MONITORING BIODIVERSITY IN SOUTH-WEST FORESTS

OPERATING PLAN

FOR SPRING 2002 and AUTUMN 2003

Science Division

Government of Western Australia

DEPARTMENT OF Conservation AND LAND MANAGEMENT

Conserving the nature of WA

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 Western 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), 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 will only fund the part of FORESTCHECK that is specific to its activities).

FORESTCHECK has been 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. 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 has taken place over 2 yrs and has included input from scientists and managers within the Department of Conservation and Land Management, and from a number of external scientific agencies. Background to this process is described in the FORESTCHECK Concept Plan.

The purpose of this Operating Plan is 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.

A significant deviation from the original concept plan has been that the Science Division will now take 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 the 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 funding provided by the FPC through a service provider agreement (to be developed).

Sampling strategy

Timber harvesting in Jarrah forests is currently 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 other forest values until the ground coppice is developed and capable of responding to release.

Monitoring will focus on the gap creation and shelterwood treatments initially 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 will take place at a number of locations throughout the forest, which will be referred to as FORESTCHECK sites. Sites will be stratified according to recognized ecological gradients of rainfall, evapo-transpiration and soil fertility and will be allocated according to mapped forest ecosystems. Allocation of sites will also take 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 will consist of up to 4 sampling grids. Grids will be established in forest subject to the following treatments:

(1) gap release,
(2) shelterwood,
(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.

The intention is that grids be 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 will be found in the one locality and it is expected that external reference forest may have to be located some distance from their harvested counterparts. It may not 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, as have previous silvicultural activities.

For spring 2001, 3 FORESTCHECK sites were established in the Darling Plateau subregion (Bevin and Mattaband vegetation complexes of Mattiske and Havel 1998) located in Kingston, Yornup, Thornton, Carter and Easter forest blocks. Three or four additional sites are scheduled for establishment in each of 2002 and 2003, and will probably be located in the Blackwood Plateau subregion (Kingia vegetation complex of Mattiske and Havel 1998) and in the Darling Plateau subregion (Dwellingup and Yalanbee vegetation complexes of Mattiske and Havel 1998). It is envisaged that each site will be resampled every 5-10 yrs.

Methodology

A range of ecosystem attributes will be monitored at each site, as follows:

1. Vertebrate fauna (birds, reptiles, frogs, mammals)
2. Invertebrate fauna
3. Vascular plants, cryptograms and soil
4. Foliar nutrients and tree growth
5. Macrofungi and coarse woody debris.

Sampling methodologies for each set of ecosystem attributes 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. will also be recorded.

Monitoring of biodiversity will be based on a sample grid, illustrated below. The main grid is 100 m x 100 m, with 30 m x 30 m vegetation sample plots at each corner. Details of sample design and protocols for each element of the biota are provided below.

Before commencing measurements, each FORESTCHECK site will be located in the field, the sample grids installed and then the various monitoring protocols for each taxonomic group (discipline) established on the grid. The figures below are a breakdown of the estimated costs of establishing an individual (single) monitoring grid (there will be 3-4 grids per site). These costs are largely one-off.

Grid Costs

Item		Cost ($)
Droppers		198
Tophat Pegs		20
Buckets for Pit traps		93
Netting for Pit traps		58
Marker Tags	Vegetation	17
	Invertebrates	6
	Fungi	5
	Soil	8
	Cryptograms	11
	Wire Traps	12
	Pit Traps	12
Marking Tape		9
Spray Paint		20
Marker pens		10
Invertebrate Pits		10
Shovel & Crowbar		100
Materials/grid		**589**
Vehicle costs/grid		**281**
Total plant + materials/grid		**870**

The set up will require about 8 people for 1.25 days or 12 person days; approx $2,100 (excluding overheads).

All of the separate budgets detailed subsequently in this plan have been collated into one table, presented overleaf.

Consolidated budget table

Estimate of costs to establish and monitor one site of 4 sampling grids for the first year (except for soil, which is based on 3 grids)

Task/Activity		One-off costs [a]	Materials (inc travel)	Vehicles	Data entry	Ord OT		Person days Tech Scientist	Salary	Salary OH
Grid establishment			2360	1125				48		8160
Road surveys (verts.)				1140		3570		cost@OT		
Birds (grid census)			100	1100	320			20		3400
Birds (nocturnal)		500		450	50	1200		cost@OT		
Fauna (grid trapping)	Standard		600	600	130			20		3400
	Kingston		600	900	150			32		5440
Invertebrates		2900	800	1000	300			10	5	2690
Flora		2000	150	900	1300			7	7	2574
Soil and foliar nutrients			5000							
Forest structure			600	300	600			8	2	1755
Soil disturbance		5000	1500	1575	1000			40	20	10760
Macrofungi			660	1000	500			4	5	1670
Total cost for first site established										**44849**
Standard grid		10400	7370	9190	4350	4770	**36080**	157	39	**34409**
Kingston grid		10400	7370	9490	4370	4770	**36400**	169	39	**36449**
GIS (Arc View)		3030 [b]								
Cost for each site established subsequently							**25680**			**34409**

(a) One-off costs include: bird census equipment (1 set); invertebrate sampling and storage equipment; digital camera; dust extraction system for processing of soil bulk density cores.
(b) This item is not essential for the first year, but should be purchased in year 2.

MACROVERTEBRATES

Leader
Graeme Liddelow

Members
Ian Wheeler, Chris Vellios, Colin Ward, Bruce Ward, John Rooney plus three other people as required.

Objectives
To count the numbers of large vertebrates (Grey kangaroo, Brush wallaby, Emu etc.) which have a large home range that exceeds the size of the FORESTCHECK grid and because of their size are excluded from trapping.

Reporting will be by number of individuals by species on a per kilometre basis.

Methods
Each species will be counted on a 2 x 20 km long road transect in a vehicle from 1 hr before sunset until 15 minutes after sunset. Each transect will have a team of 2 people (driver and observer) and the vehicle will travel at 20 km/hr. Each recording will include 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 will be repeated on 2 consecutive nights during the week of the spring/summer pit trapping and also during the autumn medium-sized mammal trapping.

			Costs ($)
Vehicles	travel to site and home	300 km @ $.50	150
	travel on transect	40 km @ $.50	20
		Total	**170**
Overtime	@ $22/ hr x 1.5 x 3 hr	Per person	99
		3 people	297
		x 3 sites	891
		x 2 nights	1782
		x 2 seasons	3564
		Total	**5604**
Additional costs	Travel to and from Harvey	320 km @ $0.50 x 2	320
		Total for Harvey	3884
TOTAL			

Data analysis
Number of individuals per kilometre by species.

Note: This transect will be on a landscape or block basis and not on a plot or grid as with other aspects of this monitoring. Time will be allocated in the set up phase of this monitoring to select a suitable transect.

FORESTCHECK
Macrovertebrate /spotlighting survey form

Location:			Observer:	
Transect:			Weather Conditions:	
Date:				
Distance	Time	Species	Where Animal Located	Comments

BIRDS

Leader
Graeme Liddelow

Members
Ian Wheeler, Chris Vellios.

Objectives
To count and record all birds that land in or utilize the 100 m x 100 m (1 ha) grid with no distinction between sight or sound recording. Birds flying over or through the grid will be noted as a species record only.

Reporting will be by species richness and total abundance per grid as well as trends of species richness and abundance.

Past experience indicates that there will be too few records to analyse the data in any great detail.

Methods
Each site will be censused 5 times during spring using the area search method in the central 1 ha core grid. Each census will be carried out at least 7 days apart. Censuses will commence at sunrise and continue until 3 hrs after sunrise in fine still weather. Each team member will census one site (i.e. 4 grids) on any one day and members will rotate through the areas over the 5 counting days.

Individual censuses take 20 mins for the 100 m x 100 m grid and the team member will spend that time walking around the grid recording on the field sheet (attached) all the birds detected by sight or sound.

		Costs ($)
One person for 5 days = 5	For 3 sites = 15 person days	
Vehicle	(1) Travel to/from Harvey	1000
	(2) for 550km @ $.50	825
Data entry and validation	5hrs @ $16	240
Consumables		60
Accommodation costs	10 nights @ $145	1450
TOTAL		**$3555**

Other costs that may occur would be overtime if members stay at work all day after the early start. This can be eliminated by members going home after 8 hrs (preferred option).

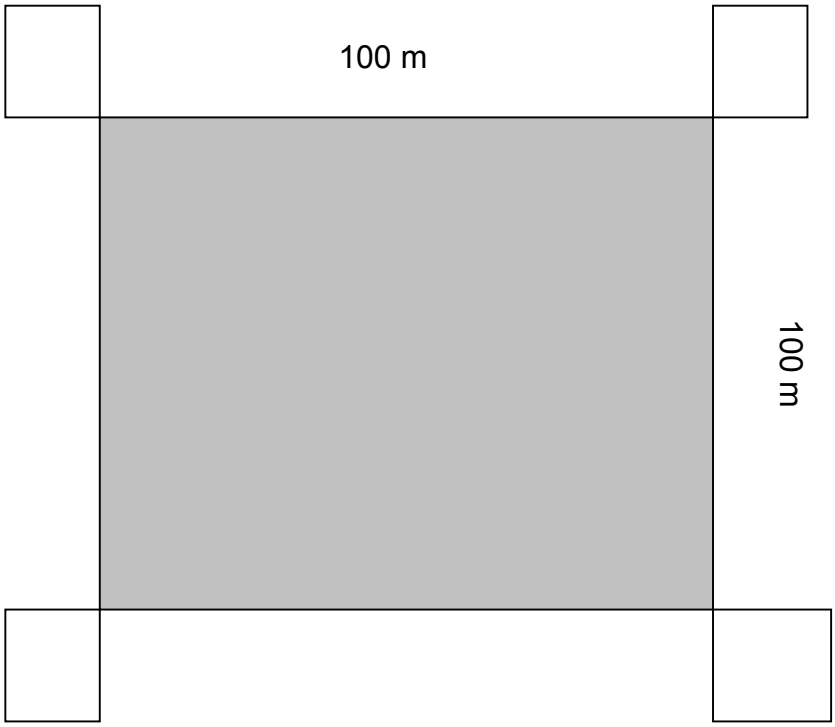
Data analysis
Total abundance, species richness, individual species trends and comparisons between treatments i.e. external reference area, coupe buffer, shelterwood and gap with time since treatment.

