*THE RAFFLES BULLETIN OF ZOOLOGY* 2011 **59**(2): 295–309
Date of Publication: 31 Aug.2011


# BIRD DIVERSITY DIFFERS BETWEEN INDUSTRIAL TREE PLANTATIONS ON BORNEO: IMPLICATIONS FOR CONSERVATION PLANNING

**Frederick H. Sheldon**
*Museum of Natural Science and Department of Biological Sciences, Louisiana State University, Baton Rouge, LA 70803, USA*
*Email: fsheld@lsu.edu (Corresponding author)*

**Alison R. Styring**
*The Evergreen State College, Olympia, WA 98505, USA*

***ABSTRACT. –*** Southeast Asia is a region of particular conservation concern because of its high endemicity and rate of deforestation. Exotic tree plantations contribute substantially to the deforestation problem, and thus appropriate policies for plantation development need to be implemented in the region. Among these policies are conservation strategies for partitioning land between tree plantations and native ecosystems. Such strategies run the gamut between complete separation of plantations from inviolate natural systems ("land-sparing") to the inclusion of extensive native forest buffers within plantations to promote local diversity. We considered the appropriateness of these alternative approaches while comparing bird occurrence between two exotic tree plantations in Malaysian Borneo. The plantations were Sabah Softwoods, located in eastern Sabah, and the Sarawak Planted Forest Project, located in central-coastal Sarawak. They comprised mainly industrial trees (particularly *Acacia mangium*) that are cultivated for pulp and other wood products. Both plantations also contained islands or corridors of logged native forest. We found that Sabah Softwoods held more birds, even though the Sarawak Planted Forest Project included a larger proportion of native forest set aside specifically to promote wildlife. Outwardly, this finding supports land-sparing: the forests of eastern Sabah are inherently richer than those of central Sarawak and, thus, merit special protection from plantation development. However, both plantations held more birds than would be expected if they lacked native forest islands and corridors. Many of their constituent birds were uncommon species that could not exist without native forest buffers. Thus, the inclusion of stands of native forest remains an essential design component of industrial tree plantations, regardless of location.

***KEY WORDS. –*** *Acacia mangium*, Albizia, land sparing, logged forest, oil palm, Sabah, Sarawak.

## INTRODUCTION

The rapid expansion of exotic tree plantations in Malaysia and Indonesia at the expense of native forest is a major conservation concern (Fitzherbert et al., 2008; Koh & Wilcove, 2008; Sodhi et al., 2008; Danielsen et al., 2009; Sodhi et al., 2010). As a result, conservationists, conscientious planters, and other stakeholders regularly discuss strategies for balancing the need for economic development in the region with the preservation of biological diversity (RSPO, 2007; Stuebing et al., 2007). A major issue in these conversations concerns the appropriate way to partition land between plantations and natural ecosystems. Arguments run the gamut from "land sparing" or complete separation of plantations from natural ecosystems (Green et al., 2005; Ewers et al., 2009; Edwards et al., 2010; Struebig et al., 2010a), to the maintenance of substantial patches and corridors of native forest within plantations (Fitzherbert et al., 2008; Koh, 2008), to extensive integration and coordination of agricultural and native landscapes (Harvey et al., 2008; Scherr & McNeely, 2008; Koh et al., 2009). A clear outcome of these discussions is that different situations require different solutions, depending on biological, political, and cultural context (Gardner et al., 2009; Ghazoul et al., 2010; Struebig et al., 2010b).

The principal industrial tree of Malaysia and Indonesia is *Acacia mangium*, or mangium, which is cultivated for pulp and wood products (Pinso & Vun, 2000; Donald, 2004; Evans, 2009). Mangium groves in the vicinity of native forest—even heavily disturbed native forest—are relatively rich in birds and mammals (McShea et al., 2009; Sheldon et al., 2010; Styring et al., 2011) because they develop rapidly into structurally and botanically diverse secondary forests (Otsamo et al., 1997; Lamb, 1998). In this respect, mangium is different from oil palm (*Elaeis guineensis*), which is an agricultural crop with little botanical structure and a relatively depauperate avifauna (Koh, 2008; Edwards et al., 2010; Sheldon, Styring & Hosner, 2010). Mangium, like industrial plantations elsewhere (Gascon et al., 1999; Renjifo, 2001; Sodhi et al., 2008), serves as a reasonably good matrix for forest fragment connectivity. Thus, the inclusion of islands and corridors of native forest in mangium plantations is a promising strategy to enhance local biodiversity. Nevertheless, a land-sparing approach, in which mangium plantations are developed only in severely degraded areas, is also a sensible strategy, because mangium is no substitute for large, abundantly rich, native forest ecosystems.

To shed more empirical light on these issues, we compared bird occurrence in two exotic tree plantations in Malaysian Borneo that are ca. 550 km apart (Sheldon et al., 2010; Styring et al., 2011). Species richness, abundance and density differed between the two plantations. The disparity appears to derive mainly from inherent differences in local ecosystems. However, diversity was higher than expected in both plantations because of the maintenance of native forest buffers among plantation groves. This discovery supports both views of plantation development: industrial plantations should be concentrated in degraded areas that are inherently poorer in wildlife, but nevertheless should comprise native forest buffers to support local biodiversity.

## MATERIAL AND METHODS

The two plantations we compared (Fig. 1) were Sabah Softwoods (SS) near Tawau in southeastern Sabah (4°30'N, 117°29'E) and the Sarawak Planted Forest Project (SPF) near Bintulu in central-coastal Sarawak (2°56'N, 113°07'E). The plantations' characteristics and our bird and habitat sampling methods were described previously (Sheldon et al., 2010; Styring et al., 2011). Briefly, SS covers about 60,000 ha, of which about 40,000 ha are planted with mangium, Albizia (*Paraserianthes falcataria*), white teak (*Gmelina arborea*), and oil palm. SPF comprises about 500,000 ha, of which about 200,000 ha are mangium. Both plantations retain fragments of heavily logged native forest. Surveys consisted of spot counts of birds and descriptions of habitat-structure using Distance sampling methods (Buckland et al., 2001; Thomas et al., 2006). Surveys at SS were conducted from 23 Jun. – 12 Jul.2005 in various ages of mangium, mature Albizia, mature oil palm, and logged native forest. Surveys at SPF were conducted from 19 Jul. – 9 Aug.2006 in various ages of mangium, logged native forest, and relatively undisturbed peatswamp forest.

Species accumulation curves, jackknifed estimates of diversity, mean point species richness, and Shannon's diversity indices were produced using PC-Ord 5 (McCune & Mefford, 2006). Bird density within each habitat was estimated using Distance 6.0 (Thomas et al., 2006). Average mass of bird species was compared between SS and SPF and among habitats within each plantation (Styring et al., 2011).

To examine rates at which birds were recorded, we compared each grove type by constructing log-log plots of sampling curves: cumulative samples (one sample = a single point survey) versus cumulative species, cumulative individuals versus cumulative species, and cumulative samples versus cumulative species/cumulative individuals. We then fit lines to the plots using least squares and compared slopes of the lines via t-tests for two plots and analysis of variance (ANOVA) for more than two plots. Because species richness and diversity metrics alone do not provide information on community structure or the value of habitats to sensitive species, we also examined the relationship between species accumulation rates and the presence of species of conservation concern (i.e., species listed by www.birdlife.org; Appendix 1). For this, we performed univariate regression of the slope of the log-log species-sample plots for each habitat versus the mean number of listed species and versus individuals (per point transect).

To compare community structure between plantations and among habitats, we performed nonlinear multidimensional scaling (NMS) in PC-ORD 5. Pearson correlation coefficients were calculated to determine correlation between habitat variables and the ordination of species. Habitat correlations with an r-squared value greater than 0.2 on any one of the first two axes were considered significant and plotted on the ordination. A multiple response permutation procedure (MRPP) was also performed in PC-ORD to determine variation in bird community composition among habitat types (Styring et al., 2011).

## RESULTS

We conducted 1,264 point counts of birds and habitat-variables (655 at SS and 609 at SPF) and recorded 171 bird species (Appendix 1). Species accumulation curves (Fig. 2)

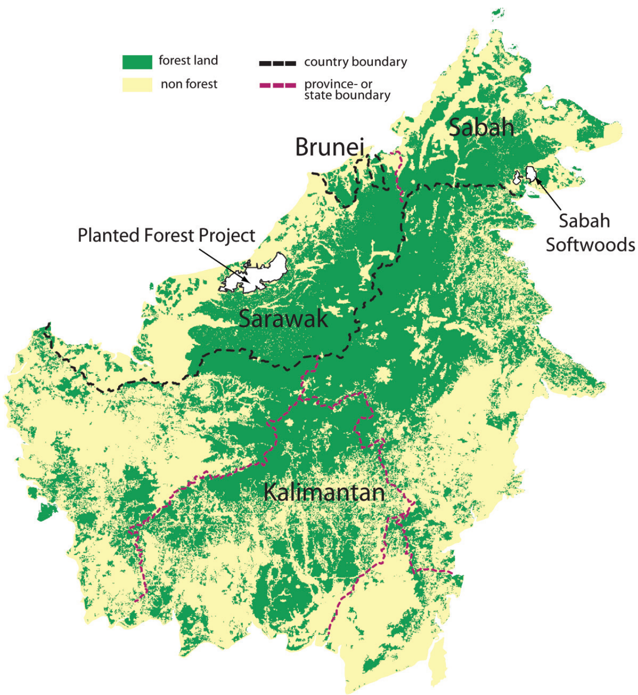


Fig. 1. Map of forest occurrence in Borneo in 2005 (WWF-Malaysia, 2005) showing the localities of the Sarawak Planted Forest Project and Sabah Softwoods plantation.

