BIRD SPECIES DIVERSITY IN PRIMARY, LOGGED AND BURNED FOREST AREAS OF CROCKER RANGE PARK, SABAH

GLORIA MURING GANANG

THESIS SUBMITTED IN FULFILLMENT FOR THE DEGREE OF MASTERS OF SCIENCE

SCHOOL OF INTERNATIONAL TROPICAL FORESTRY
UNIVERSITI MALAYSIA SABAH
2012

UNIVERSITI MALAYSIA SABAH

BORANG PENGESAHAN STATUS TESIS

JUDUL: BIRD SPECIES DIVERSITY IN PRIMARY, LOGGED AND BURNED FOREST AREAS OF CROCKER RANGE PARK, SABAH

IJAZAH: SARJANA SAINS

Saya GLORIA MURING GANANG, Sesi Pengajian 2008-2011, mengaku membenarkan tesis Sarjana ini disimpan di Perpustakaan Universiti Malaysia Sabah dengan syarat kegunaan seperti berikut:-

1. Tesis ini adalah hak milik Universiti Malaysia Sabah.
2. Perpustakaan Universiti Malaysia Sabah dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan tesis ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. Sila tandakan (/)

☐	SULIT	(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti termaktub di dalam AKTA RAHSIA RASMI 1972)
☐	TERHAD	(Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)
☑	TIDAK TERHAD	

Disahkan oleh,

(Tandatangan Penulis)

Alamat Tetap: Kg. Ranau-Ranau,
89857 Sipitang, Sabah.

Tarikh: 30 Ogos 2012

(Tandatangan Pustakawan)
NURULAIN BINTI ISMAIL
LIBRARIAN
UNIVERSITI MALAYSIA SABAH

(PROF.DR.ZAINODIN HAJI JUBOK)
Penyelia

DECLARATION

I hereby declare that the material in this thesis is my own except for quotations, excerpts, equations, summaries and references, which have been duly acknowledged.

30th August 2012

Gloria Muring Ganang
PF20088315

CERTIFICATION

NAME : **GLORIA MURING GANANG**

MATRIC NO. : **PF20088315**

TITLE : **BIRD SPECIES DIVERSITY IN PRIMARY, LOGGED AND BURNED FOREST AREAS OF CROCKER RANGE PARK, SABAH.**

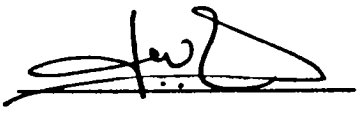
DEGREE : **MASTERS OF SCIENCE (SCIENCE IN FORESTRY)**

VIVA DATE : **26TH JANUARY 2012**

DECLARED BY

1. **SUPERVISOR**
   Dr. Andy Russel Immit Mojiol

Signature



ACKNOWLEDGMENT

I wish to express my deepest gratitude and appreciation to my supervisor, Dr. Andy Russel Immit Mojiol for being a great mentor providing me guidance, support, ideas, motivation and friendship towards the completion of this thesis. I am also pleased to thank Mr. Alim Biun of Sabah Parks who has been very helpful and supportive in providing me assistance and information during the data collection process. I would also wish to thank a list of friends; Audrey Adella, Alexander Jeremy, Jeremy Oswald, Christine Francis Iggau, Cindy Mansin, and Norainie Bte Awot for their continuous support and encouragement throughout my studies. Not forgetting Dr. Idris bin Said for his help in plant identifications. I would also like to thank the examiners for this thesis, Assoc. Prof. Dr. Abdul Hamid Ahmad of Institute for Tropical Biology and Conservation, Universiti Malaysia Sabah and Assoc. Prof. Dr. Mohamed Zakaria bin Hussin of Faculty of Forestry, Universiti Putra Malaysia for their comments which are very useful for my improvement. Finally I would like to thank Universiti Malaysia Sabah for the opportunity of carrying out such an interesting research and also the provision of the Postgraduate Research Fund which have supported me financially and allowed me to complete the research successfully. This thesis is especially dedicated to my beloved family members who have given me the best unlimited love, support and encouragement throughout the completion of my studies.

Gloria Muring Ganang
30th August 2012

ABSTRACT

BIRD SPECIES DIVERSITY IN PRIMARY, LOGGED AND BURNED FOREST AREAS OF CROCKER RANGE PARK, SABAH.

Birds are important elements of the tropical rainforest ecosystem especially in the process of destructed forest restoration through seed dispersal. The forest area of Sabah has been decreasing due to extensive human economy activities such as logging and natural phenomena like the draught period of El Niño which causes wild fire occurrences. This causes forest bird species to be threatened by the reduction of their habitat. The type of forest areas studied are primary, logged and burned forest where mist-netting method was applied in each forest type to find out the difference in bird composition, diversity, feeding guild as well as local and international conservation status. Habitat surveys were also conducted using square plots with a total of 0.1ha for each forest type. Habitat variables associated with bird composition were quantified. There were a total of 69 species recorded in the three forests combined. There were 27 species in the primary forest, 35 species in the logged forest and 38 species in the burned forest. The logged forest is highest in bird diversity with the Shannon Index diversity value of H'=3.25, followed by primary forest (H'=3.11) and burned forest (H'=2.54). However primary forest has the highest value in bird species richness, followed by logged forest and burned forest. Burned forest has the lowest species evenness value. This showed high dominance of a few species in the area. Most birds occurred in the burned forest are belonging to the nectarivore/ insectivore guild. However primary forest and logged forest has more bird belonging to insectivore guild. Primary forest has the most species that are near threatened, followed by burned forest and logged forest. The study showed that distribution of forest birds depend on vegetation of habitat. Therefore, it is important to conserve these forest areas for the continuous survival of forest bird species.