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

FORESTCHECK
Bird census grid



- The bird census is carried out within this 100 m x 100 m core check grid.
- 20 minutes is spent in each grid walking around and recording the birds of the area.
- Each grid is visited five times in spring with a minimum of 7 days between visits.
- Team members will rotate between grids.
- Team members will census all 4 grids in one area on the day.
- No distinction will be made between sight or sound as a record.
- Only birds within the grid or those that land in the grid will be included in the count.

NOCTURNAL BIRDS

Leader
Graeme Liddelow

Members
Ian Wheeler, Chris Vellios.

Objectives
To record the nocturnal birds present

Methods
Due to the large home ranges of owls, the recording sites need to be approximately 3 km apart. At each FORESTCHECK site nocturnal birds will be censused in the external control and within the treatment area at a point centrally located between areas that have been logged. Because of a low recording rate of nocturnal birds (approx 30%), each site will need to be visited 3 times in each season, i.e. spring and autumn equals 6 visits in total.

Tasks at time of census include Listening (15 mins), Playback (5 mins per species) and Spotlighting (10 mins). A minimum time per site would be 35 mins where only 2 species are included in the playback. It would be preferable to include 5 species in the playback sequence; this will necessitate 50 minutes per site. The sequence of calls on the playback tapes will be 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 only one site per night (2 census locations) and will rotate through the other areas in the season, visiting each area once.

Each area will require

Costs		**Costs** ($)
Vehicle to Collie	3 visits of 500 km / visit 1500 km @ .50c = $750 / visit x 2	1500
Data entry	2 hrs @ $16 / hr	32
Overtime for 3 hrs	X 2 nights x 3 counts x 2 sessions	1188
Equipment		500
Accommodation	12 nights @ $145 / night	1740
TOTAL		**4960**

Data analysis
Species richness and measures of abundance.

MAMMALS, REPTILES AND AMPHIBIANS

Leader
Graeme Liddelow

Members
Bruce Ward, Colin Ward and Chris Vellios

Objectives
To trap and record the suite of medium- and small-sized mammals, reptiles and amphibians within the FORESTCHECK grid.

Mammals will be individually marked and records of their species, sex, weight and breeding status noted. Reptiles and amphibians will be recorded by species only.

Methods
Mammals, Reptiles and Amphibians
Pitfall traps, (20 L buckets; 25 cm wide x 40 cm deep) with a 5 m long flywire fence, will be established. Wire cage traps (20 cm x 20 cm x 45 cm).

Traps will be set on the Monday (see plot layout attached) and then run for the next 4 mornings i.e. Tuesday, Wednesday, Thursday and Friday, after which the traps will be closed (pits) and or removed (wire cages). All animals caught will be processed on the site of capture, then released immediately. Species, sex, weight, point of capture, breeding status and individual marking will be recorded for all mammals and only species and point of capture recorded for reptiles and amphibians (see field sheet attached).

Trapping will be for small mammals, reptiles and amphibians in both spring and autumn. Both trapping sessions will also include checking of nest boxes for the presence of phascogale/mardo. Each day of trapping will also require checking across the landscape of approximately 50 1 m x 1 m x 7 cm deep sand pads spaced apart along tracks to be checked for fox and cat abundance. A lure of fish oil and chicken fat is buried in the centre of each pad, and the pad is brushed clean each day. Sand pads will also record Chuditch tracks.

Costs		**Costs** ($)
Vehicle to Collie and on site	@ 2000 km / session x 2 sessions = 4000 km	2000
Nest Boxes	45 @ $12	540
Data entry	24 hrs @ $16 / hr	384
Consumables		300
Ear tags		100
Bait material		100
Sand for pads		700
Accommodation	4 people per session = $2320 x 2 sessions	4640
TOTAL		**$8664**

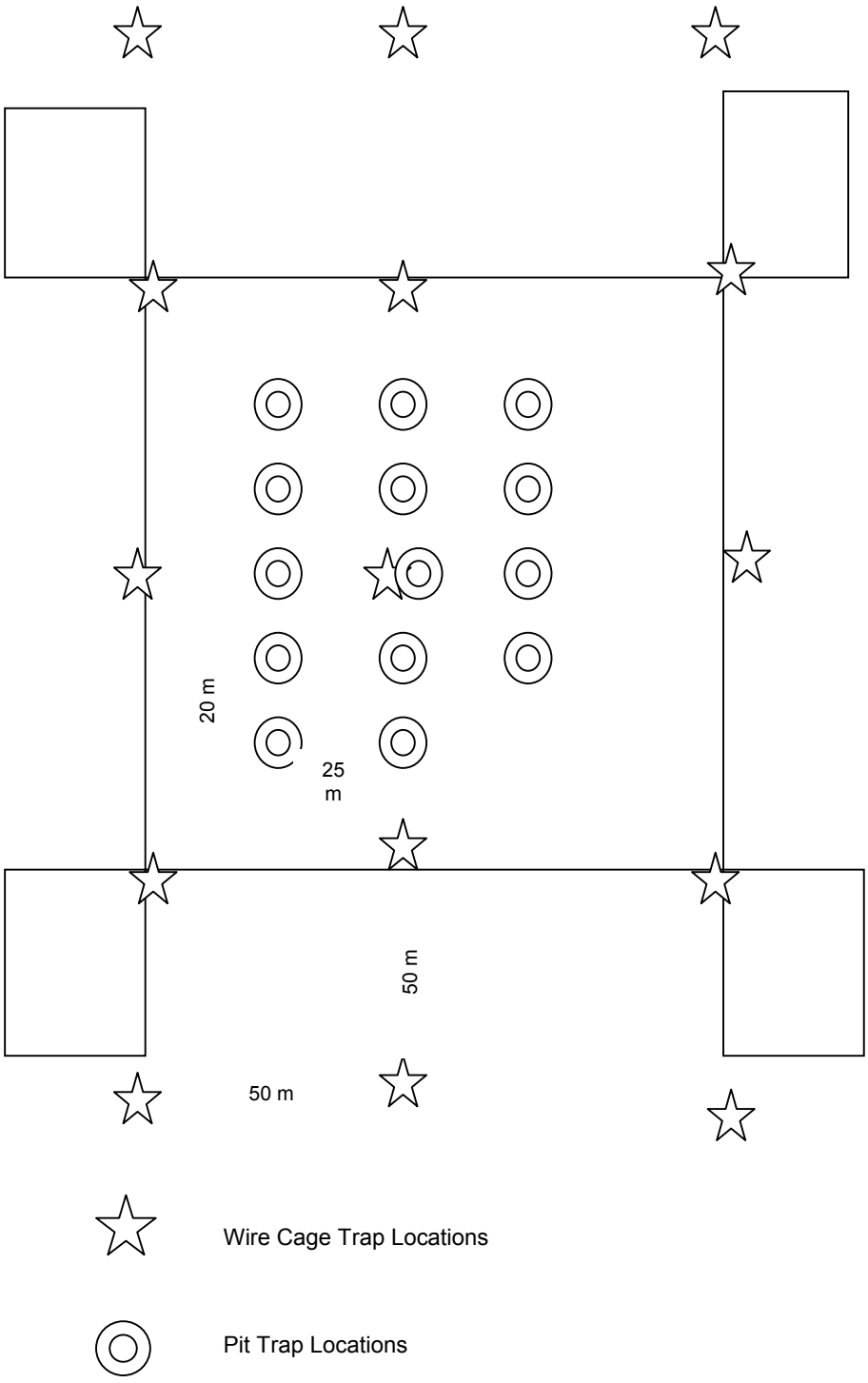
Data analysis
Species richness, abundance, sex ratios, trap percentages, and comparisons between treatments within the site and with other areas. Feral animal abundance will be measured.

FORESTCHECK
Trapping field data sheet

Location:	Treatment:	Date: Personnel:

Trap Point	Species	Weight	Tag #1	Tag #2	Sex	Breeding Condition	Comments

FORESTCHECK
Trapping grid layout



INVERTEBRATES

Leader
Janet Farr

Members
Allan Wills, Tom Burbidge

Objectives
FORESTCHECK invertebrate monitoring in Jarrah silvicultural systems is intended to provide a method to easily capture data describing the abundance and community composition of readily visible and highly identifiable components of the invertebrate fauna. The data are intended to provide a means for long-term monitoring of the state of recovery of invertebrate fauna following disturbance imposed by particular silvicultural regimes. Ground, canopy and aerial habitats will be searched. In addition, Gondwanan relic invertebrates will be noted in all habitats when observed (see appendix for summary of Gondwanan taxa).

Design
The design is potentially factorial with:

3 sites of different logging ages (1990, 1995, 2000),
4 silvicultural treatments (see below),
2 sampling seasons (autumn and spring).
Resampling of sites every 5-10 yrs.

In its simplest interpretation, the design is based around a cluster of treatments at each site such that a site = statistical 'block' = replicate. This will provide the greatest flexibility in development of analytical designs as data accumulate.

Sampling for invertebrates will be within a 1 ha quadrat within each silvicultural treatment at a site. Quadrats will be placed to maximize distance from treatment edges.

Sampling methods
Five types of sampling method will be undertaken:

1. Light trapping for night flying Gondwanan orders.
2. Foliage beating and sweep netting for day active Gondwanan orders.
3. Canopy observations of known pest species.
4. Area searches of ground habitats.
5. Pitfall trapping.

Because sample recoveries from all methods are likely to be affected by temperature and rainfall conditions, air and soil temperatures and rainfall events will be recorded as additional covariates during field sampling. Measurement of sampling conditions covariates and diversity and abundance covariates will free the design from a need to sample all logging ages at the same time and in the same conditions.

