 Ranks > 142 indicate < 5specimens of the respective species captured from WE 10; a rank = 0 indicates no specimen captured in WE 10.

Location/sample period	Specimen ID number	Order	Family	Genus	Capture frequency	WE 10 frequency rank
Wellington East/2010-11						
	10	Lepidoptera	Thaumetopoeidae	Ochrogaster	168	1
	436	Lepidoptera	Geometridae		124	2
	39	Lepidoptera	Noctuidae	Proteuxoa	108	3
	326	Lepidoptera	Geometridae		90	4
	460	Lepidoptera	Pyralidae		90	5
	18	Lepidoptera	Noctuidae	Agrotis	75	6
	4	Lepidoptera	Notodontidae	Destolmia	72	7
	423	Hymenoptera	Formicidae	Camponotus	58	8
	252	Hymenoptera	Formicidae	Myrmecia	50	9
	683	Diptera	Bombyliidae		48	10
Wellington East/2004-05						
	10	Lepidoptera	Thaumetopoeidae	Ochrogaster	204	1
	436	Lepidoptera	Geometridae		132	2
	326	Lepidoptera	Geometridae		102	4
	39	Lepidoptera	Noctuidae	Proteuxoa	87	3
	7	Lepidoptera	Thaumetopoeidae	Ochrogaster	84	27
	18	Lepidoptera	Noctuidae	Agrotis	72	6
	63	Lepidoptera			58	13
	54	Diptera	Syrphidae		50	11
	14	Coleoptera	Hydrophilidae		48	35
	444	Coleoptera	Elateridae	Conoderus	46	43
Wellington 1/2008-09						
	6	Lepidoptera	Arctiidae		120	53
	10	Lepidoptera	Thaumetopoeidae	Ochrogaster	114	1
	436	Lepidoptera	Geometridae		100	2
	73	Lepidoptera	Pyralidae		95	12
	23	Lepidoptera	Geometridae	Ectropis	66	113
	4	Lepidoptera	Notodontidae	Destolmia	57	72
	316	Lepidoptera			52	146
	326	Lepidoptera	Geometridae		48	4
	5	Lepidoptera	Noctuidae	Pantydia	46	14
	39	Lepidoptera	Noctuidae	Proteuxoa	42	3
	221	Hemiptera	Pentatomidae		42	0
	333	Lepidoptera	Pyralidae		42	0
	322	Lepidoptera		'the dart'	42	14

Finally, of the 524 morphospecies found at Wellington East in 2010-11, 248 (47%) had not been previously captured during 2004-05. Conversely, 342 species (55%) from the 2004-05 sample were not present in the current sample.

Pest presence

Jarrah leaf miner (JLM) and Bullseye borer (BEB) were present in all grids but gumleaf skeletonizer (GLS) was not seen in any grids in 2010-11 (Table 3). In 2004-5, JLM and BEB were also present at all grids. However, JLM had high populations at Nalyerin (FC28) and Godfrey (FC30), therefore at these locations populations have declined for these pests.

Table 3. Pest presence and abundance assessment at each grid for Wellington East 2010-11 (JLM = jarrah leaf miner; GLSab = gumleaf skeletonizer; BEB = bullseye borer; Skel = skeletonized leaves0 = absent, 1 = present, 2 = abundant)

Treatment	Site No	Location	JLM	GLS	BEB
Coupe buffer	FC29	Godfrey	1	0	1
External reference	FC28	Nalyerin	1	0	1
External reference	FC32	Stockyard	1	0	1
External reference	FC35	Bell	1	0	1
Gap release	FC31	Godfrey	1	0	1
Gap release	FC34	Stockyard	1	0	1
Gap release	FC37	Bell	1	0	1
Shelterwood	FC30	Godfrey	1	0	1
Shelterwood	FC33	Stockyard	1	0	1
Shelterwood	FC36	Bell	1	0	1

Conclusions

In 2010-11 the Wellington East FORESTCHECK grids were re-sampled using the same sampling methods as for previous years. Some observation resulting from the 2010-11 sample and comparisons with previous samples are summarised as follows:

- The total number of invertebrate morphospecies recorded for FORESTCHECK is now 2085.
- A decrease in diversity of invertebrates in 2010-11indicates a dryer environment compared with the earlier 2004-05 sample.
- From the raw data there is still little evidence of a treatment effect.
- In 2010-11, 47% of invertebrate species recorded were not captured in the previous 2004-05 sample.
- There is some indication of decreased jarrah leaf miner populations.
- The moth, *Ochrogaster* species 10, was consistently captured with high frequency during both 2004-05 and 2010-11 sampling.

Acknowledgements

We would like to thank Melanie Schröeder and Lisa Lutz from the University of Applied Science, Eberswalde in Germany for their assistance in the field. We also thank Asako Takahashi and Patrisha Dumitro from Curtin University of Technology for their assistance both in the field and in the laboratory.

Appendix I. Grid summary for Wellington East 2010-11 of species richness (N^{o} Spec) and abundance (Abund. = number of individuals captured at each grid) for capture methods, season (AU = autumn, SP = spring) and site

Treatment	Grid No	Location	Season	Active capture		Light		Pitfall		All capture methods	
				N^{o} Spec	Abund	N^{o} Spec	Abund	N^{o} Spec	Abund	N^{o} Spec	Abund
Coupe buffer	FC29	Godfrey	AU	13	16	46	171	13	9	72	196
Coupe buffer	FC29	Godfrey	SP	26	56	138	907	15	12	179	975
External reference	FC28	Nalyerin	AU	7	11	33	134	16	13	56	158
External reference	FC28	Nalyerin	SP	20	26	135	711	21	21	176	758
External reference	FC32	Stockyard	AU	10	10	32	135	16	15	58	160
External reference	FC32	Stockyard	SP	20	30	112	517	22	25	154	572
External reference	FC35	Bell	AU	10	11	44	129	13	16	67	156
External reference	FC35	Bell	SP	23	34	125	471	22	22	170	527
Gap release	FC31	Godfrey	AU	5	5	29	89	13	13	47	107
Gap release	FC31	Godfrey	SP	17	22	117	551	12	10	146	583
Gap release	FC34	Stockyard	AU	14	15	31	127	14	13	59	155
Gap release	FC34	Stockyard	SP	27	36	130	582	13	12	170	630
Gap release	FC37	Bell	AU	14	15	27	69	11	11	52	95
Gap release	FC37	Bell	SP	26	38	107	518	26	50	159	606
Shelterwood	FC30	Godfrey	AU	6	6	53	141	11	8	70	155
Shelterwood	FC30	Godfrey	SP	27	37	122	790	20	22	169	849
Shelterwood	FC33	Stockyard	AU	10	11	37	110	13	9	60	130
Shelterwood	FC33	Stockyard	SP	22	26	117	574	26	44	165	644
Shelterwood	FC36	Bell	AU	11	17	33	99	12	6	56	122
Shelterwood	FC36	Bell	SP	36	66	94	373	20	23	150	462

Appendix II. Species list and abundance (Abund) of invertebrates at Wellington East in 2010-11 (Tax 3 = superfamily, sub-family or tribe)

Spec ID number	Order	Family	Tax 3	Genus	Species	Abund
1471	Araneomorphae	Araneidae		*Phonographa*	*graeffei*	4
938	Araneomorphae	Gnaphosidae		*Rebilus*		1
1427	Araneomorphae	Gnaphosidae		*Rebilus*		2
1558	Araneomorphae	Lycosidae				1
3001	Araneomorphae	Lycosidae				7
741	Araneomorphae	Lycosidae				3
743	Araneomorphae	Lycosidae				1
740	Araneomorphae	Miturgidae				1
1564	Araneomorphae	Miturgidae				1
1574	Araneomorphae	Miturgidae				3
1579	Araneomorphae	Miturgidae				1
1580	Araneomorphae	Miturgidae				4
3158	Araneomorphae	Miturgidae				1
3379	Araneomorphae	Miturgidae				1
3398	Araneomorphae	Miturgidae				1
3444	Araneomorphae	Miturgidae				1
597	Araneomorphae	Miturgidae				1
794	Araneomorphae	Miturgidae				1
939	Araneomorphae	Sparassidae		*Olios*		1
3543	Araneomorphae	Stiphidiidae				2
2511	Blattodea					1
2699	Blattodea					2
3446	Blattodea					3
3448	Blattodea					1
3534	Blattodea					2
1101	Blattodea	Blaberidae				3
1115	Blattodea	Blaberidae				14
27	Blattodea	Blaberidae	Epilamprinae	*Laxta*		3
119	Blattodea	Blaberidae	Epilamprinae	*Laxta*		7
1118	Blattodea	Blattelidae				1
878	Blattodea	Blattidae				1
1555	Blattodea	Blattidae				1
2685	Blattodea	Blattidae				1
2970	Blattodea	Blattidae				1
3026	Blattodea	Blattidae				3
3151	Blattodea	Blattidae				4
3152	Blattodea	Blattidae				2
899	Blattodea	Blattidae	Polyzosteriinae	*Platyzosteria*		5
905	Blattodea	Blattidae	Polyzosteriinae	*Platyzosteria*		1
971	Blattodea	Blattidae	Polyzosteriinae	*Platyzosteria*		1
1471	Blattodea	Blattidae	Polyzosteriinae	*Platyzosteria*		1
1474	Blattodea	Blattidae	Polyzosteriinae	*Platyzosteria*		2
483	Blattodea	Blattidae	Polyzosteriinae	*Platyzosteria*		1
3410	Chilopoda					1
3441	Chilopoda					1
3526	Chilopoda					3
3528	Chilopoda					1
3544	Chilopoda					4
1531	Chilopoda	Geophilidae				3
229	Chilopoda	Lithobiidae				1
1882	Chilopoda	Scolopendridae				1
225	Chilopoda	Scolopendridae				1

Spec ID number	Order	Family	Tax 3	Genus	Species	Abund
223	Chilopoda	Scolopendridae	Otostigminae	*Ethmostigmus ?*		15
716	Chilopoda	Scolopendridae ?				1
3527	Coleoptera	Buprestidae				1
3452	Coleoptera	Buprestidae		*Melobasis*	*sp*	6
701	Coleoptera	Buprestidae	Buprestinae	*Melobasis*		1
1435	Coleoptera	Buprestidae	Buprestinae	*Melobasis*	*gloriosa ?*	2
93	Coleoptera	Carabidae				1
727	Coleoptera	Carabidae				1
253	Coleoptera	Carabidae	Broscinae	*Promecoderus*		3
264	Coleoptera	Carabidae	Harpalinae	*Cenogmus ?*		2
1059	Coleoptera	Carabidae	Lebiinae	*Agonocheila*		1
1522	Coleoptera	Carabidae	Lebiinae	*Agonocheila*		1
956	Coleoptera	Carabidae	Lebiinae	*Philophloeus*	*eucalypti*	1
747	Coleoptera	Carabidae	Pterostichinae	*Notonomus ?*		1
2127	Coleoptera	Carabidae	Pterostichinae	*Platycoelus*		4
1033	Coleoptera	Cerambycidae	Cerambycinae	*Uracanthus*		3
913	Coleoptera	Chrysomelidae	Chrysomelinae	*Paropsis*		1
667	Coleoptera	Chrysomelidae	Chrysomelinae	*Paropsis*		2
677	Coleoptera	Chrysomelidae	Chrysomelinae	*Paropsisterna*		1
155	Coleoptera	Chrysomelidae	Eumolpinae	*Edusella?*		1
695	Coleoptera	Cleridae	Clerinae	*Eleale*		1
852	Coleoptera	Curculionidae				1
3443	Coleoptera	Curculionidae				1
3520	Coleoptera	Curculionidae		*Lycosura*	*bispinosa*	4
3522	Coleoptera	Curculionidae	Amycterinae			1
3546	Coleoptera	Curculionidae	Amycterinae			1
869	Coleoptera	Curculionidae	Amycterinae	*Acantholophus*		1
970	Coleoptera	Curculionidae	Amycterinae	*Acantholophus*		1
3540	Coleoptera	Curculionidae	Amycterinae	*Acantholophus*	*sp*	1
1596	Coleoptera	Curculionidae	Amycterinae	*Aedriodes*	*fastgatus?*	1
744	Coleoptera	Curculionidae	Amycterinae	*Aedriodes*	*Mendosus?*	1
1571	Coleoptera	Curculionidae	Amycterinae	*Cucullothorax*	*horridus*	1
1461	Coleoptera	Curculionidae	Amycterinae	*Talaurinus*		4
1182	Coleoptera	Curculionidae	Aterpinae	*Pelororhinus*		2
1050	Coleoptera	Curculionidae	Aterpinae	*Pelororhinus*	*sulcirostris*	10
103	Coleoptera	Curculionidae	Aterpinae	*Rhinaria*	*aberrans ?*	15
113	Coleoptera	Curculionidae	Entiminae	*Polyphrades*	*aesalon ?*	8
161	Coleoptera	Curculionidae	Gonipterinae	*Oxyops*	*fasciata*	9
98	Coleoptera	Curculionidae	Gonipterinae	*Oxyops*	*pictipennis*	1
291	Coleoptera	Curculionidae	Molytinae	*Tranes*	*vigorsii*	1
13	Coleoptera	Dytiscidae	Colymbetinae	*Rhantus*	*suturalis*	3
651	Coleoptera	Dytiscidae	Lancetinae	*Lancetes*	*lanceolatus*	20
444	Coleoptera	Elateridae	Agrypninae	*Conoderus*		19
26	Coleoptera	Elateridae	Agrypninae	*Conoderus*		1
135	Coleoptera	Elateridae	Agrypninae	*Conoderus*		2
1120	Coleoptera	Elateridae	Agrypninae	*Drasterius ?*		4
14	Coleoptera	Hydrophilidae				965
1123	Coleoptera	Hydrophilidae	Hydrophilinae	*Hydrophilus*	*triangulans ?*	1
2851	Coleoptera	Scarabaeidae				1
3461	Coleoptera	Scarabaeidae				2
3503	Coleoptera	Scarabaeidae		*Onthophagus*		2
189	Coleoptera	Scarabaeidae	Dynastinae	*Cryptodus*		3
824	Coleoptera	Scarabaeidae	Dynastinae	*Semanopterus*		3
1021	Coleoptera	Scarabaeidae	Dynastinae	*Semanopterus*		1
2084	Coleoptera	Scarabaeidae	Dynastinae	*Trissodon*		1

