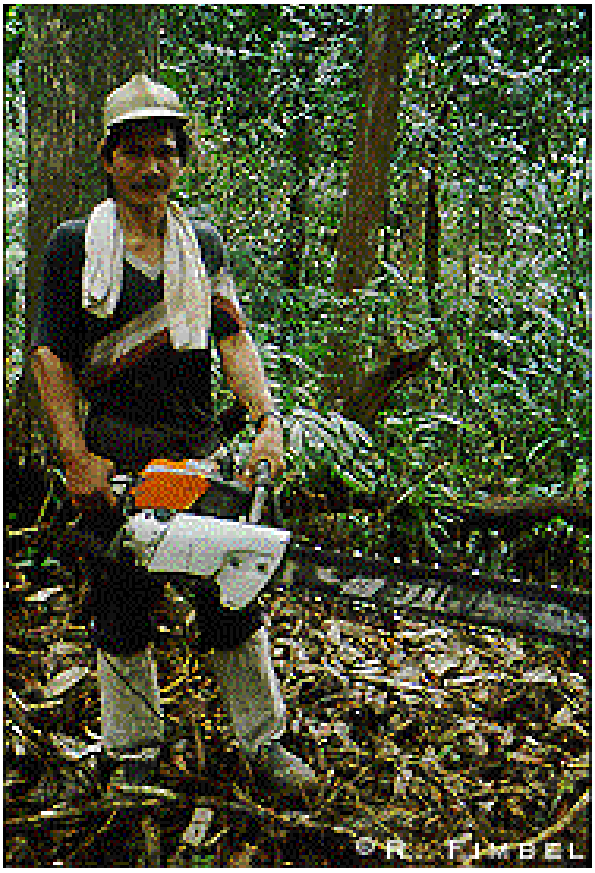
FAUNAL SURVEYS IN UNLOGGED FOREST OF THE INHUTANI II MALINAU TIMBER CONCESSION, EAST KALIMANTAN, INDONESIA



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SECTION 1: STUDY OVERVIEW

INTRODUCTION

The lowland rain forests of the island of Borneo are globally important for their high species richness and endemism. Approximately 34% of all plant species, 37 species of birds, and 44 land mammals are endemic to the island (MacKinnon *et al*. 1996). Existing protected areas, especially below 500 m elevation, are inadequate for the conservation of this rich biodiversity. Therefore, it is important to develop strategies for conserving biological diversity in the lowland forests surrounding existing protected areas in Borneo, as these forests are facing increasing threats from human exploitation.

The lowland forest surrounding Kayan Mentarang National Park (KMNP) in East Kalimantan contains high global and faunal diversity (O'Brien *et al.* 1998). This forest region is important to conservation because: (1) it is relatively intact; (2) it appears to contain a full complement of species; (3) it provides a buffer between human settlements and the Park; and, (4) it serves as a lowland extension to the mid- and high elevation habitats characterizing KMNP. This forest is currently threatened by human exploitation, notably timber harvesting and conversion to agriculture.

The development of measures to conserve the biodiversity of production forests near to KMNP requires a multi-disciplinary approach, integrating silviculture, economics, issues important to local residents, and biodiversity conservation. To this end, the Indonesian Ministry of Forestry designated 321,00 ha of hill-dipterocarp / lowland production rain forest to the Center for International Forestry Research (CIFOR) in December 1995 for forestry research. The goal of the Bulungan Research Forest (BRF) is to develop a long-term model of exemplary research-based forest management. One study being undertaken in the newly formed BRF seeks to assess the effects of reduced impact logging (RIL) on biodiversity conservation. This report presents findings from a pre-harvest faunal survey conducted by the Wildlife Conservation Society (WCS) in the fall of 1998, as a preliminary phase of the RIL study.

STUDY PURPOSE

The purpose of the study is to assess the impacts of timber harvesting practices on select native fauna within the production forest landscape of the Inhutani II Malinau timber concession, BRF, East Kalimantan (Figure 1). Specifically, the study aims to:

1) provide pre-harvest baseline data on mammal, bird, and invertebrate communities in production forest slated for harvesting using conventional logging (CL) and RIL practices;
2) assess the response of these select taxa to the two different logging practices through post-harvest monitoring;
3) assist in the refinement of forestry practices designed to conserve these animals and their habitat (biodiversity); and,
4) enhance the capacity of local institutions to promote these biodiversity conservation practices in the future.

The first aim is discussed in this report.

STUDY SITE AND DESIGN OVERVIEW

Field surveys were conducted during September-October 1998, in three contiguous 100-ha forest cutting blocks (compartments 27-29) and an adjacent control area. All sites had never been commercially logged. Two compartments were slated for conventional harvesting activities (CL) in late 1998, while the third was to receive trial reduced-impact logging (RIL) practices in early 1999. Within the CL and RIL sites, CIFOR established 24 – one hectare permanent vegetation plots (equally divided between the two treatments). Three plots within each treatment are expected to receive high, moderate and low extraction levels, while the remaining three plots are to serve as 'within compartment' uncut controls (these are different from the control area used in the fauna survey).

Select mammal, bird, and invertebrate communities were surveyed in the Malinau concession. Sampling occurred: (1) in the 24 permanent vegetation plots, (2) along transects throughout the treatment area and adjacent control site, and (3) opportunistically in other areas of the concession and the local village of Long Loreh. Survey techniques sought to identify the abundance, diversity, and activities of mammals and birds, using sightings, sign, and calls. Invertebrates were identified to species where possible, but more commonly to higher taxonomic levels, from collected specimens. Select ecological processes of these invertebrates was also investigated (e.g. decomposition and leaf herbivory). Surveys included:

1) Mammals
   a) transects ranging from 1100-2700 m for primates, squirrels, tree shrews, ungulates
   b) timed searches throughout compartments and control for same animal groups noted above
   c) small-mammal (rodent) live-trapping on 20 m grid within permanent plots
   d) opportunistic sightings in concession and interviews in Long Loreh

2) Birds
   a) variable circular plots (100 m radius) spaced at 200 m intervals along mammal transects
   b) hornbills along the entire length of mammal transects
   c) full day samples of all birds within 50 m of permanent plot centers
   d) road counts along active and inactive logging roads
   e) opportunistic sightings in concession and interviews in Long Loreh

3) Invertebrates (all within permanent plots except butterfly transects)
   a) leaf litter decomposition rates using buried litter bags
   b) leaf herbivory based on leaf damage scores
   c) litter community composition using 1 m^2 litter samples in Winkler bags
   d) butterfly transects 200 m long along ridge tops and valley bottoms
   e) ant transects 2 x 10 m, digging through the soil and litter
   f) pitfall traps along 10 m grids
   g) timed sweeps of vegetation using sweep nets in the understory

All surveys were diurnal, with the exception of 'spot-lighting' for mammals along transects (limited due to difficulties of weather and terrain). Finally, coarse measurements of wildlife

habitat were noted within the survey sites, and included: major forest type, canopy closure, woody debris, slope, elevation, and proximity to water.

Fauna taxa were compared among the three treatment sites using a variety of statistical procedures, including reports of presence/absence, abundance, diversity (Simpson, Shannon-Weiner, and alpha-diversity indices), similarity (Sorenson, Morista-Horn, and the Coefficient of Jaccard indices), t-tests, and ANOVA. These analytical techniques represent relatively coarse-grain evaluations of the data collected. More detailed analyses are underway to investigate relations and patterns among the various groups.

MAIN FINDINGS

The following summarize general patterns observed for the fauna groups surveyed within the CL, RIL, and control sites of the Malinau concession. Detailed discussions of the methodologies and results of these surveys are presented in subsequent section of the report. These results should be viewed within the limitations / constraints placed upon the experimental design and survey period, including: (1) differences in habitat between the three study areas (the CL site being wetter, flatter, and somewhat degraded compared to the RIL and control sites); (2) disruptions in the sampling process that created difficulties in accessing the study area, and in particular the control site, due to frequent river flooding; (3) the close proximity of the study areas to the logging front, which may have caused some animals to avoid the area (e.g. *Ursus malayanus*), and others to immigrate to the area as they fled the advancing logging activities (causing potential over-estimations of unlogged forest conditions); and (4) the need for several field teams to be working in the study area at one time, which may have caused some animals to become more cryptic, or to have temporarily vacated the sampling area. These differences may in part explain the subtle differences in the mammal and bird communities between the study sites. Problems associated with the surveys, and recommendations for overcoming them, are presented in Sections 2-4 of this report.

Mammals

- A total of 31 mammal species were positively identified, from 10 families (squirrels accounted for the highest number of species - nine). An additional five mammal species may have been observed, but they could not be positively identified. These observations represent approximately 60% of the mammal species that are likely to occur in the study area (Payne *et al*. 1985).

- Two species listed in the *1996 IUCN Red List of Threatened Animals* were recorded in the survey area: *Macaca nemestrina* and *Lutrogale perspicillata* (the presence of the latter could not be confirmed). Both are listed as ‘Vulnerable’.

- The RIL and CL sites have similar species compositions, while the control site appears to contain fewer tree shrews, squirrels, and ungulates. This condition, however, is probably an artifact of the shorter survey effort in the control site relative to the other two sites (26 hrs 08 mins, 90 hrs 35 mins, and 98 hrs 58 mins in the Control, Conventional, and RIL sites respectively). Rodent species composition and relative abundance in the CL and RIL sites appeared similar.

- Similarity indices (Morisita-Horn) between the three treatment sites ranged from 0.65-0.95, with the CL and RIL sites most alike in their relative abundance of primates (0.95), but less alike in their squirrel populations (0.73).

Birds

- A total of 239 bird species were observed during the study period (field surveys, road counts, and village surveys). Of these, 178 represent lowland-dependent forest birds, or approximately 73% of the 244 lowland forest birds in Borneo (Wells 1985). Families with the most species recorded included Timaliidae (18 species), Pycnonotidae (12 species), and Picidae (12 species).

- Twenty-nine bird species are considered at risk from habitat disturbance: one endangered (*Ciconia stormi*); six vulnerable (*Argusianus argus, Carpococcyx radiceus, Lophura ignita, Rhyticeros corrugatus, Rollulus rouloul, Spizaetus nanus*); one "data deficient" (*Batrachostomus auritus*); and 21 near-threatened. Nine species are Borneo endemics.

- Species diversity, evenness, and richness did not vary greatly between the study compartments. Road counts of logged areas however, produced consistently higher values than the unlogged forest blocks. The Coefficient of Jaccard similarity index indicated that the RIL and CL sites had the most similar bird communities (S_j=0.58), while the RIL and control sites were the least similar (S_j =0.50). The Morista-Horn index for the seven hornbills observed in the study showed a similar relationship among the sites, with the CL and control the most similar (0.96), while the RIL and control were the least similar (0.77).

- Hunting parties of local villagers were often seen roaming the forest, and snares to catch deer, pheasants etc. were often encountered in the forest. Also, select species such as Hill Mynahs (*Gracula religiosa*) and Blue-crowned Hanging-parrots (*Loriculus galgulus*) were captured and caged by villagers. Though both of these were still found in good numbers in the forest, the extremely popular songbird, Straw-headed Bulbul (*Pycnonotus zeylanicus*), appeared to be extinct in Malinau as in many other places within its geographical range (van Balen 1997).

Invertebrates

- Coarse litter bag decomposition rates were lower in the CL site compared to the RIL site. There was no significant difference in fine leaf-litter bag decomposition rates between these two sites. The higher soil moisture content in the CL site compared to the RIL site may explain these rate differences.

- Herbivore damage to seedlings was highly patchy, and no difference was observed between the treatment areas. Topographic and microclimatic variation, on a scale of tens of meters, may account for the apparent patchiness of herbivore impacts on seedlings.

- A total of 63 butterfly species (excluding Lyceneidae and Hesperiidae families) were recorded in the RIL and CL sites (the control was not sampled). This is equivalent to species numbers recorded for a similar length of time at other tropical forest sites in SE

Asia (Vietnam, 64 species, Spitzer *et al.* 1997; Sumba, Indonesia, 50 species, Hamer *et al.* 1997 and Buru, Indonesia, 41 species, Hill *et al.* 1995). Butterflies had greater abundance (180 and 161 respectively) and richness (34 vs. 28 species) in the RIL site compared to the CL site. Butterfly diversity values were also higher at the RIL site compared to the CL site (12.4 vs. 9.8, alpha-diversity statistic).

- There were 13 insect orders, consisting of 79 families, collected from pitfall traps; and 16 insect orders, consisting of 168 families, collected from sweeping. Three orders dominated: Diptera (flies and mosquitoes), Hymenoptera (wasps, ants, and bees), and Coleoptera (beetles). From both survey methods, and supplemental litter samples (ant transects and Winkler bags), ants (Hymenoptera: Formicidae) were the most abundant species collected (6185 ants of 134 species). The CL and the RIL pitfall trap surveys were similar in their number of species of insects (139 and 136 respectively). Results of sweeping indicated that species richness in the CL was higher than in the RIL (392 and 229 respectively). The control site exhibited the lowest species counts by both sampling methods (80 and 159), which probably reflects the lower sampling intensity in this area compared to the other two treatments (33% of that in the CL and RIL sites).

- Diversity (Simpson index) of insect species within the three sites varied little, with the control being the lowest, regardless of the pitfall trap or sweep survey techniques employed (1-*D* ranging from 0.99 - 0.89). For ants however, the control site exhibited the highest diversity (*H'* = 3.52, Shannon-Weiner index), even though only four of the 28 sampling areas occurred in the control. The CL site was also relatively high (*H'* = 3.43), with the RIL site lowest (*H'* = 2.95). Finally, sites were rather dissimilar in their insect species composition (Jaccard and Sorenson similarity indices; values ranging from 0.26-0.46 and 0.41-0.63 respectively), with the RIL and CL sites the most similar and the RIL and control sites the least similar, regardless of the survey technique. Ants showed greater similarity of their species composition between the three sites (0.67-0.77), with the RIL and control sites most similar, and the CL and control least similar (Sorenson index).

The data presented in this study provide baseline information against which subsequent data collected from the sites after logging may be compared. While the three study sites were relatively similar in their faunal composition, some significant differences in species composition and richness were observed between the CL, RIL, and control areas. These differences may be the result of different physical and vegetation attributes characterizing these sites, and differences in sampling effort between the three sites. Post-logging comparisons may be confounded by these local site differences.

SECTION 2. MAMMAL SURVEYS

Prepared by Simon Hedges and Asri Adyati Dwiyahreni

METHODS

Selection of sites

When the team first arrived in the field (8 September 1998) the 100 ha compartments 27 and 28/29 had been chosen by CIFOR as the Reduced Impact Logging (RIL) and Conventional Logging (CL) sites respectively. Two survey transects were established with each area (a total of four transects, see below). No external Control Site (CS) had been selected. Two areas had however been suggested for the CS: compartment 22 and compartments 30/31. These areas were visited to assess their suitability on 8 and 9 September.

Compartment 22 was deemed unsuitable because of the presence of a house and a recently abandoned *kebun* at the south-west corner of the compartment, a major active hunters' camp approximately 500 m upstream of the south-west corner, and several apparently heavily used trails criss-crossing the compartment. In addition, the area was something of an "island", with rivers to the east, south, and west and a recently logged (1996/97?) area to the north. Compartments 30/31 were also considered unsuitable because their northern parts (approximately half of each compartment) were potentially slated for logging, which would leave too small of a residual area to act as a control.

As a consequence of these conditions it was decided, after discussions amongst WCS and CIFOR scientists, to investigate the area lying across the Sungai Seturan to the south-west of compartments 28, 29, and 30. This area was duly investigated on 10 September. Although INHUTANI maps suggested that the area would not be logged during the 2001–2006 five-year work-plan, markers on trees indicated that the area had been allocated for logging in 2001–2006. Nevertheless, it was felt that the area was the best of the three potential control sites, and two transects were established.

When the control site was first visited crossing the Sungai Seturan River, the river presented no access difficulties; it was little more than ankle- to shin-deep. With the onset of regular heavy rain on 27 September however, the river became a raging torrent for most of the time, preventing regular access to the site. This problem might be avoided in the future by conducting the follow-up studies earlier in the year (see Problems and Recommendation discussion below).

Establishment of survey transects

Six transects (two per compartment), less than one meter wide and variable in length from 1180 m to 2700 m, were established in mid-September (Table 2.1). The transects were positioned such that they were perpendicular to major linear or near-linear features (e.g. logging roads, rivers). Routes were also chosen to maximize transect length across

Table 1: Location and length of the six survey transects.

Transect	Compartment	Length (meters)
CStransect1	External control site	2700

CStransect2	External control site	1225
CLtransect1	Conventional site (compartment 29)	1312
CLtransect2	Conventional site (compartment 28)	1180
RILtransect1	RIL site (compartment 27)	1200
RILtransect2	RIL site (compartment 27)	1265

the compartments. The six transects were laid out as single straight lines if the terrain made this possible (CLtransect1 and CStransect2); where the terrain made this impossible the transects consisted of multiple straight line segments (CStransect1, CLtransect2, RILtransect1, and RILtransect2). The original aim was to have the two transects in each compartment at least 500 m apart, but difficult terrain (very steep slopes / cliffs) and problems resulting from the highly inaccurate map of compartment 27, created conditions were RILtransect1 and RILtransect2 were only about 320 m apart for much of their lengths.

The center line of each transect was marked using brightly colored "flagging tape" so that the location of the center line could be easily determined at any point (to facilitate accurate measurement of sighting angles and to allow the transects to be followed in the dark). Distance markers were placed at 50 m intervals along each transects.

Permanent cleared transects are generally considered unsuitable for ungulate surveys because these animals (especially the social species) tend to like walking along cleared trails just as much as biologists do, which obviously leads to overestimates of abundance or density (S. Hedges, unpublished data). However in the present case the emphasis was on primates, squirrels, and tree shrews, and the terrain (and in places the vegetation) precluded the use of "one-off" uncleared transects. Furthermore, the ungulate encounter rates during the initial exploration phase of the project suggested that few data would be collected for these animals (which did indeed prove to be the case).

Characterization of transects

Slope was recorded along each transect (using an optical clinometer). Altitude was recorded at each 100 m marker and at any peak or trough between these markers.

Forest type was also recorded along each transect. Since CIFOR botanists were recording a variety of vegetation and other "microhabitat" characters as part of the study (and because a large body of data about stocking density had already been collected by INHUTANI staff), we decided to restrict the classification of the vegetation along the transects to four crude vegetation types: lowland forest, degraded lowland forest / scrub, seasonally-flooded forest, and freshwater swamp forest (Table 2.2). Swamp forest was distinguished by the presence of pneumatophores. Seasonally-flooded forest lacked

Table 2: Comparison of the six transects

Feature	**Transect**					
	Control		**RIL**		**Conventional**	
	CS transect 1	**CS transect 2**	**RIL transect 1**	**RIL transect 2**	**CL transect 1**	**CL transect 2**
Length (m)	2700	1225	1200	1265	1312	1180

Altitude range (m a.s.l.)	31–102	40–100	75–180	115–170	20–90	40–125
Slope						
% of transect 0 – 5%	?	?	18.5	33.3	80.6	68.9
% of transect 6 – 15%	?	?	18.3	11.1	3.8	0
% of transect 16 – 25%	?	?	13.6	13.8	0	15.3
% of transect 26 – 35%	?	?	14.9	4.4	7.2	0
% of transect 36 – 45%	?	?	12.5	8.1	8.4	15.8
% of transect 46 – 55%	?	?	14.8	14.2	0	0
% of transect > 55%	?	?	7.4	15.1	0	0
Vegetation type						
% lowland forest	99	97	100	100	30	41
% degraded lowland forest / scrub	0	0	0	0	36	32
% seasonally flooded forest	1	3	0	0	29	0
% swamp forest	0	0	0	0	5	27

Note: no slope data were recorded for transects CStransect1 and CStransect2 because frequent heavy flooding prevented regular access to the Control site.

pneumatophores, but was characterized by the presence of many pools of water (which often formed a more or less continuous water surface for much of the team's time in the field). This forest type also contained alluvial soils, and many lianas, palms, and epiphytes. Much of the uplands were covered by hill dipterocarp forest of intermixed with degraded lowland forest / scrub (< 50% canopy cover provided by trees); the latter containing and obvious secondary vegetation (e.g. bamboo, large numbers of shrubs, etc.).

Strangling figs and vine-type figs growing within 10 m of the transects were also recorded. Other non-strangling / non-vine fig species were not recorded because of insufficient familiarity with these species to confidently identify them (Borneo has more than 130 species of figs; MacKinnon *et al*. 1996).

Line transect survey methods

Mammal surveys concentrated on primates, squirrels, and to a lesser extent, ungulates. However, all mammals seen or heard were recorded. In an effort to detect squirrels (which are often small, silent, and high above the ground), it was decided to move along the transects at 0.5 km/hour, stopping briefly but frequently to scan the ground and various vegetation layers. Such a low speed is generally considered sub-optimal for primate surveys along transects (e.g. Brockelman & Ali 1987), but as stated above a compromise was necessary in the present case because of the need to detect squirrels and tree shrews. Finally, the team also recorded all hornbills (Bucerotidae) seen or heard along each transect (see Section 3: Birds).

Initially two observers (S. Hedges and A. Dwiyahreni) conducted each survey. This allowed methods to be standardized. It was also thought that the need to detect small mammals (e.g. tree shrews and small squirrels such as *Exilisciurus exilis*), detect and count primates, and listen for hornbills would "overload" a single observer. The encounter rates proved to be sufficiently low however, that beginning 5 October the two mammal surveyors worked alone:

Hedges concentrating on timed mammal surveys and trapping small mammals, and Dwiyahreni continuing with the transect surveys and fig censuses.

For every mammal (or hornbill) detected along a transect the following information was recorded: time, location, species, number of animals in the cluster (for those species which live in social groups or otherwise occur in clusters), sighting angle, sighting distance (i.e. the distance from the observer to the animal or from the observer to the geometric center of the cluster), and method of detection (i.e. was the animal seen or heard). Sighting angles were measured using a sighting compass. Sighting distances were measured using a topofil or paced unless the observer was prevented from doing so by difficult terrain or dense vegetation. In these cases sighting distances were estimated (both observers had experience with estimating distances under similar conditions, and periodically their estimates calibrated using a topofil).

Morning transects were surveyed between 0600h and 1100h (all times are given in Central Indonesian Time (WITA) which is GMT + 8 hours), with the majority starting between 0600h and 0630h (it became light enough to identify mammals at about 0600h). Later starts were due to heavy rain, floods, or transport problems (no or broken vehicles). Afternoon transects were surveyed between 1330h and 1740h, with the majority starting between 1400h and 1430h.

Timed mammal searches

Timed mammal searches consisted of moving quietly and systematically through a compartment, not along the survey transects mentioned above, stopping frequently to look for animals (from ground level to canopy height). The INHUTANI cruise lines[1] were used as an aid to systematic movement, and care was taken to visit the various vegetation types within each compartment in rough proportion to their occurrence.

All mammals detected were recorded noting species, group sizes, activity, any unusual features such as coloration, etc. The time spent in each compartment was recorded in order to facilitate comparisons of encounter rates per unit time between compartments. Such methods have been used with success elsewhere in Indonesia (e.g. in Baluran National Park; S. Hedges, unpublished data.).

Recording of opportunistic sightings

All encounters with mammals while moving between transects, trapping grids, etc. were recorded and the time spent moving through each compartment noted (provided such movements were judged to be sufficiently quiet and slow). All encounters with "notable" mammals (e.g. *Ursus malyanus*) were recorded regardless of walking speed.

Nocturnal surveys ("spotlighting")

Nocturnal surveys were designed to: (1) obtain a more comprehensive picture of the study area's mammalian fauna, and (2) facilitate comparisons with data collected elsewhere on Borneo (e.g. in Danum Valley, Heydon 1994; Heydon & Bulloh 1996,1997). The original plan was for Hedges to devote the second month of the survey to spotlighting (and small mammal trapping), while Dwiyahreni continued with the daytime transect surveys. However,

[1] Numbered and flagged parallel lines spaced 20 meters apart and running in a north–south direction.

two problems were encountered. The first problem was the terrain, which was characterized by steep slippery slopes or frequently flooded stretches of low-lying forest in much of the study area. The second problem was the weather: from late-September until the mammal team left the field on 28 October, it rained heavily almost every night (>70%) for more or less the whole night. The first problem was partially overcome by selecting the easier transect sections and access tracks. The second problem was rather more fundamental, and after a while it became apparent that a major systematic nocturnal survey effort would not be possible. As a consequence, both members of the mammal team concentrated on diurnal survey work and the small amount of spotlighting which could be done was of necessity opportunistic in nature.

The opportunistic nocturnal surveys either started shortly after dusk or a couple of hours before dawn. One or two observers walked slowly (0.5–1 km/h) using a headtorch (Petzl Zoom fitted with conventional bulb) to search continuously for 'eye-shine' and bodies. Sounds of movement, feeding, or vocalizations were also used to locate animals. Once located,animals were viewed using a powerful spotlamp (Nitech Xcell, 100,000 cp) and 8 x 42 binoculars.

Small mammal trapping

On 10 September, six small mammal trapping grids were located: two each in the CL, RIL, and Control sites. Unfortunately, frequent heavy flooding prevented regular access to the Control site and consequently no trapping grids could be established there. In both the CL and RIL sites one grid was placed in a one hectare high stocking density vegetation plot established by CIFOR (projected high intensity logging), and one in a low stocking density plot (projected low stocking density plot; Appendix 1).

Seventy-five Sherman live traps (23.5 x 8 cm x 9 cm tall) and 36 Tomahawk live traps (41 x 14.5 x 14.5 cm) were available to the mammal survey team. A grid of nine by eight Sherman traps spaced 10 m apart (i.e. using 72 of the traps), and a second superimposed grid of six by six Tomahawk traps spaced 20 m apart, were established in each of the four plots (on a rotating basis). The grid points (trapping stations) were marked with "flagging" tape and the traps were placed within one meter of each point. Traps were placed in locations thought likely to maximize capture rates (e.g. alongside fallen branches, under shrubs, etc.; Gurnell & Flowerdew 1994; Barnett & Dutton 1995; Jones *et al*. 1996). All traps were covered with leaf litter and the Sherman traps were provided with bedding material (dry newspaper). After each trapping round (i.e. before the traps were moved from plot to plot) all the traps were washed in forest streams.

Although it is normally considered necessary to have at least two traps at each trapping station (Gurnell & Flowerdew 1994; Jones *et al*. 1996), insufficient traps were available for such an arrangement. Trapping rates were sufficiently low that having single traps at each station was unlikely to have caused a problem.

Each trap was baited with a piece of banana, a piece of dried and salted fish, and a dollop of peanut butter. Bananas are widely used as bait in the tropics (e.g. Emmons 1984), and were used successfully in lowland rain forest in Sumatra (S. Hedges, unpublished data). Salted fish and peanut butter are also widely used baits in tropical areas (e.g. Payne *et al*. 1985; Barnett & Dutton 1995). Insufficient time was available for prebaiting (i.e. baiting traps but locking them open), a controversial practice (Barnett & Dutton 1995).

Traps were baited and set for three nights and two days. The traps were checked (and if necessary re-baited) between 0630h and 0930h, and 1530h and 1730h. All animals captured were identified, sexed, and weighed (using Pesola spring balances); their hindfoot length was also measured. Newly caught animals were given unique marks by trimming one or more small patches of fur (on their backs) with a pair of scissors (Gurnell & Flowerdew 1994). All animals were then released (no specimens were collected).

After the first two trapping sessions (plots 29/L1 and 27/D, Appendix 1), use of the Sherman traps was discontinued because ants clogged up the pressure plates with soil and other debris, disabling approximately 30–40% of the traps. This is a recognized design fault of Sherman traps (Gurnell & Flowerdew 1994), and in the future it is recommended that another design (e.g. Longworth traps) be used in the future. Longworth traps have been successfully used in lowland rain forest in Sumatra (S. Hedges, unpublished data).

Each mammal-trapping grid was mapped, and the slope and altitude recorded. The same system for classifying vegetation as used along the survey transects noted above was used, except lowland forest was further divided into lowland forest and valley bottom lowland forest. The latter was characterized by the presence of many palms, lianas, and epiphytes (it is thus very similar to the seasonally flooded forest type recorded along the transects, but it is restricted to valley bottoms and does not form the large low-lying alluvial plains of the former). This latter forest type was distinguished/recorded on the small mammal grids, but not the transects, because the grids were mapped at a smaller scale than the transects (Appendix 1).

The number of fallen logs, branches, etc. greater than 10 cm in diameter lying across every-other grid column (i.e. lines 1, 3, 5, 7, 9, and 11) were also recorded (Appendix 1). Leaf litter depth was measured to the nearest 0.5 cm using a slender probe at each of the 36 Tomahawk trap stations (two measurements were made at each station, 1 m north and 1 m east of the station). Nine vegetation quadrats were also assessed per grid. For each quadrat the projected canopy cover provided by trees; scrub, shrubs, saplings, and poles; and seedlings and herbs (≤ 50 cm tall) was recorded as was the dominant height range for the scrub, shrubs, saplings, and poles (Appendix 1).

Identification

Mammals encountered in the field were identified using manuals by Payne *et al*. (1985) and Corbet & Hill (1992). After the team returned from Kalimantan small mammal specimens held at the Zoological Museum in Cibinong, Bogor, were examined and measured to check the preliminary identifications made in the field. The common and scientific names of all species mentioned in the text are listed in Appendix 2, while a list of Merap and Punan names for many of these species are provided in Appendix 3.

RESULTS and DISCUSSION

Overall species richness and completeness of inventory

A total of 31 species of mammal were positively identified during the mammal team's seven weeks in the Malinua concession of the Bulungan Research Forest (Table 2.3). A further five species probably occurred, but were not positively identified. These latter were *Tupaia gracilis/minor* (these two species can only be distinguished positively from hindfoot or skull

measurements; Payne *et al*. 1985); *Semnopithecus cristata* (one possible sighting by K. Liston of the invertebrate crew); *Lutrogale perspicillata* (probable footprints were seen by B. Balen of the bird crew, and S. Hedges saw otter scats on two occasions which suggests that at least one species of otter must have been present); *Prionailurus bengalensis* (B. Balen saw hunters carrying what was probably a dead specimen of this species, and a fresh *P. bengalensis* skin was seen in Long Loreh by S. Hedges); and *Muntiacus muntjak* (several unidentified muntjac were seen fleetingly during transect surveys and timed mammal searches, and some of these may have been *M. muntjak* as antlers from this species were observed in Long Loreh by S. Hedges).

If we exclude all bats (because no bat work was conducted), all other predominantly nocturnal species (because very few night surveys were conducted), those species restricted to montane areas, and the Soricidae (because they were unlikely to be captured

Table 3: Mammal species positively identified in the Bulungan Research Forest, September-October 1998.

Family	**Number of species recorded**	**Species recorded** (Bornean endemics are underlined)
Tupaiidae	2	*Tupaia tana, T. dorsalis*
Cercopithecidae	3	*Macaca nemestrina, M. fascicularis, Presbytis hosei*
Hylobatidae	1	*Hylobates muelleri*
Ursidae	1	*Ursus malayanus*
Mustelidae	2	*Mustela nudipes, Martes flavigula*
Viverridae	4	*Paradoxurus hermaphroditus, Paguma larvata, Arctictis binturong, Hemigalus derbyanus*
Herpestidae	1	*Herpestes brachyurus*
Suidae	1	*Sus barbatus*
Tragulidae	2	*Tragulus javanicus, T. napu*
Cervidae	2	*Cervus unicolor, Muntiacus atherodes*
Sciuridae	8	*Ratufa affinis, Callosciurus prevostii, C. notatus, Sundasciurus lowii, S. hippurus, Lariscus insignis, Exilisciurus exilis, Rheithrosciurus macrotis*
Pteromyidae	1	*Petaurista petaurista*
Muridae	3	*Leopoldamys sabanus, Maxomys rajah, M. whiteheadi*

using the traps at the team's disposal), one would expect to encounter 51 mammal species (Payne *et al*. 1985). Applying the same restrictions to the 31 species actually identified in the Malinau surveys yields 26 species, or about 51% of the total likely to occur there according to Payne *et al*. (1985). If we include the four or five diurnal species which are suspected to occur (*Tupaia gracilis* and/or *T. minor, Semnopithecus cristata, Lutrogale perspicillata* and *Muntiacus muntjak*), the resulting total of 30 or 31 species represents about 59–60% of the total likely to occur in the Malinau area.

Threatened species recorded

Only two threatened species (i.e. species listed in the *1996 IUCN Red List of Threatened Animals*) were recorded (or probably occurred) in the survey area: *Macaca nemestrina* and *Lutrogale perspicillata*. Both are listed as 'Vulnerable'.

Comparison of transects and timed mammal searches

Preliminary data analysis suggests that both transect surveys and timed mammal searches give very similar pictures of the relative abundance of diurnal mammals (Figures 2.1 and 2.2 **under development**). The timed mammal searches tend to produce slightly higher encounter rates per unit time compared to the formal line transect surveys. This is

Figure 2. Comparison between transect and timed mammal search data: number of primates (groups) and other mammals (individuals) detected per 100 hours of search effort in the conventional site (max).

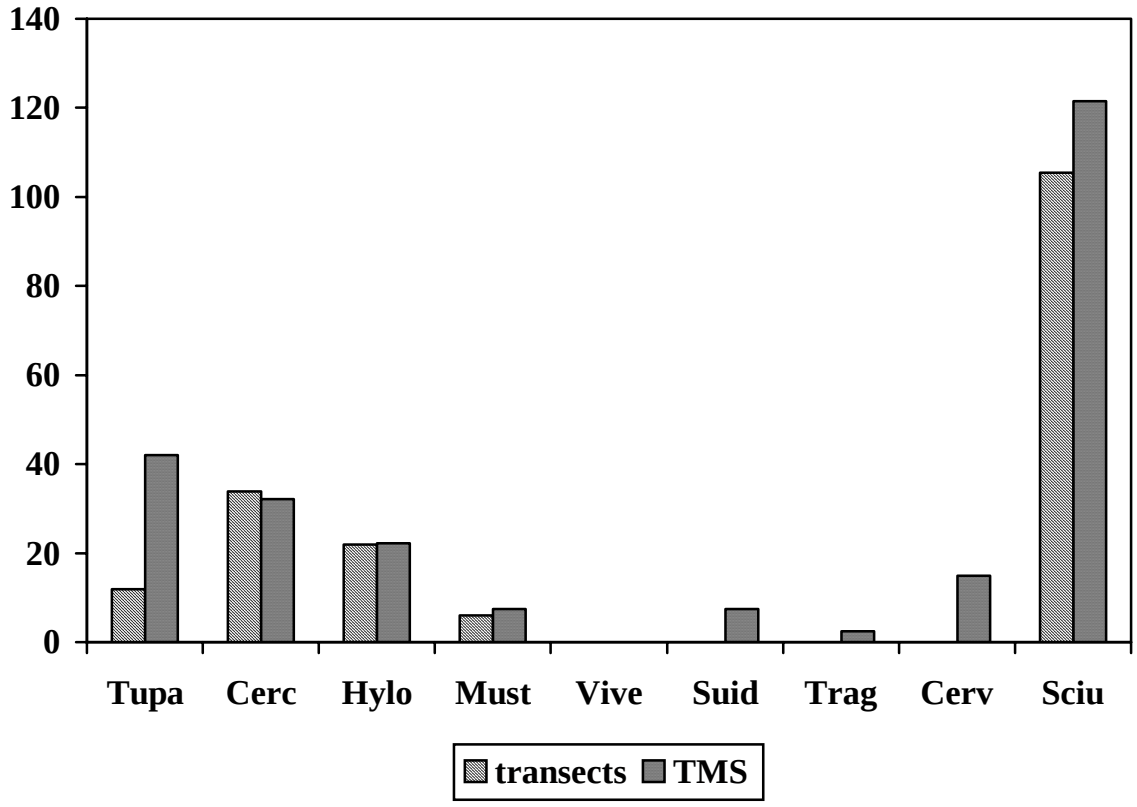
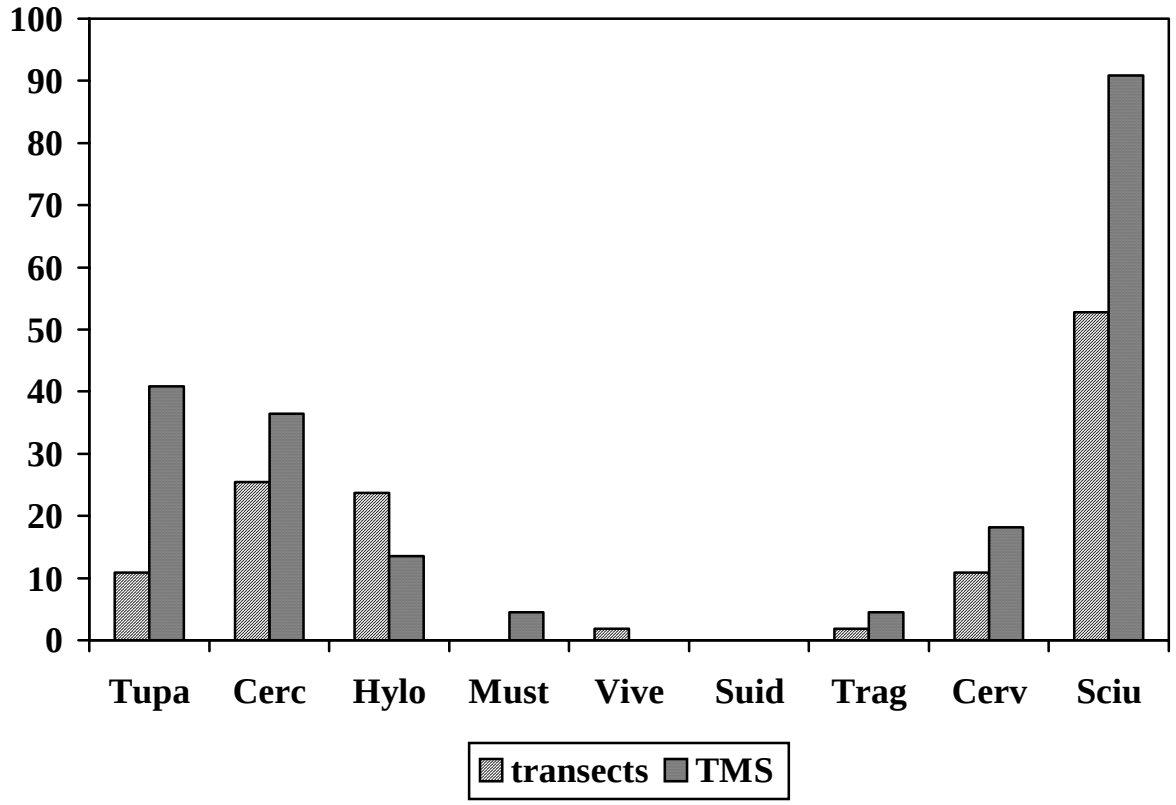


Fig 3. Comparison between transect and timed mammal search data: number of primates (groups) and other mammals (individuals) detected per 100 hrs search effort in the RIL site (maximum numbers).



presumably because the observer can: (1) spend more time looking around rather than looking at his/her feet, (2) spend more time actually looking for mammals during timed mammal searches because there is no need to measure sighting distances and angles, and (3) move more quietly if he/she doesn't have to follow a straight line irrespective of terrain or vegetation type. Similar results have been obtained in East Java (S. Hedges, unpulished data). To minimize these differences in the two survey techniques, INHUTANI cruise lines were used as an aid to systematic movement and care was taken to visit the various vegetation types within each compartment in rough proportion to their occurrence. This suggests that combining the encounter rates from the transects and timed mammal searches to produce overall encounter rates for each site is probably valid (Tables 2.4 and 2.5). Further statistical analysis is clearly required before this approach can be considered truly validated however.