Table 1. Summary statistics for bird communities in different habitats at Sabah Softwoods (SS) and the Sarawak Planted Forest Project (SPF).

| Habitat | Species Observed (and Jackknife Estimates of Richness) | | Per-point Species Richness | | Per-point Abundance | | Per-point Diversity (H') | | Mass (g) Mean (SD), Median | |
|---|---|---|---|---|---|---|---|---|---|---|
| | *SS* | *SPF* | *SS* | *SPF* | *SS* | *SPF* | *SS* | *SPF* | *SS* | *SPF* |
| peat swamp | – | 70 (89-92) | – | 4.8 | – | 6.6 | – | 1.33 | – | 30.3 (61.2), 19.4 |
| Logged forest | 115 (152-177) | 94 (103-103) | 6.7 | 5.2 | 14.1 | 7.9 | 1.66 | 1.42 | 68.3 (283.0), 17.5 | 54.7 (153.2), 20.0 |
| 10-y Albizia | 82 (106-122) | – | 6.5 | – | 9.1 | – | 1.70 | – | 31.0 (82.4), 15.4 | – |
| 7-y mangium | 74 (96-110) | 66 (81-89) | 6.3 | 6.9 | 8.4 | 9.7 | 1.69 | 1.82 | 24.0 (61.6), 15.4 | 21.8 (33.5), 15.4 |
| 5-y mangium | 60 (79-90) | 59 (72-79) | 6.0 | 5.1 | 8.9 | 7.1 | 1.64 | 1.48 | 26.5 (70.2), 15.4 | 21.2 (23.4), 15.4 |
| 2-y mangium | 37 (47-52) | 43 (52-57) | 5.2 | 4.3 | 9.0 | 6.1 | 1.48 | 1.29 | 19.8 (17.6), 15.4 | 27.6 (79.4), 15.4 |
| 10-y oil palm | 24 (29-32) | – | 4.4 | – | 6.4 | – | 1.38 | – | 20.3 (18.3), 15.4 | – |
| Total | 148 (179-189) | 123 (141-150) | 5.9 | 5.4 | 9.0 | 7.7 | 1.61 | 1.50 | 31.5 (123.5), 15.4 | 31.8 (88.6), 17.2 |

and projected species richness (Table 1) suggest our sampling was virtually complete for 2-y mangium (both sites), oil palm, and logged forest at SPF. However, sampling curves for older mangium (both sites), Albizia, logged forest at SS, and peatswamp did not reach an asymptote. Thus, further sampling would have been useful in those groves. Before the SPF survey, we realised that under-sampling of logged forest at SS was a problem (Sheldon et al., 2010). Therefore, we increased the number of surveys in SPF's logged forest from 6 to 12, and this adjustment produced satisfactory coverage. Because our ability to detect individual birds differed among habitats, we established point-spacing based on bird detectability that resulted in a reduction in sample size (130 for SS; 100 for PFP), but minimized the probability of double-counting individuals (Styring et al., 2011).

Bird richness and diversity in mangium increased at both plantations with age (Table 1). Richness and diversity was lower in 10-y (i.e., mature) oil palm than other exotic tree groves, including 2-y Acacia. They were higher in Albizia than in old mangium. Overall, logged native forest was considerably richer and more diverse than any exotic tree groves, although on a per-point basis logged forest at SPF had about the same richness and diversity as medium aged mangium. Density of birds (Table 2) generally followed richness and diversity, with a few caveats. Oil palm and 2-y SS mangium exhibited densities similar to old mangium

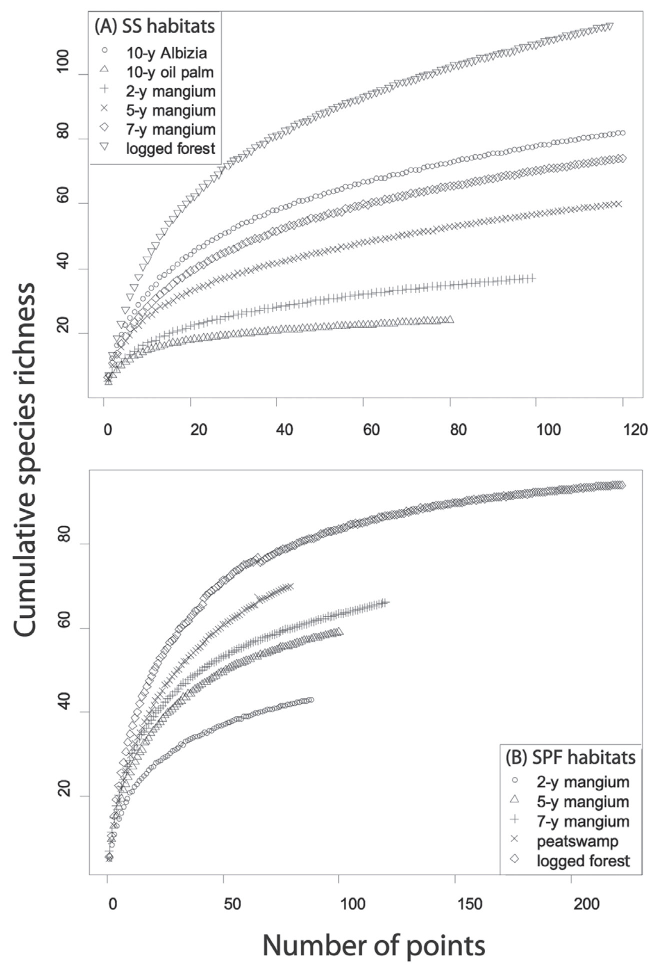


Fig. 2. Species accumulation curves for (A) Sabah Softwoods and (B) Sarawak Planted Forest Project.

Table 2. Bird density estimates (individuals/hectare) for plantation and native forest habitats types at Sabah Softwoods (SS) and the Sarawak planted forest zone (SPF). %CV is the coefficient of variation expressed as a percentage.

| Habitat | Density (%CV) | |
|---|---|---|
| | SS | SPF |
| Oil palm | 11.3 (31) | – |
| Mangium 2y | 15.9 (20.1) | 9.3 (17.9) |
| Mangium 5y | 11.6 (37.0) | 11.5 (14.7) |
| Mangium 7y | 10.4 (23.2) | 17.2 (7.8) |
| Albizia | 16.5 (18.9) | – |
| Logged forest | 23.3 (12.4) | 20.6 (13.5) |
| Peatswamp | 44.8 (20.2) | – |

and Albizia because of large numbers of common species (e.g., *Pycnonotus goiavier* and *Macronous bornensis*). The most striking result was the density estimate for relatively undisturbed peatswamp at Binyo, which was twice that of logged forest at either plantation. Comparisons between plantations showed that mangium and logged groves at SS had higher overall species richness, abundance, and diversity than comparable habitats at SPF; abundance in SS's logged forest was twice that in the SPF's.

Bird mass (Table 1) differed significantly between the two plantations (t-test: $t = 2.2$, $p = 0.026$; Kruskal-Wallis: Chi-square = 5.03; $p = 0.025$), but the difference was small (mean mass for SPF = 31.8 g, mean log mass = 2.9; and mean mass for SS = 31.5 g, mean log mass = 2.8).

Rates at which species accumulated with sampling were similar between plantations when all habitats were combined, and also in logged forest (Fig. 3:1a and 3:1b). Rates in older mangium were also similar between plantations, except for 5-y groves at SS, which had a faster rate (Fig. 3:1d). The rate in mature Albizia (SS only) was faster than in any of the older mangium groves (Fig. 3:1c). The rates in 2-y mangium and oil palm at SS were similar to one another and significantly slower than in 2-y mangium at SPF (Fig. 3:1e). Species-individual rates (accumulating species with increasing abundance) were somewhat different than the species-sample rates. In this case, overall rates between plantations were significantly different, with SS having a faster rate (Fig. 3:2a). Rates in older mangium (5-y and 7-y) and Albizia were similar between plantations, except for 7-y mangium at SPF, which was slower (Fig. 3:2c). As with species-sample accumulation, rates in 2-y mangium and oil palm at SS were similar to one another and significantly slower than in 2-y mangium at SPF (Fig. 3:2e). The mean number of listed species and listed individuals correlated strongly with species-sample accumulation rates (Fig. 4). Habitats with higher accumulation rates also had more listed species and higher abundance of listed species.

NMS randomization indicated that two dimensions generated the least stress in the ordination and explained 78% of the variation in the data (axis 1 = 43%, axis 2 = 35%; Fig. 5). The ordination and MRPP reflected a clear difference between plantations ($p < 0.001$) and forest types ($p < 0.05$ in all comparisons). Bird community structure was highly correlated with canopy height, secondary canopy height, percent secondary canopy cover, shrub height, and percent shrub cover. All of these correlations occurred primarily along axis 1 which may be interpreted as a habitat gradient, going from simple structure (young mangium and oil palm) to the more complex structure (older mangium, Albizia, and native forest). Although habitat types between plantations differed significantly in the ordination, the overall pattern of assemblage succession was similar for both, following the habitat gradient along axis 1 and displaying much larger variation among native forest assemblages than among plantation assemblages along axis 2. To some degree, values for the two plantations segregated along axis 2. Careful analysis of species occurrence showed that this reflects the influence of common species that occur in different abundance at the two plantations (e.g., *Zosterops everetti*: 208 individuals at SS; none at SPF), and also species that are mutually exclusive for taxonomic reasons (e.g., *Copsychus stricklandii*: 92 at SS, 0 at SPF; versus *C. malabaricus*: 0 at SS, 48 at SPF). Some species were just more common in Sabah, and some were more common in Sarawak.

