MONITORING BIODIVERSITY IN SOUTH-WEST FORESTS

OPERATING PLAN

(Revised, November 2006)

Science Division
Department of Environment and Conservation
Western Australia

Produced by: The Department of Environment and Conservation, Kensington, Western Australia, November 2006.

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This edition of the FORESTCHECK Operations Plan replaces the August 2001 draft.

CONTENTS

INTRODUCTION

Scope of this Document

FORESTCHECK is an integrated monitoring system that has been developed to provide information to forest managers in south-west Australia about any 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 forest, the intention is to extend the scale of monitoring over time to include other forest ecosystems, fire (prescribed and wildfire), the effects of forest disturbance for utility corridors (e.g. roads, power transmission lines), and the impacts of recreation uses.

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, which is recognized as an appropriate strategy for managing under conditions of uncertainty and change.

The development of FORESTCHECK took place over two years and included input from scientists and managers within the Department of Conservation and Land management (CALM), and from a number of external scientific agencies. The FORESTCHECK Concept Plan, which can be viewed or downloaded from DEC Naturebase web site at http://www.naturebase.net/science/science.html, provides a background description for the process of development.

The purpose of the original Operating Plan was to move from the concept stage to the implementation stage by detailing the sampling strategy, methodology, costing and timetable for establishing the initial monitoring sites in spring 2001. The current Operating Plan updates the original 2001 plan following a review of methods and details staff commitments necessary to undertake the program. It and can be viewed or downloaded from DEC Naturebase web site at http://www.naturebase.net/science/science.html.

A significant deviation from the original concept plan has been that the Science Division now takes primary carriage of FORESTCHECK. The concept plan proposed that Regional Services should be responsible for the program, with support form the Science Division. With recent changes, such as the formation of Forest Products Commission and the associated reduction of staff in forest regions and districts, together with the technical nature of the program, it was decided that the Science Division would be best placed to manage FORESTCHECK, with support from the districts and regions and operational funding provided by the Forest Products Commission (FPC) through a service provider agreement.

Sampling Strategy

Between 1995 and 2004 Timber harvesting in jarrah forests was undertaken according to Silvicultural Guideline 1/95, which recognized 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 other forest values until the ground coppice is developed and capable of responding to release.

[1] Codd, M. 1999. Forest management Plans 1994-2003: Mid-Term EPA Report on Compliance

[2] Conservation Commission of Western Australia.2004. Forest Management Plan 2004-2013. Conservation Commission of Western Australia. 144p + maps.

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

Monitoring has initially focused on the gap creation and shelterwood treatments as these are the most widespread operations and involve the greatest extent of disturbance to the forest. Thinning is more limited in extent, and only results in relatively minor disturbance of the overstorey, understorey or soil.

Monitoring has already taken place at a number of locations throughout the forest, and each location has several FORESTCHECK sites. Locations are stratified according to recognized ecological gradients of rainfall, evapo-transpiration and soil fertility and will be allocated according to mapped forest ecosystems. Allocation of locations and 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 location has 3 sites and each site consists of up to four sampling grids. Grids at each site are established in forest subject to the following treatments:

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

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 found in the one locality and several grids in external reference forest are located some distance from their harvested counterparts. It is always be possible to find gap 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.

Methodology

The location of each FORESTCHECK grid was initially determined using DEC Forest Management Branch silvicultural records and maps (SILREC). Sites were then checked in the field. Grids were established at suitable sites and the various monitoring equipment for each biodiversity group is installed on each grid.

A range of ecosystem attributes and a selection of elements contributing to biodiversity are monitored at each site, as follows:

1. Forest Structure
2. Foliar and soil nutrients
3. Soil disturbance
4. Coarse woody debris and litter
5. Vascular flora
6. Vertebrate fauna (birds, reptiles, frogs, mammals)
7. Invertebrate fauna
8. Cryptogams (lichens, moss, liverworts)
9. Macrofungi.

Sampling methodologies for each set of ecosystem attributes and individual elements of biodiversity are described in the attached sections of this document, together with examples of protocols for data collection and storage. The timetable and costing for each component of the monitoring system is presented. General site attributes such as geology, soils, landform, climate, fire history, logging history, extent of *Phytophthora* impact etc. are also recorded.

[3] CALM 2004. Silvicultural practice in the jarrah forest. Dept. CALM, SFM guideline No. 1.

Monitoring of biodiversity is based on a sample grid (Fig. 1). Each grid is 2 ha in size (100 m x 200 m) with a central 100 m x 100 m area. Four 30 m x 30 m vegetation sample plots are located outside but adjacent each corner of the central area. Details of sample design and protocols for each element of the biota are described in chapters below.

The estimated cost and equipment necessary to establish an individual (single) monitoring grid is detailed below.

Budget for grid installation

Operating budget for 2005-06	$13,000

Staff

Site selection	
1 x Research	15 days
1 x Technical	5 days

Field installation (e.g. 9 grids in jarrah forest, about 1.5 grids established per day)

1x Technical (planning, purchasing)	5 days
4-6 x Technical	30 days (6 days / person)
TOTAL staff commitment	**55 days (0.24 FTE)**

Equipment on each grid	Number required
Galvanised dropper	65
Tall 'top hat' pegs	5
Vertebrate pit traps	
• 20 litre buckets + lid	15
• Fly wire netting (5 m long x 30 cm high)	15
• Pegs to support wire net	
o Galvanised (50 cm long)	30
o Wire (50 cm long)	30
Invertebrate pit traps	
• PVC pipe guides 90 mm diam. x 150 mm deep	10
• Plastic drink cups 90 mm diam. x 110 mm deep	10
'Sheffield' wire vertebrate traps	15
• Hessian bags	20
Marker tags (plastic cattle tags)	
• Yellow (wire cages	15
• Orange (pit traps)	15
• Mauve (invert. Traps)	10
• Red (vegetation plots)	25
• White (fungi transect)	10
Marker pens (all weather - for marker tags)	5
Nest Box (20 cm x 20 cm x 20 cm)	5
Light trap (invertebrates)	1
• Batteries (one per grid)	
Spotlights (nocturnal surveys)	2
Owl recording gear	
• Megaphone	1
• Recorder	1

Flagging tape (appropriate colours)

Other tools

- Auger
- Crowbar
- Shovel

Annual Report

The Project Leader and Data Management Officer are responsible for the compilation and editing of annual individual reports into the FORESTCHECK Annual Report. Annual Reports can be viewed or downloaded from DEC Naturebase web site at: http://www.naturebase.net/science/science.html .

In addition, annual presentations highlighting preliminary results and findings are presented each year and attended by relevant Managers and Nature Conservation staff from within DEC.

Budget

No Operating budget

Staff

1 x Research (Project Leader)	10 days
1 x Technical	15 days
TOTAL staff commitment	**25 days (0.11 FTE)**

Summary Of Total Staff Commitment For Grid Establishment, Monitoring And Reporting

For breakdown of staff commitment associated with each attribute measured and element of biodiversity monitored, see each individual section in the document.

Activity	Person days	FTE
Grid establishment	55	0.24
Annual report	25	0.11
Forest structure	55	0.24
Soil and foliar nutrients	40	0.17
Soil disturbance	80	0.35
CWD, SWT and litter	18	0.08
Vascular flora	45	0.19
Macrovertebrate road survey	18	0.08
Mammal, reptile and amphibian trapping	92	0.40
Diurnal birds	35	0.15
Nocturnal birds	34	0.15
Invertebrates	166	0.72
Cryptogams	43	0.19
Macrofungi	70	0.30
Data management • (0.32 FTE included above) • Voucher processing and PERTH herbarium database entry	203	0.88
TOTAL	**980**	**4.24**

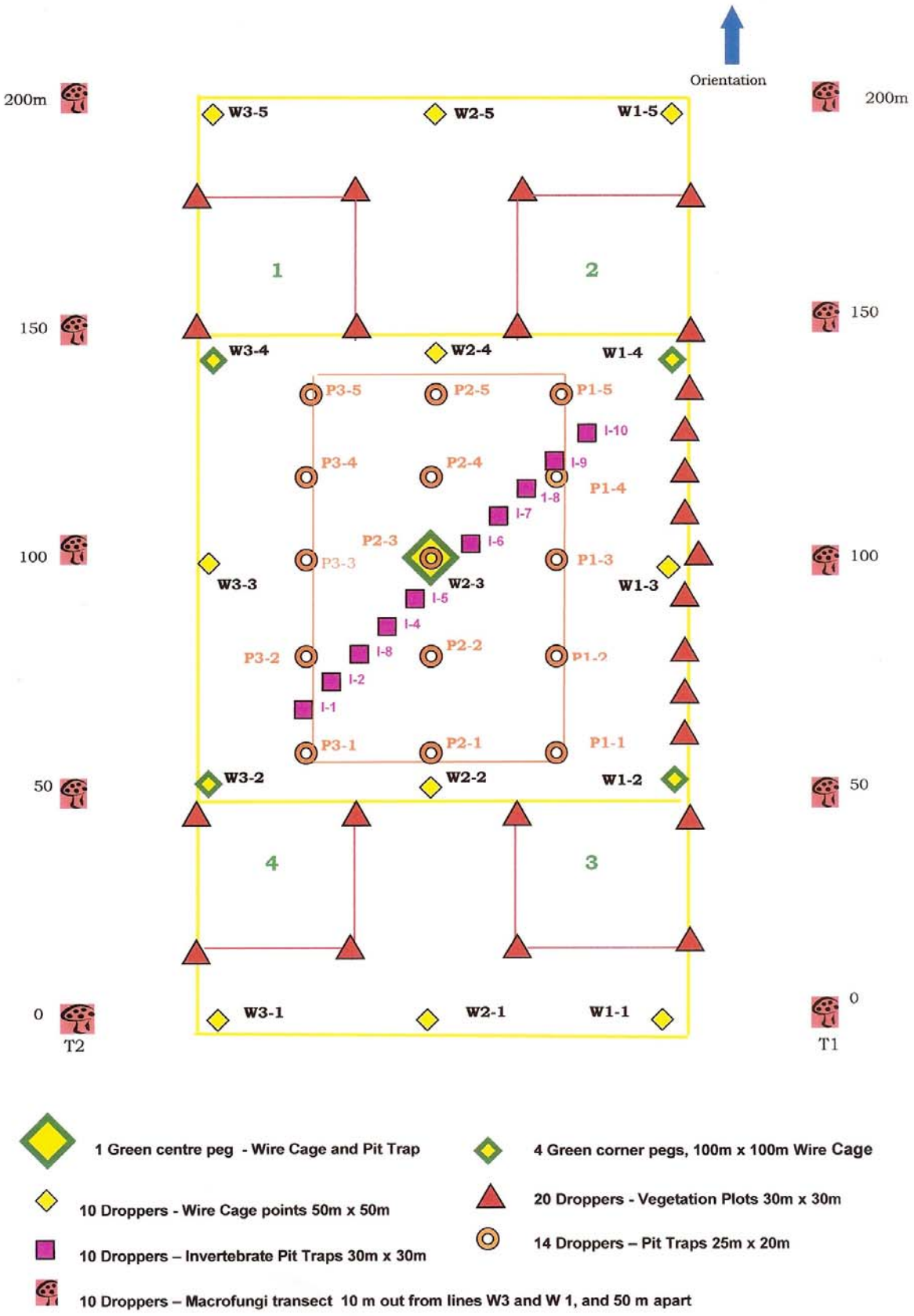


Figure 1. FORESTCHECK grid layout

FOREST STRUCTURE AND REGENERATION STOCKING

Leader
Lachlan McCaw

Members
Grant Phelan, John Neal (retired 2006), Bob Smith (retired 2006)

Objective
The objective of this component of FORESTCHECK is to:

- Describe stand structure and density, species composition and developmental stage of tree species present at FORESTCHECK grids.
- Measure the contribution of mid-storey species to stand structure, density and basal area.

