Comparison of Koala Surveys in South-Eastern NSW Coastal Forests 2007-2009 & 2010-2013

Analysis of occurrence, activity and tree preference - Report

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Contents

1 Introduction

1.1 Definition of terms and the scope of the report

This report summarizes and compares the results of two koala surveys that were undertaken in the South-Eastern New South Wales (SENSW) coastal forests to the north east of Bega during the periods 2007-2009 and 2010-2013 respectively. We note that for the 2010-2013 survey period, the samples predominantly came from the period of 2012-13. More details on the terminology, sampling methods and some of the analyses underpinning this report are in Phillips & Callaghan (2000), Allen et al. (2010) and Biolink (2011). This report examines three aspect of koala ecology within the sampling region:

- Occurrence - the presence or absence of koala faecal pellets at a sampling site
- Activity - the proportion of trees with one or more koala faecal pellets at a sampling site
- Preference (strike rate) for certain tree species - defined as the probability that a faecal pellet is found under a tree of a particular species.

Data collection consisted of searching the leaf litter within a 1 m radius of the trunks of 30 trees at each sampling site for the presence of koala faecal pellets, and identifying the species and diameter at breast height (DBH) of each tree.

1.2 Report organization

In this report, three separate analyses have been undertaken:

- The northern portion of the survey areas (herein referred to as the northern portion), which includes most of Murrah State Forest and the northern part of the southern portion
- The southern portion of the survey areas herein referred to as the southern portion, which includes most of Mumbulla State Forest, and small parts of Biamanga and Mimosa Rock National Park
- Both the northern and southern portions of the survey areas combined

Separate analyses were performed for each portion of the survey area as preliminary field survey results from the southern portion of the survey area indicated a greater concentration of koala activity clusters and a higher and increasing proportion of active sites and higher site activity. In contrast, koala activity clusters in the northern portion of the survey area were smaller and more scattered, suggesting a higher proportion of dispersing animals. For each of the analyses, we provide summaries for, and comparisons between, the 2007-2009 and 2010-2013 sampling programs. For the comparison between sampling programs, we restricted our analyses to a subset of sites for which we could find spatial pairs of sites between the two sampling programs. The need to identify spatial pairs was driven by the use of different sampling grids for the 2007-2009 and 2010-2013 survey periods. For the 2007-2009 survey period, the spatial grid was randomly generated by consultants who undertook the initial pilot study for the project and that grid was retained for the remainder of the period. For the 2010-2013 survey, a 500 m grid aligned with the MGA94 coordinate intersections was developed in order to have a grid system that was compatible with other koala surveys using the RGb-SAT method in South-Eastern New South Wales. Spatial pairs consisted of two sites (one site from the 2007-2009 sampling program and one site from the 2010-2013 sampling program) that were located within 500 m of one another. If there were multiple potential pair candidates for a site, we chose the site that was closest to the initial site so that each site had only a single pair. The complete set of sampling locations is shown in Figure 1.

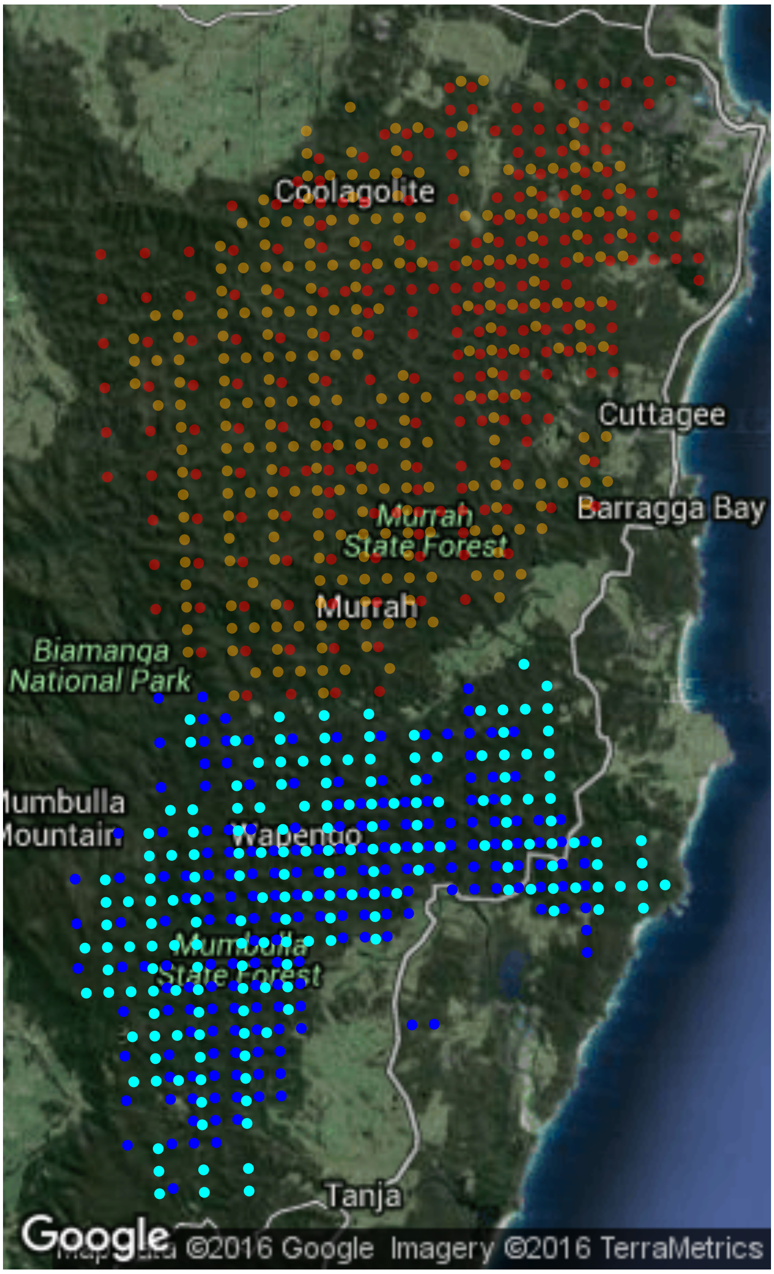


Figure 1: Location of sampling sites in the northern and southern portions for 2007-2009 (red and blue respectively) and 2010-2013 (orange and cyan respectively).

2 The northern portion of the koala survey area

2.1 Summary of 2007-2009 and 2010-2013 koala survey results

2.1.1 General summary of koala occurrence

The locations of the sampling sites in the northern portion are shown in Figure 2 while the observations of koala activity are summarised in Table 1. 246 sites were sampled during the 2007-2009 koala survey and 262 sampling sites were sampled during the 2010-2013 survey. Despite the difference in the number of sites surveyed, the spatial extent of the two surveys was similar. The percentage of sites that were active was consistent across the two years with 9% (21 sites) of sites having koala activity during the 2007-2009 survey and 8% (21 sites) of sites having activity during the 2010-2013 survey. The distribution of koala activity during the 2007-2009 survey was clumped (Figure 3) with areas of koala activity appearing to consist of small clusters of 1 to 3 active sites. Koala activity during the 2010-2013 survey was more clumped, but that was potentially due to the geometry of the sampling sites rather than a change in koala activity. Figure 4 supports this finding as there was little difference in the level of koala activity within sites across the two surveys.

Table 1: Summaries for the occurrence of koalas within the study areas for the two monitoring periods

	2007-2009	2010-2013
Visited sites	246	262
Active sites	21 (9%)	21 (8%)
Inactive sites	225 (91%)	241 (92%)
Examined trees	7373	7858
Active trees	48 (1%)	46 (1%)
Inactive trees	7325 (99%)	7812 (99%)
Trees at active sites	630 (9%)	630 (8%)
Trees at inactive sites	6743 (91%)	7228 (92%)
All tree species	44	44
Active tree species	13 (30%)	9 (20%)

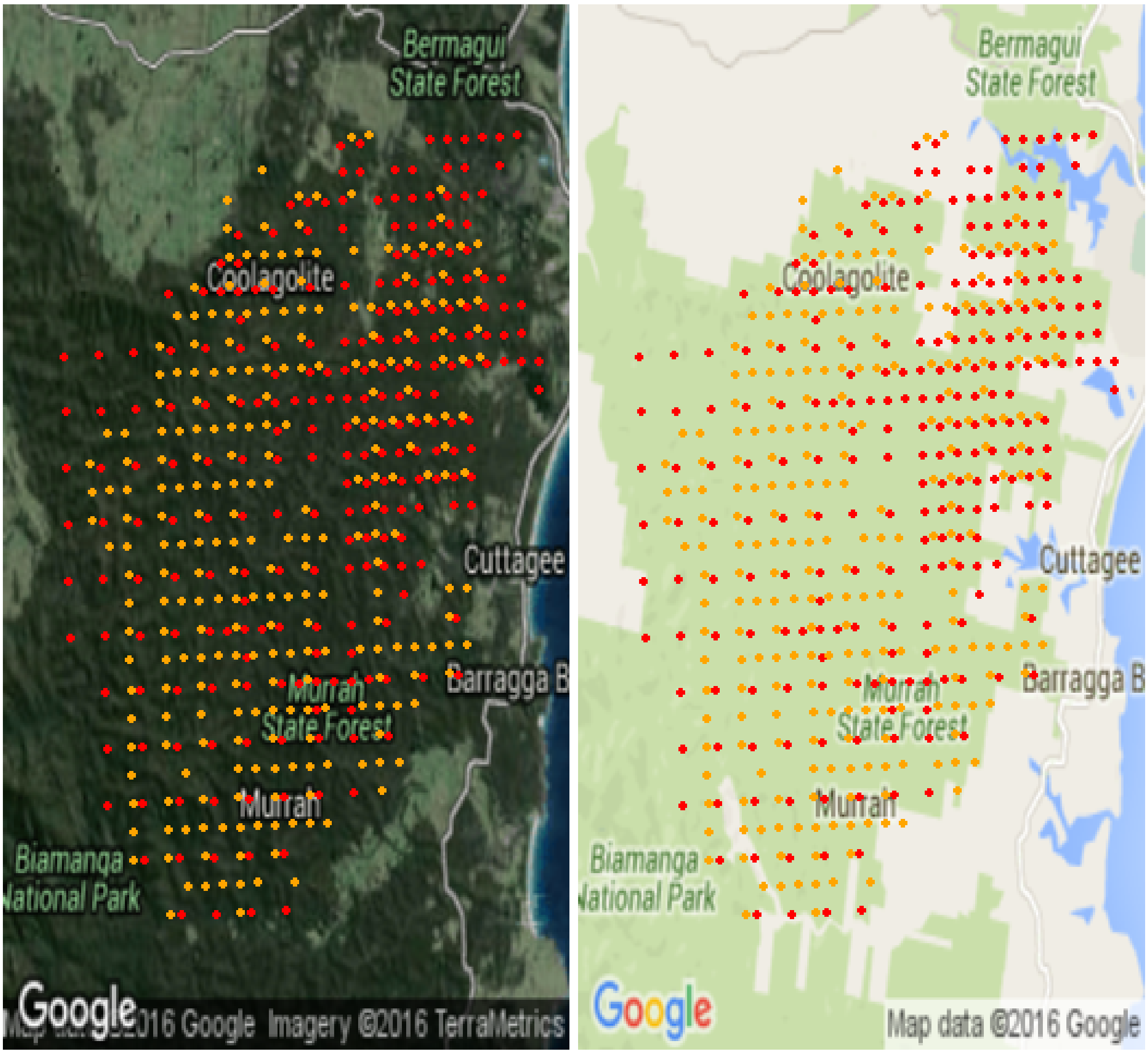


Figure 2: Sampling sites in the northern portion for 2007-2009 (red) and 2010-2013 (orange). Both panels show the same data, but use different basemaps in order to provide more spatial detail.

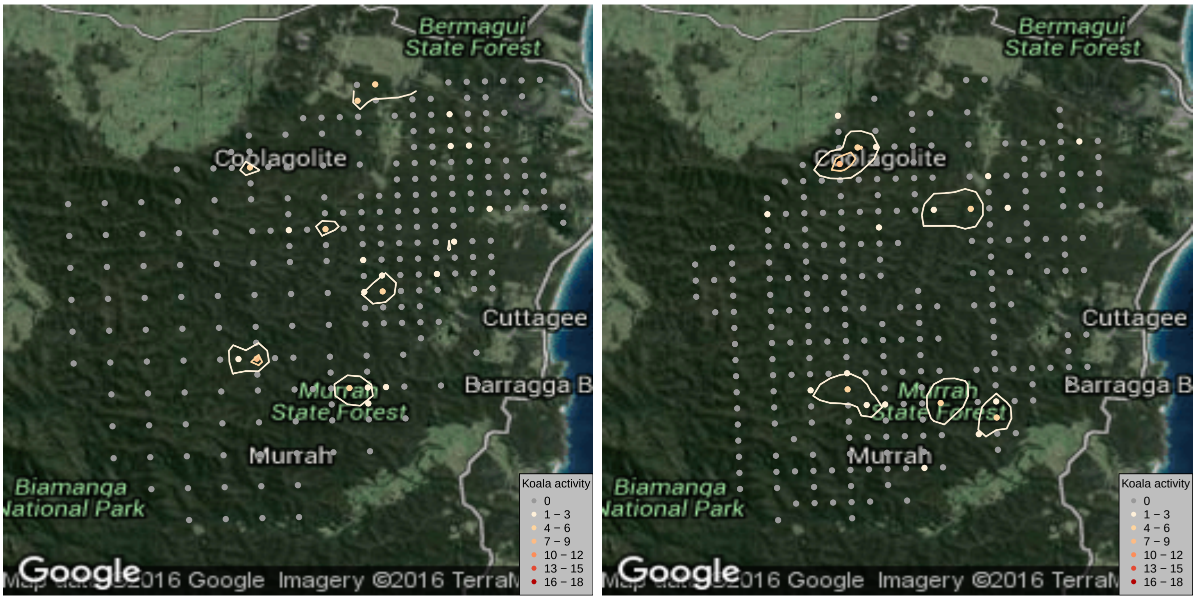


Figure 3: Site-specific koala activity levels and contour lines showing areas of equal koala activity in the northern portion for 2007-2009 (left panel) and 2010-2013 (right panel). The colour key for both site-specific koala activity and the contour lines in terms of number of active trees is shown in the bottom right of each panel.

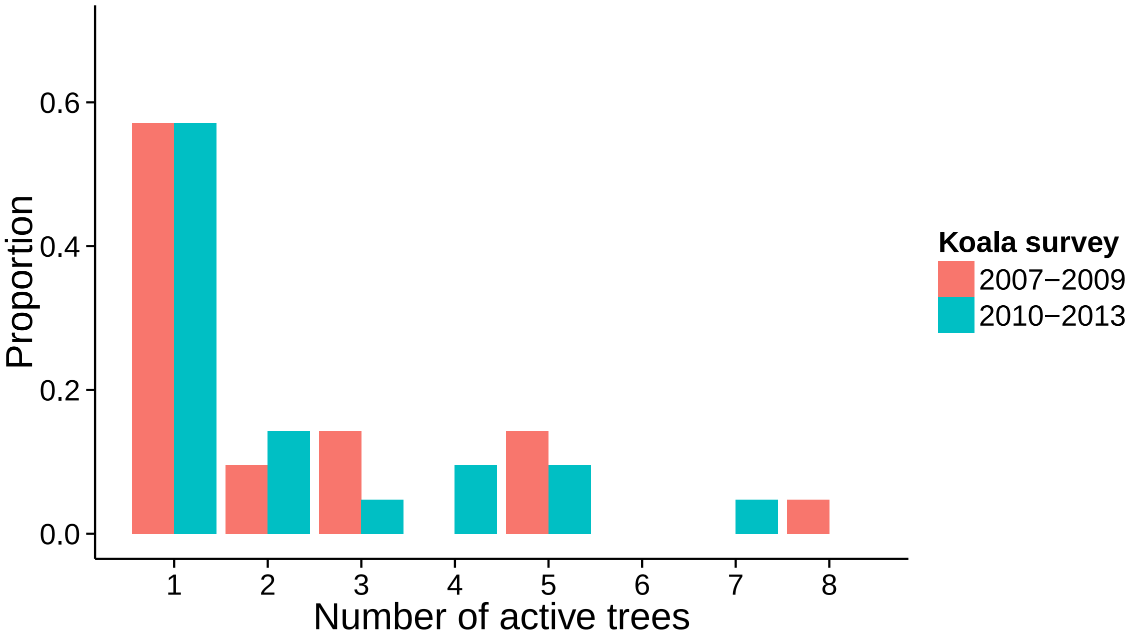


Figure 4: Comparison of the distribution of koala activity at active sites in the northern portion between the two monitoring periods (red = 2007-2009; blue = 2010-2013). Inactive sites were excluded from this analysis.

2.1.2 Tree species composition of active and inactive sites

Differences in tree composition between active and inactive sites can be visualised using non metric multidimensional scaling (NMDS) (Figures 5 and 6). The Bray-Curtis (dis)similarity measure is used to create a pairwise distance matrix between sampling sites based on the species composition of trees at sampling sites. NMDS plots are used to display the sites in two dimensions with more similar sampling sites being plotted closer together while less similar sites are plotted further apart. By colour coding sampling sites based on whether the site was active or inactive for koalas, it is possible to determine if there are differences in tree composition between active and inactive sites. The more active and inactive sites overlap, the less difference in tree species composition between active and inactive sites. Complete overlap would indicate no difference whereas complete separation of the two coloured clusters would indicate that the species compositions of active and inactive sites are completely different. Additionally, we can plot individual tree species on the plot and show how strongly individual tree species are associated with site activity. Species that are 'typical' of active sites will appear closer to the centre of the cluster of active sites while tree species that are atypical of active sites will be located some distance away from the centre of the cluster. In more general terms, if a sampling site (represented by a particular point) is located near the name of a tree species (e.g. *Eucalyptus longifolia*; Elon), this indicates that *E. longifolia* is a common tree species at that site. A list of tree species IDs and corresponding scientific and common names is provided in Table 31.

The ellipses for active sites were completely enclosed by the ellipses for inactive sites in Figures 5 and 6 indicating that there was little to distinguish active sites from inactive sites across the two sampling periods. This was likely due in part to the low number of sites with koala activity (9% in the 2007-2009 and 8% in the 2010-2013 koala surveys). With low levels of koala activity, many sites that could be used by koalas are likely to be unused and results in there being little to differentiate active sites from inactive ones. We note that for the 2007-2009 survey all highly abundant tree species (Table 2; arbitrarily set to trees with counts greater than 200) were found within the blue ellipse for active sites (Figure 5). For the 2010-2013 survey, all of the highly abundant tree species except for *Eucalyptus botryoides* (Ebot) were found within the blue ellipse. *E. botryoides* while not located within the ellipse for active sites, was located within the ellipse for inactive sites. The tree species located outside the ellipses were generally quite rare across the landscape, often numbering less than 100 across all sites.

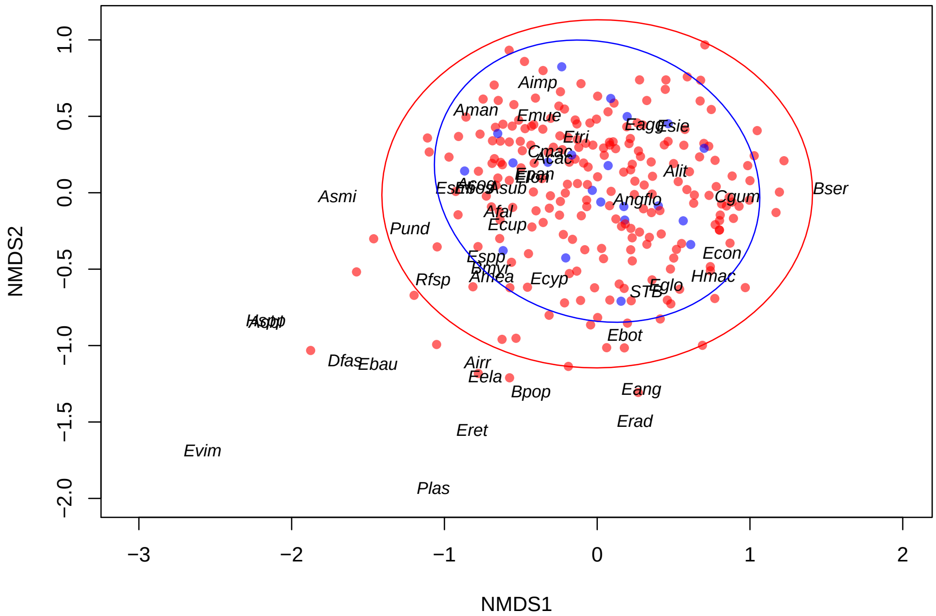


Figure 5: NMDS plot of sites (blue = active sites, red = inactive sites) within the northern portion for 2007-2009 created using Bray-Curtis distances. Ellipses show the 95% bounds for active and inactive sites. Tree names are indicative of tree species composition at the sites. Site 10479 was removed as an outlier.

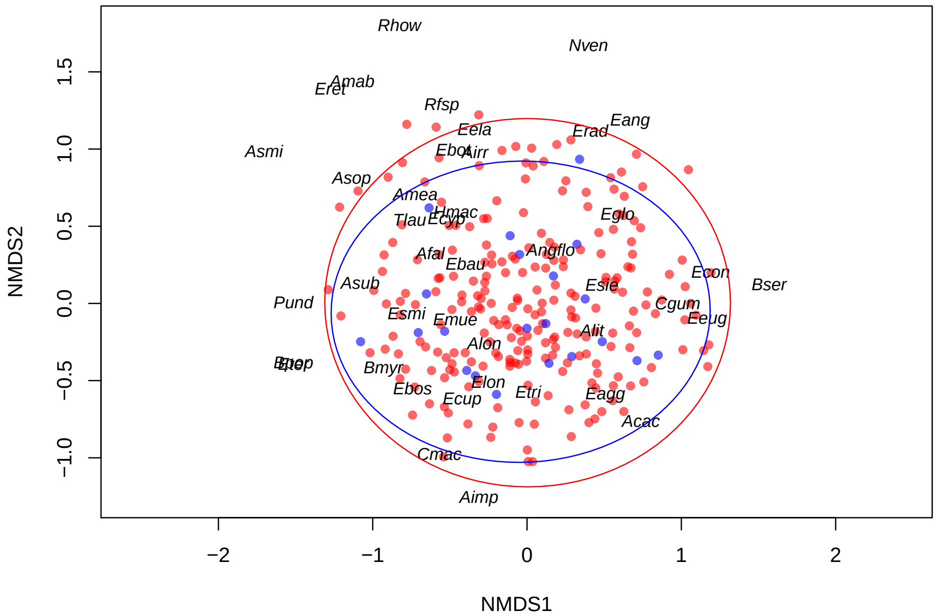


Figure 6: NMDS plot of sites (blue = active sites, red = inactive sites) within the northern portion for 2010-2013 created using Bray-Curtis distances. Ellipses show the 95% bounds for active and inactive sites. Tree names are indicative of tree species composition at the sites. Site 93704 was removed as an outlier.

2.1.3 Strike rates

Mean strike rates Preferences for certain tree species by koalas was determined as the probability (strike rate) of finding koala faecal pellets under a particular tree species. A summary of strike rates by tree species for the northern portion is provided in Tables 2 and 3. In this section, we modified the data analysis methods of Phillips & Callaghan (2000). In their report, Phillips & Callaghan (2000) defined strike rate as the probability that a faecal pellet would be found under a particular tree species and only considered trees at active sites (i.e. the number of trees of species X with one or more faecal pellets divided by the total number of trees of species X at all active sites). Here, we calculated site-specific strike rates for each tree species (i.e. the number of trees of species X with one or more faecal pellets at a site divided by the total number of trees of species X at that site) across all active sites. This enables us to visualise the distribution of strike rates across active sites for a particular species rather than just knowing the mean value of the strike rate for a particular tree species across all active sites. The distribution of strike rates for each tree species across all active sites in the northern portion is shown in Figure 7 where we overlaid box plots and dot-plots. Dot-plots show actual values of strike rates for each site. However, since multiple sites can have the same strike rate, which would not be visible using dot-plots only, the box plots provide additional information about strike rate distribution. The bottom edge of the box corresponds to the lowest 25% of strike rates for a species, the line in the box shows the median, and the top edge of the box corresponds to the upper 75% of strike rates for a particular tree species. The whiskers at the top and bottom of the box indicate 1.5* the inter-quartile range and the dots outside the range of the whiskers represent outliers (i.e. values beyond 1.5*(the 75% cut-off value - the 25% cut-off value)).

Koalas were seen to use a number of different tree species across the two surveys (Table 1). For the 2007-2009 survey, koala faecal pellets were found under 13 of 19 tree species at active sites (Table 2). The tree species not used tended to be relatively rare, with their total number of trees across all active sites ranging from 1 to 11 trees being spread across 1 to 4 active sites (Table 2). For the trees species that were used by koalas, woollybut (*E. longifolia*) was the species with the most trees with faecal pellets under them (16) followed by white stringybark (*E. globoidea*; 7 trees with faecal pellets), and yellow stringybark (*E. muelleriana*; 5 trees with faecal pellets). In terms of activity levels, hickory wattle (*Acacia falciformis*) had the highest activity level (0.33 faecal pellets tree^{-1}), however that was as a result of 1 out of 3 trees at a single active site having a koala faecal pellet. Amongst the more common species at active sites (tree species present at more than half the active sites), species specific activity levels ranged from 0.02 to 0.14 faecal pellets tree^{-1} with woollybut having the highest activity level followed by white and yellow stringybark. Figure 7 shows the range of site-specific strike-rates at active sites for each tree species. In general, all tree species had a high number of site-specific strike rates that were zero and a lesser number of site-specific strike rates that were greater than zero. The only tree species to have non-zero median strike rates were yerchuck (*E. consideniana*), white stringybark, and woollybut.

For the 2010-2013 survey, koala faecal pellets were found under 9 of 24 tree species found at active sites (Table 3). Tree species that were found at active sites, but never had a koala faecal pellet found under them typically numbered less than 10 trees across all active sites, but there were two exceptions to this trend: bloodwood (*Corymbia gummifera*) and blue-leaf stringybark (*E. agglomerata*). Amongst the more common tree species that did have koala activity, white stringybark and woollybut had the highest mean strike rates (0.26 and 0.29 faecal pellets tree^{-1} respectively; Table 2). These two tree species were also the only tree species to have median site-specific strike rates greater than zero (Figure 7).

Table 2: Summary for koala activity for trees at active and inactive sites within the northern portion during the 2007-2009 survey

Tree ID	# of inactive sites	# trees at inactive sites	# of active sites	# trees at active sites	# trees with faecal pellets	Mean strike rate	± Standard error
Acac	12	21			0		
Acog	3	10			0		
Afal	40	113	1	3	1	0.33	
Aimp	2	2	1	1	0	0.00	
Airr	11	47	1	7	0	0.00	
Alit	155	1044	16	100	2	0.02	0.01
Aman	1	2			0		
Amea	11	32			0		
Angflo	100	335	12	33	1	0.02	0.01
Aobl	1	6			0		
Asmi	3	11			0		
Asub	5	10	1	1	0	0.00	
Bmyr	15	75			0		
Bpop	1	1			0		
Bser	6	33			0		
Cgum	59	443	4	11	0	0.00	0.00
Cmac	24	201			0		
Dfas	1	2			0		
Eagg	71	293	8	44	2	0.13	0.05
Eang	2	7			0		
Ebau	4	44			0		
Ebos	48	208	6	21	4	0.19	0.07
Ebot	36	168	4	9	0	0.00	0.00
Econ	21	63	2	4	1	0.17	0.12
Ecup	30	44	3	5	1	0.11	0.09
Ecyp	52	163	5	12	1	0.10	0.06
Eela	16	111			0		
Eglo	97	544	9	63	7	0.12	0.02
Elon	145	779	18	121	16	0.14	0.02
Emue	140	1121	14	77	5	0.11	0.02
Epan	3	5			0		
Erad	10	37			0		
Eret	2	2			0		
Esie	85	449	9	71	4	0.06	0.01
Esmi	23	83			0		
Espp	3	9			0		
Etri	64	180	14	45	3	0.10	0.04
Evim	1	1			0		
Hmac	1	1			0		
Hspp	1	1			0		
Plas	1	1			0		
Pund	8	12			0		
Rfsp	1	1			0		
STB	12	28	1	2	0	0.00	

Table 3: Summary for koala activity for trees at active and inactive sites within the northern portion during the 2010-2013 survey

Tree ID	# of inactive sites	# trees at inactive sites	# of active sites	# trees at active sites	# trees with faecal pellets	Mean strike rate	± Standard error
Acac	2	2			0		
Afal	64	171	2	3	0	0.00	0.00
Aimp	1	1			0		
Airr	12	31	1	1	0	0.00	
Alit	177	1243	18	87	1	0.01	0.00
Alon	2	2			0		
Amab	1	1			0		
Amea	9	27			0		
Angflo	129	381	11	34	2	0.10	0.05
Aobl	1	1			0		
Asmi	2	25			0		
Asop	1	1			0		
Asub	16	63			0		
Bmyr	8	27	2	5	0	0.00	0.00
Bpop			1	2	0	0.00	
Bser	5	33			0		
Cgum	34	202	2	16	0	0.00	0.00
Cmac	5	24	1	2	0	0.00	
Dsas	1	15			0		
Eagg	71	469	7	37	0	0.00	0.00
Eang	1	1	1	1	0	0.00	
Ebau	3	5			0		
Ebos	45	131	6	9	0	0.00	0.00
Ebot	44	263	4	8	0	0.00	0.00
Econ	16	59	1	1	0	0.00	
Ecup	25	47	3	3	0	0.00	0.00
Ecyp	66	221	9	38	3	0.11	0.03
Eela	15	44			0		
Eeug	1	1			0		
Eglo	84	507	10	57	6	0.26	0.05
Elon	162	880	16	79	17	0.29	0.03
Emue	175	1348	16	147	8	0.06	0.01
Erad	11	29	1	2	1	0.50	
Eret	2	2			0		
Esie	100	603	12	62	6	0.12	0.04
Esmi	33	99	2	3	0	0.00	0.00
Eter			1	5	0	0.00	
Etri	90	225	10	27	2	0.04	0.02
Hmac	4	7			0		
Nven	1	1			0		
Pund	3	7	1	1	0	0.00	
Rfsp	4	15			0		
Rhow	1	1			0		
Tlau	3	13			0		

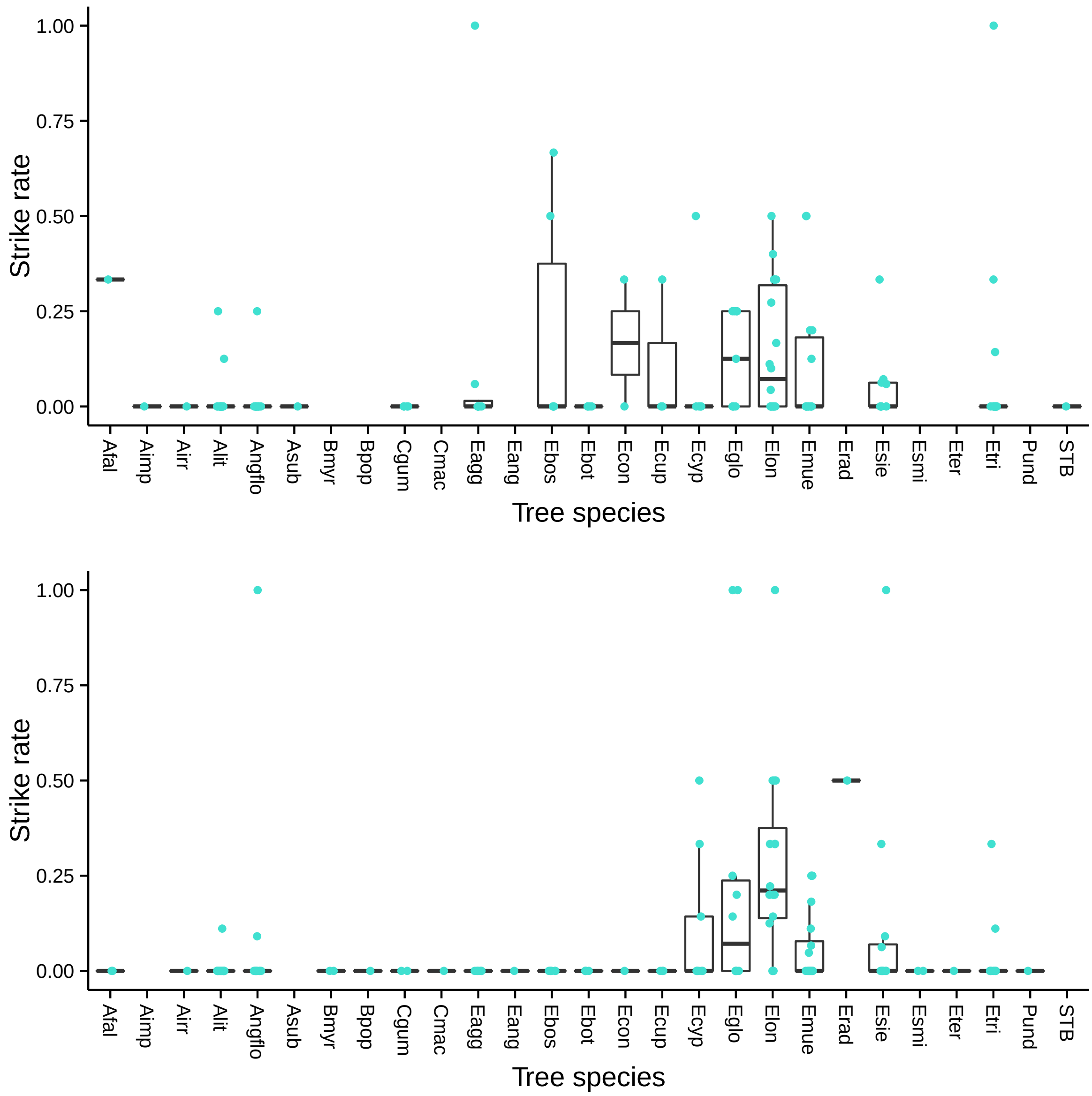


Figure 7: Distribution of strike rates at active sites in the northern portion determined using site-specific strike rates for each tree species for 2007-2009 (top) and for 2010-2013 (bottom). Some tree species were only active in one monitoring period but are included for both monitoring periods to ease comparisons between monitoring periods.