ABSTRAK

Burung merupakan elemen penting dalam ekosistem hutan tropika terutamanya dalam proses pemulihan kawasan hutan terganggu melalui penyebaran biji benih. Kawasan hutan di negeri Sabah semakin berkurang disebabkan aktiviti ekonomi manusia seperti pembalakan dan juga fenomena alam seperti kejadian El Niño yang menyebabkan kebakaran hutan. Ini telah menyebabkan spesies burung hutan terancam disebabkan gangguan habitatnya. Kawasan hutan primer, dibalak dan terbakar telah dipilih dalam kajian ini di mana kaedah jaring kabut telah diaplikasikan di ketiga-tiga jenis hutan untuk mengenalpasti perbezaan komposisi burung, kepelbagaian spesies, jenis pemakanan dan status konservasi di peringkat negeri dan antarabangsa. Pemantauan habitat bagi ketiga-tiga jenis hutan juga telah dikendalikan menggunakan plot empat segi dengan jumlah luas kawasan 0.1ha bagi setiap jenis hutan. Jenis vegetasi hutan yang dikira adalah yang berkaitan dengan komposisi burung. Terdapat 69 spesies burung yang telah direkod di ketiga-tiga kawasan. Terdapat 27 spesies burung di hutan primer, 35 spesies di hutan dibalak dan 38 spesies di hutan terbakar. Kawasan dibalak mempunyai kepelbagaian paling tinggi dengan nilai kepelbagaian Shannon Index, H'=3.25, diikuti kawasan hutan primer (H'=3.11) dan kawasan hutan terbakar (H'=2.54). Walau bagaimanapun hutan primer menunjukkan nilai tertinggi dari segi kebanyakan speseis. Burung di kawasan hutan terbakar pula adalah didominasi oleh beberapa spesies burung. Kebanyakan burung di kawasan hutan terbakar adalah daripada kategori pemakan nektar dan serangga. Walau bagaimanapun kawasan hutan primer dan dibalak terdapat lebih banyak burung daripada katergori pemakan serangga. Kawasan primer mempunyai spesies terancam yang paling tinggi, diikuti dengan kawasan terbakar dan dibalak. Kajian ini menunjukkan bahawa burung harus bergantung kepada vegetasi persekitaran dan makanan yang terdapat dalam hutan tertentu. Oleh itu, adalah penting untuk melindungi kawasan-kawasan hutan ini kerana ia menyediakan kawasan habitat yang penting untuk mengekalkan spesies burung hutan di kawasan ini.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Study Background

Tropical forests are important habitat for a large percentage of bird species in the world. There are a total of 633 bird species recorded in the tropical forest of Borneo where 430 species are residents (Myers, 2009). Birds are important components of the forest ecosystem where they act as seed dispersers and pollinators to maintain the ecological processes of the forest (Peh *et al.*, 2005). Seed dispersal of forest tree species can help limit the recolonization of pioneer species in forest gaps and therefore regulate the species richness of the forest (Pejchar *et al.*, 2008). They are also important bio-indicators in the monitoring and prediction of forest diversity changes caused by human disturbances. Bird database is extensively available and birds are easy to observe (Hoeven and Iongh, 2001). Therefore, birds are important partners of the forest ecosystem not only assisting in monitoring of forest health but also help in the restoration of forest biodiversity.

The primary forest of Sabah outside the conservation area is declining due to the commercial values of the dipterocarp trees. The logged over forests provide accessibility from logging roads offers opportunities for forest conversion to agricultural land. Some parts of the forest areas have been affected by fire during the El Nino draught event in 1993 and 1998 (Brühl *et al.*, 2003). The changes in forest vegetation structure will affect bird species composition. Sensitive bird species do not tolerate with changes in primary forest environment or microclimate change within the succession process. This will eventually cause risks to their extinction. According to Slik and Van Balen (2006), open forest bird species will increase when a forest area is affected by fire while closed forest birds will decrease. This is due to the reduction of habitat heterogeneity after a forest is burned. Rainforest birds can lose a few species immediately after deforestation because disturbed forests tend to have lower diversity due to the dominance of species that can easily adapt to the disturbed forest condition (Meijaard *et al.*,

2005). Forest specialist birds are directly affected by the reduction of forest area. They are vulnerable towards the competition and predation of invasive bird species that increases with alteration of forest vegetation. This results in the decline of forest value for birds (Sodhi and Smith, 2007). Forests that are disturbed will eventually recover and become potential habitat for forest birds. Peh *et al.* (2005) detected primary forest species in a 30-year-old logged forest where these species were previously absent in the same forest after one and 12 years since logging. This indicates the capability of these birds in recolonizing the logged forest area over time. Sodhi *et al.* (2005) found similarities in forest species richness, forest species density and population density between primary forest and 40-year-old logged forest. It is suggested that secondary forests have high conservation value if they are continuously protected and not further degraded and.

The study was conducted in the Crocker Range Park (CRP) area. The CRP is a mountain range that rises from 10 to 15 kilometers from the western coastal plain of Sabah with the altitude of 914 meters to 1829 meters above sea level. The CRP is the largest terrestrial park in state of Sabah with a total area of 139,919ha apart from other terrestrial parks gazzetted under the enactment which are Kinabalu Park and Tawau Hill Park. The Crocker Range area before gazzetted as a park was initially designated as Crocker Range Forest Reserve (CRFR) under the Forest Ordinance No. 2 in 1969. Subsistence logging by inhabitants residing in the surrounding district of the forest reserve was then allowed (Payne and Vaz, 1998). The CRFR was later converted to a State Park in 1984 with the name of Crocker Range National Park (CRNP) under the Park Enactment 1984 to conserve its natural resources and ecosystem. Extraction of timber or any other forest product within the park area was forbidden since its gazettement. The name of CRNP was later changed to Crocker Range Park (CRP) in 1996. The CRP is currently classified as Category II Protected Area in the World Conservation Union (IUCN) list of protected areas (Ministry of Culture, Environment and Tourism, Sabah, 1998). The map below showed the forest cover of Sabah in 1985. The Crocker Range area was not yet established as a park by then. Therefore, timber extraction occurred in and around the CRP boundaries. The forest cover on map is based on satellite imagery and

therefore does not necessarily represent quality of forest. The covered forest may be undisturbed or damaged by logging.