Spec ID number	Order	Family	Tax 3	Genus	Species	Abund
2625	Coleoptera	Scarabaeidae	Geotrupiinae	*Bolborhachium*	*dacoderum?*	1
831	Coleoptera	Scarabaeidae	Geotrupinae	*Blackbolbus*		1
3053	Coleoptera	Scarabaeidae	Geotrupinae	*Bolborhachium*	*bainbridgei?*	2
1847	Coleoptera	Scarabaeidae	Melolonthinae			5
1926	Coleoptera	Scarabaeidae	Melolonthinae			2
3506	Coleoptera	Scarabaeidae	Melolonthinae			1
2164	Coleoptera	Scarabaeidae	Melolonthinae	*Colpochila*		2
5	Coleoptera	Scarabaeidae	Melolonthinae	*Colpochila*	*antennalis*	1
846	Coleoptera	Scarabaeidae	Melolonthinae	*Colpochila*	*antennalis*	113
1063	Coleoptera	Scarabaeidae	Melolonthinae	*Colpochila*	*bogaria ?*	5
353	Coleoptera	Scarabaeidae	Melolonthinae	*Colpochila*	*major*	1
94	Coleoptera	Scarabaeidae	Melolonthinae	*Heteronyx*		1
347	Coleoptera	Scarabaeidae	Melolonthinae	*Heteronyx*		3
363	Coleoptera	Scarabaeidae	Melolonthinae	*Heteronyx*		14
1820	Coleoptera	Scarabaeidae	Melolonthinae	*Heteronyx*		5
17	Coleoptera	Scarabaeidae	Scarabaeinae	*Onthophagus*	*ferox*	14
1104	Coleoptera	Tenebrionidae	Alleculinae	*Metistete*		3
904	Coleoptera	Tenebrionidae	Lagriinae	*Adelium*		1
1536	Coleoptera	Tenebrionidae	Lagriinae	*Adelium*		2
192	Coleoptera	Tenebrionidae	Lagriinae	*Metriolagria*		2
1538	Dermaptera					4
3529	Dermaptera					2
3550	Dermaptera					1
734	Dermaptera					1
491	Dermaptera					3
123	Dermaptera	Anisolabididae				6
213	Dermaptera	Anisolabididae				3
258	Dermaptera	Anisolabididae				12
257	Dermaptera	Anisolabididae	Anisolabidinae			3
484	Dermaptera	Anisolabididae	Anisolabidinae			1
682	Dermaptera	Anisolabididae	Isolabelli			3
3440	Diplopoda					2
3442	Diplopoda					2
3533	Diplopoda					1
3536	Diplopoda					1
966	Diplopoda	Julida				1
1526	Diplopoda	Julida				1
1546	Diplopoda	Julida				2
717	Diplopoda	Julida				1
260	Diplopoda	Julida				1
3460	Diptera	Apioceridae ?				1
3510	Diptera	Apioceridae ?				1
1424	Diptera	Asilidae				10
1842	Diptera	Asilidae				1
2647	Diptera	Asilidae				9
2648	Diptera	Asilidae				1
2709	Diptera	Asilidae				1
217	Diptera	Asilidae				1
312	Diptera	Asilidae				2
313	Diptera	Asilidae				16
541	Diptera	Asilidae				2
751	Diptera	Asilidae				6
683	Diptera	Bombyliidae				29
907	Diptera	Bombyliidae				1
506	Diptera	Bombyliidae				2

Spec ID number	Order	Family	Tax 3	Genus	Species	Abund
1634	Diptera	Calliphoridae				3
53	Diptera	Calliphoridae	Calliphorinae	*Calliphora*		2
54	Diptera	Syrphidae				34
1421	Diptera	Syrphidae				25
3445	Diptera	Tabanidae				1
3523	Diptera	Tabanidae				1
2876	Diptera	Tabanidae				1
126	Diptera	Tabanidae				14
178	Diptera	Tabanidae				15
466	Diptera	Tabanidae				1
467	Diptera	Tabanidae				2
1151	Diptera	Tachinidae				2
16	Diptera	Tipulidae				47
1431	Gastropoda					7
1527	Gastropoda					6
916	Hemiptera	Cicadidae				1
669	Hemiptera	Pentatomidae				2
3519	Hemiptera	Pentatomidae				2
251	Hemiptera	Pentatomidae				2
680	Hemiptera	Pentatomidae				3
105	Hemiptera	Pentatomidae				14
886	Hemiptera	Reduviidae				2
714	Hemiptera	Reduviidae				6
163	Hemiptera	Reduviidae				2
433	Hemiptera	Reduviidae	Emesinae			1
2016	Hemiptera	Reduviidae	Emesinae			1
2930	Hemiptera	Reduviidae	Emesinae			1
489	Hemiptera	Reduviidae	Emesinae			1
863	Hemiptera	Reduviidae	Harpactorinae			2
150	Hemiptera	Reduviidae	Harpactorinae			2
2049	Hemiptera	Reduviidae	Peiratinae?			1
512	Hemiptera	Reduviidae	Peiratinae?			1
3439	Hymenoptera	Anthophoridae				1
52	Hymenoptera	Apidae		*Apis*	*mellifera*	4
1093	Hymenoptera	Braconidae				1
2095	Hymenoptera	Colletidae				7
1497	Hymenoptera	Formicidae				3
510	Hymenoptera	Formicidae				1
423	Hymenoptera	Formicidae	Formicinae	*Camponotus*		110
3525	Hymenoptera	Formicidae	Myrmeciinae	*Myrmecia*		1
222	Hymenoptera	Formicidae	Myrmeciinae	*Myrmecia*	*analis*	1
252	Hymenoptera	Formicidae	Myrmeciinae	*Myrmecia*	*chasei*	31
487	Hymenoptera	Formicidae	Myrmeciinae	*Myrmecia*	*clarki*	3
281	Hymenoptera	Formicidae	Myrmeciinae	*Myrmecia*	*mandibularis*	1
2046	Hymenoptera	Formicidae	Myrmeciinae	*Myrmecia*	*michaelseni*	4
1535	Hymenoptera	Formicidae	Myrmeciinae	*Myrmecia*	*pavida?*	1
712	Hymenoptera	Formicidae	Myrmeciinae	*Myrmecia*	*vindex*	4
697	Hymenoptera	Gasteruptiidae				1
2910	Hymenoptera	Ichneumonidae				1
3517	Hymenoptera	Ichneumonidae				1
1037	Hymenoptera	Ichneumonidae				15
1038	Hymenoptera	Ichneumonidae				11
1055	Hymenoptera	Ichneumonidae				49
1079	Hymenoptera	Ichneumonidae				5
1771	Hymenoptera	Ichneumonidae				1

Spec ID number	Order	Family	Tax 3	Genus	Species	Abund
2438	Hymenoptera	Ichneumonidae				1
87	Hymenoptera	Ichneumonidae	Ophioninae	*Ophion*		2
3545	Hymenoptera	Mutilidae				1
584	Hymenoptera	Pompilidae				1
611	Hymenoptera	Pompilidae				1
616	Hymenoptera	Pompilidae				1
813	Hymenoptera	Pompilidae				1
622	Hymenoptera	Pompilidae		*Cryptocheilus*	*fabricolor*	4
3549	Hymenoptera	Sphecidae				1
699	Hymenoptera	Tiphiidae				7
1530	Hymenoptera	Tiphiidae	Thynninae			1
3521	Isopoda					1
3531	Isopoda					1
3532	Isopoda					3
3538	Isopoda					2
3548	Isopoda					1
1430	Isopoda					5
262	Isopoda					1
63	Lepidoptera					41
316	Lepidoptera					2
559	Lepidoptera					5
583	Lepidoptera					2
797	Lepidoptera					27
950	Lepidoptera					1
954	Lepidoptera					1
1031	Lepidoptera					187
1075	Lepidoptera					1
1081	Lepidoptera					1
1169	Lepidoptera					2
1628	Lepidoptera					1
1643	Lepidoptera					1
1875	Lepidoptera					5
1907	Lepidoptera					2
2124	Lepidoptera					1
2713	Lepidoptera					1
2909	Lepidoptera					1
3108	Lepidoptera					134
3229	Lepidoptera					1
3428	Lepidoptera					1
3438	Lepidoptera					1
3453	Lepidoptera					7
3455	Lepidoptera					1
3456	Lepidoptera					7
3458	Lepidoptera					1
3459	Lepidoptera					2
3504	Lepidoptera					1
3505	Lepidoptera					1
3508	Lepidoptera					1
3509	Lepidoptera					1
3511	Lepidoptera					1
3512	Lepidoptera					4
3515	Lepidoptera					6
3516	Lepidoptera					1
322	Lepidoptera			*the dart*		45
48	Lepidoptera					174

Spec ID number	Order	Family	Tax 3	Genus	Species	Abund
376	Lepidoptera					2
411	Lepidoptera					6
428	Lepidoptera					1
430	Lepidoptera					17
459	Lepidoptera					2
760	Lepidoptera					2
457	Lepidoptera	Anthelidae	Anthelinae	*Anthela*	*ferruginosa?*	289
6	Lepidoptera	Arctiidae				3
987	Lepidoptera	Arctiidae	Arctiinae	*Utetheisa*	*pulchelloides*	5
1	Lepidoptera	Carthaeidae		*Carthaea*	*saturnioides*	38
324	Lepidoptera	Depressariidae				84
141	Lepidoptera	Depressariidae		*Thalamarchella*	*alveola*	52
658	Lepidoptera	Gelechioidea	Gelechiidae ?			3
66	Lepidoptera	Geometridae				1
77	Lepidoptera	Geometridae				12
855	Lepidoptera	Geometridae				1
861	Lepidoptera	Geometridae				3
915	Lepidoptera	Geometridae				1
925	Lepidoptera	Geometridae				1
978	Lepidoptera	Geometridae				1
986	Lepidoptera	Geometridae				3
1034	Lepidoptera	Geometridae				1
1106	Lepidoptera	Geometridae				3
1128	Lepidoptera	Geometridae				1
1155	Lepidoptera	Geometridae				3
1516	Lepidoptera	Geometridae				7
2123	Lepidoptera	Geometridae				1
2633	Lepidoptera	Geometridae				1
2899	Lepidoptera	Geometridae				3
2905	Lepidoptera	Geometridae				80
3113	Lepidoptera	Geometridae				51
3454	Lepidoptera	Geometridae				1
821	Lepidoptera	Geometridae				19
417	Lepidoptera	Geometridae				5
47	Lepidoptera	Geometridae				1
67	Lepidoptera	Geometridae				24
95	Lepidoptera	Geometridae				7
326	Lepidoptera	Geometridae				297
382	Lepidoptera	Geometridae				7
407	Lepidoptera	Geometridae				1
422	Lepidoptera	Geometridae				4
646	Lepidoptera	Geometridae				2
655	Lepidoptera	Geometridae				1
691	Lepidoptera	Geometridae				239
694	Lepidoptera	Geometridae				52
754	Lepidoptera	Geometridae				1
757	Lepidoptera	Geometridae				1
758	Lepidoptera	Geometridae				42
759	Lepidoptera	Geometridae				4
776	Lepidoptera	Geometridae				3
41	Lepidoptera	Geometridae				4
50	Lepidoptera	Geometridae				3
375	Lepidoptera	Geometridae				1
389	Lepidoptera	Geometridae				1
403	Lepidoptera	Geometridae				45

Spec ID number	Order	Family	Tax 3	Genus	Species	Abund
424	Lepidoptera	Geometridae				81
436	Lepidoptera	Geometridae				345
451	Lepidoptera	Geometridae				4
1518	Lepidoptera	Geometridae	Ennominae	*Ciampa*	*arietaria*	1
23	Lepidoptera	Geometridae	Ennominae	*Ectropis ?*		2
384	Lepidoptera	Geometridae	Ennominae	*Pholodes*		1
22	Lepidoptera	Geometridae	Geometrinae	*Chlorocoma*		9
19	Lepidoptera	Geometridae	Geometrinae	*Chlorocoma*	*dicloraria*	10
330	Lepidoptera	Geometridae	Geometrinae	*Crypsiphona*	*ocultaria*	7
663	Lepidoptera	Geometridae	Geometrinae	*Heliomystis*		7
835	Lepidoptera	Geometridae	Geometrinae	*Hypobapta*	*barnardi*	1
393	Lepidoptera	Geometridae	Geometrinae	*Prasinocyma*		1
455	Lepidoptera	Geometridae	Larentiina	*Xanthorhoe*		16
42	Lepidoptera	Geometridae	Larentiinae	*Xanthorhoe*		18
72	Lepidoptera	Geometridae	Oenochrominae			11
2	Lepidoptera	Geometridae	Oenochrominae	*Arhodia*		4
320	Lepidoptera	Geometridae	Oenochrominae	*Arhodia*		22
832	Lepidoptera	Geometridae	Oenochrominae	*Lissomma*	*serpentaria*	2
377	Lepidoptera	Geometridae	Oenochrominae	*Phallaria*	*ophiusaria*	1
625	Lepidoptera	Geometridae ?				21
830	Lepidoptera	Geometridae ?				3
1056	Lepidoptera	Geometridae ?				3
441	Lepidoptera	Geometridae ?				1
641	Lepidoptera	Geometridae ?				2
662	Lepidoptera	Geometridae ?				1
753	Lepidoptera	Geometridae ?				1
958	Lepidoptera	Hepialidae		*Abantiades*		4
426	Lepidoptera	Lasiocampidae	Lasiocampinae	*Entometa*		12
749	Lepidoptera	Lasiocampidae	Lasiocampinae	*Porela?*		22
413	Lepidoptera	Noctuidae				2
626	Lepidoptera	Noctuidae				4
656	Lepidoptera	Noctuidae				27
833	Lepidoptera	Noctuidae				1
859	Lepidoptera	Noctuidae				1
996	Lepidoptera	Noctuidae				1
1046	Lepidoptera	Noctuidae				2
1139	Lepidoptera	Noctuidae				2
1872	Lepidoptera	Noctuidae				2
1899	Lepidoptera	Noctuidae				4
1944	Lepidoptera	Noctuidae				3
2146	Lepidoptera	Noctuidae				1
2458	Lepidoptera	Noctuidae				1
2761	Lepidoptera	Noctuidae				1
2889	Lepidoptera	Noctuidae				9
2895	Lepidoptera	Noctuidae				2
2953	Lepidoptera	Noctuidae				10
3118	Lepidoptera	Noctuidae				1
3220	Lepidoptera	Noctuidae				8
3457	Lepidoptera	Noctuidae				3
3502	Lepidoptera	Noctuidae				1
3507	Lepidoptera	Noctuidae				1
3513	Lepidoptera	Noctuidae				1
449	Lepidoptera	Noctuidae				4
336	Lepidoptera	Noctuidae				1
412	Lepidoptera	Noctuidae				2