Light trapping
One trap per grid site to be placed in a clear area within the site so as to maximize light field attraction within the plot. The preferable killing mechanism is pest strips (placed in the capture bucket) to maximize quality of specimens. Traps will be open at a site for 1 night allowing 4 treatments at all 3 sites to be sampled in one week with daily clearance. This will be repeated 3 times within each trapping season (3 wks), such that there will effectively be 3 trap nights

per quadrat for each sampling season. Lights will be functional from sunset to sunrise. Capture will be placed in a paper bag for each site and clearly labelled with site details and date. Should storage over 2 days be required, the paper bag containing specimens will be 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.

Foliage beating and net sweeping

Within each quadrat (1 ha) sampling will be twice daily (am and pm). Understorey canopy beating will be conducted for 1 hr. Net sweeping (including targeted pursuit) will also be conducted over 1 hr. Sampling times will be broken into ½ hrly segments and each sampling technique alternated (e.g. ½ hr beating, ½ hr sweeping, ½ hr beating, ½ hr sweeping) for each sampling period. Bulk samples from each ½ hr will be sealed in a killing bag containing a (pyrethroid?) infused swab. Alternation of sampling methods and morning and afternoon sessions will reduce diurnal bias and increase operator efficiency. Should captures over the first sampling season show no difference between am and pm samples or pm is the more effective period, then the morning sampling session will be cancelled.

Observations of known pest species

Three known pest species will be monitored.

1. Jarrah Leafminer (JLM), a Gondwanan relic species. The jarrah canopy will be visually scanned for 10 min using binoculars. Evidence of JLM presence (e.g. shot holes in leaves) will be recorded as 0 = absent, 1 = present, 2 = abundant. Abundant JLM will be classed as greater than or equal to 5 shot holes per leaf present.
2. Gumleaf Skeletonizer (GLS). Both the upper Jarrah canopy and understorey will be 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 will be 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 will be scanned for borer symptoms (10 min) (e.g. kino dribble stains, bulls eyes, helical scribing in bark). Recording will be 0 = absent, 1 = present, 2 = abundant. Abundant will be classed as greater than 4 symptoms per tree.

Area searches within microhabitats

Within each quadrat, sampling by area searches will be stratified according to six microhabitat types.

1. Leaf litter. Within litter beds.
2. Bare ground. Areas of ground without litter covering that are not ash beds.
3. Lower boles. Underbark shelters and accessible hollows in lower boles below a height of 50 cm.
4. On/in/under coarse woody debris. Count logs and large branches but sample from all sizes of debris.
5. Moss swards. These develop on ash beds and logs.
6. Ashbeds. Areas of ground upon which large pieces of coarse woody debris fallen logs and branches) have burnt completely or almost completely to ash.

Search at least 3 separate areas of each microhabitat type in order to disperse sampling effort. If fewer than 3 separate areas of a type of microhabitat are present, then it will be treated as absent or insufficiently represented within the quadrat.

Search each microhabitat type for 15 minutes collecting voucher samples and recording abundance details of fauna. Each voucher specimen(s) to be given a unique identifier and stored separately in 70% ETOH at time of collection to minimize subsequent sorting. Sample within two time intervals 0900-1100 and 1500-1700.

Pitfall trapping
Pitfall sampling will not be habitat stratified. Place 10 traps at 10 m intervals along a quadrat diagonal. Open pitfall traps at about 1215 PM and close 24 hrs later. Trap cup size 90mm diameter by 110 mm deep. Use Galt's solution as a trap preservative only. Combine the contents of all 10 traps. Strain bulk sample through 0.2 mm sieve and transfer to 70% ETOH for permanent storage in sealable glass containers enclosing sample details. Sample details to be written in B or 2B pencil on durable card.

Operator effort
Sampling is to be carried out by a 3 person team. This will enable more or less simultaneous operation of all sampling methods within a site.

Light trapping
All persons assist with installation and portage. One person to manage samples.

Beating sweeping
One person to complete beating/sweeping. All assist with samples.

Area searches
One person will collect specimens and call observations. Another person will tote equipment and specimen containers, write observations, manage specimens, crosscheck with reference specimens, timekeep. This avoids the step of later recombining two sample streams. Daily data collection will be carried out in 2 periods of intense collection interspersed with less intense activities such as management of pitfall traps, site description and photography. Adequate intervals for meals, refreshment, planning and sample management are allowed that can also act as time buffers to prevent the concertina of intense data collection intervals due to unforeseen difficulties.

Variables (recorded on a durable A4 datasheet)

Site details
Site #
Date
Latitude GPS
Longitude GPS
Sketch map of landmarks and photopoints within and around quadrat
Silvicultural treatment
Principal vegetation

Sampling conditions
Frequency of microhabitats Habitat 1…H6.
Air temperature @ Time 1, T2, T3, T4.
Soil temperature @ Time 1…T4.
Rain events
Cloud conditions

Light trapping, beating/sweeping, area searches
Specimen # (S1…Sn)

Microhabitat source (H1…H6; BS1 = beating, BS2 = sweeping, L = light trapping)
Abundance (Coded: 0 = not found; 1 = few found (1 - 10); 2 = commonly found (>10)
Description of readily visible identifying features (colour, size, shape, ornament, nest type etc).

Pitfall samples
Bulk contents of 10 pitfalls for later sorting. Coded on data sheet as P = Pitfall.

Sampling schedule
Sampling of a single site with four silvicultural treatments is expected to occupy about a week. Allowance is made for travel to and from a distant site and completion of the sampling cycle within a 5-day working week.

Silvicultural treatments will be sampled in a blocking pattern from remove fatigue and experience biases.

For example:

	1	**2**	**3**	**4**
Site 1	Internal Ref	Gap	Shelterwood	External Ref
Site 2	Shelterwood	Internal Ref	External Ref	Gap
Site 3	External Ref	Shelterwood	Gap	Internal Ref
Site 4	Gap	External Ref	Internal Ref	Shelterwood
Site 5	External Ref	Gap	Shelterwood	Internal Ref
Site 6	Shelterwood	External Ref	Internal Ref	Gap
Site 7	Gap	Internal Ref	External Ref	Shelterwood
Site 8	Internal Ref	Shelterwood	Gap	External Ref
Site 9	Gap	Shelterwood	External Ref	Internal Ref

Staff time
Sampling regime: 4 (silvicultural treatments) x 3 (logging regimes) x 2 (sample seasons) = 24 sample sites.
24 sample sites @ 1 day per site = 6 wks per person for 1 yr.

Personnel	*Field (person weeks)*	*Office/Lab (person weeks)*	*Total Person weeks*	*Annual FTE*
Research Scientist	6	6	12	0.26
Technical Officer (x 2)	12	12	24	0.52
Total	18	18	36	0.78

Vehicle (Plant)

For Field: mean 150 km/day @ $0.50/km		
Total sample days for 2 seasons (6x5) 30 days = 4,500 km.		
Field vehicle cost		$2,250
Perth and Return: round trip = 750 km		
Three trips = 2250 km @ $0.50/km = $1125.00. For 2 sample seasons	$2,250	
Total		**$4,500**

Travel (accommodation)

Kingston House $90 wk (per person). For 2 = $180 pw	
For 2 seasons (6 wk)	$1,080
Meals allowance as per schedule $53/day. For 4 days	$425
For 2 seasons	$2,551
Total	$3,631

Materials

Truck Battery @ $120 x 8	$1000	
Vials	$1000	
Butterfly net & spares	$ 100	
Beating net/or equiv	$ 50	
Photography	$ 200	
Pit fall traps (10 x 12)	$ 120	
Chemicals and sundry	$ 200	
Insect collection box x10	$ 250	
Total	$2920	
Grand Total		$11,051

Data analysis

Presence/ absence data will allow ordination of sites and detection of changes in community composition over extended periods by trend analysis. Initial data analysis will focus on identification of useful indicator species of ecosystem processes.

Sampling regime for a season

The pattern of sampling activity during a week can be summarized as follows

Site# N				
NOCTURNAL LIGHT TRAPPING (daily 1730 set and 0800 clear)				
Day 1	Day 2	Day 3	Day 4	Day 5
PM Set	AM Clear D-1	AM Clear D-1	AM Clear D-1	AM Clear D-1
	PM Set	PM Set	PM Set	
Site 1Tr 1	Site 2 Tr 1	Site 3 Tr 1	S 1 Gap	
Tr 2	Tr 2	Tr 2	S 2 Gap	
Tr 3	Tr 3	Tr 3	S 3 Gap	
Tr 4	Tr 4	Tr 4		
BEATING AND SWEEPING (0900 to 1100 and 1500 to 1700)				
Day 1:	Day 2:	Day 3:	Day 4:	Day 5:
PM	AM PM	AM PM	AM PM	AM
Tr 1	Tr 1			
	Tr 2	Tr 2		
		Tr 3	Tr 3	
			Tr 4	Tr 4
AREA SEARCHES (0900 to 1100 and 1500 to 1700)				
Day 1:	Day 2:	Day 3:	Day 4:	Day 5:
PM	AM PM	AM PM	AM PM	AM
Tr 1	Tr 1			
	Tr 2	Tr 2		
		Tr 3	Tr 3	
			Tr 4	Tr 4
PITFALL TRAPPING (ca. 1215 PM open and close)				
Day 1	Day 2	Day 3	Day 4	Day 5
Open Tr 1	Close Tr 1			
	Open Tr 2	Close Tr 2		
		Open Tr 3	Close Tr 3	
			Open Tr 4	Close Tr 4

DAY 1

Morning:	Travel to site to arrive by 1100.
1100-1215	Place light traps into position on all treatments. Treatment 1. Set up 10 pitfall traps along prepared positions along quadrat diagonal. Open traps at 1215.
1215-1300	Luncheon.
1300-1400	Record frequencies of microhabitats along opposite diagonal to pitfall transect. Check location of microhabitats across plot. Prepare sampling equipment.
1400-1445	Site photography.
1450-1700	Afternoon beating and sweeping treatment 1 (JANET; alternate ½ hr beating and ½ hr sweeping x 2). Afternoon area searches treatment 1 (TOM and ALLAN) 1450 Establish air and soil temperature record. 1500 commence sampling microhabitat 1 and search for 15 minutes. 1520 commence sampling microhabitat 2 and search for 15 minutes. 1540 commence sampling microhabitat 3 and search for 15 minutes. 1600 commence sampling microhabitat 4 and search for 15 minutes. 1620 commence sampling microhabitat 5 and search for 15 minutes. 1640 commence sampling microhabitat 6 and search for 15 minutes. 1700 Establish air and soil temperature record.
1710	Check and set light trap timers. Return to base.
Evening:	Curate specimens.