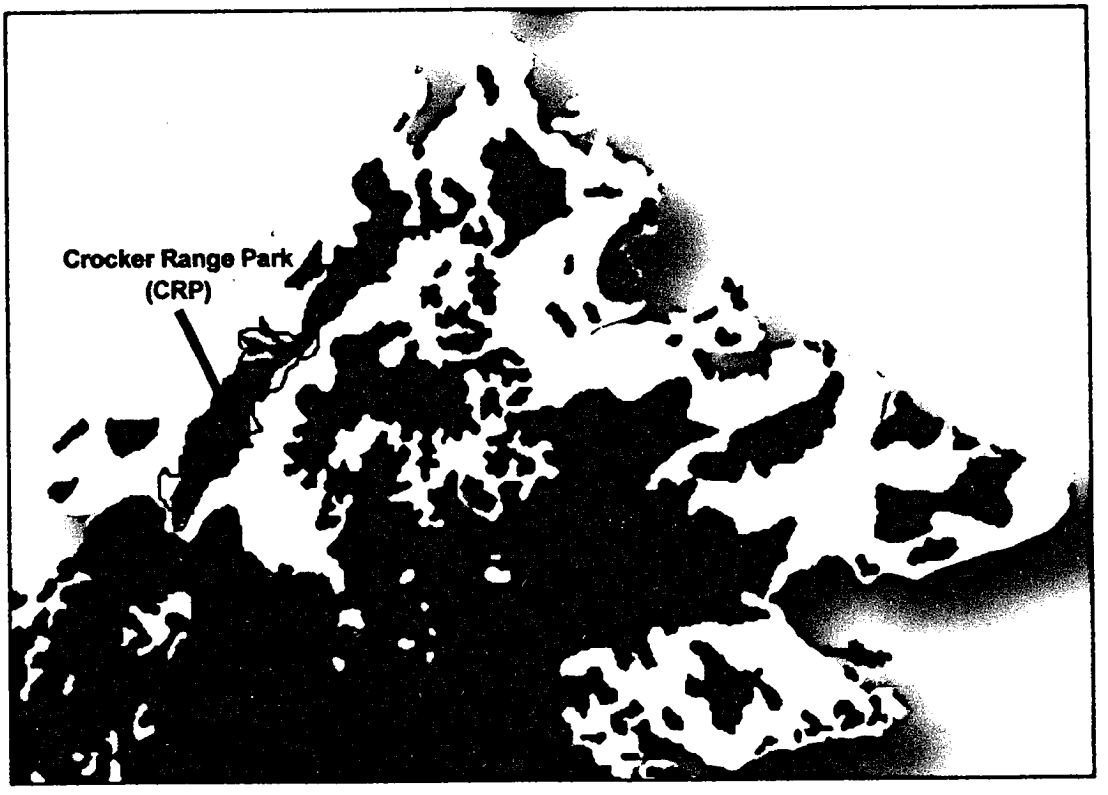


Figure 1.1: Sabah forest cover in 1985. Yellow areas show open areas and green areas are forest covered area.

Source: WWF Germany (2005)

Forest fire occurred in the Crocker Range Park several times. During the El Nino draught in 1983, much of the forest in the southern fringe of Cocker Range Park was burned. Parts of the same area were burned in the dry periods in early 1990 and 1991. A much larger area was burned again around and in the Crocker Range Park area during another major El Nino draught in 1997/1998.