## DISCUSSION

In almost all respects, Sabah Softwoods had a richer, more diverse avifauna in both its exotic tree groves and logged forest than the Sarawak Planted Forest Project. Even if the SPF's relatively undisturbed peatswamp is included, SPF had fewer birds than SS. The only exception to this pattern was 2-y mangium at the SPF, which had more species (Table 1) and greater rates of species and individual detection during surveys (Fig. 3:1e and 3:2e) than 2-y mangium at SS.

Several reasons can be invoked to explain the differences between SS and SPF. Two of these may be discarded immediately. The disparity between the plantations cannot be attributed to variation in survey quality. Although some personnel differed between surveys (Appendix 2), the rates at which birds were recorded were similar between plantations, except in 2-y mangium, which is the easiest habitat to survey accurately by virtue of its structural simplicity. (The differences between 2-y mangium groves were probably biological; see below.) Moreover, the logged forest at the SPF was surveyed twice as many times as that at SS, yet still yielded fewer species (Table 1, Fig. 2). The disparity between the plantations' bird richness and abundance also cannot be attributed to differences in management strategies. The SPF was designed to include extensive logged forest buffers to maximize wildlife content (Stuebing, 2007) and, as such, should have held more birds than SS, which was not so designed. The SPF is also contiguous with native forest in many places, enhancing the potential for colonization by birds. SS, on the other hand, is completely surrounded by oil palm, an inhospitable matrix for most colonizers. Thus, despite its management's efforts to encourage wildlife, SPF's logged forest and mature exotic groves held fewer birds than those of SS.

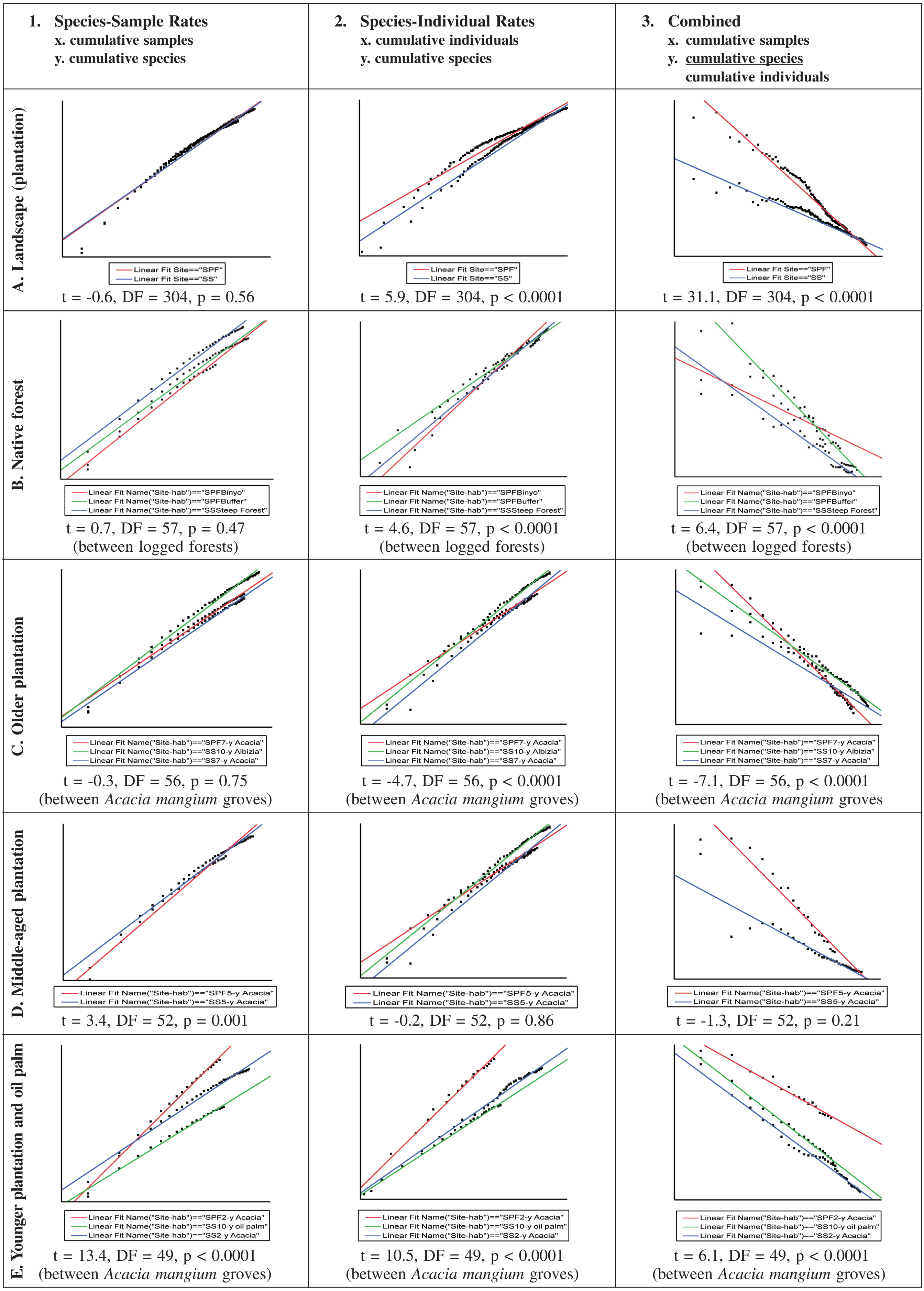


Fig. 3. Plots of rates at which species were recorded. SPF = Sarawak Planted Forest, SS = Sabah Softwoods, SPF Binyo = mostly primary peatswamp forest, SPF Buffer = logged lowland (mostly riverine) forest, and SS Steep Forest = logged upland forest on steep slopes.

The disparity in birds between plantations would appear to be the result of two main influences. First, the logged native forests of SS and the SPF are fundamentally different. The SPF has a relatively flat topography and encompasses large amounts peatswamp and kerangas, i.e., forests growing on poor soils (Brunig, 1974; Whitmore, 1984). As such, native forest at SPF has a fundamentally different botanical composition and structure than the taller, more dramatic upland forest of southeastern Sabah, which enjoys a complex topography and grows on richer alluvial soils (Thomas et al., 1976). The comparative quality of eastern Sabah's forests is well known to loggers and conservationists on the basis of commercial tree production; extraction volumes in undisturbed forest of eastern Sabah may average as much as 120 $m^3$ $ha^{-1}$ versus 90 $m^3$ $ha^{-1}$ in Sarawak (Marsh & Greer, 1992; Johns, 1996; Putz et al., 2001). Moreover, the greater topological complexity at SS potentially increases habitat variety and bird species richness (e.g., by providing microhabitat for slope specialists such as *Pitta arquata*). The second reason for habitat-quality differences between the plantations is historical. The forest at the SPF has incurred human disturbance for a much longer time than that at SS. The SPF, lying in relatively flat country near the coast with excellent river access, has been exposed to shifting cultivation and small scale logging for hundreds of years. Nowadays, because of exploitation, the native forest at the SPF lacks key components of the original forest. In contrast, the area of SS was largely uninhabited until 45 years ago, when logging began. Primary dipterocarp forest was extensive in the area until 25 years ago. The remaining stands of logged forest at SS are managed for sustained use and retain more of their original tree diversity, and hence avian richness, than those at SPF.

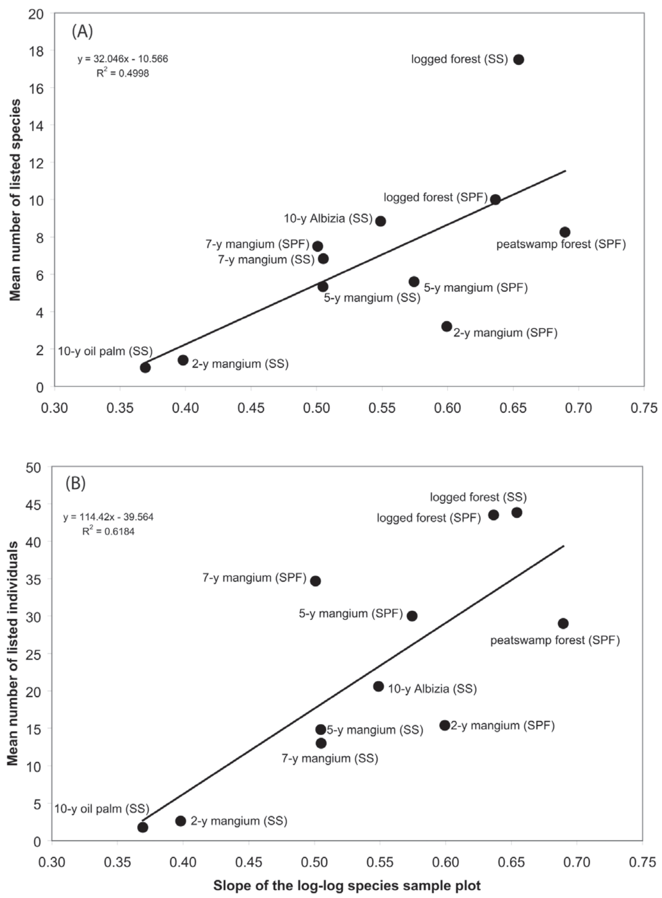


Fig. 4. Plots of (A) species and (B) individual rates (from Fig. 1) versus number of species listed by www.birdlife.org (Table 1) per habitat type.