Methods:
Regeneration stocking assessment

Stocking assessment is undertaken at 50 points along the outer perimeter of the main sampling grid from Pegs W1-1 to W3-1 inclusive (see Fig. 1 on p.8 and Table 1). Individual sampling points are 10 m apart. The sampling procedure and stocking standards applied are described in detail below and illustrated on the accompanying sheet (p.12-13). For addition information about regeneration stocking assessments see Silvicultural Practice in the Jarrah Forest (CALM 2004[4]).

Stand structure

For overstorey tree species (jarrah, marri, blackbutt and wandoo), the dbhob (diameter at breast height over bark) to the nearest cm for all stems greater than 2 m tall (saplings and larger) is recorded within a 4 m wide transect between Pegs W1-2 and W1-4, and between Pegs W3-2 and W3-4 (refer to Table below). This transect is divided into 4 sections, each section being 50 m long and extending 2 m either side of the line. Data for each of the 4 sections is recorded on a separate sheet. Stems arising from a common coppice stool or rootstock are identified as a group by bracketing the relevant diameter measurements on the booking sheet. In areas cut to gap release or shelterwood the mean height of the 2 tallest regrowth stems in a 15 m radius around Pegs W1-2, W1-4, W3-2 and W3-4 is determined. The diameter, height and species of stumps >10 cm diameter on the cut surface is also recorded in each section, as is the age of the cutting event that resulted in the stump (1 = most recent harvest event, 2 = harvested prior to the most recent event etc).

Table 1. Summary of sampling procedures

Section	Regeneration stocking	Tally dbhob by species
W1-1 to W1-2	5 points @ 10m apart	-
W1-2 to W1-3	″	50 m long x 4 m wide
W1-3 to W1-4	″	50 m long x 4 m wide
W1-4 to W1-5	″	-
W1-5 to W2-5	″	-
W2-5 to W3-5	″	-
W3-5 to W3-4	″	-
W3-4 to W3-3	″	50 m long x 4 m wide
W3-3 to W3-2	″	50 m long x 4 m wide
W3-2 to W3-1	″	-
Total length = 500 m	**50 points**	**200 m x 4 m = 800 m^2**

[4] CALM 2004. Silvicultural Practice in the Jarrah Forest, Sustainable Forest Management Series, Department of Conservation and Land Management, SFM Guide No. 1.

For mid-storey species (*Persoonia longifolia, Persoonia elliptica, Banksia grandis, Allocasuarina fraseriana, Hakea oleofolia*) the dbhob for all individuals with a dbhob of 10 cm or greater is recorded. Smaller stems are not measured, as their contribution to basal area will be insignificant.

Regeneration stocking assessment at each sample point:
(a) Retained overwood

- In gap release, any plot that falls within the influence of a retained tree (for simplicity this is assumed to be within 4m of a tree > 50 cm dbhob) is recorded as (S) and density is not estimated at that point.
- In shelterwood, any point where the retained basal area measured with a 6-factor prism is equal to or greater than 12 m^2/ha is recorded as (S). Thinned forest is recorded as (T) and non-forest as (N) with a brief description e.g. rock, swamp.

(b) Regeneration
A mark is made on the ground and the three saplings that form the most compact triangle around the mark are determined, i.e. the sample point must fall somewhere within the bounds of the triangle formed by the three selected stems (see diagram p.12). If the point is not stocked with saplings the process is repeat using a combination of saplings and ground coppice, or just ground coppice. In shelterwood cut areas, it is sometimes necessary to include lignotuberous seedlings.

The lengths of the triangle sides are estimated by pacing between the selected saplings. The distances are estimated to the nearest metre. The sum of any two sides of a triangle must be greater than the longest side. The tables have blank boxes where impossible triangle configurations occur. If a triangle cannot be formed from the measurements taken, 1 metre is added to the length of the shortest triangle side.

- When searching for saplings all three stems forming the triangle must be within an 8-metre radius of the sample point.
- When searching for saplings/ground coppice or ground coppice only use a 5-metre radius of the sample point.
- If three saplings, ground coppice or combination cannot be found within these distance limits, record the point as not stocked (X) in the stocking status column (saplings and ground coppice) and move on to the next point.
- Include with the sapling count, stool coppice that has developed from stems < 30 cm diameter at ground level.

Stocking standards
For western jarrah forest:
(a) Gaps
65% stocked at the rate of:

- 500 or more stems per hectare (spha) of saplings or stool coppice from stumps <30cm diameter, or
- 1000 or more spha of jarrah or marri saplings/stool coppice + jarrah ground coppice or marri advance growth,

(b) Shelterwood
65% stocked at the rate of:

- 500 or more spha of saplings or stool coppice from stumps <30cm diameter, or
- 1000 or more spha of jarrah or marri saplings/stool coppice + jarrah ground coppice or marri advance growth, or
- more spha of jarrah or marri saplings/stool coppice + jarrah ground coppice or marri advance growth + lignotuberous seedlings or seedling coppice.

For stocking standards in eastern jarrah forest refer to Silvicultural Guideline1/02.

Budget

Operating Budget (2005-06)	$6,000
Staff	
Field Assessment	
1 x Research	10 days
2 x Technical	20 days (10 days / person)
Office	
1 x Technical (data entry and validation)	10 days
1 x Research (analysis, reports)	15 days
TOTAL staff commitment	**55 days (0.24 FTE)**

Data forms (below)

- FORESTCHECK Stand structure assessment
- FORESTCHECK Stump assessment
- FORESTCHECK Regeneration survey – uncut stands and gap release
- FORESTCHECK Regeneration survey – shelterwood treatment
- FORESTCHECK Regeneration stocking summary

REGENERATION

Successful and rapid development of jarrah regeneration following its release depends on the stage of development of the advance growth. Except on very favourable sites, advance growth smaller than ground coppic e will not develop immediately into saplings.

Stages of jarrah regrowth development.

Seedling
Less than 1 year old, usually with cotyledons still present, but with no obvious lignotuberous swelling.

Lignotuberous Seedling (1)
Original single shoot still present, but with a small lignotuberous swelling.

Seedling Coppice (2)
Lignotuber is obvious and multiple shoots have developed after the removal of the original shoot by fire or other causes.

Ground Coppice
Shoot growth up to 1.5m. Lignotuber 10cm in diameter (may be as small as 5cm in southern forest). Capable of rapid development into a sapling.

Incipient Ground coppice (3) – multiple shoots, no defined leader.

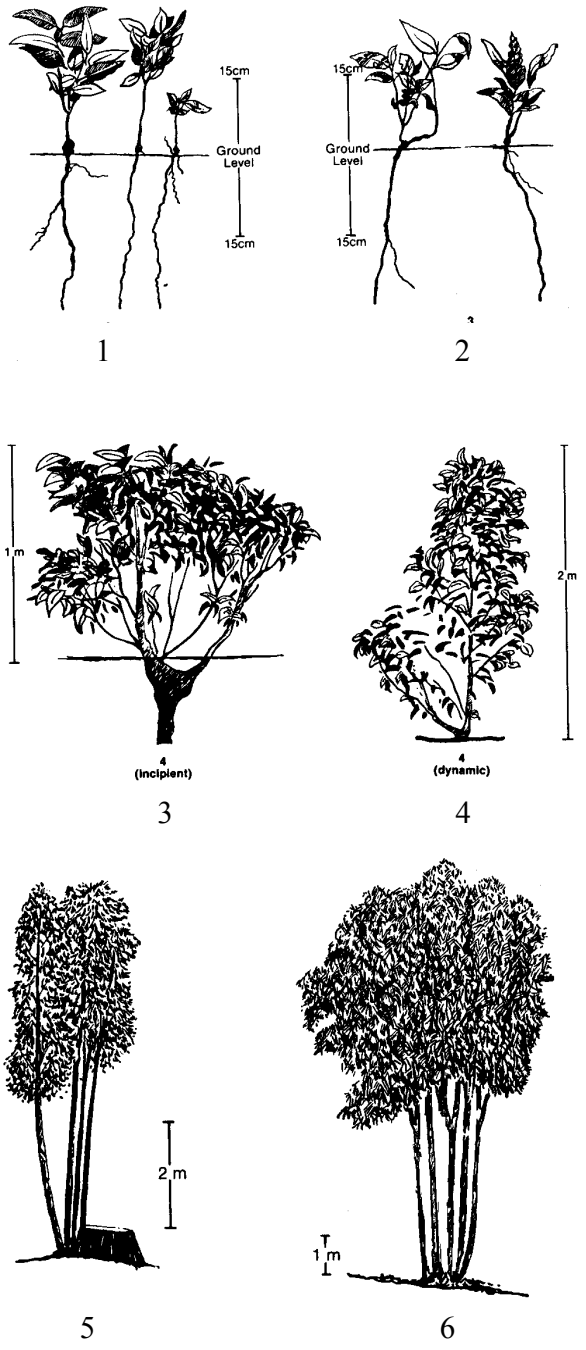
Dynamic Ground coppice (4)– multiple shoots but with a dominant leader.

Sapling
Stem taller than 1.5m, d.o.b. < 15cm. Lignotuber large and ill-defined.

Pole – 15-45 cm d.o.b., with apical dominance giving way to more persistent laterals in the crown.

Stump coppice (5) – shoots from a stump cut off above ground level. Shoots may develop from ground level or from further up the stump.

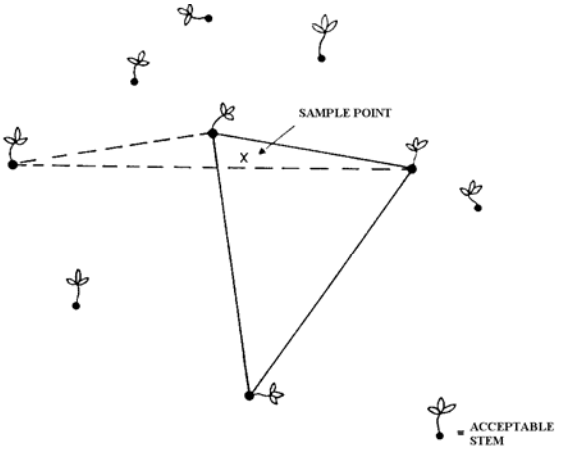
Stool coppice (6) – shoots developing from a small stump cut off at ground level.

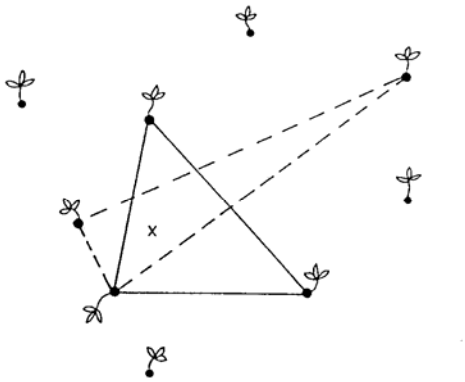


Above: Stages of jarrah regrowth development.