DAY 2

0800-0850	Clear light trap contents and curate vouchers (retain all supplementary specimens as labelled dry bulk samples).
0850-1100	Morning beating and sweeping treatment 1. (JANET) Morning area searches treatment 1. (TOM and ALLAN) 0850 Establish air and soil temperature record for treatment 1. 0900 commence sampling microhabitat 1 and search for 15 minutes. 0920 commence sampling microhabitat 2 and search for 15 minutes. 0940 commence sampling microhabitat 3 and search for 15 minutes. 1000 commence sampling microhabitat 4 and search for 15 minutes. 1020 commence sampling microhabitat 5 and search for 15 minutes. 1040 commence sampling microhabitat 6 and search for 15 minutes. 1100 Establish air and soil temperature record.
1110-1230	Treatment 1. One person to collect pitfall series from treatment 1 at 1215. Treatment 2. Other person to open treatment 2 traps at 1215. All persons assist with curation of beating/sweeping samples.
1230-1300	Luncheon.
1300-1400	Treatment 2. Record relative frequencies of microhabitats along opposite diagonal to pitfall transect. Check location of microhabitats across plot. Prepare sampling equipment. Assist with curation of beating/sweeping samples.
1400-1445	Site photography.
1450-1700	Afternoon sweeping/beating sampling. Afternoon area searches: Treatment 2. 1450 Establish air and soil temperature record. 1500 commence sampling microhabitat 1 and search for 15 minutes. 1520 commence sampling microhabitat 2 and search for 15 minutes. 1540 commence sampling microhabitat 3 and search for 15 minutes. 1600 commence sampling microhabitat 4 and search for 15 minutes. 1620 commence sampling microhabitat 5 and search for 15 minutes. 1640 commence sampling microhabitat 6 and search for 15 minutes. 1700 Establish air and soil temperature record.
1710	Check and set light trap timers. Return to base.
Evening:	Curate specimens.

DAY 3

Treatments 2 and 3 as per treatments 1 and 2 on day 2.

DAY 4

Treatments 3 and 4 as per treatments 1 and 2 on day 2.

DAY 5

0800-0850	Clear light trap contents and curate vouchers.
0850-1100	Morning beating and sweeping. (JANET) Morning area searches Treatment 4. (TOM and ALLAN) 0850 Establish air and soil temperature record for treatment 1. 0900 commence sampling microhabitat 1 and search for 15 minutes. 0920 commence sampling microhabitat 2 and search for 15 minutes. 0940 commence sampling microhabitat 3 and search for 15 minutes. 1000 commence sampling microhabitat 4 and search for 15 minutes. 1020 commence sampling microhabitat 5 and search for 15 minutes. 1040 commence sampling microhabitat 6 and search for 15 minutes. 1100 Establish air and soil temperature record.
1110-1230	Treatment 4. One person to collect pitfall series from Treatment 4 at 1215. Others assist with curation of beating/sweeping samples.
1230-1300	Secure samples and pack light trap equipment.
1300	Luncheon. Return to Kensington.

FORESTCHECK
Ground invertebrates

Site	
Silviculture	
Sample Date	
Collector	
Recorder	
Latitude	
Longitude	

Vegetation

Microhabitat intersection (% or count)

1 LITTER (%)	2 BARE (%)	3 BOLES (#)	4 DEBRIS (#)	5 MOSS (#)	6 ASHBED (#)

Site sketch (LOCATION, REFERENCE PEG, LANDMARKS, PHOTOPOINTS)

.

	Air temperature	
	Time	Temp
1		
2		
3		
4		

	Soil temperature	
	Time	Temp
1		
2		
3		
4		

Rain	
Cloud	

Date: Spring / Autumn Site Location:

Silvicultural treatment: Logging Yr:

Observer/Recorder: AM / PM

Field No	**Habitat**	**Abundance**	**Taxonomic affinity (1)**	**Taxonomic affinity (2)**	**GR Y/N**	**Description**

Taxonomic affinity (1) = order or super family. Taxonomic affinity (2) = family – genus.

FORESTCHECK
Known pests

Date: Spring / Autumn

Site Location:

Silvicultural treatment: Logging Yr:

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).

APPENDIX
Indicator species, Gondwanan and others, for Jarrah Forest

(*** Gondwanan relic; ** Gondwanan affinity; * 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 worldwide distribution. Presence/absence may be sufficient (Too small for visual searches)
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.
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. Could note Presence/absence.
Isoptera	Temopsidae**(not in SJF)	*Porotermes*** (not in SJF) *Stolotermes*** (not in SJF)	
Mantodea	Amorphoscelidae		
Dermaptera	Pygidicranidae**	Dacnodes shortridgei	
Orthoptera	Grylloidea* 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	Leaf hoppers Root feeders Seed and vertebrate blood Evolved from Gond biota Evolved from Gond biota Endemic	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** Anthicidae** Ptiliidae** Belidae*** Cerambycidae	*Phoracantha acanthocera*	Most diverse insect order.
Diptera	Psychodidae** Asilidae** Tabanidae**	Nemopalus (not in SJF)	
Trichoptera	Limnephilidae (super fam) Plectrotarsidae** (only member of Super fam. in SJF) Hydrobiosidae ? (according to	Case builders-divergence of Super fam. related to break up of Pangaea. *Apsilochorema urdalum,*	79% species endemic in SW, several families have GA's. The primitive family Limnephilidae has no records

	Hopper *et al.*)	*Taschorema pallescens*	in SJF. The family
	Philorheithridae (according to Hopper *et al.*)	*Kosrheithrus boorarus*	Plectrotarsidae is endemic to Aust. For SW species 70% are restricted to region. Again, aquatic associations.
Lepidoptera	Hepialidae**	*Perthida glyphopa*	)Archaic families but
	Incurvarridae**		) radiation unclear.
	Cossidae** (GA debated)		)Gondwanan elements
	Castniidae***	*Synemon directa*	) in some groups
	Noctuidae	*Uraba lugens**	) Look for it with JLM
Hymenoptera	Pergidae**	Sub f. Philomastiginae	Others listed in former notes
	Ichnemonidae**	Sub f. Labeninae	less conspicuous
	Tiphiidae**	Sub f. Thynninae	
	Pompilidae**	Sub f. Epipomilina	
Aranea (spiders)	Actinopodidae**	*Missulena* sp	Easy to spot. Look for burrows.
Infra order	Idiopidae**	Trap doors	Bath plug doors or silk collars.
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).

Synopsis of Gondwanan groups

Odonata	all
Plecoptera	all
Dermaptera	most
Hemiptera	many
Megaloptera	all
Neuroptera	some
Coleptera	many
Diptera	some
Lepidoptera	notably Hepialidae, Incurvariidae, Cossidae, Castiniidae
Hymenoptera	some
Aranea	trapdoor spiders and *Missulena*
Pseudoscorpions	
Peripatus	

References

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

PLANTS

Leader
Bruce Ward

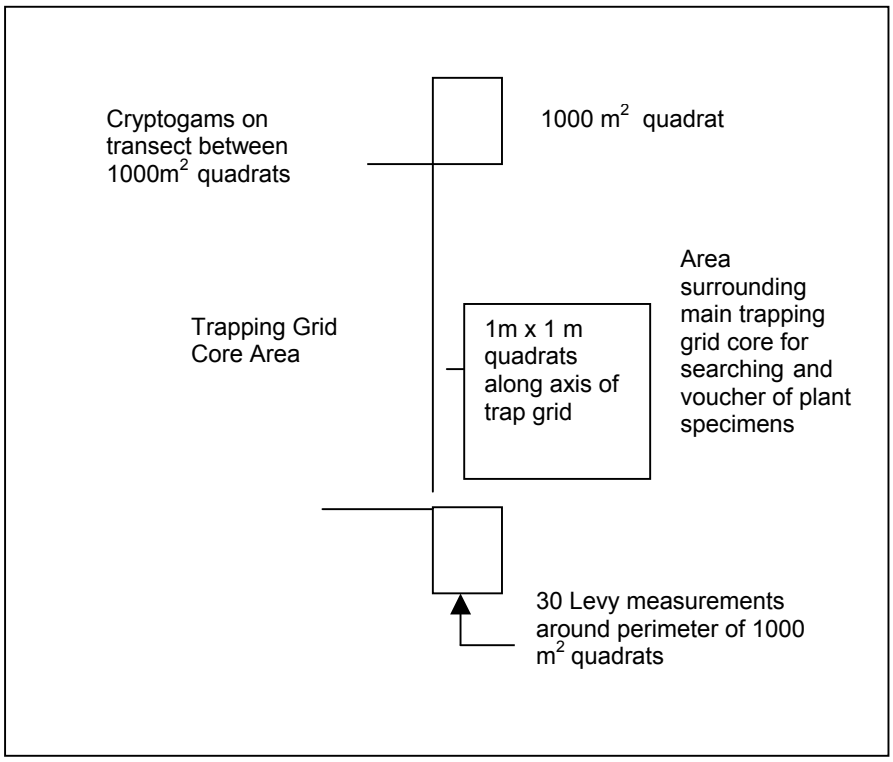
Members
Ray Cranfield (Botanist), John Neal, Bob Smith

Objectives
To monitor the impacts of timber harvesting plant species richness, species assemblages, abundance, cover and structure.