Spec ID number	Order	Family	Tax 3	Genus	Species	Abund
25	Lepidoptera	Noctuidae				61
33	Lepidoptera	Noctuidae				6
38	Lepidoptera	Noctuidae				27
75	Lepidoptera	Noctuidae				17
137	Lepidoptera	Noctuidae				1
139	Lepidoptera	Noctuidae				1
140	Lepidoptera	Noctuidae				19
383	Lepidoptera	Noctuidae				3
386	Lepidoptera	Noctuidae				7
391	Lepidoptera	Noctuidae				27
394	Lepidoptera	Noctuidae				4
454	Lepidoptera	Noctuidae				3
649	Lepidoptera	Noctuidae				3
650	Lepidoptera	Noctuidae				1
750	Lepidoptera	Noctuidae				7
770	Lepidoptera	Noctuidae				8
799	Lepidoptera	Noctuidae				3
185	Lepidoptera	Noctuidae	Agaristinae	*Periscepta*	*polysticta*	1
523	Lepidoptera	Noctuidae	Amphipyrinae			33
1512	Lepidoptera	Noctuidae	Amphipyrinae			8
1898	Lepidoptera	Noctuidae	Amphipyrinae			1
1909	Lepidoptera	Noctuidae	Amphipyrinae			1
414	Lepidoptera	Noctuidae	Amphipyrinae			8
452	Lepidoptera	Noctuidae	Amphipyrinae			40
39	Lepidoptera	Noctuidae	Amphipyrinae	*Proteuxoa*	*pissonephra*	493
415	Lepidoptera	Noctuidae	Catocalinae	*Lyncestis*	*melanoschista*	18
5	Lepidoptera	Noctuidae	Catocalinae	*Pantydia*		12
388	Lepidoptera	Noctuidae	Catocalinae	*Pantydia*		2
329	Lepidoptera	Noctuidae	Catocalinae	*Pantydia*		9
40	Lepidoptera	Noctuidae	Hadeninae	*Persectania*	*ewingii*	48
43	Lepidoptera	Noctuidae	Hypeninae	*Sandava*	*scitisigna*	12
844	Lepidoptera	Noctuidae	Noctuinae	*Agrotis*		3
18	Lepidoptera	Noctuidae	Noctuinae	*Agrotis*	*munda*	232
346	Lepidoptera	Noctuidae	Plusiinae	*Chrysodeixis*	*eriosoma*	1
1148	Lepidoptera	Noctuidae ?				2
766	Lepidoptera	Noctuidae ?				180
76	Lepidoptera	Notodontidae				11
4	Lepidoptera	Notodontidae		*Destolmia*		54
80	Lepidoptera	Notodontidae				5
374	Lepidoptera	Notodontidae				5
58	Lepidoptera	Notodontidae		*Sorama*	*bicolor*	12
1840	Lepidoptera	Oecophoridae				2
104	Lepidoptera	Oecophoridae				4
396	Lepidoptera	Oecophoridae				1
64	Lepidoptera	Oecophoridae				8
236	Lepidoptera	Oecophoridae ?				1
62	Lepidoptera	Oecophoridae?				7
1454	Lepidoptera	Psychidae	Taleporiinae	*Iphierga*		1
1051	Lepidoptera	Pyralidae				456
1134	Lepidoptera	Pyralidae				2
1489	Lepidoptera	Pyralidae				1
1834	Lepidoptera	Pyralidae				1
2901	Lepidoptera	Pyralidae				1
460	Lepidoptera	Pyralidae	Epipaschiinae			54
73	Lepidoptera	Pyralidae	Epipaschiinae ?			14

Spec ID number	Order	Family	Tax 3	Genus	Species	Abund
84	Lepidoptera	Pyralidae	Pyraustinae	*Uresiphita*	*ornithopteralis*	3
837	Lepidoptera	Pyralidae ?				3
957	Lepidoptera	Pyralidae ?				14
12	Lepidoptera	Pyralidae ?				14
661	Lepidoptera	Pyralidae ?				50
328	Lepidoptera	Saturniidae		*Opodiphthera*	*helena*	9
32	Lepidoptera	Thaumetopoeidae				5
10	Lepidoptera	Thaumetopoeidae		*Ochrogaster*		233
692	Lepidoptera	Thaumetopoeidae				84
3	Lepidoptera	Thaumetopoeidae		*Epicoma*	*melanostica*	1
7	Lepidoptera	Thaumetopoeidae		*Ochrogaster*		11
864	Lepidoptera	Thaumetopoeidae				5
78	Lepidoptera	Zygaenidae		*Pollanisus*		138
45	Lepidoptera	Zygaenidae		*Pollanisus*	*cupreus*	6
132	Mantodea	Amorphoscelidae	Paraoxypilinae			52
1459	Mantodea	Mantidae				8
2107	Mantodea	Mantidae				1
674	Mantodea	Mantidae				3
718	Mantodea	Mantidae				2
784	Mantodea	Mantidae				1
250	Mecoptera	Bittacidae		*Harpobittacus*	*phaeoscius*	2
908	Mecoptera	Bittacidae		*Harpobittacus*	*similis*	2
3403	Mygalomorphae					1
3537	Mygalomorphae					1
3542	Mygalomorphae					2
3162	Mygalomorphae	Nemesiidae				11
1560	Mygalomorphae	Nemesiidae				3
2042	Mygalomorphae	Nemesiidae				1
585	Mygalomorphae	Nemesiidae				1
3524	Neuroptera	Ascalaphidae				1
1057	Neuroptera	Chrysopidae				17
360	Neuroptera	Hemerobiidae				1
3518	Neuroptera	Mantispidae				1
687	Neuroptera	Mantispidae				5
1938	Neuroptera	Osmylidae				6
3514	Odonata					1
937	Onychophora					1
3451	Orthoptera	Acrididae				1
3541	Orthoptera	Acrididae				1
782	Orthoptera	Acrididae				6
174	Orthoptera	Acrididae				5
868	Orthoptera	Acrididae	Catantopinae	*Adreppus*		2
1323	Orthoptera	Acrididae	Catantopinae	*Adreppus*		1
890	Orthoptera	Acrididae	Catantopinae	*Cedarinia*		18
1699	Orthoptera	Acrididae	Catantopinae	*Cirphula*		1
231	Orthoptera	Acrididae	Catantopinae	*Coryphistes*		18
1470	Orthoptera	Acrididae	Catantopinae	*Goniaea*		1
1547	Orthoptera	Acrididae	Catantopinae	*Goniaea*		1
2019	Orthoptera	Acrididae	Catantopinae	*Goniaea*		1
2682	Orthoptera	Acrididae	Catantopinae	*Goniaea*		2
233	Orthoptera	Acrididae	Catantopinae	*Goniaea*		1
872	Orthoptera	Acrididae	Catantopinae	*Goniaea*		38
235	Orthoptera	Acrididae	Catantopinae	*Goniaea*		5
272	Orthoptera	Acrididae	Catantopinae	*Goniaea*		2
304	Orthoptera	Acrididae	Catantopinae	*Goniaea*		2

Spec ID number	Order	Family	Tax 3	Genus	Species	Abund
232	Orthoptera	Acrididae	Catantopinae	*Goniaea*	*vocans?*	2
834	Orthoptera	Gryllidae				2
857	Orthoptera	Gryllidae				4
3535	Orthoptera	Gryllidae				1
608	Orthoptera	Gryllidae				1
609	Orthoptera	Gryllidae				10
180	Orthoptera	Gryllidae				10
1557	Orthoptera	Stenopelmatidae				1
3530	Orthoptera	Stenopelmatidae				1
526	Orthoptera	Stenopelmatidae	Henicinae	*Onosandrus*		1
873	Orthoptera	Tettigoniidae				1
1026	Orthoptera	Tettigoniidae				1
1224	Orthoptera	Tettigoniidae				1
2192	Orthoptera	Tettigoniidae				1
3450	Orthoptera	Tettigoniidae				1
3547	Orthoptera	Tettigoniidae				1
314	Orthoptera	Tettigoniidae				1
708	Orthoptera	Tettigoniidae				1
715	Orthoptera	Tettigoniidae				1
688	Orthoptera	Tettigoniidae		*Pachysaga*		3
3449	Phasmatodea					1
2005	Phasmatodea	Phasmatidae				1
2423	Platyhelminthes					2
1568	Platyhelminthes	Tricladida				1
1451	Scorpionida					1
1600	Scorpionida					1
2693	Scorpionida					1
629	Scorpionida					2
1042	Trichoptera					1
1849	Trichoptera					14
144	Trichoptera					72
145	Trichoptera					17

DIURNAL AND NOCTURNAL BIRDS

Graeme (Tub) Liddelow, Christos Vellios and Verna Tunsell

Introduction

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

- Recording species richness and abundance within each treatment (external reference, coupe buffer, shelterwood and gap release);
- Comparing species richness and abundance between each treatment; and
- Analysing trends within species between treatments.

Monitoring

There are 10 FORESTCHECK monitoring grids at the Wellington East location. Three external reference, one coupe buffer, three shelterwood and three gap release grids. Sight and sound are both used to identify birds and the census techniques are detailed in the FORESTCHECK Operating Plan (DEC 2006). Briefly, for diurnal birds, each grid was monitored five times during the spring of 2010, with at least 7 days between each census. Monitoring commenced at sunrise and continued for four hours after sunrise in fine still weather. The central 1 ha area at each grid is monitored for 20 mins before moving on to the next grid. Monitoring of diurnal birds was undertaken in spring 2010.

For nocturnal birds, monitoring is carried out at a point central to a set of grids (a set consists of one of each external reference, shelterwood and gap release grid). Each census included periods of listening (15 mins), playback (5 mins per species) and spotlighting (10 mins). However, formal monitoring for nocturnal birds was not conducted in 2010-11.

Results and discussion

Diurnal birds

2010 survey

A total of 26 species of birds comprising 527 individuals were recorded in 2010, with 12 species having 10 or more individuals (Fig. 1 & Table 1). There were 18 species and 143 individuals in the external reference, 19 species and 197 individuals in the shelterwood and 19 species and 154 individuals in the gap release treatments. The coupe buffer had only 9 species and 33 individuals. This appears low, but there was only one coupe buffer grid compared to three each in the external reference, shelterwood and gap release treatments.

Seven species of birds were recorded in only one treatment (either external reference, coupe buffer, shelterwood or gap release — see Table 1); however, none of these would be expected to be restricted to that particular treatment.

The most common bird recorded was the broad-tailed thornbill (*Acanthiza apicalis*) with a count of 104, followed by the striated pardalote (*Pardalotus striatus*) with 92 and then the western

gerygone (*Gerygone fusca*) with 67. These three birds account for 50% of the total records for the 2010 survey (263 of 527). The golden whistler (*Pachycephala pectoralis*) with 46, the grey shrike-thrush (*Colluricincla harmonica*) 32, the red-capped parrot (*Platycerus spurius*) 25 and the western spinebill (*Acanthorhynchus superciliosus*) with 23 were the next most common birds encountered. These seven birds made up 75% of the total individuals recorded.

