Monitoring for Wungong Catchment Forest Thinning Project KPI 11 Fauna

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November 2009 Dave Kabay

Summary

KPI 11 fauna concerns "Changes in the status of Faunal Assemblages including Threatened Fauna". Performance Measure of this KPI relates to changes in species and faunal assemblages numbers due to forest thinning treatments and the reduction in forest canopy.

A monitoring program involving two replicate plots, each in areas that were to be treated with one of the two forest thinning treatments (plots 1 to 4) together with two controls (plots 5 and 6) in forest that were to be untreated, was set up in selected similar sites in 2006 to measure these changes and a pre treatment program carried out in the same year.

In 2007 and 2008 the various forest thinning treatments were applied to the areas where the plots had been established.

In 2009 a second fauna survey was undertaken using the same techniques and procedures as the 2006 survey.

The method of assessing change in the KPI included analyzing changes in

- Taxa and their numbers
- Community parameters such as species diversity, evenness, species richness, total numbers, community feeding guilds and species functional groups
- Multivariate community measurements such Principal Component Analysis (PCA) and Multi Dimensional Scaling (MDS)

The initial analysis indicated that, on average, only the bird fauna were affected 12 to 18 months after the forest thinning treatments.

Introduction

When the Water Corporation developed the KPI's for the Wungong Catchment forest thinning project, the one for fauna (KPI-11 fauna) was "Changes in the status of threatened fauna species" which was similar to a KPI in the Forest Management Plan. After a recent review of the biological projects being supported by the Water Corporation in the Wungong catchment under the Forest Thinning project, the KPI was changed to "Changes in the status of faunal assemblages including threatened fauna". The details of the Performance measures, targets, reporting frequency and response to target short falls relevant to this new KPI are still being developed.

In 2006, six fauna monitoring plots were set up to measure this KPI. Two plots (1 and 2) were set up in an area that was to be thinned by non commercial thinning techniques which involved notching selected trees and applying glyphosate to the notch with a possible burn being carried out at a latter date. Two plots (3 and 4) were set up in an area

that was to have the forest canopy reduced by commercial logging followed by a burn to consume the forest debris left after the logging. Finally two plots (5 and 6) were placed in forest that was not to undergo any treatment other than the normal forest management carried out under the Forest Management Plan (Kabay 2006).

In 2006 a pretreatment fauna survey was undertaken (Kabay 2006)

In 2008 and 2009 the forest thinning treatment were applied. Plots 1 and 2 were treated in the same way, but only Plot 3 was logged and burnt while Plot 4 was only logged leaving the forest debris on the forest floor. This plot will be burnt in the coming year. Plots 5 and 6 did not under go any treatment at all.

In 2009 the fauna monitoring program as implemented in 2006 was duplicated, to assess the degree of changes (if any) that had occurred in KPI 11 fauna.

Methodology

All plots were selected to be in as similar forest as possible. The design of the monitoring techniques was outlined in the 2006 report. In 2009 the same techniques and monitoring intensity and periods used in 2006 were repeated, with the addition that bats were monitored through analysis of their eco-location call recordings.

The methodology of analyzing changes to the KPI was similar to that used by the Plymouth Marine Laboratory in their commercially available software "Primer" which involves linking environmental variables to changes in community measures. The process involves linking Principal Component Analysis(PCA) of abiotic factors with Multi Dimensional Scaling (MDS) of fauna data.

Specifically monitoring the performance measures of the Wungong Catchment forest thinning project KPI 11 fauna involved determining changes in all plots between 2006 and 2009 in:

- Univariate data such as taxa and their numbers.
- Community data such as species diversity, evenness, total abundance, species richness, abundance distribution, community feeding guilds and species functional groups and
- Multivariate community data such as PCA of vegetation data and MDS of fauna data collected in 2006 and 2009

to identify effects of the forest thinning treatments and forest canopy reduction.

The fauna groups that were analyzed with the above techniques were

- Arthropod orders
- Beetle species
- Ant species
- Non bird vertebrates
- Bird species

