DIVERSITY OF BIRDS ACROSS LAND USE AND HABITAT GRADIENTS IN FORESTS, RUBBER AGROFORESTS AND RUBBER PLANTATIONS OF NORTH SUMATRA

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DIVERSITY OF BIRDS ACROSS LAND USE AND HABITAT GRADIENTS IN FORESTS, RUBBER AGROFORESTS AND RUBBER PLANTATIONS OF NORTH SUMATRA. Birds play a pivotal role in the ecosystem, but in disturbed areas their roles may be limited due to the changes of their natural habitats. This paper studies the birds' habitats in Simalungun and Asahan Districts, North Sumatra. The study was conducted in four habitats: natural forest, rubber agroforests, rubber monoculture plantations and emplacement areas. The birds were observed using descriptive survey methods by implementing a quick biodiversity survey, data were collected along one km transect. The results showed that in total, 142 species of birds from 42 families were observed in the four habitats. Natural forests had the highest diversity of bird species, followed by rubber agroforests, emplacement areas and rubber plantations, with a Shannon-Wiener index of 3.8, 3.6, 3.0 and 2.9, respectively. Regarding the IUCN red list species, 12 bird species of near-threatened status and 2 species of vulnerable status were recorded. Based on CITES categories, one species was listed in the Appendix I, 12 species were classified in Appendix II and 26 bird species were protected under Indonesian regulations. Changes in the structure and composition of the vegetation in disturbed forests and cleared land determined the richness of the bird species. The different tree compositions in the four habitats of the rubber estate plantations and surrounding areas influenced the number of bird species, bird diversity and species composition.

Keywords: Species composition, conservation, CITES, guild type

KERAGAMAN JENIS BURUNG PADA BERBAGAI PEMANFAATAN LAHAN DAN GRADASI DI HUTAN, AGROFOREST KARET DAN PERKEBUNAN KARET DI SUMATERA UTARA. Burung berperan penting dalam ekosistem, namun pada ekosistem yang terganggu peran mereka menjadi terbatas akibat perubahan habitat. Studi komunitas burung di berbagai tipe habitat, pada hutan, agroforest karet, monokultur karet dan daerah pemukiman telah dilakukan di Kabupaten Simalungun dan Asahan, Provinsi Sumatra Utara. Burung diamati dengan melakukan survei deskriptif dengan metode survei cepat biodiversitas, dengan mengkoleksi data pada transek sepanjang 1 km. Hasil studi di keempat tipe habitat menjumpai 142 jenis burung dari 42 suku. Burung yang dijumpai di hutan memiliki tingkat keragaman jenis tertinggi, selanjutnya habitat karet agroforest, daerah pemukiman dan karet monokultur, memiliki tingkat keragaman jenis yang lebih rendah, dengan index Shannon-Wiener secara berturut-turut 3,8, 3,6, 3,0 dan 2,9. Tercatat 12 jenis burung dengan status kelangkaan terancam punah dan dua species dengan status rentan, menurut red-list IUCN. Berdasarkan kategori CITES, tercatat satu jenis burung yang termasuk Appendix I, 12 jenis burung yang termasuk Appendix II, dan 26 jenis burung yang dilindungi berdasarkan peraturan perundang-undangan di Indonesia. Perubahan struktur dan komposisi vegetasi di hutan yang terganggu dan lahan terbuka menentukan kekayaan jenis burung. Perbedaan komposisi jenis pohon di keempat habitat di sekitar perkebunan karet monokultur mempengaruhi jumlah, keragaman, dan komposisi jenis burung.

Kata kunci: Komposisi jenis, konservasi, CITES, relung pakan

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I. INTRODUCTION

Sumatra has the lowest number of endemic bird species in Indonesia. This is related to its geological history of separation from the plains of Asia. Sumatra has about 306 bird species that are also found in Borneo, 345 species that can be found in the Malayan Peninsula and 211 species that also live in Java (MacKinnon & Phillips, 1993). A total of 583 recorded species inhabit the island of Sumatra and 438 species are breeding in Sumatra (Andrew, 1992). These numbers increase to 602 and 450 species, respectively when we include the small islands along the coast of Sumatra. There are 12 endemic bird species in the lowlands of Sumatra (Marle & Marle, 1988).

North Sumatra is covered by natural forests including Batang Gadis, Bohorok, Batang Toru and other forested areas, although most of these forests are fragmented and under considerable pressure from land-use changes (MacKinnon, Phillips, & van Balen, 1998; Sirait, 2007). Human activities change natural environments, such as turning forest into agricultural land, plantations and infrastructure for industrial activities. Forest areas of Sumatra remained at about 30% (13 million ha) of the total area of Sumatra in 2007 (Laumonier et al., 2010). Forest losses cause loss of bird habitat and decrease the number of bird species (Danielsen & Heegard, 1995; O'Brien & Kinnaird, 1996; Lane et al., 2011). Besides hunting and trade, deforestation and habitat destruction are the most dominant drivers in reducing the number of bird species and their possible extinction.

Agroforestry may reconcile ecological and economic objectives, balancing the need to generate income along with protecting the environment (Nair & Garrity, 2012). In 2005, agroforests covered about 16.3 million ha, or 8% of the total area of Indonesia (ICRAF, 2011). Rubber agroforests (RAFs) are part of Sumatra's man-made ecosystem and have been used by farmers for many decades. Farmers with limited resources plant rubber trees within the agroforestry system and manage the farm extensively. Rubber agroforests include a mixture of trees, lianas, shrubs and herbaceous plants. Monoculture rubber plantations are managed by companies and farmers with greater resources. The basal area of rubber monocultures is lower than that in the natural forest, because there are no large trees in the plantations (van Noordwijk, Tata, Xu, Dewi, & Minang, 2012; Tata, van Noordwijk, & Werger, 2008).

In conservation, it is important to analyse the response of birds to habitat fragmentation and the diversity found in a fragmented habitat, such as rubber monocultures. Bird conservation activities tend to be focused on protected natural forests (NF) and emphasise threatened species faced with extinction, but most of the remaining forest in Sumatra is secondary (Ekadinata & Vincent, 2011). Currently little attention is given to common species or species that inhabit secondary forests and agro-ecosystems, such as rubber agroforests (RAF) and rubber monocultures (RMP). This paper studies at Simalungun and Asahan Districts, North Sumatra, Indonesia bird richness and diversity, the composition of bird communities and their roles in secondary and primary forests, RAF systems, rubber monoculture (RMP) and emplacement areas (EA) of RMP.