Estimating point density by 'tesselated triangulation'

1. Select three individuals to form a triangle - solid line is the preferred triangle.





2. Enter table as follows:

Longest Triangle Side (metres)

Shortest Triangle Side (metres)

	3	4	5	6
3	1283	1118	1206	
4		899	833	937
5			699	668
6				574

Remaining Triangle Side (metres) ← Estimate of Point Density (spha)

Example: 3 metres x 4 metres x 6 metres = Density of 937 spha

	1	2	3	4	5	6	7	8	9	10
1	11547									
2		5164								
3			3381							
4				2520						
5					2010					
6						1672				
7							1432			
8								1252		
9									1113	
10										1001

	2	3	4	5	6	7	8	9	10
2	2887	2520							
3		1786	1721						
4			1291	1316					
5				1021	1068				
6					845	899			
7						722	777		
8							630	684	
9								559	611
10									503

	3	4	5	6	7	8	9	10
3	1283	1118	1206					
4		899	833	338				
5			699	668	770			
6				574	559	654		
7					488	481	569	
8						424	423	504
9							376	377
10								337

	4	5	6	7	8	9	10	11	12	13	14
4	722	641	630	738							
5		546	504	510	611						
6			442	417	430	523					
7				373	357	372	458				
8					323	313	329	406			
9						285	278	295	367		
10							255	250	267	334	
11								231	228	244	306
12									211	209	225
13										195	193
14											180

	5	5	6	7	8	9	10	11	12	13	14
5	462	417	400	417	510						
6		367	340	334	354	439					
7			306	289	287	308	386				
8				263	251	252	273	344			
9					231	223	225	245	311		
10						207	200	204	223	284	
11							187	182	186	204	
12								170	167	171	
13									157	154	
14										145	

	6	6	7	8	9	10	11	12	13	14
6	321	293	280	280	302	379				
7		254	246	238	242	264	334			
8			225	213	208	214	234	300		
9				195	188	185	191	211	272	
10					175	168	167	173	192	
11						157	152	152	159	
12							143	139	140	
13								132	128	
14									122	

	7	7	8	9	10	11	12	13	14
7	236	218	207	204	210	231	296		
8		199	186	180	179	186	206	266	
9			172	163	159	160	167	186	
10				152	146	143	144	152	
11					137	132	130	132	
12						124	120	119	
13							114	111	
14								105	

	8	8	9	10	11	12	13	14
8	180	168	160	156	157	165	184	
9		155	146	141	139	141	149	
10			136	130	126	125	128	
11				122	117	114	114	
12					110	106	104	
13						101	98	
14							93	

	9	9	10	11	12	13	14
9	143	134	128	124	124	126	
10		124	118	114	111	111	
11			111	106	102	101	
12				100	96	93	
13					91	88	
14						84	

	10	10	11	12	113	14
10	115	109	104	101	100	
11		102	97	94	92	
12			92	88	85	
13				83	80	
14					76	

FORESTCHECK
STAND STRUCTURE ASSESSMENT

SITE:_____ GRID:_____ TREATMENT:_____

DATE:_ _/_ _/_ _ _ _ OBSERVERS:_ _ _ _/ _ _ _ _/ _ _ _ _

SECTION STARTS @ PEG: _ _ FINISHES @ PEG: _ _
HEIGHT OF TALLEST REGEN IN 15m RADIUS = _ _ _ m SPECIES = _ _ _
(regen height to be assessed at Pegs W1-2, W 1-4, W 3-2, W 3-4)

Species dbhob (cm)	Species dbhob (cm)	Species dbhob (cm)	Species dbhob (cm)	Species dbhob (cm)	Species dbhob (cm)	Species dbhob (cm)

FORESTCHECK
STUMP ASSESSMENT

SITE:_____ GRID:_____ TREATMENT:_____

DATE:_ _/_ _/_ _ _ _ OBSERVERS:_ _ _ _/ _ _ _ _/ _ _ _ _

SECTION STARTS @ PEG: _ _ FINISHES @ PEG: _ _

Stump species	diameter (cm)	height (cm)	Cut age	Other cause	Stump species	diameter (cm)	height (cm)	Cut age	Other Cause

FORESTCHECK

REGENERATION SURVEY – UNCUT STANDS AND GAP RELEASE TREATMENT

SITE: _ _ _ _ _ _ _ _ _ _ _ GRID: _ _ _ _ _ _ _ TREATMENT: _ _ _ _ _ _ _ _ _

DATE:_ _ / _ _ / _ _ _ _ OBSERVERS: _ _ _ _ / _ _ _ _ / _ _ _ _ SHEET: _ _ of _ _

Point No.	**Forest condition S, other**	**Density Estimate**		**Stocking Status**	**Species Mix**	
		Stool coppice + Saplings *	Stool coppice + Saplings + Ground Coppice	Sap. & G. Coppice ✓/ X /N /S	J	M

FORESTCHECK

REGENERATION SURVEY – SHELTERWOOD TREATMENT

SITE: _ _ _ _ _ _ _ _ _ _ _ GRID: _ _ _ _ _ _ _ TREATMENT: _ _ _ _ _ _ _ _ _

DATE: _ _ / _ _ / _ _ _ _ _ OBSERVERS: _ _ _ _ _ / _ _ _ _ _ / _ _ _ _ _ SHEET: _ _ of _ _

Point No.	**Forest condition S, T, other ****	**Density Estimate**			**Stocking Status**		**Species Mix**	
		Stool coppice + Saplings	Stool coppice + Saplings + G.Coppice	Stool coppice + Saplings + G.Coppice + Ligno. Seedlings+ Seedling coppice	Stool copp. + Sap. & G. Coppice ✓/ X /N/S *	Stool copp. + Sap. & G. Coppice & Seedlings O/X / N/S *	J	M

FORESTCHECK

REGENERATION STOCKING SUMMARY

SITE: _ _ _ _ _ _ GRID: _ _ _ _ TREATMENT: _ _ _ _ _ _ _ _ _ _

DATE:__ _ _/ _ _ _ / 2002 OBSERVERS: _ _ _/ _ _ _ / _ _ _ _

SPECIES COMPOSITION (based on 50 points x 3 trees/point)		
	Number (n)	Percent of total (n/total)
Jarrah		
Marri		
Blackbutt		
Other		
Total trees		
STOCKING ASSESSMENT(based on 50 points/grid)		
Stocked with saplings (>500/ha)		
Stocked with saplings + ground coppice (>1000/ha)		
(Shelterwood only)_ Stocked with saplings + ground coppice + lignotuberous seedlings (>5000/ha)		
Total of effective area stocked		
Did not meet stocking standard		
Overwood present (S)		
Not assessed (rock, non-forest)		
STAND DENSITY (average for stocked points only)	Stems/ha	
For points stocked with saplings		
For points stocked with saplings + ground coppice		
For points stocked with saplings + ground coppice + lignotuberous seedlings		

SOIL AND FOLIAR NUTRIENTS

Leader
Lachlan McCaw

Members
Grant Phelan, John Neal (retired 2006), Bob Smith (retired 2006)

Objectives
Concentrations of nitrogen, phosphorus and potassium in the foliage of overstorey trees, advanced growth and saplings, and in surface soils are measured at each FORESTCHECK grid to provide information on the nutritional status of the ecosystem. Correlations between macronutrients concentrations and measures of plant and animal abundance, and ecosystem health are investigated. The objectives of this component of FORESTCHECK are to:

- Measure concentrations of N, P and K in surface soils for correlation with measures of plant and animal abundance across the geographic range of monitoring sites;
- Measure concentrations of N, P and K in leaves from ground coppice, saplings and mature trees as an indicator of the nutritional status of the ecosystem.

Methods

Soil nutrients
Samples of surface soil (0-75 mm depth) are collected from cores at the four corners and centre of the primary grid (points W2-3, W1-2, W1-4, W3-2, W3-4, see Fig. 1 on p.8). At each of these points five sub-samples are collected and then bulked, providing a total of five replicates per grid.

Samples are then air-dried and passed through a 2mm sieve to separate the fine earth fraction. Some samples may be finely ground prior to analysis. Nitrogen is assayed by Kjeldahl digest following preparation with sulphuric acid. Total P is assayed on finely ground soil using hydrochloric acid digest and colorimetry (Murphy and Riley method). Available P is determined by sodium bicarbonate extraction on unground soil. Total K is assayed on finely ground soil using hydrochloric acid digest and flame photometry. Available K is determined by sodium bicarbonate extraction on unground soil.

Foliar nutrients
Leaf samples (minimum of 6 leaves) are stripped from 3-4 advanced growth, saplings and mature trees. Leaves are collected from the upper canopy and are in a fully developed state but not senescent (i.e. aim for one-year-old). Leaves of each cohort group are bulked to form 3 samples (advanced growth, sapling and mature). This sampling procedure is replicated for Marri and Jarrah equating to 6 samples per grid. Samples are collected at random within the grid but outside of the vegetation plots.

Samples are then air-dried and ground prior to analysis. Nitrogen is assayed by Kjeldahl digest following preparation with sulphuric acid. Phosphorus is assayed by colorimetry following tri-acid digestion. Potassium is assayed by flame photometry following tri-acid digestion.

Budget
To rationalise travel costs, field sampling is done in conjunction with surveys of stand structure and regeneration stocking. Analysis is undertaken at the WA Chemistry Centre laboratories.

Operating Budget (2005-06)	$5,000

Staff

Field sampling	
1 x Research	10 days
1 x Technical	10 days
Office	
1 x Technical (data entry and validation)	10 days
1 x Research (analysis, reports)	10 days
TOTAL staff commitment	**40 days (0.17 FTE)**

Laboratory costs (contract)

On the basis of 9 grids, and collecting 6 foliar samples and 5 soil samples per grid, the cost for soil and nutrient analysis in 2006 was ~ $650 per grid.

SOIL DISTURBANCE

Leader
Kim Whitford

Members
Kim Whitford, with technical assistance from contract Technical staff

Objective
FORESTCHECK monitoring of changes in soil physical properties caused by soil disturbance provides information on the extent of disturbance, and the intensity of disturbance on selected representative treatments. This information is relevant to interpreting data collected in other FORESTCHECK monitoring exercises. The object of this component of FORESTCHECK is to:

- Record the extent of soil disturbance on those treatments where machine disturbance (snig tracks) can be readily identified, and
- To monitor the intensity of changes to soil physical properties induced by logging, and the change in these properties over time.

Methods
External control treatments are not assessed in this study as, being physically distant from the disturbance treatments, they are not relevant reference treatments for soil compaction (bulk density) measurements, and there is no reason to suspect that disturbance adjacent to the internal control treatments (buffers) would alter soil physical properties on these internal control treatments. Monitoring is undertaken on selected gap and shelterwood treatments, internal reference treatments, and selected undisturbed (uncut) sites where such sites can provide reference measurements of bulk density for undisturbed soils.