Overall strike rates We developed a second measure of strike rates which we call the overall strike rate. The overall strike rate differs from the original strike rate in that it considers all sites regardless of koala activity (i.e. the number of trees of species X with one or more faecal pellets is divided by the sum of all trees of species X at all visited sites). Overall strike rates for each species are shown in Figure 8. Please, note that the overall strike rate for each species is a single value (i.e. the mean probability across all sites), therefore no distribution is shown in Figure 8.

For the 2007-2009 survey, native cherry (*Exocarpus cuppressiformis*) had the highest overall strike rate of 0.02 faecal pellets tree^{-1} followed by coastal grey-box (*E. bosistoana*) and woollybut (*E. longifolia*) which each had strike rates of 0.0175 faecal pellets tree^{-1}. All three of these tree species had relatively high active strike rates, which suggests that koalas may have a preference for these tree species.

For the 2010-2013 survey, narrow-leafed peppermint (*Eucalyptus radiata*) had by far the highest strike rate (0.032 faecal pellets tree^{-1}), nearly twice the next highest overall strike rate (woollybut, 0.0175 faecal pellets tree^{-1}). The extremely high overall strike rate for narrow-leafed peppermint was likely driven by the species' low number of trees as only one of the trees had a faecal pellet. Woollybut on the other hand, was one of the most abundant tree species and had a much higher overall strike rate than the next highest overall strike rates (0.11 and 0.1 faecal pellets tree^{-1} for monkey gum (*E. cypellocarpa*) and white stringybark respectively).

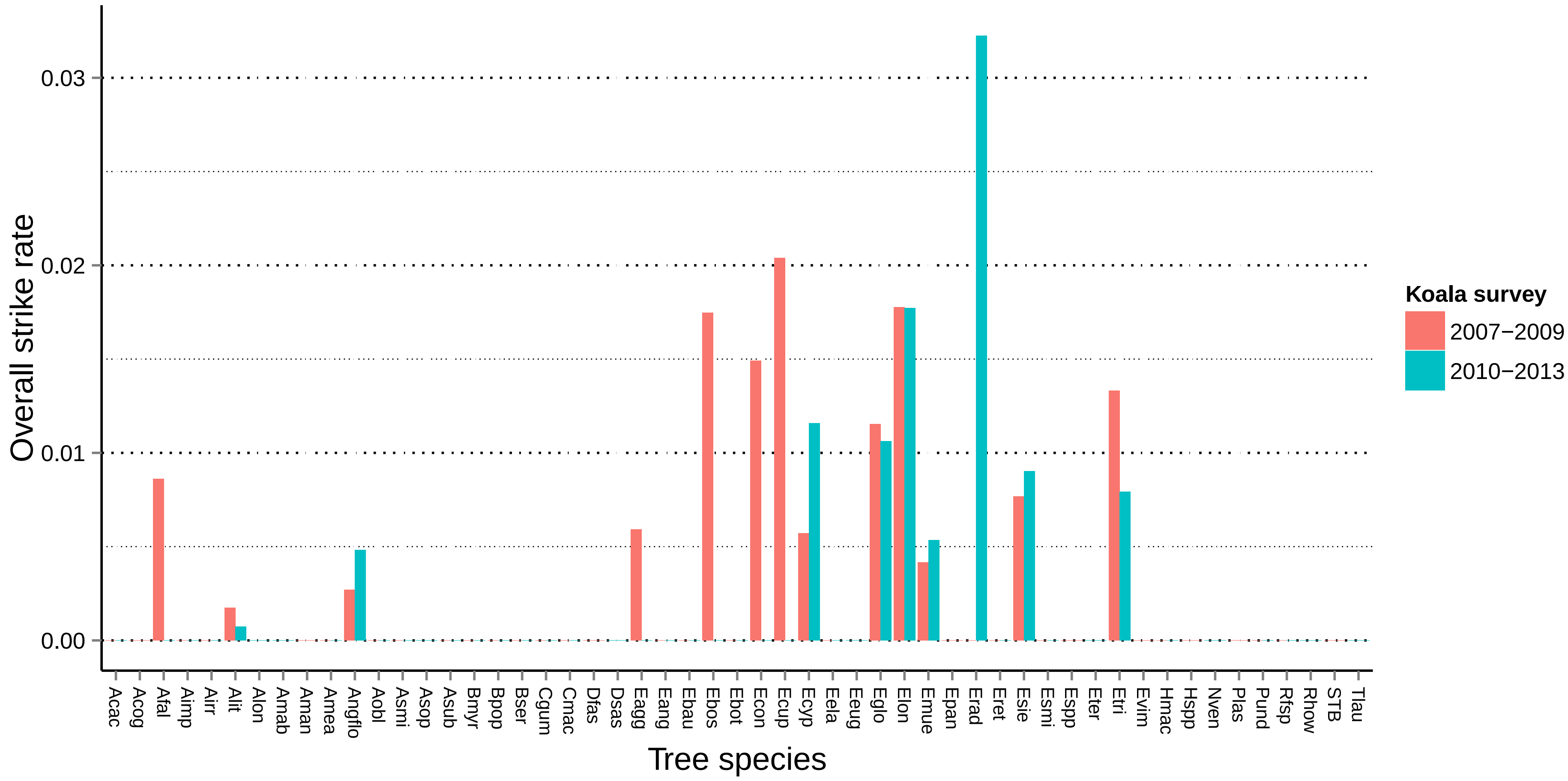


Figure 8: Overall strike rates for each tree species across all visited sites in the northern portion for the two sampling periods.

2.1.4 Tree species preference

While the overall strike rate helps to determine if koalas are showing a preference for some tree species over others, it does not account for differences in the number of trees of each species. Thus, a tree species with only a few sampled trees could have a very high overall strike rate with just 1 or 2 trees having faecal pellets. On the other hand, an abundant species would require a large number of trees with faecal pellets to have a high overall strike rate. However, this can potentially be difficult if koalas only use a small portion of the region. To account for this problem, we used bootstrap simulations to test whether the observed overall strike rate for a tree species was significantly different from the overall strike rate that would be expected if koalas were choosing trees at random (hereafter referred to as simulated strike rate).

For each tree species in the study area, we performed a bootstrap simulation with 100,000 permutations. For each set of simulations, we first determined the relative abundance of a tree species across all visited sites (i.e. the number of trees of species X / the number of all trees), the total number of trees with koala faecal pellets present, and the number of trees of species X with faecal pellets present. For each bootstrap permutation, we generated a random deviate from a binomial distribution which represented the number of strikes assuming koalas choose trees at random. The number of trials was set to the total number of trees with koala faecal pellets present (all tree species), and the probability of a success was set to the proportion of all trees that were trees of species X. As it was possible to generate a random deviate that exceeded the number of trees of a species of interest, if the random deviate exceeded the number of trees of interest we adjusted the random deviate downward to the total number of trees of a species of interest. The random deviate was then converted to simulated strike rate by dividing the random deviate by the total number of trees of species X. Finally, the difference between the observed overall strike rate and the simulated strike rate was determined. After 100,000 permutations were performed, the middle 95% of the distribution of the differences between the observed and simulated strike rates was determined. If the middle 95% of the distribution of differences for a tree species does not include 0, it indicates that koalas are actively avoiding (distribution is below 0) or selecting for (distribution is above 0) a tree species (Figure 9). Bootstrapping is a stochastic process and for tree species that are on the cusp of being positively or negatively selected, their selection status can vary from one set of bootstrap simulations to another. By using a high number of replicates, we have reduced the likelihood of that happening.

For the 2007-2009 survey, we found that all but two tree species were being neutrally selected for by koalas. The two exceptions were forest oak (*Allocasuarina littoralis*) and woollybut (*Eucalyptus longifolia*). Forest oaks were found to be negatively selected by koalas while woollybut was positively selected for. The finding that woollybut was being positively selected for by koalas is consistent with the findings for mean strike rate, the distribution of site-specific strike rates and overall strike rates. The finding that koalas apparently avoided forest oaks is also supported by the various measures of strike rates. Despite having 100 trees and being the second most abundant tree species at active sites, only 2 of them had koala faecal pellets underneath them. In contrast, woollybut, the most abundant tree species at active sites (121 trees) had 16 trees with koala faecal pellets under them while the third most abundant species yellow stringybark (*E. muelleriana*) with 77 trees at active sites had 5 trees with koala faecal pellets under them.

For the 2010-2013 survey, we again found that most species were neutrally selected for by koalas and that forest oak was negatively selected for by koalas while woollybut was positively selected for by koalas. These findings were again similar with the results for mean strike rates, distributions of site-specific strike rates, and overall strike rates.

We note that these results indicate that several of the tree species that were identified as being used heavily by koalas (e.g. having high mean strike rates, distributions of site-specific strike rates and overall strikes rates) are likely being used by koalas because the tree species are abundant across the landscape rather than because they are the species preferred by koalas. Further, these results suggest that using strike rates alone to identify key tree species for koalas may be misleading about the tree species koalas prefer.

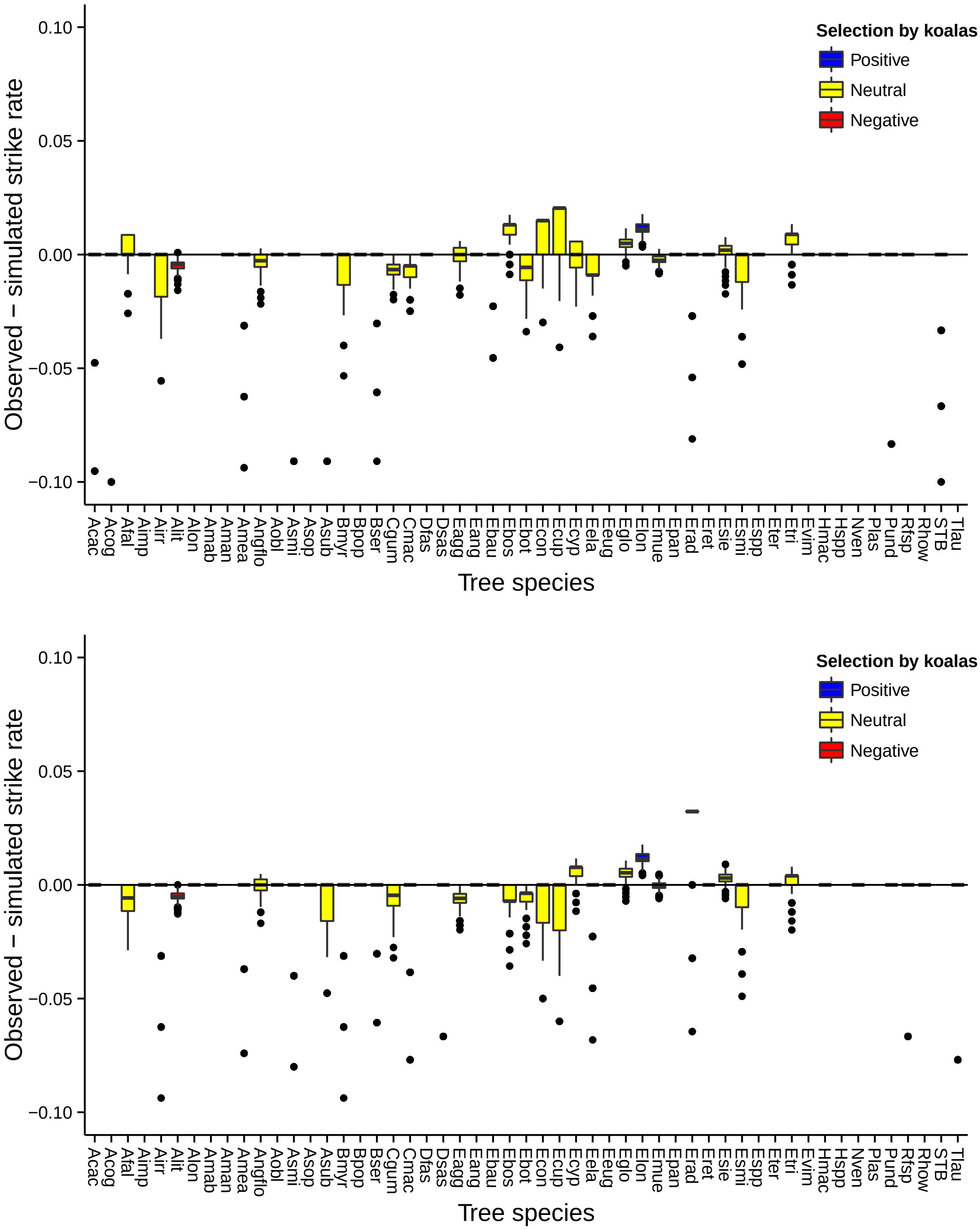


Figure 9: Distributions of observed - simulated strike rates for 2007-2009 (top) and 2010-2013 (bottom) for the northern portion, assuming that koalas choose trees within the study areas at random. Distributions whose middle 95% do not include 0 suggest that the tree species is either being positively selected (i.e. the box plot is above 0 and has a blue fill colour) or negatively selected (i.e. the box plot is below 0 and has a red fill colour). Boxes for tree species that are being neutrally selected have a yellow fill colour. Please note, the y-axes were arbitrarily adjusted to range between -0.1 and 0.1 so that colour-coding can be seen. Many outliers fall outside this range.

2.1.5 Tree size preference

In addition to the preference of koalas for particular tree species, we also investigated the preferences of koalas for different sizes of trees within a tree species. Each tree species was divided into 100 mm DBH (diameter at breast height) intervals (i.e. 100 to 199 mm, 200 to 299 mm, etc.) and the strike rate (i.e. the probability considering active sites only) for each size class in each tree species was determined. The relationship between tree size and their use by koalas is shown for the northern portion in Figure 10. For each tree species, we performed a weighted linear regression between strike rate and tree size with each size class being weighted by the number of trees (of the species of interest) in the size class. Results for all tree species are shown in Tables 4 and 5. The R^2 value shows the proportion of the change in strike rate with tree size that can be attributed to tree size. The closer the R^2 value is to 0, the weaker the relationship between tree DBH and koala strike rate for a particular specie while the closer the R^2 value is to 1, the more important the role of tree size in the selection of trees by koalas. The slope of the relationship informs us about the overall direction of the relationship. A positive slope value indicates that koalas prefer larger trees than smaller trees of a particular species, whereas a negative slope value indicates the opposite. The absolute value for the slope (i.e. how far the slope value is from zero in any direction) tells us about the steepness of the relationship. High absolute values for slopes indicate that there was a large difference in strike rates between size classes. The p-value provides information about the significance of the observed relationship - in general, only relationships with $p < 0.05$ are considered to be significant, but if regressions are being performed for a large number of tree species simultaneously, a more conservative significance level is $0.05/N$, where N is the number of regressions performed. This is because the chance of having a statistically significant result when in reality the result is actually not significant increases as the number of regressions performed increases. Making this adjustment to the significant p-value keeps the overall type I error rate at 5%.
For the 2007-2009 survey, using a non-conservative alpha of 0.05, a significant relationship (p = 0.04) between the size class of a tree species and the strike rate for that species was found for *Eucalyptus sieberi*, the silvertop ash. The slope for this relationship was negative (-0.01), indicating that strike rate decreased with tree size and the R^2 was 0.55. The relationship between size class and strike rate was not significant for any other species. We note however that the relationship between tree size class and strike rate verged on significance (p = 0.05) for *E. longifolia*. The slope was positive (0.05) and the R^2 was 0.43.

We failed to find a significant relationship between tree size class and strike rate for any of the tree species sampled during the 2010-2013 survey.

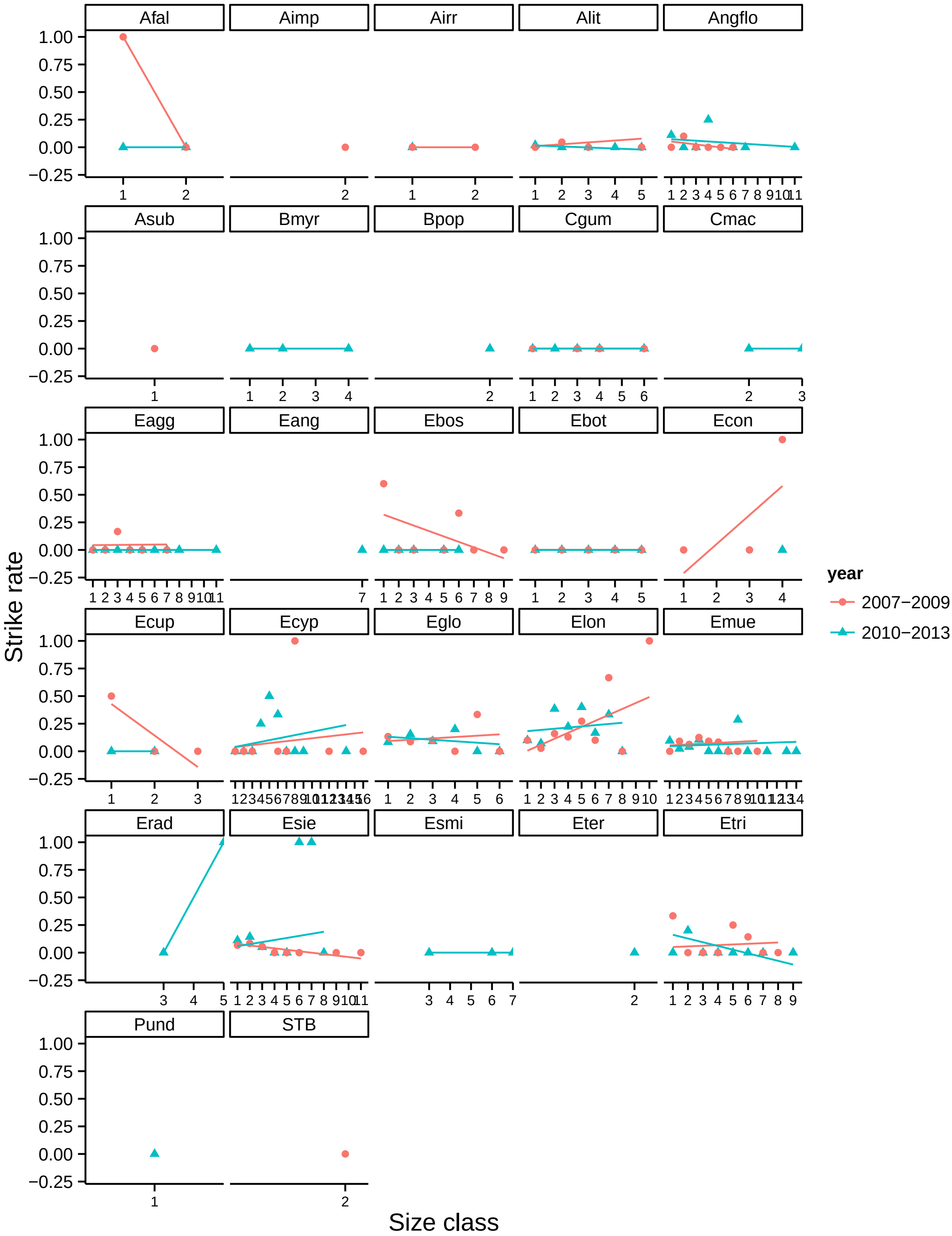


Figure 10: Relationships between tree size (DBH) and strike rates for each species for the two study periods for the northern portion.

Table 4: Summary terms for linear regressions of strike rate on tree size for each tree species found at active sites in the northern portion during the 2007-2009 survey weighted by the number of trees in each size class. Summary terms include the number of trees used in the regression (N), intercept and slope of the regression line, the R2 value and the p-value for the regression.

Tree ID	N	Intercept	Slope	R-square	p-value
Afal	3	2	-1	1.00	
Aimp	1	0		0.00	
Airr	7	-0	0		
Alit	100	-0	0	0.26	0.49
Angflo	33	0	-0	0.12	0.50
Asub	1	0		0.00	
Cgum	11	-0	-0		
Eagg	44	0	0	0.00	0.97
Ebos	21	0	-0	0.20	0.32
Ebot	9	-0	0		
Econ	4	-0	0	0.44	0.54
Ecup	5	1	-0	0.76	0.32
Ecyp	12	0	0	0.02	0.75
Eglo	63	0	0	0.04	0.71
Elon	121	-0	0	0.43	0.05
Emue	76	0	0	0.05	0.55
Esie	71	0	-0	0.55	0.04
Etri	45	0	0	0.01	0.83
STB	2	0		0.00	

Table 5: Summary terms for linear regressions of strike rate on size class for all combinations of tree species found at active sites in the northern portion during the 2010-2013 survey weighted by the number of trees in each size class. Summary terms include the p-value for the regression, the R2 value, the slope and intercept of the regression line and the total number of trees used in the regression.

Tree ID	N	Intercept	Slope	R-square	p-value
Afal	3	-0	0		
Airr	1	0		0.00	
Alit	87	0	-0	0.62	0.11
Angflo	34	0	-0	0.03	0.70
Bmyr	5	-0	-0		
Bpop	2	0		0.00	
Cgum	16	-0	0		
Cmac	2	-0	0		
Eagg	37	-0	0		
Eang	1	0		0.00	
Ebos	9	-0	0		
Ebot	8	-0	-0		
Econ	1	0		0.00	
Ecup	3	-0	0		
Ecyp	38	0	0	0.08	0.44
Eglo	57	0	-0	0.09	0.56
Elon	79	0	0	0.03	0.69
Emue	147	0	0	0.01	0.73
Erad	2	-1	0	1.00	
Esie	62	0	0	0.03	0.70
Esmi	3	-0	-0		
Eter	5	0		0.00	
Etri	27	0	-0	0.43	0.08
Pund	1	0		0.00	

2.2 Comparison of 2007-2009 and 2010-2013 koala surveys

For the northern portion, we were able to identify 145 pairs of sites between the 2007-2009 and 2010-2013 survey periods. The pairs of sites are shown in Figure 11 while a general summary of koala activity for the paired sites is provided in Table 6.

Directly comparing the 2007-2009 koala survey to the 2010-2013 survey (Table 6), the percentage of sites that were active increased marginally (not statistically significant) from 6% of sites (8 sites total) in 2007-2009 to 8% of sites (11 sites total) in 2010-2013. Over the same period, the number of active trees significantly increased (Chi-square test, $p = 0.017$), more than doubling from 14 to 31 active trees. The location and intensity of koala activity in the northern portion shifted between the two surveys (Figure 12). During the 2007-2009 survey, there were two isolated main areas of activity across this portion of the survey area. During the 2010-2013 survey, there were three main areas of koala activity and the level of koala activity appeared to be higher. Comparing the distribution of koala activity across active sites (Figure 13), active sites during the 2010-2013 survey often had several active trees (3+) while active sites during the 2007-2009 survey tended to only have 1 or 2 active trees.

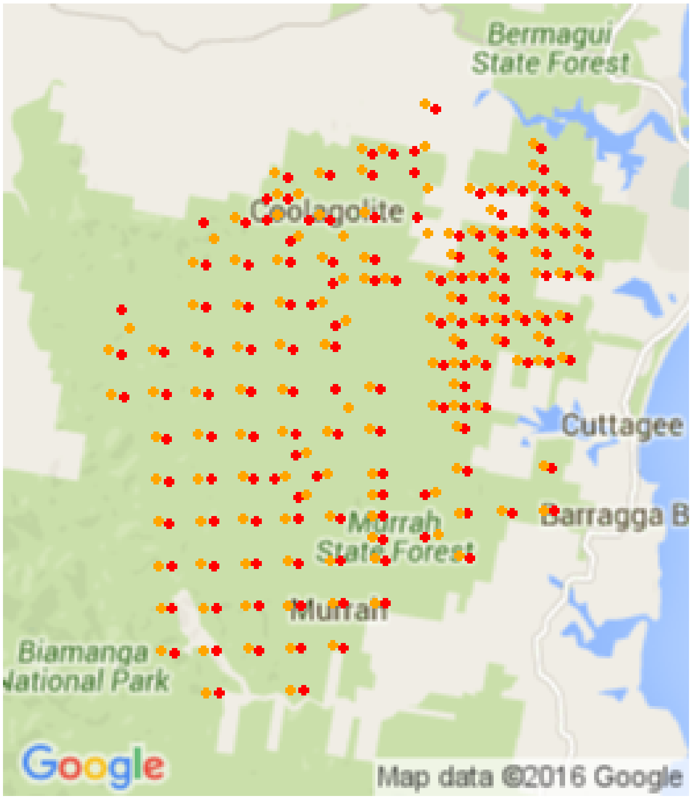


Figure 11: Paired sampling sites in the northern portion for 2007-2009 (red) and 2010-2013 (orange).

Table 6: Summaries of the occurrence of koalas within the northern portion for the two monitoring periods

	2007-2009	2010-2013
Visited sites	145	145
Active sites	8 (6%)	11 (8%)
Inactive sites	137 (94%)	134 (92%)
Examined trees	4345	4350
Active trees	14 (0%)	31 (1%)
Inactive trees	4331 (100%)	4319 (99%)
Trees at active sites	240 (6%)	330 (8%)
Trees at inactive sites	4105 (94%)	4020 (92%)
All tree species	39	40
Active tree species	7 (18%)	8 (20%)

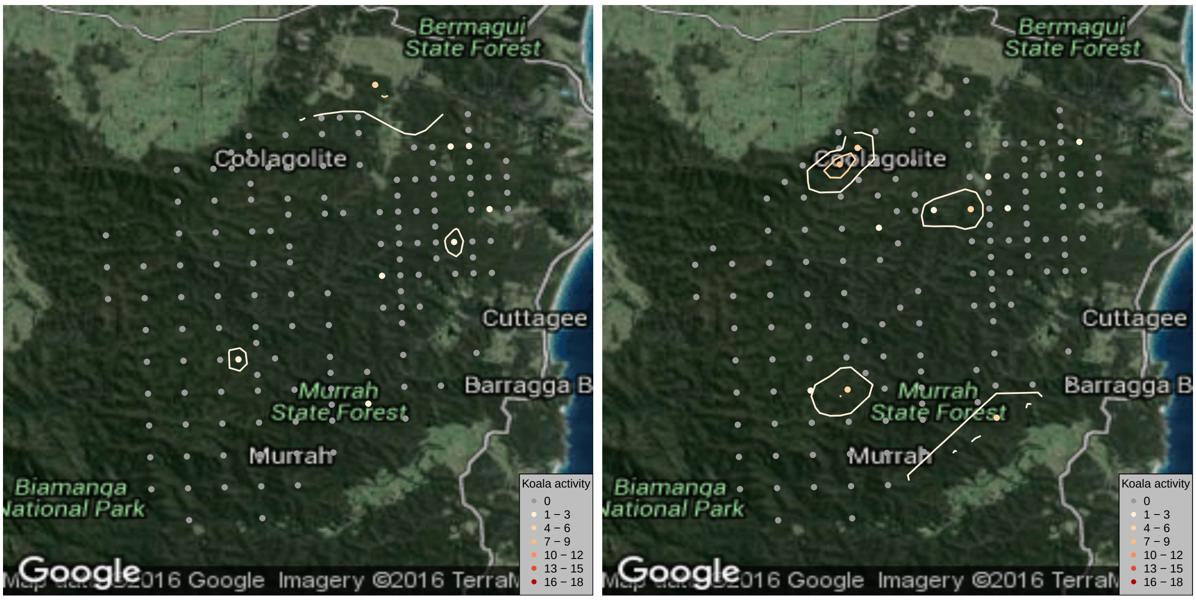


Figure 12: Site-specific koala activity levels and contour lines showing areas of equal koala activity for paired sites in the northern portion for 2007-2009 (left panel) and 2010-2013 (right panel). The colour key for both site-specific koala activity and the contour lines in terms of number of active trees is shown in the bottom right of each panel.

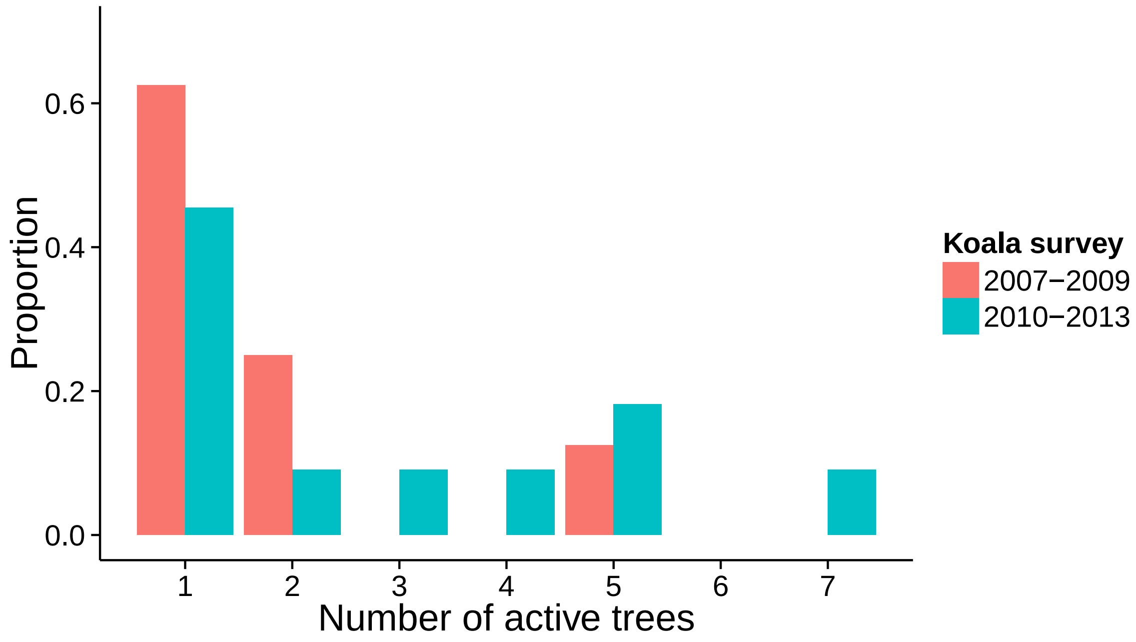


Figure 13: Comparison of the distribution of koala activity at active sites in the northern portion between the two monitoring periods (red = 2007-2009; blue = 2010-2013) for all paired sites. Inactive sites were excluded from this analysis.

2.2.1 Tree species composition of active and inactive sites

Tree species composition extensively overlapped for the active and inactive sites for the two koala surveys. This was likely because the number of active sites was small compared to the number of inactive sites. As a result, there were likely many sites that could have supported koalas, but didn't because the koala population size was at low levels which resulted in there being little to distinguish active sites from inactive ones. A cursory comparison of the NMDS plots (Figures 14 and 15) for the two surveys showed that the tree species that were located outside the two ellipses for one survey tended to be outside the ellipse for the other. This was similarly true for tree species located inside the ellipses as well.

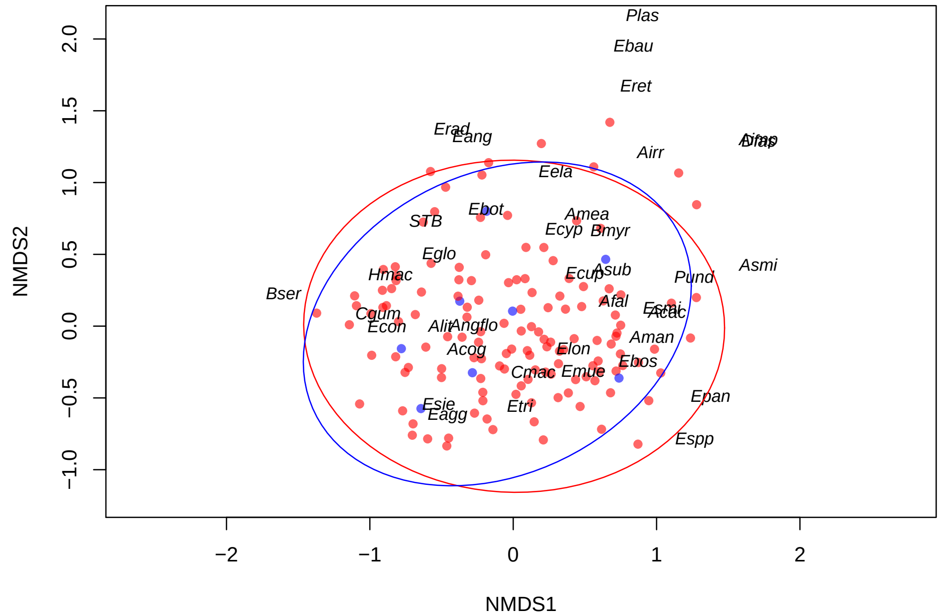


Figure 14: NMDS plot of paired sites (blue = active sites, red = inactive sites) within the northern portion for 2007-2009 created using Bray-Curtis distances. Ellipses show the 95% bounds for active and inactive sites. Tree names are indicative of tree species composition at the sites. Site 10479 was removed as an outlier.