II. MATERIAL AND METHOD

A. Study Area

The study was conducted from December 2010 to January 2011 in four habitat types: NF, RMP, RAF, and EA, in the Districts of Simalungun and Asahan in North Sumatra Province, Indonesia (02°43'4"N and 98°56'25"E) (Figure 1). The EA was located inside the rubber plantations. The RMPs have been intensively managed for many years with regular fertilisation, weeding and tapping, which affected the condition of the vegetation. The rubber stands in the RMP were grouped based on ages: 2-6 years, 12-15 years, and 22-25 years after planting. Two RAF plots were located in the surroundings of the RMPs. RAF plots were managed with less fertilisation and weeding. Other trees were allowed to grow on these farms, creating mixed vegetation of

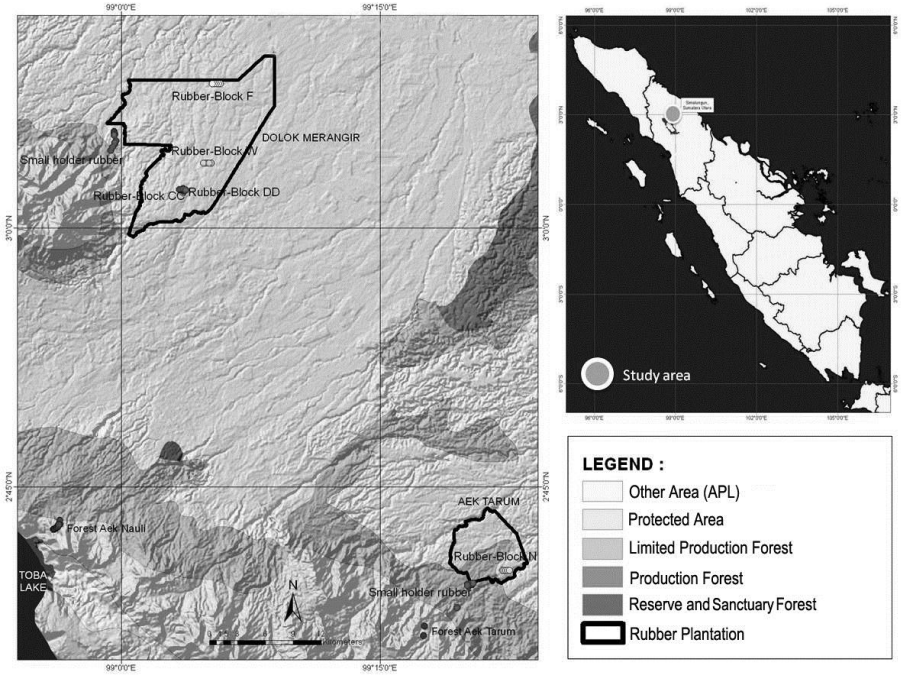

Figure 1. Study sites in Dolok Merangir (Simalungun District) and Aek Tarum (Asahan District), North Sumatra.

simple agroforestry system.

Forest plots were located in two sites: Aek Nauli (Bartong) forest research area in Dolok Merangir, Simalungun District and Aek Tarum forest in Asahan District. The elevation of the forest plots ranged from 1200 m to 1300 m above sea level (asl). The size of the Aek Tarum study area was 79,944.5 ha, and the Dolok Merangir study area was 139,353.93 ha. Each study site included RAFs, RMPs and EAs.

B. Data Collection

The birds were observed by descriptive survey methods using a quick biodiversity survey (QBSur) for birds (Tata et al., 2013), where data were collected along a 1 km transect, in total 12 transects; and from the list of 20 MacKinnon's bird species (MacKinnon & Phillips, 1993) simultaneously in four habitat types (e.g. NF, RMP, RAF, EA). The survey was completed within two weeks. The MacKinnon's list is an established method used to record and verify species and to calculate bird densities. Data was tabulated and birds were identified using this nomenclature (Sukmantoro et al., 2007). Composition of guilds, which are defined as a group of species using the same resource in the same way, was adapted from Wiens (1989), the threat of fragmentation of bird species refers to Lambert and Collar (Lambert & Collar, 2002), while IUCN status refers to the IUCN Red List (IUCN, 2012).

C. Data Analysis

Comparison of abundance was calculated from the percentage ratio of the individual numbers of a species compared to the total individual number that was caught. Diversity was calculated using the Shannon-Wiener index (Magurran, 1988).

The Shannon-Wiener index was used to determine the diversity of mammal species on each transect (Krebs, 1999) and is described by the following equation:

$$H' = \sum_{i=1}^{n} -(pi\ ln\ pi)$$

where,
H' = Shannon-Wiener diversity index
pi = Probability of species (relative density)
n = Number of species

Evenness index (E') was used to estimate the evenness of the species distribution of the birds (Krebs, 1999) and is described by the following equation:

$$E' = \frac{H}{ln\, s}$$

where,
H'= Shannon-Wiener diversity index
S = Number of species

Each bird species found in the study area was recorded in a list containing the names of the first 20 species encountered, after which a new list of the recording began. This list was used to generate a curve of bird species' richness among different sites. Observations were made twice a day, in the morning from 06:00 to 11:00 and in the afternoon from 15:00 to 17:30 (except on rainy days). Tools used in this activity were binoculars (Bushnell 10 x 25), GPS Garmin Oregon 300, a digital voice recorder (Olympus WS-560M) and a Nikon D80 (70–300 mm Tele Lens). Two field identification guides were used (King, Woodcock, & Dickinson, 1975; MacKinnnon & Phillips, 1993).

III. RESULT AND DISCUSSION

A. Bird Richness and Diversity

In total, 142 species of birds from 42 families were recorded across all the areas (Appendix 1). From the total bird species recorded, 122 species were found in the NF, 30 in the RMP, 39 in the EA and 46 in the RAF. A total of 728 individual birds were observed across different habitats. Encountered species richness, abundance, diversity and density are summarized in Table 1 and Figure 2. NF was the most diverse in bird species, indicated by a Shannon-Wiener index of 3.8, followed by RAF (3.6), EA (3.0) and RMP (2.9). All bird species were distributed evenly in every types of habitat, as shown by the evenness index value of almost 1 (ranged 0.87–0.94).

In general, the richness of bird species in North Sumatra was high. Of the 1,589 bird species found in Indonesia, 583 were found in Sumatra (Andrew, 1992). Rubber plantations and surrounding areas in the two Districts of North Sumatra have 124 of the total bird species of Sumatra or 8.9% of the whole of Indonesia.

The species' richness in Simalungun and Asahan area (142 species) was close to the richness of bird species encountered in Batang Toru (Jihad, 2009). RAF in Bungo, Jambi Province had even higher species richness (167 bird species) (Joshi et al., 2002). For comparison, in the forest habitat of Bukit Barisan Selatan National Park (Jambi-Sumatra), 276 bird species were found (O'Brien & Kinnaird, 1996).

The highest bird species' richness occurs in NF habitat (122 species), followed by RAF (46 species), EA (39 species) and RMP (30 species). Bird species were more diverse at the two NF sites than those in RAFs and RMPs. Although Aek Nauli was categorised as disturbed forest, bird composition was similar to that of the natural forest of Aek Tarum. Bird species richness in the three habitats decreased sharply from 122 species in the forest to 46 species in RAF to only 18 species in RMP (see Table 1).

The number of species in the RMP was the lowest, except along river banks, which have more diverse vegetation. RAF had greater richness of species compared with EA and RMP. Many food trees and trees suitable for nesting were still available in the RAF, such as durian (*Durio zybethinus*), candle nuts (*Aleurites mollucana*) and other fruit trees. RAF provides a compatible bird habitat, with mixed vegetation composed of fruit trees, such as durian (*Durio zibethinus*), duku (*Lansium domesticum*), jengkol (*Pithecellobium lobatum*), mangosteen (*Garcinia mangostana*) and cacao (*Theobroma cacao*). The mixed vegetations attract birds searching for food and nesting materials. In addition, RAFs provide a comfortable habitat, especially for the Helmeted Hornbill (*Rhinoplax vigil*). The bird species in the EA were fewer than those in RAF, although there were some food trees for birds, such as Ficus and other fruit trees.