1. Faller's block boundaries, snig tracks and landings on all harvested treatments are GPS surveyed and mapped. The order of mapped snig tracks is classified by concurrent or subsequent visual assessment of snig track disturbance, and relative position of the snig track in the pattern of log extraction. Photo-interpretation is used to assist in this assessment.
2. The relative area of various operational classes is determined from the GPS survey. Harvested are (HA), log landing (LL), major snig track into landing (ST0), major snig tracks primary (ST1), minor snig tracks secondary (ST2), minor snig track tertiary (ST3) and old snig track (OST) from previous logging are mapped.
3. A single treatment grid is selected for bulk density measurement. On the treatment where the visual classes of disturbance or operational categories are most clearly identifiable (preferably the most recently logged gap treatment) a grid is established for assessments and sampling of bulk density. The grid is based on the 3 major transects (W1, W2 and W3) of the FORESTCHECK sampling grid, plus 2 additional transects of similar length. These additional transects added on either side of the grid, increase the area sampled so that it better reflects the spatial variability in soil disturbance. The additional transects are generally parallel but 50 m outside to the existing grid.
4. Bulk density sampling is stratified on 6 operational classes. These strata are harvested area (HA), log landing (LL), primary snig track (ST1), secondary snig track (ST2), tertiary snig track (ST3), and old snig track from previous harvest (OST) if relevant. The aim is to collect a minimum of 75 samples from HA, and 20 samples from each of LL, ST1, ST2, ST3. Total samples per treatment = 75 + 80 = 155. Bulk density samples are collected every 15 m in HA and every 1 m where transects cross snig tracks. Samples from landings (LL) are collected at 20 points distributed across the landing on a grid separate from the FORESTCHECK grid (Total: 155 + 20 + 40 = 215).
5. Each measurement point is marked with a wire peg, flag and label.
6. Numbering of sample points on all grids follows the order of the FORESTCHECK grid points, with the lowest number on each transect always nearest the lowest numbered FORESTCHECK grid point for that transect.
7. A reference site is selected to collect measurements of bulk density of undisturbed soil for comparison with the harvested treatment site selected in step 3. This reference site should have

similar soil texture to the harvested treatment site and may be an internal reference treatment that has little or no disturbance or a nearby area of virgin forest with similar soil texture.

8. On this reference treatment bulk density samples are collected at 40 points, spread over five transects, based around the FORESTCHECK sampling grid. Sample points are spaced at 30 metres, 8 samples per transect line, each transect 210 m long. The first sample in each line is be at 5 m before the first FORESTCHECK grid point and the last sample 5 m past the last grid point on the transect line. As these internal controls are assumed to be relatively undisturbed, no visual assessment of disturbance or stratification of bulk density measurements is required.
9. Bulk density samples are processed to determine bulk density of the fine earth fraction (< 2mm).
10. Data are then entered, processed and analyzed.

The data are used to determine:

- A real proportion of treatment in each operational class (where snig tracks are visible).
- Means and standard errors of fine earth bulk density for each operational class or disturbance category, and for undisturbed reference treatments.

Budget

Operating Budget (2005-06)	$10,000
Staff	
Field Sampling and Assessment	
1 x Research	35 days
1 x Technical (Contract)	10 days
Laboratory processing	
1 x Technical (Contract)	10 days
Office	
1 x Research (data input, analysis, reports)	25 days
TOTAL staff commitment	**80 days (0.35 FTE)**

Data forms (below)

- FORESTCHECK Operational category survey form.
- FORESTCHECK Bulk density laboratory data form.

FORESTCHECK Operational category survey form

Operational categories: LL = landing, ST0-1 = Snig Track, ST2-3, snig track, OST = old snig track from previous logging, HA = harvested area. Disturbance type: R = rut, M = mound, RL = rip-line, U = undisturbed.

Site: **Grid:**	**Bearing:**
Line:	**Date:**
Treatment:	**Assessor:**

Transect distance (metres)	Sample point no.	Operational Category	Disturbance Type	Comment

FORESTCHECK bulk density laboratory data form

Site:	Grid:		All weights in grams			
Sample Point	**Tray**	**Dry soil and tray**	**Bag**	**Soil and bag**	**Gravel**	**Gravel Volume (ml)**

COARSE WOODY DEBRIS, SMALL WOOD AND TWIGS AND LITTER

Leader
Richard Robinson

Members
Julie Fielder, Bob Smith (Retired 2006)

Objectives
The objectives of this component of FORESTCHECK are to:

- Measure and record the amount of coarse woody debris (CWD), small wood and twig (SWT) and litter on the ground in the various treatments of managed jarrah forest (gap release, shelterwood, coupe buffer and external control).
- Analyse trends, within and between the treatments over time.
- Make data available for analysis of distribution and utilization patterns of associated organisms

Methods
At each grid, 2 x 100 m transects are used to assess litter, SWT and CWD. One litter/SWT/CWD transect will utilise the 0-100 m section of macrofungi (MF) transect 1 (adjacent W1-1 – W1-3) and the second litter/SWT/CWD transect will utilize the 100-200 m section of MF transect 2 (adjacent W3-3 – W3-5) (see Fig. 1 on p.8).

Litter and SWT

Litter is collected from 11 plots, each 0.05 m^2, placed every 20 m internally adjacent each transect (22 plots in total). Small wood and twigs (1 cm - 2.5 cm diam.) will be collected from 22 plots, each 1 m^2, placed directly adjacent the litter plots.

Litter and SWT samples are then oven-dried for 24 hrs and dry weights used to determine litter and SWT loads in tonnes ha^{-1}.

Coarse woody debris

CWD is measured on each transect by laying out a 100 m tape. The diameter of each piece of CWD, larger than 2.5 cm diameter, which the tape passes directly over, is recorded. At least 50 data records are collected for each grid. If 50 records are not gained transects are extended beyond 100m, and the total length recorded. Each grid is assessed in early autumn. Litter from each quadrat is collected in paper bags numbered 1-22, number 1 being at the origin and number 11 at the 100 m mark of the first MF transect, number 12 being at the 100 m mark and number 22 at the end of the second MF transect.

The volume (m^3 ha^{-1}) of CWD is calculated using the formula and method of Van Wagner (1968[5]). CWD is determined in volume due to the effect that moisture and decay stages have on the weight of dead wood.

[5] Van Wagner, C.E. 1968. The line intersect method in forest fuel sampling. Forest Science14: 20-26

Budget
Operating Budget, 2005-06 – No Budget, included within Forest Structure and Macrofungi. Sampling is co-ordinated with Forest Structure and Foliar and Soil Nutrient assessments.

Staff

Field sampling	
1 x Research	5 days
1 x Technical	5 days
Laboratory	
1 x Technical	3 days
Office	
1 x Research (analysis, report)	3 days
1 x Technical (data entry and analysis)	2 days
TOTAL staff commitment	**18 days (0.08 FTE)**

Data forms (below)

- FORESTCHECK Litter assessment
- FORESTCHECK CWD assessment

FORESTCHECK
Litter assessment

Site: **Date:**

Grid #: **Transect No.:** **Asessed by:**

Sample N$^{o.}$	Dry Wt (gms)	Sample N$^{o.}$	Dry Wt (gms)	Comments
				Mean Dry Wt:
				SE:
				Litter load: tonnes ha^{-1}

FORESTCHECK
CWD Assessment

Site: **Date:**

Grid #: **Transect No.:** **Asessed by:**

Diam. (mm)	Diam. (mm)	Diam. (mm)	Diam. (mm)	Calculations
				Σd :
				Transect length:
				Volume: $m^3\ ha^{-1}$

VASCULAR FLORA

Leader
Bruce Ward

Member
Ray Cranfield

Objectives
The object of this component of the FORESTCHECK program is to:

- Monitor vascular plant species richness and abundance on each FORESTCHECK grid.
- Compare species richness, abundance and composition recorded on treatment grids (shelterwood, gap release) to those on unlogged grids (external control).

Methods
At each FORESTCHECK grid:

- Four quadrats, each 900 m^2 (30 m x 30 m), are permanently marked with a dropper at each corner. The quadrats are located outside but directly adjacent each corner of the central 1 ha area of the grid (see Fig. 1 on p.8). Records of all species and their life form are collected. All species are rated according to cover, frequency and distribution in each plot (Bragg system).
- 1 square metre quadrats are established along the transect W1-2 to W1-4 and marked with droppers at 10 m intervals. Two 1 m^2 quadrats, offset 5 m either side of each peg, are established. Presence of all plant species and counts of individuals including Jarrah/Marri seedlings are recorded for each plot.
- Around the perimeter of the 30 m x 30 m quadrats, point transects using Levy rods are used measure vegetation height and cover. Heights are assessed using the drop plate method and recordings of height of contact by height class, number of contacts in each class whether live or dead and species making contact.
- To complete a total listing of species for the site, the central 1 ha area of the grid is searched for any additional species not recorded in the 30 m x 30 m quadrats.
- Voucher collections of all species are collected from within the grid and but outside the vegetation quadrats. Provided treatments are within close proximity (within 1 km), a combined voucher set is established for one sampling site (containing 4 treatments). If the range between treatments is too far (>1 km), then the risk of different vegetation associations may occur. In this case, a separate voucher set is established for that grid.

Monitoring provides a species list, life-form guild and fire response mechanism. Other values determined are:

- Importance values, calculated from cover, frequency and distribution data.
- Mean species richness per square metre by treatment over time.
- Mean plant density per square metre by treatment over time.
- Mean cover and height changes over time for each treatment.

Vouchered specimens are lodged with the W.A. Herbarium (PERTH) and include fertile and/or sterile plant material.

<u>Other</u>
Life form guilds are:

- Tree, woody shrub, perennial herb, geophyte, short-lived herb (regenerates by seed), grass (perennial), sedge, fern and whether native or weed.

Fire response categories are:
A- Seeder

- A1 - seed stored in soil
- A2 – seed stored on plant (serotinous)
- A3 – No seed on site (e.g. blow-in)

B -Respouter

- B1 – from epicormics
- B2 – from woody rootstock/lignotuber
- B3 – from fleshy below-ground organ (corm, bulb, tuber and rhizome)

Budget

Operating budget (2005-06)	$5,000

Staff

Field assessment	
2 x Technical (vegetation assessment)	20 days (10 days / person - 1 grid per day)
2 x Technical (vegetation structure)	10 days (5 days / person - 2 grids per day)
Office	
1 x Technical (data entry and validation)	5 days
1 x Technical (plant ID, voucher processing)	5 days
1 x Technical (analysis and reports)	5 days
TOTAL staff commitment	**45 days (0.19 FTE)**

Data forms (below)

- FORESTCHECK Vegetation booking sheet 1 (30m x 30m quadrats)
- FORESTCHECK Vegetation booking sheet 2 (1 m x 1 m quadrats)
- FORESTCHECK Vegetation booking sheet 3 (Levy measurements)

FORESTCHECK

Vegetation Booking Sheet 1
(1000 m^2 quadrats (31.6 m x 31.6 m)

Grid: ..... **Treatment:** ..... **Location:** .....

Date: ..... **Observer:** ..... **Last Burnt** .....

#	V	Species Code	Field Name/#	Life Form	Cover	Freq	Dist	Fire Response Code	#	V	Species Code	Field Name/#	Life Form	Cover	Freq	Dist	Fire Response Code

COVER CODE

0 = No plants
1 = < 1% cover
2 = 1 – 5% cover
3 = 5 – 25% cover
4 = 25 – 50% cover
5 = 50 – 75% cover
6 = 75 – 95% cover
7 = 95 – 99% cover
8 = 100% cover

Note: when estimating cover, ignore bare ground and only estimate the percentage of live.
ie: what % of the live is covered by the species being rated.