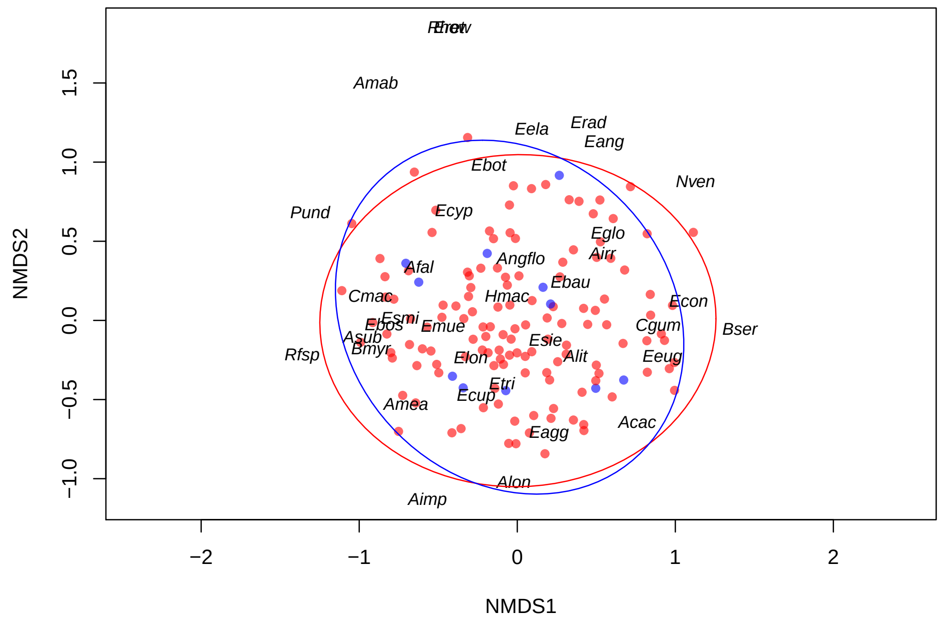


Figure 15: NMDS plot of paired sites (blue = active sites, red = inactive sites) within the northern portion for 2010-2013 created using Bray-Curtis distances. Ellipses show the 95% bounds for active and inactive sites. Tree names are indicative of tree species composition at the sites. Site 10479 was removed as an outlier.

2.2.2 Strike rates

The number of trees of each species sampled for koala faecal pellets did not differ significantly across the two surveys (Tables 7 and 8; paired t-test, t= -0.051, p = 0.96). Additionally, the overall pattern of mean strike rates did not differ significantly across surveys (paired t-test for mean strike rates of tree species that were active during both surveys t = -0.80, df = 5, p = 0.46). However, despite this finding, there were some clear differences in mean strike rates across the two surveys amongst the more abundant tree species. The mean strike rates for woollybut (*E. longifolia*), white stringybark (*E. globoidea*), rough-barked angophora (*Angophora floribunda*), and silvertop ash (*E. sieberi*) were all substantially higher in the 2010-2013 survey than in the 2007-2009 survey. In contrast, the mean strike rates for ironbark (*E. sideroxylon*) and monkey gum (*E. cypellocarpa*) declined substantially between the 2007-2009 survey and the 2010-2013 survey. The distribution of site-specific strike rates across the two surveys appeared to be consistent for the most part (Figure 16). Differences in the overall strike rates across the two surveys (Figure 17) were generally consistent with the noted differences described above for mean strike rates. The other differences were for tree species that had koala activity in one year, but not the other (see Tables 7 and 8 for specific numbers.)

Table 7: Summary for koala activity for trees at paired active and inactive sites within the northern portion during the 2007-2009 survey

Tree ID	# of inactive sites	# trees at inactive sites	# of active sites	# trees at active sites	# trees with faecal pellets	Mean strike rate	± Standard error
Acac	4	7			0		
Acog	1	2			0		
Afal	28	85			0		
Aimp	1	1			0		
Airr	7	37	1	7	0	0.00	
Alit	102	697	6	38	0	0.00	0.00
Aman	1	2			0		
Amea	5	19			0		
Angflo	59	204	4	15	0	0.00	0.00
Asmi	2	7			0		
Asub	5	10	1	1	0	0.00	
Bmyr	10	32			0		
Bser	3	14			0		
Cgum	32	273	2	6	0	0.00	0.00
Cmac	10	52			0		
Dfas	1	2			0		
Eagg	45	174	2	9	0	0.00	0.00
Eang	2	7			0		
Ebau	2	25			0		
Ebos	28	99	2	12	0	0.00	0.00
Ebot	23	112	3	8	0	0.00	0.00
Econ	11	34	1	1	0	0.00	
Ecup	18	27	3	5	1	0.11	0.09
Ecyp	30	95	3	8	1	0.17	0.10
Eela	7	33			0		
Eglo	52	250	5	33	5	0.17	0.02
Elon	92	468	6	22	2	0.08	0.03
Emue	94	782	5	27	1	0.10	0.04
Epan	1	2			0		
Erad	7	17			0		
Eret	2	2			0		
Esie	55	306	4	36	3	0.12	0.02
Esmi	19	72			0		
Espp	1	4			0		
Etri	45	128	5	12	1	0.20	0.13
Hmac	1	1			0		
Plas	1	1			0		
Pund	3	5			0		
STB	7	17			0		

Table 8: Summary for koala activity for trees at pairedactive and inactive sites within the northern portion during the 2010-2013 survey

Tree ID	# of inactive sites	# trees at inactive sites	# of active sites	# trees at active sites	# trees with faecal pellets	Mean strike rate	± Standard error
Acac	2	2			0		
Afal	32	74	1	1	0	0.00	
Aimp	1	1			0		
Airr	4	10	1	1	0	0.00	
Alit	99	668	9	37	1	0.01	0.01
Alon	1	1			0		
Amab	1	1			0		
Amea	5	7			0		
Angflo	64	172	6	25	2	0.18	0.08
Aobl	1	1			0		
Asmi	1	12			0		
Asub	7	25			0		
Bmyr	4	20	2	5	0	0.00	0.00
Bser	5	33			0		
Cgum	29	175	2	16	0	0.00	0.00
Cmac	1	1	1	2	0	0.00	
Dsas	1	15			0		
Eagg	42	250	5	35	0	0.00	0.00
Eang	1	1	1	1	0	0.00	
Ebau	2	4			0		
Ebos	24	87	4	7	0	0.00	0.00
Ebot	20	120	1	3	0	0.00	
Econ	15	58	1	1	0	0.00	
Ecup	13	31	3	3	0	0.00	0.00
Ecyp	24	85	5	22	2	0.10	0.03
Eela	5	16			0		
Eeug	1	1			0		
Eglo	51	343	4	29	4	0.35	0.08
Elon	92	510	9	42	12	0.38	0.04
Emue	91	692	7	59	5	0.08	0.01
Erad	4	8			0		
Eret	1	1			0		
Esie	58	382	5	24	4	0.27	0.09
Esmi	22	65			0		
Etri	51	136	5	16	1	0.02	0.01
Hmac	1	1			0		
Nven	1	1			0		
Pund	2	6	1	1	0	0.00	
Rfsp	2	3			0		
Rhow	1	1			0		

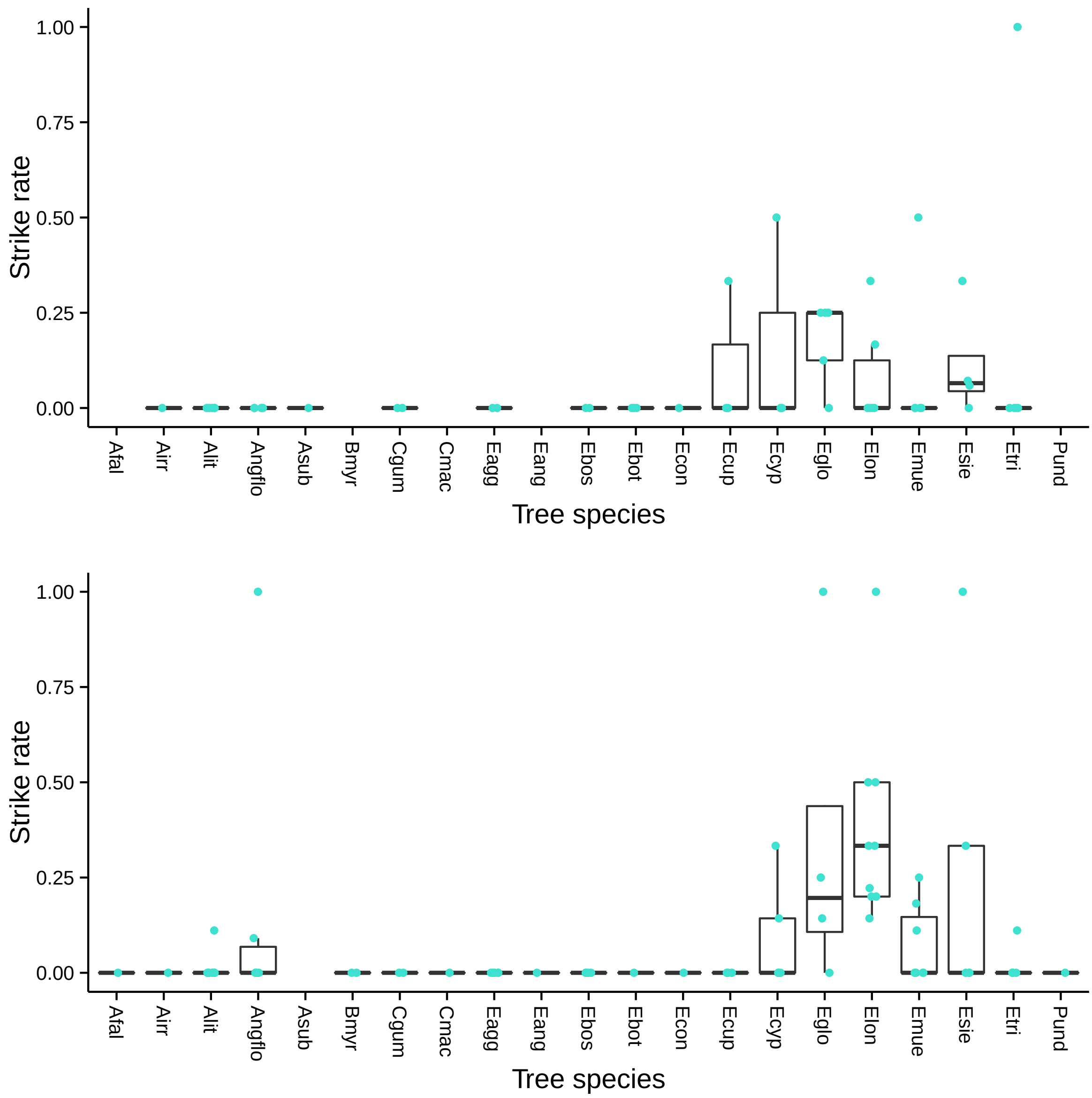


Figure 16: Distribution of strike rates at paired active sites in the northern portion determined using site-specific strike rates for each tree species for 2007-2009 (top) and for 2010-2013 (bottom). Some tree species were only active in one monitoring period but are included for both monitoring periods to ease comparisons between monitoring periods.

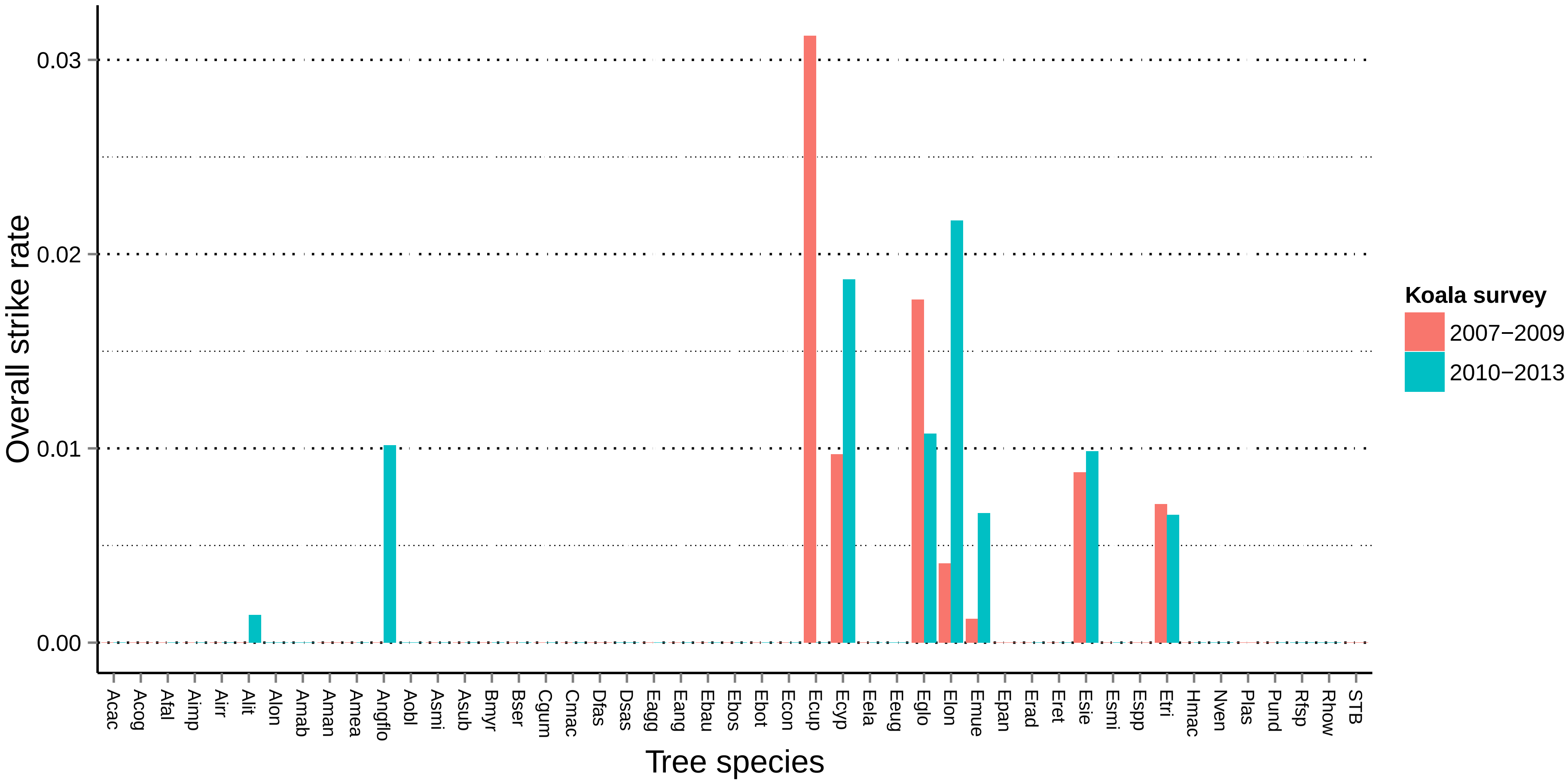
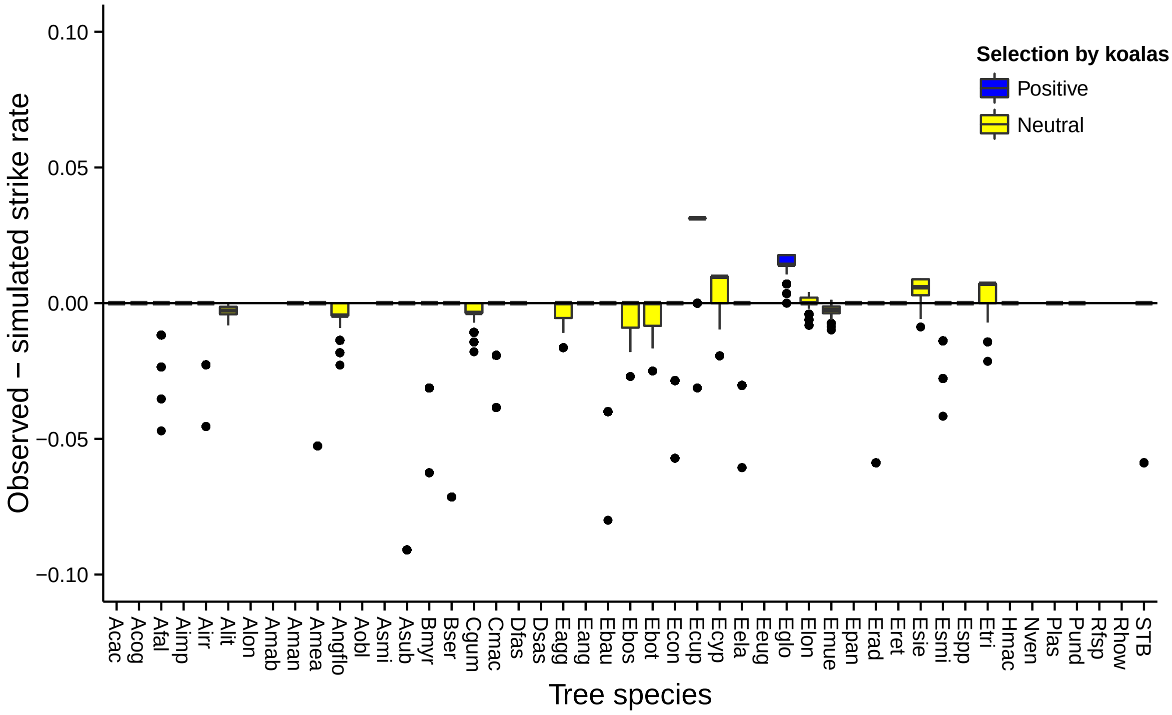


Figure 17: Overall strike rates for each tree species across all paired sites in the northern portion for the two sampling periods.

2.2.3 Tree species preference

The tree species preferences of koalas for the two surveys (Figure 18) were neutral for all but one species in each of the surveys. During the 2007-2009 survey, koalas positively selected white stringybark (*E. globoidea*) while in the 2010-2013 survey, koalas positively selected woollybut (*E. longifolia*). This result is a bit surprising as the unpaired results for the northern portion (Section 2.1.4) produced consistent results across the two surveys with *E. longifolia* being positively selected in both years and *A. littoralis* being negatively selected in both years. This difference is likely due to a substantial decrease in the number of sites included in the paired analysis vs. the unpaired analysis which subsequently reduces the number of trees being included in the comparisons.



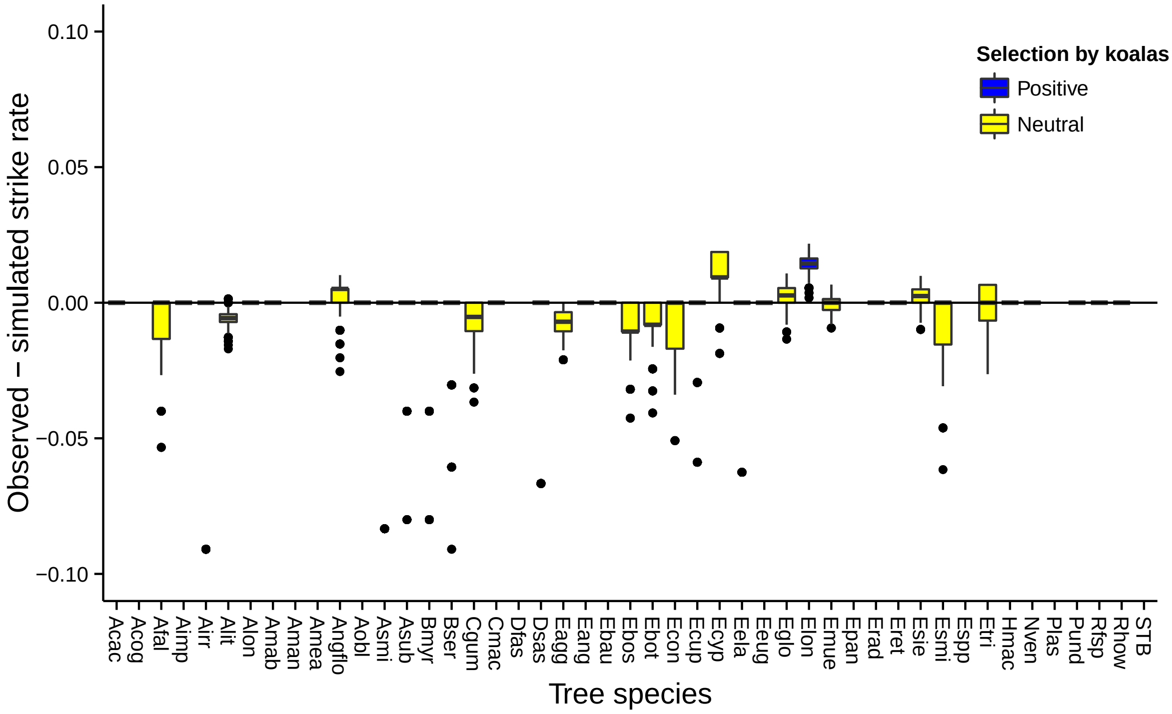


Figure 18: Distributions of observed - simulated strike rates for 2007-2009 (top) and 2010-2013 (bottom) for paired sites in the northern portion, assuming that koalas choose trees within the study areas at random. Distributions whose middle 95% do not include 0 suggest that the tree species is either being positively selected (i.e. the box plot is above 0 and has a blue fill colour) or negatively selected (i.e. the box plot is below 0 and has a red fill colour). Boxes for tree species that are being neutrally selected have a yellow fill colour. Please note, the y-axes were arbitrarily adjusted to range between -0.1 and 0.1 so that colour-coding can be seen. Many outliers fall outside this range.

2.2.4 Tree size preference

We failed to find a significant relationship between tree size class and strike rate for any of the tree species included in the two surveys for the paired sites. This is somewhat consistent with the result that we found for the sites when we analyzed the two surveys independently of one another. The lone exception being that we found a negative relationship between *Eucalyptus sieberi* size class and strike rate.

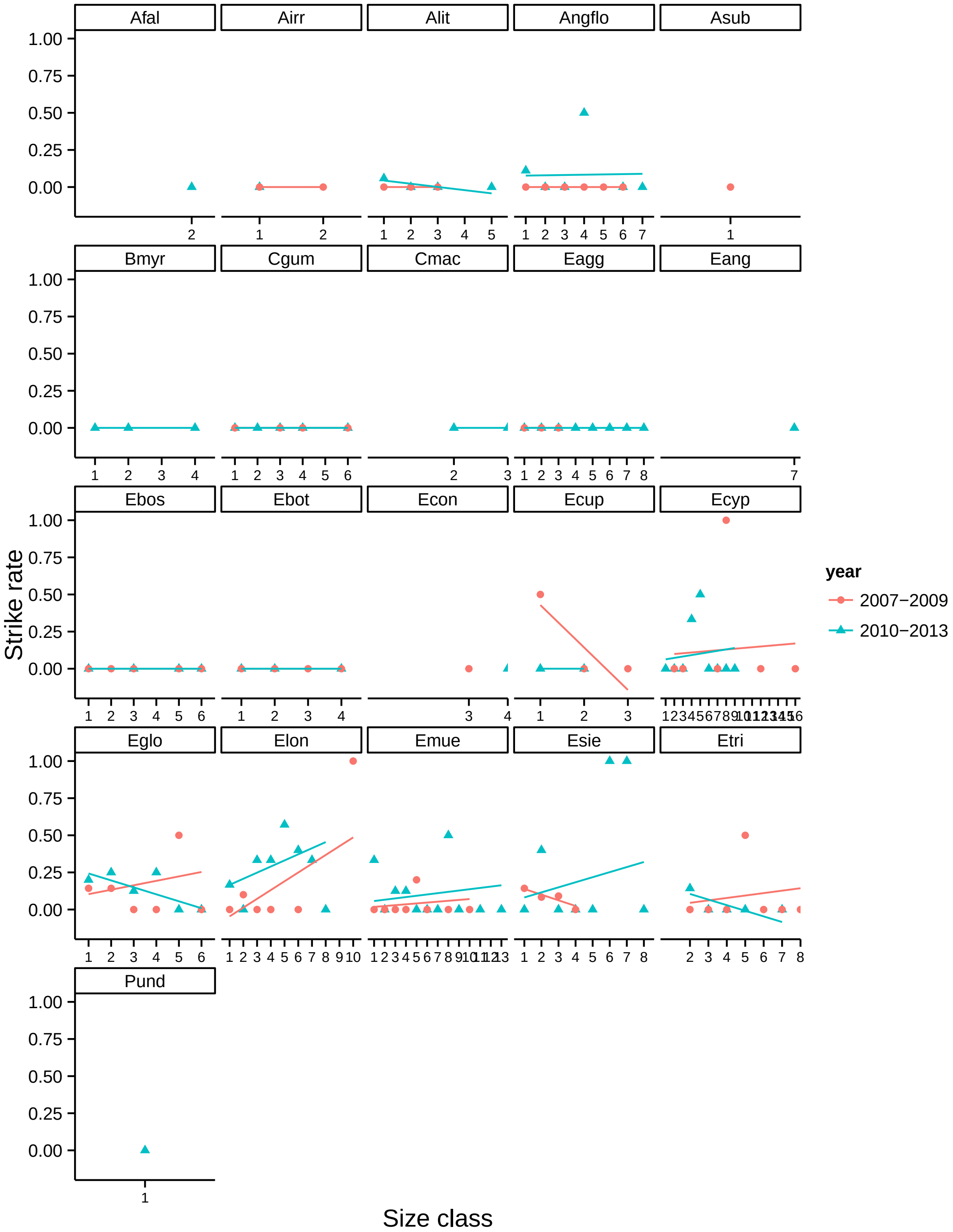


Figure 19: Relationships between tree size (DBH) and strike rates for each species for the two study periods for the northern portion.

Table 9: Summary terms for linear regressions of strike rate on tree size for each tree species found at paired active sites in the northern portion during the 2007-2009 survey weighted by the number of trees in each size class. Summary terms include the number of trees used in the regression (N), intercept and slope of the regression line, the R2 value and the p-value for the regression.

Tree ID	N	Intercept	Slope	R-square	p-value
Airr	7.00	-0.00	0.00		
Alit	38.00	-0.00	-0.00		
Angflo	15.00	-0.00	0.00		
Asub	1.00	0.00		0.00	
Cgum	6.00	-0.00	-0.00		
Eagg	9.00	-0.00	-0.00		
Ebos	12.00	-0.00	0.00		
Ebot	8.00	-0.00	0.00		
Econ	1.00	0.00		0.00	
Ecup	5.00	0.71	-0.29	0.76	0.32
Ecyp	8.00	0.09	0.01	0.01	0.89
Eglo	33.00	0.07	0.03	0.09	0.57
Elon	22.00	-0.11	0.06	0.35	0.22
Emue	27.00	0.01	0.01	0.03	0.71
Esie	36.00	0.18	-0.04	0.76	0.13
Etri	12.00	0.01	0.02	0.03	0.73

Table 10: Summary terms for linear regressions of strike rate on size class for all combinations of tree species found at paired active sites in the northern portion during the 2010-2013 survey weighted by the number of trees in each size class. Summary terms include the p-value for the regression, the R2 value, the slope and intercept of the regression line and the total number of trees used in the regression.

Tree ID	N	Intercept	Slope	R-square	p-value
Afal	1.00	0.00		0.00	
Airr	1.00	0.00		0.00	
Alit	37.00	0.07	-0.02	0.53	0.27
Angflo	25.00	0.08	0.00	0.00	0.97
Bmyr	5.00	-0.00	-0.00		
Cgum	16.00	-0.00	0.00		
Cmac	2.00	-0.00	0.00		
Eagg	35.00	-0.00	0.00		
Eang	1.00	0.00		0.00	
Ebos	7.00	-0.00	-0.00		
Ebot	3.00	-0.00	-0.00		
Econ	1.00	0.00		0.00	
Ecup	3.00	-0.00	0.00		
Ecyp	22.00	0.05	0.01	0.02	0.74
Eglo	29.00	0.29	-0.05	0.51	0.11
Elon	42.00	0.13	0.04	0.20	0.27
Emue	59.00	0.05	0.01	0.03	0.63
Esie	24.00	0.05	0.03	0.05	0.60
Etri	16.00	0.18	-0.04	0.53	0.16
Pund	1.00	0.00		0.00	

3 The southern portion of the koala survey areas

3.1 Summary of 2007-2009 and 2010-2013 koala surveys

3.1.1 General summary of koala occurrence

The location of the sampling sites in the southern portion are shown in Figure 20 while the observations of koala activity are summarised in Table 11. During the 2007-2009 koala survey, 195 sampling sites were surveyed for the presence of koala faecal pellets while 178 sampling sites were sampled during the 2010-2013 survey. As was the case for the northern portion, the spatial extent of the sampling for the two surveys was similar for the most part. Thirty active sites (Table 11; 15% of all sites) were active during the 2007-2009 survey while 41 sites were active (23%) during the 2010-2013 survey. Koala activity during the 2007-2009 survey was widespread, but at low levels, throughout the southern portion, with many isolated areas of activity. During the 2010-2013 survey, koala activity was concentrated in the north-central part of the southern portion. Additionally, there were several smaller pockets of koala activity throughout the southern portion. For both sampling surveys, there was a region of koala activity located near the large inland water body on the eastern edge of the southern portion (Wapengo Lake). This region of koala activity is likely an artifact of the contouring algorithm and it's extent beyond the sampling sites should be discounted. The number of trees with koala activity at active sites during the two surveys is shown in Figure 22. During the 2007-2009 survey, active sites typically had only 1 to 2 trees and at most 6 trees with koala activity. For the 2010-2013 survey, koala activity tended to be higher with sites typically having 2 to 4 active trees and as many as 15 active trees.

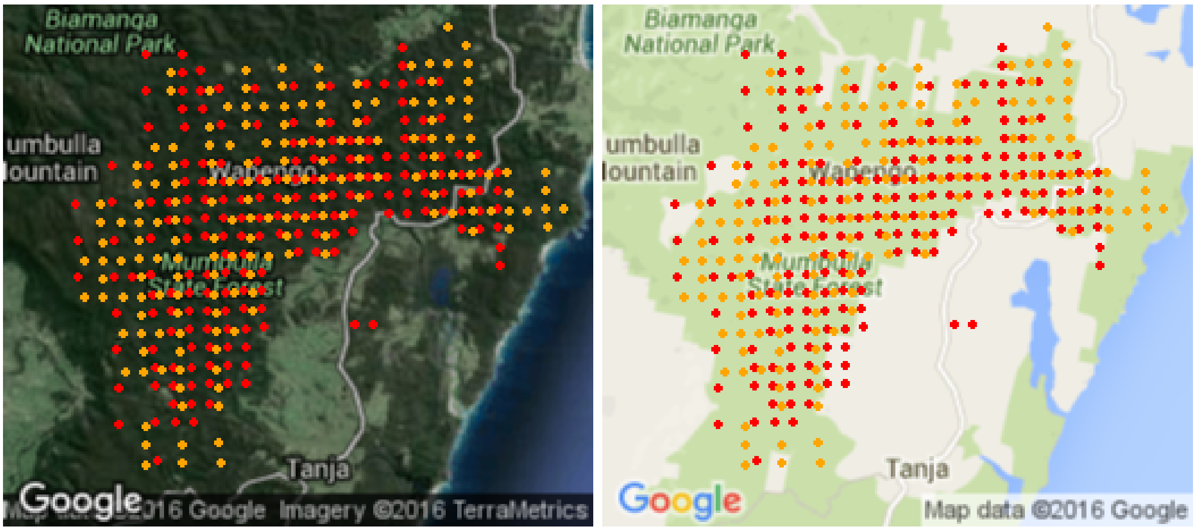


Figure 20: Sampling sites in the southern portion for 2007-2009 (red) and 2010-2013 (orange). Both panels show the same data, but use different basemaps in order to provide more spatial detail.

Table 11: Summaries for the occurrence of koalas within the southern portion for the two monitoring periods

	2007-2009	2010-2013
Visited sites	195	178
Active sites	30 (15%)	41 (23%)
Inactive sites	165 (85%)	137 (77%)
Examined trees	5846	5339
Active trees	63 (1%)	133 (2%)
Inactive trees	5783 (99%)	5206 (98%)
Trees at active sites	900 (15%)	1230 (23%)
Trees at inactive sites	4946 (85%)	4109 (77%)
All tree species	39	42
Active tree species	11 (28%)	14 (33%)

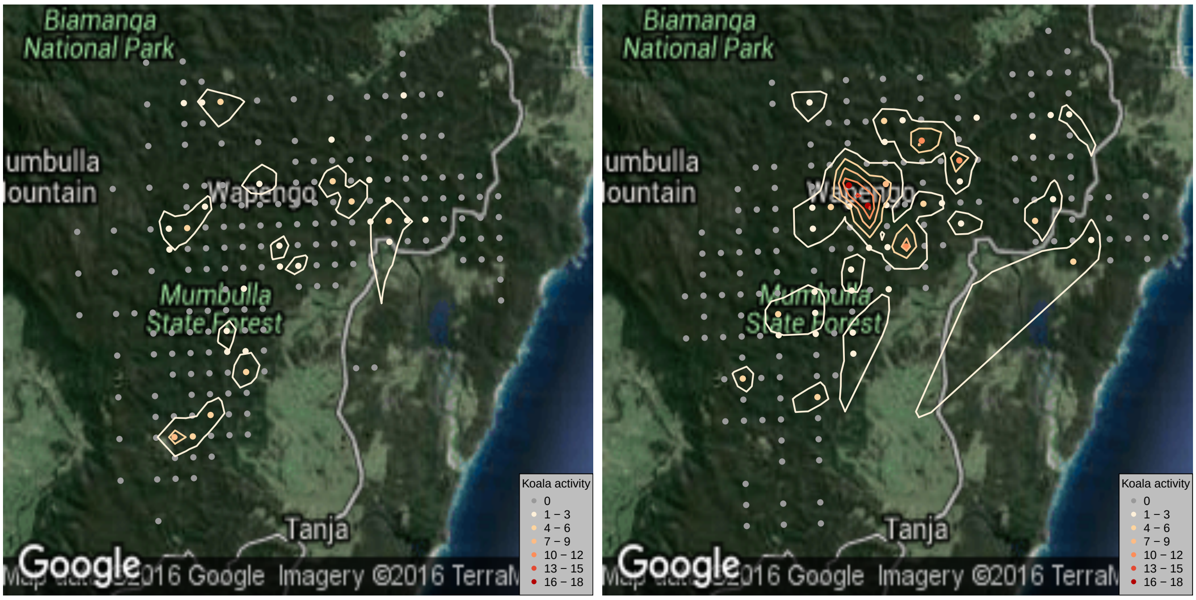


Figure 21: Site-specific koala activity levels and contour lines showing areas of equal koala activity in the southern portion for 2007-2009 (left panel) and 2010-2013 (right panel).The colour key for both site-specific koala activity and the contour lines in terms of number of active trees is shown in the bottom right of each panel.