Inter-site comparisons

Since one of the main aims of this study is to provide baseline data against which the effects of conventional and reduced impact logging can be compared, it is desirable that the three sites be very similar prior to logging. Comparisons of species richness and the relative abundance of mammals in the three sites helped to asses the habitat similarity in the three areas.

Species richness

The RIL and CL sites were very similar (21 and 24 species respectively, with 18 species in common; Tables 2.4 - 2.7; Figure 2.3**)**, while the Control site appears to be less rich (13 species by transect method alone, with 12 overlapping with either/both the RIL and CL sites; Table 2.6). The Control contained fewer tree shrews, squirrels, and ungulates than the two treatment areas (Tables 2.6 and 2.7). However, this difference likely reflects the smaller survey effort in the Control site relative to the other two sites (26 hrs 08 mins, 90 hrs 35 mins, and 98 hrs 58 mins in the Control, CL, and RIL sites respectively). Caution should be exercised in interpreting these results, as species richness is a rather insensitive measure of similarity (Magurran 1988).

Relative abundance

The number of groups (for primates) and individuals (for all other mammals) recorded during the line transect surveys are outlined in Tables 2.4 and 2.6. Table 2.5 presents the same type of data for the timed mammal searches.

The easiest way to compare how similar the three sites are is by means of similarity coefficients. A large number of such similarity indices exist but many of them are strongly influenced by species richness and sample size. An exception is the modified Morista-Horn index (Magurran 1988). This index varies from 0 (no similarity) to about 1 (complete similarity)(Krebs 1989). Looking at Tables 2.8 and 2.9 we can immediately see that the apparent similarity of the three sites depends on which group we look at. The CL and RIL sites are the most alike if we compare the relative abundance of primates

Figure 4. Maximum number of species recorded in the three sites.

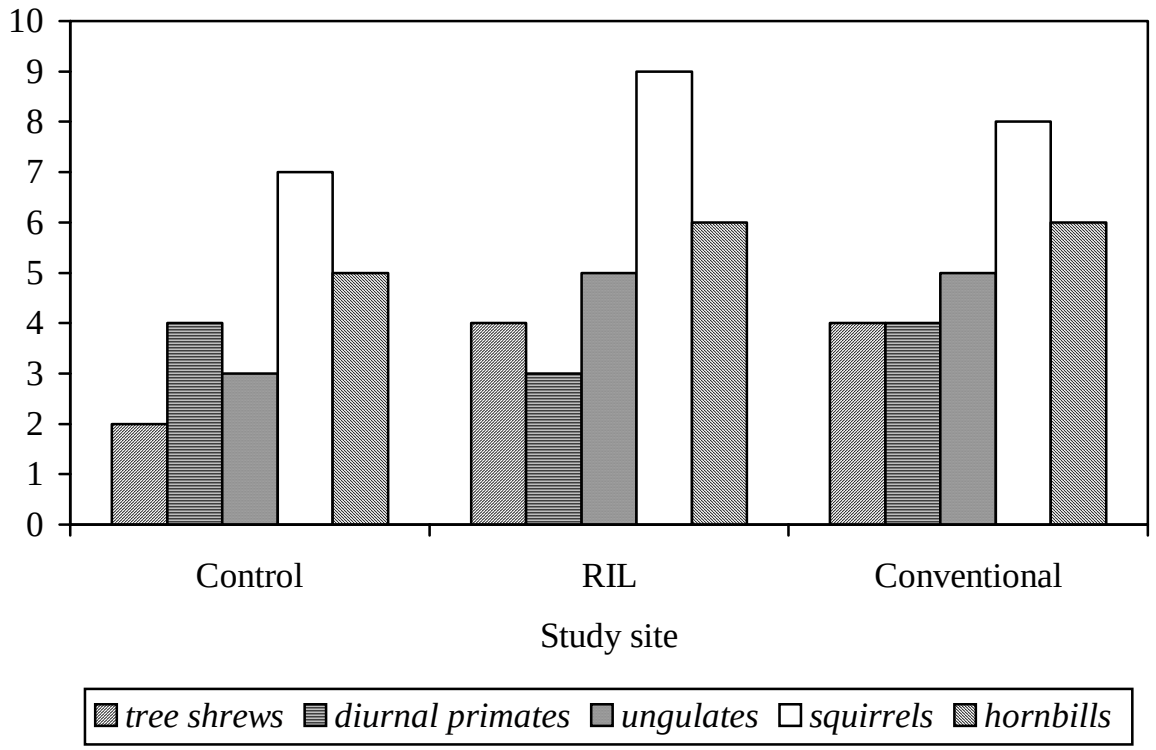


Table 4: Numbers of groups (primates) and individuals (all other mammals) recorded during transects and timed mammal searches combined (for the CL and RIL sites).

Species	Site			
	Conventional		RIL	
	Actual Count	Count per 100 hours	Actual Count	Count per 100 hours
Tupaiidae (individuals)	**22–23**	**24.3–25.4?**	**21–23?**	**21.2–23.2?**
Unidentified *Tupaia* spp.	10	11	11–12?	11.1–12.1?
Tupaia minor/gracilis	5	5.5	5	5.1
Tupaia tana	5–6?	5.5–6.6?	4–5?	4–5.1?
Tupaia dorsalis	2	2.2	1	1
Cercopithecidae (groups)	**30**	**33.1**	**29–30?**	**29.3–30.3?**
Unidentified Cercopithecidae			2	2
Macaca nemestrina	4	4.4	8	8.1
Macaca fascicularis	8	8.8		
Presbytis hosei	18	19.9	19–20?	19.2–20.2?
Hylobatidae (groups)	**20**	**22.1**	**18–19?**	**18.2–19.2?**
Hylobates muelleri	20	22.1	18–19?	18.2–19.2?
Ursidae (individuals)				
Ursus malayanus				
Mustelidae (individuals)	**5–6?**	**5.5–6.6?**	**2**	**2**
Martes flavigula	5–6?	5.5–6.6?	2	2
Viverridae (individuals)			**1**	**1**
Arctictis binturong			1	1
Suidae (individuals)	**3**	**3.3**		
Sus barbatus	3	3.3		
Tragulidae (individuals)	**1**	**1.1**	**3**	**3**
Unidentified *Tragulus* spp.			2	2
Tragulus javanicus			1	1
Tragulus napu	1	1.1		
Cervidae (individuals)	**6**	**6.6**	**14**	**14.1**
Cervus unicolor	1	1.1	1	1
Unidentified *Muntiacus* spp.	1	1.1	8	8.1
Muntiacus muntjak				
Muntiacus atherodes	4	4.4	5	5.1
Sciuridae (individuals)	**91–101?**	**100.5–111.5?**	**62–69?**	**62.6–69.7?**
Unidentified Sciuridae	7	7.7	6	6.1
Ratufa affinis	9–11?	9.9–12.1?	13	13.1
Callosciurus prevostii	15–16?	16.6–17.7?	18–21?	18.2–21.2?
Callosciurus notatus	39–43?	43.1–47.5?	10–12?	10.1–12.1?
Sundasciurus lowii	7–10?	7.7–11?	3	3
Sundasciurus hippurus	1	1.1	5	5.1
Lariscus insignis			1–2?	1–2?
Exilisciurus exilis	13	14.4	4	4
Rheithrosciurus macrotis			2–3?	2–3?
Actual number of hours spent searching	**90 hrs 35 mins**	**–**	**98 hrs 58 mins**	**–**

Note: Values denoted as xx-xx in the table refer to the range of animals recorded during the surveys (e.g. 7-10? for *Sundasciurus lowii* means that seven individuals were definitely recorded and there may have been as many as 10 individuals.

Table 5: Numbers of groups (primates) and individuals (all other mammals) recorded during timed mammal searches (for the CL and RIL sites).

Species	**Site**			
	Conventional		**RIL**	
	Actual Count	**Count per 100 hours**	**Actual Count**	**Count per 100 hours**
Tupaiidae (individuals)	**16–17?**	**39.7–42.1?**	**18**	**40.9**
Unidentified *Tupaia* spp.	8	19.8	9	20.5
Tupaia minor/gracilis	3	7.4	5	11.4
Tupaia tana	5–6?	12.4–14.9?	3	6.8
Tupaia dorsalis			1	2.3
Cercopithecidae (groups)	**13**	**32.2**	**16**	**36.4**
Unidentified Cercopithecidae				
Macaca nemestrina	2	5	4	9.1
Macaca fascicularis	2	5		
Presbytis hosei	9	22.3	12	27.3
Hylobatidae (groups)	**9**	**22.3**	**6**	**13.6**
Hylobates muelleri	9	22.3	6	13.6
Ursidae (individuals)				
Ursus malayanus				
Mustelidae (individuals)	**3**	**7.4**	**2**	**4.5**
Martes flavigula	3	7.4	2	4.5
Viverridae (individuals)				
Arctictis binturong				
Suidae (individuals)	**3**	**7.4**		
Sus barbatus	3	7.4		
Tragulidae (individuals)	**1**	**2.5**	**2**	**4.5**
Unidentified *Tragulus* spp.			2	4.5
Tragulus javanicus				
Tragulus napu	1	2.5		
Cervidae (individuals)	**6**	**14.9**	**8**	**18.2**
Cervus unicolor	1	2.5	1	2.3
Unidentified *Muntiacus* spp.	1	2.5	4	9.1
Muntiacus muntjak				
Muntiacus atherodes	4	9.9	3	6.8
Sciuridae (individuals)	**46–49?**	**114–121.5?**	**40**	**90.9**
Unidentified Sciuridae	1	2.5	3	6.8
Ratufa affinis	6	14.9	11	25
Callosciurus prevostii	9	22.3	10	22.7
Callosciurus notatus	16	39.7	3	6.8
Sundasciurus lowii	6–9?	14.9–22.3?	3	6.8
Sundasciurus hippurus	1	2.5	4	9.1
Lariscus insignis				
Exilisciurus exilis	7	17.4	4	9.1
Rheithrosciurus macrotis			2	4.5
Actual number of hours spent searching	**40 hrs 20 mins**	**–**	**44 hrs 0 mins**	**–**

Table 6: Numbers of groups (primates) and individuals (all other mammals) recorded during transect surveys.

Species	**Site**					
	Control		**RIL**		**Conventional**	
	CS transect1	**CS transect2**	**RIL transect1**	**RIL transect2**	**CL transect1**	**CL transect2**
Tupaiidae (individuals)	**2**	**0**	**2–5?**	**1**	**4**	**2**
Unidentified *Tupaia* spp.	2		1–2?	1	2	
Tupaia minor/ gracilis					1	1
Tupaia tana			1–3?			
Tupaia dorsalis					1	1
Cercopithecidae (groups)	**8**	**3**	**2**	**11–12?**	**13**	**4**
Unidentified Cercopithecidae			1	1		
Macaca nemestrina	1			4	2	
Macaca fascicularis	6	1			4	2
Presbytis hosei	1	2	1	6 –7?	7	2
Hylobatidae (groups)	**6–7?**	**0**	**6–7?**	**6**	**6**	**5**
Hylobates muelleri	6–7?		6–7?	6	6	5
Ursidae (individuals)	**0–1?**	**0**	**0**	**0**	**0**	**0**
Ursus malayanus	0–1?					
Mustelidae	**0**	**0**	**0**	**0**	**2–3?**	**0**
Martes flavigula					2–3?	
Viverridae	**0**	**0**	**1**	**0**	**0**	**0**
Arctictis binturong			1			
Tragulidae (individuals)	**0**	**0**	**0**	**0**	**0**	**0**
Tragulus javanicus			1			
Cervidae (individuals)	**0**	**0**	**4**	**2**	**0**	**0**
Unidentified *Muntiacus* spp.			3	1		
Muntiacus atherodes			1	1		
Sciuridae (individuals)	**37–39?**	**7**	**12–17?**	**10–12?**	**16–20?**	**29–33?**
Unidentified Sciuridae	1		1	2	1	5
Ratufa affinis	9			2	3–5?	
Callosciurus prevostii	10	2	5–7?	3–4?	1	5–6?
Callosciurus notatus	11	1	5–7?	2	9–10?	14–17?
Sundasciurus lowii	0–2?				1–2?	
Sundasciurus hippurus				1		
Lariscus insignis	1	2	1	0–1?		
Exilisciurus exilis	5	2			1	5
Rheithrosciurus macrotis			0–1?			
Total distance walked	14900 m	2450 m	12000 m	13915 m	13210 m	11800 m
Total time spent walking transects	20 hrs 18 mins	5 hrs 50 mins	25 hrs 25 min	29 hrs 33 min	25 hrs 32 min	24 hrs 43 min

Table 7: Numbers of groups (primates) and individuals (all other mammals) recorded per 100 hours and per 100 km of survey effort (transect data only).

Species	**Site**					
	Control (CStransect1 + CStransect2)		**RIL (RILtransect1 + RILtransect2)**		**Conventional (CLtransect1 + CLtransect2)**	
	/ 100 hours	**/ 100 km**	**/ 100 hours**	**/ 100 km**	**/ 100 hours**	**/ 100 km**
Total Tupaiidae (individuals)	**7.7**	**11.5**	**5.5–10.9?**	**11.6–23.2?**	**11.9**	**24**
Unidentified *Tupaia* spp.	7.7	11.5	3.6–5?	7.7–11.6?	4	8
Tupaia minor/ gracilis					4	8
Tupaia tana			1.8–5?	3.9–11.6?		
Tupaia dorsalis					4	8
Cercopithecidae (groups)	**42.1**	**63.4**	**23.7–25.5?**	**50.2–54?**	**33.8**	**68**
Unidentified Cercopithecidae			3.6	7.7		
Macaca nemestrina	3.8	5.8	7.3	15.4	4	8
Macaca fascicularis	26.8	40.3			11.9	24
Presbytis hosei	11.5	17.3	12.7–14.6?	27–30.9?	17.9	36
Hylobatidae (groups)	**23–26.8?**	**34.6–40.3?**	**21.8–23.7?**	**46.3–50.2?**	**21.9**	**44**
Hylobates muelleri	23–26.8?	34.6–40.3?	21.8–23.7?	46.3–50.2?	21.9	44
Ursidae (individuals)	**0–3.8?**	**5.8?**				
Ursus malayanus	0–3.8?	5.8?				
Mustelidae (individuals)					**4–6?**	**8–12?**
Martes flavigula					4–6?	8–12?
Viverridae (individuals)			**1.8**	**3.9**		
Arctictis binturong			1.8	3.9		
Tragulidae (individuals)			**1.8**	**3.9**		
Tragulus javanicus			1.8	3.9		
Cervidae (individuals)			**10.9**	**23.2**		
Unidentified *Muntiacus* spp.			7.3	15.4		
Muntiacus atherodes			3.6	7.7		
Sciuridae (individuals)	**168.4–176?**	**253.6–265.1?**	**40–52.8?**	**84.9–111.9?**	**89.6–105.5?**	**179.9–211.9?**
Unidentified Sciuridae	3.8	5.8	5.5	11.6	12	24
Ratufa affinis	34.4	51.9	3.6	7.7	6–10?	12–20?
Callosciurus prevostii	45.9	69.2	14.6–20?	30.9–42.4?	11.9–13.9?	24–28?
Callosciurus notatus	45.9	69.2	12.7–16.4?	27–34.7?	45.8–53.7?	92–108?
Sundasciurus lowii	0–7.7?	0–11.5?			2–4?	4–8?
Sundasciurus hippurus			1.8	3.9		
Lariscus insignis	11.5	17.3	1.8–3.6?	3.9–7.7?		
Exilisciurus exilis	26.8	40.3			12	24
Rheithrosciurus macrotis			1.8?	0–3.9?		
Actual search effort	26 hrs 08 mins	17350 m	54 hrs 58 min	25915 m	50 hrs 15 min	25010 m

Table 8: Relative abundances (proportions) of primates and squirrels in the three sites (transects and timed mammal searches combined, minimum numbers).

Species	Site					
	Control		RIL		Conventional	
	Actual count	Relative abundance	Actual count	Relative abundance	Actual count	Relative abundance
Primates (groups)						
Macaca nemestrina	1	0.06	8	0.18	4	0.08
Macaca fascicularis	7	0.41	0	0	8	0.16
Presbytis hosei	3	0.18	19	0.42	18	0.36
Hylobates muelleri	6	0.35	18	0.40	20	0.40
Total	**17**	**1**	**45**	**1**	**50**	**1**
Squirrels (individuals)						
Ratufa affinis	9	0.21	13	0.23	9	0.11
Callosciurus prevostii	12	0.28	18	0.32	15	0.18
Callosciurus notatus	12	0.28	10	0.18	39	0.46
Sundasciurus lowii	0	0	3	0.05	7	0.08
Sundasciurus hippurus	0	0	5	0.09	1	0.01
Lariscus insignis	3	0.07	1	0.02	0	0
Exilisciurus exilis	7	0.16	4	0.07	13	0.15
Rheithrosciurus macrotis	0	0	2	0.04	0	0
Total	**43**	**1**	**56**	**1**	**84**	**0.99**

Table 9: Similarity coefficients (modified Morista-Horn index) for number of primates and squirrels recorded in the three sites (transects plus timed mammal searches, minimum numbers).

	Control	RIL	Conventional
Primates (groups)			
Control	–	0.6474	0.8467
RIL	–	–	0.9435
Conventional	–	–	–
Squirrels (individuals)			
Control	–	0.9188	0.8716
RIL	–	–	0.7320
Conventional	–	–	–

Note: the modified Morista-Horn index is calculated from the equation

$$C_{MH} = 2 \sum (an_i \times bn_i) / (da + db)(aN \times bN)$$

Where aN = the number of individuals in site A,
bN = the number of individuals in site B,
an_i = the number of individuals of the ith species in site A,
bn_i = the number of individuals of the ith species in site B,
$da = \sum an_I^2 / aN^2$ and $db = \sum bn_I^2 / bN^2$

(0.94, compared with 0.85 for the CL and Control, and 0.65 for the RIL and Control), but the least alike if we look at the squirrel populations (0.73, compared with 0.87 for the CL and Control, and 0.92 for the RIL and Control; Table 2.9).

Vegetation types and other features of the transects / study sites

The data relating to vegetation type along the six transects, as well as the altitudinal range and slope measurements, are presented in Table 2.2. A number of very obvious differences are immediately apparent between the study sites: (1) the large proportion of seasonally flooded or swamp forest and degraded lowland forest / scrub in the CL site compared to the other two sites; and (2) the relative flatness of Cltransects 1&2 compared to RILtransects 1&2.

Since neither the detailed vegetation and other habitat data gathered by the CIFOR/INHUTANI teams are currently available for review, nor the cruise line tree data collected by INHUTANI , no further comparison of the vegetation and physical characteristics of three sites is attempted here.

Small mammal trapping

Rodents trapped in the study are listed in Table 2.10. Unfortunately, frequent heavy flooding prevented regular access to the Control site and consequently no small mammal trapping was carried out there. Furthermore, as mentioned in the methods section above, ants disabled between 30 and 40% of the Sherman traps and thus they were only used during the first two trapping sessions (plots 29/L1 and 27/D, Appendix 1).

Table 10: Total number of small mammal (rodents) captured.

Species	Site and Plot							
	CL Site				RIL site			
	Plot # 29/L1		Plot # 28/H2		Plot # 27/D		Plot # 27/I	
	Large traps	small traps	large traps	small traps	large traps	small traps	Large traps	small traps
Maxomys whiteheadi	0	2	0	–	1	2[a]	0	–
M. rajah	3	0	5[a]	–	6	0	5[a]	–
Leopoldamys sabanus	1	0	0	–	0	0	4[a]	–
Total (with re-capture)	4	2	5	–	7	2	9	–
Capture rate	3.7%	0.97%	4.63%	–	6.4%	0.97%	8.33%	–
Total (less re-capture)	4	2	4	–	7	1	7	–
Capture rate	3.7%	0.97%	3.7%	–	6.4%	0.49%	6.48%	–
Trapnights	108	206	108	–	108	206	108	–
Trapping period	6–9 Oct 1998		18–21 Oct 1998		13–16 Oct 1998		23–26 Oct 1998	

[a] Includes the recapture of one animal two times.

Capture rates (per 100 trap nights) for the Tomahawk traps varied from 3.7 to 8.3% (or 3.7–6.5% excluding recaptures). These figures are similar to the rates obtained by Wilkinson *et*

al. (ICBP undated, **reference to be added**) at their Barito Ulo study site in Central Kalimantan. The capture rates obtained in the present study also compare reasonably favorably with other studies in tropical forest areas. For example, in a study in Madagascar, Stephenson *et al*. (1994) found that on average, Sherman traps caught 10.4 small mammals (of which 8.1 were tenrecs) for every 100 trap nights; Stevens *et al*. (1998) achieved an overall capture rate of about 11% at two sites in Brazil; and Emmons (1984) reported small mammal capture rates of 6.9%, 7.1%, and 0.75% (excluding recaptures) at three sites in Amazonia.

Because of the small number of (functional) traps available to the team, the actual number of small mammals caught was very small. Given the small sample size, it is unwise to attempt to analyze the results beyond noting that murid rodent species composition and relative abundance in the CL and RIL sites appeared similar (especially when one compares the results from the two high stocking density plots (28/H2 & 27/D), and the two low stocking density plots (29/L1 & 27/I)).

PROBLEMS AND RECOMMENDATIONS

The area of the Malinau concession, which was selected for the biological surveys, had been divided into small (approximatly 1 km^2) compartments long before the mammal team and other biologists working on this project were employed to collect the baseline data. It would have been better if the vertebrate surveys had been conducted before the construction of logging roads, etc. and before the compartments were cruised, let alone logging began. As it is, we have to accept the fact that the area had been heavily and regularly disturbed prior to the surveys, and this may have led to large mammals such as *Ursus malayanus* avoiding the sites.

A similar, but perhaps rather more serious problem was the fact that logging was taking place in the compartments immediately adjacent to the study sites, both before and during the survey period. This may have led to artificially high densities of mammals and birds being recorded during the survey, especially in the RIL and Conventional sites. Clearly this has serious implications for the study if these artificially high densities were only temporary in nature, because subsequent re-surveys of the study sites may detect fewer birds and mammals irrespective of the effects of logging on the study sites. Such effects of habitat loss and/or disturbance have been documented elsewhere (see for example Hagan *et al*. 1996 and references therein). This problem should be addressed before the next round of surveys.

The two sites (RIL and Conventional logging) which had been selected prior to the team's arrival in the field were somewhat dissimilar, as were the areas which had been suggested as possible Control Sites. Although we recognize that exact matching of study sites in a project like this will never be possible, we felt that greater attention could and should have been paid to this issue. For example the Conventional site (compartments 28 and 29) is bounded on one side by a major river, has large areas of seasonally flooded and/or freshwater swamp forest, and is rather flat, whereas the RIL site (compartment 27) has no major river next to it, has relatively little swamp or seasonally flooded forest, and the topography is quite steep (see Table 2.2). Such major differences become obvious after even brief orientation visits to the field (and indeed would be obvious on topographic maps and aerial photographs or other

remote sensing imagery), and thus it may have been possible to select better matched sites. Greater attention should be paid to this issue in future.

Frequent heavy rain throughout the survey period (September–October 1998) caused the teams a number of problems (flooding prevented access to study sites, continuous heavy rain made night surveys impossible most nights, etc.). We therefore recommend that the faunal surveys be carried out earlier in the year so as to avoid periods of prolonged heavy rain. A likely suitable time would be April–June (but INHUTANI records for BRF should be consulted before deciding on the best period). Conducting the surveys earlier in the year would have few consequences for the mammals and the seasonal effects on the bird data could easily be taken into account (Bas van Balen pers. comm.). A change in the timing of the surveys may however have implications for the entomological work but such problems could be easily be avoided by conducting the entomological surveys at a different time to the mammal and bird surveys. Indeed this would help overcome the problems generated by having too many people in the field at the same time (see below).

The large number of people trying to work in the three sites during the September–October surveys (e.g. the mammal team and the ornithologists, botanists, entomologists, plot-making teams, etc.) led to scheduling problems and probably seriously disturbed a number of bird and mammal species. In the future, it would be better to conduct the faunal surveys (especially the mammal and bird surveys) during periods when few other workers are in the field.

As discussed in the text above, ants disabled 30–40% of the Sherman traps. This problem could be overcome by using another design of trap (e.g. Longworth traps). The number of Tomahawk traps should be increased too; or alternatively the locally-made live-traps, which are similar to Tomahawk traps in design (although they are not collapsible), could be used. (The locally-made traps are much cheaper than Tomahawk traps too.)

Serious consideration should be given to employing an additional mammologist for the next round of surveys. This is likely to be essential since future surveys in the BRF area as part of the Reduced Impact Logging study will involve conducting baseline surveys in additional unlogged sites as well as re-surveying the sites which were logged after the 1998 baseline surveys (i.e. compartments 27, 28, and 29).

A number of other problems such as CIFOR/INHUTANI teams moving plots after the mammal team had finished trapping and mapping them could be avoided by having an on-site coordinator with the authority to insist the various teams stick to agreed plans, plot locations, etc.

SECTION 3. BIRD SURVEYS

Prepared by Sebastian (Bas) van Balen and Nurul Winarni

METHODS

Study area

The Malinau concession is located in largely undisturbed lowland dipterocarp forest, in moderately undulating topography 40 – 120 m a.s.l. A river that is subject to flooding following heavy rainstorms intersects the area. South, west and east of the study area the forest is bordered by unlogged forest, while to the north the forest has recently been selectively logged. The study area is described in greater detail in Section 2 of this report.

Survey plots

Different census techniques, at differing scales, were applied in this survey: (1) variable circular plots (VCP) located along transects; (2) full day samples (FDS) within one hectare permanent vegetation plots established by CIFOR vegetation ecologists; and (3) road counts within old and active logging tracts.

Variable circular plots (VCP)

VCP stations were located at 200 m intervals along the mammal transects described in Section 2. Nine VCP transects ranged in length from 600 – 800 m, depending on the physical and biological characteristics of the sampling areas (Appendix 4). Five VCP were located along each transect (four on one transect), and habitat characteristics surrounding each VCP were qualitatively assessed: (1) percent vegetation cover at ground, low, mid and upper canopy layers; (2) relative abundance of ferns, saplings, rattan, small palms and herbs in the lower layers; (3) presence of fallen logs; (4) presence of moss on tree bark; (5) relative abundance of lianas and epiphytes; and (6) proximity to water (Appendix 4).

The VCP surveys were stratified into different time blocks to cover as much of the daylight bird calling time as possible: (1) early morning: 0600 – 0900 hrs, (2) late morning: 0900 – 1200 hrs, and (3) afternoon: 1400 – 1700 hrs (after Reynolds et al. 1980). At each VCP (or station), 20 minutes were spent recording all birds seen/heard within 100 m of the plot center (distances from the plot center to the bird were estimated in meters). Birds heard >100m from the plot were noted, but not used in the following analysis.

Hornbill survey

Hornbills were surveyed along the entire length of the mammal transects, by the mammal crew. For every hornbill detected along a transect, the following information was recorded: time, location, species, and number of individuals in the group. Hornbills were also noted in the VCP, FDS, and road count surveys, using the methods noted below.

Full day samples (FDS)

Full day samples of the bird populations were made within select one-hectare permanent vegetation plots (CIFOR established 24 of these across the study area). During a FDS, the observer was stationed near the center point of the permanent plot and recorded all birds within a 50 m radius (inside the boundaries of the plot). The census period extended over the entire day (06.00 – 12.00h, and 14.00 – 17.00h), with a noon break of two hours when bird activity was at its lowest. Appendix 2 provides a brief description of the nine plots sampled during the study period.

During both the VCP and FDS bird surveys, birds were almost exclusively identified by sound, as the dense vegetation hampered sighting birds inside the forest. Numerous sound recordings were made using a Sony MiniDisk Walkman MZ-R30, and a Sony recorder equipped with a ECM-PB1C parabola microphone. Recordings were taken for documentation and post-field identification. Finally, in both the VCP and FDS surveys, birds flying over the sample site (raptors, swiftlets), but which were not associated with the plots, were not recorded. Tree swifts and Silver-rumped Swifts with apparent affinity to the plots were incorporated however.

Road counts

Road counts were carried out along tracks in active and inactive areas of the concession. Data were subject to a less standardized protocol as compared to the VCP and FDS techniques (counts were done in a rather opportunistic way), and served only to develop a more complete picture of the regional avifauna (e.g. canopy feeding sunbirds, flowerpeckers, and raptors are often missed along transect counts and FDS surveys). Road counts also provide data from areas with different logging histories. Sampling procedures included recording: (1) all birds seen or heard within ca. 100 m of the logging road; and (2) the time of the day when counts were made. The sampling efforts used in this survey technique are outlined in Table 3.1

Table 11: Number of observation days (and hours) spent conducting road counts in each logged area (RKT = Rencana Kerja Tahunan, or annual cutting block).

Annual cutting block	Days	Hours
RKT 1993/94	5 days	11
RKT 1996/97	2 days	14
RKT 1997/98	3 days	26
RKT 1998/99	12 days	36

Species lists

'Species lists' were developed from dawn to dusk walks along the transects, roads, and forest paths. Efforts were made to select sampling sites that were relatively homogenous in habitat throughout the sample period. During each sample, all new species encountered were recorded until 20 species had been observed (one complete list). Any one species was only recorded once in a list of 20, but was recorded again if encountered in subsequent lists. Unidentified species were recorded with notes so that if encountered again, they could be recognized as the same species (MacKinnon & Phillips 1993). Observations in compartments were separated into their own lists so that between compartment comparisons could be made. The new species in each list were the basis for creating a species accumulation graph. The steepness of the graph reflects the species richness of an area, and indicates how many more species are still likely to be found in the area.

Mixed flocks

All mixed species flocks encountered during the survey period, regardless of the sampling method, were noted. Foraging height, flock composition and habitat were recorded for each encounter.

Ethno-ornithology

Birds observed by local hunters (members of the Punan and Merap ethnic groups) were noted through semi-structured interviews using plates from books, and to a lesser extent playing tapes with bird-calls. The knowledge of local hunters was extensive and interviews with them provided much useful information on local bird populations. Also, species of seasonal occurrence and conspicuousness were "discovered" through such interviews. Finally, inventories of local bird markets and cage birds held in Long Loreh were made to provide an idea of the impact of hunting and capturing on local bird populations.

Data analysis

Results of the VCP and FDS surveys were used to calculate Sorenson's Similarity indices (in Magurran 1988), using the following formulas:

Qualitative $Cs = 2j/(a+b)$

where j = number of species shared by two sites; a = number of species in site a, b = number of species in site b

Quantitative $CN = 2jN/(aN = bN)$

where aN = total number of individuals in site a; bN = total number of individuals in site b; jN = sum of lower of two abundances recorded for species found in both sites.

Comparison of similarity between compartments using the 'species list' survey technique were measured using presence-absence of species in each compartments with Coefficient of Jaccard (Krebs 1989):

$$S_j = \frac{a}{a + b + c}$$

Where a = Number of species in sample A and sample B
b = Number of species in sample A but not in sample A
c = Number of species in sample A but not in sample B

Density estimates from the VCP and FDS surveys are under development.

For assessing bird species diversity in each survey unit, the Shannon-Wiener Index (*H'*; cf MacArthur & MacArthur 1961) was applied:

$H' = -\Sigma\, p_i (\log_2 p_i)$

where p_i = proportion of total sample belonging to *i*th species.

Both species richness (number of species in the sample) and evenness (J) also describe diversity, and considered apart, may tell more about the structure of bird communities than *H'* alone.

$J = D / D_{max}$, where $D_{max} = -\ln 1/n$ (n = number of species in the sample)

Bird species diversity indices and evenness values were calculated from representative samples of road counts and the VCP data.

RESULTS

Species numbers and their similarity

A total of 239 bird species were observed during the study period (field surveys, road counts, and village surveys; Appendix 6), with 182 bird species occurring in the VCP (125 species) and FDS (130 species) study areas (Appendix 7 and 8 respectively). A total of 124 species from 31 families were observed in the 'species list' survey of the compartments (14 lists representing 99 species in the conventional treatment, 13 lists representing 90 species in the RIL site, and 8 lists representing 68 species from the control area). Families with the most species recorded were represented by Timaliidae (18 species), Pycnonotidae (12 species), and Picidae (12 species). These numbers compare favorably with species counts in other Borneo bird studies (Table 3.2), some of which covered longer periods and wider elevation ranges. Figures 3.1 and 3.2 illustrate the saturation curves for the VCP, FDS, and 'species list' surveys. While these curves are beginning to flatten, it appears that the sampling intensity applied in this study was insufficient to detect all bird species in the study area.

Table 12. Bird species richness observed in field studies throughout Borneo.

Location	Species (n)	Survey Duration	Area (ha)	Reference
Senggata Kutai	142	250 hrs	30	Pearson 1975
Cabang Panti (Gn Palung)	187	2-3 yr	200	Laman *et al*. 1996
Rekut (Barito Ulu)	190	39 days	150	Wilkinson *et al*. 1991
Bulungan Research Forest	182	350 hrs	300	this report

Bird communities were moderately similar between the study sites, ranging from 0.67 – 0.80 and 0.46 – 0.60 for the qualitative and quantitative Sorenson calculations respectively (Tables 3.3a and b). The VCP, FDS, and 'species list' surveys gave similar responses. Based on the latter survey technique, 70 species in the CL treatment were shared with RIL, 30 species present in CL did not occur in RIL, 20 species absent in CL did occur in RIL, and 39 species from overall species observed in the compartment area were absent in both. Comparison between RIL and the control (CS) showed that 53 species occurred in both sites, 15 species present in the CS were absent in RIL, 37 species present in RIL were absent in the CS, and 54 species were absent in both sites. Within CL and CS comparisons, 60 species were shared, 8 species present in the CS were absent in CL, 40 species absent in the CS were

Figure 5. Bird species accumulation curve for VCP and FDS surveys, Malinau concession, Sept-Oct 1998.

