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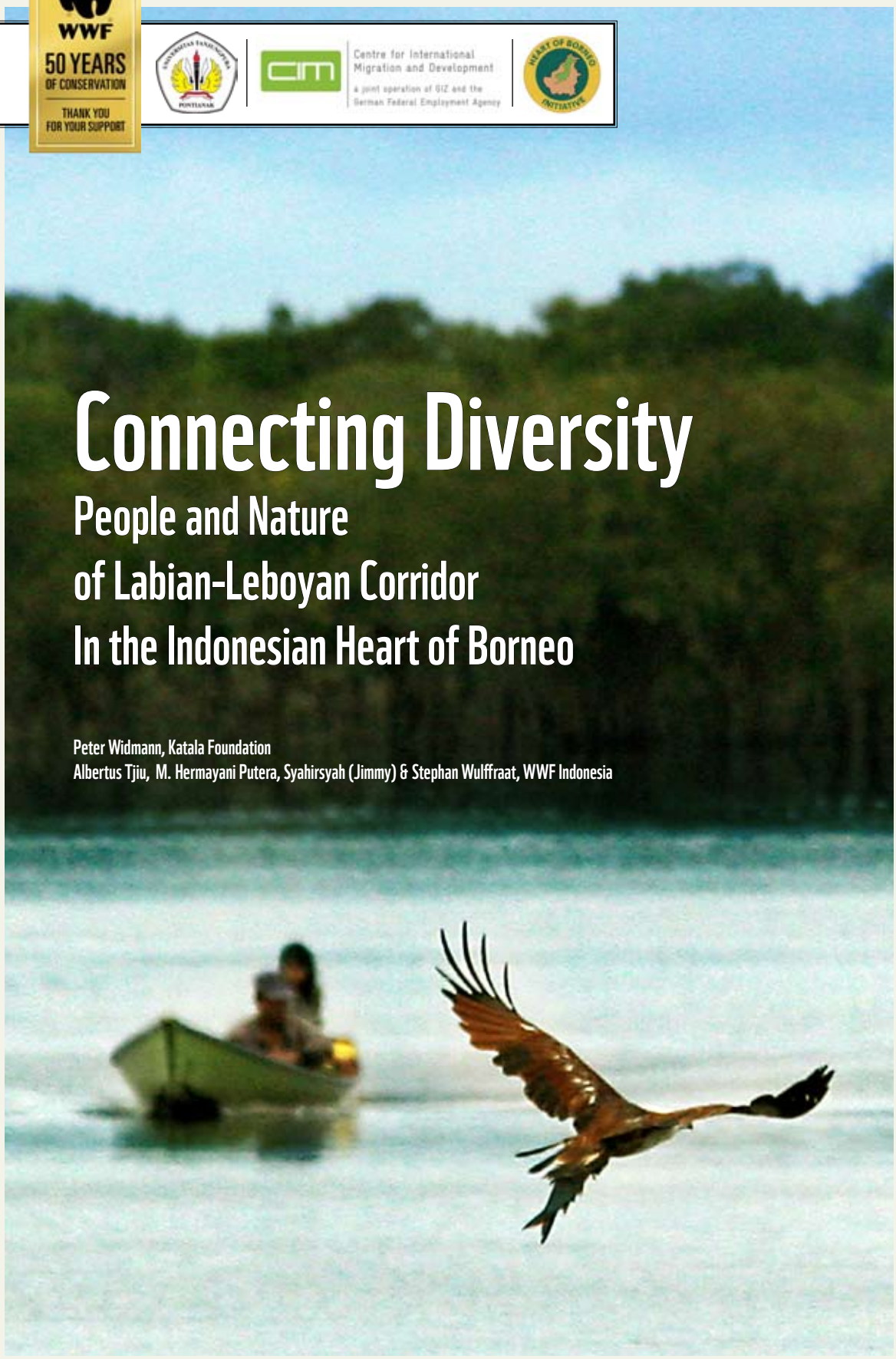

Connecting Diversity

People and Nature of Labian-Leboyan Corridor In the Indonesian Heart of Borneo

Peter Widmann, Katala Foundation
Albertus Tjiu, M. Hermayani Putera, Syahirsyah (Jimmy) & Stephan Wulffraat, WWF Indonesia

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Editorial Team:

Peter Widmann, Katala Foundation; Albertus Tjiu, M. Hermayani Putera, Syahirsyah(Jimmy) & Stephan Wulffraat, WWF-Indonesia

Contributors and co-authors:

Ambar Yoganingrum, Ambriansyah, Amri Yahya, Anas Nashrullah, Anna Paddenburg, Arif Budiman, Barbara Beckert, Elizabeth Linda Yuliani, Fitri Aryani, F. X. W. Padmarsari, Markus Lasah, Ilahang, Lia Syafitri, Hari Prayogo, Hermas Rintik Maring, Herry Hasymi, Heru Santoso, Istomo, Okta Daliyansyah, Patria Palgunadi, Radian, Rudi Zapariza, Sofwan Anwari, Syahirsyah, Syarif Usmardan, Tatang Suryadi, Valentinus Heri, and Yanieta Arbiastutie.

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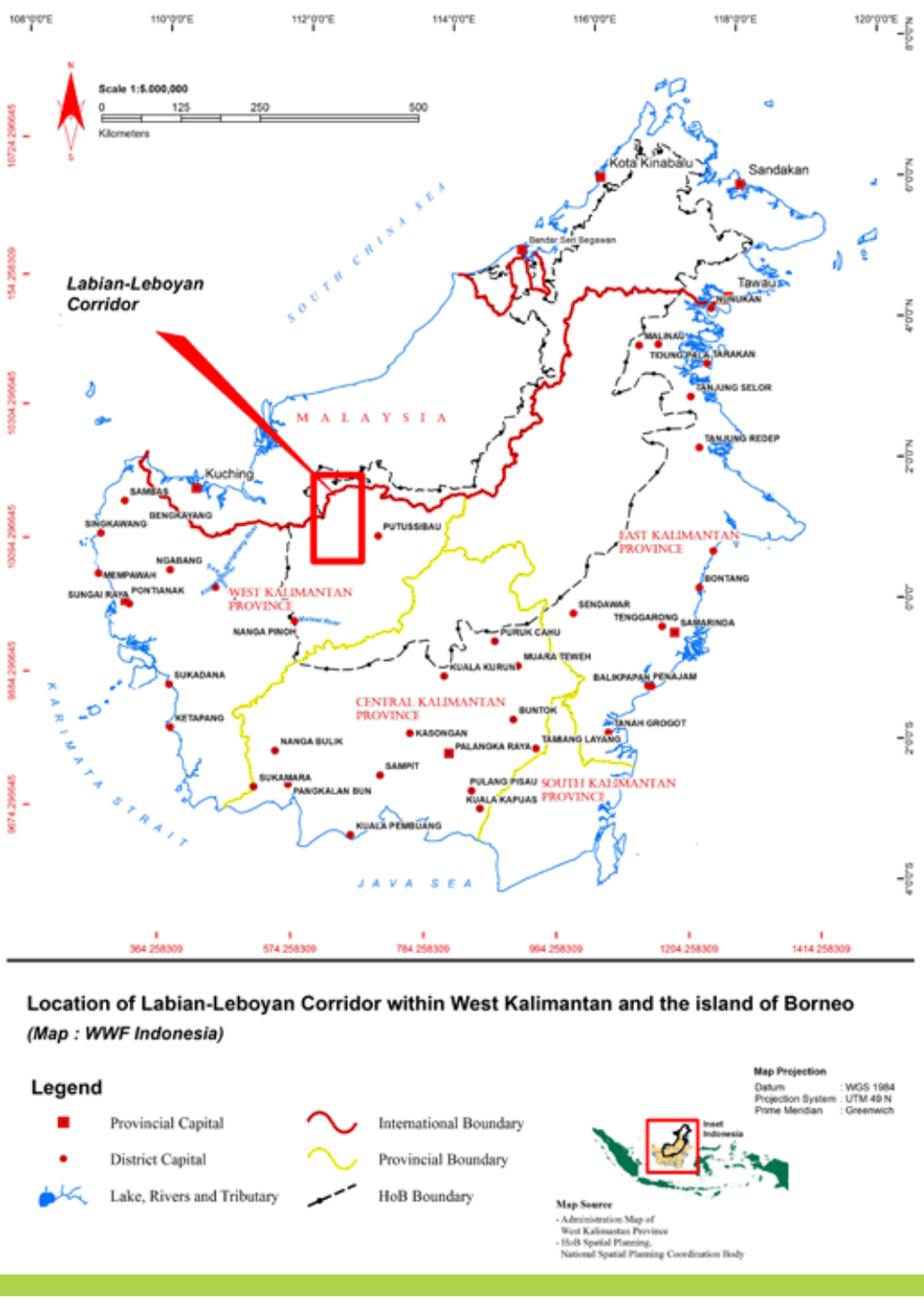
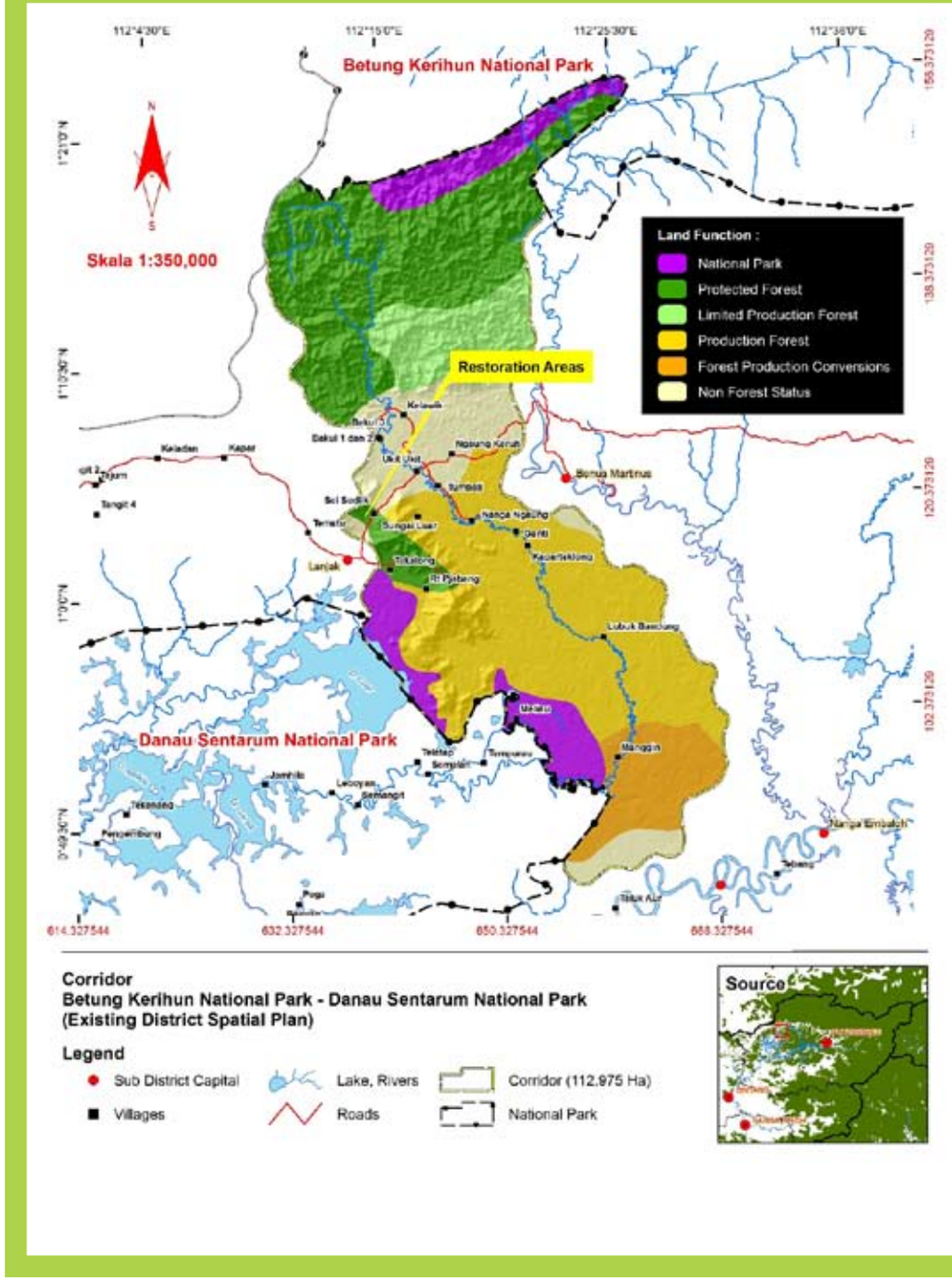
WWF-Indonesia's ultimate goal is to stop and eventually reverse environmental degradation and to build a future where people live in harmony with nature. Our mission is to conserve biodiversity and reducing human impact through promoting strong conservation ethics, awareness and actions in Indonesia society; facilitating multi-stakeholders efforts to preserve biodiversity & ecological processes on ecoregional scale; advocating for policies, law and law enforcement that support conservation; and promoting conservation for the well-being of people, through sustainable use of natural resources.



Location of Labian-Leboyan Corridor within West Kalimantan and the island of Borneo
(Map : WWF Indonesia)

Location of Labian-Leboyan Corridor within West Kalimantan and the island of Borneo
(Amri Yahya/WWF- Indonesia)



Land use in Labian-Leboyan Corridor between Betung Kerihun and Danau Sentarum National Parks
(Amri Yahya/WWF- Indonesia)

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Preface

By Dr. Efransjah
CEO WWF-Indonesia

It is with pleasure that I can witness the completion and publication of this book, highlighting WWF's important works in two outstanding places in the Heart of Borneo: Betung Kerihun and Danau Sentarum National parks. I can personally testify the natural beauty of these landscapes as I intensively visited the area back in 1998.

WWF-Indonesia started working in Betung Kerihun National Park in 1996 and in Danau Sentarum National Park in 2004. Our works with support from key strategic partners has achieved important results that lead to the production of comprehensive management plans for sustainable management of the parks. In this way WWF successfully contributed to the safeguarding of the natural richness of these two areas encompassing unique ecosystems.

As a conservation organization, WWF focuses on conservation targets without diminishing the importance of the wellbeing of humankind or our commitment to supporting socio-economic development. Although recognizing the importance of connecting the Betung Kerihun and Danau Sentarum areas as a wildlife corridor, our work in the area was actually started with livelihood studies and development initiatives for upstream- central- and downstream communities in 2004. The idea behind this was to integrate their land use and unite them to become a single stakeholder group with mutual interests, and hence to preserve the ecological functions of an entire landscape for their own welfare while simultaneously preserving the biodiversity.

A year later in 2005, a priority program on species conservation started with an intensive biodiversity surveys in Betung Kerihun. The survey revealed a large population of orangutans in the western section of the national park. Similar studies were also conducted in the Danau Sentarum national park to the south, and it was found that orangutan population there was rapidly decreasing, mainly because there was no more good connection with Betung Kerihun.

The study also found that the local communities require intact north-south connections for their livelihood, especially since this secures healthy functioning of the river ecosystem and good water quality. For instance, most communities are highly dependent on fishery and fish spawning which takes place mainly in the upstream areas after the young fish come downstream. This condition highlights the importance of protecting forest in the upstream areas.

When WWF started working in the corridor between Betung Kerihun and Danau Sentarum national parks, not much was known about the ecology and species of this area. Therefore many different biodiversity studies were conducted from 2005 to 2011, in partnership with the local university, international researchers, the local government and the Research, Development and Information institution. Of special relevance was the research on species migrations and upstream-downstream ecological interactions, which after all is the major reason for establishing the corridor.

Nevertheless, efforts to establish the corridor and conserve such a rich biodiversity landscapes would not be possible unless it is fully supported by local communities. WWF recognizes that the people living in and around WWF's priority places, and in proximity to our priority species, are vital partners for our conservation and sustainable development work. We also recognize the importance of indigenous resource rights and knowledge for the future conservation of Betung Kerihun and Danau Sentarum and its wildlife corridor. Environmental education and awareness campaign plays a significant role in reaching out to local communities around the corridor to support our ongoing conservation efforts. At an early stage, WWF

awareness program in Betung Kerihun and Danau Sentarum started by reaching out to local people about the impacts of logging operations in the upstream river areas. Later on, the awareness program was expanded to reach out to local communities and wider public audience on orangutan conservation, organic farming and environmental education, benefiting from visual-online technology and social media development.

Our work in Betung Kerihun and Danau Sentarum, as anywhere else, would not be possible without supports from our key partners. Through this opportunity, allow me to convey my highest appreciation to all partners who provided support, including local communities who live inside and outside the national parks and local NGOs partners for their dedication in support of conservation of Betung Kerihun and Danau Sentarum. I would also like to express my sincere thanks to the Ministry of Forestry through the Directorate General of PHKA and the head of national park both in Betung Kerihun and Danau Sentarum for their continuous support, commitm ent and collaboration to work together to protect these amazingly rich biodiversity landscapes. I would also like to extend my appreciation to ITTO as a pioneer, WWF-Germany, WWF US, CIM, KfW-BMU and HoB project which over the years, have provided generous financial assistance to the projects. May this good collaboration be maintained and strengthened in the future.

Last but not least, it is my strong wish that with the establishment of this corridor both livelihood as well as biodiversity can be preserved for future generations.

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The people from eight villages along the Labian-Leboyan Corridor for their comradry and cooperation: Labian Iraang, Mensiau, Labian, Sungai Ajung, Melemba, Tempurau, Semalah, and Nanga Leboyan villages.

We are particularly indebted to Riskiputro, Dinda Trisnadi, Lia Syafitri, Carolin Kugel and Indira L. Widmann for manuscript translation or proof reading.

Acronyms

BAU	**business as usual**
BKSDA	**Balai Konservasi Sumber Daya Alam**
BMU	***Bundesministerium für Umwelt, Naturschutz Und Reaktorsicherheit*** **(Federal Ministry for the Environment, Nature Conservation and Nuclear Safety)**
CIFOR	**Center for International Forestry Research)**
CIM	**Centre for International Migration and Development**
cm	**centimetre**
ENSO	**El Niño Southern Oscillation**
FASP	**Forest Area with Special Purpose**
IPCC	**Intergovernmental Panel on Climate Change**
IUCN	**International Union for Conservation of Nature**
IT	**information technology**
ITTO	**The International Tropical Timber Organization**
GIZ	***Deutsche Gesellschaft für Internationale Zusammenarbeit*** **(German Agency for International Cooperation)**
g	**gram**
ha	**hectare**
HoB	**Heart of Borneo**
KfW	***Kreditanstalt für Wiederaufbau*** **(Reconstruction Credit Institute)**
kg	**kilogram**
km	**kilometre**
LLC	**Labian-Leboyan Corridor**
MEA	**Millennium Ecosystem Assessment**
mm	**millimetre**
NGO	**non-government organization**
REDD	**Reduced Emissions from Deforestation and Forest Degradation**
SLF	**Sustainable Livelihoods Framework**
TDS	**total dissolved solid**
TIES	**The International Ecotourism Society**
BKNP	**Betung Kerihun National Park**
DSNP	**Danau Sentarum National Park**
TSS	**total suspended solids**
PES	**Payments for Environmental Services**
ppm	**parts per million**
WWF	**World Wide Fund for Nature**
VIE	**visible implant elastomer**
ZGAP	**Zoological Society for the Conservation of Species and Populations**

1. Not Only Connectivity

"The Labian-Leboyan Corridor (LLC) is the first of its kind in this endeavour which is intended to become the largest network of rainforest protected areas in Asia".

The Multiple Functions of the Labian-Leboyan Corridor

Peter Widmann, Albertus Tjiu, M. Hermayani Putera, and Stephan Wulffraat

Introduction

In the late 1980s corridors for conservation became fashionable; they were called wildlife corridors then, and were mainly intended, as the name implies, to facilitate movements of larger animals. Fragmentation of habitats was recognized as one of the biggest challenges in the conservation of populations of wild species. Conservation theory and evidence suggested that isolated and small populations were prone to extinction, partly caused by loss of genetic variability or by unfortunate random events, like forest fires or draughts. The logic behind corridors is that by facilitating movement between habitat fragments, inbreeding could be minimized and locally extinct population could be re-established. Many papers have been published since on the design of corridors (Lindenmayer and Nix 1992, Sanderson et al. 2003), and substantial amounts of money have been spent for their establishment, particularly in developed countries. A single green bridge over a multiple-lane highway in central Europe can cost several millions of Euros. Amazingly, until quite recently there was relatively few evidence whether conservation corridors serve their purpose or not (Inglis and Underwood 1992), particularly also in tropical rainforests (Laurence and Laurence 1999); fortunately, newer findings suggest they actually do work in terms of facilitating movement of individuals (Gilbert-Norton et al. 2010).

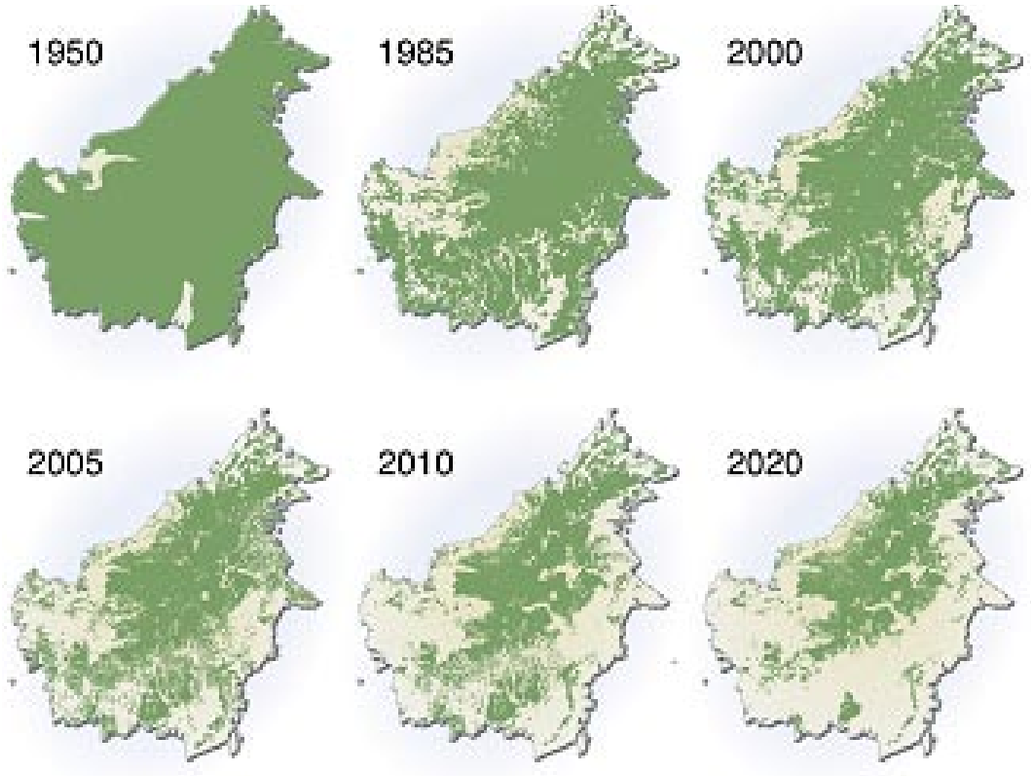

Figure 1.1 Changes of historical and projected forest cover on the island of Borneo (after Rautner et al., 2005).

Only about twenty years ago, although logging was in full swing, few people would have suggested creating conservation corridors on the island of Borneo. Back then, large unbroken forests still covered vast areas on the island, particularly in Kalimantan. Things have changed dramatically since. Continuous stretches of lowland forests on Borneo have all but disappeared and have been replaced by grassland or oil palm plantations. What forest is left is typically degraded and heavily fragmented. It is projected that by the year 2020 overall forest cover will only be around one third of the land area of the island, and will almost entirely be restricted to montane and submontane areas (Fig. 1.1); hardly any rainforest in lower altitudes will be left outside of protected areas (Rautner et al. 2005).

Figure 1.2 Giant dipterocarp, an emergent and dominant tree in lowland dipterocarp forest (Photo: Sugeng Hendratno/WWF-Indonesia)

Conservation corridors potentially can connect those remnant forest patches and will become increasingly more important as tools for conservation, particularly for large landscape-wide conservation efforts such as the Heart of Borneo Initiative. The Labian-Leboyan Corridor (LLC) is the first of its kind in this endeavour which is intended to become the largest network of rainforest protected areas in Asia. Experiences from LLC will help to shape the successive corridors in various stages of planning. Although providing connectivity is one important ecological function to be achieved, there are many more expectations on the corridor, including provision of livelihood for the local population, habitats for wild species, soil and water protection, as well as mitigation for and adaptation to a changing climate.

Connectivity

The Labian-Leboyan River connects Danau Sentarum and Betung Kerihun National Parks over a distance of 70 km. Only very mobile species are able to cover this in a lifetime. Storm's Storks *Ciconia stormi*, for example, are able to fly from one park to the other in a matter of hours; juvenile Clown Loaches *Chromobotia macracanthus* (a fish species) on the other hand need several weeks to migrate from their birth places in the Leboyan estuary to the habitat of the adult population in the central portion of the watershed. Seasonal or a-seasonal movements of species occur for various reasons, like search for food, mates or territories. They are well documented for Bornean Orangutans *Pongo pygmaeus pygmaeus* which seem to possess more or less fixed schedules of visits to the same fruiting trees at exactly the right time when fruits are ripening, which is repeated season after season (MacKinnon 1974). Seemingly independent of foraging, particularly male Orangutans often move over large distances, and this almost certainly contributes to genetic exchange between subpopulations. Legendary and for the most part a thing of the past due to forest fragmentation is the migration by the thousands of Bearded Pigs *Sus barbatus*, following the mass-fruiting of Dipterocarp trees (Pfeffer 1959).

Figure 1.3 The Bearded Pig *Sus barbatus*, although reduced in numbers, is still on the move in Labian-Leboyan Conservation Corridor. (Photo: Peter Widmann)

Different species have different requirements on the ecosystems they move in. Some larger birds of prey like Black Eagle *Ictinaetus malayensis* or Changeable Hawk-Eagle *Spizaetus cirrhatus* can easily pass over large forest tracts, as well as open areas. Müller's Gibbons *Hylobates muelleri* require a closed canopy for their movements, except for the shortest of distances. Fishes obviously need unobstructed river flows for their seasonal migrations.

For the majority of species movements in LLC are unknown. Some species-specific research on selected few is in progress or in preparation and will be presented in later chapters. However, a first approach to assess the importance and functionality of LLC in terms of connectivity is to assess which mobile species occur in Danau Sentarum and as well in Betung Kerihun and what kind of environmental features are likely needed to facilitate their movements.

Human Habitat

It is not exactly known when Labian-Leboyan watershed was settled by humans for the first time. There is an old folklore of a hunter who got lost and by accident discovered the rich natural resources of the area. It is likely that Labian-Leboyan River was visited by hunting, fishing and gathering parties since prehistoric times, as access from Danau Sentarum is easy. Larger wildlife becomes rare in the subsequent period. The largest mammal species, the Banteng *Bos javanicus*, almost certainly is extinct locally; the last Sambar *Cervus unicolor* in the central corridor area was shot about twenty years ago.

Fishing and gathering of minor forest products remain important activities until present and aspects on these forms of resource use are treated in later chapters.
Increasingly important in the last few decades, particularly since the 1950s, is agriculture and animal husbandry, including aquaculture. Only the upper portions of Labian-Leboyan watershed are dry for most parts of the year, and in these areas larger areas have been cleared permanently for cultivation. The predominant form of agriculture is shifting cultivation; however, some permanent rice paddies were established in places with reliable water supply for irrigation. Increasingly also plantation crops play a role. Due to its work intensity, rubber is a suitable crop for smallholders. Palm oil on the other hand in the corridor, as in other parts of West Kalimantan is an industrial-scale plantation crop which massively affects biodiversity and local communities.

"The lower portions of Labian-Leboyan are flooded for more than half of the time of the year, so that options for agriculture are severely limited."

Agriculture in the central Labian-Leboyan watershed is mostly restricted to the elevated river levees, since the lower-lying areas are mostly waterlogged. A big challenge will be to find solutions to harmonize this kind of land use with conservation and fisheries, since the dry riparian forests are also important wildlife habitats and migration routes and provide important input to the river for fish communities in form of invertebrate and plant food.

The lower portions of Labian-Leboyan are flooded for more than half of the time of the year, so that options for agriculture are severely limited. It is in these areas that one can observe very innovative systems of floating vegetable gardens and even rubber tree nurseries, which are established on wooden rafts along the river banks. Livestock is kept on rafts as well, and cattle are provided with fodder from floating meadows and temporary dry grasslands. Floating cages to fatten commercially important fish species like Giant Snakehead, locally known as "Toman" *Channa micropeltes* or shark catfishes, known as "Patin" *Pangasius* spp. are increasingly employed to supplement incomes. These species need large amounts of smaller fish in order to grow to marketable sizes. The sustainability of catch of fish as feeds for aquaculture is an increasing concern at Leboyan River, and number of allowed fish cages per household is restricted in some villages to avoid overutilization of fodder fish. Catching fish for the aquarium trade is a seasonally import source of income. The most valuable species, the Southeast-Asian Arowana *Scleropages formosus* does not play a role any more, since populations in the wild are economically extinct, and supply is mainly from aquaculture. By far the most important ornamental fish species is the Clown Loach *Chromobotia macracanthus* locally known as "ulang-uli" of which several hundred-thousand are caught every year in the lower portions of Leboyan River.

Minor forest products are seasonally important sources of income as well. During the dry season, populations of the Asian Honey Bee *Apis dorsata* build up considerably in order to exploit the flowering trees of the flooded forests. Local communities facilitate the establishment of bees through the installation of wooden supports for the hives, locally known as "tikung". Honey collected from these wild bees is a highly-prized forest product which is in increasing demand within Indonesia, as well as abroad. Logging has been a major industry in the area until the recent past. Timber harvest has opened substantial areas along the road to Lanjak for shifting cultivation and cattle grazing. The combination of these has led to the development of degraded grass- and shrub land in these areas, which are in urgent need of ecological restoration. Humans are an intrinsic component of LLC, and the maintenance of local livelihoods is one of the important corridor functions that needs to be maintained or improved. One of the biggest challenges in the development and management of the area is to balance this function with the other ones.

Figure 1.4 Forest in Labian-Leboyan Corridor still offers good habitats for many arboreal and terrestrial wildlife species (Photo: Sugeng Hendratno/WWF-Indonesia)

Figure 1.5 LLC is important for human livelihood, particularly for fisherman
(Photo: Sugeng Hendratno/WWF-Indonesia)

Wildlife Habitat

Many species are not mobile enough to migrate through the corridor in their lifetime. This is certainly true for most microorganisms, fungi, plants and invertebrates, but also for virtually all amphibians, reptiles, small mammals and even most bird species.

One requirement of the corridor therefore is that original habitats for as many species as possible can be maintained. Continuous suitable habitats from Danau Sentarum to Betung Kerihun would assure continuous populations of the species. This in turn facilitates demographic (exchange of individuals, though possibly over many generations) and genetic connectivity, potentially making the respective population more resilient to extinction.

To insure the viability of populations by providing suitable and sufficient habitats is one of the core problems of conservation. Habitat loss and fragmentation are the leading causes for species extinction, and although considerable effort has been put into clarifying the connection between the two, we are far from understanding it completely. A first approximation came from the findings of island biogeography (MacArthur and Wilson 1967) which indicate that less species can persist on smaller than on larger islands.
A crude rule of thumb is that 50% of species go extinct, if 90% of area is "lost". These findings were also applied to ecosystem loss in mainland areas, for example forest destruction and

fragmentation, where islands of forest remain in a "sea" of so-called non-forest matrix. A first approach to assess importance, as well as functionality of LLC as habitat complex is to compare species assemblages in the two national parks. Species which occur in both parks potentially will benefit from intact habitat within the corridor that allows continuous population that stretch over both parks. Assessments of vascular plants, fishes, amphibians, reptiles, birds and mammals have been conducted in varying intensities, resulting in more or less complete data sets.

Given the vastly different characteristics of the two national parks, Danau Sentarum being dominated by wetland ecosystems, whereas Betung Kerihun mainly contains different types of dry forests, there is an astonishing overlap in floral and faunal assemblages. An analysis of resident lowland bird species indicates that most species found in the national parks are also present in LLC. Presence or absence of organism groups in the corridor, in comparison to both parks may lead to clues of limitations of the corridor for this group and provide guidance for management interventions.

Figure 1.6 Rufous-backed Kingfisher *Ceyx rufidorsa* is a resident understorey bird in LLC
(Photo: Peter Widmann)

"Many species are not mobile enough to migrate through the corridor in their lifetime".

Figure 1.7 Several groups of Proboscis Monkeys *Nasalis larvatus* (local: Bekantan/Rancung) occur along the Labian River (Photo: Sugeng Hendratno/WWF-Indonesia)

Water and Soil Protection

Siltation of the lakes in Danau Sentarum is one of the most severe conservation problems of this protected area. In the recent past, the process accelerated dramatically, leading to the prediction that most of the 83 lakes of the wetland may be filled up by the end of this century. Deforestation and particularly establishment of oil palm plantations have been identified as leading causes for this process, since they disturb soil horizons and expose bare soil to erosion. So far, 18 permits for oil palm plantations have been issued surrounding Danau Sentarum (Verchot et al. 2010), including in LLC, one of the largest tributary of the wetland complex. Other problems related to land use change, particularly establishment of industrial-scale plantations, include eutrophication and pollution with chemicals, like pesticides or fuel.

Direct effects may include reduction of fisheries, since sediments affect oxygen content of the water body and destroy bottom microhabitats. Pollutants may directly poison aquatic organisms within the food chain. Water quality for drinking and agriculture is diminished. The efficiency of micro-hydropower-plants is affected negatively. Once the hydrological functions of Danau Sentarum are compromised, indirect and longer-term effects will include severe flood and draught periods. This will affect the majority of the 3.2 million people living in the Kapuas watershed.

Retaining a closed and multi-layered tree cover can mitigate the eroding and leaching effects

Figure 1.8 Trees in the riparian forest with their dense root mats are effective in preventing riverbank erosion (Photo: Peter Widmann)

of the torrential rain falls that frequently occur in the region. Again, a major challenge for the management of LLC is the protection and restoration of riparian forest. This ecosystem is often situated on elevated river terraces, which is particularly prone to riverbank erosion. As mentioned previously, these elevated areas are in high demand for agriculture, but also play a crucial role as migration paths and wildlife habitats, since they remain dry even during the rainy season, whereas the lower-lying terrains at some distance from the rivers are inundated.

Figure 1.9 Land use changes like shifting cultivation still happen in some lowland areas (Photo: Sugeng Hendratno/WWF-Indonesia)

Climate Change Mitigation and Adaptation

Protection of forests, particularly tropical rainforests and peatlands has been identified as a cost-effective means of mitigating effects of greenhouse gases in respect to climate change. The potential particularly in Indonesia is huge, but so are the political, administrative and technical hurdles. Nevertheless, forests and peatlands in Kalimantan can be considerable sources or sinks of greenhouse gases, depending on their management. In the vicinity of Danau Sentarum, including in LLC, some of the oldest and deepest tropical peat deposits can be found. An estimated 4,000 to 6,000 ton CO2-e (carbon dioxide equivalent) is fixed in each hectare of peatswamp forest in this area (Anshari, pers. communication August 2008).

Figure 1.10 The peatswamp forests in the corridor fix 4,000-6,000 tons of carbon dioxide equivalents per hectare. (Photo: Peter Widmann)

"Only the future will show how well the corridor will perform in the face of this and other challenges".

The degradation of these forests and soils would release considerable amounts of carbon into the atmosphere, whereas its protection would result in additional carbon sequestration over time. Restoration of already degraded forests in the northern portion of the corridor will not only improve corridor connectivity, but will also bind additional atmospheric carbon. In a later chapter, estimated biomass gains and carbon amounts fixed will be presented for different reforestation performance scenarios.

Man-made climate change adds a whole new dimension to biodiversity conservation challenges, particularly to the already severe problems of habitat loss and fragmentation. Because of changing climate, areas set aside for conservation may no longer be suitable for the complete set of species they presently hold. Shifting temperatures and precipitation patterns may cause existing biological communities to disintegrate, since reactions to these changes are species-specific (Hannah et al. 2005). Conservation corridors are tools which hopefully can aid in the adaptation to these effects of climate change by allowing shifts of species' ranges (most likely from lower to higher altitudes). LLC connects areas as low as 30 m above sea level in Danau Sentarum to mountains up to 1,767 m high in Betung Kerihun National Park.

Table 1.1 Number of species recorded from Danau Sentarum National Park, Labian-Leboyan Corridor and Betung Kerihun National Park, Kapuas Hulu. Italics indicate incomplete data sets; number in parentheses indicate species that need further confirmation (after: van Balen and Dennis (2000), Giesen (1987), Jeanes and Meijaard (2000), Prayogo et al. (1999), Rachmatika et al. (1999), Stuebing et al. (1999), this publication, unpublished data from WWF Indonesia, administrations of TNDS and TNBK)

Taxon	Danau Sentarum National Park	Labian/Leboyan Corridor	Betung Kerihun National Park
Vascular Plants	695	*327*	504
Fishes	103	*69*	240 (19)
Amphibians	53	*19*	-
Reptiles	50	*34*	24
Birds	233	*193*	237 (45)
Mammals	*52*	*50*	*55*

Only the future will show how well the corridor will perform in the face of this and other challenges. However, in order to draw conclusions for improvement or for similar projects, the status quo of geophysical, biological and socio-economic parameters at the time of the corridor establishment need to be known and documented.

Figure 1.11 In the dry season local people in LLC join in groups to catch fish in the shallow lakes (Photo: Sugeng Hendratno/WWF-Indonesia)

Figure 2.1 Rhinoceros Hornbill *Buceros rhinoceros* (local: Rangkong badak; Photo: Sugeng Hendratno/ WWF-Indonesia)

2. Biological Diversity

The following nine chapters deal with the biological diversity of the Labian-Leboyan Corridor (LLC), starting with an overview of the different ecosystems of the area, followed by taxonomic overviews of forest vascular plants and vertebrates based on repeated surveys in the past five years. Species lists of all of these groups can be found in the annex. None of the papers claims to cover the complete diversity within a certain group, but rather to provide a first baseline of species diversity in the area.

Ultimately it would be of interest to compare faunal and floral composition of LLC and the adjacent protected areas; potentially valuable information of the effectiveness of the corridor can be expected from this exercise. This was preliminarily attempted for the resident lowland bird assemblages for which the most complete data sets exist from the corridor and the adjacent two national parks: Betung Kerihun National Park (BKNP) and Danau Sentarum National Park (DSNP). There are still large knowledge gaps, for example regarding amphibians in Danau Sentarum, or small mammals and micro-bats in all three areas. The most obvious one is the almost complete lack of information on invertebrates, the most diverse section of the animal kingdom and certainly the ecologically most important.