An obvious conclusion from these arguments is that a concerted, large scale conservation effort should be focused on preserving native forest in the vicinity of SS. To some degree, this has happened. Three substantial conservation areas are located relatively close to SS: Danum Valley (438 $km^2$) ca. 20 km to the north, Maliau Basin (390 $km^2$) ca. 80 km to the west, and Tawau Hills Park (279 $km^2$) ca. 10 km to the east. Much of the intervening area between these three sites is biologically rich logged forest (Berry et al., 2010), and the importance of maintaining this area as native forest for regeneration and as a nexus for the conservation sites is well appreciated (WWF-Malaysia, 2006). On a smaller scale, however, SS is an island completely surrounded by oil palm. Native forest within the plantation is restricted to relatively small logged patches on hills that are too steep to plant. These patches range from 40–400 ha and total about 1500 ha in all. As we described earlier (Sheldon et al., 2010), the native forest patches are home to a remarkable variety of large and specialised vertebrates that require substantial forest to exist, including gibbons, monkeys, pheasants, pigeons, trogons, hornbills, barbets, woodpeckers, and over 25 passerines of conservation concern (Appendix 1). Some members of the more vagile groups—like hornbills, pigeons, barbets, and the largest woodpeckers—undoubtedly travel out of SS, across the oil palm and into the surrounding native forest to forage and nest. Most of the species in the plantation's native forest make limited use of the mangium and Albizia groves, primarily for feeding (Mitra & Sheldon, 1993; Sheldon et al., 2010; Styring et al., 2011). Several species, however, have not been found in the exotic tree groves (e.g., *Dinopium rafflesii*, *Pitta arquata*, and *Trichixos pyrropyga*), and many more are not expected to use exotic tree groves except, perhaps, incidentally. Such taxa could not

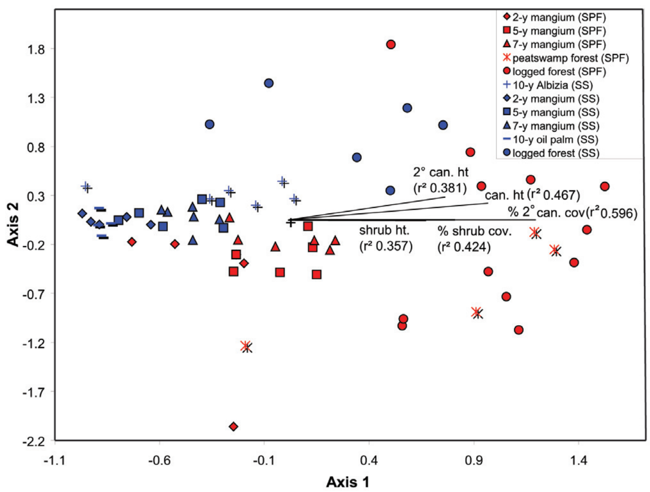


Fig. 5. Nonlinear multidimensional scaling of bird survey data pooled by point-transect. Vectors represent correlations between the ordination and habitat variables. Vectors and Pearson correlation coefficients are plotted for habitat variables with an $r^2 > 0.200$ for axis 1.

have survived thus far at SS without remnant stands of native forest. Thus, given SS's status as an island, the preservation of native forest buffer has been essential to maintaining its local bird diversity. Time will tell whether these relatively small plots of native forest will preserve non-vagile, obligate native forest bird species over the long term.

At the SPF, there are many important, complex political and cultural issues and concerns about the size, location, and management of the plantation. Most of these are outside the purview of this paper. However, from an admittedly simple biological and land-sparing perspective, the enormous SPF Project (i.e., 200,000 ha of mangium in a 500,000 ha forest project) has been developed in an appropriate part of Borneo. The central coastal forest of Sarawak is not as rich as that of southeastern Sabah for a variety of inherent and historical reasons (including its relatively poor soil and extensive human perturbation). Nevertheless, maintenance of a diverse fauna in the SPF is still important biologically, economically, and culturally (Stuebing et al., 2007), and the native forest buffers of the SPF have had a clear impact on vertebrate diversity in the plantation (Appendix 1; McShea et al., 2009). Not only is there a wide variety of species in native buffers at the SPF that could not exist solely in mangium, including many conservation-listed species (Appendix 1, Fig. 4), we believe the buffers may be directly responsible for the unusually large number of birds that occur in the youngest mangium groves at SPF (Fig. 3e). Were the buffers at SPF replaced with mangium, richness and diversity of birds and other groups in the region would undoubtedly plummet. Thus, the conscientious effort by developers of the SPF to enhance biodiversity by leaving wildlife corridors and islands is to be commended, and the practice of including buffers in plantations there and elsewhere needs to continue.

## ACKNOWLEDGMENTS

We thank the Planted Forests Project, Grand Perfect Sdn. Bhd., and Sabah Softwoods Sdn. Bhd. for their hospitality and logistical support of our research. Permission to undertake research in Sabah and Sarawak was provided by the Malaysian Prime Minister's Department, the Chief Minister's Department of Sabah, the Sabah Wildlife and Forestry Departments, and the Sarawak Forestry Department, Forestry Corporation and Biodiversity Centre. The research was funded by the Coypu Foundation of Louisiana and Disney Worldwide Conservation Fund.

## LITERATURE CITED

Berry, N. J., O. L. Phillips, S. L. Lewis, J. K. Hill, D. P. Edwards, N. B. Tawatao, N. Ahmad, D. Magintan, C. V. Khen, M. Maryati, R. C. Ong & K. C. Hamer, 2010. The high value of logged tropical forests: Lessons from northern Borneo. *Biodiversity and Conservation,* **19**: 985–997.

Brunig, E. F., 1974. *Ecological Studies in the Kerangas Forests of Sarawak and Brunei*. Borneo Literature Bureau, Kuching. 237 pp.

Buckland, S. T., D. R. Anderson, K. P. Burnham, J. L. Laake, D. L. Borchers & L. Thomas, 2001. *Introduction to Distance Sampling: Estimating Abundance of Biological Populations.* Oxford University Press, New York. 432 pp.

Danielsen, F., H. Beukema, N. D. Burgess, F. Parish, C. A. Bruhl, P. F. Donald, D. Murdiyarso, B. Phalan, L. Reijnders, M. Struebig & E. B. Fitzherbert, 2009. Biofuel plantations on forested lands: Double jeopardy for biodiversity and climate. *Conservation Biology,* **23**: 348–358.

Donald, P. F., 2004. Biodiversity impacts of some agricultural commodity production systems. *Conservation Biology,* **18**: 17–37.

Edwards, D. P., J. A. Hodgson, K. C. Hamer, S. L. Mitchell, A. H. Ahmad, S. J. Cornell & D. S. Wilcove, 2010. Wildlife-friendly oil palm plantations fail to protect biodiversity effectively. *Conservation Letters,* **3**: 236–242.

Evans, J., 2009. *Planted Forests: Uses, Impacts, Sustainability.* CAB International and FAO, Rome. 224 pp.

Ewers, R. M., J. P. W. Scharlemann, A. Balmford & R. E. Green, 2009. Do increases in agricultural yield spare land for nature? *Global Change Biology,* **15**: 1716–1726.

Fitzherbert, E. B., M. J. Struebig, A. Morel, F. Danielsen, C. A. Brulh, P. F. Donald & B. Phalan, 2008. How will oil palm expansion affect biodiversity? *Trends in Ecology & Evolution,* **23**: 538–545.

Gardner, T. A., J. Barlow, R. Chazdon, R. M. Ewers, C. A. Harvey, C. A. Peres & N. S. Sodhi, 2009. Prospects for tropical forest biodiversity in a human-modified world. *Ecology Letters,* **12**: 561–582.

Gascon, C., T. E. Lovejoy, R. O. Bierregaard, J. R. Malcolm, P. C. Stouffer, H. L. Vasconcelos, W. F. Laurance, B. Zimmerman, M. Tocher & S. Borges, 1999. Matrix habitat and species richness in tropical forest remnants. *Biological Conservation,* **91**: 223–229.

Ghazoul, J., L. P. Koh & P. Levang, 2010. Checking the reality check. *Trends in Ecology & Evolution,* **25**: 8–9.

Green, R. E., S. J. Cornell, J. P. W. Scharlemann & A. Balmford, 2005. Farming and the fate of wild nature. *Science,* **307**: 550–555.

Harvey, C. A., O. Komar, R. Chazdon, B. G. Ferguson, B. Finegan, D. M. Griffith, M. Martinez-Ramos, H. Morales, R. Nigh, L. Soto-Pinto, M. Van Breugel & M. Wishnie, 2008. Integrating agricultural landscapes with biodiversity conservation in the Mesoamerican hotspot. *Conservation Biology,* **22**: 8–15.

Johns, A. D., 1996. Bird population persistence in Sabahan logging concessions. *Biological Conservation,* **75**: 3–10.

Koh, L. P., 2008. Can oil palm plantations be made more hospitable for forest butterflies and birds? *Journal of Applied Ecology,* **45**: 1002–1009.

Koh, L. P., P. Levang & J. Ghazoul, 2009. Designer landscapes for sustainable biofuels. *Trends in Ecology & Evolution,* **24**: 431–438.

Koh, L. P. & D. S. Wilcove, 2008. Is oil palm agriculture really destroying tropical biodiversity. *Conservation Letters,* **1**: 60–64.

Lamb, D., 1998. Large-scale ecological restoration of degraded tropical forest lands: The potential role of timber plantations. *Restoration Ecology,* **6**: 271–279.

Marsh, C. & A. G. Greer, 1992. Forest land-use in Sabah, Malaysia: and introduction to Danum Valley. *Philosophical Transactions of the Royal Society B Biological Sciences,* **335**: 331–339.

McCune, B. & M. J. Mefford, 2006. *PC-ORD: Multivariate Analysis of Ecological Data. Version 5.10*. Gleneden Beach, Oregon, MjM Software.

McShea, W. J., C. Stewart, L. Peterson, P. Erb, R. Stuebing & B. Giman, 2009. The importance of secondary forest blocks for terrestrial mammals within an Acacia/secondary forest matrix in Sarawak, Malaysia. *Biological Conservation,* **142**: 3108–3119.