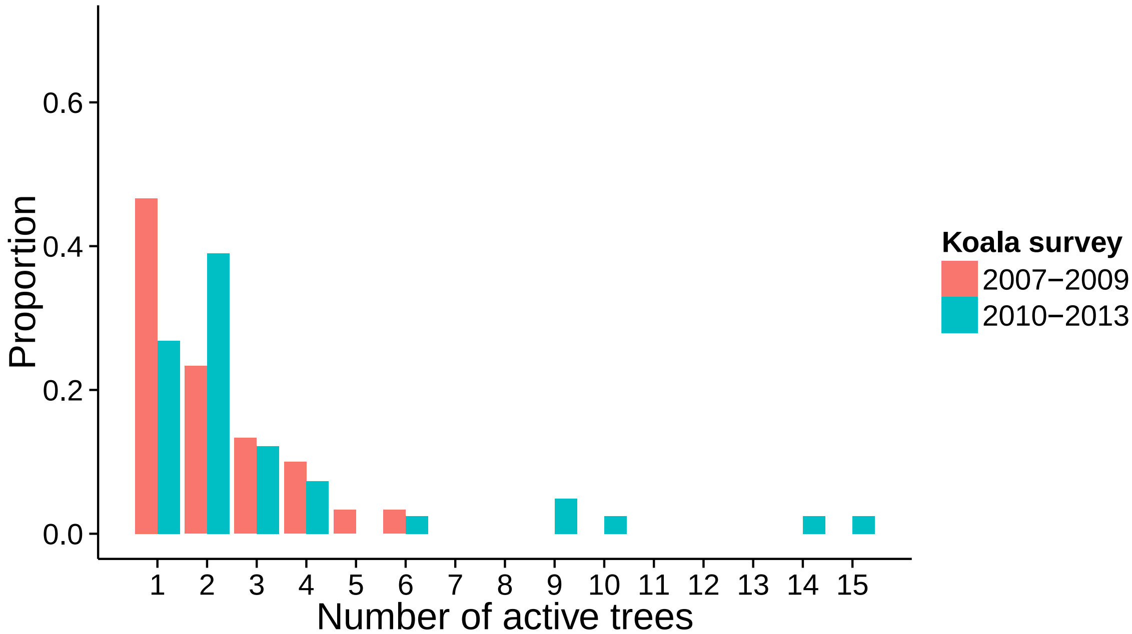


Figure 22: Comparison of the distribution of koala activity at active sites in the southern portion between the two monitoring periods (red = 2007-2009; blue = 2010-2013). Inactive sites were excluded from this analysis.

3.1.2 Tree species composition of active and inactive sites

Tree species composition for active and inactive sites in the southern portion are compared using non-metric multidimensional scaling (NMDS; Section 2.1.2) in Figures 23 and 24. The theory behind this comparison is provided in the section 2.1.2 for the northern portion. As was the case for the northern portion, the ellipses for the inactive sites are generally contained within the ellipses for the active sites. This was likely due to the number of active sites being low relative to the number of inactive sites, suggesting that there were inactive sites that could have been used by koalas but were not because koala numbers were at reduced levels. This meant it was difficult for the NMDS to distinguish between active and inactive sites as there was little to differentiate them from one another. With respect to tree species, species that were abundant and widespread tended to be located within both ellipses while species that were relatively rare (typically less than 60 trees across all sites; Tables 12 and 13) were the species found outside of the ellipses.

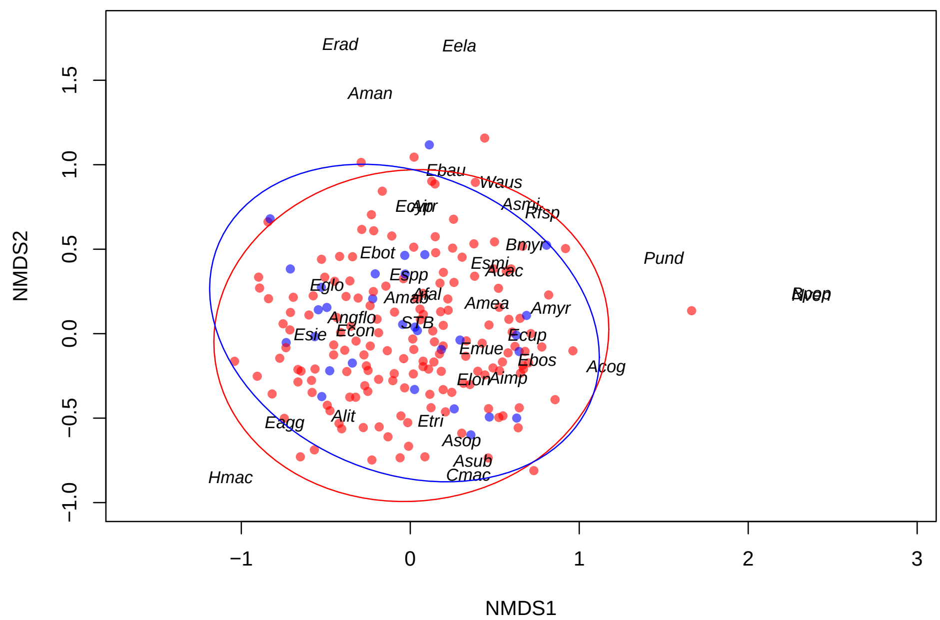


Figure 23: NMDS plot of sites (blue = active sites, red = inactive sites) within the southern portion for 2007-2009 created using Bray-Curtis distances. Ellipses show the 95% bounds for active and inactive sites. Tree names are indicative of tree species composition at the sites.

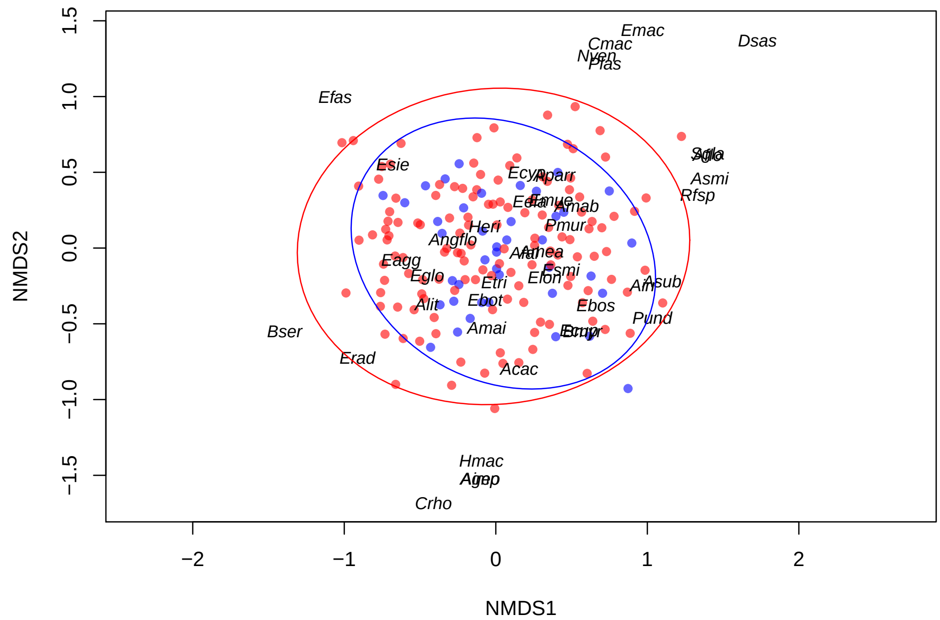


Figure 24: NMDS plot of sites (blue = active sites, red = inactive sites) within the southern portion for 2010-2013 created using Bray-Curtis distances. Ellipses show the 95% bounds for active and inactive sites. Tree names are indicative of tree species composition at the sites. Site 99112 was removed as an outlier.

Table 12: Summary of koala activity for trees at active and inactive sites within the southern portion during the 2007-2009 survey

Tree ID	# of inactive sites	# trees at inactive sites	# of active sites	# trees at active sites	# trees with faecal pellets	Mean strike rate	± Standard error
Acac	27	101	6	23	1	0.08	0.04
Acog	6	25			0		
Afal	23	57	3	10	1	0.17	0.09
Aimp	4	8	2	4	0	0.00	0.00
Airr	1	1	1	13	0	0.00	
Alit	88	510	10	56	0	0.00	0.00
Amab	9	60			0		
Aman	1	1			0		
Amea	20	98	2	16	0	0.00	0.00
Amyr	1	2			0		
Angflo	84	210	20	43	1	0.02	0.02
Asmi	2	7			0		
Asop	1	2	1	3	0	0.00	
Asub			1	2	0	0.00	
Bmyr	3	8			0		
Bpop	1	1			0		
Cmac	2	25			0		
Eagg	30	217	3	19	0	0.00	0.00
Ebau	1	1			0		
Ebos	48	137	11	30	1	0.03	0.02
Ebot	13	48	2	9	3	0.33	0.00
Econ	2	2			0		
Ecup	14	23	1	1	0	0.00	
Ecyp	68	255	9	34	4	0.16	0.06
Eela	6	34	1	8	0	0.00	
Eglo	59	408	24	188	12	0.06	0.01
Elon	121	666	18	108	19	0.26	0.03
Emue	107	803	21	168	9	0.07	0.01
Erad	1	7			0		
Esie	91	744	20	126	8	0.07	0.01
Esmi	32	155	4	10	0	0.00	0.00
Espp	4	4			0		
Etri	55	127	10	29	4	0.07	0.02
Hmac	1	1			0		
Nven	1	2			0		
Pund	3	8			0		
Rfsp	2	3			0		
STB	24	184			0		
Waus	1	1			0		

Table 13: Summary of koala activity for trees at active and inactive sites within the southern portion during the 2010-2013 survey

Tree ID	# of inactive sites	# trees at inactive sites	# of active sites	# trees at active sites	# trees with faecal pellets	Mean strike rate	± Standard error
Acac	2	11			0		
Afal	27	77	8	16	1	0.12	0.09
Aflo	1	1			0		
Ageo	1	1			0		
Aimp	1	1			0		
Airr	6	44	1	3	0	0.00	
Alit	89	569	22	163	5	0.08	0.02
Amab	11	39	6	27	1	0.17	0.08
Amai	4	9	2	12	0	0.00	0.00
Amea	23	69	4	10	0	0.00	0.00
Angflo	65	163	22	43	2	0.04	0.02
Aparr	2	4	1	3	0	0.00	
Asmi	6	51	2	3	0	0.00	0.00
Asub	7	25	4	19	3	0.09	0.04
Bmyr	9	68	2	18	0	0.00	0.00
Bser	1	1			0		
Cmac	1	13	1	1	0	0.00	
Crho	1	10			0		
Dsas	2	16			0		
Eagg	27	91	4	9	0	0.00	0.00
Ebos	36	117	11	31	3	0.13	0.06
Ebot	8	53	2	3	0	0.00	0.00
Ecup	25	34	7	10	1	0.05	0.04
Ecyp	60	199	20	89	14	0.18	0.03
Eela	8	44	4	13	2	0.07	0.04
Efas	1	3			0		
Eglo	55	359	19	144	25	0.23	0.02
Elon	93	446	38	183	44	0.28	0.02
Emac	1	2			0		
Emue	95	677	27	185	10	0.04	0.01
Erad	1	3			0		
Esie	72	652	25	187	20	0.08	0.01
Esmi	21	107	6	16	0	0.00	0.00
Etri	40	117	20	40	2	0.03	0.01
Heri	2	2			0		
Hmac	4	10			0		
Nven	1	1			0		
Plas	1	1			0		
Pmur	2	3			0		
Pund	6	7	1	1	0	0.00	
Rfsp	2	6	1	1	0	0.00	
Sgla	2	3			0		

3.1.3 Strike rates

Mean strike rates Strike rates by tree species for the 2007-2009 and 2010-2013 surveys in the southern portion are summarised in Tables 12 and 13. A description of how strike rates were calculated and the layout of the box plots (Figures 26 to 27) are provided in Section 2.1.3 for the northern portion.

For the 2007-2009 survey, koalas used 11 of 39 tree species (28% of tree species) found in the surveyed area. Tree species not used by koalas were often relatively rare (less than 50 trees across all sites), but there were also several widely abundant tree species that were not used by koalas (Table 12). 566 forest oak (*Allocasuarina littoralis*) were surveyed across 88 inactive sites and 10 active ones without a single koala faecal pellet being found. Other abundant, but unused tree species included the blue-leafed stringybark (*Eucalyptus agglomerata*; 236 trees) and the black wattle (*Acacia mearnsii*; 114 trees). Among the abundant (100 trees) tree species that were used, in terms of both strike rate and absolute counts, woollybut (*Eucalyptus longifolia*; 19 trees with faecal pellet; mean strike rate = 0.26 faecal pellets tree^{-1}) was the most heavily used tree species by koalas during this survey. White stringybark (*E. globoidea*) was the second most used tree species in absolute terms (12 trees with faecal pellet) while the monkey gum (*E. cypellocarpa*) was the most used in terms of mean strike rate (0.16 faecal pellets tree^{-1}). Among the rarer tree species, the southern mahogany (*E. botryoides*; 57 trees) had the highest mean strike rate (0.33 faecal pellets tree^{-1}) followed by the hickory wattle (*A. falciformis*; 67 trees) with a mean strike rate of 0.17 faecal pellets tree^{-1}. Figure 25 shows the range of strike rates for each tree species. The only tree species to have non-zero median strike rates were southern mahogany and woollybut, which as was noted above were two of the species with the highest strike rates.

For the 2010-2013 survey, koalas used 14 of 42 tree species (33% of tree species) found in the surveyed area. The majority of unused tree species numbered less than 20 trees spread across all active and inactive sites. The most abundant, unused tree species were the gully peppermint (*E. smithii*; 123 trees) and the blue-leafed stringybark (100 trees). Among the abundant tree species that were used by koalas, woollybut was the most heavily used in both absolute terms and strike rate (44 trees with faecal pellets; mean strike rate = 0.28 faecal pellets tree^{-1}). White stringybark was the second most heavily used in both absolute terms and mean strike rate (25 trees with faecal pellets; mean strike rate = 0.23 faecal pellets tree^{-1}) while the silvertop ash was the third most heavily used in absolute terms (20 trees with faecal pellets), but a mean strike rate of only 0.08 faecal pellets tree^{-1}. Monkey gum was third most heavily used in terms of mean strike rate (0.18 faecal pellets tree^{-1}) and fourth in absolute terms. Figure 25 shows the range of strike rates for each tree species. The only species to have non-zero median strike rates are woollybut and white stringy bark, two of the tree species most heavily used by koalas.

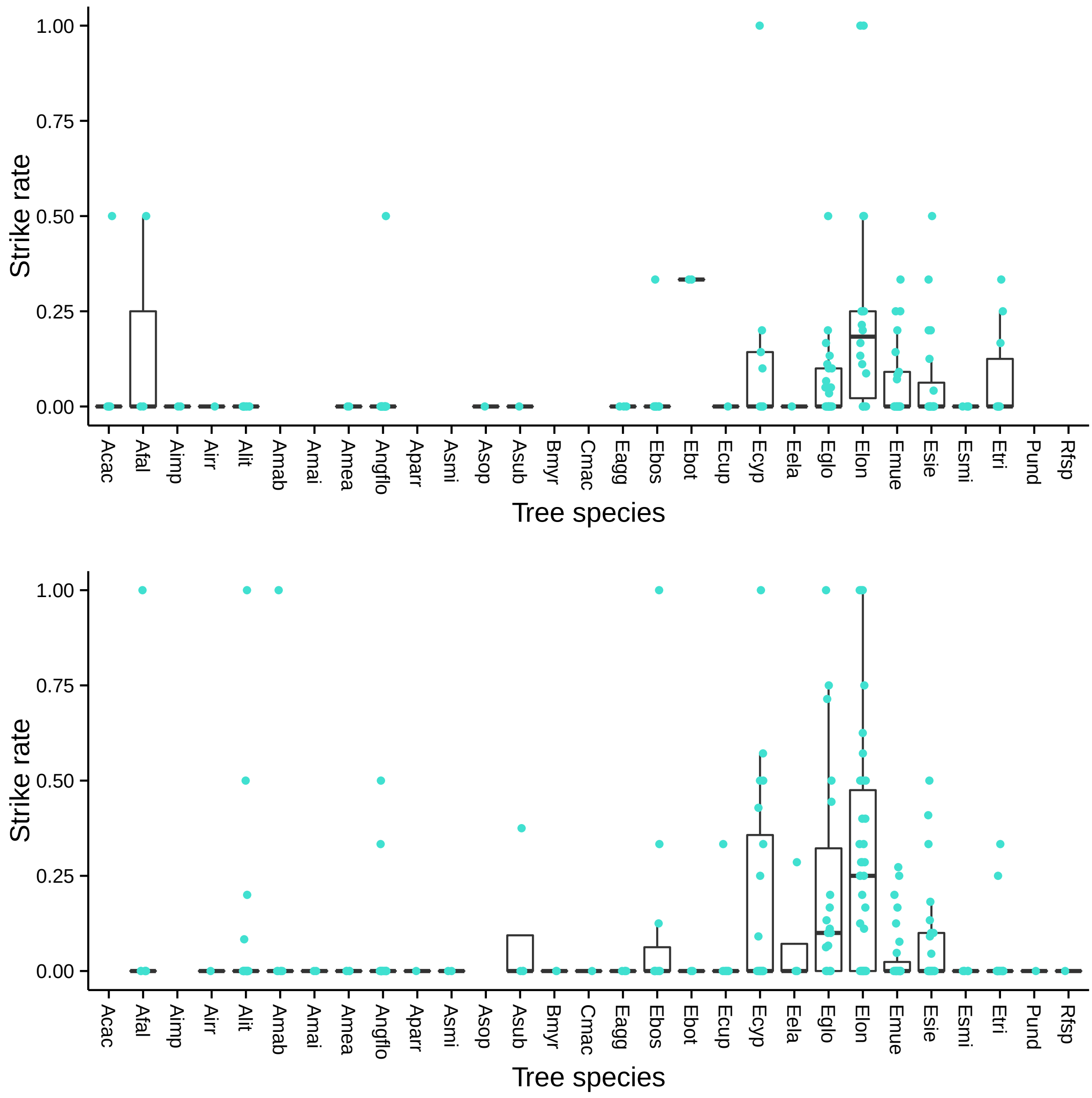


Figure 25: Distribution of strike rates at active sites in the southern portion determined using site-specific strike rates for each tree species for 2007-2009 (top) and for 2010-2013 (bottom). Some tree species were only active in one monitoring period but are included for both monitoring periods to ease comparisons between monitoring periods.

Overall strike rates We examined the overall strike rates (described in detail in Section 2.1.3) for tree species in the southern portion for the two survey periods. These strike rates take into account the abundance of a tree species over the entire sampling region rather than at just the active sites which may produce a more accurate portrayal of koala tree preferences.

For the 2007-2009 survey, the Southern mahogany (*E. botryoides*) had the highest overall strike rate, 0.052 faecal pellets tree^{-1}, twice the rate of ironbark *E. sideroxylon sub. tricarpa* and woollybut which had the next highest overall strike rates (0.025 and 0.024 faecal pellets tree^{-1} respectively). Woollybut had previously been found to be among the most heavily used tree species during this survey, and this result helps to confirm that finding. Southern mahogany had been found to have a high strike rate based solely on trees at active sites, but ironbark had been seen previously as only being used at moderate levels by koalas.

For the 2010-2013 survey, bower wattle (*Acacia subporosa*) and woollybut had the highest overall strike rates (overall strike rates = 0.068 and 0.07 faecal pellets tree^{-1} respectively) followed by white stringybark and monkey gum (overall strike rates = 0.05 and 0.048 faecal pellets tree^{-1} respectively). Woollybut, white stringybark and monkey gum had all been found to be among the more common tree species to be used by koalas. Bower wattles has a high overall strike rate, but is a relatively rare species (44 trees found at only 6% of sites) and as such may play only a limited role in koala ecology.

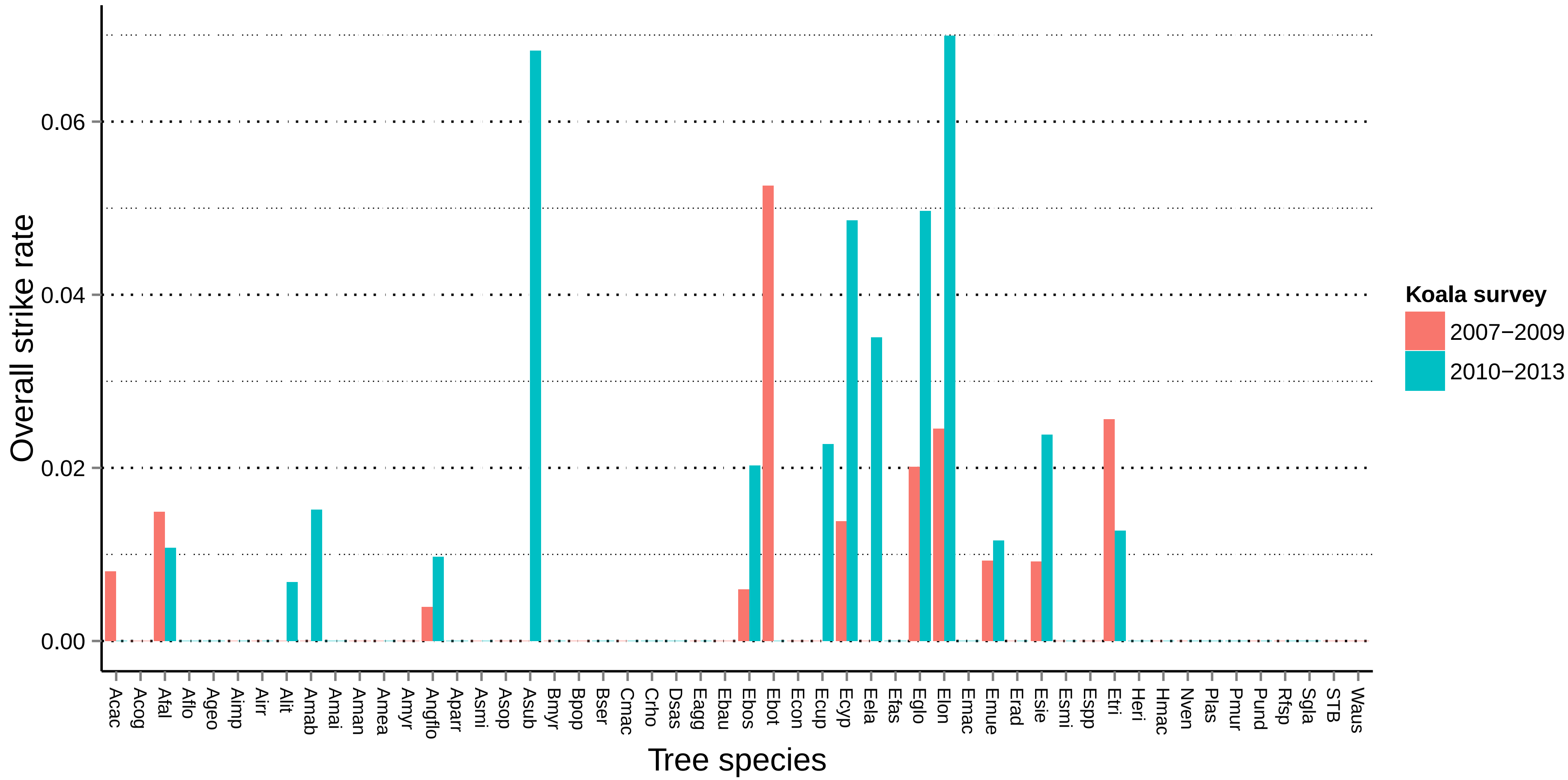


Figure 26: Overall strike rates for each tree species across all visited sites in the southern portion for the two sampling periods.

3.1.4 Tree species preference

The tree species preferences were examined separately for the 2007-2009 and the 2010-2013 surveys. The methodology is described in Section 2.1.4. For the 2007-2009 survey two tree species (white stringybark and woollybut) were found to be positively selected for by koalas while one species was selected against (forest oak; *A. littoralis*). The finding that koalas were selecting for white stringybark and woollybut is generally consistent with their active site and overall strike rates. In the case of forest oak, the finding that koalas are actively selecting against them seems quite reasonable given that the field survey failed to reveal a single tree with a koala faecal pellet, despite searching 556 trees.

For the 2010-2013 survey, koalas were found to positively select for three tree species (woollybut, white stringy bark and monkey gum) and negatively selected for two species (forest oak and yellow stringybark). All three positively selected for tree species had high mean and overall strike rates and two of them (woollybut and white stringybark) had non-zero median strike rates. In the case of the negatively selected for tree species, forest oak and yellow stringybark were both abundant (732 and 862 trees respectively) and widespread (62% and 69% of all sites surveyed), but despite their prevalence were rarely used by koalas (5 and 10 koala faecal pellets respectively).

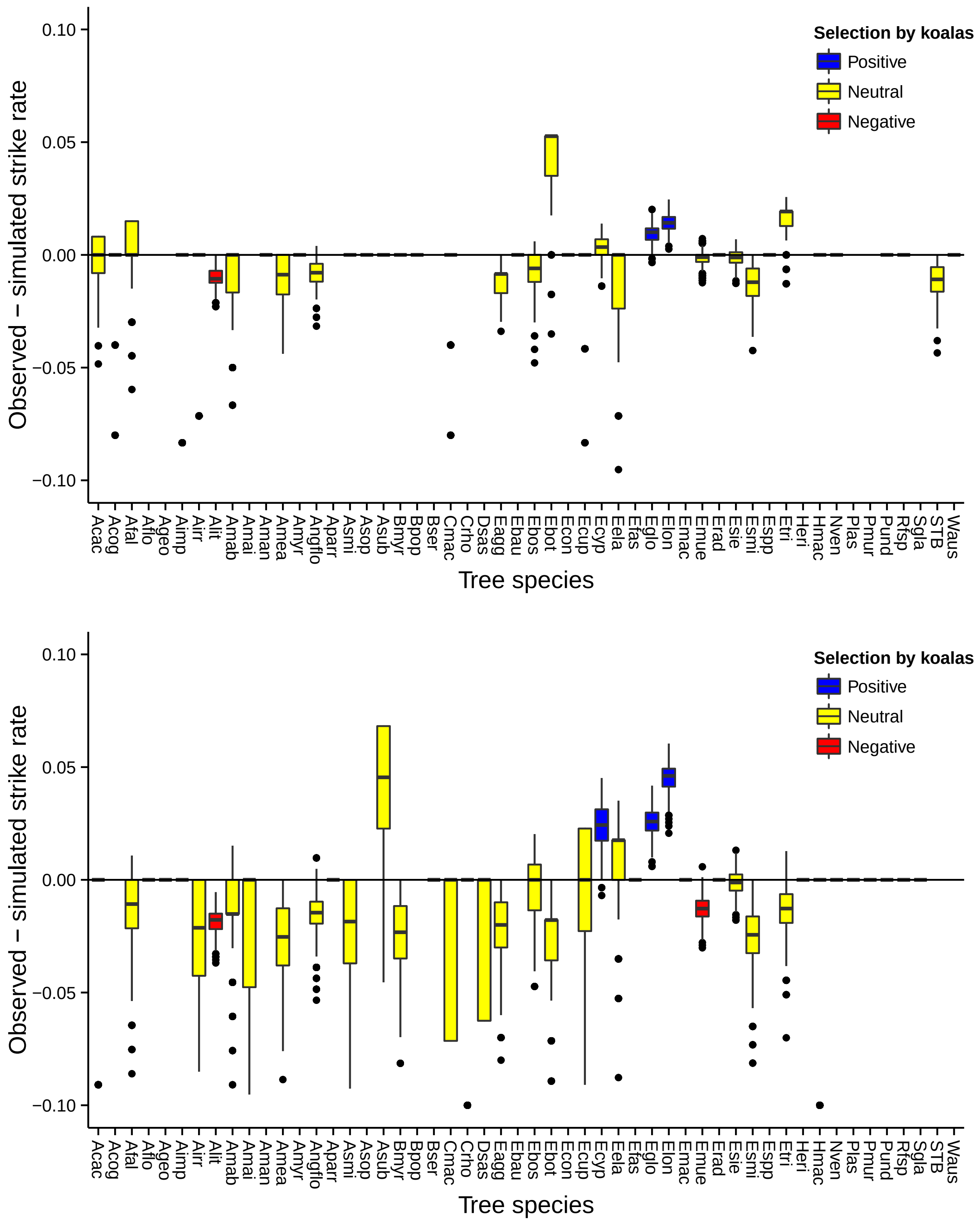


Figure 27: Distributions of observed - simulated strike rates for 2007-2009 (top) and 2010-2013 (bottom) for the southern portion, assuming that koalas choose trees within the study areas at random. Distributions whose middle 95% do not include 0 suggest that the tree species is either being positively selected (i.e. the box plot is above 0 and has a blue fill colour) or negatively selected (i.e. the box plot is below 0 and has a red fill colour). Boxes for tree species that are being neutrally selected have a yellow fill colour. Please note, the y-axes were arbitrarily adjusted to range between -0.1 and 0.1 so that colour-coding can be seen. Many outliers fall outside this range.

3.1.5 Tree size preference

We tested for a linear relationship between tree size (DBH) and strike rate for each tree species separately for the two surveys. During the 2007-2009 survey, there were no tree species with a significant relationship between tree size and strike rate. For the 2010-2013 survey, white stringybark was the lone species to have a significant relationship (R^2; $p = 0.04$) between tree size and strike rate. The relationship had a positive slope ($m = 0.06$), meaning that koalas preferred larger trees.

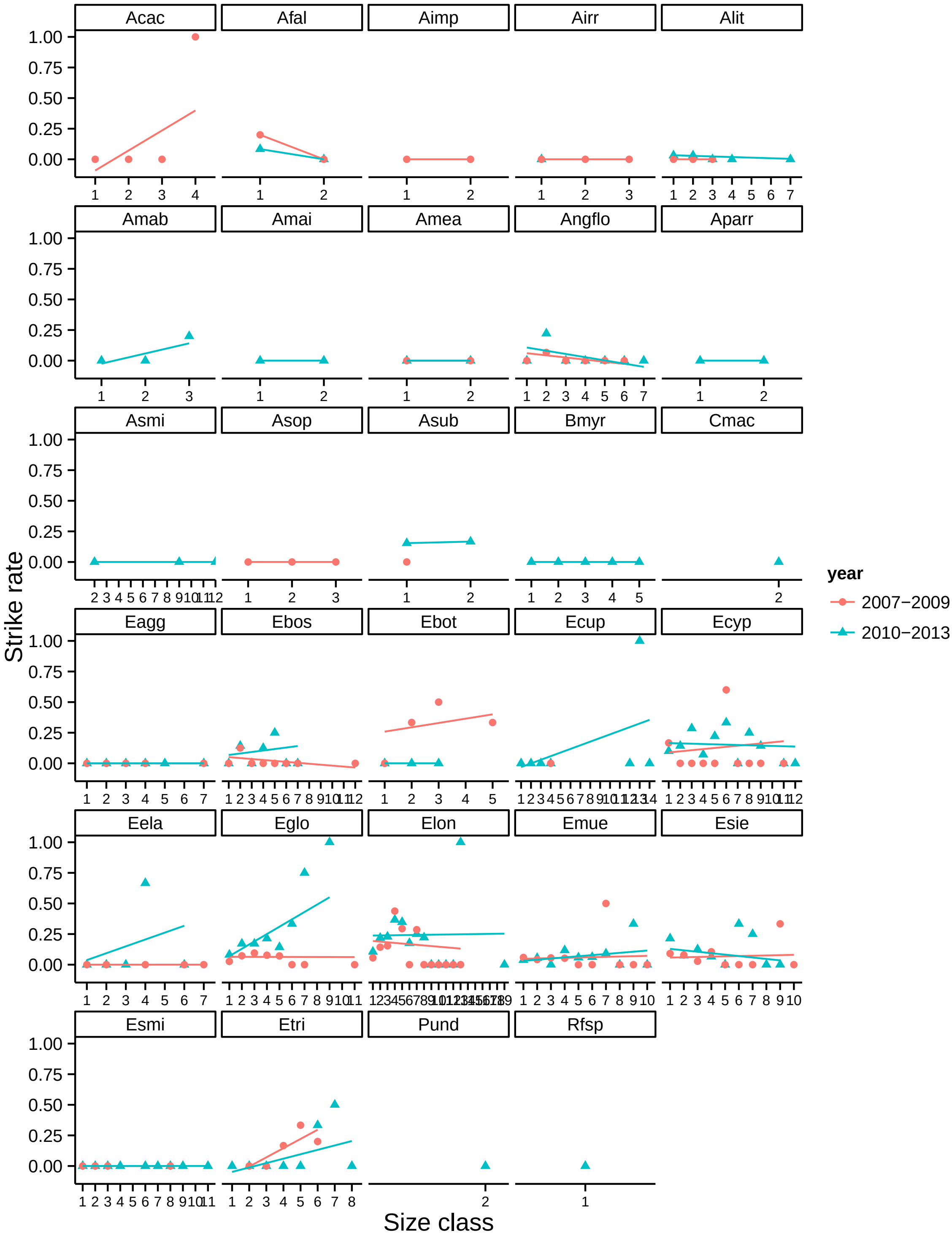


Figure 28: Relationships between tree size (DBH) and strike rates for each species for the two study periods for the southern portion.