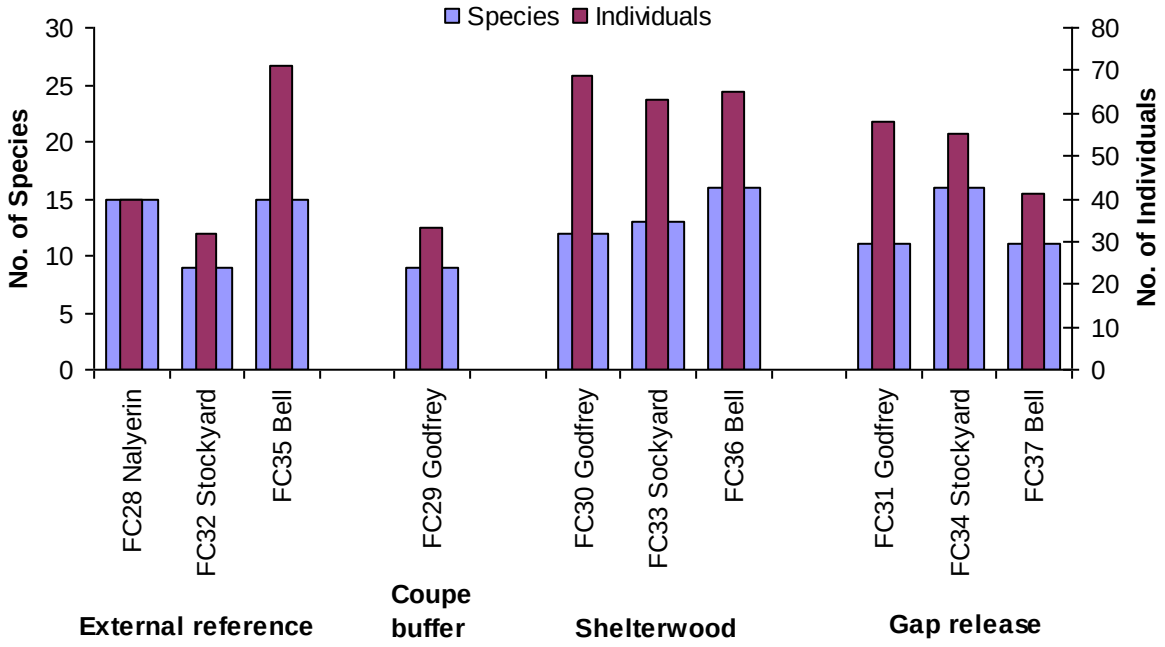

Figure 1. The number of bird species and individuals recorded in each Wellington East FORESTCHECK grid in 2010

The average density of birds within the treatments in 2010 was lower in the coupe buffer (6.6 birds ha^{-1}) and higher in the shelterwood (13.1 birds ha^{-1}) compared to the external reference (9.5 birds ha^{-1}) and gap release (10.2 birds ha^{-1}) treatments. The overall density in 2010 was 10.5 birds ha^{-1}, which is almost identical to the long-term Kingston Study (see Abbott *et al*. 2003, 2009) in the southern jarrah forest region where the yearly average density is 10.4 birds ha^{-1} (Liddelow, unpublished).

Of the small scrub bird species only two individual white-browed scrubwrens (*Sericornis frontalis*) were recorded in the Stockyard external reference (FC32 — it was also recorded in the same grid in 2004). There were no other small species, like fairy-wrens, recorded. This is surprising as the 'scrub' structure of the logged treatments has regenerated well with shrub and tree regeneration forming suitable habitat for these species.

Comparing 2004 and 2010 surveys

The total of 33 species has now been recorded on these sites over the two sample years (2004 and 2010, Table 1). The number of species recorded in each treatment was lower in 2010 compared to 2004 (Fig. 2) The number of individuals was similar for both years in the external reference and coupe buffer treatments and higher in 2010 in the shelterwood and gap release treatments (Fig. 3), which is reflected in higher bird densities recorded in 2010 (Fig. 4).

Table 1:Species list and the number of birds recorded in each treatment at Wellington East in 2010

RAOU number[1]	Species	Common Name	Treatment 2004[2]					Treatment 2010[2]				
			ER	CB	SW	GR	Total 2004	ER	CB	SW	GR	Total 2010
221	*Accipiter fasciatus*	Brown goshawk									1	1
224	*Aquila audax audax*	Wedge-tailed eagle						2				2
264	*Calyptorhynchus banksii naso*	Forest red-tailed black cockatoo	3				3	2				2
289	*Platycercus icterotis*	Western rosella								3	6	9
290	*Platycerus spurius*	Red-capped parrot			13		13	10	1	2	12	25
294	*Platycerus zonarius*	Australian ringneck	5		5		10	7	2	3	4	16
322	*Dacelo novaeguineae*	Laughing kookaburra		1			1	5				5
337	*Cuculus pallidus*	Pallid cuckoo	1		1	1	3					
344	*Chrysococcyx lucidus*	Shining bronze-cuckoo	3		4	2	9	2		7	7	16
361	*Rhipidura fuliginosa*	Grey fantail	11	2	6	2	21	3	4	2	4	13
380	*Petroica multicolor*	Scarlet robin	9	2	6	13	30			7	1	8
394	*Eopsaltria australis griseogularis*	Western yellow robin	2	1	5	3	11			3	1	4
398	*Pachycephala pectoralis*	Golden whistler	7	7	8	4	26	15	4	16	11	46
408	*Colluricincla harmonica*	Grey shrike-thrush	3	1	6	1	11	10	1	10	11	32
424	*Coracina novaehollandiae*	Black-faced cuckoo-shrike	2		1	1	4	3		1	2	6
463	*Gerygone fusca*	Western gerygone	20	4	21	16	61	18	5	28	16	67
465	*Smicornis brevirostris*	Weebill		1			1					
472	*Acanthiza inornata*	Western thornbill	7		6	19	32			10	1	11
476	*Acanthiza apicalis*	Broad-tailed (inland) thornbill	28	6	41	19	94	18	1	45	40	104
488	*Sericornis frontalis*	White-browed scrubwren	1				1				2	2
549	Daphoenositta chrysoptera	Varied sitella	7		12	6	25					
556	*Climacteris rufa*	Rufous treecreeper	2	2	6		10		5	9		14
565	*Pardalotus puntatus*	Spotted pardalote	1		3	1	5			1	1	2
574	*Zosterops lateralis*	Silvereye	1		4	2	7					
578	*Melithreptus chloropsis*	Western white-naped honeyeater	1	1	2	1	5	6		11		17
592	*Acanthorhynchus superciliosus*	Western spinebill	4		6	7	17	6		13	4	23
608	*Lichenostomus virescens*	Singing honeyeater	1				1					
638	*Anthochaera carunculata*	Red wattlebird				1	1	2				2
697	*Sterpera versicolor*	Grey currawong	1	2	2	1	6	1		3	3	7

Table 1…..cont.

RAOU number[1]	Species	Common Name	Treatment 2004[2]					Treatment 2010[2]				
			ER	CB	SW	GR	Total 2004	ER	CB	SW	GR	Total 2010
705	*Cracticus tibicen*	Australian magpie						1				1
710	*Anthochaera lunulata*	Western little wattlebird	4			2	6					
930	*Corvus coronoides*	Australian raven	1	1			2					
976	*Pardolotus striatus*	Striated pardalote	30	5	20	16	71	32	10	23	27	92
		Total Species	**25**	**14**	**21**	**20**	**29**	**18**	**9**	**19**	**19**	**26**
		Total Individuals	**155**	**36**	**178**	**118**	**487**	**143**	**33**	**197**	**154**	**527**

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

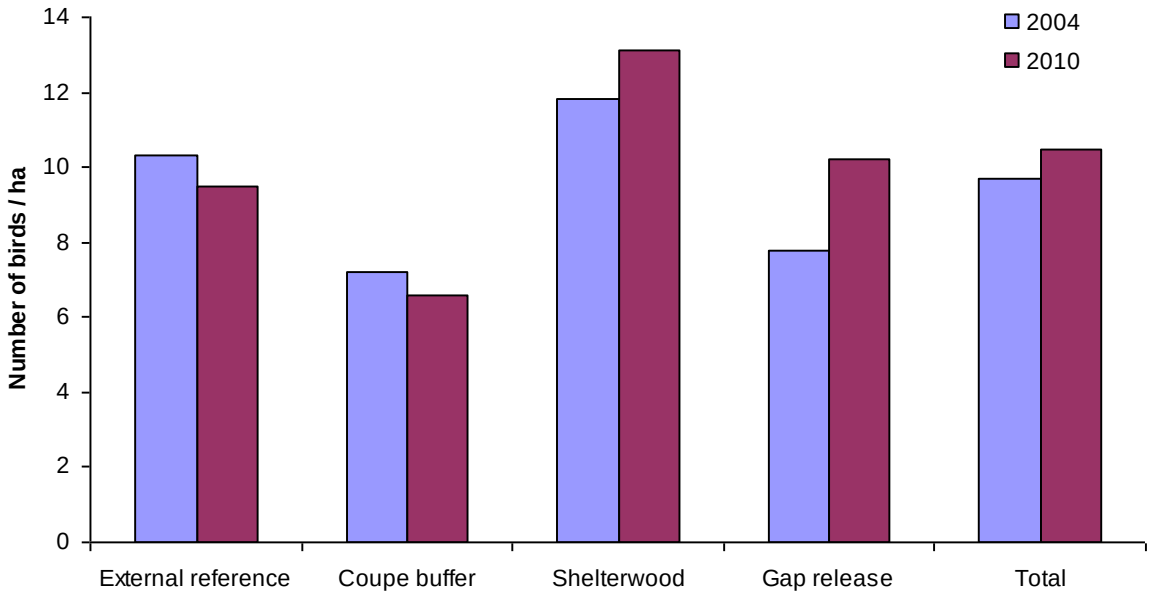

Figure 2. Bird density comparison between sample years and treatments at Wellington East FORESTCHECK grids in 2004 and 2010

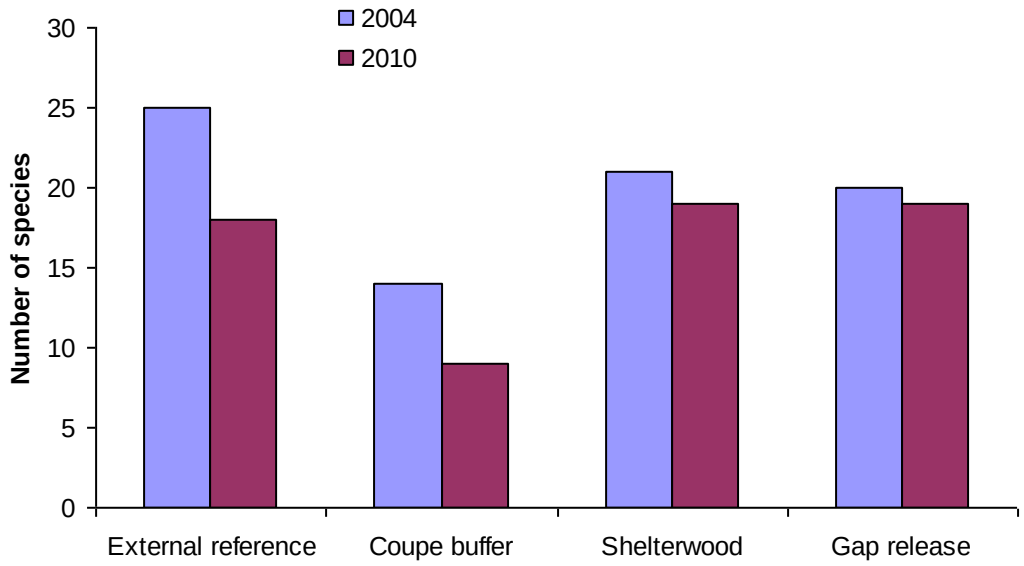

Figure 3. Number of bird species recorded in each treatment at Wellington East in 2004 and 2010

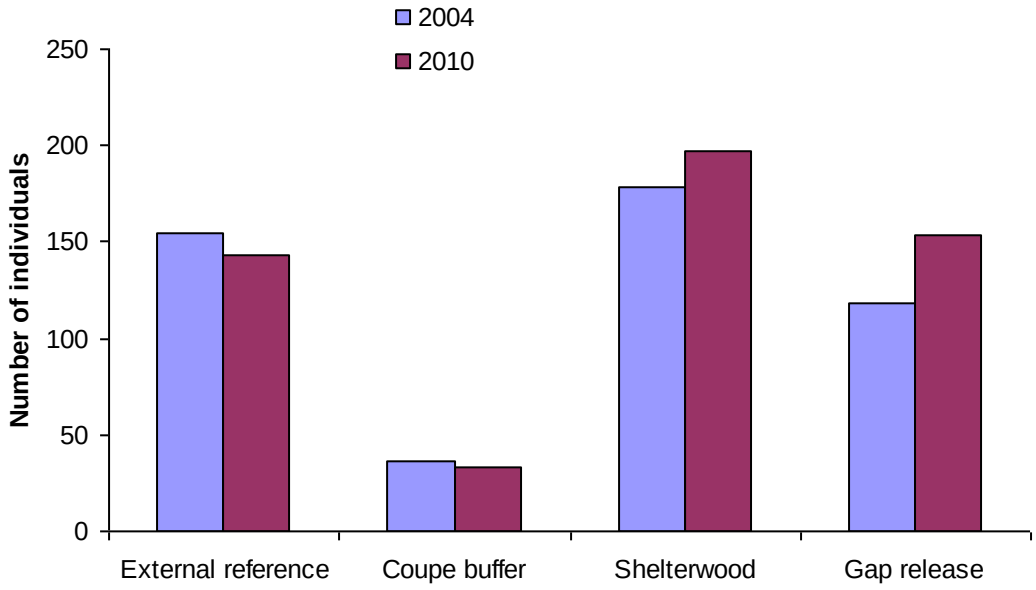

Figure 4. Number of individual birds recorded in each treatment at Wellington East in 2004 and 2010

There were seven species in 2004 that were not sighted in 2010 and four species in 2010 that were not sighted in 2004. It would be expected to sight all 11 species as none of them are exclusive to a particular serial stage following regeneration from either logging or burning. Similarly, although the western rosella (*Platycercus icterotis*) was not recorded in 2004 it is generally widespread throughout the jarrah forest area.

Since the census began in 2004, the three most common species, the broad-tailed thornbill, western gerygone and the striated pardalote, continue to be so. Numbers of the golden whistler and the grey shrike-thrush have increased, but the increases are consistent throughout the logged and unlogged treatments.

The scarlet robin (*Petroica multicolor*) and the western yellow robin (*Eopsaltria australis griseogularis*) were recorded in 2004 in all treatments, but in 2010 they were only recorded in the shelterwood and gap release treatments, but fewer individuals were recorded. Their decrease in numbers in the harvested grids may be explained by the thick growth of understory shrubs and advanced tree regeneration as both of these birds prefer open country as their preferred feeding habit. It is not understood why they were not recorded in the reference or coupe buffer grids in 2010.

