ECOREGIONAL ASSESSMENT
of
BIOLOGICAL DIVERSITY CONSERVATION
in
EAST KALIMANTAN, INDONESIA

Volume I - Report





by

The Nature Conservancy
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Preface

The Nature Conservancy's Kalimantan Program is interested in identifying and conserving the best examples of ecological systems and their floral and faunal inhabitants remaining in the East Kalimantan Province of Indonesia. To do so we have assembled a collection of locations called "portfolio sites" resulting from the most up-to-date synthesis of past and present ecological information pertaining to these rich landscapes. The selection and formation of the TNC portfolio of conservation sites in East Kalimantan was based upon an approach termed "Ridges to Reefs" where we identified the highest viability assemblages of target ecological systems contributing to and preserving the functionality of Major River systems from the uppermost occurrences of Cloud Forest to the terminal deltas and the coral reefs they supply with nutrients.

Conservation in this day and age – and especially as recommended in this report – involves the integration of compatible human uses into the management of areas for preserving the natural biological diversity for many years to come. We realize it is not likely that new National Parks will be established in this part of Indonesia, so we recommend conservation management of large enough areas of land to allow for the removal of natural resource products from the landscape such as timber, coal, rattan, fruits, and oil or gas.

There has been a tendency for some groups, when developing conservation strategies in Indonesia, to consider areas that have been seriously burnt or logged once over as not worthy of conservation effort. This has been a divisive argument used when assessing the value of continuing to place sparse conservation resources into the management of the badly burnt Kutai National Park in East Kalimantan, for example. While certainly the ecological integrity of such places has been seriously compromised – the role that these protected areas may play in the ultimate conservation of other, higher-ranked locations should not be discounted.

Some occurrences of lower viability or condition have been included in this assemblage of portfolio sites, particularly if it was felt that they would continue to contribute to the functionality of the landscape ecosystems. These disturbed, burnt or selectively logged sites will be recommended with the knowledge that if they are protected from further such disturbances, or managed in a more ecologically sensitive manner, they will have a good potential to recover in the long-term. They may eventually become important conservation areas in themselves, aside from their current function as valuable corridors connecting and thereby improving the functionality of highly ranked conservation sites. When integrated with innovative strategies for abatement of the major threats to their ecological integrity, this portfolio of sites represents the best hope for conservation of the biological diversity of this region of Borneo.

EXECUTIVE SUMMARY
For the
EAST KALIMANTAN ECOREGIONAL ASSESSMENT

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Overview

This biodiversity assessment of the Indonesian province of East Kalimantan on the island of Borneo is presented by The Nature Conservancy (TNC) with considerable assistance from many ecological experts, stakeholders and conservation partners. Following the guidelines offered in *Designing a Geography of Hope* (TNC 2000), this report identifies 33 natural areas termed "portfolio sites", whose protection by means of sound conservation management, should ensure the long-term survival of numerous globally important vulnerable species and representative natural communities in the ecoregional planning area.

The East Kalimantan planning area encompasses nearly 20 million hectares of topographically diverse landscapes ranging in altitude from the eastern coastal communities at sea level, to the upper altitude Cloud Forests (2,438 meters above sea level) on the spine of the Iban Mountain Range on the western border of the province.

The planning area supports an impressive array of organisms, many of which have yet to be described, and several birds and some primates found nowhere else in the world but on the island of Borneo. Examples of this group include the Rhinoceros Hornbill, White-shouldered Stork, the Proboscis Monkey, Leaf Monkey, Silver Langurs, and possibly one of the last refuges of the Sumatran Rhino, Borneo Asian Elephant and the Clouded Leopard. Endemic plants are also found throughout the province – often tightly associated with specific altitudes, substrates or rock formations such as the limestone karst cliffs, the perpetually moist cloud forests, or the highly acidic peat swamp habitats.

The diversity of this area is extraordinarily high, but so too are the threats to the ecological integrity and even survival, of many of these sensitive conservation targets. Illegal logging, supported by an overabundance of pulp and timber mills, coupled with an insatiable global market for inexpensive wood, is by far the most difficult challenge facing the implementation of this conservation plan. Fires, both natural and human-induced, periodically sweep across the region devastating lowland rainforest and opening up vast tracts of land to invasion by exotic grasses and creating opportunities for new plantations and human settlements. Roads bladed by legal logging concessions and ever-expanding coal mines to facilitate removal of these resources from the previously intact interior create easy avenues for other extractive and far less regulated uses such as poaching and timber theft. Additionally, these roads fragment formerly contiguous forest habitats that impede the movement patterns of arboreal species such as langurs and gibbons – as well as creating more edges susceptible to fire and invasion of exotic plant species. Fish and shrimp ponds increasingly replace valuable mangrove habitats that formerly stabilized shorelines and served as protected nurseries for innumerable aquatic organisms important to local economies and to the functionality of coastal ecosystems.