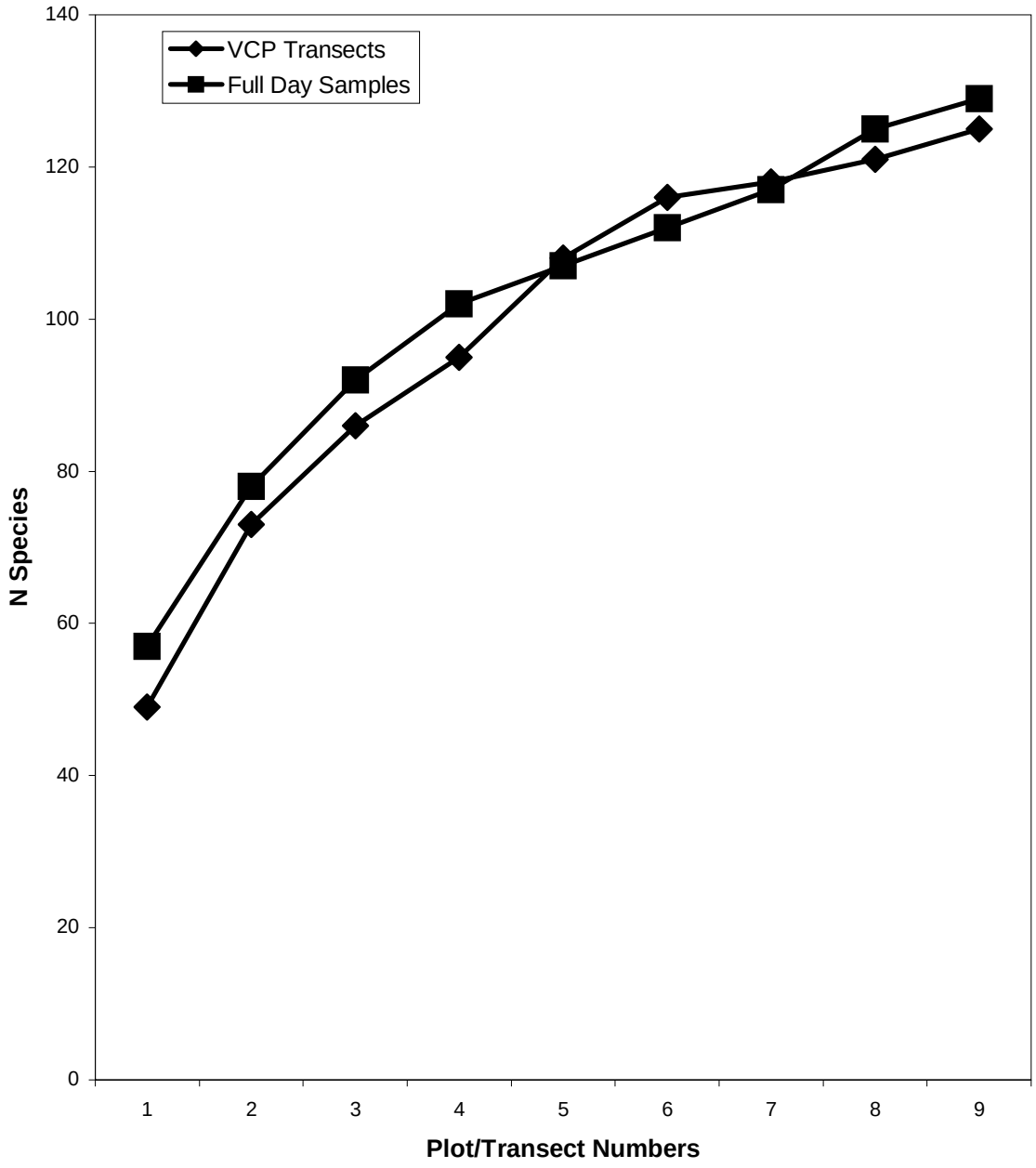
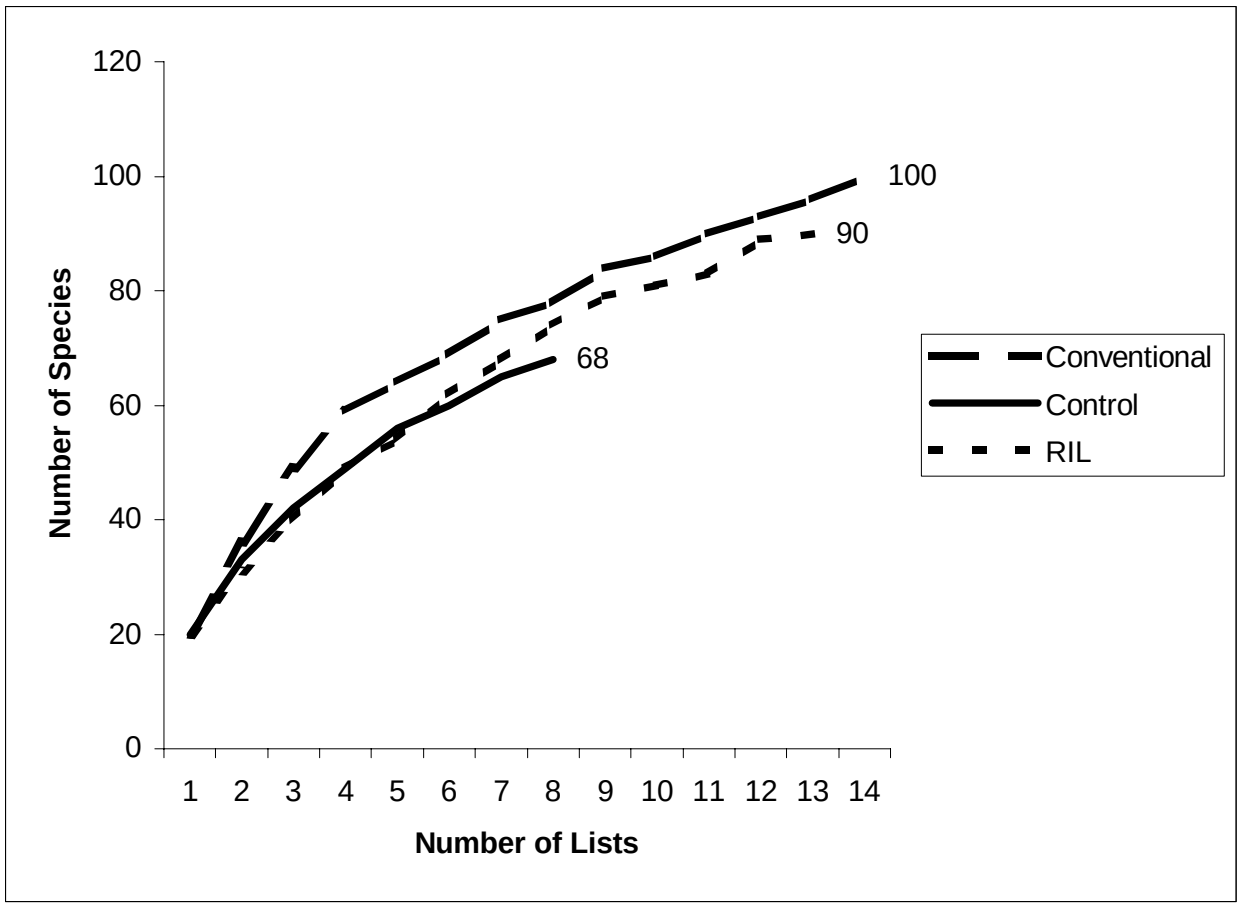


Figure 6. Accumulated new species comparison among Conventional, Control, and RIL compartments of the Malinau concession, BRF, Sept-Oct 1998.



present in CL, and 51 species were absent in both. The Coefficient of Jaccard calculation, based on the above comparisons, showed that RIL and CL sites had the greatest similarity (S_j=0.58), CL-CS were second (S_j =0.56), and RIL-CS the least similar (S_j =0.50).

Table 13. Sorenson Similarity Indices for the Malinau transects using the VCP survey technique. Qualitative and quantitative (in brackets) values are provided.

	Sites					
	Petak 27	Petak 28/29	Control	Species (n)	% of plot total	% of all species[a]
Petak 27	1	-	-	84	67	46
Petak 28/29	0.74 *[0.53]*	1	-	97	78	53
Control	0.72 *[0.56]*	0.80 *[0.69]*	1	87	70	48
Total				125		

Species diversity, richness, and evenness

Bird species diversity, richness, and evenness did not vary greatly between the study compartments (Table 3.4). Road counts (logged areas) produced consistently higher values than the VCP surveys ('within' forest block conditions).

Table 14. Sorenson Similarity Indices for the Malinau permanent plots using the FDS survey technique. Qualitative and quantitative (in brackets) values are provided.

	Sites					
	Petak 27	Petak 28/29	Control	Species (n)	% of plot total	% of all species[a]
Petak 27	1	-	-	99	76	54
Petak 28/29	80 *[.70]*	1	-	95	73	52
Control	.67 *[.46]*	.72 *[.54]*	1	78	60	53
Total				130		

Table 15. Bird species diversity (*H'*), richness, and evenness values for the Malinau study.

Survey technique	**Compartment**	**Species diversity *H'***	**Species richness**	**Evenness**	**Sample size**
Road counts	RKT 93/94	4.17	102	-.90	448
	RKT 96/97	4.25	103	-.92	477
	RKT 97/98	4.39	114	-.93	574
	RKT 98/99	4.30	115	-.91	579
VCP survey	Petak 27	4.12	84	-.92	371
	Petak 28/29	4.12	97	-.90	574
	Control	4.10	87	-.92	473

Forest birds

A total of 178 lowland-dependent forest bird species (see Wells 1985) were recorded during the present survey. This represents 73% of the 244 recorded lowland forest birds in Borneo (Table 3.5)(Andrew 1992), which includes 23 slope specialists (not observed in this study) that are unlikely to occur in the survey area. Excluding these 23 slope specialists, it is estimated that this survey recorded 80% of the maximum number of bird species that are likely to be in the Malinau area. This includes 36 'extreme' lowland

Table 16. Bird species encountered in Malinau survey vs. total number of bird species in select forests of Borneo.

	Total species in Borneo	Species in Malinau	Percent of Borneo birds represented by Malinau study
Lowland forest birds	244	178	73%
Extreme lowland specialists	49	36	73%

forest specialists (73% of the total in Borneo)(Table 3.6). Lowland forest bird species that did not show up in the survey, but which are probable residents of the Malinau area, are listed in Table 3.7. Finally, forest species that were absent in the older logged areas (RKT 1992/93 to RKT 1997/98) are listed in Table 3.8. Understory babblers and flycatchers dominate this list, suggesting groups of birds sensitive to habitat disturbance following logging.

Table 17. Extreme lowland specialists (after Wells 1985) found in the CIFOR Bulungan Research Forest.

Ciconia stormi
**Spizaetus nanus*
Lophura ignita
**Treron capellei*
**Treron olax*
Ducula aenea
**Psittinus cyanurus*
**Centropus rectunguis*
**Carpococcyx radiceus*
Ninox scutulata
Batrachostomus auritus
Hemiprocne longipennis
**Rhyticeros corrugatus*
Anthracoceros malayanus
Megalaima rafflesii
Pitta granatina
Pitta baudi
**Coracina striata*
**Pericrocotus igneus*
**Pityriasis gymnocephala*
Trichastoma rostratum
Trichastoma bicolor
**Malacopteron albogulare*
Stachyris nigricollis
Cyornis turcosa
**Cyornis caerulata*
**Nectarinia sperata*
**Aethopyga siparaja*
Arachnothera flavigaster
Gracula religiosa

Mulleripicus pulverulentus	*Dicrurus paradiseus*
**Dryocopus javensis*	**Platysmurus leucopterus*
**Pitta sordida*	*Corvus enca*

*Species without confirmed records for Kayan Mentarang NP (van Balen & Nurwatha 1997)

Table 18. Resident lowland bird species not found in the Malinau survey area, and possible reasons for their absence.

Species	Reason for absensce	Species	Reason for absence
Pseudibis davisoni	Habitat/elevation (+)	*Pycnonotus zeylanicus*	Extinct
Spizaetus alboniger	Elevation (-)	*Pycnonotus nieuwenhuisi*	extremely rare
Haliaetus leucogaster	Habitat/elevation (+)	*Pycnonotus melanicterus*	elevation (-)
Ichtyophaga ichthyaetus	Habitat/elevation (+)	*Pycnonotus squamatus*	elevation (-)
Microhierax latifrons	Range	*Setornis criniger*	?
Rhizothera longirostris	?	*Hypsipetes flavala*	elevation (-)
Arborophila charltoni	Elevation (+)	*Dicrurus hottentottus*	elevation (-)
Melanoperdix nigra	Elevation (+)	*Cissa chinensis*	elevation (-)
Lophura erythrophthalma	Elevation (+)	*Trichastoma perspicillatum*	range
Polyplectron malacense	?	*Napothera epilepidota*	elevation (-)
Treron fulvicollis	Rare and local	*Stachyris rufifrons*	elevation (-)
Ptilinopus jambu	Elevation (-)	*Stachyris leucotis*	elevation (-)
Macropygia phasianella	Elevation (-)	*Yuhina zantholeuca*	elevation (-)
Psittacula longicauda	Elevation (+)	*Zoothera interpres*	rare
Otus lempiji	?	*Abroscopus superciliaris*	elevation (-)
Ketupa ketupu	Elevation (+)	*Rhinomyias olivacea*	range
Batrachostomus harterti	Elevation (-)	*Ficedula dumetoria*	elevation (-)
Caprimulgus concretus	Elevation (+)	*Cyornis concretus*	elevation (-)
Harpactes orrhophaeus	Elevation (-)	*Cyornis unicolor*	elevation (-)
Anthracoceros albirostris	Elevation (+)	*Cyornis banyumas*	elevation (-)
Megalaima eximia	Elevation (-)	*Aethopyga mystacalis*	elevation (-)
Picumnus innominatus	Elevation (-)	*Zosterops everetti*	elevation (-)
Picoides canicapillus	Elevation (-)	*Oculocincta squamifrons*	elevation (-)
Pitta arquata	Elevation (-)	*Erythrura prasina*	season
Pitta guajana	Elevation (-)	*Lonchura leucogastra*	?
Hemipus picata	Elevation (-)		

Elevation (-) = submontane/slope specialist (Smythies 1981; Wells 1985), BRF too low; (+) = extreme lowland specialist (Wells 1985), BFR too high; occurs upriver Malinau (Tubu river).

Table 19. Possibly logging-intolerant forest birds found during the Malinau survey.

Ciconia stormi
Rollulus rouloul
Lophura ignita
Carpococcyx radiceus
Ducula aenea
Otus rufescens
Bubo sumatranus
Batrachostomus auritus
Batrachostomus stellatus
Sasia abnormis
Indicator archipelagicus
Calyptomena hosii
Pitta caerulea
Eupetes macrocerus
Malacopteron albogulare
Ptilocichla leucogrammica
Kenopia striata
Napothera atrigularis
Rhinomyias umbratilis
Cyornis superbus
Cyornis caerulatus
Cyornis turcosus
Anthreptes rhodolaema

Secondary growth species

Bird species that are indicators of secondary habitat, and rarely entering primary forest habitat, are listed in Table 3.9. Magpie Robin (*Copsychus saularis*) and Yellow-vented Bulbul (*Pycnonotus goiavier*) are examples of secondary forest species that invade immediately after logging. Most of these generalist species invade from secondary re-growth sites along rivers.

Table 20. Generalist bird species of secondary growth habitats in the Malinau area.

Centropus sinensis
Pitta sordida
Pycnonotus goiavier
Pycnonotus atriceps
Pycnonotus plumosus
Copsychus saularis
Macronous gularis
Orthotomus ruficeps
Orthotomus sericeus
Prinia flaviventris
Lonchura fuscans
Artamus leucorhynchus
Anthreptes malacensis

Mixed species flocks

Twenty-nine mixed-species flocks were observed and recorded (Tables 3.10a, b). Three different types of flocks occurred, with little or no species overlap between them: (1) canopy dwelling flocks with core species that include Green Iora, Blue-winged Leafbird, Black-winged Hemipus, Lesser Cuckoo-shrike and minivets (Chloropseid/Campephagid flock); (2) lower story dwelling flocks with Malacopteron and Stachyris babblers as core species (Timalid flocks); and (3) Woodpecker flocks. Members of mixed-species flocks almost always join flocks, unlike most other bird species, which forage alone. Finally, a few species seem to intermittently join flocks. Trogons and orioles are often seen following flocks for limited periods, while Drongos may accompany flocks for the possible purpose of stealing food resources discovered by flock members.

Table 21. Characteristics of mixed-species flocks observed in Malinau concession, Sept-Oct 1998.

Flock		Date	Time	Locality	Habitat	Height (m)
1		11-Sep	1530	RKT 98/99	forest edge	?
2		10-Sep	morning	plot 27	forest edge	?
3		10-Sep	1700	plot 27	forest edge	?
4		14-Sep	958	petak17	forest edge	?
5		15-Sep	1200	pet29/L1	forest	?
6		16-Sep	1520	pet29	forest edge	?
7		19-Sep	1200	RKT 97/98	forest edge	?
8		21-Sep	1020	C1-300	forest	?
9		21-Sep	1140	C1-850	forest	10
10		21-Sep	1242	C1-900	forest	?
11		21-Sep	1430	C1-1100	forest	?
12		24-Sep	1300	V2	forest	?
13		26-Sep	1330	C1	forest	4 to 8
14		29-Sep	1625	A1	forest	20
15		29-Sep	1630	A1	forest	4 to 8
16		2-Oct	927	C2	forest	4 to 7
17		5-Oct	1245	R1	forest	10 to 15
18		7-Oct	920	R1	forest	20
18a		7-Oct	1100	R1	forest	?
19		7-Oct	1630	R1	forest	20
20		7-Oct	1125	R1	forest	10 to 15
21		8-Oct	1428	RKT 98/98	forest edge	15-20
22		8-Oct	1615	RKT 98/99	forest edge	25
23		9-Oct	1310	RKT 98/99	forest edge	10 to 15
24		9-Oct	1445		forest edge	25 to 30
25		21-Oct	1450	plot 30/31	forest edge	15
26		22-Oct	1055	plot 29	forest	10 to 15
27		23-Oct	720	RKT 98/99	forest edge	15 to 25
28		25-Oct	1115	27	forest	1 to 3

Riverine birds

Eight of the eleven Bornean kingfishers were recorded in the Malinau study area. Among the six riverine kingfishers, habitat segregation appears related to body size:

1. Stork-billed Kingfisher (35 cm): large rivers
2. Black-capped Kingfisher (28 cm; migrant): large rivers
3. Blue-banded Kingfisher (20 cm): medium sized rivers and smaller, but ever-wet rivulets
4. Common Kingfisher (17 cm; migrant): large rivers, medium-sized ever-wet river
5. Blue-eared Kingfisher (16 cm): large rivers, medium-sized ever-wet rivers
6. Rufous-backed Kingfisher (14 cm): small forest streams, and small forest pools that often dry up after extended drought.

Table 22. Composition (number of individuals observed) of mixed-species flocks in the Malinau concession of the Bulungan Research Forest, Sept-Oct 1998

	Mixed Flock																												
Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Harpactes duvaucelii												1								1							1		
Sasia abnormis								1																					
Picus mentalis					3																								
Picus puniceus																							1						
Meiglyptes tukki					2				1																				
Dinopium rafflesii				2																									
Coracina fimbriata				1														5	1										
Hemipus hirundinaceus	1					1								2			3	1	1			2	1		2			3	
Tephrodornis gularis																		2											
Pericrocotus igneus						1													1										
Pericrocotus flammeus	3	1	3																					2				7	
Chloropsis sonnerati																								2					
Chloropsis cochinchinensis														2			2	2						1					
Chloropsis cyanopogon																		2					1					2	
Aegithina viridissima	1	1				1	3										1	3				5		3	3			2	
Pomatorhinus montanus				1																	1								
Trichastoma bicolor															1														
Malacopteron cinereum								4	3				1							2	2						1		1
Malacopteron magnum										2						5													
Stachyris maculata									4	6		6	1			6					5					1	1		
Stachyris erythroptera								2			2		2		1												1		
Macronous ptilosus										2																			
Alcippe pyrrhoptera											2																	2	
Phylloscopus borealis								1																					
Hypothymis azurea							1																						
Philentoma pyrrhopterum													1																1
Philentoma velatum																	1												
Terpsiphone paradisi								2				2																1	
Sitta frontalis	1		2				2											3				2	1						
Anthreptes singalensis																		1											
Anthreptes simplex																	1												
Dicrurus paradiseus				1				3	2	2			1							1			2			1	1		
Dicrurus aeneus									2			1																	
Platylophus galericulatus																					1								
N Individuals	6	2	5	5	5	3	6	13	12	12	4	10	6	4	2	11	8	19	3	4	9	9	6	8	5	2	5	17	2
N Species	4	2	2	4	2	3	3	6	5	4	2	4	5	2	2	2	5	8	3	3	4	3	5	4	2	2	5	6	2

Neither of the remaining two species present in the area, Banded and Rufous-collared Kingfisher, showed affinity to water.

Hornbills

Seven of the eight Bornean hornbills were recorded in the Malinau study area (Tables 3.11 – 3.13), with the Asian Black Hornbill (*Anthracoceros malayanus*), Rhinoceros Hornbill (*Buceros rhinoceros*), and Helmeted Hornbill (*B. vigil*) the most commonly observed species. Similarity coefficients (modified Morista-Horn index) for the number of hornbill groups recorded in the three study sites (transect data only) ranged from 0.77 – 0.96, with the CL and Control sites the most similar, and RIL and Control the least similar (Table 3.14).

Table 23. Number of hornbill groups recorded along the six transects.

Species	**Site**					
	Control		**RIL**		**Conventional**	
	transect 1	**transect 2**	**transect 1**	**transect 2**	**transect 1**	**transect 2**
Anorrhinus galeritus	1	2	–	2	–	1
Aceros comatus	–	–	–	–	–	0–1?
Anthracoceros malayanus	11–12?	5	6–7?	9	8	14
Medium–sized hornbills	12–13?	7	6–7?	11	8	15–16?
Aceros corrugatus	–	2	0–1?	–	–	–
Aceros undulatus	–	–	1	–	–	2–4?
Buceros rhinoceros	12–14?	2	–	2	5	7–8?
Buceros vigil	6–7?	1	1	–	3	9
Large hornbills	18–21?	5	2–3?	2	8	18–21?
All hornbills	30–34?	12	8–10?	13	16	33–37?

Birds of special interest

Thirty-eight species of special interest were observed in the Malinau area (Appendix 9). These include 28 globally threatened species (1 endangered; 6 vulnerable; 1 “data deficient”; and 21 near-threatened; Collar *et al*. 1994), nine Borneo endemics, and several species with new distribution records.

Local names

Appendix 10 provides bird names in two local languages, Punan Tubu and Merap. The Punan names are largely the same as those collected in the western portion of the Bulungan Research Forest (BRF; O’Brien 1998), and the present list serves as a refinement of the

former study. The Merap language is a very difficult language to pronounce (as admitted by the speakers themselves and members of other Dayak tribes), let alone to write (even phonetically). Therefore, the transcripts should be considered 'provisionary'.

Table 24. Number of hornbill groups per 100 hours and per 100 kilometres of survey effort in the three sites (combined transect data only).

Species	**Site**					
	Control		**RIL**		**Conventional**	
	/ 100 hrs	**/ 100 km**	**/ 100 hrs**	**/ 100 km**	**/ 100 hrs**	**/ 100 km**
Anorrhinus galeritus	11.5	17.3	3.6	7.7	2	4
Aceros comatus	–	–	–	–	0–2?	0–4?
Anthracoceros malayanus	61.2–65.1?	92.2–98?	27.3–29.1?	57.9–61.7?	43.8	88
Medium–sized hornbills	72.7–76.5?	109.5–115.3?	30.9–32.7?	65.6–69.5?	45.8–47.8?	92–96
Aceros corrugatus	7.7	11.5	0–1.8?	0–3.9?	–	–
Aceros undulatus	–	–	1.8	3.9	4–8?	8–16?
Buceros rhinoceros	53.6–61.2?	80.7–92.2?	3.6	7.7	23.9–25.9?	48–52?
Buceros vigil	26.8–30.6?	40.3–46.1?	1.8	3.9	23.9	48
Large hornbills	88–99.5?	132.6–149.9?	7.3–9.1?	15.4–19.3?	51.7–57.7?	104–116?
All hornbills	160.7–176?	242.1–265.1?	38.2–41.8?	81–88.8?	97.5–105.5?	195.9–211.9?
Actual survey effort	26.133 hrs	17350 m	54.967 hrs	25915 m	50.25 hrs	25010 m

Bird trade

Birds seen in tiny open-woven basket-cages during a single visit to Long Loreh are listed in Table 3.15. The two most common species were Hill Mynahs and Blue-crowned Hanging-parrots. The data indicate that, with the exception of mynahs and hanging parrots, birds are only incidentally kept as pets. The amount of commercial trade in birds was not quantified, however. Birds were observed in a bird market in Balikpapan (Table 3.16) where many exotic species are offered for sale. Approximately 60% of species offered were from the island of Borneo, including the very endangered straw-headed bulbul.

Table 25. Relative abundances (proportions) of hornbills (number of groups) in the three sites (transect data only, minimum numbers).

Species	Site					
	Control		RIL		Conventional	
	Actual count	Relative abundance	Actual count	Relative abundance	Actual count	Relative abundance
Anorrhinus galeritus	3	0.07	2	0.1	1	0.02
Aceros comatus	0	0	0	0	0	0
Anthracoceros malayanus	16	0.38	15	0.71	22	0.45
Aceros corrugatus	2	0.05	0	0	0	0
Aceros undulatus	0	0	1	0.05	2	0.04
Buceros rhinoceros	14	0.33	2	0.1	12	0.24
Buceros vigil	7	0.17	1	0.05	12	0.24
Total	**42**	**1**	**21**	**1.01**	**49**	**0.99**

Table 26. Similarity coefficients (modified Morista-Horn index) for number of hornbills (groups) recorded in the three sites (transects data only, minimum numbers).

	Control	RIL	Conventional
Control	–	0.773	0.9591
RIL	–	–	0.8396
Conventional	–	–	–

Note: the modified Morista-Horn index is calculated from the equation in Table 2.9.

Table 27. Caged birds observed in Long Loreh on 23 September, 1998.

Species	Individuals
Rollulus rouloul	1
Chalcophaps indica	2
Anthracoceros malayanus	1
Loriculus galgulus	18
Phodilus badius	1
Pycnonotus plumosus	1
Copsychus saularis	2
Copsychus malabaricus	1
Gracula religiosa	19

Hunting parties of local villagers were often seen roaming the forest and snares to catch deer, pheasants, and other animals were often encountered in the forest. These parties are likely also capturing birds for pets as attested by the number of Hill Mynahs and Blue-crowned Hanging-parrots held captive in a local village (Table 3.15). Although both species were relatively common in the forest, another extremely popular songbird (Straw-headed Bulbul)

appears to be locally extinct, as it is in many other parts of it's world range (van Balen 1997). No individuals of this species were seen or heard during our survey, and no birds were held in cages in the local villages. Inhutani personnel were also involved in the capture and trade of birds. An Inhutani employee who had his house in Long Loreh showed us his Crested Partridge and Crested Fireback, and told us that he had caught a dozen of each during the past year.

Table 28. Birds seen in the Balikpapan bird market (at Kebun Sayur) on 6 September 1998.

Species	**Individuals**
Treron vernans	2
Streptopelia chinensis	several
**Macropygia cf unchall*	1
Macropygia emiliana	1
Geopelia striata	several
Psittacula longicauda	2
Loriculus galgulus	5-6
***Eudynamys cf melanorhyncha*	1
Pycnonotus goiavier	2
Pycnonotus zeylanicus	15-20
Pycnonotus aurigaster	5-6
**Pycnonotus melanicterus*	1 (Javan race)
Chloropsis spp	several
Copsychus saularis	several
Copsychus malabaricus	abundant
**Zoothera sibirica*	1
**Prinia familiaris*	1
**Sturnus contra*	several
Sturnus philippensis	1
**Sturnus melanopterus*	1
* ***Acridotheres javanicus*	several
Gracula religiosa	several
**Ploceus* spec	1

Species with no records from Kalimantan, and most likely from other Indonesian islands: * Java, ** Sulawesi. Furthermore, budgerigars, canaries and Indochinese laughing-thrushes were offered for sale.

DISCUSSION

Study design

Completeness of survey

Considering the narrow altitudinal range of the survey area, and the small number of absent but expected species (see below), it is felt that the inventory has been sufficiently thorough. Many of the "expected" species have concealed behavior (e.g., partridges and night birds), and their detection is only expected with increased effort in nocturnal surveys and sampling

during other seasons of the year. Many of the sub-montane (28 spp) or extreme lowland (10 spp) species not found during the survey period may have been in very low numbers given the study area represented the margin of their distributional range. The detection of these species may occur in the future after more time is spent in the field.

Expected species not observed or in very small numbers

A number of lowland forest species were strikingly rare, or completely absent from the survey area, even though suitable habitat seemed to be present (Table 3.7). Some of the cuckoos appear to be seasonal in calling, such as Oriental (*Cuculus micropterus*)(Collard & Long 1996), which was only heard during the final weeks of the survey period. The Hook-billed Bulbul (*Setornis criniger*) was searched for in vain in the swampy habitat areas of the study site, and though not particularly common in Borneo, it was expected in the area. No Straw-headed Bulbuls (*Pycnonotus zeylanicus*) were recorded. Excessive capturing for the pet trade is very likely the cause, as local people have reported that it used to be common in the area. Grey-headed Flycatchers (*Culicicapa ceylonensis*) and the Spotted Fantail (*Rhipidura perlata*) were not observed, and both these "slope specialist" (contra Wells 1985) may be more common in the uphill areas west of BRF.

Finally, most sunbirds and flowerpeckers forage in the canopy of tall trees, making detection during the VCP and FDS surveys difficult. Not all of these species possess distinct calls, and many "chweet" and "tick"s were identified simply as "sunbirds" or *Dicaeum* spp. Most conclusive records of these groups have come from along forest edges during road counts.

Suitability of treatment blocks for logging-effect studies

The plots and transects are relatively uniform, containing similar percentages of the BRF (*stricto sensu*) species. Species occurring in only one or two of the three treatment areas tended to be rare species that occurred at low frequencies where they were observed. Finally, species diversity, evenness and richness were all relatively similar, suggesting samples taken from similarly structured bird communities.

Methods used in the survey

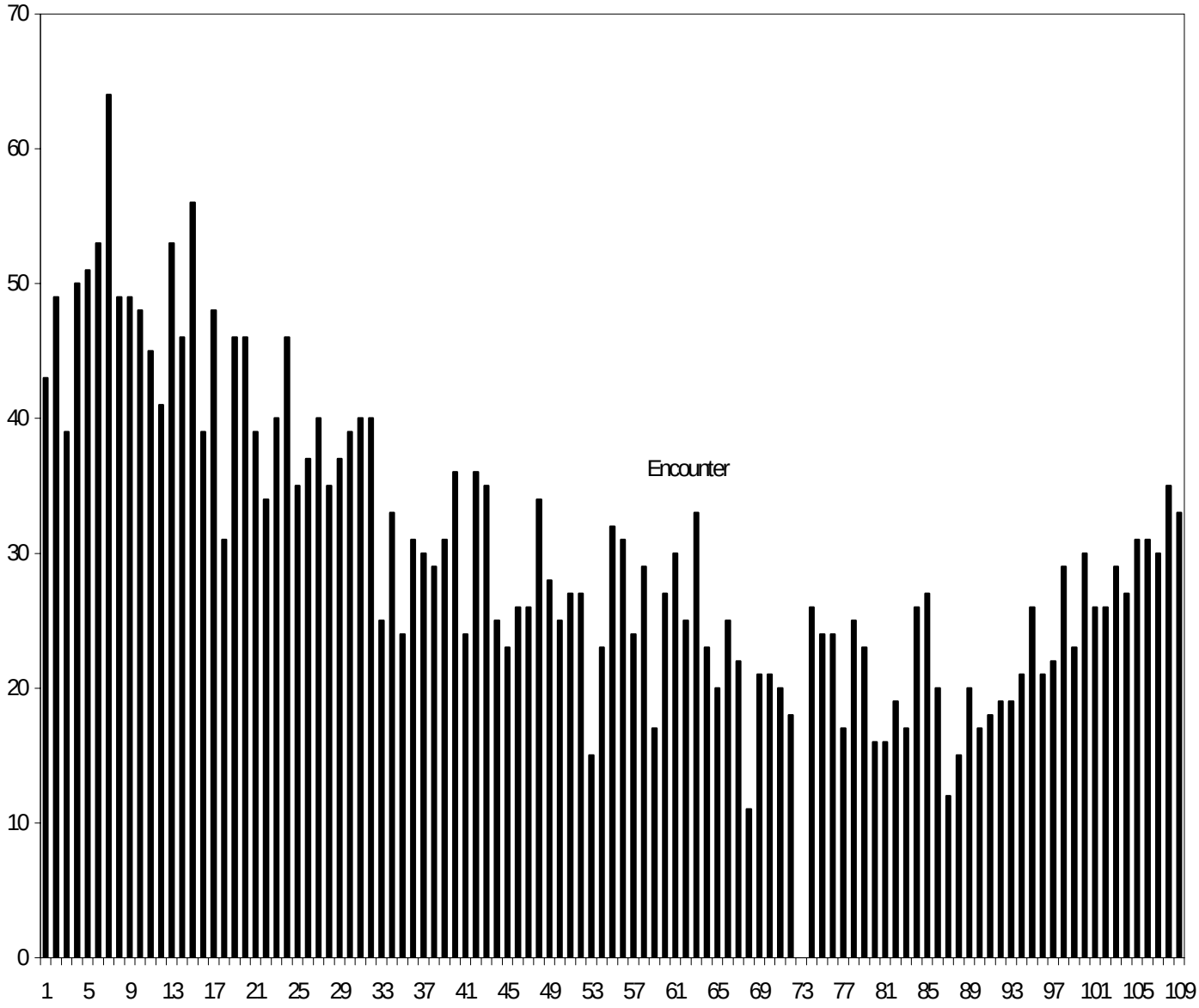
The efficiency and reliability of VCP's and other census techniques in the tropics are under much debate. The optimum size of sample plots is difficult to determine, as very little is known about the territory sizes of tropical birds. While most rain forest bird species are considered to be sedentary, banding studies (e.g., McClure 1974) have shown wide ranges for some species (e.g., Hairy-backed Bulbuls have been found to travel over 5 km in one day). To include adequate pairs of the smaller insectivores, plots of 100 ha are needed (Terborgh 1985). Even more complicated is the censusing of frugivorivorous birds. Lambert (1989) measured the home ranges of three frugivorous species (a barbet, a broadbill and a bulbul), and found weekly ranges of up to 50 ha.

The FDS surveys provided us with data on the utilization of the permanent plots by a wide array of species. In Figure 3.3 the encounter rates (for all species together) during the FDS sessions, from the morning to the late afternoon, are illustrated. Counts during the first half of the morning gave the most encounters, and are clearly the most efficient time for recording most species in the plots. However, further analysis of the encounter rates per species will

enable us to estimate the 'chance' of encountering a particular species. The use of FDS seems adequate to cover most species present in the blocks, though the asymptote shapes of Figures 3.1 and 3.2 (with a potential ceiling of 180 ± species), suggests that nearly twice as many FDS's or VCPs will be necessary to encounter all species in the area.

The higher species diversity values (*H'*) found along the logging roads as compared to the unlogged forest transects is not surprising considering the ecotonic character of the tracts and clear view of canopy trees. Surprising is the high evenness value, which would be a feature of undisturbed systems, but this may an artifact of the limited standardization and rather opportunistic nature of the road counts. Nevertheless, these combined methodologies suggest that selectively logged forest may contain most of the lowland forest avifauna, at least in the near-term, and perhaps even in reasonably well-structured communities.

Figure 7. Encounter rates (contacts/5 minute interval) for FDS plots totaled for all permanent plots between 6.00-17.00 hrs, Malinau concession, Sept-Oct 1998.



A final consideration related to the survey design concerns the observer and the conspicuousness of that individual to birds. Some birds are attracted to observers, like the highly mobile Hairy-backed Bulbul (*Hypsipetes criniger*), which may follow observers over some distances. In contrast, bulbuls such as the Grey-cheeked Bulbul (*Criniger bres*) are very wary of humans and always shun their presence . Also regional differences are possible, as found with the pheasants, which were quite trusting in our study area, but extremely wary in areas where hunting has a longer history.

The above factors should be recognized as influencing bird surveys. The methods used in this study represent 'state of the art' techniques, and until better methodologies can be developed, these factors will remain a part of survey results in the Malinau concession.

Bird community

Lowland specialists

Wells (1985) published a long list of specialized lowland forest birds. Among these, the extreme lowland specialist deserve special attention, as their narrow distribution ranges make them vulnerable to habitat fragmentation. Seventeen of these specialists were not found in the survey. Perhaps as important as lowland forest specialists are for indicating high quality habitat, so are secondary-growth generalist species for indicating degraded habitat. Hagan *et al*. (1996) pointed to the high densities of birds in newly formed fragments after fragmentation; an effect that disappears over time (depends upon the sensitivity of the species involved, duration and rate of habitat loss and fragmentation, proximity of forest stand to the disturbance, etc.). In the Malinau survey, logging occurred in the immediate vicinity of our

Table 29. Logging-intolerant bird species found in the Malinau concession of the BRF.

Species	Reference	Species	Reference
Argusianus argus	L92	**Pericrocotus igneus*	J86
Treron capellei	L92	*Criniger bres*	L92
Ducula aenea	L92	*Malacopteron affine*	J86
Otus rufescens	J86, J89	*Stachyris poliocephala*	J86
**Hirundapus giganteus*	J86	*Kenopia striata*	L92
Harpactes kasumba	J86	*Napothera atrigularis*	L92
Ceyx erithacus	J86	*Ptilocichla leucogrammica*	L92
Lacedo pulchella	J86, L92	*Alcippe brunneicauda*	L92
Actenoides concretus	J86, J89	**Macronous ptilosus*	J86
Megalaima chrysopogon	L92	*Copsychus pyrropygus*	J86
Indicator archipelagicus	L92	*Enicurus leschenaulti*	J86, J89
Sasia abnormis	J86	*Rhipidura perlata*	J86
Calyptomena viridis	L92	**Dicaeum concolor*	J86
**Hemipus hirundinaceus*	J86	*Platysmurus leucopterus*	L92

data after J86, J89: Johns (1986, 1989); L92: Lambert (1992)
* Species in Malinau concession that are also found in secondary habitat

research plots, and may have distorted our findings. If during this post-logging recovery process the population of these species begin to approach pre-logging levels (e.g., Magpie Robin declines to low numbers, see Wong 1985), some or all other these species may serve as 'indictors' that closed-forest habitat conditions are being recreated.

Johns (1984, 1989) found that understory flycatchers and terrestrial litter-gleaning species are especially sensitive to logging, while Lambert (1992) showed that taxa such as flycatchers, woodpeckers, trogons and wren-babblers become rare after logging (Table 3.17). This agrees with our findings, where in an area that had been logged up to six years ago, wren-babblers and some flycatchers had yet to return. No such effect was seen for woodpeckers or trogons however, but surveys of logged areas have not been very thorough or systematic.

Mixed flocks

Why birds forage in mixed flocks, and the composition of these flocks, is poorly understood. The disruption by logging of continuous habitat elements may have deleterious effects on the mobility of these flocks, and the local survival of species that depend on undisturbed flock foraging. (An exception however are the canopy feeding flocks, which tend to relatively insensitive to fragmentation as these flocks are regularly seen crossing gaps). During the present survey the number of observed mixed species foraging flocks was rather low, due to the fact that data collecting was rather opportunistic, and done as a secondary activity to the bird censuses. Consequently, species and individual numbers per flock are also low as compared to other flock-specific studies in Borneo (e.g., Croxall 1976; Laman 1992). Nonetheless, several interesting observations are worth noting: First, the occurrence of the Campephagid/Chloropseid flocks that normally operate high up in the canopy were frequently observed during the present survey. This would suggest their adaptability to the logging-disturbed forest landscape in Malinau. Second, noisy bird flocks often develop spontaneously after the detection of a predator, especially snakes, roosting owls and small predators. The tumult that is made by such a party rapidly attracts a large number of species that otherwise never join flocks (such as most bulbuls, spiderhunters, and many flycatchers). The point is that observer disturbance, or nearby logging activities, may have caused spontaneous flocks to form that do not represent any 'permanent' ecological group. Much work needs to be done before mixed flocks can serve as indicators of habitat change.