Mitra, S. & F. H. Sheldon, 1993. Use of an exotic tree plantation by Bornean lowland forest birds. *Auk,* **110**: 529–540.

Myers, S., 2009. *A Field Guide to the Birds of Borneo*. New Holland Publishers, London. 272 pp.

Otsamo, A., G. Adjers, T. S. Hadi, J. Kuusipalo & R. Vuokko, 1997. Evaluation of reforestation potential of 83 tree species planted on *Imperata cylindrica* dominated grassland - A case study from South Kalimantan, Indonesia. *New Forests,* **14**: 127–143.

Pinso, C. & R. Y. Vun, 2000. Incentives for forestry plantation projects in Sabah, Malaysia. *Holz Als Roh-Und Werkstoff,* **58**: 202–210.

Putz, F. E., L. K. Sirot & M. A. Pinard, 2001. Tropical forest management and wildlife: Silvicultural effects on forest structure, fruit production, and locomotion of arboreal animals. In: R. A., Fimbel, A. Grajal & G. Robinson (eds.), *The Cutting Edge: Conserving Wildlife in Logged Tropical Forests*. Columbia University Press, New York. Pp. 11–34.

Renjifo, L. M., 2001. Effect of natural and anthropogenic landscape matrices on the abundance of subandean bird species. *Ecological Applications*, **11:** 14-31.

RSPO, 2007. *Roundtable on Sustainable Palm Oil: RSPO Certification Systems*. http://www.rspo.org/files/resource_centre/RSPO%20certification%20systems.pdf.

Scherr, S. J. & J. A. McNeely, 2008. Biodiversity conservation and agricultural sustainability: Towards a new paradigm of 'ecoagriculture' landscapes. *Philosophical Transactions of the Royal Society B-Biological Sciences,* **363**: 477–494.

Sheldon, F. H., A. R. Styring & P. A. Hosner, 2010. Bird species richness in a Bornean exotic tree plantation: A long-term perspective. *Biological Conservation,* **143**: 399–407.

Sodhi, N. S., M. R. C. Posa, T. M. Lee, D. Bickford, L. P. Koh & B. W. Brook, 2010. The state and conservation of Southeast Asian biodiversity. *Biodiversity and Conservation,* **19**: 317–328.

Sodhi, N. S., M. R. C. Posa, T. M. Lee & I. G. Warkentin, 2008. Effects of disturbance or loss of tropical rainforest on birds. *Auk,* **125**: 511–519.

Struebig, M. J., G. Paoli & E. Meijaard, 2010a. A reality check for designer biofuel landscapes. *Trends in Ecology & Evolution,* **25**: 7–8.

Struebig, M. J., L. Christy, D. Pio & E. Meijaard, 2010b. Bats of Borneo: Diversity, distributions and representation in protected areas. *Biodiversity and Conservation,* **19**: 449–469.

Stuebing, R., J. Unggang, J. Ferner, J. Ferner, B. Giman & K. K. Ping, 2007. Proceedings of the regional conference of biodiversity conservation in tropical planted forests in Southeast Asia. Sarawak Forest Department, Sarawak Forestry Corporation, and Grand Perfect Sdn Bhd, Kuching, Malaysia.

Stuebing, R. B., 2007. Biodiversity conservation in theory and practice: Lessons from the Planted Forest Zone, Sarawak. In: Stuebing, R., J. Unggang, J. Ferner, J. Ferner, B. Giman & K. K. Ping (eds.), *Proceedings of the Regional Conference of Biodiversity Conservation in Tropical Planted Forests in Southeast Asia*. Sarawak Forest Department, Sarawak Forestry Corporation, and Grand Perfect Sdn Bhd, Kuching, Malaysia. Pp. 16–30.

Styring, A. R., R. Ragai, J. Unggang, R. Stuebing, P. A. Hosner & F. H. Sheldon, 2011. Bird community assembly in Bornean industrial tree plantations: Effects of forest age and structure. *Forest Ecology and Management,* **261**: 531–544.

Thomas, L., J. L. Laake, S. Strindberg, F. F. C. Marques, S. T. Buckland, D. L. Borchers, D. R. Anderson, K. P. Burnham, S. L. Hedley, J. H. Pollard, J. R. B. Bishop & T. A. Marques, 2006. *Distance 5.0. Release 2*. Research Unit for Wildlife Population Assessment, University of St Andrews, Scotland. http://www.ruwpa.st-and.ac.uk/distance/

Thomas, P., F. K. C. Lo & A. J. Heburn, 1976. *The Land Capability Classification of Sabah*. Land Resources Division, Ministry of Overseas Development, Surbiton, United Kingdom. 124 pp.

Whitmore, T. C., 1984. *Tropical Rain Forests of the Far East.* Clarendon Press, Oxford. 352 pp.

WWF-Malaysia, 2005. Proceedings: Heart of Borneo, three countries, one conservation vision. http://wwf.panda.org.

WWF-Malaysia, 2006. *The Conservation and Sustainable Use of the Highlands of Sabah and Sarawak. Vol. 2. Sabah*. Draft Final Report to the Economic Planning Unit, Government of Malaysia, Kuala Lumpur.

Appendix 1. Non-migratory forest birds recorded in Sabah Softwoods (SS) and the Sarawak Planted Forest Project (SPF) in Mangium, Albizia (Alb), Oil Palm (OP), logged native forest (LNF), and peatswamp forest (Binyo).

| Names[a] | | 2005 Survey SS | | | | | | 2006 Survey SF | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| English | Scientific[b] | Mangium | | | Alb | OP | LNF | Mangium | | | LN1F | Binyo |
| | | 2y | 5y | 7y | ≥7y | 10y | | 2y | 5y | 7y | | |
| **Phasianidae: Partridge, quail, and pheasants** | | | | | | | | | | | | |
| Blue-breasted Quail | *Coturnix chinensis* | | | | | 1 | | | | | | |
| Scaly-breasted Partridge | *Arborophila charltonii*[NT] | | | 2 | 1 | | 6 | | | | | |
| Crested Partridge | *Rollulus rouloul*[NT] | | | | | 2 | | | | | | |
| Crested Fireback | *Lophura ignita*[NT] | | | 4 | | | | | | | | |
| Great Argus | *Argusianus argus*[NT] | 1 | | | | | 10 | | | | 3 | |
| **Accipitridae: Hawks, eagles, and allies** | | | | | | | | | | | | |
| Jerdon's Baza | *Aviceda jerdoni* | | | | | | | | | 2 | | |
| Oriental Honey-buzzard | *Pernis ptilorhynchus* | | | 1 | 1 | | 2 | | | | | |
| Bat Hawk | *Macheiramhus alcinus* | | | | | | | | | | 2 | |
| Black Eagle | *Ictinaetus malayensis* | | | | | | | | | | 1 | |
| Changeable Hawk-Eagle | *Spizaetus cirrhatus* | | | | | | 1 | | | | | |
| **Columbidae: Pigeons and doves** | | | | | | | | | | | | |
| Spotted Dove | *Streptopelia chinensis* | | | | | 17 | | | | | | |
| Emerald Dove | *Chalcophaps indica* | 9 | 13 | 11 | 8 | 3 | 15 | 1 | 8 | 1 | 4 | |
| Jambu Fruit-Dove | *Ptilinopus jambu*[NT] | | | | | | 3 | | | | | |
| Little Green Pigeon | *Treron olax* | | | | 1 | | | | | | | |
| Thick-billed Green Pigeon | *Treron curvirostra* | | | | | | | | 13 | 1 | | |
| Green Imperial-Pigeon | *Ducula aenea* | | | 2 | | | | | | | | 2 |
| **Psittacidae: Parrots and parakeets** | | | | | | | | | | | | |
| Blue-crowned Hanging-Parrot | *Loriculus galgulus* | 2 | 1 | 12 | 10 | | 16 | 1 | 5 | 1 | 16 | 10 |
| Blue-rumped Parrot | *Psittinus cyanurus*[NT] | | | | | | 2 | | | | | |
| Long-tailed Parakeet | *Psittacula longicauda*[NT] | | 2 | | | | | | | | | |
| **Cuculidae: Old World cuckoos** | | | | | | | | | | | | |
| Malaysian Hawk-Cuckoo | *Hierococcyx fugax* | | | | | | | | | 2 | | |
| Banded Bay Cuckoo | *Cacomantis sonneratii* | | | | 1 | | | | | | 9 | 4 |
| Plaintive Cuckoo | *Cacomantis merulinus* | 21 | 4 | 4 | 17 | 2 | 1 | 24 | 2 | 8 | | |
| Rusty-breasted Cuckoo | *Cacomantis sepulcralis* | | | | | | 1 | | | | | |
| Violet Cuckoo | *Chrysococcyx xanthorhynchus* | | | | | | 1 | | 6 | 1 | 3 | |
| Little Bronze-Cuckoo | *Chrysococcyx minutillus* | | 1 | | 3 | | 1 | | | | | |
| Drongo-Cuckoo | *Surniculus lugubris* | | 1 | 1 | 2 | | | | | | 2 | |
| Chestnut-bellied Malkoha | *Phaenicophaeus sumatranus*[NT] | | | | | | 1 | | | | | 2 |
| Red-billed Malkoha | *Phaenicophaeus javanicus* | | | | 2 | | | | | | | |
| Raffles's Malkoha | *Phaenicophaeus chlorophaeus* | | 3 | 1 | 4 | | | | | 7 | 9 | |
| Chestnut-breasted Malkoha | *Phaenicophaeus curvirostris* | | 3 | 1 | | | | | | 1 | 2 | |
| Greater Coucal | *Centropus sinensis* | 7 | 18 | 9 | 2 | 11 | 1 | 28 | 7 | 7 | 12 | 2 |
| Lesser Coucal | *Centropus bengalensis* | 22 | 3 | | | 11 | | | | | | 1 |
| **Caprimulgidae: Nightjars** | | | | | | | | | | | | |
| Malaysian Eared Nightjar | *Eurostopodus temminckii* | | | | | | | | | | 3 | |
| **Apodidae: Swifts** | | | | | | | | | | | | |
| Glossy Swiftlet | *Collocalia esculenta* | 2 | | 1 | | | | | | | | |