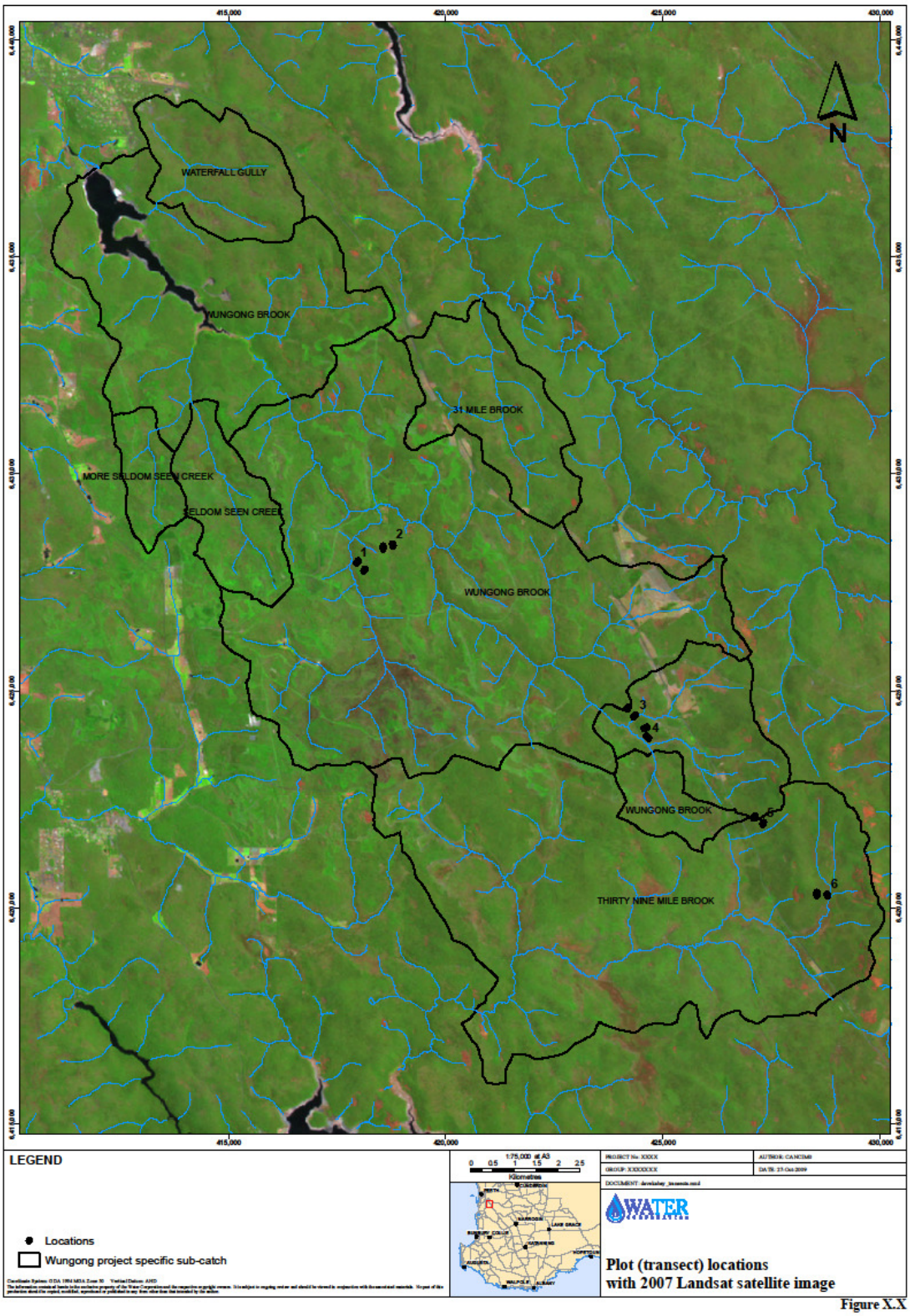


Figure X.X

Plot Locations

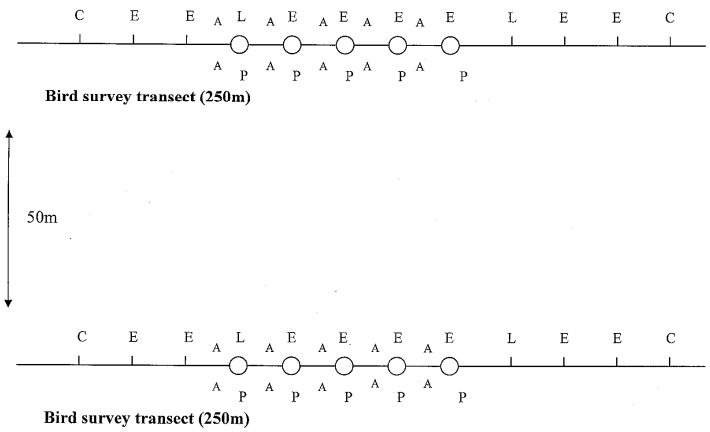


Figure 1: **Design of permanent fauna monitoring plots.**
C = Cage (Chuditch type) trap, E = Elliot trap, L = Large Elliott trap, A = ant trap, P = 150mm dia PVC Pit trap. Traps are placed 20m apart. At some sites it was necessary to bend transects eg to follow watercourses in stream zones.

Fauna Monitoring Plot Lay out

Monitoring program	Dates sampling undertaken	Consecutive Day Monitoring (inclusive)	
		Date of Start	Date of End
Mammal Early Autumn		10 April 2006	13 April 2006
		31st March 2009	3rd April 2009
Mammal Late Winter		7 August 2006	10 August 2006
		11th August 2009	14th August 2009
Ants Summer/Early Autumn		7/8th March 2006	14/15 March 2006
		6th February 2009	13th February 2009
Birds Late Winter	17th Aug, 24th Aug and 28th Aug 2006		
	24th Aug ,27th Aug and 4th Sept 2009		
Birds Early Summer	29th Dec 2006, 5th Jan, 8th Jan and 9th Jan 2007		
	13th, 15th, 21st and 22nd January 2009		
Reptiles Early Summer		12th December 2006	16thDecember 2006
		16th December 2008	20th December 2008
Bats	Not carried out		
	14th Dec 2008 to 20th Dec 2008 9		

Fauna Monitoring Period

Trap/Observation Type	Number per Plot (2 transects)	Trapping/Observation days per Monitoring Occasion per Plot	Total Trap/Observation Days per Monitoring Occasion per Plot	Total Trap/Observation Days per Sampling Year Per Plot
Medium Elliot	16	4	64	128
Large Elliot	4	4	16	32
Cage Trap	4	4	16	32
Pit Trap with 7 m fly wire drift net (Mammal)	10	4	20	20
Pit Trap with 7 m fly wire drift net (Reptiles)	10	5	25	10
Large Elliot's (Reptiles)	4	5	20	20
Arthropod pit trap with preservative	20	7	70	70
Bird Observation	1	3	3	6
Bats Echolocation recorder	1	4 or 5	4 or 5	4 or 5 6

Monitoring Intensity

Results

The following are examples of the outcomes of the above methodology of analysis of changes in KPI 11

Univariate Analysis

Changes in vegetation structure with Forest Thinning Treatments

Plot Number	1		2		3		4		5		6	
Sampling Period	*2006*	*2009*	*2006*	*2009*	*2006*	*2009*	*2006*	*2009*	*2006*	*2009*	*2006*	*2009*
Proposed Catchment Treatment	Non commercial Thinning done in December 2007. Not burnt				Logged in summer of 2007 and Burnt in Dec 2007		Logged in summer of 2007. Not burnt		Controls. No forest treatments under FMP			
Vegetation Type	P/S or P		S		P or P/S		P or P/S		P or P/S		P	
Burning History (Years since last burn)	19	21	18	20	4.5	1.5	4.5	6.5	7.5		7.5	
Dieback Status	Dieback Free											
% Canopy Cover (FB)	-58%		-58%		-57%		-57%					
Basal Area over Bark (m^2/ha (FB)	-57%		-58%		-55%		-38%					
0-100cm % Cover(M)	+8%		-12%		-44%		-33%		-44%		-36%	
100-600cm % Cover (M)	-41%		-25%		-39%		-29%		-14%		-25%	
Stems per ha	-4%		-81%		-55%		-69%					
>600cm	-13%		-17%		0%		-16%		0%		-9%	
Litter % Cover (M)	+73%		+35%		+39%		-7%		+149%		+171%	
Logs =>10cm % Cover (M)	+140%		-10%		+12%		+39%		-36%		-36%	