Riverine birds

Birds specialized in foraging along waterways are likely to suffer from the habitat disturbance resulting from logging. This group includes a number of species of kingfishers, two forktails, a jungle babbler (White-chested Babbler) and a flycatcher (Malaysian Blue Flycatcher). The hydrological balance in a forest can be severely disturbed by logging, leading to the drying-up of small streams, increased turbidity of the water, and disappearance of sheltering river bank vegetation (cf Tyler & Ormerod 1993). These changes are very likely to have a negative impact on birds dependent on small streams and riverine habitat. Our (very) preliminary results do not show a decrease yet for any of the kingfishers and forktails, but the riverine forest specialist Malaysian Blue Flycatcher showed decreasing numbers in logged forest. The effects of logging on other birds in this group may be felt in the long-term, particularly if conditions prove to remain unfavorable for breeding.

The smaller the kingfisher, the smaller scaled its preferred habitat, with the exception of Blue-banded Kingfisher. Two pairs, Stork-billed/Black-capped and Common/Blue-eared, may compete for perches and feeding grounds along the rivers during the northern winter; for the latter at least, this has been suggested by observations made on Java (van Balen & van Balen 1993). Resource partitioning related to body size has been shown for Sulawesi kingfishers (Sunarto *et al*. in press) and the present findings in Malinau may suggest a similar pattern. What consequences these interactions will have on survival chances for the birds after logging is unknown.

Hunting and trade

The capturing and keeping of birds seemed to concentrate on Hill Mynahs and Blue-crowned Hanging-parrots, as other species were seen only in small numbers. The small number of White-rumped Shamas was rather surprising as these are popular in other areas, but this may be due to the poor cage conditions in the study area (small cages, inferior food, etc.), leading to high mortality of these captured birds.

Only in the bird market in Balikpapan were Straw-headed bulbuls still in some numbers, indicating the existence of some hinterland populations of this otherwise largely extirpated bird, once so abundant throughout its range.

The capturing of birds in the BFR is believed to have already interfered with the field study in a least one case, the Straw-headed Bulbul. Other much hunted birds such as the Crested Fireback, Great Argus and Crested Partridge appear to still be common, but considerable, and most likely unsustainable, numbers are being extracted in particular from the logging-accessible parts of the forest (B. Balen, personal observation).

PROBLEMS AND RECOMMENDATIONS

During our eight weeks fieldwork no insuperable problems were encountered, but quite a few minor problems hampered our working efficiency. These problems, and their potential solutions included:

- Sampling schemes are very sensitive to weather conditions (floods, rain) that cause both logistical problems, and interfere with the detection of birds.
  Solution: Future bird surveys should be planned in the dry season (May – August).

- Permanent plots were established and sampled in conjunction with fauna surveys (not before as originally planned), leading to a) vegetation crews disturbing the habitat during bird survey periods, and b) making it difficult for bird survey crew to locate plots for the FDS surveys.
  Solution: The problem was being solved during the survey, but could arise again after logging has taken place. Vegetation work should be completed prior to scheduled fauna surveys.

- The access trails to the permanent plots are adequately flagged for daylight conditions (in a multitude of colors), but nocturnal surveys are often impossible because of poor visibility.
  Solution: Fluorescent plastic flags may be an option. To minimize confusion different crews should have specific colors of flagging, and old tapes should be removed as soon as they have no clear function anymore. Something has to be done against the damaging of tapes by ants.

- The Sungai Sidi base camp was located much too far from the plots and transects. The jungle camp at the Seturan River should be made more permanent. Canoes for emergencies, when the logging roads are not accessible, should be provided. Smaller camps or shelters might be set up near the different permanent plots to make nocturnal surveys of mammals and birds possible. The Sungai Sidi base camp should be made more suitable as a research station, for instance with a special computer room / library and solar energy source (the generator was unreliable and very noisy).

- Ridges have been intensively used by the vegetation and entomology teams to get from one plot to another. Ridges are also popular with Argus pheasants and four to five dancing ground were found along our ten transects (which did not normally follow ridge lines).
  Solution: Argus dancing grounds should be mapped and alternative routes designed for research teams in the future.

- Bird surveys often took place the day after other survey crews used that same area (some quiet, others noisy and disturbing), with unknown effect on the birds.
  Solution: The concurrence of teams of different disciplines should be avoided. For the vertebrate studies there should be as little disturbance in the area as possible, weeks before and during the data collecting.

- Coordination between the base camp, Inhutani management, our drivers etc. was difficult at most times.
  Solution: Portable radios should be provided (this would also add a safety element to the study).

- Terrain can be very wet, especially during the wetter parts of the year, and long exposure to water caused some researchers to develop foot infections (*kutu air*).
  Solution: Rubber boots should be used if longer periods are spent in the field.

- Malaria is rampant in the area (three or four people had to be evacuated because of malarial symptoms during the two months we were in the field).
  Solution: Mosquito nets should be brought along and used especially in the base camp.

- Hunting of deer, pigs, fowl etc. took place throughout the area, and undoubtedly interfered with our studies.
  Solution: Adequate protection of the forest and wildlife, which may require education programs for the Inhutani staff.

Future studies

There are a number of activities that might be undertaken in future studies in the Malinau concession to help clarify the effect of logging on bird communities. These include:

1. Foraging heights

Logging may have an impact on the foraging heights of birds. This disruption may influence survival chances of the birds concerned. Bird observations should be correlated with foraging height to the extent possible.

2. Mixed flocks
Mixed flock data should be collected in a more standardized way along the transects. These efforts should help to clarify the response of different flock types (canopy feeders, understory) to habitat fragmentation and degradation.

3. Mist netting
If carried out over long periods, mist netting will provide data on turnover rates, breeding activity, recruitment, site fidelity, longevity, and in combination with the use of color bands, it will facilitate long-term studies on brood parasitism, home ranges, mixed species flocks etc.). Main problems with mist netting are the needed expertise, long periods required to collect adequate samples, and the need for additional trained field assistants.

4. Case studies
Birds associated with waterways (kingfishers, forktails) deserve special attention and close monitoring, as their habitat is likely to be impacted by logging.

5. Further analysis of present survey's data
The VCP data have not been fully analyzed, and information is needed on the densities of species along the transects. Also, the classification of bird community into functional groups can be done with the present data.

Adjustments to current survey techniques

Variable Circular Plots: the stratified sampling regime should stay the same; for the data analysis the information from the FDSs regarding activity patterns should be used to calibrate density values.

Full Day Samples: sessions should be divided up (with more breaks), and start earlier in the morning and extend longer into the evening in order to cover night birds.

Road Counts: these should be standardized and related to habitat parameters.

SECTION 4. INVERTEBRATES

Prepared by Jaboury Ghazoul, Purnama Hidayat, Katharine Liston, and Erwin Widodo

METHODS

Study area

Research was undertaken within two-100 ha forest coupes identified for future conventional (CL) or reduced-impact (RIL) logging treatments (late 1998 / early 1999). In each coupe, nine permanent 1-ha vegetation plots representing three replicates of high, moderate and low extraction levels had been established by CIFOR, together with an additional three 1-ha control plots (see section 2 of this report, and CIFOR data, for detailed descriptions of the study area). A third forest site was identified as a control (CS). All work described below was conducted in these 1-ha plots within the CL and RIL sites, and four comparable sized plots in the CS, except: (1) leaf decomposition studies (which were limited by the available number of leaf bags), and (2) butterfly transects (which were undertaken over scales larger than 1-ha). The invertebrate groups and ecological processes monitored in this study, together with the assessment techniques used, are listed in Table 4.1.

Table 30. A list of processes and invertebrate groups monitored in the Malinau study, September 1998.

Category	Technique	Responsibility
Processes		
Leaf decomposition	Litter Bags	JG and KL
Leaf herbivory	Quantified observation	JG and KL
Invertebrate Groups		
Butterflies	Transects	JG
Leaf Litter	Winkler Traps	JG, EW and KL
Ants	Transects	EW
Ground Fauna	Pitfall Traps	PH
Folivorous invertebrates	Sweep Netting	PH
Nocturnal invertebrates	Light Trap	PH

Where: JG = Jaboury Ghazoul, KL = Katharine Liston, EW = Erwin Widodo, and PH = Purnama Hidayat

Processes

Leaf decomposition

Decomposition rate was assessed at the CL and RIL sites only. Assessment was made by measuring weight loss over several weeks of leaves placed within mesh bags placed on the forest floor. Two different mesh sizes were used: fine (1.5mm mesh) and coarse (3mm mesh) to exclude meso- and macro-invertebrates respectively. One bag of each mesh size was placed at 15 locations within each forest compartment. Freshly fallen green leaves were collected at random in the vicinity of where the bags were placed. Leaves were discarded if less than 50% green color remained. Leaves were randomly sampled and placed into one fine and one coarse mesh bag such that each bag contained between 70-80g of leaf material. The bags were weighed to the nearest 0.1g using a Pocket Prog 250-B field balance (Acculab) and placed on the forest floor. After 50 days the bags were collected and the leaves were air-dried and weighed.

Leaf herbivory

In each of the permanent vegetation plots established by CIFOR scientists, and at four sites in the control block, herbivore damage by invertebrates on seedlings was assessed by scoring leaf damage on a scale of 0-3 on ten leaves on each of 60 randomly chosen saplings. Saplings of all dicotyledon species were used for the herbivory assessment provided they had more than ten leaves and were less than one meter in height. Leaves of intermediate age (i.e. not the youngest or the oldest leaves, determined by their position on the sapling) were scored as:

0 undamaged
1 up to 1/3 leaf damage
2 1/3 to 2/3 leaf damage
3 more than 2/3 leaf damage

The scores for all ten leaves on each plant were summed, and herbivory across plots were compared using parametric statistics on the summed data.

Invertebrate groups

Butterfly transects

A reference collection of forest butterflies was made by collecting from a variety of forest locations in the CL and RIL areas of the study. Species were identified using Fleming (1983), which covers the butterflies of West Malaysia, but also includes many butterflies occurring in Borneo. Using photographs of the specimens, the identity of the butterfly species were checked by J. Ghazoul using ‘Butterflies of Borneo’ by T. Otsuka, and with comparison to collections at the Natural History Museum, London.

Twelve butterfly transects were conducted along ridgetops, and 12 in valley bottoms, in the CL and RIL compartments. Transects were 200 m long and lasted 30 minutes, during which time all the butterflies seen by two observers were recorded and identified to species (where possible). Hesperiid and Lycenid butterflies, which are difficult to identify in the field, were identified only to the family category.

Leaf litter invertebrates

Winkler bags were used to extract leaf litter invertebrates from litter collected from a one m^2 area of forest floor in each permanent vegetation plot of the CL, RIL and CS forest sites (28 sample locations). Within each plot leaf litter was collected from four randomly located 50 x 50 cm quadrats. The litter was passed through a coarse filter (7mm mesh size) and leaf litter retained by the filter was placed in envelopes for air-drying after checking for invertebrates too large to pass through the filter. These were placed in vials of alcohol. The remaining litter debris was loaded into Winkler funnel traps and allowed to dry, causing the invertebrates to fall to the bottom of the funnel where they were collected in alcohol. Each litter debris sample was allowed to dry in Winkler traps for four days. The litter debris was then sifted by hand for any remaining invertebrates and then allowed to air dry completely. The air-dried leaf litter and litter debris from each sample were weighed. Invertebrates collected from the leaf litter were sorted to morphologically similar species groups (morphospecies) and the data analyzed in conjunction with the ant transects, pitfall traps, and vegetation sweeps.

Ant transects

Ant collections were undertaken in all vegetation plots (12 CL, 12 RIL, and 4 CS). Ants were collected by digging through the soil and down coarse woody debris along a transect that was 10 m long and 2 m wide. Each transect took approximately 50 minutes to complete, and a single transect was conducted at each site. Ants were also collected from areas within each plot that appeared to be suitable for ant nests. All specimens were preserved in 70% ethanol. Ants collected by other methods (pitfall traps, sweeping and Winkler traps) were also collected, and a list of ant species from a broad spectrum of understory habitats compiled.

Pitfall Traps

Pitfall traps were used to sample ground-dwelling invertebrates, particularly large arthropods. The pitfall traps were installed in 12 plots of the conventional logging (blocks 28 and 29), 12 plots of the reduced impact logging (block 27) and 4 plots of the control (block 31). Close to the center of every plot, four traps were placed 10-15 m apart along a line running in a north-south direction. Each trap consisted of a plastic cup with a 7 cm diameter and 10 cm depth. The cup was sunk into the ground so that its rim was flush with the soil surface. It was filled with detergent water to a depth of 2 cm. Arthropods were collected two and four days later. When collecting samples, further detergent water was added if necessary. Arthropods were preserved 70% alcohol.

Sweeping

Arthropods on understory plants were sampled by sweep netting vegetation less than one meter in height. Sweeping was done in all the plots in the CL, RIL and CS sites. Eighty sweeps were done in the center of plot along two transect lines. The sweep net had a diameter of 40 cm. Arthropods collected by sweeping were killed in a cyanide killing jar and preserved in 70% alcohol. Identification was done in the Laboratory of Pest Insect Taxonomy, Bogor Agricultural University and Museum of Zoology, LIPI, through family, genus, or species if possible, using their reference specimen collection and identification books.

Identification

Unless noted otherwise, invertebrate identification was done in the Laboratory of Pest Insect Taxonomy, Bogor Agricultural University and Museum of Zoology, LIPI, to family or genus if possible using their reference specimen collection and identification books.

Statistical analysis

Data were analyzed using simple statistical analysis as suggested by Ellison (1993), including t-tests and ANOVA. Calculation of diversity indices and species abundances follow methods described in Magurran (1988).

For diversity, Simpson's index was employed. The equation is:

$$D = \Sigma \frac{(n_i(n_i - 1))}{(N(N-1))}$$

where n_i = the number of individuals in the *i* th species, and N = the total number of individuals.

Similarity measures were determined using the Jaccard and Sorenson measures.

The Jaccard's equation is: $Cj = j / (A + B - j)$
where j = the number of species common to both sites
A = the number of species in site a
B = the number of species in site b

The Sorenson's equation is: $Cs = 2j / (A + B)$
where j = the number of species common to both sites
A = the number of species in site a
B = the number of species in site b

RESULTS AND DISCUSSION

The primary objective of this survey was to compare the pre-harvest invertebrate community in select cutting compartments scheduled for treatment in the next 12 months. Leaf herbivory and decomposition were assessed as these are key aspects of the nutrient cycling process and are amenable to simple quantification. Herbivory of saplings by invertebrates is of further relevance in assessing the regeneration of forest tree communities. An additional advantage of using these processes in a comparative assessment exercise is that they are likely to have minimal seasonal or temporal variation, and are not dependent upon seasonal events such as other processes relating to tree regeneration (e.g. pollination and seed-predation).

Invertebrate communities in the leaf litter and the understory were sampled on the assumption that these are primarily responsible for the processes under observation. Larger ground invertebrates, many of which have important roles as shredders of leaf and woody material, were also sampled. Butterflies and ants were monitored as indicator groups for forest biodiversity.

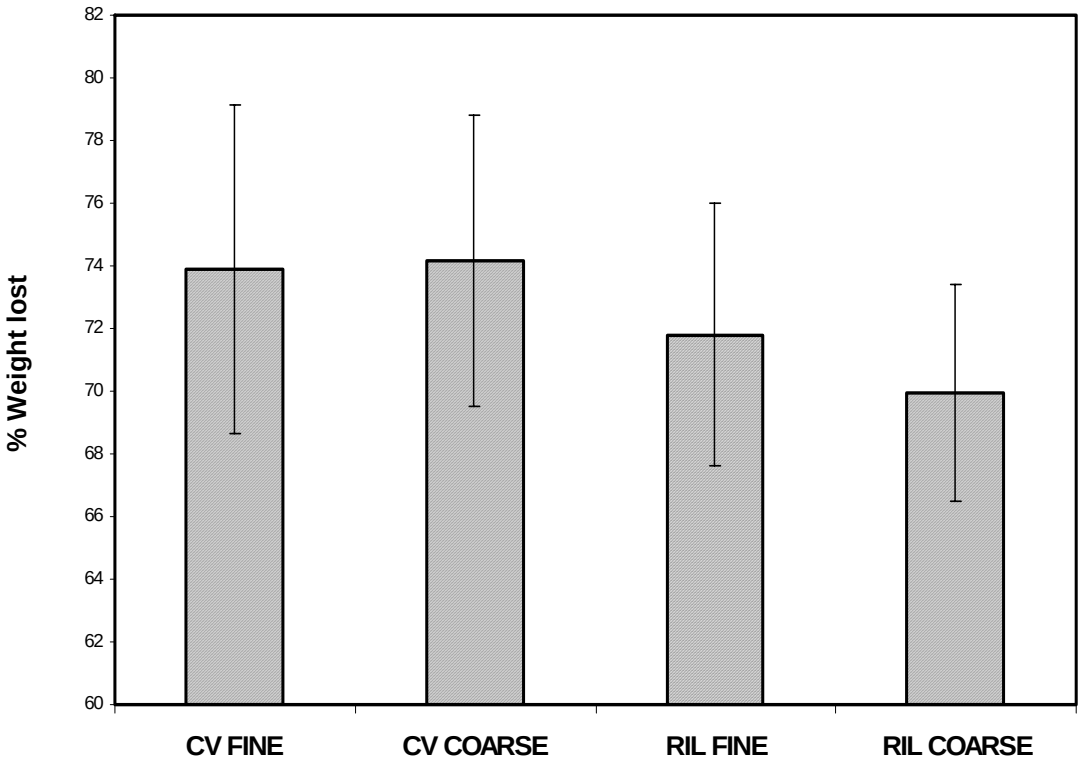
Processes

Leaf Decomposition

No meaningful changes in the wet-weight of leaf litter bags were obtained 10 and 20 days after the start of the experiment, owing to gains in weight as a result of waterlogging in the field. One CL coarse bag was not recovered from the field. The following analysis relies on the air dried weights obtained after a 50 day exposure period.

Leaf litter decomposition was recorded as the percentage of the original leaf weight lost (Figure 4.1), with high values indicating high weight loss. Mean values for site and mesh size combinations ranged from 69 to 74%. Decomposition rates in the RIL site were lower than the CL site ($t = 2.76$, d.f. = 57, $p = 0.008$) due to results obtained from coarse litter bags (post hoc t-test: $t = 2.47$, d.f. = 13, $p = 0.028$; no significant differences in the fine leaf litter bags across sites). This result may be related to soil moisture content which was higher in CL compared to RIL. Dry soils inhibit the activity of many small invertebrates and fungal growth, both of which are important elements of the decomposer community.

Figure 8. Weight loss of leaves as a proportion of original weight.



Despite local site differences, the decomposition bag experiment provides information that may be used to define a relatively narrow range of values (69-74%) to form a baseline against which to measure decomposition rates following logging treatments. Alternatively, the mean and standard variation (72.4+/-4.7%) of the four combinations of site and mesh size might be used as a single baseline value. Such a value incorporates (in its standard deviation) local site differences, and any results following logging treatments that deviate significantly from the baseline are unlikely to be due to variations in local site conditions.

Leaf herbivory

Herbivore damage to seedlings among one hectare plots was very patchy ($F_{(1, 23)} = 2.62$, $p < 0.001$; minimum 4.7 to maximum 9.3), but no difference across compartments were observed ($F_{(1, 22)} = 0.058$, n.s., Table 4.2). In the Malinau concession the topographical and micro-climatic variation, over a scale of tens of meters, may account for the apparent patchiness of herbivore impacts on seedlings. However, further analysis comparing plots located on ridge-tops with those on valley bottoms revealed no difference in seedling herbivory ($F_{(2, 20)} = 0.453$, n.s.; Table 4.2). Despite high patchiness of herbivory these data provide baseline values against which future comparisons may be made.

Table 31. Herbivory scores for CL and RIL sites in the Malinau concession of the Bulungan Research Forest, September 1998.

Site	**N**	**Herbivory Score** (mean +/- se)
CL	11	6.3 +/- 0.3
RIL	12	6.2 +/- 0.2
Ridgetop	11	6.4 +/- 0.3
Valley bottom	7	6.0 +/- 0.3
Slope	5	6.2 +/- 0.3

Invertebrate groups

Butterflies

A total of 63 butterfly species (excluding Lyceneidae and Hesperiidae) were recorded in the Malinau forest from 10 to 29 September (Appendix 11). This is equivalent to species numbers recorded for a similar length of time at other tropical forest sites in SE Asia (Vietnam, 64 species, Spitzer *et al.* 1997; Sumba, Indonesia, 50 species, Hamer *et al.* 1997; Buru, Indonesia, 41 species, Hill *et al.* 1995) and elsewhere (Brazil, 46 species, Pinheiro and Ortiz 1992). Some of the recorded species are unlikely to be normally associated with forest habitat, but rather with open and disturbed areas such as the nearby logging roads and adjacent logged areas. Consequently, only 45 species were recorded along timed transects through the forest. Randomized accumulation curves, used to estimate the total butterfly species richness in the forest habitats (EstimateS, Colwell 1994), predict a total species richness of 59.8 +/- 3.7, implying the presence of 15 rare species that were unrecorded.

Butterfly species richness and abundance differed across sites and across topographical features within sites (Table 4.3). Butterflies had greater abundance (Figure 4.2) and richness (Figure 4.3) in the RIL site compared to the CL site. Butterfly diversity was also higher in the RIL coupe compared to the CL coupe (alpha-diversity statistic, Table 4.3), which might be attributed to the differences in soil moisture and overlying vegetation types between the two sites, particularly in valley bottom areas. The abundance (Figure 4.4) and species richness (Figure 4.5) of butterflies along ridge tops was greater than along valley bottoms, but there was no difference in diversity (Table 4.3). Predicted richness using randomized accumulation curves estimate significantly higher richness in the RIL site and along ridgetops.

Table 32. Diversity and richness of butterflies in the Malinau concession of the BRF, September 1998.

Site	**Transects**	**Species**	**Abundance**	**Jack1 +/- SD**	**Alpha +/- SD**
RIL	24	34	180	46.5 +/- 3.7	12.4 +/- 1.5
CL	25	28	161	39.5 +/- 3.4	9.8 +/- 1.3
Ridge	24	31	229	40.6 +/- 3.6	9.7 +/- 1.1
Valley	23	25	104	33.6 +/- 2.7	10.4 +/- 1.6
Forest*	67	45	388	59.8 +/- 3.7	3.2 +/- 1.2

* includes transects conducted in Control site.

It should be noted that the information obtained on butterflies at this study is from a very restricted sampling period. The randomized accumulation curve in Figure 4.6 for all 67 transects predicts a richness of about 60 butterflies from forest during the month of September, but total butterfly richness across the year is probably much higher. There is likely to be some seasonality in the abundance and richness of butterflies through the year, and it is therefore important to ensure that subsequent surveys be carried out at the same time of year.

Figure 9. Cumulative butterfly abundance at CL and RIL sites.

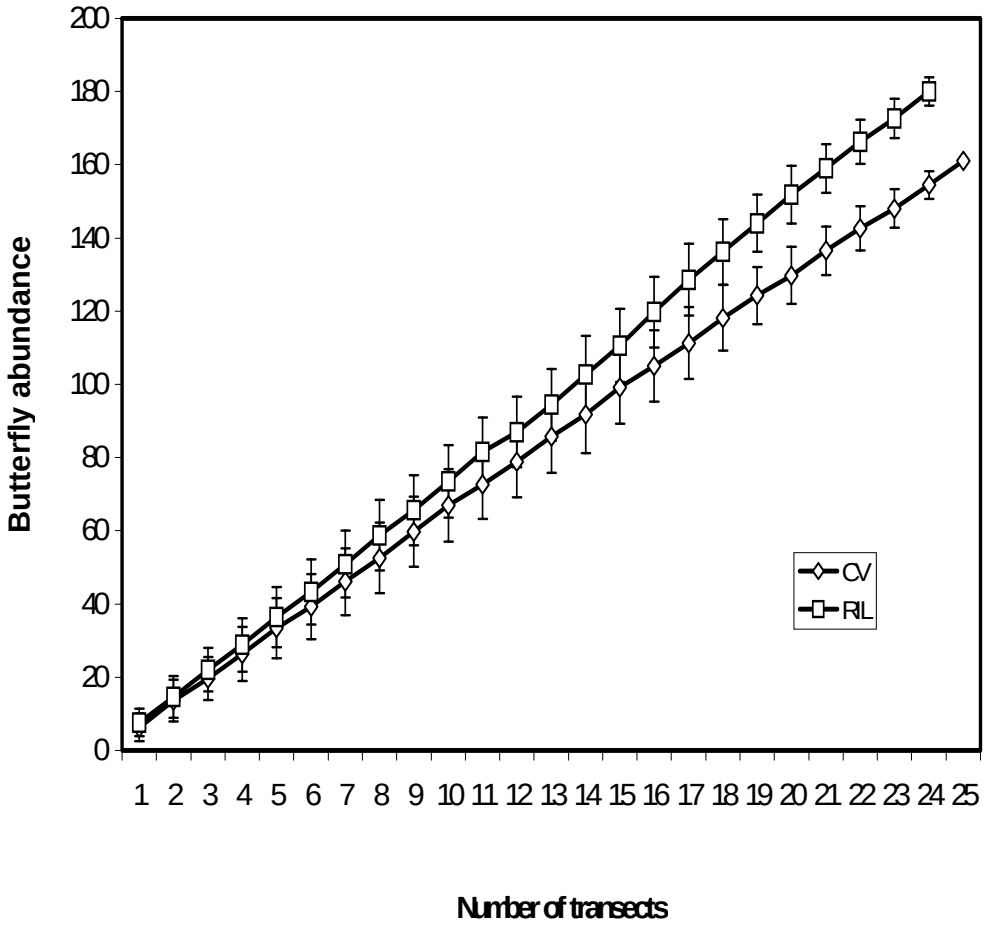


Figure 10. Cumulative species richness of butterflies from CL and RIL sites.

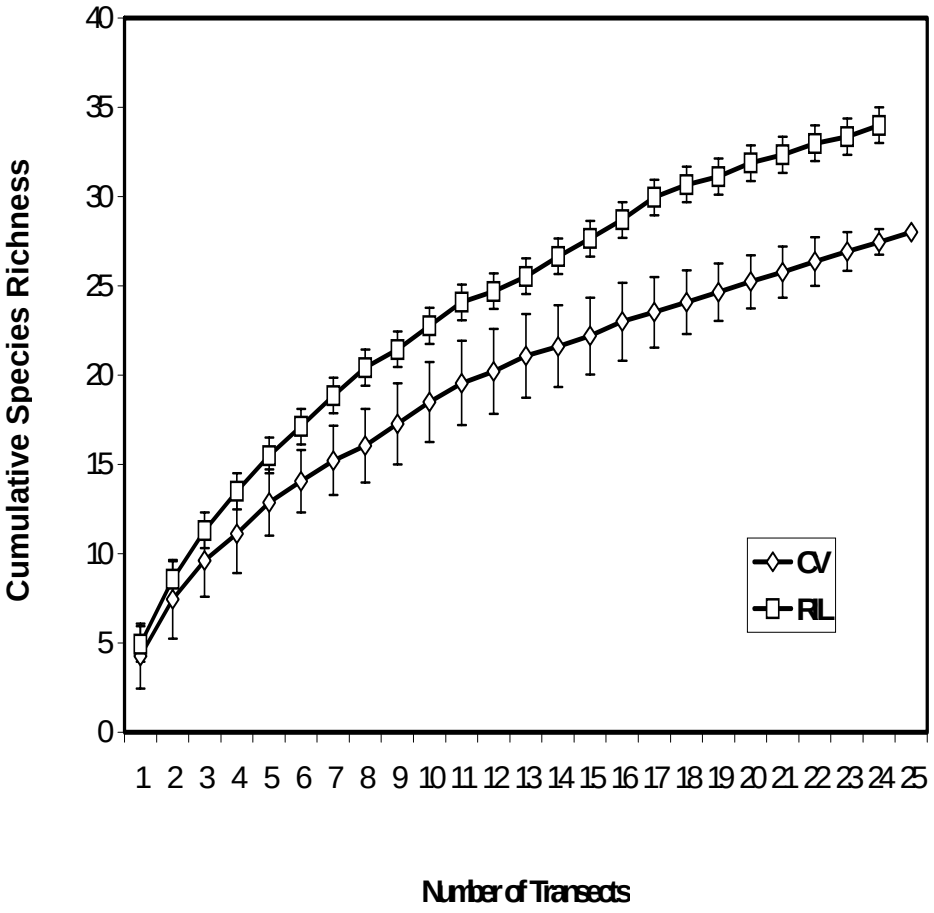


Figure 11. Cumulative increase in butterfly abundance among ridge and valley bottom communities of primary forest in the Malinau concession.

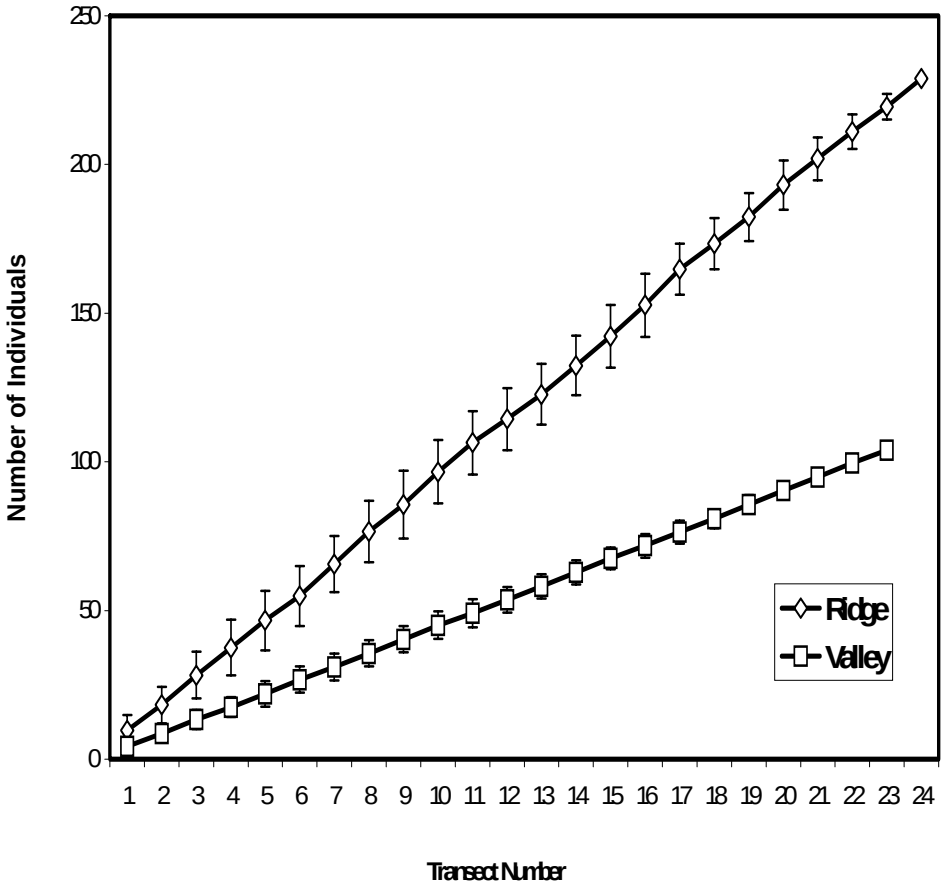
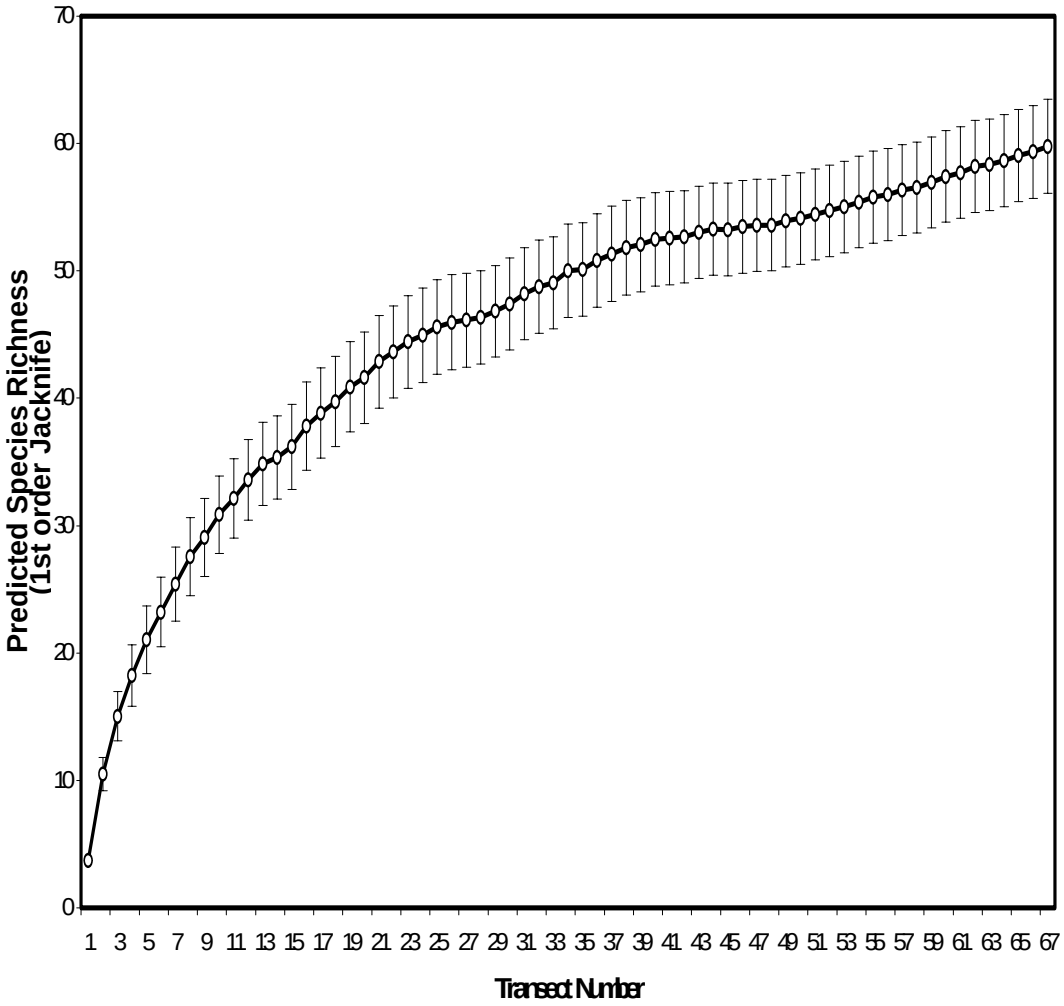


Figure 12. Predicted cumulative accumulation curve of forest butterfly richness in Malinau.



Ants

A total of 6185 ants, from 134 species (Appendix 12), were captured using a combination of leaf litter searches, transects, pitfall traps, and understory vegetation sweeps (Table 4.4).

Table 33. Diversity, richness, and similarity between ant communities in the Malinau concession of the BRF, September 1998.

	Conventional Logging (CL)	Reduce Impact Logging (RIL)	Control Site (CS)
No. of Families	One Family: Formicidae, Class Insecta		
No. of Species	111	89	83
No. of Genera	107	90	87
No. Individual	3375	1812	998
Shannon-Weaver diversity index (*H'*)	3.43	2.95	3.52
Margalef species richness (Dmg)	16.3709	17.728	19.2593
Sorenson's similarity index	CL:RIL = 0.7010	RIL:CS = 0.7674	CL:CS = 0.6734

Based on Margalef's species richness index (Dmg), the CS supported the highest richness per sample effort, followed by the RIL and CL sites (19.259, 17.728, and 16.371 respectively). The control site also exhibited the highest diversity, which was similar to the CL site, but which was higher than the RIL compartment (*H'* = 3.52, 3.43, and 2.95 respectively; $P < 0.001$; Table 4.4). Finally, a qualitative assessment of the species composition between the three sites using Soronsons Similarity Index suggests that the sites are relatively similar (0.67-0.77; Table 4.4), with the RIL and CS sites most similar, and the CL and CS sites least similar.

The CL, RIL, and CS sites support ant communities that share many species, however, high 'within' site heterogeneity (slope and wetness) and limited sampling effort, make it difficult to quantify actual similarities and differences in ant populations between the three study areas. This is especially true for canopy ant communities, which tend to be both species rich and taxonomically different from those inhabiting the forest floor (Erwin 1990; Widodo 1994; Widodo & Mohamed 1998). Future logging activities on these sites is likely to drastically alter the habitat of many species, causing major shifts in the ant fauna (Mac Kay *et. al.* 1991). Our sampling should provide insights on gross shifts in the ant communities of the study area, but may not have been sufficient to detect losses of rare or arboreal species in the wake of these disturbance activities.

Invertebrate understory community

Insects identified from the pitfall trap and sweeping samples are listed in Appendix 13 and 14. There were 13 insect orders, consisting of 79 families, collected from the pitfall traps; and 16 insect orders, consisting of 168 families, collected from sweeping. The richness and diversity of insect species collected using sweeping was higher than using pitfall traps (Tables 4.5 and 4.6). Pitfall traps yielded 139 species in the CL area, and 136 in the RIL site, while sweeping produced 392 and 229 respectively. Three insect orders dominated the catch

Table 34. Forest understory insect richness and diversity in the CL, RIL, and control sites of the Malinau concession, as determined from pitfall traps, September 1998.

	Study Sites		
	CL	RIL	CS *
Species richness (S)	139	136	80
Individuals (N)	3326	1704	668
Simpson diversity index (1-D)	0.947	0.963	0.891

* Control was sampled at one-third the intensity of the CL and RIL sites.

Table 35. Forest understory insect richness and diversity in the CL, RIL, and control sites of the Malinau concession, as determined from sweeping, September 1998.