The final two chapters in this section deal with two animal taxa of global conservation importance which have important populations within LLC: the Storm's Stork *Ciconia stormi* and the north-western subspecies of the Bornean Orangutan *Pongo pygmaeus pygmaeus*.

Figure 2.2 Upper portion of Labian-Leboyan River with elevated river banks near Ukit-Ukit (Photo: Peter Widmann)

The Ecosystems

Peter Widmann and Albertus Tjiu

LLC is characterized by the close proximity of forests, wetlands, and man-made ecosystems. There is a distinct change of vegetation types along the watershed, caused mainly by differences in landforms, elevation and drainage. The diversity in ecosystems is matched by different kinds of land use and a rich flora and fauna.

Labian-Leboyan River and Associated Wetlands

In Kalimantan, and particularly in the vicinity of Danau Sentarum, it is often impossible to set a clear boundary between forests and pure wetland ecosystems, since there are several types of forests which are waterlogged or even flooded for months on end. Labian-Leboyan River has its source in the montane area bordering Sarawak, Malaysia, comprising Betung Kerihun National Park (BKNP), and Batang Ai National Park and Lanjak Entimau Wildlife Sanctuary on the other side of the water divide. The downstream section of the Labian River is called Leboyan. Tributaries to the river are clear, cool mountain streams, typically poor in nutrients and rich in oxygen. The river bottom consists of boulders, gravel and coarse sand and currents are swift or even torrential, especially after rain. Algae can thrive in more sunny situations, but normally the forest canopy is closed over narrow water bodies. Higher plants within the river are very rare. An exception is *Myrmeconauclea strigosa,* a shrub as health indicator of watershed that grows between river boulders and is adapted to withstand strong water currents.

Figure 2.3 Lowland forest in morning mist (Photo: Sugeng Hendratno/WWF-Indonesia)

Figure 2.4 The floating Water Hyacinth *Eichornia crassipes* with its spectacular violet inflorescences was introduced from tropical America (Photo: Marzuki/Panda Click!)

Once Labian-Leboyan enters the lowland, the river starts to meander, depositing gravel and sand in the inner river banks, where the current slows down and eroding soil on the outer ones where the currents hit with full force. River banks in the middle Labian-Leboyan River are elevated and often the only dry land remaining during the rainy season in this section of LLC. Water chemistry changes markedly as well. Increasingly, tributaries from the adjacent peatswamp forests drain into the main river, carrying acidic tea-coloured water, poor in nutrients, but rich in tannins. These chemicals turn the Labian-Leboyan into a black water stream.

The main river itself changes course frequently, thereby cutting off river bends and creating shortcuts. The resulting separated stretches of river bed transform into stagnant water bodies, called oxbow lakes. Over time these wetlands accumulate organic matter until eventually they become shallow, then swampy, and finally are reclaimed by forest trees.

In the lower portion of LLC the river levees disappear and large areas left and right of the river bed are flooded during the rainy season. Terrain which is flooded for a maximum of nine months is usually covered by freshwater swamp forest. If the area stays inundated for longer, floating meadows consisting of grasses and knotweed *Polygonum* sp. can develop. If these areas fall dry completely during extended droughts, a short-lived community of dry-land grasses and herbs develops. Its members survive the next flooding as seeds in the ground, until the next dry season. Water plants are still rare in the water body, but two exotic floating plants were able to establish here: the Water Hyacinth *Eichornia crassipes* with its spectacular violet inflorescences and the aptly named Water Salad *Pistia stratiotes.* Both species were introduced from tropical America. In shallow water with weak currents fine yellow flowers are protruding above the water surface. These belong to *Utricularia*

"Sunlight can reach the under-storey in many locations and allows dense growth of ferns, tree ferns *(Cyathaceae)*, gingers *(Zingiberaceae)* and wild bananas *(Musaceae)*".

sp., a plant that complements its nutrient supply by being carnivorous and catching small aquatic organisms.

Forests

At least four major forest types exist in LLC. In the upper watershed hill dipterocarp forest can be found, starting from about 500 m above sea level until around 800 m. As the name implies, this forest is rich in species of the *Dipterocarpaceae* family, namely *Dipterocarpus mundus, Hopea beccariana*, *Vatica micrantha* and *Shorea macroptera*. Among other families, *Castanopsis* sp. and *Lithocarpus* sp. (Fagaceae), Adinandra sp., *Cryptocaria* sp., and *Litsea* sp. (Lauraceae) also *Crypteronia cumingii (*Crypteroniaceae) are particularly common at these higher altitudes. Vines and epiphytes are common, particularly ferns and orchids among the latter, due to the high humidity in this region. Canopy-forming trees are only about 20-30 m tall. Sunlight can reach the under-storey in many locations and allows dense growth of ferns, tree ferns (Cyathaceae), gingers (Zingiberaceae) and wild bananas (Musaceae).

Below 200 m above sea level the very diverse lowland dipterocarp forest can be found on well-drained soils. Emergent trees with heights of up to 40 m include *Dipterocarpus, Dryobalanops, Shorea*, and *Ficus* species. Vines and epiphytes are moderately common. The canopy closes at around 30 m, however single emergent trees can be much taller, like

Figure 2.5 Multi-layered riparian forest along LLC (Photo: Syahirsyah (Jimmy)/WWF-Indonesia)

Koompassia excelsa which can reach 60 m in LLC and is the tallest tree species in Asia. Little light penetrates to the under-storey and the vegetation on the ground is therefore less dense.

Riparian forest that grows on the elevated river levees in central LLC is possibly a subtype of lowland dipterocarp forest. Typical for this forest formation are *Dracontomelon dao, Ficus* spp., and *Shorea stenoptera*. This small band of dry forest along the river is an important habitat for terrestrial flora and fauna, because it is rarely flooded. Its trees also provide important food and shelter in the form of leaves, flowers, fruits and insects for fish and other aquatic organisms, and their roots stabilize river banks. At the same time these locations are in high demand for agriculture, and therefore this vegetation is one of the most threatened forest types in LLC. Behind the river levees, the terrain drops again and large tracts of peatswamp forests have developed on the poorly drained plains. These sites are extremely poor in nutrients. Water is mostly derived from rain and the forest grows on massive peat deposits which can be as thick as six meters in some places. Vegetation composition varies, depending mainly on drainage and therefore level of water in or above the peat. Characteristics of the forest here can be similar to dry forest types, but often trees form lower canopies and reach only smaller diameter classes. Typical tree species in this forest type are *Campnosperma coriaceum, Dactylocladus stenostachys* and *Fagraea crenulata*. Ramin *Gonystylus bancanus* was very abundant in the past, but now populations virtually become extinct due to over exploitation.

Roots of trees are often kneed or stilted to allow gas exchange in the oxygen-poor conditions of the waterlogged peat. Density of the understorey vegetation strongly depends on the height of the

Figure 2.6 The bright colour of the pitcher plant *Nepenthes bicalcarata* attracts insects which may get trapped in the tube.
(Photo: Syahirsyah (Jimmy) /WWF-Indonesia)

canopy. Typical peculiar plants of the forest understorey are the carnivorous pitcher plants of the family *Nepenthaceae.* Three species can be locally common in more open situations, namely *Nepenthes rafflesiana, N. ampullaria* and the endemic *N. bicalcarata*. In the lower LLC, peatswamp forest slowly gives way to freshwater swamp forest as the influence of flood water from the river increases. Although peat still can develop in these forest types, soils tend to be more fertile due to regular input of silt loads from the river. Forests in areas exposed to only short and shallow floods have a similar structure and composition as lowland dipterocarp forests. The longer an area is flooded, the fewer trees are able to adapt and the lower the canopy gets. Areas flooded for about nine months are often dominated by dense stands of a single species: *Barringtonia acutangula*. This small tree is particularly resilient to flooding. In the wet season it displays masses of red flowers which during this time are a major food source for the Asian Honey Bee *Apis dorsata*, whose honey in turn is one of the most important sources of income in Danau Sentarum. Freshwater swamp forest is one of the most unique forest formations in Borneo, where mouse deer, tree shrews and porcupines forage for fruits on the forest floor during the dry season, while barbs, gouramies and catfish do so during the wet time of the year.

Man-made Ecosystems

All ecosystems in the corridor are influenced by humans to a certain degree, but some much more so than others. Logging has affected most of the forests in the area, and although forest structure is still mostly intact, single timber species of high economic value have become scarce, such as Ramin. Slash and burn cultivation is common in upper and central LLC, particularly in readily accessible areas, like along the road from Putussibau to Lanjak, or on the river levees along Labian-Leboyan River. Main crops are upland rice, corn and a variety of root crops.

Logging and repeated burning has created larger areas of grassland along the road, with "Lalang" grass *Imperata cylindrica* as a dominant species. Other areas are covered by paku resam *Gleichenia linearis* ferns. If left unburned for several years a secondary succession sets in, and pioneering woody species will take over, including *Melastoma malabathricum, Macaranga* spp., and *Vitex pubescens*. If left undisturbed even further, an increasingly diverse secondary forest will develop.

Tree-based land use forms are widespread in LLC. An important cash crop is Rubber *Hevea brasiliensis*. Rubber plantations can be diverse systems integrated in the original forest matrix and enriched with fruit-bearing trees. However, pure stands of rubber are

"Chickens are certainly the most commonly kept livestock all over the corridor".

increasingly established in LLC, which are very poor in terms of wild flora and fauna. Fruit gardens in the vicinity of villages or longhouses are common, and typical fruit trees include Rambutan *Nephelium lappaceum*, Durian *Durio zibethinus* or several species of *Artocarpus* spp. In the lower watershed vegetables and even rubber seedlings are produced in floating gardens on rafts due to the extended floods. Chickens are certainly the most commonly kept livestock all over the corridor. Cattle, pigs and goats are kept grazing in upper LLC, whereas cattle is seasonally kept on rafts in the lower watershed and fed with forage cut in the floating meadows adjacent to the river. Fishing is an important form of land use and fish traps and net rows are permanent fixtures along the river. Aquaculture of fish with high value, like Giant Snakehead *Channa micropeltes* is increasing. Fish are usually kept in floating cages or in net enclosures. Due to the large amounts of food fish required for this form of production, the number of cages per household is already restricted in some villages.

Figure 2.7 Cattle is kept on rafts in the lower watershed and fed with forage cut in the floating meadows adjacent to the river (Photo: Sugeng Hendratno/WWF-Indonesia)

Forest Vascular Plants

Albertus Tjiu and Ambriansyah

The two national parks in Kapuas Hulu District exhibit very different ecosystem features. BKNP is dominated by dry lowland, hill and mountain forests; DSNP on the other hand is a large freshwater wetland ecosystem (WWF-Indonesia 1999). These two parks once formed a continuous forested landscape, gradually transforming from one to the other, but due to human activities and development they are now fragmented. LLC partly preserved this connectivity with BKNP in the upstream, and DSNP in the downstream portions. The corridor harbors unique forest types, including riparian, dry lowland and hill forests in the upper portions, and peat and freshwater swamp forests ranging from dry, semi-inundated to inundated in the lower watershed (Tjiu et al. 2007).

Methods

Research was carried out in March 2009 in three out of six villages along LLC to obtain data on condition of natural vegetation. Villages selected were Melemba Village, Sungai Ajung Village, and Mensiau Village, each representing downstream, mid-stream and upstream sections of the corridor.From a total of 5.5 ha of vegetation research plots, 2.8 ha was covered by lowland dipterocarp forest and inundated peat swamp forest in the downstream area (Ambriansyah et al. 2009). Samples were taken in three different locations, namely Peninjau Hill, Meliau Sub-Village and Manggin Sub-Village. In the midstream area 1.9 ha was sampled in in two locations: Lubuk Bandung Sub-Village and Kapar Tekalong-Kapar Toa Sub-Village, representing inundated and dry peatswamp forests. In the upstream area 0.8 ha were sampled in Pana' Hill of Kelawik Sub-Village representing lowland dipterocarp forest (Tab. 2.1).

Table 2.1. Forest types, tree numbers and diversities in the six research sites

Forest Type	Upstream	Midstream		Downstream		
	Mensiau	Sungai Ajung		Melemba		
	Bukit Pana' (0.8 ha)	Lubuk Bandung (0.9 ha)	Kapar Tekalong-Kapar Toa (1 ha)	Bt. Peninjau (1 ha)	Meliau (0.8 ha)	Manggin (1 ha)
Lowland dipterocarp forest	402 trees 43 families 142 species	-	-	437 trees 41 families 174 species	-	-
Inundated peatswamp forest	-	495 trees 33 families 79 species	-	-	370 trees 27 families 80 species	477 trees 27 families 78 species
Dry peatswamp forest	-	-	580 trees 38 families 99 species	-	-	-

In the upstream area 0.8 ha were sampled in Pana' Hill of Kelawik Sub-Village representing lowland dipterocarp forest (Tab. 2.1).

Results

From all six locations, Bukit Peninjau in the downstream area was the most diverse with 174 species, followed by Kelawik Sub-Village in the upstream area with 142 species (Tab. 2.1). In all six locations we recorded 2,761 individual trees, or 501 trees/ha on average, comprising 329 species out of 56 families.
Woody species typical for lowland dipterocarp forest recorded in Bukit Peninjau and Bukit Pana': *Pternandra* sp., *Syzygium tawahense, Vatica micrantha, Bellucia pentamera* (exotic species, well established here), *Adinandra dumosa, Dryobalanops oblongifolia, Ilex cissoidea, Shorea parvifolia, Artocarpus elasticus* and *Dehaasia* sp. A total of 243 species was recorded out of 49 families. From a previous plot of two hectares, 1,740 trees consisting 232 species [99 genera, 39 families were sampled (Tjiu et al. 2007)].

In the four locations in Meliau, Manggin, Lubuk Bandung and Kapar Tekalong covering inundated and dry peatswamp forests we found 183 species out of 46 families. Species that dominated in these swamp forests were: *Calophyllum nodosum, Campnosperma coreaceum, Combretocarpus rotundatus, Dactylocladus stenostachys, Diospyros coriacea, Dryobalanops lanceolata, Lophopetalum javanicum, Mezzettia umbellata, Neoscortechinia kingii, Palaquium psendorostratum, Shorea belangeran, S. parvifolia, S. rotundifolia, S. smithiana, Sindora wallichii, Swintonia acuta, Syzygium lineatum, S. tawahense, S. nigricens, Dyera lowii* and *Ilex* sp. In swamp forests populations of some tree species were high, but diversity was overall lower compared to dry forest types. Dominant families in this forest type were *Crypteroniaceae, Anacardiaceae, Dipterocarpaceae, Euphorbiaceae, Myrtaceae, Loganiaceae, Hypericaceae, Sapotaceae, Guttiferae, Annonaceae*, and *Celastraceae*.

Woody vegetation of riparian forests along Leboyan River included: *"Syzygium* spp., *Dracontomelon dao, Octomeles sumatrana, Pterospermum javanicum, Nauclea sp., Ficus* spp. This vegetation type was interspersed by community plantation of Rubber *Hevea brasiliensis, Shorea stenoptera* and other community cultivation. Overall, plant families with most species recorded from LLC were *Dipterocarpaceae, Euphorbiaceae, Anacardiaceae, Myristicaceae, Lauraceae* and *Guttiferae*.

Besides tree species, we also recorded useful or ornamental plants, particularly common were rattans (*Calamus* sp., *Ceratolobus* sp., *Daemonorops* sp., *Korthalsia* sp., *Plectocomiopsis* sp.) and orchids (*Appendicula* sp., *Arundina* sp., *Bulbophyllum* sp.,

"Despite its restricted area, LLC has a high diversity of different forest types: riparian, lowland dipterocarp, peat and freshwater swamp forests".

Calanthe sp., *Coelogyne* sp., *Eria* sp., *Grammatophyllum speciosum*). Medicinal plants, some with economic potential include "Pasak bumi" *Eurycoma longifolia*, "Akar kuning" *Coscinium fenestratum* and *Fibraurea tinctoria*, "Sirih merah" *Piper porphyrophyllum*, "Sarang semut" *Anthorrhiza chrysacantha*, "Pendo" *Goniothalamus* sp., "Sinduk" *Scorodocarpus borneensis*, and "Tubuk" *Pycnarrhena tumefacta.*

Conclusion

The importance of forest in LLC for conservation is highlighted by the fact that of the 25 Borneo-endemic vascular plant species known from DSNP, 23 can also be found in the corridor area. Most tree species in LLC can also be found either in BKNP or DSNP.
Despite its restricted area, LLC has a high diversity of different forest types: riparian, lowland dipterocarp, peat and freshwater swamp forests. The latter two can further be subdivided according to length and depth of inundation into inundated swamp forest, semi-inundated and dry swamp forests. (Tjiu et al. 2007). The overall vascular plant diversity of LLC is comparable to those of the adjacent national parks.

Figure 2.8 Intact lowland forest contains a high diversity of vascular plant species
(Photo: Sugeng Hendratno/WWF-Indonesia)

Fishes

F. X. W. Padmarsari, Fitri Aryani and Okta Daliyansyah

Figure 2.9 Tapah *Wallago leerii* weighing 80 kg for sale in the market
(Photo: Syahirsyah (Jimmy) /WWF-Indonesia)

Species diversity plays a key role in the function of natural ecosystems. At least 24,600 species of ray-finned fish have been identified worldwide, making them the most diverse vertebrate group on this taxonomic level (Nelson, 1994; Helfman et.al. 1997). In Indonesia's waters alone there are no less than 8,500 species (Adisoemarto and Rifai 1994). Kapuas Hulu in West Kalimantan Province is among the districts with one of the highest freshwater fish diversities in the country; it therefore has also a very high potential for fishery and aquaculture.

Several studies dealing with fish diversity have been conducted in a number of water bodies in the district; in the Kapuas basin alone 315 species were observed (Kottelat 1995; Widjanarti 1996). At least 210 species were recorded in DSNP (Kottelat 1993), of which 125 were found in the lakes. Rachmatika and Haryono (1999) reported a total number of 112 fish species caught in BKNP. However, so far a no study has been conducted for the LLC in between the two parks. In Labian-Leboyan watershed local communities heavily depend on fish, in addition to forest resources. So far, fishery-related activities in the watershed region were mainly restricted to simply catching fish from the wild. Fishery in LLC is supported

Figure 2.10 Black Snakehead *Channa melanosoma* is abundant in the shallow lakes
(Photo: Syahirsyah (Jimmy) /WWF-Indonesia)

by an extensive system of natural waters which consist of Labian-Leboyan River itself and several lakes as Kandis, Masanjan, Panubarian, and Marindang Lakes. Aquaculture is still very limited. This paper examines fish diversity and fishery potential in LLC.

Methods

The research took place in rivers and lakes within LLC such as Labian, Ngaung Tapah, and Tandung Buloh River, as well as Kandis, Masanjan, Panubarian, Marindang, Timador, Limau, and Daki Lake. Sampling was done on 10 to 24 November 2007. In addition, a second research was conducted in Labian-Leboyan River on 1-6 June 2009. We applied stratified random sampling, and fish were caught using several catching gears, including throw nests, trawls, fish traps, and hand lines. The captured fish were recorded and identified to species level, counted, weighed and measured. Fish identification was done using Mohsin and Ambak (1983); Kottelat et al. (1993) and Kottelat and Whitten (1996).

Results

The research yielded 46 species, representing 32 genera and 16 families. The largest number of species belonged to Cyprinidae, with 24 species (52.17%). As many as 36 species representing 13 families could be found in rivers, whereas in lakes 26 species were recorded which belonged to eight families. Dominant species of the family Cyprinidae included Signal Barb *Labiobarbus festivus*, Beardless Barb *Cyclocheilichthys apogon*, Tinfoil Barb *Barbonymus schwanenfeldii*, Ocellated Barb *Labiobarbus ocellatus* and *Thynnichthyes polylepis*. During the sampling in 2009 we captured 44 species representing 31 genera and 15 families. Two species captured during the 2009 sampling period belonged to the family Cobitidae.

The species diversities and abundances in Labian River were higher than those in the other two rivers. The first phase yielded 22 species out of seven families: Bagridae, Chandidae,

Figure 2.11 Clockwise: Tiger Loach *Syncrossus hymenophysa* feed on snails and worms in soft river bottoms; Toman *Channa micropeltes* is one of the largest river predators; the Marble Goby *Oxyeleotris marmorata* is a popular, but rare food fish in LLC; the Tinfoil Barb *Barbonymus schwanenfeldii* is one of the commonest members of the carp family (Cyprinidae); Featherback *Notopterus chitala*; The Giant Gourami *Osphronemus goramy* is a large herbivore in Labian-Leboyan River
(Photos: Peter Widmann - Syahirsyah (Jimmy)/WWF-Indonesia)

Cobitidae, Notopteridae, Osphronemidae (one species each), Cyprinidae (16 species) and two species of Cobitidae, namely *Chromobotia macracanthus* and Tiger Loach *Syncrossus hymenophysa*. Six species representing four families were caught in Ngaung Tapah River, eleven species were caught in Tandung Buloh River representing seven families. LLC also includes several lakes of different sizes. Quantity of the fish catches varied considerably between the lakes. The highest diversity was found in Kandis Lake with 21 species representing six families, namely Helostomatidae, Channidae, Mastacembelidae, Pristolepididae (one species each), Bagridae (two species) and Cyprinidae (15 species). The dominant species in Kandis and Masanjan Lake was the Ocellated Barb *Labiobarbus ocellatus*.

Conclusion

Compared to findings of research previously conducted in DSNP and BKNP, fish diversity in Labian-Leboyan Watershed was low. However, it is very likely that more fish species will be recorded from LLC in the future. The watershed contributes to the conservation of a number of endemic species which only have a limited distribution within Borneo or even Indonesia, such as *Puntius anchisporus* or *Thynnichthyes polylepis* (Kottelat et al. 1993). Fishes in LLC could be classified into three categories based on their uses, namely fish for consumption (C), ornamental fish (O) and such with both uses (C-O).

Larger size classes or mature stages were rarely found, except for few species, such as *T. polylepis* that dominated some lakes. The low abundance and small sizes, as compared to the previous studies, obviously indicates that overfishing increasingly takes place. The decreasing populations were likely not only caused by fishery activities but also by habitat degradation. Poor domestic waste disposal and run-off from farming activities, as

well as illegal logging greatly contributed to environmental degradation in LLC. Some species with high economic values are also affected by overfishing, due to high national and international demand, for example Clown Loach *Chromobotia macracanthus*, Tapah *Wallago leeri* and Borneo Mahseer *Tor tambroides*.

The full potential for aquaculture in LLC is not yet realized. Several water bodies, for example Panubarian Lake with its relatively good environmental conditions are highly suitable for fish, and because of their sufficient natural feed available remain underutilized in respect to fish farming.

Figure 2.12 Some fish in the Kapuas river system are of marine origin like this pufferfish (Photo: Peter Widmann)

Amphibians

Hari Prayogo and Herry Hasymi

Although migrations in amphibians are well documented in the temperate zone, this group of animals is possibly the least mobile among the vertebrates in LLC. Since it is very unlikely that exchanges between BKNP and DSNP occur through movement of single individuals, the corridor has to provide continuous habitats in order to assure connectivity for amphibian populations.

Amphibians in Borneo are represented by two groups: the highly diverse anurans (frogs) and the species-poor group of caecilians. The latter are limb-less, with elongated and annulated bodies, so that they rather resemble giant earthworms. Possibly because of their cryptic burrowing habits, they were not yet recorded from the corridor.

Experts estimate that there are some 6,000-10,000 amphibian species worldwide. According to Mattison (2005), there are 5,359 described species out of three different orders. Borneo is home to at least 155 amphibian species (Mistar 2008). Amphibians belong to a group of animals which turned out to be highly vulnerable to extinction for a number of reasons, including habitat destruction and degradation, overexploitation and climate change.

Figure 2.13 Herbaceous vegetation of oxbow lakes provides habitats for a number of amphibians: *Occidozyga laevis, Limnonectes malesianus, Rhacophorus pardalis*, R. *apendiculatus*, *Bufo asper* and *Rana baramica* (Photo: Peter Widmann)

A number of amphibian populations have sharply declined all around the globe, partly as a result of chytrid infections. The presence of amphibian species can be indicative for certain environmental conditions; particularly forest dwelling species are very sensitive to changes in microclimate and therefore are potentially valuable indicators for habitat degradation (Blaustein and Johnson 2003, Blaustein and Wake 1999; Mumpuni 2001). Amphibians have a permeable skin and therefore are also susceptible to all kinds of pollution. Most have a two-phased development stage in water and one in terrestrial habitats. Again, this makes the group particularly sensitive to environmental changes.

The aim of this research was to shed light on the diversity of amphibians in LLC. Knowledge of species composition is a precondition to the attempts of conserving and improving amphibian habitats, assessment of environmental conditions and functions of the corridor.

Methods

Data were collected using the visual encounter survey method (Heyer et al. 1994) by searching for the species in habitats along defined transects. These were stratified and covered aquatic and terrestrial habitat types (Heyer et al. 1994). After a series of preliminary surveys, final locations of transects were identified. Length of transects in aquatic habitat was 200 m, and 800 m in terrestrial habitats. Segments of 20 m were marked with colour bands. We also employed buckets as pitfall traps which were placed with openings at soil surface level at a distance of five meters from each other and which were connected with guiding fences. Visual field observations were conducted from 6 to 11 pm by searching amphibians along transects. Species encountered were captured and kept in labelled plastic bags. For identification we used Inger and Stuebing (2005). Some amphibian species which could not be identified on the spot were preserved. Habitat characteristics were recorded.

Research locations represented riparian areas adjacent to Ngaung Tapah River, hilly areas around Peninjau Hill with 170 m above sea level, and an oxbow lake, namely Panubarian Lake. Each observation location was generally characterized by a relatively flat topography. Ngaung Tapah is one of the tributaries of Labian-Leboyan River. Riparian vegetation consisted of Euphorbiaceae and Rubiaceae shrubs besides several bamboo species and planted rubber trees. Sampling was mainly done in the herbaceous riparian vegetation. Substrate in the water body was mainly organic litter and mud; the flow was on average 5-10 cm deep and 1-2 m wide. Peninjau Hill was dominated by hill dipterocarp forest on the slopes, while the swampy areas on the hill foot are dominated by "Tembesu" *Fagraea fragrans*, "Terentang" *Campnosperma auriculata*, "Mentibu" *Dactylocladus stenostachys*,

"Most of the species were tree frogs. They are typical for slightly disturbed conditions of forests and rivers."

and "Bintangor" *Calophyllum* sp. Panubarian Lake is an oxbow lake located not far from Labian River. The vegetation adjacent of this lake consists mainly of rubber and durian trees.

Results

In Ngaung Tapah River, amphibian species encountered were *Polypedates colleti, Polypedates otilophus, Rana baramica, Rhacophorus apendiculatus, Rhacophorus pardalis, Kalophrynus pleurostigma, Limnonectes ingeri, Polypedates leucomystax*. Those species generally inhabit areas in close proximity to water bodies, both flowing and stagnant. Most of the species were tree frogs. They are typical for slightly disturbed conditions of forests and rivers. However, if logging activities and rapid land conversion for farming continues, these species will likely disappear.

We also found the following species: *Limnonectes ingeri, L. malesianus, Rana erythrea, R. chalconota, R. baramica, R. glandulosa, Occidozyga laevis* in Peninjau Hill, whereas in Panubarian Lake, *Rana glandulosa* and *Macropisthodon flaviceps* were commonly found here. In waterlogged areas with herbaceous plants as dominant vegetation we observed *Occidozyga laevis, Limnonectes malesianus, Rhacophorus pardalis, R. apendiculatus, Bufo asper*, and *Rana baramica*.

Bufonidae

River Toads *Bufo asper* were encountered in secondary forest area nearby water bodies (such as rivers and lakes). The four-ridged Toad *B. quadriporcatus* was found near rivers and lakes. *Ansonia* sp. is a small-sized frog, which occurred on riverbanks.

Ranidae

The Rough-sided Frog *Rana glandulosa* was commonly found in lowland areas, in secondary forests, and even in degraded areas. It was also encountered on riverbanks or near water-logged areas. The Green Paddy Frog *R. erythrea* was mostly found in overgrown secondary shrub. The Cricket Frog *R. nicobariensis* was encountered in Ngaung Tapah and can apparently thrive in a variety of habitats. The White-lipped Frog *R. chalconota* and Copper-cheeked Frog *R. raniceps* were encountered in Peninjau Hill. Both species seem to have similar habitats. *R. baramica* was found in waterlogged area, including peatswamp forest.

The Peatswamp Frog *Limnonectes malesianus* was generally observed in lowland areas, in calmly flowing waters, or peatswamp. Its conservation status is near-threatened (IUCN 2011).The Greater Swamp Frog *L. ingeri* was found along slowly flowing waters with sandy bottoms. It was also sometimes encountered in swamp areas and listed by IUCN (2011) as near-threatened. The Yellow-bellied Puddle Frog *Occidozyga laevis* was found in waterlogged areas with muddy substrates, often in shallow water. This species was encountered in Panubarian Lake.

Microhylidae

The Rufous-sided Sticky Frog *Kalophrynus pleurostigma* was most often found among leaf litters on the forest floor around Peninjau Hill.

Rhacophoridae

The File-eared Tree Frog *Polypedates otilophus* is an arboreal frog often found near water in Ngaung Tapah. The Four-lined Tree Frog *P. leucomystax* was a common tree frog in all locations. Males usually gather in standing or slowly moving water, or in waterlogged holes. Collett's Tree Frog *P. colleti* was usually found near stagnant water; we caught it in Ngaung Tapah area. The Frilled Tree Frog *Rhacophorus apendiculatus* was found around lowland rivers and swamps. The species was encountered in Ngaung Tapah and Panubarian Lake and usually occurs on lower-branched trees or young trees, about two meters from ground level. The Harlequin Flying Frog *R. pardalis* lives in fairly high canopies, but descends to the ground for breeding. It is characterized by extensive webbing between its toes and fingers which allow the frog to glide from one branch to another. The species was found in Ngaung Tapah and Panubarian Lake areas.

Figure 2.14 The Four-lined Tree Frog *Polypedates leucomystax* can be found in forests, as well as close to human settlements (Photo: Peter Widmann)

Figure 2.15 The File-eared Tree Frog *Polypedates otilophus* is strictly a tree-dweller (Photo: Peter Widmann)

Figure 2.16 The Harlequin Flying Frog *Rhacophorus pardalis* requires intact riparian forests for building its pendulous foam nests (Photo: Peter Widmann)

Conclusions

The research locations were generally characterized by secondary forests. In the vicinity of Ngaung Tapah and Panubarian Lake land-use changes were obvious, particularly agricultural development and logging roads. Forested lands have been converted for timber extraction. Nevertheless, we still found a high diversity of amphibian species. Conditions in Peninjau Hill were still notably better than in the other two locations, because of its remoteness from settlements. The hilly topography also seems to protect the forest from conversion. Here we found the frog species most closely associated to primary forest conditions.

In order to assure the continuing presence of the amphibian community in LLC, the current condition of forest and wetland habitats need to be maintained. Further forest clearance needs to be prevented, and degraded areas, particularly in the riparian forests would greatly benefit from restoration.

Reptiles

Hari Prayogo and Herry Hasymi

Reptiles in Borneo are a diverse order within the vertebrates, represented by crocodiles, turtles, lizards and snakes. Mobility and therefore potential use of the corridor differs widely among these groups. Crocodiles, for example, are large-bodied and mobile animals which potentially can move from one end of the corridor to the other within individual lifetimes. On the other hand, small species of skinks or geckos are much restricted in their movements and therefore have significantly lower dispersal abilities.

This chapter presents information on reptiles found in LLC as baseline for activities leading to the preservation of viable populations and habitats.

Methods

The survey was carried out on 10-24 November 2007 in Ngaung Tapah River, Peninjau Hill and Panubarian Lake of LLC. For data collection we employed visual encounter surveys using transect lines (Heyer et al. 1994). Transect sampling was conducted in aquatic and terrestrial habitats. A 200-meter transect line was laid out for aquatic habitats, while for terrestrial habitats an 800-meter transect line was established. In addition, pitfall traps were used to catch terrestrial reptiles. Traps were placed at a distance of five meters and connected by a guiding fence made of plastic sheets.Visual surveys were conducted from 6 to 11 pm. Individuals encountered were usually caught, kept labelled plastic or cloth bags, identified and released. Individuals that we were unable to identify on the spot were preserved. Habitat condition and characteristics were recorded.

Survey sites included riparian areas around Ngaung Tapah River, hilly areas in Peninjau area (170 m above sea level), and an oxbow lake, namely Panubarian Lake. The sites were the same as for the amphibian survey (for description see previous chapter).

Results

All species recorded near Ngaung Tapah River were typical for secondary forest. The Plumbeous Water Snake *E. plumbea* is aquatic and was recorded in water bodies with a substrate of thick litter in this site. The species belongs to the opistoglyph snakes, with poison glands in the back of the jaws. It is usually not dangerous to humans, but its bite may lead to swelling, itches, and sometimes allergic reactions (Breuer and Murphy 2010).Three additional species of Colubridae were found in secondary forests near riverbanks, namely Rainbow Mud Snake *Enhydris enhydris*, Orange-Lipped Water Snake *Macropisthodon flaviceps* and Triangle Keelback *Xenochrophis trianguligerus*. *E. enhydris* is piscivorous

Figure 2.17 The Malayan Giant Turtle *Orlitia borneensis* is heavily hunted for food and declined dramatically in LLC and elsewhere (Photo: Peter Widmann)

Figure 2.18 The Blue-eyed Angle-headed Lizard *Gonocephalus liogaster* is restricted to intact lowland forests (Photo: Peter Widmann)

Figure 2.19 The Spiny Hill Turtle *Heosemys spinosa* is a rare inhabitant of fast-flowing creeks and forests in LLC (Photo: Sugeng Hendratno/WWF-Indonesia)

Figure 2.20 The Borneo Tree Skink *Apterygodon vittatum* is a widespread and common tree dweller which can be found in forests, plantations and gardens (Photo: Peter Widmann)

(fish-eating) according to Tweedie (1983), Iskandar and Colijn (2001), Murphy (2007) and Lim & Rozario (2009). We observed two colubrid species near Panubarian Lake, namely *M. flaviceps* and *E. enhydris*. Wagler's Pit Viper *Tropidolaemus wagleri* was found in swampy areas nearby.

Three species of Gekkonidae were found around Panubarian Lake, with Smith's Giant Gecko *Gecko smithi* being the largest, with lengths of up to 180 mm. Two species of Cyrtodactylus, were found in Ngaung Tapah and Peninjau Hill areas: Inger's Bent-toed Gecko *C. ingeri* and Grooved Bent-toed Gecko *C. pubisulcus*.

All members of Agamidae are diurnal (active in daylight). Five species were found in the three research locations, including Common Flying Lizard *Draco sumatranus*, Green Crested Lizard *Bronchocela cristatella*, Blue-eyed Angle-headed Lizard *Gonocephalus liogaster*, and *Aphaniotis fusca*. Another unidentified species of *Gonocephalus* was encountered in Peninjau Hill. Flying lizards possess sheaths of skin between the front and rear legs which enable them to easily move from one tree to another by gliding.

"Turtles were still present in a number of species in LLC, but are getting increasingly rare due to human persecution."

The four taxa of the family Scincidae recorded were Common Tree Skink *Apterygodon vittatum* (in Peninjau Hill), Three-keeled Ground Skink *Mabuya rudis* (all locations), Brooke's Water Skink *Tropidophorus brookei* (Panubarian Lake), and *Lipinia* sp. (Peninjau Hill and Panubarian Lake). *Apterygodon* was found mostly on trees, using cavities for cover. The only species of Family Varanidae we encountered was the Water Monitor *Varanus salvator*. The species was frequently observed on banks of Labian River in Ngaung Tapah while sunbathing. Turtles were still present in a number of species in LLC, but are getting increasingly rare due to human persecution. One species of the family Trionychidae we encountered was the Malayan Soft-shell Turtle *Amyda cartilaginea*. It was more commonly found in Panubarian Lake, and we assume that persecution near the lake is less intense than in Labian-Leboyan River. Populations of soft-shell turtles are in steep decline in the area. Turtles of the family Geoemydidae are getting rare as well, including the Asian Leaf Turtle *Cyclemys dentata*, and the Spiny Turtle *Heosemys spinosa*. During field work on other taxa, the False Gharial *Tomistoma schlegelii* was recorded while spotlighting in the lower portions of LLC. This crocodile species is restricted to Sundaland within Southeast Asia and apparently has a globally important population in the area in and around of Danau Sentarum.

Inger and Stuebing (1997) recorded 15 reptilian species in TNBK and eleven in Lanjak Entimau Wildlife Sanctuary respectively, significantly less than in our study. This was probably caused by the occurrence of extensive wild fires at that time, which lead to severe smoke and hampered surveys.Larger reptiles, particularly turtles, are heavily affected by hunting in all research locations in LLC. Meat is used for own consumption or for sale.

Figure 2.21 False Gharial *Tomistoma schegelii* is one of three crocodile species found in the region (Photo: Peter Widmann)

Birds

Peter Widmann and Hari Prayogo

Some aquatic reptiles are negatively affected by fishing, because they frequently drown in traps and nets. In order to sustain reptile populations, particularly of the larger species, dedicated efforts have to be undertaken to reduce hunting.

There is strong evidence that tropical forest birds are more prone to local extinction caused by habitat fragmentation than birds of temperate forests. Lambert and Collar (2002) found that of 274 bird species of Sundaland lowland forests 83 were negatively affected by fragmentation, whereas 26 suffered from selective logging. Corridors may therefore play an even more important role for birds in tropical rainforest ecosystems than in temperate regions.

Figure 2.22 Wreathed Hornbills *Aceros undulatus* are still common in central LLC; in some villages it is taboo to hunt them (Photo: Peter Widmann)

Reasons for local bird extinctions are still poorly understood, but may involve the absence of seasonal migration in most tropical birds and therefore the lower opportunity of renewed colonisation of rediscovered vacant forest fragments. Extra-pair copulations and consequently males in search of mating partners moving over large distances from their own territories are scarce among tropical forest birds, but are recorded frequently in temperate passerines (Stutchbury and Morton 2001). This limited dispersal ability of many bird species of tropical rainforests is manifested in their physiological intolerance to hot

Figure 2.23 The large eyes of the Green Broadbill *Calyptomena viridis* are an adaptation for spotting fruits in the shady forest understorey (Photo: Peter Widmann)

and dry conditions that prevail in open situations and the resulting inability to cross even moderate distances over forest gaps. This is especially the case for many under-storey birds, like some pittas, flycatchers or babblers. Forested corridors therefore seem to be an important feature to ensure the persistence of many of these species in the Heart of Borneo. We conducted ornithological surveys in the lower, central and upper sections of LLC. The aim of this study is to assess the current status of the avifauna of the area, particularly in relation to forest quality, the potential function of the Leboyan watershed as conservation corridor and as a baseline for future assessments of corridor performance. By comparing our findings with resident lowland bird assemblages from the adjacent two protected areas (BKNP and DSNP), we examine which species (groups) are potentially able to benefit from the various corridor functions.