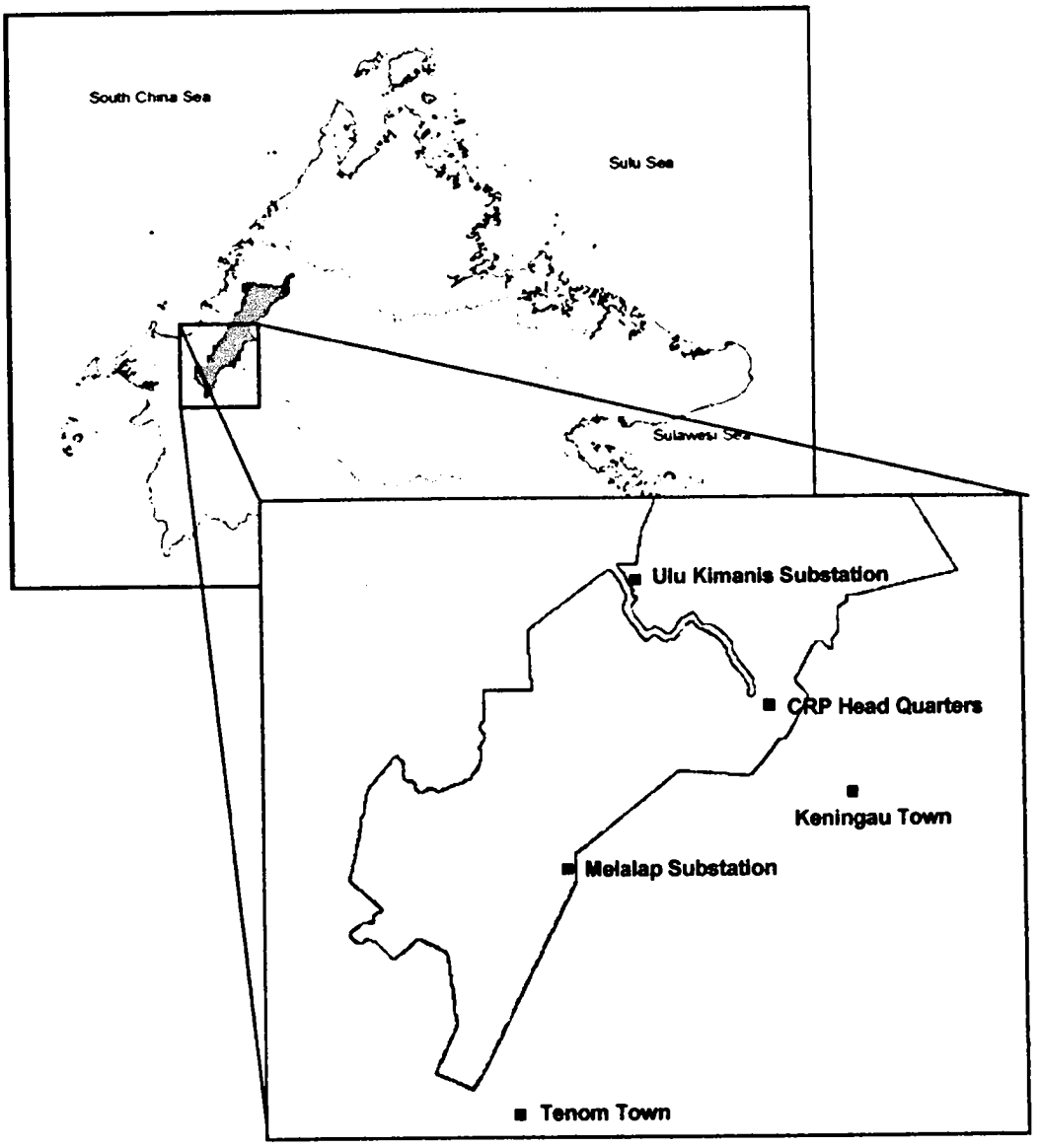


Figure 1.2: Burned areas (yellow patches) of Crocker Range Park, Sabah.

The most extensive forest fire that occurred at the Crocker Range Park areas have been commercially logged (Ministry of Culture, Environment and Tourism, Sabah, 1998). Timber extraction allows more sunlight penetration into the forest understorey and causes a drier microclimate within the forest area. The production of wood debris from logging activities also increased the chances of forest fire (McMorrow and Mustapa, 2001). Forest fire alters the community composition and population structure of the forest through differential mortality among species and tree sizes. It also changes the composition and diversity of forest plants with the increase of pioneer plants in the forest understorey.

Repetitive forest fire can also negatively affect the flora and avifauna to the point that recovery becomes impossible (Slik and Van Balen, 2006).

The Crocker Range Park is an area of important habitat for many fauna species. This includes endemic and rare bird species where its large continuous forest area provides a variety of food sources and maintains suitable microclimate condition for many birds to survive (Meijaard *et al.*, 2005). Sabah Parks recorded a total of 259 bird species in the CRP. Birdlife International has identified the CRP as one of the 218 Endemic Bird Areas (EBAs) of the world (Sabah Parks, 2006). To qualify as EBAs, an area has to be rich in endemic bird species compared to other parts of the world. The Malaysian Nature Society (MNS) rated the park as one of the Important Bird Area (IBAs) of Malaysia. This is due to the presence of globally threatened species in the CRP area.

1.2 Thesis Overview

This study aims to find out the changes of bird diversity from a primary forest to a burned and logged forest. Forest concessions and licensed forest areas are no longer permitted in the CRP since its gazzetement as a park in 1984 and the last forest fire occurred during the 1997/1998 El Niño event. The study produces data for the type of understory species that occurs in the forest several years after logging and fire. The diversity is highest in the logged forest (at least 25 years ago) and lowest in the 12-year-old burned forest. The logged forest is in the transition process of becoming a primary forest. Despite its location that is adjacent to the primary forest, the ecotone community contributes to its higher diversity with the intermixing of both forest and generalist bird species. The logged forest also contains remnants of primary forest vegetation which allows the availability of food sources for more forest birds to utilize the forest. In the regenerating burned area which is mostly dominated by a few pioneer plants contributes to the higher occurrence of several generalist bird species.

Chapter one introduces the background of the study which includes the importance of birds in forest ecology and background of the Crocker Range Park. Chapter two consists of literatures related to the field of study which includes

description of primary, logged and burned forests, previous studies of birds in Crocker Range Park, role of birds in forest ecology, bird feeding guild, birds response to habitat change and the description of edge effect and ecotone. Chapter three describes the geographical background of Crocker Range Park and methods for data collection and analysis. Understorey birds are the targeted groups in this study, therefore standardized mist netting methods were applied in the three forest areas. Vegetation variables were sampled to find out their relationship with bird species diversity in each forest types. In the data analysis section, the equations to obtain bird species density, diversity and evenness of each forest is discussed. Analysis to compare bird species diversity between forest types and its relation with forest vegetation were also explained in the chapter. Lastly, the chapter includes the list of bird feeding guilds and description of bird conservation status in the local and international level which is according to the Sabah Wildlife Enactment 1997 and IUCN Red List of Threatened Species respectively.

Chapter four focus on overall data results and analysis. The total number of bird individual, species and family were presented, followed by results of bird diversity, richness and evenness, T-test result for diversity, bird feeding guild and list of recorded plant species in the primary, logged and burned areas. The results of regression analysis were presented and threatened birds were also listed in this chapter. Chapter five explains the different findings of bird diversity in primary, logged and burned forests. Finally, Chapter six concludes the research findings and suggestions for further research and management strategies.

1.3 Objectives

1. To distinguish bird species composition in primary, logged and burned forests of Crocker Range Park (CRP).
2. To compare species diversity in primary, logged and burned forests of Crocker Range Park (CRP).
3. To relate habitat variable with birds that occur in primary, logged and burned forests at Crocker Range Park (CRP).
4. To categorize birds into feeding guilds and conservation status.

CHAPTER 2

LITERATURE REVIEW

2.1 Forest description

2.1.1 Primary forest

The primary forest has a higher tree density and number of species and has lower canopy openness compared with logged forest and burned forest (Slik *et al.*, 2002). The most common tree species in primary forest in terms of number of stems are trees from the family of Dipterocarpaceae, Euphorbiaceae and Anacardiaceae, however in terms of basal area trees of Dipterocarpaceae, Fabaceae and Anacardiaceae family are most common (Brearley *et al.*, 2004). According to Rahman *et al.* (2002), the primary forest of Crocker Range Park is dominated by large dipterocarp trees including *Shorea* spp., *Dipterocarpus* spp., and *Arthocarpus* spp. In comparing the diversity of primary forest and old secondary forest, the primary forest is significantly higher in diversity than the old secondary forest.

