Chapter 5 Results of vegetation surveys

An Antiquated Tree
Emily Dickinson

An Antiquated Tree
Is cherished of the Crow
Because that Junior Foliage is disrespectful now
To venerable Birds
Whose Corporation Coat
Would decorate Oblivion's
Remotest Consulate

Results of vegetation surveys

5.1 Definition of habitat types

Sites with distinct habitats were chosen *a priori* to maximise the likelihood of clear divisions between the sites to be studied. These were rice paddy, damar agroforest (Plate 12, Plate 13, Plate 11) and several stages along a successional gradient of 'natural' vegetation; *Imperata cylindrica* ('Imperata') grasslands, low scrub (with few trees), tall scrub (with moderate tree cover) and forest (with a tall canopy and understorey) (Plate 12, Plate 13, Plate 14).

Plate 9 Paddy (site Purajaya 1)

Plate 10 Damar (site Krui 3)

Plate 11 Imperata (site Trimulyo 2)

Plate 12 Low scrub (site Purajaya 3)

Plate 13 Tall scrub (site Tepus 4)

Plate 14 Forest (site Laksana 4)

In addition to these vegetation types, 31 coffee garden sites were surveyed. One site, Fajar Bulan 2, which was surveyed throughout the period, but whose vegetation cover was progressively removed, was omitted from analysis. It was converted from a coffee garden with mature trees of many types, to an open sun chilli farm (Plate 15). The reasons the farmer of this garden gave for the conversion were the low price of coffee and poor harvest at the time.

Plate 15 FB2, The site that was surveyed but excluded from all analyses, due to the progressive removal of trees and coffee bushes for the establishment of a chilli farm.

In order to confirm and refine groupings Principal Components Analysis was used to classify the sites on the basis of non-coffee vegetation variables. The variables used were ‘number of trees’, ‘canopy cover’, ‘tree species richness’, ‘understorey species richness’, ‘maximum tree

height', 'mean of mode tree height', 'leaf litter cover' (score out of five), 'weed cover' (score out of five), presence of 'exposed dead perches', presence of 'logs' and presence of small 'fallen wood'. The high ratio of the first PC eigenvalue to the others indicated that interpretation of the PCA plot should emphasise separation along the PC1 (horizontal) axis (
Table 5.1). The strong contributors to this axis were 'maximum tree height', 'canopy cover' and 'tree species richness'(
Table 5.2). Thus, these were the main described variables discriminating between the sites (Figure 5.1). PC 2 was most influenced by understorey species richness.

Table 5.1 Eigenvalues for the PCA of non-coffee vegetation variables.

This indicates the eigenvalues of each PC axis, as well as the percentage of total variance explained by each axis, and the cumulative explanation.

PC	Eigenvalues	%Variation	Cumulative%Variation
1	5.04	45.8	45.8
2	1.29	11.7	57.6
3	1.08	9.8	67.4
4	1.01	9.2	76.5
5	0.90	8.2	84.7

Table 5.2 Eigenvectors for vegetation variables, indicating contribution to PC axes

Eigenvectors
(Coefficients in the linear combinations of variables making up PC's)

Variable	PC1	PC2	PC3	PC4	PC5
canopy cover	-0.400	-0.129	0.250	-0.026	-0.150
tree species richness	-0.396	-0.059	-0.023	-0.238	0.071
leaf litter cover /5	-0.335	0.382	0.208	-0.107	0.075
tree height maximum	-0.410	-0.106	0.086	-0.026	-0.257
mean of mode tree height	-0.386	-0.158	0.175	0.088	-0.332
understorey species richness	-0.019	0.687	-0.220	-0.316	-0.406
weed cover /5	0.087	0.468	0.681	0.216	0.234
exposed dead perches (y/n)	-0.231	0.217	-0.470	-0.188	0.284
logs (y/n)	-0.174	0.151	-0.273	0.749	-0.288
fallen wood (y/n	-0.267	0.148	-0.213	0.391	0.505
number of trees	-0.303	-0.122	0.044	-0.164	0.390

The results justify the *a priori* classifications of the non-coffee habitats made in the field, as most replicates in these groups cluster. However, coffee sites were not separated into groups, indicating the need to consider them in more detail separately from other habitats. They also covered much of the gradient of the 'natural' habitats, as defined by these, mainly structural, vegetation characteristics. Thus there is scope for comparison of differences within the broader category of coffee garden.

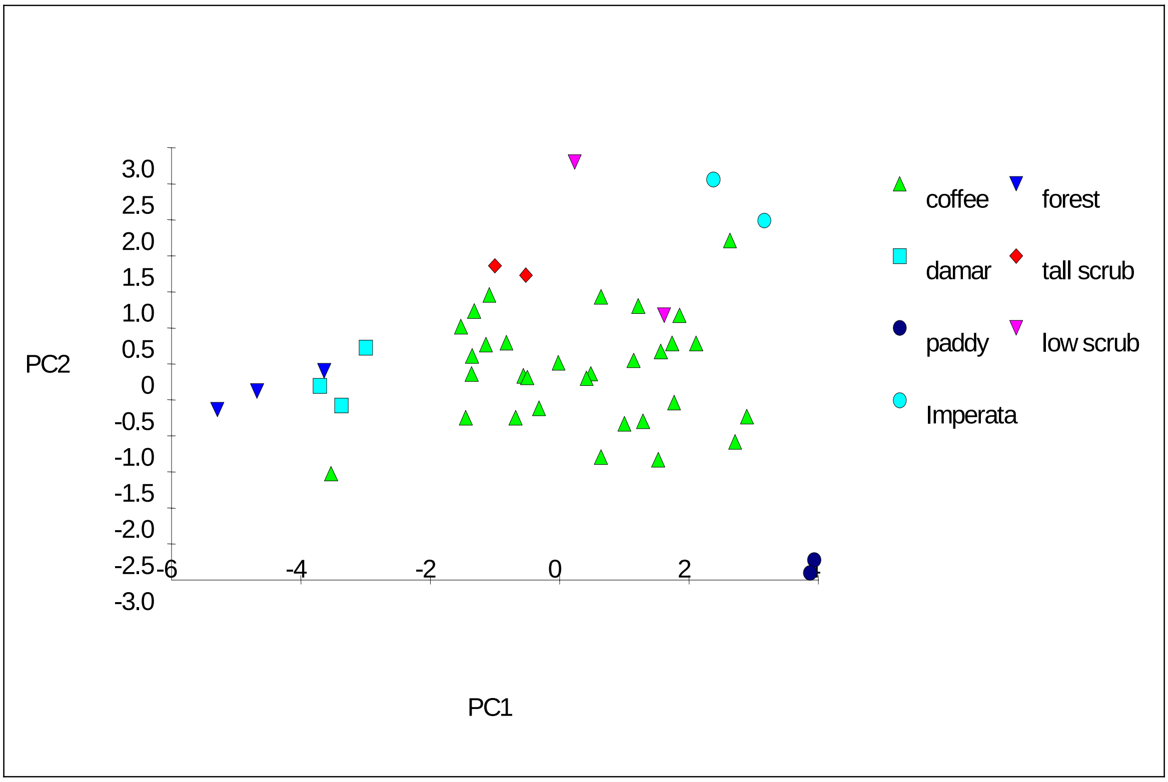


Figure 5.1 PCA of sites according to non-coffee variables.

The field classification of non-coffee sites is largely justified by this plot of variables measured. The coffee sites are grouped together, indicating the need for more detailed consideration of the vegetation present, to allow their classification. PC1 is relatively strong.

5.1.1 Coffee habitat definition

Coffee sites with few or no trees were classified as 'monoculture' on the basis of their low canopy cover, with the threshold set at 6.25%[8] (Plate 16).

[8] This is an arbitrary division equivalent to 1/16th of the plot area and would represent a cover by less than five medium-sized trees of canopy radius 4 m.

Plate 16 Monoculture coffee garden (site Leuwi Monyet 2)

These monoculture sites were excluded from the subsequent analysis that involved close consideration of the shade tree characteristics. These analyses included the potentially ecologically important parameter of dominance of the tree assemblage by individual species. An index of this quality would be meaningless if applied to sites with few trees.

5.1.1.1 PCA of shaded coffee sites

A PCA of number of trees, canopy cover, index of dominance, tree height, coffee height, tree species richness and coffee closure was conducted (Figure 5.2). A high eigenvalue for axis one suggested that emphasis should be placed upon this dimension in interpreting the plot. The sites were thus divided into two main groups, with one outlying site, LM3 forming a group on its own. The eigenvectors for each variable showed that the greatest contributions to PC1 came from 'maximum tree height', followed by 'tree species richness', 'index of dominance' (acting in the opposite direction) and 'canopy cover'. Thus, in this analysis these variables became the main grounds for the establishment of groups. The main influences on the second axis were 'coffee canopy closure' and 'number of trees'.

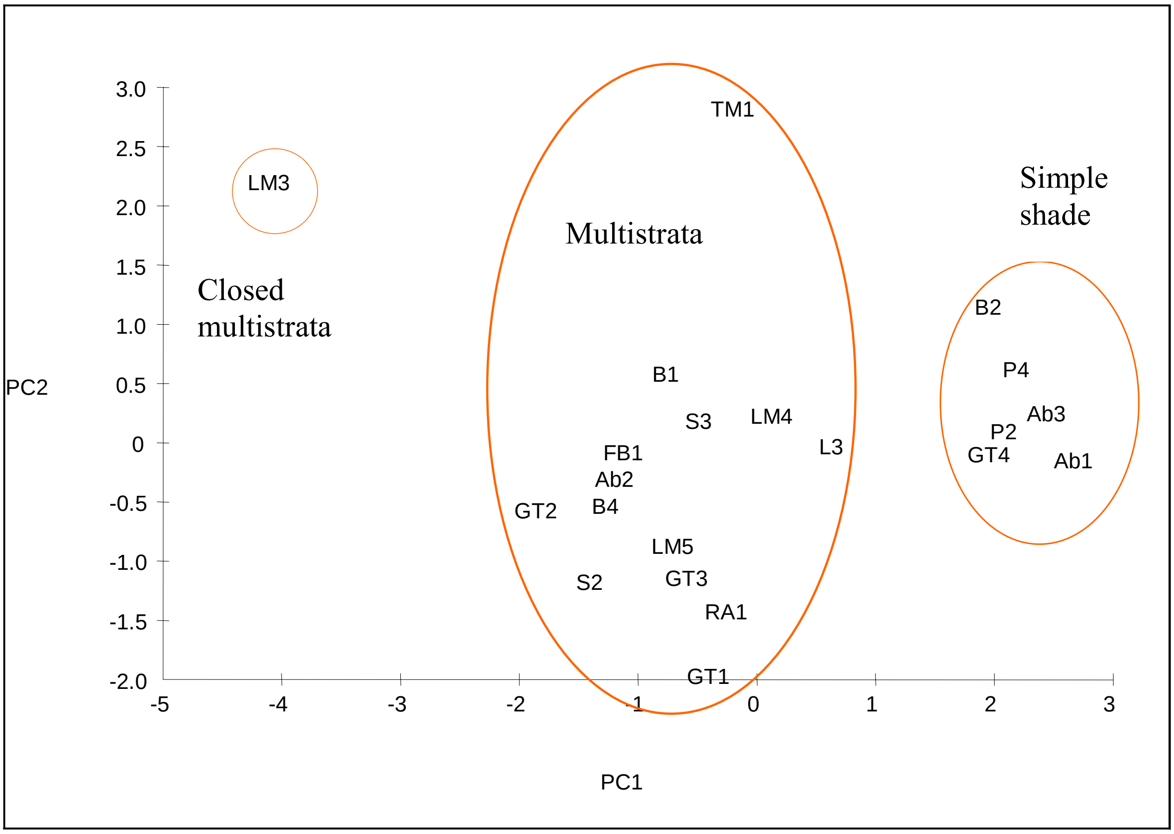


Figure 5.2 PCA of shaded coffee sites based on vegetation variables

Accordingly, one group of sites was characterised by taller trees with more dense and diverse tree canopies (those with negative or low positive values on PC axis 1, forming the central group). They were also likely to have large number of trees and a closed coffee canopy. Members of the other group (with higher positive PC axis one values) had generally sparser and more monocultural shading. Henceforth these groups are called 'multistrata' and 'simple shade' respectively (Plate 17, Plate 18). The outlier LM3, which had a highly negative value for PC axis one thus had higher species richness, tree height and canopy cover than was typical of all the other coffee sites sampled. This was a site with a tall, dense canopy of mahogany trees and a great variety of other tree species. It was classified as 'closed multistrata' (Plate 19).

5.2 Assigning sites to habitat groups

The step-wise process of site division by PCA resulted in ten habitat types. In analysis and discussion of bird survey results several broader distinctions were also useful. 'Coffee' and 'non-coffee' sites were simply distinguished by the presence of a coffee crop, 'natural' habitats described the successional gradient from Imperata sites to 'low scrub', 'tall scrub' and 'forest', whilst 'farmed' or 'agricultural' habitats included all other sites (Table 5.3). Abbreviations of site names are provided in Appendix B.

Table 5.3 Allocation of sites to habitat and other descriptive groups.

Coffee?	Coffee				Non-coffee					
	Monoculture	Shade coffee			Paddy	Damar	Forest	Successional vegetation		
Simplified habitat class	**Mono culture**	**Simple shade**	**Multistrata**	**Closed multi-strata**	**Paddy**	**Damar agro-forest**	**Forest**	**Tall Scrub**	**Low scrub**	**Imperata**
Sites	Bodong 3 Bodong 5 Leuwi Monyet 1 Leuwi Monyet 2 Laksana 2 Rata Agung 3 Simpang sari 4 Tepus 2 Tepus 3 Trimulyo 4	Bukit Abung 1 Bukit Abung 3 Bodong 2 Gunung Terang 4 Purajaya 2 Purajaya 4	Bukit Abung 2 Bodong 1 Bodong 4 Fajar Bulan 1 Gunung Terang 1 Gunung Terang 2 Gunung Terang 3 Leuwi Monyet 4 Leuwi Monyet 5 Laksana 3 Rata Agung 1 Simpangsari 2 Simpangsari 3 Trimulyo 1	Leuwi Monyet 3	Purajaya 1 Simpang sari 1	Krui 1 Krui 2 Krui 3	Bodong 6 Laksana 4 Rata Agung 2	Laksana 1 Tepus 4	Purajaya 3 Trimulyo 3	Tepus 1 Trimulyo 2

Plate 17 Simple shade coffee garden (site Gunung Terang 4)

Plate 18 Multistrata coffee garden (site Gunung Terang 2)

Plate 19 Closed multistrata coffee garden (site Leuwi Monyet 3)

5.2.1 Regional characteristics

Comparison of measured vegetation characteristics in each region did not show significant difference (ANOSIM test Global R = 0.079, P= 0.128, permutations = 999, n> Global R = 127). However, it is likely that the plots are not completely representative of those present in the region as they were selected purposefully.

5.3 Canopy depth

The canopy depth was an additional characteristic derived from the maximum tree canopy height and the mean of the mode canopy height for each site (Figure 5.3) (for definitions of vegetation descriptors see section 4.5.1.1). The differences in this were significant between simple habitat types (Kruskal-Wallis test, χ^2 = 27.340, P<0.0001, df = 5). The mean score for canopy depth was greatest for forest, followed by damar. Among coffee sites, multistrata had the greatest difference between maximum and mode canopy height, followed by closed multistrata, simple shade and finally monoculture.

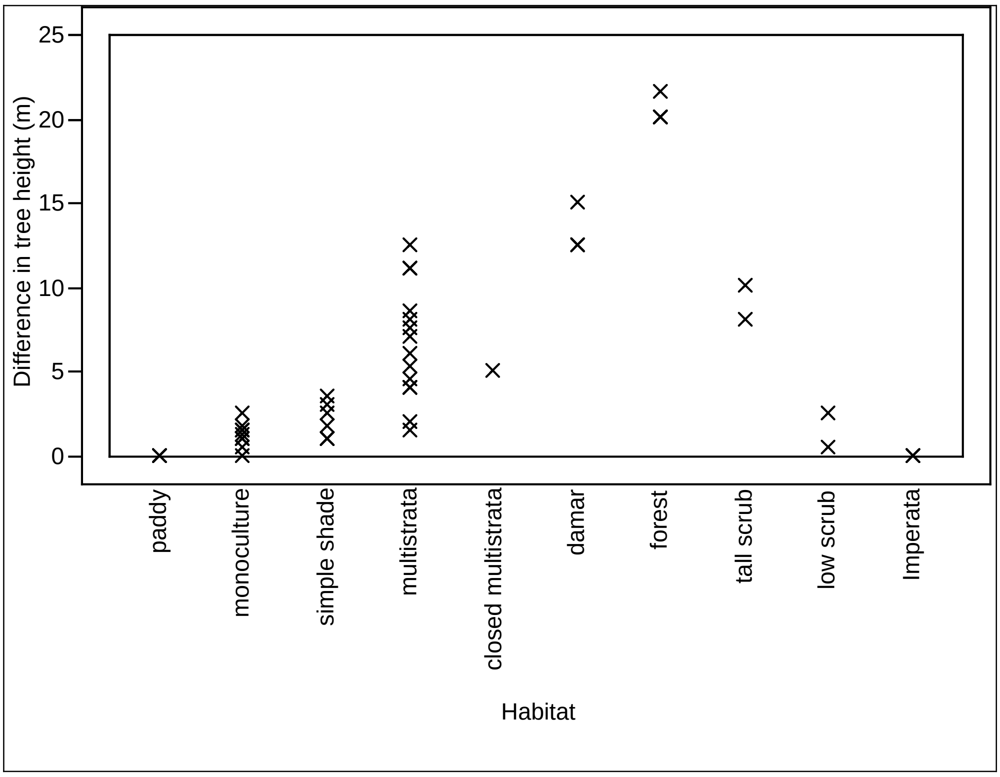


Figure 5.3 The difference between maximum tree height and the mean of the mode tree height at each site.

This gives an indication of diversity of canopy structure.

5.4 Floristic composition

Consideration of the floristic composition of each site allows a more comprehensive examination of the resources available to humans and birds respectively. Vegetation was grouped into agroforestry functional types ‘understorey’, ‘understorey crop’, ‘fruit tree’, ‘tree crop’ (non-fruit) and ‘timber’ tree indicating the end use to which the plant can be put, and abundance quantified (Figure 5.4) (Appendix D).

Overall, the vegetation density was highest in damar, closed mulitstrata and forest, and lowest in rice paddy. There was a gradient between coffee sites with closed multistrata having the highest total vegetation score per site, followed by multistrata, simple shade and monoculture. This is consistent with expectations from the earlier habitat divisions. Understorey plants, with no direct use known (although they may provide environmental services such as soil stabilisation), had greatest representation in natural habitats, particularly those in early successional stages. Understorey crops were present in all coffee types, but were best represented in multistrata. Fruit trees also, were more common in multistrata plots than in simple shade or monoculture coffee. They were also well represented in damar plots. Other tree crops were common in damar, and frequent in multistrata coffee, but infrequent in both simple shade and monoculture coffee types. The clearest difference between monoculture and simple shade coffee was the higher abundance of timber trees in simple shade sites. Multistrata sites had a still higher representation of these trees with no known crop. The highest representation of timber trees was in forest.

All plots, excepting paddy sites were analysed using MDS according to their similarity of floristic composition (Figure 5.5)[9]. In general, the results were consistent with the allocation of sites to habitat types according to a range of structural vegetation characteristics. Damar sites were most similar to forest, followed by tall scrub. Simple shade sites were generally intermediate between monoculture and multistrata sites. Site B2, on the left side of the plot is separated from the other simple shade sites due to the completely monocultural nature of the shade canopy there.

[9] Paddy sites were excluded as the great magnitude of floristic difference between them and other sites caused all other sites to collapse to a single point.

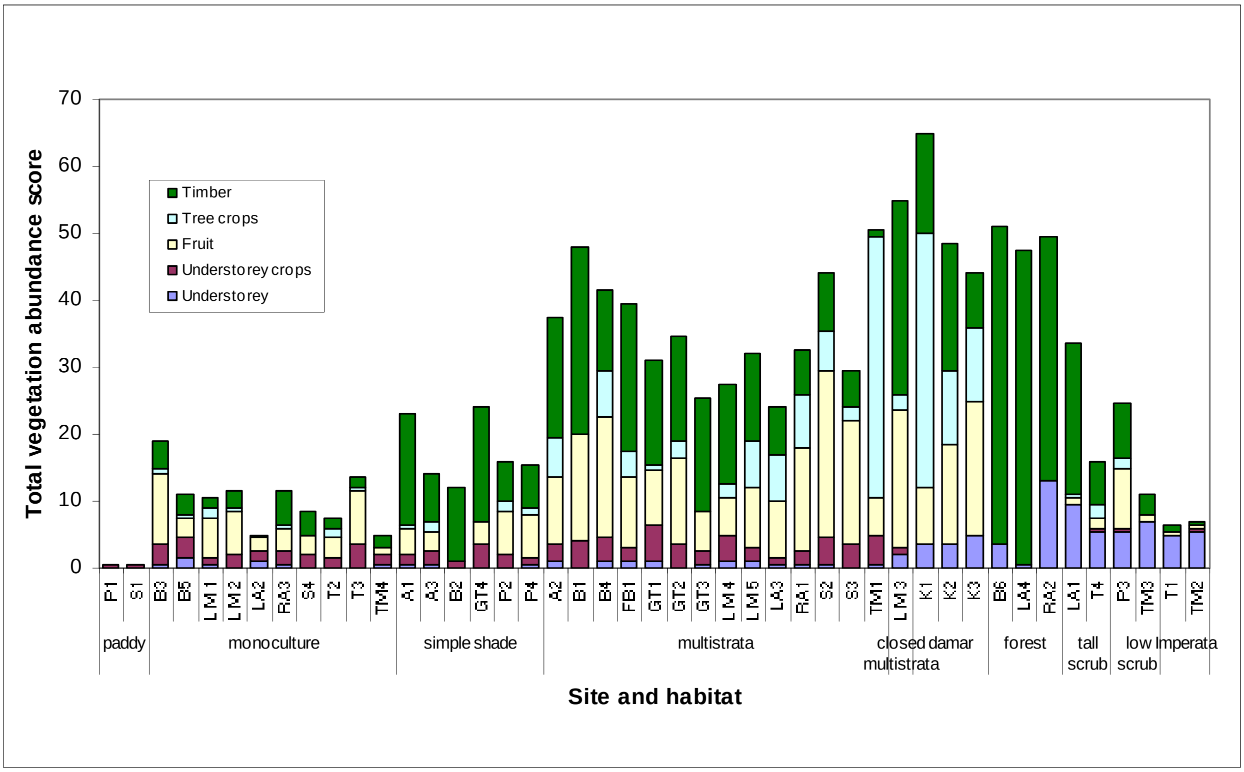


Figure 5.4 Vegetation abundance index at each site, indicating agroforestry function of vegetation type.

Scores were allocated for the classified abundance of each vegetation species. These were subsequently grouped into broader types (e.g. 'understorey') and the scores summed for each site.

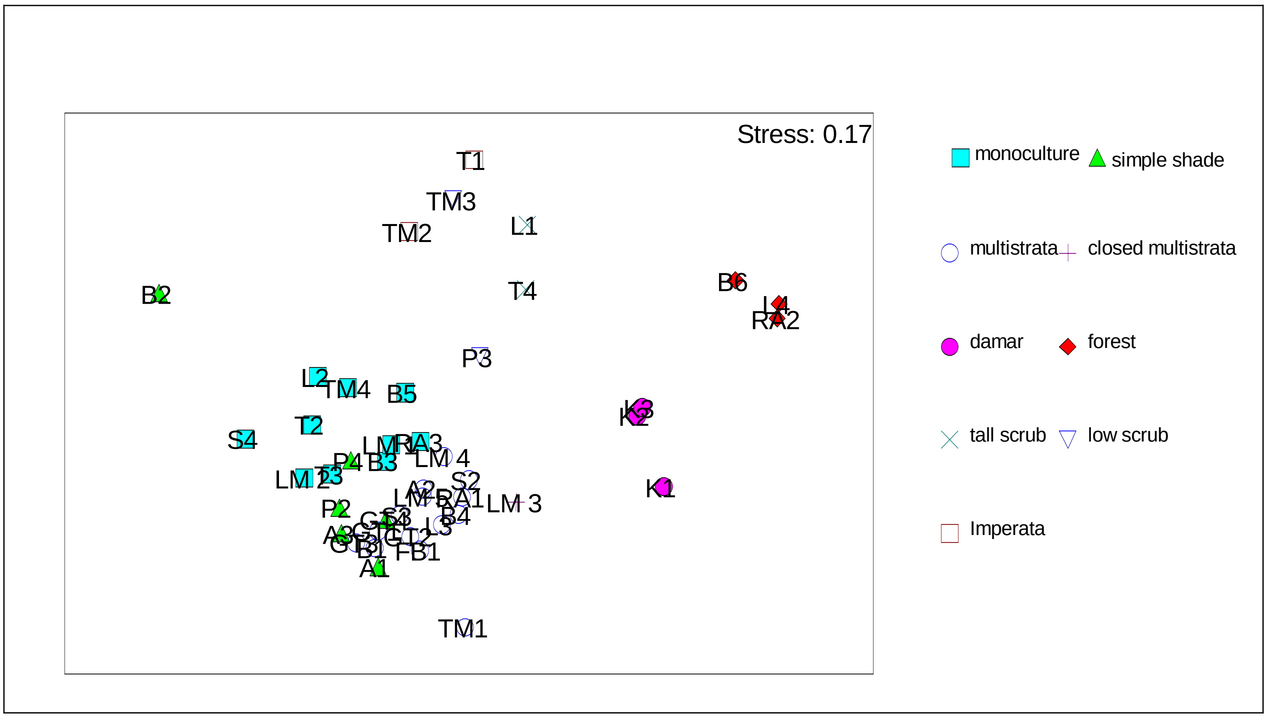


Figure 5.5 Distribution of all sites (except paddy habitats) according to their similarity of floristic composition (by abundance scores).

An ANOSIM test of the multivariate differences between the groups showed the overall differences to be highly significant (Global R = 0.756, P<0.0001, permutations = 10, 000, n>R = 0). Pairwise tests of habitats showed maximum differences between forest and all other habitats except damar, indicated by the R statistic of 1 (Appendix E). Multistrata coffee was significantly different from monoculture coffee (R= 0.599, P<0.0001), but not from simple shade coffee (R= 0.203, P= 0.068). Simple shade was floristically more similar to multistrata than to monoculture (R= 0.379, P <0.0001).

5.4.1 Dominant tree type

The dominant tree type (by an equally-weighted combination of cover and abundance measures) was determined for each study plot for which canopy cover was greater than 1/16 of the plot area (n= 34). The most commonly dominant tree type was *Gliricidia* (20.6% of all plots with sufficient cover), followed by *Erythrina* (17.6%) (Figure 5.6).

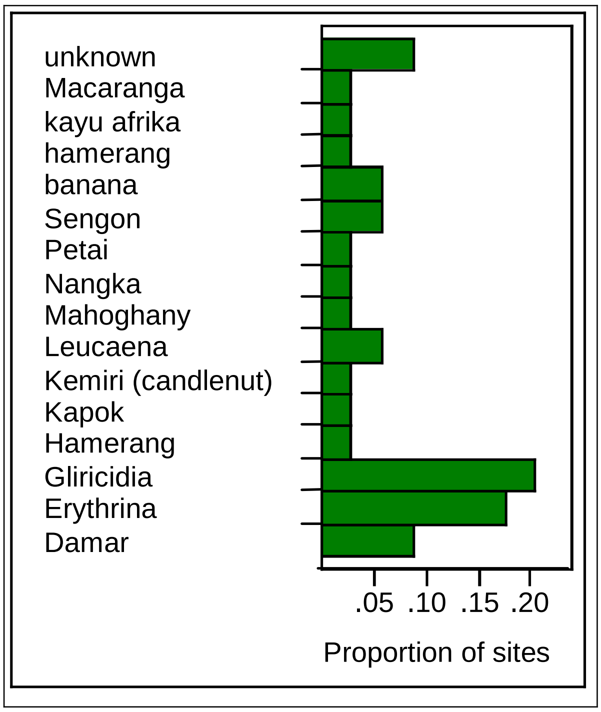


Figure 5.6 Dominant tree type in plots with canopy cover > 1/16 of area.

This was determined for each plot by equal weighting of abundance and areal cover for each tree species. *Gliricidia* was dominant in the greatest number of plots, followed by *Erythrina.*

5.4.2 Leaf litter

Leaf litter samples were taken to provide an approximate calibration of the subjective scale used in documenting the leaf litter cover at all plots. There was considerable variation in the masses of the samples within some classes due to their different content of leaves and sticks. One sample of 'score 5' was very heavy due to the presence of mahoghany fruit shells, which are woody and dense.

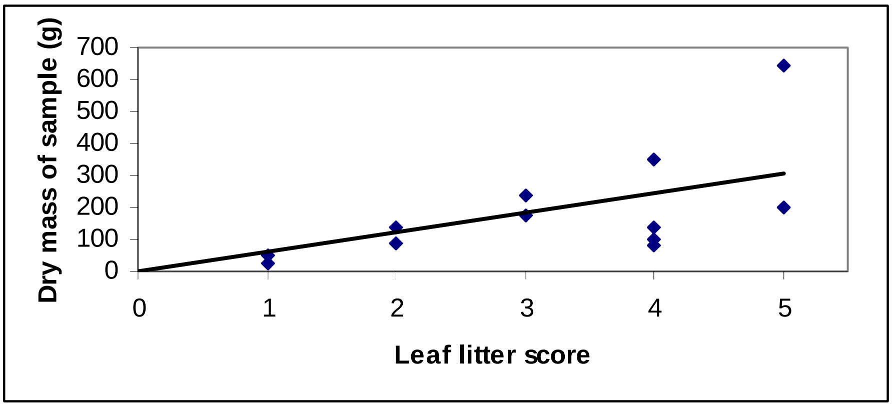
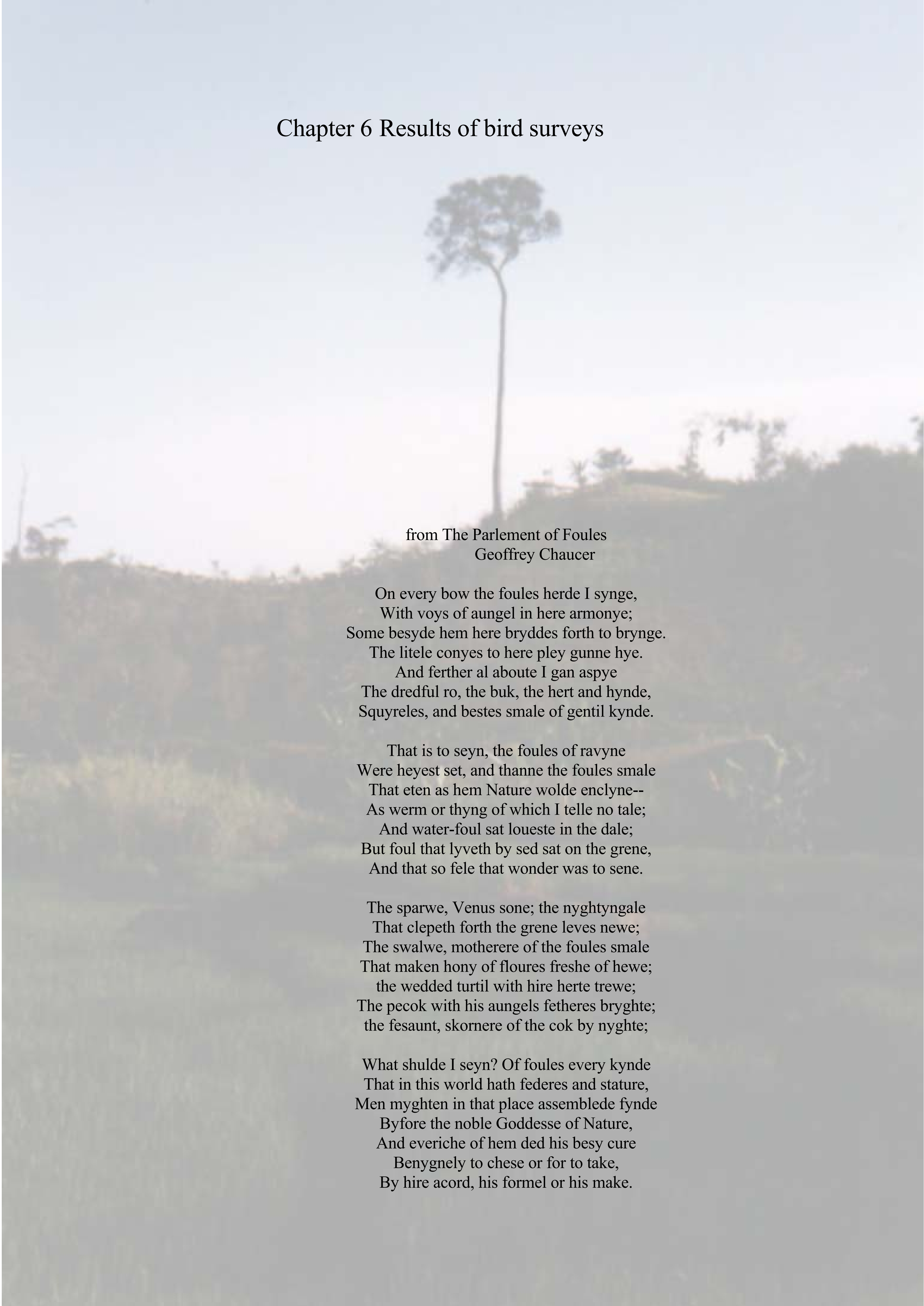


Figure 5.7 Mass of leaf litter samples from 0.25m² plots as a function of leaf litter score.

Chapter 6 Results of bird surveys



from The Parlement of Foules
Geoffrey Chaucer

On every bow the foules herde I synge,
With voys of aungel in here armonye;
Some besyde hem here bryddes forth to brynge.
The litele conyes to here pley gunne hye.
And ferther al aboute I gan aspye
The dredful ro, the buk, the hert and hynde,
Squyreles, and bestes smale of gentil kynde.

That is to seyn, the foules of ravyne
Were heyest set, and thanne the foules smale
That eten as hem Nature wolde enclyne--
As werm or thyng of which I telle no tale;
And water-foul sat loueste in the dale;
But foul that lyveth by sed sat on the grene,
And that so fele that wonder was to sene.

The sparwe, Venus sone; the nyghtyngale
That clepeth forth the grene leves newe;
The swalwe, motherere of the foules smale
That maken hony of floures freshe of hewe;
the wedded turtil with hire herte trewe;
The pecok with his aungels fetheres bryghte;
the fesaunt, skornere of the cok by nyghte;

What shulde I seyn? Of foules every kynde
That in this world hath federes and stature,
Men myghten in that place assemblede fynde
Byfore the noble Goddesse of Nature,
And everiche of hem ded his besy cure
Benygnely to chese or for to take,
By hire acord, his formel or his make.

Results of bird surveys

The results of bird surveys were used to assess of the contribution of coffee habitats to the local bird assemblage, by analysing characteristics such as the number of birds, the species richness, species composition, guild and feeding group composition. Secondly, the findings were used to investigate differences between the types of coffee habitat present in the area. Finally, they were used to explore the question of how birds respond to these habitats and other variables present in the area. Investigation of attributes such as microhabitat use and activity of birds, the vegetation used and the relative biomass of invertebrates present in different habitats and vegetation types contributed to such an interpretation. On a broader scale, the influences of biogeographic factors were considered. Such an explanation of the avifaunal patterns found is needed if management changes are to be considered for the purposes of bird conservation.

Habitats were considered in a detailed schema of coffee habitats: monoculture, simple shade, multistrata and closed multistrata sites, and other habitats: paddy, damar, Imperata, low scrub, tall scrub and forest. This gave better recognition of the gradient along which the sites varied and the patchy nature of the landscape. However, for some statistical analyses, the coffee sites were collapsed into the groups of monoculture coffee, and shade coffee (simple shade, multistrata and closed multistrata), and the Imperata, low scrub and tall scrub amalgamated to form a category 'successional vegetation' as this allowed sufficient sample sizes for these analyses[10].

6.1 Numbers of birds

The nine surveys in each of 45 sites provided 6587 formal records of birds. (For explanation of survey methods see section 4.3). Of these total records 95.6% were made by sighting the bird, and 4.4% by call alone. For individual sites, the percentage of records by sight ranged between 68.52% and 100%. There were 1528 opportunistic records of birds observed outside of survey plots or times.

The mean number of birds per site was 146.4 (s.d. = 108.06), but there was some variation in the mean scores per site between habitats (Figure 6.1). The greatest numbers of birds were

[10] Whilst habitats were defined according to measured variables, it is clear that these are in a state of flux. One survey plot in the Fajar Bulan area was excluded from analysis due to such a change, from a coffee garden with mature trees of many types, to an open sun chilli farm . This cash crop is low growing (generally observed to be less than 50 cm tall), and provides few features attractive to rainforest-adapted birds. As my bird surveys continued through the progressive conversion of the farm, the avifaunal difference between the new and the old garden was discernible. Additionally, one low scrub plot (TM3) and one tall scrub plot (T4) were each subject to minor burning during the year. However, this was considered insufficient to exclude these plots from analysis, and is a normal occurrence in the successional landscapes of the region.

found in the simplest habitats: paddy, monoculture and imperata, whilst generally lower and less variable numbers were found in the more structurally complex sites: simple shade, multistrata, closed multistrata, damar and forest. When the habitat types were amalgamated into six simple classes, in order to increase the within-group sample sizes to be sufficient for statistical analysis, there was a significant difference in numbers of birds between these groups (Kruskal-Wallis χ^2=14.62, d.f. = 5, P=0.01). However, for pairings of coffee and non-coffee, shaded and unshaded coffee sites and also between detailed coffee types (monoculture, simple shade, multistrata and closed multistrata), none of the differences were significant for P= 0.05. (For explanation of test outputs see section 4.5.4).

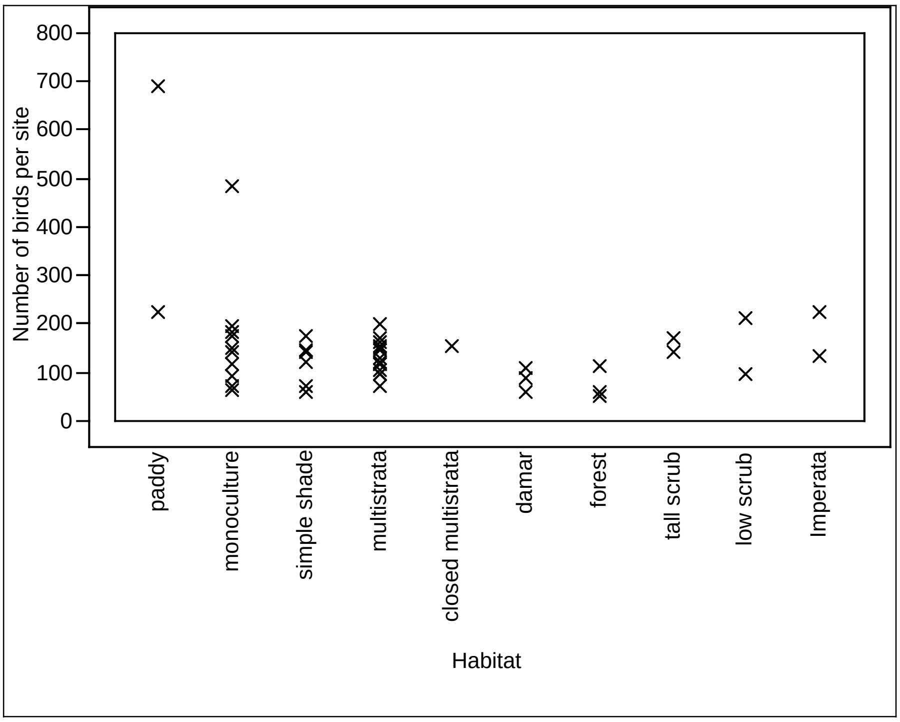


Figure 6.1 Numbers of individual birds of all species, per site, in various habitats, cumulative for all surveys.

Nine surveys were conducted at each of 45 sites, in 60 m x 60 m plots

When birds flying overhead were excluded from counts the negative relationship between number of birds and vegetation structural height and complexity was no longer apparent (Figure 6.2). The difference between numbers of birds surveyed in simple habitat types was not significant.

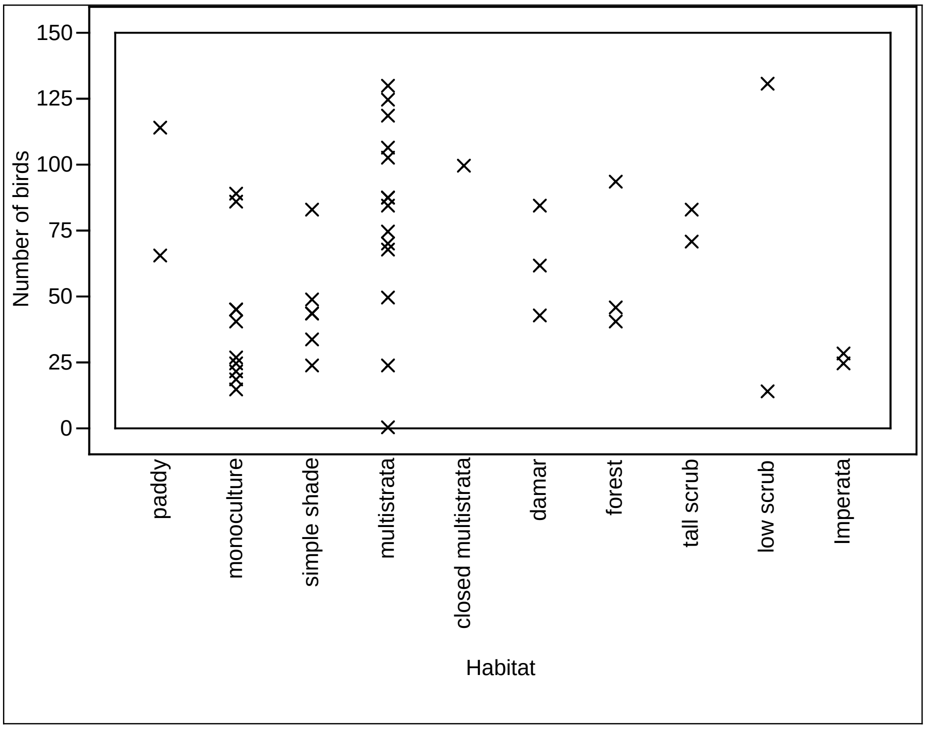


Figure 6.2 The number of birds surveyed in all habitats, excluding birds flying overhead.

6.2 Bird assemblage

In total 114 distinct taxa were recorded in surveys. Of these, 104 were identified to species level, in addition to three taxa that were identified only to family or generic level, and seven further taxa that were not identified taxonomically, but were distinct from all others surveyed. Additional birds observed opportunistically (either outside survey plots or times) are listed in Appendix L. This list indicates that particularly for forest habitats, there is a range of taxa that remain unrepresented in the following analyses.

6.2.1 Species accumulation curves

There appeared to be a general, albeit weak, relationship between the vegetation characteristics and the species accumulation curves for respective habitats, with taller, steeper curves found for the more complex habitats (Figure 6.3). Thus, whilst the numbers of new bird species found in paddy, coffee monoculture and successional vegetation habitats (imperata, tall and low scrub) began to plateau after between four and seven surveys, the species counts at simple shade and multistrata coffee, damar and forest continued to rise. This indicates that as new species were found with additional surveys within these habitats they are likely to have high total species richness. The curve for the single closed multistrata site was rather fragmented, but rose very steeply in the middle. Replicate sites for this habitat type may have smoothed this curve. In the case of simple shade, there was increased steepness over the last survey period, perhaps due to the addition of migratory species during the early wet season. Differences between coffee sites were not strong. The overall difference in curve shapes between all habitat types, and the continuing rise of some curves, suggests that with more survey effort, or surveys spread over a greater time, the observed inter-habitat differences in species richness might be greater than those found in surveys.