Table 14: Summary terms for linear regressions of strike rate on tree size for each tree species found at active sites in the southern portion during the 2007-2009 survey weighted by the number of trees in each size class. Summary terms include the number of trees used in the regression (N), intercept and slope of the regression line, the R2 value and the p-value for the regression.

Tree ID	N	Intercept	Slope	R-square	p-value
Acac	23.00	-0.25	0.16	0.37	0.39
Afal	10.00	0.40	-0.20	1.00	
Aimp	4.00	-0.00	0.00		
Airr	13.00	-0.00	-0.00		
Alit	56.00	-0.00	-0.00		
Amea	16.00	-0.00	0.00		
Angflo	43.00	0.08	-0.02	0.46	0.14
Asop	3.00	-0.00	-0.00		
Asub	2.00	0.00		0.00	
Eagg	19.00	-0.00	0.00		
Ebos	30.00	0.06	-0.01	0.10	0.44
Ebot	9.00	0.22	0.04	0.14	0.62
Ecup	1.00	0.00		0.00	
Ecyp	34.00	0.08	0.01	0.01	0.74
Eela	8.00	-0.00	0.00		
Eglo	188.00	0.06	-0.00	0.00	0.98
Elon	108.00	0.20	-0.01	0.01	0.76
Emue	168.00	0.05	0.00	0.01	0.84
Esie	126.00	0.06	0.00	0.01	0.84
Esmi	10.00	-0.00	-0.00		
Etri	29.00	-0.16	0.08	0.69	0.08

Table 15: Summary terms for linear regressions of strike rate on size class for all combinations of tree species found at active sites in the southern portion during the 2010-2013 survey weighted by the number of trees in each size class. Summary terms include the p-value for the regression, the R2 value, the slope and intercept of the regression line and the total number of trees used in the regression.

Tree ID	N	Intercept	Slope	R-square	p-value
Afal	16.00	0.17	-0.08	1.00	
Airr	3.00	0.00		0.00	
Alit	163.00	0.04	-0.00	0.43	0.23
Amab	27.00	-0.11	0.08	0.64	0.41
Amai	12.00	-0.00	0.00		
Amea	10.00	-0.00	0.00		
Angflo	43.00	0.13	-0.03	0.19	0.32
Aparr	3.00	-0.00	0.00		
Asmi	3.00	-0.00	-0.00		
Asub	19.00	0.14	0.01	1.00	
Bmyr	18.00	-0.00	0.00		
Cmac	1.00	0.00		0.00	
Eagg	9.00	-0.00	0.00		
Ebos	31.00	0.06	0.01	0.05	0.63
Ebot	3.00	-0.00	-0.00		
Ecup	10.00	-0.06	0.03	0.25	0.25
Ecyp	89.00	0.17	-0.00	0.01	0.82
Eela	13.00	-0.02	0.06	0.10	0.60
Eglo	143.00	0.01	0.06	0.55	0.04
Elon	183.00	0.24	0.00	0.00	0.95
Emue	184.00	0.02	0.01	0.16	0.26
Esie	187.00	0.14	-0.01	0.07	0.48
Esmi	16.00	-0.00	0.00		
Etri	40.00	-0.08	0.04	0.27	0.18
Pund	1.00	0.00		0.00	
Rfsp	1.00	0.00		0.00	

3.2 Comparison of 2007-2009 and 2010-2013 koala surveys

For the southern portion, we were able to identify 117 pairs of sites in the 2007-2009 and 2010-2013 koala surveys. The pairs of sites are shown in Figure 29 while a general summary of koala activity for the paired sites is provided in Table 16.

Directly comparing the 2007-2009 koala survey to the 2010-2013 survey (Table 16), the percentage of active sites significantly increased between the two surveys (Chi-square test, $p = 0.01$), nearly doubling from 15% of sites being active during the 2007-2009 survey to 29% of sites being active during the 2010-2013 survey. Similarly the number of active trees also significantly increased (Chi-square test, $p = 0.01$) from the 2007-2009 survey to 2010-2013 survey (from 30 active trees to 118 active trees). The location and intensity of koala activity also changed between the two surveys (Figure 30). During the 2007-2009 survey, koala activity was restricted to scattered, small patches of activity. The intensity of the activity in those patches was generally low, with most patches having 1 to 3 or 4 to 6 active trees. For the 2010-2013 survey, koala activity was strongly concentrated in the middle of the northern half of the southern portion with a few additional areas of koala activity scattered throughout the remainder of the area. In the area with the highest concentration of koala activity, the number of active trees at a site approached nearly half of all trees at the sites. Looking at a finer scale, it appeared that that with the exception of sites in the large area of concentrated koala activity from the 2010-2013 survey, koalas were generally not found at the same sampling sites from one survey to the next. The distribution of the number of active trees at active sites (Figure 31) also shifted from the 2007-2009 survey to the 2010-2013 survey. The mode shifted from 1 active tree per active site for the 2007-2009 survey to 2 active trees per active site for the 2010-2013 survey while the range expanded from 1 to 6 active trees to 1 to 15 active trees.

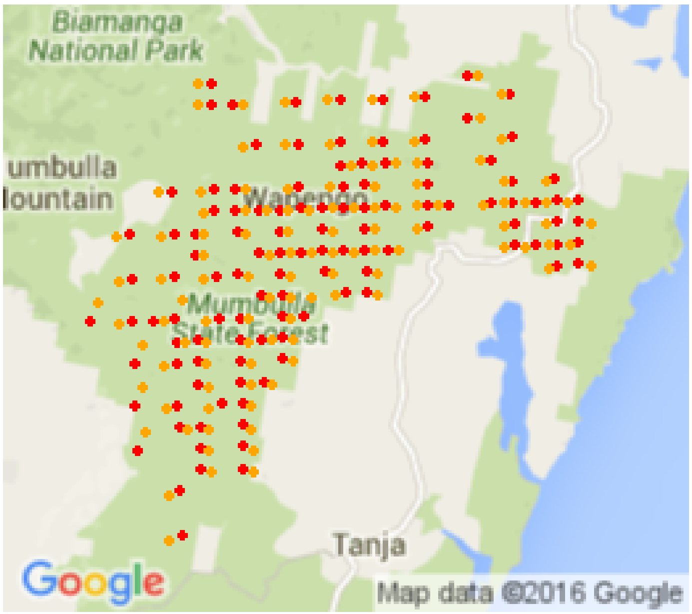


Figure 29: Paired sampling sites in the southern portion for 2007-2009 (red) and 2010-2013 (orange).

Table 16: Summaries of the occurrence of koalas within the southern portion across pairs of sampling sites for the two monitoring periods

	2007-2009	2010-2013
Visited sites	117	117
Active sites	17 (15%)	34 (29%)
Inactive sites	100 (85%)	83 (71%)
Examined trees	3508	3510
Active trees	30 (1%)	118 (3%)
Inactive trees	3478 (99%)	3392 (97%)
Trees at active sites	510 (15%)	1020 (29%)
Trees at inactive sites	2998 (85%)	2490 (71%)
All tree species	31	36
Active tree species	7 (23%)	13 (36%)

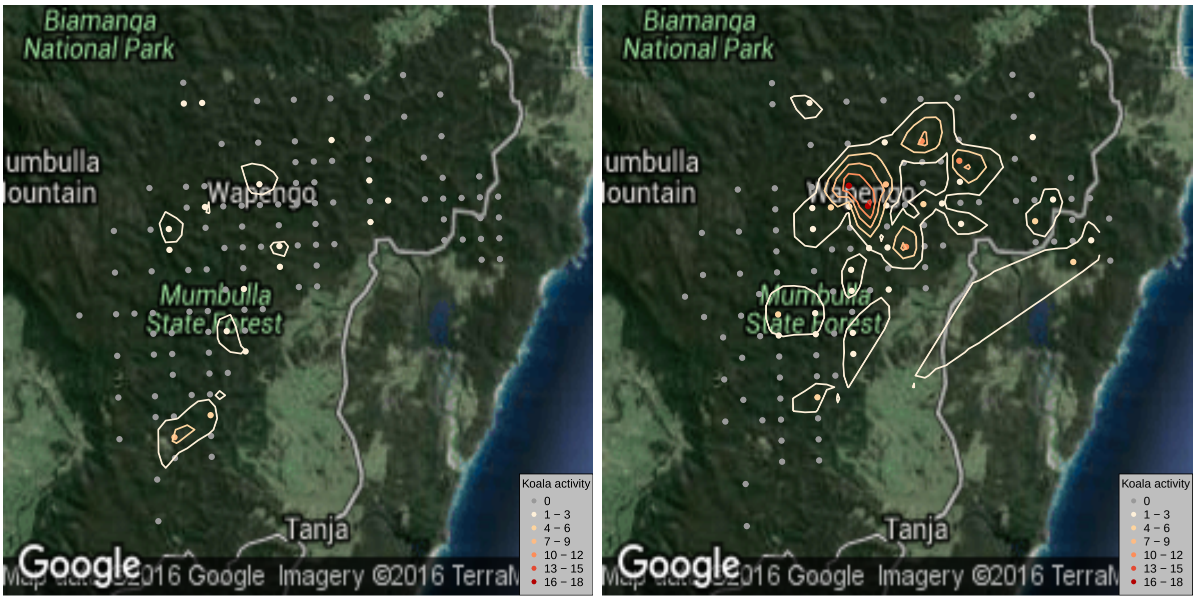


Figure 30: Site-specific koala activity levels and contour lines showing areas of equal koala activity for paired sites in the southern portion for 2007-2009 (left panel) and 2010-2013 (right panel). The colour key for both site-specific koala activity and the contour lines in terms of number of active trees is shown in the bottom right of each panel.

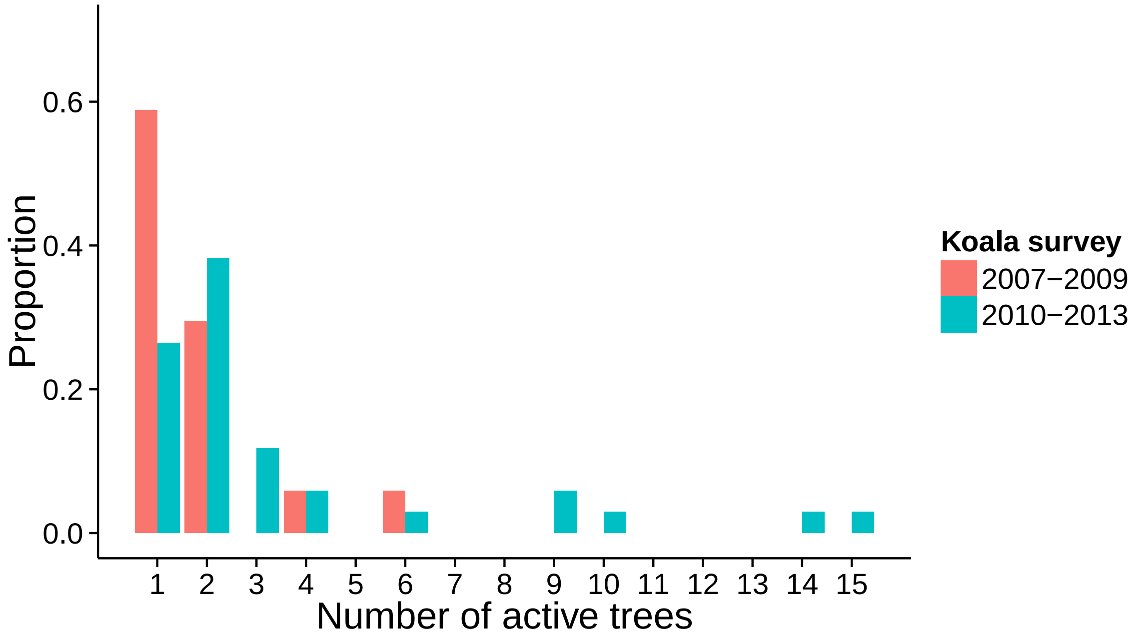


Figure 31: Comparison of the distribution of koala activity at active sites in the southern portion between the two monitoring periods (red = 2007-2009; blue = 2010-2013) for all paired sites. Inactive sites were excluded from this analysis.

3.2.1 Tree species composition of active and inactive sites

Tree species composition was generally similar across active and inactive sites for the two surveys, but some differences were noticeable. For the 2007-2009 survey, the ellipses for the active and inactive sites were approximately the same size, and extensively overlapped one another (Figure 32). This suggest that there was little to differentiate active and inactive sites, likely because koala numbers were relatively low compared to the 2010-2013 survey, suggesting that many of the inactive sites could have been used (and were subsequently used) by koalas but weren't. In the 2010-2013 survey, the ellipse for active sites was entirely encapsulated by the ellipse for inactive sites. This may indicate that while active and inactive sites are generally similar with respect to species composition, increases in koala numbers are beginning to highlight some of the differences between sites. Unfortunately, it is difficult to determine what tree species are driving the size and position of the ellipse for active sites as all of the tree species identified outside this ellipse are rare, generally numbering less than 50 trees across all sites.

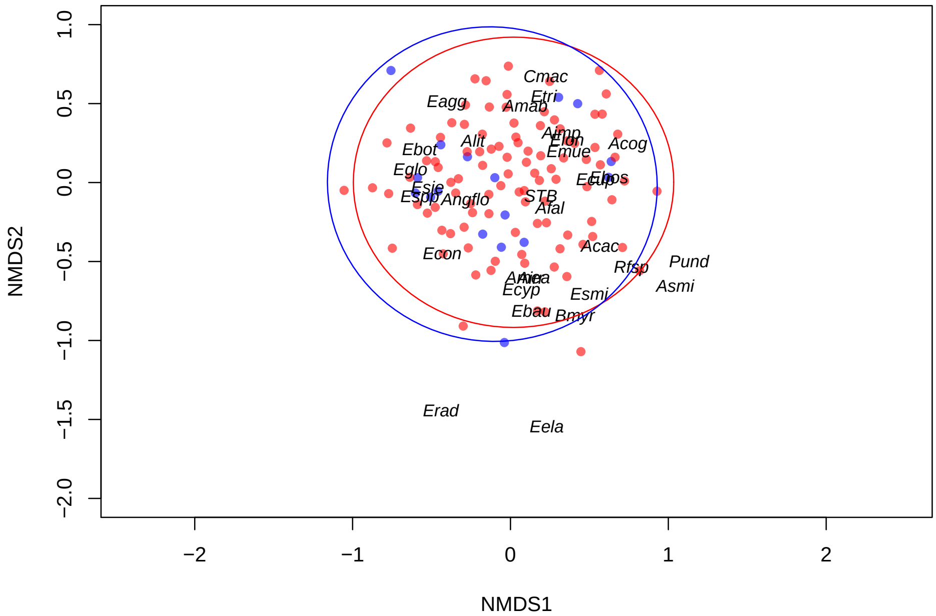


Figure 32: NMDS plot of paired sites (blue = active sites, red = inactive sites) within the southern portion for 2007-2009 created using Bray-Curtis distances. Ellipses show the 95% bounds for active and inactive sites. Tree names are indicative of tree species composition at the sites.

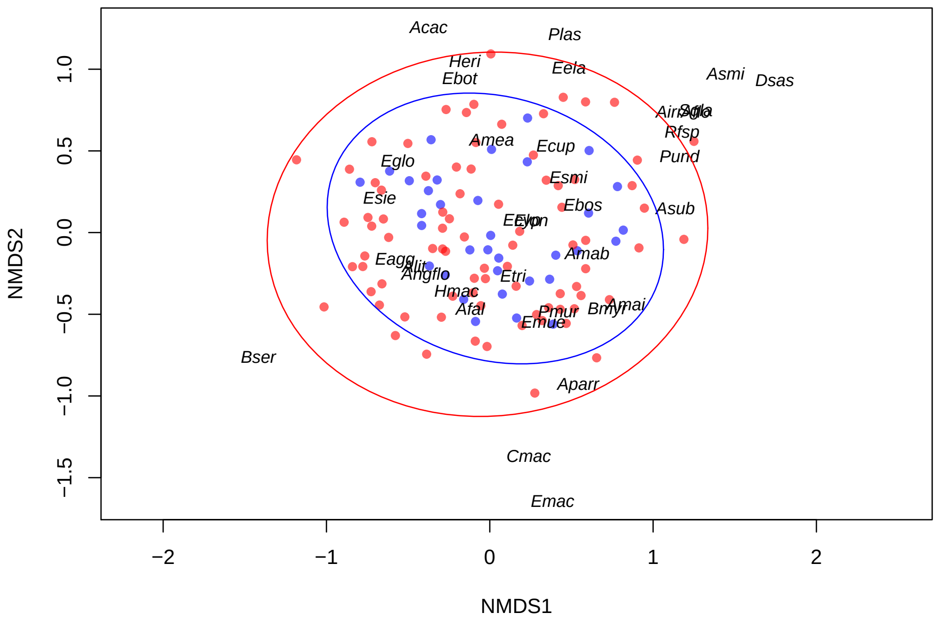


Figure 33: NMDS plot of paired sites (blue = active sites, red = inactive sites) within the southern portion for 2010-2013 created using Bray-Curtis distances. Ellipses show the 95% bounds for active and inactive sites. Tree names are indicative of tree species composition at the sites.

3.2.2 Strike rates

The number of trees of each species sampled for koala faecal pellets did not differ significantly across the two surveys (Tables 17 and 18; paired t-test, t = -0.7583, df = 23, p = 0.46). The overall pattern of mean strike rates for tree species that were present during both surveys also did not differ significantly across surveys (paired t-test, t = -1.68, df = 6, p = 0.14). In support of this, we found that woollybut (*E. longifolia*) had the highest mean strike rate and was the species with the most koala faecal pellets found underneath it during both surveys (Tables 17 and 18). Additionally, box plots showing the distribution of strike rates across active sites (Figure 34) was somewhat consistent across the two years. Despite there being no significant difference in overall strike rates across the two surveys, we note that for 5 of the 7 species that had koala faecal pellets found beneath them during both surveys, the mean strike rate was higher for the 2010-2013 survey than the 2007-2009 survey. The two species that were the exceptions were woollybut and yellow stringybark. In the case of woollybut, the decreased strike rates for the 2010-2013 survey could potentially be attributed to the increase in the number of tree species with koala faecal pellets during that survey (Table 16). For yellow stringybark, the drop in strike rates appeared to be a result of an increase in the number of trees (of that species) at active sites, rather than an actual decrease in tree usage. This is supported by Figure 35 which showed that overall strike rates were higher for all tree species used by koalas during the 2010-2013 survey than during the 2007-2009 survey.

Table 17: Summary of koala activity for trees at paired active and inactive sites within the southern portion during the 2007-2009 survey

Tree ID	# of inactive sites	# trees at inactive sites	# of active sites	# trees at active sites	# trees with faecal pellets	Mean strike rate	± Standard error
Acac	19	71	2	4	0	0.00	0.00
Acog	4	11			0		
Afal	14	32			0		
Aimp	2	4	1	2	0	0.00	
Airr			1	13	0	0.00	
Alit	56	337	5	32	0	0.00	0.00
Amab	5	23			0		
Amea	10	49	2	16	0	0.00	0.00
Angflo	51	125	10	26	0	0.00	0.00
Asmi	1	6			0		
Bmyr	1	2			0		
Cmac	2	25			0		
Eagg	17	105	2	3	0	0.00	0.00
Ebau	1	1			0		
Ebos	27	77	6	11	1	0.06	0.04
Ebot	6	18			0		
Econ	1	1			0		
Ecup	10	12	1	1	0	0.00	
Ecyp	42	172	5	28	3	0.09	0.02
Eela	3	24	1	8	0	0.00	
Eglo	36	244	15	125	8	0.07	0.01
Elon	75	373	9	53	9	0.30	0.06
Emue	64	467	12	81	4	0.06	0.01
Erad	1	7			0		
Esie	60	458	10	86	3	0.04	0.01
Esmi	17	102	1	2	0	0.00	
Espp	2	2			0		
Etri	38	91	6	19	2	0.03	0.02
Pund	2	4			0		
Rfsp	1	2			0		
STB	19	153			0		

Table 18: Summary for koala activity for trees at pairedactive and inactive sites within the southern portion during the 2010-2013 survey

Tree ID	# of inactive sites	# trees at inactive sites	# of active sites	# trees at active sites	# trees with faecal pellets	Mean strike rate	± Standard error
Acac	1	7			0		
Afal	16	49	8	16	1	0.12	0.09
Aflo	1	1			0		
Airr	4	22	1	3	0	0.00	
Alit	52	313	16	85	5	0.11	0.03
Amab	10	31	6	27	1	0.17	0.08
Amai	1	3	1	3	0	0.00	
Amea	18	45	3	6	0	0.00	0.00
Angflo	41	104	18	37	2	0.05	0.02
Aparr			1	3	0	0.00	
Asmi	4	37	1	2	0	0.00	
Asub	4	14	3	11	3	0.12	0.06
Bmyr	7	55	1	5	0	0.00	
Bser	1	1			0		
Cmac	1	13	1	1	0	0.00	
Dsas	1	3			0		
Eagg	15	58	3	8	0	0.00	0.00
Ebos	22	54	11	31	3	0.13	0.06
Ebot	5	33	1	1	0	0.00	
Ecup	16	20	5	6	0	0.00	0.00
Ecyp	38	138	19	87	14	0.19	0.03
Eela	5	31	3	11	2	0.10	0.05
Eglo	33	232	15	123	21	0.23	0.03
Elon	57	241	31	150	35	0.25	0.02
Emac	1	2			0		
Emue	59	465	24	177	9	0.04	0.01
Esie	41	357	21	179	20	0.09	0.01
Esmi	12	84	5	15	0	0.00	0.00
Etri	22	54	15	31	2	0.04	0.02
Heri	2	2			0		
Hmac	3	9			0		
Plas	1	1			0		
Pmur	2	3			0		
Pund	3	4	1	1	0	0.00	
Rfsp	1	2	1	1	0	0.00	
Sgla	1	2			0		

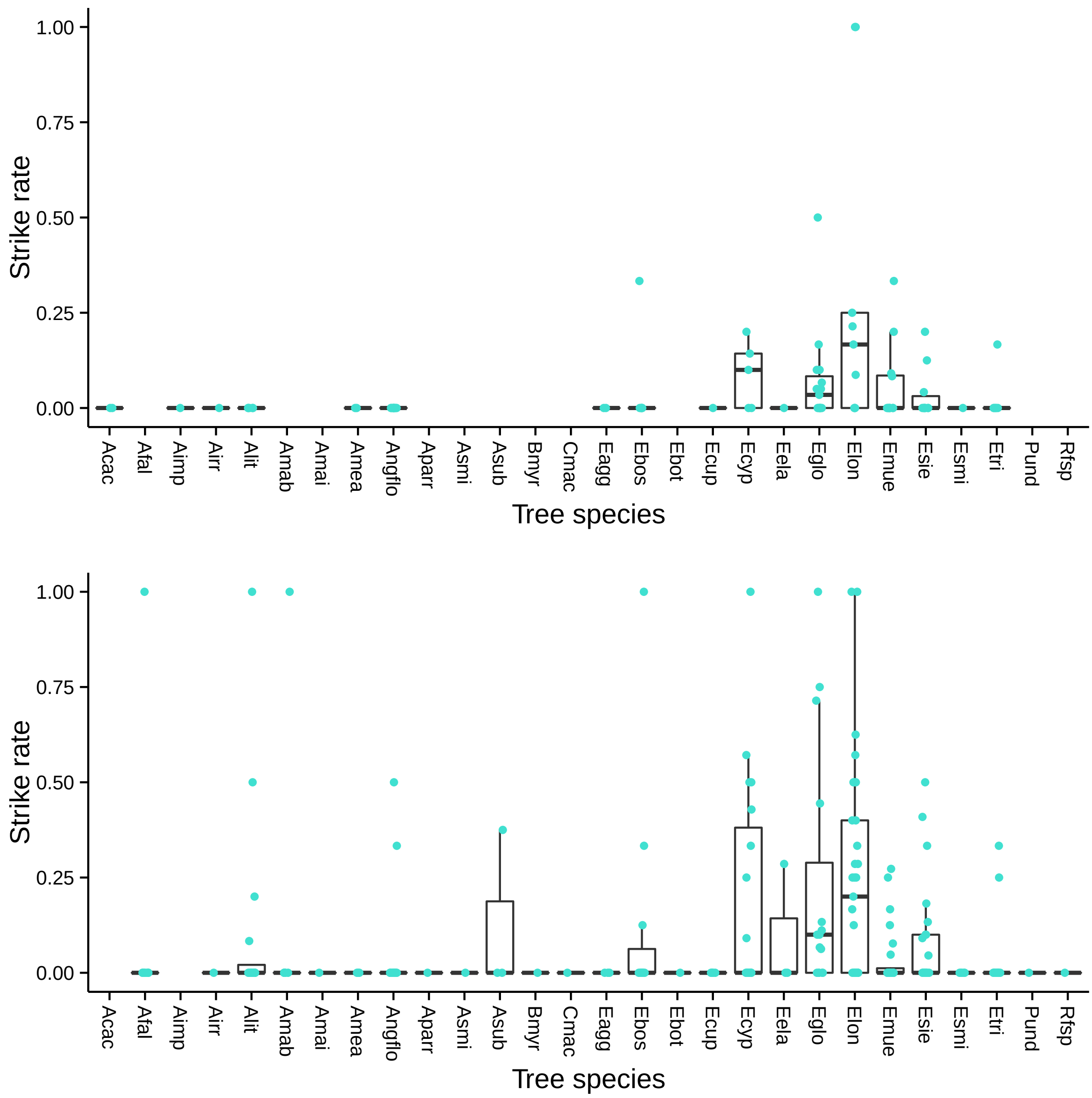


Figure 34: Distribution of strike rates at paired active sites in the southern portion determined using site-specific strike rates for each tree species for 2007-2009 (top) and for 2010-2013 (bottom). Some tree species were only active in one monitoring period but are included for both monitoring periods to ease comparisons between monitoring periods.

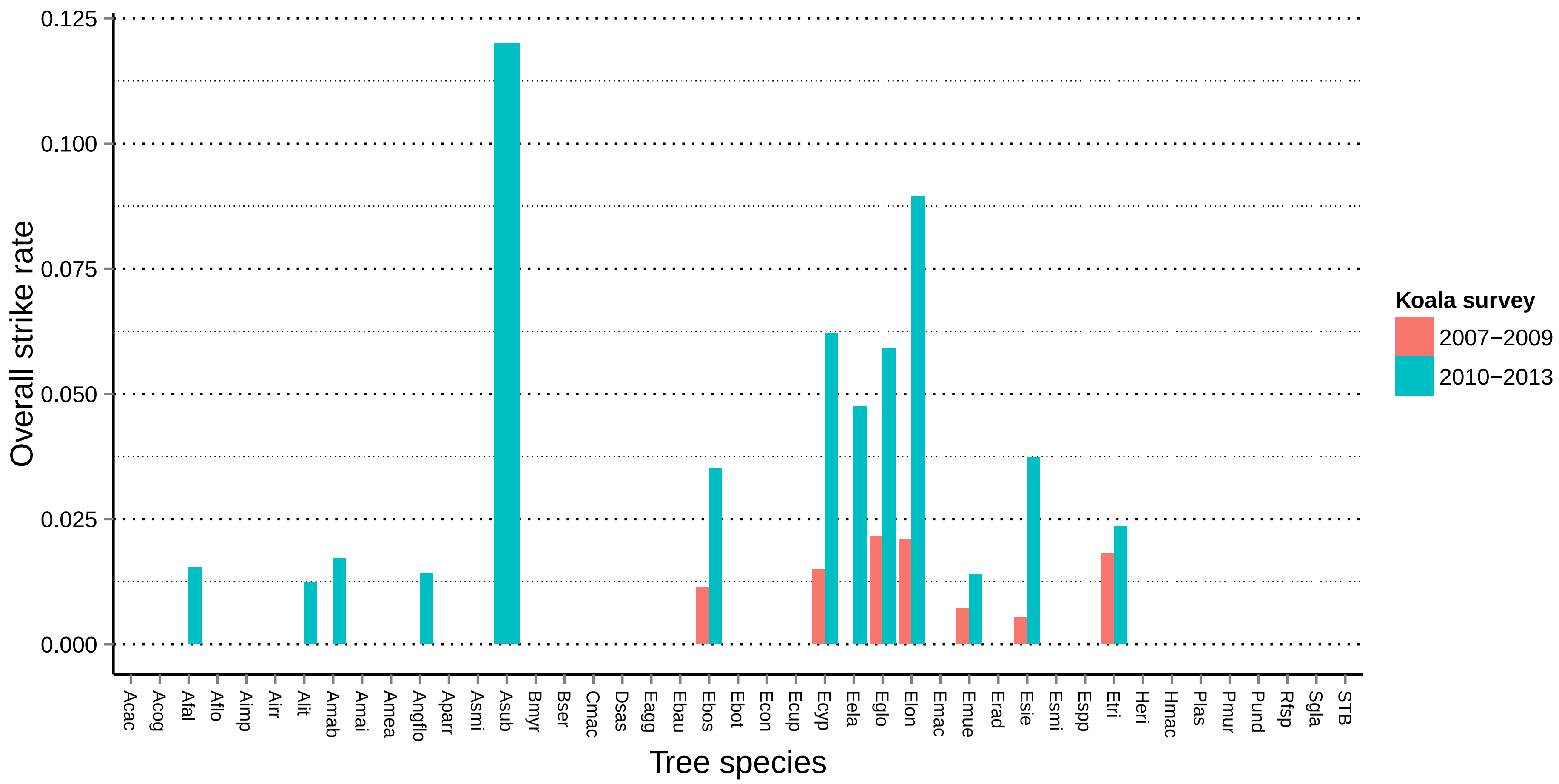


Figure 35: Overall strike rates for each tree species across all paired sites in the southern portion for the two sampling periods.

3.2.3 Tree species preference

The type of selection for each of the tree species was generally consistent across the two surveys but there were some changes between surveys. For both surveys, the majority of tree species were neutrally selected for by the koalas (e.g. strike rate is proportional to the tree species' relative abundance). The two tree species that were positively selected for in the 2007-2009 survey (woollybut and white stringybark) were also positively selected for in the 2010-2013 survey. Three tree species changed their mode of selection between the two surveys. In all three cases, the change was from neutral selection to a directional selection. Monkey gum went from being neutrally selected to being positively selected while forest oak and yellow stringybark went from being neutrally selected to being negatively selected.