	Study Sites		
	CL	RIL	CS *
Species richness (S)	392	229	159
Individuals (N)	1502	807	522
Simpson diversity index (1-D)	0.994	0.986	0.981

* Control was sampled at one-third the intensity of the CL and RIL sites.

in these surveys: Diptera (Flies and Mosquitos), Hymenoptera (Wasps, Ants, and Bees), and Coleoptera (Beetles). The number of species collected in these families using pitfall traps were 52, 71, and 43 species respectively, while the number of insects collected using sweeping were 146, 141, and 114 respectively. In both collection methods, ants (Hymenoptera: Formicidae) were the most abundance species collected. Several exotic species were also collected (based on rareness in IPB insect collections): a fly with eyes in the head stalks (Diptera: Diopsidae), and a walking stick that mimicked dry leaves.

Diversity was high and relatively similar between the study areas, with sweeping demonstrating slightly higher and more uniform results than the pitfall traps (Tables 4.5 and 4.6). In contrast, similarity indices between the CL, RIL, and CS surveys were moderate to low (Tables 4.7 and 4.8). Pitfall traps exhibited the highest similarity values (0.34-0.62 depending on method of analysis), while collections from sweeping ranged between 0.25-0.46.

The understory invertebrate community, as with the ant community, provides a benchmark against which to evaluate shifts in insect species, genera, and families following primary forest logging. It is hoped that these future responses will shed some light on: a) explaining changes in biological processes conducted by these taxa (e.g., leaf decomposition and herbivory), and b) identifying those taxa that serve as indictors of forest disturbance and recovery.

Table 36. Similarity of insect species collecting using pitfall traps in the Malinau concession, September 1998.

	CL	RIL	CS
CL	1	0.455	0.377
RIL	0.625	1	0.342
CS	0.548	0.509	1

Jaccard's (white boxes) and Sorenson's measures (gray boxes).

Table 37. Similarity of insect species collecting using sweeping surveys in the Malinau concession, September 1998.

	CL	RIL	CS
CL	1	0.302	0.264
RIL	0.464	1	0.256
CS	0.417	0.407	1

Jaccard's (white boxes) and Sorenson's measures (gray boxes).

Concluding remarks

The data presented in this study provide baseline information against which subsequent data collected from the sites after logging may be compared. Leaf decomposition, leaf herbivory and butterfly richness and abundance data all suggest that there are differences in invertebrate communities between and within compartments in the Malinau concession. Post-logging comparisons with the nearby control site may thus be confounded by local site differences.

PROBLEMS AND RECOMMENDATIONS

Other contributors to this report have suggested that the control site was somewhat dissimilar to the CL and RIL sites. This was especially true for invertebrates. Insects respond to forest structure and microclimate at much finer scales than vertebrates. Because the CS was quite different topographically, edaphically and vegetatively from the CL and RIL sites, it was not surprising to find in our initial visits to this area that the invertebrate community in the CS appeared to differ from the communities in the CL and RIL sites. Given our limited time, access difficulties, and the obvious site differences, we purposely sampled less in the CS than the other sites. It is recommended that the pre-treatment conditions in the CL and RIL compartments serve as the 'control' in the future for invertebrates. This will not allow for measures of temporal variation in undisturbed forest however.

The main problems and recommendations outlined in Sections 2 and 3 of this report, with the possible exception of logging influences in adjacent blocks of forest (although indirectly these may be influencing invertebrates if they are causing changes in their preditor populations), apply to the invertebrate surveys discussed above.

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APPENDICES

Appendix 1: Comparison of the four mammal trapping grids physical features, vegetation types, etc.

Compartment Plot # 29/L1 (L = projected low logging intensity plot)

Table A1.1: Ground course woody debris >10 cm diameter.

	1	**3**	**5**	**7**	**9**	**11**
I–K	1	2	1	0	0	5
G–I	5	2	1	1	3	3
E–G	1	3	1	2	4	2
C–E	4	3	0	2	1	3
A–C	1	0	0	3	5	1

Explanatory example: between trap points 1A and 1C there was 1 fallen branch or log and between trap points 1C and 1E there were 4 fallen branches or logs (see text for further details).

Table A1.2: Leaf litter depth (to nearest 0.5 cm) at the trap points (two measurements per trap point, 1 m north and 1 m east of each point).

	1	**3**	**5**	**7**	**9**	**11**
K	½, 2	3, 4	3, 3	2½, 3	3, 1½	2½, 4½
I	2, 2½	3½, 2	5½, 3	1½, 2	2, 3	(on treefall)
G	2½, 1	2½, 1½	1½, 1	3½, 2	(stream bed)	2, 2
E	2, 3	1½, 2½	5½, 5½	1½, 1½	(stream bed)	½, 2½
C	1, 2	1½, ½	4½, 5½	2½, 3	2, 1½	1, 3½
A	3, 2	3, 3	2, 2	2,1½	4, 4	5, 3

Explanatory example: at trap point 3 K the leaf litter was 3 cm deep 1 m north of the point and 4 cm deep 1 m east of the trap point.

Table A1.3: Vegetation quadrat data.

	Percent cover class for trees	**Percent cover class for scrub, shrubs, saplings, and poles and dominant height range**	**Percent cover class for seedlings and herbs (≤ 50 cm tall)**
Quadrat no. 1	4	4, 3–8 m	2
Quadrat no. 2	4	4, 2–9 m	1
Quadrat no. 3	3	5, 3–8 m	2
Quadrat no. 4	5	4, 2–9 m	2
Quadrat no. 5	4	5, 2–9 m	2
Quadrat no. 6	4	5, 1½–9m	1
Quadrat no. 7	4	4, 1½–10 m	2
Quadrat no. 8	4	4, 3–9 m	1
Quadrat no. 9	4	4, 2–8 m	1
Percent cover classes: 0 = 0%, 1 = 1–5%, 2 = 6–25%, 3 = 26–50%, 4 = 51–75%, 5 = 76–100%			

Compartment Plot # 28/H2 (H = projected high logging intensity plot)

Table A1.4: Number of fallen branches, logs, etc. >10 cm diameter.

	1	**3**	**5**	**7**	**9**	**11**
I–K	4	1	1	1	3	2
G–I	3	0	1	1	1	1
E–G	1	1	4	0	2	0
C–E	1	1	0	0	0	0
A–C	4	3	1	4	0	1
Explanatory example: between trap points 1A and 1C there were 4 fallen branches or logs and between trap points 1C and 1E there was 1 fallen branch or log (see text for further details).						

Table A1.5: Leaf litter depth (to nearest 0.5 cm) at the trap points (two measurements per trap point, 1 m north and 1 m east of each point).

	1	**3**	**5**	**7**	**9**	**11**
K	2, 3½	2, 3	2, 5	4½, 1½	3½, 5	5, 1½
I	2½, 2	6, 3	1, 2	4, 1	3, 2	1½, 1½
G	4½, 2	2½, 2½	½, 3½	1, 7	1½, 1	½, 1
E	3½, 5	1, 5	2½, 1½	1½, 3½	2½, 2½	6, 1½
C	2½, 3	1½, 5	3, 5	1, 2½	3½, 3	1½, 9
A	3½, 4	2, 5½	½, 2½	1, 3	1½, 2	1, 2½

Explanatory example: at trap point 3 K the leaf litter was 2 cm deep 1 m north of the point and 3 cm deep 1 m east of the trap point.

Table A1.6: Vegetation quadrat data.

	Percent cover class for trees	**Percent cover class for scrub, shrubs, saplings, and poles and dominant height range**	**Percent cover class for seedlings and herbs (≤ 50 cm tall)**
Quadrat no. 1	5	2, 2½–8 m	2
Quadrat no. 2	4	2, 3–7 m	2
Quadrat no. 3	4	2, 3–8 m	1
Quadrat no. 4	4	2, 2½–7 m	1
Quadrat no. 5	5	3, 2–8 m	1
Quadrat no. 6	4	3, 2–7 m	1
Quadrat no. 7	4	3, 3–9 m	2
Quadrat no. 8	5	3, 2–8 m	2
Quadrat no. 9	5	3, 3–8 m	1

Percent cover classes: 0 = 0%, 1 = 1–5%, 2 = 6–25%, 3 = 26–50%, 4 = 51–75%, 5 = 76–100%

Compartment Plot # 27/I (projected low logging intensity plot)

Table A1.7: Number of fallen branches, logs, etc. >10 cm diameter.

	1	**3**	**5**	**7**	**9**	**11**
I–K	0	1	4	2	1	2
G–I	2	1	2	4	2	2
E–G	2	1	1	0	1	0
C–E	1	3	0	0	0	1
A–C	1	0	1	2	1	2

Explanatory example: between trap points 1A and 1C there was 1 fallen branch or log and between trap points 1E and 1G there were 2 fallen branches or logs (see text for further details).

Table A1.8: Leaf litter depth (to nearest 0.5 cm) at the trap points (two measurements per trap point, 1 m north and 1 m east of each point).

	1	**3**	**5**	**7**	**9**	**11**
K	1½, 3	1½, 2½	5½, 2½	3, 2½	3½, 2½	2, 3½
I	5½, 11½	4½, 2½	2, 2	4, 2	1, 1½	3½, 3
G	5½, 3	9½, 4	3, 6½	3½, 3½	3½, 5½	3½, 3
E	3½, 3	1, 3	2, 1½	6½, 3½	3, 3½	2½, 5½
C	1, 1½	3½, 3½	3, 0	3½, 2	2½, 1	4, 1
A	2, 2½	3½, 2	0, 2½	3, 3½	2, 2	1½, 3

Explanatory example: at trap point 3 K the leaf litter was 1½ cm deep 1 m north of the point and 2½ cm deep 1 m east of the trap point.

Table A1.9: Vegetation quadrat data.

	Percent cover class for trees	**Percent cover class for scrub, shrubs, saplings, and poles and dominant height range**	**Percent cover class for seedlings and herbs (≤ 50 cm tall)**
Quadrat no. 1	4	3, 3–8 m	2
Quadrat no. 2	4	2, 3–8 m	1
Quadrat no. 3	5	2, 1½–7 m	1
Quadrat no. 4	5	2, 2–6 m	2
Quadrat no. 5	5	2, 1½–6 m	2
Quadrat no. 6	4	2, 2–8 m	1
Quadrat no. 7	4	3, 2–8 m	1
Quadrat no. 8	5	2, 2–7 m	1
Quadrat no. 9	5	3, 2–8 m	2

Percent cover classes: 0 = 0%, 1 = 1–5%, 2 = 6–25%, 3 = 26–50%, 4 = 51–75%, 5 = 76–100%

Compartment Plot # 27/D (projected high logging intensity plot)

Table A1.10: Number of fallen branches, logs, etc. <10 cm diameter.

	1	**3**	**5**	**7**	**9**	**11**
I–K	0	2	0	1	2	14
G–I	2	1	10	8	1	16
E–G	1	2	4	1	0	1
C–E	1	1	2	1	4	-
A–C	3	2	1	1	-	-

Explanatory example: between trap points 1A and 1C there were 3 fallen branches or logs and between trap points 1C and 1E there was 1 fallen branch or log (see text for further details).

Table A1.11: Leaf litter depth (to nearest 0.5 cm) at the trap points (two measurements per trap point, 1 m north and 1 m east of each point).

	1	**3**	**5**	**7**	**9**	**11**
K	2½, 2	2, 2½	2, 2	6½, 4½	6, 3	4, 3
I	2½, 1½	1, 2	2, 5	4, 1	2, 8	2, 3
G	3, 3	4½, 2	2, 2	3, 2½	3, 3	4, 4
E	5, 5	2½, 3	2, 2	6, 1	8, 9	3, 4
C	1½, 3½	3½, 4½	2, 2½	2, 1	2, 2½	-
A	1, 1	2, 5	2, 1	2, 5	-	-

Explanatory example: at trap point 3 K the leaf litter was 2 cm deep 1 m north of the point and 2½ cm deep 1 m east of the trap point.

Table A1.12: Vegetation quadrat data.

	Percent cover class for trees	**Percent cover class for scrub, shrubs, saplings, and poles and dominant height range**	**Percent cover class for seedlings and herbs (≤ 50 cm tall)**
Quadrat no. 1	5	2, 1–6 m	1
Quadrat no. 2	5	2, 3–7 m	1
Quadrat no. 3	5	2, 3–7 m	2
Quadrat no. 4	5	2, 3–6 m	1
Quadrat no. 5	4	2, 3–8 m	1
Quadrat no. 6	4	2, 3–6 m	1
Quadrat no. 7	-	-	-
Quadrat no. 8	5	2, 3–6 m	1
Quadrat no. 9	4	2, 3–6 m	2

Percent cover classes: 0 = 0%, 1 = 1–5%, 2 = 6–25%, 3 = 26–50%, 4 = 51–75%, 5 = 76–100%

Table A1.13: Comparison of the four mammal trapping grids

Feature	**Site and Plot**			
	Conventional Site		**RIL site**	
	Plot # 29/L1	**Plot # 28/H2**	**Plot # 27/D (high)**	**Plot # 27/I (low)**
Area (ha)	1	1	1	1
Approx. altitudinal range (m asl)	78–114	109–142	120–175	98–146
Slope				
% of grid 0-5%	13	10	10	13
% of grid 6–15%	40	0	24	29
% of grid 16–25%	43	32	36	19
% of grid 26–35%	0	16	9	22
% of grid 36–45%	4	14	12	11
% of grid 46–55%	0	16	4	1
% of grid 56–65%	0	4	5	4
% of grid 65–75%	0	0	0	0
% of grid > 75%	0	8	0	1
Vegetation type				
% Lowland forest	52	92	92	66
% Valley bottom lowl. forest	48	8	8	32
% Degraded lowland forest / scrub	0	0	0	0
% Seasonally flooded forest	0	0	0	2
% Swamp forest	0	0	0	0
Number of streams within grid / or within 15m of grid's perimeter	4 / 0	0 / 1	1 / 1	3 / 0
Number of ponds within grid	0	0	2 (1 x 3 & 6 x 3½m)	0

Appendix 2: English and scientific names of species mentioned in text

The table below provides the English names of all species mentioned in the text of the report. Systematics, taxonomy, and nomenclature follow Corbet & Hill (1992). Where the scientific or English names employed by Corbet & Hill differ from those used by Payne *et al*. (1985), the latter are given in parantheses.

Scientific name	English name
Tupaiidae	**Treeshrews**
Tupaia glis	Common Treeshrew
Tupaia minor	Pygmy Treeshrew (Lesser Treeshrew)
Tupaia gracilis	Slender Treeshrew
Tupaia tana	Large Treeshrew
Tupaia dorsalis	Striped Treeshrew
Cercopithecidae	**Monkeys**
Macaca nemestrina	Pig-tailed Macaque
Macaca fascicularis	Crab-eating Macaque (Long-tailed Macaque)
Presbytis femoralis (*Presbytis melalophos*)	Banded Leaf Monkey (Banded Langur)
Presbytis hosei	Grey Leaf Monkey (Hose's Langur)
Presbytis frontata	White-fronted Leaf Monkey (White-fronted Langur)
Presbytis rubicunda	Red Leaf Monkey (Maroon Langur)
Semnopithecus cristata (*Presbytis cristata*)	Silvered Leaf Monkey (Silvered Langur)
Nasalis larvatus	Proboscis Monkey
Hylobatidae	**Gibbons**
Hylobates muelleri	Bornean Gibbon
Hominidae	**Great Apes and Humans**
Pongo pygmaeus	Orang-utan
Ursidae	**Bears**
Ursus malayanus (*Helarctos malayanus*)	Sun Bear
Mustelidae	**Martens, Weasels, Badgers, & Otters**
Mustela nudipes	Malayan Weasel (Malay Weasel)
Martes flavigula	Yellow-throated Marten
Lutrogale perspicillata (*Lutra perspicillata*)	Smooth-coated Otter (Smooth Otter)
Viverridae	**Civets**
Paradoxurus hermaphroditus	Common Palm Civet
Paguma larvata	Masked Palm Civet
Arctictis binturong	Binturong
Arctogalidia trivirgata	Small-toothed Palm Civet
Hemigalus derbyanus	Banded Palm Civet
Herpestidae	**Mongooses**
Herpestes brachyurus	Short-tailed Mongoose
Felidae	**Cats**
Prionailurus bengalensis (*Felis bengalensis*)	Leopard Cat

Suidae	**Pigs**
Sus barbatus	Bearded Pig
Tragulidae	**Mouse–deer & Chevrotains**
Tragulus javanicus	Lesser Malay Mouse-deer (Lesser Mouse-deer)
Tragulus napu	Greater Malay Mouse-deer (Greater Mouse-deer)
Cervidae	**Deer**
Cervus unicolor	Sambar (Sambar Deer)
Muntiacus muntjak	Indian Muntjac (Red Muntjac)
Muntiacus atherodes	Bornean Yellow Muntjac
Bovidae	**Cattle, Antelopes, etc.**
Bos javanicus	Banteng (Tembadau)
Sciuridae	**Non–flying Squirrels**
Ratufa affinis	Pale Giant Squirrel (Giant Squirrel)
Callosciurus prevostii	Prevost's Squirrel
Callosciurus notatus	Plantain Squirrel
Callosciurus orestes	Bornean Black–banded Squirrel
Sundasciurus lowii	Low's Squirrel
Sundasciurus hippurus	Horse-tailed Squirrel
Lariscus insignis	Three-striped Ground Squirrel
Exilisciurus exilis	Least Pygmy Squirrel (Plain Pigmy Squirrel)
Rheithrosciurus macrotis	Tufted Ground Squirrel
Pteromyidae	**Flying Squirrels**
Petaurista petaurista	Red Flying Squirrel (Red Giant Flying Squirrel)
Muridae	**Mice, Rats, etc.**
Leopoldamys sabanus	Long-tailed Giant Rat
Maxomys rajah	Brown Spiny Rat
Maxomys surifer	Red Spiny Rat
Maxomys whiteheadi	Whitehead's Rat
Hystricidae	**Old-world Porcupines**
Hystrix brachyura	(Common Porcupine)

Appendix 3: Merap and Punan names for mammals

The information provided below was collected by S. Hedges during interviews with local hunters at Long Loreh on 4 October 1998

Scientific name	Name in Bahasa Merap	Name in Bahasa Punan
Manidae		
Manis javanica	Anang	Um
Erinaceidae		
Echinosorex gymnurus	Chloroh	Bercala
Soricidae	La'bau	
Tupaiidae	Merlakray	Ohkey
Tupaia gracilis		
Tupaia tana	New	Ohkey pongkong
Cynocephalidae		
Cynocephalus variegatus	Ko'bu	Kouvung
Pteropodidae		
Pteropus spp.	Ahwar	Mowah
Loridae		
Nycticebus coucang	Do'lum	Berkiki
Tarsiidae		
Tarsius bancanus	Keoh	Itep
Cercopithecidae		
Macaca nemestrina	Dow	Beruk
Macaca fascicularis	Kuyang	Kouyat
Presbytis femoralis	Koiyang	Ah,cou
Presbytis hosei	N'yakai	Ah'cou
Presbytis frontata		Ah'cou
Presbytis rubicunda	Hachay	Ah'ci
Semnopithecus cristata	N'yakai	Ah'cou
Nasalis larvatus	Bakarau	Berkarok
Hylobatidae		
Hylobates muelleri	Ha'bat	Klavet
Hominidae		
Pongo pygmaeus	Kwee	Kouyang
Ursidae		
Ursus malayanus	B'way	Bowang
Mustelidae		
Mustela nudipes	Langai	Dernang
Martes flavigula	S'hoar	Ah'rang
Melogale everetti		Touvang
Mydaus javaensis	B'lingm	Bilun
Lutrinae spp.	Nan	Ding'ong
Viverridae		

Viverra tangalunga	Nung	Cili'ap
Prionodon linsang	Nung	Kalung lutang
Paradoxurus hermaphroditus	Noun	Ang'an
Paguma larvata	Morhon	Ang'an
Arctictis binturong	Te'arr	Kay'tan
Arctogalidia trivirgata	Pungkut	Ang'an
Hemigalus derbyanus	Lowoh tanah	Kalung lutang
Cynogale bennettii	Ta'by	Chaven
Herpestidae		Touvanng
Herpestes semitorquatus	Langay	
Herpestes brachyurus	Tompoy	
Felidae		Kooli (Kooli burok = small cats)
Prionailurus bengalensis	Berkluk	
Pardofelis marmorata	Kloy ba	
Pardofelis nebulosa	Kloy menu	Kooli bohvong
Elephantidae		
Elephas maximus	U'rid	Gajah
Rhinocerotidae		
Dicerorhinus sumatrensis	Tam'prow	Temruh
Suidae		
Sus barbatus	Ma'bai	Bah'vui
Tragulidae		
Tragulus spp.	Kla'ow	Pelanok
Cervidae		
Cervus unicolor	Payou	Payau
Muntiacus spp.	K'low	Teloh
Bovidae		
Bos javanicus	Cepay	Kelah'chou
Sciuridae		
Ratufa affinis	M'kah	Mo'gah
Callosciurus spp.		Ko'key
Callosciurus simus	Kaay empah	
Sundasciurus spp.		Ko'key
S. hippurus borneensis	Klay p'ore	
S. hippurus pyrei	Klay tai	
Dremomys everetti		Ko'key
Lariscus insignis	Me'he	Ko'key
Rhinosciurus laticaudatus	N'youl	Ko'key
Nannosciurus melanotis	Me'he	
Exilisciurus exilis		Chouko
Rheithrosciurus macrotis	Namow	Ko'key karang
Pteromyidae		Kou'vung
Petaurista petaurista		

Muridae	Labal	Kelabu
Hystricidae		
Hystrix brachyura	T'ow	To'tung
Hystrix crassispinis	T'ow	To'tung
Trichys fasciculata	Kupah	Tay'an

Scientific nomenclature follows that of Corbet & Hill (1992).

Appendix 4. Description of the vegetation and physical characteristics of VCP Stations in Malinau concession. 1998.

Transect	Station	Habitat	Vegetation Cover				Altitude	Aspect	Slope	Water
			Ground	Low	Mid	Canopy				
R1	100	treefall	40	40	40	30	175	N	steep	-
	300		30	40	90	60	160	SW	mod.steep	-
	500	ridge	40	70	80	60-70	175	SE/NW	flat-steep	-
	700	swampy	60	80	80	70	150	flat	flat-gentle	rivulet just outside
	900	swampy	20	30	70	60	150	flat - N	flat-gentle	inundated after rain
	1100		25	60	90	70	150	SW	gentle	small river at edge
	1300		30	60-70	90	70	175	NW	gentle	-
	1500	dry	20-30	20-40	90	70	130	W	gentle	
R2	100	dry, ridge	10-60	20-80	80	70	160	E/W-flat	flat-steep	river at edge
	300	ridge	20	20-30	70	80	175	N/S, flat	flat-steep	-
	500	dry ridge	50	80	80	80-90	145	SE/NW	steep	-
	700	recent landslide	40	50	50	20	100	S	steep	rivulet at edge
	900	dry, flat	50	70	70	50	95		flat	inundated after rain
	1100	dry	50	80	70	70	125	SW/NE	mod.steep	tiny brooklet
	1300		50-60	70-80	90	90	1300	W	gentle	-
	1500									
V1	100		40	40	90-100	80	80			small rivulet at edge
	200	dry flat	30	40	70	80-90	75	flat	flat	partly inundated after rain
	300		30-40	40	70-80	70	75	N/S, flat	flat-mod	small rivulet
	400		50-70	40	70	80	90	E/S	gentle-steep	-
	500		50-70	70-80	70-80	60-70	80	W	steep	
	600	swampy	20-40	30	40-50	50-60	60	flat	flat	inundated after rain
	700		40-50	10-20	70	80	60	flat		inundated after rain
	800		50-60	50	80-90	50	60			
	900		80	40-50	90					small stream after rain
A2	100	ridge top	20-30	30	90	90	140	SW/NE	flat-steep	
	300	swampy	30-40	30-40	80	90	90	flat	flat	inundated after rain
	500	dry flat	80	50	70	60-70	100	flat	flat	inundated after rain
	700	dry flat	70-80	30-40	60	70	90	flat	flat	
	900	dry flat	60	30-40	70	80	90	flat	flat	
Appendix 3.1 Cont'd										

Transect	Station	Habitat	Vegetation Cover				Altitude	Aspect	Slope	Water
			Ground	Low	Mid	Canopy				
C1	100	ridge	30	30	70-80	70-80		N/S-flat	on ridge	
	300		40-80	60-70	40	40-50		N	gentle	small intersecting rivulet
	500	valley bottom	50-60	30-40	70-80	60-70	45	W/NE	flat to gentle	flooded after rain
	700	dry	40-60	60-70	60-70	60-70	60	SW	mod steep-gentle	-
	900	river bank	40-80	40-50	70-80	60-70	60	N/S	gentle	intersected by 2-3m stream
	1100		30-40	40-50	80-90	80	75	N/S	mod steep	mostly dry rivulet
	1300	dry	30-80	40-50	50-60	30-40	72	NW	steep	-
	1500	dry flat	25-30	30-40	80-90	60-70	31	flat	flat	small rivulet after rain
	1700		60-90	40-50	80	70-80	40	NW	steep	river at border
	1950		50-60	40-50	60-70	60-70	55	S/N	mod steep	river in vicinity
	2150	dry	40-50	40-50	70-80	60-70	61	NW	mod - steep	bordering rivulet
	2350	dry flat	70-80	60-70	50-60	60-70	68	-	gentle-flat	-
C2	100		80-90	50-60	70-80	50-60	75	N	gentle	-
	300	dry, flat	60-70	30-40	80-90	70-80	40	flat	mostly flat	inundated after rain
	500	along river	10-80	40-50	70-80	50-60	40	N/S	gentle	plot along 3-10m river
	700	ridge	10-20	30-40	80-90	70-80	75	N/W	ridge	-
	900	ridge near top	60-70	60-70	70-80	60-70	80	W/E	flat-mod	-

Appendix 4 Cont'd

Transect	Station	Epiphytes	Ferns	Lianas	Rattan	Dead logs		Leaf litter	Herbs
			ground			large	small		
R1	100	very few		some			some		
	300	none	some			3		thin	
	500	few or no					3-4	thin	
	700	some		some		-	many		
	900	many	sparse	some		few		thin, exposed parts	mod many
	1100		sparse		few	1	some		sparse
	1300	few or no				none			
	1500	none				4 very old			
R2	100	-	few	few					
	300			few	-	-			
	500	few or no							
	700	some	some			3-4		exposed soil	
	900	few	few		some		6+		
	1100	none	-	some	few			thin	
	1300				few	1		thin	
	1500								
V1	100	none or few		few		3-4		thin	
	200	mod many		mod many		1-2	some	thin	
	300	some		few				thin	
	400	some			mod many	1-2		thin on sand	some
	500	mod many		mod many	mod many	none		thin on sand	many
	600	few		some		many	many	thin, exposed sand	
	700	few	some	few		few		thin on exposed sand	many
	800	few		no	some	some		thin on sand	many
	900	some full trees		many		few		thin, bare soil after rain	many
A2	100	none		few		some			
	300								mod
	500	many large	few small	many large	many	2		thin	
	700	few				3-4	some	thin	many
	900	some	some	some		none		thin	some

Appendix 4 Cont'd

Transect	Station	Epiphytes	Ferns	Lianas	Rattan	Dead logs		Leaf litter	Herbs
			ground			large	small		
C1	100	few		many large ones		none	many	leaves and twigs	very few
	300	few		few			few	thin on sand	mod many
	500	in tree tops		many small					
	700	only higher up		few small		quite a few		thin or none	mod many
	900	abundant	-	abundant	-	quite a few			some woody
	1100	few		mod many		none	few	very thin	some
	1300	few or none		some		sevral new	many	thin on sand	mod many
	1500	mod many		many small		several		tin on sand	mod many
	1700	mod many		many small		several		thin, bare at places	some woody
	1950	some trees		many	some	several		thin on fine roots	some woody
	2150	few		many		few		thin on fine/exp roots	
	2350	few or no		many		several		thin on fine roots	
C2	100	few higher up		mod many	many	none	many	thin on exp roots	
	300	mod many		many small		few			
	500	many higher up		few small				thin, on fine roots	
	700	few or none	-	very few small	abundant	several		thin on fine roots	
	900	few or none		many	many			rather thick	

Appendix 4. Cont'd							
Transect	Station	"Pandan grass"	Epiphytes	Saplings	Small palms	Moss	Misc
R1	100		very few				
	300		none		some		selaginella on ground
	500		few or no	few small			
	700		some	many		many trees with moss	many exposed roots
	900		many	mod many			several large swamp palms
	1100			mod many			stony ground with exp roots
	1300	some	few or no	few	some		
	1500		none	sparse	some		some exposed roots
R2	100		-				ridge top
	300	moderate		few	moderate		Argus lek
	500		few or no				Fruiting fig, no other large trees
	700		some		some		
	900	few	few			some	
	1100	some	none	few	few		
	1300				few	thin, on some	
	1500						
V1	100		none or few	rather many	some	sparse on the bigger tress	center 25m from logging road
	200		mod many	sparse	many	sparsely mossed stems	exposed roots
	300		some	sparse	mod many	bare to sparsely mossed bark	
	400		some	many	some	none	
	500		mod many	many		none	
	600		few			very sparse	some "swamp palms"
	700		few				pneumatophores
	800		few	many		sparse on bark	
	900		some full trees			some trees mossy	
A2	100		none		many		
	300				many		ground with exposed roots
	500		many large		many		some exposed roots
	700		few	many			
	900		some				

Appendix 4 Cont'd							
Transect	Station	"Pandan grass"	Epiphytes	Saplings	Small palms	Moss	Misc
C1	100		few	mod many	very few	little moss on basal parts trees	
	300	mod many	few	mod many		some on bark	large gap on this plot
	500		in tree tops	many	some	sparse	
	700		only higher up	mod many	many small	some bare,some covered	exposed roots
	900		abundant	mod many		bases covered	
	1100		few	many small	mod many	at bases	
	1300	some	few or none	mod many	mod many		
	1500		mod many	mod many	none	sparse	
	1700		mod many	mod many	some	thin cover	some exposed roots
	1950		some trees	mod many	mod many	basal parts trees	
	2150		few	mod many	mod many	thin, on basal parts trees	
	2350		few or no	many	very few	on basal parts	
C2	100		few higher up	many	some	mainly bare	
	300		mod many	abundant	few	thin at base	plot along small river
	500		many higher up		mod.many		
	700		few or none	few	abundant		
	900		few or none	many small	many	none	

Appendix 5. Description of the vegetation and physical characteristics of the permanent plots used in the Malinau FDS surveys.

Control Area

Plot EC1 (Control)
Flat parts alternating with moderately steep slopes; small rivulet intersects the plot. Leaf litter on the flat parts, steeper parts often with bare sand. Few small palms, many saplings. Few logs, moss covering the basal parts of trees (some higher up) and saplings. Many epiphytes high up in some trees, but otherwise few; some small and large lianas.
Ground cover: 30-40%; Low: 40-60 %; Mid 70-80%; Canopy: 60-70 %.

Plot EC2 (Control)
On moderately sloping ridge with northwest aspect. Thin litter on sand, exposed roots; some rattan palms, many lianas (small and large) and epiphytes (mostly higher up). Trees mostly with bare bark, only very sparse moss cover..
Ground: 20-30%; Low: 40-50%; Mid: 80-90%; Canopy: 70-80%.

RIL Compartment

Plot D (Petak 27a)
On a moderately steep to undulating slope with (mostly) southern aspect. Thin layer of leaf litter on sand and fine roots. Quite a few very old logs. Few or no epiphytes and lianas. Moss and basal parts of tree, and dead logs covered with moss. Saplings and few palms form the ground and understory vegetation.
Ground cover: 10-30%; Low: 20-30%; Mid: 70-80%; Canopy: 70-80%.

Plot F (Petak 27a)
On moderately steep to flat terrain. Litter thick locally, on fine roots and stones. Few lianas, many small trees (<10-15m tall) and saplings, small palms; only few tall trees. Many dead logs; moss covering basal parts of trees and dead logs.
Ground cover: 30-40%; Low: 50-60%; Mid: 90-100%; Canopy: 50-60%.

Plot G (Petak 27a)
Two moderately steep north/south slopes inside the plot with small river in the valley. Thin litter layer on exposed roots and sand-rock. Several old logs. Many lianas and epiphytes. Moss on basal parts of most trees in the valley, but less higher up towards the ridge. Saplings, small palms and “pandanus grass” were part of the ground cover.
Ground: 60-70%; Low: 40-50%; Mid: 70-80%; Canopy: 80%.

Conventional Logging Compartments

Plot H2 (Petak 28)
On ridge top. Thick litter layer, many fallen branches and logs. Sparsely covered with herbs, young saplings and small palms. No or few lianas and epiphytes.
Ground cover: 10-15%; Low: 20-30%; Mid: 70-80%; Canopy: 80-90%.

Plot Mc (Petak 28)
Covering the rather steep west and east slopes of a valley; a (mostly dry) rivulet intersecting the plot. Thin leaf litter on sand; many dead logs and branches. Few lianas, hardly any epiphytes. Moss on logs and basal parts of trees. Some small palms and few saplings.
Ground cover: 30-40%; Low: 40-50%; Mid: 70-80%; Canopy 70-80%.

Plot L1 (Petak 29)

On moderately steep slope with southern aspect; 75-90m a.s.l. Thin layer of leaf litter on humus and roots. Some large dead logs and a few gaps in the vegetation due to tree falls. Lianas common, epiphytes (e.g., Asplenium) concentrated on a few trees only. Palms and rattan moderately common. Many saplings, no (or only few) ferns.
Ground cover: 40-60%; Low: 60-70%; Mid: 70-80%; Canopy: 80%.

Plot M2 (Petak 29)
Several large old logs and many broken branches. Bark bare, but mossy at base of most trees. Few epiphytes and lianas. Partly inundated after rain. Sparsely covered with saplings, small palms (swamp palms).
Ground cover: 20-30%; Low: 30-40 %; Mid: 70-80 %; Canopy: 70-80%

Appendix 6. Distribution of bird species recorded in the Malinau study area and its environs, 1998.