Goals

This assessment evaluated approximately 14 conservation targets including a series of nine ecological system types including: mangrove forests, peat swamps, freshwater swamps, heath forests, lowland limestone forest (karst), lowland rainforest, lower and middle montane forests, upper montane and cloud forests, and major rivers and lakes. Data sources for the assessment included LandSat™ imagery, published inventories of species and studies of ecological systems, local government spatial plans and resource management plans, expert interviews, local community workshops and in-house expertise for some of the ecological systems covered here.

Goals for conservation targets were established by considering the relative rarity and distribution of the forest types across the planning area and the island of Borneo as a whole. Additionally, goals were based upon the naturally occurring patch sizes of the respective community types as well as the Conservancy's desire to secure multiple examples of the geographic variability of targets from north to south and east to west across the planning area.

Results

The recommended portfolio of 33 landscape-scale sites encompasses approximately 33% of the province and about 9% of the island of Borneo. Nine (9) of the proposed sites, encompassing over 30% of the portfolio area, are already largely contained (greater than 75% of the site) within designated national parks or forest reserves. An additional 13 portfolio sites, encompassing another 21.7% of spatial area of the Portfolio, are located on *hutan lindung* or restricted forest areas. The remaining sites are comprised mostly of unique occurrences of forest and geological types or combinations of them, and most likely also contain unique assemblages of the outstanding biological diversity inhabiting this part of the island of Borneo.

Despite the relatively high percentage (52%) of co-location of our proposed portfolio sites with designated (often referred to as "gazetted") protected or restricted areas – in Indonesia at this time, that tends to mean very little in terms of actual conservation protection. Illegal logging is rampant throughout the national parks as are unapproved human settlements and farming. Leases for heavily damaging coal mines are routinely given out by the district and provincial governments within national parks and forest preserves. And, since the advent of decentralization of government responsibility to the district level, there is little opportunity or appetite to change the *status quo* at these local levels. But these challenges do not mean all is lost, by any means.

Strategies

There are innovative relationships being forged even now by TNC conservation staff with the multi-national logging companies and oil and gas industries. With the forces of international conservation pressure bearing down on these companies affecting the economic viability of their enterprise, they have realized an incentive to work cooperatively with constructive, solution-oriented environmental groups like TNC. Logging concessions in particular are highly motivated to get the most for their wood products, and are working with the Forest Industry, TNC, and other conservation groups like Smartwood and WWF to develop certification standards that will essentially declare their products "environmentally sound", thereby presumably fetching higher prices or more receptive outlets in overseas world markets.

It is hoped that, with the constructive engagement of these multi-national companies controlling vast expanses of the landscape in East Kalimantan, we will be able to impede, if not outright eliminate, the unequal competition of the illegal harvesters of wood and other resources. There truly are few other options. The best and most realistic outcome we should anticipate and plan for is to “buy time to preserve options” since, in Indonesia TNC cannot employ its proven U.S. strategy of buying land to effect conservation. The portfolio of sites addressed in this report represents the highest quality assemblage of landscapes that, if adequately managed, will delay the detrimental impacts of continued human population expansion across this portion of the Indonesian archipelago. Combined with innovative and effective marine conservation strategies, the unique but highly threatened wildlife and forests of Borneo may yet persist in the face of an unprecedented onslaught.

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CHAPTER 1 - BACKGROUND

Introduction

This ecoregional conservation assessment (ECA) will facilitate decisions made by The Nature Conservancy (TNC) regarding the selection of the best places to work in the province of East Kalimantan on the island of Borneo. In particular, it will lead us to select sites that best represent existing biological diversity; to ensure conservation of functional landscape scale systems; and to leverage the most conservation gain in East Kalimantan and elsewhere in Indonesia. Therefore this document has enormous utility for the TNC conservation strategy in East Kalimantan. However, this ECA does not exist in isolation from other Indonesian spatial planning scenarios, and it is hoped that this report will influence other spatial plans in East Kalimantan to adopt ecologically informed approaches to planning for natural resources management as well as those geared towards other land uses. For this reason it is necessary to understand the current framework of spatial planning in East Kalimantan.