Non bird vertebrates

Non Bird Vertebrates	Plot 1 2006	Plot 1 2009	Plot 2 2006	Plot 2 2009	Plot 3 2006	Plot 3 2009	Plot 4 2006	Plot 4 2009	Plot 5 2006	Plot 5 2009	Plot 6 2006	Plot 6 2009
Bandicoot	0	0	0	0	0	2	0	1	0	3	0	1
Black Rat	0	0	0	0	0	0	0	1	0	0	0	0
Brush Tail Possum	0	1	1	3	12	2	2	3	3	2	0	3
Mardo	1	3	1	2	25	16	19	24	28	25	21	29
Mouse	0	1	0	0	0	0	0	0	0	0	0	0
Pigmy possum	1	1	0	0	1	0	0	2	0	0	0	0
Acritoscincus trilineatus	0	0	1	1	0	0	1	0	0	0	0	0
Christinus marmoratus	0	0	0	2	0	0	0	0	0	0	0	0
Crenadactylus ocellatus	0	0	1	0	0	0	0	0	0	0	0	0
Cryptoblepharus plagiocephalus	0	1	0	0	0	0	0	1	1	0	1	3
Ctenotus delli	0	0	0	0	0	0	0	0	5	3	0	0
Egernia pulchra	0	0	0	0	0	0	0	0	0	0	1	0
Heleiporus inornatus	0	0	0	0	0	0	0	0	1	0	0	0
Hemiergis initialis	3	1	2	0	0	1	0	1	1	3	1	0
Lerista distinguenda	7	1	11	4	0	0	0	0	5	1	0	0
Mentia greyii	0	0	1	0	0	0	0	0	0	0	0	0
Morethia obscura	3	4	3	3	0	0	0	1	5	2	1	0
Pygopus lepidopodus	0	0	0	0	0	0	0	0	0	0	1	0
Ramphotyphlops australis	0	1	0	0	0	0	1	0	1	0	0	0
Tiliqua rugosa	1	1	3	1	0	0	1	2	0	0	0	0
Varanus gouldii	0	1	0	0	0	0	0	0	0	0	0	0
Crinia geogiana	1	2	0	1	0	1	0	3	1	1	1	0
Heleiporus inornatus	0	0	0	0	0	0	0	0	1	0	0	0

Beetles

Taxa	Plot 1 2006	Plot 1 2009	Plot 1 % Changes	Plot 2 2006	Plot 2 2009	Plot 2 % Changes	Plot 3 2006	Plot 3 2009	Plot 3 % Changes	Plot 4 2006	Plot 4 2009	Plot 4 % Changes	Plot 5 2006	Plot 5 2009	Plot 5 % Changes	Plot 6 2006	Plot 6 2009	Plot 6 % Changes
Anobiidae sp.1	0	0	*	0	0	*	1	0	-100%	1	0	-100%	0	0	*	0	0	*
Anobiidae sp.2	0	0	*	0	0	*	0	0	*	0	1	+1	0	0	*	0	0	*
Formicomus quadrimaculatus	0	0	*	0	0	*	0	47	+47	0	2	+2	1	1	0%	0	1	+1
Tomoderus sp.1	0	0	*	0	0	*	0	0	*	0	1	+1	0	0	*	3	1	0%
Archeocrypticidae sp.1	36	41	4000%	121	65	**6400%**	45	35	3400%	22	18	1700%	112	95	9400%	39	35	3400%
Gondwanenneboeus minutissimus	1	0	-100%	0	0	*	0	0	*	0	0	*	1	2	100%	1	0	-100%
Lamellenneboeus sp.1	0	0	*	1	0	**-100%**	0	0	*	0	0	*	1	0	-100%	0	1	+1
Bostrichidae sp.1	0	0	*	0	0	*	0	1	+1	0	0	*	0	0	*	0	0	*
Carabidae sp.1	0	0	*	0	0	*	0	0	*	0	0	*	0	0	*	0	0	*
Mecyclothorax sp.1	0	0	*	0	0	*	1	0	-100%	0	0	*	0	0	*	0	0	*
Simodontus sp.1	1	0	-100%	0	0	*	0	0	*	0	0	*	0	0	*	1	0	-100%
Alticinae sp.1	1	0	-100%	0	0	*	0	0	*	0	0	*	0	0	*	0	0	*
Anisomeristes sp.1	0	0	*	0	2	**+2**	0	0	*	1	0	-100%	0	0	*	2	1	0%
Curculionidae sp.1	0	0	*	1	0	**-100%**	2	0	-100%	1	0	-100%	0	0	*	0	0	*
Curculionidae sp.2	0	0	*	0	0	*	1	0	-100%	0	0	*	1	0	-100%	0	0	*
Curculionidae sp.3	1	0	-100%	0	0	*	0	1	+1	0	0	*	0	0	*	0	1	+1
Curculionidae sp.4	0	0	*	0	0	*	0	1	+1	0	0	*	0	0	*	0	0	*
Curculionidae sp.5	0	0	*	0	0	*	0	0	*	0	0	*	0	0	*	0	0	*
Curculionidae sp.6	0	1	+1	0	0	*	0	0	*	0	0	*	0	0	*	0	0	*
Cossoninae sp.1	2	0	-100%	0	1	**+1**	1	0	-100%	0	0	*	0	0	*	0	0	*
Scolytinae	0	16	+16	0	19	**+19**	0	6	+6	0	5	+5	0	1	+1	0	2	+2
Elateridae sp.1	2	0	-100%	0	0	*	0	0	*	0	0	*	2	0	-100%	0	0	*
Elateridae sp.2	0	2	+2	0	0	*	0	0	*	0	0	*	1	0	-100%	0	0	*
Elateridae sp.3	0	0	*	0	0	*	0	0	*	0	0	*	0	0	*	0	0	*
Holoparamecus sp.1	1	0	-100%	0	0	*	0	0	*	0	0	*	0	0	*	0	0	*
Cortinicara sp1	0	0	*	0	0	*	0	0	*	0	0	*	0	0	*	0	1	+1
Lathridius sp1	0	0	*	0	0	*	0	0	*	0	4	+4	0	2	+2	0	0	*
Lithostygnus sp.1	0	0	*	0	0	*	0	1	+1	1	0	-100%	0	0	*	0	1	+1
Cholevomorpha sp1	0	0	*	0	0	*	0	0	*	0	0	*	0	0	*	0	2	+2
Agyrtodes sp.1	1	0	-100%	0	0	*	0	0	*	0	0	*	0	0	*	0	0	*
Melyridae sp1	0	0	*	0	0	*	0	0	*	0	0	*	0	1	+1	0	0	*
Idaethina sp.1	0	0	*	0	0	*	0	0	*	0	0	*	1	0	-100%	1	0	-100%
Thalycrodes sp.1	1	0	-100%	1	0	**-100%**	1	0	-100%	1	0	-100%	6	0	-100%	3	1	0%
Ischnomera sublineata	0	0	*	0	0	*	0	0	*	0	0	*	1	0	-100%	0	0	*
Eupines sp.1	0	0	*	2	0	**-100%**	0	0	*	0	0	*	0	0	*	0	0	*
Eupines sp.2	0	0	*	0	0	*	0	0	*	0	0	*	1	0	-100%	0	0	*
Ptinus sp.1	1	0	-100%	0	0	*	1	1	0%	1	0	-100%	0	0	*	0	1	+1