Bird diversity at a given site may also

Table 1. Statistical summary of birds in the study areas of Simalungun and Asahan Districts, North Sumatra

Habitat Types	Abundance	Species Number	H'	E'
NF	267	122	3.8	0.94
RMP	147	30	2.9	0.88
2–6 yr	49	15	2.5	0.91
12–15 yr	37	18	2.7	0.95
22–25 yr	56	20	2.6	0.87
RAF	103	46	3.6	0.94
EA	211	39	3.0	0.84

Remarks : H'= Shannon-Wiener index, E'=Evenness index
NF=natural forests at a protected forest area in Aek Tarum and a research forest area in Aek Nauli
Rubber Agroforest (RAF)= mixed rubber trees with other valuable trees to form simple agroforestry system
Rubber Monoculture Plantation (RMP)=Young rubber plantation (2–6 years), medium rubber plantation (12–15 years) and older rubber plantation (22–25 years)
Emplacement Area (EA)=Settlement area of a rubber plantation with mixed fruit trees

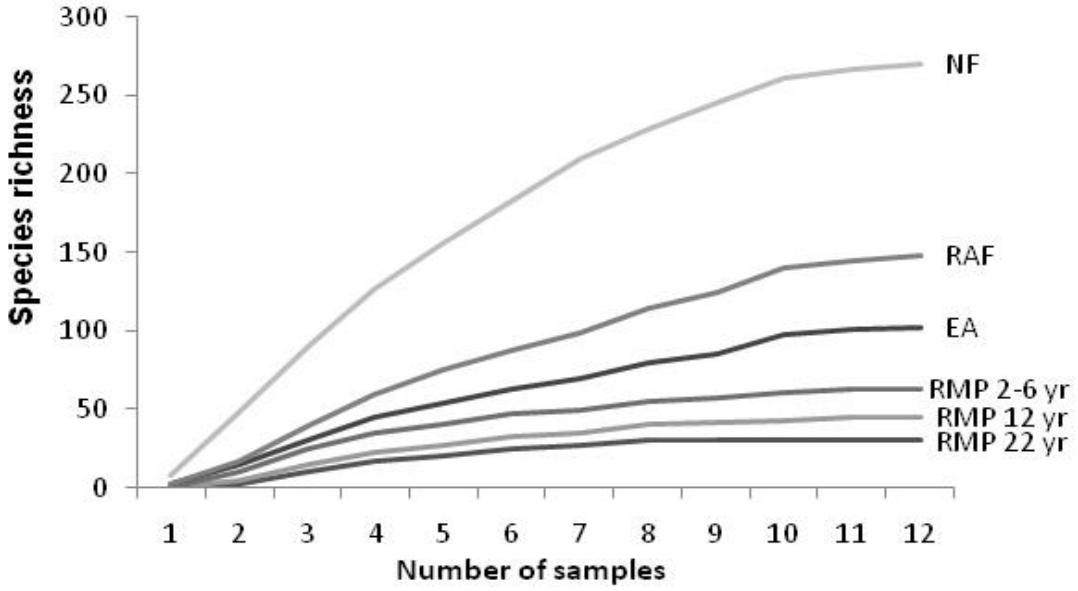

Figure 2. Species accumulation curves by habitat types (Natural Forests=NF, Rubber Agroforests=RAF, Emplacement Areas=EA and 3 differently aged Rubber Monoculture Plantations=RMP)

reflect a high biodiversity of other wildlife in the ecosystem (McNeely, 1988; Yoza, 2000). Bird species diversity in North Sumatra varied between 3.8 in forests to 2.9 in RMP areas. The diversity of bird species depends on environmental conditions. Species diversity decreased in the land use gradient from NF to RMP, which relates to a decrease in environmental factors, such as structure and composition of the vegetation. Among the four habitats, the basal area of vegetation in RMP was the lowest owing to fewer large trees growing in monocultures. Bird diversity in RMP was categorised as 'middle value', based on

the Shannon-Wienner index. Environmental factors, such as canopy height, diversity of tree species, and crop coverage, determine the diversity of bird species (Welty, 1982). The decline in bird diversity is related to the decline of carrying capacity.

B. Bird Composition

The birds in the ecosystem were classified according to their roles. There were 17 guilds represented: arboreal frugivore (AF), arboreal foliage gleaning insectivore (AFGI), arboreal foliage gleaning insectivore-frugivore (AFGIF), arboreal frugivore-predator (AFP), aerial insectivore (AL), bark gleaning insectivore (BGI), miscellaneous insectivore-piscivore (MIP), nectarivore (N), nocturnal predator (NP), nectarivore-insectivore-frugivore (NIF), piscivore (P), raptor (R), sallying insectivore (SI), sallying substrate gleaning insectivore (SSGI), terrestrial frugivore (TF), terrestrial insectivore (TI) and terrestrial insectivore-frugivore (TIF) (Figure 3).

The guilds were further categorised, based on feeding habits, into eight groups, namely frugivore, insectivore, nectarivore, nocturnal predator, insectivore-frugivore, piscivore, raptor and omnivore (Figure 4). Bird species composition in the rubber plantation was different from the three other habitats; two feeding groups of birds, i.e. omnivores and nectarivores, were not found. Aratrakorn et al. (2006) also found different bird composition and guild types in forest compared with oil palm and rubber plantation. Nectarivores birds are not found in oil palm and rubber plantations in southern Thailand.

The differences in the guild composition of the open-canopy areas (RMP) and closed-canopy areas (forest) indicated that the RAF

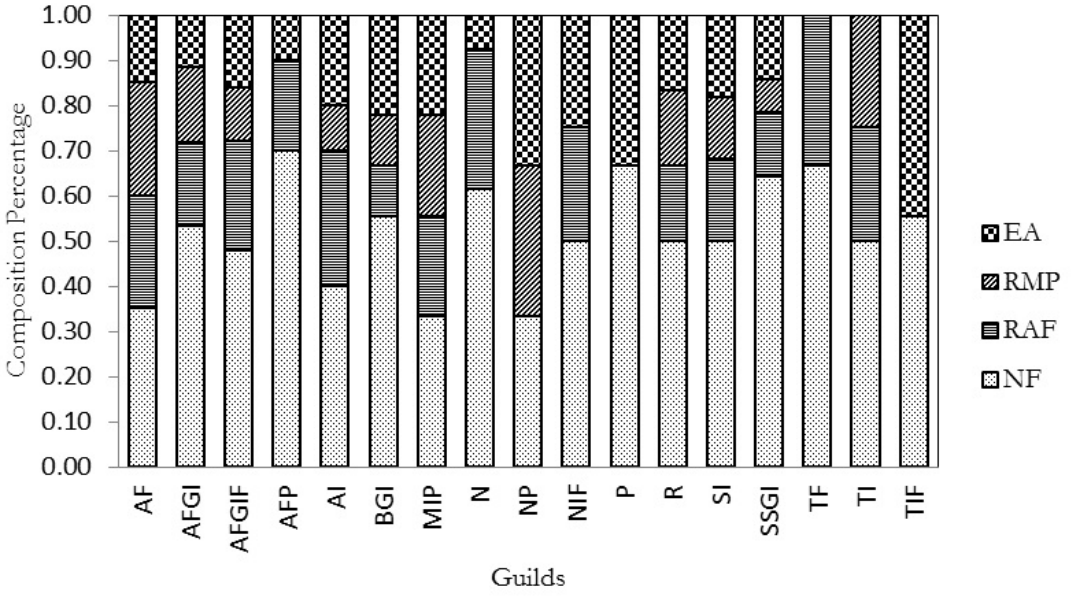

Figure 3. Bird composition guilds according to their roles in four habitats in Simalungun and Asahan Districts, North Sumatra. AF = arboreal frugivore; AFGI = arboreal foliage gleaning insectivore; AFGIF = arboreal foliage gleaning insectivore-frugivore; AFP = arboreal frugivore-predator; AI = aerial insectivore; BGI = bark gleaning insectivore; MIP = miscellaneous insectivore-piscivore; N = nectarivore; NP = nocturnal predator; NIF = nectarivore-insectivore-frugivore; P = pinsivore; R = raptor; SI = sallying insectivore; SSGI = sallying substrate gleaning insectivore; TF = terrestrial frugivore; TI = terrestrial insectivore; and TIF = terrestrial insectivore-frugivore

areas were transition areas between forest and RMP, making rubber agroforest the second choice after forests as habitat for bird nesting, foraging, and breeding (Figure 4).

