# Community patterns of birds and butterflies in Lambusango forest, Buton, Southeast Sulawesi in 2005

**Report to GEF Lambusango Conservation Program**

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**Nurul L. Winarni**
**Martin Jones**

Manchester Metropolitan University

## Introduction

For the last five years, the Lambusango Forest Area of Buton Island has been the focus for biological research carried out by the Operation Wallacea programme. These long-term studies have shown that the area supports a high level of biodiversity including anoa (*Bubalus depressicornis*) and Buton macaques (*Macaca ochreata brunnescens*). Buton island is known to support at least 231 bird species including 52 Sulawesi endemics and 9 Indonesian endemics (Catterall 1996), making it an extremely important site for bird conservation. As for butterflies, 557 species are recorded for Sulawesi (Vane-Right and de Jong 2003) and although research on Buton has not been conducted thoroughly, at least 175 species have been recorded (Opwall 2000) with at least 55 species (excluding Hesperiidae and Lycaenidae) recorded around the forest of Lambusango (Wallace 2004) and one Papilionidae species, *Papilio jordani* is considered vulnerable (IUCN 2004).

The Lambusango Forest has been suffered from various disturbance including hunting, forest conversion to agriculture, asphalt mining, illegal logging, and uncontrolled rattan extraction (Wilson 2004). Thus, in early 2005, a joint programme between Operation Wallacea and Global Environmental Fund (GEF) of the World Bank, established the Lambusango Forest Conservation Program. The programme aims to develop an integrating forest management system for the protection of forest and its surroundings and the development of the people living around the forest areas. One of the measures of success of the programme is a biodiversity monitoring project and this report focuses on one aspect of this, namely the monitoring of the bird and butterfly communities.

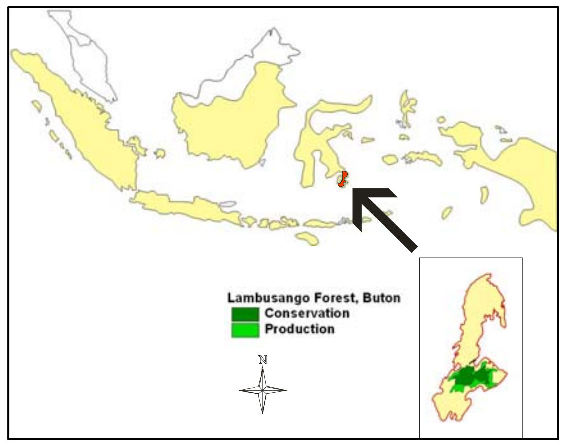
The continuous change of forests will obviously affect biological communities, and there is a necessity to conduct ecological monitoring to assess the impact on those communities (Spellerberg 2005). Spellerberg (2005) also suggests that such ecological monitoring is particularly important when the ecosystems in question have not been researched comprehensively. In addition, long-term monitoring is needed to support management schemes to combat human-induced disturbances which themselves have an impact in the longer term (Spellerberg 2005).

As part of the study to determine the community patterns of birds and butterfly in Lambusango Forest, this paper reports preliminary findings from 2005. Data on bird community patterns, species abundance and habitat structure are presented. At least one more visit is obviously required before we establish some of the parameters needed for the longer term monitoring programme (power analysis to estimate required sample sizes) Due to the time needed to identify the butterfly species, the systematic survey of the butterfly commuities will begin take place in an extended field season in 2006. During July-August 2005, we were more focused on collecting reliable data on birds and habitat whilst practising different method of surveying butterflies and learning to identify the butterfly species.

## Study Area and Methods

### *Study Area*

Studies were conducted between July-August 2005 in 5 node camps in the Lambusango Forest Area, Bala, Walahaka, Anoa, Wabalamba, and Lapago. Four are situated within the Lambusango Forest Reserve, and one within the adjacent limited production forest (Bala). Different nodes were experiencing different kinds of anthropogenic disturbance. The greatest levels of disturbance were found in Wahalaka and Wabalamba in the south of the Lambusango Forest Reserve. Both Lapago and Anoa sampling nodes are long-abandoned gardens. Bala sampling node in the limited production forest showed the least disturbed forest with a high frequency of large trees, though there was evidence of high levels of rattan collection in the area (Seymour 2004). Approximately one week was spent at each node camp. Four transects, each 3km in length, were set up at each site and each transect was marked at 50 m intervals.



Location of Lambusango Forest, Buton, Southeast Sulawesi

### *Methods*

Bird Counts

Bird species was surveyed using the Variable Circular Plot methods (point counts with distance estimates to each contact) following Bibby et al. (2000). Points were located at 150-m interval along each of the transects at each node camp and were visited between 0600 and 0800 hours. Preliminary surveys in the area suggested that bird activity started to increase at 0600 and dropped off markedly after 0800. Therefore, we decided to use 150-m interval to reduce the travelling distance between each point and increase the number of points each day. Due to increased possibility of double counting the birds, we monitored the position of calling birds so that the same birds were not recorded at more than one point. Two groups consisting of 2-3 recorders led by an experienced observer stayed at each point and recorded any birds detected around the central point for 10 minutes without the use of a settling down period .Recent research has shown that settling down periods reduce the numbers of contacts recorded (M. Jones pers.comm.). Each group visited different points each day and did point counts only once at each point. When one group conducted a count at one point, then the other group would replicate the point on the following day. All birds heard and seen were recorded (those flying were noted but not used for the subsequent analysis) and an estimate of distance was made to each contact. Amongst the assumptions of this 'Distance Sampling' method are that the birds must be correctly identified and that the distance estimates are accurate (or at least the errors are small and random). All observers spent approximately one week prior to data collection, learning to recognize bird species and bird calls, as well as practicing methods. The performance of individuals on this training programme was monitored and the results will be analysed for the final report.