Taxa	Plot 1 2006	Plot 1 2009	Plot 1 % Changes	Plot 2 2006	Plot 2 2009	Plot 2 % Changes	Plot 3 2006	Plot 3 2009	Plot 3 % Changes	Plot 4 2006	Plot 4 2009	Plot 4 % Changes	Plot 5 2006	Plot 5 2009	Plot 5 % Changes	Plot 6 2006	Plot 6 2009	Plot 6 % Changes
Byrrhomorpha verres	1	0	-100%	1	0	**-100%**	0	0	*	0	0	*	0	0	*	0	1	+1
Liparetrus sp1	0	0	*	0	0	*	0	0	*	0	1	+1	0	0	*	0	0	*
Heteronyx sp.1	1	0	-100%	1	0	**-100%**	0	0	*	0	0	*	0	0	*	0	0	*
Scydmaenus sp.1	1	0	-100%	1	2	**100%**	0	2	2%	0	1	+1	0	0	*	0	1	+1
Staphylinidae sp.1	0	0	*	1	0	**-100%**	0	0	*	0	0	*	0	1	+1	0	0	*
Staphylinidae sp.2	1	0	-100%	1	0	**-100%**	17	0	-100%	4	2	100%	2	5	400%	1	0	-100%
Staphylinidae sp.3	1	0	-100%	0	2	**+2**	0	0	*	0	6	+6	0	10	+10	0	5	+5
Staphylinidae sp.4	0	0	*	0	0	*	1	0	-100%	0	1	+1	0	0	*	0	9	+9
Staphylinidae sp.5	0	2	+2	0	0	*	0	1	+1	0	3	+3	0	36	+36	0	26	+26
Staphylinidae sp.6	0	0	*	0	3	**+3**	0	2	+2	0	6	+6	0	13	+13	0	3	+3
Staphylinidae sp.7	0	0	*	0	0	*	0	0	*	0	0	*	0	1	+1	0	0	*
Polylobus sp.1	430	0	-100%	642	0	**-100%**	34	0	-100%	21	2	100%	152	0	-100%	25	0	-100%
Tenebrionidae sp.1	0	0	*	1	0	**-100%**	0	0	*	0	0	*	0	0	*	0	0	*
Celibe sp1		0	*		0	*		0	*		2	+2		0	*		0	*
Helea sp.1	0	3	*	1	0	**-100%**	0	0	*	0	2	+2	0	0	*	0	0	*

Bats

Taxa	Plot 1 2009	Plot 2 2009	plot 3 2009	Plot 4 2009	Plot 5 2009	Plot 6 2009
Chalinolobus. gouldii	1/4*	1/5	0	0	3/4	5/5
Mormopterus sp. 4 (planiceps?)	0	0	0	0	3/4	0
Nyctophilus sp.(not able to distinguish between *geoffroyi*, *gouldi* or *timoriensis)*	0	0	0	0	1/4	0
Tadarida. australis	1/4	3/5	0	0	4/4	4/5
Vespadelus. regulus	4/4	5/5	2/4	5/5	4/4	5/5

Community parameters

Species Diversity, evenness, total abundance and Abundance distribution

	Plot 1 06	Plot 1 08	Plot 1 09	Plot 2 06	Plot 2 09	Plot 3 06	Plot 3 08	Plot 3 09	Plot 4 06	Plot 4 08	Plot 4 09	Plot 5 06	Plot 5 08	Plot 5 09	Plot 6 06	Plot 6 09
Total abundance	675	266	724	527	950	105	126	627	246	246	450	390	293	530	295	221
Species richness	33	24	35	37	33	22	21	25	18	27	21	31	20	26	12	21
Species diversity	2.12	2.35	2.19	2.76	2.43	2.45	2.63	1.92	1.76	2.15	1.62	2.42	2.42	2.47	1.02	2.09
Species evenness	0.61	0.74	0.62	0.76	0.69	0.79	0.86	0.60	0.61	0.65	0.53	0.70	0.81	0.76	0.41	0.69
Distribution	Log	log	log	Log	log	Log	log*	log	Log	log	log	Log	log*	log	Log	log

Ants

	Plot 1 2006	Plot 1 2009	Plot 2 2006	Plot 2 2009	Plot 3 2006	Plot 3 2009	Plot 4 2006	Plot 4 2009	Plot 5 2006	Plot 5 2009	Plot 6 2006	Plot 6 2009
Total	483	65	775	94	105	98	53	57	282	168	76	93
Species richness	17	6	13	7	11	11	9	16	13	12	9	18
Species Diversity	0.51	1.06	0.55	0.98	1.41	1.33	1.38	2.34	1.01	1.38	1.29	1.92
Species Evenness	0.18	0.59	0.21	0.50	0.59	0.55	0.63	0.84	0.39	0.56	0.59	0.66
Distribution	none	log	none	log	log	log	log	log	log	log	log	log

Beetles

Feeding Groups

Feeding Guild Details	Plot 1		Plot 2		Plot 3		Plot 4		Plot 5		Plot 6	
	2006	*2009*	*2006*	*2009*	*2006*	*2009*	*2006*	*2009*	*2006*	*2009*	*2006*	*2009*
Feeding Guild 1 (**Coleoptera** diptera hymenoptera **Formicidae**)	78%	57%	86%	63%	55%	56%	59%	48%	79%	52%	66%	44%
Feeding Guild 2 (**Endopterygote** Lepidoptera Orthoptera Psocoptera)	1%	2%	2%	1%	8%	4%	5%	2%	1%	2%	4%	3%
Feeding Guild 3 (Hemiptera **Acarina** Thysanoptera Blattodea **Collembola** Dermaptera Diplura isopoda Isoptera Thysanura)	19%	39%	11%	34%	32%	39%	29%	47%	17%	43%	25%	50%
Feeding Guild 4 (Mantodea **Araneae** Chilopoda Opilionida Pseudoscorpionida)	2%	2%	1%	2%	6%	1%	7%	3%	3%	3%	5%	3%