The leaf gleaning and trunk and branch feeding birds comprised eight different species. They include the western gerygone, weebill, western thornbill, broad-tailed thornbill, varied sitella, rufous treecreeper, and spotted and striated pardalotes. Overall, the abundance of these birds has not changed, with 299 recorded in 2004 and 298 in 2010. However, there had been some individual species changes. For example, the sitella was not recorded in 2010 and the numbers of the western thornbill decreased from 32 in 2004 to 11 in 2010, but generally this group has remained constant.

Potentially, about 90 bird species could inhabit jarrah forest within the range of the 48 FORESTCHECK grids (estimated from species featured in Abbott (1999) and Simpson and Day (1993)). Since FORESTCHECK surveys began in 2001 we have recorded a total of 53 bird species. This includes 41 at Donnelly, 42 at Wellington 1, 45 at the Perth Hills and 33 at the Wellington East locations after two surveys at each, and 28 at the Blackwood Plateau after one survey (the second survey at Blackwood Plateau will be conducted in 2012).

In jarrah forest there are potentially 12 species of birds of prey, nine parrots and cockatoos and nine honeyeaters, of which we recoded two, four and four respectively. Some of the potential species are vagrants or migrants that are rarely seen in the true forest and are more commonly seen on forest edges, on farmland and around town sites. Others are associated with the denser vegetation along gullies and creeks and FORESTCHECK grids are not established in these habitats as they are not harvested. However, the total FORESTCHECK grid area is only 48ha and recording 53 species represents well over half of the potential species from a much larger forest area.

Nocturnal birds

Due to constraints on time and personnel, no systematic survey of nocturnal birds was undertaken in 2010-11. However, opportunistic records were kept when possible (e.g. during spotlight surveys for mammals in spring 2010 and autumn 2011), and studies by Liddelow *et.al*. (2002) would suggest that no anomalies should be encountered at the Wellington East locations.

Southern boobook owls (*Ninox novaeseelandiae*) were heard at all sites during mammal spotlight surveys and are generally common in this type of forest. A masked owl (*Tyto novaehollandiae*) was heard in the Wandoo gully, 1 km north of Misltey Road on Boundary Road. A barn owl (*Tyto alba*) was seen on two occasions adjacent private property (farm land) along Boundary Road, 1km south of Alamo Road, which is a preferred hunting zone for this nocturnal bird of prey.

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

Conclusions

Bird species composition and abundances change continuously as the understory density and fuel ages vary. These changes occur in harvested areas as the vegetation structure changes over time and through crown separation in regrowth trees and 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 2010 related to these changes are:

- Honeyeaters increased in number from 24 in 2004 to 42 in 2010 with the western white-naped honeyeater accounting for most of this (5 in 2004, 17 in 2010);
- Numbers of both the scarlet and western yellow robins were lower than in 2004, which is to be expected as the scrub density increases with time since regeneration
- The mid-strata feeding golden whistler and grey shrike thrush increased in number since the 2004 census reflecting a positive affect on their preferred feeding habitat;

- The leaf gleaning group of birds remained constant over both census years with individual species changes.

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MAMMALS AND HERPETOFAUNA

Graeme (Tub) Liddelow, Richard Robinson 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.
- 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.

Monitoring

Trapping and spotlighting were 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) were set-up in a 50 x 50 m grid pattern and 15 20-litre pit fall traps (25 cm diam. x 40 cm deep) were installed in a 20 x 20 m grid pattern. Trapping was conducted over eight consecutive nights. In addition spotlighting surveys and road transect surveys were conducted to record macro vertebrates in the vicinity of each monitoring grid. FORESTCHECK road surveys are generally conducted by vehicle on two consecutive nights along a 40 km road transect driving at 20 kph from 2 hours before sunset to 15 minutes after sunset. At Wellington East, two 20 km road transects were utilised to cover the general area occupied by all the grids. One transect covered Godfrey Block (south) and the other Stockyard and Bell blocks (north). On these transects specific spotlight surveys were also conducted over 2 km distances in the vicinity of the grids in each of the Godfrey, Stockyard and Bell blocks.

There were 10 monitoring grids in Wellington East that were established in 2004 and initially monitored in spring 2004 and autumn 2005. The three grids located in Godfrey block (coupe buffer FC29, shelterwood FC30 and gap release FC3), were baited under Western Shield. However, the remaining seven grids not baited and this must be taken into consideration when interpreting the data collected.

Monitoring for 2010-11 was conducted from 1-8 December (spring) 2010 and from 28 April-5 May (autumn) 2011 and the program went according to plan with no interruption to any activities due to inclement weather. Since the original monitoring in 2004-05, the Bell block grids (FC35, FC36, FC37) were burnt by wildfire in December 2005 (after the spring and before the autumn trapping sessions in that year) and the Stockyard block grids (FC32, FC33, FC34) were prescribe burnt in autumn 2008.

The number of trap nights was also increased from four in 2004-05 to eight in 2010-11. Because of the difference in trapping effort and there being only one coupe buffer grid, comparisons

between treatments and between the two trapping sessions are done using average captures per night (cpn).

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

Results and discussion

Trapping

Overall

Over the two trapping sessions, spring 2010 and autumn 2011, there were a total of 4,800 trap nights. In each of the two seasons there were 1,200 trap nights for pit traps and 1,200 trap nights for wire cages. The overall capture rate was 12.9 animals per night. For spring and autumn individually it was18.3 and 7.6 cpn respectively (Fig. 1)

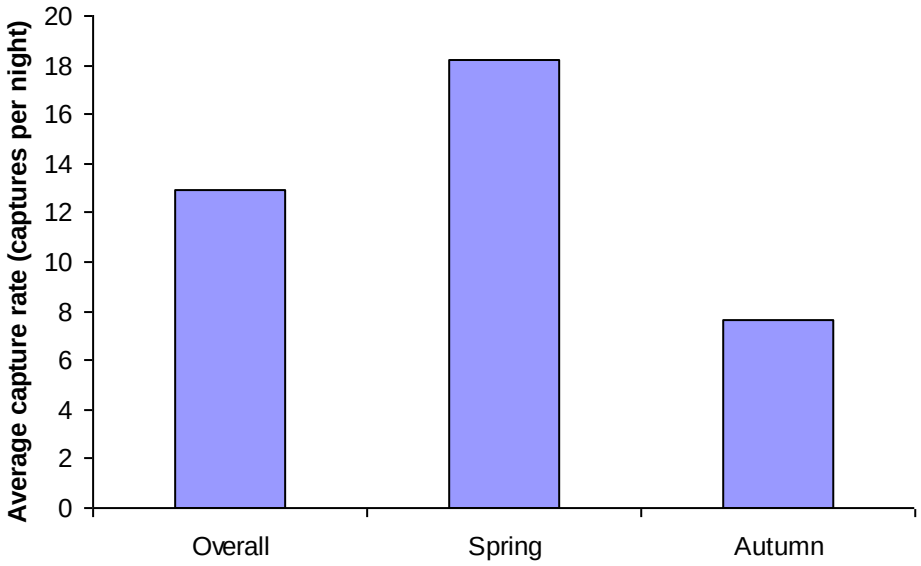


Figure 1. The average capture rate (captures per night) of animals on Wellington East FORESTCHECK grids

A total of 207 individuals were trapped (Fig. 2, Table 1) with 146 individuals trapped in spring and only 61 captures in autumn. Twenty two individual mammals, 110 reptiles and 14 amphibians were trapped in spring 2010, and 46 mammals, 13 reptiles and two amphibians were trapped in autumn 2011.

The most common mammals captured were the mardo (*Antechinus flavipes*) and the chuditch (*Dasyurus geoffroii*) with 22 captures each over the two seasons. Eighteen of the mardos and 14 of the chuditch were trapped in harvested areas (Table 1, Fig. 3) with 10 mardos and two chuditch in shelterwood and eight mardos and 12 chuditch in gap release grids.

Spring was the most successful trapping session for reptiles with 110 of the 123 captures occurring in this season (Table 1.). Lizards were the most common reptiles captured. The dwarf

skink (*Menetia greyi*) was the most common with 37 of which 27 were in spring. Next were south western orange-tailed slider (*Lerista distinguenda*) with 25 captures of which 24 were in spring, and shrubland morethia (*Morethia obscura*) and Peron's earless skink (*Hemiergis peroni*) having 15 and 13 captures respectively all in spring (Table 1).

There were only three species of amphibian caught over the two trapping sessions. The total number of captures was 16 with 14 occurring in spring. The moaning frog (*Heleioporus eyrei*) had eight individual captures with six in spring and two in autumn. The western banjo frog (*Limnodynastes dorsalis*) was captured seven times and the clicking frog (*Crinia glauerti*) captured once in spring.

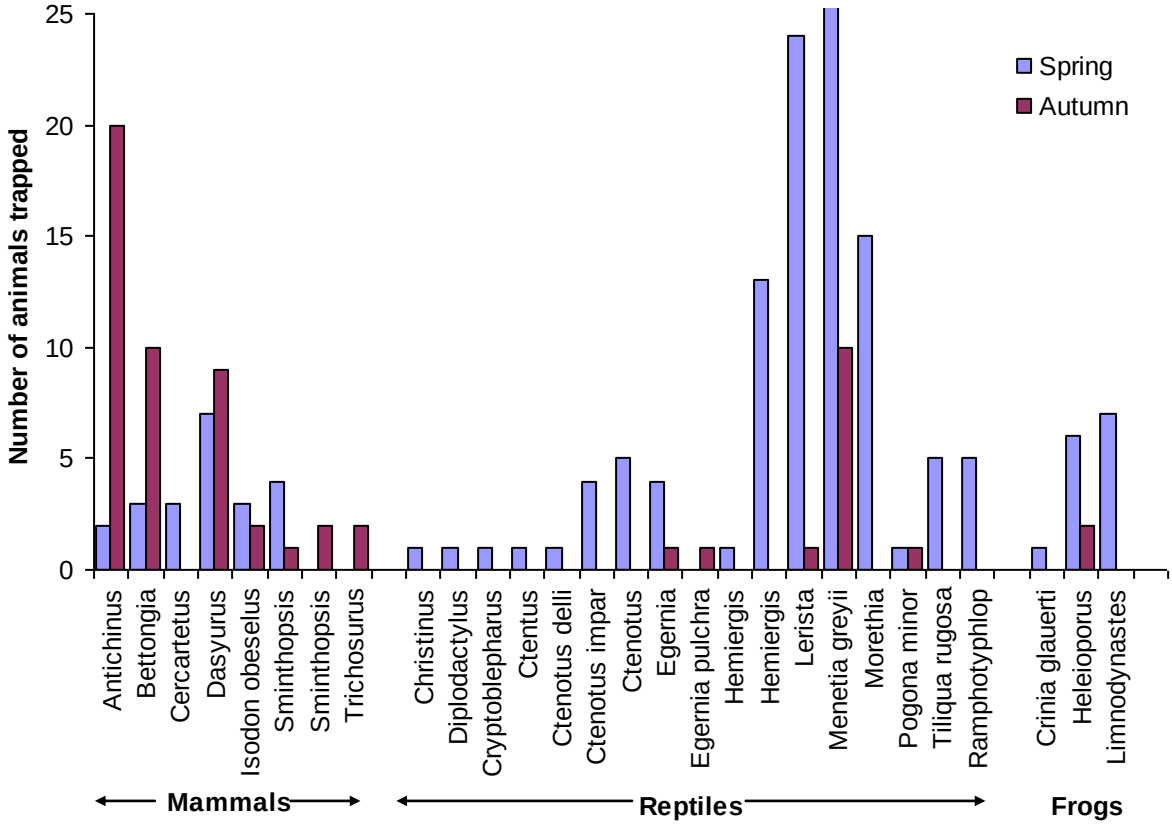
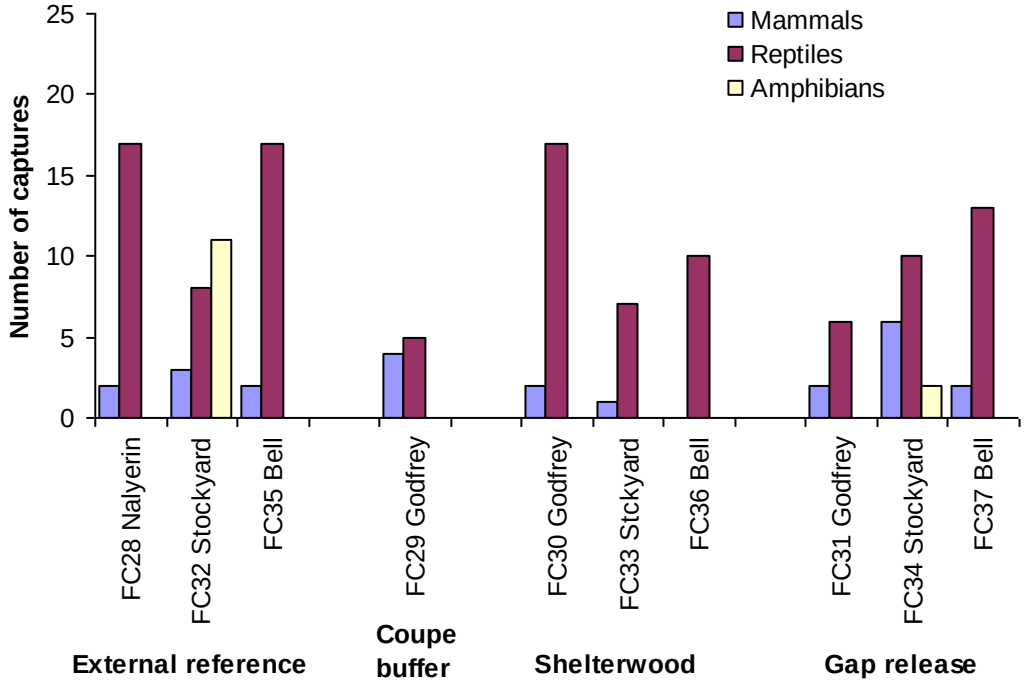