Habitat Measurement

To determine how bird communities related to habitat, we will examine the habitat association at two levels. At population level, we will compare population densities between forest areas which vary in their natural characteristics. At a smaller scale, we will try to identify the factors associated with the presence/absence of species at individual point counts. To address this, we quantified a number of vegetation structure and other variables within a 20-m radius circular area around the bird count points. We estimated the density of understory and canopy closure. Understory density was assessed using 1.5 m stick with fifty black bands and counted the number of black bands seen from a distance of 10 metres. Canopy closure was estimated using sighting tube where theobserver looked up the canopy through the sighting tube and recorded whether each field was occluded by the canopy or not. We recorded the undulation of the site (divided into flat, medium, and major undulation), slope (flat, medium slope $10^o$-$45^o$, and steep slope above $45^o$), and number of fallen trees, divided into freshly fallen, partially rotten, and well rotted fallen trees. We measured ten nearest trees with DBH $\geq$ 50 cm within 20-m radius, recorded the distance from the central point, the position of inversion (less or more than halfway of the height) as well as any indication of scars, and flowering or fruiting of the tree. Position of inversion and scars are indication of undisturbed forest. Branching above the half of the tree height is usually characteristic of undisturbed forest as the tree's ability to growth under a close canopy (Jones et al. 2003) and presence of scars may indicate a secondary reaction to the closure of the forest canopy and may indicate regeneration following natural and human induced disturbance. And other indication of disturbances, i.e. presence of rattan, palms (Palmae), lianas, *Pandanus* were also recorded. In addition, we also recorded the number of above-two-meter saplings, number of ferns, tree ferns, and bird-nest ferns. In addition for assessing butterfly-habitat association, flowering shrubs and sapling within the plot were recorded as well.

## Progress and Preliminary Results

### *Field work Progress*

The first survey was conducted between July-August 2005, and will be resurveyed in summer 2006 and 2007. During this period, we have been able to conduct 56 counts at each node camp producing about 2405 bird records. We had 5 students who helped with the data collection. The students usually spent approximately one week for bird identification prior to survey. All students are new to the area and thus, we may face some bias in the field as one of the assumptions of distance sampling requires correct identification and accurate distance estimation of the birds. To ensure that the assumptions are met needs experienced observers. We tried to lessen this bias by having at least one experienced observer at each team. However, we will also evaluate the observer heterogeneity for the final report.

Bird team in Bala

### *Patterns within the community*

<u>Diversity, abundance, and species richness</u>

A total of 54 bird species from 22 families was observed in at the 5 node camps during July-August 2005 (Appendix 1) with Wabalamba holding the highest number of species seen (40 species). Six species were seen around the camps but not at the point counts. Among the accounted species, 27 species are endemic to Sulawesi. Species listed during point counts excluded aerial birds (swiftlets and swallows) and nocturnal birds. Other species not detected during point count but were recorded in the areas were 'captured' during opportunistic walks and mist-netting. These species are Rufous-throated flycatcher (*Ficedula rufigula*) which was captured in Wahalaka and Green-backed kingfisher (*Actenoides monachus*) which was captured in Anoa, Sulawesi dwarf kingfisher (*Ceyx fallax*) and Black-billed Koel (*Eudynamys melanorhyncha*) which were recorded in Lapago, White-rumped cuckoo-shrike (*Coracina leucopygia*) in Bala, and Sulawesi scops-owl (*Otus manadensis*) which was recorded in most of node camps. These additional species are mostly rare and secretive.

The five most common species in all node camps were Green Imperial Pigeon (*Ducula aenea*), Hair-crested drongo (*Dicrurus hottentottus*), Sulawesi Babbler (*Trichastoma celebense*), Bay coucal (*Centropus celebensis*), and Black-naped oriole (*Oriolus chinensis*).

Diversity and similarity indecies were calculated using EstimateS (Colwell 2005). Shannon's index of diversity (Magurran 1988) revealed that the diversity index ranged from 2.98-3.12 with the lowest index at Anoa and the highest index at Wahalaka (Table 1). Simpson's index of diversity (Magurran 1988) which plcase more emphasis on the partitioning of birds between the different species showed the same patterns (Table 1). The Morisita-Horn similarity index which is influenced by the most abundant species depicted the closest similarity of community between Bala and Wahalaka. Lapago was the least similar to any other node camp. Total species rank encounter curve is presented below, indicating that the communites were not dominated by a small number of species (Figure 1).