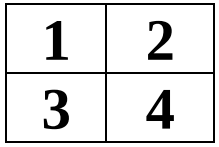
FIRE RESPONSE

CODE	FIRE RESPONSE DESCRIPTION
A1	Seed stored in soil
A2	Seed stored on plant (serotinous)
A3	No seed on site
B1	From epicormics
B2	From woody rootstock/lignotuber
B3	From fleshy underground organ (corm, bulb, tuber, rhizome)
U	Unknown

FREQUENCY CODE

0 = No plant
1 = 1 Plant
2 = < 10 plants
3 = 10 – 50 plants
4 = 50 – 100 plants
5 = 100 - 500 plants
6 = > 500 plants

DISTRIBUTION CODE



The plot is divided into 4 quadrants and if plants occur in equivalent to only 1 quadrant then:

1 = ¼
2 = ½
3 = ¾
4 = 1

LIFEFORM

Code	Life Form Description
H	Herb
F	Fern
G	Geophyte
GR	Grass
Z	Sedge
T	Tree
S	Shrub (over 31 cm)
DS	Dwarf Shrub (1 cm-30 cm)
P	Parasite
V	Vine (climber/runner)
R	Rush
C	Cycad
X	Xanthorrhoea/Kingia
U	Unknown

FORESTCHECK

Vegetation Booking Sheet 2 (1 x 1 m^2 quadrats)

Grid: ____________ **Treatment:** ______________ **Location:** ______________________

Date: ____________ **Observer:** ______________ **Last Burnt:** ______________________

Species Code	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

FORESTCHECK

Vegetation Booking Sheet 3 (Levi points)

Grid: _____ **Treatment:** _____ **Location:** _____

Date: _____ **Observer:** _____ **Last Burnt:** _____

#	Point	Scrub top height	0-20 1	20-40 2	40-60 3	60-80 4	80-100 5	100-120 6	120-140 7	140-160 8	160-180 9	180-200 10	Canopy
	1												
	2												
	3												
	4												
	5												
	6												
	7												
	8												
	9												
	10												
	11												
	12												
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	18												
	19												
	20												
	21												
	22												
	23												
	24												
	25												
	26												
	27												
	28												

#	Point	Scrub top height	0-20 1	20-40 2	40-60 3	60-80 4	80-100 5	100-120 6	120-140 7	140-160 8	160-180 9	180-200 10	Canopy
	29												
	30												
	31												
	32												
	33												
	34												
	35												
	36												
	37												
	38												
	39												
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	54												
	55												
	56												
	57												
	58												
	59												
	60												

MACROVERTEBRATES

Leader
Graeme Liddelow

Members
Chris Vellios, Bruce Ward and District staff and volunteers as required

Objectives
The size of large vertebrates (grey kangaroo, brush wallaby, emu etc.) excludes them from trapping, and they have a large home range that exceeds the size of FORESTCHECK grids. The objective is to:

- Count the numbers of these animals at the landscape scale using road-based transects.

Methods
Suitable road transects are selected using maps and ground inspection. Individuals are surveyed by spotlighting and recorded by species on a per kilometre basis. Each species is counted along a 40 km long road transect travelled in a vehicle from 2 hours before sunset until 15 minutes after sunset. Each transect has a team of three people (driver and two observers) and the vehicle travels at 20 km/hr. Each recording includes time, species, number of individuals, the side of road where the animal was first sighted and direction if they crossed the road (see attached field sheet). The transect is repeated on two consecutive nights during the week of the spring/summer pit trapping and also during the autumn (when medium-sized mammal trapping takes place).

Budget

Operating Budget (2005-06)	$4, 000
Staff	
Field Survey	
3 x Technical	12 days (4 days / person)
Office	
1 x Technical (data entry)	1 days
1 x Technical (analysis & report)	5 days
TOTAL staff commitment	**18 days (0.08 FTE)**

Data forms (below)

- FORESTCHECK Macro-vertebrate spotlighting survey form

FORESTCHECK
Macro-vertebrate - Spotlighting survey form

Location:	Observer:
Transect:	Weather Conditions:
Date:	

Distance	Time	Species	Where Animal Located	Comments

VERTEBRATE FAUNA
(MAMMALS, REPTILES AND AMPHIBIANS)

Leader
Graeme Liddelow

Members
Bruce Ward, Chris Vellios, Colin Ward and District staff and volunteers as required

Objectives
The object of this component of FORESTCHECK is to:

- Trap and record the suite of medium- and small-sized mammals, reptiles and amphibians within each FORESTCHECK grid.
- Determine species richness and abundance on each grid, and
- Analyse trends in species richness and abundance between treatments and locations.

Sex ratios and trap percentages can also be determined, and comparisons made between treatments within and between locations. Feral animal abundance is also measured.

Methods
Mammals, Reptiles and Amphibians
At each grid, 15 pitfall traps, consisting of a 20 L bucket, (25cm diameter x 40 cm deep) with a 5m long fly-wire fence constructed across the opening, are installed. Pitfall traps are located along three transects (P1, P2, P3) at points P1-1 to P3-5 within the central 1 ha area of the grid (see Fig. 1 on p.8).

Fifteen "Sheffield" wire cage traps (20 cm x 20 cm x 45 cm) are set at each grid. Trapping takes place over 4 nights in spring and autumn and Sheffield traps are located along three transects (W1, W2, W3) at points W1-1 to W3-5 within the 2 ha area of the grid (see Fig. 1 on p.8)

Traps are set on the Monday and then checked for the next 4 mornings i.e. Tuesday, Wednesday, Thursday and Friday, after which the traps are closed (pits) and or removed (wire cages). All traps are cleared by 1100 hrs each day. All animals caught are processed at point of capture, and released immediately. Species, sex, weight, point of capture, breeding status and individual marking is recorded for all mammals. Only species and point of capture is recorded for reptiles and amphibians.

At each grid, 5 wooden nest boxes (each 20 cm x 20 cm x 20 cm) are installed near each corner peg (W1-2, W1-4, W3-2, W3-4) and at the centre point (W2-3) of the central 1 ha grid area (see Fig. 1 on p.8). Each nest box is checked for occupation on each trapping day.

To monitor feral predators, 50 sand pads (1 m x 1 m, x 7 cm deep) spaced 1 km apart are installed along the road network of each FORESTCHECK location. A lure of chicken fat and tuna oil mixture is added to the centre of each pad, and the pad is brushed clean each day. Fox and cat abundance is recorded, along with opportunistic records of other feral and native animals.

Budget

Operating budget (2005-06)	$4,000
Staff	
Field survey	
3 x Technical	30 days (5 days / person x 2 sessions)
3 x District	30days (5 days / person x 2 sessions)
3 x District (additional)	12 days (2 days / person x 2 sessions)

Office

1 x Technical (data entry & validation)	5 days
1 x Technical (organise staff, analysis and report)	15 days
TOTAL staff commitment	**92 days (0.4 FTE)**

Data forms (below)

- FORESTCHECK Trapping field data form
- FORESTCHECK Sand pad data form
- FORESTCHECK Incidental Sightings form

FORESTCHECK
Trapping Field Data Sheet

Office Use Only	Location:		Treatment:				Personnel:		
Record #	**Date**	**Trap Point**	**Species**	**Weight**	**Tag #1**	**Tag # 2**	**Sex**	**Breeding Condition**	**Comments**

FORESTCHECK
Sand Pads

Record #	Pad #	Area	Species	Comments

FORESTCHECK
INCIDENTAL SIGHTINGS

Record #	Date	Location	Species	No.	Comments

BIRDS

Leader
Graeme Liddelow

Member
Chris Vellios

Objectives
The object of this component of FORESTCHECK is to:

- Count and record all birds that land in or utilize the 100 m x 100 m (1 ha) central grid area.
- Determine species richness and total abundance per grid.
- Monitor trends in species richness and abundance between treatments and locations.

Methods
Each grid is monitored five times during spring using the area search method in the central 1 ha grid area (designated by the corner points W1-2, W1-4, W3-4 and W3-2, see Fig. 1). Each census is carried out at least 7 days apart. Monitoring at each location commences at sunrise and continues until 4 hrs after sunrise in fine still weather. Each team member monitors one site (i.e. up to four grids) on any one-day and members rotate through the areas over the five counting days. Each individual census takes 20 mins and is carried out by walking around systematically within the 1 ha central grid area. Birds are detected by sight or sound and recorded on the attached field sheet.

Other guidelines for monitoring are:

- Weather permitting; all grids in at a single location are to be monitored within two days.
- No distinction will be made between sight or sound as a record.
- Only birds using the grid or those that land in the grid will be included in the count
- Birds flying over or through the grid will be noted as a species record only.

Budget

Operating budget (2005-06)	$4, 000
<u>Staff</u>	
Field survey	
2 x Technical	20 days (10 days / person)
Office	
1 x Technical (data entry & validation)	5 days
1 x Technical (analysis and report)	10 days
TOTAL staff commitment	**35 days (0.15 FTE)**

Data forms (below).

- FORESTCHECK bird census data form

FORESTCHECK
Bird Census Field Data Sheet

Area:
Treatment:

Date	Observer	Site	Wind Speed km/hr	Cloud Cover %	Time Start	Time End	RAOU Code	Male	Female	Adult	Juvenile	Unknown	TOTAL	Out of Area

NOCTURNAL BIRDS

Leader
Graeme Liddelow

Member
Chris Vellios

Objectives
The object of this component of FORESTCHECK is to:

- Record nocturnal birds present on a landscape basis over the entire area of each FORESTCHECK location.
- Determine species richness and abundance at each monitoring site.

Methods
Due to the large home ranges of owls, the recording sites need to be approximately 3 km apart. At each FORESTCHECK location nocturnal birds are monitored in each set of external control and corresponding treatment grids, at a point centrally located between those grids. Because of the generally low numbers of nocturnal birds recorded (approx 30%), each site is visited three times each in spring and autumn (six visits total).

Each census includes periods of listening (15 mins), playback (5 mins per species) and spotlighting (10 mins). The minimum time per site is 35 mins, during which two species, the masked owl and barking owl, are included in the playback. If more species are included in playback, time at the site is increased accordingly (e.g. 50 mins if 5 species are included). The sequence of calls on the playback tapes is structured so that if a bird species were heard before their playback call, it would not be necessary to play their individual call thus reducing the time required on site.

Each team member will visit each set of matched grids (external control, shelterwood, gap release) per night (i.e. 3-4 monitoring sites).

Species richness and abundance between treatments is analysed where adequate separation between grids occurs.

Budget

Operating Budget (2005-06)	$5,000
<u>Staff</u>	
Field staff	
2 x Technical	24 nights (2 nights / person x 6 sessions - 3 spring, 3 autumn)
Office	
1 x Technical (data entry & validation)	5 days
1 x Technical (analysis and report)	5 days
TOTAL staff commitment	**34 days (0.15 FTE)**

Data forms (below)

- Southwest Forest Owl Survey form

SOUTHWEST FOREST OWL SURVEY -

If found please call 08 9771 7985 WA DEC

R	Identifier	Broad Forest type	Disturbance	AMG Zone	AMG Easting	AMG Northing	Altitude (m)	Landform	Topo Position	Aspecr	Hollow Trees/ha	Undrstry Height (m)	Undrstry Density	Understorey Community	Fire	Logging
O				**50H**	**0**	**6**										

Notes

	Start Date (dd/mm/yy)	Start Time (hh:mm)	Listening	Playback	Spotlighting	Observer	MoonPhase	Moon Vis	Temp °C	Wind	Rain	Cloud %	Noise
O	/ /		15 min	10 min	10 min								

Notes

	Species Code	Count	When	How	Estimated Closest Distance (m)	Bearing	Notes
1							
2							
3							
4							
5							
6							
7							
8							
9							

INVERTEBRATES

Leader
Janet Farr

Members
Allan Wills, Paul Van Heurck, Tom Burbidge (retired 2005)

Objectives
The objectives of this component of FORESTCHECK monitoring are to:

- Monitor and record the species of invertebrates in each FORESTCHECK grid.
- Analyse trends in species, richness, abundance and composition within and between treatments.
- Monitor the presence of Gondwanan relict and affinity species.
- Monitor the presence of known insect pest species.