Figure 2. The number of animals captured in spring and autumn on Wellington East FORESTCHECK grids

Table 1. Comparison of trapping results by trap type (P = pit fall, W = wire cage) and treatment at Wellington East in 2010-11

Species	Common name	External reference				Coupe buffer				Shelterwood				Gap release				Total captures		
		Spring		Autumn		Spring		Autumn		Spring		Autumn		Spring		Autumn		Sp	Au	Total
		P	W	P	W	P	W	P	W	P	W	P	W	P	W	P	W			
MAMMALS																				
Antichinus flavipes	Mardo				4						1		9		1		7	2	20	22
Bettongia penicillata	Woylie						3		4									3	4	7
Cercartetus concinnus	Mundarda	2												1				3		3
Dasyurus geoffroii	Chuditch		1		7								2		6		6	7	15	22
Isoodon obesulus	Quenda		2		2										1			3	2	5
Sminthopsis griseoventor	Dunnart	2								1				1				4	0	4
Sminthopsis spp.	Dunnart											1				2			3	3
Trichosurus vulpecula	Common brush-tailed possum								2										2	2
REPTILES																				
Christinus marmoratus	Marbled gecko	1																1		1
Diplodactylus polyophthalmus	Speckled stone gecko									1								1		1
Cryptoblepharus plagiocephalus	Fence skink	1																1		1
Ctenotus catenifer	Chain-striped s-w ctenotus									1								1		1
Ctenotus delli	Darling Range ctenotus									1								1		1
Ctenotus impar	Odd-striped ctenotus	3																3		3
Ctenotus labillardieri	Red-legged ctenotus	2				1				1				2				6		6
Egernia napoleonis	S-w crevice skink	3												1		1		4	1	5
Egernia pulchra	S-w spectacled rock skink													1				1		1
Hemiergis initialis	Five-toed earless skink	1																1		1
Hemiergis peroni	Peron's earless skink	9				1				3								13		13
Lerista distinguenda	S-w orange-tailed slider	8				1				7				8		1		24	1	25
Menetia greyii	Common dwarf skink	11		4		2		1		8		1		6		4		27	10	37
Morethia obscura	Shrubland morethia	2								6				7				15		15
Pogona minor	Western bearded dragon											1		1				1	1	2
Tiliqua rugosa	Bobtail / shingle back										3				2			5		5
Ramphotyphlops australis	Southern blind snake	1								3				1				5		5
AMPHIBIANS																				
Crinia glauerti	Clicking frog													1				1		1
Heleioporus eyrei	Moaning frog	4										1		2		1		6	2	8
Limnodynastes dorsalis	Western banjo frog	7																7		7
TOTAL		57	3	4	13	5	3	1	6	32	4	4	11	32	10	9	13	146	61	**207**

(a) Spring - overall



(b) Autumn - overall

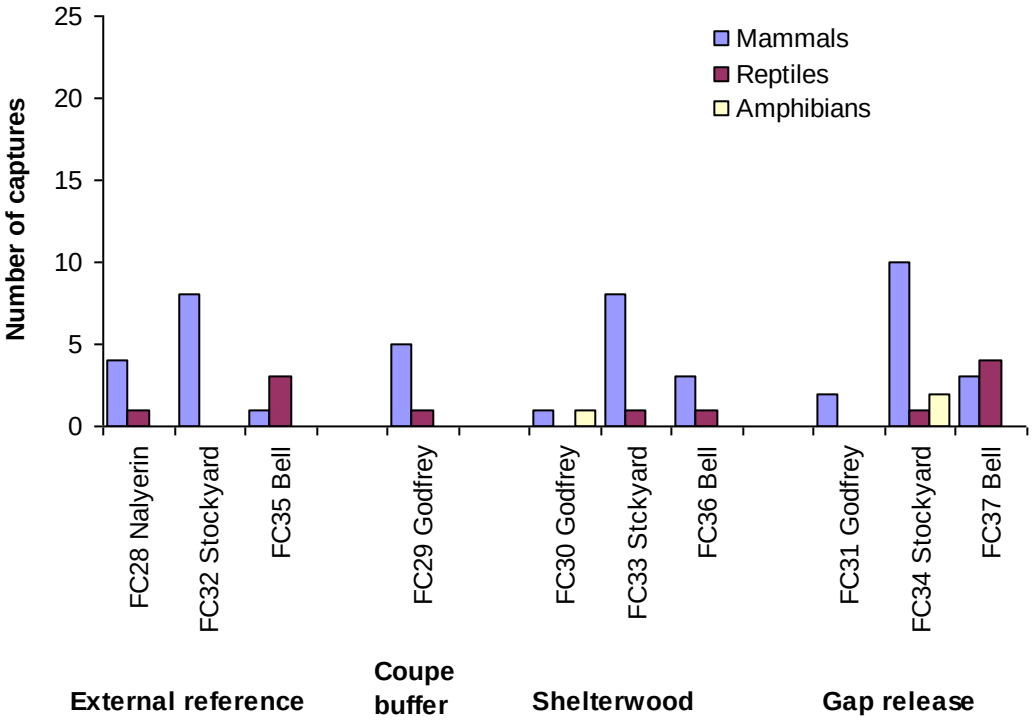


Figure 3. Number of captures of mammals, reptiles and amphibians recorded in all traps in (a) spring and (b) autumn on the Wellington East FORESTCHECK grids in 2010-11

Wire cage traps

There was a total of 63 captures recorded in wire cages, at a rate of 3.9 cpn. Twenty captures were recorded in spring (2.5 cpn) and 43 in autumn (5.4 cpn) (Table1, Fig. 4 and 5).

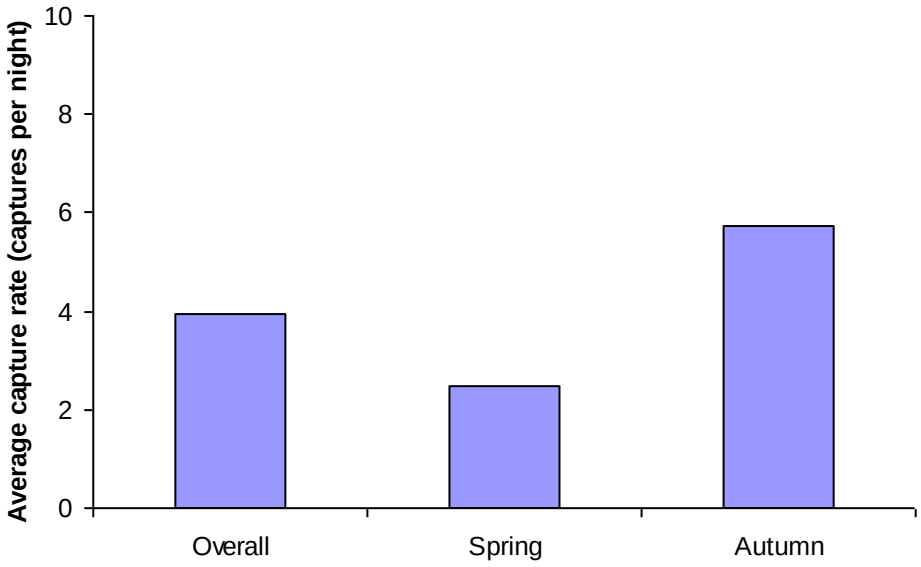


Figure 4. The average capture rate of animals for wire cage traps in Wellington East FORESTCHECK grids in 2010-11

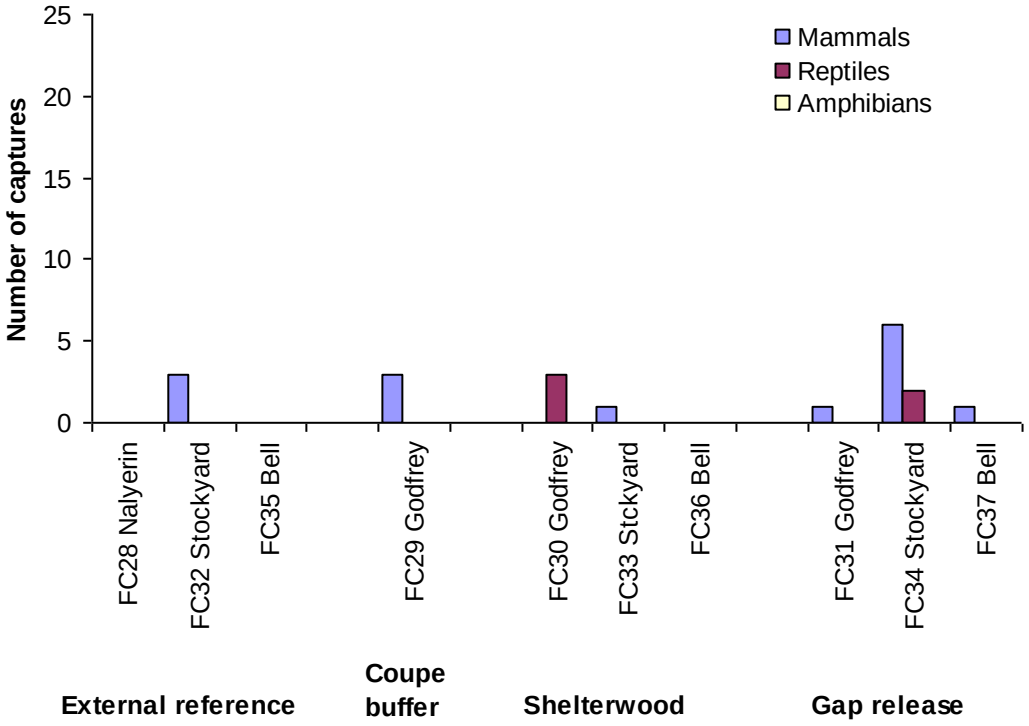
All mardo (22 captures) and chuditch (22 captures) records were from wire traps. Both species were more common in autumn when 20 of the 22 mardo and 15 of the 22 chuditch captures were recorded. There were seven woylie (*Bettongia penicillata*) captures, all from the coupe buffer in Godfrey block─3 in spring and 4 in autumn. Of the five quenda (*Isoodon obesulus*) captures, four were from the external reference and one from the gap release treatment. Only two common brushtail possums (*Trichosurus vulpecula*) were trapped and both were in the Godfrey coupe buffer (FC29) in autumn.

The only other vertebrates captured in wire traps were five bobtail skinks (*Tiliqua rugosa*) in spring, three from the shelterwood and two from the gap release treatment.

Pit fall traps

There were at total of 144 captures recorded from pit fall traps, with a capture rate of 9.0 cpn. One hundred and twenty six records were in spring (5.7 cpn) and only 18 in autumn (2.25 cpn) (Fig. 6).

(a) Spring - wire traps



(b) Autumn - wire traps

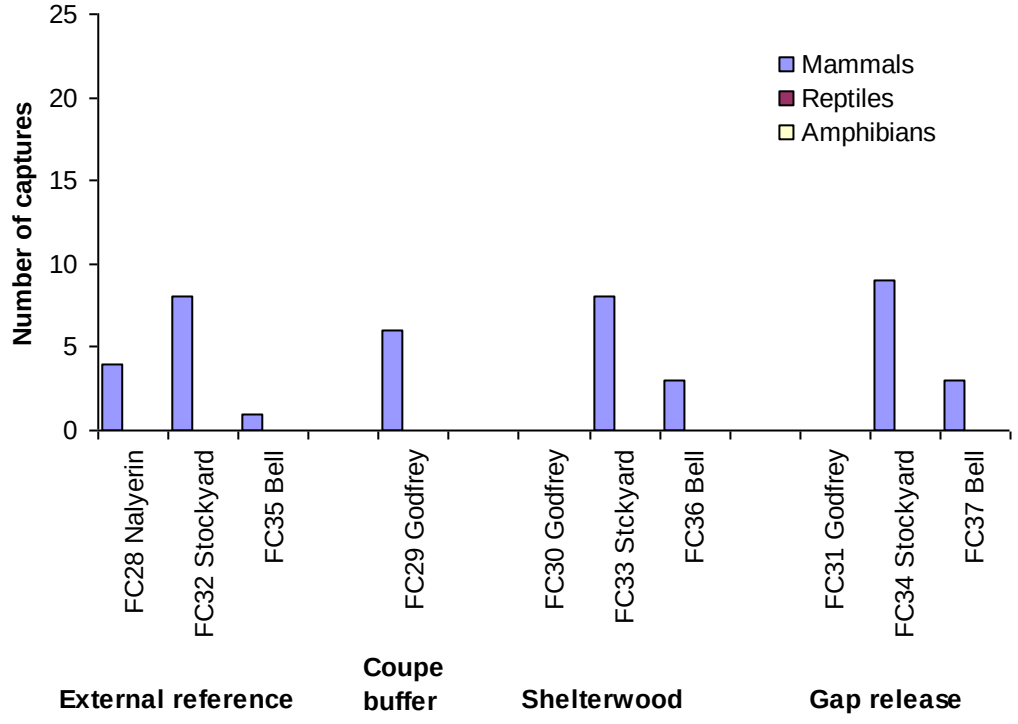


Figure 5. The number of captures of mammals, reptiles and amphibians recorded in wire traps in (a) spring and (b)autumn at the Wellington East FORESTCHECK grids in 2010-11

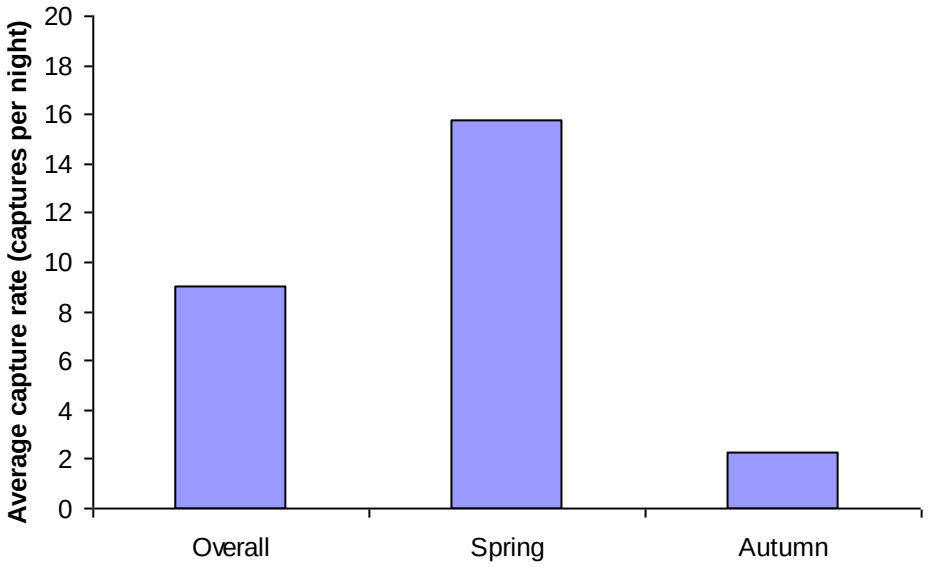


Figure 6. Average capture rate of animals for pit-fall traps at Wellington East FORESTCHECK grids in 2010-11

Only 10 mammals were trapped, of which seven were dunnarts (*Sminthopsis* spp.). The other three were western pygmy possums (*Cercartetus concinnus*), of which two were in external reference and one in the gap release treatment. Five of the seven dunnarts were caught in harvested treatments (two in shelterwood and three in gap release) and two in the external reference treatment (Table 1).