Site	Malinau	L Loreh-Malinau	Long Loreh	KM 69	KM 62	km72	RKT 93/94	RKT 96/97	RKT 97/98	Petak 15	Petak 17	Petak 22	RKT 98/99	Petak 27	Petak 28/29	Pteak 30/31	Control
Species																	
Abroscopus superciliaris																	
Accipiter trivirgatus									1								
Acrocephalus orientalis	1																
Actenoides concretus							1		1				1	1	1	1	1
Aegithina viridissima					1		1	1	1	1		1	1	1	1	1	1
Aerodramus fuciphagus								1									
Aerodramus maximus			1					1	1				1	1		1	1
Aethopyga siparaja				1	1												
Alcedo atthis																	
Alcedo euryzona								1					1	1	1	1	1
Alcedo meninting							1						1	1	1	1	
Alcippe brunneicauda							1	1	1				1	1	1		1
Amaurornis phoenicurus		1															
Anhinga melanogaster								1									
Anorrhinus galeritus							1		1				1	1	1		1
Anthracoceros malayanus				1	1		1	1	1				1	1	1	1	1
Anthreptes malacensis	1		1													?1	
Anthreptes rhodolaema														1	1		
Anthreptes simplex								1					1	1			
Anthreptes singalensis							1	1					1	1	1		1
Anthus novaeseelandiae	1																
Aplonis panayensis																	
Arachnothera affinis			1				1	1	1				1	1	1		1
Arachnothera chrysogenys								1	1				1	1	1		1
Arachnothera crassirostris							1	1	1			1	1	1	1		1
Arachnothera longirostra				1	1		11	1	1	1	1		1	1	1	1	1
Arachnothera robusta				1			1	1	1				1	1	1		1
Arachnothra flavigaster							1							1	1		
Argusianus argus							1	1	1			1	1	1	1		1
Artamus leucorynchus											1						
Aviceda jerdoni													1			1	
Batrachostomus auritus													1		1		1
Batrachostomus cornutus																?1	
Batrachostomus javensis																?1	
Batrachostomus stellatus															1	1	
Berenicornis comatus							1	1					1	1	1		1
Blythipicus rubiginosus							1		1				1	1	1	1	1
Bubo sumatranus																1	
Buceros rhinoceros							1	1	1				1		1		1
Butorides striatus																1	
Cacomantis merulinus	1		1				1		1				1			1	

Cacomantis sepulcralis									1				1	1	1		1
Cacomantis sonneratii							1						1	1	1		1
Calorhamphus fuliginosus							1	1	1				1	1	1	1	1
Calyptomena hosii															1		1
Calyptomena viridis							1		1		1		1	1	1	1	1
Carpococcyx radiceus																?1	1
Celeus brachyurus							1	1				1	1	1	1	1	1
Centropus bengalensis	1																
Centropus rectunguis												1			1		
Centropus sinensis	1			1			1				1		1			1	1
Ceyx erithacus							1						1	1	1	1	1
Chalcophaps indica			1				1		1						1	1	1
Charadrius veredus	1																
Chloropsis cochinchinensis							1		1	1			1	1	1	1	1
Chloropsis cyanopogon							1	1	1				1	1	1		1
Chloropsis sonnerati							1	1	1				1	1	1	1	1
Chrysococcyx minutillus							1										
Chrysococcyx xanthorhynchus							1	1	1			1	1	1	1		1
Ciconia stormi													1				
Collocalia esculenta								1	1				1				
Copsychus malabaricus				1	1		1	1	1				1	1	1	1	1
Copsychus pyrropygus									1				1	1	1	1	1
Copsychus saularis			1		1		1		1		1		1	1		1	
Coracina fimbriata				1			1	1	1				1	1	1	1	1
Coracina striata								1									1
Corvus enca			1	1	1		1	1	1				1	1	1	1	1
Corydon sumatranus								1	1				1	1	1		1
Coturnix chinensis	1																
Criniger bres							1		1				1	1	1	1	1
Criniger finschii								1					1	1	1	1	1
Criniger phaeocephalus									1				1	1	1	1	1
Cuculus fugax													1		1	1	
Cuculus micropterus			1				1						1	1			
Cuculus vagans							1		1		1				1	1	1
Cymbirhynchus macrorhynchos																1	
Cyornis caerulatus															?1		
Cyornis superbus													1	1	1		1
Cyornis turcosus															1	1	
Dicaeum chrysorrheum														1			
Dicaeum concolor							1										1
Dicaeum cruentatum	1																
Dicaeum everetti									1				1				
Dicaeum trigonostigma	1		1	1			1		1				1	1	1	1	1
Dicrurus aeneus							1	1	1					1	1	1	1
Dicrurus paradiseus							1	1	1				1	1	1	1	1
Dinopium rafflesii							1		1				1	1	1	1	1
Dryocopus javensis							1		1		1		1	1	1		1
Ducula aenea																1	
Ducula badia							1	1	1				1				
Egretta garzetta																	
Egretta intermedia	1																

Enicurus leschenaulti									1					1	1		1
Enicurus ruficapillus							1						1	1	1	1	1
Eumyias thalassina								1									
Eupetes macrocerus													1	1	1		1
Eurostopodus temminckii									1				1	1	1	1	
Eurylaimus javanicus							1	1	1		1		1	1	1	1	1
Eurylaimus ochromalus				1			1	1	1	1		1	1	1	1	1	1
Eurystomus orientalis			1														
Glareola maldivarum	1																
Gracula religiosa							1	1	1				1	1	1	1	1
Halcyon pileata																1	
Haliaetus leucogaster																	
Haliastur indus		1					1	1	1				1			1	
Harpactes diardii									1				1	1	1	1	1
Harpactes duvaucelii							1	1	1		1		1	1	1		1
Harpactes kasumba									1				1	1	1	1	1
Harpactes oreskios								1									
Hemicircus concretus							1		1				1		1	1	1
Hemiprocne comata							1	1	1	1			1	1	1	1	
Hemiprocne longipennis				1			1	1	1				1	1	1		
Hemipus hirundinaceus							1	1	1				1	1	1	1	1
Hieraaetus kienerii				1				1					1				
Hirundapus giganteus							1	1					1			1	
Hirundo rustica	1	1		1	1		1									1	
Hirundo striolata					1												
Hirundo tahitica			1	1			1						1				
Hypogramma hypogrammicum							1		1			1	1	1	1	1	1
Hypothymis azurea							1	1	1				1	1	1	1	1
Hypsipetes charlottae				1			1						1	?1	1		1
Hypsipetes criniger								1	1				1	1	1	1	1
Hypsipetes malaccensis							1	1	1				1	1	1	1	1
Ichthyophaga humilis							1		1			1		1	1	1	1
Ictinaetus malayensis					1												
Indicator archipelagicus													1	1			
Irena puella					1		1	1	1				1	1	1	1	1
Ixobrychus flavicollis																1	
Kenopia striata														1	1		1
Lacedo pulchella									1				1	1	1	1	1
Lanius tigrinus							1										
Lonchura fuscans	*1*	1	1	1	1		1	1	1				1		1		
Lonchura malacca		1	1														
Lophura ignita															1		1
Loriculus galgulus				1			1		1				1	1	1	1	1
Macheiramphus alcinus													1			1	
Maconous gularis	1		1	1	1		1	1	1		1		1			1	1
Macronous ptilosus							1	1	1				1	1	1	1	1
Malacopteron affine					1		1	1	1				1	1	1	1	1
Malacopteron albogulare														1	1		1
Malacopteron cinereum							1						1	1	1	1	1
Malacopteron magnirostre							1		1				1	1	1	1	1
Malacopteron magnum							1	1	1				1	1	1	1	1
Megalaima australis			1	1	1		1	1	1	1		1	1	1	1		1

Megalaima chrysopogon					1		1	1	1				1	1	1	1	1
Megalaima henricii							1	1	1			1	1		1		1
Megalaima mystacophanos				1			1	1	1						1		1
Megalaima rafflesii							1	1	1				1	1	1	1	1
Megalurus palustris	1																
Meiglyptes tristis			1				1	1	1				1	1	1		1
Meiglyptes tukki								1						1	1		
Microhierax fringillarius							1	1		1			1				
Motacilla cinerea													1	1			1
Motacilla flava	1																
Mulleripicus pulverulentus							1		1				1	1	1		1
Muscicapa dauurica					1			1	1				1		1	1	
Muscicapa griseisticta													?1	1	1	1	
Muscicapa sibirica													?1	?1			
Napothera atrigularis															1	1	1
Nectarinia sperata			1														1
Ninox scutulata															1	1	
Nyctyornis amictus							1	1	1			1	11	1	1	1	1
Oriolus xanthonotus							1	1	1		1		1	1	1		1
Orthotomus atrogularis	1						1	1	1				1	1	1	1	1
Orthotomus ruficeps					1		1	1	1	1			1	1	1		
Orthotomus sericeus	1		1	1	1		1	1	1	1	1		1	1	1	1	
Otus rufescens																1	
Passer montanus		1	1														
Pelargopsis capensis							1		1			1			1	1	1
Pellorneum capistratum				1			1	1	1				1	1	1	1	1
Pericrocotus flammeus							1	1					1				
Pericrocotus igneus													1	1	1		
Pernis ptilorhynchus						1								1		1	1
Phalaropus lobatus																1	
Philentoma pyrrhopterum												1	1	1	1	1	1
Philentoma velatum							1		1				1	1	1		1
Phodilus badius																	
Phylloscopus borealis														1	1		1
Picus mentalis								1	1					1	1	1	
Picus miniaceus														1	1	1	
Picus puniceus							1	1	1	1			1	1	1	1	1
Pitta baudii							1						1		1	1	1
Pitta caerulea															1		
Pitta granatina							1	1	1	1	1	1	1	1	1	1	1
Pitta sordida			1													1	
Pityriasis gymnocephala		1						1	1		1		1	1	1	1	1
Platylophus galericulatus							1	1	1				1	1	1	1	1
Platysmurus leucopterus							1		1				1	1	1	1	1
Pomatorhinus montanus								1	1				1	1	1	1	1
Prinia flaviventris	1		1	1			1	1									
Prionochilus maculatus							1		1				1	1	1		1
Prionochilus thoracicus													1				
Prionochilus xanthopygius							1	1	1				1	1	1	1	1
Psittinus cyanurus				1			1	1	1				1	1	1		1
Ptilocichla													1	1	1	1	1

leucogrammica																	
Pycnonotus atriceps			1	1	1										1	1	1
Pycnonotus brunneus							1	1			1		1	1	1		1
Pycnonotus cyaniventris							1	1	1				1	1	1		1
Pycnonotus erythrophthalmus				1	1		1	1	1	1	1	1	1	1	1	1	1
Pycnonotus eutilotus				1			1	1	1	1			1	1	1	1	1
Pycnonotus goiavier	1		1	1			1	1	1				1				
Pycnonotus melanoleucos									1						?1		
Pycnonotus plumosus			1		1		1	1	1							1	
Pycnonotus simplex				1			1		1				1	1	1	1	1
Pycnonotus squamatus													?1			?1	
Reinwardtipicus validus							1		1				1	1	1	1	1
Rhamphococcyx curvirostris							1	1	1				1	1	1	1	1
Rhaphidura leucopygialis				1	1		1	1	1		1		1		1	1	
Rhinomyias umbratilis													1	1	1		1
Rhinoplax vigil			1		1		1		1		1		1	1	1		1
Rhinorta chlorophaea							1	1	1				1	1	1	1	1
Rhipidura javanica	1																
Rhipidura perlata																	1
Rhopodytes diardi							1	1	1					1	1		
Rhopodytes sumatranus													1				
Rhyticeros corrugatus								1	1				1		1	1	
Rhyticeros undulatus									1		1		1	1	1	1	1
Rollulus rouloul														1	1	1	
Sasia abnormis														1	1	1	1
Sitta frontalis									1				1	1			
Spilornis cheela							1		1				1		1		1
Spizaetus cirrhatus			1	1													
Spizaetus nanus							1		1				1	1			
Stachyris erythroptera				1			1	1		1			1	1	1	1	1
Stachyris maculata							1	1	1				1	1	1	1	1
Stachyris nigricollis							1	1	1				1	1	1	1	1
Stachyris poliocephala								1								1	
Streptopelia chinensis	1																
Strix leptogrammica							1								1	1	
Surniculus lugubris							1	1	1							1	1
Tephrodornis gularis					1		1	1	1				1	1	1		
Terpsiphone paradisi							1	1	1				1	1	1	1	1
Treron capellei			1				1		1		1		1			1	1
Treron curvirostra							1	1	1					1	1		1
Treron olax				1			1	1					1	1	1		
Treron vernans	1																
Trichastoma bicolor							1	1	1				1	1	1	1	1
Trichastoma malaccense							1	1	1			1	1	1	1	1	1
Trichastoma rostratum			1				1	1	1				1		1	1	1
Tringa hypoleucos	1															1	
Zanclostomus javanicus								1			1		1				1
Total Species	25	7	28	33	25	1	125	102	122	14	19	17	147	126	149	120	134
Field hours							11	14	26				36	64	103		82

Note: The '1's in the table represent the presence of a species at a particular site (it does not indicate abundance).

Appendix 7. Bird abundance within VCPs found along nine transects in Malinua concession, September-October 1998.

	Site																														
	Reduced Impact Logging Site (RIL)										Conventional Logging Site (CL)										Control Site (CS)									
Transect number	R1			R2			R12				V1			V2			A2				C1a			C1b			C2			
Sampling period (h)	6-900	9-1200	14-1700	6-900	9-1200	14-1700	6-900	9-1200	14-1700	27 Total	6-900	9-1200	1400-1700	6-900	9-1200	14-1700	6-900	9-1200	14-1700	28/29 Total	6-900	9-1200	14-1700	6-900	9-1200	14-1700	6-900	9-1200	14-1700	Ctrl Total
Number of VCPs	5	5	5	5	5	5	5	4	5	T	5	5	5	5	5	5	5	5	5	T	5	5	5	5	5	5	5	5	5	T
Species																														
Actenoides concretus			1								1				1	1				3										
Aegithina viridissima	4		2	7	2		3	2		16				2	2		1	4		9	1			4			1		1	7
Alcedo euryzona						1				1						1				1			1							1
Alcippe brunneicauda	2					3				3			2				1			3	1	4		3	3			1		12
Anorrhinus galeritus				2		1				3													1		2					3
Anthracoceros malayanus			1	3	1			1		6	4	2		2		3	11	10	11	43	4	2	5	1	2		2			16
Anthreptes malacensis																														
Anthreptes rhodolaema						1				1							1			1										
Anthreptes simplex																														
Anthreptes singalensis						1				1						1	1			2		1				1				2
Arachnothera affinis					1					1	2									2				2	1					3
Arachnothera chrysogenys	1			1		2			1	4		1								2								1		1
Arachnothera crassirostris				1						1						2				2					1				1	2
Arachnothera longirostra	1	1			1		3	1	1	7	4	4	1		3	1	3	3	1	20	1			2	3		2	1	3	12
Arachnothera robusta	2	1		1	1				1	4	2	2	1	1	1		3			10		1			5			1	1	8
Argusianus argus																								2	2		1			5
Berenicornis comatus	1		2							2																				
Blythipicus rubiginosus	1					1	1	1		3	2						2	2	1	7	3			1		2	1			7
Buceros rhinoceros													2			3		2		7	3	3	4			2	4			16
Calorhamphus fuliginosus	1				2	2	2		1	7		1		1	2			2		6		5					2	3		10
Calyptomena viridis	1													2	1	2				5										

Celeus brachyurus							2	2		4				2				1	2	5								1		1
Ceyx erithacus			1	1			1			3		3	1	1	1		1	2	1	10	1		2	1				2		6
Chloropsis cochinchinensis				1					1	2											1					1				2
Chloropsis cyanopogon											2									2	1									1
Chloropsis sonnerati				4						4	1	1		1				1	2	6			2		2				1	5
Chrysococcyx xanthorhynchus				1		1				2							1			1			1						1	2
Ciconia stormi																			1	1										
Copsychus malabaricus											1	1	1	1		1	1	4	1	11			2		1	1	2			6
Copsychus pyrropygus			1	2		1				4	2					1	1			4				1				1		2
Coracina fimbriata			1	1	1		1	1	1	6							1			1										
Corydon sumatranus		3								3																				
Criniger bres		1							1	2		3	3				1	1		8				1	1	1				3
Criniger finschii				1						1	1									1					1					1
Criniger phaeocephalus		2	2		1					5	1		1		2	1				5	1	1		3	2	2				9
Cuculus fugax													1							1										0
Cyornis caerulatus															1					1										
Cyornis superbus		1	1	2			1		2	7	2	2			1			1		6	2		1		1		1			5
Cyornis turcosus														1						1										
Dicaeum chrysorrheum																														
Dicaeum concolor																					1									1
Dicaeum trigonostigma				1	1	1				3	1				1	1				3				1						1
Dicrurus aeneus	1										2									2										
Dicrurus paradiseus	2			4		2	4	1	2	13	1	2	2		4		5	2		16	4	2	2	3	2	3	4	2		22
Dinopium rafflesii														1	1					2										
Dryocopus javensis	1		1							39																				
Enicurus leschenaulti		1								1											1							2		3
Enicurus ruficapillus												1							1	2		1					1			2
Eupetes macrocerus																													1	1
Eurylaimus javanicus											2			1	2	1		3	3	12	2		2		1		1	1		7
Eurylaimus ochromalus		1	1		2		3	2	1	10		1	4		1	2			3	11		1	2	2						5
Gracula religiosa							1		4	5								1	3	4	1								1	2
Harpactes diardii				1	1		1	1	1	5	2	1					1			4	2									2
Harpactes duvaucelii									1	1				1					2	3		1								1

Harpactes kasumba							1	1		2								1		1	1										1
Hemiprocne comata		1		2				-		3																					
Hemiprocne longipennis									1	1			1							1											
Hemipus hirundinaceus			2	1		1			1	5															1					1
Hypogramma hypogrammicum	3	2	3	2	3		2	2	2	16	5			3		1		2	1	12	2	1	2	1	2		1		1	10
Hypothymis azurea		2	2				3	2	1	10	1			1	2			2		6	1									1
Hypsipetes charlottae				1						1																				
Hypsipetes criniger				4	3	2			3	12			3		2		1			6				2	2	1		1	1	7
Hypsipetes malaccensis														2					2	4										
Ichthyophaga humilis																													1	1
Irena puella					1	1				2				1	4		2		1	8					3				1	4
Kenopia striata									1	1			2						1	3						2	1	1		4
Lacedo pulchella	1			1	1					2		1								1	1							1		2
Loriculus galgulus			1		1	1				3					1					1										0
Macronous ptilosus												2	2	2			1			7										0
Malacopteron affine						2				2	2	1			2		5	1		11	2	2		2	2					8
Malacopteron albogulare									2	2																				
Malacopteron cinereum		1		2		2			3	8		2	1	3	2	2	3	3		16	2	2		2						6
Malacopteron magnirostre													2				1			3										
Malacopteron magnum	2			1					2	3	2		1				1	2		6	5	3	1				1	2		12
Megalaima australis			2		1				3	6	3	3	1	1	1	5	2		4	20		3	1	2	2	3	4		2	17
Megalaima chrysopogon			1			3				4	2	2		1	1	1	1	1		9			2	2	5	3	1	3	1	17
Megalaima henricii																1	1			2			1		2	2		1		6
Megalaima mystacophanos														1		1				2		1	1			1			1	4
Megalaima rafflesii			2		1	1			2	6		1	2	1		4	1		1	10			1		1					2
Meiglyptes tristis																									1					1
Mulleripicus pulverulentus														1						1	1									1
Nectarinia sperata																												1		1
Nyctyornis amictus					1	1				2		1	3		2	1	1			8	1			3	2		1	2	1	10
Oriolus xanthonotus			1	1	2		2	2		8			1		1	1	1		2	6				2	1	1		1		5
Orthotomus atrogularis		1								1		1						1		2			1	1						2
Pellorneum capistratum	1						2	2		4	3	1		1		1	5	2	1	14	1	2		3	1	1	1			9
Pericrocotus igneus	2	2								2																				

Philentoma pyrrhopterum		2					1			3	1			1			1	1		4		1		1			1			3
Philentoma velatum					1					1							1		1	2				1	1					2
Phylloscopus borealis	1					1				1								1		1										
Picus miniaceus																																
Pitta baudii											1	1						1		3		1	3		1	2				7
Pitta granatina	1	1		1	2				2	6	2	1	2	1	1		2	1	2	12	1	5	2	1	2	1	1	1	1	15
Pityriasis gymnocephala					4					4							2		4	6										
Platylophus galericulatus							1	1		2																				
Platysmurus leucopterus																	1			1		2		1				5		8
Pomatorhinus montanus																1	1			2						1				1
Prionochilus maculatus	1	1	1	2	3		1	1		9	1	2	2	2	1	2	5	1	2	18		1		3	1	2	2		3	12
Prionochilus thoracicus																														
Prionochilus xanthopygius	1			2	1					3		1		1	1					3	2			2			2	1		7
Psittinus cyanurus	1		1	2		1	1	1	1	7							1			1				2	1					3
Ptilocichla leucogrammica				2			1	1		4				1						1										
Pycnonotus brunneus									1	1	1					2				3		2								2
Pycnonotus cyaniventris				2						2			1	2	4	2			1	10		1	2	2		3		1	1	10
Pycnonotus erythrophthalmus	1		2		1					3	1	2	2	3	2	2	2	4	1	19	1	1	2		3			2		9
Pycnonotus eutilotus															1		1			2		1						1		2
Pycnonotus melanoleucos																1				1										
Pycnonotus simplex									1	1				2						2						1				1
Reinwardtipicus validus																	1	2		3										
Rhamphococcyx curvirostris																			2									1		
Rhaphidura leucopygialis															1					1										
Rhinomyias umbratilis									1	1																				
Rhinoplax vigil																					1					2				3
Rhinorta chlorophaea									1	1			1					2		3									1	1
Rhipidura perlata																														
Rhopodytes diardi					1					1																				0
Rhyticeros undulatus																					1									1
Rollulus rouloul																		4	4											
Sasia abnormis											1						1			2										

Sitta frontalis		2	1							1	2																										
Spizaetus nanus		1																																			
Stachyris erythroptera								1	1		2	2	1		2	3		6	4		18		3	4	2		2			1			14				
Stachyris maculata		2			5			6	5	1	17	5	1	3	6		2	10		2	29		6		2		4	2	1	4		2		21			
Stachyris nigricollis													3					2	2		7		4						2			6				
Tephrodornis gularis						3				1	4																										
Terpsiphone paradisi															1				1		2				1					1		2				
Treron capellei																														1			1				
Treron curvirostra														1			1				2		1		1							2				
Trichastoma bicolor		2								1	1			1					1		2		1			1					1	3				
Trichastoma malaccense							2	2	2		6	3			1			3			7		4	2		1		1					8				
Trichastoma rostratum																				1	1								1		1	2				
babbler				1	1	1		2	1		6						1				1																
barbet														1						1	2																
bulbul			1	1						1	3					2			1		1		1					1	1	2			5				
drongo																		1			1																
flowerpecker			1		1	1	1				4										0		1										1				
leafbird				1	1						2					1					1										1		1				
malkoha						1					1	1								1	2											2	2				
spiderhunter			1			1				1	3										0										1		1				
sunbird			2		2		1			1	6										0			1									1				
trogon													1				1				2										1		1				
Total number of individuals		40	30	35		70	48	37		49	34	53	356		70	53	52		58	59	54		102	80	67	584		74	58	50		68	67	44		48	46	31	485

Appendix 8. Bird abundance noted in FDS plots in compartments 27-29 of the Malinua concession, September-October 1998.

	Sites													
	Control Site (CS)			Conventional Logging Site (CL)					Reduced Impact Logging Site (RIL)					
Permant Plot number[a]	EC1	EC2		H2	L1	M2	Mc		D	F	G	I		Total
Species														
Rollulus rouloul						3			8					11
Argusianus argus		1		2		4	2				4			13
Treron curvirostra				1			2					1		4
Treron olax						4								4
Chalcophaps indica	1													1
Psittinus cyanurus		1		5		3	2		2	7	1	1		22
Loriculus galgulus				3			1		1		2			7
Cuculus vagans	17	15												32
Cuculus fugax							1							1
Cuculus micropterus												2		2
Cacomantis sonneratii									2	6				8
Chrysococcyx xanthorhynchus	1			2		1				3	3			10
Rhinorta chlorophaea	6													6
Zanclostomus javanicus	1													1
Rhamphococcyx curvirostris				2		4				1				7
Carpococcyx radiceus		9												9
Centropus sinensis		1												1
Rhaphidura leucopygialis				1										1
Hemiprocne longipennis										1	5	10		16
Hemiprocne comata				1								1		2
Harpactes kasumba						3					10			13
Harpactes diardii	2	1		1	6		3							13
Harpactes duvaucelii	5	8		1	2	4	2			2	3	2		29
Alcedo meninting											1			1
Alcedo euryzona											1			1
Ceyx erithacus	1	6		2	22	6	1		5	2	5	4		54
Lacedo pulchella	4	3		10	1	9	2		1	3	3	3		39
Actenoides concretus		4		1		1			5					11
Nyctyornis amictus	11	30		23	4	9	4		25	21	11	4		142
Berenicornis comatus					5									5
Anorrhinus galeritus		2								3				5
Rhyticeros undulatus					1									1
Anthracoceros malayanus	30	3		4	10	7	4				4	2		64
Buceros rhinoceros	4	12		1			2							19
Rhinoplax vigil	2			4			6					1		13
Megalaima chrysopogon	6	2		1	3	11	2			3	3			31
Megalaima rafflesii		4		6	2	11	1		2	2	1	1		30
Megalaima henricii							3							3
Megalaima australis	9	2		3	8	15	8		1	13	17	3		79
Calorhamphus fuliginosus				8	3	15	11		7	20	7	3		74
Indicator archipelagicus									31					31
Sasia abnormis										1				1
Celeus brachyurus					1		2			2	2			7
Picus mentalis						3			1		10			14

Picus puniceus	1													1
Meiglyptes tristis											1			1
Meiglyptes tukki											1			1
Mulleripicus pulverulentus		1												1
Dryocopus javensis									22			3		25
Hemicircus concretus	1													1
Blythipicus rubiginosus		1			3		1							5
Reinwardtipicus validus	2			1	1	1	19			5				29
Corydon sumatranus	4								1					5
Eurylaimus javanicus	4	11		2			7			2				26
Eurylaimus ochromalus	17	5		10	11		18		18	20	2	10		111
Calyptomena viridis	5	2		6	1		2			1				17
Pitta granatina	23	13		14	18	14	6		1	7	6	6		108
Pitta baudii	18	1												19
Coracina striata		1												1
Coracina fimbriata							1		1	14	9	1		26
Pericrocotus igneus							1		3					4
Hemipus hirundinaceus		1		4	1	4	10		16	7				43
Tephrodornis gularis				7			2			2	1	2		14
Pycnonotus atriceps	3				1									4
Pycnonotus cyaniventris	2	2		9		5	13			8				39
Pycnonotus eutilotus	2				1	2				5				10
Pycnonotus simplex										1				1
Pycnonotus brunneus				2										2
Pycnonotus erythrophthalmus	6	9		5	3	8	4			8	4	1		48
Criniger finschii	1	1			5	1				18				26
Criniger bres	1	5				8	3		1		3	3		24
Criniger phaeocephalus	4	4		1		2	4			1	3	1		20
Hypsipetes criniger	2	7		2	2	1	4		1	15	3	2		39
Hypsipetes malaccensis		1			1	2	2							6
Aegithina viridissima	3	1		10	3	5	18		14	12	8	2		76
Chloropsis sonnerati		3		2	6	7	8		3	3	2	2		36
Chloropsis cyanopogon	4					1				2				7
Chloropsis cochinchinensis				1										1
Irena puella	1			3	1	5	1			2				13
Pityriasis gymnocephala		10									3	19		32
Copsychus malabaricus	13	7			1	4					1	4		30
Copsychus pyrropygus	1	3		1					2	7	1	1		16
Enicurus ruficapillus	1				4		1		2		1			9
Enicurus leschenaulti					2									2
Eupetes macrocerus					5									5
Pellorneum capistratum	4	4		5	2	4	16			2	12			49
Trichastoma malaccense	6	11		3	8	4	4		6	8	6	1		57
Malacopteron magnirostre	9	5		1		4			1		3	4		27
Malacopteron affine	3								1	1				5
Malacopteron cinereum	12	7		8		16	23		1	3	23	2		95
Malacopteron magnum	4	12					7		5	5	22	2		57
Malacopteron albogulare										6				6
Pomatorhinus montanus						4	16			5	21	13		59
Ptilocichla leucogrammica				9			4		15		1			29
Kenopia striata					5	2			2			6		15
Napothera atrigularis	1													1
Stachyris maculata	13	25		32	13	13	20		4	16	30	11		177

Stachyris nigricollis	10	4		10		6	1			5				36
Stachyris erythroptera	8	44		6	9	7	8			13	8	2		105
Macronous ptilosus		4				1				1				6
Alcippe brunneicauda					8					3	16			27
Orthotomus atrogularis										4		1		5
Orthotomus ruficeps										1				1
Phylloscopus borealis				14								2		16
Rhinomyias umbratilis					2		4		2		1	5		14
Cyornis superbus	3	2			3	5	1		4	4	7	3		32
Philentoma pyrrhopterum				4	1	2	5		1	1	27	7		48
Philentoma velatum		2		3	3		5				12	4		29
Hypothymis azurea				9	7		2		1	5	6	3		33
Terpsiphone paradisi		7		1	3	3			1		4	2		21
Sitta frontalis									1	2				3
Prionochilus maculatus	6	3		1	6	10	3		4	3	7	3		46
Prionochilus xanthopygius		1		4	4	2	2		8	8	2	1		32
Dicaeum trigonostigma		1												1
Anthreptes simplex									1					1
Anthreptes singalensis										3				3
Hypogramma hypogrammicum	13	9		2	7	4	12		2	15	7	2		73
Arachnothera longirostra	6	7		4	9	7			4	4	2			43
Arachnothera crassirostris		6		15	1	8	8		14	4	5	7		68
Arachnothera robusta				7		1	1		7		3	1		20
Arachnothera flavigaster					3							1		4
Arachnothera chrysogenys							2		3					5
Arachnothera affinis	5	1		3	2	2	1		2	5		1		22
Gracula religiosa	2						1		1					4
Oriolus xanthonotus		4		29	2	6	4		5	28	8	16		102
Dicrurus aeneus					1									1
Dicrurus paradiseus	22	22		19	4	30	12		11	27	21	23		191
Platylophus galericulatus				4							13	1		18
Platysmurus leucopterus	6	6		2	12	1								27
Corvus enca	1	5		1							1			8
Encounters Total	353	385		358	253	325	346		283	412	410	219		
Species Total	57	61		63	55	57	63		52	63	61	54		

[a] Sites qualitatively described in Appendix 3.2

Appendix 9. Bird species of special interest in the Malinau area.

Birds of special interest

Oriental Darter *Anhinga melanogaster*
Single bird seen on 17 September at small pool along the logging road through RKT 96/97. Near-threatened (Collar *et al*. 1994).

Storm's Stork *Ciconia stormi*
A single bird was seen on 13 October inside the swampy forest part of Petak 28/29; perhaps the same bird was seen soaring above the forest on 24 October. Endangered (Collar et al. 1994)

Jerdon's Baza *Aviceda jerdoni*
Seen on three occasions. Near-threatened (Collar *et al*. 1994)

Lesser Fish-eagle *Ichthyophaga humilis*
This eagle could be heard and seen daily while soaring at noon high above the forest. Near-threatened (Collar *et al*. 1994)

Wallace's Hawk-eagle *Spizaetus nanus*
Seen on four occasions, mostly in the first part of our survey period. Vulnerable (Collar *et al.* 1994)

Crested Partridge *Rollulus rouloul*
Regularly groups of up to a dozen birds could be seen along most transects and the permanent plots. Vulnerable (McGowan *et al*. 1995)

Crested Fireback *Lophura ignita*
Seen on a number of occasions throughout the area. A female bird was kept captive in the Sungai Sidi camp by a local Inhutani employee who told us that he had caught a dozen in the area during the past few months. Vulnerable (Collar *et al.* 1994)

Great Argus *Argusianus argus*
Heard daily throughout the area. Our transects crossed 4-5 dancing grounds on ridges. Vulnerable (McGowan & Garson 1995)

Oriental Plover *Charadrius veredus*
A single juvenile bird was seen by S. Hedges and B. Balen on 30 October at the airfield of Malinau. This comprises the first record of this plover for mainland Indonesian Borneo.

Large Green Pigeon *Treron capellei*
Regularly seen in trees along the logging roads. Near-threatened (Collar *et al*. 1994)

Blue-rumped Parrot *Psittinus cyanurus*
Seen daily flying overhead. Near-threatened (Collar *et al*. 1994)

Sunda Ground-cuckoo *Carpococcyx radiceus*
Several times heard and tape-recorded, and on 20 October a single bird was seen in the control area. Vulnerable (Collar *et al.* 1994). The Sumatran and Bornean races of this species are better considered as full species (Collar & Long 1996).

Short-toed Coucal *Centropus rectunguis*
On several occasions its characteristic “boo, boobooboo…” was heard in the forest around our jungle camp. Near-threatened (Collar *et al*. 1994)

Large Frogmouth *Batrachostomus auritus*
Single birds were heard and tape-recorded on six occasions throughout the survey area. Data deficient (Collar *et al*. 1994)

Gould's Frogmouth *Batrachostomus stellatus*
Up to 4-5 could usually be heard during moonlit nights around our jungle camp on the east bank of of the Seturan River. No recent records from Kalimantan.

[?Sunda Frogmouth *Batrachostomus cornutus*
Two birds seen in the early morning near our jungle camp were tentatively identified as this species, but no calls were heard during subsequent nights. No recent records from Kalimantan.]

Brown-backed Needletail *Hirundapus giganteus*
Almost daily a flock of up to 60 birds could be seen dipping from the river near our camp along the Seturan River; pairs were seen above the forest on a number of occasions. No recent published records are known from Kalimantan.

Wrinkled Hornbill *Rhyticeros corrugatus*
Almost daily seen and heard during the first weeks of our survey, but later only sporadically. Vulnerable (Collar et al. 1994).

Black Hornbill *Anthracoceros malayanus*
Common in small numbers throughout the survey area. Near-threatened (Collar *et al*. 1994)

Helmeted Hornbill *Rhinoplax vigil*
Common in small numbers throughout and heard daily. Near-threatened (Collar *et al*. 1994).

Red-crowned Barbet *Megalaima rafflesii*
Common throughout the area. Near-threatened (Collar *et al*. 1994)

Malaysian Honeyguide *Indicator archipelagicus*
Most likely the same bird seen and tape-recorded on three occasions in September and October in Petak 27. Near-threatened (Collar *et al*. 1994)

Hose's Broadbill *Calyptomena hosii*
Heard on three occasions in Petak 28 and the control area. Bornean endemic.

Blue-headed Pitta *Pitta baudii*
Common and widespread in small numbers. Bornean endemic. Near-threatened (Collar *et al*. 1994).

Giant Pitta *Pitta caerulea*
One female was seen on 21 October on the bank of a rivulet in Petak 29 north of our riverside camp. Near-threatened (Collar *et al*. 1994)

Bornean Bristlehead *Pityriasis gymnocephala*
On many occasions heard and seen in groups of 5-6 birds roaming the forest. Bornean endemic. Near-threatened (Collar *et al*. 1994).

White-chested Babbler *Trichastoma rostratum*
Commonly seen and heard along the larger rivers, but not elswehere. Near-threatened (Collar *et al*. 1994)

Ferruginous Babbler *Trichastoma bicolor*
Quite common and widespread in small numbers. Near-threatened (Collar *et al*. 1994)

Grey-breasted babbler *Malacopteron albogulare*
Seen and heard on least five occasions throughout the survey area. Always in the damp parts of our area. This babbler was thought to be absent from eastern Borneo (Smythies 1981). Near-threatened (Collar *et al*. 1994).

Bornean Wren-babbler *Ptilocichla leucogrammica*
Seen and heard on a number of occasions. Bornean endemic. Near-threatened (Collar *et al*. 1994)

Black-throated Wren-babbler *Napothera atrigularis*
Heard and glimpses seen on three occasions. Bornean endemic.

Striated Grassbird *Megalurus palustris*
Single bird seen and heard in the grass and shrubland bordering the Malinau airfield. This comprises the first record of this species for Kalimantan. First recorded for northern Borneo in 1982 (Francis 1985) and now common along the Sabah coast (G. Davison per DA Holmes 1998; F. Lambert pers. comm. 1998).

Bornean Blue Flycatcher *Cyornis superbus*
One of the most common flycatchers in the area. Bornean endemic.

Sunda Blue Flycatcher *Cyornis caerulatus*
Seen on one occasion. No recent records from Kalimantan. Near-threatened (Collar *et al*. 1994)

Malaysian Blue Flycatcher *Cyornis turcosus*
Locally common along the riverbanks in our survey area. Bornean endemic. Near-threatened (Collar *et al*. 1994)

Yellow-rumped Flowerpecker *Prionochilus xanthopygius*
The most common flowerpecker in the area. Bornean endemic.

Brown-backed Flowerpecker *Dicaeum everetti*
A single bird perched in the canopy of a roadside tree in Petak 28/29 on 9 October was recognized by its tail swinging and finch bill. Near-threatened (Collar *et al*. 1994)

Dusky Munia *Lonchura fuscans*
Common along the road to the north, but seldomly seen in the more recent logging areas. Bornean endemic.

Black Magpie *Platysmurus leucopterus*
Commonly seen and heard throughout our survey area. Near-threatened (Collar *et al*. 1994)

Appendix 10. Local names for birds in the Malinau area.

Punan Bird Names

Ajah	large spiderhunters *Arachnothera* sp
Balang owo'	*Oriolus xanthonotus* (owo' = fallen log)
Bangko'	*Treron capellei*
Bekukèn	*Chalcophaps indica*
Belara'	*Eurylaimus ochromalus*
Belara' ucan	*Eurylaimus javanicus*
Belekukun	*Berenicornis comatus* (AK)
Berenat	**Anthracocros malayanus*
Berenat laut	*Anthracoceros albirostris*
Balut	*Ducula* spp
Berbak	*Dryocopus*, *Mulleripicus*
Blekokow	*Nyctiornis amictus*
Butbut	*Centropus sinensis*
Buco burak	*Macronous gularis*
Bukong	*Sasia*
Bungei	**Pitta* spp
Cabong	*Copsychus pyrropygus*
Cagap	*Lacedo pulchella*
Cemubung	*Macronous ptilosus*, *Stachyris* spp (AK)
Cemubung uvan	*Macronous ptilosus* (uvan = gray hairs)
Ceriut	*Prinia flaviventris*
Gé ta'	**Indicator archipelagicus*
Guntit	*Motacilla* spp
Jané balah	*Pycnonotus* spp
Ka	*Corvus enca*
Kakap patot	*Cuculus micropterus* (AK)
Kakap uih	*Cacomantis* spp, *Surniculus*
Keli	*Orthotomus* spp
Kelèngo	*Dicrurus* spp
Kelèngo langa'	*Dicrurus aeneus* (langat = arrow for blow pipe)
Kelèngo mangat	*Dicrurus paradiseus*
Kenawai	White herons
Kicit	*Arachnothera* spp
Kiking	*Pericrocotus* spp
Kilang jemit	*Copsychus malabaricus*
Kilang punyuh	*Copsychus saularis* (punyuh = black)
Kilan lunang	*Copsychus malabaricus* (lunang = forest)
Kilan umoh	*Copsychus saularis* (umoh = ladang)
Kokow	**Nyctyornis*
Kovat	**Phodilus badius*
Kubikabau	**Pycnonotus zeylanicus*
Kuku bua'	**Megalaima henrici*, *M. chrysopogon* (bua' = fruits)
Kuju	dark herons and other long-necked water birds
Kuku sulau	**Megalaima* spp
Kunè	small *Treron* spp
Kupi'	**Malacopteron* spp

Lugom	*Lonchura* spp
Lukap	**Anorrhinus*
Matih	*Enicurus* spp
Menyang	*Pycnonotus atriceps*
Menyang punyuh	*Pycnonotus melanoleucos*
Metuy	**Rhyticeros* spp
Nyau abu'	*Ichthyophaga* spp
Nyau mengan	*Haliastur indus* (mengan = red)
Nyau telu'o	large black eagles (as big as telu'o = left over sago bark
Nyau uki	crested eagles/hawks (uki = squirrel)
Pa'ang	*Batrachostomus* spp
Pecakuh	**Rhinoplax vigil*
Pingpilang	*Pycnonotus cyaniventris*
Pingpilau	*Pericrocotus* spp (AK)
Pirit	*Lonchura* spp
Pitau	*Erythrura prasina*
Prit	**Criniger* spp
Prot	**Pycnonotus goiavier, P. plumosus*
Ruh	malkohas
Ruh kelirih	*Rhinortha chlorophaea*
Ruh tok	*Rhopodytes, Zanclostomus, Rhamphococcyx*
Tarak	**Megalaima australis*
Tekalih	*Blythipicus*
Tekuan	**Buceros rhinoceros*
Tekuan ha(n)	*Alcedo* spp, *Pelargopsis* (ha = dead wood along the river)
Tekukur	*Streptopelia*
Telecan	*Platylophus galericulatus*
Tembah	*Irena puella*
Tepilih	swiftlets, tree swifts
Tetiau	*Psittinus cyanurus* (onomatopoeia)
Titikowit	*Corydon sumatranus*
Tiun	small woodpecker
Tiung	*Gracula*
Towei	**Argusianus argus*
Tumburanau	*Cymbirhynchus*
Upau	**Harpactes* spp (small and large species were distinguished by calls, not named)
Wé ta'	**Indicator archipelagicus*
Wit	sunbirds, flowerpeckers
Wit apuy	Aethopyga spp (apuy = fire)
Wit morong	*Nectarinia sperata*
Wit pa'	*Anthreptes* spp
Wongwong	*Calyptomena viridis* (on)
Yané cegorih	*Malacopteron* spp
Yané gonggong	*Stachyris nigrcollis*
Yané	

Yané langit	*Aegithina viridissima*
Yané	
Yané ta’	**Chloropsis* spp
Yané tano	*Pellorneum capistratum* (tano = ground)
Yokuyat	*Terpsiphone paradisi*

Merap birdnames

Bai rasik	*Cacomantis merulinus*
Bau’	*Centropus*
Blara’	*Eurylaimus*
Blarei taleiy	*Copsychus malabaricus*
Blekbay	woodpeckers
Bo’ai	*Lophura bulweri*
Ci(t)	*Arachnothera* spp
Hiabiy	ducks
Hoyt	sunbirds
Hoyt tapai	*Aethopyga* spp
Hoyt taun	*Chloropsis* spp
Ka	*Corvus*
Kaka kakaw	*Cuculus micropterus*
Kauw	*Strix leptogrammica*, *Ketupa*
Kav	*Megalaima* spp
Kebiyekabau	*Pycnonotus zeylanicus*
Kehliye(ng)	*Copsychus saularis*
Kentuol	*Phalaropus* (“u” hardly pronounced)
Keyluit	*Actitis*
Kiauw	*Gracula religiosa*
Kikiy	*Psittinus*
Klancang	*Platylophus galericulatus*
Koco’	*Anhinga melanogaster*
Kwei	*Argusianus argus*
Lokua	*Anorrhinus*
Loyh	*Hirundapus* spp (large swifts)
Lukon	*Chalcophaps*
Manau èk	*Psittacula*
Manau kbéow	*Terpsiphone paradisi*
Manau kléy	*Pycnonotus atriceps*
Manau langa’	*Dicrurus* spp.
Manau lauw	firebacks *Lophura* spp
Manau matei(h)	*Enicurus* spp
Manau payèy	*Platysmurus leucopterus*
Manau talaum	brown bulbuls, *Criniger* spp
Manau tangei	*Treron* spp (tangei = to cry)
Manau tegap	*Nyctiornis amictus*
Manau tarai	*Oriolus xanthonotus*
Manau truw	*Streptopelia chinensis*
Matalow	*Rhinoplax*
Mna	*Anthacoceros malayanus*
Mpalanau	*Cymbirhynchus*

Ntau gwéy	*Rhopodytes, Zanclostomus, Rhamphococcyx*
Ntau mbla	*Rhinortha chlorophaea*
O’	*Otus lempiji*
Péi’	*Picus* spp
Sayem loloy	*Rollulus rouloul*
Tai	*Rhyticeros undulatus*
Téauw	*Lonchura* spp, *Passer montanus*
Téauw tim	*Lonchura fuscans*
Téauw tengkei	*Erythrura prasina*
Tekehow	*Berebicornis*
Tekua	*Buceros rhinoceros*
Tekua ha	kingfishers
Tempa	*Irena puella*
Tengkam	*Ducula* spp
Tengkei	*Loriculus*
Teplih	swiftlets
Teplih ngkau	*Hemiprocne* spp
To’taraw	*Eurostopodus temmincki*
Tuap	*Ninox scutulata*
Tukuong	*Sasia*
Yau	hawks and eagles

(*recognized from tapes); Punan names are from the following informants from Respen Malinau/Sungai Tubu: Murang, Kasim Amat, Awang, Ubang, Injau & Asing Ubang, except for AK (Ajang Ka); Merap names are from the following informants from Long Loreh: Anyi’ Laing, Alang Injau, Liah Lungu and Yusup Anyi’

Appendix 11. Butterflies recorded between 10-28 September 1998 in the Malinau concession of the Bulungan Research Forest, E. Kalimantan (Otsuka 1988; Tsukada et al. 1981, 1982, 1985, 1991).