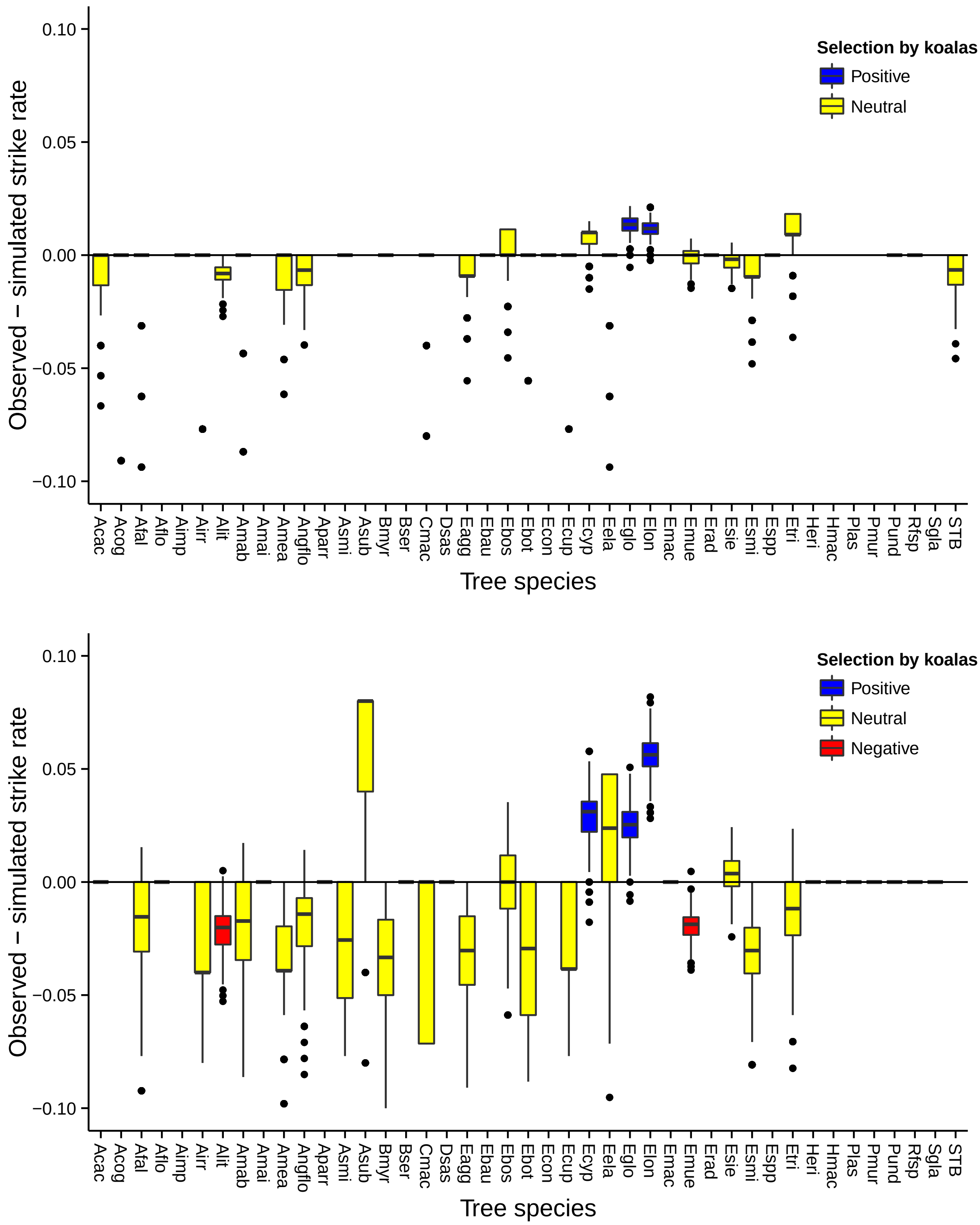


Figure 36: Distributions of observed - simulated strike rates for 2007-2009 (top) and 2010-2013 (bottom) for paired sites in the southern portion, assuming that koalas choose trees within the study areas at random. Distributions whose middle 95% do not include 0 suggest that the tree species is either being positively selected (i.e. the box plot is above 0 and has a blue fill colour) or negatively selected (i.e. the box plot is below 0 and has a red fill colour). Boxes for tree species that are being neutrally selected have a yellow fill colour. Please note, the y-axes were arbitrarily adjusted to range between -0.1 and 0.1 so that colour-coding can be seen. Many outliers fall outside this range.

3.2.4 Tree size preference

We failed to find a significant relationship between tree size class and strike rate for any of the tree species included in the two surveys for the paired sites. This is somewhat consistent with the result that we found for the sites when we analyzed the two surveys independently of one another. The lone exception being that we found a positive relationship between white stringybark (*Eucalyptus globoidea*) size class and strike rate.

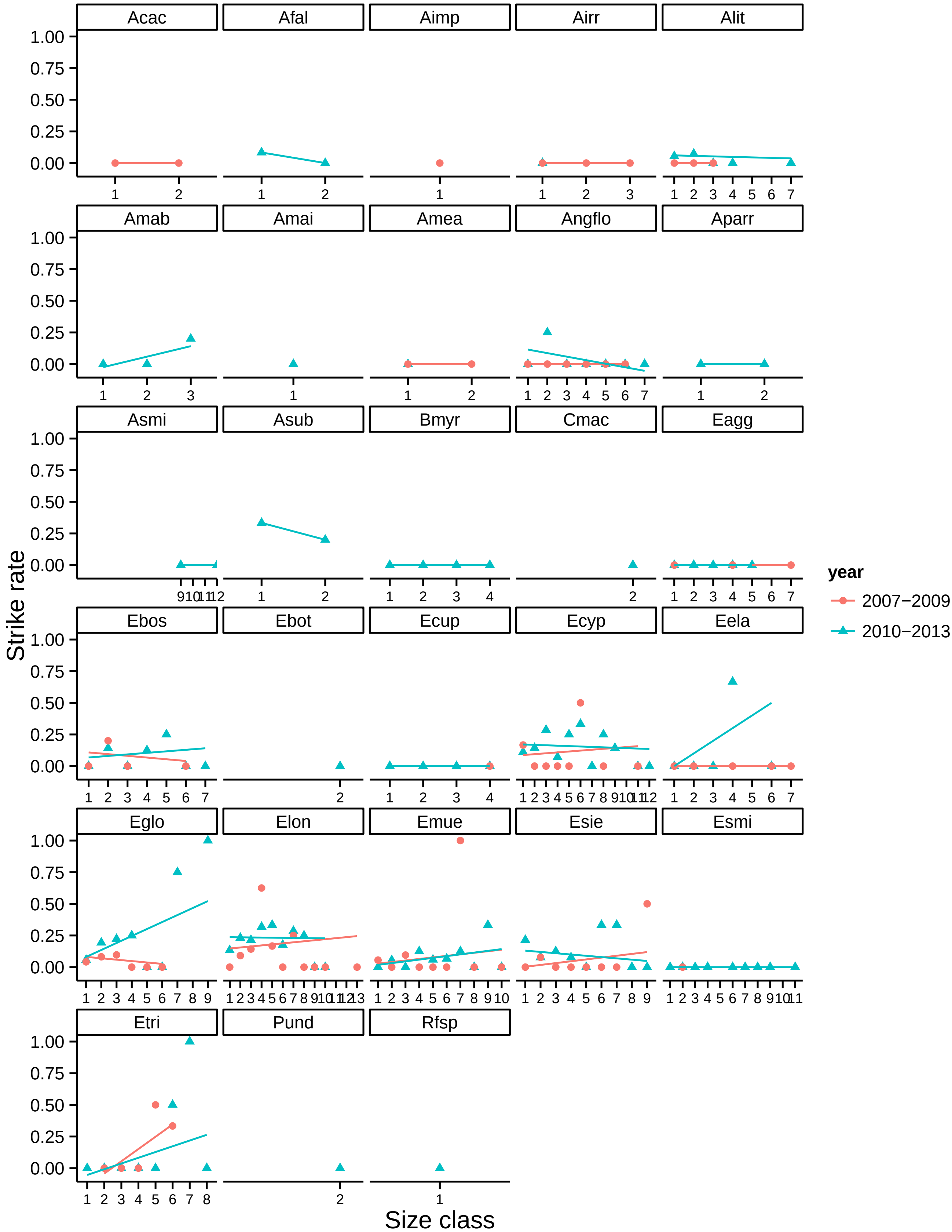


Figure 37: Relationships between tree size (DBH) and strike rates for each species for the two study periods for the southern portion.

Table 19: Summary terms for linear regressions of strike rate on tree size for each tree species found at paired active sites in the southern portion during the 2007-2009 survey weighted by the number of trees in each size class. Summary terms include the number of trees used in the regression (N), intercept and slope of the regression line, the R2 value and the p-value for the regression.

Tree ID	N	Intercept	Slope	R-square	p-value
Acac	4.00	-0.00	0.00		
Aimp	2.00	0.00		0.00	
Airr	13.00	-0.00	-0.00		
Alit	32.00	-0.00	-0.00		
Amea	16.00	-0.00	0.00		
Angflo	26.00	-0.00	0.00		
Eagg	3.00	-0.00	-0.00		
Ebos	11.00	0.12	-0.01	0.03	0.82
Ecup	1.00	0.00		0.00	
Ecyp	28.00	0.08	0.01	0.01	0.79
Eela	8.00	-0.00	0.00		
Eglo	125.00	0.09	-0.01	0.17	0.41
Elon	53.00	0.14	0.01	0.01	0.77
Emue	81.00	0.02	0.01	0.03	0.63
Esie	86.00	-0.01	0.01	0.09	0.47
Esmi	2.00	0.00		0.00	
Etri	19.00	-0.24	0.10	0.61	0.12

Table 20: Summary terms for linear regressions of strike rate on size class for all combinations of tree species found at paired active sites in the southern portion during the 2010-2013 survey weighted by the number of trees in each size class. Summary terms include the p-value for the regression, the R2 value, the slope and intercept of the regression line and the total number of trees used in the regression.

Tree ID	N	Intercept	Slope	R-square	p-value
Afal	16.00	0.17	-0.08	1.00	
Airr	3.00	0.00		0.00	
Alit	85.00	0.06	-0.00	0.05	0.71
Amab	27.00	-0.11	0.08	0.64	0.41
Amai	3.00	0.00		0.00	
Amea	6.00	0.00		0.00	
Angflo	37.00	0.14	-0.03	0.17	0.36
Aparr	3.00	-0.00	0.00		
Asmi	2.00	-0.00	0.00		
Asub	11.00	0.47	-0.13	1.00	
Bmyr	5.00	-0.00	-0.00		
Cmac	1.00	0.00		0.00	
Eagg	8.00	-0.00	0.00		
Ebos	31.00	0.06	0.01	0.05	0.63
Ebot	1.00	0.00		0.00	
Ecup	6.00	-0.00	-0.00		
Ecyp	87.00	0.17	-0.00	0.01	0.79
Eela	11.00	-0.10	0.10	0.24	0.40
Eglo	122.00	0.03	0.06	0.33	0.13
Elon	150.00	0.24	-0.00	0.00	0.94
Emue	176.00	0.00	0.01	0.27	0.13
Esie	179.00	0.14	-0.01	0.05	0.56
Esmi	15.00	-0.00	0.00		
Etri	31.00	-0.10	0.05	0.19	0.28
Pund	1.00	0.00		0.00	
Rfsp	1.00	0.00		0.00	

4 Combined koala surveys

4.1 Summary of 2007-2009 and 2010-2013 koala surveys

4.1.1 General summary of koala occurrence

This analysis combines the sampling sites that were analyzed separately above into a single analysis. The combined sampling sites from the northern and southern portions are shown in Figure 38 while the observations of koala activity are summarised in Table 21. During the 2007-2009 koala survey, 441 sites were sampled and 440 sampling sites were surveyed for the 2010-2013 survey. As was the case before, the spatial extent of the two koala surveys generally overlapped, but there were some differences between the two surveys. The percentage of sites that were active was similar, with 12% of sites being active during the 2007-2009 survey and 14% during the 2010-2013 survey. The distribution of active sites during the 2007-2009 survey was somewhat scattered with koala activity being concentrated in clusters of 2-3 active sites throughout the area being surveyed. The level of koala activity was generally low, with the mode for the number of active trees at an active site being 1 and the maximum number of active trees at a site being 8 (Figure 40). Koala activity during the 2010-2013 survey was more concentrated with a large cluster of active sites in the southern portion of the survey region that was surrounded by several additional clusters of activity. In the northern portion of the survey region, there were several small clusters of 2-4 actives sites. The mode for the number of active trees at an active site was 1, the same as for the 2007-2009 survey, but the range was wider, ranging from 1 to 15 active trees.

Table 21: Summaries for the occurrence of koalas within the study areas for the two monitoring periods

	2007-2009	2010-2013
Visited sites	441	440
Active sites	51 (12%)	62 (14%)
Inactive sites	390 (88%)	378 (86%)
Examined trees	13219	13197
Active trees	111 (1%)	179 (1%)
Inactive trees	13108 (99%)	13018 (99%)
Trees at active sites	1530 (12%)	1860 (14%)
Trees at inactive sites	11689 (88%)	11337 (86%)
All tree species	49	55
Active tree species	15 (31%)	15 (27%)

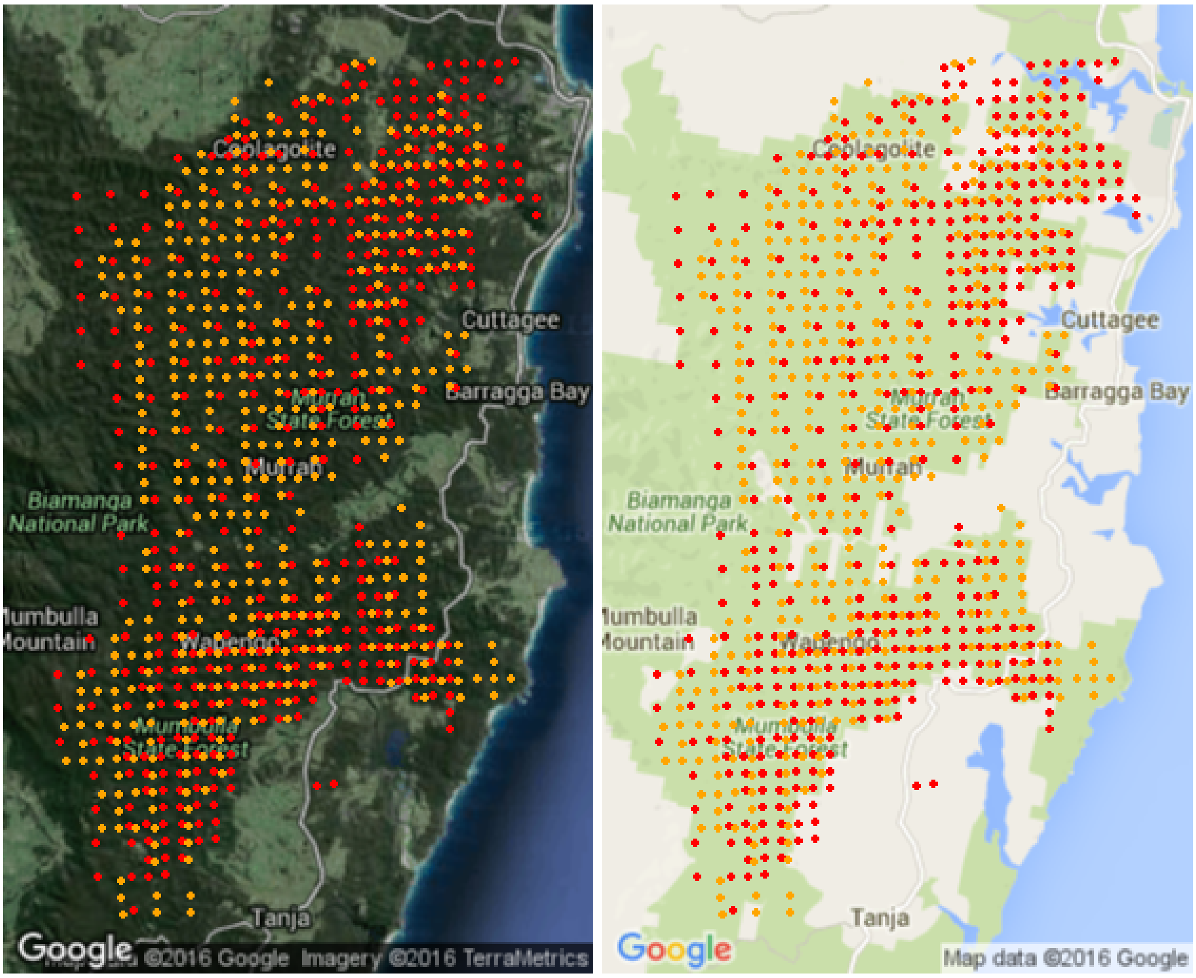


Figure 38: Sampling sites across the survey areas for 2007-2009 (red) and 2010-2013 (orange). Both panels show the same data, but use different basemaps in order to provide more spatial detail.

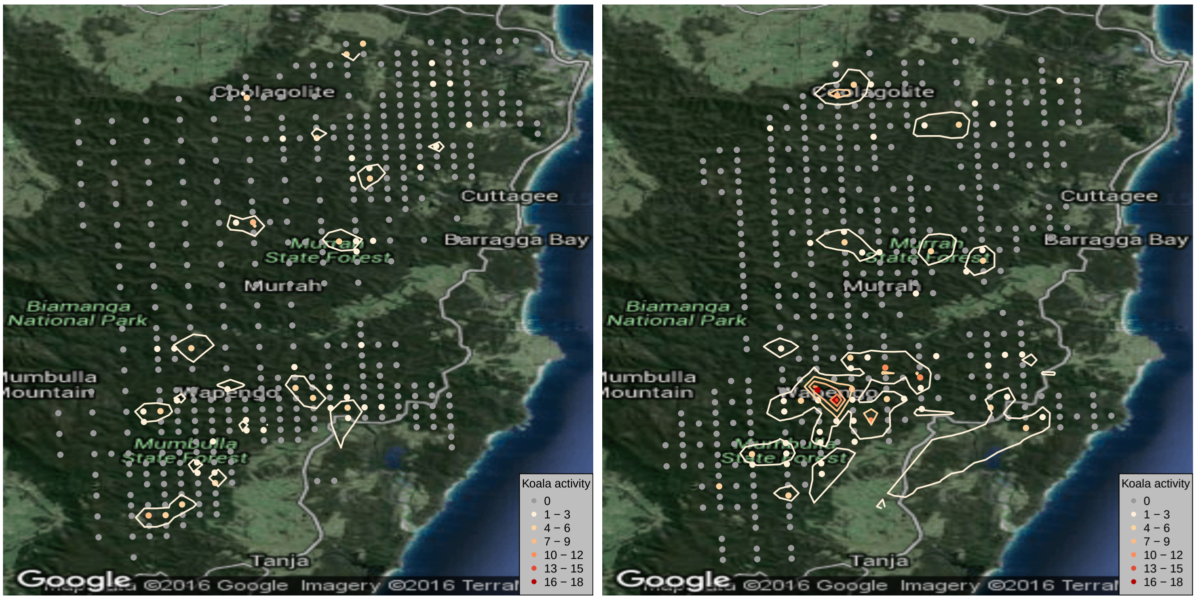


Figure 39: Site-specific koala activity levels and contour lines showing areas of equal koala activity across the survey area for 2007-2009 (left panel) and 2010-2013 (right panel). The colour key for both site-specific koala activity and the contour lines in terms of number of active trees is shown in the bottom right of each panel.

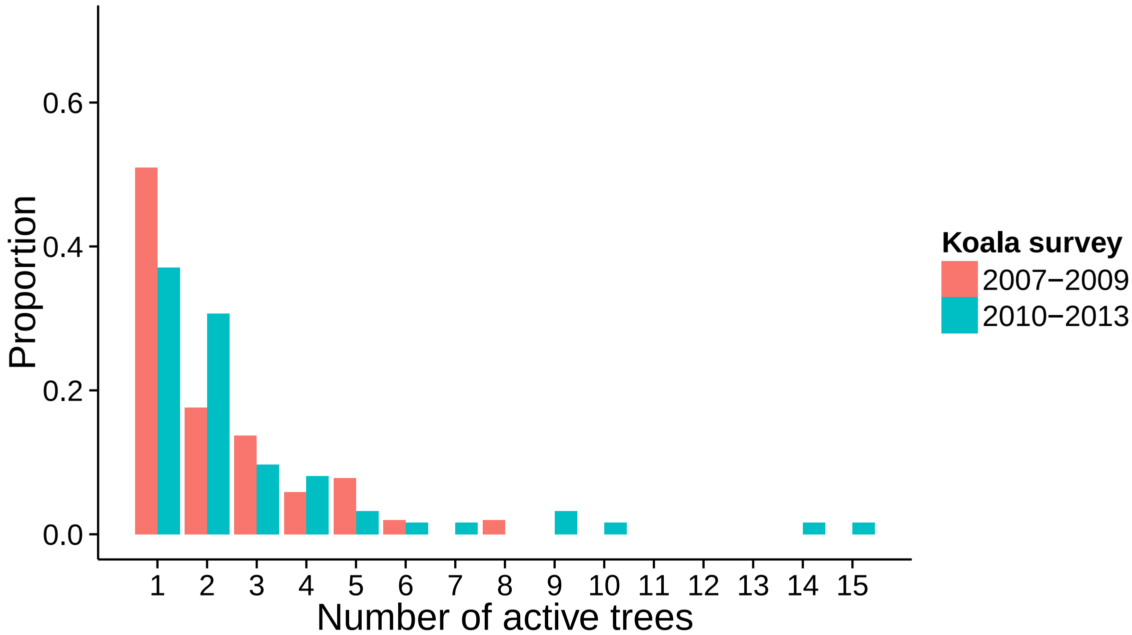


Figure 40: Comparison of the distribution of koala activity at active sites across the survey areas between the two monitoring periods (red = 2007-2009; blue = 2010-2013). Inactive sites were excluded from this analysis.

4.1.2 Tree species composition of active and inactive sites

Tree species composition for active and inactive sites in the combined survey regions were compared using non-metric multidimensional scaling (NMDS) in Figures 41 and 42. The theory behind this comparison is provided in Section 2.1.2 for the northern portion. For the 2007-2009 survey, the ellipses for active and inactive sites mostly overlapped one another and it wasn't possible to clearly differentiate the tree species composition of active sites vs. inactive sites. As was the case before, this is likely due to inactive sites that were capable of hosting koala activity not being used due to the relatively low levels of koala activity in the region. The NMDS plot for the 2010-2013 survey was similar with the ellipses for active and inactive sites extensively overlapping. In both cases, tree species that were inside the ellipses were typically abundant tree species while the tree species outside of the ellipses were relatively rare.

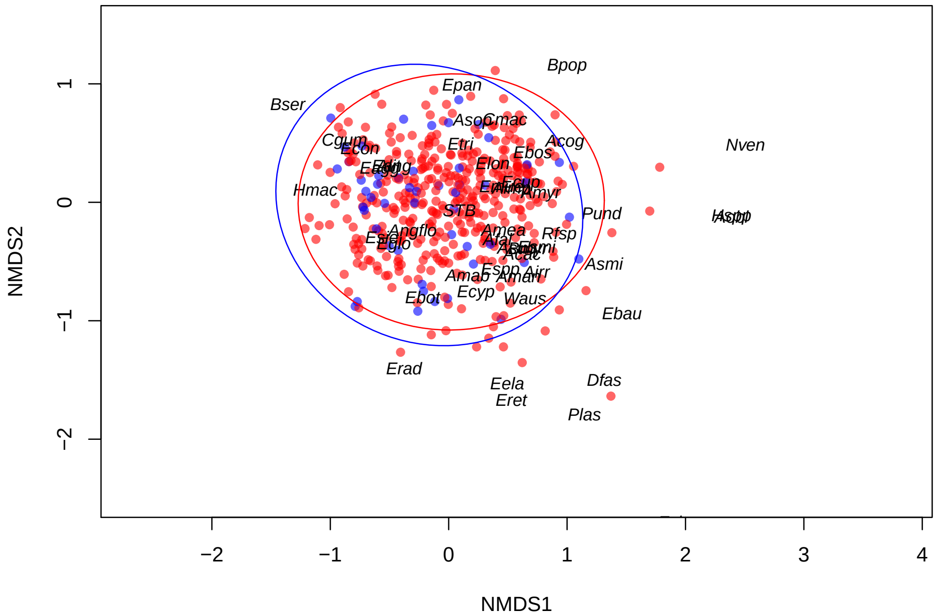


Figure 41: NMDS plot of sites (blue = active sites, red = inactive sites) across the survey area for 2007-2009 created using Bray-Curtis distances. Ellipses show the 95% bounds for active and inactive sites. Tree names are indicative of tree species composition at the sites.

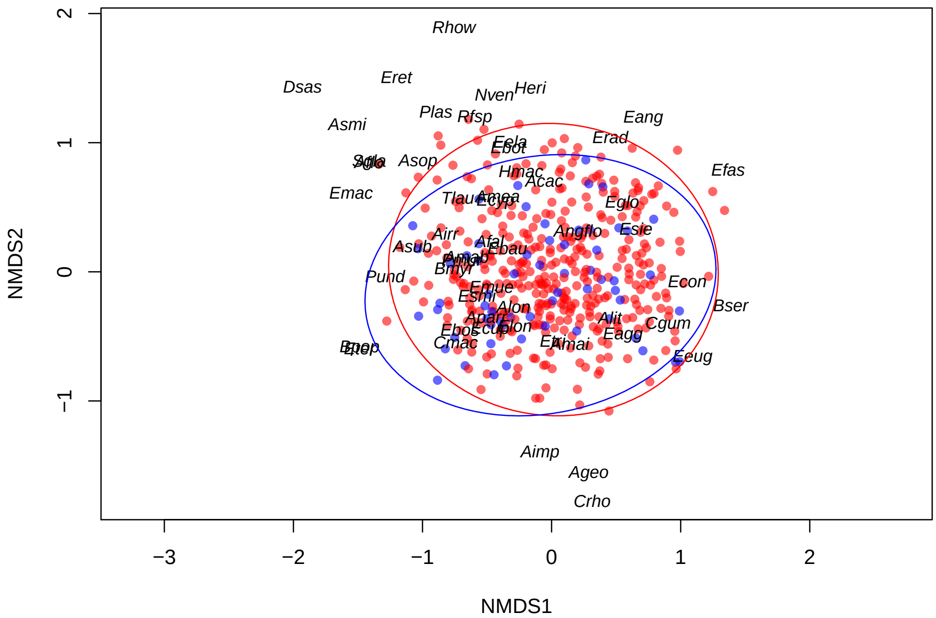


Figure 42: NMDS plot of sites (blue = active sites, red = inactive sites) across the survey area for 2010-2013 created using Bray-Curtis distances. Ellipses show the 95% bounds for active and inactive sites. Tree names are indicative of tree species composition at the sites.

Mean strike rates Strike rates by trees species for the 2007-2009 and 2010-2013 surveys in the combined survey region are summarised in Tables 22 and 23. A description of how strike rates were calculated and the layout of the box plots (Figures 43 to 45) are provided in Section 2.1.3 for the northern portion.

For the 2007-2009 survey, koalas used 15 of 49 tree species (31% of tree species) found in the combined surveyed region. Tree species not used by koalas were often relatively rare (less than 50 trees across all sites), but there were also several widely abundant tree species (more than 100 trees) that were not used by koalas (Table 22). Among the most abundant, unused tree species were bloodwood (*Corymbia gummifera*; number of trees = 454), gully peppermint (*E. smithii*; number of trees = 248), and spotted gum (*C. maculata*; number of trees = 226). Among the tree species that were used, in terms of the number of tree with faecal pellets, woollybut (*E. longifolia*; 35 trees), white stringybark (*E. globoidea*; 19 trees), and yellow stringybark (*E. muelleriana*; 14 trees) were the most heavily used tree species. In terms of mean strike rates, the hickory wattle (*A. falciformis*; mean strike rate = 0.21 faecal pellets tree^{-1}) was the most heavily used tree species, however only 2 of 13 trees at active sites had faecal pellets compared to the tree with the second highest strike rate, woollybut (mean strike rate = 0.20 faecal pellets tree^{-1}) which had 35 trees with faecal pellets out of 229 trees at active sites. Other species with notable strike rates were yerchuck (*E. consideniana*; mean strike rate = 0.17 faecal pellets tree^{-1}), monkey gum (*E. cypellocarpa*; mean strike rate = 0.14 faecal pellets tree^{-1}), and southern mahogany (*E. botryoides*; mean strike rate = 0.11 faecale pellets tree^{-1}). Three of the tree species had non-zero median strike rates (Figure 43): hickory wattle, yerchuck, and woollybut. Plots of the overall strike rates showed that woollybut, white stringybark and ironbark (*E. sideroxylon sub tricarpa*) had the highest overall strike rates.

For the 2010-2013 survey, koalas used 15 of 55 species (27% of tree species) found in the combined surveyed region. As was the case before, most of the tree species that went unused by koalas were relatively rare (less than 50 trees; Table 23). There were also several species that were quite abundant, but weren't used by koalas. In particular, we note that there were 606 blue-leaf stringybark trees and 327 southern mahogany, but there were no faecal pellets found beneath them. Among the tree species that were used, in absolute terms, woollybut was the most heavily used with 61 trees having faecal pellets, followed by white stringybark (31 trees with faecal pellets) and silvertop ash (*E. sieberi*; 26 trees). In terms of mean strike rate, the most heavily used tree species was narrow-leaf peppermint (*E. radiata*; mean strike rate = 0.50 faecal pellets tree^{-1}), but that was due to 1 out of 2 trees at active sites having faecal pellets. More abundant tree species with higher strike rates included woollybut (mean strike rate = 0.28 faecal pellets tree^{-1}), white stringybark (mean strike rate = 0.24 faecal pellets tree^{-1}), and monkey gum (mean strike rate = 0.16 faecal pellets tree^{-1}). Three tree species had non-zero median strike rates (Figure 43): woollybut, white stringybark, and narrow-leafed peppermint. Plots of overall strike rates woollybut, white stringybark, monkey gum, narrow-leafed peppermint and bower wattle (*Acacia subporosa*) had among the highest overall strike rates.

Table 22: Summary of koala activity for trees at active and inactive sites across the survey area during the 2007-2009 survey

Tree ID	# of inactive sites	# trees at inactive sites	# of active sites	# trees at active sites	# trees with faecal pellets	Mean strike rate	± Standard error
Acac	39	122	6	23	1	0.08	0.04
Acog	9	35			0		
Afal	63	170	4	13	2	0.21	0.07
Aimp	6	10	3	5	0	0.00	0.00
Airr	12	48	2	20	0	0.00	0.00
Alit	243	1554	26	156	2	0.01	0.00
Amab	9	60			0		
Aman	2	3			0		
Amea	31	130	2	16	0	0.00	0.00
Amyr	1	2			0		
Angflo	184	545	32	76	2	0.02	0.01
Aobl	1	6			0		
Asmi	5	18			0		
Asop	1	2	1	3	0	0.00	
Asub	5	10	2	3	0	0.00	0.00
Bmyr	18	83			0		
Bpop	2	2			0		
Bser	6	33			0		
Cgum	59	443	4	11	0	0.00	0.00
Cmac	26	226			0		
Dfas	1	2			0		
Eagg	101	510	11	63	2	0.10	0.04
Eang	2	7			0		
Ebau	5	45			0		
Ebos	96	345	17	51	5	0.09	0.03
Ebot	49	216	6	18	3	0.11	0.04
Econ	23	65	2	4	1	0.17	0.12
Ecup	44	67	4	6	1	0.08	0.07
Ecyp	120	418	14	46	5	0.14	0.04
Eela	22	145	1	8	0	0.00	
Eglo	156	952	33	251	19	0.08	0.01
Elon	266	1445	36	229	35	0.20	0.02
Emue	247	1924	35	245	14	0.08	0.01
Epan	3	5			0		
Erad	11	44			0		
Eret	2	2			0		
Esie	176	1193	29	197	12	0.07	0.01
Esmi	55	238	4	10	0	0.00	0.00
Espp	7	13			0		
Etri	119	307	24	74	7	0.09	0.03
Evim	1	1			0		
Hmac	2	2			0		
Hspp	1	1			0		
Nven	1	2			0		
Plas	1	1			0		
Pund	11	20			0		
Rfsp	3	4			0		
STB	36	212	1	2	0	0.00	
Waus	1	1			0		

Table 23: Summary of koala activity for trees at active and inactive sites across the survey area during the 2010-2013 survey

Tree ID	# of inactive sites	# trees at inactive sites	# of active sites	# trees at active sites	# trees with faecal pellets	Mean strike rate	± Standard error
Acac	4	13			0		
Afal	91	248	10	19	1	0.10	0.07
Aflo	1	1			0		
Ageo	1	1			0		
Aimp	2	2			0		
Airr	18	75	2	4	0	0.00	0.00
Alit	266	1812	40	250	6	0.05	0.01
Alon	2	2			0		
Amab	12	40	6	27	1	0.17	0.08
Amai	4	9	2	12	0	0.00	0.00
Amea	32	96	4	10	0	0.00	0.00
Angflo	194	544	33	77	4	0.06	0.02
Aobl	1	1			0		
Aparr	2	4	1	3	0	0.00	
Asmi	8	76	2	3	0	0.00	0.00
Asop	1	1			0		
Asub	23	88	4	19	3	0.09	0.04
Bmyr	17	95	4	23	0	0.00	0.00
Bpop			1	2	0	0.00	
Bser	6	34			0		
Cgum	34	202	2	16	0	0.00	0.00
Cmac	6	37	2	3	0	0.00	0.00
Crho	1	10			0		
Dsas	3	31			0		
Eagg	98	560	11	46	0	0.00	0.00
Eang	1	1	1	1	0	0.00	
Ebau	3	5			0		
Ebos	81	248	17	40	3	0.09	0.04
Ebot	52	316	6	11	0	0.00	0.00
Econ	16	59	1	1	0	0.00	
Ecup	50	81	10	13	1	0.03	0.03
Ecyp	126	420	29	127	17	0.16	0.02
Eela	23	88	4	13	2	0.07	0.04
Eeug	1	1			0		
Efas	1	3			0		
Eglo	139	866	29	201	31	0.24	0.02
Elon	255	1326	54	262	61	0.28	0.02
Emac	1	2			0		
Emue	270	2025	43	332	18	0.05	0.00
Erad	12	32	1	2	1	0.50	
Eret	2	2			0		
Esie	172	1255	37	249	26	0.09	0.01
Esmi	54	206	8	19	0	0.00	0.00
Eter			1	5	0	0.00	
Etri	130	342	30	67	4	0.03	0.01
Heri	2	2			0		
Hmac	8	17			0		
Nven	2	2			0		
Plas	1	1			0		
Pmur	2	3			0		
Pund	9	14	2	2	0	0.00	0.00
Rfsp	6	21	1	1	0	0.00	
Rhow	1	1			0		
Sgla	2	3			0		
Tlau	3	13			0		

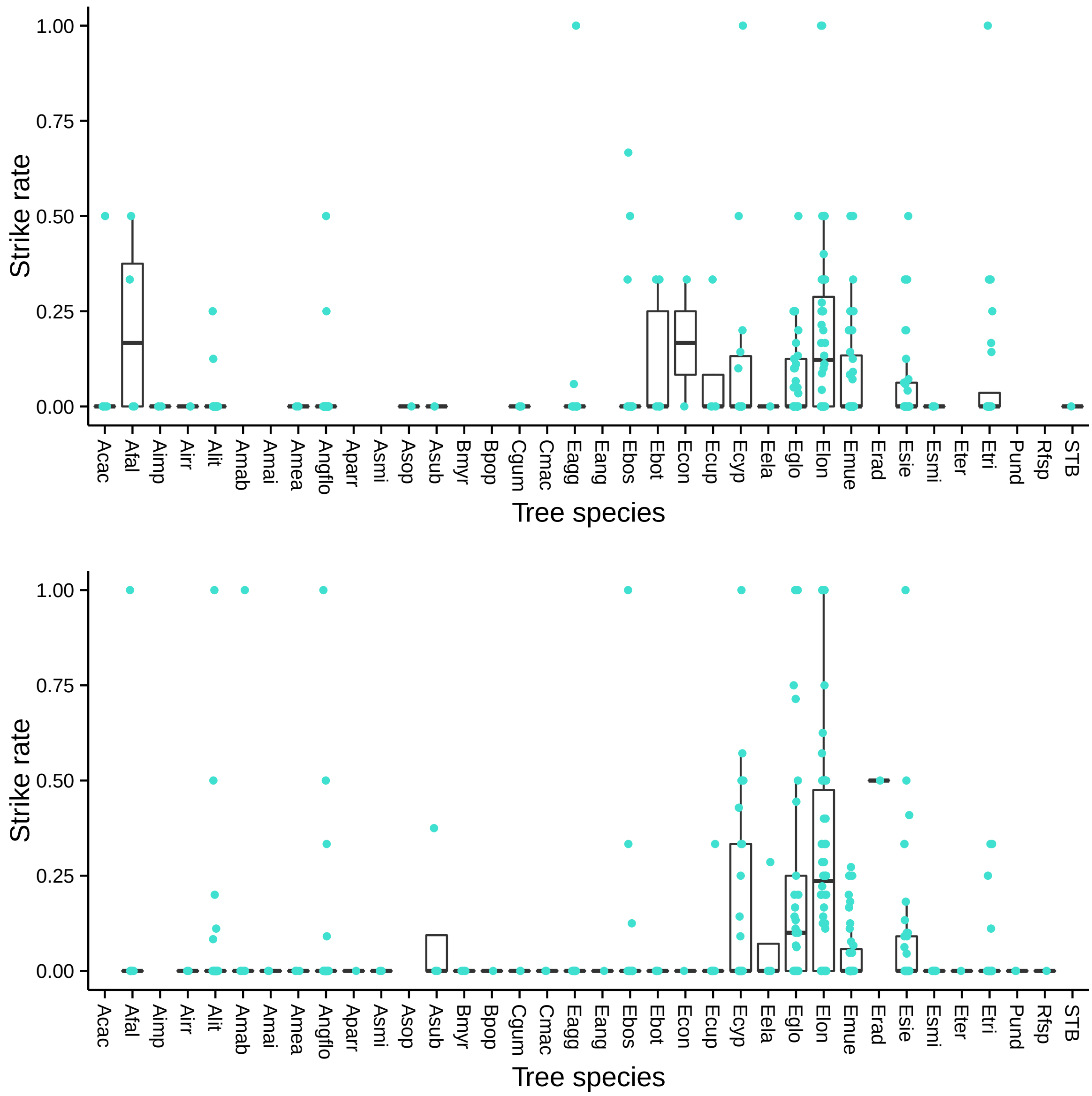


Figure 43: Distribution of strike rates at active sites across the survey areas determined using site-specific strike rates for each tree species for 2007-2009 (top) and for 2010-2013 (bottom). Some tree species were only active in one monitoring period but are included for both monitoring periods to ease comparisons between monitoring periods.