Arthropods Feeding Guild

Bird Food Group	Plot 1 2006	Plot 1 2009	Plot 2 2006	Plot 2 2009	Plot 3 2006	Plot 3 2009	Plot 4 2006	Plot 4 2009	Plot 5 2006	Plot 5 2009	Plot 6 2006	Plot 6 2009
Predator	0	0	0	0	0	1	0	0	0	0	0	0
Leguminous seeds	2	0	0	2	0	0	0	0	0	0	0	0
Seeds of eucalypt trees and other species	4	5	15	1	15	6	8	1	1	0	0	5
reptiles larger insects, small birds and mammals	2	0	0	0	0	0	0	0	0	0	0	0
Small insects	2	0	0	0	1	1	0	0	0	1	0	1
Mainly medium sized insects in trees and shrubs	0	0	1	0	0	1	0	2	0	0	0	1
Small insects in all strata by flying and on the ground	1	10	6	1	4	2	1	2	0	2	0	1
Small insects in vegetation in shrubs and low trees.	7	8	6	2	6	3	3	6	4	6	2	1
Small insects in low dense vegetation, on ground in leaf litter	0	0	1	0	4	0	0	6	0	0	4	2
Small insects on leaves in mid to upper canopy of forest	1	3	5	1	1	1	1	0	2	3	0	1
small insects, visits flowers for insects	1	0	0	0	1	0	0	0	0	0	0	0
Nectar and insects	2	3	15	0	11	12	0	5	2	0	0	10
Large insects, fleshy seeds, snails	0	0	3	0	0	0	0	0	0	0	0	0
Large insects, small reptiles, nestlings dead animals	0	0	0	0	3	0	0	0	0	0	0	0
Insects under bark	0	0	0	0	0	3	0	0	0	0	0	5
Total	**22**	**29**	**52**	**7**	**46**	**30**	**13**	**22**	**9**	**12**	**6**	**27**

Birds Feeding Guilds

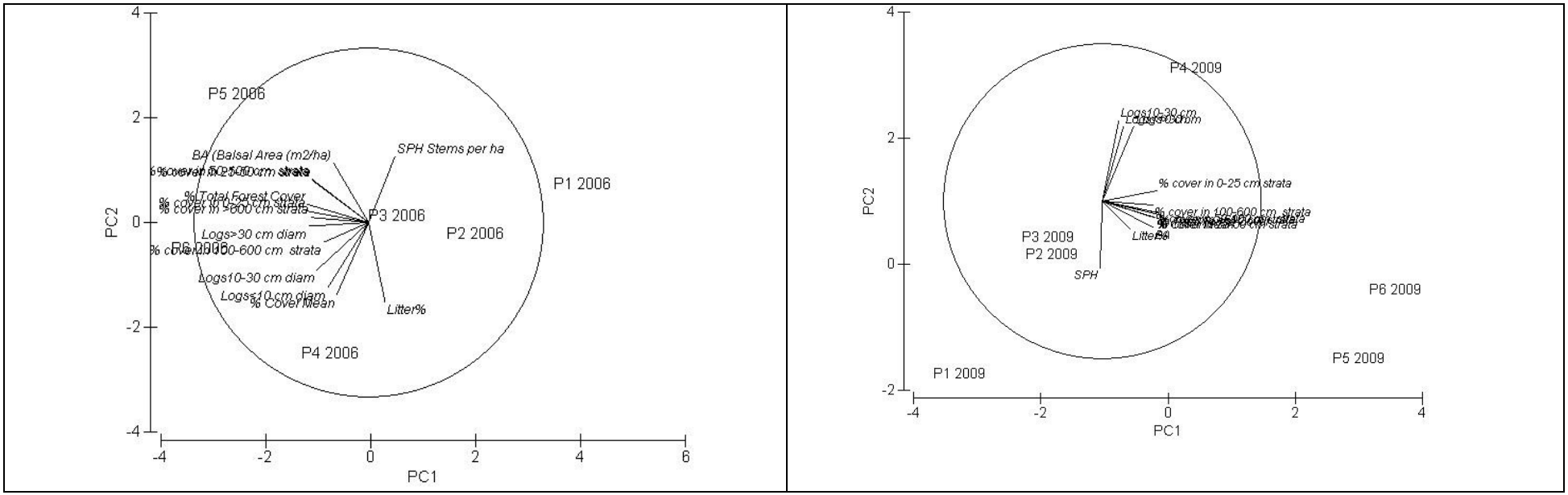
Functional groups

Functional Groups	Plot 1 2006	Plot 1 2008	Plot 1 2009	Plot 2 2006	Plot 2 2009	Plot 3 2006	Plot 3 2008	Plot 3 2009	Plot 4 2006	Plot 4 2008	Plot 4 2009	Plot 5 2006	Plot 5 2008	Plot 5 2009	Plot 6 2006	Plot 6 2009
Dominant Dolichoderinae Total Numbers	9%	20%	46%	22%	9%	2%	6%	48%	7%	3%	4%	1%	1%	1%	0%	3%
Generalized Myrmicinae Total Numbers	53%	12%	23%	23%	39%	42%	50%	31%	74%	80%	72%	45%	38%	40%	83%	67%
Opportunist Total Numbers	20%	39%	10%	28%	17%	26%	4%	7%	8%	4%	2%	31%	41%	35%	0%	2%
Subordinate Camponotini Total Numbers	2%	1%	1%	1%	0%	3%	13%	7%	0%	1%	2%	1%	0%	2%	1%	2%
Hot Climate specialist Total Numbers	11%	26%	17%	21%	33%	2%	14%	4%	2%	7%	12%	16%	12%	9%	1%	2%
Cold climate specialist Total Numbers	1%	0%	1%	3%	0%	24%	11%	2%	9%	4%	8%	3%	9%	6%	13%	14%
Cryptic Total Numbers	0.4%	0%	0.3%	1.3%	0.4%	1.9%	0.8%	0.0%	0.4%	1.6%	0.0%	3.1%	0.0%	0.4%	1.0%	1.4%
Specialist predators Total Numbers	2.2%	2.3%	1.4%	0.4%	0.5%	0.0%	0.0%	0.0%	0.4%	0.4%	0.2%	1.0%	0.0%	7.4%	0.3%	7.7%
Ant Community Structure	DD0 GM	DD1 OP	DD3 GM	DD2 OPP	DD0 GM	DD0 GM	DD0 GM	DD3 GM	DD0 GM	DD0 GM	DD0 GM	DD0 GM	DD0 GM	DD0 GM	DD0 GM	DD0 GM