Methods

We used MacKinnon-lists with twelve species per list to accumulate species records during transect walks. Species of conservation concern and cryptic species were actively searched in adequate habitats by using playbacks of vocalizations. In addition, mist nets (9x4m, 4 banks) were placed in all major vegetation types covering heights from 0-8 m above the ground. Adequacy of sampling effort was assessed by calculating total species employing three different estimators (Jacknife 2, Chao 2, Bootstrapping) using EstimateS 7.5 software package (Colwell 2005).

"We recorded a breeding pair of Storm's Stork *Ciconia stormi* in the lower portion of LLC which is listed as "Endangered" by IUCN (2011)".

We compared composition of the bird assemblages of LLC with those of adjacent DSNP and BKNP using published sources (van Balen and Dennis 2000; Prayogo et al. 1999) and own records from these areas.

Results

We recorded 177 resident and 16 migratory bird species in LLC. All species were encountered during transect walks; mist-netting did not yield any additional species. Using MacKinnon-Lists compiled in the central corridor area, three estimators indicate a total species richness of 155, 165 and 186 for Bootstrapping, Chao 2 and Jacknife 2 respectively (Fig.2.24).

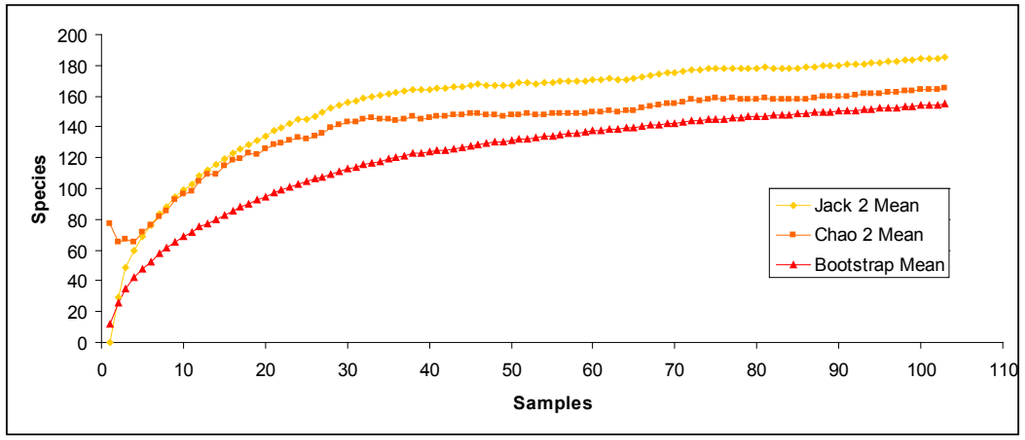

Figure 2.24 Estimation of total bird species numbers in central Leboyan watershed using Jackknife 2, Chao 2 and Boostrapping estimator models

We recorded a breeding pair of Storm's Stork *Ciconia stormi* in the lower portion of LLC which is listed as "Endangered" by IUCN (2011). DSNP and adjacent areas are of global importance for the conservation of this species. Therefore, and because of specific conservation activities devoted to this rare bird, we will treat this species in a separate chapter. Four species recorded were listed as "Vulnerable" by IUCN (2011): Great Slaty Woodpecker *Mulleripicus pulverulentus*, Short-toed Coucal *Centropus rectunguis*, Wallace's Hawk Eagle *Spizaetus nanus* and Hook-billed Bulbul *Setornis criniger*. The woodpecker is a recent addition to the red list of threatened species; it is widely distributed in tropical Asia in a variety of forest habitats, but declining over most of its range. It is locally common in DSNP and the lower LLC, but is scarce or absent in the central and upper watershed. The Short-toed Coucal can be found in low densities in central LLC, particularly in riparian

"Bird species which are known to occur in both national parks, but which we failed to find in the corridor in between may shed some light on the conservation challenges of LLC".

forests. Great care has to be taken to distinguish this species form the much more common Lesser Coucal *C. bengalensis* which resembles in size, and the Greater Coucal *C. sinensis* which is larger, but has a similar vocalization. Densities of the Wallace's Hawk Eagle in the corridor still appear to be high and the species can regularly be observed in the entire watershed. The Hook-billed Bulbul is a low-density endemic to the islands of Sumatra and Borneo, where it is restricted to forests growing on nutrient deficient soils, particularly peatswamp and heath forests (Birdlife 2001). We found the species in peatswamp forests in DSNP and the lower LLC, and even in a riparian forest with inter-planted rubber trees, close to an oxbow lake.

A further 29 species are listed as "Near-threatened" (IUCN 2011). These are exclusively taxa restricted to lowland forests in Sundaland and which are negatively affected by the large-scale destruction of this ecosystem in the region (Birdlife 2001). Their presence in the area indicates still good overall forest conditions in the corridor.

The species richness of resident bird species recorded in LLC is comparable to resident lowland bird species numbers in DSNP and BKNP, which are 219 and 194 respectively (App 7; records which need further confirmation are marked with "?" and are not considered in the following discussion). Some 145 species can be found in both parks and the interconnecting corridor. For instance, all six lowland barbet, three trogon, three parrot and three leafbird species found both in DSNP and in BKNP are also present in the corridor. These bird groups are typically canopy and sub-canopy dwellers. Bulbuls are generally well represented in the corridor, with Straw-headed Bulbul *Pycnonotus zeylanicus* being a notable exception. This riverbank specialist is one of the most sought-after cage birds in Indonesia. Because of the high price it fetches and the ease of access of its habitat it is close to extinction in the area. We did not record it in the corridor and found it only in one location in DSNP. Prayogo et al. (1999) failed to find the species in BKNP, despite the fact that it is historically recorded in the park.

Bird species which are known to occur in both national parks, but which we failed to find in the corridor in between may shed some light on the conservation challenges of LLC. Absence of a record however does not necessarily mean that the species is absent in the corridor. However, we put some effort in finding some of the rarer species, particularly some of the skulking understory pittas and babblers, without being successful. Other species, particularly the hornbills, are so conspicuous, that it seems highly unlikely that we missed them during our surveys.

A number of larger bodied bird species, particularly pheasants and larger pigeons were absent or scarce, particularly in the more densely settled central watershed. This is almost certainly due to the intense hunting pressure in this area. We found the three forest pheasant species, Crested Partridge *Rollulus rouloul*, Crested Fireback *Lophura ignita* and Great Argus *Argusianus argus* only in the uppermost portions of the watershed. We did not find Green Imperial Pigeons *Ducula aenea* anywhere in LLC, despite they are known to occur in both adjacent national parks. The absence of pheasants in the lower watershed is likely due to the lack of permanently dry forest areas. We did not find Helmeted Hornbill *Buceros vigil* and White-crowned Hornbill *Aceros comatus* in the corridor. The former depends on large tracts of closed canopy forest as habitat; in contrast to the other hornbill species it has a solid casque, which is known as hornbill ivory. The species is intensively persecuted for this product. The White-crowned Hornbill is generally uncommon in Kalimantan and may be particularly vulnerable to hunting, because of its preference to easily-accessible riparian vegetation. The persistence of six other species of hornbills in the central watershed, which otherwise are also prime targets for hunters in Kalimantan was likely due to a taboo which is still in place in some areas of LLC.

Figure 2.25 The Hook-billed Bulbul *Setornis criniger* is a globally threatened bird inhabiting peat swamp forests in central LLC (Photo: Peter Widmann)

Although woodpeckers were quite well represented in the lower portions of LLC, they were much less so in the central watershed. This might indicate the absence or scarcity of larger tree diameter classes, which have been removed during earlier logging activities. Birds typical for Bornean rivers were present in a number of species. Again, larger species which are vulnerable to hunting or other human disturbance, including boat traffic, were not recorded from the central watershed: Wandering Whistling Duck *Dendrocygna arcuata*, Oriental Darter *Anhinga melanogaster* and Storm's Stork.

Understorey birds were well represented in LLC, particularly in areas with intact riparian forests. Many birds in this group are sensitive to logging and habitat fragmentation. These species can serve as indicators for forest quality in the corridor. Therefore we invested considerable time in searching for some of these species, which are recorded for at least one of the adjacent parks. This involved repeatedly playing of recorded vocalizations of pittas and babblers. Despite these efforts, we only found Hooded Pitta *Pitta sordida* as the sole member of the first group. We also did not find any wren-babblers (*Ptilocichla, Kenopia, Napothera*) which are known to be sensitive to habitat degradation and fragmentation. This may indicate that previous selective logging and shifting cultivation, particularly in the central corridor area have caused some local extinction among birds. It however has to be noted that the swamp forests in the lower portion of LLC are less suitable for a number of understorey bird species due to seasonal flooding.

Figure 2.26 The Brahminy Kite *Haliastur indus* is a common scavenger along Labian-Leboyan River (Photo: Peter Widmann)

Enrichment planting of riparian forest with rubber trees is common practice in the corridor. As long as density of these trees remains low and the original vegetation remains undisturbed, relatively diverse understorey bird assemblages can persist. If the original vegetation is completely removed however, bird diversity rapidly declines. In a preliminary study we netted only eight bird species in a rubber plantation with almost clear-cut understorey, in contrast to 23 species in an adjacent residual peatswamp forest. A residual riparian forest with widely spaced rubber trees and intact understorey yielded 21 species, including the globally threatened Hook-billed Bulbul (Table 2.2)

Table 2.2. Birds netted in rubber systems of different intensity and lowland peat swamp forest in LLC

Rubber plantation, no understorey	Widely spaced rubber trees in residual forest	Residual peat swamp forest
Oriental Dwarf Kingfisher	Rufous Piculet	Blue-eared Kingfisher
Emerald Dove	Blue-eared Kingfisher	Oriental Dwarf Kingfisher
Pied Fantail	Oriental Dwarf Kingfisher	Emerald Dove
Black-naped Monarch	Emerald Dove	Green Broadbill
Oriental Magpie Robin	Hooded Pitta	Pied Fantail
Red-eyed Bulbul	Green Broadbill	Greater Racket-tailed Drongo
Brown-throated Sunbird	Black-naped Monarch	Black-naped Monarch
Little Spiderhunter	Grey-chested Jungle Flycatcher	Common Iora
	Oriental Magpie Robin	Grey-chested Jungle Flycatcher
	White-rumped Shama	Malaysian Blue Flycatcher
	Rufous-tailed Shama	Oriental Magpie Robin
	Olive-winged Bulbul	White-rumped Shama
	Red-eyed Bulbul	Olive-winged Bulbul
	Spectacled Bulbul	Spectacled Bulbul
	Short-tailed Babbler	Rufous-tailed Tailorbird
	Black-throated Babbler	Short-tailed Babbler
	Bold-striped Tit Babbler	Black-throated Babbler
	Fluffy-backed Tit Babbler	Chestnut-winged Babbler
	Yellow-breasted Flowerpecker	Fluffy-backed Tit Babbler
	Purple-throated Sunbird	Yellow-breasted Flowerpecker
	Little Spiderhunter	Crimson-breasted Flowerpecker
		Purple-naped Sunbird
		Little Spiderhunter

A number of species have colonized open areas following forest clearance for infrastructure and agriculture, particularly on the drier portions of the river levees which are most suitable for slash-and-burn agriculture ("ladang") and settlements. These bird assemblages include exotics to Borneo, namely Eurasian Tree Sparrow *Passer montanus* and Scaly-breasted Munia *Lonchura punctulata*. We recorded 16 migratory bird species, all of which originate from (northern) Asia and which spend the northern winter in Borneo (App 8). Most of these migrants utilize open habitat in the corridor, particularly wetlands and agricultural fields. Only Japanese Sparrow hawk *Accipiter gularis*, Arctic Warbler *Phylloscopus borealis*, Dark-sided and Asian Brown Flycatcher (*Musicapa sibirica, M. dauurica*) predominantly forage in closed forests.

Figure 2.27 The Chestnut-rumped Babbler *Stachyris maculata* often forages in mixed bird flocks in the forest understorey (Photo: Peter Widmann)

Conclusions and Recommendations

Protection of the still extensive forest cover is considered a precondition to safeguard the incessant functioning of the area as a corridor between two major protected areas in West Kalimantan. The persistence of a considerable diversity of forest-dependent birds, particularly a very high number of globally near-threatened species indicates the outstanding value of the area itself for conservation. Commencement of commercial logging or large-scale monoculture plantations need to be avoided in this area to maintain its important ecosystem functions, including as habitat and corridor for birds.

Most forest conversion currently takes place along the river, mainly because of creation of shifting cultivation fields. Restoration of riparian forest with indigenous species, as planned by WWF-Indonesia will not only help to maintain corridor functions and contribute to river bank stabilization, but can also contribute to the recovery of larger-bodied birds which require dry forests on more nutrient-rich soils, such as forest pheasants.

There is currently very little we can recommend for mitigating disturbances of wetland birds along the river. In any case, the role of oxbow lakes for the persistence of water birds and birds typical for the forest-water ecotones needs to be further investigated.

To counter the very destructive effects of hunting on parts of the avifauna is a big challenge in the area, since hunting is an integral part of the Dayak culture. The problem is so grave that we recommend initiating an educational project with hunting as the focal topic. Furthermore the option to implement a community-based hunting management project which includes monitoring of hunting harvest and setting quotas for threatened species should be explored.

Rubber plantations of different intensity are on the rise in LLC. Whereas enrichment planting of rubber in existing residual forest in low densities apparently only has little effect on bird assemblages, pure stands of rubber only provide habitats for a handful of species. The latter should be avoided in critical areas of the corridor, particularly the riparian forests.

Mammals

Peter Widmann and Hari Prayogo

The island of Borneo has a diverse mammal fauna which predominantly is dependent on forests (Payne et al. 1985). Although relatively well studied taxonomically, habitat requirements for many mammals in Kalimantan remain poorly known. A recent review of impacts of logging on selected groups of wildlife (Meijaard et al. 2005) provides important insights for forest utilization, conservation and restoration in respect to wildlife management in LLC.

Mammals are a very diverse class of vertebrates. They occupy a wide variety of habitats and niches with terrestrial, arboreal, aquatic and even flying forms. A variety of survey methods is therefore needed to generate a picture of the mammal assemblages present in LLC. This needs to be an on-going effort, and certainly will yield a number of additional records in the future.

Figure 2.28 Because of its use in traditional medicine and its meat the Javan Pangolin *Manis javanica* declined dramatically all over its range, including in LLC (Photo: Sugeng Hendratno/WWF-Indonesia)

Methods

We conducted a rapid assessment of mammals in central LLC in 2007 and in the lower catchment from 2008 to 2011, including trapping and netting. We also recorded mammal observations during visits to the corridor with other research priorities. Larger species were recorded employing direct observations during day and also during the night using strong flashlights ("spotlighting"). We searched for indirect signs, particularly tracks, wallows, faeces, dens and signs of feeding. Mist nets (9x4m, 4 banks) were placed in all major vegetation types covering heights from 0-8 m above the ground for capturing

"We gathered primary or secondary information of presence for 52 mammal species".

bats and flying squirrels. Potential roost sites, particularly in bamboo were checked for bat occupancy. Sixty snap traps and twenty cage traps were set in single trap lines in suitable situations (potential pathways, in front of holes, on fallen logs, etc.) on the ground and elevated on trees and vines. We used roasted coconut with peanut butter as bait. Pitfall trap lines consisting of 22 buckets with guiding fences were established in riparian, peatswamp and lowland dipterocarp forest. Buckets were positioned in about five meters distance from each other; no bait was applied. Information from local hunters was obtained through informal interviews regarding past and present occurrence of larger mammals and methods of hunting. Whenever possible, carcasses or trophies were examined to verify species identifications by hunters.

Results

We gathered primary or secondary information of presence for 52 mammal species. Of these, 46 were caught one way or another, and 27 were directly observed in the wild, or identifiable indirect signs were found (App. 9). For six additional species we gathered secondary records from local hunters. These taxa were only included in the list, if evidence could be produced in form of trophies, skins, skulls or teeth.

For none of the capturing or observation methods the species-effort curves indicated that sampling effort was adequate, with the possible exceptions of mist-netting for fruit bats (Megachiroptera) and visual encounters for primates. Almost certainly more mammal species will be recorded in LLC in the future, particularly treeshrews (Scandentia), insectivorous bats (Microchiroptera), Carnivora and Rodentia.

The Sunda Pangolin *Manis javanica* persisted in low numbers in LLC. We saw several skins in houses in the lower and central watershed. It was heavily persecuted, because the animals are in high demand for food and traditional medicine.

We recorded two species of Insectivora in central LLC. A Moonrat *Echinosorex gymnurus* was spotlighted in secondary riparian forest; despite its strong smell it was regularly hunted in the area. The terrestrial Southeast Asian White-toothed Shrew *Crocidura fuliginosa* was caught in pitfall traps in dry riparian forest, but not in adjacent peatswamp forest.
The only treeshrew (Scandentia) that was regularly observed was the Common Treeshrew *Tupaia glis* in secondary forest and cultivated areas in central LLC. An additional sight record of Lesser Treeshrew *T. minor* needs to be confirmed, as well as other observations of unidentified members within this group.

Small and medium-sized fruit bats are relatively easy to sample with mist nets, and we caught more than 160 individuals of five species and observed an additional large species feeding in the canopy. Analysis of species numbers and sampling effort indicate that this represents a fairly comprehensive species number of this group of bats to be expected in secondary and residual lowland forest in the absence of caves. Dusky fruit bats *Penthetor lucasi*, Dayak Fruit bat *Dyacopterus spadiceus* and Spotted-winged Fruit Bat *Balionycteris maculata* forage in the understorey and are indicative for good forest conditions. Three other fruit bat species were more common in secondary forest and particularly in cultivated areas. Because insectivorous bats (Microchiroptera) are more effective in avoiding mist nets due to their ability to echolocate, records of this group in LLC are still incomplete. Several species of microbats rely heavily on closed forests. These bat species of the forest interior typically have short and broad wings which do not allow a swift flight, but make the bats highly manoeuvrable in dense vegetation. Forest bats use high frequencies for echo-location which do not carry very far, but allow for fine resolution of the highly complex environment.

Figure 2.29 The Dayak Fruit Bat *Dyacopterus spadiceus* requires diverse lowland forests, it is usually absent from monoculture plantations (Photo: Peter Widmann)

The required morphological adaptations are likely the main reason why certain species are restricted to certain habitats (closed forest in this case) and are not able to forage in open areas (Racey and Entwistle 2003). We recorded a number of horseshoe-bats (*Hipposideros* and *Rhinolophus*) which belong to this category. The recorded species roost in tree cavities or hollow logs. Most representatives of these two genera however roost in caves, and therefore are probably not present in LLC. In the central corridor area, Lesser and Greater Bamboo Bats (*Tylonycteris*

Figure 2.30 Greater Bamboo Bats *Tylonycteris robustula* roost inside of bamboo stalks; the sucker-like pad near its thumb aids the animal in climbing the smooth bamboo (Photo: Peter Widmann)

pachypus and *T. robustula*) are very common, undoubtedly because of the large stands of bamboo present in mostly disturbed forest. Both bats belong to the smallest mammal species in tropical Asia, and therefore they are able to roost in the internodes of bamboo, if openings are created by certain beetle species. Several other insectivorous bats were observed in LLC, but could not be identified on the wing. Future studies employing harp traps and bat detectors are highly recommended in order to complete the inventory of this important group of mammals.

Primates are well represented in the corridor in terms of species diversity; they are however becoming increasingly rare in number in the upper and central portions of the watershed due to intense hunting pressure. Possible exceptions may be the two nocturnal species: Horsfield's Western Tarsier *Tarsius bancanus* and the Greater Slow Loris *Nycticebus menagensis*. The only species active during day time that still can be regularly encountered is the Long-tailed Macaque *Macaca fascicularis*.

The Bornean Orangutan *Pongo pygmaeus* is present in the corridor with a population of global significance. Because this species is listed as "Endangered" (IUCN 2011), it has been the subject of more detailed research in the corridor, and therefore will be treated in more detail in the last chapter of this section. A significant record from the lower catchment of the Labian-Leboyan River is the Proboscis Monkey *Nasalis larvatus*, which is likewise listed as "Endangered" (IUCN 2011). Particularly during dusk and dawn groups can be found in riparian forests. In one occasion a group was feeding on water hyacinths in close vicinity to Leboyan village in the lower Leboyan River (inside DSNP).Traditionally the animals are not hunted by the predominantly Muslim fishing communities downriver.

Figure 2.31 Proboscis Monkey *Nasalis larvatus* at dusk feeding on water hyacinths in Leboyan Village (Photo: Peter Widmann)

Dayak hunting parties in the lower LLC and even inside DSNP are a potential threat for this species, as was reported by Meijaard & Nijman (2000), and appear to become even more frequent in recent years, according to information from local fishing communities.

Carnivores are a very diverse group of mammals in Borneo which is also well represented in LLC. Most species were confirmed through hunting trophies, but also during nocturnal surveys along the river and in the forest. A significant record in central LLC was of a foraging Otter Civet *Cynogale bennetii* at the bank of Labian-Leboyan River which was encountered during spotlighting. The species is listed as globally "Endangered" by IUCN (2011). Interviews with hunters in the area indicated that some are familiar with the species and are able to separate it from the more common otters. At least two species of the latter occur in LLC, particularly in the lower portion, the relatively common Oriental Small-clawed Otter *Aonyx cinerea* [Vulnerable (IUCN 2011)]and the rarer Smooth Otter *Lutrogale perspicillata* [Vulnerable (IUCN 2011)].

Both species are sometimes active during daytime, and can be observed in groups while fishing or raiding fish traps. Also during daytime we were able to observe a Malayan

"Bearded Pigs *Sus barbatus* belong to culturally and economically most important mammal species in the corridor area".

Figure 2.32 Group of Smooth Otters *Lutrogale perspicillata* in lower LLC (Photo: Busur/DSNP)

Sunbear *Helarctos malayanus* and a Bearcat *Arctictis binturong* in trees of riparian forest along Labian River. Both species are listed as "Vulnerable" by IUCN (2011). We never encountered wild cats in the forest, but remnants of a skin of Clouded Leopard *Neofelis diardi* were seen in the collection of a hunter in LLC. It is likely that more intensive carnivore surveys, especially employing camera traps, like for instance in Kayan Mentarang National Park (Wulffraat et al. 2006) would possibly produce records of additional species, particularly civets and cats.

Bearded Pigs *Sus barbatus* belong to culturally and economically most important mammal species in the corridor area. They are the preferred game species for Dayak hunting communities and, until recently, one of the most common. Although still present, they are quite scarce now due to over-hunting, as are the two recorded deer and two mouse deer species. Hunters in Nanga Leboyan stated that the last Sambar *Rusa unicolor* in the central watershed was shot some twenty years ago. We heard vocalizations of an unidentified muntjac (barking deer) and also saw trophies of Common Muntjac *Muntiacus muntijak*, as well as of Lesser and Greater Mouse Deer (*Tragulus javanicus* and *T. napu*). The presence of a second species of muntjac in LLC needs further confirmation. Bearded Pigs, deer

"Diversity of rodents in LLC was moderately high, but sampling effort was not adequate to record the complete assemblage expected in the area".

and mouse deer are known to tolerate a fair degree of habitat alteration. In some locations they may even occur in higher densities in forest-farmland mosaics, compared to the original closed forest. Their scarcity or partly absence in LLC is certainly due to intense hunting, particularly in the upper and middle watershed. Diversity of rodents in LLC was moderately high, but sampling effort was not adequate to record the complete assemblage expected in the area. Terrestrial rodents were generally rare and virtually restricted to riparian and other elevated dry forest areas, possibly as a consequence of seasonal flooding that affects particularly freshwater and peatswamp forests. Muller's Rat *Sundamys muelleri* is almost entirely terrestrial and was exclusively caught in elevated riparian forest. Whitehead's Rat *Maxomys whiteheadi* and Dark-tailed Tree Rat *Niviventer cremoriventer* were recorded from dry forest on an isolated hill in central LLC. Both species are usually associated with old-growth forest (Meijaard et al., 2005). We found gnaw marks and faeces of a porcupine in central LLC, but we were not able to identify the species. Arboreal rodents were more diverse than terrestrial ones, and still more species are expected to be recorded, as more surveys are carried out. Squirrels were relatively common in all types of forest. The Black-eared Pigmy Squirrel *Nannosciurus melanotis* is possibly the most frequently encountered mammal in peatswamp and freshwater swamp forests in the lower LLC. Smaller and medium-sized squirrels are still relatively common. We did however not find the Giant Squirrel *Ratufa affinis*, although it was reported by local hunters to still occur. We recorded three representatives of flying squirrels (Pteromyidae); Horsfield's and Vordermann's Flying Squirrel (*Iomys horsfieldii* and *Petinomys vordermanni*) were caught in mist nets, whereas the Giant Red Flying Squirrel *Petaurista petaurista* was recorded during spotlighting in central LLC.

Figure 2.33 Presence of Vordermann's Flying Squirrel *Petinomys vordermanni* indicates fair forest conditions (Photo: Peter Widmann)

Conclusions and recommendations

The most striking observation in the corridor in respect to mammals was the absence or extreme scarcity of larger species, which is certainly due to intense hunting. This finding is in line with a number of studies which document the negative impact of hunting on wildlife in tropical forest ecosystems in Borneo (e.g. Caldecott 1988). LLC forms a "bottleneck" between BKNP and DSNP, which is easily checked or controlled by hunters and might lead to the development of a sink area. This eventually could reduce populations of larger wildlife in both protected areas. Intensive conservation education might be one adequate strategy to address the problem. First efforts of WWF-Indonesia seemed to have achieved that at least high-profile species like Orangutan are not anymore persecuted, not lastly because hunters were informed about the high penalties for killing this species.

To achieve similar results for other game species however is certainly more challenging, since some are not legally protected. The possibility to enter into an agreement with local hunters to manage wildlife in a more sustainable way ("conservation contract") should be explored. Attempts to restrict access to cheap ammunition from Malaysia might result in an overall decline of hunting with rifles (see also chapter on hunting by Widmann et al., this volume).

An assessment of mammal species that occur in both national parks, and therefore might benefit most from the corridor, is presently not possible, since information on this group is still incomplete, particularly on BKNP. Movements of large animals in the corridor remain poorly documented and are mostly anecdotal. Research on corridor utilization by Bornean Orangutans is on-going and will potentially aid in demonstrating the conservation benefits of LLC.

Storm’s Stork

Peter Widmann

Storm’s Storks *Ciconia stormi* belong to the most threatened representatives of the stork family and are listed as “Endangered” by IUCN (2011). Possibly less than one thousand individuals survive in forests of flood plains of Sundaland. The species is found in a variety of forest types in the region, including mangroves, freshwater and peatswamp, as well as dry lowland forest types. It usually forages near shallow and forested creeks and pools, but sometimes can be encountered far from water. During faunistic and floristic field work in LLC, the species has been regularly observed between 2007 and 2011.

Although large riparian forest expanses along the main flow of Kapuas River have been cleared, there are still extensive areas of potentially suitable habitats along the smaller lowland tributaries in the region. Another potentially important area for the species is the Kapuas estuary.

Destruction and degradation of forest habitats due to logging, burning or conversion into oil palm plantation is a major threat factor for the species (Birdlife International, 2001). Hunting and trapping is another threat for storks and other large water birds in West Kalimantan, even in protected areas.

Figure 2.34 Waterbirds are hunted for food and often kept as pets in the wider Danau Sentarum area, like this Lesser Adjutant *Leptoptilos javanicus* (Photo: Peter Widmann)

Storm’s Stork in Kapuas Hulu

Figure 2.35 Storm’s Storks circling in thermals in lower LLC (Photo: Albertus Tjiu/ WWF-Indonesia)

Figure 2.36 The Storm’s Stork is one of the rarest birds in Sundaland; the population of this species in Kapuas Hulu is of global importance (Photo: Peter Widmann)

The species was regularly recorded in DSNP. Population estimates remain difficult because of the inaccessibility of the swamp forest habitat, as well as the secretive behaviour of this species. There is a historic record from Sibau watershed, within or adjacent to BKNP (Birdlife International, 2001), but no recent observations from this protected area are known.

Storm’s Storks in DSNP are more common during the dry season and can be observed foraging in the shrinking lakes in the periphery of this wetland, where fish and other aquatic organisms concentrate in the shallow water. During the wet season the species seem to virtually disappear from the park, and it is likely that they retreat to dry forest areas in the vicinity. So far not much is known about these local migrations. Birds in DSNP occur typically alone or in pairs. One bird was observed roosting on top of an emergent dead tree in within a freshwater swamp forest. Two birds were regularly observed circling over the river during the dry season in lower LLC. On one occasion four birds could be recorded *(see on top)*.

"Several other records of the species could be made in the Kapuas estuary and coastal West Kalimantan".

Breeding in Labian-Leboyan Corridor

Breeding of Storm's Storks in Sumatra was described in detail by Danielsen et al. (1997). We recorded two birds entering and leaving a patch of swamp forest in lower LLC in 2009 (Widmann et al. 2010). According to information of a Dayak hunter this forest contained an active nest of these birds. Attempts to reach the nest were unsuccessful because of the very dense vegetation. The hunter agreed not to poach the nest and later in the same year two juvenile storks could be observed together with two adult ones. No nesting attempt could be recorded in 2010. This year was extremely wet; during most of the year there was hardly a dry spot in lower LLC, and we failed to record Storm's Storks altogether.

Stork Conservation

Storm's Storks are still hunted for food in Kapuas Hulu, together with the much more common herons and whistling ducks. Sometimes nestlings are taken and kept or sold as pets. They are not preferred over more common species and seem also not to fetch higher prices.

Attempts were made to protect Storm's Stork, together with the other stork species of Borneo, the Lesser Adjutant *Leptoptilos dubius*, with focus on LLC, and also the Kapuas estuary. Main goal was to motivate local communities in the vicinity of stork populations to refrain from hunting the species and instead protect nests of the species. Aside from one nest which was protected in 2009 in LLC, another nest in the coastal district of Ketapang was guarded and one stork fledged successfully in 2010.

Several other records of the species could be made in the Kapuas estuary and coastal West Kalimantan. All these records initially were based on secondary information which subsequently could be verified.

Conservation education was conducted using a specifically produced stork poster financed by the Zoological Society for the conservation of Species and Populations (ZGAP) and through focus group discussions. Raised awareness among people living close to storks is attempted to be translated into conservation action, particularly protection of nests instead of poaching them.

North-west Bornean Orangutan

Albertus Tjiu

Orangutans can only be found in Borneo and Northern Sumatra. Both islands have been disconnected by the South China Sea for the last 8000 years (Harrison et al. 2006 in Serge A. Wich et al. 2009). The geographical separation lead to the development of physical and genetic differences between populations in Borneo and Sumatra which eventually resulted in two different species namely *Pongo pygmaeus* in Borneo and *Pongo abelii* in Sumatra. Borneo Orangutans consist of three subspecies which are separated geographically: *Pongo pygmaeus pygmaeus* in north-western Kalimantan, ranging from north of Kapuas River to north-eastern Sarawak; *P. p. wurmbii* in southern and south-western Kalimantan, ranging from south of Kapuas River to west of Barito River; and *P. p. morio* which ranges from Sabah to Mahakam River in East Kalimantan. The estimated population of the species is approximately 42,000 - 44,000 across Borneo.

Figure 2.37 Fully grown male West Bornean Orangutan *Pongo pygmaeus pygmaeus* observed near Jaung 2 Village in the buffer zone of DSNP (Photo: Sugeng Hendratno/WWF-Indonesia)

The nominate form *P. p. pygmaeus* is the most threatened of the subspecies. It inhabits seven forest blocks in West Kalimantan, especially in the Kapuas Hulu District, and Sarawak, Malaysia. Its total population is estimated to be between 3,000 and 4,500 individuals (PHVA 2004, OUAP 2007, Wich et al., 2008).

WWF-Indonesia carried out a series of surveys in BKNP starting in 2005. About 1,030 (550-1,830) individuals were found to be surviving within an area of 800,000 hectares. Out of these, some 700 Orangutans were concentrated in Embaloh watershed in the western sections of the BKNP. In addition, WWF-Indonesia conducted a survey in 2009 which was focused on the lower part of LLC and the adjacent DSNP with an area coverage of 132,000 hectares. Orangutan population in this region ranged between 771 and 1,006 individuals. Over half of the population was observed in the eastern portion of the park and within LLC connecting both parks.

Figure 2.38 Monitoring is an important activity in order to collect data on population trends of Orangutans in LLC
(Photo: Sugeng Hendratno/WWF-Indonesia)

Figure 2.39 While foraging Orangutans disperse seeds of many tree species
(Photo: Sugeng Hendratno/WWF-Indonesia)

"It was found that 154 forest trees serve as food sources for Orangutans, around 47% of total tree species found in LLC."

The survey also provided information on food availability. It was found that 154 forest trees serve as food sources for Orangutans, around 47% of total tree species found in LLC. In addition, understory plants such as climbers, small trees, and various shrubs producing fruits consumed by the ape were also found in abundance in the region.

Presently, BKNP and DSNP, as well as LLC serve as the most important habitats of *Pongo pygmaeus pygmaeus*, yet increased forest conversions there leads to serious habitat reduction and fragmentation (Wilcove et al. 1986, Shafer 1990 in Wiratno et al. 2001). Impacts of the fragmentation may result in reduced migration possibilities.

Failure of inclusion of protected areas and corridors in the spatial planning process and national-level forest management policies is one of the underlying causes of thinning and fragmentation of wildlife habitats. Other impacts of these developments are conflicts between wildlife and humans. Orangutans frequently enter home gardens of the communities next to the forests while foraging for fruits,creating damage to local farmers.

Within the context of conservation of Orangutans and their habitats, one of the most important strategies for the long-term conservation at landscape level is to provide conservation corridors, like LLC (Wiratno et al. 2001).

Figure 2.40 One of the Orangutan's preferred food tree *Diospyros coriacea*, forming a "fruit garden" in a swamp forest (Photo: Syahirsyah (Jimmy) /WWF-Indonesia)

"Larger habitats with carrying capacities of 250 Orangutans are required for maintaining robust demographic and genetic stability".

An early initiative to connect both populations in the two parks took place in the forests block of Pana' Hill (roughly 1,050 hectares) which contains a small Orangutan habitat in the upper parts (population density: 3.48 individuals/km^2) and forest habitats in Melemba Village in the lower parts (population density 0.79 individual/km2)(WWF-Indonesia, 2009). The two small Orangutan populations were isolated populations inhabiting two different forest types, namely lowland forests (the Pana' hill) and peatswamp forests (Meliau). Long term monitoring of Orangutan population in these two different forest types will be answer the idea of wildlife corridor in Labian-Leboyan River.

Preliminary simulations of several scenarios for Borneo-specific Orangutan populations indicate that a limited habitat that can carry some 50 individuals may subsist for a some years. However, it is unstable and prone to extinction in the longer run. Larger habitats with carrying capacities of 250 Orangutans are required for maintaining robust demographic and genetic stability. It is important to note that there are many small forest blocks in Kalimantan containing only very small populations of Orangutans. These, which are below the threshold of about 50 individuals, are highly susceptible to extinction if isolated from other populations (PHVA, 2004). Considering the size of home ranges in relation to different forest types occupied by Orangutans in Kapuas Hulu, it becomes apparent that only a landscape approach will succeed in the long-term preservation of the species in West Kalimantan. Actions for better protection of the subspecies in West Kalimantan should take into account the following aspects and activities:

- Further studies to clarify/identify the status of all Orangutan subpopulations in the remaining unprotected habitat blocks, in particular the corridors, are required;
- Monitoring should commence for the populations in BKNP, in particular Embaloh watershed, as well as in Sibau watershed;
- Building of a network of parties involved in Orangutan conservation through local community awareness and collaborating with local non-government organizations in the province;
- Development of ecotourism projects with main focus on Orangutan observation through collaboration with local communities;
- Collaboration with private companies exploiting unprotected forest concessions that function as Orangutan habitats;
- Dissemination of recent information on Orangutans in Kapuas Hulu through strategic and action plans for BKNP, DSNP and its LLC;
- Conducting conservation education campaigns;
- Putting prevailing laws and regulations into force.

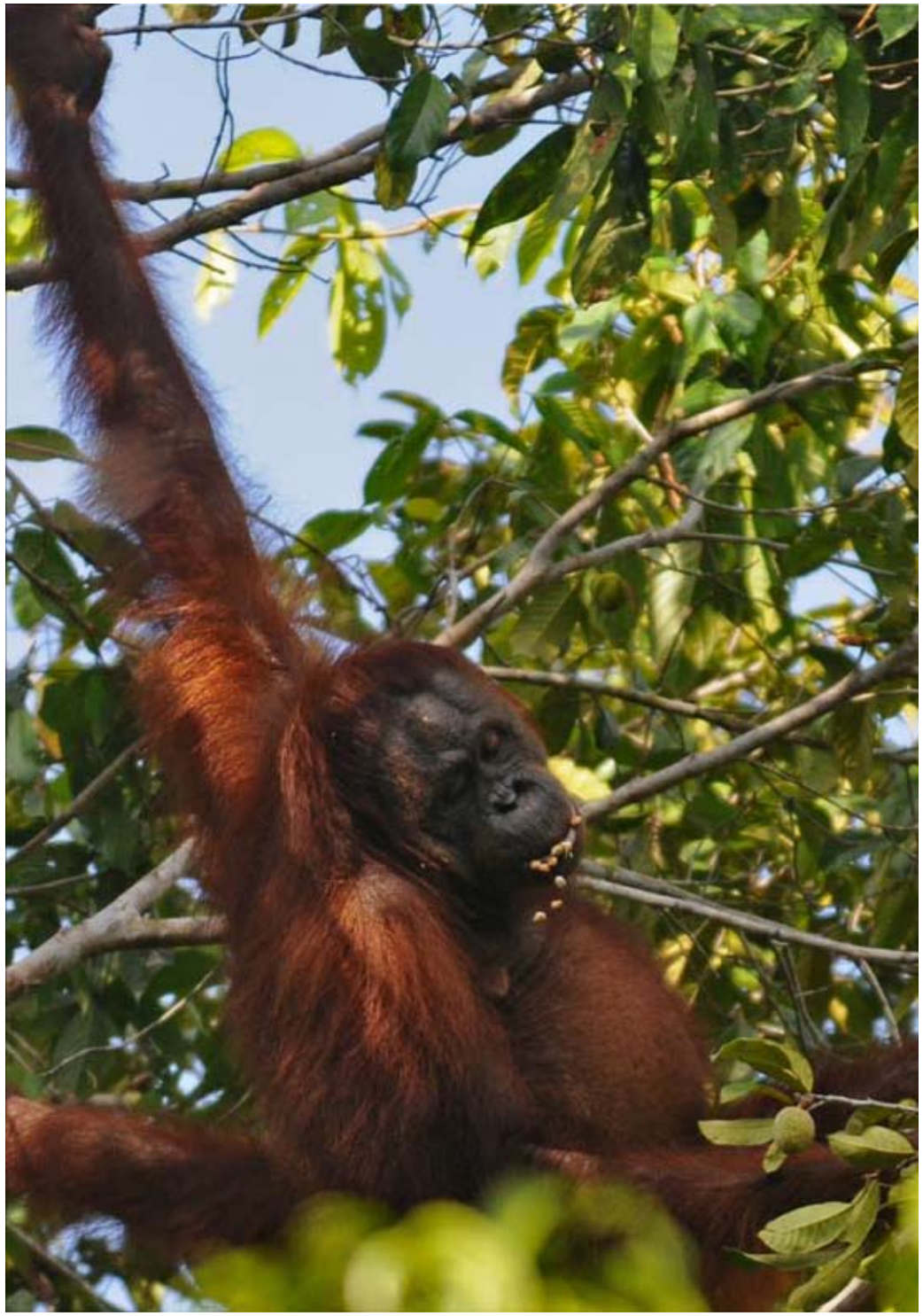

Figure 2.41 Orang-utans are best described as "gardeners" of the forest; they play a vital role in seed dispersal, especially for large seeds that are not dispersed by smaller animals
(Photo: Sugeng Hendratno/WWF-Indonesia)

Figure 3.1 Release of a Golden Arowana *Schelerophages formosus* into its natural habitat in Merebung Lake, Meliau (Photo: Robert Clarke)

3. People and Biodiversity

Human communities in Labian-Leboyan Corridor (LLC) are highly diverse, ranging from various Dayak groups in the upper reaches of the watershed to Melayu villages near DSNP. The use of natural resources consequently differs in many ways. Hunting is still an important part of Dayak life. Agriculture is important, wherever flooding and soil properties permit it. Forest plant and fish resources are essential for all of them.