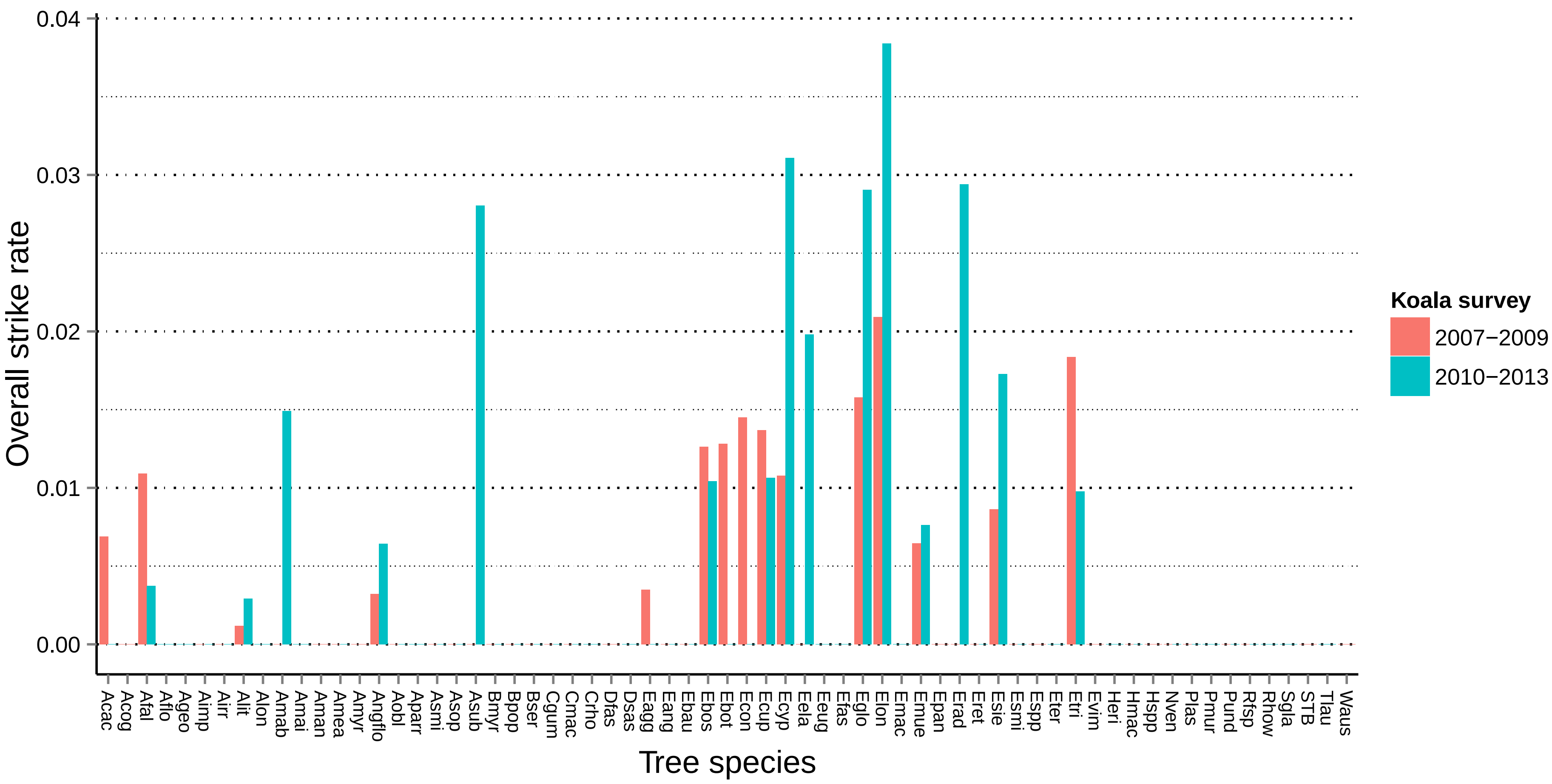


Figure 44: Overall strike rates for each tree species across all visited sites in the survey areas for the two sampling periods.

4.1.3 Tree species preference

The tree species preferences for the overall survey areas were examined separately for the 2007-2009 and the 2010-2013 surveys. The methodology is described in the Section 2.1.4. For the 2007-2009 survey two tree species (white stringybark and woollybut) were found to be positively selected for by koalas while two species was negatively selected (forest oak (*A. littoralis*); and bloodwood (*Corymbia gummifera*). The finding that koalas were selecting for white stringybark and woollybut is generally consistent with their mean and overall strike rates. Negative selection for forest oak and bloodwood seems plausible as koala faecal pellets were only found under 2 out of over 1700 forest oaks (156 trees at active sites) and there were no faecal pellets under the 454 bloodwoods (11 at active sites).

For the 2010-2013 survey, there were three positively selected for tree species and three negatively selected for tree species. The three positively selected species were woollybut, white stringybark and monkey gum. These species were all observed to have high mean strike rates or overall strike rates. The three negatively selected for species were forest oak, blue-leafed stringybark and yellow stringybark. There were 6 forest oaks with faecal pellet out of over 2,000 trees (250 at active sites) which is one of the higher absolute counts of trees with faecal pellets by tree species, but its mean strike rate was among the lowest for tree species being used by koalas. The other two species each had several hundred trees (blue-leafed stringybark 606 trees; yellow stringybark 327 trees), but none with faecal pellets.

We note that the majority of trees for both surveys were neutrally selected for.

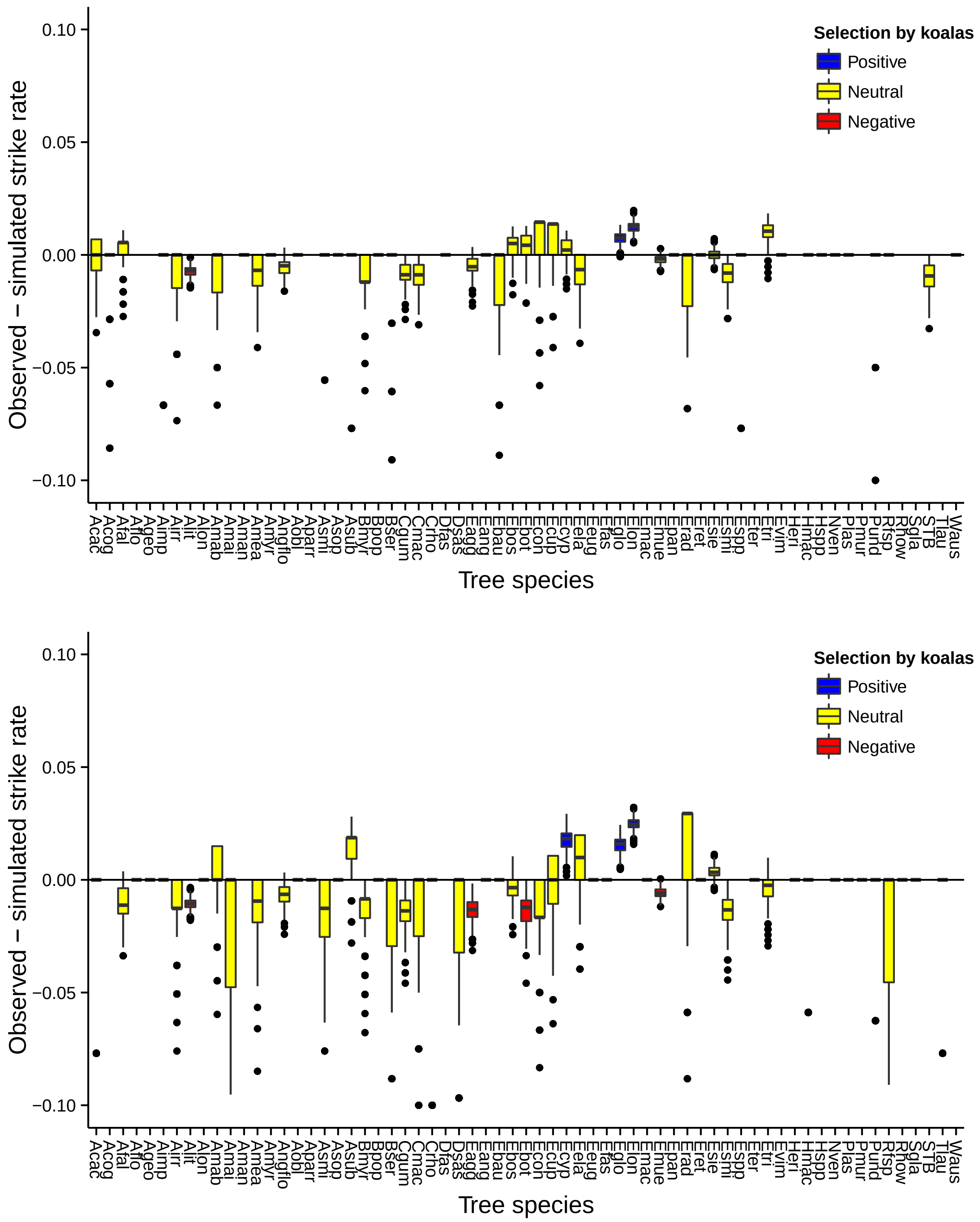


Figure 45: Distributions of observed - simulated strike rates for 2007-2009 (top) and 2010-2013 (bottom) across the survey areas, assuming that koalas choose trees within the study area at random. Distributions whose middle 95% do not include 0 suggest that the tree species is either being positively selected (i.e. the box plot is above 0 and has a blue fill colour) or negatively selected (i.e. the box plot is below 0 and has a red fill colour). Boxes for tree species that are being neutrally selected have a yellow fill colour. Please note, the y-axes were arbitrarily adjusted to range between -0.1 and 0.1 so that colour-coding can be seen. Many outliers fall outside this range.

4.1.4 Tree size preference

We tested for a linear relationship between tree size (DBH) and strike rate for each tree species separately for the two surveys. During the 2007-2009 survey, there were no tree species with a significant relationship between tree size and strike rate. For the 2010-2013 survey, forest oak (*Allocasuarina littoralis*) was the lone species to have a significant relationship ($R^2 = 0.84$; $p = 0.01$) between tree size and strike rate, but the slope was negative, indicating that koalas preferred smaller trees over larger ones. We note that koalas were found to negatively select for this species with only 6 trees having faecal pellets out of over 2,000 trees.

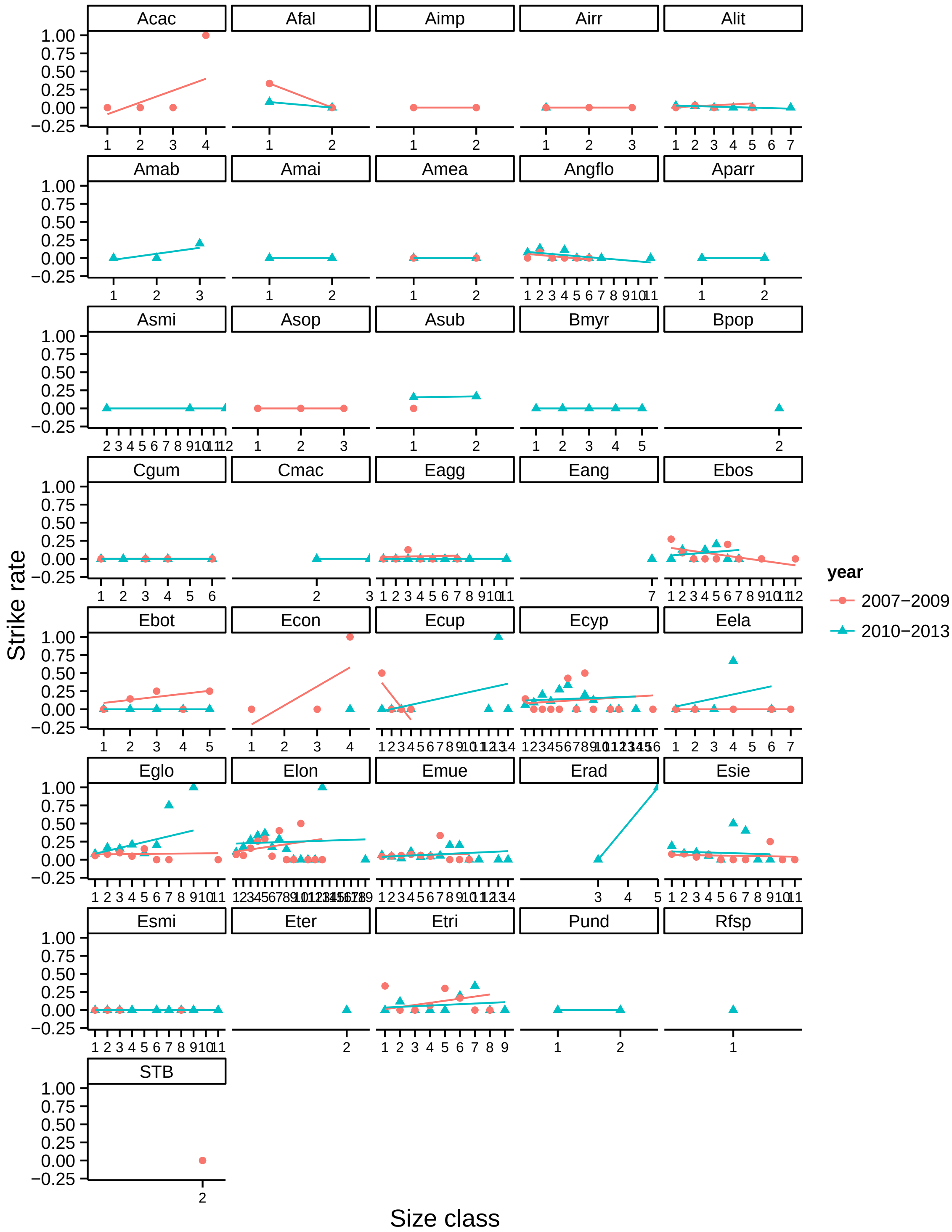


Figure 46: Relationships between tree size (DBH) and strike rates for each species for the two study periods across the survey areas.

Table 24: Summary terms for linear regressions of strike rate on tree size for each tree species found at active sites across the survey area during the 2007-2009 survey weighted by the number of trees in each size class. Summary terms include the number of trees used in the regression (N), intercept and slope of the regression line, the R2 value and the p-value for the regression.

Tree ID	N	Intercept	Slope	R-square	p-value
Acac	23.00	-0.25	0.16	0.37	0.39
Afal	13.00	0.67	-0.33	1.00	
Aimp	5.00	-0.00	0.00		
Airr	20.00	-0.00	-0.00		
Alit	156.00	-0.01	0.01	0.32	0.44
Amea	16.00	-0.00	0.00		
Angflo	76.00	0.07	-0.02	0.27	0.29
Asop	3.00	-0.00	-0.00		
Asub	3.00	0.00		0.00	
Cgum	11.00	-0.00	-0.00		
Eagg	63.00	0.02	0.00	0.01	0.88
Ebos	51.00	0.17	-0.02	0.21	0.21
Ebot	18.00	0.05	0.04	0.39	0.26
Econ	4.00	-0.47	0.26	0.44	0.54
Ecup	6.00	0.54	-0.17	0.60	0.23
Ecyp	46.00	0.07	0.01	0.02	0.66
Eela	8.00	-0.00	0.00		
Eglo	251.00	0.07	0.00	0.01	0.86
Elon	229.00	0.10	0.01	0.08	0.34
Emue	244.00	0.05	0.00	0.02	0.66
Esie	197.00	0.07	-0.00	0.01	0.76
Esmi	10.00	-0.00	-0.00		
Etri	74.00	-0.02	0.03	0.16	0.33
STB	2.00	0.00		0.00	

Table 25: Summary terms for linear regressions of strike rate on size class for all combinations of tree species found at active sites across the survey area during the 2010-2013 survey weighted by the number of trees in each size class. Summary terms include the p-value for the regression, the R2 value, the slope and intercept of the regression line and the total number of trees used in the regression.

Tree ID	N	Intercept	Slope	R-square	p-value
Afal	19.00	0.15	-0.08	1.00	
Airr	4.00	0.00		0.00	
Alit	250.00	0.03	-0.01	0.84	0.01
Amab	27.00	-0.11	0.08	0.64	0.41
Amai	12.00	-0.00	0.00		
Amea	10.00	-0.00	0.00		
Angflo	77.00	0.10	-0.01	0.22	0.24
Aparr	3.00	-0.00	0.00		
Asmi	3.00	-0.00	-0.00		
Asub	19.00	0.14	0.01	1.00	
Bmyr	23.00	-0.00	0.00		
Bpop	2.00	0.00		0.00	
Cgum	16.00	-0.00	0.00		
Cmac	3.00	-0.00	0.00		
Eagg	46.00	-0.00	0.00		
Eang	1.00	0.00		0.00	
Ebos	40.00	0.03	0.01	0.07	0.55
Ebot	11.00	-0.00	-0.00		
Econ	1.00	0.00		0.00	
Ecup	13.00	-0.06	0.03	0.27	0.23
Ecyp	127.00	0.12	0.00	0.02	0.68
Eela	13.00	-0.02	0.06	0.10	0.60
Eglo	200.00	0.04	0.04	0.31	0.15
Elon	262.00	0.22	0.00	0.01	0.80
Emue	331.00	0.03	0.01	0.11	0.28
Erad	2.00	-1.50	0.50	1.00	
Esie	249.00	0.12	-0.00	0.01	0.82
Esmi	19.00	-0.00	0.00		
Eter	5.00	0.00		0.00	
Etri	67.00	0.03	0.01	0.04	0.60
Pund	2.00	-0.00	0.00		
Rfsp	1.00	0.00		0.00	

4.2 Comparison of 2007-2009 and 2010-2013 koala surveys

Across the survey areas, we were able to identify 262 pairs of sites between the 2007-2009 and 2010-2013 koala surveys. The pairs of sites are shown in Figure 47 while a general summary of koala activity for the paired sites is provided in Table 26. Using paired sites, we found that there was a significant (Chi-square test, $p = 0.015$) increase in the percentage of active sites from 10% of sites during the 2007-2009 survey to 17% of sites during the 2010-2013 survey. Similarly, the number of active trees also increased significantly (Chi-square test, $p << 0.0001$) from the 2007-2009 survey to the 2010-2013 survey. The spatial pattern and intensity of koala activity shifted from the first survey to the second (Figure 48). During the 2007-2009 survey, koala activity was scattered and generally at low levels throughout the survey area. During the 2010-2013 survey, koala activity was more clustered, with a large cluster of koala activity in the southern portion, and an increase in the size of the clusters of koala activity in the northern portion. The intensity of koala activity appeared to be higher in the 2010-2013 survey as shown in Figure 48. This is born out by Figure 49 which showed the 60% of active sites during the 2007-2009 survey had only a single active tree while for the 2010-2013 survey, nearly 70% of active sites had 2 or more active trees. Additionally, the range for the number of active trees increased from 1 to 6 for the 2007-2009 survey to 1 to 15 for the 2010-2013 survey.

Table 26: Summaries of the occurrence of koalas throughout the survey areas across pairs of sampling sites for the two monitoring periods

	2007-2009	2010-2013
Visited sites	262	262
Active sites	25 (10%)	45 (17%)
Inactive sites	237 (90%)	217 (83%)
Examined trees	7853	7860
Active trees	44 (1%)	149 (2%)
Inactive trees	7809 (99%)	7711 (98%)
Trees at active sites	750 (10%)	1350 (17%)
Trees at inactive sites	7103 (90%)	6510 (83%)
All tree species	41	48
Active tree species	8 (20%)	13 (27%)

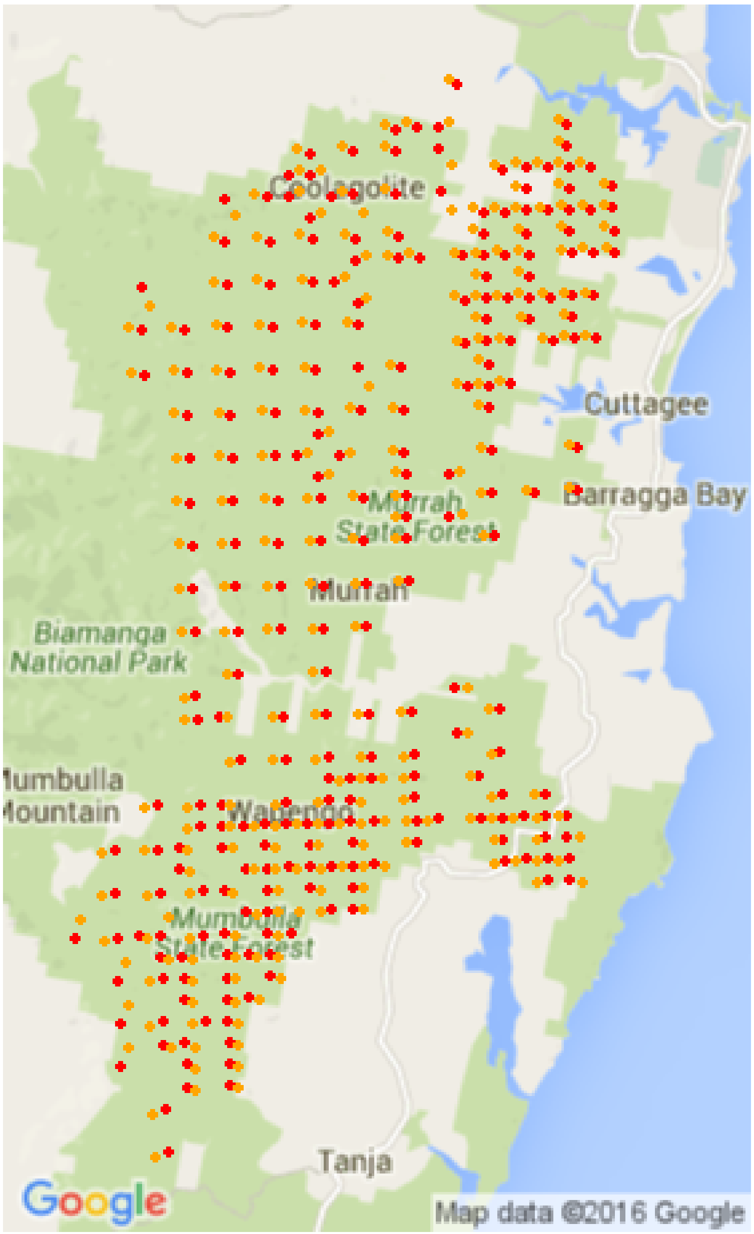


Figure 47: Paired sampling sites across the survey areas for 2007-2009 (red) and 2010-2013 (orange).

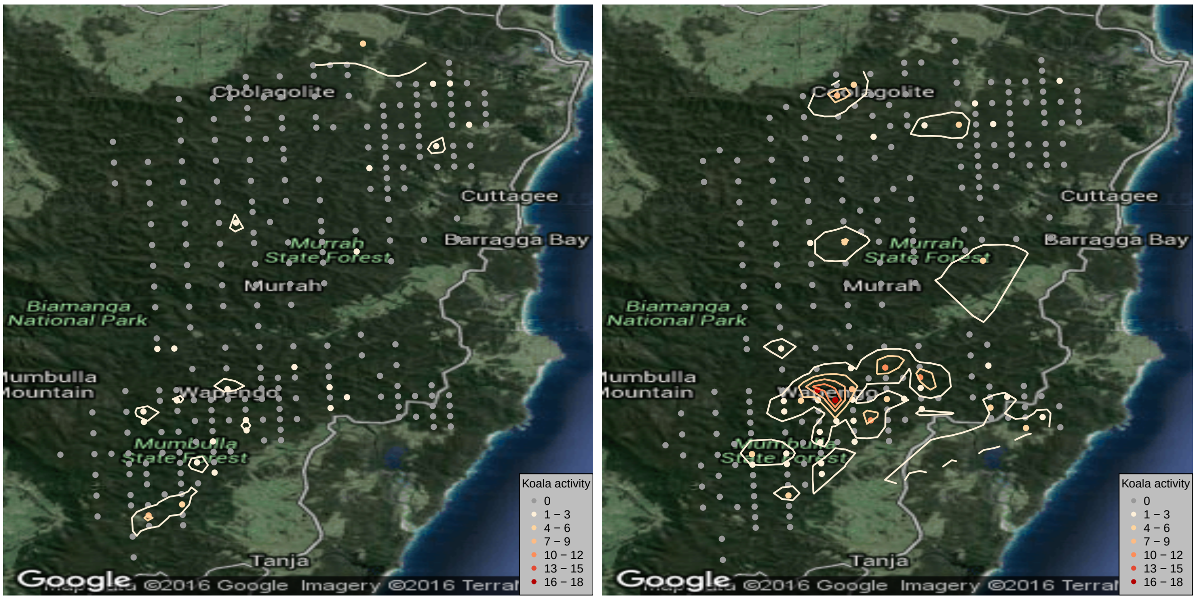


Figure 48: Site-specific koala activity levels and contour lines showing areas of equal koala activity for paired sites across the survey areas for 2007-2009 (left panel) and 2010-2013 (right panel).The colour key for both site-specific koala activity and the contour lines in terms of number of active trees is shown in the bottom right of each panel.

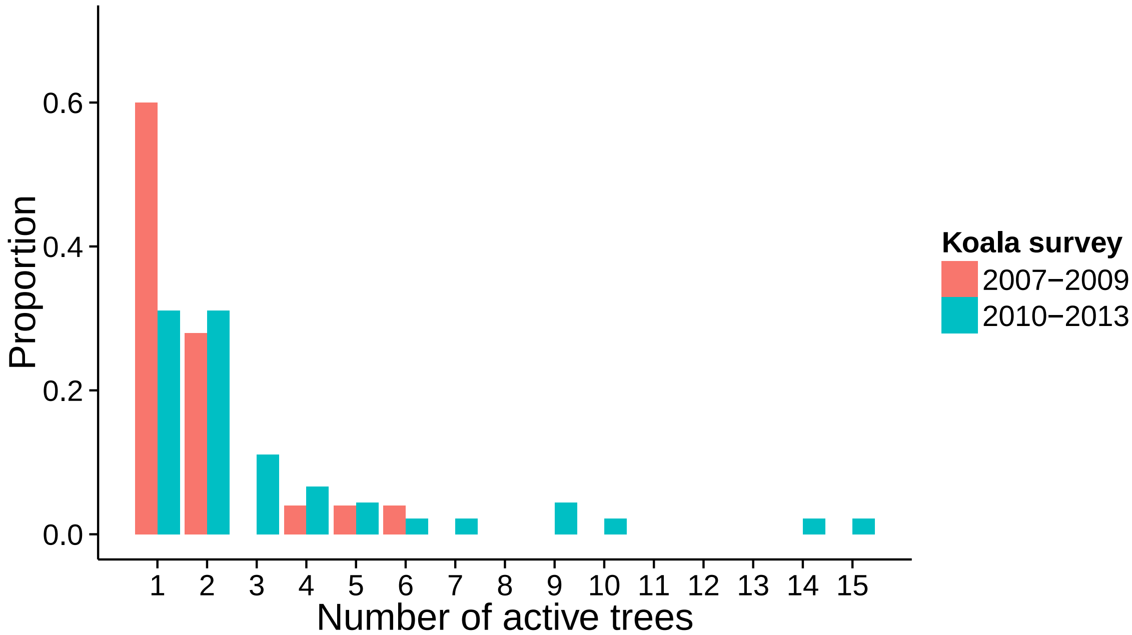


Figure 49: Comparison of the distribution of koala activity at active sites across the survey areas between the two monitoring periods (red = 2007-2009; blue = 2010-2013) for all paired sites. Inactive sites were excluded from this analysis.

4.2.1 Tree species composition of active and inactive sites

For both surveys, the ellipses for inactive sites extensively overlapped the ellipses for inactive sites. Unlike the plots for the two portions of the survey areas, the ellipses for active sites tended to be smaller than the ellipses for inactive sites and appeared to be more of a subset of inactive sites meaning that there were some differences in the composition of active vs. inactive sites. Unfortunately, inactive sites vastly outnumbered active sites and it was still not clear what was driving these differences and how the compositions differed across surveys.

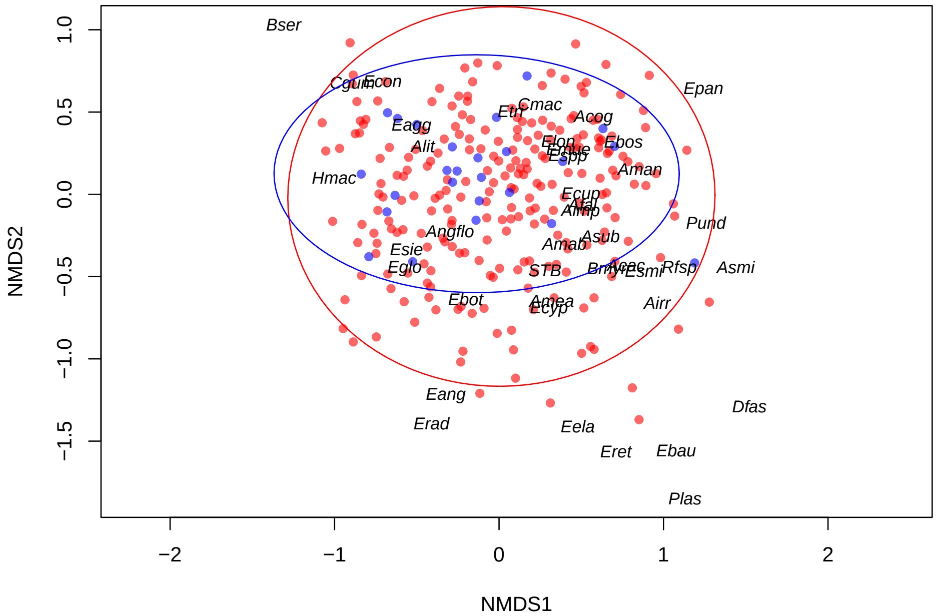


Figure 50: NMDS plot of paired sites (blue = active sites, red = inactive sites) across the survey area for 2007-2009 created using Bray-Curtis distances. Ellipses show the 95% bounds for active and inactive sites. Tree names are indicative of tree species composition at the sites.