PAPILIONIDAE
Troides brookiana brookiana
Troides sp.
Atrophaneura nox noctis
Papilio iswara araspes
Papilio memnon memnon
Graphium sarpedon sarpedon
Graphium agamemnon agamemnon

PIERIDAE
Catopsilia pyranthe pyranthe
Eurema hecabe hecabe
Eurema lacteola lacteola
Eurema ada ada
Eurema sari sodalis

NYMPHALIDAE: DANAINAE
Parantica crowley or P.luzonenis
Idea hypermnestra hypermnestra
Euploea eyndhovii strix
Euploea mulciber portia
Euploea midamus aegyptus
Euploea diocletianus lowii

NYMPHALIDAE: MORPHINAE
Faunis canens borneensis
Faunis gracilis gracilis
Zeuxidia amethystus wallacei

NYMPHALIDAE: NYMPHALINAE
Cupha erymanthis erymanthis
Vindula erota montana
Cirrochroa tyche thilina
Cirrochroa satellita satellita
Terinos terpander terpander
Terinos clarissa praestigiosa
Junonia iphita viridis
Hypolimnas misippus misippus
Hypolimnas bolina philippensis
Chersonesia risa cyanee
Pantoporia dindinga
Lasippa tiga empat
Neptis leucoporos cresina

Athyma pravara pravara
Athyma nefte subrata
Pandita sinope sinope
Parthenos sylvia borneensis
Tanaecia munda munda
Tanaecia aruna aparasa
Euthalia godartii vacillaria *
Euthalia iapis ambalika *
Euthalia monina bipunctata
Bassarona dunya monara
Lexias dirtea chalcenoides
Lexias canescens canescens
Euripus nyctelius borneensis

NYMPHALIDAE: CHARAXINAE
Prothoe franckii borneensis
Polyura delphis concha
Polyura screiber malayica
Charaxes bernardus reptitus

LYCAENIDAE: RIODIONINAE
Abisara geza litavisus
Paralaxita damajanti cyme or lola
Paralaxita telesia lyclene
Paralaxita telesia ines
Paralaxita orphna orphna

NYMPHALIDAE: SATYRINAE
Erites elegans elegans
Neorina lowii lowii
Mycalesis sp. 1
Mycalesis horsfieldii hermana
Mycalesis mineus macromalayana
Mycalesis dohertyi excelsior
Orsotriaena medus medus
Ragadia makuta umbrata

* Specimen needs to be checked to confirm name.

Appendix 12. Ant species collected in the Malinau concession, E. Kalimantan, September 1998.

No. of Species	Taxa	Conventional Logging	Reduce Impact Logging	Control	Total
1	*Acanthomyrmex* sp. 1	5	9	1	15
2	*Acanthomyrmex* sp. 2	7	11	5	23
3	*Acanthomyrmex* sp. 3	11	2	1	14
4	*Anochetus* sp. 1	2	2	4	8
5	*Anochetus* sp. 2	1		2	3
6	*Anoplolepis*sp	2	1		3
7	*Aphaenogaster*sp. 1	2	29		31
8	*Aphaenogaster*sp. 2	45	61	9	115
9	*Aphaenogaster*sp. 3	2	13	2	17
10	*Aphaenogaster*sp. 4	320	104	106	530
11	*Aphaenogaster*sp. 5	277	92	124	493
12	*Aphaenogaster*sp. 6	1	20	1	22
13	*Aphaenogaster*sp. 7	11	4	7	22
14	*Caliptomyrmex*sp. 1	16		4	20
15	*Caliptomyrmex*sp. 2	14	1		15
16	*Caliptomyrmex*sp. 3	3		3	6
17	*Camponotus* sp. 1		3	1	4
18	*Camponotus* sp. 2	32	10	12	54
19	*Camponotus* sp. 3	41	1	8	50
20	*Camponotus* sp. 4			21	21
21	*Cataulacus* sp. 1	46	5	3	54
22	*Cataulacus* sp. 2			2	2
23	*Cerapachis* sp. 1	1	3		4
24	*Cerapachis* sp. 2	1			1
25	*Cerapachis* sp. 3	5	13		18
26	*Cerapachis* sp. 4	2	9		11
27	*Colobopsis* sp. 1	2	1	2	5
28	*Colobopsis* sp. 2	16	6	3	25
29	*Colobopsis* sp. 3	8			8
30	*Crematogaster* sp. 1	3	13	1	17
31	*Crematogaster* sp. 2	1			1
32	*Crematogaster* sp. 3	1			1
33	*Crematogaster* sp. 4			23	23
34	*Crematogaster* sp. 5	2	1	11	14
35	*Crematogaster* sp. 6	2	19	7	28
36	*Crematogaster* sp. 7	2	2	2	6
37	*Crematogaster* sp. 8	316	395	82	793
38	*Crematogaster* sp. 9		2	1	3
39	*Crematogaster* sp. 10	1			1
40	*Diacamma* sp	4	7		11
41	*Discotheria* sp	3			3
42	*Dorilus*sp	31	10	1	42
43	*Echinoopla*sp. 1	2	4		6
44	*Echinoopla*sp. 2	1		1	2
45	*Euprenolepis* sp	136	3	28	167
46	*Gnamptogenys* sp. 1	1	4	1	6
47	*Gnamptogenys* sp. 2	4		3	7
48	*Gnamptogenys* sp. 3	12	15	29	56
49	*Gymnomyrmex* sp	96	24	19	139
50	*Hypoclinea* sp		28	1	29
51	*Hypoponera* sp. 1	36	79	36	151
52	*Hypoponera* sp. 2	3			3
53	*Iridomyrmex* sp. 1	1	5		6

54	*Leptogenys* sp. 1		34	3	37
55	*Leptogenys* sp. 2	1	2	14	17
56	*Leptogenys* sp. 3	21	6	5	32
57	*Leptomyrmex* sp	7	5	1	13
58	*Mistrium* sp	6	14	6	26
59	*Myrmecina* sp	2	2	1	5
60	*Myrmica* sp. 1	13	3	31	47
61	*Myrmica* sp. 2	1		9	10
62	*Myrmica* sp. 3		2		2
63	*Myrmica* sp. 4			2	2
64	*Myrmica* sp. 5	7	2	12	21
65	*Myrmica* sp. 6		4	2	6
66	*Myrmicaria* sp. 1	16	4		20
67	*Myrmicaria* sp. 2	23			23
68	*Myrmoteras* sp. 1	1			1
69	*Myrmoteras* sp. 2	1	17	2	20
70	*Neostruma* sp	223	19	17	259
71	*Odontomachus* sp. 1	61	38	25	124
72	*Odontomachus* sp. 2		11	1	12
73	*Odontoponera* sp	129	63	34	226
74	*Oecophyla* sp	1	2	2	5
75	*Oligomyrmex* sp	2	1		3
76	*Pachycondyla* sp. 1	37	3	2	42
77	*Pachycondyla* sp. 2	7		11	18
78	*Pachycondyla* sp. 3	7	4		11
79	*Pachycondyla* sp. 4	3	1		4
80	*Parathrechina* sp	23	6	6	35
81	*Paratopula* sp. 1	2			2
82	*Paratopula* sp. 2	1	1		2
83	*Paratopula* sp. 3		8		8
84	*Paratrechina* sp. 1	198	128	16	342
85	*Paratrechina* sp. 2	9			9
86	*Paratrechina* sp. 3	22	13	2	37
87	*Paratrechina* sp. 4	1			1
88	*Paratrechina* sp. 5	1	5		6
89	*Pheidole* sp. 1	117	30	33	180
90	*Pheidole* sp. 2	3			3
91	*Pheidole* sp. 3	1			1
92	*Pheidole* sp. 4	8	5	2	15
93	*Pheidole* sp. 5	7		12	19
94	*Pheidole* sp. 6	16	19	39	74
95	*Pheidole* sp. 7			1	1
96	*Pheidole* sp. 8	38		2	40
97	*Pheidole* sp. 9	121	4	2	127
98	*Pheidole* sp. 10	261	20	13	294
99	*Pheidologeton* sp. 1		1		1
100	*Pheidologeton* sp. 2		15	3	18
101	*Pheidologeton* sp. 3	5			5
102	*Polyrhachis* sp. 1	9	1	5	15
103	*Polyrhachis* sp. 2		13	1	14
104	*Polyrhachis* sp. 3	2	1	2	5
105	*Polyrhachis* sp. 4			2	2
106	*Polyrhachis* sp. 5	13	1	6	20
107	*Polyrhachis* sp. 6		5	4	9
108	*Polyrhachis* sp. 7	10			10
109	*Polyrhachis* sp. 8	1		1	2
110	*Polyrhachis* sp. 9	6			6
111	*Polyrhachis* sp. 10	3			3
112	*Polyrhachis* sp. 11	1			1

113	*Polyrhachis* sp. 12			3	3
114	*Ponera* sp. 1	21		5	26
115	*Ponera* sp. 2	40		10	50
116	*Ponera* sp. 3			2	2
117	*Ponera* sp. 4	33			33
118	*Ponera* sp. 5	4			4
119	*Pristomyrmex* sp. 1	9	17		26
120	*Pristomyrmex* sp. 2		2		2
121	*Proatta* sp	9	7	4	20
122	*Solenopsis* sp. 1	3	1	3	7
123	*Solenopsis* sp. 2	1			1
124	*Strumigenys* sp	242	174	66	482
125	*Tapinoma* sp. 1	1	4		5
126	*Tapinoma* sp. 2	11	22	2	35
127	*Tetramorium* sp. 1	4	5	3	12
128	*Tetramorium* sp. 2		1		1
129	*Tetramorium* sp. 3	1	14		15
130	*Tetraponera* sp. 1	3		1	4
131	*Tetraponera* sp. 2		2		2
132	*Vollenhovia* sp. 1	9	39		48
133	*Vollenhovia* sp. 2	4			4
134	*Vollenhovia* sp. 3	1			1
	Total	**3375**	**1812**	**998**	**6185**

ORDER	FAMILY	SPC. CODE	BLOCK PLOT	CL H1	CL H2	CL H3	CL HC	CL M1	CL M2	CL M3	CL MC	CL L1	CL L2	CL L3	CL LC	CL	RIL A	RIL B	RIL C	RIL D	RIL E2	RIL F	RIL G	RIL H1	RIL H2	RIL I	RIL K	RIL L	RIL	C 1	C 2	C 3	C 4	C
Blattaria	Cryptoceridae	Bla-Cry-1		2	1	2	4	9		5		1			1	25	1			3				2		5		11				3	3
Blattaria	Blattelidae	Bla-Blat-1		6	1					1						8			2						2	1	1	6					0
Coleoptera	Anobiidae	Col-Ano-1					1									1												0					0
Coleoptera	Bostrichidae	Col-Bos-1					2						2			4												0					0
Coleoptera	Bostrichidae	Col-Bos-2					14									14				1								1					0
Coleoptera	Brentidae	Col-Bre-2														0					1							1					0
Coleoptera	Bruchidae	Col-Bru-1		1	1	1										3						8		2		1		11					0
Coleoptera	Carabidae	Col-Car-1						1								1									1			1					0
Coleoptera	Carabidae	Col-Car-5														0					1							1					0
Coleoptera	Chrysomelidae	Col-Chr-1		2												2												0					0
Coleoptera	Chrysomelidae	Col-Chr-21												1		1												0					0
Coleoptera	Chrysomelidae	Col-Chr-19														0	1											1			1		1
Coleoptera	Coccinelidae	Col-Coc-2								3						3												0					0
Coleoptera	Curculionidae	Col-Cur-1														0												0	1				1
Coleoptera	Curculionidae	Col-Cur-2														0							1					1					0
Coleoptera	Elateridae	Col-Ela-1														0									1			1				1	1
Coleoptera	Eucnemidae	Col-Euc-2													1	1												0					0
Coleoptera	Histeridae	Col-His-1			3								7			10												0					0
Coleoptera	Hydrophilidae	Col-Hyd-1				1										1	1								1			2	1				1
Coleoptera	Lathridiidae	Col-Lat-1										1				1												0					0
Coleoptera	Lathridiidae	Col-Lat-2											2			2												0					0
Coleoptera	Mordellidae	Col-Mor-1						1								1												0					0
Coleoptera	Nitidulidae	Col-Nit-1			5								17		3	25				2	3	3			1	1	1	11					0
Coleoptera	Nitidulidae	Col-Nit-2														0				1								1					0
Coleoptera	Phalacridae	Col-Pha-1			1											1	1		1	1			2					5			2		2
Coleoptera	Phalacridae	Col-Pha-2														0									1			1	4				4
Coleoptera	Pselaphidae	Col-Psel-1														0								1				1					0
Coleoptera	Ptilidae	Col-Pti-1					1		3	7	1	1	2	5	1	21	2	3	7	1		1		5	4	2	1	26	3			2	5
Coleoptera	Scarabaeidae	Col-Sca-1														0				3	1	1						5					0
Coleoptera	Scarabaeidae	Col-Sca-2			1			1								2			1					3	1			5					0
Coleoptera	Scarabaeidae	Col-Sca-10					1									1												0		1			1
Coleoptera	Scolytidae	Col-Sco-1			3							1	7			11	1		2	4								7					0
Coleoptera	Scolytidae	Col-Sco-2			6								1			7	2	1				7	2	5	1			18					0
Coleoptera	Scolytidae	Col-Sco-3			2											2												0					0
Coleoptera	Scolytidae	Col-Sco-4										1	4			5				2		2						4					0
Coleoptera	Scolytidae	Col-Sco-5										1	3			4		1	1	2								4					0
Coleoptera	Scolytidae	Col-Sco-6										1	1			2	1	4	4									9					0
Coleoptera	Scolytidae	Col-Sco-8														0								1				1					0
Coleoptera	Sphaeriidae	Col-Sph-1														0	27					1	2					30					0
Coleoptera	Sphindidae	Col-Sphi-1														0												0	1				1
Coleoptera	Staphylinidae	Col-Sta-1		18	12	17	9	14	9	29	7	11	15	20	10	171	16	7	10	2	24	5	7	41	20	12	14	5	163	3	8	20	5	36
Coleoptera	Staphylinidae	Col-Sta-2		6	4	5	1	7	2	4		6	5	5	4	49	5	4	8		2	1		7	7	1	1		36	3				3
Coleoptera	Staphylinidae	Col-Sta-3			2	2			2						1	7	2						1				1		4					0
Coleoptera	Staphylinidae	Col-Sta-4							1				2			3			4						4	2			10					0
Coleoptera	Staphylinidae	Col-Sta-5							2							2												0					0
Coleoptera	Tenebrionidae	Col-Ten-1			1											1												0	1				1
Collembola	Isotomidae	Coll-Iso-1		2	1	3	1	2		4	1		2	3	10	29	3			2		3	1	1	1			11				2	2
Collembola	Entomobryidae	Coll-Ent-1			14	21	20	7	7	22	10	7	6	13	17	144	5	4	10	3		23	1	10	9	10	3	4	82	11		2		13
Collembola	Entomobryidae	Coll-Ent-2												1		1											15	15					0
Collembola	Onychiuridae	Coll-Ony-1			5	1				1	1	4		6	1	19	2				1		5	11		3	7	29	3			4	7
Collembola	Sminthuridae	Coll-Smi-1			1		1		7	6			1	1	3	20	1	1	3			1		1	2			9				1	1
Collembola	Poduridae	Coll-Pod-1			1											1				1	1							2					0
Collembola	Hypogastruridae	Coll-Hyp-1					1									1			1			74		1					76					0
Collembola	Hypogastruridae	Coll-Hyp-2														0									1			1					0
Diptera	Asteiidae	Dip-Ast-1														0						1						1		1			1

Diptera	Aulacigastridae	Dip-Aul-1													0											1		1					0
Diptera	Calliphoridae	Dip-Call-1				1		1							2													0					0
Diptera	Calliphoridae	Dip-Call-2							1						1													0					0
Diptera	Cecidomyidae	Dip-Cec-1	1	2		1				1				10	15			3						2				5		1			1
Diptera	Cecidomyidae	Dip-Cec-2							1	1					2	2												2			1		1
Diptera	Cecidomyidae	Dip-Cec-3										2	4		6	3				1								4			1		1
Diptera	Cecidomyidae	Dip-Cec-4											13		13			1						4	2		2	9			4		4
Diptera	Cecidomyidae	Dip-Cec-5													0			1					1	1			1	4					0
Diptera	Cecidomyidae	Dip-Cec-6													0										1			1					0
Diptera	Ceratopogonidae	Dip-Cer-1		1		1	3						1		6	6								1				7					0
Diptera	Ceratopogonidae	Dip-Cer-2													0							1	1					2					0
Diptera	Ceratopogonidae	Dip-Cer-3		1											1								1					1					0
Diptera	Chamaemyidae	Dip-Cha-1									2				2													0					0
Diptera	Chironomidae	Dip-Chi-1													0	3												3					0
Diptera	Chloropidae	Dip-Chl-1						3							3				1									1			1		1
Diptera	Dolichopodidae	Dip-Dol-1	2						1						3													0		2	1		3
Diptera	Dolichopodidae	Dip-Dol-5											2		2													0					0
Diptera	Drosophilidae	Dip-Dro-1													0													0		6			6
Diptera	Drosophilidae	Dip-Dro-2													0													0		2			2
Diptera	Empididae	Dip-Emp-1											1		1						1							1					0
Diptera	Empididae	Dip-Emp-2													0						1		1					2					0
Diptera	Ephidridae	Dip-Eph-1												1	1													0		1			1
Diptera	Heleomyzidae	Dip-Hel-1													0			1					1	2				4					0
Diptera	Hippoboscidae	Dip-Hip-1	1												1													0					0
Diptera	Lauxaniidae	Dip-Lau-1							2						2	1							1					2					0
Diptera	Muscidae	Dip-Mus-1													0								1					1					0
Diptera	Mycetophilidae	Dip-Myc-1								1					1													0					0
Diptera	Mycetophilidae	Dip-Myc-4							1						1													0					0
Diptera	Neriidae	Dip-Ner-1						2							2													0					0
Diptera	Phoridae	Dip-Pho-1	5		8			7	1				3	2	26	2				8			10		4			24		1	5		6
Diptera	Phoridae	Dip-Pho-2			2			6	17	7	2	1	1	4	40	6		5	2	17	1	1	28	7	2	5	11	85	3		2	2	7
Diptera	Phoridae	Dip-Pho-3											4	1	5								3					3					0
Diptera	Phoridae	Dip-Pho-4						7							7						1		4					5	1				1
Diptera	Psycodidae	Dip-Psy-1							1						1													0					0
Diptera	Rhagionidae	Dip-Rha-1						4							4													0					0
Diptera	Sciaridae	Dip-Sci-1	12		1	1	3			1					18				1		1		8	2				12	1	3	2	1	7
Diptera	Sciaridae	Dip-Sci-2			.										0													0			1		1
Diptera	Sciaridae	Dip-Sci-3													0													0	1	2			3
Diptera	Sciaridae	Dip-Sci-4		3											3													0					0
Diptera	Sciomyzidae	Dip-Scio-1													0	1				1					8		1	11					0
Diptera	Sphaeroceridae	Dip-Sph-1	1		5	5			3	1			3	2	20	4	1						11	2	1		1	20					0
Diptera	Sphaeroceridae	Dip-Sph-2			1	4	6		14	1		8	35	3	72	7		10			3		13	9	1	1		44	3		3		6
Diptera	Sphaeroceridae	Dip-Sph-3											4		4								2		3			5					0
Diptera	Sphaeroceridae	Dip-Sph-4						1	2	1		10	3	2	19			1						1				2					0
Diptera	Sphaeroceridae	Dip-Sph-5													0											1		1					0
Diptera	Tethinidae	Dip-Tet-1													0				2									2					0
Diptera	Tipulidae	Dip-Tip-1				1									1													0					0
Diptera	Dip-B	Dip-B-1													0													0		1			1
Diptera	Dip-C	Dip-C-1													0								1					1					0
Diptera	Dip-D	Dip-D-1					1	1							2													0		1			1
Diptera	Dip-E	Dip-E-1													0				8									8					0

Diptera	Dip-F	Dip-F-1													0													0	1				1
Ephemeroptera	Baetidae	Eph-Bae-1													0	5		1						1				7					0
Hemiptera	Coreidae	Hem-Cor-1													0													0		10			10
Hemiptera	Cydnidae	Hem-Cyd-1													0													0				1	1
Hemiptera	Lygaeidae	Hem-Lyg-1	1					9							10													0					0
Hemiptera	Miridae	Hem-Mir-1				3			4	3	3	5	18	2	38	2	8	16		1	1	2	11	14		1		56	2	2	14		18
Hemiptera	Reduviidae	Hem-Red-1													0											1		1					0
Hemiptera	Tingidae	Hem-Tin-1													0					1								1					0
Homoptera	Cicadellidae	Hom-Cic-2	2				2								4													0					0
Homoptera	Delphacidae	Hom-Del-1									1		1		2													0					0
Homoptera	Cercopidae	Hom-Cer-1													0	2												2					0
Homoptera	Cercopidae	Hom-Cer-2													0		2	1										3					0
Hymenoptera	Ceraphronidae	Hym-Cer-1					1								1								1					1	2				2
Hymenoptera	Chrosididae	Hym-Chro-1													0											1		1					0
Hymenoptera	Conophidae	Hym-Con-1				1									1													0					0
Hymenoptera	Cynipidae	Hym-Cyn-1													0								1					1					0
Hymenoptera	Diapriidae	Hym-Dia-1	1												1				1									1					0
Hymenoptera	Drynidae	Hym-Dry-1													0								1					1					0
Hymenoptera	Eulophidae	Hym-Eul-1							1				1	2	4													0		2			2
Hymenoptera	Eulophidae	Hym-Eul-2													0													0			1		1
Hymenoptera	Formicidae	Hym-For-1	2	5	1			3	1				4	6	22			1		1			3	2	3			10		1	2	3	6
Hymenoptera	Formicidae	Hym-For-2			2	1		10		2	1	3		7	26		2	7				3		2	1			15			1	12	13
Hymenoptera	Formicidae	Hym-For-4											4		4													0	1				1
Hymenoptera	Formicidae	Hym-For-8					1						1		2		2	1	1	7	1			1				13	1				1
Hymenoptera	Formicidae	Hym-For-26										3			3							1						1	1				1
Hymenoptera	Formicidae	Hym-For-28		5						1				9	15	5	6	2	5		1		1	3		1		24	6	1	21	4	32
Hymenoptera	Formicidae	Hym-For-34		7	1	72	##	2	1	13		12	4	9	223	6	21	18	1	16	1	10	56	3		1		133	4	6	11	2	23
Hymenoptera	Formicidae	Hym-For-46	15	51	2	2	8	17	1	11	2	14	24	14	161	4	5	2			4	5	35	1	2	3		61	1	3	6		10
Hymenoptera	Formicidae	Hym-For-50								4		6		33	43		1	1					1					3					0
Hymenoptera	Formicidae	Hym-For-60													0									2				2					0
Hymenoptera	Formicidae	Hym-For-62											4	2	6						4	2						6					0
Hymenoptera	Formicidae	Hym-For-63			1				1						2						1	5	1					7					0
Hymenoptera	Formicidae	Hym-For-67		3	24					1					28													0					0
Hymenoptera	Formicidae	Hym-For-72	3	7	17	7	7	3	1						45							1						1		6		1	7
Hymenoptera	Formicidae	Hym-For-73	2					2							4	1		1	2					2				6			1		1
Hymenoptera	Formicidae	Hym-For-75							2			3			5													0					0
Hymenoptera	Formicidae	Hym-For-85	79	7	##	6	6	4	3	2	4	34	79	1	366	7				1			2		16	12	8	46	1	16	9	3	29
Hymenoptera	Formicidae	Hym-For-87				12					2		240	11	265	4				1			4		1			10	2			1	3
Hymenoptera	Formicidae	Hym-For-97		5	17	15	12	3	7	8	5	9	157	3	241		12	10	4		1	11	1			3		42	2	78	5	4	89
Hymenoptera	Formicidae	Hym-For-98		1											1				1									1					0
Hymenoptera	Formicidae	Hym-For-102		1				2		1					4													0	5				5
Hymenoptera	Formicidae	Hym-For-104	2						9	1	3		1	1	17		2				1						1	4	3	1		1	5
Hymenoptera	Formicidae	Hym-For-117		2						5		7			14	6												6					0
Hymenoptera	Formicidae	Hym-For-125					1					1			2										9			9					0
Hymenoptera	Formicidae	Hym-For-126		8	72	27		2	2	3	22	8	81	13	238	9	3				1		3					16	3		7	6	16
Hymenoptera	Formicidae	Hym-For-128						3				3			6			1										1	7				7
Hymenoptera	Formicidae	Hym-For-129						1	6		1			1	9							1	2					3					0
Hymenoptera	Formicidae	Hym-For-130							1				1		2													0			1		1
Hymenoptera	Formicidae	Hym-For-131										1			1						1		13					14				1	1
Hymenoptera	Formicidae	Hym-For-132											2		2													0					0
Hymenoptera	Formicidae	Hym-For-136											1		1													0					0
Hymenoptera	Formicidae	Hym-For-138											1		1													0					0
Hymenoptera	Formicidae	Hym-For-141													0	3												3	1				1
Hymenoptera	Formicidae	Hym-For-142													0												1	1	2				2
Hymenoptera	Formicidae	Hym-For-143													0								45					45					0
Hymenoptera	Formicidae	Hym-For-150	1	1											2	1												1	4				4

Hymenoptera	Formicidae	Hym-For-155	4							1					5				5				1					6		1			1
Hymenoptera	Formicidae	Hym-For-156													0	1							1					2					0
Hymenoptera	Formicidae	Hym-For-157	2												2	1	1	1					1					4					0
Hymenoptera	Formicidae	Hym-For-161		151		1	1		2			1	9		165				7	1	1	11						20					0
Hymenoptera	Formicidae	Hym-For-162	1		4	2						1			8	1							6		1	2		10			5		5
Hymenoptera	Formicidae	Hym-For-166													0													0					0
Hymenoptera	Formicidae	Hym-For-163				2									2													0				1	1
Hymenoptera	Formicidae	Hym-For-169													0							1						1					0
Hymenoptera	Formicidae	Hym-For-173											6	1	7									2	1			3	16	1			17
Hymenoptera	Formicidae	Hym-For-175					1								1								1					1					0
Hymenoptera	Formicidae	Hym-For-176					6	1	1				13		21	2						1						3					0
Hymenoptera	Ichneumonidae	Hym-Ich-1	1											1	2											1		1			1		1
Hymenoptera	Ichneumonidae	Hym-Ich-20	1												1													0					0
Hymenoptera	Mymaridae	Hym-Mym-1				1			1				4		6													0	5	1			6
Hymenoptera	Mymaridae	Hym-Mym-5						1							1													0					0
Hymenoptera	Perilampidae	Hym-Per--1													0				1									1					0
Hymenoptera	Platygasteridae	Hym-Pla-1													0													0			1		1
Hymenoptera	Platygasteridae	Hym-Pla-3									1				1													0					0
Hymenoptera	Platygasteridae	Hym-Pla-4											1		1													0					0
Hymenoptera	Pteromalidae	Hym-Pte-1					1								1									1				1		1			1
Hymenoptera	Scelionidae	Hym-Sce-1			2	1			3			2	1		9	1						4	1					6			1		1
Hymenoptera	Scelionidae	Hym-Sce-2											3		3							1	1					2	1				1
Hymenoptera	Scelionidae	Hym-Sce-3											1		1	1									1			2					0
Hymenoptera	Scelionidae	Hym-Sce-4													0												2	2					0
Hymenoptera	Scelionidae	Hym-Sce-5									1		2		3													0					0
Hymenoptera	Stephaniidae	Hym-Ste-1							2						2													0					0
Hymenoptera	Hym-D	Hym-D-1													0			1										1					0
Hymenoptera	Hym-E	Hym-E-1													0			1										1					0
Isoptera	Termitidae	Iso-Ter-1	71	2	2			176			2	21	1	28	303	38	2	4	58			39	1	5				147	1	182	5		188
Isoptera	Termitidae	Iso-Ter-2													0											8		8					0
Isoptera	Rhinotermitidae	Iso-Rhi-1													0										2			2					0
Lepidoptera	Limacodidae	Lep-Lim-1													0							1						1					0
Microcoryphia	Machilidae	Mic-Mac-1													0							1						1					0
Orthoptera	Acrididae	Ort-Acr-2									1				1													0					0
Orthoptera	Gryllidae	Ort-Gry-1	7	3	13	1	6	1	3	3	2	2	3	2	46	1	2	2	1		1	2	2		1	1		13		4	4	2	10
Orthoptera	Gryllidae	Ort-Gry-2				2	2	8			4				16	2							5		5		1	13	2		1		3
Orthoptera	Gryllidae	Ort-Gry-3											1		1													0					0
Orthoptera	Tetrigidae	Ort-Tet-1													0								12		1			13	1			1	2
Psocoptera	Lepidopsocidae	Pso-Lep-1			1										1													0					0
Thysanoptera	Phlaeothripidae	Thy-Pha-1													0				3									3					0
		Num. Ind.													3326													1704					668
		Num. Spc.													139													136					80

Appendix 14. Insects collected using sweep nets in the Malinau concession of the BRF, September 1998.