Species that were absent from bird communities in different habitats (forests, RAF, RMP and EA) allowed comparison of habitat function. In general, species composition was dominated by insect-eaters (insectivores) and seed or fruit-eaters (frugivores). Each type of forest, e.g. primary forest at Aek Tarum and secondary forest at Aek Nauli education-forest, contained similar bird species. While RAFs and RMPs held different species compared to both the primary and secondary forests. Groups of insectivores, which were not found in RMPs, play the role as pollinators, as they feed on nectar and transfer pollen at the same time. However, rubber is not pollinated by birds, but usually through controlled pollination by insects (Warmke, 1952). Rubber monocultures do not provide a suitable environment for specific bird species with particular roles.

The difference in guild composition between open-canopy areas (such as rubber plantations) and closed-canopy areas (such as natural forest) indicate that RAF and smallholder rubber plantations provide a transition area between forests and RMP. Insectivores, frugivores, and nectarivores were commonly found in secondary forests and the more open forest fringes, whereas arboreal frugivores, terrestrial frugivores and bark gleaning insectivores prefer to live in the middle of the forest.

Bird species in North Sumatra as shown in Figure 4 are dominated by the Nectariniidae and Pycnonotidae families. These birds prefer to live in secondary forests, forest edges and settlements (MacKinnon et al., 1998), where insects and nectar are available. Other studies

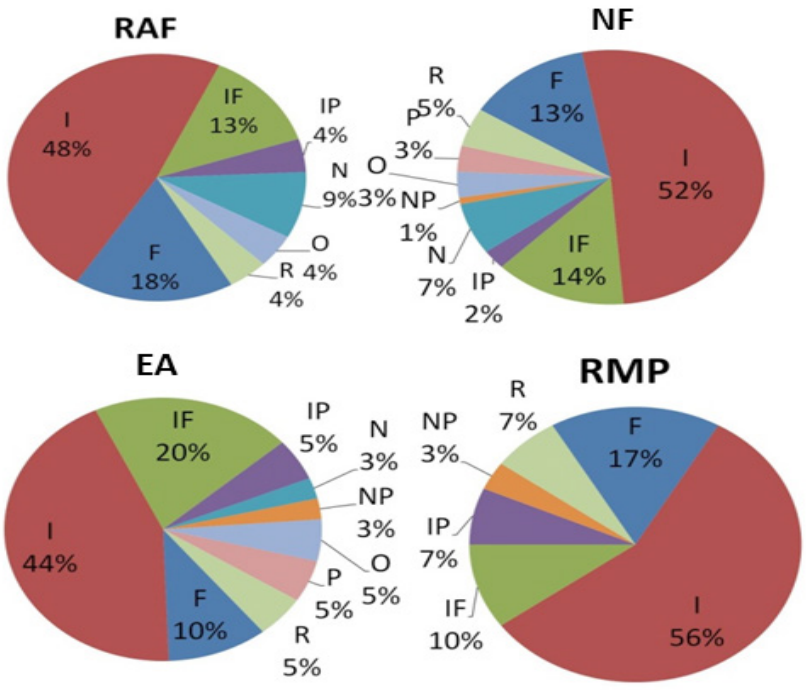

Figure 4. Bird composition guilds based on feeding habitat in four habitat types in Simalungun and Asahan Districts, North Sumatra

Remarks : F = frugivore (AF, AFGI, AFGIF, AFP, TF); I = insectivore (AI, BGI, MIP, SI, SSG, TI); N = nectarivore; NP = nocturnal predator; IF = insectivore-frugivore; (TIF), P = piscivore; R = raptor; and O = Omnivore (NIF)

show that bird communities are usually dominated by a few specific types, which have a high relative abundance, and most other species are much rarer (Karr, Schemske, & Brokaw, 1983; Prawiradilaga, Astuti, Marakarmah, Wijayamukti, & Kundarmasno, 2002).

Based on the guild feeding groups, species' compositions in forests and RAF were relatively similar, dominated by the insectivores and frugivores, and followed by nectarivores, piscivores, raptor and granivores. Bird communities in the study area clearly showed a mix of the species that prefer the central parts of forests (*Picidae*, *Capitonidae*, *Trogonidae*, *Pittidae*) and forest edges (such as *Pycnonotidae*, *Nectariniidae*, *Sylviidae*, *Laniidae*, *Timaliidae*). In the forests, we found frugivores (*Bucerotidae*, *Capitonidae*, *Columbidae*, *Pycnonotidae*, *Decidae* and *Chloropsidae*) suggesting the presence of fruit trees. Fruit trees create a good ecosystem for many species, providing refuge, perches and food.

Rubber monoculture plantations where food is depleted, has less support on birdlife. Therefore, an ecotone such as riparian and emplacement, is important as an intermediary region between two adjacent ecosystems. An ecotone allows various types of life which are better adapted to changes in the environment (Fitri & Ford, 2003). The diversity of bird species in an ecotone is a combination of species from the surrounding areas. Hence, bird species diversity in an ecotone is usually higher than that of the surrounding area (Odum, 1971; Baker, French, & Whelan, 2002).

Bird composition in rubber plantations was clearly different from bird composition in RAF. Only four guild groups of birds were found in RMP: insectivores, frugivores, piscivores and raptors. The other four groups found in the forests were not encountered in RMP. Bird compositions in the three differently aged stands of rubber trees were not significantly different. Bird types were dominated by Alcedinidae, Pycnonotidae, Strigidae, Apodidae, Sylviidae, Cuculidae and Columbiae. Insectivorous groups comprised large percentage in plantation areas and were present in large numbers in all habitat types. We observed insectivore birds, such as Yellow-vented Bulbul (*Pycnonotus goiavier*), Common Tailorbird (*Orthotomus sutorius*), Ashy Tailorbird (*Orthotomus ruficeps*) and Yellow-browed Warbler (*Phylloscopus inornatus*). Various insectivore-piscivore species were abundant in the plantations, like White-throated Kingfisher (*Halcyon smyrnensis*) and Collared Kingfisher (*Halcyon chloris*). There were also groups of nocturnal predators, which play an important role in maintaining the biological balance, such as the Buffy Fish-Owl (*Ketupa ketupu*).