Ant functional groups

Multi Variate Community data

PCA
vegetation



	2006	2009	2006	2009
PC	% Variation	% Variation	Cum. % Variation	Cum.% Variation
1	61	58.9	61	58.9
2	23.5	20.1	84.5	79
3	8.9	12	93.4	91.1
4	5	5.7	98.4	96.7
5	1.6	3.3	100	100

Variable	2006 PC1	2009 PC1	2006 PC2	2009 PC2	2006 PC3	2009 PC3
BA	***-0.199***	**0.322**	**0.338**	-0.167	**-0.236**	-0.023
SPH	***0.151***	-0.015	**0.377**	***-0.424***	**-0.364**	**-0.527**
% Cover Mean	***-0.184***	**0.331**	***-0.415***	-0.105	***0.236***	0.139
% Total Forest Cover	**-0.351**	**0.351**	0.105	-0.084	0.04	0.038
% cover in 0-25 cm strata	**-0.352**	**0.347**	0.065	0.067	-0.143	-0.093
% cover in 25-50 cm strata	**-0.325**	**0.336**	0.242	-0.105	-0.085	-0.032
% cover in 50-100 cm strata	**-0.325**	**0.325**	0.248	-0.066	-0.093	0.223
% cover in 100-600 cm strata	**-0.256**	**0.322**	-0.113	-0.024	***0.536***	0.253
% cover in >600 cm strata	**-0.332**	**0.352**	0.029	-0.073	0.065	0.021
Logs<10 cm	**-0.234**	0.133	***-0.374***	**0.476**	**-0.345**	**-0.361**
Logs10-30 cm	**-0.297**	0.104	***-0.273***	**0.514**	**-0.273**	**-0.266**
Logs>30 cm	**-0.344**	**0.197**	-0.021	**0.475**	0.004	0.032
Litter%	0.093	0.176	***-0.455***	-0.178	**-0.482**	**-0.612**

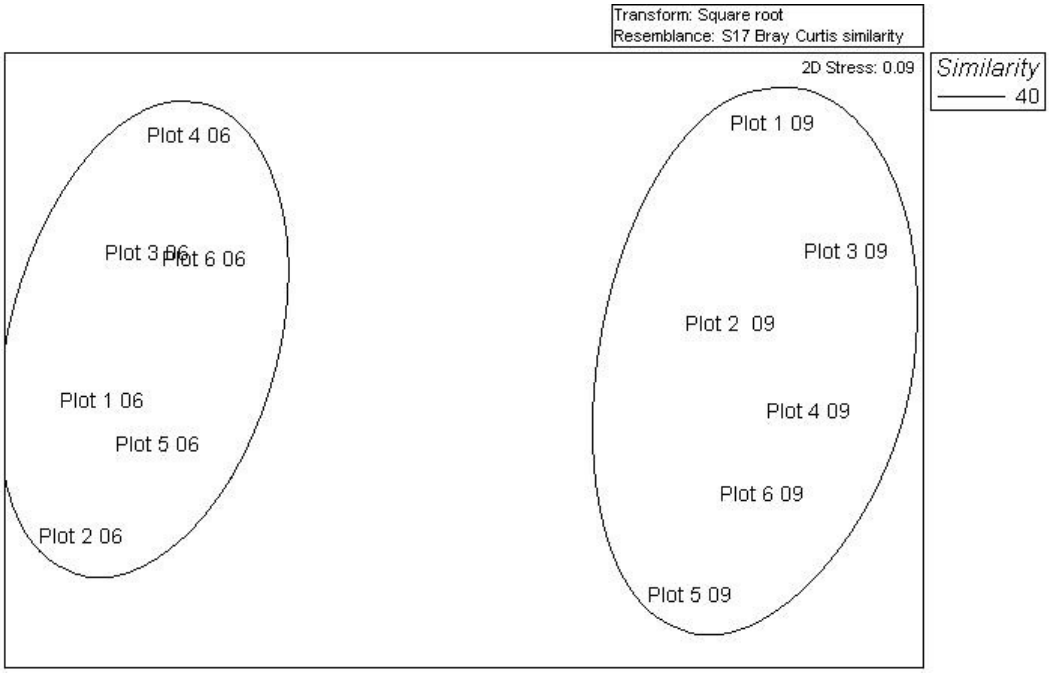
PC 1: This explains about 60% of the variation. The 2006 data has similar –ve mid values (- 0.2 to -0.3) eigenvectors for all vegetation parameters (biomass and large forest debris) except SPH and % litter (small forest debris) which are low. For 2009 the living biomass dominates with +ve mid values (+0.3) for BA and % cover for the various vegetation strata and lower (but still +ve) values for all the forest debris indicators (logs and leaf litter). The treatments have greatly reduced the biomass of the forest increasing the amounts of large log debris in the process. PC 1 seems to reflect the vegetation biomass both dead and alive of the forest ecosystem.

PC2. This explains a further 20% of the variation. The 2006 data shows the contrast between the +ve mid value eigenvectors for **density** of the large and small trees (BA and SPH) and -ve mid values for the small dead biomass (smaller logs and leaf litter) and the %canopy cover which produces this type of litter-higher the amount of cover the more litter that is produced. This group of –ve eigenvectors combines the producer of small forest debris and the small debris of the forest itself. After the treatments the stems are reduced and amount of large forest debris increased. This is reflected in –ve mid value (-0.4) for SPH (and a lesser extent for BA) and +ve mid value (+0.4) for all size logs with little effect on leaf litter.