2.1.2 Logged forest

The regeneration of logged forest vegetation varies between the logging methods and system used. In the selectively logged dipterocarp forest of Pasoh Forest Reserve in Peninsular Malaysia for example, Okuda *et al.* (2003) found difference in canopy height and tree height when compared with primary forest. The forest area was logged using Malaysian Uniform System (MUS) approach in 1958. The study was conducted in 1999 which is 41 years after logging. It was found that there was less variation in canopy height in the logged forest compared to primary forest due to the immediate regeneration of trees after logging. In the primary forest, trees regenerate irregularly after natural gap formation. Logged forests also have smaller average canopy crown and high density of small crowned trees. Primary forests have uneven crown sizes and many emergent crowns. It takes more than 40 years of a selectively logged forest to allow emergent species to grow tall enough and penetrate the canopy layer. In terms of composition, the regenerating forest

comprise of medium sized trees which may be remnants of the selectively logged forest. These trees were left unharvested because it had not reached the minimum size during the logging operation. Typical early-successional species such as *Porterandia anisophylla, Croton argyratus* and *Endospermum malaccense* were found more common in regenerating forest after logging.

2.1.3 Burned forest

Fire destruction will affect the habitat heterogeneity by the reduction of vegetation structure, plant species diversity and composition. The maximum tree height also decreases and the ground cover is dominated by terrestrial ferns, gingers, bamboo and wild bananas. The woody species is dominated by pioneer trees from the genus *Macaranga* (Slik and Van Balen, 2006). According to Harrison (2001), eighty percent of lianas and trees less than 5cm dbh died during the 1982-1983 El-Niño Southern Oscillation (ENSO) in East Kalimantan. However, larger trees of above 30cm dbh were less affected. Cleary and Priadjati (2005) found that the density of sapling and seedling, species richness and composition are significantly different between burned and unburned forest area. Seedlings and saplings species were mostly found in unburned forest. Most of the species found in the burned area are non-dipterocarp species. Seedling density declined from burned to unburned forest and this is related to the particular patterns of regrowth after fire. Pioneer species especially *Macaranga gigantea* and ferns (*Blechnum orientale, Microlepia speluncae* and *Pteridium aquilinum*) were the principle sources of regrowth in the burned forest.

According to Slik (2004), the difference between tree mortality during the 1997/1998 El nino drought is influenced by tree composition. Tree mortality is found to be higher in the logged area compared to the unlogged area. This tree mortality is contributed by the pioneer *Macaranga* trees which are common in logged forest and almost absent in unlogged forest. The reason of high mortality in *Macaranga* tree is unclear but it is suspected that it is due to the rooting system of the tree which does not reach to the lowered soil water level during droughts. Besides seedlings, sprouts, lianas and young trees which are not protected by thick barks and can easily burn, fire can also kill dipterocarp trees which also lack thick

barks and has flammable tree resin (Meijaard *et al.* 2005). Trees of the family Dipterocarpacea which are the most important trees in Borneo may not have resprouting capabilities, however they can regenerate in lightly burned areas.

2.2 Birds in Crocker Range Park (CRP)

In comparison with the information of bird community in Kinabalu Park, a protected area under the Sabah Parks administration, less is known about birds in CRP (Rahman *et al.*, 2002). There are only several research and records of birds in the park area. Sabah Parks compiled a total of 259 species of birds in the CRP area (Sabah Parks, 2006). An inventory of bird species diversity by Rahman *et al.* (2002) captured 17 species from seven families after 840 mist netting hours and recorded 51 species from 24 families in their transect studies. The findings showed no marked difference in bird diversity between secondary and primary forests. Majority of these birds utilize both secondary and primary forest such as the Little Spiderhunter (*Arachnothera longirostra)* and Yellow-bellied Bulbul (*Pycnonotus phaeocephalus*). There were also migrant species present such as the Mugimaki Flycatcher (*Ficedula mugimaki*) and Siberian Blue-Robin (*Erithacus cyane*). Endemic species recorded includes White-crowned Shama (*Copsychus stricklandi*) and Duski Munia (*Lonchura fuscans*). The relative density of bird was 0.03 bird/net unit in secondary forest and 0.05 bird/net unit in primary forest. It is suggested that agricultural development which caused forest fragmentation in the secondary forest area affects the distribution of and diversity of birds in the secondary area.

Shahrul Anuar *et al.* (2002) recorded 11 species from eight families after conducting half day of field observation in Mahua Substation of Crocker Range Park. They also conducted a 6-day bird observation and mist netting of disturbed and undisturbed areas in the Ulu Senagang Substation, and recorded 41 species from 18 families. The most species recorded were from the family of Pycnonotidae (Bulbuls), Muscicapidae (Flycatchers), Cuculidae (Cuckoos) and Eurylaimidae (Broadbills). There were a total of 45 resident species and four migrant species recorded in both Ulu Senagang and Mahua forest areas. The migratory species includes the Grey Wagtail (*Motacilla cinerea*), Blue and White Flycatcher (*Cyanoptila cyanomelana*), Pied Wagtail (*Motacilla alba*) and Siberian Blue Robin (*Erithacus*

cyane). Endemic birds were also recorded in these areas including the Bornean Treepie (*Dendrocitta cinerascens*) and Dusky Munia (*Lonchura fuscans*). Many of the birds at the undisturbed area of Crocker Range Park are regular visitors that utilize the forest as food source and nesting site.

2.3 Role of birds in forest ecology

Birds play important role as seed dispersal agents which is an important process of forest regeneration and maintaining forest tree diversity. This is through the advantages of success regeneration of seeds when dispersed a distance from their adult trees (Phillips, 1997). Birds seed dispersing ability is also important in recolonizing forests. Sodhi *et al.* (2005) found that forest bird species utilizing mixed rural habitat provide ecosystem services by seed dispersal and pollination which will contribute to native tree regeneration. This applies especially to the regeneration of disturbed areas adjacent to primary forests, where birds that utilize both areas would bring native seeds of primary forests to the disturbed area.