Methods
At each FORESTCHECK site, one grid will be established in each of four treatments, Gap, Shelterwood, Coupe buffer and an undisturbed Reference area. Each grid will consist of

- Four quadrats each 1000 m^2 (31.6 m x 31.6 m), permanently marked with a dropper at each corner. The quadrats will be located at the corners of each mammal trapping grid. Records of all species and their life form will be collected.
- 1 m^2 quadrats will be established along the side of the mammal grids and marked with droppers at 10 m intervals and 2 x 1 m^2 quadrats offset 5 m either side of the peg. Records of all plant species and counts of individuals including Jarrah/Marri seedlings.
- Around the perimeter of the 30 m x 30 m quadrats point transects using Levy rods will measure vegetation height and cover. Heights will be 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 area around the mammal trap grid will be searched for any additional species not recorded in the 30 m x 30 m quadrats.
- Vouchering of all species will be conducted from the surrounds of the mammal grids and outside of any vegetation quadrats. A combined voucher set will be constructed for one sampling site (containing 4 treatments). Provided the treatments are within close proximity (within 1 km), if the range between treatments is considered to be too far (> 1 km) and the risk of different vegetation associations occurring, then a separate voucher set will be constructed for that grid.
- Map occurrence of *Phytophthora cinnamomi*, evidenced by death of indicator species and collate the information gathered by dieback interpreters.

Plot layout



Time estimates

- Measure 1000 m^2 quadrats with a team of 2 would take approximately 30 minutes per quadrat = 2 hrs per grid, times 4 grids = 8 hrs per site and 24 hrs for 3 sites. Costs based on 60 km travel and 2 people.
- Measure 1 m x 1 m quadrats, this would be done on the same day as the 30 m x 30 m plots above and share same vehicle costs.
- Measure levy around 30 m x 30 m quadrats would also take place at the same time as the vegetation quadrats and shared travel cost.
- Vouchering and search for additional species outside of main core area. Collection would go on at the same time with visits to measure quadrats above with shared travel costs, with an additional cost for processing and data entry.

Costs

Travel to the sites 24 days	$ 1800/yr	
Wages for entry of the above vegetation data	$ 2400/yr	
Processing of voucher specimens (mounting/databasing)	$ 1200/yr	
Level 4 Technical officer time 24 days in the field @ $25/hr	$9600/yr	(est.)
	$15000 /yr	

Data analysis

- Species richness per 1000 m^2 by treatment with time. Provide species list and tabulated number of species by life form guild and fire response mechanism.
- Mean species richness per square metre by treatment over time. Tabulated mean number of species with standard error.
- Mean plant density per square metre by treatment over time. Calculate mean plants per square metre by treatment and graph trends over time.

- Mean cover and height changes over time for each treatment. Tabulate mean cover and height for each treatment with standard error.
- Vouchered specimens lodged with the WA Herbarium – include fertile or sterile plant material.
- Analysis of various guilds or fire response categories.

Other

Classify plants by life form guilds:

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

Fire response categories:

A	Seeder	
		A1: seed stored in soil
		A2: Seed stored on plant (serotinous)
		A3: No seed on site (e.g. blows in)
B	Resprouters	
		B1: from epicormics
		B2: from woody rootstock/lignotuber
		B3: from fleshy below ground organ (corm, bulb, tuber, and rhizome)

Booking sheets

1	Vegetation booking sheet 1	1000 m^2 quadrats (31.6m x 31.6m)
2	Vegetation booking sheet 2	1 x 1 m^2 quadrats
3	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………………….

Species name	Code	Field name/no	Life form	Fire response code

FORESTCHECK

Vegetation booking sheet 2

1x1 m^2 quadrats

Grid:……………….. Treatment……………….. Location……………….. Date………………… Observer………………….

Species name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30

'Bragg rating system':

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, ignor bare ground and only estimate the percentage of live. Ie what % of the live is covered by the specie being rated.

Frequency code	0	=	No plants
	1	=	1 plant
	2	=	< 10 plants
	3	=	10 – 50 plants
	4	=	50 – 100 plants
	5	=	> 100 plants

Distribution code

1	**2**
3	**4**

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

FORESTCHECK
Vegetation booking sheet 3

Levy measurements
Grid:…….. Treatment……. Location……...

Date…… Observer…….

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
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
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29											
30											

CRYPTOGAMS

Leader
Ray Cranfield

Member
Karina Knight

Objectives
To record, compare and monitor taxon diversity within various logging treatments and forest types, in particular,

- Species richness and abundance
- Habitat and substrate abundance
- Substrate usage
- Disturbance effects

Equipment requirements
- Digital camera (for site data and species images)
- 10 cm x 10 cm clear plastic grid
- 100 m tape
- Collection book (species)
- Data sheets
- Site maps

Estimated cost
- $350 field related costs

Methods
Field
Each site will be assessed every 3-5 yrs over the winter months into spring (June-November) after the initial survey. This will involve the following tasks:

1. Overall site classification to be assessed and recorded.
2. Microhabitat requirements assessed and recorded.
3. Permanent marker positioned.
4. Species collection of whole site area carried out, within in 300 m x 300 m quadrant but outside 100 m x 100 m inner quadrants.
5. 4 x 100 m lines established (3 m from edge of 100 x 100 m^2).
6. Indicator species (from grids) vouchered and identified.
7. Site species uniquely number identified.
8. Data on each species scored on site.

Estimated time per site: 3 hr/ treatment (27 hrs for 3 sites)
Number of staff: 2
Estimated Vehicle costs: $400 (total running costs)

Laboratory
Each species placed into a separate paper bag and air/oven dried.
Each species identified as far as possible or sent to experts.
Estimated time per site: 1 – 48 hr / sample x 30 samples = approx. 45 hrs
Number of staff: 2
Estimated costs: $1400 sample preparation and materials

Other

- Voucher preparation and databasing of samples for lodgement into state collection.
- Each sample mounted in sample box ready to incorporate at Perth Herbarium.
- Samples sent to Perth Herbarium.
- Data sheets and collecting book production

Estimated time per site: 4 hrs
Number of staff: 2
Cost of sample preparation $300
Transport to Perth: $100 samples, botanists $650, Karina $650 (from Perth)
Accommodation: $750 Ray, $480 Karina
Herbarium costs: $400
Total number of hours required to achieve the initial cryptogam monitoring target is approximately 126 hrs per yr.
Total costs $5500

Data analysis

- Cryptogam species listing for each site.
- Species richness.
- Cryptogam density.
- Habitat requirements.
- Substrate usage.
- Facultative host/s.
- Effects of treatments upon species occurrences.

Indicator species

The indicator species recommended in 2001 appeared to perform satisfactorily. It must be emphasized that this list of indicator species requires constant review as new site locations are established.

Conclusions

Although cryptogams are difficult to study and interpret in the field, the methods used were simple and reliable.

Future tasks

The limited available information and high degree of complex issues associated with cryptogams will necessitate the development of a backlog. It is envisaged that a portion of this material can be passed onto relevant experts for identification, though few experts are available. To address this problem I have provided phrase names for many of these unknown species that can be linked to a voucher with an exclusive Perth Herbarium identification bar code. This will facilitate future access to these samples via interrogation of Perth Herbarium databases and capture any name changes resulting from identifications supplied either by experts or from taxonomic revisions. By using phrase names it is possible to designate a specific species that can be cited in reports and publications.

It could be useful to prepare a field guide to nominated cryptogam indicator species with illustrations and information to help recognize individual species in the field. It would also be desirable to prepare a photographic or scanned record of all cryptogam taxa identified in this initial FORESTCHECK survey and for any other sites in future surveys.

FORESTCHECK
Cryptogam field assessment data sheets

Site No:	**Date:**
Locality:	

Map sheet: Contour range (altitude):

Site aspect: N S E W Slope °:

Latitude: ° ‘ “ S Longitude: ° ‘ “ E

GPS fixed: Yes ☐ No ☐

B G Muir Classification:

Life Form Density Classes (LFDC):

Associated vegetation:

Weed abundance: nil ☐ few ☐ common ☐ abundant ☐

Site modifier: Open / Closed / Exposed / Mist layered / Regenerated

---

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

Soil surface: Bare / Littered / Gravelly / Stony / Cryptogamic / Crusted / Compacted / Loose / Soggy / Moist / Dry / Modified / other:

Litter depth: Litter Condition: new / old / decomposed

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

Soil type: Sand / Clay / Loam / Sandy clay / Clayey sand / Peaty /other:

Type of rock outcropping: % of area

Soil pH:

Fire history (year): Fire type: wild / controlled

Erosion / Disturbance: absent / present Type: Water / Wind / Logging / other:

Micro habitats:	Soil / Stream Banks / Litter or organic mats / Stones / Rock Sheets / Overhangs / Crevasse / Logs / Shrubs / Trees / other:
Habitat condition:	exposed / sheltered / wet / dry
Substrate:	
Soil:	present / absent.
Type:	clay / loam / sand / gravelly
Stone:	present / absent.
Type:	granite / laterite / ironstone / quartz / limestone / sandstone other:
Organic:	present / absent
Type:	litter / bark / twigs / wood / burnt / unburnt / decayed / other:
Inorganic:	present / absent.
Type:	ash-bed / fresh / old / other:
Other:	present / absent.
Type:	ant hill / dung / other:
Substrate used:	0 1 2 3 4
Facultative host/s:	

Collectors :

Photographic images:

Photograph No:

Taxa diversity

Lichens: present / absent

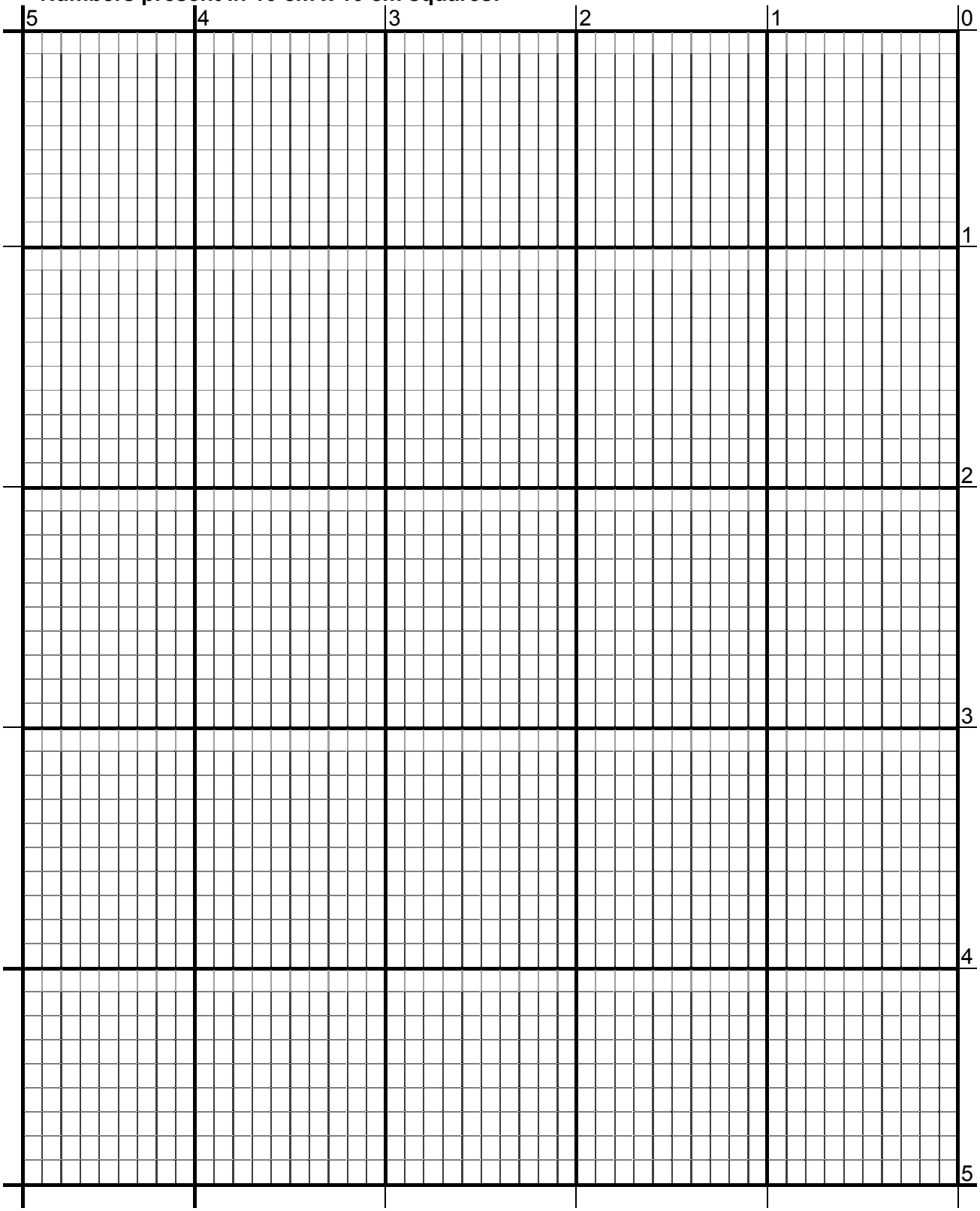
Mosses: present / absent

Liverworts present / absent

Transect points:

Point	Lichens	Mosses	Liverworts
10			
20			
30			
40			
50			
60			
70			
80			
90			
100			
Between transects			

Numbers present in 10 cm x 10 cm squares:



C = Cryptogam (Lichens) B = Bryophyte (Mosses) H = Heptaphyte(Liverwort/Hornwort)

Grid location: **Number present in square:**

Cryptogam: Bryophyte: Heptaphyte:

Voucher No:

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/ Gravelly/ 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	

SOIL AND FOLIAR NUTRIENTS

Leader
Lachlan McCaw

Members
Shelley McArthur, Lin Wong, John Neal, Bob Smith, Kim Whitford

Background
Concentrations of nitrogen, phosphorus and potassium in the foliage of overstorey trees, advanced growth and saplings, and in surface soils are measured at FORESTCHECK monitoring sites to provide information on the nutritional status of the ecosystem. Correlations between macronutrients concentrations and measures of plant and animal abundance, and ecosystem health will be investigated.

Objectives
1) 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;
2) To 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) will be collected from cores at the four corners and centre of the primary grid (points W2-3, W1-2, W1-4, W3-2, W3-4). At each of these points five sub-samples will be collected and then bulked, providing a total of 5 replicates per grid.

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

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

Samples will be air-dried and ground prior to analysis. N will be assayed by Kjeldahl digest following preparation with sulphuric acid. P will be assayed by colorimetry following tri-acid digestion. K will be assayed by flame photometry following tri-acid digestion.

Budget

Field sampling will be done in conjunction with surveys of stand structure and regeneration stocking to economize on travel costs. Soil and foliage samples will be delivered to the Kensington laboratory where all preparation and analysis will be undertaken.

Field sampling:	$ 500
Budget for laboratory analysis	$4500
Total cost	$5000

FOREST STRUCTURE, REGENERATION STOCKING AND FOLIAR NUTRIENTS

Leader
Lachlan McCaw

Members
Bob Smith, John Neal

Objectives
1) to describe stand structure and density, species composition and developmental stage of tree species present at FORESTCHECK grids;
2) to measure the contribution of mid-storey species to stand structure, density and basal area.

Methods

Regeneration stocking assessment
Stocking assessment will be undertaken at 50 points along the outer perimeter of the main sampling grid from Pegs W1-1 to W3-1 inclusive (Table 1). Individual sampling points will be 10 m apart. The sampling procedure and stocking standards to be applied are described in detail in the accompanying sheet. For addition information about regeneration stocking assessments see Silvicultural Guideline 1/02 Silvicultural Practice in the Jarrah forest (in draft at June 2002)

Stand structure
For overstorey tree species (Jarrah, Marri, Blackbutt, Wandoo) record dbhob to the nearest cm for all stems greater than 2 m tall (saplings and larger) in a 4 m wide transect between Pegs W1-2 and W1-4, and between Pegs W3-2 and W3-4 (refer to Table). This transect will be 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 will be recorded on a separate sheet. Stems arising from a common coppice stool or rootstock should be identified as a group by bracketing the relevant diameter measurements on the booking sheet. In areas cut to Gap or Shelterwood determine 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.

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

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

FORESTCHECK

Regeneration stocking assessment at each sample point:

- *Retained Overwood*

- In Gaps, record as (S) 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 dbh) and do not estimate density at this point.
- In Shelterwood, record as (S) any point where the retained basal area measured with a 6 factor prism is equal to or greater than 12 m^2/ha. Record thinned forest as (T) and non-forest as (N) with a brief description eg rock, swamp.

- *Regeneration*

Make a mark on the ground and determine the three saplings which form the most compact triangle around the mark. i.e. the sample point must fall somewhere within the bounds of the triangle formed by the three selected stems (See diagram overleaf). If the point is not stocked with saplings repeat the process using a combination of saplings and ground coppice, or ground coppice only. In shelterwood cut areas, lignotuberous seedlings may also be included if necessary.

Estimate the length of the triangle sides by pacing between the selected saplings. The distances are to be 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, simply add 1 m to the length of the shortest triangle side.

- When searching for saplings all three stems forming the triangle must be within an 8 m radius of the sample point.
- When searching for saplings/ground coppice or ground coppice only use a 5 m radius of the sample point.
- If three saplings, ground coppice or combination can not 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:

Gaps

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,

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
  5000 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.

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 yr 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.

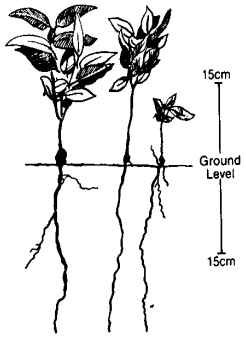
Dynamic Ground coppice (4)– multiple shoots but with a dominant leader.

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

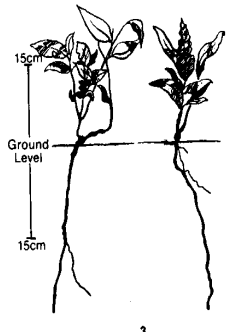
Pole – 15-45 cm d.o.b., with apical dominance giving way to more persistent laterals in the crown.

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

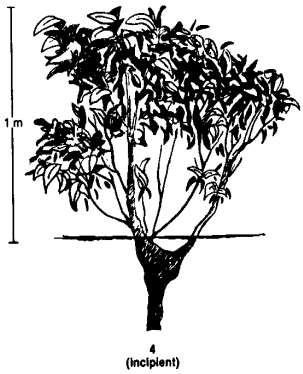
Stool coppice (6) – shoots developing from a small stump cut off at ground level.



1



2

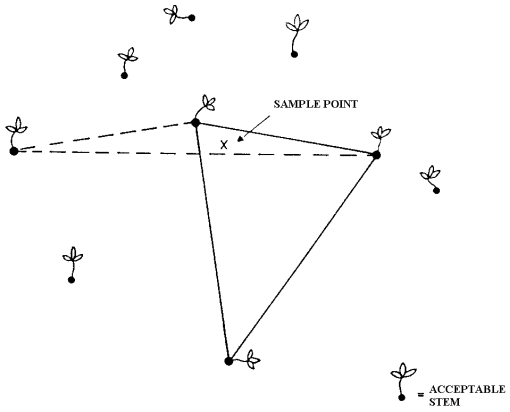


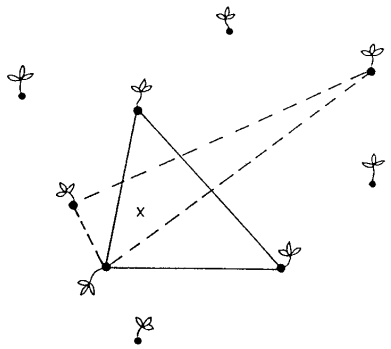
5

6

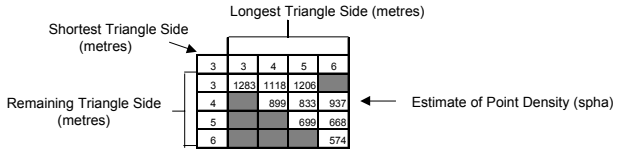
Estimating point density by 'tesselated triangulation'

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





2. Enter table as follows:



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

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	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	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	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	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	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	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

Regeneration survey - uncut stands and gap treatments

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 DISTURBANCE

Leader
Kim Whitford

Members
Kim Whitford, Beth MacArthur, John Neal, Bob Smith

Background
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.