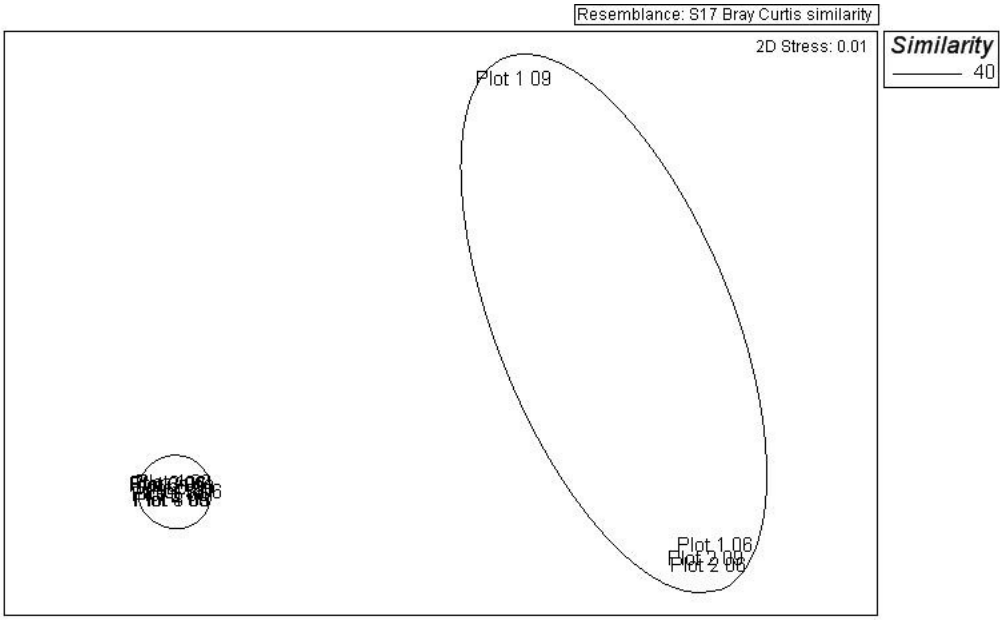
PC3. This explains about 10% of the variation. The 2006 data contrasts the producers of small forest debris in terms of the **density** of small and large trees (BA and SPH) and the small forest debris (smaller logs and leaf litter) (all having –ve mid value eigenvectors (-0.3) with the larger +ve mid-value (+0.2 to +0.5) eigenvectors vegetation biomass (% cover of trees and % cover of larger shrubs). Forest thinning treatments only effected the eigenvector of BA (larger trees in contrast to SPH which include large and small tress and tall shrubs) and didn't seem to affect other eigenvectors for the other parameters as these remained the same after the treatments.