Birds are also important bio-indicators that reflect forest health. According to Heoven and Iongh (2001), understorey insectivores are the most consistent in predicting disturbance in the Bornean forests. Besides its availability in database and current research, understorey insectivores are more sensitive to forest disturbances. According to Barlow *et al.* (2006), understorey birds responds to the changes in forest vegetation structure, floristic composition and food availability. Johns (1996) found the decline in abundance of terrestrial insectivore from a logged to an unlogged area of Sabah. This may due to the reduction of litter arthropods which are food sources for the terrestrial insectivores, which is related to the dried out litter in the forest after logging. The sensitivity of bark gleaning insectivores and understorey foliage-gleaning insectivores are useful ecological indicators of forest degradation. It is because forest degradation can affect food availability for bird occurrence in the area (Arriaga-Weiss *et al.*, 2008).

According to Zakaria *et al.* (2005), the number of Red-eyed bulbul (*Pycnonotus brunneus*) and Grey-bellied bulbul (*Pycnonotus cyaniventris*) is less in logged forest compared to the primary forest. There was also a high occurrence of

Rufous-tailed shama (*Trichixos pyrropyga*) in the primary forest. However, the number of Moustached babbler (*Malacopteron magnirostre*) in primary forest is higher than logged forest. The changes in number of these habitat sensitive species can be good indicators to reflect the condition of a forest. According to Soh *et al.* (2006), the loss of montane-restricted bird species and emerging of lowland and geographically wide ranging bird species can indicate degradation of montane habitat. The sensitivity of montane birds species to slight deforestation is because of the high proportion of these birds with restricted ranges and specialized physiology that adapts with the mountain environment.

2.4 Bird feeding guild

The occurrence of birds is influenced by the availability of food source in an area. The alteration of vegetation composition which changes food availability of a forest area will affect bird composition. For example, the composition and number of individual of insectivorous birds change from logged to unlogged forest (Zamri and Zakaria, 2002). The high numbers of frugivore/insectivore birds in logged forest are mostly colonizing secondary species which are the bulbuls (Pycnonotidae). Their ability to switch to insectivorous diet is also an advantage to tolerate seasonal variation in fruit abundance in logged forest (Zakaria *et al.*, 2005). Meijaard *et al.* (2005) suggested that species with wider ecological niches such as those that feed on many food items are more tolerant with changing environmental conditions. After a forest is logged or burned, the availability of insect is reduced due to the loss of trees for the leaf feeding, bark feeding, crevice-dwelling and wood boring insects (Zakaria and Nordin, 1998). Slik and Van Balen (2006) found that there is a significant increase in insectivorous birds foraging on forest floor and above forest canopy after fire. This is related to the changes in forest understorey after fire with the appearance of more woody plants and pioneer herbs as well as the reduction of foliage cover in the middle and upperstorey level of the burned forest. The recorded insectivore birds are also possibly those that are passing through within the burned area since the location of study area next to unburned forest.

The loss of continuous supply of fruits due to deforestation in small forest remnants will impact frugivorous birds. Sodhi *et al.* (2005) found the abundance of

the Knobbed Hornbill (*Rhyticeros cassidix*) in mixed-rural vegetation around Central Sulawesi, Indonesia. This indicates that the species are driven from the primary forest and they are capable of utilizing the sub-optimal habitat following the increase of degraded area. According to Zakaria and Nordin (1998), frugivorous birds will make fewer visits to logged forests compared to unlogged forests. This is due to the reduction of food sources and increase of forest temperature from greater sunlight penetration. Arriaga-Weiss *et al.* (2008) suggested that the presence of wide ranging arboreal frugivore species is dependant on high trees in less disturbed sites and is related to tree density. Changes in frugivore abundance are influenced by fruit availability which is related to edge effects and human disturbance which also changes microclimate condition. These birds are depending on availability of large trees for nesting sites.

2.5 Response of birds to habitat change

The response of birds to the modification of their habitat varies between species, which is according to their habitat affiliation and their ability to tolerate in the modified area (Brooks *et al.*, 1997; Maas *et al.*, 2009). Sodhi *et al.* (2005) suggested that the occurrence of species in degraded areas is influenced by their species-specific ecological habits and their behavioral flexibility in choosing nesting sites. According to Maas *et al.* (2009), forest birds and understorey birds which have more specific ecological requirements responds negatively to habitat modification. The competitive pressure in primary forest where a high density of a species occurs could also drive these species away to a lesser optimum surrounding areas.

Habitat sensitive birds may not exist in disturbed forests. The changes of forest vegetation will affect the composition of these birds. Maas *et al.* (2009) concluded the factors affecting high endemic forest avifauna in tropical forests depends on extrinsic and intrinsic factors. Extrinsic factors include disturbance history, quality and quantity of remaining forest and food supply. Intrinsic factors include preferred microhabitat, dispersal abilities and feeding and nesting habitats. The study of Slik and Van Balen (2006) in a fire destructed forest showed increase of habitat generalist species and decrease in habitat specialist species. There is also

REFERENCES

Anonymous, . 2012. "Birds on the IUCN Redlist". http://www.birdlife.org/action/science/species/global_species_programme/red_list.html. Retrieved in 29 January 2012.

Arriaga-Weiss, S. L., Calmé, S. and Kampichler, C. 2008. Bird Communities in Rainforest Fragments: Guild Responses to Variables in Tobasco, Mexico. *Biodiversity Conservation* **17**: 173-190.

Barlow, J., Peres, C. A., Henriques, L. M. P., Stouffer, P. C. and Wunderle, J. M. 2006. The Response of Understorey Birds to Forest Fragmentation, Logging and Wildfires: An Amazonian Synthesis. *Biological Conservation* **128**: 182-192.

Barlow, J., Mestre, L. A. M., Gardner, T. A. & Peres, C.A. 2007. The value of primary, secondary and plantation forests for Amazonian birds. *Biological Conservation* **136**: 212-231.