Objective
The purpose of this work 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 will not be assessed in this study as, being physically distant from the disturbance treatments, they are not relevant reference treatments for 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 those internal control treatments. Monitoring will be confined to gap and shelterwood treatments and internal reference treatments.

1. GPS survey coupe boundaries, snig tracks and landings on all treatments. Determine snig track order by concurrent or subsequent visual assessment of snig track disturbance, and layout. Photo-interpretation may assist in this assessment.

2. Determine the relative area of the various operational classes from the GPS survey, namely Harvested (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.

3. Select a single treatment grid 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) establish a grid for assessments and sampling of bulk density. The grid is based on the 3 major transects 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. These additional transects will be parallel to the existing grid and typically 50 m outside of it.

4. Collect bulk density samples from the internal reference treatment if it is of similar soil type and located adjacent to the selected bulk density monitoring treatment (selected in step 3). On this treatment collect bulk density samples at 40 points spread over 5 transects based around the FORESTCHECK sampling grid. Sample points spaced at 30 m, 8 samples per transect line, each transect 210 m long. The first sample in each line will 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 will be required.

5. Select another reference treatment if the internal reference treatment is not on a similar soil type to the adjacent disturbed treatment.
6. Number the sample points on all grids so as to follow 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. Wire peg, flag and label each measurement point. Always record the location of the sample collection or measurement relative to the pegged point.
8. Establish a 3 m grid spacing along the 5 transect lines (n = 338 points) where the disturbance intensity on the treatment selected for bulk density measurement can be clearly visually assessed. Visually assess these grid points for soil disturbance classes (Whitford 2001). Stratify the bulk density sampling from these disturbance classes: 150 bulk density samples, consisting of 75 undisturbed and 25 each of lightly, moderately, and heavily disturbed grid points. Alternatively, where visual assessment of disturbance classes is not possible, stratify sampling of bulk density on the 6 operational classes HA, ST0 and LL, ST1, ST2, ST3, and OST if relevant. Aim 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. Collect bulk density samples every 15 m in HA and every 1 m where transects cross snig tracks. Collect samples from the landing (LL) at 20 points distributed across the landing on a grid separate from the FORESTCHECK grid.
9. Process bulk density samples to determine bulk density of the fine earth fraction (< 2 mm).
10. Enter data, process and analyse.

Costs

GPS survey of snig tracks and landings

Field time = 2 days per treatment x 6 treatments = 12 days + 2 days office time 14 days for 6 treatments **14 days for scientist**

Collect bulk density samples

175 samples from gap, 40 samples from internal reference. Total is 215 samples from 2 treatments. 14 minutes per point = 50 hrs (includes travel time to site from Dwellingup) **8 days for 1 contract technical officer**
$1500

Contract lab processing

215 bulk density samples = 50 hrs x $27.50 **$1375**

Dust extraction

One-off cost for installation of noise reduction enclosure for dust extraction system. **$1500**

Managing field work and data handling and analysis

Kim Whitford to advise on data collection techniques and methods (1 week)
GPS survey of snig tracks (3 weeks)
Inspection of field sites and supervision of field work (2 weeks)

Data entry 500 points	(1 week)
Data analysis and presentation	(2 weeks)
Supervision of bulk density laboratory work	(1 week)
Total	**10 weeks for Kim Whitford**

Vehicle, travel costs

20 return trips from Dwellingup to Harvey field locations (250)	5000 km
6 trips from Dwellingup to Kensington (250)	1500 km
Total	6500 km
Total 6500 x $0.50 =	**$ 3250**

Accommodation/travel costs	**$200**

Material costs:

GPS software	$ 170
Flagging tape	$ 100
Corer replacement and repairs	$ 600
Wire pins	$ 300
Paint	$ 100
References	$ 100
Total	**$1370**

Total costs	**$ 9195**

Data analysis

- Areal 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.

Data collection forms

- Soil disturbance classification (Table 1).
- Soil disturbance survey form (Table 2).
- Operational category survey form (Table 3).
- Bulk density laboratory data form (Table 4).

Table 1. Soil disturbance classification

A: Operation categories		
Harvested area	HA	General logging within which trees are felled
Unharvested area	UA	Areas of retained forest within the coupe boundary
Firebreak	FB	Perimeter boundary
Snig tracks	ST0	Major snig track, into landing
	ST1	Major snig tracks, Primary
	ST2	Minor snig tracks, Secondary
	ST3	Minor snig track, Tertiary
	OST	Old Snig track from previous logging
Landing	LL	Area where logs are snigged for sorting and loaded for transportation
	OL	Old landing from previous logging
Access roads	AR	Temporary forest roads falling within the coupe boundary

B: Soil disturbance categories				
Soil profile disturbance	Classification		Type of mixing/removal	Dominant horizon
Undisturbed	D0	LI	Litter layer intact	O
Lightly disturbed	D1	LR	Litter layer broken/partially removed	O
Moderately disturbed	D2	TE	Litter completely removed and topsoil exposed	A
		LM	Litter mixed with topsoil	A
		TD	Topsoil disturbed	A
		TM	Topsoil mixed with subsoil	A
		TR	Topsoil partially removed	A
Severely disturbed	D3	SE	Topsoil completely removed and subsoil exposed	B
		SM	Topsoil mixed with subsoil	B
		SD	Subsoil disturbed	B
		SC	Subsoil mixed with parent material	B
		SR	Subsoil partially removed	B
Very severe disturbance	D4	PE	Subsoil removed and parent material exposed or mixed with subsoil parent material	C or R

Non-soil	(t)	Tree stump	***Qualifiers***	(d)	Obvious soil displacement
	(r)	Rock		(p)	Obvious soil compaction
	(w)	Fallen large tree or log		(a)	Animal digging

1. Assess the soil disturbance category that occupies the majority of the 1 m x 1 m quadrat.
2. If dense slash, bark or soil does not allow soil disturbance to be accurately assessed, score soil disturbance according to surrounding area and most likely soil disturbance category.
3. Topsoil is A_1, A_2 & A_3 horizons except where A_2 is conspicuously bleached whereby A_2 & A_3 are regarded as subsoil.
4. Subsoil includes B_1 & B_2 horizons and A_2 and A_3 if A_2 is conspicuously bleached.

Table 2. FORESTCHECK soil disturbance survey form

Site: **Treatment:** **Transect:**			**Grid:** **Grid line:**		**Bearing:** **Date:** **Assessor:**
Transect point	**Distance**	**Grid point**	**Operational category**	**Soil Disturbance**	**Comment e.g. sample no.**
0	0				
1	3				
2	6				
3	9				
4	12				
5	15				
6	18				
7	21				
8	24				
9	27				
10	30				
11	33				
12	36				
13	39				
14	42				
15	45				
16	48				
17	51				
18	54				
19	57				
20	60				
21	63				
22	66				
23	69				

Table 3. 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 = ripline, U = undisturbed

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

Transect distance (m)	**Sample point no.**	**Operational category**	**Disturbance type**	**Comment**

Table 4. 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)

MACROFUNGI AND COARSE WOODY DEBRIS

Leader
Richard Robinson

Members
Bob Smith

Fungi occur on trees, dead wood and on the ground and have specific microclimate requirements. Transects are the most appropriate sampling method and will take in the wide variation of substrate and microclimate present in a forest.

The only practical method of monitoring forest fungi is by measuring fruitbodies. This presents several problems:

(i) fungal fruiting is weather dependent, and with a low monitoring frequency temporal variation in the species recorded can occur.

(ii) the presence of fruitbodies of a particular species of fungi indicates the presence of the fungus, however, the absence of fruitbodies does not indicate absence of the fungus (it may be present in the soil/wood substrate but has not fruited).

It is not meaningful to measure abundances (numbers) of fruitbodies of a particular species, as one mycelium in a substrate may produce either multiple or single fruitbodies and abundance will vary from year to year. A better measure is the presence or absence of fruitbodies of a particular species.

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.

Objectives
1. To monitor and record the species of macrofungi fruiting in the various treatments of managed jarrah forests (gap, shelterwood, coupe buffer and reference area). Trends in species richness and abundance will be analysed over time.
2. To measure and record the amount of coarse woody debris (CWD) on the ground in the various treatments of managed jarrah forests (gap, shelterwood, coupe buffer and reference area). Trends, within and between the various treatments, will be analysed over time.

Methods
At each FORESTCHECK site, grids are to be installed in each of the four treatments (gap, shelterwood, coupe buffer and reference area). Grids are 9 ha (300 m x 300 m) and will contain plots, transects etc for all monitoring groups. Sites to be assessed every 3-5 yrs in the autumn (mid-May to late-June, depending on rainfall and temperature). The following protocol is to be followed at each grid.

Macrofungi
Site preparation
At each grid, establish and permanently mark 2 x 200 m transects. The origin of each transect will be 50 m in from the origin of the centre line and perpendicular at 90 m on each side of the centre line (see grid design attached). The origin of each transect will be permanently marked with a dropper and its GPS recorded. The bearing of each transect from its origin will also be recorded and droppers put in at 100 and 200 m. The width of each transect will be one metre, the actual line of the transect being the 'inside' boundary of the assessment area.