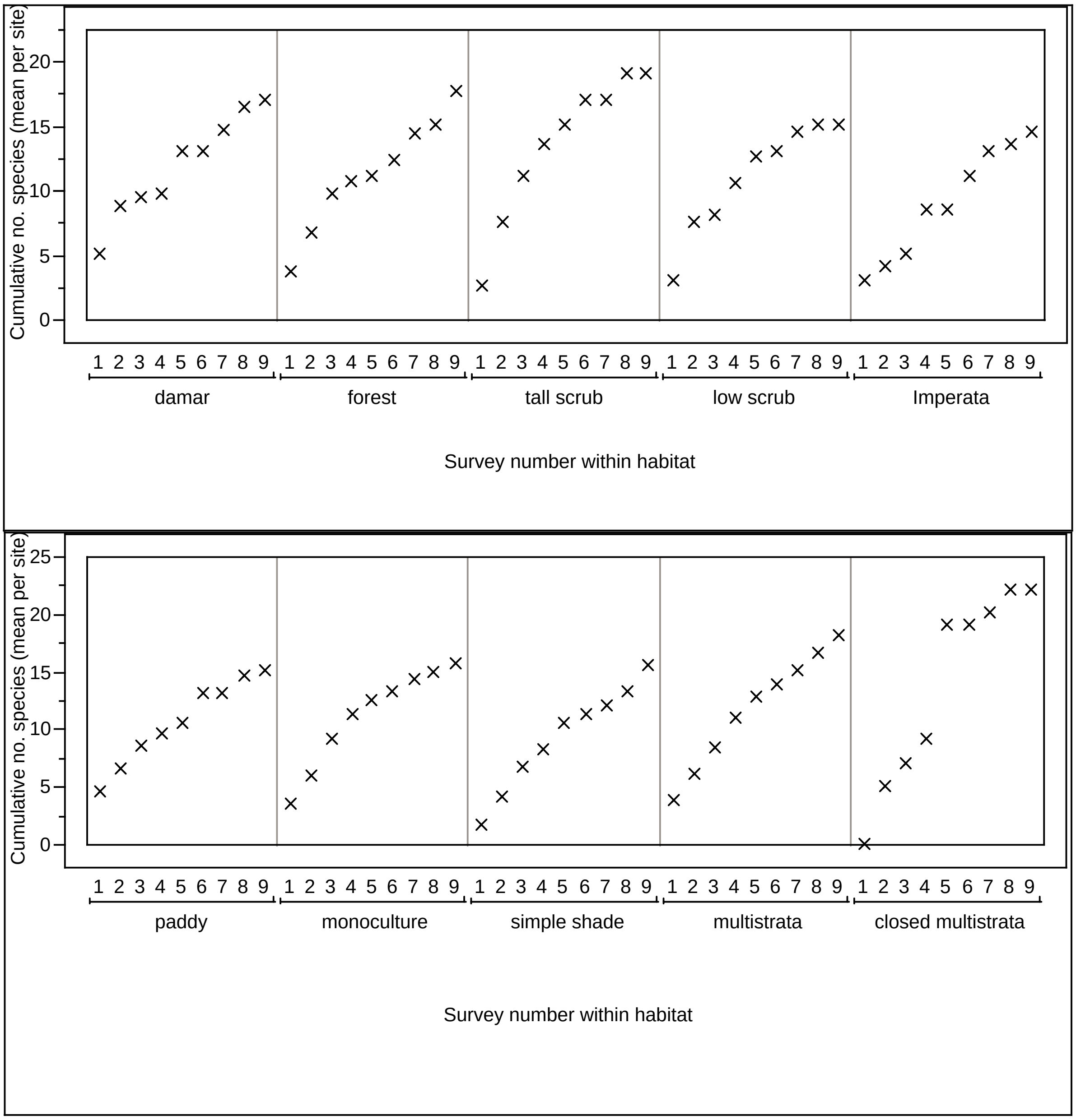


Figure 6.3 Cumulative number of species for each habitat type (mean per site) in each survey

6.2.2 Bird species richness and diversity

The Shannon-Wiener species diversity for the whole sample of birds identified to species level (n=5962) was 1.33 ($\log_{10}$) or 3.07 ($\log_e$).

Site diversity

A conservative measure of bird species richness was made for each site (alpha diversity). This was limited by some identifications that were not to species level. In these cases, only taxa that were certainly distinct from other species at the site were counted. The difference between bird species richness in simplified habitat types was not significant (Kruskal-Wallis χ^2=3.28, d.f.=5, P = 0.66). Inter-habitat differences in mean Shannon-Wiener diversity per site, including only birds identified to species level (n=5962), were marked but not significant for simplified habitat types (Kruskal-Wallis χ^2 = 9.6239, d.f.= 5, P= 0.09) (Table 6.1). Damar and forest were equally the most diverse whilst the least diverse was paddy. Shade coffee sites had higher diversity than did monoculture sites.

Table 6.1 Shannon-Wiener taxonomic diversity at species, genus and family level.

Mean per site and (standard error).

Habitat	Number of sites	Shannon-Wiener Species diversity (S.E.)	Shannon-Wiener Genus diversity (S.E.)	Shannon-Wiener Family diversity (S.E.)
Imperata	2.00	1.75 (0.08)	1.52 (0.00)	1.48 (0.01)
closed multistrata	1.00	2.34	2.18	2.07
damar	3.00	2.42 (0.11)	2.33 (0.07)	2.07 (0.12)
forest	3.00	2.40 (0.12)	2.27 (0.06)	2.05 (0.09)
low scrub	2.00	2.10 (0.45)	1.66 (0.03)	1.60 (0.03)
monoculture	10.00	2.00 (0.11)	1.75 (0.11)	1.65 (0.13)
multistrata	14.00	2.19 (0.08)	2.02 (0.06)	1.94 (0.04)
paddy	2.00	1.69 (0.12)	0.98 (0.02)	0.63 (0.16)
simple shade	6.00	2.08 (0.13)	1.87 (0.13)	1.78 (0.13)
tall scrub	2.00	2.31 (0.07)	2.00 (0.00)	2.00 (0.02)

When diversity was calculated on the basis of genera, thus including all individuals identified to the level of genus (n= 6163), the differences between simplified habitats were significant (Kruskal-Wallis χ^2=22.22, d.f.= 5, P= 0.0005). There appeared to be a relationship between vegetation structure and generic diversity (Figure 6.4). Shade coffee had significantly higher diversity of genera than did monoculture coffee (Wilcoxon Z=-1.97, P= 0.05, χ^2 =3.95, d.f.=1, P=0.05) . When coffee sites were compared according to the complex habitat system, the difference was recognisable but not significant (Kruskal-Wallis χ^2= 5.73, d.f.=3, P=0.13). Generic diversity of birds within coffee habitats was highest in closed multistrata, followed by multistrata, simple shade and finally monoculture.

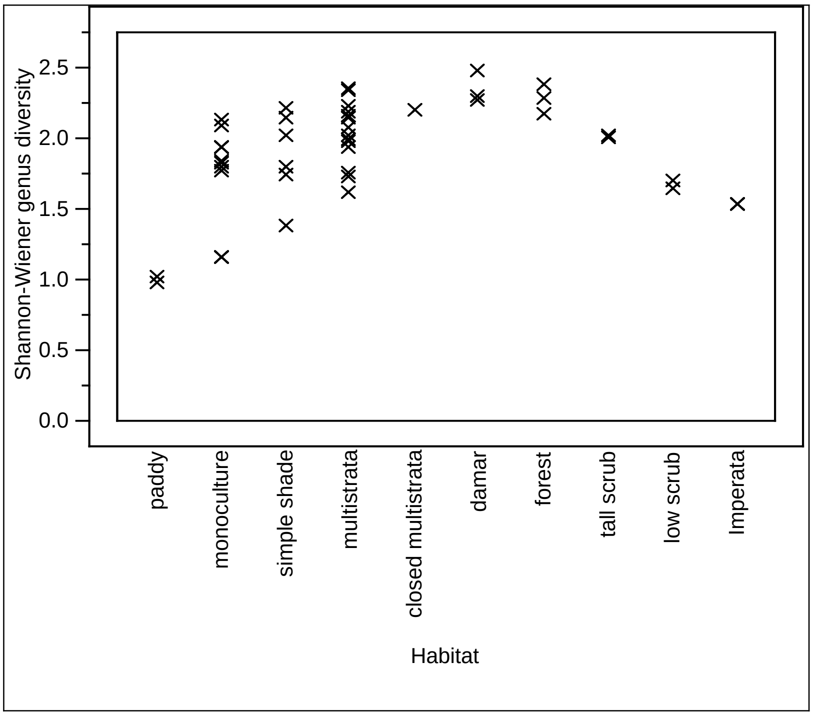


Figure 6.4 Shannon-Wiener genus diversity for individual sites for all habitats

Finally, when diversity was calculated on the rather coarse-grained basis of family (n= 6494), the results were similar to those at other taxonomic levels, showing an apparent relationship with vegetation structure. Overall, the differences between simplified habitats were significant (Kruskal-Wallis χ^2=14.84, d.f.=5, P=0.01). Greatest family diversity was found in damar sites closely followed by forest. The lowest diversity at family level was found in paddy. While comparison between coffee sites showed that shade coffee had higher family diversity than did monoculture coffee, for the complex schema of coffee habitats, differences were not significant (Kruskal-Wallis χ^2=6.44, d.f.=3, P=0.09). Within coffee habitats the highest family diversity of birds was in closed multistrata, followed by multistrata, simple shade and finally monoculture.

6.2.3 Species uniqueness and turnover between sites

In addition to the species richness of individual sites, the contribution of coffee habitats to the regional species assemblage was examined. The lists of unique taxa for all 14 non-coffee sites and 14 randomly-chosen coffee sites was compared. Of 106 taxa represented, 43 (41%) were shared between the coffee and non-coffee habitats. Of those not represented in both coffee and non-coffee, 18 taxa (17%) were found only in coffee gardens and 45 (43%) were only found in other habitats. Thus, the coffee sites contributed to regional species richness, but did not contain many of the species found in other habitats in the region.

Turnover of species between sites also gave an indication of the relative value of each coffee habitat type within the landscape (see section 4.5.5.3). For six randomly chosen sites in the coffee habitats monoculture, simple shade and multistrata the number of species unique to each habitat, or combination of habitats, is given (Table 6.2).

Table 6.2 Number of species unique to particular coffee habitat combinations

(6 sites per habitat)

Habitats	Number of species unique to habitat or habitat combination (% of total)
All three coffee habitats	16 (23)
Any two coffee habitats	12 (17)
One coffee habitat only	42 (60)
Monoculture only	12 (17)
Simple shade only	12 (17)
Multistrata only	18 (26)
Monoculture and simple shade	2 (3)
Monoculture and multistrata	5 (7)
Simple shade and multistrata	5 (7)

The habitat with the greatest number of unique species for the six sites was multistrata (18), whilst monoculture and simple shade coffee held the same number (12). Habitat pairs involving multistrata also supported more unique species than did the pairing of monoculture and simple shade. The result was the same for pairing of multistrata with either monoculture or simple shade (n=5). Thus, inclusion of a variety of coffee habitat types in the landscape increased species richness, but the greatest contribution came from multistrata. The extent to which species assemblages were replicated across sites within one habitat was investigated by the use of species accumulation curves plotted by site (see section 4.5.5.2) (Figure 6.5). The accumulated species richness over six sites was 34 species for monoculture, 36 species for simple shade and 48 species for multistrata. Whilst the monoculture species curve was rather flat after the first three sites, indicating that the species present are largely common across all sites, the simple shade curve continued to rise more steeply, suggesting that with additional sites more species may still be found. The multistrata curve was steepest of the three, indicating that more new species were added with each additional site rather than the species found at the first sites being re-represented at subsequent sites.

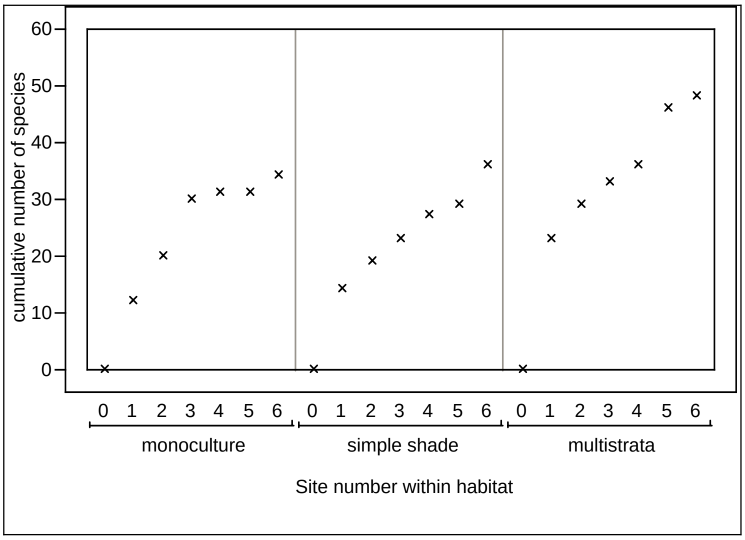


Figure 6.5 Species accumulation with site for six randomly chosen and ordered sites in each of three coffee habitats: monoculture, simple shade and multistrata.

The overall species richness of multistrata is higher than that of other habitats due both to a high species richness at the first site, and the continued increase with additional sites.

6.3 Species composition

Some species were found in high numbers across a range of habitats (Table 6.3). These included *Lonchura maja*, *L. leucogastroides* and *L. punctulata*, also *Zosterops palpebrosus*, *Pycnonotus aurigaster* and *P. goiavier* and *Collocalia esculenta*. *Passer montanus* was found in high numbers in a smaller range of habitats. Species found in moderate numbers across many habitats included *Pynonotus melanicterus* and *P. atriceps*, *Orthotomus ruficeps*, *Lanius schach*, *Nectarina jugularis*, *Dicaeum trigonostigma*, and *Erythrura prasina* (common names in Appendix A).

Table 6.3 The mean number of birds of each species per site in each habitat, and the total number of birds of each species counted in nine surveys at each site.

			Number of birds per site in each habitat										
Family	Genus	Species	paddy	mono-culture	simple shade	multi-strata	closed multi-strata	damar	forest	tall scrub	low scrub	Imperata	Total number of birds
ACCIPITRIDAE	Accipter	soloensis			0.33								2
		trivirgatus			0.17								1
	Spizaetus	cirrhatus			0.17	1.14			0.67	0.50	0.50		21
	unknown							1.00					3
ALCEDINIDAE	Ceyx	erithacus		0.40		0.14		0.33			0.50		8
	Halcyon	smyrnensis							0.33				1
	Ictinaetus	malayensis		0.20	0.17	0.50	1.00			0.50		0.50	13
	Todirhamphus	chloris		0.20	0.17	0.43							9
	unknown					0.14	1.00						3
APODIDAE	Apus	affinus				0.36					0.50		6
		pacificus	4.00	4		1.57		0.67					70
	Collocalia	esculenta	15.00	16	6.00	5.14	11.00		0.67	30.00	20.00	38.00	485
		sp.		0.50				3.33					15
	Rhapidura	leucopygialis		0.60		0.07		1.67					12
	unknown			1.20	3.00	4.14		5.67	3.67	0.50			117
ARDEIDAE	Ixobrychus	cinnamomeus	1.50		0.17								4

			Number of birds per site in each habitat										
Family	Genus	Species	paddy	mono-culture	simple shade	multi-strata	closed multi-strata	damar	forest	tall scrub	low scrub	Imperata	Total number of birds
ARTAMIDAE	Artamus	leucorynchus	1.00	1.60		0.21	2.00			0.50	1.00		26
BUCEROTIDAE	Buceros	bicornis							0.33				1
CAMPEPHAGIDAE	Coracina	fimbriata				0.07							1
	Hemipus	picatus				0.36		0.33					6
		sp.						0.33					1
	Lalage	nigra		0.20	2.33	1.57	1.00						39
	Pericrotus	flammeus						2.00	2.33				13
		igneus						2.00	0.67				8
		sp.				0.07		6.00	1.33				23
CAPITONIDAE	Calorhamphus	fuliginosus						0.33	4.67				15
	Megalaima	chrysopogon							0.33	2.00			5
		haemacephala			0.33	0.21				5.50	0.50		17
		oortii		0.10		0.07			4.00				14
		sp.						0.33	1.00				4
CHLOROPSEIDAE	Aegithinia	viridissima						3.00					9
		sp.						2.33					7
	Chloropsis	venusta							1.67				5
COLUMBIDAE	Chalcophaps	indica						1.33					4
	Ducula	badia		0.70									7
	Geopelia	striata		0.40		0.29					0.50		9
	Macropygia	ruficeps						0.67					2
		unchall		0.50	0.17	0.21		0.67					11
	Streptopelia	chinensis	0.50		0.17								2
	unknown			0.10		0.14				1.00			5
CUCULIDAE	Cacomantis	merulinus		0.40	0.83	1.29	3.00	0.33			0.50		32
		sepulchralis				0.07							1
		sp.				0.14							2
	Centropus	bengalensis		0.10		0.07						1.00	4
		sinensis			0.33								2
		sp.		0.10									1
	Surniculus	lugubris					1.00						1
	unknown				0.17	0.29							5
DICAEIDAE	Dicaeum	chrysorrheum							0.33				1
		concolor				0.14		0.33					3
		cruentatum		0.30		0.50				1.50			13
		ignipectus		0.10									1
		trigonostigma	0.50	6.40	4.00	10.64	17.00	11.33	3.67	9.50	9.00	0.50	338
		trochileum							0.33			0.50	2
	Prionochilus	maculatus						1.33	0.33				5
		percussus		0.10				2.33					8
	unknown			1.40	0.17	0.21		4.00	1.00	2.50			38
EURYLAIMIDAE	Calyptomena	viridis							0.33				1
	Eurylaimus	ochromalus						1.67					5
FALCONIDAE	Microhierax	fringillarius				0.07							1
HIRUNDINIDAE	Delichon	dasypus		0.50		0.21							8
	Hirundo	rustica	10.00	5.00	2.50	1.00			0.67	0.50	7.00	8.50	133
LANIIDAE	Lanius	schach		4.40	5.67	2.57	1.00			1.00	1.50	1.00	122
		tigrinus				0.07							1
MEROPIDAE	Merops	viridis							0.67				2
		sp.				0.64							9
MONARCHIDAE	Hypothymus	azurea						0.33					1
MOTACILLIDAE	Anthus	novaseelandiae	9.50		0.17								20
	Dendronanthus	indicus			0.50								3
	Motacilla	cinerea	5.50	0.30	0.67	0.14					0.50	0.50	22
MUSCICAPIDAE	Eumyias	indigo						0.33					1
		thalassina			0.33	0.07							3
	Ficedula	zanthopygia				0.07							1
	Muscicapa	dauurica		0.40	0.83	1.50				0.50	0.50		32
	Rhinomyias	olivacea							3.33				10
	unknown					0.07			1.00				4
NECTARINIIDAE	Aethopyga	temminckii							0.33				1
	Anthreptes	Anthreptes simplex		0.10				0.33	0.33				3
		singalensis				0.14							2
	Arachnothera	longirostra		0.10				3.67	0.67	1.50			17
		sp.				0.14		7.33	3.33	2.00			38

			Number of birds per site in each habitat										
Family	Genus	Species	paddy	mono-culture	simple shade	multi-strata	closed multi-strata	damar	forest	tall scrub	low scrub	Imperata	Total number of birds
	Hypogramma	hypogrammicum						1.67					5
	Nectarinia	jugularis	0.50	4.00	3.17	3.57	3.00			4.50		1.50	125
	unknown			0.30				1.00	1.00	1.50			12
ORIOLIDAE	Oriolus	chinensis		0.10									1
PHASIANIDAE	Coturnix	chinensis		0.70		0.21							10
PICIDAE	Picoides	moluccensis		0.60	1.33	2.14	1.00			0.50		1.00	48
	Sasia	abnormis		0.10				0.67					3
PLOCEIDAE	Erythrura	prasina	7.50	2.10	7.67	0.64	6.00				1.50		100
	Lonchura	leucogastroides	79.00	29.30	4.17	5.93	10.00			2.00	13.50	3.50	607
		maja	85.50	6.20	3.17	0.14				4.00	10.50	70.50	424
		punctulata	148.50	28.80	15.50	6.79	3.00			8.00	7.00	1.00	808
		sp.	16.00	0.10		2.14				1.00	26.00		117
	Passer	montanus	40.00	1.80		1.36							117
	unknown		23.00	3.40	2.67							7.50	111
PYCNONOTIDAE	Alophoixus	bres							3.33				10
	Hypsipetes	flavala							1.67				5
	Ixos	malaccensis							0.33				1
	Pycnonotus	atriceps		0.10	2.67	1.43		1.00	0.67				42
		aurigaster	6.00	22.50	27.83	18.57	20.00			12.50	22.50	15.50	785
		goiavier		2.40	2.33	5.36	2.00			28.00	7.00	11.00	207
		melanicterus		0.50		1.86	1.00	1.00	5.33	4.00	0.50	0.50	61
		sp.							0.33				1
	unknown			0.80					0.33				9
RALLIDAE	Amaurornis	phoenicurus	1.00										2
SITTIDAE	Sitta	frontalis						1.33					4
STRIGIDAE	Otus	sp.					1.00						1
	unknown					0.07	1.00						2
STURNIDAE	Acridotheres	javanicus		0.30		0.21							6
SYLVIIDAE	Locustella	lanceolata										0.50	1
	Orthotomus	ruficeps		1.60	1.67	11.29	14.00	0.33		7.50	3.00		220
		sericeus				1.29	4.00	3.67					33
	Phylloscopus	borealis			0.50	2.07	2.00		1.00	0.50			38
	Prinia	atrogularis		0.50						1.00	8.50	5.50	35
		familiaris		1.00		0.07					0.50		12
		flaviventris		0.90							0.50	2.50	15
		Prinia sp.									0.50		1
TIMALIIDAE	Ixos	malaccensis							0.33				1
	Macronous	gularis				0.14		1.00					5
	Napothera	rufipectus						0.67					2
	Pellorneum	capistratum						0.33					1
	Pteruthius	flaviscapis							0.67				2
	Stachyris	striolata							0.67				2
		sp.									0.50		1
	Trichastoma	bicolor		0.10									1
		sp.		0.00					0.33	1.00			3
	unknown			0.10				0.67	1.67	0.50			9
TROGONIDAE	Harpactes.	sp.							0.33				1
TURDIDAE	Copsychus	saularis			0.83	0.64				2.00			18
	Trichixos	pyrrhopygus							0.33				1
ZOSTEROPIDAE	Zosterops	atricapilla				0.07							1
		palpebrosus		8.30	12.67	23.43	42.00		0.67	14.00	2.00	1.50	566
Unknown		unknown		0.90	0.50	0.79	1.00	3.00	10.00	1.50	2.50	3.00	77
		unknown a							1.00				3
		unknown b				0.07							1
		unknown c						0.33			0.50		2
		unknown d				0.07							1
		unknown e							0.67				2
		unknown f							0.33				1
		unknown g							2.00				6
Mean number of birds		29.32	454.5	163.50	116.00	127.3	149	82	71	153.5	149.5	175.5	
Total number of birds													6587

6.3.1 Conservation status

A search of the bird lists in the IUCN threatened categories of Critically Endangered, Endangered, Vulnerable, Near Threatened and Data Deficient found that seven of the surveyed species were listed as “Near Threatened”(IUCN (World Conservation Union) 2006). However, these were only represented by a total of 32 individuals (Table 6.4). Most of these birds were recorded in the Pesisir region, rather than Sumberjaya. Additionally, amongst the records determined to generic level only, nine birds in five genera may belong to species listed in the ‘Near Threatened’ category.

Table 6.4 Near threatened species surveyed

Species	Common name	Family	Habitat	Site	No. birds
Aegithina viridissima	Green Iora	CHLOROPSEIDAE	damar	Krui 1	6
			damar	Krui 3	3
Chloropsis venusta	Blue-masked Leafbird	CHLOROPSEIDAE	forest	Laksana 4	5
Buceros bicornis	Great Hornbill	BUCEROTIDAE	forest	Rata Agung 2	1
Calyptomena viridis	Green Broadbill	EURYLAIMIDAE	forest	Rata Agung 2	1
Eurylaimus ochromalus	Black and yellow Broadbill	EURYLAIMIDAE	damar	Krui 2	4
			damar	Krui 3	1
Ixos malaccensis	Streaked Bulbul	PYCNONOTIDAE	forest	Rata Agung 2	2
Pericrotus igneus	Fiery Minivet	CAMPEPHAGIDAE	damar	Krui 1	3
			damar	Krui 2	3
			forest	Laksana 4	2
Trichixos pyrrhopygus	Rufous-tailed Shama	TURDIDAE	forest	Rata Agung 2	1

6.3.2 Bird assemblage differences between habitats

Multi-Dimensional Scaling of the species abundance at each site showed that the avifauna of forest set it apart from that of all other surveyed habitats. As the main original habitat type for the area, this bird assemblage is considered as a baseline with which other assemblages should be compared. The forest bird assemblage was most similar to that of damar agroforest (Bray-Curtis similarity = 31.37, (Figure 6.6)). In rank similarity of bird assemblage to forest, damar was followed by tall scrub (similarity = 16.33) and multistrata coffee (similarity = 14.94). Bird assemblages in simple shade coffee were slightly more like those of forest than were those in monoculture coffee (similarities 11.41 and 9.51 respectively), whilst the bird assemblage in the single closed multistrata site was the furthest of coffee habitat types from forest bird assemblages (similarity = 7.27). The successional habitats of Imperata, low scrub and tall scrub had bird assemblages that, gradationally, became more similar to those of forest. The avifauna in rice paddy was most similar to that in Imperata (similarity = 36.03) and most dissimilar to that in damar (Figure 6.6, Figure 6.1).

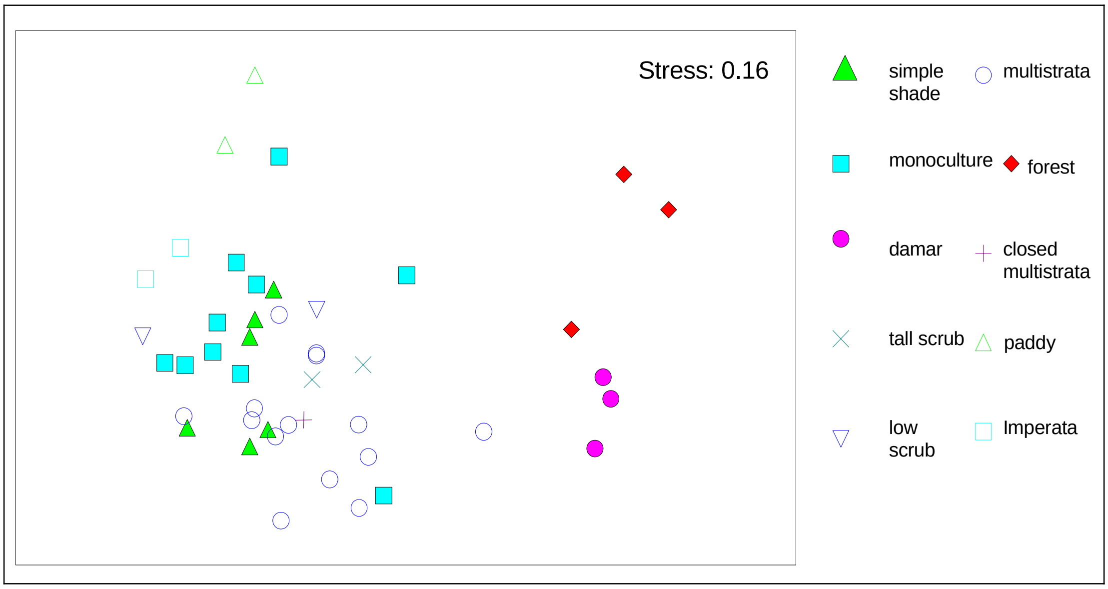


Figure 6.6 MDS of sites according to the similarity of their bird species composition .

The stress value of 0.16, indicates that the plot is “useable”, although high reliance should not be made upon its detail (Clarke and Warwick 2001).

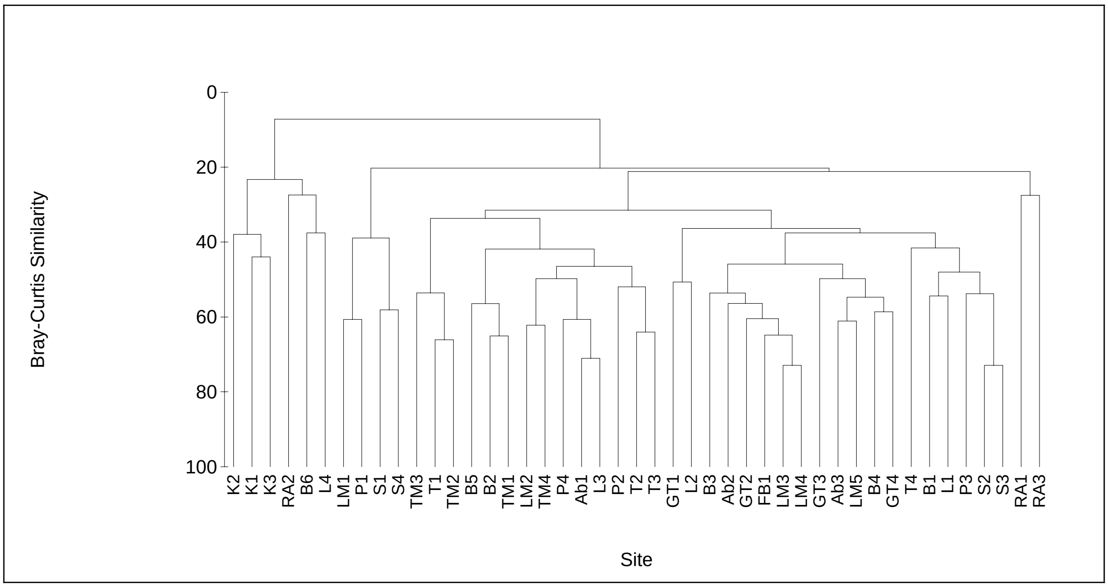


Figure 6.7 The levels of Bray-Curtis similarity between the bird species composition at each site.

Differences between habitats on the basis of their similarity of species composition were significant (ANOSIM test Global R=0.462, P=0.001). Pairwise tests showed that the only pair of simply-classified coffee habitats that had significantly different bird assemblages were multistrata and monoculture (R= 0.273, P= 0.4). The results of all pairwise comparisons are in Appendix F.

The respective differences between the amalgamated shade coffee bird assemblage and the forest bird assemblage, and the forest assemblage and the monoculture coffee assemblage, were of a similar magnitude (R = 0.979 and R= 0.972 respectively) (Table 6.5). However, the monoculture bird assemblage was much more similar to that of rice paddy than it was to the shade coffee assemblage (R= 0.908 and R = 0.357 respectively).

Table 6.5 Pairwise Tests of simplified habitats according to species composition

This table shows the similarity between the bird assemblages in each type of plot by the R statistic (positive value close to 1 indicates difference between sites while a zero or negative value indicates lack of difference), whilst the significance level (%) is also shown. Significant comparisons are in bold (P<0.05). Also indicated are the number of permutations tried and the number of these that produced an R statistic greater than that for the real distribution of sites.

Habitat pair	R Statistic	Significance level (%)	Possible permutations	Actual permutations	Number >= Observed R
Shade, monoculture	**0.255**	**0.4**	**44352165**	**10000**	**35**
Shade, forest	**0.979**	**0.**	**2024**	**2024**	**1**
Shade, damar	**0.951**	**0.**	**2024**	**2024**	**1**
Shade, successional	**0.472**	**0.1**	**296010**	**10000**	**6**
Shade, paddy	**0.908**	**0.4**	**253**	**253**	**1**
monoculture, forest	**0.972**	**0.3**	**286**	**286**	**1**
monoculture, damar	**0.911**	**0.3**	**286**	**286**	**1**
monoculture, successional	0.079	20.6	8008	8008	1652
monoculture, paddy	0.357	12.1	66	66	8
forest, damar	0.741	10.	10	10	1
forest, successional	**1**	**1.2**	**84**	**84**	**1**
forest, paddy	1.	10.	10	10	1
damar, successional	**1.**	**1.2**	**84**	**84**	**1**
damar, paddy	1.	10.	10	10	1
successional, paddy	**0.969**	**3.6**	**28**	**28**	**1**

6.4 Guilds and feeding groups

Guilds and feeding groups characterise the bird assemblages in a more ecological manner.

6.4.1 Feeding groups

6.4.1.1 Site differences on the basis of feeding groups.

An MDS of sites on the basis of the feeding groups, represented by the birds surveyed there, showed strong clustering in respective groups of damar, forest and paddy sites (Appendix A). There was some segregation between multistrata and monoculture coffee, but broad overlap between simple shade and the other coffee types (Figure 6.8).

The inter-habitat differences between the number of birds in each feeding group within simplified habitats were significantly different (ANOSIM test Global R= 0.353, P<0.00001, permutations =10, 000). Pairwise tests of simplified habitats showed substantial and significant differences between pairs including shade coffee and forest, shade coffee and paddy, monoculture coffee and forest, monoculture coffee and paddy. The differences between shade coffee and forest in feeding group representation, (R=0.756) were greater than those between monoculture and forest (R= 0.443), although this is not easily visible from the two-dimensional MDS plot. All pairwise values are presented in Appendix G.

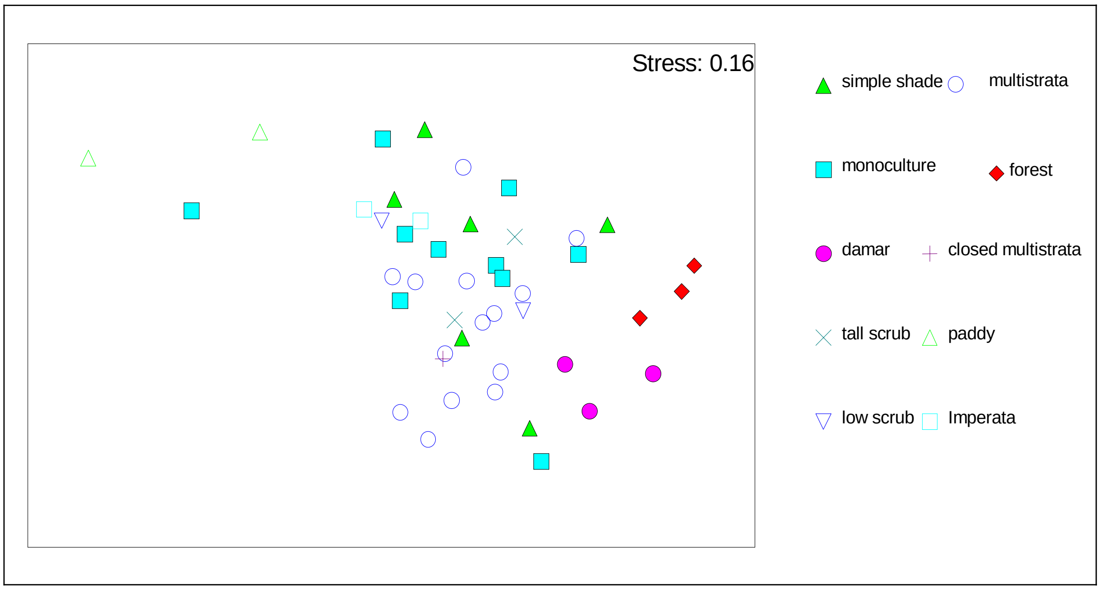


Figure 6.8 MDS of sites on the basis of the feeding groups represented by the bird assemblage at each site.

The most pronounced difference between the representation of feeding groups in the various habitats was the great abundance of granivores at open sites, particularly paddy (Figure 6.9). Some groups such as frugivores were present only in very low numbers and largely restricted to forest habitats.

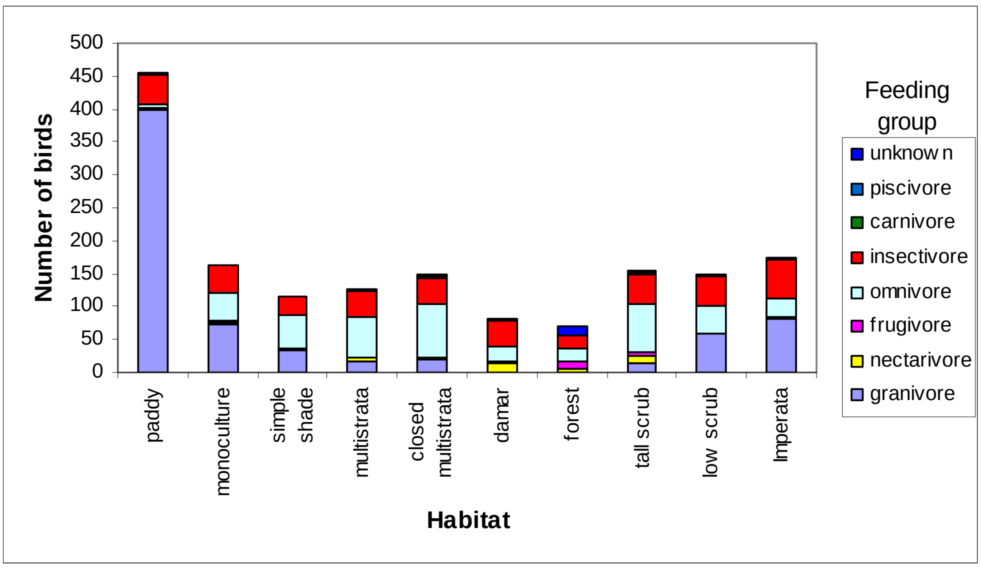


Figure 6.9 The number of surveyed birds in feeding groups in each habitat

Granivores

There were 2299 'granivore' birds surveyed. There appeared to be a negative relationship between the number of granivores and complexity of vegetation structure. The number of birds per site in each guild was significantly different between simplified habitat types (Kruskal-Wallis χ^2 = 19.95, d.f.=5, P=-0.001). The highest mean rank score was held by paddy, followed by monoculture, whilst the lowest was for forest. Granivores were more highly represented in monoculture coffee than in shade coffee. The difference in numbers of granivores in coffee and non- coffee habitats was not significant. The differences between the coffee types by complex habitat definition were also not significant, but monocultures had significantly more granivores per site than the amalgamated shade coffee sites (Wilcoxon test Z= 2.29, P= 0.02, χ^2=5.34, d.f.=1, P=0.02).

Frugivores

The number of frugivores was also significantly different between simplified habitat types (Kruskal-Wallis test χ^2=17.39, d.f.=5, P = 0.004). The highest mean rank score was for forest, followed by damar. The lowest mean rank score was for paddy, where no fugivores were present. Within coffee habitats a higher mean rank score was achieved by monoculture than shade coffee. These rather surprising results are qualified by the small sample size (n=31). Additionally, when the individual observations for frugivores in monocultures were identified, all of them were shown to be birds flying overhead, rather than interacting strongly with the immediate habitat. There was no significant difference between the numbers of frugivores in monoculture, simple shade, multistrata and closed multistrata coffee (Kruskal Wallis χ^2=2.82, d.f.=3, P= 0.42). There was also no significant difference between coffee and non-coffee habitats in the number frugivorous birds.

Nectarivores

There were 204 birds surveyed in the 'nectarivore' simple feeding group. Differences between simplified habitats were not significant (Kruskal-Wallis χ^2=6.31, d.f.=5, P = 0.28). The highest mean rank score was held by damar followed by forest. The lowest representation was in paddy. Monoculture coffee had marginally higher representation of nectarivores than did shade coffee. The differences in numbers of nectarivores between coffee and non-coffee were insignificant.

Carnivores

Only 38 birds in the 'carnivore' category were recorded in surveys. The relatively large number at one multistrata site (Leuwi Monyet 4) was due to the likely repeated observations of Black Eagles (*Ictinaetus malayensis*), that nested and raised a juvenile within the site during the survey. There was no significant difference between simplified habitat types (Kruskal-Wallis χ^2 =7.5, d.f.=5, P= 0.19). The highest score mean was for damar, whilst the lowest was for paddy. Shade coffee had slightly higher representation than did monoculture.

Insectivores

There were 1728 'insectivore' birds surveyed, however there was no significant difference between simplified habitat types (Kruskal-Wallis χ^2= 6.71, d.f.=5, P=0.24). The highest score mean was for successional vegetation, whilst the lowest was for forest. Interestingly, damar had a much greater representation of insectivores than did forest. There were no significant differences in the number of insectivores between coffee and non-coffee, shade coffee and monoculture or detailed coffee habitat types.

Omnivores

There was a significant difference in the numbers of simply defined 'omnivores' in simple habitat types (Kruskal Wallis χ^2=18.87, d.f.=5, P=0.002). The highest mean score was for shade coffee, whilst the lowest was for paddy. Monoculture coffee had a moderate score. The definition of habitat types according to the simple schema forced many bird species with more than one important food source (but not necessarily highly flexible in their food choice) into this group. For this reason, the analysis for the omnivore group was repeated using those species defined by the complex *schema*, which reduced the number of species within this feeding group from eighteen to two (Blue-breasted Quail and White-breasted Waterhen). According to this analysis there was still a significant difference between habitats, although the ranking was rather different (Kruskal Wallis χ^2=13.49, d.f.=5, P= 0.02). The highest mean rank score was for monoculture, followed by paddy, while the lowest score mean was held equally by forest, damar and successional vegetation.

6.4.2 Guilds

6.4.2.1 <u>Site differences on the basis of guilds</u>

Ecological differences in the bird assemblages present in each habitat are also evident in the representation of birds in each guild (Figure 6.10).(Guild definition is in Appendix A).

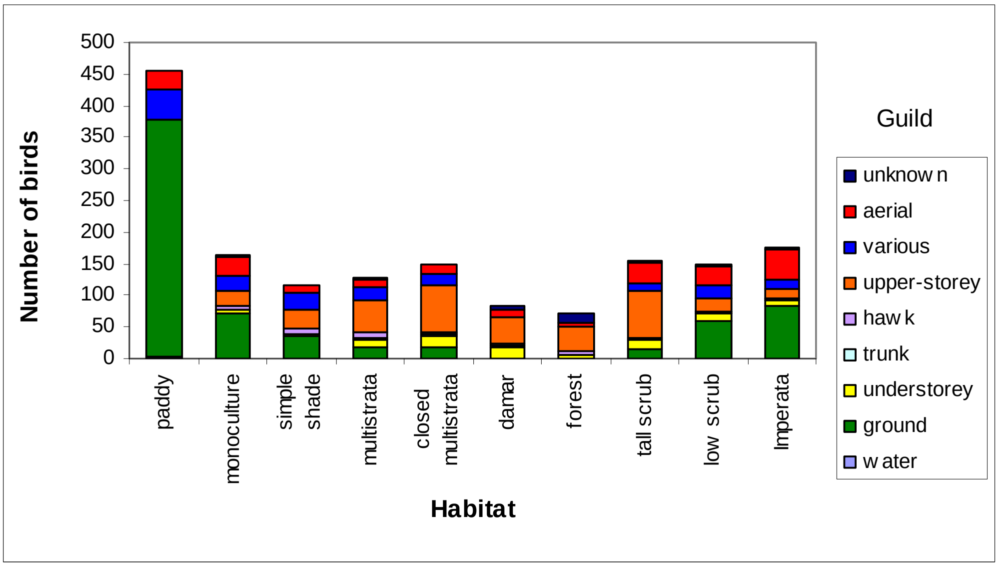


Figure 6.10 The number of surveyed birds in guilds in each habitat

An MDS of sites according to the number of birds in each guild shows some habitats to have their respective sites clustered (Figure 6.11). These included forest, damar, tall scrub, Imperata and paddy respectively. This suggests that the guild membership within replicate sites was similar, and so likely to be responding to the habitat features present. The guild assemblages of coffee habitats were more variable. There was some separation between monoculture and multistrata coffee, with simple shade coffee overlapping the middle ground. Of the coffee types, multistrata had the most similar bird guild assemblage to that of forest.

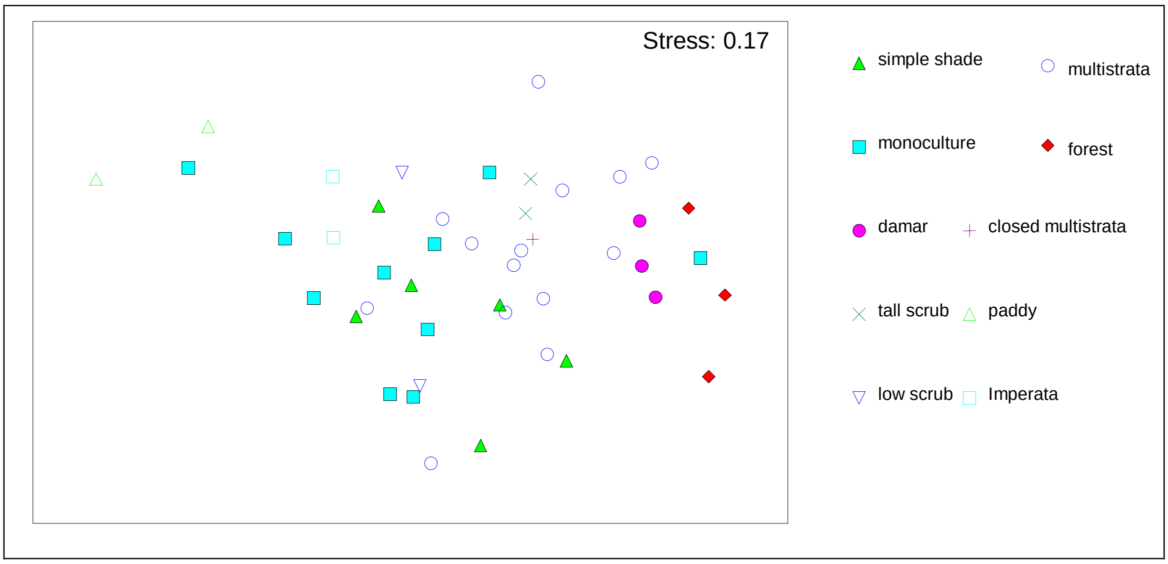


Figure 6.11 The two dimensional MDS plot of all sites according to the similarity of their constituent bird guilds.

Whilst the stress level of 0.17 is rather high, the plot is still useful for cautious interpretation.

Differences between habitat groups were significant (ANOSIM test Global R = 0.36, P<0.0001, permutations = 10, 000). The pairwise tests were significant for most cases with more than the minimum number of replicates needed for significance. There were strong significant differences between monoculture and forest (R= 0.67). Shade coffee and forest had bird guild assemblages that were more similar (R= 0.52). Whilst shade coffee and monoculture coffee guild assemblages were significantly different, with upper-storey and ground birds likely to have caused this result, the actual difference between them was rather small according to the R statistic (0.22). All pairwise values are presented in Appendix H.

Ground

In total 2239 birds in the simplified guild category 'ground' were observed. Differences between simplified habitat types were significant (Kruskal-Wallis test χ^2=21.90, d.f.=1, P=0.0005). The highest mean rank score was for paddy, whilst the lowest was equally held by forest and damar. Monoculture coffee had more 'ground' birds than did shade coffee. The difference between complex coffee habitats was not significant, and neither was that between coffee and non-coffee habitats.