Utilization of some resources is increasingly unsustainable, for example bushmeat, or certain fish species; other resources are underutilized, and may even have potential for income generation for local communities, like forest medicinal plants. The following compilation describes selected aspects of relations between people in LLC and the biological diversity that surrounds them.

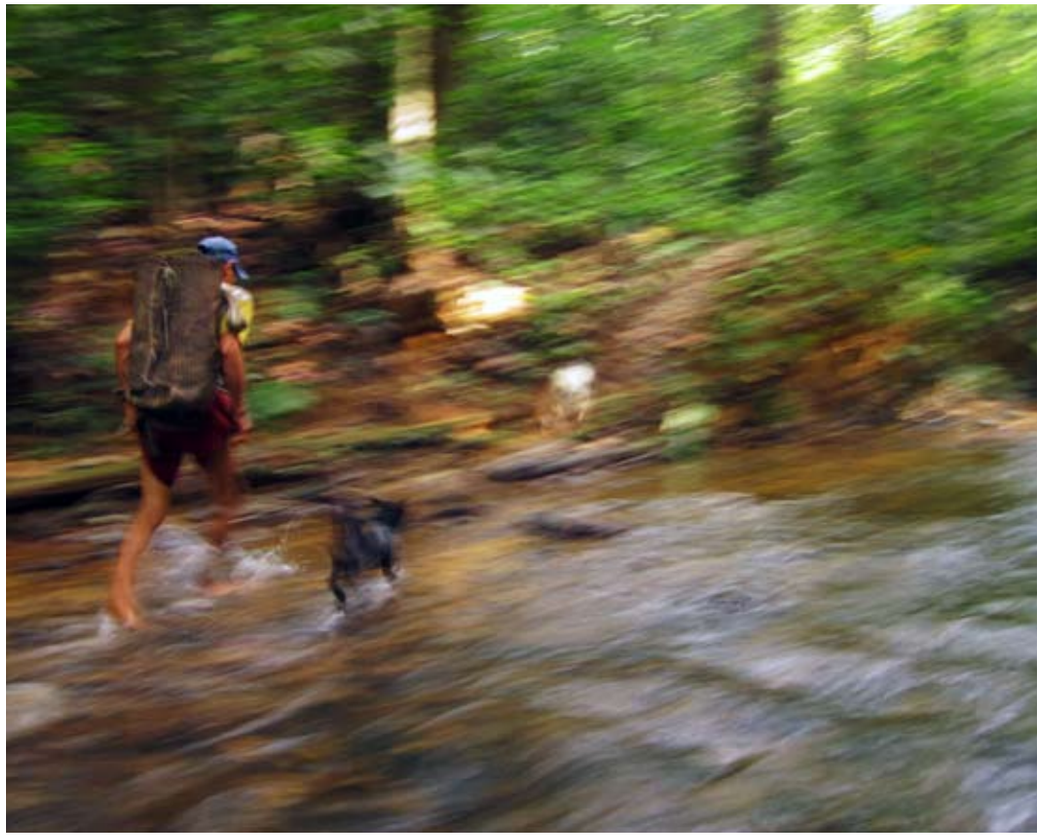

Figure 3.2 Hunting time (Photo: Panda Click!/WWF-Indonesia)

Traditional Knowledge Management for Medicinal Plants

Ambar Yoganingrum

Introduction

Traditional knowledge on use of plants has become an important source of information for developing medicinal compounds (Heinrich and Bremner 2006). Many communities have traditionally used locally available plant species to cure illnesses. Systems to transfer knowledge from one generation to the next are important to assure that traditional knowledge does not get lost over time. Strategies for the development of traditional medical knowledge management include inventories of useful plants, information sharing, cooperation between traditional healers and health workers, and provision of training and education on health care for traditional healers (WHO 2002, Colfer et al. 2006).

This chapter presents the potential forms of cooperation and provisions of a knowledge management system for traditional healers and health workers as a strategy to preserve knowledge on suitable local plant species in Nanga Leboyan and Melemba Villages in LLC.

Results

In rural Indonesia commonly both a “manang” (shaman) as well as health workers provide health services for people in the villages. The “manang” uses plants or other natural resources to treat diseases. Some of the most commonly used plants include “Sabang” *Cordyline terminalis*, Rice *Oryza sativa* and Turmeric *Curcuma domestica*.

While some people choose to visit the health workers, others prefer consulting the “manang”. In case the latter cannot heal a sick person, another “manang” from a different village might be consulted, or the patient seeks advice from health workers. The same is true if the “manang” gets sick. The “manang’s” medicinal knowledge is usually accumulated over generations. An exception seems to be the “manang” in Nanga Leboyan Village who claims that he gained the knowledge himself. Health workers in this village generally are not familiar with local traditional medicines. There is a growing trend among the communities in LLC towards visiting community health centers (Puskesmas) rather than consulting the “manang”. From the viewpoint of public health care this might look like a positive development. However, with the “manang” loosing patients and the communities no longer sticking to traditional treatments, knowledge on traditional medicinal plants and their uses gradually disappear. Moreover, many useful plants in the region have not even yet been documented and scientifically studied. One strategy to prevent the loss of this knowledge will be to facilitate knowledge transfer between the “manang” and health workers. Another possibility could be the formal integration of the “manang” in the community health center system, for example by providing space at the center. People then would be able to choose between traditional and modern treatments or possibly combine both. A joint practice would also facilitate knowledge in modern medicine and contemporary health care training for the “manang”. For example, cooperation with shaman as a strategy to overcome diseases like diabetes and HIV/AIDS has successfully been conducted in African countries (Mbeh et al. 2010, Shuster et al. 2009, Peltzer, 2006, Mills et al. 2006, Somse et al. 1998). A similar strategy has been successful in forging partnerships between traditional midwives and the health workers in Indonesia (Arismawati 2010).Thus, the preservation of local medical knowledge does not necessarily exclude modern public health aspects, and vice versa.

Figure 3.3. The “manang” shaman uses plants or other natural resources to treat diseases.
(Photo: Syahirsyah (Jimmy)/WWF-Indonesia)

Identification and documentation of useful plants in the two villages is the priority in order to preserve traditional knowledge. The research results on medicinal plants should be openly available to researchers, traditional healers, health workers or other interested people in an appropriate format. Currently, research results cannot readily be understood and used by the “manang”. Planning of knowledge management systems should involve the relevant government institutions, non-governmental organizations and the involved “manang”. Additional inputs can be provided by ethnobotanists, information technology (IT) specialists (to establish information systems), health workers, librarians and anthropologists. Information provided has to include the ecology of plant species, their characteristics, information about how to use and combine them, expected toxic side effects and other relevant information. The information system should include a simple paper format, so it remains interactive and the “manang” can contribute information on his experience with certain medical plants. The information system needs to be managed by information centers and libraries already present in the district, which cooperate with institutions responsible for providing health related information on the sub-district level. Establishing a local plant information system in DNSP and LCC will contribute to documentation, research, education, and conservation of local knowledge on traditional methods of healing.

Phyto-pharmacological Potential of Understorey Plants in Danau Sentarum National Park

Yanieta Arbiastutie

Introduction

Inventories of locally known medicinal plants in various protected forest areas in Indonesia showed that many plants contain active components with the potential to cure a wide variety of illnesses. Some of these plants may be used for the development of subsistence and commercial medicines in the future (Zuhud 2008).

A number of plants of tropical forest understories are known to potentially inhibit cancer cell growth. In modern medicine there is a recent trend to include traditional medicine and drugs from plants in cancer treatments, rather than synthetic drugs alone (Haryanto1994). Bioactivity of plants is strongly influenced by the content of their chemical compounds (Cutler and Cutler 2000, Katzung et al. 1995, Siswandono 1998). Active compounds

Figure 3.4 The climber *Hoya* sp. is one of the many medicinal plant species used in Meliau (Photo: Sugeng Hendratno/WWF-Indonesia)

"Phytochemical screening and bioactivity tests were conducted at the Laboratory of Mathematics and Natural Sciences, Tanjungpura State University, Pontianak".

of plants are mostly secondary metabolites such as alkaloids, flavonoids, steroids, or triterpenoids. Selection of the method to test bioactivity also plays an important role in providing meaningful results for pharmacological applications (Cassady et al. 1980, Colegate et al. 1993). The brine shrimp lethality bioassay method is a preliminary and easy to use cytotoxicity test for finding new bioactive compounds, particularly anticancer compounds.

Methods

Field work for this study was conducted in DSNP, in a swamp forest area in Meliau Sub-Village, Melemba Village, Batang Lupar Sub-District, Kapuas Hulu for two weeks in May 2010. Phytochemical screening and bioactivity tests were conducted at the Laboratory of Mathematics and Natural Sciences, Tanjungpura State University, Pontianak.

For the vegetation analysis, sampling plots were established within a six hectare sample site with a sampling intensity of 0.4%. Each sample plot had a size of two by two meters, with a

Figure 3.5 Tiger Betel *Piper porphyrophyllum* probably has market potential as medicinal plant because of its high content of flavonoid compounds (Photo: Sugeng Hendratno/WWF-Indonesia)

total number of fifty plots. The sample plots were arranged along transects with a distance between sample plots of ten meters. Distance between transects was 100 m. Quantitative parameters that were used included density, frequency, area closures, dominance, diversity index, among others (Indriyanto 2006).

Phytochemical testing included alkaloids, flavonoids, saponins and sterols. The Brine shrimp lethality bioassay method (BSLT) was used as cytotoxic test determining the lethal concentration of 50% of individuals (LC50; McLaughlin et al. 1991).

Results

"Riang Bejid" *Medinilla crassifolia* was the medicinal understorey plant with the highest density, with 5,050 individuals per hectare. This density may already allow sustainable harvest. This species also had the highest frequency value with 0.08 and Importance Value Index of 20.625%. The Shannon Diversity Index of the site was 1.579, indicating high species diversity overall.

A total of 23 understorey plant species out of 60 which were tested contained active components with LC50 smaller than 1000 ppm and therefore should be screened further for their properties. Even a relatively small forest patch within DSNP holds a high diversity of potentially valuable medicinal plants. At least one species occurs in densities which may allow carefully planned sustainable harvest.

Figure 3.6 The roots and stems of *Fibraurea tinctoria* have medicinal properties. The stem yields a yellow dye (Photo: Syarif/BKNP)

Women's Involvement in Local Natural Resources Management

Anas Nashrullah

Introduction

Women play an important role in various social, cultural, religious, health and political aspects of village life in LLC. This chapter explores their contribution to natural resource management in the villages of Labian and Sungai Ajung within the corridor. Data were gathered by conducting informal interviews and focus group discussions.

Women in the two villages are involved in a number of income-generating natural resource utilizations, in addition to their daily household chores. Despite their prominent roles in the family, women frequently still do not have the same status as men; wives still are expected to be subordinated to their husbands. Underlying causes of this are very complex and mainly rooted in culture, unequal education and possibly also current legislation. Statistics in both villages indicate that average education of women is only up to primary school level. Empowerment of women is not only hampered by male perceptions, but also by lack of awareness among women themselves (The Indonesian Institute of Sciences/LIPI, 2007).

Figure 3.7 A woman from Malay tribe living in lower part of LLC collecting the rubber early in the morning (Photo: Sugeng Hendratno/WWF-Indonesia)

Women's Involvement in Natural Resources Management

Both men and women in the two villages are involved in natural resource utilization and conservation. Women's knowledge and experience in this field is a result of their daily interaction with the surrounding environment. Women's potential role in sustainably managing the environment and conserve natural resources is not yet fully recognized. They for example are the driving force in restoring exhausted soils of abandoned fields by replanting them with fruit, rubber or timber trees. Women's role in routine agricultural activities can be illustrated in the mixed farming and gardens practices in two villages. Cultivation of fields and forest gardens is mainly the task of women, and the majority of time is allocated to these agricultural activities. Women therefore have extensive knowledge in shifting cultivation and mixed garden management, particularly on seed varieties, intercropping, fertilization and land management, but also in harvesting and post-harvesting techniques, like timing of harvest, drying, milling and packaging.

Efforts of Women Empowerment

Women's empowerment should primarily be attempted by strengthening their social, cultural, economic or political roles in society. Aspects of their involvement and knowledge in local natural resource management have to be integrated in all these fields. In order to achieve this, the strategic role of women in household and natural resource management has to be appreciated both by men and women. This involves encouragement of members of the women's organizations to express their opinions in different forums that exist in the two villages, especially in decision-making processes involving natural resources management.

Figure 3.8 Natural seeds and beads are often combined in interesting handicraft produced by women in Ukit-Ukit Village. (Photo: Sugeng Hendratno/WWF-Indonesia)

Figure 3.9 Weaving baskets and mats is a daily activity for women in Meliau Village (Photo: Sugeng Hendratno/WWF-Indonesia)

A longer-term goal is to develop and build a common perspective towards increasing of women's empowerment, self-actualization and appreciation of their significant contributions to society. One outcome could be a fairer share of benefits derived from natural resources management for women (Nashrullah 2008).

WWF's women program in LLC involves the following objectives to achieve this goal:

- Women's cooperative for handicraft production (beads made of forest seeds established.
- Natural resources management group for agriculture developed, with focus on production of organic ancient rice.
- Early childhood education management group developed.
- Strategic plan for women empowerment in the context of family welfare education in Labian Village developed.
- Women's role in local art and culture institutionalized.

Effects of Hunting on Avian and Mammalian Communities

Peter Widmann, Hari Prayogo, Albertus Tjiu and M. Hermayani Putera

Introduction

Hunting and trapping of birds and mammals for food, body parts or as pets has long been identified as a major threat for wildlife in Borneo (Harrison 1955), and that nowadays may have reached proportions which leave seemingly suitable forest habitats without larger wildlife (Nasi 2008). Most studies on hunting in tropical forests however are conducted in the Neo- or Afrotropics, and studies in insular Southeast Asia are still rare.
We compared compositions of bird and mammal communities in DSNP and BKNP, with those from LLC. Hunting pressure from the local Dayak population in this watershed is very intense, with potentially negative impacts on the local bird and mammal communities. We predict that large size-classes of birds and mammals are disproportionately affected, because most desirable game species are those with larger body weights.

Methods

We compared published and unpublished species lists of birds and mammals in DSNP and BKNP (Jeanes 1997, Prayogo et al. 1998, WWF-Indonesia West Kalimantan Program's data base) with results of our own surveys in LLC. Only resident lowland species were included in the analysis, since the maximum altitude of the central corridor area is only 170 m above sea level. Adequacy of sampling effort was assessed using Estimates software ver.7.5 (Colwell 2005). Since sampling efforts for microchiropteran (insect-eating) bats and murid rodents (rats and mice) were insufficient in LLC and possibly also in BKNP, these groups were excluded from the analysis. Information on bird and mammal weights from the literature and from our own measurements were used to group the recorded species in four weight classes for birds and five for mammals. We conducted informal interviews with hunters to preliminarily assess frequency of hunting, targeted species in the past and present, as well as methods, costs and benefits.

Results

A total of 279 resident lowland bird and 78 lowland mammal species (exclusive Microchiroptera and Muridae) were recorded from the three areas. The percentage of resident lowland bird species with body weights over 200 g in DSNP and BKNP was 22.3% and 14.9% respectively, whereas in LLC it was 14.0%. Only 1.5% of bird species in LLC weighed more than two kilograms, compared to 4.1% in DSNP and 3.3% in BKNP.
Species not any more recorded from the central corridor area include popular game species

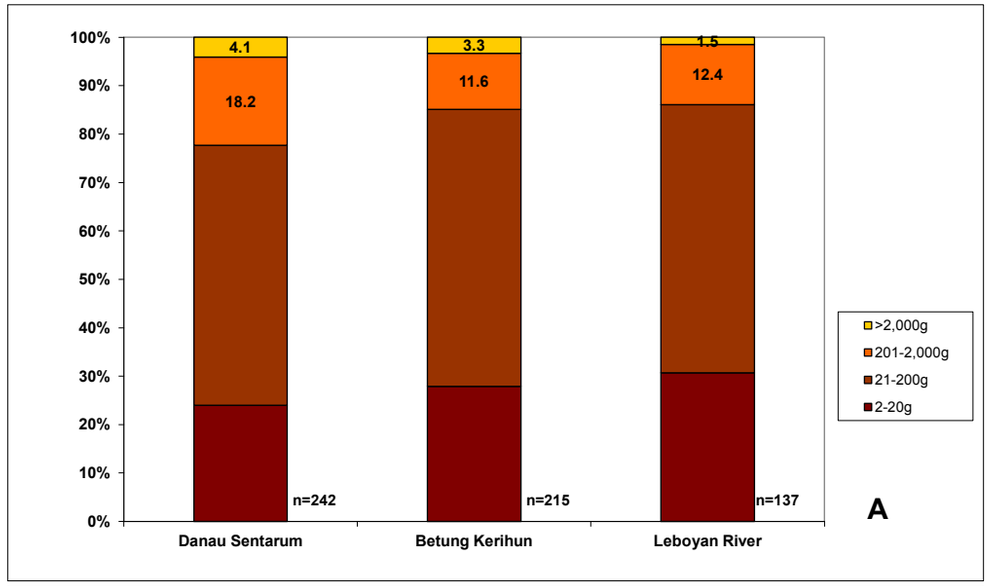

Figure 3.10 Percentage of resident lowland bird (A) and lowland mammal (B) species in different weight classes recorded from Danau Sentarum, Betung Kerihun and Leboyan River, Kapuas Hulu, West Kalimantan.

like large-bodied Phasianidae (pheasants) and Columbidae (pigeons).
Among lowland mammal species (exluding Microchiroptera and Muridae) 69.2% weighed more than 200g in DSNP, 70.2% in BKNP, but only 59.2% in LLC. Mammals with body weights of more than 20 kg comprised 5.1, 8.1 and 3.7% of the total community DSNP, BKNP and LLC respectively. Several large species of Artiodactyla (some deer), Primates and Carnivora that presently can still be found in DSNP and BKNP could not be recorded from LLC. Almost all adult males in the Tamambaloh village communities we visited were (part-time) hunters. Because animals were taken predominantly because of the meat, larger game species were preferred over smaller. All respondents noted that larger animals have become scarce over the last twenty years. Most hunters stated that because of the scarcity

"If current levels of hunting are maintained in LLC it is unsure whether the area can still function as a corridor for larger animals as intended under "Heart of Borneo" initiative".

of larger game they had to switch to smaller species. Birds that were commonly taken recently were small pigeons and rails, and most commonly hunted mammals were civets, porcupines and fruit bats. This shift was still feasible, because most hunters had access to cheap ammunition. Cartridges from Malaysia were readily available, though relatively expensive at IDR 20,000 (ca. 1.7 Euro; Jan. 2008 exchange rate) per 8-gage. However, used cartridges could be cheaply reloaded five times on average, which then reduced the cost to ca. IDR 4,400 (0.37 Euro) per cartridge, or even less if recycled more often.

Conclusion

Our own observations and information form hunters indicated that unsustainable levels of hunting cause the disappearance of bird and mammal species in the larger weight classes. Habitat destruction, fragmentation and degradation almost certainly are important threat factors as well, but many larger birds and mammals in Borneo (e.g. Orangutan) can tolerate this to certain degrees, while others even benefit from it(most Artiodactyla; Caldecott 1988, Meijaard et al. 2005).

If current levels of hunting are maintained in LLC it is unsure whether the area can still function as a corridor for larger animals as intended under "Heart of Borneo" initiative. As soon as LLC remains the only connection between the two national parks (after unprotected neighboring forests are logged or converted into oil palm plantations), it may become a sink for some populations, since especially highly mobile and conspicuous species like Orangutan will run a high risk to be shot in the bottleneck of the corridor.

Figure 3.11 Bearded Pigs *Sus barbatus* are possibly the only mammals with a body weight above 20 kg that still are permanent residents in Leboyan watershed (Photo: Peter Widmann).

Approaches to for make harvests of animals through hunting more sustainable in LLC need to be developed. Potentials for participatory wildlife management and restriction of access to cheap ammunition from Malaysia should be explored.

Fisheries Management

F.X.W. Padmarsari

Introduction

Fish of economic importance are classified into marine and inland stocks. The latter covers rivers, lakes, swamps, and manmade ecosystems, such as ponds, reservoirs and irrigated systems. Local stock volumes in the wild are correlated with biodiversity and utilization management. Several studies show that environmental impacts such as changes in land use, forest degradation, water pollution and overfishing can cause reduction in fish biodiversity and stock (Barus 2007, Hiddink et al. 2008). LLC has a high potential for freshwater fisheries. It harbors several freshwater ecosystems of various sizes, with marked differences in stream characteristics, physico-chemical conditions and vegetation.

In general, there are two types of wetlands, based on water movement. Lotic systems comprise fast-flowing streams, for instance Labian-Leboyan River and several tributaries (Ngaung Tapah and Tandung Buloh Rivers); lentic systems comprise stagnant waters, like several lakes of different sizes: Panubarian, the biggest lake in LLC, as well as Kandis, Marindang, Masanjan, Timador, Daki and Limau Lakes. Several of these ecosystems are highly acidic.There has been no fisheries resources management in LLC so far. Consequently, there was no data on fish diversity and production, as well as on regular fishing activities available until recently. Sound fisheries management has the potential of improving fish production, as well as helping to introduce more sustainable fishing practices in an area. Sound information on fish diversity, fishery activities and habitat conditions are necessary in order to introduce effective fisheries resources management in LLC.

Methods

A survey was conducted with the fishing communities in Labian and Ganti Villages within LLC. Information was generated through interviews with fishermen and analysis of total catch per site. Habitat conditions in LLC were characterized through direct measurement of several water parameters (temperature, water depth, visibility, pH, nitrate and phosphate). Data collection took place on 10-24 November 2007 and 1-6 June 2010.

Figure 3.12 Woman in Semangit Village dries salt fish in the sun during dry season in DSNP (Photo: Sugeng Hendratno/WWF-Indonesia)

Results

Fish in LLC are harvested using trawl nets (36%), gill nets (30%) and hook and line (15%); less common methods include locally made fish traps ("pengilar"). Selection of fishing method usually takes into consideration the specific location and target species. "Pengilar" usually is used to catch species of higher economic value, like Featherback *Chitala lopis* or Giant Gouramy *Osphronemus goramy.* These traps are installed overnight and harvested the next day. In order to catch living Clown Loaches *Chromobotia macracanthus,* a valued ornamental fish, fishermen employ special fish traps made of bamboo. Several years ago, nets with smallest mesh size were used for this species as well, but this practice was given up due to high mortalities. Based on interviews with local communities, several fish species are locally extinct already, indicating occurrence of unsustainable fishing methods in the area. Fish that were once abundant, but now are difficult to find include Featherbacks and Clown Loaches. Fishing takes place year-round with peak seasons from April until August and at the beginning of the rainy season from September to October. Fish catch monitoring in June indicates that this peak is not very pronounced. Among the economically important fish, most are used for food (37 species), followed by ornamental fish (seven species) or both (five species). Most fish caught during the study in Labian-Leboyan watershed were not fully grown, based on maximum size standard lengths given in the literature (Kottelat et al. 1993). Mature fish were very rare except for several dominant species in lakes, such as *Thynnichthys polylepis*, a representative of the carp family.

Figure 3.13 Catching fish is a communal activity during the dry season
(Photo: Panda Click!/WWF-Indonesia)

Results of waters quality analyses in LLC (Tab. 3.1) indicate that several water bodies are within the range of physico-chemical parameters to provide adequate conditions for fish life, such as in Labian and Tandung Buloh Rivers, as well as Kandis, Panubarian and Marindang Lakes. Others, like Ngaung Tapah, Daki and Limau Lakes had low pH levels, as well as high nitrate and phosphate concentrations, making them less suitable for fishery and aquaculture.

Table 3.1. Physico-chemical parameters of selected water bodies in LLC

Location	Temperature [ºC]	Water depth [cm]	Visibility [cm]	pH	PO_4^{3-} [mg/l]	NO_3^- [mg/l]
Sungai Labian	27	250	59	5.65	0.099	0.108
S.Tandung Buloh	25	49	49	4.49	0.276	0.511
S. Ngaung Tapah	25.5	205	45	2.65	3.734	0.67
Danau Kandis	29	160	53	5.57	0.096	0.065
D. Masanjan	29	251	-	-	-	-
D. Panubarian	29	197	68	5.85	0.029	0.074
D. Marindang	28.5	192	72	5.38	0.811	0.045
D.Limau	28	150	49	2.84	0.511	0.276
D. Daki	29	291	62	3.10	0.498	0.253

Discussion

Prevalence of suboptimal fish sizes are an indicator that overfishing was taking place in LLC. Deteriorating environmental conditions, such as unregulated domestic waste disposal, nutrient run-off from cultivation and illegal logging may also play a role in the reduction of fish populations, but this could not be conclusively demonstrated in this study. Some species with high economic value seem to be overfished, such as the Featherbacks and Clown Loaches.

Some species may be candidates for aquaculture, considering their market potential and biology. For example Tiger Fish *Datnioides microlepis* has both potential as food and as ornamental fish. The use for the aquarium trade is increasing each year. It can be easily caught during breeding season, but mature individuals are now difficult to be found. Meat of this species is very high in protein, and vitamins A and E (Padmarsari and Setyawati 2009).

"Fishing methods need to be better regulated, including the use of standard equipment, in order to protect several species from extinction, assuring sustainable use of fish stocks in LLC".

Featherback is another potential candidate for aquaculture, due to its high economic value and the depletion of natural stocks. Fisheries development in LLC in respect to aquaculture has a relatively high potential. Panubarian and Marindang Lakes both have suitable environmental parameters for fish, adequate natural food supplies and could be restocked with appropriate, non-predatory fish, which occurred there before. The capabilities to provide offspring artificially in sufficient numbers as well as the development of feeding and disease control techniques are preconditions for establishment of aquaculture methods for selected species. Additional studies are therefore necessary for promising fish species, particularly on breeding biology, potential size and maximum age, growth rate, gonad maturity size and age, feeding behavior and migration patterns.

Serious attention has to be paid to the control of sedimentation in LLC, which is considered a major threat to fisheries and aquaculture development. Several waters have undergone marked reductions of area due to sedimentation impacts, such as Timador Lake. Fishing methods need to be better regulated, including the use of standard equipment, in order to protect several species from extinction, assuring sustainable use of fish stocks in LLC.

Figure 3.14 People from Semalah Village pack salted fish in baskets (Photo: Sugeng Hendratno/WWF-Indonesia)

Potential for Monitoring Wildlife Utilization: Three Case Studies

Peter Widmann, Hari Prayogo and Sofwan Anwari

Introduction

Unsustainable utilization is widely regarded as one of the most important factors for the decline of wild species, second only to habitat destruction and fragmentation. In West Kalimantan wild plant and animal species play an important role for the subsistence of human populations, as well as in national and international wildlife trade (e.g. Lee and Ng 2005, Nijman 2005). Although laws exist for the protection of species and ecosystems, enforcement is often lacking, due to insufficient technical capacity or resources of the enforcing agencies. Awareness of the precarious status of wildlife in West Kalimantan and knowledge on wildlife laws is still low among traders, law enforcers, decision makers and consumers (although timber and illegal logging has recently received some public attention).

West Kalimantan shares a long border with Malaysia and the steep socio-economic gradient between Indonesia and Malaysia is a major driving force for trans-boundary trade and unsustainable exploitation of biodiversity on the Indonesian side, including LLC. This chapter assesses direct population monitoring, as well as the suitability of monitoring methods for sustainable use schemes. We selected three species/species groups which are utilized in LLC, but are either not protected by law, or have an allowable quota. Clown Loaches *Chromobotia macracanthus* are endemic to Kalimantan and Sumatra. They are highly valued ornamental fish in the aquarium trade (Aglionby 1995); in 2009 between six to seven million animals were exported from West Kalimantan alone, based on information from exporters. Unlike other freshwater aquarium fish they cannot be bred on a commercial scale so that virtually all animals in trade are caught from the wild in Indonesia.

The Asian Softshell Turtle *Amyda cartilaginea* is in high demand for food, locally and internationally, particularly in East Asian cuisine. In the late 1990s up to fifty tons annually were sold from Kapuas Hulu to Sarawak (Walter 2000). Since then populations collapsed in parts of DSNP, from where most animals originated. Songbirds are traditionally kept as pets in Indonesia, particularly those with elaborate songs, or the capacity to imitate human voice. In West Kalimantan species in very high demand are Oriental Magpie Robin *Copsychus saularis*, White-rumped Shama *Copsychus malabaricus* and Hill Myna *Gracula religiosa*. These species are regularly available in larger numbers in bird markets in Pontianak. The most prized species was the Straw-headed Bulbul *Pycnonotus zeylanicus*, which got extremely rare due to trapping and can be considered "economically extinct" in West Kalimantan.

Methods

In order to develop monitoring protocols for the selected taxa, we tested methods for assessment of actual animal populations, intensity of utilization and availability in markets.

Clown Loaches: a mark-recapture study using Visible Implant Elastomers (VIEs) allowed calculation of population densities of mature individuals on a stretch of 1.5 km of Labian-Leboyan River. A questionnaire survey involving fisher folks produced estimates for catch-per-effort-unit for the current catch season, and less consistently for the previous four seasons. In contrast to the former method, questionnaire surveys are time-efficient enough to cover the majority of respondents involved in catching Clown Loaches in DSNP and vicinity.

Figure 3.15 Juvenile Clown Loach *Chromobotia macracanthus* (Photo: Sugeng Hendratno/WWF-Indonesia)

"Questionnaire interviews also indicate that softshell turtles were more common in past years than they are nowadays".

Asian Softshell Turtle: despite considerable trapping efforts, capture rates of softshell turtles were too low to allow estimation of population densities in upper LLC, in contrast to the lower watershed, where persecution is not yet intense. Questionnaire interviews also indicate that softshell turtles were more common in past years than they are nowadays. However, because of the opportunistic pattern of utilization, it turned out to be difficult to calculate catch-per-effort rates. Figures of annual quota and actual numbers taken from registered traders were readily available from The West Kalimantan Natural Resources Conservation Agency (Balai Konservasi Sumber Daya Alam/BKSDA). It however seems that many traders are not registered and particularly vendors in meat markets and owners of restaurants serving bush meat did not readily share information regarding sales and consumption of softshell turtle meat, which makes monitoring of utilization on provincial level difficult.

Figure 3.16 The Asian Softshell Turtle *Amyda cartilaginea* was formerly abundant in LLC (Photo: Syahirsyah (Jimmy) /WWF-Indonesia)

Songbirds: we tested two methods to assess population densities of the three songbird species: distance sampling using line transects and mark-recapture using mist nets and with a combination of colored leg bands as markers. Distance sampling worked well for the three species in LLC, and two additional sites in the province, in Kubu Raya and Pontianak. Mist-netting and color-banding yielded good results for Oriental Magpie Robin and White-vented Shama, but was discontinued because of the considerably larger effort necessary, compared to distance sampling.

Figure 3.17 The White-rumped Shama *Copsychus malabaricus* is one of most popular cage birds in Indonesia (Photo: Syahirsyah (Jimmy) /WWF-Indonesia)

Direct Population Assessment: Results and Discussion

Clown Loaches: population densities of mature individuals in upper LLC ranged between 20 to 24 individuals per kilometer of river. This appears to be a remarkable low number. The species is known to be long-living in captivity, with single individuals reaching more than 40 years (Sernotti and Boruchowitz 2008). This suggests that although the harvest of large numbers of juveniles may be sustainable, this may not be the case for the adult upriver population, where adult Clown Loaches are opportunistically taken as food fish. Loaches are dependent on washed-out roots of trees growing at the river banks, as well as dead wood on the river bed for cover. The species is therefore likely negatively affected by destruction of riparian forest as well.

Asian Softshell Turtles: a preliminary figure for population density of this species in lower LLC was 26.7 individuals per kilometer of river. This number only included animals with carapace widths of 30 cm and above, since smaller ones were likely to escape from the traps. Capture rates in upper LLC, where the species is intensively trapped, were not sufficient to calculate population densities.

Songbirds: among three research sites for songbirds, upper LLC held the highest population densities: Oriental Magpie Robin with 60 individuals per square kilometer, White-rumped Shama (47 ind./km^2) and Hill Myna (27 ind./km^2; Tab. 3.2). This was also the site with the lowest trapping intensity for the cage bird trade, although the latter was difficult to quantify.

Table 3.2. Density of three songbird species (ind./km^2) frequently trapped for the songbird trade in West Kalimantan, Indonesia

	LLC, Kapuas Hulu	Ambawang, Kubu Raya	Southern Pontianak
Vegetation type	Residual dry forest	Residual dry forest	Degraded peat swamp forest
Trapping intensity	Low	High	Very high
Oriental Magpie Robin	60	35	15
White-rumped Shama	47	25	no record
Hill Myna	27	20	no record

Conclusions and Recommendations

We were able to identify methods which allow long term population monitoring for all three taxa (Clown Loaches, Asian Softshell Turtles and Songbirds), either directly and/or using catch-per-effort information as substitute. At least one set of data exists for all surveyed species. In order to establish population trends, we recommend continuing these studies for another three years in the same study sites. After this period it should be decided, in what time intervals surveys should be repeated. Monitoring can be conducted by trained field workers, for example students of Tanjungpura University. Necessary skills are taught in the course of a newly established curriculum with focus on sustainable management of forest and wetland resources (e.g. distance sampling, mark-recapture, interview and market surveys).

Aside from collecting data on population and utilization of Clown Loaches, we were also able to add information on the biology of the species. Reproductive adults stay upriver for most of the year, while the lakes and flooded forests of DSNP serve as nursery. Only in the latter location are loaches caught for the aquarium trade. Hence, human upriver populations do not directly benefit from protecting adult clown loach populations in their area. Possibilities of inclusion of this species in upriver-downriver compensation mechanisms should be explored.

"Preliminary analysis indicates that most current capture rates for Oriental Magpie Robin, White-vented Shama and Hill Myna are almost certainly not sustainable."

If it is the case that, based on the preliminary monitoring results, utilization of Clown Loaches should turn out to be sustainable, feasibility of a certification system should be assessed. Currently, a certification scheme only exists for marine aquarium species, but not yet for freshwater fishes. Despite considerable catching effort, data for softshell turtles were insufficient for calculation of population densities in the upper LLC, where persecution is most intense. Difficulty to catch the species, absence of mature individuals, in combination with secondary information all point to a very drastic decline of the species in the research sites.

This seems to be even more pronounced in the upriver areas which are dominated by Dayak ethnic groups, which regularly trade and consume the species. Likewise alarming is the recent occurrence of specialized Dayak hunting parties which enter into areas with predominantly Melayu population and even into the protected area of DSNP itself, in order to hunt softshell turtles. The overharvest of this species need to be addressed immediately, for example through intensive conservation education, improved law enforcement and development of community-based management schemes to prevent local extinction of the species in West Kalimantan.

Preliminary analysis indicates that most current capture rates for Oriental Magpie Robin, White-vented Shama and Hill Myna are almost certainly not sustainable. Possible scenarios for the future could be either to introduce and enforce a quota system for these species, or to prohibit catching from the wild altogether and substitute it with captive-breeding schemes in combination with a system to identify origins of individual birds (Jepson et al. 2008). The three assessed groups should be integrated in a more comprehensive strategy of species management in LLC, particularly focusing on species threatened by direct utilization, be it mainly for subsistence needs (e.g. a variety of game and fish species), or market economic purposes (most primates, particularly Orangutans, Clown Loaches, song birds) or a combination of both (e.g. softshell turtles and Bearded Pigs).

Figure 3.18 The Oriental Magpie Robin *Copsychus saularis* is often caught for the cage bird trade, but so far still common in LLC (Photo: Syahirsyah (Jimmy) /WWF-Indonesia)

Figure 4.1 The wild bee colonies in a giant Lalau tree *Dipterocarpus* sp. can produce more than one ton of honey (Photo: Sugeng Hendratno/WWF-Indonesia)

4. Ecological Functions and Impacts

With effects of made-made climate change becoming more apparent, there is a renewed awareness of the importance of environmental services that should keep conditions within a range comfortable for life on earth. Best known are regulatory mechanisms for the carbon and water cycle; and others include erosion control, nutrient retention, provision of food, construction material, medicine, pollination, seed dispersal and natural pest control, education and recreation. The following chapter includes articles on selected aspects of ecological functions and impacts as they are relevant for the wider corridor area. Future research in this field will undoubtedly uncover many more environmental services provided by LLC and further highlight its importance.

Figure 4.2 Preparing land for rice cultivation in Kelawik Village (Photo: Syahirsyah (Jimmy) /WWF-Indonesia)

Figure 4.3 Abandoned land after shifting cultivation; succession will start with bushland, and pioneer trees (Photo: Anas Nasrullah/WWF-Indonesia)

The Importance of Ecosystem Services for Human Well-Being in the Landscape between Danau Sentarum and Betung Kerihun National Parks.