Birds play a role in controlling insect populations, consuming up to one third of their body weight (Hernowo, Soekmadi, & Ekaelawan, 1991) daily. Of the 494 bird species found in Java, 331 (67 %) are insectivorous, with 24 percent of these being primary insectivores, and 76 % secondary insect eaters (Andrew, 1992). Some insects such as Orthoptera (grasshoppers, crickets), Homoptera (leafhoppers, mites) and Heteroptera (ladybugs) are pests on plants, and therefore the insectivore birds play an important biological control in the ecosystem.

Frugivorous birds act as a dispersal agent for plants (Welty, 1982). Nectarivores birds act as polinators (MacKinnon & Phillips, 1993). Birds also help nitrogen and phosphorus cycles (Odum, 1971). High numbers of large arboreal frugivores were encountered in the rubber plantation, such as Spotted Dove (*Streptopelia chinensis*) and Zebra Dove (*Geopelia striata*). In addition, two groups of birds were found in the ground-cover of the rubber plantation in all stand-ages, namely sallying insectivores and arboreal foliage gleaning-insectivores, such as the Tiger Shrike (*Lanius tigrinus*) and Hill Prinia (*Prinia atrogularis*). Velvet bean (*Mucuna*) as a cover crop provided insect food for these two species.

Different compositions of bird communities were found in the EA. Emplacement sites, which are located inside the RMP, were planted with a variety of large trees. Some trees, such as ficus, pine, palm, banana, mango, rambutan and cocoa and woody-tree species provide

Table 2. Status of birds according to IUCN, CITES and Indonesian law

Scientific Name	English Name	Status			Habitats			
		IUCN[1]	CITES[2]	UU/ PP RI[3]	NF	RMP	RAF	EA
Ardea alba	Great Egret			AB	#			
Egretta garzetta	Little Egret			AB	#			
Haliastur indus	Brahminy Kite		II	AB	#			
Haliaeetus leucogaster	White-bellied Sea Eagle		II	AB	#			
Ictinaetus malayensis	Black Eagle		II	AB	#		#	#
Spizaetus cirrhatus	Crested Hawk-Eagle		II	AB	#			#
Spizaetus alboniger	Blyth's Hawk-Eagle		II	AB	#			
Spilornis cheela	Crested Serpent Eagle		II	AB	#	#	#	
Accipiter virgatus	Besra		II	AB		#		
Argusianus argus	Great Argus	NT	II	AB	#			
Treron capellei	Large Green Pigeon	VU			#			
Loriculus galgulus	Blue-crowned Hanging Parrot		II		#		#	
Rhopodytes diardi	Black-bellied Malkoha	NT			#			
Tyto alba	Barn Owl		II					#
Ketupa ketupu	Buffy Fish-Owl		II			#		
Glaucidium brodiei	Collared Owlet		II		#			
Collocalia vulcanorum	Volcano Swiftlet	NT			#			
Harpactes kasumba	Red-naped Trogon	NT		AB	#			
Alcedo meninting	Blue-eared Kingfisher			AB	#			
Halcyon smyrnensis	White-throated Kingfisher			AB	#	#	#	#
Halcyon chloris	Collared Kingfisher			AB	#	#	#	#
Buceros rhinoceros	Rhinoceros Hornbill	NT	II	AB	#			
Rhyticeros undulatus	Wreathed Hornbill		II	AB	#			
Rhinoplax vigil J	Helmeted Hornbill	NT	I	AB	#			
Rhipidura javanica	Pied Fantail			AB	#			
Anthreptes simplex	Plain Sunbird			B	#			
Anthreptes singalensis	Ruby-cheeked Sunbird			AB	#		#	
Anthreptes malacensis	Brown-throated Sunbird			AB	#			
Cinnyris jugularis	Olive-backed Sunbird			AB	#		#	#
Arachnothera longirostra	Little Spiderhunter			AB	#			
Arachnothera affinis	Streaky-breasted Spiderhunter			B	#		#	
Anthreptes malacensis	Brown-throated Sunbird			AB	#		#	
Anthreptes rhodolaema	Red-throated Sunbird	NT		AB	#			
Padda oryzivora	Java Sparrow	VU	II					
Gracula religiosa	Common Hill Myna		II	AB	#	#		
Dicrurus sumatranus	Sumatran Drongo	NT			#		#	#

[1]Status based on IUCN; [2]CITES; [3]Indonesian laws: A = Republic of Indonesia of Act no. 5/1990; B = Regulation of Indonesian Government no. 7/1999

suitable sites for nesting, resting and foraging. The number of birds that like forest edges or open areas increased, such as mynas, barbets, sparrows, bulbuls, pigeons, cuckoos, doves, prinias, white-eyes, woodpeckers and raptors. Nonetheless, forest-edge is important as a

buffer zone for bird diversity and as an area for the succession process of bird communities (Novarino & Salsabila, 2005).

In the EA, Ficus trees were the food source for the frugivores. A total of 23 species of birds from 11 families were recorded in three Ficus trees that grew in the emplacement, 17 of which were recorded eating fruit. Barbets and bulbuls were common on Ficus caulocarpa and Ficus microcarpa, which have relatively small fruits. Large frugivores, such as Imperial Pigeon and hornbills, were not observed in these trees, although they were frequently seen flying overhead. Frugivore birds in the emplacement of RMP in Dolok Merangir were lower than that found in lowland tropical forest in Kuala Lompat, Malaysia (Lambert & Marshall, 1991). Twenty nine bird species were reported as Ficus dispersal agents. Ficus forms an exclusive group within the subset of plants with bird-eaten fruit owing to the synchronized fruit ripening of each tree, the relatively short intervals between fruiting seasons, large crop sizes and different fruiting seasons in each population. These factors make Ficus an important keystone plant resource (Lambert & Collar, 2002).

Birds are one of the most important seed dispersal agents in tropical forests (Jordano et al., 2007). Plants are food sources for animals and effective seed dispersal may reduce competition between plants and their derivatives, as well as enabling the distribution of plant species to new locations. If there are no animals to disperse the seeds, the seeds will fall on the ground and will grow around the parent tree only, affecting plant regeneration.

C. Prominence of Protected Birds

Bird species encountered in the four habitats were grouped based on their status according to the International Union for Conservation of Nature and Natural Resources (IUCN). Twelve near-threatened (NT) species and 2 vulnerable (VU) species we recorded. Referring to the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES), one species was listed in Appendix I, and 12 species were listed in Appendix II. Regarding Indonesian regulations, under Law no. 7/1999, we found that 26 species were listed as protected species (Table 2).

Nine species of the 24 restricted range species were found. A restricted range species is one with a known breeding area of less than 50,000 km^2 (Sujatnika, Soehartono, Crosby, & Mardiastuti, 1995) and, by virtue of its small range, is suitable for identifying areas for conservation. It was reported that there were five Important Bird Areas (IBA) in North Sumatra and 24 restricted range species (Holmes & Rombang, 2001).

Some noteworthy bird species that are protected under Indonesian law were encountered in North Sumatra, such as the Great Argus (*Argusianus argus*), Red-naped Trogon (*Harpactes kasumba*), Rhinoceros Hornbill (*Buceros rhinoceros*), Wreathed Hornbill (*Rhyticeros undulatus*), Blue-masked Leafbird (*Chloropsis venusta*), Java Sparrow (*Padda oryzivora*), Sumatran Drongo (*Dicrurus sumatranus*), Finsch's Bulbul (*Criniger finschii*), Large Green Pigeon (*Treron capellei*), Blue-crowned Hanging Parrot (*Loriculus galgulus*), Black-bellied Malkoha (*Rhopodytes diardi*), Volcano Swiftlet (*Collocalia vulcanorum*), Barn Owl (*Tyto alba*), Buffy Fish Owl (*Ketupa ketupu*), Collared Owlet (*Galucidium brodiei*), Helmeted Hornbill (*Rhinoplax vigil*), Buff-necked Woodpecker (*Meiglyptes tukki*), Green Broadbill (*Calyptomena viridis*) and the Common Hill Myna (*Gracula religiosa*).