Appendix 1. Cont'd.

| Names[a] English | Scientific[b] | 2005 Survey SS Mangium 2y | 2005 Survey SS Mangium 5y | 2005 Survey SS Mangium 7y | 2005 Survey SS Alb ≥7y | 2005 Survey SS OP 10y | 2005 Survey SS LNF | 2006 Survey SF Mangium 2y | 2006 Survey SF Mangium 5y | 2006 Survey SF Mangium 7y | 2006 Survey SF LN1F | 2006 Survey SF Binyo |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Swiftlet | *Aerodramus* sp? | 2 | | | | | | | | | | |
| Silver-rumped Needletail | *Rhaphidura leucoygialis* | | | | | | 30 | | | | 59 | 4 |
| House Swift | *Apus affinis* | | | | | | | 1 | | | | |
| Grey-rumped Treeswift | *Hemiprocne longipennis* | | | 2 | 1 | | | | | | 5 | 10 |
| Whiskered Treeswift | *Hemiprocne comata* | | | | | | 14 | | | | | |
| **TROGONIFORMES: Trogonidae** | | | | | | | | | | | | |
| Red-naped Trogon | *Harpactes kasumba*[NT] | | | 1 | 1 | | 8 | | 2 | | 42 | 2 |
| Diard's Trogon | *Harpactes diardii*[NT] | 1 | 1 | 2 | 2 | | 5 | | | 8 | 10 | |
| Scarlet-rumped Trogon | *Hapractes duvaucelii*[NT] | | | 1 | 5 | | 12 | 1 | | 2 | 2 | 1 |
| **Alcedinidae: Kingfishers** | | | | | | | | | | | | |
| Collared Kingfisher | *Todiramphus chloris* | | 1 | 1 | 3 | 6 | | | | | | |
| Rufous-backed Kingfisher | *Ceyx rufidorsum* | | 1 | 1 | | | | | 1 | 1 | | |
| Blue-eared Kingfisher | *Alcedo meninting* | | | | | 1 | | | | | 11 | 8 |
| **Meropidae: Bee-eaters** | | | | | | | | | | | | |
| Red-bearded Bee-eater | *Nyctyornis amictus* | | | | | | 2 | | | 1 | 4 | 2 |
| Blue-throated Bee-eater | *Merops viridis* | 2 | | | | | 11 | | | | | |
| **Bucerotidae: Hornbills** | | | | | | | | | | | | |
| Bushy-crested Hornbill | *Anorrhinus galeritus* | | | | 1 | | 26 | | | | 2 | |
| Black Hornbill | *Anthracoceros malayanus*[NT] | | 6 | | | | | 3 | 1 | | 40 | |
| Rhinoceros Hornbill | *Buceros rhinoceros*[NT] | 1 | | | | | 7 | | | | 9 | |
| Helmeted Hornbill | *Rhinoplax vigil*[NT] | | | | | | 1 | 1 | | | | |
| Wreathed Hornbill | *Aceros undulatus* | | | | | | 4 | | | | 1 | 3 |
| **Capitonidae: Barbets** | | | | | | | | | | | | |
| Gold-whiskered Barbet | *Megalaima chrysopogon* | | | | | | 6 | 2 | | 1 | 7 | |
| Red-crowned Barbet | *Megalaima rafflesii*[NT] | | | | | | | | 7 | | 2 | 4 |
| Red-throated Barbet | *Megalaima mystacophanos*[NT] | | | | | | 7 | 4 | | | | |
| Yellow-crowned Barbet | *Megalaima henricii*[NT] | | | | | | 1 | | | | 6 | |
| Blue-eared Barbet | *Megalaima australis* | | | | | | 9 | 2 | 1 | | 37 | 2 |
| Brown Barbet | *Calorhamphus fuliginosus* | | | | | | 4 | | | | 22 | |
| **Picidae: Woodpeckers** | | | | | | | | | | | | |
| Rufous Piculet | *Sasia abnormis* | 1 | 13 | 13 | 13 | 1 | 6 | 3 | 5 | 4 | 7 | 1 |
| Grey-capped Woodpecker | *Dendrocopos canicapillus* | | | | 1 | | 3 | | | | | 4 |
| White-bellied Woodpecker | *Dryocopus javensis* | | | | | | | | | 2 | 10 | 8 |
| Rufous Woodpecker | *Micropternus brachyurus* | | | | | | 1 | 3 | 1 | 1 | 10 | 1 |
| Banded Woodpecker | *Picus miniaceus* | | | | | | | | | | | 2 |
| Crimson-winged Woodpecker | *Picus puniceus* | | | | | | 1 | | | 1 | | 3 |
| Olive-backed Woodpecker | *Dinopium rafflesii*[NT] | | | | | | 1 | | | | 1 | |
| Maroon Woodpecker | *Blythipicus rubiginosus* | | | | 1 | | 3 | 1 | | 1 | 3 | |
| Orange-backed Woodpecker | *Reinwardtipicus validus* | | | | | | | | | | 4 | 6 |
| Buff-rumped Woodpecker | *Meiglytes tristis* | | | 4 | | | 1 | | 3 | 4 | | 3 |
| Buff-necked Woodpecker | *Meiglytes tukki*[NT] | | 1 | | | | 3 | | | | | |
| Grey-and-buff Woodpecker | *Hemicircus concretus* | | | | | | 2 | | | | 1 | |

Appendix 1. Cont'd.

| Names[a] English | Scientific[b] | 2005 Survey SS Mangium 2y | 5y | 7y | Alb ≥7y | OP 10y | LNF | 2006 Survey SF Mangium 2y | 5y | 7y | LN1F | Binyo |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Great Slaty Woodpecker | *Mulleripicus pulverulentus* | | | | 1 | | | | | | | |
| **Eurylaimidae: Broadbills** | | | | | | | | | | | | |
| Green Broadbill | *Calyptomena viridis*[NT] | | | | | | 5 | | 1 | 2 | 7 | |
| Dusky Broadbills | *Corydon sumatranus* | | | 2 | | | | | | | 3 | 11 |
| Banded Broadbill | *Eurylaimus javanicus* | | | | | | 2 | | | | 4 | 3 |
| Black-and-yellow Broadbill' | *Eurylaimus ochromalus*[NT] | | 1 | 5 | 6 | | 23 | | | 11 | 52 | 11 |
| **Pittidae: Pittas** | | | | | | | | | | | | |
| Hooded Pitta | *Pitta sordida* | | 2 | | 5 | | | | | | | |
| Blue-banded Pitta | *Pitta arquata* | | | | | | 1 | | | | | |
| Black-and-crimson Pitta | *Pitta ussheri*[NT] | | 2 | | 3 | | 3 | | | | | |
| Garnet Pitta | *Pitta granatina*[NT] | | | | | | | | | | 5 | |
| **Vireonidae: Shrike-babblers, erpornis, and allies** | | | | | | | | | | | | |
| White-bellied Erpornis | *Erpornis zantholeuca* | | 6 | 10 | 3 | | 1 | | | | | |
| **Acanthizidae: Thornbills and allies** | | | | | | | | | | | | |
| Golden-bellied Gerygone | *Gerygone sulphurea* | | | 1 | | | 1 | | | | | |
| **Campephagidae: Cuckooshrikes, trillers, and minivets** | | | | | | | | | | | | |
| Lesser Cuckooshrike | *Coracina fimbriata* | | | | | | 2 | | 1 | | 3 | |
| Fiery Minivet | *Pericrocotus igneus*[NT] | 1 | | | 5 | | 6 | | | | | |
| Scarlet Minivet | *Pericrocotus flammeus* | | | | | | 1 | | | | | |
| **Oriolidae: Old World orioles** | | | | | | | | | | | | |
| Dark-throated Oriole | *Oriolus xanthonotus*[NT] | 3 | 6 | 9 | 9 | | 10 | | | | 5 | 8 |
| **Genera Incertae Sedis: Woodshrikes, flycatcher-shrikes, & philentomas** | | | | | | | | | | | | |
| Large Woodshrike | *Tephrodornis gularis* | | | | 1 | | 1 | | | | | |
| Black-winged Flycatcher-shrike | *Hemipus hirundinaceus* | | 3 | 1 | 1 | | 6 | | 2 | | | |
| Rufous-winged Philentoma | *Philentoma pyrhopterum* | | | 2 | 1 | | 1 | 2 | 2 | 5 | 2 | |
| Maroon-breasted Philentoma | *Philentoma velatum*[NT] | | | | 1 | | 1 | | | | | |
| **Aegithinidae: Ioras** | | | | | | | | | | | | |
| Common Iora | *Aegithina tiphia* | | | | | | | | | | | 8 |
| Green Iora | *Aegithina viridissima*[NT] | | 1 | 8 | 10 | | 9 | | 1 | 13 | 3 | 14 |
| **Rhipiduridae: Fantails** | | | | | | | | | | | | |
| Pied Fantail | *Rhipidura javanica* | 44 | 44 | 46 | 45 | 24 | 1 | 9 | 3 | 7 | 8 | 3 |
| Spotted Fantail | *Rhipidura perlata* | | | | | | | | | | 5 | |
| **Monarchidae** | | | | | | | | | | | | |
| Black-naped Monarch | *Hypothymis azurea* | 1 | 17 | 20 | 16 | | 26 | 3 | 9 | 21 | 11 | 9 |
| Asian Paradise-Flycatcher | *Terpsiphone paradisi* | | 1 | 2 | 4 | | 5 | 1 | 3 | 5 | 45 | 2 |
| **Dicruridae: Drongos** | | | | | | | | | | | | |
| Greater Racket-tailed Drongo | *Dicrurus paradiseus* | | | | | | | 2 | | | 14 | |
| Hair-crested Drongo | *Dicrurus hottentottus* | | | | | | | | | | | 2 |
| **Corvidae: Crows, jays, magpies, and treepies** | | | | | | | | | | | | |
| Slender-billed Crow | *Corvus enca* | 6 | 17 | 9 | 16 | 10 | 29 | | 7 | 4 | 7 | 1 |
| Bornean Black Magpie | *Platysmurus aterrimus*[NT] | | | | 5 | | | | | | | |