Elizabeth Linda Yuliani and Valentinus Heri

Introduction

Many essential ecosystem services and much of the world's biodiversity occur outside protected areas in fragmented landscape mosaics (Rodrigues et al. 2004a, 2004b), and therefore are prone to over-exploitation and land-use change. The importance of ecosystem services for human's livelihoods is often overlooked – or less understood by decision makers either at community level, as well as district and national levels. Land-use decisions are largely made based on short-term economic benefits and driven by investors and markets. Conservation on the other hand is often considered expensive and burdensome, rather than beneficial, despite of the benefits of ecosystem services protection derived. Forested landscapes in Kalimantan that provide significant ecosystem services are currently subject to large-scale projects such as plantation development, mining or transmigration, with minimum attempts to maintain services or to minimize negative environmental and social impacts.

This article aims to provide a brief definition of ecosystem services and how they are essential for human societies, followed by a description of some major ecosystem services in the landscape between DSNP and BKNP. Recommendations are made on how to manage those services for local people's livelihoods improvement and generation of district's revenue.

Major Ecosystem Services in the Landscape between Danau Sentarum and Betung Kerihun

A definition of ecosystem services based on the Millennium Ecosystem Assessment (2005) runs as follows:

- *Ecosystem services* are the benefits people obtain from ecosystems. These include provisioning services, regulating services, supporting services and cultural services;
- *Provisioning services* are the benefits people obtain from the ecosystems, such as food, fuel, fiber, fresh water and genetic resources;
- *Regulating services* are the benefits people obtain from the regulation of ecosystem processes, including air quality maintenance, climate regulation, erosion control and water regulation;
- *Supporting services* are those that are necessary for the production of all other ecosystem services, such as primary production, production of oxygen, and soil formation;

" Most of these resources are used for subsistence, except Rice, Honey and Pepper which are also sold and contribute to the household income".

- *Cultural services* are the nonmaterial benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation and aesthetic experiences.

Ecosystem services have strong linkages with human well-being (Millennium Ecosystem Assessment 2005), as described in Figure 4.4. Thus protecting ecosystems is inextricably interlinked with the maintenance and improvement of human well-being. This most fundamental issue needs to be well understood by land-use decision makers.

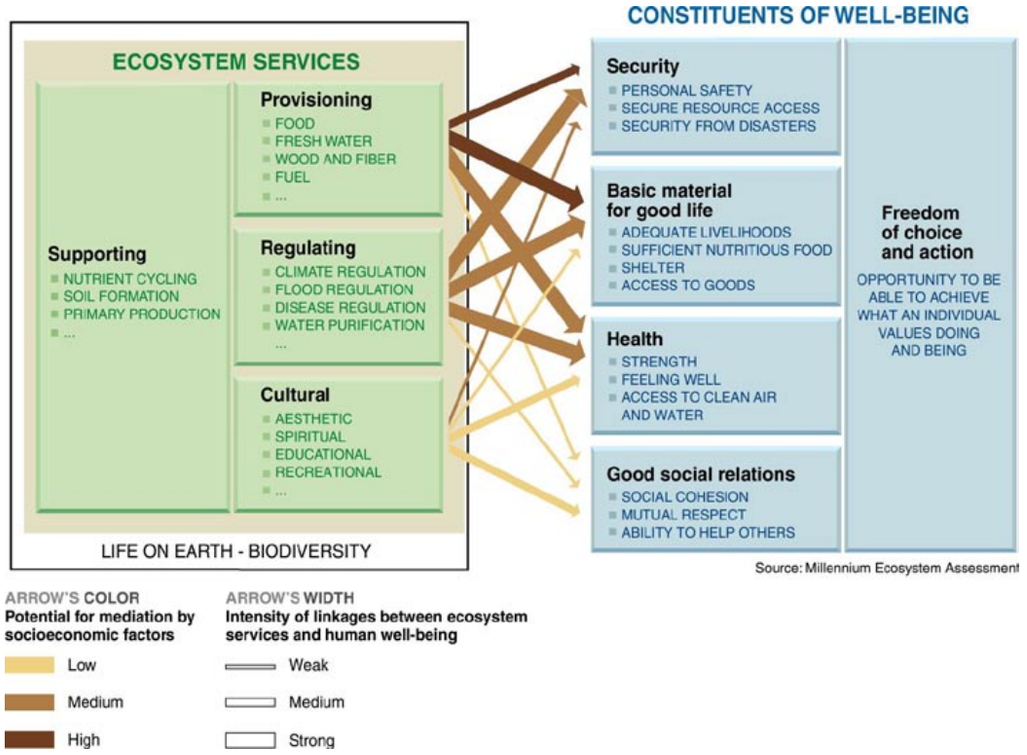

Figure 4.4 Linkages between ecosystem services and human well-being (Source: Millennium Ecosystem Assessment 2005)

This section provides a brief description of some major ecosystem services of the region, following the classification of the MEA.

Provisioning Services

Food and medicinal plants: Natural forests and wetlands, along with the community's agro-forests and mixed crops gardens in the landscape between DSNP and BKNP provide food sources that local people highly depend on, in the forms of wild plants and animal food products, crops, livestock and fish. A compilation of data from Colfer et al. (2000), Yuliani and Erman (2005) and Wadley and Colfer (2004) reveal that at least 89 plant taxa and 114 wild animal taxa (excluding fish) are used for food by local people in and around DSNP. The recorded 15 medicinal plant species being used are likely an underestimate. Food collected from the forest in this area comprises mushrooms, wild honey, edible plants such as bamboo shoots and ferns, and fruits with high nutritional value, such as Rambutan *Nephelium lappaceum* and several species of durian *Durio* spp. Sources of animal protein include freshwater fish and wildlife such as barking deer *Muntiacus* spp., Bearded Pig *Sus barbatus* and possibly also feral pigs *Sus scrofa*. Community agro-forests and mixed gardens are planted with crops such as Rice *Oryza sativa* and Sweet Potato *Ipomoea batatas*, vegetables like Cucumber *Cucumis sativus*, Chayote *Sechium edule*, Long Bean *Vigna sinensis* and spices like Pepper *Piper nigrum*. Most of these resources are used for subsistence, except Rice, Honey and Pepper which are also sold and contribute to the household income.

The importance of forest for food security and maintenance of health of the local people has been highlighted by many authors (e.g. Pimentel et al. 1997, Colfer et al. 2006, Dounias and Froment 2006, Sunderland 2011), and forest protection for food security now becomes a major issue. Therefore protection of forest in the landscape between DSNP and BKNP is critical to maintain food security and health of the local people.

Timber and fiber: The main sources of non-commercial timber for the people in the area are from the remaining forests. Data compiled from Colfer et al. (2000) and Yuliani and Erman (2005) indicate that there are at least 48 tree species used for making houses, boats, artificial hives for wild bees and other domestic uses. People also collect fuel wood as main source of energy. There has been increasing use of fuel wood triggered by the dramatic rise of fossil fuel prices since about 2005.

Since 2007, there has been significant decline of forest cover in this area caused by forest clearing for large scale oil palm plantations (Yuliani et al. 2010). Since local communities heavily depend on forest resources, they have been tried to meet their needs from remaining

"Based on the list of plant species from Giesen (2000) and Yuliani (unpublished data), the forests have many other indigenous fruits species and other edible plants with market potential".

forests of protected areas. This has led to the increasing pressure and over exploitation of some natural resources in DSNP (Heri et al. 2010).

Local plant resources with market potential: The forests in the landscape between DSNP and BKNP have high-quality indigenous fruit species and variants e.g. durian and rambutan. The durians from particular villages have small seeds and thick flesh with sweet-bitter taste, while some rambutan varieties produce large fruits with extremely thick flesh and small seeds, and a sweet and crunchy pulp. Based on the list of plant species from Giesen (2000) and Yuliani (unpublished data), the forests have many other indigenous fruits species and other edible plants with market potential. However these commodities have not yet been managed properly. Transport to markets is too expensive; therefore local producers highly rely on collectors or middle persons, there by cutting their profit margins. If managed, propagated and marketed properly, these local varieties could become a prominent product of the district and a source of significant income for local people.

Freshwater resources: As much as 80.4% of the population in Kapuas Hulu has no access to the government's clean water supply (Indonesia Human Development Report 2004). Therefore, people rely mostly on the nearest river, springs and streams for drinking, cooking and washing. Quality and quantity of the water is determined by hydrological functions and vegetation cover of the area. Thus, preserving the remaining forests and rehabilitating degraded land in the corridor would help secure people's access to freshwater.

Figure 4.5 High sedimentation indicated by yellow-brown water in LLC downstream after heavy rain, Meliau village (Photo: Linda Yuliani/CIFOR)

Community-based indigenous fruit business (case study): Indigenous fruits from this area, in particular *Durian* could become a significant source of alternative income for the local people and the district. It is vital however that the fruits trees are cultivated in a mixed agro-forestry and forested landscapes to maintain plant diversity and forest cover in the region. To increase the local economic value of the indigenous fruits simultaneously with forest cover protection, the district and national government needs to improve the trade and agricultural programs and policies. This should improve the indigenous fruit market and support local farmers. Government and NGOs could also help reduce marketing costs e.g. by cutting the market chain and connecting local farmers with market and network; and improve methods and build technical skills of the local people in propagation, harvesting, marketing and processing indigenous fruits.

The success of the above programs to protect the remaining forest and improve the livelihoods of the local people, will largely depend on good governance at all levels (local, regional and national), the existence of strong local institutions, the government's long-term development objectives and the government's understanding on the importance of ecosystem services. Capacity building for local people and the government is essential to provide them with knowledge and skills to develop and manage the programs successfully.

Regulating Services

Water regulation (hydrological functions): Hydrological functions of the Kapuas Hulu area affect a higher number of people than the other services. BKNP at the northern tip of the district is the source of three major rivers of the island, i.e. Kapuas, Rejang and Lupar (Lusiana et al. 2008). The Kapuas is the longest river in Indonesia and its watershed is home to over 3.2 million people and six major cities and towns in West Kalimantan. The Lupar River flows to Sarawak (Malaysia), thus the significance of hydrological functions of Kapuas Hulu extends beyond the district and country boundaries.

The landscape between DSNP and BKNP is part of the Kapuas Hulu watershed. Conversion of forest to non-forest uses in the landscape significantly affects the hydrological function of the whole Kapuas watershed. Hydrological modelling by Lusiana et al. (2008) shows that run-off in degraded land in Kapuas Hulu region can reach 2,951 mm, significantly higher than in forested land (12 mm). Such large increase of run-off in an area that lacks original vegetation cover causes erosion and siltation, and consequently floods further downstream.

Our data of water quality in five locations between 2005 and 2006 in DSNP and its buffer zone shows that turbidity, total dissolved solids (TDS) and total suspended solids (TSS) increased significantly during the rainy season, in particular 1-2 days after rain in the water catchment area, and often do not meet the Indonesian Ministry of Health's drinking water standards.

Based on our observations and discussions with local people in the five locations, extreme turbidity and siltation began when the forests in the upstream of major water catchment were heavily logged in early 2000. The people along Leboyan River reported that heavy siltation was also caused by land clearing and land preparation for road construction that traverses the river and tributary systems in Manggin, one of settlements in LLC. The people of Meliau often need to store water and wait for several days until soil particles sink to the bottom, otherwise water consumption would cause stomach ache. Bathing in river during the event reportedly also caused skin rashes.

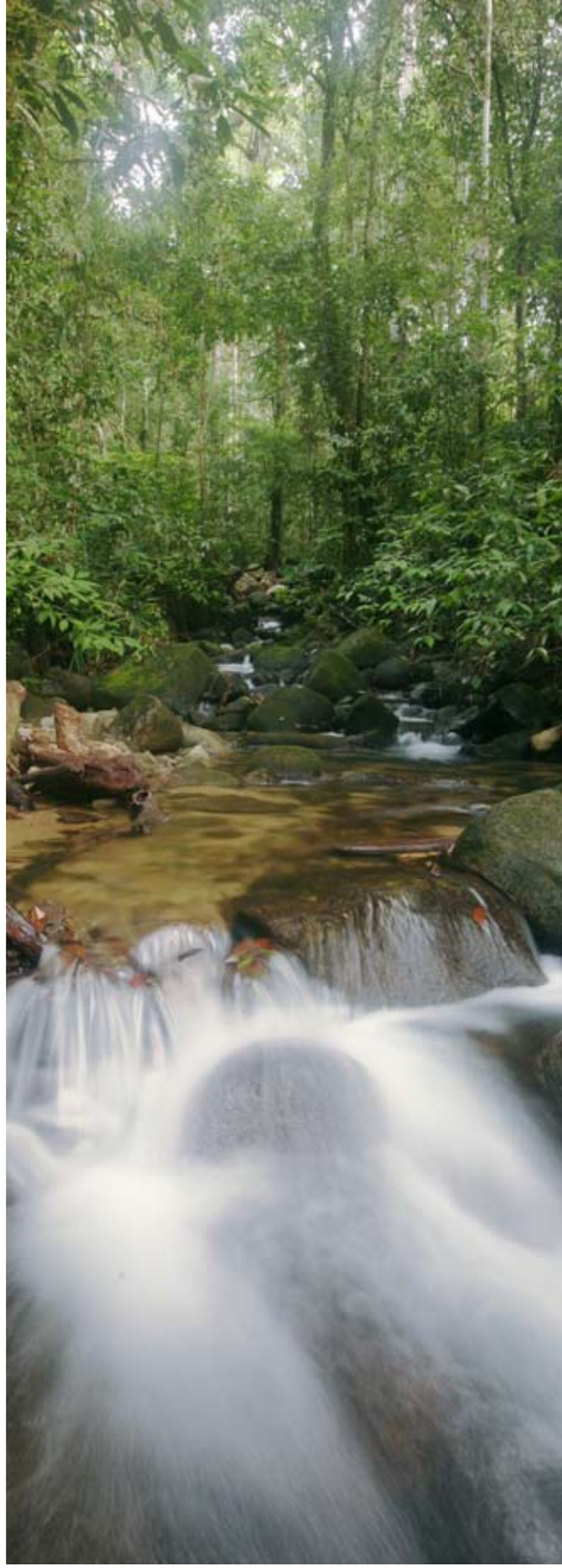

Figure 4.6 Overall water supply in the catchment depends heavily on the forest conditions upstream (Photo: Syahirsyah (Jimmy) /WWF-Indonesia)

Kapuas Hulu district contributes 26.8% of West Kalimantan freshwater fish production, with Danau Sentarum being the main source area (West Kalimantan Fishery Office 2007). Fish reproduction and survival depends on water quality. Siltation has also affected the fish population inside the Danau Sentarum wetlands, where tolerant species like Giant snakehead *Channa micropeltes* have become more dominant, while clean-water fish diversity and abundance is declining. Yuliani et al. (2010) report that at least 104 fish species in Danau Sentarum (49.29% of total number of species) can only live or reproduce in clean water, therefore cannot survive under high turbidity conditions. Declining fish diversity and abundance would significantly affect the fish production and the income of the local population.

Climate regulation: Significant changes of local and regional climate potentially affect human health, food production and income. Tropical forests and deep peat provide significant carbon storage; therefore their good presentation in the corridor suggests that the area has an important role in sequestration of greenhouse gases. Based on work by Wahyunto and Subagjo (2004), below ground carbon from deep peat deposits in Kapuas Hulu reaches 40.5 %, or the highest in the province (Figure 7). The largest deep peat deposits within Kapuas Hulu in turn are located within the corridor, in particular in the southeast of DSNP. Forests and deep peat deposits in Kapuas Hulu can contribute to climate change mitigation efforts at a global level through carbon sequestration and storage, as well as at local and regional level, through regulating local temperature, wind, rainfall, precipitation and humidity.

Sustainable freshwater fish industry and Arowana fish farms (case study): As mentioned above, Kapuas Hulu has a significant role in West Kalimantan's freshwater fish industry. Local people's income from inland fisheries totals IDR 34.75 billion (US$ 4.1 million; 1 US$ = IDR 8,500 as per October 2011) per year (Indriatmoko 2010), while the Arowana breeding farms in Suhaid and Selimbau Sub-Districts provide net cash incomes of approximately IDR 70 billion to 140 billion per year (US$ 8.2 million to 16.5 million) (Yuliani et al. 2010). These substantial fish industries with significant economic value depend on water of sufficient quality from Kapuas River, therefore Kapuas Hulu government should protect the forests in the landscape between DSNP and BKNP, especially along the Kapuas watershed to maintain the water quality of the Kapuas river network. Maintaining forest cover in the area is critical to the sustainability of the fish industries, as well as the local people's livelihoods. Converting the forests in this landscape for large scale plantations and other non-forest uses will cause significant economic loss for the local people along the Kapuas River.

"To maximize benefits for the local people and district revenue, and minimize leakage from the local economy, the need to put up local businesses using indigenous materials and using local labor has to be emphasized (Cuizon 2008)".

Cultural Services

The area between DSNP and BKNP accommodates more than 30 long-houses in 58 Dayak villages, a great variety of community conserved areas of spiritual significance and for resources management purposes, indigenous knowledge, cultural heritage and tradition, and sites with potential for ecotourism. Knowledge and tradition of indigenous peoples are results of long-term adaptation strategies and observations, based on complex ecological systems, and transmitted from generation to generation (Gadgil et al. 1993). Livelihood strategies and culture of these peoples are part of their adaptation strategies in response to different environments. Forests managed traditionally by Dayak communities include community protected forest and sacred land (Iban: *pulau*), where orangutan and other wildlife encounters are more frequent than in other types of land uses.

Ecotourism: The distinct culture of local population and the wilderness of the Bornean rainforest can attract ecotourism activities. Visiting long-houses, staying with the local communities and witnessing their daily activities such as hand-weaving, watching cultural ceremonies, enjoying orangutan natural habitat, bird watching and swimming in natural swimming pools are appealing ecotourism activities that the government should be more aware of. If properly managed, ecotourism could become the district's main source of revenue through taxes, licenses and occupancy taxes. In Costa Rica, ecotourism is the key to the country's tourism industry which reaches $1 billion a year and has become the second largest source of income after silicon chip production (Dasenbrock 2002).

To maximize benefits for the local people and district revenue, and minimize leakage from the local economy, the need to put up local businesses using indigenous materials and using local labor has to be emphasized (Cuizon 2008). Local people should be the main actors in the management and operation of ecotourism, including providing services and facilities, e.g. accommodation, transport, food including raw materials, traditionally made materials (linen, table cloth, curtain etc.) for daily use in the accommodation, and as local guides (Cochrane pers. comm.). Collaboration across villages and households is required to prevent revenue leakage. The government should provide financial aid and apply policies that make local businesses more competitive, rather than giving the opportunities to external investors.

Having a good understanding on the definition and principles of ecotourism is fundamental, in order not to confuse it with mass tourism or nature-based tourism. Ecotourism can be

defined as "… responsible travel to natural areas that conserves the environment and improves the well-being of local people."

"Ecotourism is about *uniting conservation, communities, and sustainable travel.* This means that those who implement and participate in ecotourism activities should follow the following ecotourism principles:

- Minimize impact;
- Build environmental and cultural awareness and respect;
- Provide positive experiences for both visitors and hosts;
- Provide direct financial benefits for conservation;
- Provide financial benefits and empowerment for local people; and
- Raise sensitivity to host countries' political, environmental, and social climate."

(Source: http://www.ecotourism.org).

Reward mechanisms: There are various forms of ecosystem services that have been well maintained or protected by the local people in this area, e.g., community protected forests in Ngaung Keruh, Sungai Sedik, Pelaik and Meliau. Local people who have been maintaining their forests should be properly acknowledged and rewarded, for examples through conservation award schemes, environmental audit/certification and formal recognition of community protected forests. The conservation awards should be aimed to build social capital for long-term benefits, as well as self-organized capacity. Examples of such conservation awards for local people can include learning opportunities, job/livelihoods support and health facilities (see Prasetyo 2008 for details).

Local and district governments that can prove their commitment and consistency in conservation should receive national and international attention and be rewarded. If the forested landscape between DSNP and BKNP is maintained, conservation awards for the government should also be in place. In addition to the reward mechanisms described above, there are two other forms of reward mechanisms currently being explored in Kapuas Hulu district by many institutions i.e. Payments for Environmental Services (PES) and Reducing Emissions from Deforestation and Forest Degradation (REDD). As the landscape between DSNP and BKNP has important hydrological and carbon-storage functions that can affect the lives of people within the landscape and beyond the provincial and country boundary, Kapuas Hulu district government could explore the possibility of setting up a PES scheme (see Lusiana et al. 2008 for details about PES in Kapuas Hulu) and/or explore the REDD+ scheme as another potential reward mechanisms. Yet both require a careful examination

Figure 4.7 Planting local tree species is an important activity in order to restore riparian forest along Labian-Leboyan (Photo: Yoyon)

of the risks and benefits, and mechanisms of the payment in order to provide a long-term and equitable benefit for the local communities. Wunder (2005) defines PES as a *voluntary* transaction where a well-defined environmental service (or a land-use likely to secure that service) is being 'bought' under the condition that the service is actually provided. Based on this definition where the transaction should be voluntary, PES mechanisms should involve negotiation and free prior informed consent of the involved stakeholders, especially local people who live in the area that provides the environmental service. In addition, where land tenure is unclear, defining who is the provider of the service (subsequently who has the rights to get the payment) is complicated and could lead to conflict. Therefore, in order to reach the intended objectives, there are a series of prerequisites, which are among others:

- Strong local institutions, with good governance, good leadership and negotiation capacity;
- Deep understanding of the involved stakeholders on the risks and benefits;
- Clear, transparent and accountable mechanisms to ensure long-term and equitable benefits for local people, especially those whose land provides the environmental service.

Lusiana et al. (2008) conducted and reported a detail study on the possibility of developing PES in Kapuas Hulu district including methods and mechanisms. For more details on PES and REDD, the following literature could provide some useful overviews: Wunder (2005), Angelsen (2008), Angelsen et al. (2009), CIFOR (2009), Luttrell et al. (2011), Madeira et al. (2010), Secretariat of the Convention on Biological Diversity, Deutsche Gesellschaft fur Internationale Zusammenarbeit (GIZ) (2011).

Climate Change Impacts on People in Labian-Leboyan Corridor

Heru Santoso

Introduction

Climate change is a global phenomenon resulting from accelerated overall warming, with impacts that locally vary. It can affect people directly, for example in the form of heat stroke or dehydration. However, many of the impacts to the people are indirect, such as natural resources degradation like soil erosion due to increase of rain intensity or lowland inundation due to sea level rise. The impacts can also be through meteorological hazards as results of climate variations and meteorological extremes such as floods, droughts, landslides, wild fires or crop failure. These hazards are becoming more imminent because climate variation has amplified and has become more difficult to predict.

Local Dependence on a Predictable Climate

This paper addresses the impacts of climate change to people living in LLC from the perspective of changes in ecological functions as a result of climate change. People living in the corridor are highly dependent on a predictable climate. Their main livelihood is farming. People living by the river usually additionally practice fishing. They normally grow a local slow-growing rice variety during the Danau Sentarum low water level which coincides with the dry season in most parts of Indonesia. Growing paddy is an important aspect of life in LLC, and rice is mainly used for subsistence for villages close to the river, whereas communities in higher areas also derive cash income from farming. Fishing is a major livelihood activity in the lower LLC, also both for subsistence and income generation. In normal conditions these activities can support the livelihood of villagers. Other crops, such as local fruit trees, taro, sweet potato, sugar cane and corn are grown for own consumptions or as animal fodder.

Irregular weather events are a threat to these farmers who are generally poor. Villagers cannot prepare the land for farming when there is too much rain. Planting in these cases needs to be delayed and the periods from planting to harvesting are shortened, which is particularly a problem for the slow-growing varieties. On the other hand, it was observed that faster growing paddy varieties are more sensitive to pest attacks. Particularly insect pests are known to attack this paddy variety in storage. Seeds are more sensitive to pests that attack during germination.

Failure in planting and harvesting could cause significant financial losses, particularly given the high initial expenses for land preparation, fertilizers and pesticides. Therefore, a one-time meteorological anomaly can have effects on food stock over two years and can increase poverty. If high water levels persist over extended periods of time, villagers are forced to open new land for planting on the hill sides. Farmers potentially have alternative sources of income such as handicrafts and animal rising, but these are not yet well developed. Rubber was introduced with support of NGOs and local government as additional cash generation for the villagers. However, rubber tapping is also weather dependent and cannot be done during long rainy conditions.

Climate Change Effects in LLC

The climate of the corridor region is typically moist tropical. Its annual precipitation ranges from 2,800 to 5,500 mm with an average around 4,200 mm (WWF-Indonesia, 1999), and until recently did not show significant changes over 100 years (Berlage Jr. 1949 cited from WWF-Indonesia 1999, Firdaus 2010, Darea 2010). Monthly precipitation distribution shows a V-shape monsoonal pattern, even though nearly all months are wet (more than 100 mm/month). El Niño Southern Oscillation (ENSO) affects inter-annual climate variability and brings long droughts in Indonesia.

Figure 4.8 Exposed bed of Kapuas River during dry season (Photo: Sugeng Hendratno/WWF-Indonesia)

Extreme large vegetation fires in Indonesia correlate with intense drought (Murdiyarso and Adiningsih 2006, Adiningsih et al. 2008). Massive wildfires in DSNP occurred during the El Niño event in 1997-1998 and have caused great damages to trees in the area. The opposite phenomenon, La Niña, brings higher amount of precipitation than normal. This high precipitation creates problems in the corridor area in the forms of flood or prolonged high water levels and resulting crop failure.

A recent study by WWF-Indonesia showed that air temperature of the corridor area might increase by 4°C until 2050, and 5.5°C until 2100. The annual precipitation might decrease, even though monthly precipitations showed variations of increase and decrease relative to the respective weather data in year 2000 (Firdaus 2010). A study in nearby East Kalimantan by Santoso and Herawati (2010) also showed a similar trend of a decreasing annual precipitation with climate change by up to 12% by the end of the 21st century relative to the baseline period 1960-1990. The precipitation differences between average wet months and average dry months would increase by 200 mm or more than 50%. Their study also showed that the number of days with extreme droughts would increase significantly from 14 days/year to between 43 and 55 days/year as indicated by Keetch-Byram Drought Index projection.

More studies are necessary to understand the characteristics and effects of future extreme meteorological events in this area caused by climate change. Global warming could be responsible in accentuating the mechanism of the extreme events (Mimura et al. 2007). The Intergovernmental Panel on Climate Change (IPCC) has recognized that extreme events in the Asian region have increased in intensity and frequency (Lal et al. 2001). Extreme wet years like in 2010 and dry years like in 1997 are likely to occur more frequently in the future.

Climate Change Impacts and Vulnerability

Climate change, including changes in climate variability, is likely to affect ecosystems and their services, for example the flowering time of some plants (Fischlin et al. 2009), decreased water availability, due to higher evaporation, and higher soil erosion due to higher rain intensity (Firdaus 2010, Santoso and Herawati 2010), and higher risk of wildfire occurrences as indicated by longer and more intense droughts. Changes in the availability of ecosystem services could adversely affect the people whose livelihoods dependent on these ecosystem services. As discussed above, potential impacts of climate change on people in this corridor could be in the form of reduced food security and increased poverty. The impact

"The integrity of the upstream ecosystem needs to be protected to ensure maximum function of the ecosystem, and therefore enable it to buffer climate anomalies or extremes".

Figure 4.9 Danau Luar is the biggest lake in the Sentarum complex and regularly falls dry in drought years (Photo: Sugeng Hendratno/WWF-Indonesia)

of climate change to inhabitants of LLC in the future will depend on the adaptive capacity of the villagers, particularly in respect to vulnerability of livelihoods to extreme weather events. These impacts could be reduced through increasing adaptive capacities, namely through development of alternative livelihoods or income sources that are less weather-dependent. Finding alternative livelihood or other sources of income for the villagers in the corridor area and community empowerment in general are indirect means to help villagers to have additional cash to buy food to reduce the risk of hunger.

The integrity of the upstream ecosystem needs to be protected to ensure maximum function of the ecosystem, and therefore enable it to buffer climate anomalies or extremes. In general, good quality forests have a better capacity to absorb stresses and therefore are more resilient to climate change (Seppala et al. 2009). The government has an important role to stimulate community empowerment, including alternative livelihood, and to ensure the integrity of the environment through spatial plans and regulations on land management and practices that reduce stresses to the ecosystem. Civil society groups could take part in the community empowerment through technical supervisions, as well as skill and entrepreneurship development. Good coordination among players of different levels and sectors in helping the vulnerable villagers is essential.

Biomass and Carbon Stocks Assessment and Forest Rehabilitation in Labian-Leboyan Corridor

Rudi Zapariza, Istomo, Arif Budiman and Amri Yahya

Introduction

WWF as a global conservation organization is involved in the response to worldwide environmental issues, including climate change mitigation and adaptation activities. One of the efforts of WWF-Indonesia is the rehabilitation of forest ecosystems in West Kalimantan on more than 1,000 ha in Lanjak Protected Forest, BatangLupar Sub-District, Kapuas Hulu. The location has been strategically chosen because the rehabilitation of currently degraded land will not only sequester carbon but also connect two national parks (DSNP and BKNP) through a Labian-Leboyan Corridor.

Methods

Mixed plantations will be developed in four planting stages over four years (2010-2014). Quantitative data is gathered to find out the amount of carbon sequestration from this project. To achieve this, conditions of the areas are characterized, including the general trend or the dynamics of carbon stocks in the future without intervention (business as usual/ BAU). Therefore, a baseline assessment is needed to provide information as a starting point for the project as well as for monitoring. In addition relevant demographic data, social economic and livelihoods profiles, biophysical data, and information on potential obstacles and challenges will be gathered. The assessment will give a projection of the trends in land cover use led by this project and, thus, carbon sequestration can be estimated. This information will also help to inform governmental and non-governmental stakeholders to develop and implement local Reduced Emissions from Deforestation and Forest Degradation (REDD) pilot activities elsewhere.

The Lanjak Protected Forest landscape comprises different types of land cover, namely: (1) dense forest; (2) logged medium dense forest; (3) open, logged, burnt forest; (4) tall shrubs; (5) underbrush; (6) shifting cultivation; (7) grasslands; and (8) fallow or abandoned agricultural land. Planting patterns and tree species to be planted are chosen according to land cover conditions. Priority is given to multipurpose trees, producing non-woody forest products such as fruits (e.g. 'Tengkawang' *Shorea* spp., 'Durian' *Durio zibethinus* and 'Cempedak' *Artocarpus* sp.), 'Nyatoh' *Palaquium gutta* and 'Rubber" *Hevea brasiliensis*).

The selection of such useful trees is meant to encourage participation in the tree planting and in the subsequent maintenance of the planting plots. Planting patterns and tree combinations are selected according to land cover types and tree characteristics. The trees are planted at intervals of 5 m, resulting in 400 trees per ha. Until a canopy is formed, local people can use spaces in between all the trees for growing crops. The climax trees, 'Tengkawang' and 'Nyatoh', are interplanted in medium or open-canopy forest areas, as they cannot grow in open lands (grasslands, shrubs, etc.) while Rubber, 'Durian' and 'Cempedak' are planted on open lands.

Satellite images are used to identify land use types classified (after geometric corrections and enhancements) according to pre-defined land cover class types to produce a land cover map. Validation of images is based on field data.
Biomass and carbon stock have been calculated based on secondary data. Different estimations of biomass in forest and land cover areas are applied to find the total biomass in the study area. The biomass estimation of the landscape is achieved in four steps:

1. Identification of forest and land-cover types in the project location through spatial analysis;
2. Biomass estimation of each type of land-cover based on biomass value data found in literature;
3. Calculation of total biomass in study area by multiplying (extrapolation) biomass/ha value and the area of each land cover type;
4. Calculation of carbon stock in each land cover type by multiplying total biomass and carbon in biomass (50%).

Figure 4.10 Monitoring and evaluation visit to the ironwood nursery of the LLC restoration project (Photo: Dedy Wahyudi/WWF-Indonesia)

Results

Literature research yielded information on biomass for different land cover types found in the forest landscape (Table 4.1).

Tabel 4.1 Biomass values for different land cover types

No	Land cover type	Biomass (ton/ha)	Source
1	Dry lowland forest - medium open canopy	264	Brown (1997)
2	Dry lowland forest - very open canopy	73	Prakoso (2006)
3	Peat swamp forest medium open canopy	234	Uryu et al. (2008)
4	Forest regrowth	37	Michel et al. (2005)
5	Swampy forest regrowth	37	Michel et al. (2005) in Uryu (2008)
6	Shrubs	30	Prasetyoet al. (2000)
7	Mixed garden	56	Prasetyoet al. (2000)
8	Mixed agriculture	51	Michel et al. (2005)
9	Grassland	12	Prasetyoet al. (2000)

Figure 4.11 Ironwood *Eusideroxylon zwagerii* nursery managed by local people in LLC (Photo: Yuliantini/WWF-Indonesia)

The area contains about 36,872.9 tons of biomass, with a carbon stock (about 50% of the biomass) of 18,436.4 tons. Biomass and carbon stock for each land cover type can be seen in Table 4.2.

Tabel 4.2 Biomass and carbon stock estimation of each land cover type in the rehabilitation area

Block	No	Land cover type	Area (ha)	Biomass (ton)	Carbon (ton)
1a	1	Dry lowland forest medium open canopy	2.53	667.4	333.7
	2	Forest regrowth (Belukar)	53.24	1,970.0	985.0
	3	Mixed agriculture	13.25	675.6	337.8
	4	Mixed garden	30.05	1,682.8	841.4
	5	Shrubs (Semak/BelukarMuda)	85.97	2,579.1	1,289.6
Total			**185.04**	**7,574.9**	**3,787.5**
1b	1	Cleared	0.67	-	-
	2	Dry lowland forest medium open canopy	2.13	561.1	280.6
	3	Forest regrowth (Belukar)	39.70	1,468.7	734.4
	4	Mixed agriculture	35.98	1,834.9	917.5
	5	Mixed garden	24.28	1,359.6	679.8
	6	Shrubs (Semak/BelukarMuda)	94.99	2,849.8	1,424.9
	7	Forest regrowth (Belukar)	0.24	8.9	4.5
	8	Mixed agriculture	0.24	12.3	6.1
Total			**198.22**	**8,095.3**	**4,047.8**
2a	1	Mixed agriculture	37.05	1,889.8	944.9
	2	Shrubs (Semak/BelukarMuda)	173.75	5,212.4	2,606.2
Total			**210.80**	**7,102.20**	**3,551.1**
2b	1	Forest regrowth (Belukar)	26.20	969.3	484.7
	2	Mixed agriculture	30.94	1,577.8	788.9
	3	Peat swamp forest medium open canopy	0.09	20.1	10.0
	4	Shrubs (Semak/BelukarMuda)	177.65	5,329.6	2,664.8
Total			**234.88**	**7,896.8**	**3,948.4**
2c	1	Forest Re-growth (Belukar)	74.97	2,774.1	1,387.0
	2	Mixed agriculture	25.97	1,324.6	662.3
	3	Shrubs (Semak/BelukarMuda)	70.16	2,104.9	1,052.5
Total			**171.1**	**6,203.6**	**3,101.8**
Grand Total			**1,000.05**	**36,872.9**	**18,436.4**

"Since the study location was a shifting cultivation area, every year parts of the area was periodically cleared using the slash and burn technique".

Carbon sequestration scenario with planting: about 400,000 seedlings are needed for 1,000 ha (planted at intervals of 5 m or 400 trees/ha). At an 80% survival rate, the number of trees would be 320,015, while at 60% there would be 240,011 trees. The planting scenarios include four stages of planting, with each comprising 250 ha per year. Tree composition will be 30% hardwood, 40% fruit and 30% rubber trees. The expected biomass and carbon for each of the planting phase is given in Table 4.3 for survival rates of 100%, 80% and 60%.

Tabel 4.3 Expected biomass and carbon for different survival rates (100, 80, 60%)

Project duration	Biomass (ton)			Carbon (ton)		
	100%	80%	60%	100%	80%	60%
Year 5th	4,210	3,368	2,526	2,105	1,684	1,263
Year 10th	12,879	10,304	7,728	6,440	5,152	3,864
Year 5th	46,493	37,194	27,896	23,246	18,597	13,948
Year 30th	326,542	261,234	195,925	163,271	130,617	97,963

Since the study location was a shifting cultivation area, every year parts of the area was periodically cleared using the slash and burn technique. Therefore, if there is no planting intervention, it is estimated that land cover type in the area will remain in an early stage of succession with low biomass and carbon content.

Leakage (carbon emission) assumption during the activity principally includes effects from forest fires, logging and from decomposition. Carbon leakage from forest fires can be measured by the forest fire area, biomass and carbon loss per year, while the rate of logging is calculated from the number of trees removed by this activity in a year. Leakage of biomass and carbon in this planting project due to forest fire and logging has been included in the estimates of plant growth percentages within the different scenarios.

Conclusion

1. Vegetation types of the study site in Lanjak Protection Forest included in the planting project comprising 1,000 ha were dry lowland forest - medium open canopy, dry lowland forest - very open canopy, forest regrowth, shrubs, mixed agriculture, mixed gardens and grasslands. Based on satellite imagery of 1990 – 2000 – 2009, the area is dominated by shrub and regrowth, indicating that most of it is utilized for shifting cultivation.

2. Biomass and carbon in this study location ha under present coverage conditions, before planting, was 36,872 tons and 18,436 tons respectively. The trend of carbon release during ten years was almost stable at about 288 tons/year.

3. Group of tree species being planted include hardwood species, rubber and fruit trees. The hardwood species include 'Tengkawang' *Shorea* spp., 'Nyatoh' *Palaquium gutta*, and Balau *Hopea* spp.which comprise 30% of the species used, Rubber *Hevea brasisliensis* for community livelihood,with 30%. Other species, namely fruit trees, have the potential to supply food for both orangutan and community and include 'Durian' *Durio zibethinus*, 'Cempedak' *Artocarpus* sp., and Rambutan *Nephelium lappaceum* (40% of the trees).

4. In a scenario with four planting phases and survival rates of 100%, 80% and 60% respectively, after 30 years biomass will be 326,542; 261,233; and195,925 tons respectively in the restored area. Assuming the carbon content of biomass is 50%, in 30 years the carbon sequestration of all plants at 100%, 80% and 60% will be 163,271; 130,616; and 97,962 tons respectively, indicating that the project has a high potential for carbon sequestration.

Pollination Biology of Orchids of the Genus *Bulbophyllum* in Labian-Leboyan Corridor

Radian and FX.Widadi Padmarsari

Introduction

Bulbophyllum is the biggest genus of Orchidaceae, estimated to include 2,400 species (Vermeulen 1991). Interest in these plants is high because of their uniqueness and beauty, causing increasing demand for horticulture. To avoid unsustainable harvest from the wild, ex-situ preservation through cultivation and breeding needs to be developed. In order to do that, basic information on reproductive biology, particularly pollination mechanisms, is required. Understanding of these mechanisms is also important for the development of hybridization techniques (Azevedo 2007).