Understorey

There were 425 'understorey' birds surveyed . The difference between simplified habitats, for the number of understorey guild birds, was significant (Kruskal-Wallis, χ^2=12.71, d.f.=5, P=0.026). The habitat with the highest mean rank score was damar. The lowest mean score was for paddy, as there were no understorey guild birds observed in this habitat. Shade coffee had greater representation of understorey guild birds, than did monoculture coffee. When complex coffee habitats were tested separately, differences between them were also significant (Kruskal-Wallis χ^2=9.04, d.f.=3, P =0.029). The highest score mean was for the single closed multistrata site, followed by multistrata , simple shade and monoculture. The total number of understorey guild birds in coffee habitats was 271. The number of understorey guild birds was not significantly different between coffee and non-coffee habitats.

Upper-storey

The differences between numbers of upper-storey birds in simplified habitat types were not significant (Kruskal Wallis χ^2=9.55, d.f.=5, P=0.089). The highest mean rank score was for damar, closely followed by shade coffee. Monoculture coffee scored moderately whilst the lowest mean score was for paddy. The differences in the upper-storey guild between coffee and non-coffee habitats were not significant. While there were significantly more upper-storey birds in shade coffee than in monoculture (χ^2=3.95, d.f.=1, P=0.047), the pattern between the complex coffee types was less clear, and marginally insignificant.

Hawk

The difference between numbers of birds in the 'hawk' guild in simplified habitats was significant (Kruskal Wallis χ^2=18.03, d.f.=5, P=0.003). The highest mean rank score was for shade coffee while the lowest was for paddy. Monoculture coffee scored highly. The number of 'hawk' guild birds in coffee habitats was also significantly greater than that in non-coffee habitats (Wilcoxon test Z=3.63, P= 0.0003; χ^2=13.29, d.f.=1, P=0.0003)

While statistically significant, these results do not relate as intuitively to vegetation structure as do some of the other findings. One possibility is that the overall result was overwhelmed by the 46.6% representation by a single species, the Long-tailed Shrike (*Lanius schach*). This bird is rather tolerant of open areas and often chooses low perches from which it can pounce on insects on the ground, and in a more detailed classification, might be considered a 'pounce insectivore' (van Marle and Voous 1988; MacKinnon and Phillips 1993) . In this regard it is probably not representative of the hawking guild as a whole, which is often considered intolerant of forest disturbance. When this species was temporarily excluded, in order to better recognise the patterns for other species, the differences between simplified habitats were still highly significant (Kruskal Wallis χ^2=24.01, d.f.=5, P=0.0002). The highest mean rank score was still for shade coffee, closely followed by forest. Monoculture coffee scored more modestly, whilst the lowest score mean was for paddy.

Aerial

The difference between simplified habitats for the numbers of birds in the 'aerial' guild was significant (Kruskal-Wallis χ^2=13.20, d.f.=5, P=0.022) (n=910,). The highest mean rank score was for paddy closely followed by successional vegetation. The lowest mean score was for forest. Monoculture had many aerial guild birds compared with shade coffee. The differences between the numbers of birds in the aerial guild in coffee and non-coffee habitats were not significant, neither were those between monoculture and shade coffee and coffee types as defined by the complex system.

Various

There were 902 birds surveyed in the guild defined as using 'various' strata. These birds could be considered generalists. The differences were significant for simplified habitats (Kruskal-

Wallis χ^2=16.05, d.f.=5, P=0.007). There was a very strong contrast between the tall timbered habitats, forest and damar, and the other habitats. The highest mean rank score was for paddy followed by monoculture. This was followed closely by shade coffee. The number of 'various' guild birds in coffee habitats was also significantly higher than in non-coffee habitats (Wilcoxon Z=-2.8, P= 0.0049; χ^2=7.92, d.f.=1, P=0.005). There were no significant differences between the numbers of 'various' guild birds in coffee habitats by the simple or complex definition.

6.4.3 Species affinity to forest or tolerance of open habitats

I examined the distribution of the groups defined *a priori* by their constituent species' tolerance of open habitats (as reported in literature, see section 4.5.5.5). In the structurally simple habitats (plotted at either end of the horizontal axis), there were not only larger numbers of birds, but they consisted primarily of 'open country' species (Figure 6.12). There were very few of these exposure-tolerant birds in either the damar or forest sites, but they had high representation in the successional sites and all the coffee types. These overall results support the local application of the 'forest affinity' definitions derived by literature survey.

Within coffee habitats, the greatest number per site of 'open country' birds was indeed found in monoculture, followed by simple shade, multistrata and the single closed multistrata site. However, there were also slightly more 'moderate-cover' birds in monoculture sites than in simple shade. However, in multistrata sites, the proportion of 'moderate cover' birds was higher still. In the closed multistrata site, the majority of birds were in this 'moderate cover' group. When natural and coffee habitats were compared, monoculture coffee appeared to have a profile similar to low scrub or Imperata; simple shade coffee appeared similar to low scrub, while multistrata and closed multistrata were most similar to the profile of tall scrub. Damar and forest were the only habitats with substantial representation of 'forest core' and 'forest edge' birds. These groups were very poorly represented in all coffee types. Sample sizes for these groups were too small to allow statistical testing.

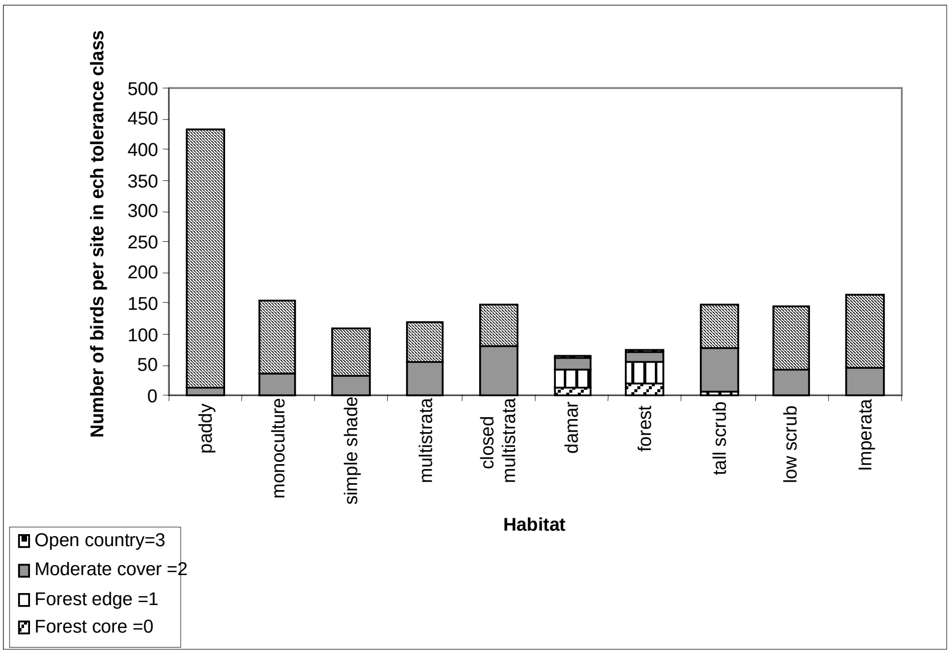


Figure 6.12 The mean number of birds per site in the *a priori* defined groups of species' tolerance to open habitats, as they occurred in all the habitats surveyed.

(0=forest core, 1= forest edge, 2= moderate cover, 3= open country). (Species allocated to groups by literature, see Appendix A)

6.4.4 Migratory and residential birds

The vast majority of the birds surveyed were residents. There were no clear patterns for the distribution of migratory birds, although it seems that birds that could be either migrants, or residential, formed a greater proportion of the assemblage in the habitats with tall vegetation, while there were low numbers of obligative migrants in these habitats (Figure 6.13).(Definition of species' migratory status is in Appendix A).

Table 6.6 No. of migratory and residential birds per site and (proportion) of birds in each habitat . (excludes birds with insufficient identification)

	paddy	monoculture	simple shade	multistrata	closed multistrata	damar	forest	tall scrub	low scrub	Imperata	Total no.
migrant	19.5 (0.14)	9.6 (0.34)	4.50 (0.10)	5.14 (0.26)	2.00 (0.01)	0.67 (0.01)	1.67 (0.02)	1.00 (0.01)	7.50 (0.05)	9.50 (0.07)	279 (0.04)
resident	434 (0.14)	150.4 (0.25)	107.00 (0.11)	114.14 (0.27)	145.00 (0.02)	68.33 (0.03)	50.00 (0.02)	149.00 (0.05)	138.00 (0.05)	163.00 (0.05)	6012 (0.93)
resident or migrant	1 (0.01)	2.5 (0.13)	4 (0.12)	6.86 (0.50)	1.00 (0.01)	9.33 (0.15)	4.33 (0.07)	1.00 (0.01)	1.00 (0.01)	0.00 (0.00)	193 (0.03)
Total per habitat	454.5 (0.14)	162.5 (0.25)	115.5 (0.11)	126.14 (0.27)	148.00 (0.02)	78.33 (0.04)	56 (0.03)	151 (0.05)	146.5 (0.05)	172.5 (0.05)	6484 1.00

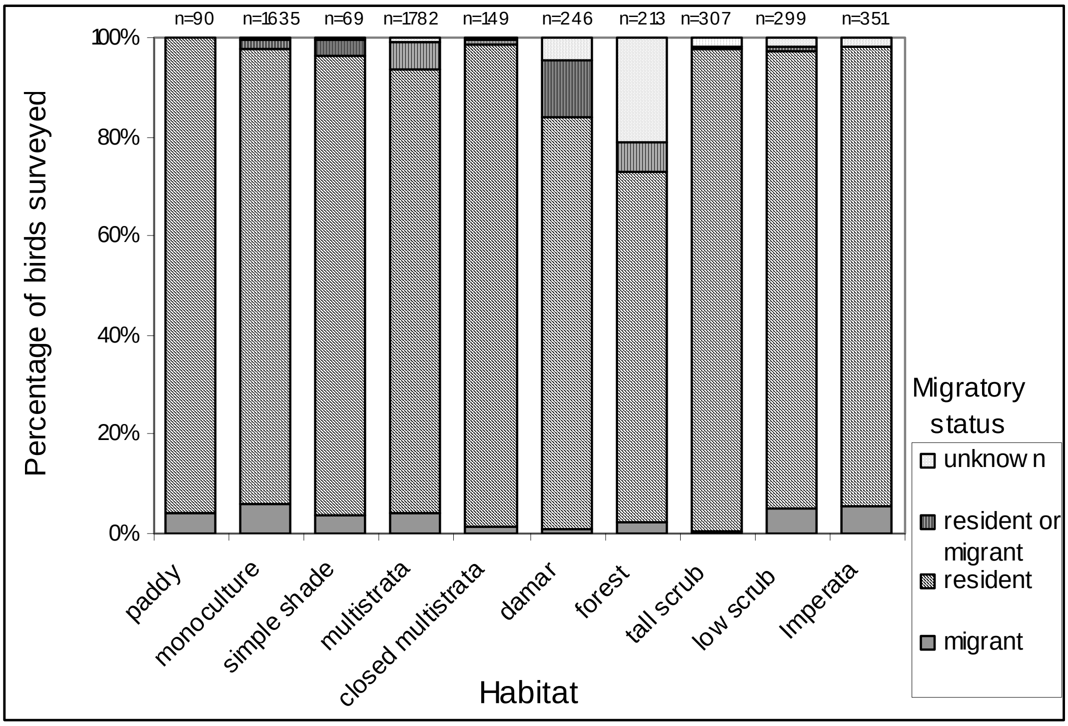


Figure 6.13 The mean number of birds per site and proportion of birds in each habitat that were considered to be' resident', 'migrant', or 'either resident or migrant'.

6.5 Bird assemblage and vegetation features

Having established that local coffee habitats have distinctive bird assemblages, examination of vegetation features may indicate some of the factors influencing the regional assemblages. Of all the birds surveyed, a total of 3887 were not observed using vegetation. The remaining 2701 (41% of the total) were recorded as using vegetation of some kind. Of these, 1720 used trees, and 623 used vegetation of 'non-tree' form, whilst 343 were recorded as using an 'unknown' vegetation type.

6.5.1 Structural features

Various structural features showed patterns with relation to bird species assemblage.

6.5.1.1 Canopy cover

There was a relationship evident between the canopy cover of a site and the bird assemblages (Figure 6.14). The bird assemblages fell into three main groups. One of these groups was also characterised by the high canopy cover at the survey sites. These were damar (K1-3) and forest sites B6, L4 and RA2 (in the top right of the plot). The vegetation conditions and bird assemblages of these forest sites form the baselines for comparisons. A second group was present at sites, including coffee sites, with medium canopy cover. This graded into a third type of bird assemblage, found at sites where there was little or no canopy cover.

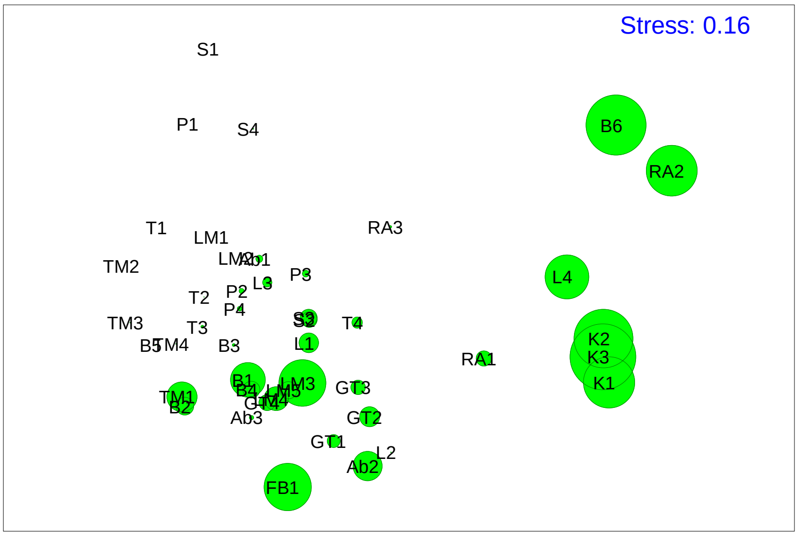


Figure 6.14 MDS of sites by bird assemblage.

Overlain are circles proportional to the tree canopy cover at the site.

6.5.1.2 *Maximum tree height*

The relationship between bird species assemblages and maximum tree height appears to be a similar one to that with tree canopy cover. This is not surprising as the size of trees and canopy cover are likely to be related. While the bird assemblages at sites with very tall trees were clearly different from those of all other sites, there was a gradation from the bird assemblages at those sites with moderately tall trees to those where trees were very short or not present (Figure 6.15).

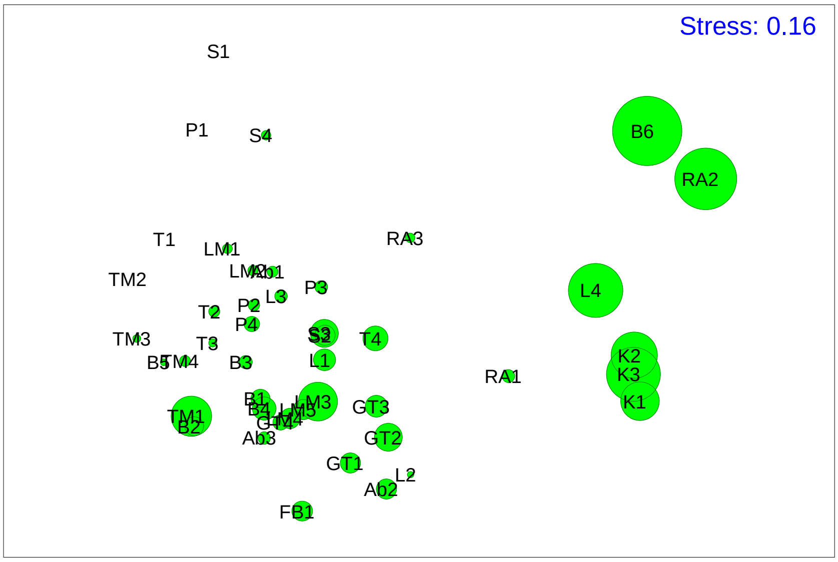


Figure 6.15 MDS of sites by bird assemblage.

Overlain are circles proportional to the maximum tree height at the site.

6.5.1.3 *Canopy depth*

There was a clear relationship between bird assemblages and tree canopy depth. The assemblages again clustered into three main groups; deep canopy, moderate depth canopy and shallow canopy.

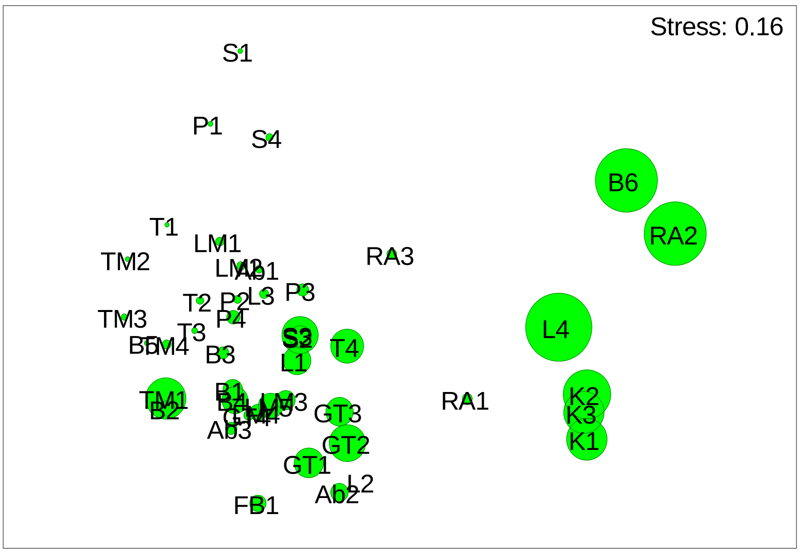


Figure 6.16 MDS of sites by bird assemblage.

Overlain are circles proportional to the showing tree canopy depth (Maximum minus mean of mode tree height) at the site.

6.5.1.4 Number of trees

The relationship between bird assemblages and number of trees at the surveyed sites was less clear (Figure 6.17). The bird assemblages were different for those sites that had no trees than at sites with trees present. However, where trees were present, the bird assemblage was not clearly related to the number of trees, as there was no strong clustering of sites with either high or low numbers of trees respectively.

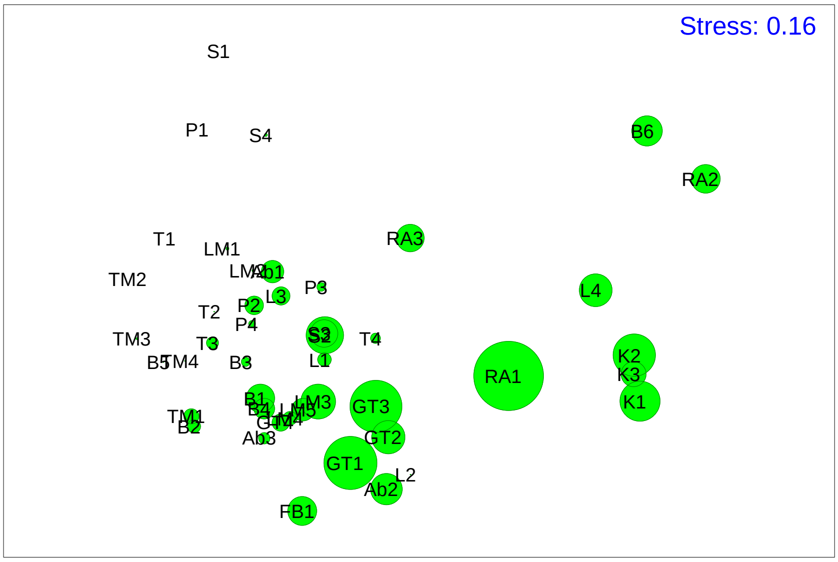


Figure 6.17 MDS of sites according to bird assemblage

Overlain are circles proportional to the number of trees at each site.

6.5.2 Floristic features

6.5.2.1 Vegetation type

Of the vegetation types recorded, 65 were recorded in surveys as being used by birds. The largest individual group were birds in 'unknown' vegetation type (n=633). The most commonly used vegetation of known type was *Erythrina* (n=494) followed by coffee (n=300).[11] *Erythrina* was one of the most common shade trees in coffee plantations in the area. *Gliricidia* was also often planted, and was the birds' next most commonly used vegetation type (n= 211), followed by sengon *(Paraserianthes falcataria)*, another leguminous shade tree (n=101).

[11] As the type of vegetation used by the birds is a product of both its availability and the birds' preference, without a comprehensive measure of the availability of each plant species, the birds' preferences cannot be deduced

Table 6.7 The number of birds surveyed in each vegetation type

Vegetation type	Number of birds	Vegetation type	Number of birds
Aren	15	Macaranga	14
Avocado	30	Mahoghany	23
Bamboo	27	Mango	7
Banana	4	Mara	9
Bracken	27	Nangka	67
Calliandra	5	Nangka cempodak	1
Candlenut	43	Pasang	2
Cassava	2	Pawpaw	1
Chromolaena	6	Pepper	1
Cinnamon	28	Petai	39
Clove	12	Pulus	9
Coconut	5	Rambutan	4
Coffee	300	Sawo	17
Conifer	4	Sengon	101
Damar	48	Shieri	4
Duku	20	Sonokeling	1
Durian	34	Suren	14
Erythrina	494	Teak	23
Ginger	2	Tenam	2
Gliricidia	211	Tepos	4
Gnetum	8	Tireup	35
Hamerang	13	Waru	2
Hanjuang	4	Dead	13
Hanyerek	1	Epiphyte	2
Imperata	2	Fern	2
Jambu	15	Grass	28
Kapok	52	Mistletoe	2
Kayu Afrika	54	Pepper	1
Kecubungi	1	Rice	96
Kiola	11	Rushes	11
Kupa	1	unknown	632
Lamae	3	unknown-fruiting	4
Lantana	4	None	3887
Leucaena	43		

6.5.2.2 Understorey species richness

There was no clear relationship apparent between bird species assemblage and understorey species richness. Low species-richness sites mixed in with others having high understorey species richness indicating that they had similar bird assemblages regardless of this floristic difference (Figure 6.18).

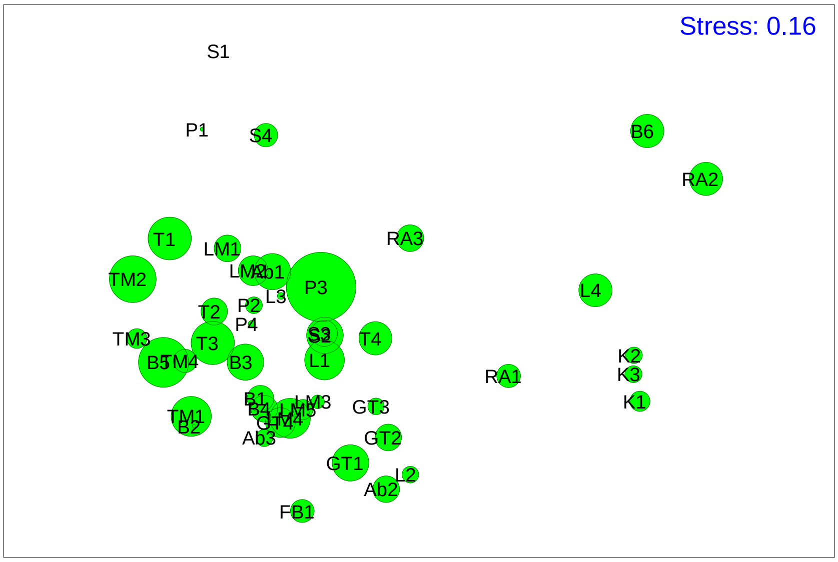


Figure 6.18 MDS of sites by bird assemblage.

Overlain are circles proportional to the understorey species richness at each site[12].

6.5.2.3 Tree species richness

Tree species richness appeared to have had a stronger relationship with the bird assemblages than did understorey species richness (Figure 6.19). While there were some sites that had similar bird assemblages in spite of having very different tree species richness, in general there was a distinction between the bird assemblages of sites with moderate or high tree species richness, and those where there were few tree species present.

12 Excludes forest due to insufficient data on understorey species richness for these sites

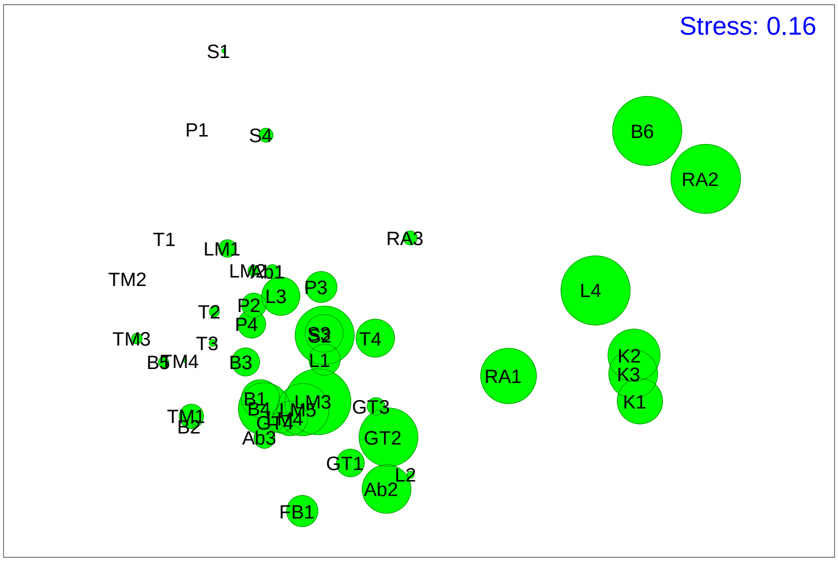


Figure 6.19 MDS of sites by bird assemblage.

Overlain are circles proportional to the tree species richness at each site[13] .

6.5.2.4 Index of tree species dominance

There was generally some distinction between the species assemblages of sites where the vegetation was dominated by a single tree species, and those where it was not (Figure 6.20). However, the pattern of clustering is not a very strong one, and there is some intermixing of sites with respectively low and high levels of tree species dominance.

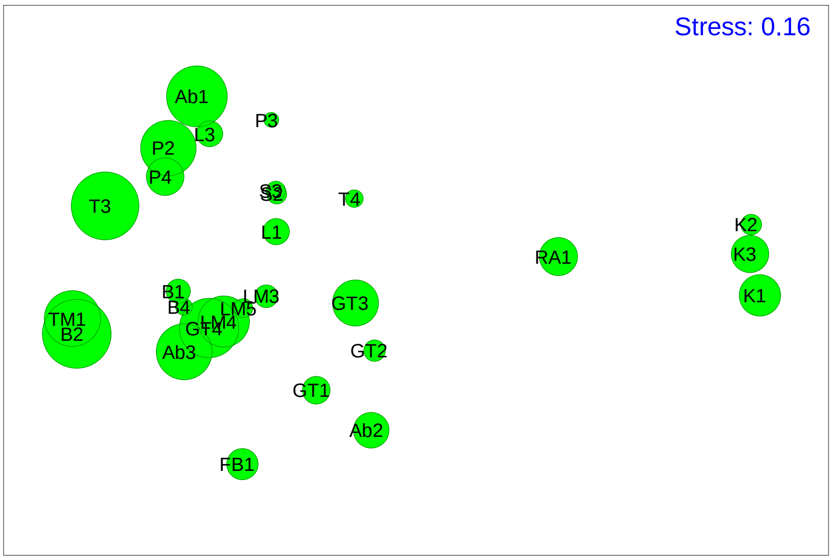


Figure 6.20 MDS of sites by bird assemblage.

Overlain are circles proportional to the index derived for tree species dominance in shaded coffee sites.

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[13] Excludes forest due to insufficient data on tree species richness for these sites.

6.5.2.5 Dominant tree type

Some groups that had the same dominant tree type also had similar bird assemblages Figure 6.21). These included sites dominated by damar trees and those dominated by *Leucaena*. However, in general the groups were rather mixed, suggesting that dominant tree was not one of the more important factors in determining bird assemblage regionally.

ANOSIM indicated that the overall differences were not significant (Global R = 0.20, P= 0.081, permutations= 10000). Pairwise tests of the dominant tree species in each plot showed generally low levels of differences between the bird assemblages recorded at these sites. Of the pairings with sufficient numbers of replicates, the only assemblages showing strong differences were *Gliricidia* and Damar (R=0.97, P= 0.01) and *Erythrina* and Damar (R= 0.87, P= 0.018) (Appendix I). Thus, the common tree types used to shade coffee plants were unlikely to have a strong influence on the bird assemblages. Furthermore, when the similarities of bird assemblages in shaded coffee sites were considered, according to the more simple dominant tree groups of legume or non-legume, there was no significant difference.

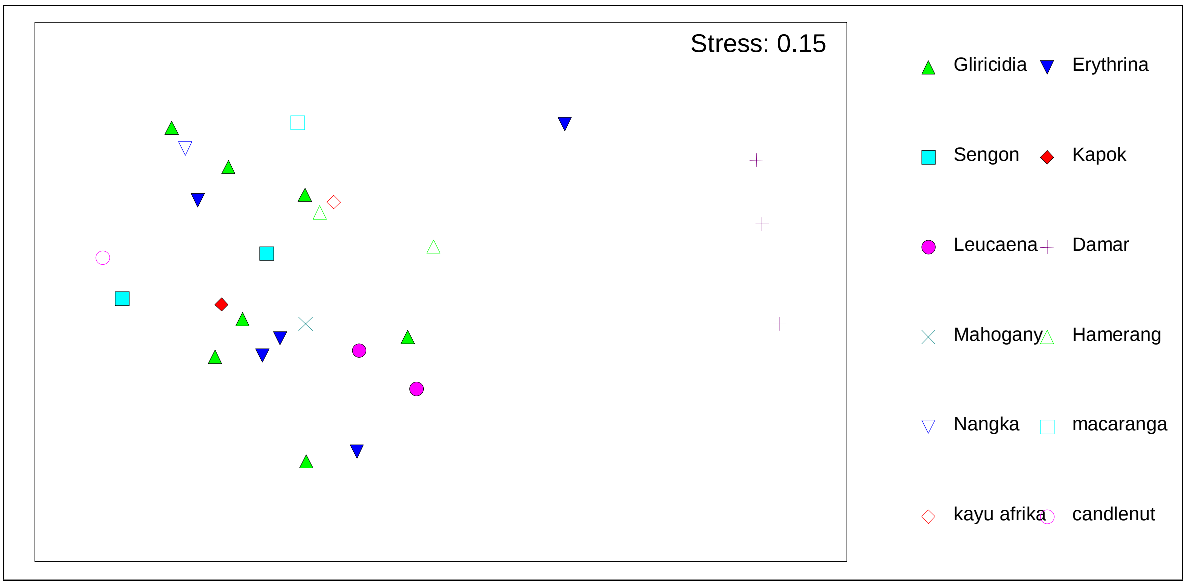

Figure 6.21 Distribution of sites by bird assemblage, indicating the dominant tree type at the site.

6.5.3 Floristic or Structural features?

A RELATE comparison of vegetation and bird assemblages showed inter-site differences to be highly significant (sample statistic (Rho) = 0.46, P= 0.0001, permutations = 10,000, n>Rho = 0). Thus the birds present at the sites do appear to be responding to the floristic assemblage. However, this is clearly not independent from structural features, as abundance in particular types of plants leads to particular suites of vegetation structures. In comparison, a RELATE test between the similarity matrix for vertical structural parameters of the vegetation (mean of mode tree height, maximum tree height, presence of exposed dead branches, presence of logs, presence of small fallen wood, maximum coffee height, mean of mode coffee height) and that for bird assemblage was highly significant (Rho= 0.52, P= 0.0001, permutations = 10000, n>Rho= 0). The marginally higher value of Rho for this test, compared to that for floristic characteristics, suggests that for these sites the vertical structural parameters had a slightly closer relationship with bird assemblage than do floristic parameters. However, both floristics and structure appear to be important.

For coffee sites evaluation of the best explanation for the bird species assemblage was chosen from the following 12 variables: canopy cover, tree species richness, coffee canopy closure (score from 3), leaf litter cover (score from 5), tree height maximum, mean of mode tree height, understorey species richness, weed cover /5, mean of mode coffee height, exposed dead perches (y/n), number of trees, logs (y/n), fallen wood (y/n), canopy depth, coffee height maximum. Of these, the best explanation involving no more than five variables included, mean of mode coffee height and weed cover (score from 5) (BioEnv test, standardised, Correlation 0.337). Of the best ten explanations, all included mean of mode coffee height.

6.5.4 Microhabitat

Differences between the bird assemblages supported by each habitat, including the different coffee garden types, may be partly explained by the microhabitats available for birds to use in each of these systems. As described in section 4.3.3 individual birds surveyed were allocated to the microhabitat types 'ground', 'rice', 'understorey', 'coffee', 'trunk', 'branch', 'canopy' and 'air'. The distribution of birds between microhabitats was significantly different in different habitats (χ^2=209.85, d.f=8, P<0.0001), and there was a distinction between open habitats and densely vegetated ones (Figure 6.22).

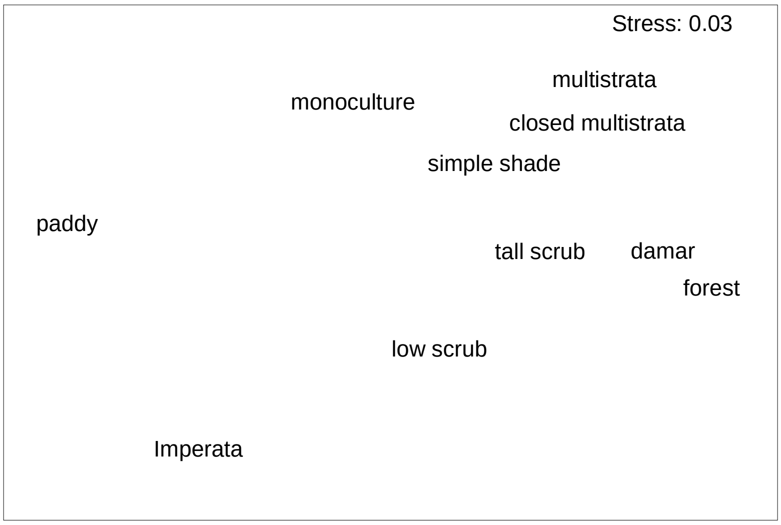

Figure 6.22 The relative similarity of habitats according to the mean number of birds surveyed in each of their constituent microhabitats.

The very low stress value of 0.03 for the plot suggests that this representation is an accurate one with low risk of misinterpretation (Clarke and Warwick 2001).

There was a pattern of microhabitat use change with increasing structural complexity for agricultural and natural habitats. This suggests that increasing complexity of the agricultural habitats, including coffee, acts in a similar way to natural succession in the way that these habitats are able to be used by birds; birds' use of microhabitats in shade coffee was similar to that in forest and tall scrub, but different from that in Imperata. These inter-habitat differences in microhabitat use are significant (ANOSIM test Global R = 0.483, P<0.0001, 10 000 permutations). Thus, birds were clearly using features as they became available in each habitat, with a general gradient from structurally simple to complex sites.

Pairwise comparisons between habitats showed that of the coffee types, the single closed multistrata site was the most similar to forest in terms of microhabitat usage (R=0.56) but there were insufficient replicates for this to be significant. Microhabitat use in monoculture was the most different from forest (R=0.83), followed by simple shade (R= 0.80) and multistrata (R=0.74). All these differences were significant (P<0.05). The table of all pairwise ANOSIM results is in Appendix J.

Having established the habitats in which microhabitat use was different, it remains to be shown from where these differences are derived. The patterns of microhabitat use by birds in agricultural systems approximately mirrored that of birds in natural systems with similar vegetation structure (Table 6.2).

Table 6.8 Microhabitat use by birds in each habitat type.

The table gives the mean number of birds per site counted across all censuses for each microhabitat for each habitat type.

	Number of birds per site per microhabitat										
Microhabitat	paddy	mono-culture	simple shade	multi-strata	closed multi-strata	damar	Forest	Tall scrub	low scrub	Imperata	Total number of birds
Ground	14.50	4.70	0.17	0.93	0.00	0.67	0.00	0.00	0.00	0.50	93
Rice	45.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	91
understorey	5.50	4.10	2.00	0.57	2.00	7.33	7.33	11.50	41.50	22.00	268
Coffee	0.00	15.80	2.17	8.43	3.00	0.00	0.00	0.00	0.00	0.00	292
Trunk	0.00	0.10	1.00	0.71	0.00	0.67	0.00	0.50	0.00	0.00	20
Branch	0.00	7.90	24.67	25.64	22.00	13.67	15.33	29.00	11.50	0.00	776
Canopy	0.00	2.90	6.00	34.36	57.00	30.33	22.67	20.00	2.50	0.00	807
Air	367.50	125.80	74.83	48.93	59.00	23.00	12.67	85.00	85.00	151.50	3936
unknown	21.50	2.20	5.17	7.71	6.00	6.33	13.00	7.50	9.00	1.50	304
Mean number of birds per site per habitat	454.50	163.50	116.00	127.29	149.00	82.00	71.00	153.50	149.50	175.50	
Total number of birds											6587

Large numbers of birds were found in the air at open sites such as paddy, monoculture, scrub and Imperata. In contrast, in multistrata, forest and damar there were more birds found in the canopy. The birds using branches were distributed more evenly across all of the habitat types that contained some trees. The (non-coffee) understorey layer was more intensively used in the natural habitats than in agricultural ones. Yet, in coffee gardens, this was partly compensated for by birds using the coffee layer. This was particularly true in monoculture and multistrata sites. Visibility constraints limited the ability to confidently assign microhabitat use in the denser habitats. Thus, for habitats such as forest, where more birds were recorded by call, the number of birds assigned to 'unknown' microhabitat is higher, causing other categories to be underestimated.

Examination of the numbers of birds using each microhabitat, within broader habitat groups clearly showed inter-habitat variation in the numbers of birds using the canopy. In coffee habitats there were a greater number of birds using the canopy in coffee habitats than in non-coffee habitats. The coffee layer was also used possibly as an alternative to the other types of understorey that were more intensely used in non-coffee habitats

A test of the best explanations by the measured variables for the distribution of birds between microhabitats at the coffee sites involved coffee canopy closure mean of mode tree height, presence of logs and presence of fallen wood (BioEnv test, standardised, Correlation = 0.516). Of the ten best explanations, all involved mean of mode tree height and presence of fallen wood.

The relationships between microhabitat use at each site in all habitats with measured vegetation variables was examined visually, by overlaying proportional circles of the variables on an MDS plot of sites according to microhabitat use (Appendix K) This suggested a strong relationship exists between patterns of microhabitat use and canopy cover, maximum tree height, canopy depth and tree species richness. There appeared a moderate relationship between microhabitat use and number of trees in each plot, and a poor relationship with each of understorey species richness and tree species dominance.

6.6 Activity

Records of bird activities at the time of census give some indication of how habitat resources were being used. Observed bird activities were clustered into broad groups that were related to habitat features (as described in Chapter 4). Birds that were heard, rather than seen, were assigned to the 'call' group. Strong inter-habitat differences were evident in the birds' recorded activities.

Most of the birds surveyed were 'flying overhead' (57.05%, n=3758), which is consistent with expectations created by the extensive use of 'air' as a microhabitat. 'Perch' was the next most represented category with 12.96% (n=854), followed closely by 'fly between perches' (12.14%, n=800) and 'forage' (12.0%, n=791). 'Walk/hop/run', 'combat' and 'unknown' categories combined contributed less than 2% of the total bird activity recorded.

6.6.1 Activity and habitat

There were clear differences between the activities of birds in different habitats. The magnitude of the differences varied, dependent on whether proportionate or absolute data are viewed.

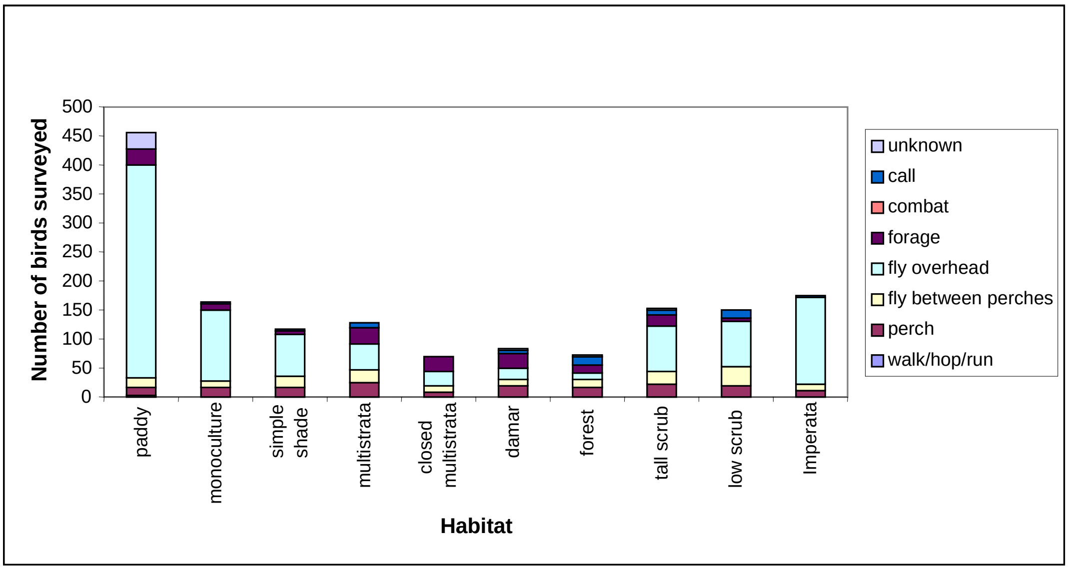

Figure 6.23 Number of birds engaged in various activities in each habitat

The absolute number of birds flying overhead in open habitats such as paddy, coffee, monoculture and Imperata was higher than that for other sites (Figure 6.23). This was the most variable category. Few birds were seen 'foraging' in the open sites, apart from paddy.

The proportional representation of bird activities for coffee sites collectively, was also very similar to that for all sites together. However, there were marked differences between shade and monoculture sites. Whilst shade coffee sites had a relatively low proportion of birds flying overhead (41.9% n=1092), in monocultures this was much higher (75.8%, n=1231). In contrast, the shade sites had high numbers of birds 'perching' (17.6%, n=460) and 'flying between perches' (17.4%, n=454) compared with 10.2% of birds in monoculture sites 'perching' (n=166) and 5.8% 'flying between perches' (n=94). Additionally, there was a greater representation of 'foraging' birds (18.1%, n=473) in shade sites than in monocultures (6.8%, n=111).

6.6.1.1 Flying between perches

There were inter-habitat differences in the number of birds 'flying between perches'. These differences were significant for simplified habitat groups (Kruskal-Wallis χ^2=12.55, d.f.=5, P=0.03). The greatest number of birds 'flying between perches' occurred in shade coffee habitats, while the smallest number occurred in monoculture. Of all the birds flying between perches, 33.4% were observed flying to a branch, 21.6% were mainly observed in the air, whilst 21.4% were flying between perches in the canopy.

Comparison of the numbers of birds flying between perches in coffee and non-coffee habitats was insignificant. However, within coffee sites, there were significantly more birds flying between perches in shade coffee (score mean = 19.79) compared with monoculture coffee (score mean = 8.05) (Wilcoxon Z=-3.35, P=0.001; χ^2=11.35, d.f.=1, P=0.001).

6.6.1.2 Perching

The inter-habitat trends for birds observed perching were similar to those for birds flying between perches but differences were insignificant on the basis of simplified habitats (χ^2=5.87, d.f.=5, P=0.32, d.f.=5). The largest number of perching birds was found in shade coffee sites (score mean= 27.81), whilst the smallest number was in paddy (score mean=16.50). The greatest number of perching birds was found in branches (49.18%), followed by coffee (18.15%) and canopy (17.10%). There was no significant difference between coffee and non-coffee habitats. While there were more birds perching in shade coffee than in monoculture coffee, this difference was marginally insignificant (Wilcoxon Z=-1.89, P=0.059; χ^2=3.64, d.f.=1, P=0.06).

The inter-habitat patterns were reinforced when the two closely related activities 'perch' and 'fly between perches' were combined. Within monoculture coffee sites 15.90% of birds in monocultures undertook these two activities compared with 34.79% of the birds in shade coffee habitats. Thus the overall perching behaviour of birds in monocultures seemed closer to the pattern of birds in paddy or Imperata, whilst that in shaded gardens was more akin to that in forest. Birds in structurally complex habitats were perched at a greater height above the ground than those in simpler habitats. Comparison of the types of shade coffee shows a small difference, with 5.39m being the mean height for birds perching in multistrata, whilst it was 4.85m for birds in simple shade.

6.6.1.3 Foraging

Whilst damar was the habitat with the greatest number of birds foraging, successional vegetation had the lowest mean rank Kruskal-Wallis score. Differences between simplified habitats were insignificant (Kruskal-Wallis χ^2=6.12, d.f.=5, P=0.294). There were no significant differences between shade and monoculture coffee in the numbers of birds observed foraging.

In shade coffee gardens, the canopy was where 72.3% (n=342) of foraging birds were found but it only accounted for 9.9% of the foraging birds in monocultures (n=11) (Figure 6.24)[14]. The coffee layer was more commonly used as a foraging substrate in monocultures (40.5% of foraging birds in monoculture; n=45), than in shade coffee, where only 7.8% of foraging birds used this layer (n=37).