Table 1. Morisita-Horn similarity index between node camps with Shannon's index and Simpson's index of diversity at each node camps.

| Sites | Anoa | Bala | Lapago | Wabalamba | Wahalaka | Shannon's index | Simpson's index |
|---|---|---|---|---|---|---|---|
| Anoa | | 0.347 | 0.116 | 0.586 | 0.322 | 2.98 | 16.23 |
| Bala | | | 0.358 | 0.5 | 0.857 | 3.07 | 16.91 |
| Lapago | | | | 0 | 0 | 3.1 | 17.36 |
| Wabalamba | | | | | 0.5 | 3.11 | 17.34 |
| Wahalaka | | | | | | 3.12 | 17.54 |

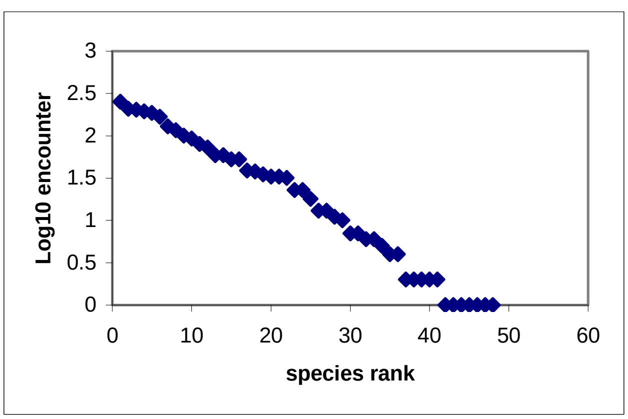



Figure 1. Abundance distribution based on species encounters

When areas are divided into two based on level of disturbance (least disturbed and highly disturbed), we see that the two groups have rather different community patterns. Based on Seymour (2004), Wahalaka and Wabalamba are the most disturbed areas compare to other node camps. Wahalaka experienced heavily rattan extraction and heavily logging occurs at Wabalamba (Seymour 2004). Although encounter of bird species in both levels of disturbance did not show a significant difference ($t = 1.144$, $df = 83$, $P = 0.256$), the least disturbed areas tend to reflect a more complex community as they are less likely to be dominated by a small number of species (Figure 2). The frequency distribution of species abundance in the least disturbed areas fitted a log normal distribution whereas the disturbed areas fitted a log-series model. The greater Simpson's index in the highly disturbed areas also indicated that the more species dominated the areas than in the least disturbed areas (Table 1).

However, the overall diversity is greater in highly disturbed areas (Table 1). Wabalamba and Wahalaka have greater diversity than other areas. The sample-based rarefaction curve of both areas (Figure 3) showed that the highly disturbed areas depicted more richness than the least disturbed areas which is as expected as disturbed-open areas usually have higher species richness (Hill and Hamer 2002) as it attracts edge species. The rarefaction curves reach an asymptote at the fifth sample indicating that more sampling would not produce many more species – only the very rare ones have not yet been recorded. The use of the rarefaction curve allows us to toassess the differences in species richness of areas with different species accumulation rates.

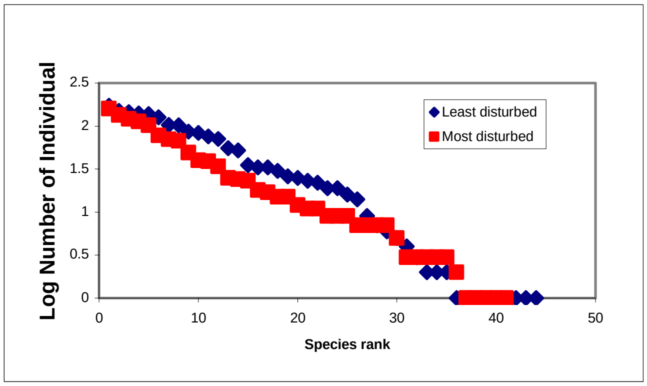



Figure 2. Abundance distribution of most disturbed and least disturbed areas based on number of individuals observed

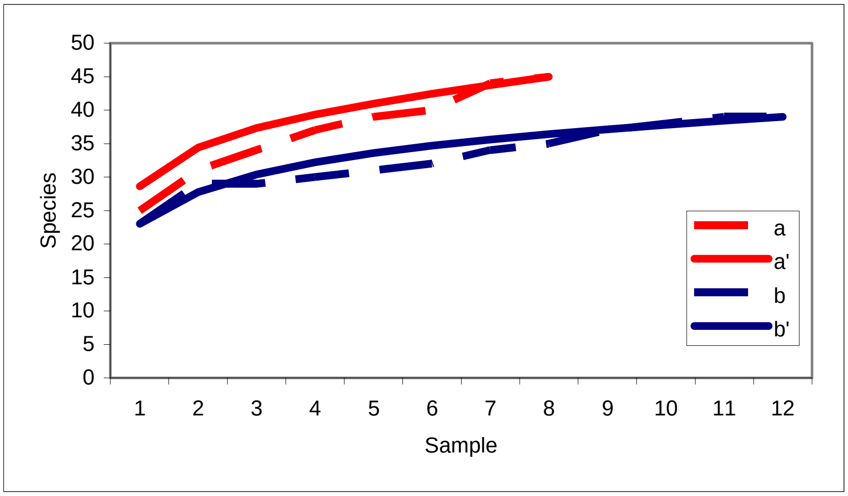



Figure 3. Species richness in 'disturbed' and 'undisturbed' areas; (a) actual species accumulation in disturbed areas, (a') results of species rarefaction in disturbed areas, (b) species accumulation in undisturbed areas, and (b') results of species rarefaction undisturbed areas

Density estimation

Density of birds was estimated using DISTANCE 4.1 (Buckland et al. 1993, Buckland *et al*. 2001). At this preliminary stage we only estimate the densities of the more common birds as sample sizes for some of the others are too small. Distances were fitted into different models of detection - half-normal, uniform, and hazard rate. The DISTANCE software then selected the best models based on the minimum AIC (Akaike's Information Criterion) values for further density estimation (Buckland *et al*. 2001).