Birdlife International, 2008. *Critically Endangered Birds A Global Audit: A State of the World's Birds Report.*

Brearley, F. Q., Prajadinata, S., Kidd, P. S., Proctor, J., Suriantata. 2004. Structure and Floristics of an Old Secondary Rain Forest in Central Kalimantan, Indonesia, and a Comparison with Adjacent Primary Forest. *Forest Ecology and Management* **195**: 385-397.

Brooks, T.M., Pimm, S.L. and Collar, N.J. 1997. Deforestation Predicts the Number of Threatened Birds in Insular Southeast Asia. *Conservation Biology* **2**: 382-394.

Brown, S. and Lugo, A. E. 1990. Tropical Secondary Forests. *Journal of Tropical Ecology* **6**: 1-32.

Brühl, C. A., Eltz, T. and Linsenmair, K. E. 2003. Size Does Matter – Effects of Tropical Rainforest Fragmentation on The Leaf Litter Ant Community in Sabah, Malaysia. *Biodiversity and Conservation* **12**: 1371-1389.

Castelletta, M., Thiollay, J. M., Sodhi, N. S. 2005. The effects of extreme forest fragmentation on the bird community of Singapore Island. *Biological Conservation* **121**: 135-155.

Chazdon, R. L. 2003. Tropical forest recovery: legacies of human impact and natural disturbances. Perspectives in Plant Ecology, Evolution and Systematic **6**: 51-71.

Cleary, D. F. R., and Priadjati, A. 2005. Vegetation Responses to Burning in a Rain Forest in Borneo. *Plant Ecology* **177**: 145-163.

Dunn, E. H. and Ralph, C. J. Undated. Use of Mist Nets as a Tool for Population Monitoring. *Studies in Avian Biology* **29**: 1-6.

Food and Agriculture Organization (FAO), 2009. *State of The World's Forest 2009.*

Harrison, R. D. 2001. Drought and Consequences of El-Niño in Borneo: A Case Study of Figs. *Population Ecology* **43**:63-75.

Hammer, Ø. 2010. Paleontological Statistics PAST Version 2.05 Reference Manual. Natural History Museum. University of Oslo.

Hoeven, C. A. van der & Iongh, H. H. de. 2001. The use of Fauna Indicators for Monitoring the Impact of Disturbance; A Review. *The Balance Between Biodiversity Conservation and Sustainable Use of Tropical Rain Forest.* Tropenbos International, Netherlands.

IUCN, 2011. Guidelines for Using the IUCN Red List Categories and Criteria Version 9.0 (September 2011).

Jayson, E. A. and Sivaperuman C. 2010. *Community Ecology of Tropical Birds.* New India Publishing Agency, New Delhi.

Jenni, L., Leuenberger, M. and Rampazzi, F. 1996. Capture Efficiency of Mist Nets with Comments on Their Role in Assessment of Passerine of Habitat Use. Journal of Field Ornithology **67** (2): 263-274.

Johns, A. G. 1996. Bird Population Persistence in Sabahan Logging Concessions. *Biological Conservation* **75**: 3-10.

Lambert, F. R. & Collar, N. J. 2002. The Future for Sundaic Lowland Forest Birds: Long Term Effects of Commercial Logging and Fragmentation. *Forktail* **18**: 127-146.

Lewis, O. T. 2009. Biodiversity Change and Ecosystem Function in Tropical Forests. *Basic and Applied Ecology* **10**: 97-102.

Maas, B., Putra, D. D., Waltert, M., Clough, Y., Tscharntke, T., and Schulze, C. H. 2009. Six Years of Habitat Modification in a Tropical Rainforest Margin of Indonesia Do Not Affect Bird Diversity but Endemic Forest Species. *Biological Conservation* **142**: 2665-2671.

Mackinnon, J. and Phillips, K. 1993. A Field Guide to the Birds of Borneo, Sumatera, Java and Bali. Oxford University Press.

Magurran, A. E. 2005. *Measuring Biological Diversity.* Carlton: Blackwell Science Ltd.

Marsden, S. J. 1998. Changes in Bird Abundance Following Selective Logging on Seram, Indonesia. *Conservation Biology* **12** (3): 605-611.

McCollin, D. 2006. Forest Edges and Habitat Selection in Birds: A Functional Approach. *Ecograpghy* **21** (3): 247-260.

McMorrow, J. and Mustapa A. Talip. 2001. Decline of Forest Area in Sabah, Malaysia: Relationship to State Policies, Land Code and Land Capability. *Global Environment Change* **11**:217-230.

Meijaard, E., Sheil, D., Nasi, R., Augeri, D., Rosenbaum, B.,Iskandar, D., Setyawati, T., Lammertink, M., Rachmatika, I.,Wong, A., Soehartono, T., Stanley, S. and O'Brien, T. 2005. *Life After Logging: Reconciling Wildlife Conservation and Production Forestry in Indonesian Borneo.* Jakarta: Centre of International Forestry Research.

Myers, S. 2009. *A Field Guide to the Birds of Borneo.* Singapore: Talisman Publishing Pte Ltd.

Ministry of Culture, Environment and Tourism, Sabah. 1998. *Sabah Biodiversity Conservation Project, Malaysia: Consolidated Project Completion Report.*

Newton, A. C. 2007. *Forest Ecology and Conservation: A Handbook of Techniques.* Oxford University Press, New York.

Nik Fadzly, N. R., Shahrul Anuar Mohd Sah and Mashhor Mansor. 2007. Avian Distribution and Diversity in Forest Gap and Closed Canopy of Lowland Tropical Forest. *Jurnal Biosains* **18** (2): 57-75.

Okuda, T., Suzuki, M., Adachi, N., Quah, E. S., Hussein, N. A., Manokaran, N. 2003. Effect of Selective Logging on Canopy and Stand Structure and Tree Species Composition in Lowland Dipterocarp Forest in Peninsular Malaysia. *Forest Ecology and Management* **175**: 297-320.