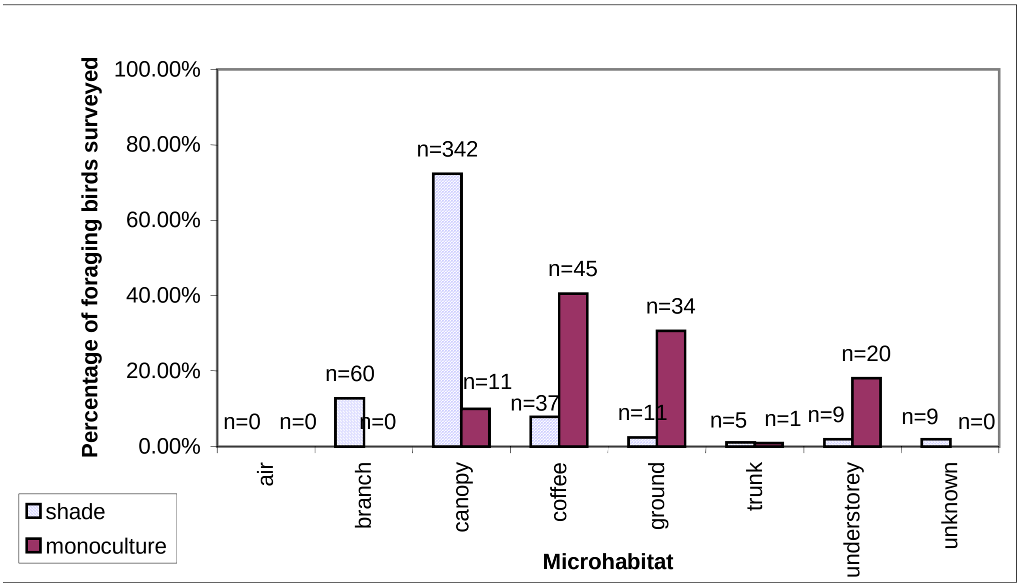

Figure 6.24 Distribution of foraging birds between microhabitat types in shade and monoculture coffee habitats [15].

There was a clear relationship between foraging height and vegetation structure implying that when foraging substrates were available, they were used by birds (Figure 6.25). The greatest mean height for foraging was in damar (26.34 m), whilst the lowest, of 0.0 m, was based on a single record in Imperata. The inter-habitat differences between actual foraging height were significant (Kruskal-Wallis χ^2=386.51, d.f.=9, P=0.0001). Comparison between complex coffee types also showed significant differences (Kruskal-Wallis χ^2=219.16, d.f.=3, P<0.0001). The mean rank score for foraging height was greatest for closed multistrata, followed by multistrata, monoculture and simple shade coffee.

14 'Monocultures' had some potential for birds to be found in the canopy due to the presence of isolated trees, to a threshold of 6.25% canopy cover.

15 The absolute numbers are provided, not to allow direct comparison between habitat types as these are represented by different numbers of sites, but rather to indicate the number of observations as a guide to the confidence with which interpretation may be made.

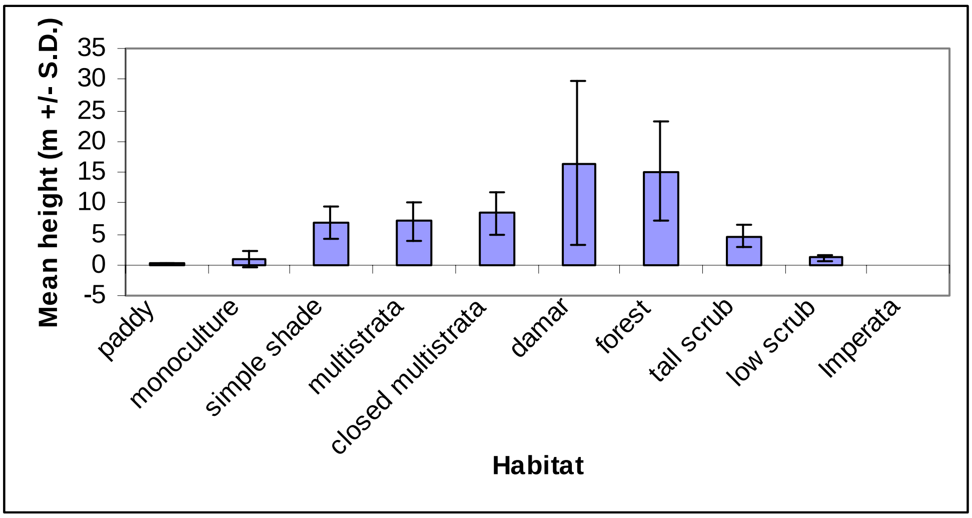

Figure 6.25 Mean height of foraging birds in all habitats.

6.6.1.4 Fly overhead

Birds flying overhead were the most numerous of the activity groups. There was a significant difference between simplified habitat types for the absolute number of birds flying overhead (Kruskal-Wallis χ^2=23.95, d.f.=5, P=0.0002). This appears to bear some relationship with structure, with more birds flying overhead in open habitats. There may also have been some bias in survey due to the better visibility of over-flying birds when there was no canopy present. The highest mean rank score for numbers flying overhead was for paddy whilst the lowest was for forest. The number of birds flying overhead in monoculture coffee was significantly greater than that for shade coffee (Wilcoxon Z=2.39, P=0.0169; χ^2= 5.81, d.f.=1, P=0.016).

6.6.2 Vegetation type and bird activity

6.6.2.1 Activity and vegetation form

The distribution of bird activities in tree and non-tree forms of vegetation shows little overall difference between the two categories (Figure 6.26). For both vegetation types the greatest proportion of birds were perching, followed by foraging and flying between perches.

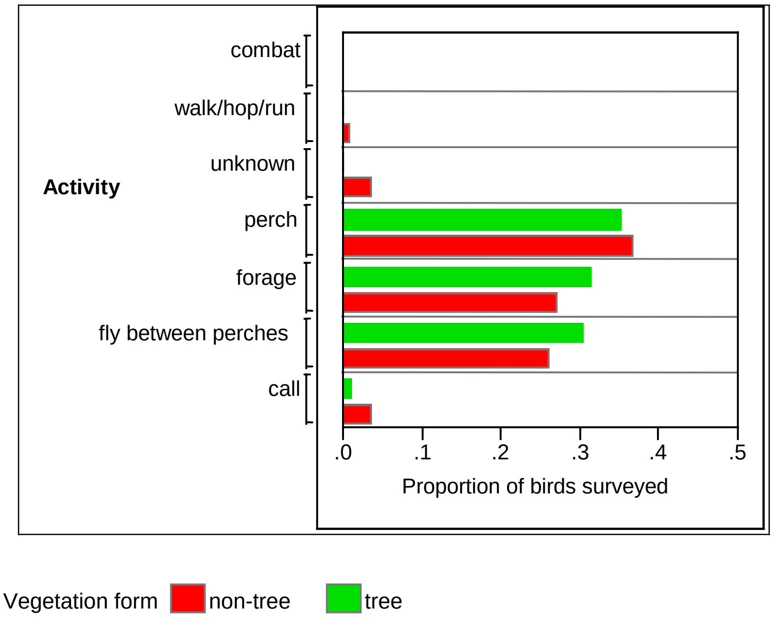

Figure 6.26 The distribution of bird activities in both tree and non-tree vegetation types.

The data show the proportions of birds in each activity based on sample sizes of 1734 and 623 birds for the two vegetation types respectively.

Some tree types, such as *Aren*, Clove, *Macaranga*, *Nangka*, Teak and *Petai* ,were frequently observed providing perches for birds, but no birds were seen foraging there. This was also true for Bracken and rushes, in the non-tree category. Grass was the only vegetation type seen to provide only foraging opportunities to large numbers of birds. Several other types are recorded as purely foraging sites, but with small bird samples. There were also vegetation types that provided both foraging and perching opportunities to substantial numbers of birds. These included damar, durian, *kayu Afrika*, *kapok*, mahogany, *Erythrina*, *Leucaena* and sengon in the tree category, and rice in the non-tree group. Coffee and *Gliricidia* also provided foraging sites for many birds, although in each case these represented less than 25% of the total number of birds observed using these vegetation types. Most of the widely cultivated, leguminous species provided both foraging and perching opportunities. However, the types of food available were not necessarily the same in each vegetation type (Figure 6.27).

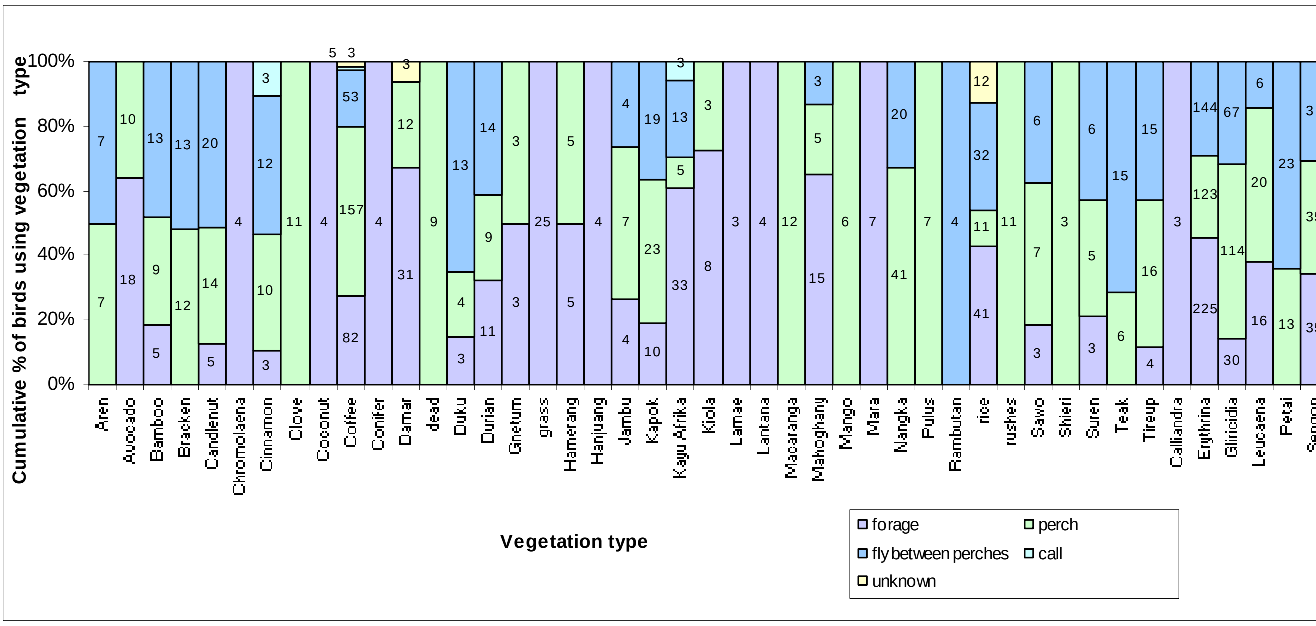

Figure 6.27 Bird activities in various vegetation types.

Only categories represented by at least three birds have been included. The absolute numbers of birds in each group is shown on the relevant bar.

6.7 Biogeographic Factors

6.7.1 Distance to forest

As forest patches may act as a potential source of birds, the distance of survey sites from these remnants was estimated in the field and from satellite images. The most outstanding feature was the great distance of the damar plots from the primary forest (Figure 6.28). In fact, on the satellite images, it is rather unclear where one of these habitats ends and the other begins, due to their similarity in reflectance characteristics. Differences between simplified habitats in distance from forest margins were marginally insignificant (Kruskal-Wallis χ^2= 9.05, d.f.=4, P = 0.0599)(forest excluded). The highest mean rank based on distance was clearly for damar, as due to the extensive nature of the damar gardens, the survey plots that were located in old gardens were far from the forest. In contrast, the lowest rank was for coffee monoculture, with these gardens often located on the forest margin, or indeed, encroaching upon it. Successional vegetation was also located close to forests, although distance was generally higher for later successional stages (Figure 6.28). Shade coffee was located slightly further from forest margins (score mean = 21.62), these gardens often being longer established.

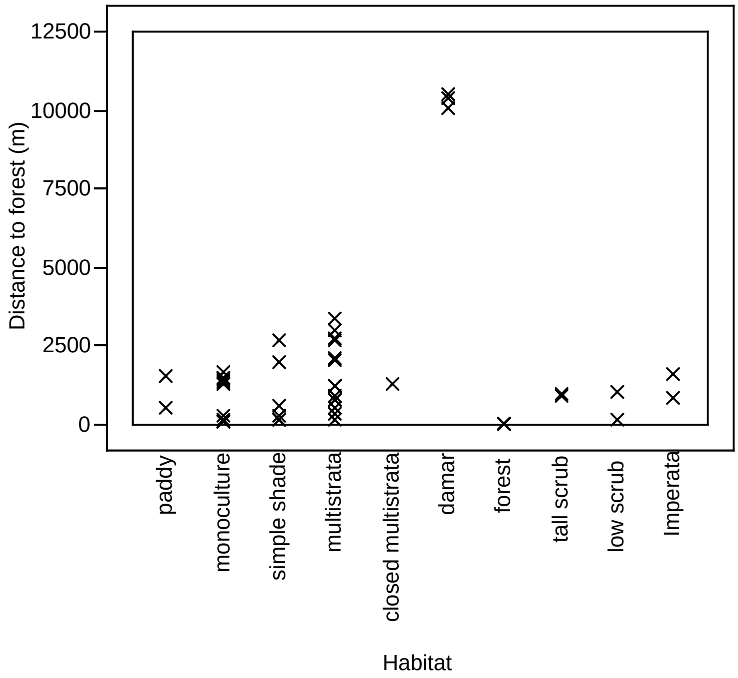

Figure 6.28 The estimated distance, in metres, from forest of all study sites, grouped by habitat type

6.7.1.1 Bird assemblage and distance from forest

Bird assemblages were found to be significantly different on the basis of classified distance from forest (ANOSIM test Rho = 0.024, P<0.0001, permutations = 10,000). This test does not take into account the actual distance represented by the classes, but simply the distinction of one class from another.

Due to the great distance of the damar plots from the forest, these sites also dominated an MDS of sites, plotted according to similarity of bird assemblage, and showing distance of the sites from the forest. Exclusion of the damar plots showed more subtle differences between other sites (Figure 6.29). The forest sites RA2, B6 and L4 had bird assemblages distinctive from the other sites. However, there was no clear relationship between distance from forest and bird assemblage for the other sites. Sites of the same vegetation type generally were clustered indicating regional similarity (as shown by the similar site codes). However, there was often similarity between bird assemblages at sites respectively close to, or far from, the forest. The absence of a smooth gradient of avifaunal change, with increasing distance from forest, suggests that factors other than accessibility from forest are determining bird assemblages.

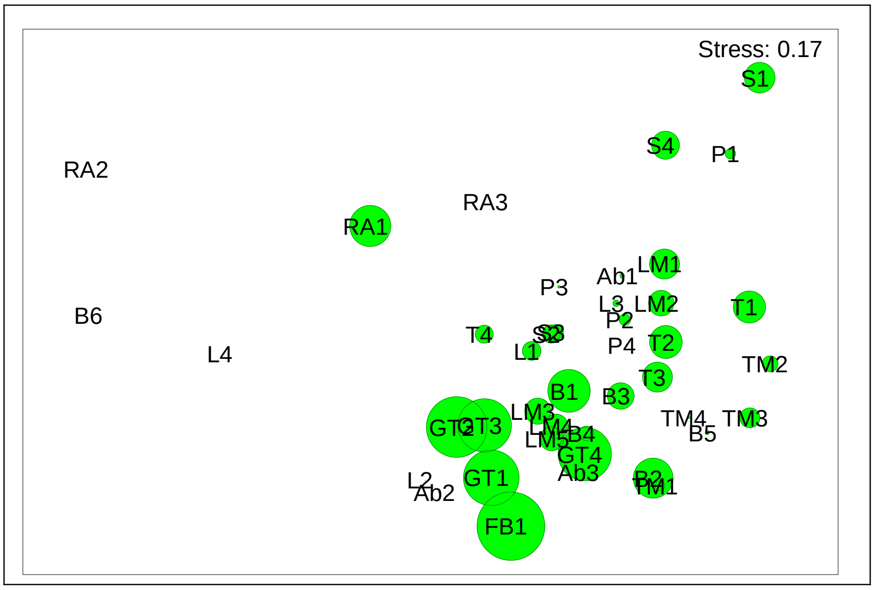

Figure 6.29 The distribution of sites according to similarity of bird assemblage

Overlain are circles proportional to the distance from forest. This plot excludes damar habitats due to their dominance.

6.7.2 Region

MDS of the bird assemblage showed clear similarity between sites within each region, although in some cases there were sites with avifaunal assemblages rather different from the others surveyed in the same region (Figure 6.30). In the case of L. Monyet, the sites were divided into two types of bird assemblage (Fig 0.29). An ANOSIM showed the inter-regional differences to be significant (Global R = 0.38, P<0. 0001, permutations = 10,000, n> R = 0).

6.7.3 Neighbourhood habitat

The 17 neighbouring habitat types documented were Creek, Pond, Paddy, Crops, Bare ground, Imperata, low scrub, Tall scrub, Forest, Monoculture coffee, Near monoculture coffee - scattered trees, Simple shaded coffee – open, Simple shaded coffee- med closed, Multistrata coffee – open, Multistrata coffee- med closed, Damar agroforest and Human structures (in the plot). MDS of the sites on the basis of the similarity of their neighbourhoods showed some clustering of sites according to the plot's habitat. This is not surprising given the likelihood that at least some of the neighbourhoods would be similar to the habitat within the plot (Figure 6.31).

A RELATE test comparing the similarity matrix for sites on the basis of their neighbourhood, with that of bird species abundance, showed there to be a significant relationship between the two matrices (Rho = 0.57, P=0.001, permutations = 999). A BIOENV test was conducted to select the neighbourhood variables best explaining the multivariate distribution of the bird assemblage. The best combination of no more than five of the documented neighbourhood habitats was low scrub, monoculture coffee, near monoculture coffee, simple shaded coffee-open, and multistrata coffee-open (correlation = 0.52). Thus, the coffee farms of neighbouring areas appear important in determining the bird assemblage at any given plot.

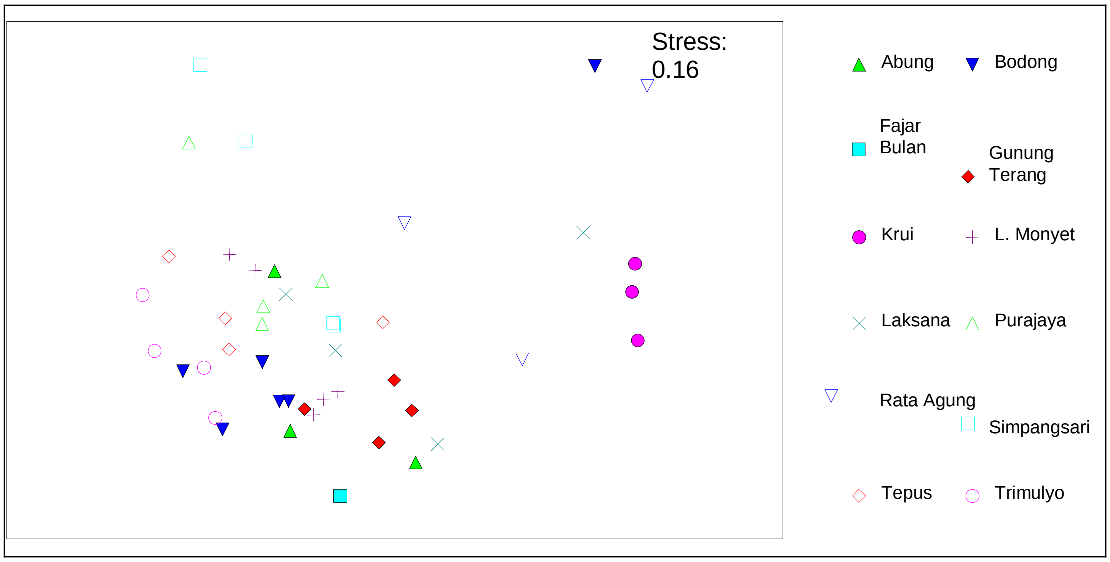

Figure 6.30 MDS of bird assemblages by region.

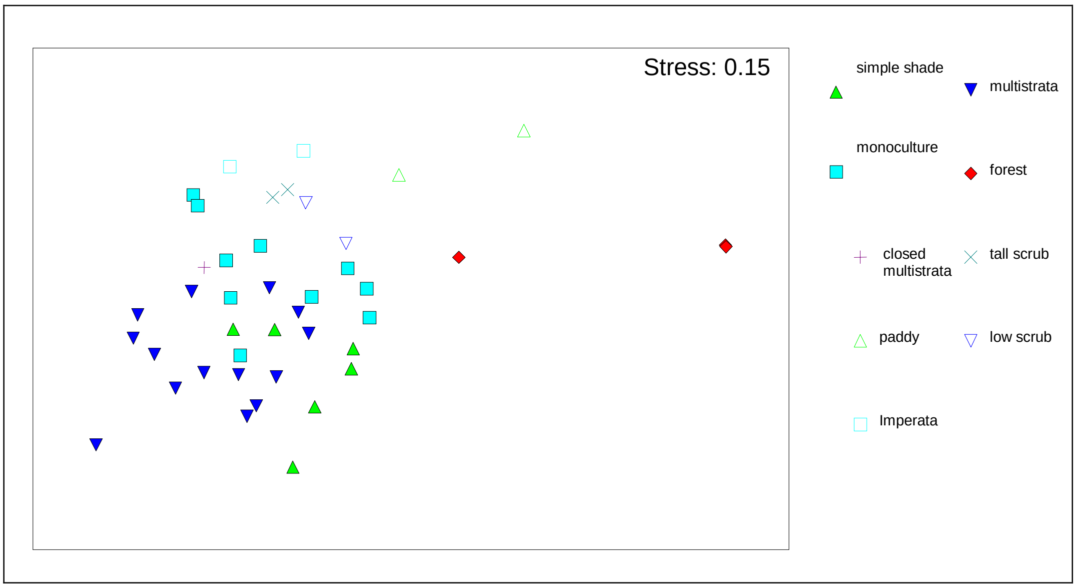

Figure 6.31 The distribution of sites according to the similarity of their neighbouring habitats.

Damar sites are excluded as the extreme difference of their neighbours (100% damar) from all other sites dominates differences in the plot and collapses other sites to a single point.

6.8 Invertebrates

Quantification of the invertebrate biomass gives some indication of the food resources potentially available to insectivorous birds, which are a group of particular interest in disturbed environments. Comparison of common plant types from the coffee gardens, as well as the monocultural and multistrata garden types, indicates how changes in farm management could influence the availability of these food resources.

6.8.1 Invertebrates and plant type

6.8.1.1 Absolute number of invertebrates

When the invertebrates in eight samples for each of five vegetation types were compared, the numbers were very variable for *Gliricidia* in particular. One sample was outlying due to the presence of a large number of very small creatures. When the outlier was excluded the numbers of invertebrates per dry weight were relatively uniform, with the exception of two *Gliricidia* samples, although somewhat more variable in *Erythrina* (Table 6.9) .

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Table 6.9 The mean number of invertebrates per dry mass of vegetation (g) for five plant types.

Site	Plant type					Total
	Erythrina	Gliricidia	Sengon	Nangka	Coffee	
Bodong			1.49			
Bukit Abung	1.13	57.12	1.46	1.14	1.10	
L.Monyet	9.04					
Purajaya		1.45			0.85	
Simpangsari				2.19		
Total no. invertebrates/g per plant type	10.17	58.58	2.95	3.33	1.95	76.98

6.8.1.2 Invertebrate mass

There was considerable variation in invertebrate mass between samples within species, particularly for *Erythrina*, while the differences between plant species were not significant (χ^2=4.1780, d.f.=4, P=0.382). The highest mean score was for *Erythrina* (score mean = 26.13), whilst coffee and *Nangka* scored equal lowest (score mean= 16.3750).

The plants were also designated as leguminous or non-leguminous. Legumes are often popular as agroforestry species, but some farmers reported insect problems with trees in this family, whilst insect damage is also often evident in the field (personal observation). While legumes appeared to have somewhat higher invertebrate masses, the difference between legumes and non-legumes was not significant (Wilcoxon Z= -1.8, P = 0.07, χ^2=3.32, d.f.=1, P= 0.0684).

There was also no significant difference between the invertebrate biomass coffee and non-coffee plants (Wilcoxon Z=-1.10, P= 0.27, χ^2=1.25, d.f.=1, P= 0.27).

Table 6.10 Invertebrate mass (derived from body length) found on eight vegetation samples from each of five plant types commonly found in coffee gardens.

Site	Invertebrate mass (mg/g dry vegetation)					
	Plant type					Total
	Legume			Non-legume		
	Erythrina	Gliricidia	Sengon	Coffee	Nangka	
Bodong			7.31			
Bukit Abung	1.07	1.05	1.43	0.70	0.34	
L.Monyet	7.39					
Purajaya		1.28		0.90		
Simpangsari					0.95	
Total per plant type	8.47	2.33	8.74	1.59	1.30	22.44

6.8.2 Invertebrates and habitat

6.8.2.1 Ground

Micropitfall traps in monoculture coffee collected a total of 1065 invertebrates, compared with 710 invertebrates in multistrata coffee (n=40). Although the mass of invertebrates in the monoculture traps were generally higher than in the multistrata, the difference was not significant (Wilcoxon Z=-1.32, P= 0.19, χ^2 = 1.76, d.f.=1, P= 0.19)(Table 6.11).

Table 6.11 Invertebrate mass in monoculture and multistrata coffee habitats

		Invertebrate mass (mg)			
Habitat	Site	Stratum Ground (pitfall traps)	Coffee (bottle traps)	Aerial (sticky board)	Total mass per habitat
Monoculture	L. Monyet 1	66.13	2.96	0.00	69.09
	L. Monyet 2	101.86	8.61	2.72	113.19
	Simpangsari 4	97.79	1.26	4.94	103.99
	Simpangsari O	64.71	12.17	2.29	79.17
Monoculture Total		330.49	25.00	9.95	365.44
Multistrata	Abung 2	65.60	26.08	4.61	96.29
	L. Monyet 3	49.48	2.75	5.09	57.32
	Simpangsari 2	83.56	19.17	8.46	111.18
	Simpangsari 3	32.93	6.19	2.42	41.55
Multistrata Total		231.56	54.20	20.59	306.34
Total mass per stratum		562.05	79.20	30.54	671.78

6.8.2.2 Coffee layer

In contrast with the ground layer, for traps set at coffee height (1.5 m), the total mass of invertebrates in multistrata (54.20 mg) was greater than that for monoculture (25.00 mg).

However, both these masses, and the number of individuals they represent (40 and 45 individuals for monoculture and multistrata respectively), were very small. The difference between habitats was not significant (Wilcoxon Z=1.19, P =1.93, χ^2= 1.46, d.f.=1, P=0.23).

6.8.2.3 Aerial

Sticky boards mounted at 4m above coffee habitats yielded a total of 20.59 mg of invertebrates in multistrata, compared with 9.95 mg in monoculture. The difference of more than double the mass is a substantial one. However, due to the low total sample mass, as well as the small number of traps, statistical tests were not undertaken.

6.9 Summary of main findings

The numbers of birds were significantly different between habitats. This, however, was largely because there were more overflying birds in open habitats. Bird taxonomic diversity showed a gradient between sites with diversity increasing with structural complexity. This pattern was also true in coffee sites. Differences were significant for all habitats, and between amalgamated shade and monoculture coffee types at genus and family level, but not significant between monoculture, simple shade, multistrata and closed multistrata coffee. All coffee types had lower bird taxonomic diversity than did forest.

Species accumulation curves were also steeper for more complex sites. The curves had not reached plateau but by end of surveys, those in shaded coffee still rising more steeply than that in monoculture. Investigation of species uniqueness showed that in equal samples of coffee and non-coffee sites, 41% of taxa were shared, 17% unique to coffee and 43% were unique to other habitats. In coffee, 23% of taxa were shared between monoculture, shade and multistrata habitats. Of these taxa, 17% were found in two habitats and 60% were found in a single habitat. Clearly there was a difference in the types of birds supported in each habitat. Of those found in a single habitat 33% more species were found in only multistrata than in either monoculture or simple shade. Species turnover between coffee sites was also highest for multistrata, followed by simple shade and finally monoculture. Thus, over the region, multistrata is likely to support a greater number of species than other coffee habitats

Whilst damar and forest habitats had some birds listed as ‘near threatened’, no IUCN-listed birds (and thus, birds of greatest conservation dependence) were found in coffee habitats. Similarity of bird assemblages to that in forest was greater for multistrata coffee than for simple shade coffee, whilst monoculture coffee was even more dissimilar. Interestingly, the single closed multistrata site had a bird assemblage more dissimilar to forest than did monoculture.

The inter-habitat differences between the numbers of birds in each feeding group within simplified habitats were significantly different. However, for many of the individual feeding groups, differences were not significant. There were significantly more granivores in monocultures than in amalgamated shade sites. There was no significant difference between coffee habitat types in the number of insectivores. Nectarivores were particularly well represented in damar, whilst frugivores were only represented well in forest, and moderately in tall scrub.

Inter-habitat differences in guild assemblages were also significantly different. Of the four coffee habitats, multistrata had the most similar guild structure to forest. Again, many of the differences, on the basis of individual guilds, were not significant. However, there were significantly more upper-storey guild birds in the amalgamated shade coffee than monoculture coffee. The hawk guild was well represented in monoculture coffee when the Long-tailed Shrike was included, but modestly represented if it were excluded. Shade coffee scored highly for this guild regardless of whether this species was included or excluded.

The overall inter-habitat patterns were as expected for species classified *a priori* according to their affinity to forest habitats. Within complex coffee types, open country species decreased along a gradient of monoculture, simple shade, multistrata and closed multistrata, whilst ‘moderate cover’ species acted conversely. These differences in ‘moderate cover’ species were significant. Representation of forest edge and forest interior species was poor in all coffee habitats.

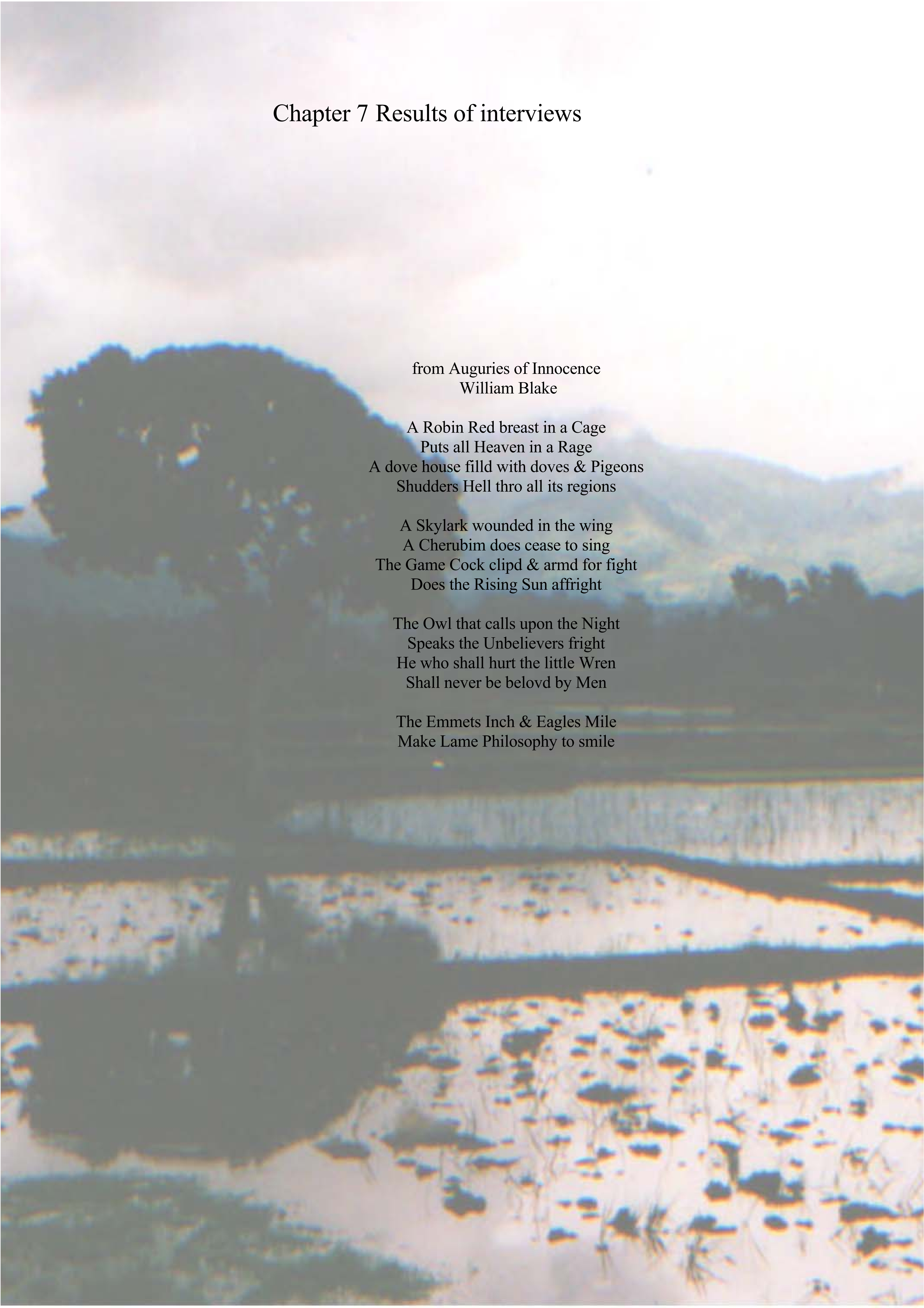
Of those birds recorded using vegetation, most were using trees rather than non-tree types of vegetation. Canopy cover, maximum tree height and canopy depth were variables that appeared to have strong relationships with the bird assemblages. The pattern for ‘number of trees’ was less clear. Of the floristic features examined, tree species richness appeared to have a strong relationship with bird assemblage, while the relationships for understorey richness and dominance by a single species of tree were less clear. The type of dominant tree appeared to have little bearing on the assemblage. Structural and floristic features appeared to have approximately equal importance in explaining the bird assemblage, but the situation appeared rather more complex than the measured variables could adequately explain. Within coffee sites, the strongest contributions to explanation of the bird species assemblages came from the mean of mode tree height and the cover of weeds.

Microhabitat use by birds was significantly different between habitats, and it appeared that both in agricultural and natural habitats, the birds made use of structural features as they became available. In general, there was a pattern for more of the surveyed birds to be in the air in structurally simple habitats, while more were seen using the canopy in the more complex habitats. This pattern was also observed across the gradient of coffee habitats. Of the measured variables, the combination that best explained the patterns of microhabitat use in coffee sites were coffee canopy closure, mean of mode tree height, presence of logs and presence of fallen wood.

Activities undertaken by birds also differed with habitats. In the more open habitats the majority of birds were seen flying overhead, and thus not obviously interacting intensively with the habitats. In more structurally complex habitats there were more foraging birds. These differences were also observed in the various coffee habitats. While many of the inter-habitat differences in individual activities were insignificant, in shade coffee the birds' activities were more broadly spread, including many birds observed perching and flying between perches. For those birds observed foraging, the upper stratum was more commonly used in shade coffee habitats, whilst in monoculture, the coffee and understorey were used more often.

For most sites, there was no clear relationship between the avifauna and the distance from forest, but there appeared to be some regional influence on bird assemblages. Examination of the influence of neighbouring habitats also indicated the importance of management of coffee farms throughout the community.

Finally, while invertebrate biomass was generally higher in samples of leguminous plant species, in particular *Erythrina*, the differences were not significant. Additionally, the invertebrate biomass was higher in multistrata coffee than in monoculture coffee plots at ground, coffee and aerial levels, but, due to the small sample sizes, the differences were not significant.



Chapter 7 Results of interviews

from Auguries of Innocence
William Blake

A Robin Red breast in a Cage
Puts all Heaven in a Rage
A dove house filld with doves & Pigeons
Shudders Hell thro all its regions

A Skylark wounded in the wing
A Cherubim does cease to sing
The Game Cock clipd & armd for fight
Does the Rising Sun affright

The Owl that calls upon the Night
Speaks the Unbelievers fright
He who shall hurt the little Wren
Shall never be belovd by Men

The Emmets Inch & Eagles Mile
Make Lame Philosophy to smile

Results of interviews

The interviews with farmers provided information regarding the management of individual farms that was unavailable elsewhere. Additional information provided by these interviews included the limitations and benefits of growing shade trees of various species. The opinions of farmers and other residents regarding the past and present bird populations in the region were also stated while people also gave opinions regarding the best ways of achieving conservation for avifauna within the agricultural context of the area. Additional investigations of the local functioning of the coffee market, and of the captive bird trade, also provided context for the study.

7.1 Interviewee characteristics

7.1.1 Demography

The interviewed residents were of various ethnicities. Many were transmigrants, mostly born on Java island. However, most had been in the area for at least ten years and some for up to 50 years, having arrived as part of the Government BRN soldier resettlement program. There were also people who were born in the area, both as second-generation transmigrants and previously settled groups, such as the Semendo, who originated from South Sumatra. The latter group were particularly numerous around the Gunung Terang area. In the Sumberjaya area most respondents were of Javanese or Sundanese origin, with the latter group particularly numerous around the location where the study was based, Simpangsari village. In the Pesisir region all interviewed people were of native Lampung origin.

Most of the coffee and damar farmers interviewed were men (30 of 33), although their female relatives were sometimes also involved with the gardens. In some cases these women made comments during the interviews. Of the additional interviewees, who were asked questions regarding their attitudes towards birds and conservation, five of the eleven were women; young women were particularly sought due to their under-representation in the previous sample. The occupations of the additional interviewees were varied. Several were coffee and rice farmers, two were damar farmers, one conducted domestic duties, one was a school student and another worked for a university as an agricultural extension officer.

The ages of the farmers ranged between approximately 30 and 75, whilst the additional interviewees were between 15 and approximately 70 years of age. The interviewees were not questioned regarding their level of education. However, from discussions with local people, it seems likely that many would have been educated to a primary level, with the younger respondents more likely to have secondary education. A few interviewees also mentioned learning about some topics from books, including coffee management theory and the roles of birds in pollination, pest control and seed dispersal. One of the 'additional respondents' was educated to postgraduate level.

7.1.2 Accuracy

The interviewees are the only possible sources of some types of information, such as management practices within their own farms. Thus, there was little potential for cross-checking of data. In one case a farmer claimed to not use herbicide, but was observed doing so during the course of bird surveys. Sometimes there was internal inconsistency within the interview, with apparently contradictory opinions expressed. For example, one farmer said that trapping of birds should be forbidden, but also said that it is alright for people to keep birds as a hobby, despite the fact that these birds are almost all trapped in the wild. Where possible, the multi-faceted nature of opinions offered by individuals has been recorded. In some cases, the additional interviews with people other than the owners of the coffee plots surveyed provided extra, and sometimes contradictory information regarding the sites subject to farmer interviews. For example, a father and son provided strongly contrasting impressions of the local situation regarding bird trapping. In general the interviews have been taken at face value, and interpreted with recognition that the sources are uncorroborated and much of the material relates to the personal opinions of the interviewees.

7.1.3 Farming education

The farmers were asked from where they learned their methods for farming coffee. Some listed only one source of influence whilst others mentioned two or three. Categories were constructed subsequently to encompass the range of answers given. In some cases one answer fitted more than one category, and so has been counted in both.

Learning coffee management from 'relatives' (most commonly being parents), 'experience' and local people of 'Semendo or Lampungnese' ethnicity were most commonly described, being mentioned by 41.4% of respondents (total n= 29) (Figure 7.1). The last category identifies those learning from people likely to have long experience at growing coffee in the region, as these ethnicities were present before the influx of Javanese and Sundanese transmigrants in the 1950s. Thirty one percent of farmers cited 'neighbours' as their source of knowledge, 10.3%

mentioned Government programs, 6.9% mentioned successful farmers in other areas and 3.4% (a single farmer), said that he had learned from his employer.

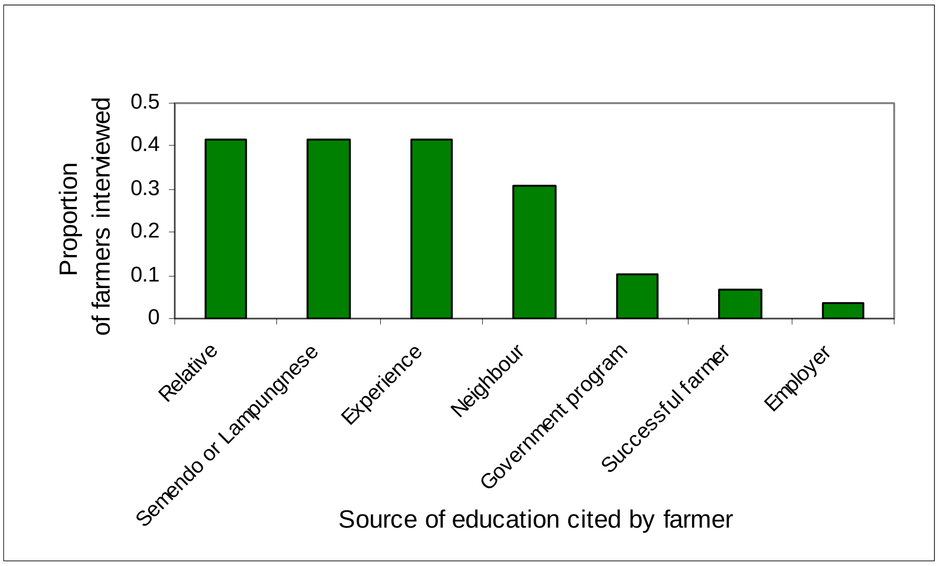


Figure 7.1 Proportion of interviewed farmers citing various sources of education for coffee management techniques.

Many farmers mentioned more than one source, and the groups are not independent, so proportions add to more than 1.

7.2 Farm characteristics

7.2.1 Land tenure

Coffee farmers were asked the tenurial status of the land they managed. Of 31 farmers, 61.3% said that their farm was of '*marga*' freehold status, 29.0% said that the farm fell within '*kawasan*' protected state forest land, 6.4% (2 farmers) said that their farm straddled the border between these two land types, and one farm was on the edge of the national park (Table 7.1). There were inter-regional differences in the balance between these land types in the sampled plots. Simpangsari plots were all of '*marga*' status, while those in Laksana, neighbouring Tepus and also Trimulyo, were all '*kawasan*'. Most regions had a mixture of land status types within the plots studied. Sample sizes were small so the sampled ratios may not be representative of the region as a whole. However, as the regions vary in their distance from protected forest land, they also differ in the likelihood of their constituent farms having a given land status.

Table 7.1 Farm history, tenure and harvest indicated by farmers at all properties surveyed

Site	Habitat	Simple habitat	Tenurial status	Time since deforested (years)	Time since this coffee planted (years)	Length of coffee harvest (months)	Number of harvesters
Abung 1	simple shade	Shade	marga	51	8	3	3
Abung 2	multistrata	Shade	marga	50	26		
Abung 3	simple shade	Shade	kawasan	51		4	4
Bodong 1	multistrata	Shade	marga	70	11	3	3
Bodong 2	simple shade	Shade	marga		12	3	3
Bodong 3	monoculture	monoculture	marga		30	3	5
Bodong 4	multistrata	Shade	marga		25	3	3.5
Bodong 5	monoculture	monoculture	kawasan		2	1	2
Fajar Bulan 1	multistrata	Shade	marga	50	30	4	4
Gunung Terang 1	multistrata	Shade	marga		22	4	4
Gunung Terang 2	multistrata	Shade	kawasan	50	20	4	3
Gunung Terang 3	multistrata	Shade	marga	26	8	2	10
Gunung Terang 4	simple shade	Shade	marga	30	30	4	4
Krui 1	damar	Damar	special Krui arrange ment	60	60		
Krui 2	damar	Damar					
Krui 3	damar	Damar	marga	150	148		
L. Monyet 1	monoculture	monoculture	marga	50	14	4	3
L. Monyet 2	monoculture	monoculture	border	41	5	5	4
L. Monyet 3	closed multistrata	Shade	marga	50	25	3	4
L. Monyet 4	multistrata	Shade	marga	50	50	4	5
L. Monyet 5	multistrata	Shade	marga	50	17	3	3
Laksana 2	monoculture	monoculture	kawasan	50	30	4	3
Laksana 3	multistrata	Shade	kawasan	55		4	1
Purajaya 2	simple shade	Shade	marga	49	8	3	2
Purajaya 4	simple shade	Shade	border	42	3	3	3
Rata Agung 1	multistrata	Shade	marga	20	5	2	2
Rata Agung 3	monoculture	monoculture	national park border	7	7	3	4
Simpangsari 2	multistrata	Shade	marga	70	19	3	5
Simpangsari 3	multistrata	Shade	marga	40	12	3	2
Simpangsari 4	monoculture	monoculture	marga	50	3		5
Tepus 2	monoculture	monoculture	kawasan		2	3	3
Tepus 3	monoculture	monoculture	kawasan	30	2	2	2
Trimulyo 1	multistrata	Shade	kawasan	31	26	4	6
Trimulyo 4	monoculture	monoculture	kawasan	22		3	4

7.2.2 Time since deforestation

Most, but not all farmers knew the time since deforestation of their farms (n=26) (Table 7.1). The maximum time was 150 years, for a Krui damar garden, whilst the minimum time was 7 years, for a Rata Agung coffee garden on the margin of Bukit Barisan National Park. The mean time was 47.0 years (sd = 25.51) whilst the median was 50 years. Many garden locations were first deforested approximately 50 years ago when the Government BRN settlement program began in the Sumberjaya area. There was a difference between coffee habitats in the length of time since deforestation (total n = 28). However, for simplified coffee types this was insignificant (Wilcoxon Z= -1.49, P= 0.1367; χ^2 = 2.3, d.f.=1, P = 0.129). The mean rank Kruskal-Wallis score was higher for shade coffee than for monoculture. This difference is reflected in the landscape, where new, often monocultural, gardens are established at the forest margins, whilst the older gardens are more likely to have mature trees.