Estimated density in least disturbed and highly disturbed areas depicted different patterns. Birds with highest estimated density in highly disturbed areas (Wabalamba and Wahalaka) were birds such as the Bay coucal, Pied cuckoo-shrike, Green imperial pigeon, Black-naped oriole, Drongo cuckoo, and Sulawesi babbler. The highest density birds in least disturbed areas (Anoa, Bala, Lapago) included the White-bellied imperial pigeon, Red junglefowl, Ashy woodpecker, Golden-mantled racquet-tail parrot, and Sulawesi dwarf hornbill and Red-knobbed hornbill. For most birds, highest density reflected highest abundance in the area (Table 3).

Table 3. Density (per ha) and encounter rates of most common species in 5 node camps

| Species | Anoa | | Bala | | Lapago | | Wabalamba | | Wahalaka | |
|---|---|---|---|---|---|---|---|---|---|---|
| | D | ER | D | ER | D | ER | D | ER | D | ER |
| *Accipiter trinotatus* | 0.064 | 0.010 | 0.064 | 0.012 | 0.084 | 0.027 | **0.133** | 0.018 | 0.064 | 0.011 |
| *Centropus celenbensis* | 0.246 | 0.046 | 0.321 | 0.074 | 0.193 | 0.075 | 0.433 | 0.070 | **0.707** | 0.142 |
| *Coracina bicolor* | 0.398 | 0.034 | 0.234 | 0.025 | 0.152 | 0.027 | **0.825** | 0.061 | 0.140 | 0.013 |
| *Coracina morio* | 0.131 | 0.014 | **0.376** | 0.050 | 0.056 | 0.013 | 0.478 | 0.041 | 0.319 | 0.037 |
| *Cuculus crassirostris* | 0.043 | 0.012 | **0.065** | 0.022 | 0.032 | 0.019 | 0.007 | 0.002 | 0.072 | 0.022 |
| *Culicicapa helianthea* | 1.253 | 0.044 | 1.025 | 0.045 | 0.797 | 0.059 | 1.181 | 0.036 | **1.651** | 0.062 |
| *Dicaeum spp.* | 2.072 | 0.060 | 1.174 | 0.042 | 0.794 | 0.048 | **2.507** | 0.063 | 1.657 | 0.052 |
| *Dicrurus hottentottus* | 1.403 | 0.076 | 0.988 | 0.089 | 0.467 | 0.071 | **1.679** | 0.106 | 1.098 | 0.088 |
| *Ducula aenea* | 0.728 | 0.087 | 0.695 | 0.104 | 0.480 | 0.121 | 0.909 | 0.095 | **0.910** | 0.118 |
| *Ducula forsteni* | **0.207** | 0.062 | **0.207** | 0.077 | **0.207** | 0.017 | 0.076 | 0.020 | 0.080 | 0.026 |
| *Gallus gallus* | 0.039 | 0.020 | **0.051** | 0.032 | 0.014 | 0.015 | 0.012 | 0.005 | 0.023 | 0.013 |
| *Hypothymis azurea* | 1.328 | 0.078 | 0.749 | 0.057 | 0.715 | 0.088 | **1.342** | 0.068 | 0.885 | 0.056 |
| *Macropygia amboinensis* | **0.099** | 0.016 | 0.025 | 0.005 | 0.080 | 0.027 | 0.128 | 0.018 | 0.000 | 0.000 |
| *Mulleripicus fulvus* | 0.276 | 0.020 | **0.386** | 0.035 | 0.097 | 0.015 | 0.229 | 0.014 | 0.386 | 0.030 |
| *Oriolus chinensis* | 0.860 | 0.062 | 0.527 | 0.047 | 0.624 | 0.094 | **1.496** | 0.094 | 1.110 | 0.086 |
| *Penelopides exarhatus* | 0.077 | 0.026 | **0.101** | 0.042 | 0.021 | 0.015 | 0.080 | 0.023 | 0.053 | 0.019 |
| *Prioniturus platurus* | 0.475 | 0.024 | **0.830** | 0.052 | 0.079 | 0.008 | 0.533 | 0.023 | 0.119 | 0.006 |
| *Ptilinopus melanospila* | **0.364** | 0.060 | 0.085 | 0.017 | 0.248 | 0.086 | 0.151 | 0.022 | 0.133 | 0.024 |
| *Rhyticeros cassidix* | 0.063 | 0.020 | **0.132** | 0.052 | 0.069 | 0.046 | 0.033 | 0.009 | 0.006 | 0.002 |
| *Surniculus lugubris* | 0.121 | 0.016 | 0.015 | 0.002 | 0.060 | 0.017 | **0.219** | 0.025 | 0.030 | 0.004 |
| *Trichastoma celebense* | 1.689 | 0.080 | 1.267 | 0.074 | 0.676 | 0.067 | 1.577 | 0.065 | **2.787** | 0.142 |
| *Zosterops consobrinorum* | **0.731** | 0.026 | 0.169 | 0.007 | 0.056 | 0.004 | 0.642 | 0.020 | 0.169 | 0.006 |