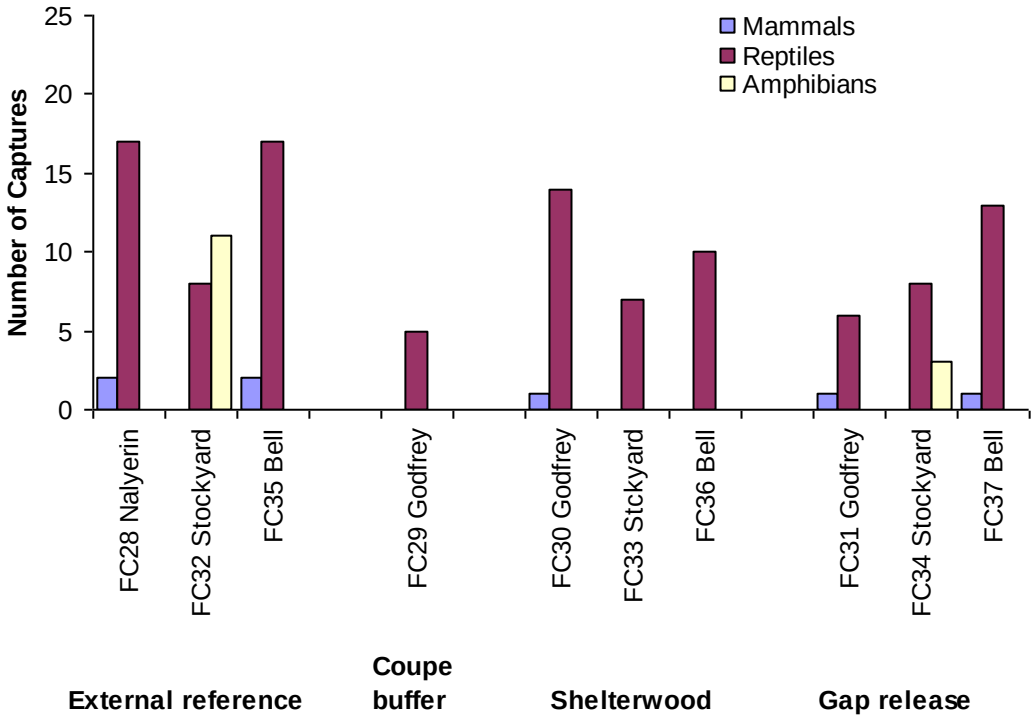
One hundred and eighteen of the 123 reptiles were captured in pit traps. Reptiles were more prevalent in spring with105 captures and only 13 in autumn (Fig. 7). In the shelterwood treatment there was 31 reptile captures in spring and two in autumn. The gap release had 27 in spring and six in autumn. The external reference had 42 in spring and only four in autumn, and the coupe buffer had five in spring and one in autumn. The only snake caught in 2010-11 was the southern blind snake (*Ramphotyphlops australis*), one in the external reference, three in the shelterwood and one in the gap release treatment. All were caught in spring. Bobtail skinks were the only reptiles caught in wire cages. Five captures were recorded in spring, three in shelterwood and two in gap release grids.

All 16 amphibians were caught in pit fall traps and 14 were recorded in spring. Eleven were in the external reference, one in the shelterwood and four the gap release treatments.

Comparison with 2004-05

In 2004-05, a total of 173 captures (21.6 cpn) were recorded and in 2010-11, 207 captures (12.9 cpn) (Fig. 8). Overall mammal captures decreased from 91 (11.4 cpn) in 2004-05 to 68 (4.3 cpn) in 2010-11 with a fall in captures of the woylie and common brushtail possum accounting for most of the decrease. Table 2 shows the difference in trapping results from the two sample sessions. Since sampling in 2004-2005 we have increased trap nights from four to eight being the standard for all FORESTCHECK monitoring locations.

(a) Spring – pit-fall traps



(b) Autumn – pit-fall traps

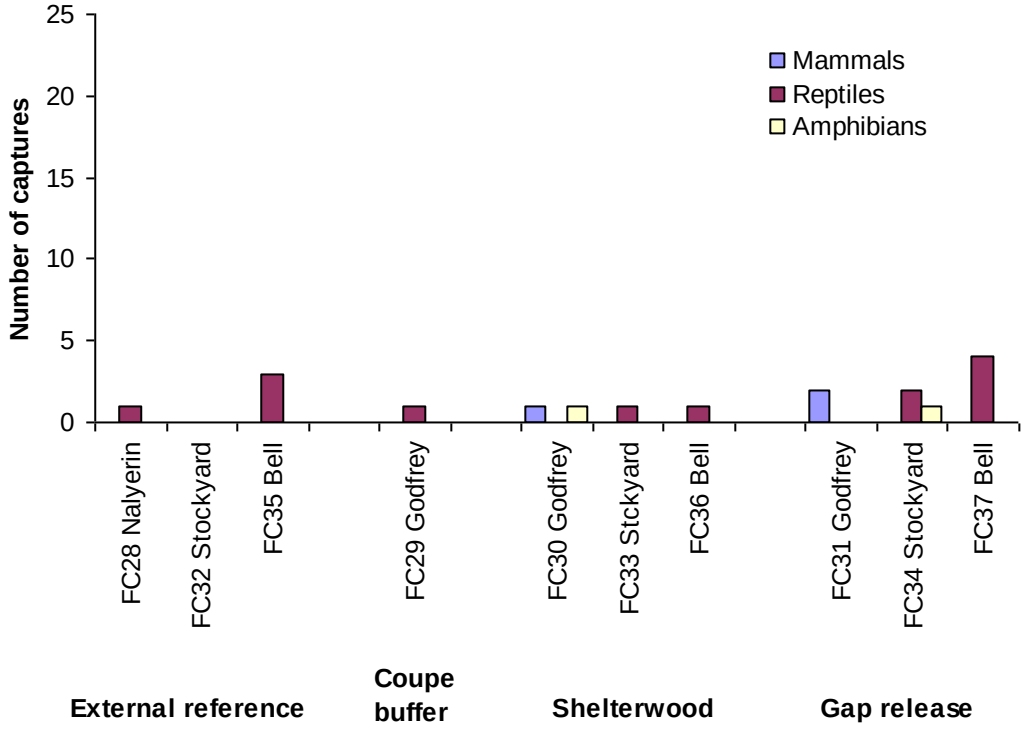


Figure 7. Number of captures of mammals, reptiles and amphibians from pit fall traps in (a) spring and (b) autumn on Wellington East FORESTCHECK grids in 2010-11

Table 2. Comparison between 2004-05and 2010-11 trapping results at Wellington grids (Sp = spring, Au = autumn).

		2004-2005			2010-2011		
Species	**Common name**	**Sp**	**Au**	**Total**	**Sp**	**Au**	**Total**
MAMMALS							
Antichinus flavipes	Mardo	1	6	**7**	2	20	**22**
Bettongia penicillata	Woylie	18	28	**46**	3	4	**7**
Cercartetus concinnus	Mundarda		1	**1**	3		**3**
Dasyurus geoffroii	Chuditch	1	12	**13**	7	15	**22**
Isoodon obesulus	Quenda				3	2	**5**
Sminthopsis griseoventor	Dunnart				4	1	**5**
Sminthopsis gilbertii	Dunnart	5		**5**			
Sminthopsis spp.	Dunnart (unidentified)					2	**2**
Tachyglossus aculeatus	Short-beaked echidna		2	**2**			
Trichosurus vulpecula	Common brush-tailed possum	3	14	**17**		2	**2**
REPTILES							
Christinus marmoratus	Marbled gecko				1		**1**
Diplodactylus polyophthalmus	Speckled stone gecko				1		**1**
Cryptoblepharus plagiocephalus	Fence skink				1		**1**
Ctenotus catenifer	Chain-striped s-w ctenotus	1		**1**	1		**1**
Ctenotus delli	Darling Range ctenotus				1		**1**
Ctenotus impar	Odd-striped ctenotus				4		**4**
Ctenotus labillardieri	Red-legged ctenotus	1		**1**	5		**5**
Egernia napoleonis	S-w crevice skink	5		**5**	4	1	**5**
Egernia pulchra	S-w spectacled rock skink				1		**1**
Hemiergis initialis	Five-toed earless skink	4		**4**	1		**1**
Hemiergis peroni	Peron's earless skink		2	**2**	13		**13**
Lerista distinguenda	S-w orange-tailed slider	31		**31**	24	1	**25**
Menetia greyii	Common dwarf skink	4		**4**	27	10	**37**
Morethia lineocellata	Western pale flecked morethia	7		**7**			
Morethia obscura	Shrubland morethia	12		**12**	15		**15**
Pogona minor	Western bearded dragon	2		**2**	1	1	**2**
Tiliqua rugosa	Bobtail / shingle back	1		**1**	5		**5**
Ramphotyphlops australis	Southern blind snake	3		**3**	5		**5**
AMPHIBIANS							
Crinia georgiana	Quacking frog	1		**1**			
Crinia glauerti	Clicking frog				1		**1**
Heleioporus eyrei	Moaning frog	4	1	**5**	6	2	**8**
Limnodynastes dorsalis	Western banjo frog	2		**2**	7		**7**
Pseudophryne guentheri	Günther's toadlet	1		**1**			
Total		107	66	**173**	146	61	**207**

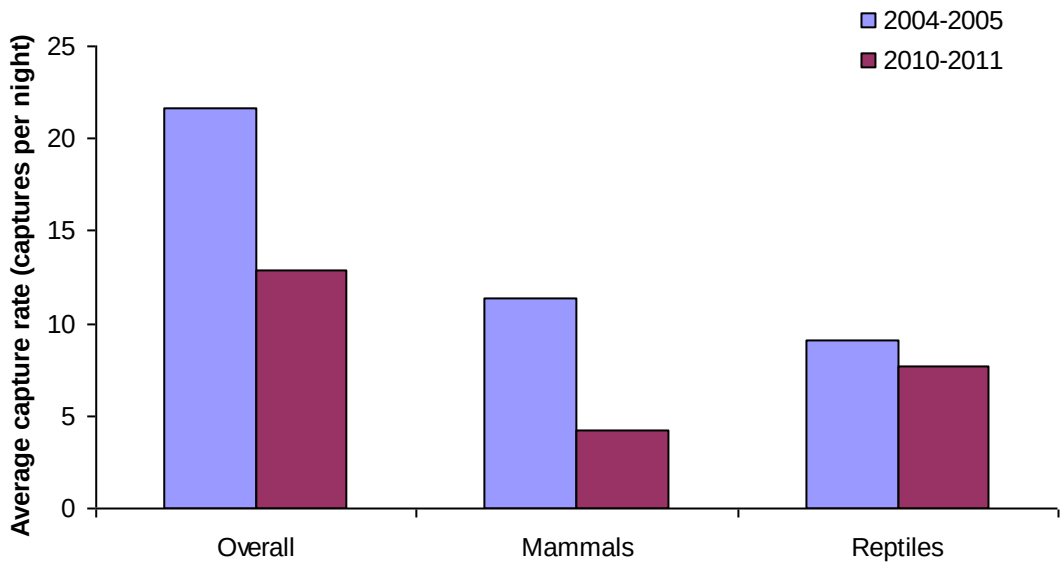


Figure 8. Average capture rates for mammals, reptiles and all terrestrial vertebrates at Wellington East in 2004-05 and 2010-11

The capture rate of reptiles also decreased slightly in 2010-11 compared to 2004-05. There were 73 captures (9.1 cpn) in 2004-05 and 123 (7.7 cpn) in 2010-11. In both sessions, the majority of animals were trapped in spring with 71 in 2004-05 and 110 in 2010-11. Dwarf skink capture numbers increased from four in 2004-2005 to 37 in 2010-2011 and Peron's earless skink increased from two to 13 in the same period. Numbers of the remaining species remained low but steady or decreased in number relative to the extra days trapping. For example, total captures of south western orange tailed slider decreased from 31 in 2004-2005 to 25 in 2010-2011 and captures of shrubland morethia decreased in relative terms from 12 (1.5cpn) to 15 (0.9 cpn).