7.2.3 Age of coffee

The age of the coffee present in gardens ranged from 2-50 years (mean = 16.4 years, sd = 11.97, median = 13) (Table 7.1). Some sites may have previously had coffee on them but had been cleared and re-planted. The age of coffee was greater in multistrata gardens than in monoculture or simple shade. However, the difference in age between the simplified habitats monoculture coffee and shade coffee was marginally insignificant (Wilcoxon Z= -1.93, P= 0.054; χ^2= 3.80, d.f.=1, P= 0.051) (total n = 28).

7.2.4 Coffee pruning

Ninety three percent of respondents said that they pruned their coffee, whilst the remaining seven percent planned to in the future (total n= 30) (Table 7.2). None of the coffee farmers interviewed stated an intention not to prune. One farmer explained that pruning began after five years and continued every year with entire branches also being removed, as too many branches led to poor fruiting. Another farmer mentioned that his method for pruning coffee changed in 1990 after he introduced grafting. Previously he had only cut the top from the coffee plant (*potong pucak*) but now he cuts all branches to increase fruiting. He claimed that if the branches were uncut the yield of coffee was only 3 kg, but if pruned, it was at least 5 kg.

The frequency of coffee pruning ranged from one to twelve times per year. The mean frequency was 3.05 times (s.d = 3.37), whilst the median was once (total n= 21). There was very little difference in the frequency of coffee pruning between shade (rank score mean = 11.07) and monoculture gardens (rank score mean = 10.96), and the difference was insignificant (Z= 0.00, P= 1.000; χ^2 = 0.002, d.f.= 1, P = 0.966).

New buds were removed rather more frequently than were branches, with the minimum being twice per year and the maximum 24 times per year. The median was six times per year and the mean was 7.54 times (sd.= 4.78), total n = 22).

Table 7.2 Frequency of management activities as indicated by property owners

Site	Habitat	Simplified habitat	Prune coffee? (y/n) f= future	Clean buds (x per year)	Frequency of grass cleaning (x per year)	Grass cleaned manually (x per year)	Herbicide (x per year) (r=rare)	Pesticide (x per year) (r=rare)	Frequency of tree pruning (x per year)
Abung 1	simple shade	Shade	Y	12	3	2	1	y	1
Abung 2	multistrata	Shade	Y	6	4	4	0	0	
Abung 3	simple shade	Shade	Y	8	3	3	r	0	
Bodong 1	multistrata	Shade	Y		6	4	2	0	1
Bodong 2	simple shade	Shade	Y	4	6	6	0	0	
Bodong 3	monoculture	monoculture	Y	6	10	10	0	0	
Bodong 4	multistrata	Shade	Y				r	r	0.3
Bodong 5	monoculture	monoculture	F		4	4	r	0	
Fajar Bulan 1	multistrata	Shade					r	1	2
Gunung Terang 1	multistrata	Shade	Y		5	5	r	3	3
Gunung Terang 2	multistrata	shade	Y	8	4	4	r	0	
Gunung Terang 3	multistrata	shade	Y	7	5	5	r	0	
Gunung Terang 4	simple shade	shade	Y	8	8	8	0		1
L. Monyet 1	monoculture	monoculture	Y	4	4	3	1	0	4
L. Monyet 2	monoculture	monoculture	Y	6	4	3	1.5	1	
L. Monyet 3	closed multistrata	shade	Y		3	3	3	2	
L. Monyet 4	multistrata	shade	Y		6	1	5	0	0
L. Monyet 5	multistrata	shade	Y	12	5	4	1	2	1
Laksana 2	monoculture	monoculture	Y	12	5	5	0	r	
Laksana 3	multistrata	shade	Y	12	6	3	3	r	0
Purajaya 2	simple shade	shade	y	6	5	2	2	2	0.5
Purajaya 4	simple shade	shade	y	6	2	2	0	r	1
Rata Agung 1	multistrata	shade	y	3	5	5	r	2	
Rata Agung 3	monoculture	monoculture	y	3	7	7	7	3	1
Simpangsari 2	multistrata	shade	y	4	4	4	0	2	
Simpangsari 3	multistrata	shade	y		8	5	2	y	
Simpangsari 4	monoculture	monoculture	y	24	6	5	r		
Tepus 2	monoculture	monoculture	y	8	6	6	0	0	
Tepus 3	monoculture	monoculture	f	5	5	5	5	r	
Trimulyo 1	multistrata	shade	y		4	0	4	2	0
Trimulyo 4	monoculture	monoculture	y	2	4	2	2	0	

7.2.5 Weeding

All respondents removed grass and other weeds from their coffee gardens, with the frequency varying between twice per year and ten times per year (total n = 29) (Table 7.2). The median frequency was five times per year. This was done by either weeding manually, using a hoe-type tool called a *cankul*, or by using herbicides. Many farmers used a combination of these techniques.

The frequency of grass removal was slightly higher in monocultures than in shade gardens, but not significantly so (Wilxoxon Z = 0. 73, P = 0. 467; χ^2 = 0.564, d.f.=1 P= 0.453). Manual weeding was more common than herbicide use. Some farmers commented that herbicide was used more frequently in the past when coffee prices were higher. Additionally, some respondents commented that herbicides were damaging to the soil and to crops. The frequency of manual weeding ranged between 0 -10 times per year. The median was 4 times, whilst the mean was 4.14 (s. d. = 2.08) (total n= 29). The frequency of herbicide use ranged from 0 - 7 times per year, with the distribution skewed towards the low end of this range. The mean frequency was 1.8 times per year (s.d. = 1.99) whilst the median was 1.25 times (total n = 22). An additional nine farmers stated that they 'rarely' used herbicide.

7.2.6 Fertiliser

Of the 29 respondents to the question regarding frequency of fertiliser use, 35% did not use any industrially produced fertiliser during the survey year (Table 7.2). Some farmers who did not use fertiliser said that they would prefer to do so, as they had done in the past, but current financial conditions did not allow this. The maximum frequency of fertiliser application was twice per year. The median frequency was once, whilst the mean was 0.86 (s.d. = 0.73) times per year. There was very little difference between frequency of application in monoculture and shade coffee gardens.

7.2.7 Pests

All of the farmers who were asked about the occurrence of pests in their coffee mentioned at least one type of pest, and in many cases described two or three. Their responses have been grouped into the lay categories of 'grub', 'ant', 'insect', 'fungus' and 'unknown pest'. These categories are clearly not taxonomically independent but fit the way in which the major pests are perceived and described locally. 'Grubs' were described in the soil, boring in the coffee stems and on the leaves and fruit. Problem ants were described variably as disturbing workers and defaecating on flowers, allegedly preventing fruit set.

Of 31 respondents, 77% reported problems with 'fungus', 71% with 'grubs', 39% with 'ants' and 9% with 'insects'. Ten percent reported unknown pests as causing problems (total n = 30), whilst 47% suggested that pest problems were serious (total n= 17). The mean number of 'pest types' was slightly higher in monocultures (2.13) than in either simple shade (1.67) or multistrata (1.64), although the total sample size of 28 is rather small and the method of description simple. Farmers described various strategies for dealing with the disturbances to their coffee. These included spray application of pesticide, burying of pesticide and burning and burying of affected branches (for fungal problems). Some farmers stated that they did not know how to respond to the pests.

When asked whether they used pesticides, 41% of farmers responded that they did not (Table 7.2). The most frequent application was three times per year (7% of farmers) (total n = 29). A further 7% stated that they used pesticide, but did not say with what frequency. Seventeen percent of farmers said that they used pesticides rarely, when it was apparent that they were needed. When monoculture and shade coffee farms were compared, 55% of the shade farms did not have pesticide application, whilst 35% of the monocultures had no pesticide in the current year. However, this result must be treated with caution due to the small sample sizes of 20 and 9 farmers respectively.

7.2.8 Organic status

According to a local coffee trader, an international coffee buyer enquiring about organic coffee described the required condition as a farm being free from manufactured chemical application for at least two years. (OCIA certification requires three years 'chemical-free'). According to the farmers' accounts of fertiliser, pesticide and herbicide application, during the year 2002 only two of the farms studied met the 'chemical free' status (Figure 7.2). These were Abung 2 (a 'multistrata' farm) and Bodong 3 (a 'monoculture' farm). It is not known if they would have met these requirements in the previous or following year. Many farmers said that they had reduced or ceased their application of various chemicals due to the high price relative to the price received for coffee at the time.

If those farmers who did not quantify application of pesticide and herbicide beyond the description 'rare' are considered to have an acceptably low application frequency, the number of farms having potential to achieve organic status, with minimal change in management, is extended by three farms (of 24 with sufficient information provided) (Figure 7.3). The additional farms were Abung 3 ('monoculture'), Laksana 2 ('monoculture') and Purajaya 4 ('monoculture'). Thus it appears that monocultures are disproportionately represented in the farms with near 'chemical-free' status.

Viewed as regions (albeit on the basis of small samples), Bodong appears to have very low use of pesticide and herbicides, but higher frequency of fertiliser application. Gunung Terang farms studied also had low use of herbicides and only annual application of fertiliser.

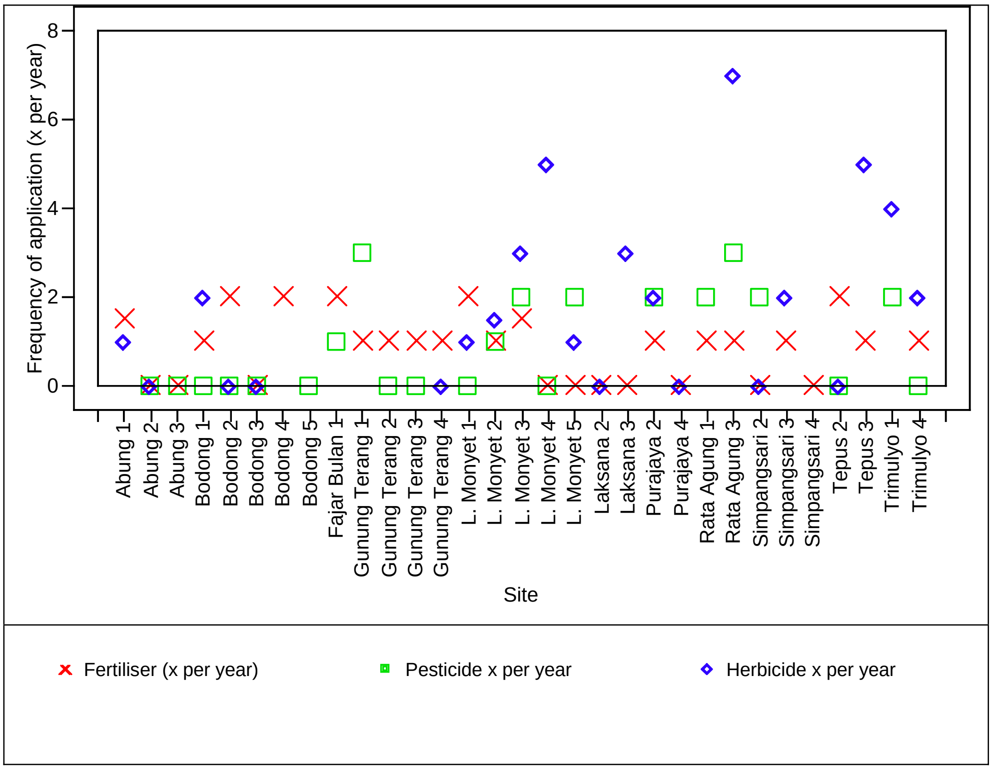


Figure 7.2 Stated frequency of application of manufactured chemicals (pesticides, herbicides and fertilisers) at each site, including only those frequencies quantified by farmers.

Only Abung 2 and Bodong 3 appear potential candidates for 'organic' status.

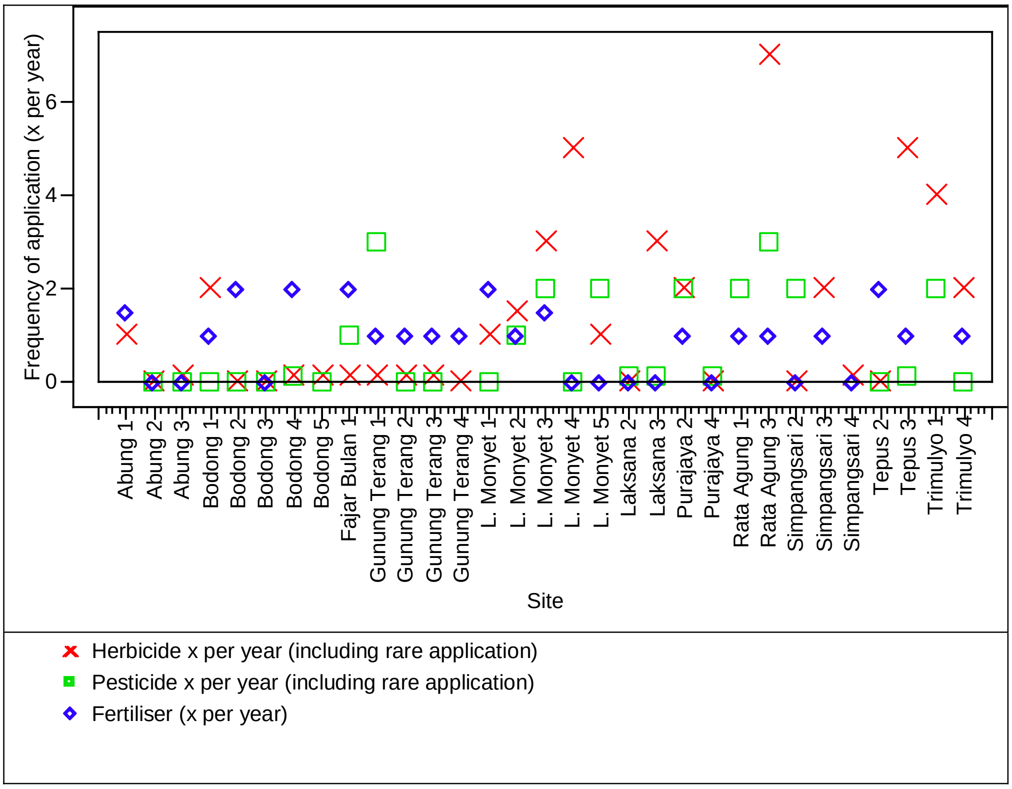


Figure 7.3 Frequency of application of fertilser, pesticides and herbicides stated by farmers at each site.

Assigns a frequency of 0.1x per year to the descriptions of 'rare' application of pesticide and herbicide.

Some farmers said that it would be possible to grow coffee organically, although there were some concerns regarding the availability of sufficient organic fertilisers, making it difficult to maintain soil fertility. In some cases the soil was described as being fertile from the forest for several decades after deforestation.

7.2.9 Harvest

Coffee harvest would appear to be one of the most intensive disturbances to fauna within a coffee garden in that it requires the constant and ongoing presence of labourers in the garden, physically disturbing the coffee bushes. Harvest length ranged from one month to five months (median = 3, mean = 3.24, s. d. = 0.83) (Table 7.1). The median length of harvest was the same in shade and monoculture coffee.

Intensity of disturbance seems likely to be influenced by the number of harvesters involved. This ranged from one person to ten. The median number was 3.25 whilst the mean number was 3.65 people (s. d. = 1.64). The median number of harvesters in monoculture was 3.5, compared with 3.25 in shade coffee.

7.3 Shade trees

7.3.1 Sources of trees

The farmers cited various sources of trees, which were planted either as seeds, seedlings, cuttings, or self-germinated. Some tree seeds and seedlings were bought from Government agencies, such as the Forestry Department and the Department for Agriculture, or from other commercial sources. Other seedlings were also given to farmers by the Government, as part of various agricultural and re-vegetation schemes. Farmers also mentioned self-selecting seeds and germinating these, particularly those from productive fruit trees. Many seeds and cuttings were taken from other gardens owned by the farmer, or from neighbours. Cuttings from *Gliricidia* trees in particular were often sourced in this way. In some cases seedlings were taken from the scrub or forest and transplanted. This was particularly frequent in the Pesisir region. In the damar gardens of Krui there was also a tendency for self-germinating forest trees to be retained, if they were known to be of a useful species. Several farmers mentioned past problems with availability of suitable trees and with the cost of these, but it seemed that in 2002 fewer people found this a problem.

7.3.2 Age of trees

The maximum known age of trees was 100 years, in a mature damar agroforest. The minimum age was one year. These saplings were not yet of sufficient size to be recorded as ‘trees’ in the vegetation survey, but were species that would later grow to tree size. Distribution was greatly skewed towards young trees, with most farms having trees of less than ten years. The median age was 9 years, while the mean was 22.3 years (sd = 26.5, total n = 28).

7.3.3 Pruning

Eighty-three percent of farmers said that they currently pruned their trees (total n= 29), thirteen percent said they did not, and three percent (one farmer) planned to in the future (Table 7.2). For the farmers who quantified this, the frequency of pruning ranged from never to four times per year. The mean was 1.28 (s. d. = 1.16), whilst the median was one pruning per year (total n = 14). Reasons for pruning commonly included maintaining light penetration to the coffee understorey, but some farmers also mentioned that removing side branches would cause the trees to grow taller (which was seen as desirable), or that *Gliricidia* trees supporting pepper vines should be maintained below a certain height.

7.3.4 Reasons for having trees

The farmers named the main motivating factors for maintaining or planting trees in coffee farms. Many farmers mentioned more than one advantage of trees that they found important (Figure 7.4). The most common answer, mentioned by 83.3% of respondents, was to “shelter coffee” from sun and wind (total n= 30). Many farmers stated further, that without shade, coffee plants would become too dry, have yellow leaves and low survival. Trees being grown for their produce, including fruit, nuts, timber and kapok were described by 51.6%, 40.0% mentioned that they grew trees to improve soil fertility, and 36.7% for support of other crops (in particular, pepper vines), while 30.0% each mentioned erosion prevention and improvement or control of soil moisture. Two farmers (6.67%) said that weed prevention was a reason for growing trees, while a single farmer (3.3%) said that trees were grown to fill farmer group requirements.

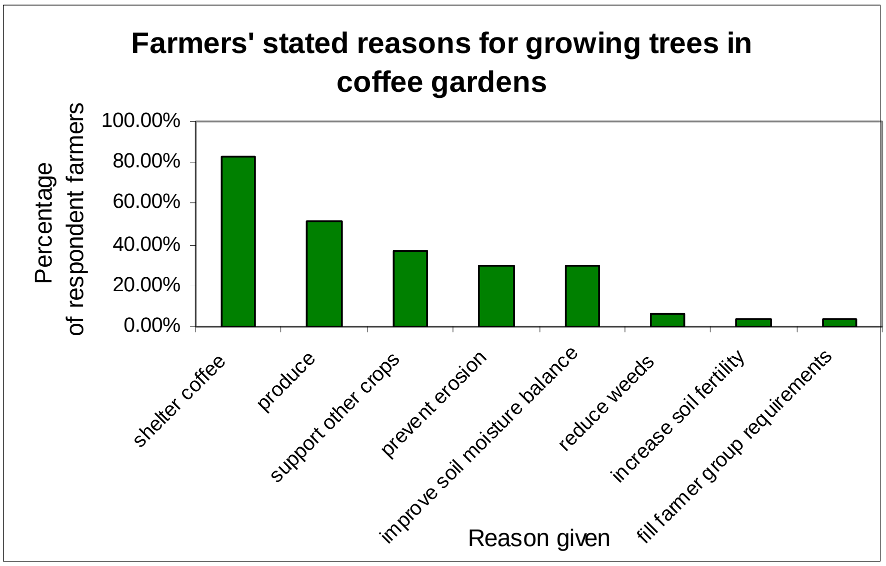


Figure 7.4 Interviewed coffee farmers' stated reasons for growing trees in their gardens.

Farmers often gave more than one reason, thus percentages sum to greater than 100. (Total n= 30)

7.3.5 Problems with shade tree health

Of 24 coffee farmers, 37.5% stated that they had problems with the health of their trees, 54.1% did not, while 8.3% had experienced problems in the past. Both of the damar farmers in the main pool interviewed also cited problems with tree health. Of 25 coffee farmers, 92% said that the species of trees they were growing were suitable for the area, while 4% (one farmer) each stated that their trees were unsuitable and that species were mixed in suitability. Farmers described problems including pests, particularly affecting *Erythrina*, which is vulnerable to borers. Borers also apparently damaged mahoghany, while grubs ate the leaves of some trees. Some trees were also described as being vulnerable to fungal damage, particularly damar trees that have their trunks regularly opened for tapping. One coffee farmer also suggested that fungus may have affected his candlenut trees. This weakening was described as leaving both the candlenut and damar trees vulnerable to breakage in the wind. Other trees were described as suffering from unknown pests. The seriousness of problems ranged from widespread tree death to slow growth or poor fruiting. The former problem was explained as occurring throughout the region for clove trees, which were affected by a fungal problem in the early 1980s, causing entire plantations to die. Other trees had died *en masse* for unknown reasons, but farmers suggested a lack of suitability for the region and lack of information provided for their care. These comments particularly related to seedlings provided as part of Government revegetation programs. In particular, farmers mentioned problems with fruiting and growth of durian, *petai*, *nangka* and mango trees, possibly due to the climate of the area, which is cooler than much of the province, and also Java island. Poor quality seedlings were also mentioned as a limiting factor, while inadequate soil fertility and moisture content were also blamed for poor growth of some trees. Root competition was mentioned as an additional problem.

7.3.6 Impact of trees

Of the 31 coffee farmers interviewed, all said that shade trees had benefits for coffee farms. However, only 17.29% stated absolutely that the trees had no negative impact on coffee (total n=29). A single farmer (3.5%) said that his trees currently had a negative impact on the coffee, while most farmers (75.8%) held some reservations, saying that trees of some species, or trees planted in the wrong place or with the wrong maintenance, could interfere with coffee productivity.

The main reasons for the reservations stated by the farmers were that too dense shading by the canopy would reduce coffee fruiting, and that inappropriate tree species choice or distribution would result in root competition for soil nutrients. However, there were also farmers who maintained that the benefits of dense shade out-weighed any detrimental effect; that coffee would still be healthy if it were properly maintained or that there was simply no problem with a dense canopy. One farmer commented that it was not the very tall over-canopy, but the mid canopy that provided over-shading problems. Methods for avoiding problems with over-shading commonly included pruning of trees to increase light penetration as well as wide spacing of trees.

Differences in leaf size and canopy architecture of various tree species also prompted a comment that some trees, such as candlenut and *jengkol,* are unsuitable due to over-shading, but *petai* (which is a legume with feathery, segmented leaves) does not cause the same problems. In contrast, another farmer with many candlenut trees claimed no problem with over-shading. Alternatively, difference was also identified in species of coffee, with a Krui damar farmer stating that when coffee was grown in the region, for a lengthy period below a canopy, it was of *Coffea arabica* species, rather than *Coffea robusta*, which is most commonly grown in Lampung today. One farmer also mentioned that grafted coffee has higher shade requirements than does ungrafted coffee, but was directly contradicted in this claim by another. Also in the Pesisir region, farmers described the loss of coffee production due to over-shading as being unimportant if other crops such as damar trees were simultaneously coming into production. Several farmers also mentioned potential problems of shade being excessive for pepper to produce well, stating that coffee requires or tolerates a higher level of shading.

The second main potential problem identified was that of root competition. This was also commonly related to particular species. Amongst the trees mentioned as being ‘greedy’ of nutrients were durian, candlenut, *kapok*, rambutan, *Calliandra* (a plant used locally in Government re-afforestation programs of the 1990s), *kayu afrika*, cinnamon, coconut, rambutan, bamboo, *sonokeling* and sugar palm. One farmer disagreed that candlenut caused problems due to root competition, as did another regarding durian. Another contradicted the opinions of most farmers by saying that *Gliricidia* was too demanding of nutrients. Some farmers mentioned that problems of root competition could be overcome by planting trees and coffee with sufficient spacing, or by distributing ‘greedy’ trees around the perimeter of gardens. The rate of composting of leaves was another factor for discriminating tree suitability as this affected the return of nutrients to the soil. *Erythrina*, *suren* and mahogany were mentioned as having leaves that rapidly composted, whilst cinnamon and candlenut were identified as being undesirable due to slow rates of leaf decomposition. Additional problems for coffee associated with shade trees included the harbouring of insect pests and fungal growth if coffee is not allowed to dry. In contrast, one farmer said that coffee must not be able to dry or it would suffer, and another said that a dense canopy was problematic as it allowed insufficient rain infiltration to the coffee underneath.

7.3.7 Planting succession

Farmers were asked in what order coffee and shade trees should be planted, and the preferred length of time between plantings. Sixty percent of interviewed farmers stated that coffee should be planted before shade trees (total n= 31) (Figure 7.5). One reason given for this was the avoidance of root competition. The maximum length of time suggested before planting of shade trees was four years. Nine farmers (30%) said that coffee and shade trees should be planted at the same time. Only three farmers (10%) suggested planting shade trees before coffee, with the maximum gap recommended for this being three years. One of the farmers who recommended planting shade trees first said that this would avoid problems of drought for the coffee plants.

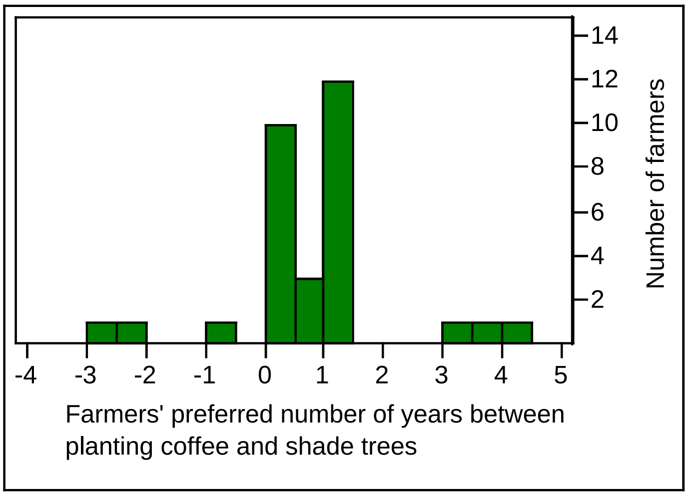


Figure 7.5 Distribution of interviewed farmers' preferences for length of gap between planting coffee and shade trees.

A positive number indicates coffee being planted first, while a negative number indicates shade trees being planted first.

Farmers were further asked if coffee could be successfully planted and grown beneath a mature, pre-existing canopy. Of 29 farmers, 44.85% said that this was possible, 17.2% said that it might be possible, but had reservations or conditions on this, 3.4% (one farmer) each was neutral in opinion, and moderately negative regarding the possibility and 31% said that it was not possible. Those who had reservations cited reasons including root competition and over-shading causing poor growth and fruiting. Many farmers suggested that these problems could be managed if there was sufficient distance maintained between the trees, and between the coffee plants. One farmer suggested a spacing of at least three metres between stems. Farmers also recommended that the trees first be pruned, to allow greater light infiltration. In addition, some farmers distinguished between species of shade tree when commenting on likely success of planting below a mature canopy. The locally popular agroforestry trees *Erythrina*, *Gliricidia* and *sengon* were seen as creating little problem. One farmer said that durian, sugar palm and mango would also be suitable, whilst another suggested that durian would not be appropriate for planting over coffee. One respondent said that he had successfully planted coffee below *nangka* trees already aged 50 years.

7.3.8 Additional comments on tree choice

Some farmers made additional, interesting comments on their choice of trees. The benefits of diversifying income were noted by several damar and coffee farmers, with one farmer particularly identifying the variation in price of cash crops such as cloves, as a reason for planting various tree types. Cocoa was particularly mentioned as a useful crop for growing when coffee prices are low. Additionally, one farmer commented that farmers should be careful in planning crops; to be prepared, patient and not merely reactive. He suggested that they should plant particular crops while their prices are low and maintain them to be already productive when prices have risen, so as not to be left behind economically. Pepper, which had a rather low price at the time of survey, was mentioned as a crop that was timely for cultivation. Other farmers who had unusual crops such as mahoghany fruit (which is apparently valuable as a medicine), as well as arabica coffee, cited problems with marketing these products.

7.4 Birds

7.4.1 Attitudes towards birds

The farmers indicated whether they felt positively or negatively about birds, and in particular, the birds that visited their gardens (Table 7.3). Of 33 respondents, 72.7% were clearly positive, 6.0% were marginally positive and 21.2% felt neutral. No farmers stated an overall negative feeling. On the basis of farm-type, both damar farmers were clearly positive in their view of birds; 50.0% of monoculture farmers were positive and 10% marginally positive, while 81% of shade coffee farmers were positive and 4% marginally positive.

7.4.2 Knowledge about birds

In order to assess overall farmer perceptiveness and understanding of local avifauna they were subjectively assessed regarding their knowledge of local birds. They were shown pictures of species and asked if these were found in the gardens, as well as being asked for further explanations of the birds' locations and habits. Scores between one and three were assigned. Of 29 farmers, 55.2% were assessed as having 'good' knowledge. The overall profile was similar for monoculture and shade farmers (Table 7.3).

Table 7.3 Respondent attitude toward and knowledge of birds

Respondent type	Attitude to birds				Knowledge of birds						
	Negative	Neutral	Marginally Positive	Very Positive	Poor	Moderate	Good	Very good	Excellent	Not known	Total
monoculture		4	1	5	2	1	5		1	1	10
shade		3	1	17	4	3	11		1	2	21
damar				2				1		1	2
extra interview				9	2		1		1	5	9
Total		7	2	33	8	4	17	1	3	9	42

7.4.3 Birds in gardens

7.4.3.1 Benefits of birds and damage by birds

Of 33 coffee and damar farmer respondents, 57.6% said that birds helped the garden (Table 7.4). The remainder were neutral; either having no opinion or identifying ways in which birds damaged the garden as well as ways in which they helped the garden. No farmers felt that birds only damaged coffee or damar gardens, although some were resentful of damage to rice paddy.

Farmers also specified in the way in which their garden was helped by birds. Of the 33 farmers, 66.7% said that birds helped control pests, 12.1% said that they helped with pollination, 6% said that soil fertility was benefited and 3.0% (one farmer) said that birds helped with seed dispersal, particularly of sugar palm and durian. Within the 'shade' coffee farmers, 78.6% of 14 multistrata coffee farmers said that the birds controlled pests, compared with 50% of the 6 simple shade coffee farmers ; 28.6% of the multistrata farmers cited pollination as a benefit, compared with no simple shade coffee farmers. Control of ants and grubs was particularly attributed by one farmer to woodpeckers and Sooty-headed Bulbuls, and by another to spiderhunters.

Table 7.4 Perceived help and damage by birds in gardens

(Number of responses is greater than number of respondents due to multiple responses by individuals).

Habitat	Damage or help garden			How help?			How damage?		Total number of farmers
	overall damage	neutral	overall help	eat pests	pollination	fertilise soil	eat wood	eat flowers	
closed multistrata			1	1			1		1
damar		1	1	2			1	1	2
monoculture		7	3	5		1			10
multistrata		3	11	11	4				14
simple shade		3	3	3					6
Total number of responses	0	14	19	22	4	1	2	1	33

In specifying damage 6.1% of all respondents said that birds damaged trees by eating the wood (in particular woodpeckers were described as speeding up tree death), and 3.0% (one farmer) said that sunbirds feeding from durian flowers caused them to fall. However, another farmer said that birds help to pollinate durian flowers. Also, one farmer said that cuckoo doves eat some unripe coffee berries, but not in sufficient numbers to be a pest.

7.4.3.2 <u>*Perceived number of birds in garden*</u>

Farmers gave their opinion on whether many birds visited their gardens. Of 33 damar and coffee farmers[16], 51.5% responded positively, 42.4% responded negatively and 6.1% (2 farmers) were uncertain. When examined in categories of farm types coffee 'shade', 'monoculture' and 'damar', a greater proportion of farmers of coffee monocultures believed that they had many birds at their farms, than did shade coffee farmers. However, sample sizes within categories are rather small. All damar farmers believed that many birds visited their farms. In some cases it is not entirely clear whether the farmers interpreted "many birds" to mean many individuals or many bird species.

7.4.3.3 <u>*Observed bird microhabitat use*</u>

The farmers indicated the parts of the garden where they observed birds. Of 32 interviewees, the majority (71.8%) said that birds were seen in shade trees, in coffee (65.6%), in the air (18.8%) and in the understorey or ground (also 18.8%). There were some differences between the responses of farmers of monoculture coffee, shade coffee and damar (Figure 7.6). The monoculture farmers more commonly cited seeing birds in the coffee and in air, than did their shade coffee counterparts, whereas the latter observed more birds in the shade trees and in the understorey.[17] Both damar farmers described seeing birds in tree canopies.

7.4.3.4 <u>*Observed bird activity*</u>

Farmers also described the activities of birds that they observed in their gardens. Again, many people gave more than one answer. The most popular response was 'foraging' (78.1% of respondents), followed by 'nesting' (37.5%). The other responses were 'flying' and 'playing', each mentioned by 15.6% of respondents, 'singing' (9.4%), 'perching' (6.25%) and 'sleeping' (3.1%)(total n= 32, Figure 7.7). Shade coffee farmers more commonly reported foraging behaviour than did monoculture coffee farmers, while flying was reported more often by monoculture farmers than by shade coffee farmers. 'Playing' was also more commonly reported by shade coffee farmers. Both damar farmers identified birds as 'foraging'.

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16 This number includes two damar farmers interviewed additional to the main pool linked with survey sites, as the sample of damar farmers was small.

17 Coffee gardens that were classified as "monocultures" for the purpose of the bird surveys may have some trees, up to a maximum of 6.25% cover. Additionally, the survey plots rarely covered the entire farm but farmers are likely to refer to their experiences across their entire farms, some of which may have tree cover different from that in the plot that was classified for the study.

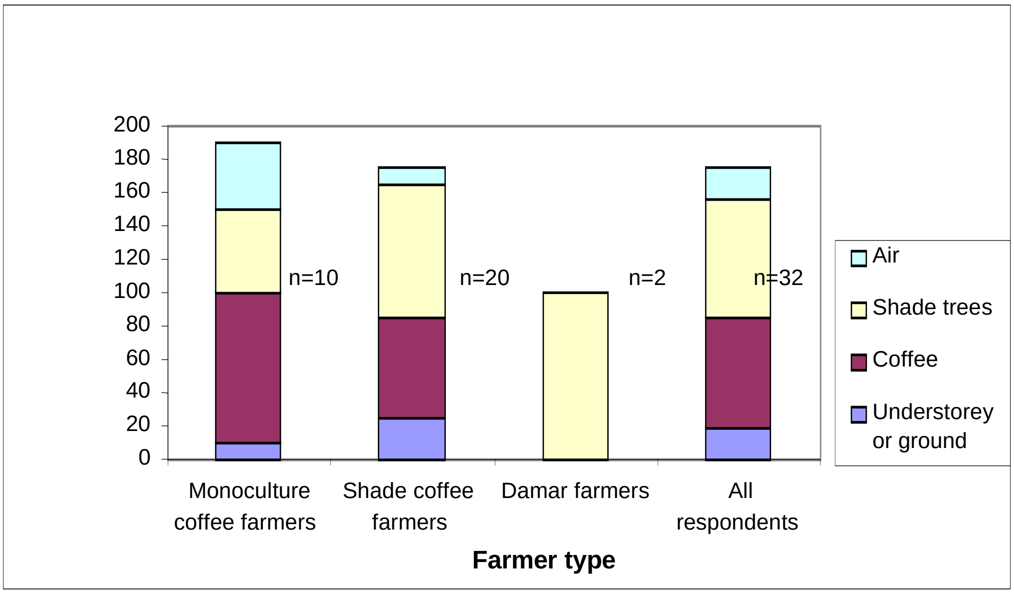

Figure 7.6 The percentage of respondent farmers of gardens classified as 'monoculture coffee', 'shade coffee' and damar for this study, and their descriptions of where they have seen birds in their gardens.

Percentages for each group may add to more than 100 as many farmers gave more than one answer.

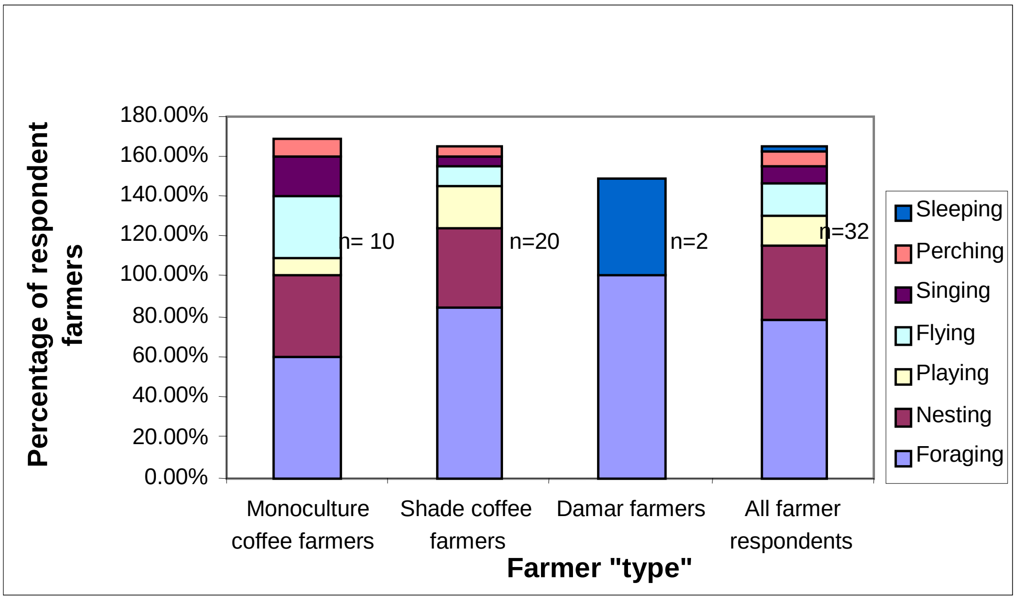

Figure 7.7 The percentage of respondent farmers of gardens classified as 'monoculture coffee', 'shade coffee' and damar for this study, and their descriptions of the activities in which they have seen birds engaged in the gardens.

Some respondents gave more than one answer so percentages add to more than 100.

7.4.4 Perceived bird population trends and assemblage change

7.4.4.1 Bird population

Region

The opinions of respondents (including the ‘extra interviewees’) regarding the trend in bird populations were examined by region, which naturally influences peoples’ immediate experiences of local bird assemblages[18] (Table 7.5). Due to the great number of areas, the sample sizes are rather small, ranging between two and seven people. However, it is clear that for the total population, there was a dominant feeling that bird populations had declined, with 69.77% identifying a clear decline and an additional 9.3% claiming a slight decline. In the total sample of 43 people, 18.6% said there had been no change, and only 2.33% (one person) said that local bird populations had increased.

Table 7.5 Responses collected from different regions regarding bird population and assemblage change and possible causes

Bird assemblage change?									Possible reasons for change						No. per region
	Population increase or decrease?					Species change			trap to sell			habitat loss			
Region	major decrease	minor decrease	no change	increase	no response	no	yes	no response	no	yes	no response	no	yes	no response	
Abung	2		1			1	2		3			1	2		3
Bodong	4		2			2	2	2	5	1		4	2		6
Fajar Bulan	2						2		1	1		2			2
Gunung Terang	3		1			1	3		2	2		3	1		4
Krui	3	1			1	2	2	1	1	3	1	2	2	1	5
L. Monyet	5		1	1		1	4	2	4	3		1	6		7
Laksana	3						3			3		2	1		3
Purajaya	3						3			3		1	2		3
Rata Agung	1		1			1	1			2		2			2
Simpangsari	3	1	1		1	2	3	1	4	2		3	3		6
Tepus		1	1			1	1		1	1		2			2
Trimulyo	1	1					1	1		2			2		2
No. respondents	30	4	8	1	2	9	21	6	21	23	1	23	21	1	45

Farm type

The opinions of farmers were also examined with relation to the type of farm they maintained (Figure 7.8). Of 35 farmers, including two damar farmers additional to the main pool linked to survey sites, the majority (65.7%) believed that there had been a decline in the bird population; an additional 8.6% said there had been a slight decline, 22.8% said that there had been no change. Only one farmer (2.9%) believed that there had been an increase. Whilst damar and shade coffee farmers overwhelmingly believed that populations had declined, a high proportion of monoculture farmers believed that there had been no change.

[18] For “extra interviewees” the region was assigned by the location of the person’s usual work. For those sometimes involved in coffee garden maintenance it was defined by the location of the garden.

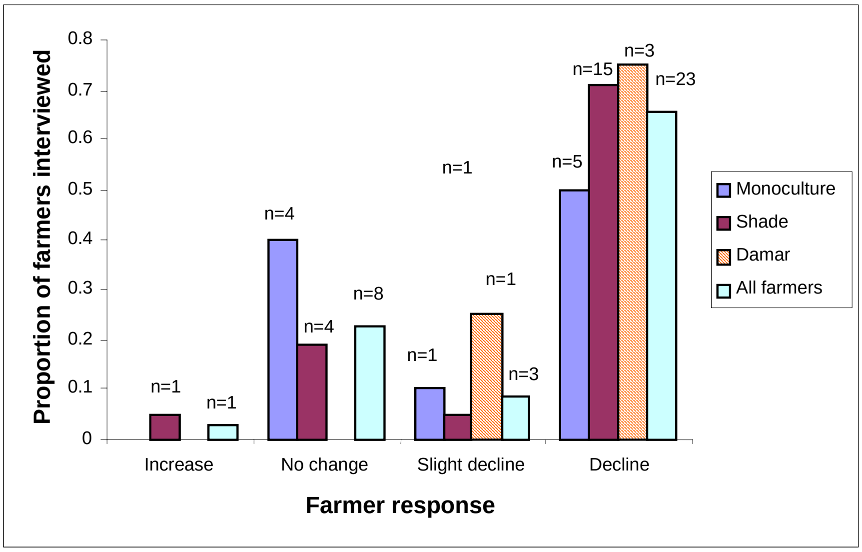

Figure 7.8 Responses of farmers on bird population trends.

7.4.4.2 Species change

Of the 38 respondents who expressed an opinion, 71.1% said that there had also been a change in the bird species locally present within their memory (Table 7.5). The belief in a species change varied somewhat between regions. In Purajaya, all three respondents believed that there had been a change in bird species composition, whereas in both Bodong and Krui, two of the four respondents in each region said that there had been no change. While these sample sizes are again very small, these examples illustrate the possibility for substantial, inter-regional difference in opinion regarding the status of bird populations. Again, these results were differentiated on the basis of garden type, with 79% of the 19 shade coffee farmers stating that there had been a change in the species present, whilst only 59% of the seven shade coffee farmers stated such a belief.

Several people commented that more bird species used to live close to their village. These included barbets, Java and Hill Mynas (*jalak* and *beo*), fruit pigeons, magpie robins and drongos. The latter birds were described as roosting in the forest and coming out to the coffee gardens to feed after rain. Farmers also said that in contrast with the past there are now only a few common species locally, including Long-tailed Shrike and Sooty-headed Bulbul. There was some indication of birds such as the Sooty-headed Bulbul, becoming more common, as well as other species becoming more rare, or absent. Some farmers said that there were now 'small' rather than 'good' birds in their gardens. One farmer quantified the change as '20% less species' than in the past. In contrast, some respondents were adamant that there had been no change.

7.4.5 Reasons for and time of bird population change

7.4.5.1 <u>Time of change</u>

Some of the respondents who identified a decrease in populations also gave an opinion about the length of time this had taken to occur. The respondents were almost evenly divided between groups stating that the changes had mainly occurred since some time in the past ten years (42.8%) and those who believed that they had occurred at least 20 years ago (50%)(total n= 14; Figure 7.9).

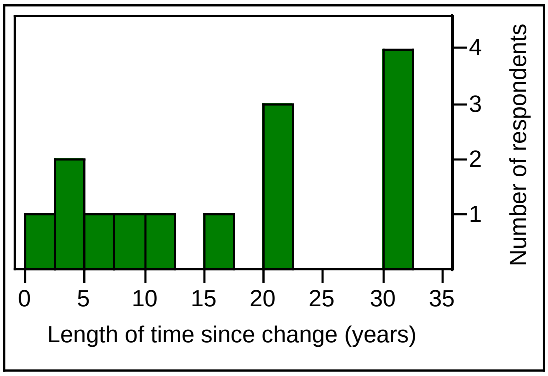

Figure 7.9 Distribution of respondents' opinions regarding the length of time over which bird populations have declined. (total n=13)

7.4.5.2 <u>Region</u>

The opinions regarding the length of time over which bird declines have occurred were also compared with the farmers' reports of time since deforestation for plots within the same region. However, no clear pattern emerged beyond that the observed bird declines were always subsequent to the stated time of deforestation in each region (Figure 7.10).