Data collection

Along each transect, the distance from the origin, the species and the number of fruitbodies, and the substrate will be recorded. Additional comments to be noted where necessary. See data sheet (attached). Each grid will be visited three times on a fortnightly basis in autumn. Voucher collections to be made of each species collected in each forest type.

Litter and coarse woody debris

Site preparation

One hundred metres of each macrofungi (MF) transect will also be used to assess CWD. One CWD transect will cover the first 100 m of a MF transect and the second CWD transect will utilize the second 100 m of the other CWD transect. Litter will be collected from 22 x 0.05 m^2 quadrats placed every 10 m externally adjacent the CWD transects.

Data collection

For each transect, a 100 m tape will be laid out. The diameter of each piece of CWD, larger than 2.5 cm in diameter, that the tape passes directly over will be recorded. At least 50 data records will be needed for each grid. If 50 records are not gained an additional transect will be surveyed and used. Additional transects will be marked with droppers, and GPS of origin, bearing and length will be recorded. Each grid will be assessed in autumn. Litter from each quadrat will be collected in paper bags numbered 1-22, number 1 being at the origin and number 11 at the end of the first transect, number 12 being at the 100 m mark and number 22 at the end of the second transect. Site details will be entered onto a master map for each grid.

Costs

Staff

Grids can be monitored by 2 people at the rate of 2 per day when assessing all three (macrofungi, litter and CWD) attributes, and at the rate of 3-4 per day when assessing macrofungi only. For each site (12 grids) it will therefore take 14 days with 2 people. The same time (14 days) allocated to data entry and sample/voucher collection treatment. 20 days have been allocated to data analysis and report writing by the Group Leader.

FTEs:	Group Leader	48 days
	Technician	28 days

Budget

Salaries/Wages/Overtime	$500*
Overheads	
Equipment	$510
Vehicle	$2000
Travel	$300
Other	
Total	**$3310**

Vehicle km: (6 x 150) + (8 x 200) = 2,500 @ 50c per km, plus incidentals.

Equipment:	Droppers x 75	(cost included in Grid set-up)
	Voucher boxes x 300 @ 30 cents ea.	$90
	Plastic bags x 500 @ $2 per 25	$40
	Paper bags x 300	$180
	Other (Wax paper, film and processing etc)	$350

* Voucher Collection Entry and Lodgment into Herbarium Wages @ Level 2 yr 1 ($15.50/hr) with an estimated productivity of 10-15 specimens / hr.

Data analysis and storage

Each year species richness and abundance will be calculated for each treatment at each site. Species richness and abundance will be compared between treatments at each site, between sites and between forest types. Over time species richness and abundance curves will be determined for each treatment in each forest type.

Macrofungi will also be assigned to life-mode type (e.g. saprophytic on wood, saprophytic on leaf litter, saprophytic on twigs, fungi fruiting on soil). Use of ranking's, such as 0 (not found); 1 (few found); 2 (commonly found), will be explored.

Another method of monitoring change is to measure 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 will 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 (control), and how or if management treatments affect this ratio.

The volume (m^3 ha^{-1}) of CWD will be calculated using the formula and method of Van Wagner (1986). Litter samples will be oven-dried for 24 hrs and dry weights used to determine litter loads (tonnes ha^{-1}). Litter loads and CWD can be compared between treatments at each site, between sites and between forest types. Litter and CWD accumulation curves will be generated as data accrue.

Data will be entered onto Microsoft EXCELL worksheets. Originals to be stored at the Manjimup Research Centre, on the Group leader's PC and backed up on the local server and a floppy disc/CD. New data for each year will also be sent to the FORESTCHECK Data Co-ordinator (Amanda Mellican) at the Kensington Research Centre.

FORESTCHECK
Fungi monitoring

Site: Date:

Grid #: Transect No.: Assessed by:

Distance (m)	No. of fruits	Substrate*	Species / Comments

Soil, Litter, Twig < 2 cm diameter, Wood, Log.

FORESTCHECK
Litter assessment

Site: Date:

Grid #: Transect No.: Assessed by:

Sample No.	Dry wt (gms)	Sample No.	Dry wt (gms)	Comments
				Mean dry wt:
				SE:
				Litter load: **tonnes ha^{-1}**

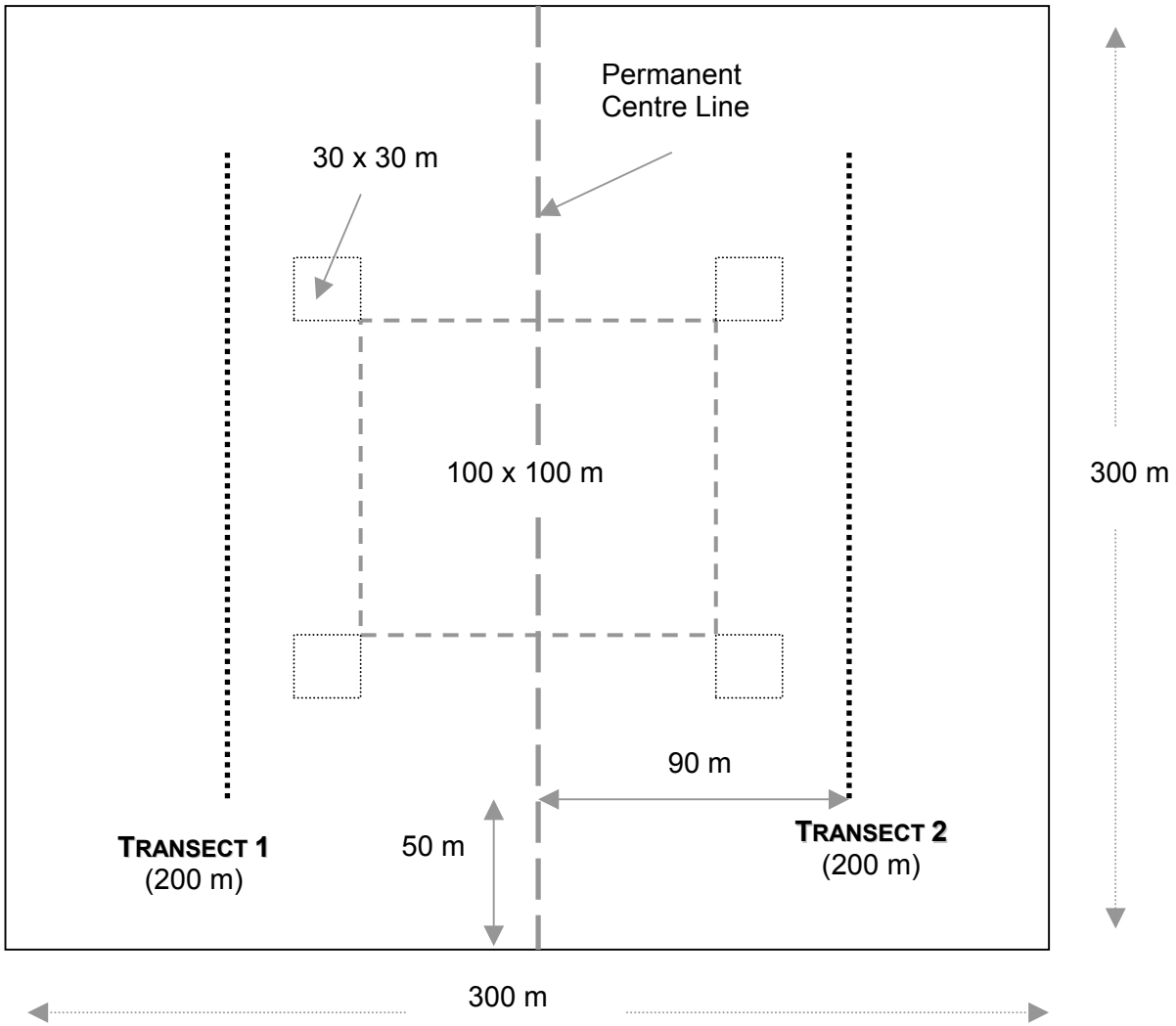
FORESTCHECK
CWD assessment

Site: Date:

Grid #: Transect No.: Assessed by:

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

Position of Fungi and CWD transects in each grid



DATA MANAGEMENT AND STORAGE

Leader
Amanda Mellican

Members
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 have been finalized for each group, consultation with an expert from each group will define the classification of each variable (type: character or numeric and allowable values). Then, all necessary descriptions and explanations of the variables will be recorded in a Microsoft EXCEL worksheet (namely **DESCRIPTIONS.XLS**).

Creation of a database file
A database file for recording data will be 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 will be provided.

Data Entry, validation and storage
The **DESCRIPTION** file and the **FIELD-DATA-SHEET** file will be provided to the officer in each group responsible for data entry. Data will be entered onto the **FIELD-DATA-SHEET** file. In addition, a metadata form (appendix A) will be 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,** will then be returned to the database co-ordinator.

Data validation and storage
The co-ordinator will validate the data and indicate the validation on the metadata form. The **DESCRIPTION** file and the **FIELD-DATA-SHEET** file are to be 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 to be saved in **TEXT** format, so that they are easily retrievable.

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

All the individual sampling data will be saved and backed up as individual files. Over time a Microsoft EXCEL file will be created. This will contain the accumulated data of every individual sampling. The original field sheet will be 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 that they were saved, and the description of the file will be recorded on the metadata form. (Appendix B).

Requirements
Allocated space on the network drive.

GIS

It is important that a capability to produce visualized biological and physical spatial data is developed. To achieve this ArcView 3.2 for Windows/NT – Box should be purchased in yr 2 ($3,030).

REPORTING

Each team will provide annual reports on progress and data to the Program Team Leader (ESFM) in the Science Division. As data accrue, small taxa-based working groups will be convened so that interim results can be interpreted by experts in the Department, CSIRO, Universities etc.

Results will be posted on the internet.

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 (CALM's Network dive) →

Location 2 (on PC) →

No	File name	File size (KB)	File type	Date and time	Description of the file name

Data Co-ordinator: Amanda Mellican

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