Payne, J. and Vaz, J. 1998. *Crocker Range Foothills: Final Report.* Sabah Biodiversity Conservation Project, Malaysia: Identification of Potential Protected Area Component.

Peh, K. S. H., Jong, J., Sodhi, N. S., Lim, S. L. H., and Yap, C. A.M. 2005. Lowland Rainforest Avifauna and Human Disturbance: Persistence of Primary Forest Birds in Selectively Logged Forests and Mixed-Rural Habitats of Southern Peninsular Malaysia. *Biological Conservation* **124**:489-505.

Pejchar,L., Pringlea, R.M., Ranganathana, J., Zookb, J.R., Duranc, G., Oviedoc, F. and Dailya, G.C. 2008. Birds as Agents of Seed dispersal in a Human-dominated Landscape in Southern Costa Rica. *Biological Conservation* **(141)**: 536-544.

Phillips, O. L. 1997. The Changing Ecology of Tropical Forests. Biodiversity and Conservation **6**: 291-311.

Rahman, M.A., Salleh, M.A., and Tuen, A. A. 2002. Bird Diversity of Crocker Range National Park, Sabah, Malaysia. *ASEAN Review of Biodiversity and Environmental Conservation (ARBEC)* (July-September):1-8.

Ralph, C. J., Geupel, G. R., Pyle, P., Martin, T. E. and DeSante, D. F. 1993. *Handbook of Field Methods for Monitoring Landbirds.* Albany: Pacific Southwest Research Station.

Rosli, R., Hashim, R. and Daicus, B. 2004. Use of Mist-Netting Technique to Study Community Structure of Understory Birds at Labuk Tapah Base Camp, Endau-Rompin National Park, Johore, Malaysia. *Malaysian Journal of Science* **23**: 79-83.

Ross, C. 2011. Public Summary Report: Initial RSPO Certification Assessment. Sime Darby Plantation Sdn. Bhd.

Round, P. D., Gale, G. A. and Brockelman, W. Y. 2006. A Comparison of Bird Communies in Mixed Fruit Orchards and Natural Forest at Khao Luang, Southern Thailand. *Biodiversity and Conservation* **15**: 2873-2891.

Sabah Parks, 2006. *Crocker Range Park Management Plan 2006.*

Sabah Wildlife Department, 1997. *Wildlife Conservation Enactment 1997.*

Shahrul Anuar Mohd. Sah, Mohd Hifni Baharuddin and Muthaiya, G. 2002. A Brief Survey of Birds at Mahua Basecamp and Ulu Senagang, Crocker Range National Park, Sabah. *ASEAN Review of Biodiversity and Environmental Conservation (ARBEC)* (July-September): 1-5.

Slik, J. W. F., Verburg, R. W. and Keblerm P. J. A. 2002. Effects of Fire and Selective Logging on the Tree Species Composition of Lowland Dipterocarp Forest in East Kalimantan, Indonesia. Biodiversity and Conservation **11**: 85-98.

Slik, J. W. F. and Van Balen, S. 2006. Bird Community Changes in Response to Single and Repeated Fires in Lowland Tropical Rainforest of Eastern Borneo. *Biodiversity and Conservaiton* **15**: 4425-4451.

Sodhi, N. S. 2002. A Comparison of Bird Communities of Two Fragmented and Two Continuous Southeast Asian Rainforests. *Biodiversity and Conservation* **11**: 1105-1119.

Sodhi, N. S., Lian, P. K., Prawiradilaga, D. M., Tinulele, D. I., Putra, D. D. and Han, T.T.T. 2005. Land Use and Conservation Value for Forest Birds in Central Sulawesi (Indonesia). *Biological Conservation* **122**: 547-558.

Sodhi, N. S. and Brook, B. W. 2006. *Southeast Asian Biodiversity in Crisis.* Cambridge University Press, Cambridge, United Kingdom.

Sodhi, N. S., and Smith, K. G. 2007. Conservation of Tropical Birds. Mission Possible?. *J Onithol* **148** (2): S305-S309.

Soh, M. C. K., Sodhi, N. S., Lim, S. L. H. 2006. High Sensitivity of Montane Bird Communities to Habitat Distrubance in Peninsular Malaysia. *Biological Conservation* **129**: 149-166.

Smith, R. L. and Smith, T. M. 1998. Elements of Ecology. The Benjamin/Cummings Publishing Company, Inc., Menlo Park, CA.

Subramanyam, N. S. and Sambamurty, A. V. S. S. 2006. Ecology: Second Edition. Alpha Science International Ltd, Oxford, UK.

Thomas, P. A. and Packham, J. R. 2007. Ecology of Woodlands and Forests: Description, Dynamics and Diversity. Cambridge University Press, Cambridge, UK.

WWF Germany, 2005. *Borneo: Treasure Island at Risk.* Frankfurt am Main.

WWF-Malaysia, 2009. *High Conservation Value Forest (HCVF) Toolkit for Malaysia: A National Guide for Identifying, Managing and Monitoring High Conservation Value Forests.*

Zhou, T. and Peng, S. L. 2008. Spatial Scale Types and Measurement of Edge Effects in Ecology. *Acta Ecologica Sinica* **28** (7): 3322-3333.

Zakaria, M. and Nordin, M. 1998. *Comparison of Frugivory Birds in Primary and Logged Lowland Dipterocarp Forests in Sabah, Malaysia.* Universiti Pertanian Malaysia and Universiti Kebangsaan Malaysia, Malaysia.

Zakaria, M., Puan, C. L., Yusuf, M. E. 2005. Comparison of Species Composition in Three Forest Types: Towards Using Bird as Indicator of Forest Ecosystem Health. *Journal of Biological Sciences* **5** (6): 734-737.

Zamri, R., and Zakaria, M. 2002. Immediate Effects of Selective Logging on the Feeding Guild of the Understory Insectivorous Birds in Ulu Muda Forest Reserve, Kedah, Malaysia. *Proceedings of the Regional Symposium on Environment and Natural Resources*, **1**: 737-744.