In both 2005 and 2011, the season breaking autumn rains did not occur until well after the trapping session was completed, which would explain why low numbers of amphibians were recorded in both years.

As has occurred elsewhere in the jarrah forest, Woylies have declined in Wellington East. Forty six individuals were captured in 2004-05 (5.8 cpn) and only seven (0.4 cpn) in 2010-11. Common brushtail possums also declined from 17 (2.1 cpn) in 2004-05 to two (0.1 cpn) in 2010-11. All seven woylies and the two possums trapped this year were from grids in the areas baited under the Western Shield Program. In the Donnelly FORESTCHECK location, possum captures remained constant over the two trapping sessions (2001-02 and 2007-08). Captures at Wellington 1 (2002-03 and 2008-09) also remained constant but low (these grids are not baited under Western Shield), and in the Perth Hills possum captures increased over the two trapping years (2003-04 and 2009-10). Figure 9 shows the capture rates for baited and unbaited grids at Wellington East in 2004-05 and 2010-11.

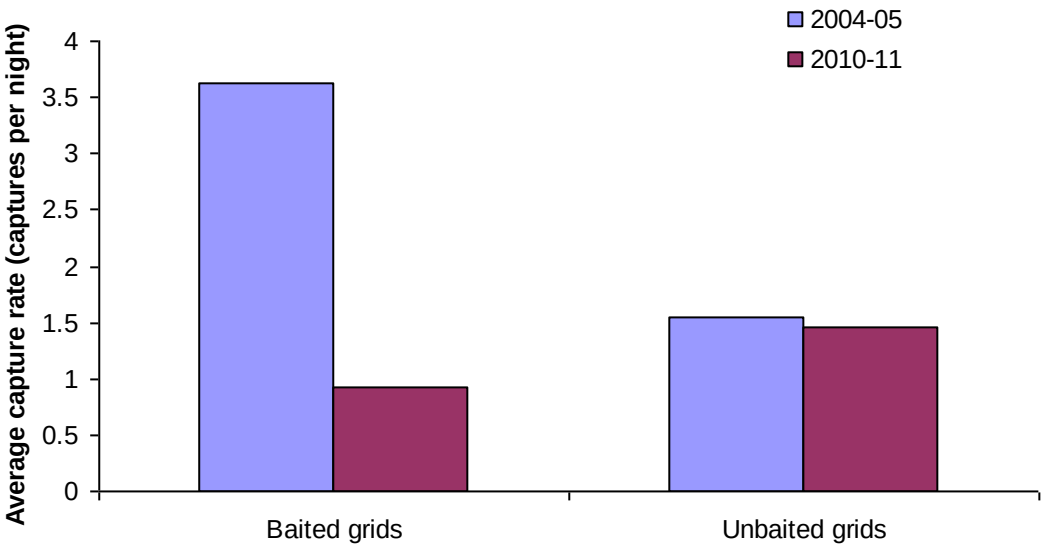


Figure 9. Average capture rates at baited and unbaited Wellington East FORESTCHECK grids for 2004-05 and 2010-11

At Wellington East, mardo numbers increased from seven (0.875 cpn) in 2004-05 to 22 (1.38 cpn) in 2010-11, whereas total numbers of chuditch increased from 13 to 22 but their capture rate dropped from 1.6 to 1.4 per night (Fig. 10).

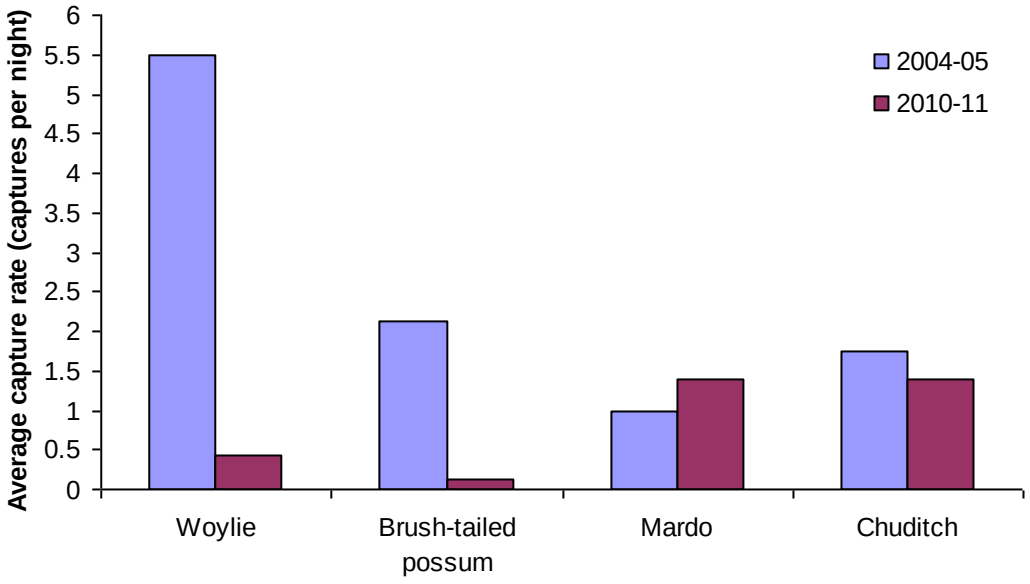


Figure 10. Capture rates of selected species on Wellington East FORESTCHECK grids for 2004-05 and 2010-11

Spotlighting

The spotlight surveys were carried out on two nights in both spring and autumn (Fig. 11). One feral cat (*Felis catus*) and one southern boobook owl (*Ninox novaeseelandiae*) were seen in spring on the southern transect. In both spring and autumn, western brush wallaby (*Macropus irma*) sightings were higher in the southern transect which is within the Western Shield baited area of Godfrey forest block. No possums or woylies were seen on spotlight transects which reflects the low number of captures from trapping. Kangaroo (*Macropus fuliginosus*) numbers seen during this survey are indicative of what would be expected to be seen in this type of forest area.

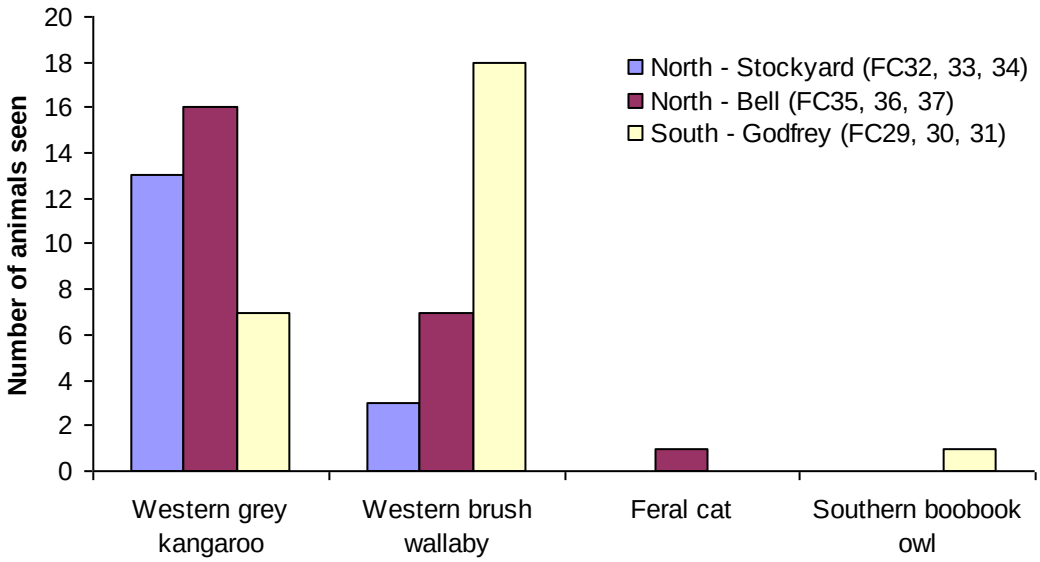


Figure 11. Species recorded along spotlight transects

Road transect surveys

Road surveys consist of two road transects of approximately 20 km each covering the general area of the grids. A northern transect covered Bell and Stockyard blocks and a southern transect covered Nalyerin and Godfrey blocks. During the survey, no distinction was made between treatments as the species being targeted on these transects move over large distances and their presence is assessed in terms of the landscape. Kangaroos and western brush wallabies were the main species encountered.

Kangaroo numbers were similar in both transects with 51 animals seen in the north and 59 in the south. Western brush wallaby numbers mirror the results of the spotlighting with the southern transect having double the number seen on the northern transect (34 versus 16). There were three Baudin's cockatoo (*Calyptorhynchus baudinii*) seen on the northern and one dugite (*Pseudonaja affinis affinis*) seen on the southern transect.

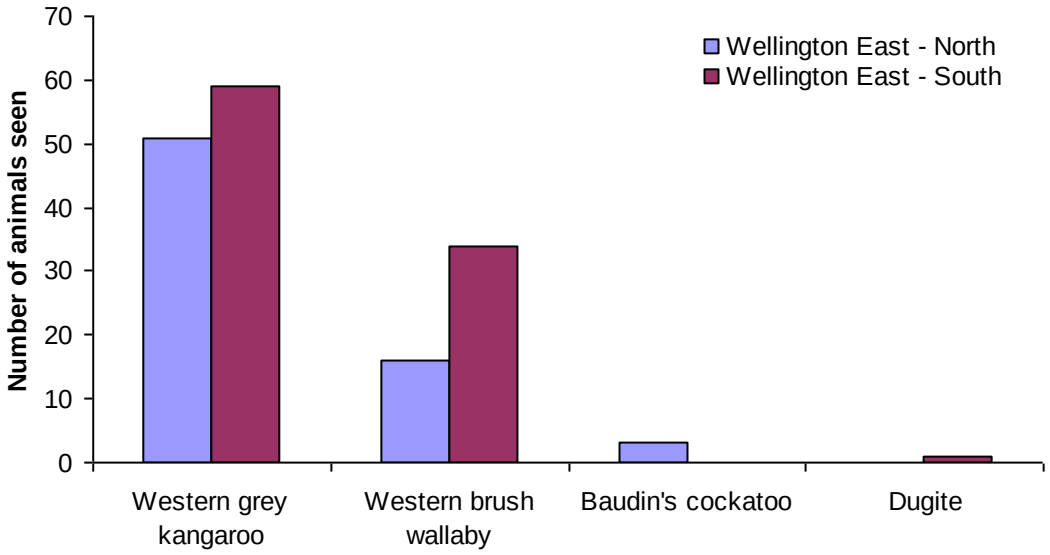


Figure 12. Numbers of macro fauna recorded on road transects

Conclusions

Main observations made following monitoring of terrestrial vertebrates at the Wellington East FORESTCHECK grids in 2010-11 are:

- Western Shield baiting has a significant impact on trapping results.
- Captures of woylies were lower than in 2004-05, which coincides with a general decline of woylies across their range.
- In 2010-11, all seven captures of woylies occurred in grids located within the Western shield baiting program. Similarly in 2004-05, 43 of the 46 captures were also recorded in the baited area of Godfrey block.
- Common brushtail possum captures were lower than in 2004-05. The reason for the reduced abundance at Wellington East is uncertain, as reduced numbers have not been observed at other FORESTCHECK locations.
- Captures of mardo were greater than in 2004-05. In 2010-11 the majority of mardos (18 of 22) were caught in shelterwood or gap release grids at Stockyard or Bell blocks and four were captured in the long unburnt external reference grid in Nalyerin block. In 2004-05 there were only seven mardo captures, of which three were in the Nalyerin external reference, one in the shelterwood and three in the gap release grid at Stockyard.

Acknowledgements

We would like to thank Neil Burrows and Bruce Ward from DEC Science Division, Christina Gilbert, Kelly Bennett and Simon Watts of Wellington District Nature Conservation program and Melanie Schröeder and Lisa Lutz from the University of Applied Science, Eberswalde in Germany for their assistance.

DATA MANAGEMENT AND STORAGE

Verna Tunsell

Introduction

The FORESTCHECK data management and storage service is responsible for entering and storing all data collected from the project into an electronic format, and databasing collected voucher specimens (Flora, Cryptogams and Fungi) into the Western Australian Herbarium (PERTH).

Data entry

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

Data storage

The individual sampling data is saved and backed up as individual files on the network drive. The data are saved and secured when the 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 voucher collections are housed at the Manjimup Insectary. The collection contains a large number of unnamed and previously unknown taxa. Specimens are either pinned or stored in 80% alcohol. Non voucher specimens are bulked according to site, date of

capture and capture method. Light trap specimens are dried and stored in sealed plastic bags and pitfall and active capture samples are stored in alcohol. Therefore these specimens are available for further examination. The whole collection is managed using a Microsoft Access® database linked to photos, collection details and taxon descriptors. Taxa are reviewed annually to update and consolidate new taxa.

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

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

WESTERN AUSTRALIAN HERBARIUM, PERTH
Flora of Western Australia

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

Lauraceae

Identified by:

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

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

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

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

Voucher: Forestcheck Monitoring Program

WESTERN AUSTRALIAN HERBARIUM, PERTH
Flora of Western Australia

Lomandra nigricans T.Macfarlane

Dasypogonaceae

Identified by:

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

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

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

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

Voucher: Forestcheck Monitoring Program

WESTERN AUSTRALIAN HERBARIUM, PERTH
Flora of Western Australia

Leucopogon capitellatus DC.

Epacridaceae

Identified by:

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

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

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

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

Voucher: Forestcheck Monitoring Program

WESTERN AUSTRALIAN HERBARIUM, PERTH
Flora of Western Australia

Leucopogon pulchellus Sond.

Epacridaceae

Identified by:

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

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

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

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

Voucher: Forestcheck Monitoring Program

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

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		