Research on pollination mechanisms in orchid genera, such as *Dendrobium, Coelogyne* and *Phalaenopsis* has resulted in selection of properties desirable for ornamental plants. However, pollination mechanisms of *Bulbophyllum* were not known until recently.

Surveys in LLC yielded the presence of eleven species of this genus, namely *Bulbophyllum beccarii, B. cirlihanensis, B. epicrianthes, B. lilacinum, B. macranthum, B. purpurescens, B. pahudii, B.obtusipetalum, B. uniflorum, B. lasianthum*, and *B*. sp.1.

The objective of this paper is to clarify the pollination biology of *Bulbopyllum* spp. in LLC. It is hoped that this information could be used as basis for the development of artificial hybridization techniques for this orchid genus.

Figure 4.12 Hymenopterans (bees and wasps) are important pollinators of orchids (Photo: Sugeng Hendratno/WWF-Indonesia)

Methods

The research was conducted in LLC and field observations were carried out from May until early October 2009. We observed phenology (including flower production and time of flowering), flower characteristics, pollinators and pollination mechanisms of four members of *Bulbophyllum* spp.

Results

From eleven species of *Bulbophyllum* spp. in LLC, only four species were flowering during our research, namely *B. lilachinum, B. lasianthum, B. macranthum* and *B. pahudii. B. macranthum* and *B. lilachinum* had the same flowering season, during early summer in the dry season (May-June). Flowering in *B. macranthum* was five days, while inflorescences only lasted three days in *B.lilachinum*. *B. pahudii* and *B. lasianthum* were flowering at the end of dry season or early rainy season (August-September). The flowering time of *B. pahudii* is longer (8-10 days) than that of *B. Lasianthum* (5 days).

Members of the order Diptera are pollinating *Bulbophyllum*, with distinct differences among the observed orchid species. Pollinators of *B. macracanthum* were species of the family Tephritidae, including *Bractocera albistrigata. Milichiidae pollinate B. lilachinum, Syrphidae pollinate B. lasianthum*, and flowers of *B. pahudii* are visited by members of both of these families.Visiting time of pollinators on *Bulbophyllum* was in the morning from 7.30 until around 12.30 except for *B. pahudii*, which continued to attract pollinators until afternoon around 17.00 o'clock.

Discussion

Our observation that all four monitored species *Bulbophyllum* in LLC are pollinated by Diptera is in line with Dressler (1981), who also states that *Bulbophyllum* is a miophyllus orchid genus that produces smell attractive to these pollinators. According to Christensen (1994) Diptera of the families Calliphoridae, Lonchaeidae, Milichiidae and Tephridae act as pollinators of orchids. Our research indicates that additionally Syrphidae play a role as pollinators for *Bulophyllum*.

Each monitored *Bulbophyllum* species was visited by a restricted set of insects that do not necessarily visit other members of the genus. Exclusivity of pollinators is probably caused

"Natural hybridization in *Bulbophyllum* is avoided by differential timing of flowering, varying flower characteristics, and pollinator specificity".

by specific chemical compounds produced by the orchids, working as species-specific attractors. Orchids of the genus *Bulbophyllum* do not produce nectar to attract insects. According to Tan and Nishida (2001), there are several volatile chemical compounds produced by *Bulbophyllum*, namely metal eugenols, raspberry ketones and zingerome. These compounds are functional, or precursor of pheromones in *Bractocera* flies.

Pollination in *Bulbophyllum* is not only affected by attractor compounds produced, but also flower morphology. Particularly the labellum of *Bulbophyllum* plays a role in assuring species-specific pollination (Vermeulen 1991,Chan et. al. 1994). This organ attracts insect and facilitates pollination during the visit. Three types can be distinguished: straight labellae with high attractant production, such with low attractant production and smooth lateral sepal surface, and hanging labellae with high attractant production.

Natural hybridization in *Bulbophyllum* is avoided by differential timing of flowering, varying flower characteristics, and pollinator specificity. In LLC, hybridization is only possible between *B. lasianthum* and *B. pahudii* due to overlapping flowering seasons and similar sets of pollinators. Even though having a similar flowering period, hybridization between *B. lilachinnum* and *B. macranthum* is unlikely because of different pollinator assemblages.

Figure 4.13 Flower of a *Bulbophyllum* sp. which is commonly found along forests on river banks (Photo: Sugeng Hendratno/WWF-Indonesia)

Figure 4.14 *Bulbophyllum acuminatum*, flowers may appears in red, orange and yellow with brownish gradient tone; members of the order Diptera are pollinating *Bulbophyllum* with distinct differences among the monitored orchid species. (Photo: Sugeng Hendratno/WWF-Indonesia)

5. Conservation and Livelihood Interventions

The Labian/Leboyan Corridor is an essential component of two higher level initiatives: the Conservation District Declaration of Kapuas Hulu at district level and the Heart of Borneo Initiative at international level. At the core of both initiatives is development that takes into account the framework of local ecological conditions.

The following articles deal with aspects of conservation and livelihood interventions, particularly forest restoration, conservation education, ecotourism, and agroforestry, and the effects of these changing patterns on local communities. The last article explores the legal frame conditions for the establishment of the corridor under Indonesian law.

Figure 5.1 "Ancient rice" - red rice from Tumbali, Labian village is one of the important programme intervention to support the livelihood and conservation in Labian-Leboyan Corridor (Photo: Syahirsyah (Jimmy)/WWF-Indonesia)

Figure 5.2 Dayak woman winnowing rice (Photo: Marc Ancrenaz/HUTAN-KOCP)

Corridor Restoration

Rudi Zapariza and Markus Lasah

The two main approaches to manage climate change are adaptation and mitigation. Adaptation emphasizes adjustment, including patterns of livelihood or resilience of ecosystems. Mitigation includes efforts to keep climate change in a range that will not lead to major disruptions of the energy balance of Earth and includes measures such as forest protection and restoration, reduction of fossil energy generated, or emission trading.

Landscape restoration is a tool that combines these two approaches, at least at a local level. In Labian-Leboyan Corridor (LLC) between Danau Sentarum National Park (DSNP) and Betung Kerihun National Park (BKNP), it is an essential method to re-connect fragmented forest areas and to contribute to overall corridor functions. In general, landscape restoration is defined as "a planned process that aims to regain ecological integrity and enhance human well-being in deforested and degraded landscapes" (Dudley et al. 2005). Ecological integrity comprises the full range of native species and supporting processes of an ecosystem as characteristic of the geographic location, while human well-being includes aspects of economics, peace, health, stability and good governance.

Preceding the implementation of the restoration program, suitable open areas to be planted were identified through a Geographic Information System (GIS) study. Following the analysis ground-truthing took place in the target locations, and land ownership in the community had to be clarified. Agreements with the land owners were sought to initiate the restoration process. Phases of restoration program which were carried out together with the community included:

1. Site identification
2. Negotiations with community
3. Formation of groups involved in restoration
4. Formulation of restoration work plan
5. Implementation

Selection of tree species to be planted in the corridor took into account conservation and economical needs. Other considerations in the selection of plant species was based on the legal status of the area, such as areas for non-forest use (APL), production forest (HP) and protection forest (HL). |For instance, in protection forest areas with rather steep contours, focus was on use of species with high soil and water retention capabilities, interspersed with local fruit crops and Orangutan fruit tree species. In this kind of forest, timber extraction is not allowed, whereas in production forest areas Community Plantation Forest (HTR) is one of the options, which can be reflected in the choice of tree species used for restoration.

Figure 5.3 Rubber *Hevea brasiliensis* is one of the important plantation species in LLC (Photo: Syahirsyah (Jimmy)/WWF-Indonesia)

Flat areas of this forest category could be planted with trees that have direct economic value, such as rubber or agarwood, interspersed with other crops adapted to agroforestry conditions.

Restoration projects always included a capacity building component for involved communities, in order to enable them to manage the restoration sites later on. This was achieved through knowledge sharing within the community, government agencies, as well as other institutions and included nursery and group management, or development of activity plans. Transfer of knowledge between communities was facilitated as well, in cases where groups already had advanced technical expertise and were able to share this with other groups.

Orangutan Education and Awareness Campaign

Lia Syafitri

Indonesia is known as a hotspot of biodiversity (megadiversity), regarding both flora and fauna. The World Conservation Institute states that more than 16% of the world's flora and fauna species are found in Indonesia. Certain species can serve as flagship species for their habitats and promote conservation. A flagship species of West Kalimantan is the Orangutan *Pongo pygmaeus pygmaeus*. However, populations are decreasing rapidly in the province, and their habitats are more and more under threat. Efforts to protect the Orangutan are undertaken to halt the decline of the remaining populations, as well as the rate at which forested lands are decreasing.

One approach used to spread knowledge and understanding of wildlife conservation, particularly for said species, is through the 'Orangutan Conservation Campaign', which is carried out in LLC. The campaign uses educational methods in an interactive way. It involves the wider community of forest-dependent people living in the corridor area, which is an Orangutan important habitat itself, but also connects to Orangutan populations in Betung Kerihun and Danau Sentarum National Parks.

Figure 5.4 Awareness campaigns target school children since they still have open minds with regard to conservation (Photo: Sugeng Hendratno/WWF-Indonesia)

Activities and strategy

Between 2008 and 2011, WWF-Indonesia West Kalimantan Program conducted six 'Orangutan Conservation Campaigns'. The target locations were villages in protected areas and their surroundings, such as national parks and other conservation areas serving as Orangutan habitat in LLC. The target groups were pupils of elementary and secondary schools, as well as the wider community.

Locations in which the Orangutan Conservation Campaign was carried out include:

1. Ukit-Ukit Sub Village, Labian Village, Batang Lupar Sub District (2008)
2. Nanga Leboyan Village, Selimbau Sub District (2008)
3. Sungai Sedik Sub Village, Sungai Abau Village, Batang Lupar Sub District (2009)
4. Meliau Sub Village, Melemba Village, Batang Lupar Sub District (2010)
5. Senunuk Village (Keladan, Kapar, and Guntul Sub Village), Batang Lupar Sub District (2011)
6. Setulang Village (Libung and Sumpak: Sumpak Layang and Sumpak Setulang – Sub Village), Batang Lupar Sub District (2011)

The time allocated for each campaign was three days and two nights, during which the participants, along with a local committee (teachers, villagers) and the WWF crew spent time together in the field. The main strategy was to build environmental awareness and understanding of the sustainable use of forest and other natural resources from an early age. The campaign served as a tool to build a more complex understanding among local communities of ecosystem components and their interactions, such as water, soil, air, plants, and animals.

The last two locations of the Orangutan Conservation Campaign included six Iban longhouses. An activity conducted in the evening emphasized on the socialization of law enforcement on Orangutan conservation (protection laws and legal punishments, based on Regulations No. 5 of 1990 on the Conservation of Natural Resources and Ecosystems), and how Orangutan conservation efforts can be reinforced or strengthened through religious values. Sessions were attended by the majority of inhabitants of the longhouse of all age classes.

The average number of attendees for a one-time event of the Orangutan Conservation Campaign was about 300 people. The presented material covered information on the decreasing Orangutan population in the wild, decreasing remaining natural habitats due to illegal logging, plantation establishment, and habitat fragmentation, as well as hunting/ poaching, keeping Orangutans as pets, and illegal trading.

Local communities were generally very receptive to the information provided. In some cases local people handed over the young Orangutans which they had found in the wild, or which they kept as pets. As an effect of the campaign, the number of Orangutan hunting activities was observed to be declining. Additionally, customary law either implicit or written, was again implemented and led already to customary punishments for Orangutan hunting in some cases. A network of communities involved in Orangutan conservation and sustainable management of natural resources is being built up. Through direct involvement, the communities were gaining a sense of ownership of the project.

Figure 5.5 Film documentaries are effective tools to deliver the conservation message to the public (Photo: Sugeng Hendratno/WWF-Indonesia)

Figure 5.6 Winning entry for a colouring activity for elementary school children.
(Photo: Sugeng Hendratno/WWF-Indonesia)

Strategies for a Conservation District: Ecotourism in Kapuas Hulu

Tatang Suryadi and Syarif Usmardan

This presents the concept of areal development and spatial planning in Kapuas Hulu District, based on theoretical and empirical aspects of spatial planning in the district and the country. Two aspects are unique for Kapuas Hulu, namely the district was nationally selected as Conservation District, and that it has a land border to Malaysia with unique local physical or ecological, socio- cultural and economical aspects. The last section deals with district policies and strategies of spatial planning passed by the government in order to put in place the goals of District Spatial Planning by means of ecotourism as main strategy.

The concept of area development

In Indonesia, spatial planning has a relatively long history. A more established legal instrument on spatial planning passed by Indonesian Government was the Law 24/1992. However, due to progressively more complicated demands in all sectors throughout the country, the government then had to improve this instrument through another law (26/2007). According to the Directorate of Spatial Planning (2005), area development in Indonesia basically materialized from an interactive process combining theoretical understanding and practical experiences that are dynamically implemented. Some familiar Western spatial plan theories include the space-forming theory by Walter Isard which examines the causality between primary factors forming space including physical, social-economic, and cultural factors; Hirschmann's theory (1950s era) regarding the polarization effect and trickle- down effect states that the development of an area does not happen concurrently (unbalanced development, just to mention a few. In Indonesia, above mentioned theories were re-developed by Poernomosidhi (transition era) that contributed to the emergence of cities' hierarchy and road hierarchy concepts. A temporary conclusion that can be drawn from the brief histories outlined above is that the area development concepts we adopt in the country are combining different increasingly changing theories and models that have been tested and then reformulated to fit Indonesian characteristics.

Strategic issues

In order to develop a safe, productive and sustainable spatial plan as mandated by Law 26/2007, a Revised Spatial Plan of Kapuas Hulu District of 2010 was implemented under a shared budget form the Ministry of Public Works and the district government. The District Technical Team consists of various agencies within Kapuas Hulu District Government SKPD and NGOs (WWF, FFI, SKALA, GIZ, CIFOR, etc.). The active involvement of the NGOs, particularly WWF, in providing critical information for the revised Spatial Planning Document has been crucial for the success of the process, particularly in respect to responses to global issues, like climate change. At district level, the most important issues to be considered by land use planning include poverty alleviation, unequal development,

"Tourism and particularly ecotourism as core strategy can be seen nested in a set of other goals (cores) with several clusters each".

environmental degradation (deforestation and land degradation), local autonomy and area expansion; and ecological richness (biodiversity in two national parks, upriver water catchment areas, particularly Danau Sentarum, extensive peat land acting as "giant sponge" during dry spells), and cultural diversity of the many ethnic groups present in the district. The conservation district approach also includes ecotourism in Kapuas Hulu District for the planning period 2010-2031.

Ecotourism as core strategy

Every area on the planet has its genuine characteristics. This also applies to Kapuas Hulu District. However, the lack of capital and investment has been slowing down the rate of development of Kapuas Hulu District in respect to tourism despite its potential and natural richness. One indication of the outstanding biological richness of the district is the inclusion of entire Kapuas Hulu area into the Heart of Borneo initiative (ca. 3,117 million hectares or equal to ± 13 % of HoB area) Awareness and inclination of the local community towards environmental protection dates back much further, as indicated by District Head Decree No. 144 of 2003 declaring Kapuas Hulu District as District of Conservation in May of 2003. This is also reflected in the Revised District Spatial Planning of 2010, with ecotourism singled out as particular development goal. Tourism and particularly ecotourism as core strategy can be seen nested in a set of other goals (cores) with several clusters each. The second core within three clusters, includes forestry, fishery, and agriculture; all these clusters are expected to support each other for the sake of realization of Kapuas

Figure 5.7 Meeting with the spatial planning unit of the district to introduce the District Strategic Areas of the corridor (Photo: Rudi Zapariza/WWF-Indonesia)

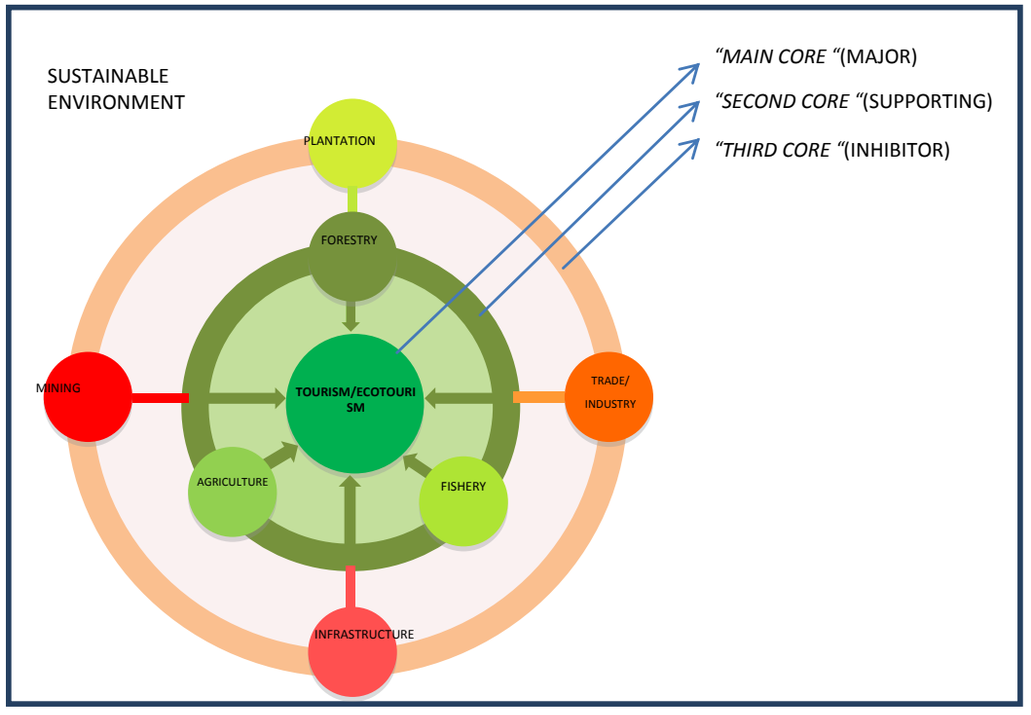

Figure 5.8 Development concept of Kapuas Hulu District in respect to tourism

Hulu's ecotourism goals. The third core, poses a potential threat to the other cores and includes plantation, mining, trading/industry, and infrastructure. It is therefore the third core development which must strictly apply best management practices in order to avoid to serious degradation of the other cores.

The concept springs from intense and long discussions among various stakeholders in 2010 which resulted in the formulation of policies for Kapuas Hulu District as a Conservation District which will mainly depend on ecotourism (tourism sector). This strategic choice is quite different from other districts across West Kalimantan Province. Consequently, there has been criticism of the concept of Kapuas Hulu District relying on the tourism sector (ecotourism) for revenue generating in the future. A forest cover of 71%, out of which 52% is situated in two national parks, puts the district into an advantageous situation for this kind of strategy compared to other districts.

LLC as district strategy

A more detailed workplan is required in order to accelerate investment of development in Kapuas Hulu District. This will be achieved in the form of a more specific spatial planning document, the District Detailed Spatial Planning (RDTR), which is derived from documents of the District, Provincial, and National Spatial Plans. Three strategic areas (KSK) for the district include agriculture, ecotourism and conservation corridor development. Realization has been complicated by the lack of funds. However, with the support of WWF and GIZ the three KSK's documents can be realized within 2011 – 2012.

Ecotourism as Alternative Source of Income for Local Communities

Hermas Rintik Maring

Introduction

World tourism shows a trend away from mass travel, which usually does not contribute much to local economies, and sometimes is accused of disrupting local communities. Efforts are increasing to make travel more environmentally friendly and create positive economic impacts for local communities in tourist destinations.

This is supported by another trend of tourists increasingly being interested in visiting places that have both natural attractions and authenticity of local culture. This kind of tourism style is known as ecotourism. According to The International Ecotourism Society (TIES), ecotourism, or ecological tourism, is responsible travelling to natural places while preserving the environment and improving welfare of local communities. Ecotourism should contribute to preservation of existing natural resources and provide incentives for communities and ecotourism actors to improve natural resources conservation efforts. The main asset for the development of ecotourism activities is the existence and authenticity of the natural resources. Ideally an environment should be created, where both tourists and the communities are able to exchange knowledge and information. Economically, ecotourism activities should provide additional income for the region and the communities in sites of interest. Ecotourists should not erode habits and customs of local people, but instead contribute to maintaining and even reviving traditional practices of local communities.

Ecotourism potential of Kapuas Hulu and Labian-Leboyan Corridor

In term of authenticity of local cultures and natural beauty, Kapuas Hulu District has opportunities to develop ecotourism and thereby increase local income. Kapuas Hulu has two national parks with distinct landscapes, as well as a diversity of unique cultures.

LLC is set between the two national parks and shares many of their unique features. Access is relatively easy from several gateways. There is a land border crossing between Indonesia and Malaysia (Sarawak) only about 180 km from Kapuas Hulu.

LLC is a microcosm of local cultures, namely Dayak in the upriver areas adjacent to Betung Kerihun National Park and Malay settlements nearby Danau Sentarum, and visitors could thus experience first-hand the culture and daily life of the Iban, Tamambaloh and Melayu communities in their respective villages. LLC is important also as wildlife corridor, particularly for Orangutans, which together with other wildlife may be observed by visiting tourists.

Figure 5.9 One World Group tour from Germany starting their jungle trek in the Heart of Borneo, Mendalam River (Photo: Albertus Tjiu/WWF-Indonesia)

Economic assessment of ecotourism activities

Local communities may derive direct, as well as indirect benefits from ecotourism activities. Direct benefits are those that have a direct positive economic impacts on communities, such as wages, incentives, or other local spending by tourists. Indirect benefits or sometimes called social benefits are in the form of development and attention paid to communities. Tourist destinations almost always are priority areas for development and receive special attention by governments and private sectors alike. This is partly due to mass media exposure and presence of visitors from foreign countries. In Indonesia the island of Bali is the best example for a region developed as result of tourism.

The potential macro-economic impact of ecotourism for communities in LLC can be calculated. For example, a single family household which develops accommodations for tourists (homestay) can create an income of Rp. 600.000 per month, assuming ten visitors stay for two nights each, with accommodation expenses of Rp. 30.000 per person and night. Modest lodging can be managed by just one person and could considerably augment family income. Still, this family could easily enter into other related activities such as catering service, laundry, transportation and others. This income is comparable to revenues generated by farming activities, for example planting rice. On household level this activity generates about Rp. 1,000,000 a month, not considering farming inputs (ca. Rp. 100,000 per month) and full-time labour of two persons.

Finally, a functional ecotourism scheme will likely provide additional motivation for communities to better protect forest and wildlife around them.

Production and Marketing Potential of Rubber in Batang Lupar District - A Case Study in Mensiau, Labian, and Abau River Villages

Anas Nasrullah and Ilahang

Introduction

Rubber is one of most important livelihood sources for people in LLC. Consequently, forest restoration activities in the corridor included the development of rubber production systems. Integration into multi-species agroforestry systems is expected to increase the productivity of rubber, without eliminating the environmental benefits of forests and even contribute to preserve Orangutan habitats.

Aside from cultivation aspects in the development of rubber-based forest restoration projects, some related aspects of post-production and marketing also need to be considered. A research project was therefore conducted which aimed to obtain information on: (1) the area of rubber plantations that presently exist and the development of additional areas within the next few years, (2) the potential production of rubber (local and imported varieties) in the study area, (3) types of rubber produced by farmers, (4) different qualities of rubber, (5) the marketing chain of rubber in LLC, and (6) the price of rubber within each link of the marketing chain.

Figure 5.10 Raw rubber harvest ready for shipping (Photo: Ilahang)

Methods

The research was conducted from19 to 23 January 2011 in Kelawik and Bakul Sub-villages, MensiauVillage, Ukit-Ukit; Labian and Long River Sub-village, Abau River Village, Batang Lupar District, Kapuas Hulu District. Data collection was done using group discussions which were attended by rubber farmers, traders, village officials and traditional leaders. Data processing was done by tabulation in order to obtain prices, production volume, trade system margins and to clarify the trade system chain.

Results and Discussion

Area of rubber plantations: the largest rubber plantations were located in Bakul I, II and III Sub-villages (257.5 ha), followed by Kelawik (164 ha), Ukit-Ukit. The individually-owned plots of rubber plantation ranged from 0.5 ha to 10 ha, with tree numbers of 100-1,000 trees / ha. Categories distinguished during the survey were: rubber plants older than 25 years (TT), highly productive plantations aged 10-15 years (TM), not-yet productive plantions aged 1-10 years (TBM). Planting materials of the older and productive rubber plantations were local varieties, while local and superior varieties were used for the newly established plantations. The largest category was the newly established plantations.

Production potential of local and superior rubber varieties

Most households in the research site still rely on old rubber plantations (TT), and partly on the highly productive medium-aged plantations (TM; Tab. 5.1). Kelawik Village currently has a production potential of 20,550 kg, Bakul I, II and III Villages 16,120 kg of wet rubber per month, an Sei Sedik and Ukit-ukit Village 8,940 kg of wet rubber per month respectively. Five years in the future the production in Ukit-Ukit will increase sevenfold, due to maturation of newly-established plantations using superior varieties as planting material.

Table 5.1 Actual and potential production of different plantation categories in the research sites

Village	Potential Production (wet kg/ha/month)			
	Old plantations (TT)	Medium-aged plantations (TM)	New plantations(TBM)[1]	Total present production
Kelawik, Mensiau	19.950	600	51.000	20.550
Bakul, Mensiau	14.520	1.600	90.500	16.120
Ukit-ukit, Labian	5.400	1.200	51.000	6.600
Sei Sedik, Sungai Abau	5.440	3.500	8.000	8.940
				52.210

Estimated production within next five years

Generally, the quality of rubber produced in the research sites is "class Araw" rubber (bokar), with dry rubber content ranging from 50-52%. There are hardly any contaminants found, such as leaves, soil, rocks, or sand. Storage duration has the largest influence on the quality of the raw product.

Bokar trade chains

The rubber trading system at the research site follows a common pattern from producers, in this case farmers, to the middlemen, to the processors or factories. Several variations of the pattern exist from one village to the next. Number of middlemen can vary, so there are chains of different lengths. The causes of these differences are: (1) the distance of the producer to the processing factory, (2) ease of payment, (3) the relationship between farmers and middlemen (4) relations between middlemen and processing plants, and (5) marketing time of *bokar*.

Price of bokar

The *bokar* price at farm gate is determined mainly by the length of marketing chain and the negotiation process. Farmers from Ukit-Ukit Village receive the highest price with 72% of factory price. This is because the middlemen in Ukit-Ukit directly sell to the wholesalers

or to brokers in Badau. Farmers from Bakul receive the lowest price of only about 45% of the factory price, because of the number of middlemen involved. Clearly, infrastructure affects the trading system and the length of trade chain which in turn affects the prices received by farmers. The frequency of *bokar* transactions between farmers and traders at the village level is generally once a week. Traders not only provide a predictable cash flow, but can also provide farm inputs or cash loans. Procedures of the transactions are flexible and based on mutual trust. In this region there have not yet been any institutionalized bokar marketing efforts through organized farmers' groups or koperasi, nor any partnership systems or auctions.

Conclusions and recommendations

It is recommendable to expand the use of high quality varieties, which are superior in terms of production. Estimated production in Kelawik and Bakul per month is 36.5 tons. This means that every month about Rp 365 million are generated with rubber, based on a price of Rp 10.000/kg. By cutting the trading chain, profit margins can be increased. Institutional marketing tools need to be introduced in these villages, like marketing groups consisting of producers. Direct sales to Lanjak can increase the margin by 29% for farmers in Bakul and by 17% for farmers in Kelawik.

Figure 5.11 Ten-year-old rubber plantation (Photo: Sugeng Hendratno/WWF-Indonesia)

These cooperatives could also provide other basic needs and possibly cash loans.
Cooperatives should then partner directly with rubber processing factories.
Study visits for farmers to existing rubber cooperatives in other areas are advisable to introduce new marketing strategies, as well as advanced processing methods. The latter could also help to buffer market price fluctuations.

Livelihoods and Conservation – The Impact of Shifting Land Use Patterns on Rural Livelihoods in the Labian-Leboyan Corridor

Barbara Beckert

Introduction

In international conservation, grassroots and benefits for the local people living in proximity to protected areas are nowadays widely recognized. The topicality of rainforest destruction and global conservation programmes is complemented by scientific research on livelihoods, forest and conservation (e.g. Salafsky and Wollenberg 2000, Sunderlin et al. 2005, Naughton-Treves et al. 2005, Agrawal and Redford 2006). The disappearance of forests in developing countries severely affects rural people, who are often very much dependent on forest products and services, as markets and labour opportunities are usually far away. Access to natural resources is often restricted through national park laws. However, there is a recent shift in global conservation strategies, which now focus on local realities of the rural poor and include them into conservation plans.

Today, the environment in LLC can be regarded as contested. Conservation attempts from different actors and stakeholders, such as the regional government, national park offices and environmental organizations, stand in stark contrast to illegal cross-border activities, such as logging and wildlife trade, and to the granted concessions for oil palm plantations. At the local level, society seems to be divided into two groups. One group believes in the long-term benefits of environmental conservation, reforestation, sustainable farming, usage of Non-Timber-Forest-Products (NTFP) and future benefits of ecotourism programmes. Another group of people is strongly against these attempts. The core question of the study which has been undertaken in Labian and Mensiau Villages from February to March 2010 is: What are the effects of conservation programmes at household level in the corridor area? In order to tackle this central question, a focus on rural farmers' livelihoods provides the basis of analysis. Shifting land use patterns influence rural livelihoods and are in return influenced by a range of actors operating on different levels.

Theoretical background of the study

The Sustainable Livelihoods Framework (SLF) (DFID 1999) is regarded as basis of analysis and is depicted against the background of a political ecology (Blaikie and Brookfield 1987) and an environmental entitlements approach (Leach et al. 1999). This theoretical foundation helps to analyse the specific vulnerability context of farmers operating in a contested environment. Simply put, a combination of the more structure-oriented perspective of political ecology approaches with the actor-orientation of the SLF seems to be crucial in order to understand the shifting land use patterns and their implications on rural livelihoods

"The analysis has revealed that shifting land use patterns had significant impacts on livelihoods of farmers in the research villages".

in the corridor area. The SLF views people operating in a vulnerability context (trends; shocks; seasonality). Within this context, people have access to certain assets and poverty-reducing factors which gain their meaning through the existing social, institutional and organizational environment. In a context of the prevailing structural conditions the assets or 'capitals' lead into livelihood strategies (agricultural intensification/extensification; livelihood diversification; migration), pursuing beneficial livelihood outcomes which meet the people's own livelihood objectives (DFID 1999: 1.1). Analysing the asset endowments and environmental entitlements of local farmers facilitates an understanding of livelihood strategies undertaken in a vulnerability context and helps depicting the effects environmental conservation programmes have on local households. At the same time, agents operating on various levels and influencing the negotiation processes of shifting land use patterns were integrated.

The impact of shifting land use patterns on rural livelihoods

The analysis has revealed that shifting land use patterns had significant impacts on livelihoods of farmers in the research villages. In comparison to income derived from illegal logging, the actual income has generally declined in both research villages. However, through the extension of market access for rubber, organic farming and handicraft products, income levels are assumed to rise in the future. Beside income generation, forest restoration plays an important role. Valuable timber species as well as fruit trees are mixed with rubber trees. A more sustainable use of the natural resource base is becoming a major concern of villagers in the area. Most of the interviewed households, which pursued the livelihood strategies of intensification and diversification, regard the shift in land use patterns from resource depletion towards economic and environmental sustainability as an investment for their future generations. In this sense a more sustainable use of the natural resource base is valued as major benefit. Through agroforestry systems and reforestation of the land area, the exposure towards shocks arising from the vulnerability context, like floods, landslides and erosion processes will be diminished along with the growing of the trees, especially in Labian where conservation plays already today a very important role. Impacts from seasonality still affect households; however the pursued livelihood diversification strategies can diminish the extent of vulnerability.

The sensitivity and particularly the capacity of response have decreased implicitly in recent years in both villages especially due to lower natural and financial capital endowment. This was most significant in Labian Village. Nevertheless, measures of conservation have already and will continue to decrease these components of vulnerability in future. In terms of food security, agricultural yields are complemented by hunting and gathering activities in forest areas. As these areas have been degraded significantly in recent history also food security has decreased, especially so in Kelawik. Observing increasing conservation efforts indicates a more positive picture for the future, though. Moreover, farming activities have been intensified in Labian Village so that more yields can be derived for sale as well as for own consumption. Food security in Kelawik depends much on success in shifting cultivation which has become increasingly difficult, threatening the food security of many people in this village. However, an environmental awareness trend has become apparent recently indicating the importance of conservation. Well-being is not only factor of income and food security. Dayak cultural traditions are related to the environment and affect people´s well-being. Resource depletion has undermined traditional cultural values and perceptions of the environment. Environmental sustainability and conservation can thus lead to a future sense of well-being of people in the corridor area.

Figure 5.12 Shifting cultivation is still a standard practice in some areas of LLC (Photo: Barbara Beckert/University of Bonn, Germany)

Conclusions

The case study has elaborated on the vulnerability context of local farmers, and identified adverse asset endowments. Mensiau Village is located relatively far away from the main road and market access is therefore restricted. In comparison, Labian Village has a better infrastructure and therefore benefits derived from agriculture and agroforestry play a significant role in their livelihoods. Access to natural resources is not only regulated by e.g. national park laws, but also by communal and customary laws. In a short term perspective conservation restricts the usage of natural resources and therefore the immediate material benefits decline. Long-term benefits of environmental sustainability and conservation are not only predicted by NGOs but are also acknowledged by the villagers, however varying in the extent between Labian and Mensiau Village. Agency relations are central in farmer's livelihood settings, not only on a local but also on a national level. Global operating agents in turn shape not only natural resource extraction but also conservation strategies on a local level. Linking livelihoods and conservation is an emerging topic in scientific research as well as a new guiding principle of conservation management. Thus, this field study revealed that environmental conservation in the corridor area can only be tackled by strengthening local livelihoods. Participatory bottom-up approaches in Labian Village show that participation and inclusion of local actors can lead to mutual strengthening of conservation action practices among the villagers.

Figure 5.13 Farmers traditionally work in groups during times of planting (Photo: Barbara Beckert/University of Bonn, Germany)

Legal and Administrative Framework of Labian-Leboyan Corridor

Patria Palgunadi

Definitions

The term "corridor" in an Indonesian legal context can be found in Government Regulation No. 26 of 2008 on national spatial planning, as one form of nationally protected area. In Government Regulation No. 26 of 2008, it is stated that:

> (7) Corridor for protected wildlife species and marine biota as of clause 52 verse (6) letter g is defined as:
>
> a. Area with a unique ecosystem, endemic biota, or processes of life support;
> b. Supporting the migration of marine biota.

Area status of LLC

The Decree of the Ministry of Forestry No. 259 of 2000 on West Kalimantan Forest Areas and Aquatic Resources has identified the following land use categories within LLC:

1. **National Park**
   a. Betung Kerihun National Park
   b. Danau Sentarum National Park
2. **Lanjak Hill Protected Forest**
3. **Production Forest**
   a. Limited Production Forest
   b. Conversion Production Forest
4. **Area of Other Use**

Relevant forestry legislations and policies regarding planning, management, and utilization of forest are regulated in Act No. 41 of 1999 on Forestry. The government defines the forests by its principal function, such as:

a. Conversion forest
b. Protection forest (Lanjak Hill Protected Forest, etc.)
c. Production forest (in LLC there are limited areas within this category)

"Wildlife corridor are explicitly mentioned in the Government Regulation No. 26 of 2008 on the National Spatial Plan, characterized by unique ecosystem, endemic biota, or the processes of life support."

Aspects of spatial plan legislations and policies

In the realm of spatial policy there are five classifications based on the primary function of an area, administrative area, activity area and the strategic value of the area.
Based on Act No. 26 of 2007 on Spatial Planning the main area functions found in LLC include:

1. ***Protected Areas (Clause 52 Government Regulation No. 6 of 2008):***
   a. Betung Kerihun National Park
   b. Danau Sentarum National Park
   c. Lanjak Hill Protected Forest
   d. Corridor area (LLC) for Orangutan (Clause 52 verse (6) letter g, Government Regulation No. 6 of 2008).

2. ***Cultivated Area (Clause 63 Government Regulation No. 6 of 2008):***
   a. Limited Production Forest
   b. Conversion Production Forest
   c. Settlements
   d. Agriculture
   e. Fisheries
   f. Tourism

3. ***National Strategic Areas of TNBK and TNDS***

Planning instruments as applicable for LLC

Central Government: Based on the Act No. 26 of 2007 on Spatial Planning within the framework of the implementation of spatial planning, the government has the authority to plan, utilize and control the national area. Also mentioned in this law is that the nature of spatial planning is hierarchic.