Notes: bold numbers indicate the highest density

## Habitat structure

The first stage in the habitat analysis was to see whether there were differences between the node camps in terms of the vegetation and other variables which were measured. All of the variables (except the categorical ones) for each point were entered into a Dicriminant Function Analysis with the node camps as the grouping variable. Classification of node camps were differentiated through 4 functions (Table 4 & 5). Overall 88% of point count sites were correctly assigned to their node camp. Most node camps were correctly classified between 70.8-95.2%, except for Anoa which was 100% correctly classified (Table 6). When looking at differences of individual habitat variables between sites, canopy openness is significantly different between sites ($F = 49.756$, $df = 4$, $P < 0.001$) with Wahalaka having the most dense canopy and Wabalamba the least. Number of trees in 20 $m^2$ areas are significantly different among sites ($F = 31.097$, $df = 4$, $P < 0.001$) showing Bala with higher number of trees compare to others (Appendix 2). However, mean dbh of trees among sites are not significantly different ($F = 2.377$, $df = 4$, $P = 0.055$) although in average, Bala has larger trees than other sites (Figure 4, Appendix 2). Understory density among sites are significantly different (F = 8.241, df = 4, P < 0.001). Bala has a significantly higher understory density than the other sites (Appendix 2). Other variables measured are presented in Appendix 2.

Table 4. Wilks' lambda and chi-square statistics of the Discriminant Function Analysis.

**Wilks' Lambda**

| Test of Function(s) | Wilks' Lambda | Chi-square | df | Sig. |
|---|---|---|---|---|
| 1 through 4 | .018 | 384.507 | 60 | .000 |
| 2 through 4 | .101 | 220.062 | 42 | .000 |
| 3 through 4 | .345 | 102.028 | 26 | .000 |
| 4 | .689 | 35.734 | 12 | .000 |

Table 5. Standardized canonical discriminant function coefficient**s**

**Standardized Canonical Discriminant Function Coefficients**

| | Function | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| Canopymeans | .764 | .544 | .199 | -.215 |
| SAPLINGS | -.667 | -.417 | -.355 | .095 |
| RATTAN | -.504 | -.114 | .044 | -.318 |
| PANDAN | .373 | .021 | -.675 | .199 |
| FERNS | .068 | .004 | .186 | .186 |
| Treeferns | -.137 | .401 | .216 | -.037 |
| PALM | -.109 | .142 | -.148 | .401 |
| Treevines | .157 | .202 | .102 | .183 |
| Birdsnests | .244 | -.466 | .456 | .522 |
| Undergrowth means | .367 | -.465 | .482 | -.540 |
| Upperhalf | .080 | .201 | -.187 | -.496 |
| DENSTREE | .609 | .102 | .431 | .136 |
| NOTREES | -1.161 | .787 | .202 | .217 |
| Meandisttree | .244 | .061 | .249 | .085 |
| Meandbhtree | .007 | -.077 | -.134 | -.052 |

Table 6. Actual and predicted group membership of the five node camps: 1) Anoa, 2) Bala, 3) Lapago, 4) Wabalamba, 5) Wahalaka.

**Classification Results[a]**

| | | | Predicted Group Membership | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | SITECODE | 1 | 2 | 3 | 4 | 5 | Total |
| Original | Count | 1 | 14 | 0 | 0 | 2 | 0 | 16 |
| | | 2 | 0 | 23 | 0 | 0 | 0 | 23 |
| | | 3 | 0 | 0 | 17 | 6 | 1 | 24 |
| | | 4 | 1 | 0 | 2 | 20 | 0 | 23 |
| | | 5 | 1 | 0 | 0 | 0 | 20 | 21 |
| | % | 1 | 87.5 | .0 | .0 | 12.5 | .0 | 100.0 |
| | | 2 | .0 | 100.0 | .0 | .0 | .0 | 100.0 |
| | | 3 | .0 | .0 | 70.8 | 25.0 | 4.2 | 100.0 |
| | | 4 | 4.3 | .0 | 8.7 | 87.0 | .0 | 100.0 |
| | | 5 | 4.8 | .0 | .0 | .0 | 95.2 | 100.0 |

a. 87.9% of original grouped cases correctly classified.