ORDER	FAMILY	SPC. CODE	BLOCK METHOD PLOT	CL SN H1	CL SN H2	CL SN H3	CL SN HC	CL SN M1	CL SN M2	CL SN M3	CL SN MC	CL SN L1	CL SN L2	CL SN L3	CL SN LC	CL	RIL SN A	RIL SN B	RIL SN C	RIL SN D	RIL SN E2	RIL SN F	RIL SN G	RIL SN H1	RIL SN H2	RIL SN I	RIL SN K	RIL SN L	RIL	C SN 1	C SN 2	C SN 3	C SN 4	C
Blattaria	Cryptoceridae	Bla-Cry-1							1		1				1	3					1							1	2		1			1
Blattaria	Cryptoceridae	Bla-Cry-2											2			2													0					0
Blattaria	Blattelidae	Bla-Blat-1				1			1		1					3			1	3				1					5	1				1
Blattaria	Blattelidae	Bla-Blat-2														0								1					1					0
Blattaria	Blattidae	Bla-Blati-1										1				1													0					0
Blattaria	Blattidae	Bla-Blati-2													2	2										1			1					0
Blattaria	Blattidae	Bla-Blati-3														0										1			1					0
Blattaria	Blattidae	Bla-Blati-4														0										1			1					0
Coleoptera	Anthicidae	Col-Ant-1			1										1	2													0					0
Coleoptera	Brentidae	Col-Bre-1													1	1				1									1					0
Coleoptera	Brentidae	Col-Bre-2		2					1			3				6		1						1					2					0
Coleoptera	Brentidae	Col-Bre-3								3		1	1			5													0					0
Coleoptera	Bruchidae	Col-Bru-1		2						1	1					4													0					0
Coleoptera	Bruchidae	Col-Bru-2								1		1	3			5													0		1			1
Coleoptera	Bruchidae	Col-Bru-3								2						2													0		1			1
Coleoptera	Bruchidae	Col-Bru-4											1			1													0					0
Coleoptera	Byrrhidae	Col-Byr-1														0											1		1					0
Coleoptera	Cantharidae	Col-Can-1														0				1									1					0
Coleoptera	Carabidae	Col-Car-1		1									1		1	3													0					0
Coleoptera	Carabidae	Col-Car-2														0													0		2			2
Coleoptera	Carabidae	Col-Car-4														0													0		1			1
Coleoptera	Carabidae	Col-Car-5		1												1													0					0
Coleoptera	Cerambycidae	Col-Ceram-1											1			1													0					0
Coleoptera	Cerambycidae	Col-Ceram-2				1					5					6													0					0
Coleoptera	Chelonariidae	Col-Che-1											1			1													0					0
Coleoptera	Chelonariidae	Col-Che-2														0													0		1			1
Coleoptera	Chelonariidae	Col-Che-3										3				3													0					0
Coleoptera	Chrysomelidae	Col-Chr-1		1	1		1		1							4				1	1							1	3					0
Coleoptera	Chrysomelidae	Col-Chr-2							2							2									2				2				1	1
Coleoptera	Chrysomelidae	Col-Chr-3													1	1													0					0
Coleoptera	Chrysomelidae	Col-Chr-4														0										3			3		1			1
Coleoptera	Chrysomelidae	Col-Chr-5			2							1				3													0					0
Coleoptera	Chrysomelidae	Col-Chr-7													2	2													0					0
Coleoptera	Chrysomelidae	Col-Chr-8											1			1													0					0
Coleoptera	Chrysomelidae	Col-Chr-9										1	1			2													0					0
Coleoptera	Chrysomelidae	Col-Chr-10			1	1				1		1				4													0					0
Coleoptera	Chrysomelidae	Col-Chr-22								1						1													0					0
Coleoptera	Chrysomelidae	Col-Chr-19		3												3													0					0
Coleoptera	Chrysomelidae	Col-Chr-13													3	3													0					0
Coleoptera	Chrysomelidae	Col-Chr-14											1			1													0					0
Coleoptera	Chrysomelidae	Col-Chr-16				1					1					2													0					0
Coleoptera	Chrysomelidae	Col-Chr-17					1									1													0					0
Coleoptera	Chrysomelidae	Col-Chr-18														0				1									1					0
Coleoptera	Cleridae	Col-Cle-1								1			5		1	7													0	2		1		3
Coleoptera	Cleridae	Col-Cle-4												1		1													0					0
Coleoptera	Coccinelidae	Col-Coc-1			1								2	3		6													0					0
Coleoptera	Coccinelidae	Col-Coc-2														0			1										1					0
Coleoptera	Coccinelidae	Col-Coc-3														0			1										1					0
Coleoptera	Coccinelidae	Col-Coc-4									1					1													0					0

Coleoptera	Coccinelidae	Col-Coc-5										1		1											0					0
Coleoptera	Coccinelidae	Col-Coc-6	1					1						2											0					0
Coleoptera	Corylophidae	Col-Cor-1												0									1		1					0
Coleoptera	Cryptocephalidae	Col-Cryp-2						1						1											0					0
Coleoptera	Curculionidae	Col-Cur-1									6			6			1								1					0
Coleoptera	Curculionidae	Col-Cur-2			1						1			2											0		1			1
Coleoptera	Curculionidae	Col-Cur-3			1									1											0	2				2
Coleoptera	Curculionidae	Col-Cur-4						2				1		3											0					0
Coleoptera	Curculionidae	Col-Cur-5						1						1											0					0
Coleoptera	Curculionidae	Col-Cur-6							1					1											0			1		1
Coleoptera	Curculionidae	Col-Cur-7												0								1			1					0
Coleoptera	Curculionidae	Col-Cur-9							1					1					1						1					0
Coleoptera	Curculionidae	Col-Cur-11		1										1											0					0
Coleoptera	Curculionidae	Col-Cur-14								1				1											0					0
Coleoptera	Elateridae	Col-Ela-1										1		1	1	1								1	3			1		1
Coleoptera	Elateridae	Col-Ela-2						2						2											0					0
Coleoptera	Elateridae	Col-Ela-3	1					9			3		2	15						1		1	1		3	2	1			3
Coleoptera	Elateridae	Col-Ela-5												0					1						1					0
Coleoptera	Elateridae	Col-Ela-6			2								1	3					1						1					0
Coleoptera	Elateridae	Col-Ela-7										1		1											0					0
Coleoptera	Elateridae	Col-Ela-8											1	1											0			2		2
Coleoptera	Elateridae	Col-Ela-9									1			1											0					0
Coleoptera	Elateridae	Col-Ela-10									1			1											0					0
Coleoptera	Eucnemidae	Col-Euc-1										2		2											0					0
Coleoptera	Eucnemidae	Col-Euc-3							1					1											0					0
Coleoptera	Hydrophilidae	Col-Hyd-1												0											0				1	1
Coleoptera	Lathridiidae	Col-Lat-1												0										1	1					0
Coleoptera	Leiodidae	Col-Lei-1												0											0			1		1
Coleoptera	Leiodidae	Col-Lei-5						1						1											0					0
Coleoptera	Lycidae	Col-Lyc-1												0					1						1			1		1
Coleoptera	Lycidae	Col-Lyc-2						1				1		2											0					0
Coleoptera	Lycidae	Col-Lyc-3						2			1			3											0					0
Coleoptera	Meloidae	Col-Melo-1					2							2											0					0
Coleoptera	Melyridae	Col-Mer-1								1				1											0					0
Coleoptera	Mordellidae	Col-Mor-1			1	1					4		2	8		2	1		1	1					5	1	1			2
Coleoptera	Mordellidae	Col-Mor-2												0			1								1					0
Coleoptera	Mordellidae	Col-Mor-3							1	1			1	3	1										1					0
Coleoptera	Mordellidae	Col-Mor-4		1				3			2			6											0					0
Coleoptera	Mycetophagidae	Col-Myc-1												0	1										1					0
Coleoptera	Nitidulidae	Col-Nit-2												0											0		2			2
Coleoptera	Noteridae	Col-Not-1												0		1									1					0
Coleoptera	Oedemeridae	Col-Oed-1			1	1	1		1		1			5											0					0
Coleoptera	Phalacridae	Col-Pha-5			2									2											0					0
Coleoptera	Pselaphidae	Col-Psel-1											3	3											0					0
Coleoptera	Pselaphidae	Col-Psel-2						2					1	3			1								1					0
Coleoptera	Ptilidae	Col-Pti-1										3		3											0					0
Coleoptera	Ptilodactilydae	Col-Ptil-2						1						1											0					0
Coleoptera	Ptinidae	Col-Ptin-1		2						2				4											0					0
Coleoptera	Ptinidae	Col-Ptin-2								2	3			5											0					0
Coleoptera	Rhipiphoridae	Col-Rhi-1											1	1											0					0
Coleoptera	Rhysodidae	Col-Rhy-1												0						1					1					0
Coleoptera	Salpingidae	Col-Sal-1												0			1								1					0
Coleoptera	Scarabaeidae	Col-Sca-7								1				1											0					0
Coleoptera	Scarabaeidae	Col-Sca-8						1						1											0					0
Coleoptera	Scolytidae	Col-Sco-1												0								1			1					0
Coleoptera	Scolytidae	Col-Sco-2												0						3				1	4					0
Coleoptera	Scolytidae	Col-Sco-5												0											0			5		5
Coleoptera	Scolytidae	Col-Sco-12								1				1											0				1	1
Coleoptera	Scolytidae	Col-Sco-13	2									2		4											0					0

Coleoptera	Staphylinidae	Col-Sta-1							1				1	1	3		1	1			1						3			1		1
Coleoptera	Staphylinidae	Col-Sta-2											1		1		2								1	2	5					0
Coleoptera	Staphylinidae	Col-Sta-3													0			1									1					0
Coleoptera	Staphylinidae	Col-Sta-4													0				1								1					0
Coleoptera	Staphylinidae	Col-Sta-11		1							1			2	4									1			1					0
Coleoptera	Staphylinidae	Col-Sta-13				1							3		4												0					0
Coleoptera	Staphylinidae	Col-Sta-14													0				1								1					0
Coleoptera	Staphylinidae	Col-Sta-16													0									1			1					0
Coleoptera	Staphylinidae	Col-Sta-17							1						1												0					0
Coleoptera	Tenebrionidae	Col-Ten-1			1					1	1		3		6		1										1					0
Coleoptera	Tenebrionidae	Col-Ten-3													0												0		1			1
Coleoptera	Tenebrionidae	Col-Ten-5						1							1												0					0
Coleoptera	Tenebrionidae	Col-Ten-7													0												0	1		1		2
Coleoptera	Trogossitidae	Col-Tro-1													0	1								1			2					0
Coleoptera	Col-B	Col-B-1													0												0		1			1
Collembola	Isotomidae	Coll-Iso-1	8			7	1								16	1			1		1			1			4					0
Collembola	Entomobryidae	Coll-Ent-1			3	1	2	2	1	3		2		11	25	1			10		1	4		14	4		34		1			1
Collembola	Entomobryidae	Coll-Ent-2			1				2			7	1		11							3					3				1	1
Diptera	Anisopodidae	Dip-Ani-1							1						1												0					0
Diptera	Anthomyzidae	Dip-Ant-1									1			2	3									1			1					0
Diptera	Asilidae	Dip-Asi-1										1			1												0					0
Diptera	Asteiidae	Dip-Ast-1						1						1	2												0					0
Diptera	Blephariceridae	Dip-Blep-1													0												0	1				1
Diptera	Calliphoridae	Dip-Call-1											1		1												0					0
Diptera	Calliphoridae	Dip-Call-2												1	1												0					0
Diptera	Carnidae	Dip-Car-1													0		1										1					0
Diptera	Cecidomyidae	Dip-Cec-1					1								1	1											1					0
Diptera	Cecidomyidae	Dip-Cec-4													0							1		3			4					0
Diptera	Cecidomyidae	Dip-Cec-5													0												0		1			1
Diptera	Cecidomyidae	Dip-Cec-6										1			1												0					0
Diptera	Cecidomyidae	Dip-Cec-8													0										1		1					0
Diptera	Cecidomyidae	Dip-Cec-10			1										1												0					0
Diptera	Cecidomyidae	Dip-Cec-11			1										1									4			4					0
Diptera	Ceratopogonidae	Dip-Cer-1				1	1	1					1		4	10		3						3			16	3				3
Diptera	Ceratopogonidae	Dip-Cer-2		2		2			1						5									12	2	2	16		1			1
Diptera	Ceratopogonidae	Dip-Cer-3			2	4			1			4		3	14							1		3			4					0
Diptera	Ceratopogonidae	Dip-Cer-4							6	5		1			12									10	1		11		5			5
Diptera	Ceratopogonidae	Dip-Cer-5										1			1										1		1					0
Diptera	Ceratopogonidae	Dip-Cer-6										2			2		4					1			3		8					0
Diptera	Ceratopogonidae	Dip-Cer-7			2										2		1		2					6			9					0
Diptera	Ceratopogonidae	Dip-Cer-8									2	7			9	1											1		1			1
Diptera	Ceratopogonidae	Dip-Cer-9												2	2									4			4					0
Diptera	Ceratopogonidae	Dip-Cer-10									1	4			5		4								1		5					0
Diptera	Ceratopogonidae	Dip-Cer-12				1									1										4		4		5			5
Diptera	Ceratopogonidae	Dip-Cer-13			2										2												0					0
Diptera	Ceratopogonidae	Dip-Cer-14												1	1												0					0
Diptera	Chamaemyidae	Dip-Cha-1							1						1												0					0
Diptera	Chamaemyidae	Dip-Cha-2							2						2												0					0
Diptera	Chironomidae	Dip-Chi-1								1				1	2											5	5					0
Diptera	Chironomidae	Dip-Chi-2							4						4		2										2					0
Diptera	Chloropidae	Dip-Chl-1	9					2				1			12			1	1								2					0
Diptera	Chloropidae	Dip-Chl-2													0				1								1	1				1
Diptera	Chloropidae	Dip-Chl-3										2			2												0					0
Diptera	Clusiidae	Dip-Clu-1													0			2									2					0
Diptera	Culicidae	Dip-Cul-1												4	4			1									1					0
Diptera	Diastatidae	Dip-Dia-1						1							1			1				1					2					0
Diptera	Diastatidae	Dip-Dia-2												1	1												0					0
Diptera	Diopsidae	Dip-Dio-1						1							1												0					0
Diptera	Diopsidae	Dip-Dio-2							1						1												0		1			1

Diptera	Dixidae	Dip-Dix-1													0		1						2					3					0
Diptera	Dolichopodidae	Dip-Dol-1	10				1	1	1				2	5	20			1	3			3	1					8				1	1
Diptera	Dolichopodidae	Dip-Dol-2			1						1				2						2							2		3		1	4
Diptera	Dolichopodidae	Dip-Dol-3						8	3		2	1	2	10	26							9	2				1	12	1	1	2	1	5
Diptera	Dolichopodidae	Dip-Dol-4		1	2		1		3		1			8	16			7								3		10				1	1
Diptera	Dolichopodidae	Dip-Dol-5						6						1	7											1		1		10			10
Diptera	Dolichopodidae	Dip-Dol-6									1			11	12			1										1			1		1
Diptera	Dolichopodidae	Dip-Dol-7		1					2			1		20	24								1					1		2			2
Diptera	Dolichopodidae	Dip-Dol-8								1					1			5										5		32			32
Diptera	Dolichopodidae	Dip-Dol-9										2			2													0		1			1
Diptera	Dolichopodidae	Dip-Dol-10		1											1													0		1		1	2
Diptera	Dolichopodidae	Dip-Dol-11										1			1													0				1	1
Diptera	Dolichopodidae	Dip-Dol-12											1		1													0		1		2	3
Diptera	Dolichopodidae	Dip-Dol-13							7			1	3		11													0		3	6	4	13
Diptera	Dolichopodidae	Dip-Dol-14												3	3			2										2		24		2	26
Diptera	Dolichopodidae	Dip-Dol-16												3	3								1					1					0
Diptera	Dolichopodidae	Dip-Dol-17							2					9	11								1					1		1			1
Diptera	Dolichopodidae	Dip-Dol-18										1			1								1					1		3			3
Diptera	Dolichopodidae	Dip-Dol-19							3		1		2	1	7													0		1			1
Diptera	Dolichopodidae	Dip-Dol-20		1					1			3		1	6													0					0
Diptera	Dolichopodidae	Dip-Dol-21											3	1	4													0		2			2
Diptera	Dolichopodidae	Dip-Dol-22		1							2			4	7													0					0
Diptera	Dolichopodidae	Dip-Dol-23							2						2													0		2			2
Diptera	Dolichopodidae	Dip-Dol-25							1					1	2													0		2			2
Diptera	Dolichopodidae	Dip-Dol-26										2			2													0					0
Diptera	Dolichopodidae	Dip-Dol-27						1							1													0					0
Diptera	Dolichopodidae	Dip-Dol-28												1	1													0					0
Diptera	Drosophilidae	Dip-Dro-1										1			1							1						1			1		1
Diptera	Drosophilidae	Dip-Dro-2									1				1			1										1					0
Diptera	Drosophilidae	Dip-Dro-3							1						1			4										4					0
Diptera	Drosophilidae	Dip-Dro-4									1				1			2										2					0
Diptera	Drosophilidae	Dip-Dro-5													0													0			1		1
Diptera	Empididae	Dip-Emp-1				2						2			4		2		5			1	1			4		13		12			12
Diptera	Empididae	Dip-Emp-2			1	1			4		1			5	12													0					0
Diptera	Empididae	Dip-Emp-3			1	2			2		2			3	10			2								1		3					0
Diptera	Empididae	Dip-Emp-4											5		5													0					0
Diptera	Empididae	Dip-Emp-5		1											1													0					0
Diptera	Empididae	Dip-Emp-6			1										1		1											1					0
Diptera	Empididae	Dip-Emp-7									8		2	1	11											3		3				1	1
Diptera	Empididae	Dip-Emp-8							5		4		1	6	16										3	1		4				1	1
Diptera	Empididae	Dip-Emp-9											1		1													0				1	1
Diptera	Empididae	Dip-Emp-10									1				1													0		1			1
Diptera	Ephidridae	Dip-Eph-1													0										3			3					0
Diptera	Heleomyzidae	Dip-Hel-2													0	1												1					0
Diptera	Lauxaniidae	Dip-Lau-1	2	2											4						2							2		3			3
Diptera	Milichiidae	Dip-Mil-2								2					2													0					0
Diptera	Muscidae	Dip-Mus-1											1		1				1	1	2							4			1		1
Diptera	Muscidae	Dip-Mus-3													0													0		1			1
Diptera	Muscidae	Dip-Mus-4								1					1													0					0
Diptera	Mycetophilidae	Dip-Myc-1					2	1							3		2						3				6	11		10			10
Diptera	Mycetophilidae	Dip-Myc-2													0												1	1					0
Diptera	Mycetophilidae	Dip-Myc-3							2						2													0					0
Diptera	Mycetophilidae	Dip-Myc-6												2	2													0					0
Diptera	Mycetophilidae	Dip-Myc-7									3		2	3	8											2		2		6		1	7
Diptera	Mycetophilidae	Dip-Myc-8								1	2				3			2										2		9			9
Diptera	Mycetophilidae	Dip-Myc-9								1	3			7	11								1		4			5		1			1
Diptera	Mycetophilidae	Dip-Myc-10												3	3													0		5			5
Diptera	Mycetophilidae	Dip-Myc-11													0											2		2		10			10
Diptera	Mycetophilidae	Dip-Myc-12							2						2													0			1		1

Diptera	Mycetophilidae	Dip-Myc-13													0										1		1					0
Diptera	Mycetophilidae	Dip-Myc-14									1				1												0		5			5
Diptera	Mycetophilidae	Dip-Myc-15									3				3												0		3			3
Diptera	Neriidae	Dip-Ner-1								1					1												0					0
Diptera	Odiniidae	Dip-Odi-1												1	1												0					0
Diptera	Phoridae	Dip-Pho-1	1				2	1	4	2		2		6	18			10		1		5					16		3			3
Diptera	Phoridae	Dip-Pho-2		2		5			11			10		1	29	14				1	28	5			4	6	58	1	5			6
Diptera	Phoridae	Dip-Pho-3										1			1				2	7	2	1		1		4	17	1		1		2
Diptera	Phoridae	Dip-Pho-4		3								1	1		5		5								3		8					0
Diptera	Phoridae	Dip-Pho-5			1				1						2												0		1		1	2
Diptera	Phoridae	Dip-Pho-6			1				3						4		3		1								4					0
Diptera	Phoridae	Dip-Pho-7			4				9			4			17												0		35	1		36
Diptera	Phoridae	Dip-Pho-8										2			2												0			1		1
Diptera	Phoridae	Dip-Pho-9							3			10			13												0					0
Diptera	Platypezidae	Dip-Plat-1												1	1												0					0
Diptera	Platypezidae	Dip-Plat-2												1	1												0					0
Diptera	Psycodidae	Dip-Psy-1							2	1				1	4						1						1					0
Diptera	Psycodidae	Dip-Psy-2				1									1		1										1					0
Diptera	Sciaridae	Dip-Sci-1	5							2		3		1	11				1		2	4			1		8			1	1	2
Diptera	Sciaridae	Dip-Sci-2		1				1	1			2		1	6											2	2					0
Diptera	Sciaridae	Dip-Sci-3								1	1	1	1	6	10					3		1			1		5					0
Diptera	Sciaridae	Dip-Sci-4								2	1				3		1			2							3					0
Diptera	Sciaridae	Dip-Sci-5		3										1	4												0					0
Diptera	Sciaridae	Dip-Sci-6			1				1						2				2								2					0
Diptera	Sciaridae	Dip-Sci-7												2	2												0					0
Diptera	Sciaridae	Dip-Sci-8												6	6												0					0
Diptera	Sciaridae	Dip-Sci-9				1								2	3												0					0
Diptera	Sciaridae	Dip-Sci-10			1										1												0					0
Diptera	Simuliidae	Dip-Sim-1													0		1										1					0
Diptera	Sphaeroceridae	Dip-Sph-1								1					1												0					0
Diptera	Sphaeroceridae	Dip-Sph-2							3			5			8												0		6			6
Diptera	Sphaeroceridae	Dip-Sph-3							2						2												0					0
Diptera	Tabanidae	Dip-Tab-1				2			1						3												0					0
Diptera	Tabanidae	Dip-Tab-2								1					1												0					0
Diptera	Tachinidae	Dip-Tac-1													0			1									1	1				1
Diptera	Tachinidae	Dip-Tac-2			1								1		2							1					1					0
Diptera	Tephritidae	Dip-Tep-1					1	1				1		4	7			1									1		5			5
Diptera	Tephritidae	Dip-Tep-2							2	2		6		1	11												0		5			5
Diptera	Tephritidae	Dip-Tep-3							2						2												0					0
Diptera	Tipulidae	Dip-Tip-1					1			3					4				1			2		7	1		11	1	21	2		24
Diptera	Tipulidae	Dip-Tip-2			4				2			3			9							2					2		1	1		2
Diptera	Tipulidae	Dip-Tip-3													0		2										2					0
Diptera	Tipulidae	Dip-Tip-4													0		3										3			1		1
Diptera	Tipulidae	Dip-Tip-5			1				1						2		1										1		1			1
Diptera	Xylophagidae	Dip-Xyl-1													0			1									1					0
Diptera	Dip-A	Dip-A-1													0			1									1					0
Diptera	Dip-D	Dip-D-1						1							1			1									1					0
Hemiptera	Berytidae	Hem-Ber-1							4						4												0					0
Hemiptera	Enicocephalidae	Hem-Eni-1													0												0		1			1
Hemiptera	Nabidae	Hem-Nab-1													0												0		2			2
Hemiptera	Hebiidae	Hem-Heb-1													0			1									1					0
Hemiptera	Reduviidae	Hem-Red-1													0												0		1			1
Hemiptera	Reduviidae	Hem-Red-3		1											1												0					0
Hemiptera	Reduviidae	Hem-Red-4										1		1	2												0					0
Hemiptera	Reduviidae	Hem-Red-5										1			1												0					0
Hemiptera	Reduviidae	Hem-Red-6							1			1			2												0					0
Hemiptera	Reduviidae	Hem-Red-7									1				1												0					0
Hemiptera	Tingidae	Hem-Tin-1		1						1			1		3		1		1							1	3					0
Hemiptera	Tingidae	Hem-Tin-2										2			2												0					0

Hemiptera	Hem-B	Hem-B-1									1				1													0					0
Hemiptera	Hem-C	Hem-C-2													0	1												1					0
Homoptera	Cicadellidae	Hom-Cic-1	3	1		3	1	3	2	1	5			3	22		1		4	3		3	3					14	1	2		1	4
Homoptera	Cicadellidae	Hom-Cic-2			3	1	4	3	3		2	5		7	28				1		3		1		2	2	4	13		8			8
Homoptera	Cicadellidae	Hom-Cic-3				6			3					5	14		1		7			4			4	2		18	4		1		5
Homoptera	Cicadellidae	Hom-Cic-4			3	2				6					11								1			1		2		1			1
Homoptera	Cicadellidae	Hom-Cic-5												12	12			1					1			2		4					0
Homoptera	Cicadellidae	Hom-Cic-6											2		2								1					1					0
Homoptera	Cicadellidae	Hom-Cic-7									3				3			1								1		2					0
Homoptera	Cicadellidae	Hom-Cic-8		1							4	3		4	12										20	2		22		1		1	2
Homoptera	Cicadellidae	Hom-Cic-9									1			3	4										3			3		2			2
Homoptera	Cicadellidae	Hom-Cic-10													0										1			1					0
Homoptera	Cicadellidae	Hom-Cic-11			3										3													0					0
Homoptera	Cicadellidae	Hom-Cic-12		2									13		15													0					0
Homoptera	Cicadellidae	Hom-Cic-13										1			1													0					0
Homoptera	Cicadellidae	Hom-Cic-14										1			1											2		2					0
Homoptera	Cicadellidae	Hom-Cic-15							1			4			5													0					0
Homoptera	Cicadellidae	Hom-Cic-16			1						1				2													0					0
Homoptera	Cicadellidae	Hom-Cic-17		1	2				2			5	4		14													0					0
Homoptera	Cicadellidae	Hom-Cic-18										1			1													0					0
Homoptera	Cicadellidae	Hom-Cic-19											1		1													0					0
Homoptera	Cicadellidae	Hom-Cic-21										2			2													0					0
Homoptera	Cicadellidae	Hom-Cic-22													0				7									7					0
Homoptera	Cicadellidae	Hom-Cic-24										1			1													0					0
Homoptera	Delphacidae	Hom-Del-1	1												1													0					0
Homoptera	Delphacidae	Hom-Del-3									1				1													0					0
Homoptera	Delphacidae	Hom-Del-4									1				1													0					0
Homoptera	Achilidae	Hom-Ach-1		1	1							1			3													0					0
Homoptera	Folgoridae	Hom-Fol-1		1											1													0					0
Homoptera	Derbidae	Hom-Der-1		1											1													0					0
Homoptera	Membracidae	Hom-Mem-1													0						1							1					0
Homoptera	Cixiidae	Hom-Cix-1						1	1		3				5													0					0
Homoptera	Cixiidae	Hom-Cix-2												2	2													0					0
Homoptera	Tropiduchidae	Hom-Tro-1										1		1	2													0					0
Homoptera	Issidae	Hom-Iss-1													0			3								1		4					0
Homoptera	Cercopidae	Hom-Cer-1	1				1					1		4	7					3			3		1		2	9			1		1
Homoptera	Cercopidae	Hom-Cer-2							1			2			3								6					6	2				2
Homoptera	Cercopidae	Hom-Cer-3												1	1											5		5					0
Homoptera	Cercopidae	Hom-Cer-4													0								1					1					0
Homoptera	Cercopidae	Hom-Cer-5							7					2	9													0					0
Homoptera	Cercopidae	Hom-Cer-6									1				1													0					0
Homoptera	Cercopidae	Hom-Cer-7													0					2								2					0
Homoptera	Psylidae	Hom-Psy-1									1				1													0					0
Homoptera	Hom-A	Hom-A-1										1			1													0		1			1
Hymenoptera	Agaoniidae	Hym-Aga-1													0											1		1					0
Hymenoptera	Apidae	Hym-Api-1	1	1											2													0					0
Hymenoptera	Aulachidae	Hym-Aul-1						1							1													0					0
Hymenoptera	Bethylidae	Hym-Bet-1	1	3								3			7			1										1					0
Hymenoptera	Bethylidae	Hym-Bet-2													0			1										1					0
Hymenoptera	Braconidae	Hym-Bra-1				3			1	4		2			10		3	2		1			1			1		8	1	7			8
Hymenoptera	Braconidae	Hym-Bra-2				1			4		1	2			8			1										1	1	7	1		9
Hymenoptera	Braconidae	Hym-Bra-3			1				2			3		1	7					3			1		1	3		8	1				1
Hymenoptera	Braconidae	Hym-Bra-4							1			2		2	5			2					1					3		1			1
Hymenoptera	Braconidae	Hym-Bra-5				1			1		2	1			5													0		2			2
Hymenoptera	Braconidae	Hym-Bra-6								1			1		2													0					0
Hymenoptera	Braconidae	Hym-Bra-7													0													0		2	1		3
Hymenoptera	Braconidae	Hym-Bra-8							1		1				2													0		1			1
Hymenoptera	Ceraphronidae	Hym-Cer-2							2						2													0					0
Hymenoptera	Ceraphronidae	Hym-Cer-3							3						3													0					0

Hymenoptera	Ceraphronidae	Hym-Cer-6												1	1												0					0
Hymenoptera	Chalcididae	Hym-Cha-2				2									2												0					0
Hymenoptera	Chalcididae	Hym-Cha-3									1			2	3												0					0
Hymenoptera	Chalcididae	Hym-Cha-4													0												0			1		1
Hymenoptera	Cynipidae	Hym-Cyn-2													0							1					1					0
Hymenoptera	Cynipidae	Hym-Cyn-3												1	1												0					0
Hymenoptera	Cynipidae	Hym-Cyn-4												1	1												0					0
Hymenoptera	Diapriidae	Hym-Dia-1	1								1				2												0					0
Hymenoptera	Diapriidae	Hym-Dia-2							1						1												0					0
Hymenoptera	Diapriidae	Hym-Dia-3												1	1												0					0
Hymenoptera	Euchariidae	Hym-Eue-1													0				1								1					0
Hymenoptera	Eulophidae	Hym-Eul-2													0									1			1					0
Hymenoptera	Eulophidae	Hym-Eul-3													0												0		2			2
Hymenoptera	Eulophidae	Hym-Eul-4												1	1									3			3					0
Hymenoptera	Eulophidae	Hym-Eul-5													0									2			2					0
Hymenoptera	Eulophidae	Hym-Eul-6			1										1												0		1			1
Hymenoptera	Eulophidae	Hym-Eul-8												1	1												0					0
Hymenoptera	Eulophidae	Hym-Eul-9												1	1									1			1					0
Hymenoptera	Evaniidae	Hym-Eva-1								1					1	1											1	1				1
Hymenoptera	Evaniidae	Hym-Eva-2													0												0	1				1
Hymenoptera	Formicidae	Hym-For-2		2		2				1		5	1		11			1	1		1	1					4			1	3	4
Hymenoptera	Formicidae	Hym-For-3	2			3									5												0					0
Hymenoptera	Formicidae	Hym-For-4		1	1										2												0			1		1
Hymenoptera	Formicidae	Hym-For-8			1										1							1					1		2			2
Hymenoptera	Formicidae	Hym-For-20													0												0	1				1
Hymenoptera	Formicidae	Hym-For-26													0												0		5			5
Hymenoptera	Formicidae	Hym-For-28							1						1										2		2					0
Hymenoptera	Formicidae	Hym-For-34		1	3	1			1					1	7			2				1		1			4		6			6
Hymenoptera	Formicidae	Hym-For-36		1	1				4			7			13									1			1			1		1
Hymenoptera	Formicidae	Hym-For-37		1											1												0					0
Hymenoptera	Formicidae	Hym-For-43		1	2				2						5				2					1			3					0
Hymenoptera	Formicidae	Hym-For-46													0		1										1					0
Hymenoptera	Formicidae	Hym-For-48													0									12			12					0
Hymenoptera	Formicidae	Hym-For-50			2										2												0					0
Hymenoptera	Formicidae	Hym-For-53									1				1												0					0
Hymenoptera	Formicidae	Hym-For-58										7			7												0					0
Hymenoptera	Formicidae	Hym-For-62													0										1		1					0
Hymenoptera	Formicidae	Hym-For-67		2					1	1	2			2	8									3	2		5					0
Hymenoptera	Formicidae	Hym-For-68								1					1												0			1		1
Hymenoptera	Formicidae	Hym-For-69											5		5												0					0
Hymenoptera	Formicidae	Hym-For-72			6										6												0					0
Hymenoptera	Formicidae	Hym-For-73	1												1											1	1					0
Hymenoptera	Formicidae	Hym-For-84													0									1			1					0
Hymenoptera	Formicidae	Hym-For-85													0												0			1		1
Hymenoptera	Formicidae	Hym-For-87												1	1										1		1					0
Hymenoptera	Formicidae	Hym-For-91								2		1			3												0		1			1
Hymenoptera	Formicidae	Hym-For-97			1		21		1					1	24					8							8					0
Hymenoptera	Formicidae	Hym-For-104												3	3												0					0
Hymenoptera	Formicidae	Hym-For-110							1						1												0					0
Hymenoptera	Formicidae	Hym-For-113											5		5												0					0
Hymenoptera	Formicidae	Hym-For-114										3			3												0					0
Hymenoptera	Formicidae	Hym-For-117										3			3												0					0
Hymenoptera	Formicidae	Hym-For-125	3												3			3		3							6				1	1
Hymenoptera	Formicidae	Hym-For-126													0			1			1						2					0
Hymenoptera	Formicidae	Hym-For-130			1									3	4		1							1			2					0
Hymenoptera	Formicidae	Hym-For-131													0			1									1					0
Hymenoptera	Formicidae	Hym-For-138													0					1							1					0
Hymenoptera	Formicidae	Hym-For-142													0	2				1							3					0
Hymenoptera	Formicidae	Hym-For-143													0				1								1					0

Hymenoptera	Formicidae	Hym-For-148											3				3										1			1					0
Hymenoptera	Formicidae	Hym-For-150						1				1	2	1		2	7				1									1					0
Hymenoptera	Formicidae	Hym-For-152															0										3			3					0
Hymenoptera	Formicidae	Hym-For-155															0				1									1					0
Hymenoptera	Formicidae	Hym-For-156															0													0				1	1
Hymenoptera	Formicidae	Hym-For-157				1											1													0					0
Hymenoptera	Formicidae	Hym-For-161										2		1			3													0					0
Hymenoptera	Formicidae	Hym-For-162															0													0		2			2
Hymenoptera	Formicidae	Hym-For-166															0								1					1					0
Hymenoptera	Formicidae	Hym-For-169				1		1									2												2	2					0
Hymenoptera	Formicidae	Hym-For-174															0													0			1		1
Hymenoptera	Formicidae	Hym-For-180															0													0		2			2
Hymenoptera	Formicidae	Hym-For-181				5	3										8													0					0
Hymenoptera	Formicidae	Hym-For-182					1										1													0					0
Hymenoptera	Formicidae	Hym-For-184														1	1													0					0
Hymenoptera	Ichneumonidae	Hym-Ich-1			3	1								1		1	6				3									3		1			1
Hymenoptera	Ichneumonidae	Hym-Ich-2						2									2													0		1			1
Hymenoptera	Ichneumonidae	Hym-Ich-3					1							4	1		6													0					0
Hymenoptera	Ichneumonidae	Hym-Ich-5					1										1													0					0
Hymenoptera	Ichneumonidae	Hym-Ich-6									1		3				4										2			2	1		1		2
Hymenoptera	Ichneumonidae	Hym-Ich-7					4				1		3	1	2		11		1				2		1					4					0
Hymenoptera	Ichneumonidae	Hym-Ich-8											2	1			3													0					0
Hymenoptera	Ichneumonidae	Hym-Ich-9					1									1	2							1						1		3		2	5
Hymenoptera	Ichneumonidae	Hym-Ich-10														2	2													0					0
Hymenoptera	Ichneumonidae	Hym-Ich-11									1				1		2													0					0
Hymenoptera	Ichneumonidae	Hym-Ich-12															0		3				1							4					0
Hymenoptera	Ichneumonidae	Hym-Ich-13														1	1				1									1					0
Hymenoptera	Ichneumonidae	Hym-Ich-14													2	1	3													0		2			2
Hymenoptera	Ichneumonidae	Hym-Ich-15				1										1	2													0		2			2
Hymenoptera	Ichneumonidae	Hym-Ich-16															0													0		1			1
Hymenoptera	Ichneumonidae	Hym-Ich-17									3						3													0					0
Hymenoptera	Ichneumonidae	Hym-Ich-18														1	1													0					0
Hymenoptera	Ichneumonidae	Hym-Ich-19															0			1										1				1	1
Hymenoptera	Mymaridae	Hym-Mym-1									1			1			2													0					0
Hymenoptera	Mymaridae	Hym-Mym-3														1	1													0					0
Hymenoptera	Mymaridae	Hym-Mym-4														1	1													0					0
Hymenoptera	Mymaridae	Hym-Mym-6											1				1													0					0
Hymenoptera	Mymaridae	Hym-Mym-7														1	1													0					0
Hymenoptera	Mymaridae	Hym-Mym-8				8					1					1	10													0					0
Hymenoptera	Mymaridae	Hym-Mym-9											1				1													0		1			1
Hymenoptera	Mymaridae	Hym-Mym-10											1			5	6													0					0
Hymenoptera	Mymaridae	Hym-Mym-11											3				3													0					0
Hymenoptera	Mymaridae	Hym-Mym-12											2	1			3													0					0
Hymenoptera	Mymaridae	Hym-Mym-13												1			1													0					0
Hymenoptera	Pergidae	Hym-Perg-1					1										1													0		7	1		8
Hymenoptera	Perilampidae	Hym-Per--1					3							1			4				1									1					0
Hymenoptera	Perilampidae	Hym-Per--3												1			1													0					0
Hymenoptera	Perilampidae	Hym-Per--4												1			1													0					0
Hymenoptera	Platygasteridae	Hym-Pla-1						1		2	1						4											1		1		2			2
Hymenoptera	Platygasteridae	Hym-Pla-4															0													0		2			2
Hymenoptera	Pteromalidae	Hym-Pte-1															0				1									1					0
Hymenoptera	Pteromalidae	Hym-Pte-3															0			1										1					0
Hymenoptera	Roproniidae	Hym-Rap-1			2												2													0					0
Hymenoptera	Scelionidae	Hym-Sce-1												4		2	6								1					1					0
Hymenoptera	Scelionidae	Hym-Sce-2			1											1	2						1		2					3					0
Hymenoptera	Scelionidae	Hym-Sce-3									1						1							1						1					0
Hymenoptera	Scelionidae	Hym-Sce-4															0													0		1			1
Hymenoptera	Scelionidae	Hym-Sce-6															0			3							1			4					0
Hymenoptera	Scelionidae	Hym-Sce-7															0			3		2								5					0

Hymenoptera	Tiphiidae	Hym-Tip-1							1								1													0					0
Hymenoptera	Torymidae	Hym-Tor-2															0													0		10			10
Hymenoptera	Torymidae	Hym-Tor-3															0													0		1			1
Hymenoptera	Trichogrammatidae	Hym-Tri-1					1										1													0					0
Hymenoptera	Trigonalidae	Hym-Trig-1															0				3									3					0
Hymenoptera	Vespidae	Hym-Ves-1															0								1					1					0
Hymenoptera	Hym-C	Hym-C-1									2		1				3			1										1		1			1
Hymenoptera	Hym-F	Hym-F-1												1			1													0					0
Hymenoptera	Hym-G	Hym-G-1															0								1					1					0
Isoptera	Termitidae	Iso-Ter-1												1			1				1	1		1			3			6					0
Lepidoptera	Gelechiidae	Lep-Gel-1			2				1			1		1			5											6		6					0
Lepidoptera	Geometridae	Lep-Geo-1			2									1			3													0					0
Lepidoptera	Lep-A	Lep-A-1												1		3	4					1	1		1					3			1		1
Mantodea	Mantidae	Man-Man-1												1			1													0					0
Microcoryphia	Meinertellidae	Myc-Mei-1										1				1	2								1					1	1		2		3
Odonata	Coenagrionidae	Odo-Coe-1												1			1													0					0
Orthoptera	Acrididae	Ort-Acr-1										2		1			3													0		1	2	1	4
Orthoptera	Acrididae	Ort-Acr-2														1	1			1										1			1	6	7
Orthoptera	Eumastacidae	Ort-Eum-1												1			1													0	1	1			2
Orthoptera	Gryllacridae	Ort-Gryl-1									8						8													0					0
Orthoptera	Gryllacridae	Ort-Gryl-2									1						1													0		1			1
Orthoptera	Gryllidae	Ort-Gry-1			3				2	1	2	1	2	1			12			2	1				11					14		6			6
Orthoptera	Gryllidae	Ort-Gry-2									9		5		8	3	25			1		2	1	2	5			1		12	7	2		2	11
Orthoptera	Gryllidae	Ort-Gry-3											1				1													0				1	1
Orthoptera	Tetrigidae	Ort-Tet-1															0													0	1	5			6
Orthoptera	Tettigonidae	Ort-Tett-1															0		1											1			1		1
Orthoptera	Tettigonidae	Ort-Tett-2											1				1													0					0
Orthoptera	Tettigonidae	Ort-Tett-3									1						1													0					0
Psocoptera	Asiopsocidae	Pso-Asi-1										1					1													0					0
Psocoptera	Ectopsocidae	Pso-Ect-1					1										1													0					0
Psocoptera	Lachesillidae	Pso-Lac-1										1	1				2							1						1					0
Psocoptera	Lepidopsocidae	Pso-Lep-1						2									2												1	1					0
Psocoptera	Liposcelidae	Pso-Lip-1															0													0		1			1
Psocoptera	Psocidae	Pso-Pso-1												1			1													0					0
Psocoptera	Psyllipsocidae	Pso-Psy-1				1											1													0					0
Psocoptera	Pso-A	Pso-A-1															0					1							1	2					0
Psocoptera	Pso-B	Pso-B-1												2			2					1								1					0
Psocoptera	Pso-B	Pso-B-2															0					2								2					0
Psocoptera	Pso-C	Pso-C-1												1			1													0					0
Psocoptera	Pso-D	Pso-D-1															0										1			1					0
Thysanoptera	Phlaeothripidae	Thy-Pha-1								1							1													0					0
Thysanoptera	Phlaeothripidae	Thy-Pha-2															0										1			1					0
Thysanoptera	Thripidae	Thy-Thr-1															0					1								1					0
Tricoptera	Hydropsychidae	Tri-Hyd-1										2					2							1						1					0
Tricoptera	Hydroptilidae	Tri-Hydro-1														1	1													0					0
Tricoptera	Lepidostomatidae	Tri-Lepi-1											1				1													0					0
Tricoptera	Leptoceridae	Tri-Lep-1									1						1													0					0
Tricoptera	Phrygaenidae	Tri-Phr-1														1	1													0					0
Tricoptera	Philopotamidae	Tri-Phy-1														2	2						1							1					0
		Num. Ind.															1502													807					522
		Num. Spc.															392													229					159