A number of raptor species were also found in the area, such as the Brahminy Kite (*Haliastur indus*), White-bellied Sea Eagle (*Haliaeetus leucogaster*), Black Eagle (*Ictinaetus malayensis*), Crested Hawk-Eagle (*Spizaetus cirrhatus*), Blyth's Hawk-Eagle (*Spizaetus alboniger*) and the Crested Serpent Eagle (*Spilornis cheela*). All these raptors are protected under Indonesian law. Moreover, the high number of raptor birds in this area implies it is a part of their home range. Raptors are known to have a wide home range compared to other bird species. Their prey includes various mammals and reptiles, including squirrels, rats and lizards. The study

Table 3. Number of protected bird species in four habitat types

Habitats	Status		
	IUCN	CITES	UU/PP RI
NF	9	13	26
RAF	1	3	8
RMP	0	4	5
EA	1	3	5

[1]Status based on IUCN; [2]CITES; [3]Indonesian laws: A = Republic of Indonesia Act no. 5/1990; B = Regulation of Indonesian Government no. 7/1999.

area in North Sumatra may provide significant amounts of food. Some bird species (predator and raptor guild types) benefit to agriculture. Predators, like eagles (family: Accipitridae) and owls (family: Strigidae) prey rodents, which are pests to crops and tree crops, such as oil palm. However, there are very few studies of the potential relationship of birds in either natural or agricultural ecosystems.

Number of protected birds based on IUCN status, CITES, and Indonesian regulations are issummarized in Table 3. High number of protected bird species found in NF, consecutively followed by RAF, RMP and EA. Forests provide suitable habitat for protected bird species, which can not be replaced by any other habitats.

D. Implications for Conservation

Forest per se is not sufficient to protect bird diversity in a given habitat. Each species of birds occupies a particular habitat in accordance with its needs and plays a certain role in the environment (Mulyani, 1985).The diversity of bird species is affected by a decline in the carrying capacity of the habitat. Changes in vegetation structure and species composition in disturbed forests and cleared land affect on richness of bird species, thus altering composition of bird species. Habitats fragmentation in the study area consisted of patchy forest, RAFs and RMPs which are composed of different species. Forest has the highest index diversity compared with RAF and RMP (Ningsih, Rahayu, & Tata, 2011). Differences in tree composition in the three habitats of North Sumatra affected bird species richness, diversity and composition. Gonzalez-Oreja et al. (2012) reported there is a positive correlation between tree diversity and bird diversity.

Rapid land-use change and high deforestation are threatening the diversity and conservation status of birds (Rittenhouse et al., 2010). Forest cover in Aek Tarum study area has lost dramatically from 45 018 ha (56.03%) in 1970 to 10 220 ha (12.80%) in 2010 (Said, Ekadinata, & Widayati, 2011). Habitat fragmentation will cause the loss of specialist types (interior species) which includes terrestrial birds. Another consequence of the habitat fragmentation is the presence of edge effects. The area will be occupied by the edge of the bird species that are at risk of ecological disturbance or interference from outside. Degraded and fragmentation areas will impact on the dynamics and meta-population (Wiens, 1989; Lunberg & Moberg, 2003). Our observation showed that bird species in the study area have different tolerances of fragmentation and canopy openings. Some, such as hornbills and woodpeckers, were only encountered in forest habitat, being very sensitive to habitat change. Other species have a wider range of adaptive abilities, such as Pycnonotidae (bulbul), Columbidae (pigeon and dove) and Sylvidae (prinias and wabler), which were found across different land uses.

Implications of forest fragmentation caused three important processes, namely extinction, migration and colonization. Fragmented region will lead to solving the sub-sub-populations and reduces movement (migration) types among

sub-populations thereby increasing the risk of extinction. Separation between sub-populations will decrease colonization opportunities for regeneration (Wiens, 1989; André, 1994). Birds with large territorial requirements, such as raptors, apparently are sensitive to habitat fragmentation.

Birds act as mobile conduits, transferring energy among ecosystems, and contribute to ecosystem functions and resilience with their foraging. Bird-plant interactions like pollination and seed dispersal have a high impact on ecosystems (Lunberg & Moberg, 2003). The pollination process of some tree species is assisted by birds. Nectarivore birds (family: Nectariniidae) that only consume nectar, pollinate some trees species and were encountered in both forests and RAF, but not found in RMP. Four species of nectarivore were found in both forest and RAF, namely *Anthreptes singalensis*, *Cinnyris jugularis*, *Arachnothera affinis* and *Anthreptes malacensis*.

Birds disperse seeds through fruit consumption. Frugivore birds (family: Columbidae and Sturnidae) that only consume fruit, were encountered in the four habitats. Birds disperse seeds of many woody plant species of value to humans for timber, medicine, food and other uses. A number of frugivore birds and those who combine frugivore with other food were encountered in forests, however far fewer frugivores were found in RAF and RMPs.

Large frugivore birds, such as Bucerotidae, were not found in RAF and RMP, as they are very susceptible to anthropogenic and environmental change. Larger fruits require larger birds to carry and disperse the fruit at a distance from the mother trees. A lower density of frugivores birds may result in seedlings being concentrated under the mother trees and not widely dispersed (Wenny et al., 2011), which in turn may decrease tree diversity in the ecosystems.

Birds also contribute to the nutrient cycling in the ecosystems. Aquatic and marine birds produce guano, which is a valuable phosphorous fertilizer (Wenny et al., 2011). Aquatic birds belonging to the piscivore type that consume fish were found in the forest only (*Ardea* spp. and *Egretta garzetta*). The landscape of the study area consisted of hilly mountains, valleys, and lowlands along the rivershed of Aek Tarum and Sigura-gura of North Sumatra. Forest area concentrated at the hilly mountains (Asahan and Bukit Barisan landscape) for birds' habitat of mountain species up to 700 m asl level such as Silver-breasted Broadbill (*Serilophus lunatus*), Long-tailed Broadbill (*Psarisomus dalhousiae*) and Fire-tufted Barbet (*Psilopogon pyrolophus*). Although piscivores are considered predators, they also contribute to nutrient cycling in their habitats. All birds contribute to maintaining the equilibrium of the food chain in the ecosystems.

When forest habitat is degraded, RAFs become an alternative sanctuary where birds can nest and forage. The vegetation in RAFs provides good carrying capacity for bird diversity. To improve biodiversity in the area it is recommended to preserve intermediary regions, such as along riverbanks and main roads in the RMPs. An intermediary region could be a corridor between one region and another along the border of the RMPs. In such places, planting rubber trees mixed with fruit trees, such as Ficus, that could provide habitat for birds is recommended.