Methods
Sampling is conducted in spring and autumn of the following calendar year. Precise timing is dependant on weather and relies on fine days with moderately warm nights (overnight minimum preferably>10°C). Ground, understorey canopy and aerial habitats are searched. Known forest pest species, a number of determined indicator species and Gondwanan relict species are also noted in all habitats and sample grids when observed and/or captured (see Appendix 1 for summary of Gondwanan taxa).

Seven sampling strategies are used, which include two main sampling methods (passive and active):

- Light trapping for night flying invertebrate orders (passive).
- Pitfall trapping (passive).
- Area searches of ground and litter habitats (active)
- Area searches of coarse woody debris (active).
- Foliage beating (active).
- Sweep netting for day active insects, (active).
- Canopy observations of known pest species

Because sample recoveries from all methods are likely to be affected by temperature and rainfall conditions, air and soil temperatures at the start and finish of each sampling session for each sample grid and rainfall events are recorded as additional covariates.

Light trapping
Traps are a standard funnel and bucket light trap with a 12 v/8 w battery powered ultra violet light on a timing switch. One trap per grid is placed on the ground in a clear area close to the grid centre (Point W2-3, see Fig. 1 on p.8), to maximize light field attraction within the plot. A thermometer to record the overnight minimum temperature is also placed near each trap. To maximize quality of specimens and reduce specimen escape, the preferable killing mechanism is pest strips (placed in the capture bucket). However, since 2004 pest strips have been unavailable and bin pest strips are now used. Traps are open at each sample grid simultaneously for 1 night with clearance the following morning. This is repeated 3 times within each trapping season (3 wks), such that there are effectively be 3 trap nights per sample grid for each sampling season. Lights are functional from sunset to sunrise. Captures are placed in a paper bag for each site and clearly labelled with site details, date and minimum overnight temperature. Should storage over 2 days be required, the paper bag containing specimens is placed in a plastic bag and the sample frozen. Trapping periods are preferably close to a new moon to avoid light interference from a full moon, though near full moon conditions can be accommodated in one trapping night.

Pitfall trapping

Pitfall sampling is not habitat stratified. Pitfall trap sites are prepared at grid establishment by placing 10 collar guides (consisting of PVC piping 90mm diameter and approximately 150 mm long) at 10 m intervals along the sample grid diagonal which intersects the plot centre (Points P1 – P10 on Fig. 1, see p.8). Pitfall traps consist of plastic drink cups Solo® P12S (Solo Cup Company, Urbana Illinois USA, 90 mm diameter x 110 mm deep) that slip into the collar guides. Pitfalls are open for 10 days by inserting a container in each trap guide and filling it with approximately 2 cm of ethylene glycol. On trap closure and collection the containers are removed from their guides and the contents of traps 1-5 and 6-10 are combined. To enable escape should an animal fall in the hole and to facilitate trap location, a stick is placed in each collar guide. Trap catches are labelled by writing sample details in B or 2B pencil on durable card that is placed in the sample vial. Sorting is done in the laboratory.

Area searches for litter and Coarse woody debris (CWD)

Within each grid, sampling by area searches is stratified according to two main habitat types, litter and CWD. Litter searches include bare ground, moss swards and ash beds. CWD searches include on, in or under CWD and lower tree boles (below 50 cm). On each grid, a total of 1 person hour of sampling is applied to each of litter and CWD. Samples are collected in vials that are labelled with the site, date and sampling method. Samples are bagged for each site and taken back to the research base in a thermally insulated container where they are frozen. Any soft-bodied invertebrates are preserved in 70% alcohol on site before freezing. Usually, only adult insects are taken and moth and beetle larvae are not sampled due to difficulty in identification. Exceptions are very distinctive juvenile insect forms such as the dryandra moth larvae. However, Soft-bodied invertebrates such as earthworms, platyhelminthes and onychophora are included in sampling.

Foliage beating and net sweeping

Understorey canopy beating using a beating tray is conducted for 1 hr at each sample grid. Net sweeping (including targeted pursuit) is also conducted over 1hr. Samples are collected in vials, labelled and bagged for each site before freezing as above.

Observations of known pest species

Three known pest species are monitored.

1. Jarrah Leaf Miner (JLM).

The jarrah canopy is visually scanned for 10 min using binoculars. Evidence of JLM presence (e.g. shot holes in leaves) is recorded as 0 = absent, 1 = present, 2 = abundant. Abundant JLM are classed as greater than or equal to 5 shot holes per leaf present.

2. Gum Leaf Skeletonizer (GLS).

Both the upper Jarrah canopy and understorey is visually scanned (10 min) for (a) leaf damage peculiar to GLS, (b) GLS egg rafts, (c) GLS moulting casts, (d) GLS larvae. Each individual symptom is scored as present or absent. In addition a general score for abundance level will be given as 0 = absent, 1 = present, 2 = abundant (greater or equal to 5 symptom groups found)

3. Bullseye Borer.

Tree boles are scanned for borer symptoms (10 min) (e.g. kino dribble stains, bulls eyes, helical scribing in bark). Recording is 0 = absent, 1 = present, 2 = abundant. Abundant is classed as greater than 4 symptoms per tree.

Frequency of microhabitats

On each grid, frequency of microhabitats are recorded along the diagonal pitfall transect (P1-P10). An estimate is made of percent cover for litter, bare ground, moss and ash-beds at 8 intervals along the transect (intervals between 10 pitfall traps). Stems above 10 cm diameter within 1m of the transect and intersections with coarse woody debris above 5 cm diameter are also counted at 8 intervals along the transect.

Specimen processing

Sampling for FORESTCHECK invertebrates is designed to occur during a 4 week time period (variation can occur subject to site location and traveling distance between sites). Most specimens are also processed during this 4-week period (dependant on size of samples) Databasing is done later. Specimens are sorted and compared to a reference collection to establish their morphospecies assignment. The morphospecies assigned number and the abundance of that morphospecies is recorded against the site, capture method and capture date. Specimens >10mm only are considered unless they have Gondwanan associations (see Appendix 1) or are otherwise considered an indicator species. Indicator species are selected as those invertebrates that are distinctive and immediately recognizable. Indicator species are assigned to each major habitat (e.g. capture technique) and endemism is also considered (see Appendix 2 for discussion on Indicator species). When a new morphospecies is encountered the specimen is retained as a voucher (a minimum of 4 copies of each voucher is preferred). Details of the specimen are entered into the Morphospecies Master List database (see data sheet), and the next available morphospecies identification number (Voucher number) is allocated. Sample labels always include Project name, region, site number, date of collection and collection method (e.g. light trap, sweep net, CWD). Voucher specimens are either pinned (P) or kept in 70% ethanol (with a few drops of glycerine) (A) and an additional code is included to indicate whether the specimen is the original voucher (P.1 or A.1) or a duplicate (P.2 or A.2). If there is doubt about whether a specimen is different from a previous voucher, a conservative approach is followed and a new morphospecies is erected. Voucher light trap specimens and other hard-bodied insects are preserved by pinning. Soft bodied invertebrates and those captured by pitfalls are preserved in ethanol.

Example of specimen voucher label

FORESTCHECK		*FC48*
Nannup		*13/11/2005*
UV Light	*P.1*	
		1234

Specimens < 10 cm are retained and also labeled according to grid, capture date and capture method. Light trap capture remainders are returned to the capture bag and dried at 50°C for over 72 hours. Extra active capture sample specimens are bulked according to site and capture method, stored in McCartney vials in 70% ethanol and labeled as above with BULK replacing the morphospecies number.

Pitfall traps are sorted by straining samples through 0.2mm sieve and transferring to 70% ethanol in a large open dish (e.g. white enamel) to facilitate invertebrate recognition. Specimen identification usually requires examination under a dissecting microscope and comparison to vouchers. Recognised morphospecies are recorded as above and new morphospecies are numbered and labelled for inclusion in the voucher collection. Those samples not vouchered are bulked according to site and kept in 70% ethanol. Sealable glass containers (McCartney vials) are `used for permanent storage and include sample details recorded in indelible waterproof black pen on durable card.

In addition to sample sorting, an additional 2 weeks per year is spent refining the morphospecies list by working on the voucher collection.

Budget

Operating budget (2005-06)	$13,000
Staff	
Field sampling	
1 x Research	10 days
2 x Technical	26 days (13 days / person)

\Laboratory

1 x Research	30 days
2 x Technical	80 days (40 days / person)

Office

1 x Research (data entry, analysis, report)	20 days

TOTAL Staff commitment	**166 Days (0.72 FTE)**

Data forms (below)

- FORESTCHECK Invertebrates Morphospecies Master List
- FORESTCHECK Invertebrates Specimen collection Record sheet
- FORESTCHECK Pit fall (collection record sheet)
- FORESTCHECK Known pests
- FORESTCHECK Ground cover data sheet
- FORESTCHECK Light trap overnight temperatures
- FORESTCHECK Active sampling temperature sheet

FORESTCHECK Invertebrates Morphospecies Master List **FC Date……**

Page No_____of_____ **Season….....Yr…….....**

Field No	Col Met/ Habit	Tax affinity (1) Order	Tax affinity (2) (family)	Tax affinity (3)	Tax affinity (4) Genus	Tax affinity (5) Species	Length (mm)	Colour (Pred)	GR/ Icon	Spec loc	Date	Site

Tax affinity (1) = order. Tax affinity (2) = family . Tax (3) = subfamily.
GR= Gondwanan relict; GA = Gondwanan affinity; K = Indicator. Spec loc refers to whether pinned (P) or in alcohol (A)

FORESTCHECK Invertebrates Specimen collection Record sheet

Spring / Autumn **Forest Block**:
Site Location: **Collection Date**: _____
Collection Method: _____

Page of Day/Night
Observer/Recorder:

Field No	Coll Meth	Abund-ance	GR/ Icon	Specimen Status	Comments

G= Gondwanan Relict; GA = Gondwanan Affinity; K = Indicator species: Specimen Status = if erected as voucher then pinned or alcohol (pin.1 = type; pin.2 = replica of type; same applies for alcohol specimen) no of specimens can be noted in comments.
Note: Field No refers to Field No on Master List of Morphospecies

FORESTCHECK PIT FALL (collection record sheet)

Spring / Autumn **SiteLocation:**

Collection date:_________________

Page **of** **Capture method:** PIT FALL

Observer/Recorder:

Trap	Field No	Abund	GR/ Icon	Specimen status	Comments

Trap refers to trap group (eg 1= 1,2,3,4,5; 2= 6,7,8,9,10); Specimen status refers to P= pinned, A = alcohol; G= Gondwanan Relict; K = Indicator species: Note: Field No refers to Field No on Master List of Morphospecies

FORESTCHECK KNOWN PESTS

Date: **Spring / Autumn** **SiteLocation:**

Silvicultural treatment: **Logging Year:**

Observer/Recorder:

Record abundance as 0 = absence; 1 = present; 2 = abundant
Tick damage boxes when symptom observed

10 min per pest species.