Appendix 1. Cont'd.

| Names[a] | | 2005 Survey SS | | | | | | 2006 Survey SF | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| English | Scientific[b] | Mangium | | | Alb | OP | LNF | Mangium | | | LN1F | Binyo |
| | | 2y | 5y | 7y | ≥7y | 10y | | 2y | 5y | 7y | | |
| **Pityriaseidae: Bristlehead** | | | | | | | | | | | | |
| Bornean Bristlehead | *Pityriasis gymnocephala*[NT] | | | 1 | | | | | | | | |
| **Nectariniidae: Sunbirds and spiderhunters** | | | | | | | | | | | | |
| Plain Sunbird | *Anthreptes simplex* | | | 4 | 1 | | 28 | | 1 | | | |
| Brown-throated Sunbird | *Anthreptes malacensis* | 1 | 1 | | 3 | | 1 | 11 | 1 | 6 | 4 | |
| Red-throated Sunbird | *Anthreptes rhodolaema*[NT] | | 4 | | | | 6 | | | | | |
| Ruby-cheeked Sunbird | *Anthreptes singalensis* | | | | | | | 2 | 3 | 11 | 27 | 29 |
| Van Hasselt's Sunbird | *Leptocoma brasiliana* | | | 5 | | | 6 | | | | | |
| Olive-backed Sunbird | *Nectarinia jugularis* | | 2 | | 2 | | | | | | | |
| Crimson Sunbird | *Aethopyga siparaja* | 13 | 12 | 18 | 8 | 19 | 19 | | 5 | | | 2 |
| Temminck's Sunbird | *Aethopyga temminckii* | | | | 2 | | | | | | | |
| Purple-naped Sunbird | *Hypogramma hyopgrammicum* | | 2 | 5 | 7 | | 6 | | 10 | 8 | 28 | 1 |
| Little Spiderhunter | *Arachnothera longirostra* | 20 | 38 | 48 | 41 | 8 | 13 | 41 | 102 | 98 | 84 | 27 |
| Thick-billed Spiderhunter | *Arachnothera crassirostris* | | | | | | 1 | | | | 3 | 1 |
| Long-billed Spiderhunter | *Arachnothera robusta* | | | 1 | | | 1 | | | | | 1 |
| Spectacled Spiderhunter | *Arachnothera flavigaster* | | | | | | 2 | | | 4 | | 1 |
| **Dicaeidae: Flowerpeckers** | | | | | | | | | | | | |
| Yellow-breasted Flowerpecker | *Prionochilus maculatus* | | | | | | 2 | | | | 7 | 2 |
| Yellow-rumped Flowerpecker | *Prionochilus xanthopygius* | 14 | 12 | 39 | 16 | 1 | 37 | | 5 | 1 | 21 | 6 |
| Scarlet-breasted Flowerpecker | *Prionochilus thoracicus*[NT] | | | | | | | | | | | 1 |
| Orange-bellied Flowerpecker | *Dicaeum trigonostigma* | 11 | 25 | 40 | 40 | 12 | 15 | 3 | 12 | 5 | 37 | 9 |
| Plain Flowerpecker | *Dicaeum concolor* | | | 1 | | | 1 | | 1 | | | |
| Scarlet-backed Flowerpecker | *Dicaeum cruentatum* | | | | | | | | | | | 13 |
| **Chloropseidae: Leafbirds** | | | | | | | | | | | | |
| Greater Green Leafbird | *Chloropsis sonnerati* | 4 | 1 | | 8 | | 18 | | 1 | | | |
| Lesser Green Leafbird | *Chloropsis cyanopogon*[NT] | | | | | | | | | 1 | 5 | |
| **Irenidae: Fairy bluebirds** | | | | | | | | | | | | |
| Asian Fairy-bluebird | *Irena puella* | | | | 20 | | 21 | | 4 | 6 | 26 | 16 |
| **Sittidae: Nuthatches** | | | | | | | | | | | | |
| Velvet-fronted Nuthatch | *Sitta frontalis* | | | | 10 | | 1 | | | | | |
| **Estrildidae: Avadavats, parrotfinches, munias, and allies** | | | | | | | | | | | | |
| Dusky Munia | *Lonchura fuscans* | | | 6 | | | 6 | | | | | 4 |
| Chestnut Munia | *Lonchura atricapilla* | 6 | | | | | | | | | | |
| **Sturnidae: Starlings and mynas** | | | | | | | | | | | | |
| Common Hill Myna | *Gracula religiosa* | 2 | | | 4 | | 5 | 3 | 4 | 30 | 40 | |
| **Turdidae: Thrushes and allies** | | | | | | | | | | | | |
| **Muscicapidae: Old World flycatchers, chats, forktails, and allies** | | | | | | | | | | | | |
| Oriental Magpie-Robin | *Copsychus saularis* | | | | | 32 | | 2 | | 2 | | |
| White-rumped Shama | *Copsychus malabaricus* | 3 | 30 | 26 | 23 | | 10 | 5 | 13 | 12 | 18 | |
| Rufous-tailed Shama | *Trichixos pyrropyga*[NT] | | | | | | 2 | | | | 4 | |
| White-crowned Forktail | *Enicurus leschenaulti* | | | 1 | | | 1 | | | | | |
| Verditer Flycatcher' | *Eumyias thalassina* | | | | | | 1 | | | | | |

Appendix 1. Cont'd.

| Names[a] English | Scientific[b] | 2005 Survey SS Mangium 2y | 5y | 7y | Alb ≥7y | OP 10y | LNF | 2006 Survey SF Mangium 2y | 5y | 7y | LN1F | Binyo |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rufous-chested Flycatcher | *Ficedula dumetoria*[NT] | | | | 1 | | | | | | | |
| Grey-chested Jungle-Flycatcher | *Rhinomyias umbratilis*[NT] | | | 1 | 1 | | 7 | | | | 3 | 4 |
| **Stenostiridae: Canary-flycatchers and allies** | | | | | | | | | | | | |
| **Pycnonotidae: Bulbuls** | | | | | | | | | | | | |
| Black-headed Bulbul | *Pycnonotus atriceps* | 22 | 26 | 14 | 47 | | 83 | 12 | 37 | 72 | 17 | 33 |
| Grey-bellied Bulbul | *Pycnonotus cyaniventris*[NT] | | | | | | 2 | | | | | |
| Puff-backed Bulbul | *Pycnonotus eutilotus*[NT] | | | | 3 | | | | | | | 1 |
| Yellow-vented Bulbul | *Pycnonotus goiavier* | 231 | 126 | 108 | 99 | 139 | 90 | 39 | 4 | 3 | 2 | |
| Olive-winged Bulbul | *Pycnonotus plumosus* | | | 9 | 1 | 2 | | | | | 6 | |
| Cream-vented Bulbul | *Pycnonotus simplex* | | 1 | 4 | 3 | | 17 | 8 | 14 | 34 | 50 | 48 |
| Red-eyed Bulbul | *Pycnonotus brunneus* | 1 | 19 | 17 | 79 | | 89 | 34 | 23 | 73 | 16 | 16 |
| Spectacled Bulbul | *Pycnonotus erythropthalmos* | 3 | 30 | 43 | 85 | | 86 | 5 | 19 | 20 | 73 | 2 |
| Buff-vented Bulbul | *Iole olivacea*[NT] | | | | | | 27 | | | | | |
| Hairy-backed Bulbul | *Tricholestes criniger* | 1 | 1 | | | | 8 | 2 | | | 14 | |
| Finsch's Bulbul | *Alophoixus finschii*[NT] | | | | | | 2 | | | | | |
| Grey-cheeked Bulbul | *Alophoixus bres* | | | 1 | 1 | | 2 | | | | | |
| Streaked Bulbul | *Ixos malaccensis*[NT] | | | | | | 5 | | | | | |
| **Timaliidae: Babblers** | | | | | | | | | | | | |
| Brown Fulvetta | *Alcippe brunneicauda*[NT] | | | 9 | 4 | | 47 | | | | 10 | |
| Everett's White-eye | *Zosterops everetti* | | 20 | 52 | 66 | | 70 | | | | | |
| Black-throated Babbler | *Stachyris nigricollis*[NT] | | 6 | 2 | 13 | | 7 | | 5 | | 42 | 4 |
| Grey-headed Babbler | *Stachyris poliocephala* | | | 2 | 3 | | | | | | | |
| Chestnut-winged Babbler | *Stachyris erythroptera* | 6 | 28 | 12 | 16 | | 41 | 6 | 50 | 75 | 88 | 30 |
| Chestnut-rumped Babbler | *Stachyris maculata*[NT] | | 4 | 2 | 1 | | 31 | 16 | 49 | 47 | 57 | 17 |
| Chestnut-backed Scimitar-Babbler | *Pomatorhinus montanus* | | | | | | 14 | | | | | |
| Rufous-fronted Babbler | *Stachyris rufifrons* | 1 | 5 | 3 | 8 | | 28 | 11 | 7 | 6 | 11 | 1 |
| Bold-striped Tit-Babbler | *Macronous bornensis* | 183 | 197 | 153 | 119 | 131 | 12 | 132 | 48 | 137 | 29 | 3 |
| Fluffy-backed Tit-Babbler | *Macronous ptilosus*[NT] | 6 | 32 | 13 | 16 | | 15 | 42 | 47 | 65 | 86 | 7 |
| Black-capped Babbler | *Pellorneum capistratum* | 3 | 27 | 25 | 20 | 3 | 1 | | 6 | 12 | 26 | |
| Moustached Babbler | *Malacopteron magnirostre* | | 1 | 1 | | | 3 | 1 | 2 | 3 | 22 | |
| Sooty-capped Babbler | *Malacopteron affine*[NT] | | 3 | 5 | 1 | | 10 | 13 | 1 | 15 | 33 | 6 |
| Scaly-crowned Babbler | *Malacopteron cinereum* | | | 3 | | | 12 | | | | 9 | 2 |
| Rufous-crowned Babbler | *Malacopteron magnum*[NT] | 2 | 5 | 4 | 4 | | 5 | | | 5 | 9 | 16 |
| White-chested Babbler | *Trichastoma rostratum*[NT] | | 7 | 4 | 6 | 6 | | | 8 | 26 | 68 | 25 |
| Ferruginous Babbler | *Trichastoma bicolor* | | 3 | 6 | 6 | | 4 | | 3 | 11 | 23 | |
| Short-tailed Babbler | *Malacocincla malaccensis*[NT] | 3 | 24 | 11 | 22 | | 16 | | 33 | 17 | 60 | |
| **Cisticolidae: Cisticolas, tailorbirds, prinias, and allies** | | | | | | | | | | | | |
| Ashy Tailorbird | *Orthotomus ruficeps* | 69 | 69 | 50 | 58 | 20 | 25 | 29 | 17 | 28 | 4 | |
| Rufous-tailed Tailorbird | *Orthotomus sericeus* | 87 | 159 | 175 | 123 | 83 | 11 | 49 | 130 | 181 | 7 | 11 |
| Dark-necked Tailorbird | *Orthotomus atrogularis* | | | | | | 1 | 2 | 6 | 17 | 59 | 8 |
| Yellow-bellied Prinia | *Prinia flaviventris* | 90 | 27 | 12 | 11 | 39 | 3 | 28 | 6 | 8 | 10 | 21 |