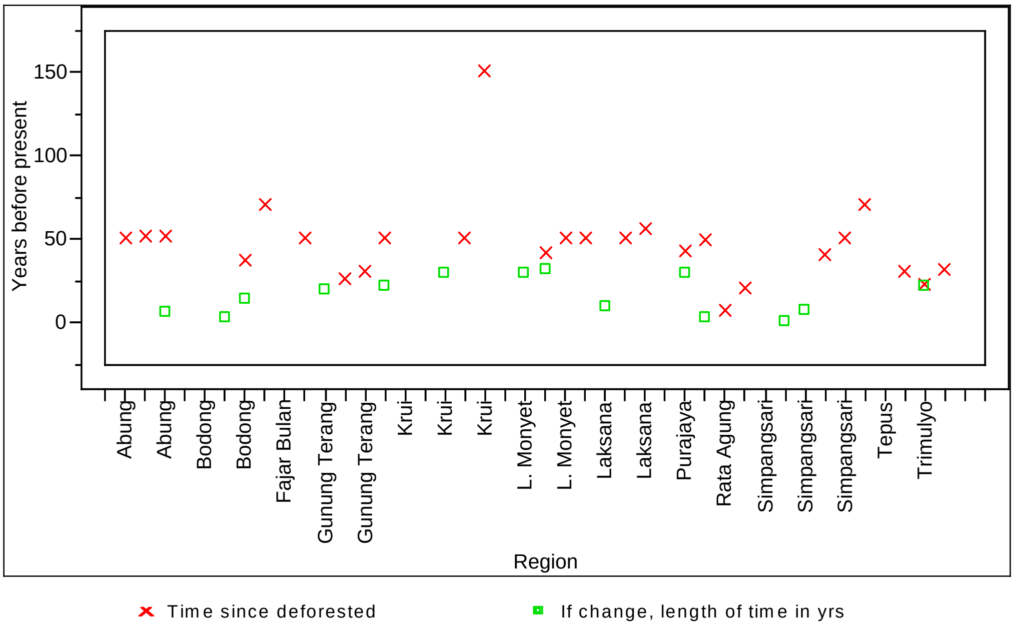

Figure 7.10 Respondents' opinions of the time over which bird declines have occurred in each region, as well as the length of time since deforestation, as defined by farmers maintaining gardens in the same region. Each entry denotes one respondent. The data suggest a lag between deforestation and bird declines.

7.4.5.3 Perceived reasons for bird assemblage change

The interviewees gave opinions regarding the possible reason for changes in bird populations and species type. In many cases more than one reason was given[19]. The most common responses were 'trapping for sale or recreational bird keeping' (52.3% of respondents) followed by 'habitat loss' (47.7%). Far fewer interviewees mentioned 'hunting for recreation' (27.2%), 'unknown' (13.6%), 'disturbance' (9.7%), and 'hunting for food' (6.8%) (total n= 44)[20] . There was some regional variation in respondents' opinions regarding the impacts of trapping and habitat loss, although sample sizes for some regions are rather small. At Bodong, a small proportion of interviewees said that habitat loss was a problem, in comparison with a greater proportion at Simpangari, and the majority of respondents from Leuwi Monyet (Table 7.5). In the Pesisir region (Krui and Rata Agung) it was mentioned that deforestation had occurred as people had little fear of the law being enforced, and that officials were sometimes involved in the deforestation, or received payment for 'tolerance'.

The pattern between these three, best-represented regions was similar for the issue of trapping, with a greater proportion of Leuwi Monyet respondents citing this as a reason for bird population decline than respondents from Simpangsari and Bodong respectively (Table 7.5).

19 The categories were created following the interviews, on the basis of the responses, which were then attributed to the closest category.

20 On the basis of local advice, in cases where the type of hunting was not specified, it was generally assumed that the respondent intended that the hunting was for recreation rather than subsistence.

Several people gave the opinion that any declines in bird population have been caused sequentially by deforestation followed by trapping. There were also some clear statements that both habitat loss and trapping were not problems.

7.5 Attitudes towards conservation

7.5.1 Role of birds in environment

Farmers and other interviewees predominantly believed that the role of birds in the environment was ‘to keep people happy’ (57.9% of respondents) or the closely related response for ‘natural beauty’ (23.7%) (total n= 38, Table 7.6). Responses grouped in these categories commonly mentioned enjoyment provided by birdsong. Interestingly, the balance between these categories was different for monoculture and shade coffee farmers, although the sample sizes are small. Another popular answer was ‘pest control’ (23.6%). This was also more commonly mentioned by shade coffee farmers. The role of birds was described as ‘unknown’ by 15.8% of respondents, while 10.5% mentioned ‘seed dispersal’. ‘Pollination’, ‘maintaining sustainability’ and ‘no role’ were each mentioned by 7.9%. Two people (5.3%) mentioned soil fertility increase as a benefit.

Table 7.6 Perceived role of birds in the environment

(Number of responses is greater than number of respondents due to multiple responses by individuals).

Respondent type	To keep people happy	natural beauty	pest control	seed distribution	soil fertility	pollination	maintain sustain-ability	none	un-known	Total respondents of each type
monoculture	2	3	1				1	1	3	10
Shade	13	5	7	2	2		1	2	3	21
Damar	2	1	1							3
Extra interview	5			2		3	1			11
Total responses of each type	22	9	9	4	2	3	3	3	6	45

7.5.2 Trapping

Interviewees were asked if they preferred birds caged or free, as keeping of caged birds is a popular hobby, especially within the Javanese community. Of 41 respondents, 73.1% said they preferred birds free, 26.9% said that they liked both caged and free birds. None said that they preferred caged birds. Amongst the reasons given for liking caged birds was that the birds could be seen easily any time of day. In contrast, those who were opposed to the keeping of caged birds made comments including that it was a ‘shame for the birds’, that the birds would be ‘bored’ if they were fed and ‘not able to look for food with their friends’, ‘they would die if they were not looked after properly’, it was ‘not natural’, ‘they could not breed properly’, and that Islam forbade the keeping of animals in cages. Asked their opinions of bird trapping, 52.4% of respondents said that they did not approve of trapping, 33.3% said that they were happy with trapping occurring and 14.3% were neutral in opinion.

Several methods and practitioners of bird capture were described in the interviews. These ranged from children taking eggs and small birds from nests for play, to organised inter-provincial, and possibly international trade. While there was some mention of people eating trapped birds, including Sooty-headed Bulbuls found in the scrub, the majority of people spoke of trapping for keeping and sale as pets. Some of the birds were said to be trapped for the local market, and it was said that most people in the village had caged birds (Plate 20). Some of the birds trapped recreationally were also said to be released. The methods described for capture included traps constructed with cables and sticks, glue and nets. Professional trappers were described by several people as increasingly using large nets, as well as using recordings of bird calls or caged birds as lures to attract birds, instead of the traditional method of spreading glue or resin on branches.

Plate 20 Caged birds for sale in Simpangsari village

An established hierarchy was described as governing the bird trade, with traders from Java and Bandar Lampung both trapping and buying birds from farmers. All birds were said to have a price; for Sooty-headed Bulbuls this was 5000 Rp. Thus, trapping was not selective. Another Sumberjaya respondent said that high prices were offered by dealers to anyone who could produce sought-after species, allowing locals to supplement their income. These species, such

Hill Mynas and Black-winged Starlings, had now both disappeared from the area. Similarly, another person claimed that prices were high enough to interest all locals in trapping by going to the forest for several days to find expensive species. An interviewee from the Pesisir region said that trapping was mainly by locals but that the birds were bought by outsiders. In this case, expensive species were said to be targeted, including thrushes, Hill Myna and White-rumped Shama.

There were also some respondents who said that the local impact of trapping was unclear or minimal, either due to its rarity or the release of birds. In one case in Krui, there was sharp disagreement between related respondents regarding the impact of trapping; one said that it was a profitable and organised trade driven by players from outside the area, whilst the other said that it was only a small-scale local activity for recreation.

Some of the people who said that they preferred birds to be free also said that others were welcome to trap birds if they wanted. In some cases this seemed to be for the reason of allowing personal liberties, provided that other people were not disturbed. Further to this, some appeared to have a reluctance to criticise the behaviour of others, even if they disapproved of the results of this behaviour. They mentioned that local enforcement of rules was difficult due to social concerns, and that people could not be stopped from their activities as they would be made angry. Many more were adamant that trapping should be forbidden, and people made aware of the rules. Enforcement of these rules was another issue discussed, with some people saying that this was difficult without the involvement of authorities. One said that while he did not like trapping, it was difficult to control such activities, and that farmers had no influence, so 'stay quiet'. Wildlife authorities were described as having insufficient employees to regulate trapping, while allegations were made of corruption by officials in multiple regions. One person objected to the small number of people who benefit from the sale of birds. Several also said that there should be penalties, not only for trappers and sellers, but also for buyers, as there would be no incentive to trap illegally if there were not people willing to offer high prices for rare birds.

7.5.3 Role of gardens

Of 40 respondents, 87.5% believed that gardens had a role to play in bird conservation (Figure 7.11). An additional 5% said that perhaps they may have some role, whilst 7.5% said they did not. Shade coffee farmers more frequently said that gardens could play a conservation role than did monoculture farmers. One damar farmer said that while gardens definitely had a role to play in bird conservation, it was also important that natural forests be retained, as these forests would not return once lost.

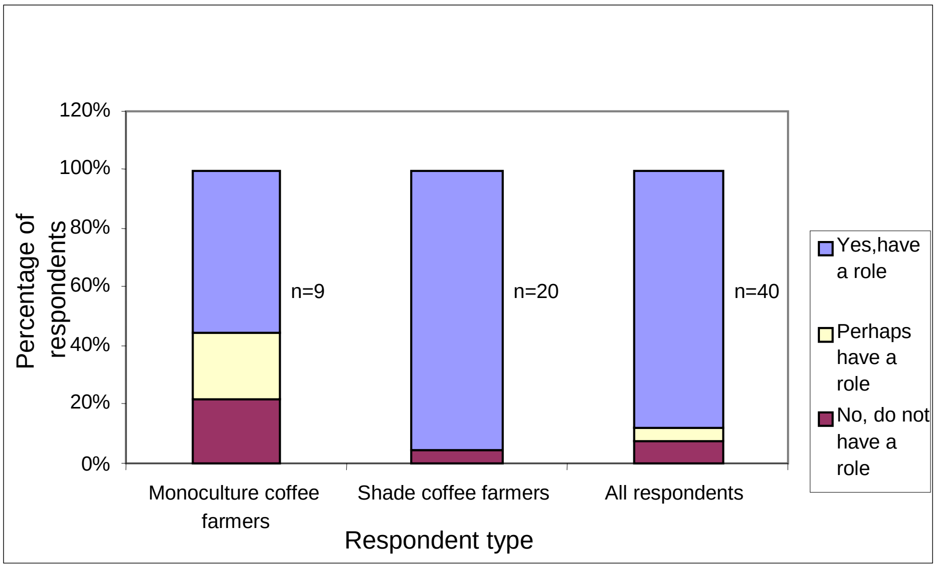

Figure 7.11 Stated opinions of the community regarding the role of coffee and damar gardens (as locally relevant) to bird conservation.

When asked further what the role of gardens in bird conservation might be, 74.1% of the 32 respondents said that it was to provide food, 45.2% to provide nest sites, 19.3% said that it was to provide perches or roosts and 12.9% to provide hiding places (total n=31).

When people specified the characteristics of gardens that would make them suitable for birds they commonly mentioned tall trees, providing safe nesting places, although some felt that trees only needed to be of medium height to be useful. A need for structural diversity with multiple layers mimicking the forest, was specified by one respondent. Other factors mentioned included the need for high species richness and for fruiting trees, such as bananas and guavas. Some felt that the tree species was unimportant as birds are flexible in their behaviour, while others said that not only domestic fruiting trees, but trees particularly known to provide fruit eaten by birds should be planted. One farmer said that once forest or scrub had been opened for cultivation, insectivorous birds would continue to eat the grubs in dead wood, but that forest fruit-eating birds would not eat domestic fruits such as bananas. Another farmer said that 'normal' agroforestry species and forest species should be mixed. Some farmers also mentioned the value of flowers of *Erythrina*, durian and coffee for nectar feeders. Another characteristic that was mentioned was the need for high canopy density, provided by trees such as durian, rambutan and cloves. One farmer said that a dense cover of coffee would provide small birds with shelter from eagles. Another said that gardens would be more suitable for birds if more care were taken to avoid disturbing nests during maintenance work, such as grass removal. Another said that reducing pruning frequency would also reduce disturbance, but this would be difficult due to its inconsistency with management for coffee productivity.

Other possible problems with prioritising bird conservation in garden maintenance that farmers mentioned included potential competition between trees and coffee. However, some also said that this could be managed by planting trees at garden edges. Others mentioned difficulties with potential over-shading of coffee, but one farmer turned this hypothetical situation around by saying that shade-tolerant crops such as a local, mint-like herb could be cultivated under the trees. Inadequate sources of seedlings and funding were also mentioned, as well as the 'laziness' of farmers and unwillingness to wait for the benefits provided by fruiting trees. One farmer also had concerns related to land tenure, and while he was in favour of tree planting for bird conservation, thought this should be restricted to public areas and National Parks. Multiple respondents said that it was possible for farmers to manage a garden in a 'bird friendly' manner if they had the motivation. People also commented on the need for tree species to be chosen that would also benefit farmers and motivate them to participate, and that more information is needed regarding tree characteristics. One respondent said that gardens can have a special role in protecting birds as they are already actively managed and monitored, so the owners can provide security and make sure birds are not taken by trappers.

7.5.4 Willingness to manage gardens for birds

The majority of farmers said that they would be willing to manage their garden in a manner that would suit the needs of local birds (59.2%) and said that this would cause no great problem to them. A large minority (37.0%) said that they were not interested, while one further farmer simply stated that it would be difficult (total n= 27).

7.5.5 Effect of forest loss

People were asked what would happen to the birds living in the forest if this habitat were lost. Of 35 respondents, 45.7% said that the birds would live in gardens, 31.4% said that they would move to forests elsewhere, another 31.4% said that they would move to another non-specified habitat or place, 28.6% said that they did not know and 8.6% said that the birds would die. Two farmers expressed some frustration at city residents being critical of deforestation by farmers who are 'forced to open the forest if they want to eat'.

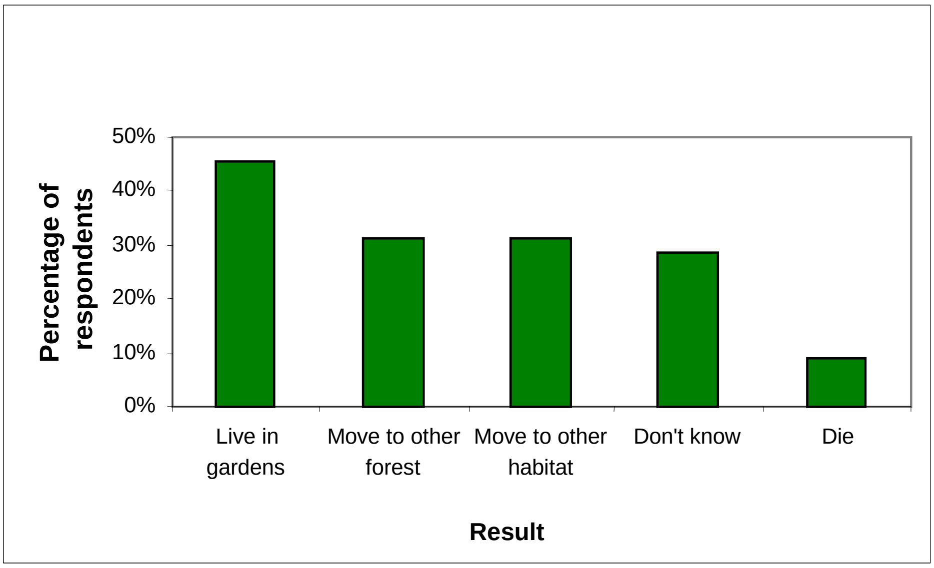

Figure 7.12 Stated community perceptions of the result for birds if the forests in which they live are lost. (Total n=35)

7.5.6 Responsibility for conservation

When indicating who was responsible for conservation, the most popular answers were equally 'everyone' and 'Government', with 40.5% of respondents listing these (total n= 42). 'Nobody' was thought responsible by 23.8% of respondents while another 19.0% said they did not know who was responsible. An additional 19.0% said that 'the community' was responsible, while 14.3% said that Non-Government Organisations or research institutions were. No respondents said that they themselves were responsible. Many interviewees mentioned more than one bearer of responsibility, so the answers do not imply that sole responsibility should be taken by any of these sources. There was sometimes confusion between the issues of who currently takes responsibility for conservation and who should. Thus, some farmers answered that no-one is responsible, but somebody should be. Some people seemed genuinely confused by the concept of allocation of this responsibility.

7.5.7 Best model for conservation and the role of Government

Interviewees were asked what was the best method or model for conservation in the area, as well as their feelings on co-operation with the Government in conservation projects. Many people needed prompting with some possible answers to the first question, such as 'tree planting by farmers, 'tree planting by the Government', 'NGO programs' and 'co-operation between farmers and the Government' before making an initial response. However, this categorical response was often augmented by further comments, particularly regarding past problems. The most common response was 'co-operation between farmers and the Government' chosen as at least one of the responses by 76.2% of people. It is acknowledged that this very high level of response is likely to have been influenced by the provision of this response as one possible option, as well as further questioning on the issue. Another popular response was 'Government regulation', mentioned by 45.2% of respondents, 'education' was suggested by 31.0% while 'forest preservation' and 'NGO projects' were each mentioned by 14.3%. Individual farmer or farmer-group tree planting or other local community-based programs were mentioned by 11.9% of people, while 9.3% suggested 'Government tree planting' and 7.1% said that they 'did not know'. Clearly, some of these categories are overlapping and the strategies envisaged may involve several of these actions.

Many people said that co-operation with the Government was currently lacking, but it would be better if this could be achieved. Some reference was made to past problems in Government-led conservation programs, both through the inconsistency of policy and lack of recognition of farmer needs; seedlings were provided but then gardens were destroyed and farmers evicted. Other farmers said that when they had been given seedlings in the past, these had been of poor quality or unsuitable types such as durian, damar and *petai*. One farmer suggested that candlenut, *pinang* or sugar palm would be more suitable. Additionally the seedlings given were not accompanied with sufficient advice about their care, and so had subsequently died, causing disappointment. It was suggested that more research on the altitude, soil and climatic requirements of tree species be conducted and that tree species could be selected from similar regions where they currently grow. Some were concerned that any program of tree planting should involve sufficient consultation with farmers, to find out their needs, while there was also criticism that the Government is unaware of practical needs. Further to this, the tree species chosen should be directly beneficial to farmers, such as trees that can be later used for timber, including mahoghany, *bayur* and teak, as well as fruit trees including *petai*, avocado and nutmeg. Some mentioned the additional benefits that could be provided by understorey crops, and the advantages to farmers of diversifying their sources of income. Many people said that farmers should be given choices about what trees were grown, but there was also suggestions that there be minimum requirements for planting some large trees, in return for concessions in state owned land. In the past, revegetation efforts have involved planting of trees such as *sonokeling* and *Calliandra*, which disturb coffee. One farmer noted the lack of success of such programs in that the areas planted with this vegetation had since been re-opened for coffee cultivation.

The lack of sustainability of programs was also described as a past problem, with organisers not providing ongoing support and programs often abandoned after several months. Many people said that there should be examples provided by the Government and successful farmers. It was believed that the demonstration of good results would encourage more people to participate. In addition, some people asked for training and education in garden care.

While the majority of thoughts regarding conservation programs seemed associated with Government, education was thought by some to be better provided by Non-Government Organisations. These could act as a conduit between farmers and the Government, whilst local farmer groups were important for organising efforts, making objectives clear and achieving accountability and solidarity. Additionally it was suggested that NGOs could raise Government awareness of conservation and farmer issues. Education was also thought necessary to raise community awareness of the value of biodiversity in the environment. Multiple people said that it was a problem that local people did not have sufficient understanding of conservation issues. While there is some biological education available in schools, many people do not complete this. Also, teachers were said to have little field experience regarding environmental issues. One person commented that if farmers were aware of practical benefits, such as a potential saving of pest-management costs and increased health of coffee due to soil moisture conservation, they would be more interested in being involved in conservation programs.

People were of mixed opinion in the type of assistance they wished for in achieving local conservation. Some said that funding should be provided, as well as tools and fertiliser, as it was not fair to expect farmers to meet these costs. However, others said that due to systemic corruption, it would be better to provide seedlings, as these would be more likely to reach the farmers. Many farmers said that they would be very happy to plant seedlings if these were provided. Additionally, one farmer who had been involved in past programs as the head of a farmer group, said that if seedlings were not provided, and farmers required to produce their own, the less motivated would lag behind targets. In contrast, several farmers said that they could produce seedlings themselves, and would wish to choose the varieties individually, but would prefer instead, to be given education and training. Even seedling distribution was not seen as immune from systemic failure. In the past, seedlings have been given, including *petai*, breadfruit, mango, *Gmelina* and *Gliricidia*, but these only reached a few farmers.

Official corruption was also cited as a barrier to law enforcement regarding bird trapping and deforestation. In some cases the officials responsible for forest protection were alleged to be involved in its destruction, as well as accepting bribes for allowing illegal trapping and logging. This is obviously a very sensitive area, and it is impossible to tell if more people shared such views than expressed them. However, some fear was expressed of Government repercussions, particularly in areas that had been subject to physical intervention by the authorities in the past.

Ironically, given the residual fear from this heavy-handed law enforcement, some people commented that currently existing laws are not sufficiently known and they are not enforced. People were mixed in their faith that the community could be responsible for enforcing rules. Some said that they could be entrusted with this, while others cited social difficulties and said that wildlife officials were needed to regulate. One person commented that the involvement of various Government institutions, including National Parks and also the Forestry Department, could provide greater cross-checking and minimise the potential for corruption subverting conservation efforts.

*7.5.8 Community forestry management (*Hutan Kemasyarakatan*)*

Sumberjaya region coffee farmers were asked if they were familiar with the HKm program which has been created by the provincial Government in an attempt to enlist the involvement of farmers on State forest land in watershed conservation efforts, in return for greater tenurial security. Of this group of farmers 43.5% said that they were familiar with the program (total n= 23). When examined with relation to land status, 57.1% of the 'kawasan' farmers of state forest land had familiarity, compared with 35.7% of farmers with 'marga' freehold land status. Of the two farmers who declared that they were on the border of these two land types one was familiar with the program, and one was not.

People were also asked whether they considered HKm to be a suitable framework to include animal conservation objectives, as well as watershed protection objectives. Many considered that it was, particularly as the scheme aims to provide incentives to farmers. One said that biodiversity gains would occur automatically if vegetation was maintained. Another said that HKm includes conservation responsibilities already; people must conserve the contents of the forest. However, she added that most concern is focused on large mammals and little thought is given to birds. She further suggested that some secondary benefit could flow from the conservation of flagship species. Thus, the concept was described as being good and it was suggested that while ideally HKm could be suitable, the scheme is still in an experimental stage so it remains to be seen if it is effective in practice. Another interviewee had reservations due to the problems with people from outside damaging the forest, making local accountability through programs such as HKm difficult. Also, communities near the forest entrusted to protect it may have a conflict of interests, for example allowing others to have access to forests to clear their own debts.

7.5.9 Sustainable coffee

Coffee farmers were mixed in their willingness to take part in a hypothesised ‘sustainable coffee’ scheme, but most were open-minded to such an idea. They were told that such a scheme may involve conditions regarding garden care; minimal use of manufactured chemicals and a threshold tree canopy cover; regarding harvest, with only ripe berries being selected, to allow a high quality product. Of 28 farmers, 64.3% said that they would be interested, 28.6% were potentially interested, but voiced reservations or conditions that must be met while 7.1% said they would not be interested. Many farmers said that they would be interested in such a scheme, and prepared to follow company rules for garden maintenance provided that the trees did not interfere with the coffee. Others said that they would participate if the price were high enough, compensating for factors such as lost production. Some farmers also identified additional benefits of having ‘useful’ trees in the garden providing other resources as well as improving health of the coffee plants. One farmer said that the additional produce would offset any reduction in coffee production due to heavy shading. One respondent said that the trees would need to provide farmers with immediate returns, while another said that the strategy must be seen as a long-term goal. Another anticipated benefit mentioned by several farmers was the provision of horticultural advice.

Farmers’ comments were mixed, regarding a potential need for organic status in such schemes. Some said that this would cause no problem, while others said that the transition would be difficult, due to poor availability of organic fertilisers and the “dependence” of plants on agricultural chemicals, although, the potential for use of tree prunings for compost was also mentioned. One farmer said that there is currently no Government program rewarding organic practice, but that it would be good if such a system were available, as operates in Vietnam. Another said that he was suspicious of the effects of agricultural chemicals on health, and so would be pleased to be part of an organic scheme, with the only disadvantaged stakeholders being chemical companies. One farmer expressed problems with a lack of tenure; while he would like to practice sustainable farming, he was working on somebody else’s land.

Some farmers stated reservations due to bad experiences with past projects, including vanilla and arabica coffee planting schemes, in which market availability was a problem. Several people said that they would prefer to see the scheme in operation first, rather than making risky investments, and stressed the need for the scheme to be well thought out. Some people said that they would join if others were joining. Another market-related issue raised was the need for accountability, and the difficulty in achieving this as the origin of coffee is not visibly evident by its quality. A different farmer said that the sale process could be controlled by companies only buying the yield predicted from the local multistrata gardens. This could limit the possibility of coffee from other gardens being mixed in to gain the sustainability premium. This would be best achieved if the entire community joined such a scheme together. Another farmer also reinforced the need for co-operation between farmers and the Forestry Department.

While many farmers were interested in gaining a higher price for their coffee, a few also discussed the increase in quality that might help achieve this. Two farmers said that it would be good to produce higher quality coffee, although this may be more time consuming if it involved more selective harvest, and that farmers may not be happy to spend more time unless the price earned was high. Otherwise they would be left in debt. However, coffee of various qualities could be differentiated, with the high quality and high priced coffee from East Java providing an example. Additionally, some farmers could remember that in the past there was a company in the region that had paid a higher price for selectively harvested berries. Another farmer extensively discussed issues of quality related to post-harvest treatment, and the need to change this, as well as garden conditions, in order to attract premium prices. He said that the coffee prices are determined by the farmers' behaviour. Coffee must be dried properly on mats, rather than on the ground; most coffee sold locally was far too wet, with 20% moisture content. During the period of very high coffee prices in the 1990s, people were selling the coffee after it had been dried for only two days. He also said that that local farmers do not want to dry their coffee properly as they feel that they will be disadvantaged in trading, due to its lower weight. However, if coffee is dried properly it can be stored much longer, and prices will subsequently be higher for a better product. He felt that in the long-term farmers themselves are disadvantaged by the sale of poor quality coffee as prices of all coffee are reduced to reflect this level. Another farmer said that there would be benefit in stabilising prices and excluding middle-traders who manipulate these; he would be very interested in selling directly from his garden.

7.6 Marketing of coffee in Lampung

A local coffee merchant discussed in an interview at his house (19/7/02) the nature of the coffee market in Sumberjaya.

7.6.1.1 Path of coffee

From the garden, coffee is sold to a *warung* (small shop), or directly to a dealer such as himself. He then carries it to Bandar Lampung to sell directly to coffee exporters. He trades with three companies depending on their current demand and price offered. They dry and sort coffee by machine, then directly export it without roasting or packaging. Destinations include Japan, Saudi Arabia and the Netherlands. He had also experienced dealing with *Nestlé*, who produce instant coffee, but said they had a limited and unreliable demand. The Indonesian Coffee Exporters' Association receive a commission from all exporters for providing information about the coffee market and price. They also set the rules for export. If exporters do not buy sufficient quantities they lose their export licence.

7.6.1.2 Coffee assessment and pricing

Coffee is individually assessed by the merchant on receipt, to set the price for the entire quantity. He takes samples and spreads them out to assess quality.

The criteria used are:

- *kada air* - percentage weight water: for export this must be below 14% but most coffee from Sumberjaya is above 18% and as much as 25%. The price benefit for drier coffee is low, and it is possibly insufficient to compensate for the reduced weight sold. The coffee is re-dried in ovens in the factory in Bandar Lampung.
- *Abu/ kulit* - percentage of loose husks.
- *Coklat* - percentage of beans black or dark brown. A high quantity of dark beans indicates low quality caused by slow drying, as it is an effect of mould. For export this must be no greater than 1%.
- *Trease* - defective dry beans
- *Gelondongan* - percentage of beans not completely hulled. There is variable practice between farmers for hulling; some do this only once, others twice
- *Bigi kecil* and *Bigi besar* - relative quantities of small (5 mm) and large (8 mm) beans. Only large beans are exported, while the small are used for the domestic market.

The quality of Indonesian coffee is Class 4, equivalent to that of Vietnam. In comparison, Class 1 originates from Brazil and Colombia. Problems with coffee quality in Sumberjaya result from the mixture of ripe and unripe beans at harvest, and slow drying due to constant rain and unavailability of ovens. However, the price for wet, unhulled coffee is considered too low for farmers to consider selling it in that form. If the price for unhulled coffee were higher, the quality of the end product could be higher if the coffee could be dried quickly in a factory. However, potential problems include higher transport costs, potential for mould before transport and less flexibility regarding time of sale, dependent upon price conditions.[21] The problem with harvesting berries of mixed ripeness results from a price not being sufficient to make it worthwhile harvesting repeatedly. Also, the technique for harvest is much easier if the berries are mixed (the branch is simply stripped longitudinally). Thirdly, the farmers' need for instant capital encourages immediate harvest and sale.

In the past this trader was visited by a representative from a Japanese importer of coffee, however quality of coffee in Sumberjaya was found to be too low for a deal to be struck. The buyer indicated interest in greater selectivity at harvest, with only ripe berries taken, and more thorough drying in cleaner conditions; on mats or concrete rather than soil as is the common practice in Sumberjaya. The trader had also asked about the availability of organic coffee, (defined by him as being free of manufactured chemicals for at least two years). However local availability was too limited as only a few farmers could guarantee those conditions.

Organic coffee

The local market does not yet exist for organic coffee, and the merchant seemed quite unaware of this as a standard classification, although he had received enquiries regarding coffee with these qualities in the past. He said that the organic origin of coffee can be determined by the smell of the beans, but it is difficult to assess the state of a coffee garden.

7.7 Captive bird trade

7.7.1 Bandar Lampung Bird Market

Two shops were visited, having a combined area of approximately 160 m². There are probably four such shops in Bandar Lampung. Approximately ten people browsing were informally asked questions, as well as three agents. The shop conditions were crowded and dark and many cages hung together high from the ceiling. Some cages contained individual birds whilst others had up to 25 individuals of the same species. Some birds appeared to be in poor condition, such as a cage of Black-crested Bulbuls. The owners said that turnover occurs every one to two weeks but some birds had apparently been there for much longer, such as a thrush which had been there for six months.

A wide range of birds were available for sale. These included Emerald Dove, Zebra Dove, pigeons, barbets, Lesser and Greater Green Leafbirds, Yellow-vented Bulbuls, Black-crested Bulbuls, Javan Myna, Sunda Laughingthrush, White-rumped Shama, Magpie Robin, Hill Myna,

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[21] Some farmers store coffee which has been sun-dried and hulled for up to two years, so that they can sell it when prices are high (pers. comm.).

Long-tailed Shrike, Chestnut-capped Thrush, Grey-cheeked Bulbul, Banded (?) Wodpecker, Long-tailed Sibia (?), Large-billed Crow, Crested Jay, Maroon-breasted Philentoma, Baya or Asian Golden Weaver, Java Sparrow, Pale-blue (?) Flycatcher, canaries and lovebirds.

Prices were highly variable. Sparrows and Yellow Munias (5, 000 rp) were for sale for release at Chinese parties; Black-winged Starling (*poksai*) (70, 000 Rp), Magpie Robin (*kacer*) (75, 000 Rp), White-rumped Shama (*murai batu*) (at least 150, 000 Rp), thrushes (*anis*) (at least 250, 000 Rp), Long-tailed Shrike (*towet*) (300, 000)[22]. Prices were said to be partly dependent on the age of the bird and whether or not it was already singing.

The agents said that the birds originated from various areas in Sumatra. In Lampung province these included Liwa and Rata Agung, but also included Benkulu, Jambi and Sumatra Utara provinces. There were also some birds from outside Sumatra, such as lovebirds and canaries, which had been exchanged through the markets in Jakarta. Some buyers were reportedly agents for markets in Jakarta, but most were buying for their own home hobbies. Some birds were also sold for competitions, for example Zebra Doves (*perkutut*), but these were said to be more popular with older men.

The shop owners said that they had agents (*anak buah*) who buy from designated areas, such as Bengkulu. One shop had eight of these *anak buah*. Furthermore, each of these buyers has contacts with local professional trappers. All of the trappers' birds are bought and the contracts are exclusive. Orders are sometimes taken for particular birds.

The trappers are local professionals who go in groups of approximately five people to the forest interior for one to two weeks at a time. Birds are trapped using nets and using live calling birds as lures. The results are variable but approximately 30 birds can be trapped in that time. The birds are carried back in woven boxes. This information was consistent with what I had learned from discussions with trappers in Sumberjaya. The prices rise by approximately 100% from the trapper to the shop. Thus a trapper might be paid 75,000 Rp for a Magpie Robin, but this would be sold for 150,000 Rp in the shop. One shop owner said that the birds came from protection forest areas, but not from National Parks.

During 1.5 hours there were approximately 30 potential customers and 5 apparent sales. The customers were all male, between approximately 15 and 45 years of age, but mostly 30 to 40 years of age. They were of various ethnicities, including Lampungnese, Javanese and Betawi. One buyer's wife was waiting outside the shop, but not involved in the browsing. Of the

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[22] At the time, the casual rate of pay for agricultural labourers in Lampung was 15, 000 Rp per day, whilst the exchange rate was approximately 4,500 Rp = $1Aus.

customers, approximately 70% had some idea of what species they were looking for. Most (approximately 90%) had already owned a bird, and of these many (at least 60%) had already owned a bird of the same species. Many also said that their friends also kept birds. The birds sought were White-rumped Shama (*murai batu*) (3 people), Magpie Robin (*kacer*) (2 people), Hill Myna (*Beo*), Sunda Laughingthrush, other thrushes (*anis*) Black-winged Starling (*Poksai*), canary and Grey-cheeked Bulbul (*Kutilang jengot*) (all one person each). Three people were uncertain of what type of bird they wanted, and so were browsing. The buyers were asked their reasons for buying birds. The main stated reason given was as a hobby. This was mainly related to the bird's song, but also to its appearance. It was said that people like "busyness" (*ramai*). One buyer said that there is no longer wild birdsong locally, so it is necessary to have a caged bird. Another buyer was building a collection. One man said that looking after birds was so absorbing that he did not wash until midday, as he was so busy taking care of his bird. One buyer said that the birds in Lampung were nearly gone, or greatly reduced, due to people constantly taking them from the wild. He said that he was not happy about that situation, but there were still plenty of birds in areas further north in Sumatra, and that he still wanted to buy birds.

People in the shop were also asked the general nature of purchasers. Accounts were varied but included businessmen who have money to spend and "normal" people with time to spend. One browser said that if people have a bird hobby they will buy regardless of their financial situation, but perhaps choose less expensive species such as Sooty-headed Bulbul.

7.7.2 Jakarta Bird Markets

(Jalan Pramuka, 4 Nov 2002)

I also visited the Jakarta Bird Markets, as this is the ongoing destination of some of the birds caught in Lampung. These markets are very extensive with many separate traders on multiple levels. Approximately ten traders were questioned informally. They said that customers were mixed in their purpose, most bought birds to keep themselves, but some bought for resale. Various types of birds were sought including small birds, unusual birds, and particularly thrushes and White-rumped Shama. Some, but not all, buyers arrived knowing what they are looking for. Traders said that there are more trappers now than in the past, and trappers are now using large nets. Some agents said that this made birds easier to access than in the past, while other traders said that it was now more difficult. One seller said that in the past they received 1000 birds per month from Lampung, but now only 100 birds, from the same trappers. Reasons given for this rarity were the loss of habitat and also trapping. However, this was seen not to matter, as there are still more birds further north.

Some birds in particular had become more rare, such as flycatchers. The difficulty in trapping these had raised their price. Three traders said that most of the birds for sale could be bred in captivity, including White-rumped Shama, Magpie Robin, lovebirds and finches. One seller said that this produced better results, but while it is cheaper and easier to take them from the forest this will continue.

There were a very wide variety of birds available in the market, as well as some other types of animals. Taxa commonly present included White-rumped Shama, Long-tailed Shrike, Magpie Robin, Sooty-headed Bulbul, sunbirds (*burung madu*), thrushes, leafbirds (from central Java), Grey–cheeked Bulbul (from Java and Sumatra), Pittas (*anis Bali*), white cockatoos, Zebra Finch (that had been captively bred), Black-winged Starling, Java Myna, Black-crested Bulbul, as well as imported thrushes and starlings from Hong Kong. Other birds available included Crested Serpent Eagle, owls, Red-capped Woodpeckers, flycatchers, coucals, parrots (from Papua), budgerigars, canaries, lovebirds, Hill Mynas, and hornbills (Plate 21, Plate 22).

Plate 21 Hornbills in Pramuka bird market, Jakarta

Plate 22 Captive eagles for sale in Pramuka bird market, Jakarta

Prices were again variable; Sooty-headed bulbuls (25, 000 –50, 000 Rp); Long-tailed Shrike (from 100, 000 Rp); sunbirds (150 000 Rp); pittas (250, 000 Rp); thrushes (from 250, 000 Rp); Magpie Robin (250, 000 – 600, 000 Rp); White-rumped Shama (400, 000 – 1,000, 000 Rp); (750, 000 Rp), scops owl (750, 000 Rp) juvenile hornbills (from Madura) (1,000, 000 Rp)

7.8 Conclusion

Management styles of farms in West Lampung were prescribed by the horticultural requirements of the crops planted (in particular, robusta coffee), local environmental conditions, social practices and beliefs. At the time of study it was not common for organic farming practices to be used, although financial constraints were limiting some farmers in their use of manufactured chemicals. Shade trees were commonly perceived to have benefits, such as sheltering coffee plants and providing additional produce. Yet many farmers were also apprehensive about the potential for over-shading to reduce coffee production. The majority also stated that coffee should be planted before a shade canopy is established.

Most respondents felt positively about birds in the environment, but many claimed that bird populations had declined and assemblages changed within their memories. The most common reasons given for this were trapping for the caged bird trade and habitat loss. The operation of the captive bird trade was one visible limitation to regional bird conservation. Whilst many interviewees did not approve of trapping, the market for caged birds was a large and lucrative one. Investigations of bird markets showed that many wild-trapped species were available for sale. In spite of the recognition of habitat loss as a past problem, few people felt that forest loss would lead to bird deaths. Instead, there was a general perception that other suitable and accessible habitat for displaced birds existed elsewhere. A substantial proportion of the farmers interviewed believed that coffee gardens had potential to provide useful bird habitat. This was more commonly suggested by farmers of shaded coffee than by those maintaining monocultures.

There was generally a perception that both the Government and the community are responsible for conservation. Many people showed interest in conservation programs and co-operation with the government, particularly if schemes allowed some flexibility to farmers. There was also a belief that faunal conservation could be advanced within currently developing schemes which reward farmers with secure tenure. Many farmers also expressed some interest in market-based schemes such as eco-certification for sustainably produced coffee. However, there was some apprehension due to experience with failed schemes in the past. Discussion with a local coffee trader also highlighted problems with coffee quality that could limit the feasibility of such a scheme.

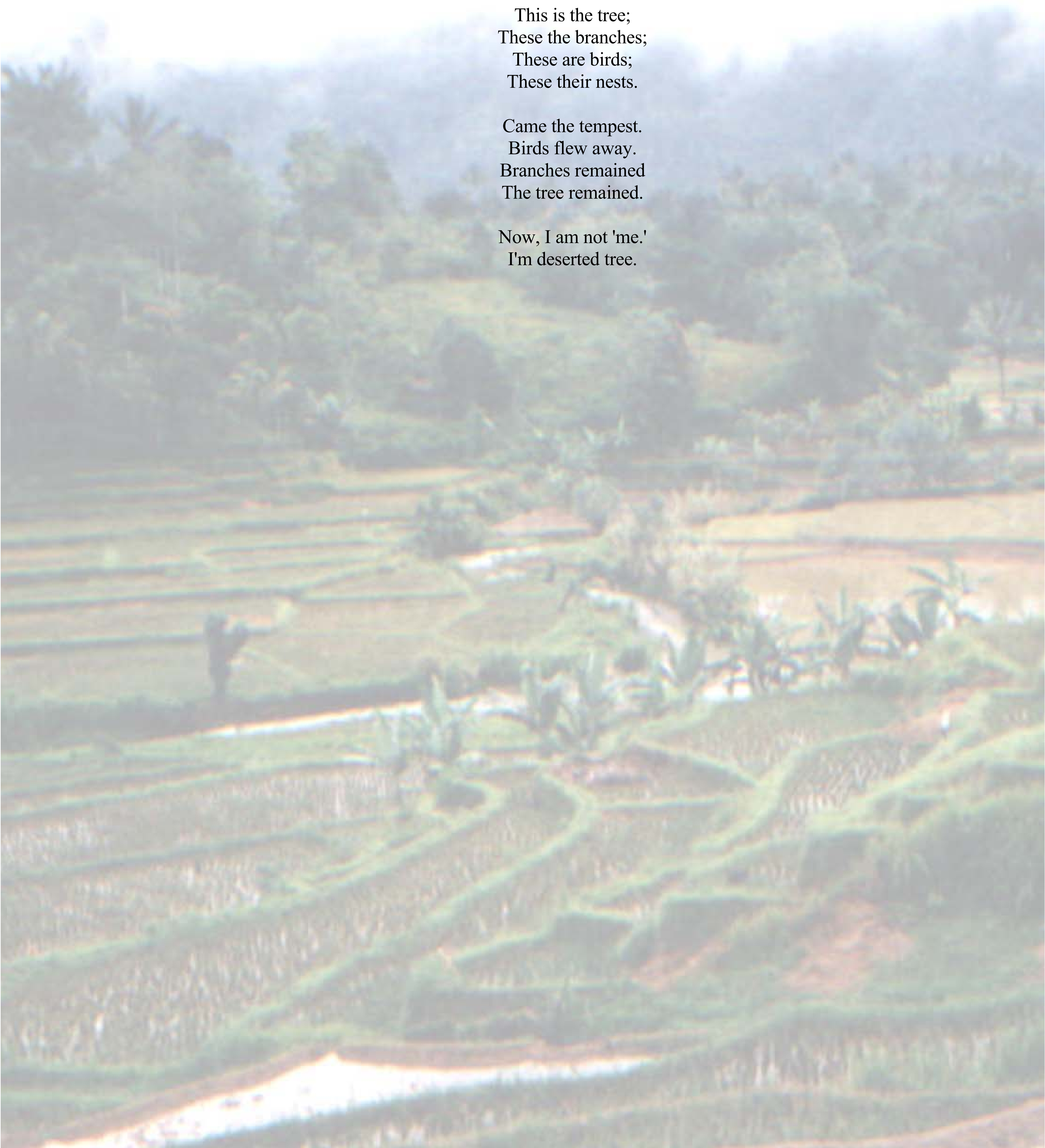
Chapter 8 Discussion: The state of birds and conservation in West Lampung coffee landscapes

I, a tree without birds.
Shah Pravinchandra Kasturchand

This is the tree;
These the branches;
These are birds;
These their nests.

Came the tempest.
Birds flew away.
Branches remained
The tree remained.

Now, I am not 'me.'
I'm deserted tree.



Discussion: The state of birds and conservation in West Lampung coffee landscapes.

The situation of landscape management and bird conservation in Lampung is a complex one. Indeed, as for many field-based studies, the number of variables in the landscape preclude easy explanations of the patterns of avifaunal use of habitats. Likewise, the multitude of variables including ecological, social and market factors also suggest that a simple 'solution' to the local conservation challenges is unlikely to present itself. In order to approach these intricate issues, I have reduced the focal questions to "What is the contribution of coffee gardens to bird assemblages in the region?" "What are the differences between bird assemblages in coffee garden types?" and "What is the most promising way to achieve conservation for birds in the area?" The final question is the most applied, and thus the most complex and subjective, as it involves both ecological and social factors. Given the human-dominated nature of the landscape, the opinions, motivations and incentives for the local people who make management decisions are of crucial importance in evaluating the potential for habitat restoration.

8.1 Contribution of coffee gardens to regional bird assemblages

Evaluation of the contribution made by any habitat to faunal conservation is dependent on the nature of the alternative. Forest provides an intuitive baseline, as the original habitat in the area, and thus the habitat to which the 'natural' bird assemblages are adapted. Yet the region of this study is now heavily modified. The presence of large populations of humans dependent upon agricultural industries implies that a great, and still increasing proportion of the landscape is dedicated to economically productive and subsistence uses. This then provides an alternative baseline for comparison. There are general global trends towards both intensification and extensification of agriculture (Siebert 2002). Consequently, monocultural and increasingly industrialised modes of production may become a standard with which other habitats are compared. In Sumberjaya, between these two poles of habitat quality, there is a range of successional habitats as well as other more diversified agricultural systems, including coffee gardens.

The coffee gardens of Sumberjaya are used by a large number of birds in comparison with many other habitats present in the region. For example, compared with rice paddy, which was the other agricultural habitat studied, there were fewer individual birds. However, on a site basis, the bird assemblages in coffee gardens were much richer in species, feeding groups and guilds, and far more similar to the forest assemblages that need to be conserved locally. Additionally, more of the birds in coffee plots were seen engaging with the visible habitat features at the sites, rather than flying overhead, as they often were in rice paddy areas. However, aerial foraging was not documented, and also circling flocks of birds may have preferred to land outside the plot under examination. That said, agronomic requirements such as drainage characteristics also dictate the place of these respective agricultural types in the landscape. Thus, in spite of its generally simple structure and floristics, paddy still supported some of the birds typical of the low-lying stream and wetland habitats it has replaced. These birds included the White-breasted Waterhen (*Amaurornis phoenicurus*), pipits and wagtails (Motacillidae), which were not commonly found in the coffee gardens. Nevertheless, most common in the paddy were the ubiquitous munias (*Lonchura* spp.) and Eurasian Sparrows (*Passer montanus*) that fed on the grain (to the great frustration of farmers, who attempted to scare the birds with elaborate systems of wires, cans and flags). These weavers were also represented in coffee habitats, albeit in lesser numbers, as well as in successional habitats. Thus, of the two main types of agricultural habitats present in the region, coffee appeared to provide more habitat features, allowing it greater potential for supporting bird species traditionally adapted to this region.