Wildlife corridor legislation

Wildlife corridor are explicitly mentioned in the Government Regulation No. 26 of 2008 on the National Spatial Plan, characterized by unique ecosystem, endemic biota, or the processes of life support. There are several options in forestry laws and policies in order to develop wildlife corridors, for example:

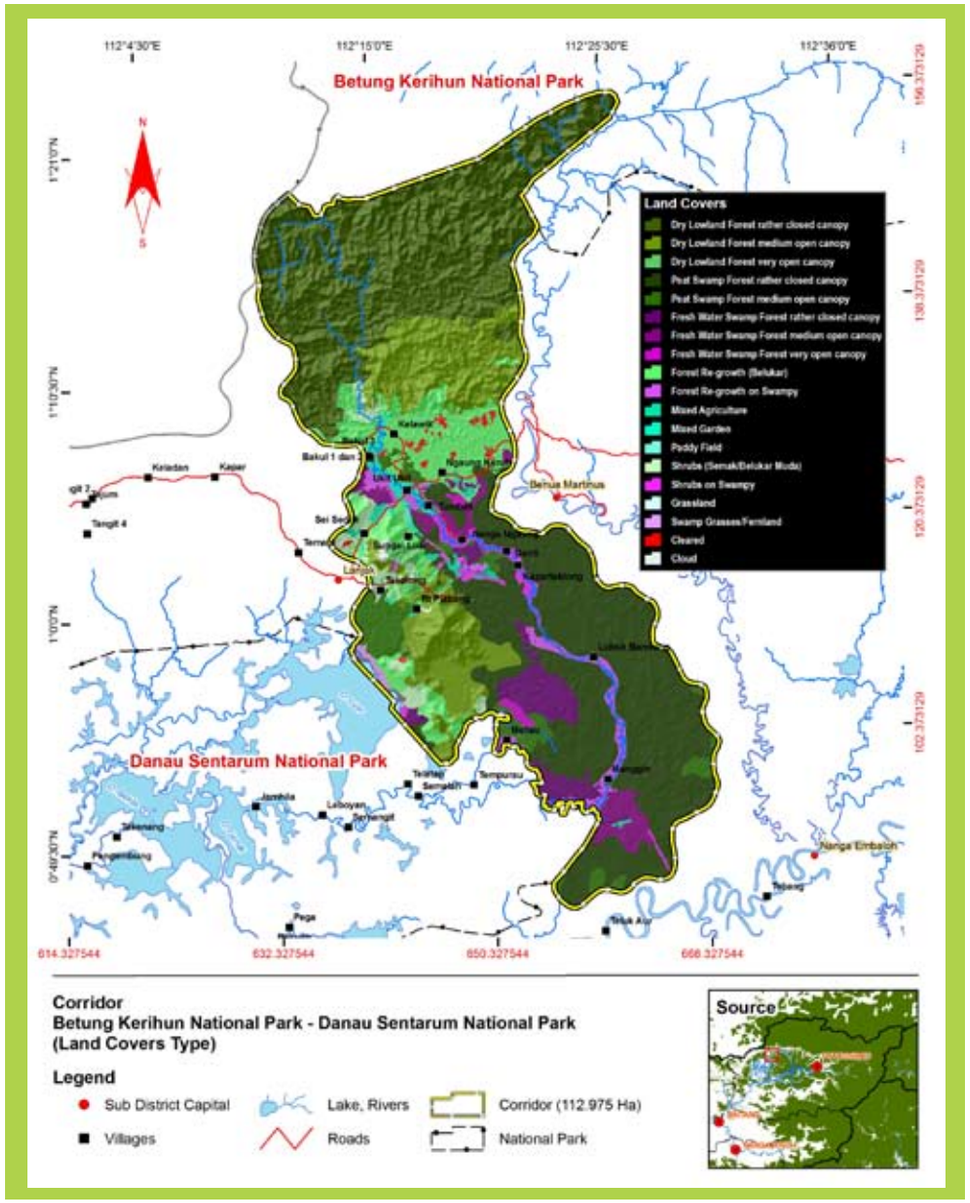

Figure 5.14 Land cover categories of Labian-Leboyan Corridor

Forest Area with Special Purpose (FASP)

The Forestry Act No. 41 of 1999 states in Clause 8 (1) that the government can set aside a certain forest area for particular purposes. Further described in clause 8 (2) that the establishment of a forest area with special purposes, is required for public purposes such as:

- Research and development
- Education and training
- Religion and culture

Furthermore, the Government Regulation No. 6 of 2007 on Forest Order and Forest Management Planning and Forest Utilization, clause 11 (2) stipulates that certain forest areas can be declared Community Forest, Indigenous Forest, Village Forest, or Forest Areas with Special Purpose (FASP).

FASP establishment mechanism

The process of FASP establishment is elaborated in the Government Regulation No. 38 of 2007 concerning the division of governmental affairs among central, provincial and district/city government. In the attachment of the forestry section, the mandates are defined as follows:

Central Government	Provincial Government	District/Municipality Government
Establishment of norms, standards, procedures, and criteria, and establishment of forest area manager with the special purpose for indigenous people, research and development, education and training of forestry, social and religious institutions.	Proposal and the technical considerations of forest management with the special purpose for indigenous people, research and development, education and training of forestry, social and religious institutions on provincial scale.	Forest management proposal with the special purpose for indigenous people, research and development, education and training of forestry, social and religious institutions on the scale of district/municipality with the governor's consideration.

Establishment of wildlife corridors

Government Regulation No. 28 of 2011 on the Management of Nature Reserves and Nature Conservation Areas states that the establishment of wildlife corridors aims to prevent conflicts of interest between people and wildlife, as well as to facilitate wildlife movement based on home range area from one region to the other. Establishment of regional wildlife corridors can be decided jointly by the heads of area management units that are connected by these features. In case non-forest areas are included, local governments have to be included in the process.

Heart of Borneo (HoB) Strategy

Anna Paddenburg

The three Bornean governments, Indonesia, Malaysia and Brunei jointly declared in February 2007 that they are committed to preserve and sustainably develop the forests within the Heart of Borneo, an area of over 22 million ha of continuous forest, 16 million ha in Indonesia's Kalimantan. Together they emphasised the fact that these tropical rainforests have strategic, global, national and local functions, not only for citizens of these three countries but for the global human race. The Heart of Borneo Initiative sets an example where conservation and sustainable development go hand in hand, developing a green economy that is fair, resilient to climate change, values natural capital and provides a better quality of life for all.

In Indonesia, the Government set up the Heart of Borneo's framework of working groups at national, provincial and local levels. National, provincial and district level working groups include among others members from Foreign Affairs, Home Affairs, Public Works, Defense, Development (Bappenas), Forestry, Environment, Mining, Agriculture. These cross-sectoral and multilevel working groups are a unique mechanism in Indonesia as it allows for regular dialogue and communication across different sectoral agencies and at the different levels (national, provincial, and district). Such a mechanism allows for healthy and much needed dialogues around institutional responsibilities and overlapping regulations and policies related to reducing deforestation.

Within the context of the Government of Indonesia's Heart of Borneo National Action Plan, the government is currently undertaking a consultation process to designate the HoB as a 'Kawasan Strategis National' (KSN) or National Strategic Area (NSA). This is an area whose spatial plan is considered as a national priority. Historically, such designations are for reasons of state sovereignty, national security or for economic, social or cultural reasons. The HoB is the first KSN to be proposed for environmental reasons. The HoB KSN will aim to clarify the spatial plan and give clearer guidance for land users as to the definition of 'conservation and sustainable development' across the 16 M ha. This is important as it provides the scale, multi-sectoral and cross-administration enabling framework to conserve and maintain ecosystem services, use abandoned lands and enforce responsible management practices and principles and ensures balance between the environment and sustainable development.The Labian-Leboyan Corridor (LLC) is an integral part of the new spatial plan.

Sustainable Finance and Policy

The economy in this region is largely dependent upon primary / extractive sectors and has left large parts of this corridor fragmented and degraded. Habitat loss and fragmentation continues to happen particularly because forests are undervalued in the current market system. Almost none of the Labian-Leboyan Corridor's natural capitalist priced on the market as forests are usually solely valued for their main commercial resource, timber.

The Heart of Borneo overall and LLC in particular has valuable biodiversity and ecosystem services (Fig x).Its conservation and sustainable management is not only important for ecological connectivity but also for people's prosperity and welfare, both for those living within the corridor and beyond. A well-managed corridor sustains and secures biodiversity and ecosystem services to support earth's life systems and maintain nature's store species for food (fish, honey), community-based tourism, red rice, rubber plantation, medicinal and scientific purposes. A sustainably managed corridor provides a variety of ecosystem services to people, including carbon sequestration to mitigate climate change, watershed protection to provide clean and reliable water supplies for commercial and livelihood purposes and not only for those living within the corridor but more so for other users closer to the coastline.

Sediment retention, siltation and erosion prevention, fertililty, nutrient cycling etc. are other important services nature provides which benefits livelihoods, agriculture and various industries. Besides the above range of physical services, landscape amenities, to support various natural resource dependent industries and community-based tourism also provide important economic value to people. Above range of ecosystem services clearly shows that conservation does not only benefit the ecological integrity of the forests and the survival of species but has a compelling economic value to the wellbeing of people as well. There is a need to integrate the value of forests and watershed services into national, provincial and district medium and long term development plans to build for a fair and resilient economy which provides a better quality of life for all, within the ecological limits of nature. Appropriate legislation, policies and enabling conditions are necessary to mainstream the value of nature and mobilize lasting financial mechanisms to encourage both companies and local government officials to think and plan with long term sustainability in mind. Integrating the value of natural capital in decision making will bolster the value of natural capital and needs to be done by all agencies that play a role in this corridor. Along with such mainstreaming, sufficient financial resources (based on the value of its natural capital)

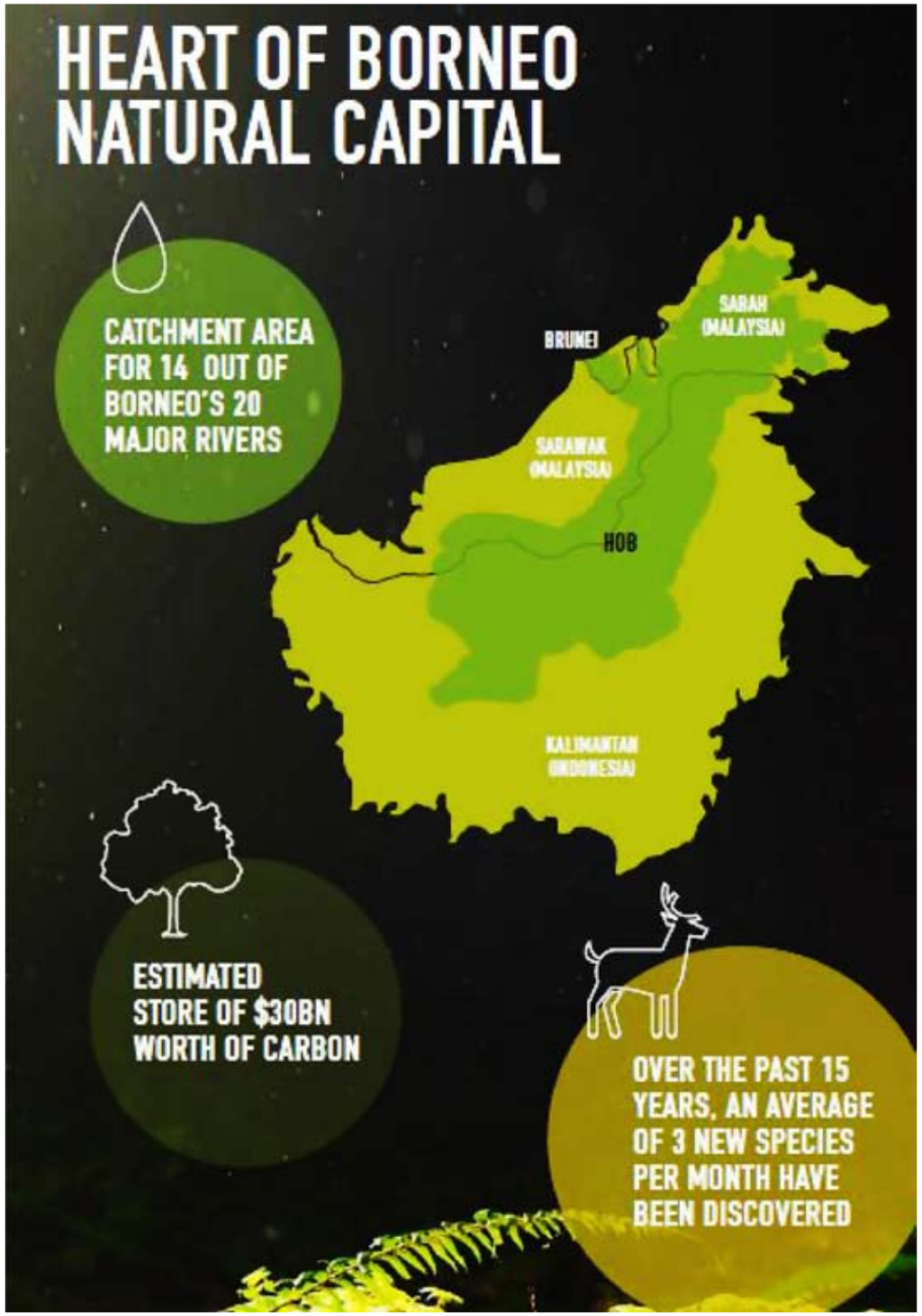

Figure 5.15 Heart of Borneo's contribution to water supply, carbon storage and biodiversity conservation.

Figure 5.16 A four-phased sustainable finance approach of the Heart of Borneo Initiative

need to be allocated to cover the full cost of managing a sustainable landscape. This includes financial resources to allow for the distribution of incentives and subsidies to selected stakeholders. This is what often is referred to as sustainable finance. The Heart of Borneo Initiative is in the process of designing an appropriate sustainable financing architecture (which is an umbrella/framework of various mechanisms). In October 2010, at the UN Convention on Biological Diversity in Nagoya, Japan,the three HoB countries have launched their intention to further assess sustainable financing mechanisms. A phased approach is currently underway.

This approach at the Heart of Borneo scale is also relevant at the district scale and even at the scale of Labian-Leboyan Corridor (Fig 5.16).

For long term sustainability, it is most important to address three objectives:

1. A diverse range of financing sources – some of these sources are described in the paragraphs below;
2. Ensure that the flow of finance includes performance based incentives and subsidies to district government and local stakeholders who preserve their forests or provide for 'green' job opportunities. To encourage best practices, payments and incentives can be based on aggregate indicator outcomes, for example carbon emission reduction, deforestation reduction, reduction in incidence of fires, and;
3. The disbursement of finances results in real change on the ground (well-managed corridor for wildlife migration, sustaining local livelihoods and maintaining valuable ecosystem services for users and beneficiaries.

Along side actions related to above three objectives, a series of dialogues at district, provincial and national levels with targeted stakeholders is needed to direct legislation, policies, incentives and subsidies to set up the enabling conditions for mobilizing some of these sources of finance to the management of the Corridor and to provide incentives and subsidies to district governments and local stakeholders who preserve their forests and encourage green' job opportunities (jobs which are dependent on the conversion of land or the destruction of forests).

Based on the Heart of Borneo sustainable finance report (2010) sources of finance for the LLC could include:

1. Green fiscal stimulus packages including fiscal incentives such as tax breaks and subsidies to:
   a. FSC certified logging companies
   b. Companies engaged in land swap deals
   c. Mining companies which follow best management practises
   d. Innovative businesses which are not dependent on primary resource extraction/ land conversion

2. Reduce operational costs for logging, palm oil and mining companies which follow best management practises.

3. Direct a small percentage of licensing and royalty fees derived by national and provincial governments through various tax and non-tax revenue schemes across forestry, mining, and palm oil sectors to HoB districts government and local stakeholders based on their performance.

4. Direct reforestation funds (DR/Dana Bagi Hasil) which collects fees from timber concessionaries at national, provincial and district level to HoB districts government and local stakeholders.

5. Effectively utilize and/ or reassess the policy on Reclamation Bonds (Jaminan Reklamasi), which every mining company must pay to the state before operations to guarantee reclamation and restoring environmental conditions.

6. Channel the regulated Corporate Social Responsibility (CSR) funds paid by businesses to fulfil their social and environmental responsibilities to the maintenance of ecosystem services.

7. Assess and optimize the use of: (a) Special Allocation Funds (Dana Alokasi Khusus/ DAK), an annual grant distributed from the central government budget (Anggaran Pendapatan dan Belanja Negara/ APBN) to district governments to finance specific activities which fall under national development priorities, and (b) the upcoming performance based Regional Incentive Fund (Dana Insentif Daerah) for social and economic performance.

"Building a fair and resilient economy which provides a better quality of life for all, within the ecological limits of nature is ultimately the goal of the Heart of Borneo Initiative".

8. Assess the potential to implement a revised tourism fee mechanism (direct % of national parks entrance fee, set a tourism tax mechanisms as airport tax etc.) which can contribute to conservation and biodiversity management.

9. Assess the value of the Corridor's forests and watershed in providing various services to people (beneficiaries and users), particularly to downstream districts and industries and develop associated policies and payment/incentive schemes for the provision of these services, e.g. protection from flooding, erosion and sediment retention, use of river for transportation, etc.)

10. Assess the opportunity for REDD+, a financing mechanism which pays for the reduction of forest carbon emissions. Carbon sequestration services are provided through conservation activities, reduced impact logging and reforestation efforts. These carbon sequestration services can support a global effort of mitigating climate change. Clear land use plans and land tenure, as well as clarity on financial flows and monitoring are important issues to address when implementing REDD+ in a voluntary / upcoming regulated market.

11. Assess the opportunity for developing a regulated mechanism to earn revenue from bio-prospecting. Mobilizing research to catalogue all species present in the HoB will be a first step to make this happen. .

Building a fair and resilient economy which provides a better quality of life for all, within the ecological limits of nature is ultimately the goal of the Heart of Borneo Initiative. The conservation of LLC plays an important role in the larger HoB Initiative and cannot be seen in isolation. It contributes to a good balance between economic growth, social equity and environmental security through its valuable biodiversity and ecosystem services.

Understanding the appropriate model which works will open up new markets through Payments and Markets for Ecosystem Services. Along with appropriate legislation, policies, incentives and subsidies, this leads the way to sustainable finance.

Figure 5.17 Glorious morning in Bian Subvillage, Semitau Subdistrict (Photo: Sugeng Hendratno/WWF-Indonesia)

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Annex

Appendix 1. Forest woody plants in Labian-Leboyan Corridor recorded by Albertus Tjiu & Ambriansyah

Species	Family	Local Name	Location
Saurauia sp.	Actinidaceae		BP
*Alangium ridleyi**	Alangiaceae		BP
Bouea oppositifolia	Anacardiaceae	Kundung	M
Buchanania sessifolia	Anacardiaceae	Rengas	M, BP, LB, KT, K
Campnosperma auriculatum	Anacardiaceae	Beringin	BP, K
Campnosperma coriaceum	Anacardiaceae	Beringin	M, KT
Dracontomelon dao	Anacardiaceae	Sengkuang	LB, K
Gluta renghas	Anacardiaceae	Rengas	M, LB, KT
Gluta sp.1	Anacardiaceae	Rengas	M, BP, M, LB, KT, K
Gluta sp.2	Anacardiaceae	Rengas	M
Gluta wallichii	Anacardiaceae	Rengas manuk	BP
Koordesiodendron pinnatum	Anacardiaceae		BP
Mangifera pajang	Anacardiaceae	Asam	K
Parishia sp.	Anacardiaceae		BP
Semecarpus sp.	Anacardiaceae	Temelak	BP, K
Swintonia acuta	Anacardiaceae	Kerintak	M, LB, KT, K
Swintonia schwenkii	Anacardiaceae	Kerintak	BP
Goniothalamus sp.	Annonaceae	Selukai	KT
Mezzettia umbellata	Annonaceae	Suluh	M, LB, KT
Polyalthia glauca	Annonaceae	Lada	KT
Polyalthia lateriflora	Annonaceae	Lada	BP, M, KT
Polyalthia rumphii	Annonaceae	Lada	KT, K
Polyalthia sumatrana	Annonaceae	Lada	BP, K
Sageraea lanceolata	Annonaceae		M, KT
Xylopia ferruginea	Annonaceae	Jangkar/Jangkang	M, KT
Xylopia malayana	Annonaceae	Jangkar/Jangkang	M
Xylopia sp.	Annonaceae	Jangkar/Jangkang	M
Alstonia iwahigensis	Apocynaceae	Pelai	BP
Dyera lowii	Apocynaceae	Jelutung	M, Mg, KT
Tabernaemontana macrocarpa	Apocynaceae	Lada (iban)	BP, K
Ilex cissoidea	Aquifoliaceae		K
Ilex cymosa	Aquifoliaceae	Telur	M
Ilex sp.	Aquifoliaceae	Telur	M, LB, KT
Coelostegia sp.	Bombacaceae		BP
Durio acutifolius *	Bombacaceae	Durian burung	BP, LB
Durio excelsus	Bombacaceae	Durian bukit	BP
Durio graveolens	Bombacaceae	Durian burung	BP
*Durio kutejensis**	Bombacaceae	Empekung	BP, LB
Durio sp.	Bombacaceae	Durian burung	BP, KT
Durio testudinarius *	Bombacaceae	Durian kura-kura	K
Neesia synandra	Bombacaceae		BP
Canarium sp.	Burseraceae		BP
Dacryodes costata *	Burseraceae	Kemayau	BP, K
Dacryodes laxa *	Burseraceae	Tulang salai	BP
*Dacryodes rostrata**	Burseraceae	Kemayau	BP, K
Dacryodes rugosa	Burseraceae	Kemayau	K
Santiria apiculata	Burseraceae	Bunyau	BP
Santiria griffithii	Burseraceae	Bunyau	BP, KT
Santiria oblongifolia	Burseraceae	Bunyau	BP, M
Santiria sp.	Burseraceae	Bunyau	K
Santiria tomentosa	Burseraceae	Bunyau	BkP, LB, K
Bhesa paniculata	Celastraceae		BkP, LB, K
Lophopetalum javanicum	Celastraceae	Perupuk	Mg
Atuna racemosa	Chrysobalanaceae		BP, K
Licania splendens	Chrysobalanaceae		BP, K
Terminalia foetidissima	Combretaceae		BP, K
Vernonia arborea	Compositae		K
Mastixia sp.	Cornaceae		M, BP, LB
Crypteronia borneensis	Crypteroniaceae		K
Crypteronia macrophylla	Crypteroniaceae		K
Crypteronia sp.	Crypteroniaceae		BP
Dactylocladus stenostachys	Crypteroniaceae	Mentibu	M, Mg, LB, KT
Dillenia excelsa	Dilleniaceae	Ringin juing	BP
Dillenia reticulata	Dilleniaceae	Ringin juing	K
Dillenia suffruticosa	Dilleniaceae	Ringin juing	K
Cotylelobium melanoxylum	Dipterocarpaceae	Pukul kawi	M, Mg
Dipterocarpus crinitus	Dipterocarpaceae	Empelas	BP, K
Dipterocarpus gracilis	Dipterocarpaceae	Temputau	BP
Dipterocarpus pachyphyllus	Dipterocarpaceae	Tempurau	BP
*Dipterocarpus stellatus**	Dipterocarpaceae	Tempurau	BP
Dipterocarpus validus	Dipterocarpaceae	Tempurau	LB
Dipterocarpus verrucosus	Dipterocarpaceae	Tempurau	BP, K
Dryobalanops lanceolata	Dipterocarpaceae	Kelansau	M, LB, KT, K
Dryobalanops oblongifolia *	Dipterocarpaceae	Kelansau bukit	BP, M
Hopea dryobalanoides	Dipterocarpaceae	Tekam air	BP, K
Hopea kerangaensis	Dipterocarpaceae	Tekam air	BP, KT
Shorea almon	Dipterocarpaceae		BP, LB, KT
Shorea angustifolia *	Dipterocarpaceae		BP, K
Shorea atrinervosa	Dipterocarpaceae	Masang	K
Shorea belangeran	Dipterocarpaceae	Kawi	M, Mg, LB
Shorea gibbosa	Dipterocarpaceae		BP
Shorea gratissima	Dipterocarpaceae		BP
Shorea hopeifolia	Dipterocarpaceae		BP, K
Shorea inappendiculata	Dipterocarpaceae		BP
Shorea laevis	Dipterocarpaceae	Masang	BP
*Shorea macrobalanops**	Dipterocarpaceae		BP
*Shorea macrophylla**	Dipterocarpaceae		BP
Shorea macroptera *	Dipterocarpaceae		BP, K
Shorea maxwelliana	Dipterocarpaceae		M, BP
Shorea mujongensis *	Dipterocarpaceae		BP, K
Shorea multiflora	Dipterocarpaceae	Barit	BP, K
Shorea parvifolia	Dipterocarpaceae	Rup	M, BP, LB, KT, K
*Shorea parvistipulata**	Dipterocarpaceae		BP
Shorea pauciflora	Dipterocarpaceae	Balik	BP, K
Shorea peltata	Dipterocarpaceae		BP
*Shorea pinanga**	Dipterocarpaceae	Tengkawang layar	BP, K
Shorea rotundifolia	Dipterocarpaceae		M, LB, KT
Shorea seminis	Dipterocarpaceae	Kerintak	M, BP, Mg
*Shorea smithiana**	Dipterocarpaceae	Tengkawang	M, BP, KT, K
Shorea sp.1	Dipterocarpaceae		M, Mg, LB, KT
Shorea sp.2	Dipterocarpaceae		M, Mg, KT
Shorea sp.3	Dipterocarpaceae		LB, KT
Shorea sp.4	Dipterocarpaceae		Mg, K
Shorea sp.5	Dipterocarpaceae		K
Shorea sp.6	Dipterocarpaceae		K
*Shorea stenoptera**	Dipterocarpaceae	Tengkawang	LB
Vatica micrantha	Dipterocarpaceae	Resak padi	BP, K
Vatica rassak	Dipterocarpaceae	Resak	BP, M, K
Vatica sp.	Dipterocarpaceae	Resak	KT, K
Vatica umbonata (Hook.f.)	Dipterocarpaceae	Resak	M, BP, Mg, LB, KT, K
Vatica venulosa	Dipterocarpaceae	Resak seluang	BP

Diospyros confertiflora	Ebenaceae	Kayu malam	M, LB, K
Diospyros coriacea	Ebenaceae	Kenarin	M, Mg, LB
Diospyros sp.1	Ebenaceae	Kayu malam	BP, Mg, LB, KT, K
Diospyros sp.2	Ebenaceae	Kayu malam	BP, Mg
Diospyros sumatrana	Ebenaceae	Kayu malam	K
Elaeocarpus mastersii	Elaeocarpaceae	Ensubal	M, K
Elaeocarpus sp.1	Elaeocarpaceae	Ensubal	M
*Elaeocarpus stipularis**	Elaeocarpaceae		K
Antidesma neurocarpum	Euphorbiaceae	Engkunik	KT, K
Aporusa frutescens	Euphorbiaceae		M
Aporusa lunata	Euphorbiaceae		BP
Aporusa sp.	Euphorbiaceae		KT, K
Baccaurea angulata	Euphorbiaceae	Ucung	BP
Baccaurea bracteata	Euphorbiaceae	Puak	M, Mg, LB, KT
Baccaurea lanceolata	Euphorbiaceae	Lempasau	K
Baccaurea macrocarpa	Euphorbiaceae	Tampui	M, BP, LB
Baccaurea pyriformis	Euphorbiaceae	Jelentik	BP, K
Baccaurea sp.1	Euphorbiaceae	Puak	BP
Baccaurea sp.2	Euphorbiaceae	Puak	K
Baccaurea tetrandra	Euphorbiaceae	Suluh	BP
Blumeodendron sp.1	Euphorbiaceae		M
Blumeodendron sp.2	Euphorbiaceae		M
Bridelia glauca	Euphorbiaceae		K
Chaetocarpus castanocarpus	Euphorbiaceae		M, KT
Cleistanthus myrianthus	Euphorbiaceae		M, BP, KT, K
Cleistanthus sp.	Euphorbiaceae		K
Drypetes polyneura	Euphorbiaceae		BP, K
Drypetes sp.	Euphorbiaceae		LB
Endospermum diadenum	Euphorbiaceae		BP
Glochidion arborescens	Euphorbiaceae	Manyam	BP, KT, K
Macaranga bancana	Euphorbiaceae		BP
Macaranga conifera	Euphorbiaceae		BP, KT
Macaranga gigantea	Euphorbiaceae	Merkubung	BP, K
Macaranga hypoleuca	Euphorbiaceae	Garong	K
Macaranga lowii	Euphorbiaceae		K
Macaranga pearsonii	Euphorbiaceae		KT, K
Macaranga repandodentata	Euphorbiaceae		BP
Mallotus penangensis	Euphorbiaceae		K
Neoscortechinia kingii	Euphorbiaceae	Teluk	Mg, LB
Neoscorthechinia sp.	Euphorbiaceae	Teluk	LB
Pimelodendron griffithianum	Euphorbiaceae		LB, K
Ptychopyxis sp.	Euphorbiaceae		BP, KT
Castanopsis evansii	Fagaceae	Berangan	K
Castanopsis megacarpa	Fagaceae	Berangan	BP
Castanopsis sp.	Fagaceae	Berangan	KT
Lithocarpus conocarpus	Fagaceae	Kempilik	BP, LB, KT
Lithocarpus gracilis	Fagaceae	Kempilik	BP, K
Lithocarpus sp.	Fagaceae	Kempilik	LB, KT
Quercus argentata	Fagaceae	Kempilik	BP, K
Hydnocarpus sp.	Flacourtiaceae		M, BP, LB, KT
Ryparosa javanica	Flacourtiaceae		BP, KT, K
Ryparosa sp.	Flacourtiaceae		M
Calophyllum inophyllum	Guttiferae	Mentangur jangkar	M, KT
Calophyllum nodusum	Guttiferae	Mentangur	BP, Mg, KT, LB
Calophyllum sp.1	Guttiferae	Mentangur	KT
Calophyllum sp.2	Guttiferae	Mentangur	M, Mg, LB, K
Calophyllum sp.3	Guttiferae	Mentangur	BP, Mg, LB, K

Garcinia bancana	Guttiferae	Sikup	LB, K
Garcinia parvifolia	Guttiferae	Kandis	BP, Mg, LB, K
Garcinia sp.1	Guttiferae	Sikup ruai	KT
Garcinia sp.2	Guttiferae	Sikup timah	KT
Kayea borneensis	Guttiferae		KT, K
Mesua conoidea	Guttiferae	Kamsia	BP, K
Mesua sp.	Guttiferae	Kamsia	BP, Mg, KT
Cratoxylum arborescens	Hypericaceae	Temau	BP, LB
Cratoxylum sumatranum	Hypericaceae	Gerunggang	M, BP, LB, K
Platea sp.	Icacinaceae		LB, M
Stemonurus scorpioides	Icacinaceae		M, KT
Actinodaphne sp.1	Lauraceae		M, BP
Actinodaphne sp.2	Lauraceae		M
Alseodaphne sp.	Lauraceae		BP
Beilschmiedia sp.	Lauraceae		M, BP, LB, KT, K
Cinnamomum sp.	Lauraceae	Cendana	BP
Cryptocarya crassinervia	Lauraceae		M, LB
Cryptocarya sp.	Lauraceae		M, KT, K, BP
Dehaasia sp.	Lauraceae		M, BP, Mg, K
Eusideroxylon zwageri	Lauraceae	Belian	BP
Litsea angulata	Lauraceae	Medang danau	M, Mg, LB, KT
Litsea ferruginea	Lauraceae		M
Litsea garciae *	Lauraceae	Engkala'	
Litsea firma	Lauraceae	Medang bukit	BP, Mg, K
Litsea oppositifolia	Lauraceae		Mg, K
Litsea sp.	Lauraceae	Medang	M, LB, KT
Barringtonia macrostachya	Lecythidaceae	Putat	K
Planchonia sp.	Lecythidaceae	Putat	LB, KT
Dialium indum	Leguminosae-Caes.	Keranji madu	M, LB
Dialium sp.	Leguminosae-Caes.	Keranji	M, LB
Koompassia excelsa	Leguminosae-Caes.	Mengeris	K
Koompassia malaccensis	Leguminosae-Caes.	Mengeris	M, BP, Mg, LB
Sindora sp.	Leguminosae-Caes.	Sempetir	M, Mg, LB, KT
Sindora velutina	Leguminosae-Caes.	Sempetir	BP
Sindora wallichii	Leguminosae-Caes.	Sempetir	M, BP, KT, K
Sympetalandra unijuga	Leguminosae-Caes.		BP, K
Archidendron clypearia	Leguminosae-Mim.		BP, M
Archidendron sp.	Leguminosae-Mim.		M
Parkia speciosa	Leguminosae-Mim.	Petai	K
Fordia splendidissima	Leguminosae-Pap.	Limau antu	BP, K
Fagraea racemosa	Loganiaceae	Tapak labi	K
Bellucia pentamera	Melastomataceae	Jambu moyet	BP, KT, K
*Memecylon borneensis**	Melastomataceae		BP
Memecylon sp.	Melastomataceae		BP
Pternandra sp.1	Melastomataceae	Kelusuk	BP, LB, K
Pternandra sp.2	Melastomataceae	Kelusuk	BP, K
Aglaia simplicifolia	Meliaceae		K
Aglaia sp.	Meliaceae	Pasak	BP, M, KT, K
Dysoxylum sp.	Meliaceae	Ensunut	Mg, LB, K
Lansium domesticum	Meliaceae	Lansat	KT
Sandoricum borneensis	Meliaceae	Kapas	M, BP
Sandoricum koetjape	Meliaceae	Kapas	M, BP, LB, KT
Walsura sp.	Meliaceae		K
Artocarpus anisophyllus	Moraceae	Bintawa	BP, K
Artocarpus elasticus	Moraceae	Terap	BP, K
Artocarpus integer	Moraceae	Cempedak/Bukoh	BP
Artocarpus lanceifolius	Moraceae	Koledang	BP, K

Artocarpus tamaran	Moraceae	Terap	K
Ficus aurata	Moraceae		K
Ficus obscura	Moraceae	Karak	K
Ficus sp.	Moraceae		BP, M, K
Ficus variegata	Moraceae		K
Gymnacranthera farquhariana	Myristicaceae		BP, M, LB, KT
Horsfieldia borneensis	Myristicaceae		M
Horsfieldia grandis	Myristicaceae		LB
Horsfieldia sp.1	Myristicaceae		BP, KT, K
Horsfieldia sp.2	Myristicaceae		KT, K
Knema galeata	Myristicaceae		BP, LB, KT
Knema latericia	Myristicaceae		M, BP, Mg, LB, KT
Knema pallens *	Myristicaceae		K
Myristica iners	Myristicaceae		BP
Myristica	Myristicaceae		M, KT
Myristica sp.1	Myristicaceae		KT, K
Myristica sp.2	Myristicaceae		K
Myristica villosa	Myristicaceae		BP
Ardisia sp.	Myrsinaceae		KT
Acmena acuminatissima	Myrtaceae	Ubah	M, Mg
Acmena sp.	Myrtaceae	Ubah	BP, KT
Eugenia caudatilimba	Myrtaceae	Uba	BP
Eugenia heteroclada	Myrtaceae	Uba	BP, Mg, LB, KT
Eugenia stapfiana	Myrtaceae	Uba	K
Syzygium lineatum	Myrtaceae	Uba	BP, Mg, LB, KT, K
Syzygium napiforme	Myrtaceae	Uba	BP
Syzygium nigricens	Myrtaceae	Uba	M, BP
Syzygium sp.1	Myrtaceae	Uba	M, BP, Mg, LB, KT
Syzygium sp.2	Myrtaceae	Uba	M, BP, Mg, LB, KT
Syzygium sp.3	Myrtaceae	Uba	M, BP, KT, K
Syzygium sp.4	Myrtaceae	Uba	M, BP, LB, KT
Syzygium sp.5	Myrtaceae	Uba	M, KT, K
Syzygium sp.6	Myrtaceae	Uba	K
Syzygium tawahense	Myrtaceae	Uba	M, BP, Mg, LB, KT, K
Tristaniopsis sp.	Myrtaceae		M, LB, KT
Ochanostachys amentacea	Olacaceae		BP, K
Strombosia sp.	Olacaceae		BP, LB, KT
Sarcotheca diversifolia	Oxalidaceae		KT
Xanthophyllum sp.	Polygalaceae		BP, LB, KT
Helicia sp.	Proteaceae	Putat rimba	KT
Carallia brachiata	Rhizophoraceae	Tahun / tulang ular	M, Mg
Combretocarpus rotundatus	Rhizophoraceae	Meripat, engkersii	M, Mg, KB, KT
Pellacalyx axillaris	Rhizophoraceae	Tulang ular	BP, K
Prunus beccarii	Rosaceae	Suluh	K
Prunus polystachya	Rosaceae	Suluh	K
Prunus sp.	Rosaceae	Suluh	LB, KT
Dichilanthe borneensis	Rubiaceae	Berus	Manggin
Gardenia sp.	Rubiaceae		BP, M
Jackiopsis ornata	Rubiaceae		KT
Musaendopsis sp.	Rubiaceae		BP
Nauclea subdita	Rubiaceae	Bengkal	BP, Mg, K
Pertusadina eurhyncha	Rubiaceae		BP
Porterandia anisophylla	Rubiaceae		BP
Rothmannia sp.	Rubiaceae		KT
Timonius sp.	Rubiaceae	Temirit	K
Urophyllum sp.	Rubiaceae	Kebesi	Mg
Acronychia pedunculata	Rutaceae		Mg, LB, KT

Meliosma sp.	Sabiaceae		KT
Dimocarpus longan	Sapindaceae		BP
*Lepisanhtes amoena**	Sapindaceae		
Nephelium cuspidatum	Sapindaceae	Sibau	K
Nephelium lappaceum	Sapindaceae	Rambutan	BP, M
Nephelium maingayi	Sapindaceae		M, Mg, LB, KT
Nephelium ramboutan-ake	Sapindaceae		K
Nephelium uncinatum	Sapindaceae		BP, K
Pometia pinnata	Sapindaceae		BP, Mg, K
Xerospermum laevigatum	Sapindaceae	Keranjik tikus	BP, KT, K
Xerospermum sp.	Sapindaceae	Keranjik tikus	M
Madhuca kingiana	Sapotaceae	Nyatuh	BP
Madhuca pallida	Sapotaceae	Nyatuh	BP
Madhuca sericea	Sapotaceae	Nyatuh	Mg
Madhuca sp.1	Sapotaceae	Nyatuh	M, LB
Madhuca sp.2	Sapotaceae	Nyatuh	BP, KT, K
*Palaquium beccarianum**	Sapotaceae	Nyatuh	BP
Palaquium leiocarpum	Sapotaceae	Nyatuh	M, Mg
Palaquium psendorostratum	Sapotaceae	Nyatuh	M, Mg, LB, KT
Palaquium quercifolium	Sapotaceae	Nyatuh	BP
Palaquium sp.1	Sapotaceae	Nyatuh	M, LB
Palaquium sp.2	Sapotaceae	Nyatuh	M, Mg
Palaquium stenophyllum	Sapotaceae	Nyatuh	BP, K
Payena lucida	Sapotaceae	Nyatuh	BP
Payena sp.	Sapotaceae	Nyatuh	M
Polyosma integrifolia	Saxifragaceae		K
Duabanga moluccana	Sonneratiaceae	Binuang	K
Scaphium macropodum	Sterculiaceae	Semangkok	BP, K
Sterculia rubiginosa	Sterculiaceae		BP, K
Sterculia sp.	Sterculiaceae		KT, K
Adinandra dumosa	Theaceae		BP, Mg, KT, K
Gordonia havilandii	Theaceae		M
Ploiarium alternifolium	Theaceae		M
Ternstroemia sp.	Theaceae		Mg, LB
Tetramerista glabra	Theaceae		M, Mg
Gonystylus affinis	Thymelaeaceae		BP
Gonystylus bancanus	Thymelaeaceae	Ramin, Gaharu buaya	M, BP, Mg, LB, KT
*Microcos crassifolia**	Tiliaceae	Tengkurung asam	BP, Mg, LB, K
Microcos sp.	Tiliaceae	Tengkurung asam	BP
Microcos tomentosa	Tiliaceae	Tengkurung asam	Mg, K
Pentace laxiflora	Tiliaceae		K
Pentace triptera	Tiliaceae		BP, K
Trigoniastrum sp.	Trigoniastraceae		kt
Gironniera nervosa	Ulmaceae		M, BP
Gironniera subanequalis	Ulmaceae		BP
Teijsmanniodendron sp.	Verbenaceae		M, BP, K
Vitex pinnata	Verbenaceae	Leban	K