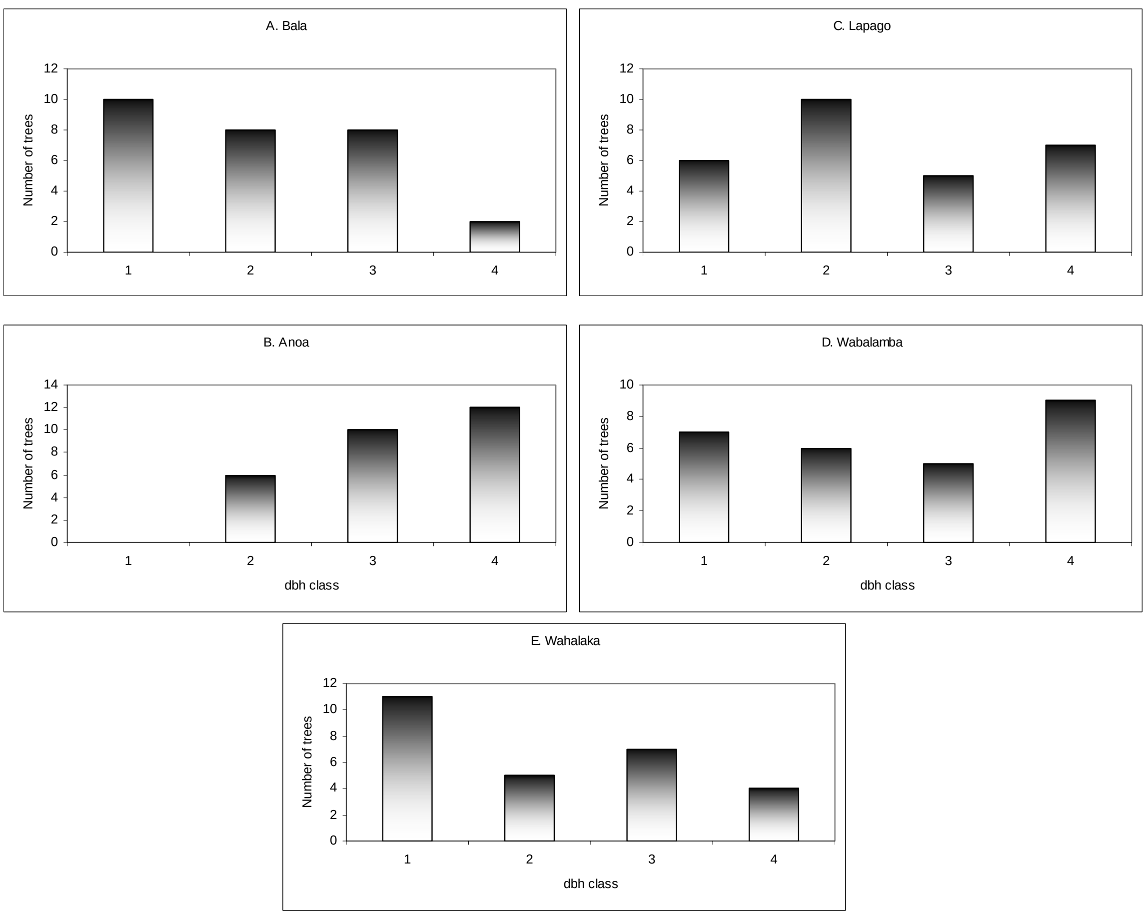



Figure 4. Distribution of trees with dbh > 50 cm in all sites divided into 4 class size (1 = 50-60 cm, 2 = 60-70 cm, 3 = 70-80 cm, 4 = > 80 cm)

We will also try to look at other analyses to understand the habitat associations of bird species using discriminant function analysis. In the end, we hope to be able to present bird species that may be used as indicator of habitat quality.

*Butterfly communities*

In 2005, we have tried out different methods of surveying butterflies such as 'Pollard' walks and fruit-bait traps as well as trying to identify butterfly species in the field. We decided to use Pollard walks for the future surveys as the methods provides a greater chance to get more species than fruit-bait traps and is less time-consuming. We have also prepared a complete field guide based on "Butterflies of Southeast Sulawesi" by K. Wilmott. All the butterfly pictures are printed and laminated into a small handy folder that will be easy to carry in the field.

Some butterfly species captured around Labundo-bundo: *Cethosia myrina, Troides hypolitus*

## Workplan for 2006

The workplan for 2006 is divided into 3 phases. The first and last phases will be spent in hometown of PhD candidate (Jakarta). The first term will mainly focus in preparation for the field work which including production of handy field guide and any permits needed for the field work. The second term will be spent in Buton which include all the field preparation and all field surveys. Prior to surveys, candidate will spent one week to get familiar with the bird and butterfly species. Butterflies will be collected just for reference collection to help identification in the field. The third phase will be mostly concerned with the data management and analyses.

| **Description** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Preparation: field guides, method try out | | | | | | | | | | | | |
| Field equipment & logistics | | | | | | | | | | | | |
| Field survey (pre Opwall season) | | | | | | | | | | | | |
| Field survey (Opwall season) | | | | | | | | | | | | |
| Data entering | | | | | | | | | | | | |
| Data analysis and report writing | | | | | | | | | | | | |

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Appendix 1. List of bird species recorded at Lambusango forest in 2005, including their status and encounter rate at each camp.