IV. CONCLUSION

Natural forests have the highest bird diversity compared with RAFs, RMPs and EAs. Changing natural ecosystems to man-made ecosystems affected bird species' composition and numbers. Habitat loss reduced bird composition, and birds with specialist roles have the highest risk of extinction. Compared with RAFs, RMPs are less suitable for all bird species. Birds provide many ecosystem services, especially regulating and supporting services, which directly and indirectly benefit humans. Efforts to conserve habitats and bird populations will maintain the diverse services provided by ecosystems, thus contributing to human well-being.

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Appendix 1. List of birds found in different habitat types in North Sumatra

Scientific Name[1]	English Name	Guild[2]	Status[3]			P	Habitat			
			IUCN	CITES[4]	UU/ PP RI[5]		NF	RMP	RAF	EA
Ardeidae										
Ardea cinerea	Grey Heron	P				s	#			#
Ardea purpurea	Purple Heron	P				s	#			#
Ardea alba	Great Egret	P			AB	s	#			
Egretta garzetta	Little Egret	P			AB	s	#			
Accipitridae										
Haliastur indus	Brahminy Kite	R		II	AB	s	#			
Haliaeetus leucogaster	White-bellied Sea Eagle	R		II	AB	s	#			
Ictinaetus malayensis	Black Eagle	R		II	AB	s	#		#	#
Spizaetus cirrhatus	Crested Hawk-Eagle	R		II	AB	s	#			#
Spizaetus alboniger	Blyth's Hawk-Eagle	R		II	AB	s	#			
Spilornis cheela	Crested Serpent Eagle	R		II	AB		#	#	#	
Accipiter virgatus	Besra	R		II	AB	s		#		
Phasianidae										
Lophura inornata	Salvadori's Pheasant	TIF				h+r	#			
Gallus gallus	Red Junglefowl	TIF				h+r	#			
Argusianus argus	Great Argus	TIF	NT	II	AB	h	#			
Turnicidae										
Turnix suscitator	Barred Buttonquail	TIF				s	#			
Rallidae										
Amaurornis phoenicurus	White-breasted Waterhen	TIF				s	#			
Columbidae										
Treron capellei	Large Green Pigeon	AF	VU			s	#			
Treron olax	Little Green Pigeon	AF				s	#			
Treron vernans	Pink-necked Green Pigeon	AF				s	#	#	#	#
Macropygia ruficeps	Little Cuckoo Dove	AF				s+h	#			
Streptopelia chinensis	Spotted Dove	AF				s+h	#	#	#	#
Geopelia striata	Zebra Dove	AF						#	#	
Psittacidae										
Loriculus galgulus	Blue-crowned Hanging Parrot	AF		II		s	#		#	
Cuculidae										
Cuculus saturatus	Oriental Cuckoo	AFGI				s		#		
Cacomantis sepulcralis	Rusty-breasted Cuckoo	AFGI				h				#
Surniculus lugubris	Asian Drongo-Cuckoo	AFGI				h	#	#		
Eudynamys scolopaceus	Asian Koel	AFGI				h	#			
Rhopodytes diardi	Black-bellied Malkoha	AFGI	NT			s	#			
Rhinortha chlorophaeus	Raffles's Malkoha	AFGI				s	#			
Centropus sinensis	Greater Coucal	TI				s+h	#			
Centropus bengalensis	Lesser Coucal	TI				h	#	#	#	
Tytonidae										
Tyto alba	Barn Owl	NP		II		s				#
Strigidae										
Ketupa ketupu	Buffy Fish-Owl	NP		II		s		#		
Glaucidium brodiei	Collared Owlet	NP		II		s	#			
Apodidae										
Collocalia vulcanorum	Volcano Swiftlet	AI	NT			s	#			
Collocalia fuciphagus	Edible-nest Swiftlet	AI				s				#
Collocalia esculenta	Glossy Swiftlet	AI				s	#	#	#	
Collocalia linchi	Cave Swiftlet	AI				s			#	
Hirundapus caudacutus	White-throated Needletail	AI				s	#			
Apus nipalensis	House Swift	AI				s	#		#	#
Hemiprocnidae										
Hemiprocne comata	Whiskered Treeswift	SI				s	#			#
Trogonidae										
Harpactes kasumba	Red-naped Trogon	SSGI	NT		AB	s+r	#			
Alcedinidae										
Alcedo meninting	Blue-eared Kingfisher	MIP			AB	s	#			
Halcyon smyrnensis	White-throated Kingfisher	MIP			AB	s	#	#	#	#
Halcyon chloris	Collared Kingfisher	MIP			AB	s	#	#	#	#
Meropidae										
Merops leschenaulti	Chestnut-headed Bee-eater	SI				s			#	
Merops viridis	Blue-throated Bee-eater	SI				s	#	#		#
Bucerotidae										
Buceros rhinoceros	Rhinoceros Hornbill	AFP	NT	II	AB	h	#			
Rhyticeros undulatus	Wreathed Hornbill	AFP		II	AB	s+h	#			
Rhinoplax vigil J	Helmeted Hornbill	AFP	NT	I	AB	h+r	#			
Capitonidae										
Psilopogon pyrolophus	Fire-tufted Barbet	AFP				s	#			
Megalaima chrysopogon	Golden-whiskered Barbet	AFP				s	#			
Megalaima oorti	Black-browed Barbet	AFP				s+h	#			
Megalaima haemacephala	Coppersmith Barbet	AFP				s+h	#		#	#
Calorhamphus fuliginosus	Brown Barbet	AFP				s			#	