Indonesian Government Spatial Planning in East Kalimantan

Spatial planning was introduced to Indonesia in 1992 with the Spatial Use Management Law (UU 24/1992). A number of government laws and regulations enacted since 1992 have clarified and elaborated on provisions of UU24/1992. These regulations are listed in Craven (2000: Table 2.1). The Indonesian Planning Agency‘s (BAPPEDA) stated goals for spatial planning in East Kalimantan are to assist in:

- Formulating policies and regulations to guide spatial (land) uses.
- Promoting integrity, interdependence, balance, and sectoral harmony in inter-district development plans.
- Guiding location of public and private investments.
- Developing spatial plans at sub-district levels.

Craven further states that at the district level it is expected that spatial plans will provide answers to very specific questions. The most cited use of spatial plans is that they should inform investors of opportunities to invest their money! Craven concludes that spatial plans "are being used in an entirely inappropriate way as a basis for issuing permits that give companies access and use rights over land, forest and mineral resources".

In 1997, BAPPEDA updated its spatial planning map for East Kalimantan and it was further updated in June 29, 2000 by a consultant. The Director of BAPPEDA in Samarinda (Anon 2002) gave a speech on 22 April 2002 which, while focused on spatial planning in the Mahakam River Basin, was relevant to the broader spatial planning scenario in East Kalimantan. The Ketua Director of BAPPEDA listed the following six reasons for the current absence of an integrated spatial plan of broad value in East Kalimantan (many of his points are affirmed by Craven 2000):

1) Existing spatial plans have been drawn up by consultants who worked outside the Province.
2) Absence of community involvement in the preparation of these plans as required by Government.
3) Plans were derived from inaccurate secondary sources, which were not later ground checked.
4) Plans ignore traditional community rights.
5) Insufficient involvement from civil society, e.g. non-governmental organizations (NGOs).
6) Information on the planning process and final plans was poorly disseminated outside a restricted group of insiders.

According to the Ketua BAPPEDA, the following conditions need to be met to achieve a working spatial plan in East Kalimantan that will have wide community support:
1) Local village leaders have to be consulted.
2) Information on the process has to be shared with the community.
3) Aspirations of the community have to be considered.
4) Spatial plans have to be consulted with, and have value to guide decisions of, government.
5) Overlapping and competing land-use requirements have to be considered.
6) Plans have to be politically realistic.

Further, the Ketua BAPPEDA stated that the spatial plans that are currently available:
1) Do not work.
2) Are out of date and have no reality on the ground.
3) Have no mechanisms to enforce them.
4) Do not inform communities of decisions related to implementation of the plans.

The seriousness of this situation comes into sharper focus when it is realized that the process of government decentralization, ratified in January 2001, shifted much of the responsibility for managing natural and biological resources from Indonesia's central government on the island of Java to the provincial governments and district (*kabupaten*) governments. The current relationship and responsibility between these latter two governments is a matter of both conjecture and considerable discussion.

There are 11 kabupatens in East Kalimantan, and all are required to produce spatial plans. Craven (2000) examined the spatial planning efforts in two of these kabupatens (Kutai and West Kutai). A number of policy and implementation reviews indicate that, particularly at the district level, spatial planning is still confused and not very effective (Craven 2000; Jarvie 1999; Fox 1999; Brown and Jarvie 1998). The main reasons for this arise from the following:

- Spatial plans have limited authority when put up against private sector interests.
- Technical specifications of plans are related to scale, and the detail required cannot be met.
- Terminology of plans is vague, particularly concerning forest status and land classification.
- Institutional capacity to carry out the planning is limited.

- Spatial information is out of date and inaccurate, especially for base maps and forest status maps.

Other spatial plans

The German government-sponsored Transmigration Area Development Project (GTZ-TAD, 1972) aimed to develop a strategic plan for the selection of development centers in East Kalimantan. The intention was mainly to discourage movement of people from the rural inland areas to the coastal population centers, but also to direct the location of transmigrants from other more populous islands of Indonesia. This TAD project focused almost entirely on a commercially viable planning strategy and had no consideration for environmental factors. For example, Thiel (1980) stated that TAD had as its main criterion of selection that such development centers have the *"ability to form regional units in an integrated development according to political goals"*. The proposed development regions consisted of *"existing central places, their catchment areas, and agricultural potentials located near these places and areas"*. The TAD plans focused on the middle Mahakam River lake country of East Kalimantan and encouraged it as a major center for development.