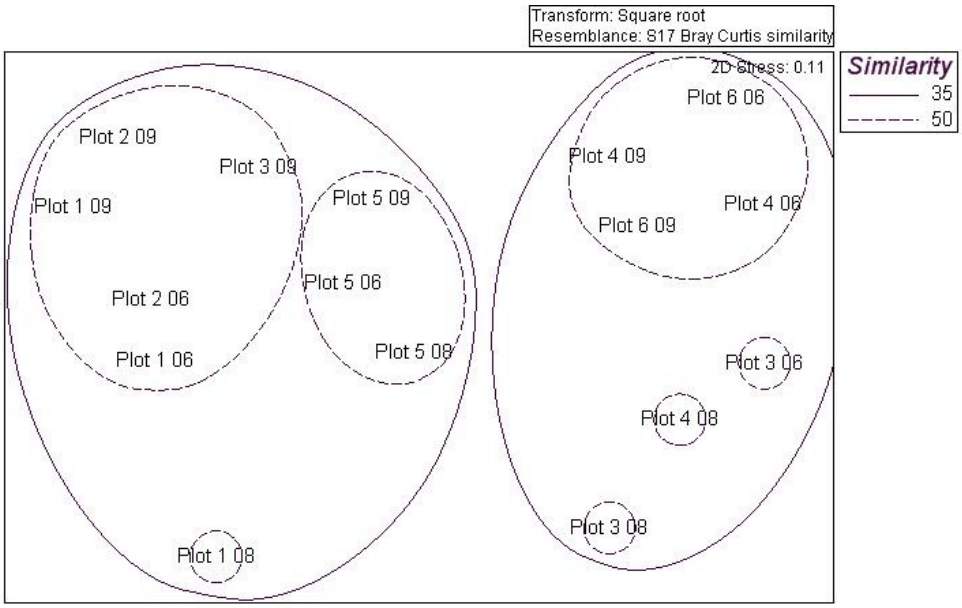
MDS

Beetles

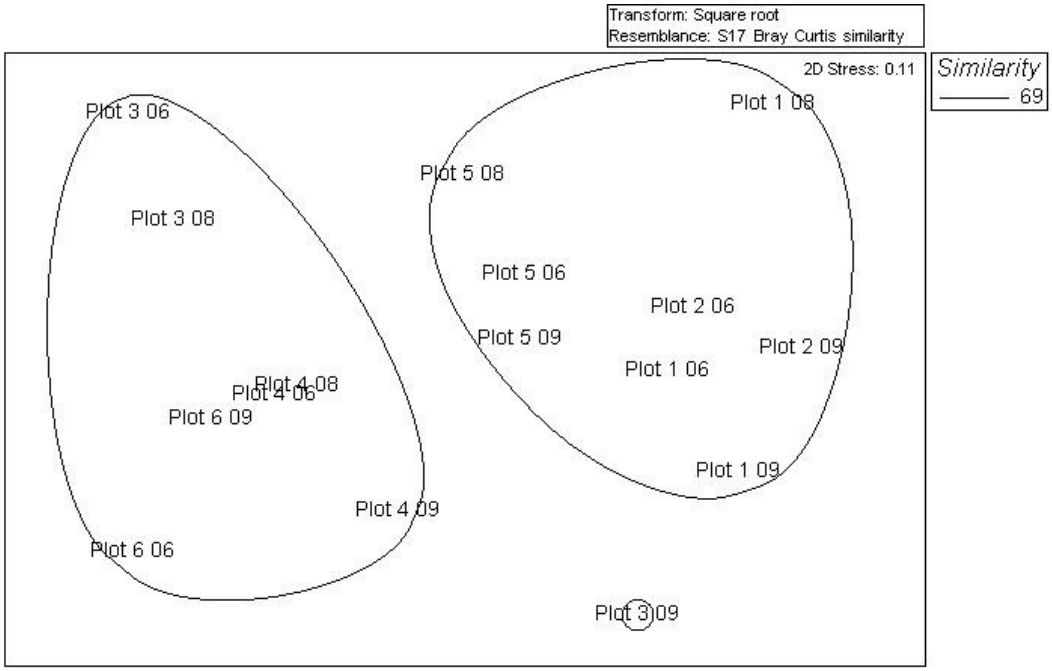


Non bird Vertebrates





Ant abundance



ant functional groups

Summary of Changes

Process

Character	Plot 1 % Change	Plot 2 % Change	*Average 1-2*	Net 1 and 2 from Controls	Net 1 and 2 from Controls (max 100%)	Plot 3 % change		Net 3 from Controls	Net 3 from Controls Max 100%	Plot 4 % Change		Net 4 from controls	Net 4 from controls Max 100%	Plot 5 % Change	Plot 6 % Change	Average 5-6
Arthropoda																
Univariate Data																
Taxon																
Coleoptera	-85%	-84%	***-85%***	**-116%**	**-100%**	5%		**-26%**	**-26%**	137%		**106%**	**100%**	-29%	90%	**31%**
Diptera	-44%	-73%	***-59%***	**-22%**	**-22%**	-33%		**4%**	**4%**	-34%		**2%**	**2%**	-11%	-63%	**-37%**
Formicidae	7%	80%	***44%***	**38%**	**38%**	497%		**492%**	**100%**	83%		**78%**	**78%**	36%	-25%	**5%**
Hymenoptera	-63%	-77%	***-70%***	**-48%**	**-48%**	-82%		**-60%**	**-60%**	-81%		**-59%**	**-59%**	14%	-59%	**-22%**
Community Data																
% Change in Feeding groups																
100%	-31%	-16%	-24%	-17%	**-17%**	205%		212%	**100%**	70%		77%	**77%**	-300%	-1100%	-7%
200%	49%	126%	88%	50%	**50%**	47%		9%	**9%**	-3%		-41%	**-41%**	7200%	400%	38%
300%	100%	253%	177%	-24%	**-24%**	262%		62%	**62%**	242%		42%	**42%**	27000%	17500%	200%
400%	-3%	80%	39%	27%	**27%**	-38%		-50%	**-50%**	-24%		-36%	**-36%**	4200%	-1900%	12%
Total				**36%**				**121%**				**42%**				
Average				**9%**				**30%**				**11%**				
N<0%/Total No				**2/4**				**1/4**				**2/4**				
Diversity %	3%	-12%	***-5%***	**-55%**	**-55%**	-22%		**-72%**	**-72%**	-8%		**-58%**	**-58%**	2%	98%	**50%**
Evenness %	2%	-9%	***-4%***	**-42%**	**-42%**	-24%		**-63%**	**-63%**	-13%		**-52%**	**-52%**	9%	68%	**39%**
Abundance Distribution	No	No	***100%***	**200%**	**100%**	No		**200%**	**100%**	N0		**200%**	**100%**	No	No	**-100%**
MDS Changes abundance																
2006 Similar?	Yes		***100%***	**200%**	**100%**	Yes	100%	**200%**	**100%**	yes	100%	**200%**	**-100%**	1 and 2	3 and 4	**-100%**
group	1	1				2				2				1	2	
2009 similar?	Yes		***100%***	**0%**	**0%**	Yes	100%	**0%**	**0%**	Yes	100%	**0%**	**0%**	Yes		**100%**

Character	Plot 1 % Change	Plot 2 % Change	*Average 1-2*	Net 1 and 2 from Controls	Net 1 and 2 from Controls (max 100%)	Plot 3 % change		Net 3 from Controls	Net 3 from Controls Max 100%	Plot 4 % Change		Net 4 from controls	Net 4 from controls Max 100%	Plot 5 % Change	Plot 6 % Change	Average 5-6
group	3	3				3				3				3	3	
Changes between 06/09	Yes	Yes	***-100%***	**0%**	**0%**	Yes	-100%	**0%**	**0%**	Yes	-100%	**0%**	**0%**	Yes	Yes	**-100%**

Example of one Group Taxa

Fauna Community Parameter	Measurement	Plot Treatment	Changes in Measurement				
			Arthropods	Ants	Beetles	Non Bird Vertebrates	Birds
Taxa and Numbers Changes	*Mean*	Plots 1 and 2. Thin	-9	9	-33	21	-48
		Plots 3 Log and Burn	-7	17	0	28	-5
		Plots 4 Log	18	12	20	46	6
	No<o%	Plots 1 and 2. Thin	12/25	28/90	29/52	6/22	24/33
		Plots 3 Log and Burn	13/25	24/90	18/52	4/22	12/33
		Plots 4 Log	7/25	23/90	15/52	1/22	9/33

Sum of all groups

Fauna Community Parameter	Measurement	Plot Treatment	Changes in Measurement				
			Arthropods	Ants	Beetles	Non Bird Vertebrates	Birds
Total For the Plot/Treatment	*Mean*	Plots 1 and 2. Thin	3	7	-31	7	-36
		Plots 3 Log and Burn	4	11	2	17	-5
		Plots 4 Log	14	10	21	26	5
	No<o%	Plots 1 and 2. Thin	14/34	40/120	36/64	10/33	35/54
		Plots 3 Log and Burn	15/34	36/120	21/64	8/33	21/54
		Plots 4 Log	10/34	35/120	16/64	7/33	13/54

Discussion and conclusions

The data suggests:

1. The arthropods, ants and non bird vertebrates were on average not affected by any of the treatments (all changes were positive taking into account the changes that occurred in the controls.
2. The non commercial thinning had on average a negative effect on the beetles. The other treatments (commercial logging with and without a burn) had no effects on the beetles.
3. The non commercial thinning and commercial logging followed by burning had on average a negative effect on the birds. There was no effect with just commercial logging with no burning.

Recommendations

The data for the beetles suggested they may have been in a plague condition in 2006 which returned to normal by 2009. The changes to the bird community occurred over a wide range of feeding guilds for both plots 1 and 2 and plot 3. Though birds are very mobile and respond quickly to changes (e.g. food), this needs to be further monitored.

Though on average there were no negative effects of the treatments on the arthropods, ants and non bird vertebrates there were some negative changes in a few of the community parameters within these fauna groups. These need to be looked at in more detail if they persist in the next monitoring program which will be carried out in 3 to 5 years time

Bats were sampled for the first time in 2009. Given the lack of information on bats in the northern jarrah forest it would be worth while to carry out more surveys using the echolocation call technique.

Acknowledgements

Frank Batini and Libby Mattiske carried out the various vegetation parameters on the plots