Species					**Abundance**
JLM	Shot holes (>5 per leaf = abundant)				
GLS (> 5 damage or insect clusters in 1 ha = abundant)	Leaf damage (skeletonizing)	Egg rafts	Moulting Casts	Larvae	
Bullseye Borer (> 4 symptoms per tree = abundant)	Kino stain	Bullseye	Helical bark scribes		

Any additional observations regarding a pest species may be recorded below (e.g. very high levels of above pest species notable of outbreak proportions. A new pest not listed above in high numbers. Severe canopy browning. GLS fresh egg rafts in spring)

FORESTCHECK
Ground Cover Data Sheet

Forest Area.....

Site: **Date:**

Rep #	Litter	Bare Gr	Moss	Ash bed	Stems (count)	CWD (count)
1						
2						
3						
4						
5						
6						
7						
8						

Number refers to estimated % area covered along FORESTCHECK invertebrate pitfall transect.
Count of stems is count of stems above 10 cm diam within 1m of transect
CWD is count of coarse woody debris above 5 cm diameter.

Site: **Date:**

Rep #	Litter	Bare Gr	Moss	Ash bed	Stems (count)	CWD (count)
1						
2						
3						
4						
5						
6						
7						
8						

Number refers to estimated % area covered along FORESTCHECK invertebrate pitfall transect.
Count of stems is count of stems above 10 cm diam within 1m of transect
CWD is count of coarse woody debris above 5 cm diameter.

FORESTCHECK **Rep no……..**

Light trap Overnight Temperatures

Forest Area:.....

Site	Date	Min O/N Temperature	Comments

FORESTCHECK
Active Sampling Temperature Sheet

Forest Area:.....

Site	Date	Time	Soil Temp	Air Temp	Comments

APPENDIX 1
Indicator Species, Gondwanan and others, for SW Jarrah Forest

(*** Gondwanan relic; ** Gondwanan affinity; * taxa of note)

Order, Tax affinity	Family	Species	Comment
Collembolla	Hypogastruridae Isotonidae Sminthuridae	Many species introduced *Folsomides parvulus*	Important ecologically, but GA's limited due to world-wide distribution. Presence/absence may be sufficient (Too small for visual seaches)
Diplura	Campodeidae	*Metriocampa spinigera* *Notocampa*	**? Not recorded in SJF, Gondwanan dist **
Thysanura			GA not mentioned in CSIRO
Ephemeroptera	Leptophlebiidae **	75% genera indigenous to Australia	Most primitive order of living winged insects. Aust biota result of Gondwanan dispersal (difficult to catch using FC techniques).
Odonata**	Gomphidae*** Aeshnidae*** Petaluridae*** Corduliidae*** (Sythemistinae)	40% Gondwanan	*** Problem, water associated, will need net to catch
Plecoptera**	Grpopterygidae***		*** definite Gondwanan
Blattodea?		*Methana*, *Polyzetria* are oriental; *Tryonicus* New Caledonian; *Celatoblatta* NZ. All others are confined to Australia	Due to diversity, GA difficult to pin point.
Isoptera	Temopsidae**(not in SJF)	*Porotermes*** (not in SJF) *Stolotermes*** (not in SJF)	
Mantodea	Amorphoscelidae		
Dermaptera	Pygidicranidae**	Dacnodes shortridgei	
Orthoptera	Grylloidea*(Gryllotalpidae) Tettigoniidae Acrididae	44% endemism 100% endemism 90% endemism	* Primitive
Phasmatodea			None recorded in SJF
Poscoptera			GA's not strong
Hemiptera	Cicadellidae** Corixidae** Lygaeidae** Miridae** Psyllidae* Coccoidea Eurymelidae Thaumastocoridae**	Leaf hoppers Root feeders Seed and vertebrate blood Evolved from Gond biota Evolved from Gond biota Endemic Gond. relictual distribution	Order contains ancient and recent insects.
Megaloptera***	Corydalidae	*Archichauliodes cervulus***	Endemic to WA
Neuroptera*	Ithonidae Myrmeleontidae	Almost entirely Aust 100% Australian	Over 90% of Australian species endemic
Coleoptera	Carabidae** Dermestidae** Tenebrionidae** Leiodidae** Staphylinidae** Trogossitidae** Zopheridae**		Most diverse insect order.

Order, Tax affinity	Family	Species	Comment
	Anthicidae**		
	Ptiliidae**		
	Curculionidae	Belidae***, Amycterinae***	
	Cerambycidae	*Phoracantha acanthocera*	Pest
Mecoptera	Meropeidae	*Austromerope*	Endemism high for all families
Diptera	Psychodidae**	Nemopalus (not in SJF)	
	Asilidae**		
	Tabanidae**		
	Bombyliidae**		
	Apioceridae		
	Therevidae		
Trichoptera	Limnephilidae (super fam)	Case builders-divergence of Super family related to break up of Pangaea. *Apsilochorema urdalum, Taschorema pallescens Kosrheithrus boorarus*	79% species endemic in SW, several families have GA's. The primitive family Limnephilidae has no records in SJF. The family Plectrotarsidae is endemic to Aust. For SW species 70% are restricted to region. Again, aquatic associations.
	Plectrotarsidae** (only member of Super fam. in SJF)		
	Hydrobiosidae ? (according to Hopper *et al*.)		
	Philorheithridae (according to Hopper *et al.*)		
Lepidoptera	Hepialidae**	*Perthida glyphopa* (JLM)	)Archaic families but
	Incurvarridae**		) radiation unclear.
	Cossidae** (GA debated)	*Synemon directa*	)Gondwanan elements
	Castniidae***		) in some groups
	Noctuidae	*Uraba lugens**(GLS)	) JLM & GLS pests
Hymenoptera	Pergidae**	Sub f. Philomastiginae	Others listed in former notes less conspicuous
	Ichnuemonidae**	Sub f. Labeninae	
	Tiphiidae**	Sub f. Thynninae	
	Pompilidae**	Sub f. Epipomilina	
	Myrmecinae		
Aranea (spiders)	Actinopodidae**	*Missulena* sp	Easy to spot. Look for burrows. Bath plug doors or silk collars.
Infra order	Idiopidae**	Trap doors	
Mygalomorphae	Ctenizidae**	Form of trap door	
Pseudoscorpionida	Garypidae***		Pseudoscorpions (under rocks, bark, damp regions of tree trunks, leaf litter)
Phylum: Onychophora	Peripatus***		As for pseudoscorpions

All species and families listed are present in southern jarrah forest unless otherwise indicated. Species list obtained from Abbott (1995) and Hopper *et al.* (1996).

Summary of Gondwanan groups

Odonata	all
Plecoptera	all
Dermaptera	most
Orthoptera	some
Hemiptera	many
Megaloptera	all
Neuroptera	some
Coleoptera	many including Belidae and Amycterinae
Mecoptera	most
Diptera	some
Trichoptera	Limnephiloidea
Lepidoptera	notably Hepialidae, Incurvarridae, Cossidae, Castiniidae
Hymenoptera	some including Ichneumonidae, Pompillidae and Thynninae
Aranea	Mygalamorphs and Missulena
Pseudoscorpions	
Peripatus	

References used to determine Gondwanan taxa

Abbott, I. (1995). Prodomus of the occurrence and distribution of insect species in the forested part of south-west Western Australia. *CALMScience* 1: 365-464.

Hopper, S., Chappill,J., Harvey, M., George, A. (eds) (1996). *Gondwanan Heritage*. Surrey Beatty & Sons, Sydney.

Grimaldi D., Engel M.S (2005) *Evolution of the insects*. Cambridge Press

APPENDIX 2
Invertebrate species nominated as Indicator species

Overview

An objective process for identifying a subset of collected species as indicators of forest health and biodiversity following disturbance is necessary. We term these monitored species "Indicator" species. Some suggestions by Taylor and Doran (2001) Journal of Insect Conservation 5: 221-231 are cogent to the nomination of indicator or "representative" species.

Stratification according to important microhabitats.

> "We suggest species are chosen to be representative by ensuring that species selected cover major important microhabitats represented in forests. We favour the following categorisation: soil and litter, foliage and canopy, bark and branch, dead standing trees and coarse woody debris.
> "Note: Fauna of dead standing trees and branches are not directly sampled in FORESTCHECK monitoring due to logistic and safety constraints.

Inclusion of worst-case responses or most sensitive species.

> "(There are) mechanisms … to assist in conservation of fauna at regional level rather than harvesting unit level … Examples include: riparian reserves, wildlife corridors, larger reserves … Species that are not catered for at a harvesting unit level will have to rely on these … mechanisms."
> i.e. Species with populations destroyed within coupes by harvesting disturbance should to be considered as indicator species and their continued presence monitored on buffers and areas excluded from logging, as well as the reappearance of viable populations in disturbed habitat.

Precautionary selections to cater for the unanticipated.

> As a precautionary measure, there should be nominated "a selection of species, possibly chosen on the basis of their ease of monitoring and covering a range of functional groups, as a means of endeavouring to pick up adverse impacts that had not been foreseen."

Some factors of relevance to selection of FORESTCHECK invertebrate indicator species

In selecting indicator, or monitored species, several factors can be identified as important in *a posteriori* selections.

Geographical scale of conservation strategy

Distribution of species across sampled sites may relate to species geographical distribution and/or habitat preferences. Species that are abundant in samples, have regional distributions, and which also exhibit clear disturbance responses would be the closest to ideal indicator species.

Regional conservation**:** Tens of kilometres between site clusters.
- Species present across region
- Species within controls, buffers and coupes
- Species within buffers and controls only
- Species within coupes only

Harvesting unit conservation: A few hundred metres between coupe and buffer pairs of sites.
- Species present only within single cluster of sites
- Species within single coupe and buffer pair
- Species within single coupe
- Species within single buffer or control.

Qualitative differences within and between coupe and buffer/control habitat

Distribution of species within sites may relate to microhabitat preferences. Microhabitat extent and abundance are related to disturbance histories.

Species collected by more than one sampling strategy
Species collected by only one sampling strategy
- Light trap
- Pitfall trap
- Litter
- CWD
- Bark
- Foliage beat
- Sweep net

Seasonal differences

Species collected spring and autumn
Species collected only spring
Species collected only autumn

Relict/primitive species

Species designated Gondwanan relicts. i.e. primitively of southern origin.

Species must be of sufficient body size to enable easy visual appraisal of identifying features.

Light trap.
- Coleoptera >10mm
- Lepidoptera and other alates >about 13mm unless very distinctive.

Pitfall
- All specimens >10mm

Active searches
- All specimens >10mm unless very distinctive.

CRYPTOGAMS

Leader
Ray Cranfield

Objectives
The object of this component of FORESTCHECK is to:

- Monitor and record species richness and diversity of lichens, moss, and liverworts on each FORESTCHECK grid.
- Compare species richness and cryptogam community structure between treatments.
- Record habitat and substrate preference of each taxon.
- Monitor changes in species richness and composition on substrates and at various strata levels between treatments over time.
- Identify possible indicator species.
- Compile a detailed species list of cryptogams for jarrah forest.
- Determine species distributions.