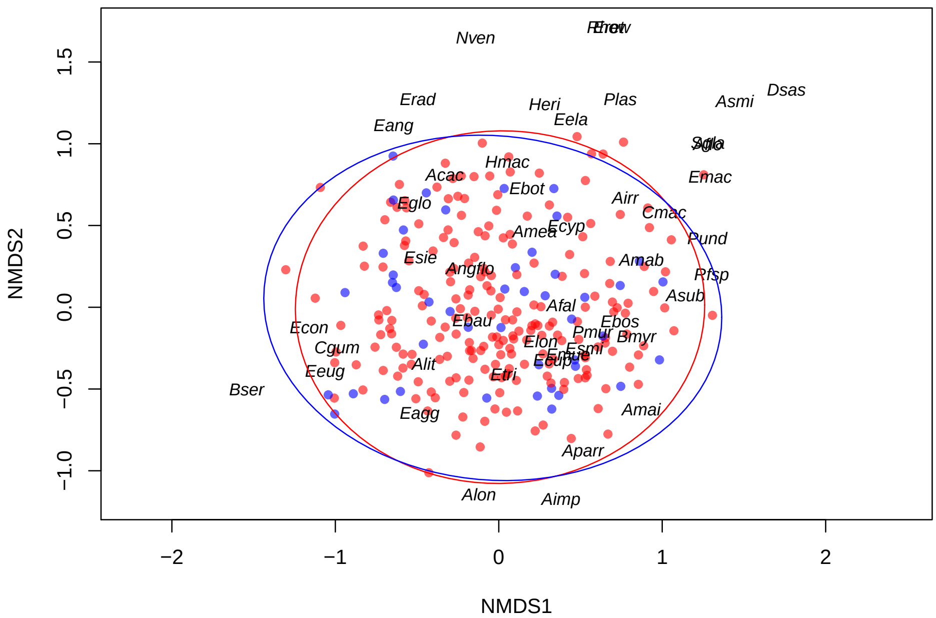


Figure 51: NMDS plot of paired sites (blue = active sites, red = inactive sites) across the survey area for 2010-2013 created using Bray-Curtis distances. Ellipses show the 95% bounds for active and inactive sites. Tree names are indicative of tree species composition at the sites.

4.2.2 Strike rates

The number of trees of each species sampled for koala faecal pellets did not differ significantly across the two surveys (Tables 27 and 28; paired t-test, t = -0.75, df = 34, p = 0.46). The overall pattern of mean strike rates for tree species that were present during both surveys differed significantly across surveys (paired t-test, t = -2.63, df = 34, p = 0.013). Much of this difference was driven by the mean strike rates for the 2010-2013 survey being higher than the mean strike rates for the 2007-2009 survey. Exceptions to this trend were native cherry (*Exocarpus cuppressiformis*), yellow stringybark (*E. muelleriana*), and ironbark (*E. sideroxylon sub. tricarpa*) which all recorded declines in mean strike rate. The distribution of strike rates across active sites (Figure 52) were roughly similar across the two surveys. For both sets of plots, woollybut and white stringybark had non-zero medians. Differences included monkey gum (*E. cypellocarpa*) having a non-zero median strike rate for the 2007-2009 survey but not the 2010-2013 survey and bower wattle (*Acacia subporosa*) and river peppermint (*E. elata*) having unvarying strikes rates of 0 during the 2007-2009 survey and varying strike rates for the 2010-2013 survey. The overall strike rates (Figure 53) confirmed the general increase in strike rates across tree species in the 2010-2013 survey vs. the 2007-2009 survey. The only exception was for native cherry which had an overall strike rate of 0.022 faecal pellets tree^{-1} in 2007-2009 but no overall strike rate in the 2010-2013 survey.

Table 27: Summary of koala activity for trees at paired active and inactive sites across the survey area during the 2007-2009 survey

Tree ID	# of inactive sites	# trees at inactive sites	# of active sites	# trees at active sites	# trees with faecal pellets	Mean strike rate	± Standard error
Acac	23	78	2	4	0	0.00	0.00
Acog	5	13			0		
Afal	42	117			0		
Aimp	3	5	1	2	0	0.00	
Airr	7	37	2	20	0	0.00	0.00
Alit	158	1034	11	70	0	0.00	0.00
Amab	5	23			0		
Aman	1	2			0		
Amea	15	68	2	16	0	0.00	0.00
Angflo	110	329	14	41	0	0.00	0.00
Asmi	3	13			0		
Asub	5	10	1	1	0	0.00	
Bmyr	11	34			0		
Bser	3	14			0		
Cgum	32	273	2	6	0	0.00	0.00
Cmac	12	77			0		
Dfas	1	2			0		
Eagg	62	279	4	12	0	0.00	0.00
Eang	2	7			0		
Ebau	3	26			0		
Ebos	55	176	8	23	1	0.04	0.02
Ebot	29	130	3	8	0	0.00	0.00
Econ	12	35	1	1	0	0.00	
Ecup	28	39	4	6	1	0.08	0.07
Ecyp	72	267	8	36	4	0.12	0.03
Eela	10	57	1	8	0	0.00	
Eglo	88	494	20	158	13	0.10	0.01
Elon	167	841	15	75	11	0.21	0.04
Emue	158	1249	17	108	5	0.07	0.01
Epan	1	2			0		
Erad	8	24			0		
Eret	2	2			0		
Esie	115	764	14	122	6	0.06	0.01
Esmi	36	174	1	2	0	0.00	
Espp	3	6			0		
Etri	83	219	11	31	3	0.11	0.05
Hmac	1	1			0		
Plas	1	1			0		
Pund	5	9			0		
Rfsp	1	2			0		
STB	26	170			0		

Table 28: Summary of koala activity for trees at paired active and inactive sites across the survey area during the 2010-2013 survey

Tree ID	# of inactive sites	# trees at inactive sites	# of active sites	# trees at active sites	# trees with faecal pellets	Mean strike rate	± Standard error
Acac	3	9			0		
Afal	48	123	9	17	1	0.11	0.08
Aflo	1	1			0		
Aimp	1	1			0		
Airr	8	32	2	4	0	0.00	0.00
Alit	151	981	25	122	6	0.08	0.02
Alon	1	1			0		
Amab	11	32	6	27	1	0.17	0.08
Amai	1	3	1	3	0	0.00	
Amea	23	52	3	6	0	0.00	0.00
Angflo	105	276	24	62	4	0.08	0.03
Aobl	1	1			0		
Aparr			1	3	0	0.00	
Asmi	5	49	1	2	0	0.00	
Asub	11	39	3	11	3	0.12	0.06
Bmyr	11	75	3	10	0	0.00	0.00
Bser	6	34			0		
Cgum	29	175	2	16	0	0.00	0.00
Cmac	2	14	2	3	0	0.00	0.00
Dsas	2	18			0		
Eagg	57	308	8	43	0	0.00	0.00
Eang	1	1	1	1	0	0.00	
Ebau	2	4			0		
Ebos	46	141	15	38	3	0.10	0.04
Ebot	25	153	2	4	0	0.00	0.00
Econ	15	58	1	1	0	0.00	
Ecup	29	51	8	9	0	0.00	0.00
Ecyp	62	223	24	109	16	0.17	0.02
Eela	10	47	3	11	2	0.10	0.05
Eeug	1	1			0		
Eglo	84	575	19	152	25	0.26	0.03
Elon	149	751	40	192	47	0.28	0.02
Emac	1	2			0		
Emue	150	1157	31	236	14	0.05	0.01
Erad	4	8			0		
Eret	1	1			0		
Esie	99	739	26	203	24	0.12	0.02
Esmi	34	149	5	15	0	0.00	0.00
Etri	73	190	20	47	3	0.04	0.01
Heri	2	2			0		
Hmac	4	10			0		
Nven	1	1			0		
Plas	1	1			0		
Pmur	2	3			0		
Pund	5	10	2	2	0	0.00	0.00
Rfsp	3	5	1	1	0	0.00	
Rhow	1	1			0		
Sgla	1	2			0		

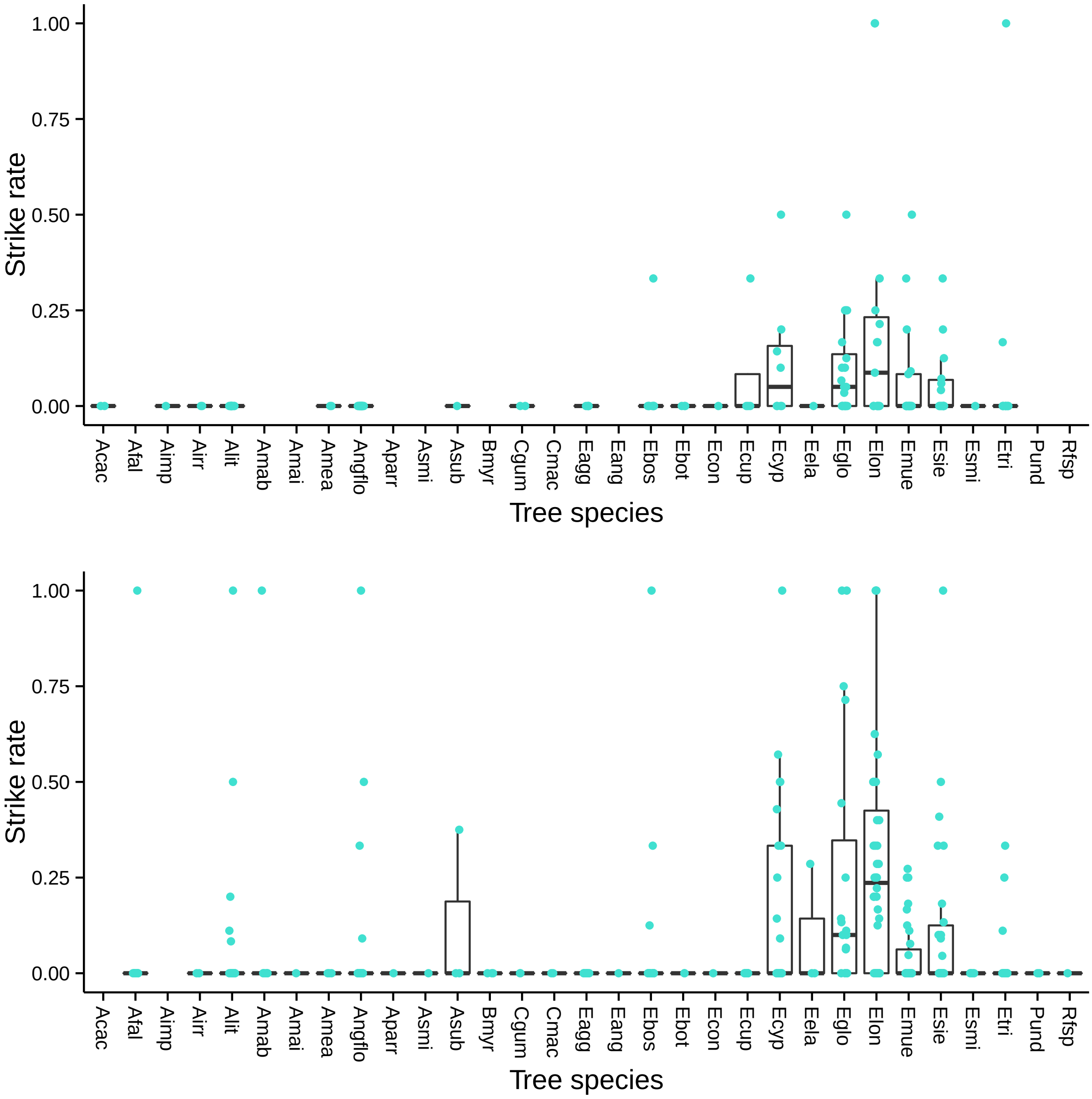


Figure 52: Distribution of strike rates at paired active sites across the survey areas determined using site-specific strike rates for each tree species for 2007-2009 (top) and for 2010-2013 (bottom). Some tree species were only active in one monitoring period but are included for both monitoring periods to ease comparisons between monitoring periods.

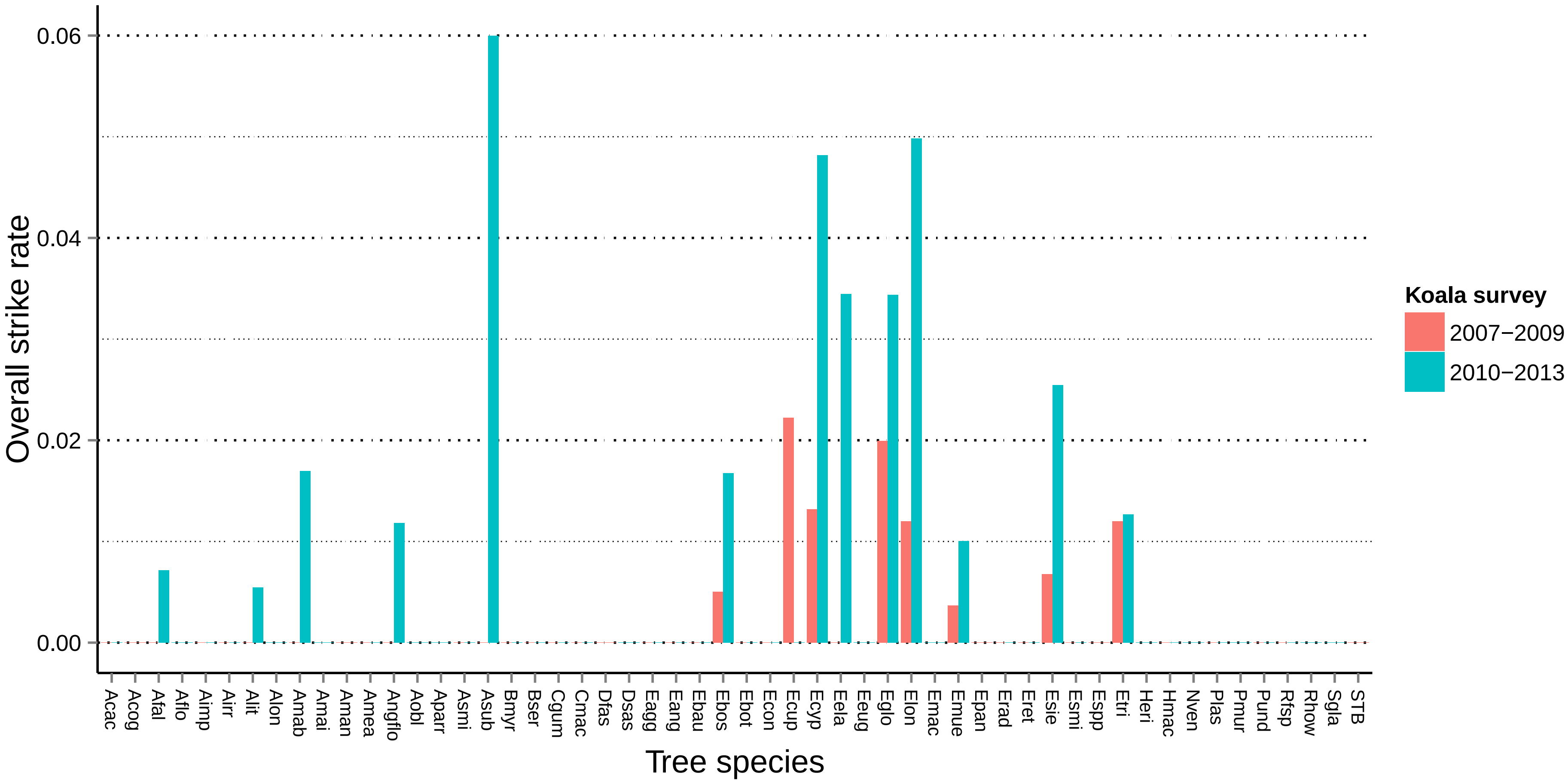


Figure 53: Overall strike rates for each tree species across the survey areas for the two sampling periods.

4.2.3 Tree species preference

For both surveys, the majority of tree species experienced neutral selection. Among the tree species that did experience positive or negative selection, woollybut and white stringybark experienced positive selection during both surveys while forest oak was negatively selected for during both surveys. Three tree species transitioned from being neutrally selected during the 2007-2009 survey to being directionally selected for in the 2010-2013 survey. The blue-leafed stringybark (*E. agglomerata*) and yellow stringybark (*E. muelleriana*) became negatively selected while the monkey gum became positively selected.

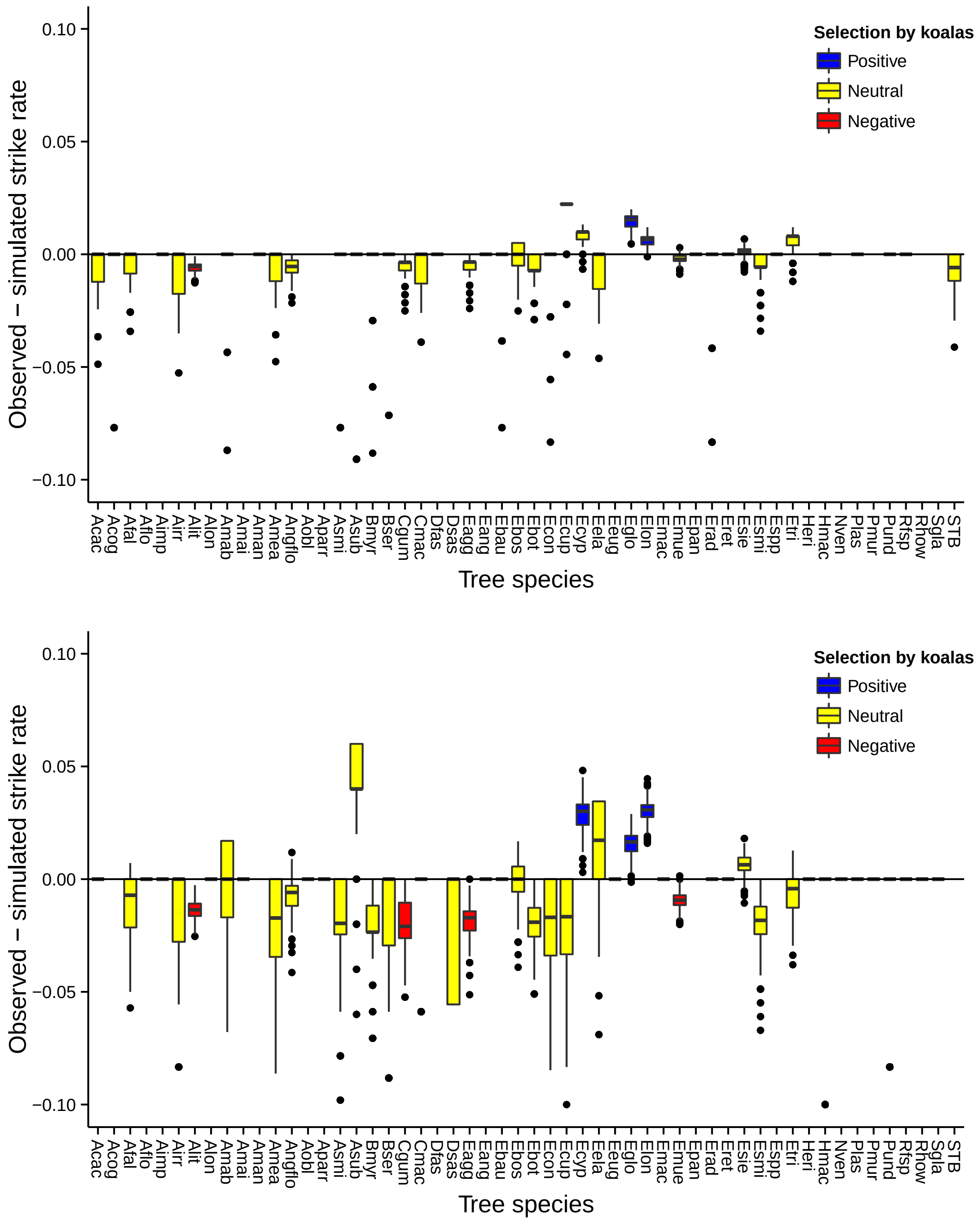


Figure 54: Distributions of observed - simulated strike rates for 2007-2009 (top) and 2010-2013 (bottom) for paired sites across the survey areas, assuming that koalas choose trees within the study area at random. Distributions whose middle 95% do not include 0 suggest that the tree species is either being positively selected (i.e. the box plot is above 0 and has a blue fill colour) or negatively selected (i.e. the box plot is below 0 and has a red fill colour). Boxes for tree species that are being neutrally selected have a yellow fill colour. Please note, the y-axes were arbitrarily adjusted to range between -0.1 and 0.1 so that colour-coding can be seen. Many outliers fall outside this range.

4.2.4 Tree size preference

We only found a significant relationship between tree size and strike rate for the forest oak (*Allocasuarina littoralis*) during the 2010-2013 survey ($R^2 = 0.76$, $p = 0.02$). All other regressions for the two surveys were non-significant. was the only species for which there was a significant linear relationship between tree size and strike rate. The relationship between tree size and strike rate for forest oak during the 2007-2009 survey was non-significant as there were no trees with koala faecal pellets during that survey.

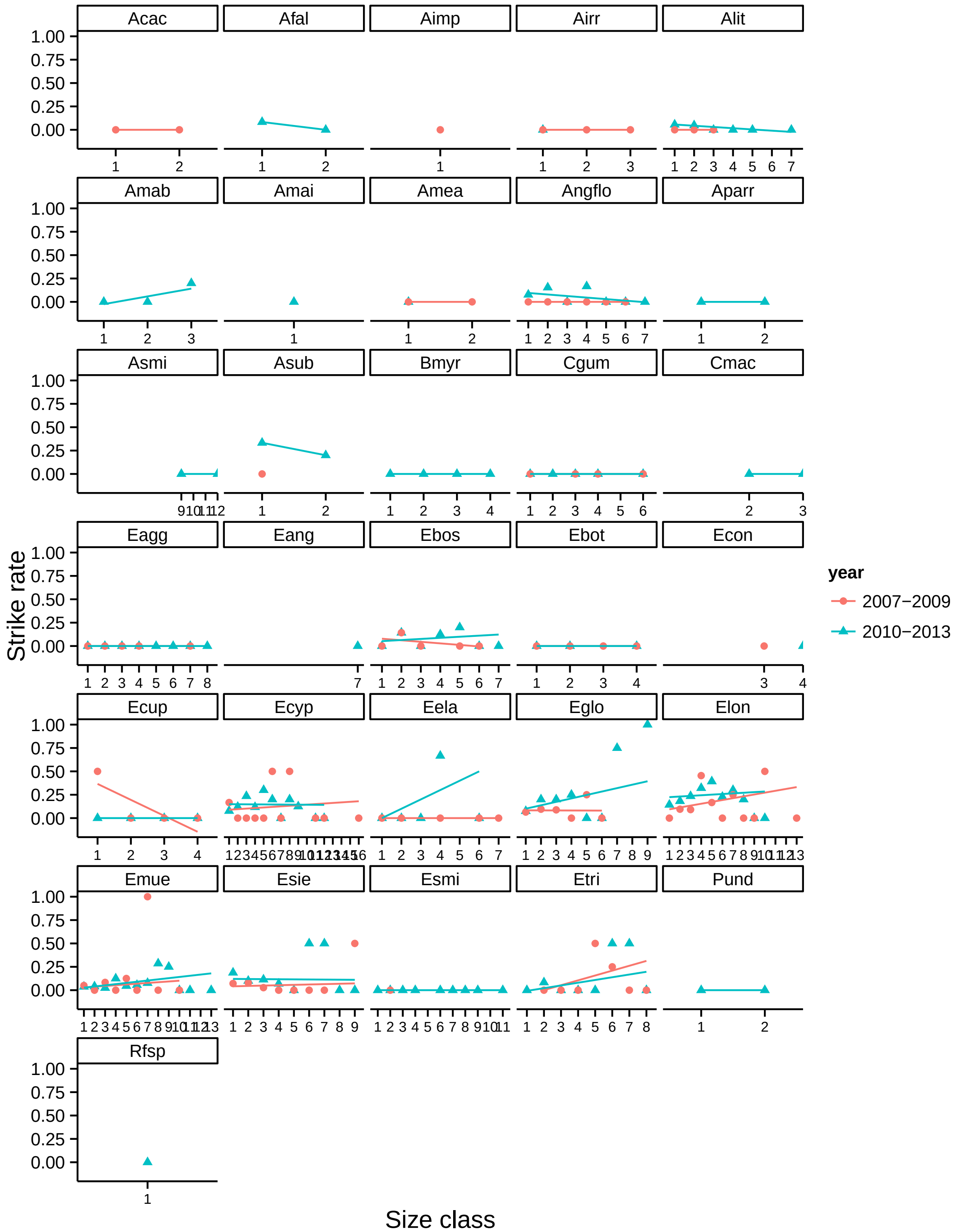


Figure 55: Relationships between tree size (DBH) and strike rates for each species for the two study periods across the survey areas.

Table 29: Summary terms for linear regressions of strike rate on tree size for each tree species found at paired active sites across the survey area during the 2007-2009 survey weighted by the number of trees in each size class. Summary terms include the number of trees used in the regression (N), intercept and slope of the regression line, the R2 value and the p-value for the regression.

Tree ID	N	Intercept	Slope	R-square	p-value
Acac	4.00	-0.00	0.00		
Aimp	2.00	0.00		0.00	
Airr	20.00	-0.00	-0.00		
Alit	70.00	-0.00	-0.00		
Amea	16.00	-0.00	0.00		
Angflo	41.00	-0.00	0.00		
Asub	1.00	0.00		0.00	
Cgum	6.00	-0.00	-0.00		
Eagg	12.00	-0.00	-0.00		
Ebos	23.00	0.09	-0.02	0.18	0.48
Ebot	8.00	-0.00	0.00		
Econ	1.00	0.00		0.00	
Ecup	6.00	0.54	-0.17	0.60	0.23
Ecyp	36.00	0.08	0.01	0.01	0.73
Eela	8.00	-0.00	0.00		
Eglo	158.00	0.08	-0.00	0.00	0.98
Elon	75.00	0.07	0.02	0.09	0.36
Emue	108.00	0.02	0.01	0.02	0.69
Esie	122.00	0.04	0.00	0.01	0.83
Esmi	2.00	0.00		0.00	
Etri	31.00	-0.10	0.05	0.24	0.26

Table 30: Summary terms for linear regressions of strike rate on size class for all combinations of tree species found at paired active sites across the survey area during the 2010-2013 survey weighted by the number of trees in each size class. Summary terms include the p-value for the regression, the R2 value, the slope and intercept of the regression line and the total number of trees used in the regression.

Tree ID	N	Intercept	Slope	R-square	p-value
Afal	17.00	0.17	-0.08	1.00	
Airr	4.00	0.00		0.00	
Alit	122.00	0.07	-0.01	0.76	0.02
Amab	27.00	-0.11	0.08	0.64	0.41
Amai	3.00	0.00		0.00	
Amea	6.00	0.00		0.00	
Angflo	62.00	0.11	-0.02	0.14	0.41
Aparr	3.00	-0.00	0.00		
Asmi	2.00	-0.00	0.00		
Asub	11.00	0.47	-0.13	1.00	
Bmyr	10.00	-0.00	-0.00		
Cgum	16.00	-0.00	0.00		
Cmac	3.00	-0.00	0.00		
Eagg	43.00	-0.00	0.00		
Eang	1.00	0.00		0.00	
Ebos	38.00	0.04	0.01	0.06	0.59
Ebot	4.00	-0.00	-0.00		
Econ	1.00	0.00		0.00	
Ecup	9.00	-0.00	-0.00		
Ecyp	109.00	0.15	-0.00	0.00	0.95
Eela	11.00	-0.10	0.10	0.24	0.40
Eglo	151.00	0.06	0.04	0.17	0.31
Elon	192.00	0.22	0.01	0.03	0.65
Emue	235.00	0.01	0.01	0.26	0.09
Esie	203.00	0.12	-0.00	0.00	0.96
Esmi	15.00	-0.00	0.00		
Etri	47.00	-0.04	0.03	0.15	0.34
Pund	2.00	-0.00	0.00		
Rfsp	1.00	0.00		0.00	

5 Appendix

Table 31: List of tree IDs used in this report and corresponding scientific and common names

Species	Scientific name	Common name
Acac		
Acog	Acacia cognata	Narrow-leaf bower wattle
Afal	Acacia falciformis	Hickory wattle
Aflo	Acacia floribunda	White sallow wattle
Ageo	Acacia georgensis	Bega wattle
Aglau	Allocasuarina glauca	
Aimp	Acacia implexa	Lightwood
Airr	Acacia irrorata	Green wattle
Alit	Allocasuarina littoralis	Forest oak
Alon	Acacia longifolia	Sallow wattle
Amab	Acacia mabellae	Mabel's Wattle
Amai	Acacia maidenii	Maiden's Wattle
Aman		check
Amea	Acacia mearnsii	Black wattle
Amel	Acacia melanoxylon	Blackwood
Amyr		myrtle wattle
Angflo	Angophora floribunda	Rough-barked angophora
Aobl	Acronychia oblongifolia	
Aparr	Acacia parramattensis	South Wales Wattle, Sydney Green Wattle, Parramatta Wattle
Asmi	Acmeni smithii	Lillypilly
Asop	Acaia longifolia sophorae	Coast wattle
Asub	Acacia subporosa	Bower wattle
Barb	Bedfordia arborescens	Blanket leaf
Bmar	Banksia marginata	Silver Banksia
Bmyr	Backhousia myrtlefolia	Grey myrtle
Bpop	Brachychiton populneus	Kurrajong
Bser	Banksia serrata	Saw banksia
Cend	Callitris endlicheri	Black cyprus pine
Cgum	Corymbia gummifera	Bloodwood
Cmac	Corymbia maculata	Spotted gum
Crho	Callitris rhomboidea	Port Jackson pine, Oyster Bay pine
Dfas		
Dsas	Doryphora sassafras	Nsw Sassafrass
Eagg	Eucalyptus agglomerata	Blue-leafed stingybark
Eang	Eucalyptus angopheroides	Apple-topped box
Ebau	Eucalyptus baueriana	Blue box
Ebos	Eucalyptus bosistoana	Coastal grey-box
Ebot	Eucalyptus botryoides	southern mahogany, Bangalay
Ebri	Eucalyptus bridgesiana	Applebox
Econ	Eucalyptus consideniana	Yerchuck
Ecup	Exocarpus cuppressiformis	Native cherry
Ecyp	Eucalyptus cypellocarpa	Monkey gum, Mountain grey gum
Edal	Eucalyptus dalrympliana	
Ediv	Eucalyptus dives	Broad-leafed peppermint
Eela	Eucalyptus elata	River peppermint
Eeug	Eucalyptus eugenoides	Narrow-leafed stringybark
Efas	Eucalyptus fastigata	Brown barrell
Eglo	Eucalyptus globoidea	White stringybark
Elon	Eucalyptus longifolia	Woollybut
Emac	Eucalyptus macroryncha	Red stringybark
Emai	Eucalyptus maidenii	Maiden's gum
Eman	Eucalyptus mannifera	Brittle gum
Emue	Eucalyptus muelleriana	Yellow stringybark
Emut		
Enor	Eucalyptus nortonii	Narrow-leafed box
Eobl	Eucalyptus obliqua	Messmate stringybark
Epan	Eucalyptus paniculata	Grey ironbark
Epau	Eucalyptus pauciflora	Snowgum
Erad	Eucalyptus radiata	Narrow-leafed peppermint
Eret	Elaeocarpus reticulatus	Blue olive berry
Eros	Eucalyptus rossii	Scribbly gum
Erub	Eucalyptus rubida	Candlebark
Esie	Eucalyptus sieberi	Silvertop ash
Esit		
Esmi	Eucalyptus smithii	Gully peppermint
Espp	Eucalyptus species unidentified	

Table 31: List of tree IDs used in this report and corresponding scientific and common names

Species	Scientific name	Common name
Este	Eucalyptus stellulata	Black Sally
Etas		
Eter	Eucalyptus tereticornis	Forest Red Gum
Etri	Eucalyptus sideroxylon subb tricarpa	Ironbark
Evim	Manna gum , Manna Gum	
Heri	Hakea eriantha	Tree hakea
Hmac	Hakea macraeana	Macrae's hakea
Hspp	Hakia species	
Ltra	Lomatia traseri	Tree lomatia
Maze	Melia azedarach	White Cedar, Tulip cedar, Chinaberry tree, Persian lilac
Nven	Notalea venosa	Mock olive
Oarg	Olearia argophylla	Musk Daisy bush
Pasp	Pomaderris aspera	Hazel Pomaderris
Plas	Prostanthera lasianthos	Mint bush
Pmur	Polyscias murrayi	Pencil cedar, Umbrella tree, Murray's basswood, Chinky pine
Pspp	Pomaderris species	Unidentified pomaderris spp.
Pund	Pittosporum undulatum	Pittosporum
Rfsp	Rainforest species	
Rhow	Myrsine howittiana	Brush muttonwood
Sgla	Synoum glandulosum	Scentless rosewood
STB	Unidentified stringybark	
Tlau	Tristaniopsis laurina	Kanooka (Water Gum)
Waus	Wikstroemia australis	Kurrajong