| Familia | Species name | English name | Status | Anoa | Bala | Lapago | Wabalamba | Wahalaka |
|---|---|---|---|---|---|---|---|---|
| Accipitridae | *Accipiter trinotatus* | Spot-tailed goshawk | E | 0.010 | 0.012 | 0.027 | 0.018 | 0.011 |
| Accipitridae | *Ictinaetus malayensis* | Black eagle | | 0.002 | 0.000 | 0.000 | 0.000 | 0.000 |
| Accipitridae | *Spilornis rufipectus* | Sulawesi serpent-eagle | E | 0.000 | 0.000 | 0.002 | 0.002 | 0.004 |
| Alcedinidae | *Halcyon chloris* | White-collared kingfisher | | 0.000 | 0.000 | 0.000 | 0.011 | 0.002 |
| Alcedinidae | *Halcyon coromanda* | Ruddy kingfisher | | 0.000 | 0.000 | 0.000 | 0.002 | 0.000 |
| Artamidae | *Artamus monachus* | Ivory-backed wood-swallow | E | 0.002 | 0.000 | 0.000 | 0.000 | 0.002 |
| Bucerotidae | *Penelopides exarhatus* | Sulawesi dwarf hornbill | E | 0.026 | 0.042 | 0.015 | 0.023 | 0.019 |
| Bucerotidae | *Rhyticeros cassidix* | Red-knobbed hornbill | E | 0.020 | 0.052 | 0.046 | 0.009 | 0.002 |
| Campephagidae | *Coracina bicolor* | Pied cuckoo-shrike | | 0.034 | 0.025 | 0.027 | 0.061 | 0.013 |
| Campephagidae | *Coracina morio* | Sulawesi cicadabird | E | 0.014 | 0.050 | 0.013 | 0.041 | 0.037 |
| Columbidae | *Chalchopaps stephani* | Stephan's dove | E | 0.002 | 0.000 | 0.000 | 0.000 | 0.000 |
| Columbidae | *Ducula aenea* | Green Imperial pigeon | | 0.087 | 0.104 | 0.121 | 0.095 | 0.118 |
| Columbidae | *Ducula forsteni* | White-bellied imperial pigeon | E | 0.062 | 0.077 | 0.017 | 0.020 | 0.026 |
| Columbidae | *Ducula luctuosa* | Silver-tipped imperial pigeon | E | 0.000 | 0.002 | 0.000 | 0.004 | 0.006 |
| Columbidae | *Macropygia amboinensis* | Brown cuckoo-dove | | 0.016 | 0.005 | 0.027 | 0.018 | 0.000 |
| Columbidae | *Ptilinopus melanospila* | Black-naped fruit-dove | | 0.060 | 0.017 | 0.086 | 0.022 | 0.024 |
| Columbidae | *Treron griseicauda* | Grey-cheeked green pigeon | E | 0.000 | 0.000 | 0.002 | 0.002 | 0.000 |
| Columbidae | *Turacoena manadensis* | Sulawesi black pigeon | E | 0.008 | 0.005 | 0.000 | 0.027 | 0.004 |
| Corvidae | *Corvus typicus* | Piping crow | E | 0.022 | 0.000 | 0.002 | 0.002 | 0.000 |
| Cuculidae | *Centropus celebensis* | Bay coucal | E | 0.046 | 0.074 | 0.075 | 0.070 | 0.142 |
| Cuculidae | *Cuculus crassirostris* | Sulawesi hawk-cuckoo | E | 0.012 | 0.022 | 0.019 | 0.002 | 0.022 |
| Cuculidae | *Phaenicophaeus calyorhynchus* | Yellow-billed malkoha | E | 0.002 | 0.002 | 0.002 | 0.004 | 0.000 |
| Cuculidae | *Surniculus lugubris* | Drongo cuckoo | | 0.016 | 0.002 | 0.017 | 0.025 | 0.004 |
| Dicaeidae | *Dicaeum aureolimbatum* | Yellow-sided flowerpecker | E | 0.010 | 0.000 | 0.000 | 0.002 | 0.000 |
| Dicaeidae | *Dicaeum celebicum* | Grey-sided flowerpecker | E | 0.000 | 0.000 | 0.000 | 0.002 | 0.000 |
| Dicaeidae | *Dicaeum spp.* | | | 0.060 | 0.042 | 0.048 | 0.063 | 0.052 |
| Dicruridae | *Dicrurus hottentottus* | Hair-crested drongo | | 0.076 | 0.089 | 0.071 | 0.106 | 0.088 |
| Hemiprocnidae | *Hemiprocne longipennis* | Greu-rumped tree-swift | | 0.002 | 0.000 | 0.000 | 0.000 | 0.000 |
| Monarchidae | *Hypothymis azurea* | Black-naped monarch | | 0.078 | 0.057 | 0.088 | 0.068 | 0.056 |
| Muscicapidae | *Culicicapa helianthea* | Citrine flycatcher | E | 0.044 | 0.045 | 0.059 | 0.036 | 0.062 |
| Nectarinidae | *Aethopyga siparaja* | Crimson sunbird | | 0.004 | 0.000 | 0.000 | 0.000 | 0.000 |
| Nectarinidae | *Nectaria spp.* | | | 0.000 | 0.000 | 0.004 | 0.000 | 0.000 |
| Nectarinidae | *Nectarinia aspasia* | Black sunbird | E | 0.014 | 0.000 | 0.000 | 0.002 | 0.004 |
| Oriolidae | *Oriolus chinensis* | Black-naped oriole | | 0.062 | 0.047 | 0.094 | 0.094 | 0.086 |
| Phasianidae | *Gallus gallus* | Red junglefowl | | 0.020 | 0.032 | 0.015 | 0.005 | 0.013 |
| Picidae | *Mulleripicus fulvus* | Ashy woodpecker | E | 0.020 | 0.035 | 0.015 | 0.014 | 0.030 |
| Pittidae | *Pitta erythrogaster* | Red-breasted pitta | E | 0.000 | 0.002 | 0.000 | 0.002 | 0.004 |
| Psittacidae | *Loriculus stigmatus* | Large Sulawesi hanging-parrot | E | 0.012 | 0.012 | 0.013 | 0.007 | 0.004 |
| Psittacidae | *Prioniturus platurus* | Golden-mantled racquet-tail parrot | | 0.024 | 0.052 | 0.008 | 0.023 | 0.006 |
| Psittacidae | *Tanygnathus megalorhyncos* | Great-billed parrot | | 0.004 | 0.002 | 0.010 | 0.002 | 0.004 |
| Psittacidae | *Trichoglossus ornatus* | Ornate lorikeet | | 0.016 | 0.002 | 0.000 | 0.007 | 0.000 |
| Sturnidae | *Basilornis celebensis* | Sulawesi crested myna | E | 0.004 | 0.000 | 0.000 | 0.009 | 0.000 |
| Sturnidae | *Scissirostrum dubium* | Grosbeak starling | E | 0.000 | 0.000 | 0.000 | 0.002 | 0.002 |
| Sturnidae | *Streprocitta albicollis* | White-necked myna | E | 0.008 | 0.007 | 0.004 | 0.014 | 0.002 |
| Timaliidae | *Trichastoma celebicum* | Sulawesi babbler | E | 0.080 | 0.074 | 0.067 | 0.065 | 0.142 |
| Turdidae | *Zoothera sp* | Thrush | | 0.000 | 0.000 | 0.002 | 0.000 | 0.000 |
| Zosteropidae | *Zosterops consobrinorum* | Sulawesi white-eye | E | 0.026 | 0.007 | 0.004 | 0.020 | 0.006 |