Location: * = endemic Kalimantan

BP = Bukit Peninjau
KT = Kapar Tekalong
K = Kelawik
LB = Lubuk Bandung
Mg = Manggin
M = Meliau

Appendix 2. Fish species caught in rivers of Labian-Leboyan Corridor, their relative abundance and potential; K: food fish, H: ornamental fish

Species	Family	Relative abundance (%) of fish caught bymethod 1)	2)	3)	Potential
Mystus nigriceps	Bagridae		12.5	28.26	K
Hemibagrus nemurus	Bagridae	1.49			K
Pseudomystus stenomus	Bagridae			4.34	H
Betta akarensis	Belontidae			2.17	K-H
Channa lucius	Channidae		25		K
Channa striata	Channidae				K
Parambassis macrolepis	Chandidae	0.75	12.5		K
Clarias batrachus	Clariidae			4.34	K
Clarias teijsmanni	Clariidae			2.17	K
Barbonymus collingwoodi	Cyprinidae	0.75			K
Barbonymus gonionotus	Cyprinidae	1.49			K
Barbonymus schwanenfeldii	Cyprinidae	16.42			K
Barbichthys laevis	Cyprinidae	1.49			K
Cyclocheilichtys apogon	Cyprinidae	16.42			K
Labiobarbus festivus	Cyprinidae	23.13			K
Labiobarbus fasciatus	Cyprinidae	6.72			K
Labiobarbus ocellatus	Cyprinidae	4.48			K
Luciosoma trinema	Cyprinidae	2.24			K
Macrochirichthys marochirus	Cyprinidae	0.75			K
Puntioplites bulu	Cyprinidae	2.24			K
Puntioplites waandersii	Cyprinidae	5.22			K
Puntius binotatus	Cyprinidae			15.22	K-H
Rasbora caudimaculata	Cyprinidae	7.46	12.5	28.26	H
Rasbora kalochroma	Cyprinidae			2.17	H
Osteochilus hasselti	Cyprinidae	2.24			K
Osteochilusmicrocephalus	Cyprinidae	1.49	12.5		K
Osteochilus waandersii	Cyprinidae	2.24			K
Datnioides microlepis	Datnioidiidae	0.75			K-H
Zenarchopterus buffonis	Hemiramphidae			4.34	H
Mastacembelus notophthalmus	Mastacembelidae			4.34	K-H
Chitala lopis	Notopteridae	0.75			K
Osphronemus goramy	Osphronemidae	1.49			K
Pristolepis grooti	Pristolepididae		25		K
Silurichthys schneideri	Siluridae			4.34	H

1) gill net
2) fish trap
3) hook and line

Appendix 3. Fish species caught in lakes of Labian-Leboyan Corridor,their relative abundance and potential; K: food fish, H: ornamental fish

Species	Family	Relative abundance (%) of fish caught by method 4)	5)	6)	7)	Potential
Anabas testudinus	Anabantidae				3.92	K
Mystus nigriceps	Bagridae	4.4	3.125	0.97	3.92	K
Hemibagrus nemurus	Bagridae	0.63		0.48		K
Helastoma temmincki	Helastomatidae	0.63		0.97	3.92	K
Trichogaster leeri	Belontidae		3.125		1.96	H
Channa lucius	Channidae	0.63				K
Channa striata	Channidae				7.84	K
Barbonymus collingwoodi	Cyprinidae	1.25	18.75			K
Barbonymus schwanenfeldii	Cyprinidae	0.63				K
Cyclocheilichtys apogon	Cyprinidae	4.4				K
Hampala macrolepidota	Cyprinidae	1.25				K
Labiobarbus festivus	Cyprinidae	30.19				K
Labiobarbus fasciatus	Cyprinidae	0.63				K
Labiobarbus ocellatus	Cyprinidae	28.93	43.75	19.32	3.92	K
Luciosoma trinema	Cyprinidae	0.63				K
Parachela oxygastroides	Cyprinidae	0.63		0.48	5.88	K
Puntioplites waandersii	Cyprinidae	3.77				K
Puntius anchisporus	Cyprinidae			0.97		H
Puntius binotatus	Cyprinidae		9.375			K-H
Rasbora caudimaculata	Cyprinidae	0.63		2.42		H
Osteochilus kahajanensis	Cyprinidae	6.92			1.96	K
Osteochilus microcephalus	Cyprinidae	1.89	3.125			K
Osteochilus melanopleura	Cyprinidae	1.89				K
Thynnichthyes polylepis	Cyprinidae	8.18	18.75	73.43	66.67	K
Macrognathus aculeatus	Mastacembelidae	0.63				K-H
Pristolepis grootii	Pristolepididae	1.25		0.97		K

4) gill net
5) fish trap
6) fish trap; hook and line
7) hook and line

Appendix 4. Additional fishes recorded in Labian-Leboyan Corridor

Species	Family
Acrochordonichtys sp.	Akysidae
Anguilla sp.	Anguillidae
Gastromyzon sp.	Balitoridae
Homaloptera sp.	Balitoridae
Parosphronemus sp.	Belontiidae
Chaca bankanensis	Chacidae
Channa micropeltes	Channidae
Acantopsis dialuzona	Cobitidae
Chromobotia macracanthus	Cobitidae
Syncrossus hymenophysa	Cobitidae
Cynoglossus sp.	Cynoglossidae
Epalzeorhynchos kalopterus	Cyprinidae
Rasbora gracilis	Cyprinidae
Schismatorhynchos heterorhynchus	Cyprinidae
Tor tambroides	Cyprinidae
Oxyleotris marmorata	Eleotridae
Gyrinocheilus pustulosus	Gyrinocheilidae
Luciocephalus pulcher	Luciocephalidae
Osphonemus septemfasciatus	Osphronemidae
Scleropages formosus	Osteoglossidae
Pangasius sp.	Pangasiidae
Kryptopterus sp.	Siluridae
Wallago leeri	Siluridae
Tetraodon leiurus	Tetraodontidae

Appendix 5. Amphibians recorded in Labian-Leboyan Corridor

Species	Family	English name
Ansonia sp.	Bufonidae	
Bufo asper	Bufonidae	River Toad
Bufo quadriporcatus	Bufonidae	Four-ridged Toad
Kalophrynus pleurostigma	Mikrohylidae	Rufous-sided Sticky Frog
Limnonectes ingeri	Ranidae	Greater Swamp Frog
Limnonectes limnocharis	Ranidae	Grass Frog
Limnonectes malesianus	Ranidae	Peat Swamp Frog
Occidozyga laevis	Ranidae	Yellow-bellied Puddle Frog
Rana baramica	Ranidae	Brown Marsh Frog
Rana chalconota	Ranidae	White-lipped Frog
Rana erythraea	Ranidae	Green Paddy Frog
Rana glandulosa	Ranidae	Rough-sided Frog
Rana nicobariensis	Ranidae	Cricket Frog
Rana raniceps	Ranidae	Copper-cheeked Frog
Polypedates colletti	Rhacophoridae	Collett's Tree Frog
Polypedates leucomystax	Rhacophoridae	Four-lined Tree Frog
Polypedates otilophus	Rhacophoridae	File-eared Tree Frog
Rhacophorus appendiculatus	Rhacophoridae	Frilled Tree Frog
Rhacophorus pardalis	Rhacophoridae	Harlequin Flying Frog

Appendix 6. Reptiles recorded in Labian-Leboyan Corridor

Species	Family	English name
Aphaniotis fusca	Agamidae	Dusky Earless Agama
Bronchocela cristatella	Agamidae	Green Crested Lizard
Draco sumatranus	Agamidae	Common Flying Lizard
Gonocephalus liogaster	Agamidae	Blue-eyed Angle-headed Lizard
Gonocephalus sp.	Agamidae	
Ahaetulla prasina	Colubridae	Asian Vine Snake
Boiga dendrophila	Colubridae	Mangrove Snake
Chrysopelea paradisi	Colubridae	Paradise Flying Snake
Enhydris enhydris	Colubridae	Rainbow Mud Snake
Enhydris plumbea	Colubridae	Plumbeous Water Snake
Macropisthodon flaviceps	Colubridae	Orange-Lipped Water Snake
Xenochrophis trianguligerus	Colubridae	Triangle Keelback
Tomistoma schlegelii	Crocodylidae	False Gharial
Tropidolaemus wagleri	Crotalidae	Wagler's Pit Viver
Naja sumatrana	Elapidae	Golden Spitting Cobra
Cyrtodactylus ingeri	Gekkonidae	Inger's Bent-toed Gecko
Cyrtodactylus pubisulcus	Gekkonidae	Grooved Bent-toed Gecko
Gecko smithii	Gekkonidae	Smith's Giant Gecko
Gehyra mutilata	Gekkonidae	Stump-toed Gecko
Hemidactylus frenatus	Gekkonidae	Asian House Gecko
Hemidactylus platyurus	Gekkonidae	Flat-tailed House Gecko
Cuora amboinensis	Geoemydidae	Southeast Asian Box Turtle
Cyclemys dentata	Geoemydidae	Asian Leaf Turtle
Heosemys spinosa	Geoemydidae	Spiny Hill Turtle
Orlitia borneensis	Geoemydidae	Borneo River Terrapin
Siebenrockiella crassicollis	Geoemydidae	Black March Turtle
Apterygodon vittatum	Scincidae	Borneo Tree Skink
Python reticulatus	Pythonidae	Reticulated Python
Lipinia sp.	Scincidae	
Mabuya rudis	Scincidae	Three-keeled Ground Skink
Tropidophorus brookei	Scincidae	Brooke's Water Skink
Amyda cartilaginea	Trionychidae	AsianSoftshell Turtle
Dogania subplana	Trionychidae	Malayan Softshell Turtle
Varanus salvator	Varanidae	Water Monitor

Appendix 7. Resident lowland bird species in Betung Kerihun National Park (BKNP), Labian-Leboyan Corridor (LLC) and Danau Sentarum National Park (DSNP). Species marked with "?" need further confirmation.

Species	Family	English name	BKNP	LLC	DSNP
Accipiter trivirgatus	Accipitridae	Crested Goshawk	1	1	1
Accipiter virgatus	Accipitridae	Besra	0	0	?
Aviceda jerdoni	Accipitridae	Jerdon's Baza	1	1	1
Haliaeetus leucogaster	Accipitridae	White-bellied Sea Eagle	?	0	1
Haliastur indus	Accipitridae	Brahminy Kite	1	1	1
Hieraaetus kienerii	Accipitridae	Rufous-bellied Eagle	1	0	0
Ichthyophaga humilis	Accipitridae	Lesser Fish Eagle	1	1	1
Ichthyophaga ichthyaetus	Accipitridae	Grey-headed Fish Eagle	1	0	1
Ictinaetus malayensis	Accipitridae	Black Eagle	1	1	1
Macheiramphus alcinus	Accipitridae	Bat Hawk	0	0	?
Pernis ptilorhynchus	Accipitridae	Oriental Honey-buzzard	1	1	1
Spilornis cheela	Accipitridae	Crested Serpent Eagle	1	1	1
Spizaetus cirrhatus	Accipitridae	Changeable Hawk Eagle	1	1	1
Spizaetus nanus	Accipitridae	Wallace's Hawk Eagle	1	1	1
Alcedo euryzona	Alcedinidae	Blue-banded Kingfisher	1	0	0
Alcedo meninting	Alcedinidae	Blue-eared Kingfisher	1	1	1
Ceyx erithacus	Alcedinidae	Oriental Dwarf Kingfisher	1	1	1
Anhinga melanogaster	Anhingidae	Darter	1	1	1
Apus affinis	Apodidae	House Swift	1	1	1
Collocalia esculenta	Apodidae	Glossy Swiftlet	1	1	1
Collocalia maxima	Apodidae	Black-nest Swiftlet	1	1	1
Collocalia sp.	Apodidae	Swiftlet	1	1	1
Hirundapus giganteus	Apodidae	Brown-backed Needletail	1	1	1
Rhaphidura leucopygialis	Apodidae	Silver-rumped Needletail	1	1	1
Ardea purpurea	Ardeidae	Purple Heron	0	1	1
Ardea sumatrana	Ardeidae	Great-billed Heron	0	0	1
Butorides striatus	Ardeidae	Little Heron	1	1	1
Casmerodius albus	Ardeidae	Great Egret	1	1	1
Dupetor flavicollis	Ardeidae	Black Bittern	0	0	1
Egretta garzetta	Ardeidae	Little Egret	1	1	1
Ixobrychus cinnamomeus	Ardeidae	Cinnamon Bittern	0	1	1
Ixobrychus sinensis	Ardeidae	Yellow Bittern	0	0	1
Mesophoyx intermedia	Ardeidae	Intermediate Egret	0	0	1
Nycticorax caledonicus	Ardeidae	Rufous Night Heron	0	0	?
Nycticorax nycticorax	Ardeidae	Black-crowned Night Heron	0	1	1
Batrachostomus javensis	Batrachostomidae	Javan Frogmouth	0	1	0
Batrachostomus sp.	Batrachostomidae	Frogmouth	0	0	1
Aceros comatus	Bucerotidae	White-crowned Hornbill	1	0	1
Aceros corrugatus	Bucerotidae	Wrinkled Hornbill	1	1	1
Aceros undulatus	Bucerotidae	Wreathed Hornbill	1	1	1
Anorrhinus galeritus	Bucerotidae	Bushy-crested Hornbill	1	1	1
Anthracoceros albirostris	Bucerotidae	Oriental Pied Hornbill	1	1	1

Anthracoceros malayanus	Bucerotidae	Black Hornbill	1	1	1
Buceros rhinoceros	Bucerotidae	Rhinoceros Hornbill	1	1	1
Buceros vigil	Bucerotidae	Helmeted Hornbill	1	0	1
Caprimulgus concretus	Caprimulgidae	Bonaparte's Nightjar	0	0	1
Centropus bengalensis	Centropodidae	Lesser Coucal	0	1	1
Centropus rectunguis	Centropodidae	Short-toed Coucal	0	1	?
Centropus sinensis	Centropodidae	Greater Coucal	1	1	1
Ciconia stormi	Ciconiidae	Storm's Stork	1	1	1
Leptoptilos javanicus	Ciconiidae	Lesser Adjutant	0	0	1
Prinia flaviventris	Cisticolidae	Yellow-bellied Prinia	1	1	1
Chalcophaps indica	Columbidae	Emerald Dove	1	1	1
Ducula aenea	Columbidae	Green Imperial Pigeon	1	0	1
Ducula badia	Columbidae	Mountain Imperial Pigeon	1	0	?
Geopelia striata	Columbidae	Peaceful Dove	0	0	?
Ptilinopus jambu	Columbidae	Jambu Fruit Dove	0	0	?
Streptopelia chinensis	Columbidae	Spotted Dove	0	1	1
Treron capellei	Columbidae	Large Green Pigeon	0	0	?
Treron curvirostra	Columbidae	Thick-billed Green Pigeon	0	1	1
Treron fulvicollis	Columbidae	Cinnamon-headed Green Pigeon	0	0	1
Treron olax	Columbidae	Little Green Pigeon	0	1	1
Treron vernans	Columbidae	Pink-necked Green Pigeon	1	1	1
Eurystomus orientalis	Coraciidae	Dollarbird	1	1	1
Aegithina tiphia	Corvidae	Common Iora	1	1	1
Aegithina viridissima	Corvidae	Green Iora	1	1	1
Artamus leucorynchus	Corvidae	White-breasted Woodswallow	1	0	0
Coracina fimbriata	Corvidae	Lesser Cuckooshrike	1	1	1
Coracina striata	Corvidae	Bar-bellied Cuckooshrike	0	1	?
Corvus enca	Corvidae	Slender-billed Crow	1	1	1
Corvus macrorhynchos	Corvidae	Large-billed Crow	?	0	1
Dicrurus aeneus	Corvidae	Bronzed Drongo	1	1	?
Dicrurus paradiseus	Corvidae	Greater Racket-tailed Drongo	1	1	1
Eupetes macrocerus	Corvidae	Rail-babbler	0	0	1
Hemipus hirundinaceus	Corvidae	Black-winged Flycatcher-shrike	1	1	1
Hypothymis azurea	Corvidae	Black-naped Monarch	1	1	1
Lalage nigra	Corvidae	Pied Triller	?	0	0
Oriolus chinensis	Corvidae	Black-naped Oriole	?	0	0
Oriolus xanthonotus	Corvidae	Dark-throated Oriole	1	1	1
Pachycephala grisola	Corvidae	Mangrove Whistler	0	1	1
Pericrocotus flammeus	Corvidae	Scarlet Minivet	1	1	1
Pericrocotus igneus	Corvidae	Fiery Minivet	0	0	1
Philentoma pyrhopterum	Corvidae	Rufous-winged Philentoma	1	1	1
Philentoma velatum	Corvidae	Maroon-breasted Philentoma	1	0	1
Pityriasis gymnocephala	Corvidae	Bornean Bristlehead	1	0	1
Platylophus galericulatus	Corvidae	Crested Jay	1	0	1

Platysmurus leucopterus	Corvidae	Black Magpie	1	1	1
Rhipidura javanica	Corvidae	Pied Fantail	1	1	1
Rhipidura perlata	Corvidae	Spotted Fantail	1	1	1
Tephrodornis gularis	Corvidae	Large Woodshrike	0	1	1
Terpsiphone paradisi	Corvidae	Asian Paradise-flycatcher	1	1	1
Cacomantis merulinus	Cuculidae	Plaintive Cuckoo	1	1	1
Cacomantis sepulcralis	Cuculidae	Rusty-breasted Cuckoo	1	1	1
Cacomantis sonneratii	Cuculidae	Banded Bay Cuckoo	0	1	1
Carpococcyx radiatus	Cuculidae	Bornean Ground Cuckoo	0	0	?
Chrysococcyx minutillus	Cuculidae	Little Bronze Cuckoo	0	0	1
Chrysococcyx xanthorhynchus	Cuculidae	Violet Cuckoo	0	1	1
Cuculus micropterus	Cuculidae	Indian Cuckoo	1	1	1
Hierococcyx fugax	Cuculidae	Hodgson's Hawk Cuckoo	1	0	1
Hierococcyx vagans	Cuculidae	Moustached Hawk Cuckoo	0	0	1
Phaenicophaeus chlorophaeus	Cuculidae	Raffles's Malkoha	1	1	1
Phaenicophaeus curvirostris	Cuculidae	Chestnut-breasted Malkoha	1	1	1
Phaenicophaeus diardi	Cuculidae	Black-bellied Malkoha	1	1	1
Phaenicophaeus javanicus	Cuculidae	Red-billed Malkoha	1	0	0
Phaenicophaeus sumatranus	Cuculidae	Chestnut-bellied Malkoha	1	0	1
Surniculus lugubris	Cuculidae	Drongo Cuckoo	1	1	1
Dendrocygna arcuata	Dendrocygnidae	Wandering Whistling-duck	0	1	1
Eurostopodus temminckii	Eurostopodidae	Malaysian Eared Nightjar	1	1	1
Calyptomena viridis	Eurylaimidae	Green Broadbill	1	1	1
Corydon sumatranus	Eurylaimidae	Dusky Broadbill	1	0	1
Cymbirhynchus macrorhynchos	Eurylaimidae	Black-and-red Broadbill	1	1	1
Eurylaimus javanicus	Eurylaimidae	Banded Broadbill	1	1	1
Eurylaimus ochromalus	Eurylaimidae	Black-and-yellow Broadbill	1	1	1
Microhierax fringillarius	Falconidae	Black-thighed Falconet	0	0	1
Actenoides concretus	Halcyonidae	Rufous-collared Kingfisher	1	0	0
Halcyon capensis	Halcyonidae	Stork-billed Kingfisher	1	1	1
Halcyon coromanda	Halcyonidae	Ruddy Kingfisher	1	0	0
Lacedo pulchella	Halcyonidae	Banded Kingfisher	1	0	1
Hemiprocne comata	Hemiprocnidae	Whiskered Treeswift	1	1	1
Hemiprocne longipennis	Hemiprocnidae	Grey-rumped Treeswift	1	1	1
Hirundo tahitica	Hirundinidae	Pacific Swallow	1	1	1
Indicator archipelagicus	Indicatoridae	Malaysian Honeyguide	0	0	1
Chloropsis cochinchinensis	Irenidae	Blue-winged Leafbird	1	1	0
Chloropsis cyanopogon	Irenidae	Lesser Green Leafbird	1	1	1
Chloropsis sonnerati	Irenidae	Greater Green Leafbird	1	1	1
Irena puella	Irenidae	Asian Fairy Bluebird	1	1	1
Sterna albifrons	Laridae	Little Tern	0	0	1
Calorhamphus fuliginosus	Megalaimidae	Brown Barbet	1	1	1
Megalaima australis	Megalaimidae	Blue-eared Barbet	1	1	1

Megalaima chrysopogon	Megalaimidae	Gold-whiskered Barbet	1	1	1
Megalaima henricii	Megalaimidae	Yellow-crowned Barbet	1	1	1
Megalaima mystacophanos	Megalaimidae	Red-throated Barbet	1	1	1
Megalaima rafflesii	Megalaimidae	Red-crowned Barbet	1	1	1
Merops viridis	Meropidae	Blue-throated Bee-eater	0	0	1
Nyctyornis amictus	Meropidae	Red-bearded Bee-eater	1	1	1
Copsychus malabaricus	Muscicapidae	White-rumped Shama	1	1	1
Copsychus saularis	Muscicapidae	Oriental Magpie Robin	1	1	1
Culicicapa ceylonensis	Muscicapidae	Grey-headed Canary Flycatcher	1	1	0
Cyornis caerulatus	Muscicapidae	Large-billed Blue Flycatcher	?	0	0
Cyornis superbus	Muscicapidae	Bornean Blue Flycatcher	?	0	?
Cyornis turcosus	Muscicapidae	Malaysian Blue Flycatcher	1	1	1
Cyornis unicolor	Muscicapidae	Pale Blue Flycatcher	1	1	1
Enicurus leschenaulti	Muscicapidae	White-crowned Forktail	1	0	1
Enicurus ruficapillus	Muscicapidae	Chestnut-naped Forktail	1	0	1
Eumyias thalassina	Muscicapidae	Verditer Flycatcher	1	0	0
Ficedula dumetoria	Muscicapidae	Rufous-chested Flycatcher	1	0	0
Rhinomyias olivacea	Muscicapidae	Fulvous-chested Jungle Flycatcher	?	0	0
Rhinomyias umbratilis	Muscicapidae	Grey-chested Jungle Flycatcher	1	1	1
Trichixos pyrropyga	Muscicapidae	Rufous-tailed Shama	1	1	1
Zoothera interpres	Muscicapidae	Chestnut-capped Thrush	?	0	0
Aethopyga siparaja	Nectariniidae	Crimson Sunbird	1	1	1
Anthreptes malacensis	Nectariniidae	Brown-throated Sunbird	1	1	1
Anthreptes rhodolaema	Nectariniidae	Red-throated Sunbird	0	0	?
Anthreptes simplex	Nectariniidae	Plain Sunbird	1	1	1
Anthreptes singalensis	Nectariniidae	Ruby-cheeked Sunbird	1	1	1
Arachnothera affinis	Nectariniidae	Grey-breasted Spiderhunter	1	1	1
Arachnothera chrysogenys	Nectariniidae	Yellow-eared Spiderhunter	?	0	?
Arachnothera crassirostris	Nectariniidae	Thick-billed Spiderhunter	1	1	1
Arachnothera flavigaster	Nectariniidae	Spectacled Spiderhunter	1	0	1
Arachnothera longirostra	Nectariniidae	Little Spiderhunter	1	1	1
Arachnothera robusta	Nectariniidae	Long-billed Spiderhunter	1	0	1
Dicaeum chrysorrheum	Nectariniidae	Yellow-vented Flowerpecker	1	0	1
Dicaeum concolor	Nectariniidae	Plain Flowerpecker	1	1	1
Dicaeum cruentatum	Nectariniidae	Scarlet-backed Flowerpecker	1	1	1
Dicaeum everetti	Nectariniidae	Brown-backed Flowerpecker	?	0	?
Dicaeum trigonostigma	Nectariniidae	Orange-bellied Flowerpecker	1	1	1
Hypogramma hypogrammicum	Nectariniidae	Purple-naped Sunbird	1	1	1
Nectarinia calcostetha	Nectariniidae	Copper-throated Sunbird	0	0	?
Nectarinia jugularis	Nectariniidae	Olive-backed Sunbird	1	1	1
Nectarinia sperata	Nectariniidae	Purple-throated Sunbird	1	1	1
Prionochilus maculatus	Nectariniidae	Yellow-breasted Flowerpecker	1	1	1
Prionochilus percussus	Nectariniidae	Crimson-breasted Flowerpecker	1	0	1
Prionochilus thoracicus	Nectariniidae	Scarlet-breasted Flowerpecker	1	0	1
Prionochilus xanthopygius	Nectariniidae	Yellow-rumped Flowerpecker	1	1	1
Parus major	Paridae	Great Tit	0	0	?
Lonchura atricapilla	Passeridae	Chestnut Munia	1	1	1
Lonchura fuscans	Passeridae	Dusky Munia	1	1	1
Lonchura leucogastra	Passeridae	White-bellied Munia	0	0	1
Lonchura punctulata	Passeridae	Scaly-breasted Munia	1	1	0
Passer montanus	Passeridae	Eurasian Tree Sparrow	1	1	1
Argusianus argus	Phasianidae	Great Argus	1	1	1
Coturnix chinensis	Phasianidae	Blue-breasted Quail	0	1	1
Lophura erythropthalma	Phasianidae	Crestless Fireback	0	0	?
Lophura ignita	Phasianidae	Crested Fireback	1	1	1
Melanoperdix nigra	Phasianidae	Black Partridge	0	0	?
Rollulus rouloul	Phasianidae	Crested Partridge	1	1	1
Dendrocopos moluccensis	Picidae	Sunda Pygmy Woodpecker	?	0	1
Blythipicus rubiginosus	Picidae	Maroon Woodpecker	1	1	1
Celeus brachyurus	Picidae	Rufous Woodpecker	1	1	1
Chrysocolaptes lucidus	Picidae	Greater Flameback	0	0	1
Dendrocopos canicapillus	Picidae	Grey-capped Pygmy Woodpecker	1	1	1
Dinopium javanense	Picidae	Common Flameback	1	1	1
Dinopium rafflesii	Picidae	Olive-backed Woodpecker	?	0	0
Dryocopus javensis	Picidae	White-bellied Woodpecker	0	1	1
Hemicircus concretus	Picidae	Grey-and-buff Woodpecker	1	1	1
Meiglyptes tristis	Picidae	Buff-rumped Woodpecker	1	1	1
Meiglyptes tukki	Picidae	Buff-necked Woodpecker	1	0	1
Mulleripicus pulverulentus	Picidae	Great Slaty Woodpecker	1	1	1
Picus mentalis	Picidae	Checker-throated Woodpecker	0	1	1
Picus miniaceus	Picidae	Banded Woodpecker	1	1	1
Picus puniceus	Picidae	Crimson-winged Woodpecker	1	0	1
Reinwardtipicus validus	Picidae	Orange-backed Woodpecker	1	0	1
Sasia abnormis	Picidae	Rufous Piculet	1	1	1
Pitta baudii	Pittidae	Blue-headed Pitta	1	0	0
Pitta granatina	Pittidae	Garnet Pitta	1	0	0
Pitta guajana	Pittidae	Banded Pitta	1	0	0
Pitta sordida	Pittidae	Hooded Pitta	0	1	1
Loriculus galgulus	Psittacidae	Blue-crowned Hanging Parrot	1	1	1
Psittacula longicauda	Psittacidae	Long-tailed Parakeet	1	1	1
Psittinus cyanurus	Psittacidae	Blue-rumped Parrot	0	1	1
Alophoixus bres	Pycnonotidae	Grey-cheeked Bulbul	1	1	?
Alophoixus finschii	Pycnonotidae	Finsch's Bulbul	1	0	1
Alophoixus phaeocephalus	Pycnonotidae	Yellow-bellied Bulbul	1	1	1
Iole olivacea	Pycnonotidae	Buff-vented Bulbul	1	1	1
Ixos malaccensis	Pycnonotidae	Streaked Bulbul	1	1	1

Pycnonotus atriceps	Pycnonotidae	Black-headed Bulbul	1	1	1
Pycnonotus aurigaster	Pycnonotidae	Sooty-headed Bulbul	?	0	0
Pycnonotus brunneus	Pycnonotidae	Red-eyed Bulbul	1	1	1
Pycnonotus cyaniventris	Pycnonotidae	Grey-bellied Bulbul	1	0	1
Pycnonotus erythropthalmos	Pycnonotidae	Spectacled Bulbul	1	1	1
Pycnonotus eutilotus	Pycnonotidae	Puff-backed Bulbul	1	1	1
Pycnonotus goiavier	Pycnonotidae	Yellow-vented Bulbul	1	1	1
Pycnonotus melanoleucos	Pycnonotidae	Black-and-white Bulbul	1	1	1
Pycnonotus plumosus	Pycnonotidae	Olive-winged Bulbul	1	1	1
Pycnonotus simplex	Pycnonotidae	Cream-vented Bulbul	1	1	1
Pycnonotus zeylanicus	Pycnonotidae	Straw-headed Bulbul	1	0	1
Setornis criniger	Pycnonotidae	Hook-billed Bulbul	1	1	1
Tricholestes criniger	Pycnonotidae	Hairy-backed Bulbul	1	1	1
Amaurornis phoenicurus	Rallidae	White-breasted Waterhen	1	1	1
Gallicrex cinerea	Rallidae	Watercock	0	0	?
Gallirallus striatus	Rallidae	Slaty-breasted Rail	0	0	1
Rallina fasciata	Rallidae	Red-legged Crake	0	0	?
Sitta frontalis	Sittidae	Velvet-fronted Nuthatch	1	0	1
Bubo sumatranus	Strigidae	Barred Eagle Owl	0	0	1
Ketupa ketupu	Strigidae	Buffy Fish Owl	1	1	1
Ninox scutulata	Strigidae	Brown Hawk Owl	0	1	1
Otus bakkamoena	Strigidae	Collared Scops Owl	0	1	1
Otus rufescens	Strigidae	Reddish Scops Owl	0	1	1
Strix leptogrammica	Strigidae	Brown Wood Owl	0	0	1
Aplonis panayensis	Sturnidae	Asian Glossy Starling	0	0	1
Gracula religiosa	Sturnidae	Hill Myna	1	1	1
Alcippe brunneicauda	Sylviidae	Brown Fulvetta	1	1	1
Kenopia striata	Sylviidae	Striped Wren Babbler	1	0	1
Macronous bornensis	Sylviidae	Bold-striped Tit Babbler	1	1	1
Macronous ptilosus	Sylviidae	Fluffy-backed Tit Babbler	1	1	1
Malacocincla abbotti	Sylviidae	Abbott's Babbler	?	0	?
Malacocincla malaccensis	Sylviidae	Short-tailed Babbler	1	1	1
Malacocincla sepiarium	Sylviidae	Horsfield's Babbler	1	1	0
Malacopteron affine	Sylviidae	Sooty-capped Babbler	1	1	1
Malacopteron albogulare	Sylviidae	Grey-breasted Babbler	1	1	0
Malacopteron cinereum	Sylviidae	Scaly-crowned Babbler	1	1	1
Malacopteron magnirostre	Sylviidae	Moustached Babbler	1	1	1
Malacopteron magnum	Sylviidae	Rufous-crowned Babbler	1	1	1
Napothera atrigularis	Sylviidae	Black-throated Wren Babbler	1	0	?
Orthotomus atrogularis	Sylviidae	Dark-necked Tailorbird	1	1	1
Orthotomus ruficeps	Sylviidae	Ashy Tailorbird	0	1	1
Orthotomus sericeus	Sylviidae	Rufous-tailed Tailorbird	1	1	1
Pellorneum capistratum	Sylviidae	Black-capped Babbler	1	1	0
Pomatorhinus montanus	Sylviidae	Chestnut-backed Scimitar Babbler	1	0	1
Ptilocichla leucogrammica	Sylviidae	Bornean Wren Babbler	1	0	0

Stachyris erythroptera	Sylviidae	Chestnut-winged Babbler	1	1	1
Stachyris leucotis	Sylviidae	White-necked Babbler	?	0	0
Stachyris maculata	Sylviidae	Chestnut-rumped Babbler	1	1	1
Stachyris nigricollis	Sylviidae	Black-throated Babbler	1	1	1
Stachyris poliocephala	Sylviidae	Grey-headed Babbler	?	0	0
Stachyris rufifrons	Sylviidae	Rufous-fronted Babbler	?	0	0
Trichastoma bicolor	Sylviidae	Ferruginous Babbler	1	1	1
Trichastoma rostratum	Sylviidae	White-chested Babbler	1	1	1
Yuhina zantholeuca	Sylviidae	White-bellied Yuhina	?	0	0
Harpactes diardii	Trogonidae	Diard's Trogon	1	1	1
Harpactes duvaucelii	Trogonidae	Scarlet-rumped Trogon	1	1	1
Harpactes kasumba	Trogonidae	Red-naped Trogon	1	1	1
Harpactes orrhophaeus	Trogonidae	Cinnamon-rumped Trogon	?	0	0
Phodilus badius	Tytonidae	Oriental Bay Owl	0	0	1

Appendix 8. Migratory bird species in Labian-Leboyan Corridor

Species	Family	English name
Accipiter gularis	Accipitridae	Japanese Sparrowhawk
Pandion haliaetus	Accipitridae	Osprey
Alcedo atthis	Alcedinidae	Common Kingfisher
Bubulcus ibis	Ardeidae	Cattle Egret
Clamator coromandus	Cuculidae	Chestnut-winged Cuckoo
Hirundo rustica	Hirundinidae	Barn Swallow
Lanius cristatus	Laniidae	Brown Shrike
Lanius tigrinus	Laniidae	Tiger Shrike
Muscicapa dauurica	Muscicapidae	Asian Brown Flycatcher
Muscicapa sibirica	Muscicapidae	Dark-sided Flycatcher
Motacilla cinerea	Passeridae	Grey Wagtail
Motacilla flava	Passeridae	Yellow Wagtail
Pitta moluccensis	Pittidae	Blue-winged Pitta
Actitis hypoleucos	Scolopacidae	Common Sandpiper
Tringa glareola	Scolopacidae	Wood Sandpiper
Phylloscopus borealis	Sylviidae	Arctic Warbler

Appendix 9. Mammal species recorded in Labian-Leboyan Corridor (prim.: primary data: record through direct observation, indirect through identifiable signs or capture; sec.: secondary information: trophy or other identifiable part produced by hunter and claimed to originate from LLC.

Species	Family	English name	prim.	sec.
Macaca fascicularis	Cercopithecidae	Long-tailed Macaque	X	
Nasalis larvatus	Cercopithecidae	Proboscis Monkey	X	
Presbytis rubicunda	Cercopithecidae	Maroon Langur	X	
Muntiacus muntjac	Cervidae	Common Muntjac	X	X
Rusa unicolor	Cervidae	Sambar		X
Echinosorex gymnurus	Erinaceidae	Moonrat	X	X
Neofelis diardi	Felidae	Sunda Clouded Leopard		X
Hipposideros cervinus	Hipposideridae	Fawn Roundleaf Bat	X	
Hipposideros diadema	Hipposideridae	Diadem Roundleaf Bat	X	
Pongo pygmaeus	Hominidae	Bornean Orangutan	X	X
Hylobates muelleri	Hylobatidae	Bornean Gibbon	X	X
Gen. sp.	Hystricidae	Porcupine	X	X
Nycticebus menagensis	Lorisidae	Greater Slow Loris	X	X
Manis javanica	Manidae	Sunda Pangolin		X
Megaderma spasma	Megadermatidae	Lesser False Vampire	X	
Leopoldamys sabanus	Muridae	Long-tailed Giant Rat	X	
Maxomys whiteheadi	Muridae	Whitehead's Rat	X	
Niviventer cremoriventer	Muridae	Dark-tailed Tree Rat	X	
Rattus tanezumi	Muridae	Asian House Rat	X	
Sundamys muelleri	Muridae	Mueller's Rat	X	
Aonyx cinereus	Mustelidae	Oriental Small-clawed Otter	X	
Lutrogale perspicillata	Mustelidae	Smooth Otter	X	
Iomys horsfieldii	Pteromyidae	Horsfield's Flying Squirrel	X	
Petaurista petaurista	Pteromyidae	Red Giant Flying Squirrel	X	
Petinomys vordermanni	Pteromyidae	Vordermann's Flying Squirrel	X	
Balionycteris maculata	Pteropodidae	Spotted-winged Fruit Bat	X	
Cynopterus brachyotis	Pteropodidae	Short-nosed Fruit Bat	X	
Dyacopterus spadiceus	Pteropodidae	Dayak Fruit Bat	X	
Macroglossus minimus	Pteropodidae	Long-tongued Nectar Bat	X	
Penthetor lucasi	Pteropodidae	Dusky Fruit Bat	X	
Pteropus vampyrus	Pteropodidae	Large Flying Fox	X	X
Rhinolophus sedulus	Rhinolophidae	Lesser Wooly Horseshoe Bat	X	
Rhinolophus trifoliatus	Rhinolophidae	Trefoil Horseshoe Bat	X	
Callosciurus notatus	Sciuridae	Plantain Squirrel	X	
Callosciurus prevostii	Sciuridae	Prevost's Squirrel	X	
Exilisciurus exilis	Sciuridae	Plain Pigmy Squirrel	X	
Nannosciurus melanotis	Sciuridae	Black-eared Pigmy Squirrel	X	
Sundasciurus lowii	Sciuridae	Low's Squirrel	X	
Crocidura fuliginosa	Soricidae	Southeast Asian White-toothed Shrew	X	
Sus barbatus	Suidae	Bearded Pig	X	X
Tarsius bancanus	Tarsiidae	Horsfield's Tarsier	X	
Tragulus javanicus	Tragulidae	Lesser Mouse Deer		X
Tragulus napu	Tragulidae	Greater Mouse Deer		X
Tupaia glis	Tupaiidae	Common Treeshrew	X	
Helarctos malayanus	Ursidae	Malayan Sunbear	X	X
Kerivoula hardwickii	Vespertilionidae	Hardwicke's Wooly Bat	X	
Tylonycteris pachypus	Vespertilionidae	Lesser Bamboo Bat	X	
Tylonycteris robustula	Vespertilionidae	Greater Bamboo Bat	X	
Arctictis binturong	Viverridae	Bearcat	X	X
Cynogale bennettii	Viverridae	Otter Civet	X	
Paradoxurus hermaphroditus	Viverridae	Common Palm Civet	X	

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