Scientific Name[1]	English Name	Guild[2]	Status[3]			P	Habitat			
			IUCN	CITES[4]	UU/ PP RI[5]		NF	RMP	RAF	EA
Picidae										
Picumnus innominatus	Speckled Piculet	BGI				s				#
Picus flavinucha	Greater Yellownape	BGI				s	#			
Dinopium javanense	Common Goldenback	BGI				s	#			
Meiglyptes tukki	Buff-necked Woodpecker	BGI	NT			s	#			
Dendrocopos moluccensis	Sunda Pygmy Woodpecker	BGI				s	#	#	#	#
Reinwardtipicus validus	Orange-backed Woodpecker	BGI				s	#			
Eurylaimidae										
Serilophus lunatus	Silver-breasted Broadbill	SSGI				s	#			
Psarisomus dalhousiae	Long-tailed Broadbill	SSGI				h	#			
Calyptomena viridis	Green Broadbill	SSGI	NT			h	#			
Hirundinidae										
Delichon dasypus	Asian House Martin	AFGI				s	#	#	#	#
Campephagidae										
Pericrocotus divaricatus	Ashy Minivet	AFGI				s	#			
Pericrocotus flammeus	Scarlet Minivet	AFGI				s	#			
Hemipus picatus	Bar-winged Flycatcher-shrike	AFGI				s	#			
Aegithinidae										
Aegithina tiphia	Common Iora	AFGI				s+h	#		#	#
Chloropseidae										
Chloropsis venusta	Blue-masked Leafbird	NIF	NT			s	#			
Chloropsis sonnerati	Greater Green Leafbird	NIF				s	#			
Pycnonotidae										
Pycnonotus atriceps	Black-headed Bulbul	AFGIF				s	#			
Pycnonotus melanicterus	Black-crested Bulbul	AFGIF				s	#		#	
Pycnonotus aurigaster	Sooty-headed Bulbul	AFGIF				s	#	#	#	#
Pycnonotus bimaculatus	Orange-spotted Bulbul	AFGIF				s	#			
Pycnonotus goiavier	Yellow-vented Bulbul	AFGIF				s	#	#	#	#
Pycnonotus simplex	Cream-vented Bulbul	AFGIF				s	#		#	
Pycnonotus erythropthalmos	Spectacled Bulbul	AFGIF				s	#			
Criniger finschii	Finsch's Bulbul	AFGIF	NT			s	#			
Laniidae										
Lanius tigrinus	Tiger Shrike	SI				s	#	#		
Lanius cristatus	Brown Shrike	SI				s	#			
Lanius schach	Long-tailed Shrike	SI				s	#		#	#
Turdidae										
Brachypteryx montana	White-browed Shortwing	AFGI				h+s			#	
Copsychus saularis	Oriental Magpie-robin	AFGI				s	#	#	#	#
Copsychus malabaricus	White-rumped Shama	AFGI				h+s	#		#	
Timaliidae										
Malacocincla sepiarium	Horsfield's Babbler	AFGI				h	#			
Malacocincla abboti	Abbott's Babbler	AFGI				h	#			
Stachyris rufifrons	Rufous-fronted Babbler	AFGI				h	#			
Macronous gularis	Striped Tit-Babbler	AFGI				h	#			
Garrulax leucolophus	White-crested Laughingthrush	AFGI				h+r	#			
Garrulax lugubris	Black Laughingthrush	AFGI				h+r	#			
Sylviidae										
Cettia vulcania	Sunda Bush-warbler	AFGI				h	#		#	
Prinia atrogularis	Hill Prinia	AFGI				s	#	#	#	
Prinia familiaris	Bar-winged Prinia	AFGI				s	#		#	
Orthotomus cuculatus	Mountain Tailorbird	AFGI				s	#			
Orthotomus sutorius	Common Tailorbird	AFGI				s	#	#	#	
Orthotomus atrogularis	Dark-necked Tailorbird	AFGI				s	#			
Orthotomus sericeus	Rufous-tailed Tailorbird	AFGI				s	#			
Orthotomus ruficeps	Ashy Tailorbird	AFGI				s	#			#
Phylloscopus inornatus	Yellow-browed Warbler	AFGI				s	#	#	#	
Phylloscopus borealis	Arctic Warbler	AFGI				s	#	#		
Phylloscopus trivirgatus	Mountain Leaf Warbler	AFGI				s				
Seicercus grammiceps	Sunda Warbler	AFGI				s	#			
Abroscopus superciliaris	Yellow-bellied Warbler	AFGI				s	#		#	#
Muscicapidae										
Saxicola caprata	Pied Bush Chat	SI				s	#		#	
Muscicapa dauurica	Asian Brown Flycatcher	SI				s	#			
Ficedula hyperythra	Snowy-browed Flycatcher	SI				s	#			
Ficedula westermanni	Little Pied Flycatcher	SI				s	#		#	
Acanthizidae										
Gerygone sulphurea	Golden-bellied Geryone	SI				s+h	#	#		#
Rhipiduridae										
Rhipidura javanica	Pied Fantail	SI			AB	h	#			
Paridae										
Parus major	Great Tit	SI				s				
Dicaeidae										
Dicaeum sanguinolentum	Blood-breasted Flowerpecker	NIF				s	#			
Dicaeum cruentatum	Scarlet-backed Flowerpecker	NIF				s	#		#	
Dicaeum trochileum	Scarlet-headed Flowerpecker	NIF				s+h			#	#
Dicaeum trigonostigma	Orange-bellied Flowerpecker	NIF				s				#

Scientific Name[1]	English Name	Guild[2]	Status[3]			P	Habitat			
			IUCN	CITES[4]	UU/ PP RI[5]		NF	RMP	RAF	EA
Nectariniidae										
Anthreptes simplex	Plain Sunbird	N			B	s	#			
Anthreptes singalensis	Ruby-cheeked Sunbird	N			AB	s	#		#	
Anthreptes malacensis	Brown-throated Sunbird	N			AB		#			
Cinnyris jugularis	Olive-backed Sunbird	N			AB	s	#		#	#
Arachnothera longirostra	Little Spiderhunter	N			AB	s	#			
Arachnothera affinis	Streaky-breasted Spiderhunter	N			B	s	#		#	
Anthreptes rhodolaema	Red-throated Sunbird	N	NT		AB	s	#			
Zosteropidae										
Zosterops palpebrosus	Oriental White-eye	AFGI				s	#	#		#
Zosterops everetti	Everett's White-eye	AFGI				s	#			
Zosterops montanus	Mountain White-eye	AFGI				s	#	#		
Estrildidae										
Lonchura striata	White-rumped Munia	TF				s	#			#
Lonchura leucogastroides	Javan Munia	TF				s	#		#	#
Lonchura maja	White-headed Munia	TF				s				#
Padda oryzivora	Java Sparrow	TF	VU	II		s				
Ploceidae										
Passer montanus	Eurasian Tree Sparrow	TF				s				#
Sturnidae										
Acridotheres javanicus	White-vented Myna	AF				s		#	#	#
Gracula religiosa	Common Hill Myna	AF		II	AB	r	#	#		
Oriolidae										
Oriolus chinensis	Black-naped Oriole	AFGIF				s	#	#	#	#
Dicruridae										
Dicrurus macrocercus	Black Drongo	SSGI				s	#	#		
Dicrurus leucophaeus	Ashy Drongo	SSGI				s	#			
Dicrurus remifer	Lesser Racquet-tailed Drongo	SSGI				s+h	#		#	
Dicrurus sumatranus	Sumatran Drongo	SSGI	NT			s	#		#	#
Artamidae										
Artamus leucorynchus	White-breasted Woodswallow	SSGI				s	#			#
Corvidae										
Dendrocitta occipitalis	Sumatran Treepie	AFGIF				s	#			
Corvus enca	Slender-billed Crow	AFGIF				s	#			
Corvus macrorhynchos	Large-billed Crow	AFGIF				s	#		#	#
TOTAL							122	30	46	39

Remarks :

[1]Clasification name based on Sukmantoro et al. (2007)

[2]Clasification of guild composition based on Lambert and Collar (2002):AF=arboreal frugivore, AFGI=arboreal foliage gleaning insectivore, AFGIF= arboreal foliage gleaning insectivore-frugivore, AFP=arboreal frugivore-predator, AI=aerial insectivore, BGI=bark gleaning insectivore, MIP=miscellaneous insectivor-piscivore, N=nectarivore, NP=nocturnal predator, NIF=nectarivore-insectivore-frugivore, P=piscivore, R=raptivore, SI=sallying insectivore, SSGI=sallying substrate gleaning insctivore, TF=terrestrial frugivore, TI=terrestrial insectivore and TIF=terrestrial insectivore-frugivore. AI, N, NIF, SI, MIP, SSGI: Thisgroupof birds for age sin theair, whileflying. BGI: This group for ages in trees, by searching in ordisassemblingbark. TF, TI, TIF:This group for ages on the ground or the forest floor.

[3]Status: IUCN=International Union Conservation of Nature, CITES=Convention on the International Trade in Endangered Flora and Fauna, A = Undang-undang RI No. 5/1990; B = Peraturan Pemerintah No. 7/1999

[4]Birds' presence in location survey (P): s=seen, h=heard, r=reported

[5]Habitat: NF (Natural Forest), RAF (Rubber Agroforest), RMP (Rubber Monoculture Plantation), EA (Emplacement Area)