| Familia | Species name | English name | Status | Anoa | Bala | Lapago | Wabalamba | Wahalaka |
|---|---|---|---|---|---|---|---|---|
| **Birds not recorded during point count** | | | | | | | | |
| Alcedinidae | *Ceyx fallax** | Sulawesi dwarf kingfisher | E | | | | | |
| Alcedinidae | *Actenoides monachus** | Green-backed kingfisher | E | | | | | |
| Campephagidae | *Coracina leucopygia** | | | | | | | |
| Cuculidae | *Eudynamys melanorhyncha** | Black-billed koel | | | | | | |
| Muscicapidae | *Ficedula rufigula** | Rufous-throated flycatcher | | | | | | |
| Strigidae | *Otus menadensis** | | E | | | | | |

## Appendix 2. Vegetation structure collected at each point count along with means and standard deviation

| | Anoa | | Bala | | Lapago | | Wabalamba | | Wahalaka | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Vegetation structure** | **Means** | **Std dev** | **Means** | **Std dev** | **Means** | **Std dev** | **Means** | **Std dev** | **Means** | **Std dev** |
| Canopy openness | 2.96 | 0.29 | 2.88 | 0.27 | 3.14 | 0.23 | 3.43 | 0.36 | 2.36 | 0.30 |
| Understory density | 28.32 | 9.90 | 18.79 | 8.26 | 14.78 | 6.67 | 22.11 | 11.24 | 20.23 | 9.18 |
| DBH trees > 50 cm | 61.67 | 20.34 | 78.11 | 11.47 | 68.81 | 19.34 | 69.39 | 19.78 | 62.10 | 36.60 |
| Number of trees (counts) | 4.11 | 2.35 | 9.68 | 1.02 | 4.39 | 2.95 | 3.54 | 2.44 | 3.57 | 3.07 |
| Number of saplings (counts) | 39.86 | 30.49 | 54.39 | 20.55 | 35.11 | 28.51 | 22.82 | 19.16 | 49.04 | 39.98 |
| Rattan (percentage) | 4.57 | 5.25 | 34.46 | 18.77 | 18.12 | 23.41 | 19.29 | 25.93 | 46.79 | 27.70 |
| *Pandanus* sp. (counts) | 5.96 | 7.53 | 3.88 | 5.87 | 29.54 | 27.53 | 9.86 | 21.71 | 0.96 | 2.65 |
| Ferns (counts) | 1.45 | 4.99 | 4.18 | 8.90 | 2.46 | 5.32 | 1.71 | 1.86 | 0.46 | 1.77 |
| Treeferns (counts) | 1.00 | 1.72 | 6.00 | 11.85 | 0.00 | 0.00 | 0.00 | 0.00 | 0.86 | 2.48 |
| Palm (counts) | 1.64 | 2.04 | 4.93 | 7.49 | 9.39 | 17.59 | 0.71 | 1.65 | 2.58 | 4.83 |
| Birdsnest ferns (counts) | 15.64 | 14.94 | 2.71 | 3.98 | 3.36 | 4.37 | 2.54 | 3.82 | 4.71 | 8.09 |
| Freshly fallen trees (counts) | 0.79 | 0.96 | 0.46 | 1.23 | 1.04 | 1.17 | 3.29 | 5.69 | 0.46 | 1.10 |
| Intermediate-rotten trees (counts) | 0.39 | 0.63 | 1.82 | 1.83 | 0.64 | 0.95 | 0.50 | 1.55 | 0.71 | 1.08 |
| Well-rotten trees (counts) | 0.89 | 1.52 | 0.43 | 0.96 | 0.11 | 0.42 | 0.32 | 0.82 | 0.25 | 0.65 |
| Upperhalf branching (counts) | 0.47 | 0.33 | 0.76 | 0.24 | 0.63 | 0.34 | 0.75 | 0.36 | 0.57 | 0.44 |
| Lowerhalf branching (counts) | 0.46 | 0.33 | 0.24 | 0.24 | 0.33 | 0.32 | 0.22 | 0.33 | 0.28 | 0.39 |
| Tree scars (count) | 0.89 | 0.99 | 1.32 | 2.07 | 0.00 | 0.00 | 0.11 | 0.57 | 0.46 | 1.91 |
| Mean distance trees | 14.14 | 5.67 | 18.42 | 5.55 | 14.49 | 4.73 | 13.91 | 5.93 | 13.71 | 7.45 |