[a] Taxic order follows Myers (2009).
[b] Abbreviation at the ends of names indicate conservation status: VU = vulnerable, NT=near threatened (www.birdlife.org).

Appendix 2. Transects conducted at Sabah Softwoods and the Sarawak Planted Forest Zone.

| Transect | Habitat | Plot Age (in years) or characteristics<br>Sabah Softwoods | Survey Date | Surveyor[a] |
|---|---|---|---|---|
| 1. AM2Y1 | Mangium | 2 | 23 Jun.2005 | FHS/PAH |
| 2. AM2Y2 | Mangium | 2 | 27 Jun.2005 | FHS |
| 3. AM2Y3 | Mangium | 2 | 28 Jun.2005 | FHS |
| 4. AM2Y4 | Mangium | 2 | 5 Jul.2005 | FHS |
| 5. AM3Y1 | Mangium | 2 | 12 Jul.2005 | FHS |
| 6. AM5Y1 | Mangium | 5 | 25 Jun.2005 | PAH |
| 7. AM5Y2 | Mangium | 5 | 29 Jun.2005 | PAH |
| 8. AM5Y3 | Mangium | 5 | 30 Jun.2005 | FHS |
| 9. AM5Y4 | Mangium | 5 | 6 Jul.2005 | FHS |
| 10. AM5Y5 | Mangium | 5 | 10 Jul.2005 | FHS |
| 11. AM5Y6 | Mangium | 5 | 11 Jul.2005 | FHS |
| 12. AM7Y1 | Mangium | 7 | 24 Jun.2005 | FHS/PAH |
| 13, AM7Y2 | Mangium | 7 | 30 Jun.2005 | PAH |
| 14. AM7Y3 | Mangium | 7 | 7 Jul.2005 | PAH |
| 15. AM7Y4 | Mangium | 7 | 8 Jul.2005 | PAH |
| 16. AM7Y5 | Mangium | 7 | 10 Jul.2005 | PAH |
| 17. AM7Y6 | Mangium | 7 | 12 Jul.2005 | PAH |
| 18. AF7Y1 | Albizia | 7 | 27 Jun.2005 | PAH |
| 19. AF10Y2 | Albizia | 10 | 1 Jul.2005 | PAH |
| 20. AF10Y3 | Albizia | 10 | 1 Jul.2005 | FHS |
| 21. AF10yr 4 | Albizia | 10 | 4 Jul.2005 | FHS |
| 22. AF10yr 5 | Albizia | 10 | 8 Jul.2005 | FHS |
| 23. AF10yr 6 | Albizia | 10 | 1 Jul.2005 | PAH |
| 24. OP10Y1 | Oil Palm | 10 | 29 Jun.2005 | FHS |
| 25. OP10Y2 | Oil Palm | 10 | 2 Jul.2005 | PAH |
| 26. OP10Y3 | Oil Palm | 10 | 2 Jul.2005 | FHS |
| 27. OP10Y4 | Oil Palm | 10 | 7 Jul.2005 | FHS |
| 28. SF1 | “Steep” forest | Logged native forest | 28 Jun.2005 | PAH |
| 29. SF2 | “Steep” forest | Logged native forest | 4 Jul.2005 | PAH |
| 30. SF3 | “Steep” forest | Logged native forest | 5 Jul.2005 | PAH |
| 31. SF4 | “Steep” forest | Logged native forest | 6 Jul.2005 | PAH |
| 32. SF5 | “Steep” forest | Logged native forest | 9 Jul.2005 | PAH |
| 33. SF6 | “Steep” forest | Logged native forest | 9 Jul.2005 | FHS |
| | | **Sarawak Planted Forest Project** | | |
| 1. AM2Y1 | Mangium | 2 | 19 Jul.2006 | ARS |
| 2. AM2Y2 | Mangium | 2 | 28 Jul.2006 | FHS |
| 3. AM2Y3 | Mangium | 2 | 28 Jul.2006 | ARS |
| 4. AM2Y4 | Mangium | 2 | 29 Jul.2006 | FHS |
| 5. AM2Y5 | Mangium | 2 | 9 Jul.2006 | ARS |
| 6. AM5Y1 | Mangium | 5 | 20 Jul.2006 | ARS |
| 7. AM5Y2 | Mangium | 5 | 30 Jul.2006 | FHS |
| 8. AM5Y3 | Mangium | 5 | 30 Jul.2006 | ARS |
| 9. AM5Y4 | Mangium | 5 | 1 Aug.2006 | FHS |
| 10. AM5Y5 | Mangium | 5 | 1 Aug.2006 | ARS |
| 11. AM7Y1 | Mangium | 7 | 26 Jul.2006 | FHS |
| 12. AM7Y2 | Mangium | 7 | 26 Jul.2006 | ARS |
| 13. AM7Y3 | Mangium | 7 | 27 Jul.2006 | FHS |
| 14. AM7Y4 | Mangium | 7 | 27 Jul.2006 | ARS |
| 15. AM7Y5 | Mangium | 7 | 31 Jul.2006 | FHS |
| 16. AM7Y6 | Mangium | 7 | 1 Jul.2006 | ARS |
| 17. Binyo 1 | Peatswamp | 1° forest | 9 Aug.2006 | ARS |
| 18. Binyo 2 | Peatswamp | 1° forest | 10 Aug.2006 | ARS |
| 19. Binyo 3 | Peatswamp | 1° forest | 11 Aug.2006 | ARS |
| 20. Binyo 4 | Peatswamp | 1° forest | 12 Aug.2006 | ARS |
| 21. Buffer A1 | “Buffer” | Logged riverine forest | 21 Jul.2006 | ARS |
| 22. Buffer A2 | “Buffer” | Logged riverine forest | 22 Jul.2006 | ARS |
| 23. Buffer A3 | “Buffer” | Logged riverine forest | 23 Jul.2006 | ARS/FHS |
| 24. Buffer A4 | “Buffer” | Logged riverine forest | 24 Jul.2006 | ARS |
| 25. Buffer A5 | “Buffer” | Logged riverine forest | 25 Jul.2006 | ARS |
| 26. Buffer A6 | “Buffer” | Logged riverine forest | 24 Jul.2006 | FHS |
| 27. Buffer B1 | “Buffer” | Logged riverine forest | 3 Aug.2006 | FHS |

Appendix 2. Cont'd.

| Transect | Habitat | Plot Age (in years) or characteristics Sabah Softwoods | Survey Date | Surveyor[a] |
|---|---|---|---|---|
| 28. Buffer B2 | "Buffer" | Logged riverine forest | 3 Aug.2006 | ARS |
| 29. Buffer B3 | "Buffer" | Logged riverine forest | 4 Aug.2006 | FHS |
| 30. Buffer B4 | "Buffer" | Logged riverine forest | 4 Aug.2006 | ARS |
| 31. Buffer B5 | "Buffer" | Logged riverine forest | 5 Aug.2006 | FHS |
| 32. Buffer B6 | "Buffer" | Logged riverine forest | 5 Aug.2006 | ARS |

[a] ARS = Alison R. Styring, FHS = Frederick H. Sheldon, and PAH = Peter A. Hosner.