There were also some bird species, such as the insectivorous Pied Triller (*Lalage nigra*), that were found only in coffee gardens and not in other habitats. Perhaps with longer survey effort these taxa would be found to be more widespread. However, there were many more taxa that were present in other habitats in the landscape but not found in coffee plots (43% of all taxa, compared with 18% of all taxa found only in coffee plots). Taxonomic diversity of birds in coffee habitats was comparable with that in tall scrub, but less than that of damar agroforests or forests. Multidimensional Scaling showed the species assemblages of coffee habitats in general to be similar to those of other habitats locally present, with the exception of damar and forest. These two habitats had bird assemblages very distinct from those of coffee gardens. Species accumulation curves suggested that further surveys would have recorded more species, while difficult survey conditions in the tall and complex forest habitats led to the surveys at these sites being the least adequate, as indicated by the relatively high number of unidentified taxa. The reduced visibility in these tall habitats suggest that the real differences between these, and the other habitats may be greater than those found in surveys. Indeed, a number of additional species were observed opportunistically in the forest, either outside of the survey time or site. The full species list including opportunistic sightings is provided in Appendix L. Frequently, the forest birds occurred in mixed species flocks, raising the level of 'chance' required for their survey. Additional sites, or a longer survey period may have allowed these extra species present in the area to be included in analysis. Nevertheless, the clustering of the individual sites of forest and damar habitats indicates that survey was sufficient to distinguish the bird assemblages and that their primary differences are likely to be habitat based, rather due to regional or other factors. It was only in these two tall habitats that the species with IUCN threat listings, and thus of greatest immediate conservation concern, were found. Thus, for those species designated as having highest immediate conservation value, the range of coffee gardens present are certainly no viable substitute for forest. This contrasts somewhat with the relative value of these land-cover types suggested by studies of soil and watershed properties (Verbist and Putra 2002).

8.1.1 Feeding groups

On the basis of feeding groups, coffee sites also had representation of birds similar to that of the natural successional habitats present in the region (tall scrub, low scrub and Imperata), but were again distinct from damar, forest and paddy. The main source of difference from paddy was a reduced dominance by granivores, whilst a paucity of nectarivores and frugivores contributed to the separation from damar and forest bird assemblages respectively. The latter two feeding groups were present in small numbers in tall scrub. As early successional forest, this habitat has floristic features that are likely to be more similar to those in forest gaps caused by tree-fall (Bawa and Seidler 1998). Whilst for statistical reasons, it was sometimes necessary to amalgamate successional habitats, there were real differences between the constituent habitat types. It seems that these differences are sometimes disregarded, with only the categories of ‘grass’ and ‘shrubs’ recognised by Verbist and Eka Dinata (2002) in their analysis of land use change. However, the observed differences in the plant and bird assemblages suggest that any local conservation plan should recognise these differences, rather than only distinguishing forest and non-forest habitats. While it could be difficult to convince the community of the value of retaining tall scrub, there is conservation value in the succession that has already occurred in these habitats. Although patches were generally small and isolated (the two tall scrub plots studied were respectively 875 metres and 910 metres from forest), they could perhaps become the core of vegetative ‘islands’, which Thiollay (1986) suggests allow forest species to hunt or to cross clearings. They may also facilitate later colonisation of coffee gardens by frugivorous birds.

8.1.1.1 Frugivores

Within tall scrub, the large-bodied frugivores that are dependent on mature forest trees were still largely absent, with the only hornbill (Bucerotidae) surveyed frequenting forest. However, like the secondary scrub in Sheldon’s (1992) study, the colonising fruiting trees, such as hamerang (*Ficus pandana*), present in tall scrub allowed some of the more edge-adapted frugivores the chance to forage. These opportunities were less available in coffee habitats. The representation of the frugivorous barbet family (Capitonidae) illustrates this pattern. In forest, there were at least four individuals per site of barbet species classified as being 'forest edge' taxa[23]. In tall scrub there were two individuals per site of this group and 5.5 individuals of species requiring 'moderate cover'. However, in any coffee habitat, the maximum representation per site was 0.1 individual per site of 'forest edge' barbets and 0.33 per site of 'moderate cover' barbets. Similarly, the frugivorous Blue-winged leafbird (*Chloropsis venusta*) was only found in forest surveys. Furthermore, whilst forest-associated frugivorous pigeons (*Ducula badia, Macropygia unchall* and *M. ruficeps*) were counted in coffee garden surveys, these long-distance fliers were all seen overhead, and thus apparently not tempted to engage with the coffee habitats. These birds flew at a substantial mean height of 18.4 m above the ground, and in all cases there was forest less than 120 m from the plot, so it seems likely they were flying to or from this vegetation. The interpretation that large canopy frugivorous birds were likely absent from coffee gardens due to a lack of suitable food resources is consistent with observations Mitra and Sheldon (1993) made in a Sabah timber plantation. Thus, to reduce the disadvantage to these bird species, it seems that a change in species composition of the auxilliary plants and trees in the coffee gardens would be necessary.

8.1.1.2 Insectivores

Insectivores are another group with apparent conservation significance, as many species are sensitive to disturbances such as logging, and thus vulnerable in many locations within their range (e.g. in Bawa and Seidler 1998; Marsden 1998). Overall, the inter-habitat differences in numbers of insectivores were not significant in this study, but some groups were more common in particular habitats. Babblers (Timaliidae) are ground and understorey dwelling birds having a generally close association with forest habitats. Whilst surveys found moderate numbers of these in damar agroforests, and some in tall scrub as well as in forest sites, only isolated individuals were observed in coffee plots. Perhaps the umbrella-like shape of the coffee, which provides little cover close to ground level, was structurally insufficient as a replacement for the scrubby understorey in which the babblers were commonly found in the forest. Warblers, tailorbirds and prinias (Sylviidae) fared rather better in coffee habitats. However, there was some intra-family variation in response. *Prinia* spp. were found only in low numbers in coffee habitats, but were more common in successional vegetation where there was a denser groundcover. In contrast, *Orthotomus* spp. were relatively abundant in coffee habitats, and were able to make use of the coffee layer. Indeed, it was their most commonly used microhabitat, the most important foraging stratum and the second most important perching

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[23] One additional individual per site of *Megalaima* sp.. cannot be assigned to a forest affinity class due to identification only to the level of genus.

stratum for birds of this genus, whilst their nests were also observed there. The migratory Arctic Warbler (*Phylloscopus borealis*) also made use of coffee gardens. This species was classified by literature as requiring 'moderate cover' and was also found in the forest and tall scrub. Thus, the coffee gardens may be aiding to support locally this somewhat forest-associated bird. The addition of more scrubby patches, perhaps at garden boundaries, may allow better representation of bird taxa preferring the dense understorey that has usually been replaced by coffee bushes.

Cuckoos and coucals (Cuculidae) were another insectivorous group represented in coffee habitats, but not in forest. The cuckoo species found were classified as requiring moderate cover. Whilst the coffee habitats supported more of these birds than did natural vegetation assemblages, as nest-predators their presence could be seen as a sign of disturbance to other insectivorous birds. Yet Mitra and Sheldon (1993) described poor representation of cuckoos in timber plantations. Furthermore, as Marsden (1998) related a lack of cuckoos in Sulawesi to a possible reduction in other insectivorous birds acting as hosts, perhaps their presence in the coffee gardens is at least an indication that there were sufficient nesting hosts to support such a relationship.

Flycatchers (Muscicapidae), are an insectivorous family that has been identified by studies of forest disturbance as being particularly vulnerable (e.g. Mitra and Sheldon 1993; Johns 1996). Within coffee gardens there was some representation of species classified as requiring 'moderate cover', as well as one 'forest edge' visitor found in a garden near the forest margin. In particular, the migratory Asian Brown Flycatcher (*Muscicapa dauurica*) was found using coffee gardens as well as successional vegetation, but not forest. This is consistent with literature that relates migratory status to generalism (e.g. Carlson 1986; Perfecto, Rice et al. 1996), and with the relatively high representation of migrants in the birds using the coffee gardens in Latin America. In Sumberjaya, the flycatcher species defined by literature as being more forest-associated were not seen in the coffee gardens, although even in the forest, species richness and abundance was not very high. This is consistent with the comments of a Jakarta bird trader who identified birds from this family as becoming rare and difficult to trap resulting in an increase in prices for caged birds of this type.

8.1.2 Guilds

The patterns defined by guild representation were similar for feeding group, with the contribution by coffee habitats being similar to that of successional habitats, although inter-site variation was higher than for feeding groups. Distinction from paddy was largely on the grounds of the smaller number of ground-feeding birds in coffee habitats, whilst damar and forest sites had still fewer of these birds, but a greater representation of upper-storey birds. One exception to this was Laksana 2, a monoculture coffee garden at the forest edge, where the birds had similar guild characteristics to the forest bird assemblages.

One of the few significant guild differences between coffee and non-coffee habitats was found in hawking birds. The greatest advantage provided in coffee habitats seemed to be for the Long-tailed Shrike (*Lanius schach*), which by the detailed description of guilds, was classified as 'hawk/pounce'. Whilst the overwhelming majority of birds of this species were found in coffee gardens, the most commonly used microhabitat within these gardens was not coffee, but branches. Perhaps the presence of perches overlooking a relatively open and simple understorey provided good opportunities for these 'open country' birds to see and pounce on their prey. Whilst locally abundant, the popularity and potentially high price of this species as a caged bird (100, 000 to 300, 000 Rp in Bandar Lampung and Jakarta bird markets) suggests that it may be prudent to encourage large wild populations.

8.2 Differences between the bird assemblages of coffee garden types

Whilst the coffee gardens of Sumberjaya were distinct from the other habitats in the region, they also varied substantially along floristic and structural gradients. Thus, having established the general contribution and limitations of coffee gardens as bird habitats within the local landscape, it remains to be considered how the bird assemblages varied across this spectrum. Moreover, association of bird assemblage characteristics with particular garden management styles may suggest how benefits could theoretically be maximised within the framework of a coffee-dominated agricultural landscape.

8.2.1 Quantitative descriptors of assemblages

Rates of species accumulation with survey in each of the coffee garden types suggested that with increasing structural height, diversity and floristic richness, there was a corresponding increase in the number of bird species using the garden. The total bird species richness surveyed in closed multistrata coffee was higher than the mean for any other habitat, but this was derived from one site only. Nevertheless, the overall pattern between sites was that new species were observed at a higher and more sustained rate in the more complex coffee habitats. Additionally, there was a positive relationship between coffee garden complexity and taxonomic diversity at species, genus and family levels, with the steepest gradient occurring at family level. Thus, localised measures of biodiversity may be enhanced within coffee gardens by manipulating structural and floristic features. Not only did the species richness and diversity of bird species vary between coffee habitats, but also the composition of the assemblages was rather different. This is illustrated by the representation of 60% of the coffee garden bird taxa in no more than one of the three main garden types (monoculture, simple shade and multistrata). Thus, given the limitations incurred by the small number of samples, it appears that for the coffee gardens of the region to continue supporting the range of bird species present at the time of survey, it is necessary to preserve the spectrum of garden types. Turnover of species was highest in multistrata coffee and it appears likely that the loss or transformation of this habitat to another agricultural type might cause a disproportionate loss in bird taxa.

8.2.2 Bird assemblage compositions

In a conservation context, taxa are not considered equal in importance (Vane-Wright, Humphries et al. 1991; Quammen 1996; Amos 2000). An MDS showed bird assemblages to vary markedly with garden type. Forest bird assemblages can be used as one baseline for the assessment of the distinctive suites of birds found in each coffee habitat. Whilst the coffee assemblages varied, their gradient did not move strongly towards the forest assemblage points. This indicates that no coffee habitat had a suite of birds dramatically more similar to forest assemblages than that of any other. Thus, in this landscape, maintenance of forest areas seems to be more critical than modification of coffee habitats. This is similar to the findings of Waltert (2004) for Sulawesi. Nevertheless, within this shallow gradient of similarity between the forest bird assemblages and those of respective coffee habitats, the greatest similarity to forest was achieved by multistrata coffee. Exceptions to the generally low similarity between forest and monoculture coffee bird assemblages occurred in two cases (Rata Agung 3 and Laksana 2). Both of these sites had forest within 50 m of the study plot. This highlights firstly the general importance of neighbouring habitats in influencing the bird assemblage, and secondly, the particular role of forests as a source population for birds in surrounding habitats and finally, the potential for adjacent gardens to act as buffer zones and provide resources for birds that are prepared to venture beyond the forest margin. The simple shade gardens were intermediate between monoculture and multistrata in their bird assemblages' similarity to those of forest, as they also were in their combined measured vegetation characteristics. This supports the interpretation that these measured features played an important role in determining bird assemblage.

The general pattern of bird composition in coffee gardens mirrored that of succession in natural habitats, changing with vegetation structure and species richness characteristics. The bird assemblages of monoculture coffee were slightly more similar to those of forest than were Imperata grasslands, and overlapping those of low scrub. Simple shade coffee contained bird assemblages similar to those between low scrub and tall scrub. Multistrata coffee held bird assemblages overlapping those of tall scrub and grading towards those of damar, which was, avifaunally and structurally, the most similar habitat to forest. However, the assemblages of this multistrata coffee were still far less similar to forest birds than were those of damar. Curiously, closed multistrata surveys showed a bird assemblage less similar to that of forest than did other coffee habitats, but interpretation of this is difficult due to the lack of replication in this habitat type. The evidence that variation in management style can result in a bird assemblage that is equivalent to a later successional state is encouraging for the development of more sustainable coffee systems. Yet the general distinction of coffee garden birds from forest bird assemblages highlights the need to defend forest remnants. Indeed, these results are certainly not locally supportive of the claim made in the Latin American context, that "shade coffee plantations can contain as much biodiversity as forest habitats' (Perfecto, Rice et al. 1996, p.598).

8.2.3 Species differences

Differences between coffee habitats were evident in the distribution of some omnivorous birds. One of the best-represented families in surveys was Pycnonotidae (bulbuls). Bulbuls varied widely in their expected tolerance of open habitats. Several with a strong forest affiliation were never found in coffee gardens: *Alophoixus bres,* (Grey-cheeked Bulbul), *Hypsipetes flavala* (Ashy Bulbul) and *Ixos malaccensis* (Streaked Bulbul). However, 'open country' species such as the Yellow-vented Bulbul (*Pycnonotus goiavier*) and the Sooty-headed Bulbul (*Pycnonotus aurigaster*), were respectively very abundant and moderately abundant in all coffee gardens as well as in successional vegetation. Since *P. aurigaster* was introduced to Sumatra (possibly in the c19th) this species has increased its range, and particularly in Lampung, is "slowly replacing *P. goaiavier* as the common open country bird" (Homes, cited in van Marle and Voous 1988). These two species were not found in the forest, and the coffee habitats could be seen as further aiding the diversion of resources to these invasive birds. However, the less gap-tolerant species *P. melanicterus* (Black-crested Bulbul) and *P. atriceps* (Black-headed Bulbul), were found both in the forest and in coffee. The former species was far more abundant in forest and tall scrub, than in coffee habitats, but abundance did increase with coffee habitat complexity. Therefore, this forest-edge species might be locally aided by the careful management of shade trees in coffee gardens. *Pycnonotus atriceps* was not found in successional habitats, and thus the coffee gardens may be providing them habitat that would otherwise be unavailable outside the forest, although the pattern between coffee habitats was less clear for this species.

Another omnivore, the small Oriental White-eye (*Zosterops palpebrosus*), also showed clear differentiation between different coffee garden types, with a steep increase in abundance coincident with vegetation height and complexity. These birds move through the canopy in flocks, and only very rarely used the coffee layer. Thus, the presence of shade trees seems critical for maintaining the species in gardens. The trees do not need to be dense or tall to be used by this species, which was far more common in tall scrub than in forest habitats. However, a near continuous cover would facilitate flocks' behaviour of moving from tree to tree, and allow them to use the gardens at least as a corridor.

Flowerpeckers (Dicaeidae) is also an omnivorous family. One species, *Dicaeum trigonostigma* (Orange-bellied Flowerpecker), was well represented in coffee gardens, and benefited from increasing vegetation complexity. The inter-habitat differences were accentuated if birds flying over the plots were excluded from analysis. When *D. trigonostigma*, which is adapted to 'moderate cover', was excluded, and the more specialised flowerpeckers considered, there were far fewer in the coffee habitats than in most natural habitats and in damar. Thus, it seems that habitat complexity must be further increased for other flowerpeckers to use coffee gardens. The relatively high representation of non-*D. trigonostigma* flowerpeckers within tall scrub, which is structurally at least superficially similar to multistrata coffee, suggests that floristic factors are important for these birds, which often specialise on mistletoes (MacKinnon and Phillips 1993). However, the large numbers of this group also present in damar agroforests indicates that the farmers' tolerance of spontaneous germinants within a managed system can allow at least some flowerpecker species to persist.

The availability of perches from which to forage is important for hawking birds. This variable provides an explanation for the significant difference between the numbers of these birds (excluding the Long-tailed shrike, which has been previously discussed) in different types of coffee gardens, between which there was architectural variation. The relative abundance of the Asian Brown Flycatcher *(Muscicapa dauurica)* at different coffee sites demonstrates this gradient. The Arctic Warbler *(Phylloscopus borealis)* was another migratory insectivore, found in shaded coffee gardens as well as in forest and tall scrub. This upper-storey gleaning bird was more commonly seen in tree canopies and branches, than in the coffee layer.

While the present spectrum of coffee garden types does not support a forest-type bird assemblage, for many birds the maintenance of a canopy is critical. In the absence of this canopy, the bird assemblage supported by coffee gardens was similar to that of rice paddy, or the most degraded of the natural vegetation types present, Imperata grasslands. Whilst the case of the Passenger Pigeon warns that no bird species is too common to become extinct (Quammen 1996), most of the birds supported jointly by rice paddy and monoculture coffee were species that are common, tolerant of habitat disturbance and relatively independent of conservation action. The likelihood that valley floors will stay under rice cultivation in the foreseeable future secures habitat for such species in the landscape, without assistance from coffee gardens.

8.2.4 Beneficiaries of shade coffee

Within the study region there was an absence of forest-core birds in coffee gardens, while habitats such as paddy and Imperata had a high representation of open-country birds. Thus, it seems reasonable to suggest that the main avifaunal differences that might result from changing the coffee landscape from being predominantly monocultural, to one with shade trees, would be for the 'forest edge' and 'moderate-cover' bird species ('forest affinity' categories 1 and 2). For species requiring 'moderate cover' there was a clear gradient across coffee garden types. It seems then that this is a group with potential for 'manipulation' by change in the coffee landscape. The forest edge species fared better in the natural successional vegetation, possibly due to the availability of plants providing food to which local species are adapted, as well as the presence of a dense understorey of native species. However, the great abundance of forest edge birds in damar agroforest does suggest that, with sufficient time and widespread adoption of suitable practices, these moderately sensitive birds might be locally supported within managed systems. Thus, a viable aim for managing local coffee gardens is to provide habitat for those birds with intermediate requirements, potentially as a buffer for forest areas. Given the generally high level of disturbance in the landscape, it seems preferable that as much as possible, managed habitats mimic those of a late successional sere, in both structure and floristics. Vegetation structure has traditionally been seen as more determinative of bird assemblages than are floristic characteristics. However, tests in this study suggested that for the characteristics measured, these two groups of descriptors offered equally good explanations for the bird species composition at each site, although structural features are more amenable to interpretation.

8.2.4.1 Use of habitat features by birds

A relative lack of interaction between birds and structurally simple habitats was a common feature in both coffee and non-coffee areas. Indeed, the significant difference between habitats in the number of birds flying overhead appears to bear some relationship with structure. Perhaps a lack of available perches or other attractions may encourage birds to keep flying rather than stop in the site. Additionally, some of the birds flying overhead may have been foraging for air-borne insects, but field observation could not sufficiently distinguish this behaviour.

Ordination of the distribution of birds between microhabitats in each habitat showed a distinction between open habitats and densely vegetated ones. The gradient of increasing structural complexity suggested that, when particular structural features were provided, they were used by birds. Within coffee gardens, of those birds using a microhabitat other than air, only 18% used the coffee layer. This was a common feature in this originally tall-timbered landscape, as most birds seen using vegetation were using 'tree' rather than 'non-tree' types, which thereby re-inforces the importance of the shade tree layer. 'Mean of mode tree height' and presence of fallen timber were the microhabitat features identified as contributing most to the explanation of bird distribution. The first feature suggests further the importance of availability of structural features. Perhaps the higher canopy volume available in these large trees explains the higher number of birds found in the canopy (foliage) in multistrata, than in shade coffee. In the latter habitat, many birds were found in branches. This may not suggest a preference for a dense canopy, but at least the willingness by some species to make use of any structures available. The importance of fallen timber is less clear, due to the low abundance of birds present that might be expected to forage on these substrates. Several possible explanations seem apparent. Firstly, fallen timber may support invertebrates that are then available to non-ground foraging birds. Secondly, logs may provide low perches from which to pounce. Additionally, the non-collection of this timber for uses such as firewood may indicate a generally low level of disturbance. More simply, it may be correlated with the greater size of trees present, perhaps also being older and dropping, as well as producing, more branches. The clear relationships between perching heights, foraging heights and the habitats' vegetation structure further implied that when additional foraging substrates were available, the birds present used these.

In the medium term, while the transmigrant farmers seem relatively unfamiliar with local species, as is indicated by their non-inclusion in gardens, vegetation structure may be the easier characteristic to manipulate in this landscape. Nevertheless, unless attention is also given to floristic features, it seems likely that suites of birds that are dependent on fruit will be excluded, whilst those dependent on nectar may be limited.

8.3 Optimising the landscape for birds and people

Given the almost complete deforestation of the landscape studied, as well as the clear dependence of many bird species of conservation concern on forest conditions, this area is one in need of ecological rehabilitation. Given the manifold difficulties in such a process, the obvious first provision is that further encroachment upon, and damage within, forest remnants is minimised. These areas, though small and disturbed, form the biodiversity core of the landscape. There is theoretical debate regarding the ideal configuration of vegetation patches or the relative benefits of integrating remnants in agricultural plots or separating them. However, in this case, it seems that these difficult arguments are sidestepped, due to the already dire state of the situation, with forest cover reduced to 12% by 2000 (Verbist and Putra 2002). This signals that all current forest cover should be maintained as core habitat, and if possible, buffered by further areas with substantial canopy cover.

8.4 Maximising benefits of coffee farms for birds

The establishment of canopy cover and floristic diversity in coffee gardens is dependent on the willingness and capacity of farmers. Many land managers described advantages of a shade canopy for increasing the health of their coffee plants, as well as for other reasons, including the additional produce that the trees might supply. Thus, there seemed a basic willingness to plant trees. However, there was widespread concern that a dense shade cover would reduce coffee productivity. This problem seems likely to limit the canopy closure that could realistically be expected within the landscape, whilst coffee remains the dominant crop. This occurrence of a reduction of fruiting under dense shade is supported by evidence elsewhere (e.g. Soto-Pinto, Perfecto et al. 2000). However, as only 45% of farmers said that it was possible to successfully plant coffee beneath a pre-existing canopy, their attitudes also appear different from those of traditional coffee farmers in Latin America (although some differences may arise from the dominant planting of robusta or arabica coffee). Thus, resistance to planting under trees could be partly evidence-based and partly due to tradition. There was an overwhelming belief by Sumberjaya farmers that coffee should be planted before shade trees. This view seems likely to limit the overall maintenance of canopy cover, and thus further research and education on local limits of shade use may be helpful.

The Latin American practice of 'rustic coffee' planting beneath a forest canopy, that is praised for its contribution to migratory bird habitats (e.g. Perfecto, Rice et al. 1996), seems inappropriate in the Sumberjaya context, given the primary need to defend forest remnants. A non-discriminating policy of planting under shade may discourage tree removal at forest margins but encourage damage of the understorey. Rather, it seems that change to coffee cultivation practices could be used to rehabilitate other areas of the landscape. Perhaps the choice of trees with segmented leaves would maximise the structures available to birds whilst remaining below the threshold level of cover to allow adequate fruiting of coffee. Many leguminous species, such as *Parkia speciosa,* have such architecture and would have the additional advantage of soil nitrogen fixation, if the appropriate rhyzobial partners were present. Pruning of trees was also widely practised to allow sufficient light penetration to the coffee layer. This may allow greater tree height and cover for part of the season, and is well tolerated by trees including *Gliricidia sepium* and *Erythrina* spp. However, when the trees are pruned this reduces the structures useful to birds, and may disturb nests. In other studies, gardens with a severe pruning regime have also had reduced flowering and fruiting of the trees, limiting the availability of food resources (Greenberg, Bichier et al. 1997; Calvo and Blake 1998).

Overshading by trees is only a potential problem if the farms are viewed as static, with the assumption that robusta coffee, or even more shade intolerant crops, will be produced indefinitely. However, if this expectation is removed, there is greater potential to manage profitable farms with a dense canopy cover. In the higher altitude areas, one possibility would be to introduce arabica coffee, which tolerates a higher degree of shading. The intolerance of high temperatures by arabica would provide further incentive to retain shade cover. However, the reduced productivity, increased maintenance requirements and greater susceptibility to disease of arabica coffee would require sufficient financial compensation. Indeed, O'Brien and Kinnaird believe that "Shadegrown coffee is *arabica* coffee, which does not grow well at low elevations and is thus not a viable option for Asian farmers living on the borders of lowland rainforest (in response to Dietsch, Philpott et al. 2004, p. 626). Farmers also reported that there was insufficient local market for arabica coffee and that prices paid were not high enough to encourage its cultivation. One farmer reported planting arabica coffee as part of a development project, but later removed it due to the lack of available markets.

8.4.1 A successional model?

Another way in which the farmers could maintain the dense shade in their farms, would be by adopting a successional model, similar to that used in Krui. The many structural and floristic differences between the coffee gardens and the damar gardens make it impossible to conclude that the difference between the dominant tree species was responsible for the differences in bird assemblage. The combination of features there included tall, mature trees providing dense shade, structural and floristic diversity, as well as many spontaneous germinants in the understorey. There was also wide areal coverage in this agroecosystem, which provided a largely unbroken canopy cover. This series of characteristics has allowed many more forest-edge bird species to persist, in spite of great distance from the forest (although it is acknowledged that as reported by Thiollay (1994), many forest core species still appear to be missing). Perhaps more of these may colonise the gardens after further succession if disturbance is minimised. In logged forests in Gabon, birds of Pycnonotidae, Turdidae and some flycatchers (families common to Indonesian primary rainforests) did not re-occur for 30 to 60 years (Brosset 1986). The damar gardens are also a system in regeneration, following de-forestation. Whilst now extensive, this landscape of gardens has been established over generations. Perhaps the change in habitat that has occurred gradually across the region, in a linear fashion, minimising the immediate gap that birds must cross between tall habitats, has allowed relatively successful colonisation. This contrasts with the rapid isolation of the forest remnants in the Sumberjaya area, with possibly 90% reduction in cover in the district over a century (Verbist and Putra 2002). Modern encroachment on forest in the frontier regions of the Pesisir (north of Krui, near Rata Agung, as well as to the south) is also a problem, with Bukit Barisan National Park shrinking and losing integrity as it plays host to coffee farms (O'Brien and Kinnaird 2003). These farms benefit from the high fertility of the forest soils, which is another factor encouraging ongoing intrusion into the forest in Sumberjaya (Schalenbourg 2004).

Notwithstanding forest damage the frontier coffee regions of the Pesisir, the attitudes accompanying the management of shade and crops expressed by farmers seemed different from those of the coffee farmers in Sumberjaya. In the latter area, recent changes evident in crop choice showed different orientation, with substitution of the perennial coffee with annuals such as chilli. This process is occurring throughout the area (Kusworo 2005, pers.comm.). In the case of the plot I excluded from my analysis (Fajar Bulan 2), the reasons the farmer of this garden gave for its conversion were the low price of coffee and poor harvest at the time.

A culture of risk-spreading

Many of the coffee farms in the Sumberjaya area seem to have had a mixed history, with reported cultivation of primary crops including vanilla, cloves and oranges. Each of these had been removed following either failure of the crops or market, with the farms being almost entirely replanted. However, as commented by one farmer, it seems that this pattern of farmers planning crop choice in a reactive manner may leave them a step behind markets, and vulnerable to fluctuating commodity prices. In contrast, damar prices have, thus far, remained relatively stable (Poffenberger undated). Perhaps this is partly due to the lesser potential for production of this delayed harvest commodity to be rapidly expanded in many other areas, swamping the market. Such expansion has certainly caused both local, and global over-production and price reduction for coffee (Ponte 2002). In the Krui damar systems, a family owning two hectares of agroforest reportedly earns an income slightly higher than that earned in the same area of rubber monoclonal plantations ‘one of the most profitable land-use systems for smallholders in Sumatra' (de Foresta and Michon 1997, p.115). Further, the range of products produced from the systems suggests that the farmers would be buffered against a change in damar prices should this occur. Also, a Krui damar farmer of advanced years explained to me that he would continue to plant tree seedlings, which would not be productive in his lifetime, but would benefit his grandchildren. Such a successional model has some features in common with swidden agriculture, but in Sumberjaya, it should necessarily exclude the clearance of the scarce remnant forest.

Some zoned, long-term rotation of areas with established tree crops (not necessarily damar) may allow the regeneration of currently degraded soils, provision of moderately stable habitat for forest-edge fauna and the production of long-term crops for which the markets may be less volatile than those for annual cash crops. This does not necessarily exclude the growth of cash crops or annual food sources, but rather spreads investment. Whilst establishment of long-term crops involves capital, for which there would be no return for a long time, carefully staged intercropping provides for immediate and medium-term needs (de Foresta and Michon 1997). Such use of succession in a patchy landscape is also described by Toledo *et al.* (2003) in the context of indigenous land management in Mexico. This involves the acceptance that particular areas will not always support the same crops, but that the advent of shade will provide alternative sources of livelihood.

8.4.2 Choice of tree species

Another factor associated with maintaining trees in coffee gardens, that concerned farmers, was the possibility of root competition. Several farmers also suggested strategies to minimise this problem, including maintaining adequate spaces between 'greedy' trees and coffee, possibly by planting these trees at the margins of gardens. The selection of appropriate species might be helped by networking between farmer groups, possibly aided by Non-Government Organisations or other institutions. Of the trees currently used, *Erythrina* seems to satisfy many requirements. These trees were said to be the traditional shade providers to coffee grown in the area, but in recent times, planting of *Gliricidia sepium* has become more common. *Erythrina* species appear to be useful trees for maintaining soil fertility. They can grow to a substantial size, tolerate pruning, may be long lived and, being bird-pollinated, provide rich nectar resources as well as insects for foraging birds (Yusuf 1997). The wood is rather soft and the trunks were observed being used by woodpeckers, although woodpeckers were also identified by some farmers as accelerating tree death. Whilst *Erythrina* spp. trees were only dominant in 16.2% sites, 43% of the woodpeckers surveyed were observed in these trees. These trees were also useful for other bird species. Whilst the generally smaller insect pollinated *Gliricidia* *sepium* was the dominant tree species at more sites, there were over twice as many individual birds observed using *Erythrina*. However, farmers did identify some problems with insect pests associated with poor health of trees in this genus.

In the Sumberjaya coffee gardens there was very little planting of native tree species. Indeed, in transmigrant communities, such as Simpangsari, local tree species were almost absent from gardens. The trees used primarily for shade tended to be of species used for this purpose throughout the world (in particular *Gliricidia sepium* and *Erythrina* spp.). In locations such as Gunung Terang, where farmers are predominantly of Semendo ethnicity (having earlier migrated from South Sumatra), there was some use, and tolerance, of local trees recorded. However, in communities such as Krui, where the people are of native Lampung ethnicity, the use of local species was extensive.

Institutions working inter-regionally may be able to facilitate wider co-operation between farmer groups. In particular, those farmers who have been established in Lampung for longer may be prepared to share their extensive knowledge of local tree species. However, it must be recognised that this intellectual property is valuable. Given the reported resentment by some Lampungnese due to the loss of their land to the transmigrant majority (Tjondronegoro 2002), the desire to widely share this information should not be assumed.

If it was available, information regarding which species are useful for timber, fruit or other products, as well as their interactions, could be valuable in creating more indigenous systems in Sumberjaya. Local tree species would also be likely to be better adapted to the (non-degraded) soils and climate of the region. This may potentially reduce the frustration some farmers have felt when unsuitable tree seedlings have died, or trees planted locally have not produced fruit. Given the reported difficulties in establishing hardwood forest trees on degraded land it might be necessary to begin by planting species other than forest specialists. Perhaps, during the rotation, fast-growing exotics may still be necessary to condition highly damaged soil (Lamb 1998). Otherwise local 'gap' and forest edge species might be used (Maury-Lechon 1993). These are more tolerant of disturbance than forest core species, and likely to germinate or be cultivated from cuttings in bright and open conditions. Their fast growing characteristics may allow them to compete successfully and shade out invaders such as Imperata. They would also condition soil by returning organic matter to the top horizons and by breaking up compacted areas (Parrotta 1993; Whitmore 1998). Also, in time, these pioneer trees may act as a nursery species, not only to coffee, but also to more sensitive species. Thus, gardens would mimic the succession of the forest. Whilst exotic species might also fulfil some of these agronomic functions, their contribution to food resources for birds may be less than that of local species. If many farmers across the landscape embraced such a system, in time it may also become partly self-sustaining, as well-adapted species reproduce spontaneously. The maintenance of such germinants within gardens might support some of the bird species currently absent, if the colonising plants provide suitable fruit and flowers, in addition to structural diversity. Indeed, the role of these birds as pollinators and seed dispersers may increase their appreciation by observant farmers. These people might then feel more strongly about maintaining the birds in the landscape, further encourage their presence by increasing the use of plants attractive to birds. They may also discourage the capture of birds for trade.

A substantial change in attitude seems feasible given the apparent differences in farmers' opinions regarding the usefulness of birds in the garden. Of the multistrata farmers interviewed, 79% stated that birds had an overall positive impact, compared with 50% of simple shade coffee farmers and 30% of monoculture farmers. Multistrata farmers were the only ones who cited pollination as a benefit of birds in their gardens. Indeed, as coffee is insect-pollinated, for birds to provide any pollination benefit, other fruiting species must be present. Of the fruit trees currently present in the coffee gardens, there seemed few that were identifiable as being bird pollinated or dispersed. This contrasted with tall scrub, where trees such as *Ficus* were found, some species of which are recognised as supporting many frugivorous animals (Lambert 1991; Whitmore 1998). The removal of some of these scrub trees during the survey year indicates that their wood is also useful, and so would be an asset in a farmer's garden. However, some of the observed garden trees did have bird-dispersed fruit. The advantage of seed dispersion by birds might be realised collectively across the coffee growing community if there was widespread development of a canopy. The early planting of selected pioneer species with fruit known to attract birds or bats would encourage these animals to feed in the area. The shade trees could then provide perches and roosts for the dispersing birds increasing the effectiveness of the trees' nursery role (Parrotta 1993). One potential problem might be the taking of some fruit intended for human harvest by birds or other animals such as monkeys. Some of the farmers commented that they would be happy to lose some fruit to birds. Perhaps such difficulties would be better tolerated if the perceived benefits of seed dispersal were sufficiently high.

8.4.3 Garden management and disturbance

Whilst the planting of trees is one of the most obvious differences between styles of garden management, there were also other characteristics that varied. Coffee pruning is one potential source of disturbance to birds, particularly to those such as tailorbirds (*Orthotomus* spp.), which sometimes built nests in coffee bushes. The frequency of pruning varied greatly between farms, but not significantly between farms with different shade classifications. Traditionally, Semendo farmers did not prune coffee, but levels of production on these farms were not maintained as well as under pruning regimes (Verbist and Putra 2002). Whilst it is usually thought necessary for coffee to be pruned to maintain productivity (van der Vossen, Soenaryo et al. 2000), if production was still adequate on farms where minimum frequency of pruning was used, perhaps frequency could be reduced on other farms, and timed so as to avoid the main breeding season. However, it seems possible that farmers not maintaining high pruning frequency might be perceived locally as not diligent. Further investigation would be required to answer these questions in the local context.

Harvest of coffee causes another intense period of disturbance in gardens. Whilst the length of harvest and number of workers varied between farms, this did not seem to be related to farm shade characteristics. However, if attempts were made to increase the quality of coffee produced locally by only harvesting ripe berries, the length of time during which the gardens were disturbed would probably increase.

A further source of disturbance observed in the coffee gardens was removal of grass and weeds. This was done both manually using a hoe, and with herbicide sprays. The disturbance created by the grass removal may be immediately higher for manual weeding, due to the longer presence of the workers and greater noise. However, dependent on the type of herbicides used by the individual, it seems possible that their build up had other impacts on the birds and their breeding success, particularly for those high in the food chain. Several types of fertiliser are reportedly used in Sumberjaya, including the non-accumulative glyphosate, as well as the cheaper gramazone, "a paraquat herbicide, banned in Europe and North America for suspected carcinogenicity" (Schalenbourg 2004, Annex XIII). The removal of weeds would change the availability of habitat for ground-dwelling birds, such as quails, regardless of which technique was used, although the use of herbicides may allow cover to be maintained for longer due to the presence of dry grass. Removal of weeds may also impact on the availability of food for granivores such as munias, as was found by Greenberg *et al.* (1997) in Guatemala. It is interesting that, while most birds using vegetation were using trees, and few birds other than munias and sparrows were seen on the ground, one of the best contributors to BioEnv explanations for the character of bird assemblages in coffee gardens was the weed cover. Perhaps this layer provides habitat for insects that become food to other birds. It may also be a proxy for overall level of disturbance, or an indication of the light passing through the canopy and the coffee to the ground. Either of these explanations are consistent with the negative correlations (albeit weak) between the weed cover score and each of mean of mode tree height (R=-0.29) and % canopy cover (R=-0.22).

Other industrial chemicals applied included fertilisers and pesticides. Whilst there was little difference between shade and monoculture farm management in frequency of application of herbicides and fertilisers, a lower proportion of shade coffee farmers than monoculture farmers had used pesticides in the previous year. Many farmers said that they used pesticides opportunistically rather than habitually, only using them when a problem was apparent. It is unclear whether the differences in bird assemblage were related to the frequency of pesticide use, either as cause or effect. In spite of the reputation of coffee as being relatively pest resistant due to its leaves being tough and high in alkaloids (Perfecto, Rice et al. 1996), pests were clearly a relevant issue to farmers. All farmers described pests to coffee in their garden, and nearly half of these were described as 'serious'. The numbers of 'pest types', described in lay terms, were slightly higher in monoculture than in other garden types, but this finding is derived from a small sample. There was no significant difference between the numbers of insectivores in different coffee garden types.

Monocultures had a higher biomass of invertebrates trapped at ground level, but multistrata had greater masses of invertebrates than did monocultures within both coffee and aerial strata. However, all these differences were insignificant. It is also unknown which of these invertebrates were 'pests'. Literature from Latin America suggests that shaded coffee has greater diversity of invertebrate assemblages (Perfecto, Vandermeer et al. 1997; Moguel and Toledo 1999). Thus, as described by Stamps (1998), according to the theory that diversity begets stability, there may be an element of control of pests, not by birds, but by predators that are themselves invertebrates. Two thirds of farmers stated that control of pests was a benefit of having birds in their coffee gardens. There was a low positive correlation between the number of pest types described and the number of birds surveyed in the simplified 'insectivore' feeding group. However, this trend needs further confirmation with more detailed information. Furthermore, no study was made of the effectiveness of birds in pest control, or differences in this characteristic between garden types. Indeed, as in the study of Wunderle and Latta (1998), most insectivores were in the canopy rather than in the coffee layer. Nevertheless, control of insect pests in the overstorey would provide an advantage to farmers. While any benefit perceived by farmers may encourage them to create conditions amenable to birds, without direct evidence that the benefit is a real one, it seems unjustified to use the concept in promotional material for farmers.

In order for coffee to be recognised as 'organic' by the Organic Crop Improvement Association (OCIA) it must be grown free from the addition of industrial chemicals for at least three years (OCIA 2005). This project did not collect sufficient information to judge whether this was the case for any farms studied. However, according to the information given by farmers for the year 2002, only two of the thirty-one coffee farms studied seemed to achieve 'chemical free' status in that year. Due to the low price paid for raw coffee at the time, many farmers indicated that they had reduced their use of industrial chemicals. Additionally, subsidies for commodities such as fertilisers have been reduced, reducing the capacity of farmers to purchase these inputs (O'Brien and Kinnaird 2003; Potter 2005). It is interesting that, in spite of the empirically demonstrated potential for shade trees to reduce the requirement for added fertilisers due to leaf-fall, reduced erosion of topsoil and increased nitrogen fixation by leguminous species, there was little difference in reported frequency of fertiliser use in shade and monoculture. Nevertheless, the use of a wide variety of practices regarding industrially-produced agrochemicals suggests that there is potential for farmers' routines to be modified. In some regards sustained low prices of coffee may accidentally provide a 'window of opportunity' for qualification of farms as being certifiably 'organic'. Additionally, the self-realisation of the potential dangers of high use of toxins, for example, the fish kills reported in local ponds, may encourage such a change (Verbist and Putra 2002). However, it appears that there is also high-level opinion that may be perverse to the aim of reducing the input of industrially produced chemicals. The executive secretary of the Indonesian Coffee Exporters' Association (who provide licences for all coffee exports) has been reported as suggesting that the Government follow the example set by Vietnam, where the rapid expansion of production has been facilitated by policies including subsidies for fertiliser (Hari 2005).

8.5 Engaging the community

While physical surveys and review of literature can suggest models by which conservation could occur within the landscape, transferring these ideals to action involves another level of complexity. As commented by Abensperg-Traun *et al.* (2004), issues of payment for restoration and public attitudes towards conservation are critical for gaining the cooperation of landholders. Additionally, the involvement of local people depends on their 'ecological literacy', with the success of restoration projects tied to its social integration. In Sumberjaya this is borne out by the lack of success of the "heavy handed" (Verbist and Putra 2002, p.17) and non-consultative programs that have taken place in the past.

8.5.1 Existing community interest

Engagement of the community in efforts to maintain biological resources in the region requires, not only interest in this goal, but also means and incentives to achieve it. Positive attitudes towards birds and their conservation seem to be a fundamental requirement. Interviews suggested that this is generally present in the farming community, although there may have been some bias in answers due to a wish by the respondents to fulfil what they saw as expectations upon them. A higher proportion of shade coffee farmers felt positively about birds than did monoculture farmers. Perhaps this was because of the greater number of species not perceived as pests (as the grain-eating munias are viewed), or the greater expectation of birds actively playing a helping role in the garden. Indeed, although the sample size is small, the difference between farmer attitudes was marked, with 30% of monoculture farmers stating that, overall, birds help their garden, compared with 50% of shade coffee farmers and 78% of multistrata farmers. Thus, the situation seems to involve positive feedback, with perceived benefits from birds accruing to farmers who provide birds with benefits. Reports of damage were rare, a factor which may smooth the path for conservation efforts.

Another factor that seems important for engaging community interest in conservation efforts is a perception of need. This may take the form of a belief that there is a problem with declining populations of some species. The majority of interviewees suggested that bird populations, as a whole, have declined and the species composition changed within their memory. There are no scientific records with which to compare these observations, but it seems consistent with the generally recognised patterns of bird assemblage deterioration with forest loss. It is also consistent with the comments of some bird traders, who said that birds were becoming more difficult to find in the province, and so were progressively sought from further north. This trapping may have also played a role in reducing local populations of desirable species. The comments by residents that some species, that used to be seen around villages, are now absent are consistent with the retreat of forest margins. Indeed, one farmer, who had been in the area since the 1950s, recalled seeing elephants close to Simpangsari village. Although there are now occasional sightings of elephants in agricultural areas closer to Bukit Barisan National Park, observations such as the earlier one would seem surprising now.

The difference in perceptions of bird declines between different types of farmers is also interesting. There seem to be several possible explanations for fewer monoculture farmers identifying changes in bird populations. Firstly, there were many individual birds seen from monoculture gardens. These may be highly visible due to the openness of the habitat and their likelihood of flying overhead, rather than being obscured by vegetation. For those farmers for whom birds do not seem critically important in the environment (most people identified the role of birds as 'to keep people happy' or 'for natural beauty'), these birds may contribute to a view that birds are still present, while the species of these birds may go unnoticed. Secondly, as monoculture farms were generally closer to forest margins, there may have been more forest-dwelling birds seen locally, due to the birds' reliance on forest habitats. Thirdly, as monoculture farms tended to be younger, perhaps the more recently cleared areas were subject to ongoing 'species relaxation', as species richness often takes some time to reach a stable level following disturbance (Turner, Tan et al. 1994; Magsalay, Brooks et al. 1995). Indeed, there did appear to be some relationship between time since deforestation and bird assemblage, although this is not easily separable from differences in current habitat. However, there was no clear relationship between bird species richness and time since deforestation in coffee plots. Thus, it seems that with increased time since deforestation, the number of species present may be similar to the earlier level, but the identity of the species different. Yet, there was no clear relationship between age of trees in gardens and the bird assemblages there, implying that the patterns of loss were stronger than those of recovery.