Methods
Monitoring is generally carried out in the winter but it may also be undertaken in the spring if necessary. At each FORESTCHECK grid, the presence of taxa is recorded during a walking foray search of the outer perimeter of the grid. Voucher collections of each taxon are made from each grid, identified, processed, databased and then curated at PERTH. Vouchers are also used to confirm identities on uncertain or unknown taxa.

In the next round of monitoring (2007 onwards) cryptogams will be monitored using a 200 m line-transect (1 m wide) 10m outside and adjacent each lateral boundary of the grid (i.e.T1 and T2 on Fig. 1, p.8). Presence and absence of each taxon will be recorded on each 50 m section of transect. Frequency of each taxon will then be scored out of 8.

For each taxa the substrate and the level of the strata on which they are located is recorded. The substrate types are:

- Wood
- Bark
- Anthill
- Soil
- Stone
- Organic matter
- Charcoal

The strata levels are:

- 0 – 30 cm (ground level)
- 31 – 300 cm (shrub layer)
- 301 cm (tree layer)

All taxa are recorded, with the long-term goal to identify possible ‘indicator’ species.

Budget

Operating Budget (2005-06)	$5,000
Staff	
Field sampling	
1 x Technical	5 days
Laboratory (specimen ID, voucher processing)	20 days
Office	
1 x Technical (data entry and validation)	5 days
1 x technical (data analysis, report)	13 days
TOTAL staff commitment	**43 days (0.19 FTE)**

Data forms

- FORESTCHECK Collecting Book Data Sheets for Herbarium Cryptogam Voucher specimens

FORESTCHECK
Collecting Book Data Sheets for Herbarium Cryptogam Voucher specimens

Site No.: Associated Vegetation:

B G Muir Classification:

Life Form Density Classes (LFDC): Horizontal View Distance (HVD):

Floristic Richness: 0-20 21-50 51-100 100 + species

Habitat: Plain/ Valley/ Breakaway/ Outcrop/ Hill/ Dune/ Ridge/ Flood Plain/ Water Course/ River/ Lake/ Pool/ Swamp/ Wetland/ Salt Lake/ Modified/ Other

Microhabitats: Soil/ Stream banks/ Litter or organic mats/ Stones/ Rock sheets/ Overhangs crevasse/ Logs burnt unburnt decaying/ Shrubs alive dead/ Trees alive dead/ Other

Site Aspect: N S E W

Site Modifier: open closed exposed mist layered

Slope of area: (angle of inclination): ^{0} ☐

Weed Abundance: nil ☐ few ☐ common ☐ abundant ☐

Dead Plants (in an area): Absent / Present/ % of Population:

Fire History (year): Time of Fire: A / S / Su / W /

Fire Type: Wild/ Controlled

Erosion/ Disturbance: Absent / Present Type of Erosion: Water/ Wind/ other

Soil Surface: Bare/ Littered/ Gravely/ Stony/ Cryptogamic/ Crusted/ Compacted/ Loose/ Soggy/ Moist/ Dry/ Modified/ other

Litter Depth (cm):

Litter Condition: new / old / broken down

Soil Colour: Red/ Brown/ Yellow/ Black/ White/ Grey/ Mottled/ other

Soil Type: Sand/ Clay/ Loam/ Sandy Clay/ Clayey Sand/ Peaty/ other

Soil pH: Underlying Geology:

Type of Rock Outcropping: % of Area:

Locality:

Map Sheet: Contour Range (altitude):

Latitude: º ‘ “S Longitude: º ‘ “E

GPS Fixed: Y N

Collector(s): Date:

Collecting Book Species Data Sheet

Det Name:	Field Ident:
Family:	Collection No:
Biotic Type:	Epiphyte/ Saprophyte/ Parasite/ Free living
Growth Phase:	Dormant/ Active/ Vegetative/ Fruiting/ Desiccated/ Stressed/ other
Growth Substrate:	Exposed/ Sheltered/ Wet/ Dry/ Wood (alive/ dead)/ Bark (alive/ dead)/ Leaf (alive/dead)/ Charcoal/ Ant Hill/ Soil/ Stone (epipetric)/ Dung/ Organic Material/ other
Facultative Host:	
Associated cryptogams:	
Stratal position:	ground level (0-30 cm) shrub layer (31cm-3m) tree layer (3.5 m+)
Frequency of Occurrence (Micro):	Numerous/ Frequent/ Occasional/ Solitary/ Localised
Site Area Frequency:	Abundant/ Frequent/ Occasional/ Isolated/ other

Taxa Description

Lichen				
Thallus:	erect / immersed / appressed / not obvious			
Thallus Colour	Wet/ Dry	upper surface		lower surface
Spore/ Fruit Bodies:	Absent/ Present/ other			
Colour:				
Substratum:	Saxicolous (rock)	Terricolous (soil)	Corticolous (wood/bark)	
Liverwort/ Hornwort				
Thallus Colour	Wet/ Dry			
Spore/ Fruit Bodies:	Absent/ Present/ other			
Substratum:	Saxicolous (rock)	Terricolous (soil)	Corticolous (wood/bark)	
Moss				
Plant Colour:	Wet/ Dry			
Spore/ Fruit Bodies*:*	Absent/ Present/ other			
Substratum:	Saxicolous (rock)	Terricolous (soil)	Corticolous (wood/bark)	
Algae				
Habit:				
Colour:				
Habitat:	Marine / Fresh Water / Terrestrial / Organic material / Other			
Substratum:				

Chemistry:	**Cortex**	**Medulla**		
	K	K	P	
	C	C	I	N
	KC	KC	UV	

MACROFUNGI

Leader
Richard Robinson

Members
Julie Fielder, Bob Smith (retired 2006)

Objectives
Fungi play three major and very important roles in forests, acting as (i) nutrient suppliers to plants (in the form of mycorrhizas), (ii) nutrient recyclers (decomposers) and (iii) pathogens. In addition they are a significant component of the biodiversity of forest ecosystems. The objectives for this component of FORESTCHECK are to:

- Monitor and record the species richness of macrofungi and abundance of fruit bodies in each FORESTCHECK grid
- Analyse trends in species richness, abundance and composition within each treatment and between treatments
- Record substrate utilisation
- Monitor changes in species richness, abundance and composition on substrates within and between treatments over time.
- Generate detailed descriptions of unknown and unnamed species
- Compile a detailed species list of fungi for the jarrah forest

A potential method of monitoring change is to determine the change in ratio of mycorrhizal, saprotrophic and pathogenic fungi. Knowledge on certain species of fungi in all these groups is available. Monitoring the presence and absence of these species over a long time frame may indicate what ratio of M:S:P is present on the monitoring sites. Although the M:S:P ratio cannot be interpreted as yet, in time it may be possible to determine which M:S:P ratio is indicative of a healthy forest, and how or if management treatments affect this ratio.

Methods
On each grid, macrofungi are recorded on 2 x 200 m line-transects (T1 and T2 on Fig. 1, p.8). The origin and end of Transect 1 is 10 m to the right of W1-1 and W1-5 respectively. The origin and end of Transect 2 is 10 m to the left of W3-1 and W3-5 respectively. Each transect is divided into four 50 m sections marked by droppers at 0, 50,100, 150 and 200 m. The width of each transect is one metre.

Each grid is monitored twice on a fortnightly basis in autumn. For each 50 m of transect, all species of fungi and the number of fruit bodies is recorded. Species frequency is used as a measure of how common a species is on a grid and is determined by the number of transect sections in which it is recorded on each grid (i.e. a score out of 8). For each species the substrate on which it occurred is also recorded as well as its life-mode status (mycorrhizal, saprotrophic or parasitic).

Voucher collections are made of each species collected at each FORESTCHECK location. All species are photographed *in situ* in the field. Species identification is confirmed in the laboratory. For unknown or undescribed species, detailed morphological descriptions of macro- and microscopic characters are compiled.

Budget

Operating Budget (2005-06)	$6, 000
Staff	
Field	
1 x Research	10 days
2 x Technical	20 days (10 days / person)
Laboratory	
1 x Research	5 days
1 x Technical	20 days
Office	
Research x 1 (analysis, report)	10 days
1 x Technical (Data entry and validation)	5 days
TOTAL staff commitment	**70 days (0.30 FTE)**

Data forms

- FORESTCHECK Fungi monitoring form

FORESTCHECK
FUNGI MONITORING

Site: Date:

Grid #: Transect No.: Asessed by:

Dist. (m) on transect	No. of Fruit bodies	Subs-trate*	Species / Comments	Sp. N^{o.}	Coll. N^{o.}

* (S) soil, (L) litter, (T) twig < 2 cm diameter, (W) wood, (D) dung

DATABASE MANAGEMENT AND STORAGE

Leader
Amanda Mellican

Member
Verna Tunsell

Objectives
To maintain and manage the hard copy and the electronic copy of the recording sheet for each group.

Methods
Categorizing of variables
After all field data sheets are finalized for each group, consultation with an expert from each group defines the classification of each variable (type: character or numeric and allowable values). Then, all necessary descriptions and explanations of the variables are recorded in a Microsoft EXCEL worksheet (namely DESCRIPTIONS.XLS).

Creation of a database file
A database file for recording data are created in a Microsoft EXCEL worksheet (namely FIELD-DATA-SHEET.XLS). For each of the categorized variables, such as species code and vegetation life form, a pull down menu is provided.

Data Entry, validation and storage
The DESCRIPTION file and the FIELD-DATA-SHEET file are provided to the officer in each group responsible for data entry. Data are entered onto the FIELD-DATA-SHEET file. In addition, a metadata form (appendix A) is provided to each data entry officer to record the file name, file size and the date that the data entry was completed. The original field sheet, the metadata form and the database file, FIELD-DATA-SHEET**,** is then returned to the database co-ordinator.

Data validation and storage
The co-ordinator validates the data and indicates the validation on the metadata form.

The DESCRIPTION file and the FIELD-DATA-SHEET file are backed up on to Science Division network drive and on the PC of the database co-ordinator at Science Division, Kensington. The files are also saved in TEXT format, so that they are easily retrievable.

All the data from the DESCRIPTION file and the FIELD-DATA-SHEET file is printed and kept as a hardcopy in the co-ordinator's office at Science Division, Kensington.

All the individual sampling data are saved and backed up as individual files. Over time a Microsoft EXCEL file is to be created. This will contain the accumulated data of every individual sampling.

The original field sheet is returned to the team leader with the electronic copy (in EXCEL, by e-mail).

The location of recorded data, the file name, file size, file type, the date and time they were saved, and the description of the file is recorded on the metadata form. (Appendix B).

Requirements
Allocated space on the network drive.

Data Co-ordinator Amanda Mellican
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Technology Park
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Budget
No operating budget

Staff

1 x Technical (data entry, Herbarium database entry, Annual Report) (NB. Does not include 73 days (0.32 FTE) as part of data entry and validation shown in individual sections above).	158 days
1 x Research	46 days
TOTAL staff commitment	**204 days (0.88 FTE)**

Data forms (below)

- Metadata Form for Data Entry
- Metadata Form for Storage

APPENDIX A - Metadata Form for Data Entry

Group Name →

Leader →

Contact Officer →

No	File Name	File Size (KB)	Date entered	Name of Data Entry Person	Validated Date

Appendix B - Metadata Form for Storage

Group Name →

Leader →

Contact Officer →

Location 1 (DEC Network dive) →

Location 2 (on PC) →

No	File Name	File Size (KB)	File Type	Date and Time	Description of the file name