Another possible explanation for the differences in farmers' observations also relates to the age of coffee gardens, which differed slightly with garden type. It seems likely that the farmers of the older gardens, had been farming in the area for longer[24]. These gardens were also further from the forest and more likely to have established trees and secure tenure. Some of these farmers had maintained the same gardens for several decades. Perhaps these farmers had a greater chance of recognising change in the birds present. Additional data would be required to provide an adequate explanation. However, it is noteworthy that while the community in general identified change in bird assemblages and populations, it seems that the farmers with greatest potential to modify their practices to provide additional habitat for birds, were, in fact, the least likely to recognise such a need. Thus, whilst decisions for farm management are clearly limited by circumstance, including the availability of capital, there also seems to be potential for education regarding ecosystem functions, the developing crisis of biodiversity decline and the role that individual land managers can play.

8.5.2 Farmer knowledge and education

Some farmers suggested that if more of the community were aware of the roles that birds play in the environment then they would make greater efforts to protect them. Limits in ecological education provided in schools were identified by several interviewees. There also seemed to be

[24] Many of the gardens were still maintained by their original owners.

limited opportunities for further education. Descriptions by participants of Government programs educating farmers in coffee cultivation suggest that these focused on immediate production issues, rather than on sustainability or ecology. My tests of farmers' recognition of species only gave a rough indication of their knowledge of local birds. Comparison between interviews and bird survey results does show differences between on-farm bird abundance indicated by monoculture and shade coffee farmers to be reflected in the mean survey data. However, the median number of birds was similar for both garden types. In contrast, the species richness data were not so consistent with the coffee farmers' self-assessment of their farm's avifauna. As a population, the farmer's observations of microhabitat use and activities of birds were also similar to my own observations. There were some differences between the responses of farmers of monoculture coffee, shade coffee and damar. The monoculture farmers more commonly cited seeing birds in the coffee and in the air, than their shade coffee counterparts, whereas the latter observed more birds in the shade trees and in the understorey. Both damar farmers described seeing birds in tree canopies. Farmers' descriptions of birds' activities in different types of coffee garden were also generally consistent with my observations. The farmers' description of 'playing' might also be considered largely equivalent to my recorded activity category of 'flying between perches'. Of course this compiled data does not indicate the observations of individual farmers. However, as respondents were allowed to list multiple answers, the fact that the main activities and microhabitats (as far as my own data can indicate them) were recognised by the majority of farmers, indicates both observation and interest by farmers. This suggests some potential for birds to be a useful focus of biodiversity conservation efforts.

Whilst it seems that the farmers had some interest (albeit generally a light-hearted one) in the birds locally present, and the community had also recognised local declines, there was a widespread impression that quality habitat existed elsewhere. Few people suggested that deforestation resulted in the death of birds. Most said that they would move to other locations or habitats. This indicates a general unawareness that forest core species are dependent on this habitat and unable to adapt to other habitats, as well as of the general pattern of de-forestation throughout the region. This situation has apparent similarity with the findings of an Australian study on incentives and barriers to conservation of white box woodland. Whilst farmers were interested in conservation, they were surprised at the need for programs, and did not perceive that grassy understoreys are threatened throughout the region (Elix and Lambert 1997). Similarly, Lampung has suffered deforestation to a greater extent than most of Sumatra, due to its close proximity to Java and rapid population growth. Encroachment upon the iconic Bukit Barisan National Park occurs progressively, reducing much of this elongated park to disturbed 'edge' habitat. However, further to this local loss, throughout the island deforestation has been very rapid, and Kinnaird (2002) predicted that by 2005 the lowland rainforest would be largely gone. While this may have not eventuated, the 2005 report of Ekadinata *et al.* (2005) makes it clear that deforestation in the Bukit Barisan Selatan region is continuing. Thus a parochial approach to the problem appears to be a dangerous one. Contrary to the local opinion that the birds will go to forest elsewhere, there will be few places for them to go. Many of the species intolerant of gaps would also be unable to make such a journey across the wide areas of hostile habitat that lie between. Perhaps then, education should emphasise the role of the region in the larger situation, in addition to identifying what action can be taken locally at an individual and group level.

One approach that has been favoured by BirdLife International, is the reinforcement in communities of the uniqueness of their local wildlife, with a particular focus on endemic species (Sujatnika, Jepson et al. 1995). It seems incumbent upon scientists to share information they have collected on wildlife with the communities who may act as environmental stewards. For the many of the community who have limited opportunity to travel, there may be little understanding that the species present locally do not exist everywhere. According to BirdLife definitions, of the 36 range-restricted bird species present in the Bukit Barisan Endemic Bird Area, 20 are endemic to Sumatra. A greater feeling of community pride and responsibility might result from the promotion of the unique characteristics of charismatic birds such as the Fire-tufted Barbet (*Psilopogon pyrolophus*), which is the only member of its genus. Yet, like some other species, I only ever observed this range-restricted bird in a cage. This illustrates the potential dilemma between the desire to educate the community and encourage their appreciation of these species, which are declining to rarity in the embattled local forests, but also to restrict further losses due to trapping. Nevertheless, in a study of the captive bird market in South Kalimantan, non- bird keepers were found to be more educated than keepers (Soendjoto 1997). Perhaps this gives some cause for hope in the potential role of targeted education in Sumberjaya.

8.5.3 Policy and incentive

Tomich *et al.* (2004) have argued that answering global concerns, such as biodiversity preservation, may place a great immediate burden on local communities unless these are linked to incentives. Caldecott (1996, p. 174) goes further, by suggesting that "most wild species will be safe only to the extent that the people who conserve them feel themselves to be rewarded by doing so". Tomich *et al.* (2004) also add that action plans for conservation should not be limited to aims to change patterns for landuse, but should also consider the policy instruments by which this change will be led. Thus, scientists might provide viable alternatives to damaging activities, and 'broker deals' for conservation, seeing biodiversity as their "constituents" (Richter and Redford 1999). Otherwise, scientific information must be sufficiently accessible to, and valued by, the decision-makers in bureaucracy for conservation to be integrated into their plans. The limited success of past Government-led forest conservation projects in Sumberjaya highlights the local importance of these concerns.

Ideally, commodity-based systems, such as those involving the coffee gardens of Sumberjaya, would allow sufficient recognition and reward for landusers who minimise deleterious environmental impacts. However, as explained by Rappole *et al.* (2003), achieving this involves many "ifs". There is a moral and practical imperative to involve local people in land management planning. Yet this is complex, as providing strong incentives to locals may increase attractiveness of the area to outsiders, and thus cause further forest encroachment (O'Brien and Kinnaird 2003; Rappole, King et al. 2003). Conversely, chronic low prices undermine the capacity of farmers to produce a quality product, to protect their farms, natural resources, and sustain their livelihoods (Mallet 2001). Thus, tuning incentives for biodiversity conservation is a complex task, and likely to need ongoing monitoring and revision.

8.5.3.1 The role of Non Government Organisations and community groups

In the context of developing workable schemes for integrating bird conservation into the local landscape, many of the tasks, such as agronomic and social research, could be carried out by a range of organisations. These include farmers themselves, Government, universities and non-government organisations, or partnerships between these. However, there was some suggestion by the community that non-government organisations could play a particular role in education. For members of the community who have had negative experiences with past Government interventions, an approach by an intermediate organisation could be less intimidating and more effective. As several organisations with aims of assisting the community socially, environmentally and agronomically already exist, both infrastructure and some level of trust are already in place.

Most farmers said that they had learned their farming methods from family members or neighbours. In order to maximise the impacts of investment made in programs to encourage garden diversification and structural change, initial effort could be targeted at community leaders who may act as role-models to their neighbours. This targeting of 'reformist' landholders who may lead others has been recognised in diverse farming contexts (e.g. Elix and Lambert 1997). Additionally, the lack of success of several past programs has made some farmers nervous of investing in risky strategies in the absence of a clearly successful example. NGOs have the potential to provide greater security for the establishment of such demonstration plots, and could provide some insurance against failure. Indeed, collaborative research on privately managed plots is already occurring in the area. However, this could be extended to include trials and demonstrations using indigenous tree species and arabica coffee, farming according to organic guidelines and testing the local limits for coffee productivity under shade. In addition to leading education, agronomic and ecological research, NGOs promoting the growth of alternative species should investigate the availability of markets for these products, as in the past a lack of markets has reportedly caused project failure. Also, NGOs with local organisational ability could provide co-ordination of production, as there seems to be somewhat of a circular problem with the unavailability of markets and insufficient production to establish a market. This was reported for arabica coffee, which is only grown in small quantities due to the insufficient recompense for effort. Local markets giving a clear price benefit do not currently exist, partly due to the low and irregular production. Similarly, the low prices available to farmers match, and are matched by, the poor quality of the coffee produced. This reportedly results from the practices such as strip-picking, slow and insufficient drying and drying on unclean surfaces.

Collective action may have advantages in this situation. If sufficient numbers of farmers produced higher quality coffee they might collectively secure a new price level for this coffee, distinguishing it from the more easily produced, but poorer quality coffee. However, due to the many players in the coffee market, and the control of prices and demand by roasters, as described by Ponte (2002), it is not clear how effective local action would be. In this case, NGOs may also play a negotiation role, serving as an intermediary between the coffee farmers, traders and other institutions such as the Indonesian Coffee Exporters Association. However, as discussed by Lane and Morrison (2005), NGOs are not, as it is sometimes implied, completely independent, interest-free or unbiased; they each have their own agenda, and any community accepting involvement should do so with prudence.

In some countries, perhaps in the absence of strong Government-based incentive schemes, self-organised farmer collectives have done much to create momentum for environmentally-focused agronomic reform. In Australia, this has most notably taken the form of Landcare groups (Abensperg-Traun, Wrbka et al. 2004). Some collective action is already practised in the Sumberjaya region, with farmer groups operating in *kawasan* areas where *HKm* (*Hutan Kemasyarakatan*) community forestry status has either been granted or is sought. Community groups also protect the springs that are locally important, and Kusworo (2000) notes that in the villages where such traditional arrangements are absent, this is due to a lack of organisation and regulation, rather than a lack of understanding of the benefits. In such cases, NGOs could aid in the negotiation of such arrangements, although ultimately, the structures must be self-sustaining. Farmer groups provide a forum for information sharing, and can also create economies of scale by sharing in transport and hulling costs. The group purchase of hulling machines has already occurred in some locations in the area. However, it is noted that such practices may be difficult if organic certification is sought by only some farmers, as equipment cannot be shared with that used for conventional production (OCIA 2005). Also, where there is group decision-making, there is a trade off in autonomy. This may be unacceptable to some farmers who expressed their desire for choice over farm management, particularly regarding selection of tree species. This follows their experience of the enforced cultivation of species such as *Calliandra calothyrsus,* which is not compatible with coffee farming.

8.5.3.2 The role of Government

One of the problems identified with addressing issues such as biodiversity conservation or loss, is the diffuse nature of the externalities. That is, that impacts of any loss could be spread over a large area, and be delayed for some time, rather than acutely affecting those who benefit immediately from causing the damage. Thus, there is generally low community awareness of the issue; it is often seen to be of low immediate importance, and thus action becomes 'stuck' in the first stage of the policy cycle (Tomich, Chomitz et al. 2004). In turn, this may contribute to a lack of political will for action. The Indonesian Government has, in the past, responded strongly to the rapid encroachment on the margins of local protection forest (Kusworo 2000). However, it is pointed out that the "*raison d'etre*" for the protection status is for "watershed protection" (van Noordwijk and de Foresta 1998). Thus, it is less clear what political will exists for biodiversity protection. At this stage it is a less clearly defined goal, with poorly understood benefits and significance (Tomich, Chomitz et al. 2004). Indeed, the advent of local research suggesting that watershed properties may be maintained adequately in non-forested areas (e.g.van Noordwijk, Poulsen et al. 2004), may have the unintended effect of de-prioritising forest conservation. Indeed, it seems that until now, the maintenance of watersheds, rather than biodiversity has been the main motivation for forest protection (Schalenbourg 2004).

Various models exist for the involvement of Government in conservation action in largely agricultural areas (Abensperg-Traun, Wrbka et al. 2004). Two extreme cases are described for Austria and Western Australia, featuring relatively high and low involvement respectively. In these cases, the complementary role is played by autonomous farmer groups, which are conversely poorly and well developed in the respective locations. In Indonesia, it seems likely for the Government to fall between these extremes. Whilst funds that are collected, such as logging royalties, could potentially be used to educate and change farming behaviour, the use of subsidies to reduce agricultural production does not exist as it does in Austria. Yet, the encouragement of higher quality, rather than more extensive coffee production might be useful for discouraging further encroachment on forest. At least for the areas with 'protection forest' status, there is leverage for Government action on landuse, and a demonstrated history of its use.

Regulation

Following the forceful approach of the Government towards 'illegal' farmers in the past it seems that they must re-establish trust before expecting hearty engagement with conservation plans. Indeed, it is suggested that, in the changed political climate of Indonesia, the past approach is no longer possible (Verbist and Putra 2002). However, whilst the past approaches to forest protection were imperfect, the Government retains official responsibility to achieve this goal. The need to depart from the old methods of implementation does not necessarily mean that land status should not be used as a lever for Governmental protection of areas for conservation. Indeed, given the rapidity of land conversion, it may be a valuable tool, although Wells *et al.* (1999) caution that in general, in Indonesia, threats to protected areas from local communities were less than those posed by large projects. It should be noted, that the suggestion to use Government claims over land tenure as a tool assumes the validity of these claims, but Verbist *et al* (2005) question this validity in some locations.

Perhaps motivated by their wish to avoid repetition of their traumatic past experiences of conflict with Government agencies, the majority of respondents in Sumberjaya stated that the best path for achieving conservation was by co-operation between farmers and the Government. Additionally, for the question regarding responsibility for conservation, 'Government' and 'everyone' were the most popular responses. Thus, the community did appear to wish for a collaborative conservation effort to take place. However, as described by observers including Kinnaird (2002), Tjondonegoro (2002) and Verbist (2002), the process of Government de-centralisation caused some confusion regarding responsibility for forest protection, as well as feeling that previous laws were invalid. This appears common with the warning by Wells *et al.* (1999, p.5) that "the extent to which the effective enforcement of laws and regulations is a basic requirement for successful ICDPs is deeply underappreciated". In Trimulyo, residents in protection forest areas also told Suyanto *et al.* (2005) that they would be less likely to leave their farms without compensation than they would have been before the Government reformation. This raises the level of challenge to be faced by any body attempting coherent regional planning. Education in current regulations and penalties seems needed, both for the protection of forest structure, as well as the understanding of the protection status for wildlife that is currently trapped for trade.

Although corruption seems an intractable problem, greater trust might be gained by consistent ruling. In the absence of this, the situation is rather like that famously described by Hardin (1968): without rules that are respected and enforced, individuals act to maximise immediate individual gain with little regard for the long term costs shared by the community. As described by Caldecott (1996), conservation efforts may be compromised by conflicts of interest high up in the system. It also seems that this role model may have allowed such behaviour to become pervasive throughout. Budidarsono *et al.* (2000) suggest that the payment of "unofficial fees" to officials (reportedly Rp 50, 000 per hectare in 2000) gives farmers the feeling of legitimacy in clearing state forest land for coffee cultivation. Policing and enforcement of laws also implies the employment of adequate staff to care for local forest. There currently seem to be very few forest management staff (Kusworo 2005, pers. comm..). Public respect for the process may allow people to be further engaged in enforcement of these rules, greatly expanding the area that is effectively regulated. A more profound realisation of the community and individual benefits provided by maintenance of forest may, in time, allow greater community autonomy in regulation, as is described for the Krui region (Poffenberger undated). However, given the urgency of the situation, in the apparent absence of an indigenous system for resource management adapted to the local area, some external definition of rules seems mandatory.

With relation to the captive bird trade, there was also a suggestion that it is unjust for penalties to apply only to those trapping birds. The market is driven by the demand for caged birds, and the willingness of buyers to pay high prices for them. Thus, some people indicated their support for penalties for these buyers. Indeed, there was widespread disapproval of the trade expressed in the community (although some of this may have been in an effort to provide 'expected' answers). However, the 20.7% differential between this group, and the number who said that they preferred birds free, is perhaps indicative of the desire not to interfere with, or criticise, others' behaviour, in spite of personal opinion. Several people explained a difficulty in regulation within the community, due to social pressures, and expressed the need for outside help with this. Within the framework described by Naryan (1999), action seems to be limited by insufficient 'bonding social capital'. That is, the local social structures do not allow people to be held accountable for damage to public resources. Some intervention by Government institutions may allow better policing of regulations that are generally supported by the community. Nonetheless, it seems that there is a fine line between what is seen as useful assistance in regulation of resources, and what might be at least seen as being overbearing and reminiscent of the old system.

Consultation

Secondly, if farmers are to be engaged enthusiastically and genuinely in the ecological rehabilitation of the region, they must be consulted during project planning. In apparent agreement with the suggestion by Verbist (2001; 2002), farmers indicated that the re-opening of areas subject to Government 'reafforestation' efforts was evidence of the failure of these projects, due to the 'non-usefulness' of the trees planted. It could be argued that on state forest land, particularly in the context of rapid and widespread deforestation, the primary goal is not necessarily utility. However, the lack of community participation in planning that has been identified as a common reason for failure of Integrated Conservation and Development Projects (ICDPs), and where there are large local populations dependent on agriculture, it seems unrealistic, as well as incompassionate, to ignore their needs (Brandon and Wells 1994). This seems particularly valid for those long-established farmers, to whom, earlier Governments reportedly gave reason to believe that their farming would be tolerated (Verbist and Putra 2002). For more newly-established farms, definition becomes more difficult, and there is indeed the risk that the provision of incentives may encourage local population growth and, in fact, increase the risk to the forest remnants (Brandon and Wells 1994).

Many farmers also complained at the lack of choice in seedling species in the past, but expressed greater interest in programs that could provide flexibility in this. Government has the opportunity to use duties collected from logging companies to fund research into tree species that are suitable locally. This might be conducted through local NGOs and involve farmers in the trials, to give them greater ownership of the process. By recording farmer preferences, the benefit for funds spent could be maximised, as farmers who feel they have an interest in the outcome seem much more likely to take great care of any trees they are entrusted to plant (Kuncoro, Budidarsono et al. 2003). Education in agronomy and environment, funded by Government, could also take the form of workshops organised by NGOs, or local extension officers, who may both provide immediate help to farmers and reduce disillusionment.

Tenure

According to Caldecott (1996), secure tenure over resources is essential for local participation. The relationship observed within Sumberjaya, between tenurial security and the establishment of trees on farms (Budidarsono, Kuncoro et al. 2000), suggests that granting farmers greater stability would be advantageous, as long as this does not encourage forest encroachment. This balance seems likely to be a fine one. According to Tomich *et al*. (2004, p.8)

"the feasibility of key conservation objectives rests on the ability to stabilize *(sic)* the boundaries of the so-called 'protected' areas through some combination of incentives and enforcement. Again, this requires capacities for conflict management, including a mechanism for compensating local people for foregone opportunities."

The most obvious means by which more secure tenure arrangements could be achieved within the local protection forest area is the HKm community forestry program. Since 1999 agreements have been formed between Provincial Government and local farmer groups (Kusworo 2005, pers. comm.). However, as these have focused on watershed protection issues, it remains to be seen to what extent biological conservation, particularly for birds, could benefit from these arrangements. Indeed, foreseeing the potential for this is complicated by past changes and re-invention within the HKm program. Whilst still within the five year probationary period required for agreements, there is still considerable uncertainty concerning requirements (Kusworo 2005, pers.comm.). Whilst the lack of finality in current arrangements may allow potential for incorporation of new elements, the general confusion regarding the scheme may quench any desire to futher complicate the arrangements. Misunderstanding of the scheme by even the officials entrusted with its administration has already been cited as one limitation. There has also been criticism that the program has become increasingly Government-regulated, less 'bottom-up' and less suited to indigenous communities (Chidley 2002). However, within the Sumberjaya context, where it seems that some regulation is needed, and the majority of residents are not indigenous, and are engaged in non-forest dependent activities, the program may still be a suitable one. Some pilot projects on degraded land allowed the planting of crops between the young trees that were intended to restore forest cover (Chidley 2002). Perhaps such an arrangement would be a suitable one for establishing a successional-type of agroforestry system, as demonstrated in Krui. The orientation of the *kawasan* areas around the forest, as well as the need for farmers to co-operate in groups to apply for HKm status, suggest that this could be a way of achieving a consistent and continuous cover to act as a buffer. A degree of community autonomy seems important for long-term success of conservation programs. However, the tenurial zonation of the landscape could be a useful tool for maintaining the existing forest, whilst quickly increasing overall canopy cover, and especially the use of trees beneficial to wildlife, within strategic locations.

8.5.3.3 <u>The role of private companies</u>

The most easily apparent manner in which private companies, such as coffee traders and roasters, could become involved in increasing the habitat value of the local landscape, would be by eco-certification. This has played a substantial role in giving a measurable value of coffee farmers 'shade trees in Latin America. However, within Sumberjaya, there seemed to be some substantial problems for this strategy within the foreseeable future. Few of the coffee gardens studied appeared to have immediate potential to fit into existing eco-certification schemes. Not all vegetation parameters were measured in the same way as for evaluation under the Smithsonian Migratory Bird Center Bird-Friendly Coffee guidelines (Smithsonian Migratory Bird Center undated). Nevertheless, some comparison can be made of broad parameters. Firstly, this scheme recommends that shade cover from backbone trees does not fall below 40%. Of the 31 coffee gardens studied, only 6 had canopy cover measured above this threshold. These backbone trees are also expected to have a height of 12-15 m. The maximum tree height of 14 gardens was over 12 m, and the mean of mode height of only two gardens was above this level. Both of these gardens also fitted the canopy cover requirements. Another regulation concerns dominance. Whilst the requirements concerning the genus *Inga* are not locally relevant, they seem to indicate effectively that cover by a single species should not exceed 35%. Of the gardens fitting the basic cover requirements, three also met this standard. Tree species richness is also recommended to be at least ten species. Of the coffee gardens meeting basic cover requirements, four also met this threshold. Overall, only one garden met all of these requirements. This was LM3, the single 'closed multistrata' garden studied. This garden was established by one of the pioneering farming couples in the 1950s and is still maintained by them. It had a dense canopy of mature mahogany trees and other species. Its uniqueness in the area was demonstrated by its location as an outlying point on the PCA of garden characteristics. To my knowledge this was the only site of its type in the area, but is demonstrative of what can be established under long stewardship. Nevertheless, the absence of tree species native to the area would still disqualify it from certification under the 'Bird Friendly' scheme or OCIA organic regulations (Smithsonian Migratory Bird Center undated) (OCIA 2005).

For certification of coffee to promote sustainable practices and the maintenance of useful bird habitat in the Sumberjaya region it seems likely that schemes would need to be altered substantially. One model that might have potential is a 'star'- based graded scheme. Such an arrangement would allow farmers, or farmer groups, to join the program having made minimal changes from conventional practices. This would allow them to receive immediate incentives, and make program entry achievable. The existence of increased levels of incentive for improved practice would encourage further changes to be made, and recognise achievements such as the maintenance of trees to maturity or the progressive replacement of exotic nursery trees with native species. Education regarding the benefits of various tree species as well as advice in agronomy and harvesting practices could be provided by the company, as part of the contract. While the complication of certification may risk the confusion of customers, a simple graded system may also provide the opportunity for customers to be further educated regarding the real conservation benefits of various types of shaded systems. This may help to meet some of the concerns of commentators such as Rappole *et al.* (2003; 2003), that customers are misled regarding the benefits of some of the farms producing certified coffee. However, the establishment of such a scheme would require substantial investment in research, infrastructure and negotiation. The Sumberjaya situation alone seems unlikely to warrant this, particularly given the problems of coffee quality that exist locally. Yet if such an Indonesian-oriented scheme were developed in an area more renowned for its coffee quality, the extra investment required for extension in 'bulk coffee' producing areas such as Lampung may be more feasible. Currently the certified market appears to be a boutique one, priding itself on quality as well as social and environmental responsibility. However, perhaps either one of the major players in roasting, or one of their 'minnow' competitors, may perceive a niche in the development of a 'conservation coffee' for the non- connoisseur who wishes to respond to environmental and social concerns. Indeed, recent reports of arrangements between major roasters Kraft and Procter and Gamble and the Rainforest Alliance, to buy certified coffee in Guatemala, seem promising for such a prospect (Mackenzie 2005).

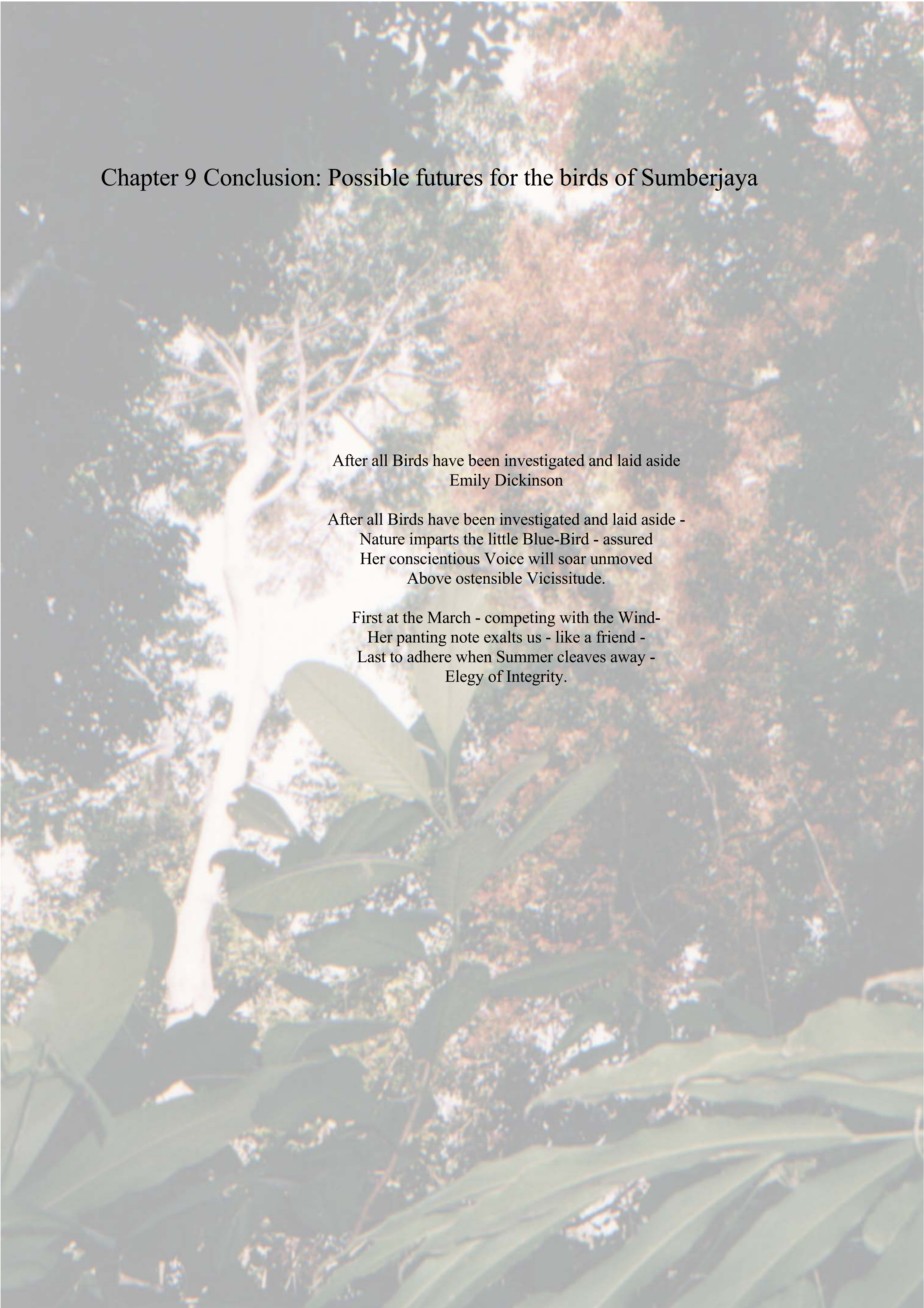
8.6 Conclusion

Whilst the many variables acting upon the Sumberjaya landscape are confounding for any research, the local coffee gardens did support a range of bird species, at least providing for some of their needs. The ability of coffee gardens to support all life activities of the birds, including breeding, would require further and more detailed work. Secondly, there did appear to be differences in the birds' ecological use of various garden types. These were evident in the species composition, diversity, feeding groups, guilds, activity and microhabitat use. Thus, given that birds did seem to respond to largely human-created variations in habitat, even within the category of 'coffee garden', there does seem to be potential for these characteristics to be manipulated for goals including bird conservation. This finding warrants further investigation regarding the way in which garden characteristics could be used for the maximum benefit of the regional avifauna. However, one of the most profound, albeit unsurprising findings, is that none of the coffee garden types even approached forest in their ability to support habitat specialist birds. This finding contrasted with some of the suggestions made in the context of Latin America, where coffee gardens are championed as important habitats for migratory birds.

It is not clear if the difference lies mainly in different ecological traits of the Lampung birds (for example, there are far fewer migrants), or is more related to the nature of the coffee growing landscape. Indeed, the fact that none of the gardens studied would satisfy the conditions required for entry to "Bird Friendly Coffee" certification designed for the new world situation suggests that the coffee landscape of Lampung is a rather different one. The lack of native tree species in Sumberjaya coffee gardens is one outstanding factor that may explain some of the differences. This may be partly associated with the demographic characteristics of the area, which is largely populated by transmigrants, whose knowledge of local tree species is limited by their short experience in the area. Yet there seems to be some hope for positive change. There has been an overall trend towards shading of coffee during recent decades, and many farmers expressed positive opinions regarding the potential benefits of trees for their coffee gardens. Likewise, they had positive opinions regarding birds, but little understanding that some of these species are restricted in range, and face threats of habitat loss throughout the region. It seems that some change might be achieved by education, including demonstrations of successful gardens that provide features useful to birds. Whilst the most important factor for retaining specialist bird species within the landscape appears to be protection and maintenance of forest, this inherently involves local people. Thus, as discussed by Caldecott (1996), there is need for a local solution, and there is a wide range of options beyond reserve creation. Within the local landscape, tenure is one incentive that seems to have greatest potential within the areas immediately adjacent to forest. However, beyond these margins, other incentives are possible, including financial measures. Along with rewards, there also seems to be need for regulation, particularly in a relatively new community, where in-migration is still occurring, especially when coffee prices are high. There is also a danger of rewards providing perverse incentives, for example, any increase in bird species richness across the landscape might encourage bird trapping, which has the potential to provide high immediate returns. Yet, as demonstrated during the 1990s, there is also danger of over-regulation reducing community cooperation.

Over the long term, it appears that maintenance of the local ecology will depend upon the attitudes and behaviour of the local people. If these people develop greater understanding of habitat requirements, and empathy for wildlife, perhaps aided by a sense that these organisms may have benefits for them, then perhaps there is a greater chance that they will moderate their activities in the interests of preservation. The 'best case' example for this is the development of the damar systems in Krui, where there appeared to be a strong community perception that it is in their own interest to create a sustained and sustainable system. In contrast to the monocultural model for farming, a wide variety of organisms are seen as being integral to the maintenance of the whole. The consistency of approach across the community, partly achieved by a strong local system of resource regulation, allows people to manage their land in a manner not entirely defined by immediate rewards. While it would not be possible to replicate such an intricate system elsewhere, it provides a useful model which, to an extent, overcomes the widespread problem that immediate returns from biodiversity are insufficient to encourage its conservation.

Chapter 9 Conclusion: Possible futures for the birds of Sumberjaya



After all Birds have been investigated and laid aside
Emily Dickinson

After all Birds have been investigated and laid aside -
Nature imparts the little Blue-Bird - assured
Her conscientious Voice will soar unmoved
Above ostensible Vicissitude.

First at the March - competing with the Wind-
Her panting note exalts us - like a friend -
Last to adhere when Summer cleaves away -
Elegy of Integrity.

Conclusion: Possible futures for Sumberjaya's birds

This study revealed inter-habitat patterns in bird assemblage in the Sumberjaya coffee farming landscape, which is located within a region generally considered a biodiversity 'hotspot'. A multi-disciplinary approach including surveys of birds, vegetation, environmental variables and community interviews allowed many of the social and environmental variables present in this real farming community to be considered. These factors included the character of bird assemblages in various agricultural and 'natural' habitats, the birds' behaviour and habitat use, farm management, community opinion, and potential activities of market and Government. Some of these fields are increasingly recognised as critical in determining conservation outcomes. Although locally variable, they are very relevant for addressing the urgent and complex problem of retaining species of the tropics. While my area of general enquiry was broad, the focus was reduced to three main questions; "What is the contribution of coffee gardens to bird assemblages in the region?", "What are the differences between bird assemblages in coffee garden types?" and "What is the most promising way to achieve conservation for birds in the Sumberjaya area?".

9.1 Study findings

There were observable differences between the bird assemblage compositions in the habitats studied. For example, interhabitat differences in guild assemblage and feeding groups were significantly different. Different types of coffee garden, as defined by mainly structural, but also some floristic, characteristics showed clear differences. For instance, the numbers of bird taxa unique to each of monoculture coffee and simple shade coffee were substantially lower than the number only found in the vegetationally more complex multistrata coffee. Thus, over the region, multistrata may support a greater number of species than other coffee habitats. Likewise, bird assemblages of multistrata coffee were more similar to those of the forest than were the assemblages in simple shade or monoculture coffee gardens. However, when put in the context of the overall landscape, the differences between coffee gardens were small relative to the greater differences between all coffee gardens and forest.

Some groups, such as frugivores, were particularly poorly represented in most coffee gardens. This may be related to the scarcity of suitable food resources present, as few indigenous tree species were planted within coffee gardens. Additionally, while damar and forest habitats supported some birds listed by the IUCN as 'near threatened' (BirdLife International 2003), no listed birds were found in coffee habitats. Triage for conservation is a subjective exercise. However, by existing methods, the forest-dependent birds, that are absent from the coffee gardens, are judged to be of greatest conservation dependence. Thus, these habitats appear not to be contributing to maintaining viable populations of these priority species.

The interviewees' descriptions of declining bird populations, and assemblage change, within their memories, suggests that there has been a local loss of bird species with forest habitats, rather than adaptation to new habitats. The most common reasons given for this were trapping for the caged bird trade and habitat loss. The operation of the captive bird trade was one visible limitation to regional bird conservation, and also to the population augmentation of financially valuable rare taxa. While many interviewees stated disapproval of trapping, the market for caged birds was a large and lucrative one, and social difficulties in addressing trapping were expressed. Investigations of bird markets, at the local, provincial and national level showed, that many wild-trapped species were available for sale.

In spite of the recognition of habitat loss as a past problem, few people felt that forest loss would lead directly to bird deaths. Instead, there was a general perception that other suitable and accessible habitat for displaced birds existed elsewhere. This attitude appears dangerous to biodiversity considering the general pattern of habitat loss throughout the province. Perhaps there is potential for education to provide a greater understanding of the urgency and widespread nature of the threats facing the forest-adapted fauna of Sumatra. A substantial proportion of the farmers expressed a belief that coffee gardens had potential to provide useful bird habitat. This was more commonly suggested by farmers of shaded coffee, than by those who maintained monocultures. It is not known if a pre-existing difference in attitudes may have led to different management styles by the farmers, or whether their different experiences of avifauna within their gardens has led to a difference in opinion.

The findings of this study generally support the local application of the Conservation Principles for Coffee Production produced collaboratively by several organisations in 2001 (Mallet 2001). However, in many cases in Sumberjaya, management options were limited or influenced by factors such as financial constraints, horticultural difficulties or insecure tenure. For example, while at the time of study it was not common for completely organic farming practices to be used, financial constraints did limit farmers in their use of manufactured chemicals. Shade trees were widely perceived to have benefits, such as sheltering coffee plants, and providing additional produce. Yet many farmers were also apprehensive about the potential for over-shading to reduce coffee production. The majority also stated that coffee should be planted before a shade canopy is established. This limitation to the development of tree canopies may be partly attitudinal, but there are also real shade restrictions for economic production of coffee.

Thus, while the area remains predominantly a coffee farming one, rehabilitation sufficient to conserve forest-affiliated fauna is likely to be restricted.

In spite of the difficulties evident for bird conservation in the area, there appears to be some hope for management change. Most respondents felt positively about birds in the environment, and 57% of farmers said that birds benefited their gardens. Interestingly, there were distinct kinds of benefits described by farmers with different garden types. Many people also showed interest in conservation programs and co-operation with the Government, particularly if schemes allowed some flexibility to farmers. There was generally a perception that both the Government and the community are responsible for conservation. Additionally, there was a belief that faunal conservation could be advanced within the current HKm scheme, which rewards farmer groups with secure tenure, in return for following guidelines for tree establishment and forest protection. Many farmers also expressed some interest in market-based schemes, such as eco-certification, for producing coffee sustainably. However, there was some apprehension due to experience with failed programs in the past. Discussion with a local coffee trader also highlighted problems with coffee quality that could limit the feasibility of such a scheme.

Comparison of vegetation surveys with the requirements for currently operating certification schemes, in particular, the ‘Bird Friendly’ scheme (Smithsonian Migratory Bird Center undated), suggested that local farms are far from reaching these criteria. There are also problems of poor coffee quality, and the lack of infrastructure for garden inspection and regulation of trade. Thus, ecocertification is not likely to be a useful path for providing incentives within the near future. However, this does not mean that there is no potential for a less complex, and possibly less rigorous, Government-based scheme for rewarding farmers for increasing sustainability.

The situation in Sumberjaya appeared rather different to those of many of the locations in Latin America that have been subject to similar studies. In the latter case, there have been bold claims regarding the usefulness of shaded coffee gardens as coffee habitat (e.g.Perfecto, Rice et al. 1996), although sometimes these were tempered with caution regarding the differences in quality of habitat locally present (Greenberg, Bichier et al. 1997; Rappole, King et al. 2003). However, the situation in Latin America is also different in that it is frequently one that involves long-established coffee gardens, grown under a forest canopy, or gardens that mimic forest, and contain many local tree species. In that context, campaigns have frequently been directed to conserving the existing gardens, in the face of rapid transformation to an industrialised monoculture style of production. In contrast, in Sumberjaya the pattern is one of recent but rapid deforestation, largely for the purpose of coffee garden establishment. Many local people are transmigrants, and do not have a culture that is long adapted to local conditions. Also, the 'default' model for coffee gardens has been robusta monoculture. Only over recent decades has there been a substantial change towards the shading of coffee. Thus, the landscape is more in need of overall restoration, than preservation of its current state, although the existing forest patches should be retained. Rather than "How can current practices be maintained, so that birds are conserved?", the appropriate question in Sumberjaya may be "How can current practices be improved, so that birds are conserved?"

9.2 What can be done?

There is no obvious panacaea for conservation in Sumberjaya. However, whilst the landscape has been degraded by the removal of most of its original forest cover, the broader context of deforestation throughout the province increases the value of those patches that remain. Within Sumberjaya, some initially modest steps might improve the value of the broader landscape for birds adapted to moderate cover, or perhaps forest edge conditions. More importantly, the same actions may help to maintain the integrity of forest remnants such as those at Bukit Rigis and Bukit Abung, which were within the study area.

Consistent with Waltert's (2004) findings in Sulawesi, conservation of the species rich and diverse bird assemblages in the region appears highly dependent on the maintenance of forest remnants. Zones across the landscape have different potential for involvement in conservation-oriented schemes. While forest areas may be the cornerstones of conservation efforts, other areas may be used to support their role as core habitats, both physically, and more indirectly, by involving the broader community who manage and live within this landscape. In areas of coffee gardens that are designated as 'protection forest areas', and surround the forest remnants, there is an opportunity to use HKm agreements to achieve stability of forest margins and create more sensitive buffer habitats involving native tree species. In freehold areas, there may be more potential for subsidies from Government, or from coffee companies, to act as incentives. These incentives might not be most appropriate in the form of cash, with alternatives including provision of seedlings, training and education.

Due to biogeographic characteristics and the small size of farms, the best results across the region are likely to occur through group action. For most sites, there was no clear relationship between the avifauna and the distance from forest, but there appeared to be some regional influence on bird assemblages. Examination of the influence of neighbouring habitats also indicated the importance of management of coffee farms throughout the community. Collective effort may establish a canopy cover that is largely continuous throughout the region, and thus fill large gaps that are avoided by many bird species adapted to the region's forests. The farmer groups that have already been established for HKm purposes could be useful for achieving this co-operation. Furthermore, the opportunity to collaborate in organised trials of native tree species and share results of these may make this proposition less daunting than if conducted individually. Perhaps if eco-certification became a more promising option, joint applications could also be made for certification of coffee.

There are also other, more general difficulties facing any program aimed at bird conservation in the area. These include a lack of understanding of environmental processes, such as the extinction resulting from habitat loss. Also, in the absence of clearly quantified and immediate benefits to people of having birds in the landscape, there remains a lack of direct incentive for their conservation. While education alone is rarely sufficient to solve serious conservation problems, it may be a useful tool. A greater understanding of both ecological relationships and the conservation urgency of the situation could be provided. Increasing pride in uniqueness and a feeling of local ownership has also been successful in giving some communities elsewhere a feeling of stewardship over local fauna (Australian Nature Conservation Agency 1994). Advice in agronomy could include information on benefits and cultivation of native tree species and methods of coffee cultivation and processing that might make eco-certification a more realistic proposition.

Advocacy is likely to be another useful input, perhaps by NGOs that are already working in the area. These might lobby Government to provide incentives for farming sustainably. In the longer term, they may also negotiate with coffee companies and the Indonesian Coffee Exporters' Association to create suitable certification programs. If such schemes included graded incentives, perhaps with a 'star rating', or a similar system, it may be more realistic for farmers to become involved, and progressively change their practices. Furthermore, consumers may become more aware of differences that exist across the coffee garden spectrum.

9.3 Study limitations and further study.

This study was a preliminary investigation, and being conducted largely independently, in field conditions that were sometimes difficult, was subject to various constraints. These may be attributed variously to a lack of prior research on this subject within the region, limited local expertise in the subject, my limited prior local experience, as well as limits in time and physical resources. Detailed survey of rainforest vegetation requires a great deal of time, and training for species identification, and was beyond the scope of this study. Additionally, species identification was limited due to factors such as the birds' high mobility and the challenging survey conditions. The varying levels of precision that resulted have been accommodated by measures such as calculation of diversity at three taxonomic levels. A greater number of survey sites, and also a greater number of survey repetitions, would also increase confidence in interpretations. Perhaps this would be better achieved by reducing the number of habitats surveyed, in order to increase the numbers of samples per site, within the same time. However, in the absence of prior information regarding inter-habitat differences, it was important to cover the range of habitats present in such a patchy landscape. This patchy landscape, and the great number of variables present, was also limiting to interpretation. Similarly, a greater number of samples would be required to adequately explore differences between invertebrate biomass in different plant and garden types. My study included only brief exploration of these questions, conducted to identify any clear patterns important for interpretation of my other results. Accurate identification of invertebrates is difficult, and particularly so in the context of tropical regions.

Further research in the area may illuminate some of the important subjects untouched, or inconclusively addressed by my study. Regarding bird ecology, these may include the food requirements of individual species, and availability within various habitats, nesting success, source-sink relationships between habitat types, the ability to travel, and movement of individuals, and the interaction between gardens and forest habitats (including factors such as pollination and seed dispersal). Studies addressing invertebrate communities in various habitats may yield useful information regarding the food resources potentially available to insectivorous birds. Research on local tree species could indicate their usefulness to people, and to birds, as well as agronomic information. Trials of local shade tolerance of coffee for adequate fruiting, organic cultivation and other interactions between coffee and the overstorey may allow the most effective compromise between ecology and production to be met within the system. These studies could involve local people who have direct interests in this knowledge. Furthermore, explorations of more forest-like alternatives that also meet livelihood objectives may pave the way for a more ecologically and economically stable landscape in the longer term.

9.4 The place of Sumberjaya in global biodiversity conservation

Consideration of biodiversity and landuse is scale dependent, thus, landscapes that are locally high in species richness may not contribute greatly, over large scale, if the same species are replicated widely. There seems to be further difficulty caused by the general inability of Sumberjaya people to travel beyond the region, and thus appreciate what is unique, and what is widespread. Whilst the field of conservation and development currently has emphases on local autonomy and ground-up planning (e.g. Bayliss-Smith 1994; Chidley 2002), this may be problematic for large scale management of highly fragmented and damaged ecosystems. In such systems, co-ordination of efforts may be judged more important than autonomy. Whilst the past attempts by Government to slow the rate of deforestation in Sumberjaya do not provide a good example, the official control they hold over land management planning in protection forest areas may yet be a useful tool for shaping land management on forest margins in a consistent manner.

Maintenance of biodiversity over a broad area remains a great challenge. Either extreme position of an exclusive focus on conservation reserves, or non-recognition of differences in ecological value between habitat types, seems unlikely to achieve an optimal solution, in either ecological, or social terms. However, the recognition of prime conservation areas as a valued part of a much bigger system, rather than in complete contrast with it, may be a more effective approach within the region. The development of a zoned system, with gardens near the forest maintaining a dense canopy of native trees, could protect the core forest areas and enhance their value in the landscape. For indigenous bird assemblages, the habitat value of coffee growing areas is never likely to approach that of forest, but it could be improved beyond that of the monocultures that are still widespread. Perhaps ideally, the areas around the forest will no longer produce coffee in the long term, but evolve to harness the successional qualities of local vegetation systems, provide stable incomes and diverse resources to the human population, and useful habitat for the birds and other fauna of the region.