The World Wide Fund for Nature (WWF) Indonesian Program, Kalimantan Biodiversity Assessment (Momberg *et al*. 1998) was a pioneering attempt, using GAP analysis, to look at the capacity of the existing protected area system to conserve a representative sample of existing important 'habitats' in East Kalimantan. They overlaid known important biological areas (IUCN/WWF Centers of plant species diversity, WWF ecoregions, Myers (1988) globally important conservation areas, Bird Life International endemic bird areas, existing protected areas, land conversion types, forestry types, fire burning and hot spot maps and major vegetation types) and concluded that only nine of the 23 existing reserves in East Kalimantan retained their biological integrity – and that three of these nine had also been partially degraded.

There are also 14 areas that have been proposed as protected areas by McKinnon (1996). The WWF report concluded that six of these proposed areas, as well as some of the already designated reserves had been irrevocably "lost" and four more severely degraded. They concluded that "the ability to ensure the long-term survival of Bornean species and habitats occurring in East Kalimantan has been seriously compromised".

In particular, the WWF report concluded that the remaining protected area system does not represent the North Bornean Moist Forest ecoregion (WWF recently renamed this 'Borneo Lowland Rainforests') and the Sundaland Rivers and Swamps ecoregion. Their major recommendation was that a large landscape area stretching from the mouth of the Sebuku / Sembakung River to its upper catchment area should be included in the protected area system. This would represent habitat types missing in the current protected area system and would increase the proportion of some habitat types, such as Mangroves. Most importantly it would for the first time conserve "an intact altitudinal gradient of natural habitats from sea to lower montane forests". We incorporated this recommendation into our portfolio assembly as will be seen later in this report.

Momberg *et al*. (1998) also introduce for the first time in East Kalimantan the concept of including the eco-cultural framework of the various tribal land-use patterns into conservation planning for biological diversity. They argue strongly that most landscapes and habitats, including forests, in East Kalimantan are already human-modified and best thought of as cultural landscapes. They state that possibly only the Belayan-Kongkemul Mountain Range (in the southwestern border region of East Kalimantan) can be considered a primary landscape in the sense that past human activities have had no discernable impact on the ecology of the region. All other areas have a long history of human modification. They state that the Krayan Highland Plateau, Apo Kayan Beratus Mountains, and Benuaq/Tanjung lowlands are examples of well-developed cultural landscapes. Finally, the report tentatively describes some 25 ‘Eco-Cultural’ regions for East Kalimantan.

The TNC approach

This ECA, following the guidelines of TNC Ecoregional Planning (TNC 2000), addresses some of the inherent problems that exist in past and current spatial planning in East Kalimantan. It does this by defining a scale at which the available data can be applied; clearly describing terminology; producing topical map layers where possible; and, applying a clear logic and documentation to the process of selecting target ecological systems and species, and the viability ranking of these target systems – such as has been formulated in a number of TNC conservation programs worldwide. Further, we have strived to make the process transparent, methodical and repeatable. Data will be entered into a conservation database with input and discussion invited from a wide range of stakeholders, including environmental and biological experts, and all appropriate levels of government as well as local communities.

Our process differs from the prior WWF effort (Momberg *et al*. 1998) in that it goes above and beyond consideration of only existing protected areas. This assessment looks at the entire landscape of East Kalimantan and reviews current condition of major forest types, underlying geology and landforms, and known species occurrences to assemble a portfolio of sites to build in functionality and viability for long term conservation across the province. It also proposes strategies for addressing broad-scale threats with the goal of improving the situation for not only the existing “protected areas” but also for the non-gazetted areas of high ecological importance.

We are interested in the Eco-Cultural regional concept espoused by the WWF report for East Kalimantan, and this concept was considered for inclusion in this current planning process. However, the nascent state of knowledge about such regions in East Kalimantan, coupled with the paucity of information about the trajectory of change resultant from traditional human impact on the East Kalimantan environment, led to our decision not to incorporate this concept into this first basic portfolio of conservation sites. Once the recommended portfolio is finalized, traditional human impacts will be considered in the Site Conservation Planning (now Conservation Area Planning) stage, a much more detailed analysis process, which will propose a suite of conservation implementation strategies to be applied at sites by TNC or others.

It is the keen hope that this ECA will be widely accepted in East Kalimantan and that its logic and findings will be inculcated into other current and future spatial planning processes in this province and elsewhere in Indonesia. For it is, after all, the resident villagers, landowners, lease holders and agencies who will ultimately determine its success or failure in achieving the goal of conserving the representative biological diversity of this rich province on the island of Borneo.

Decision Process for Selection of Landscape Scale

In East Kalimantan, ECA is strongly dependent on the identification of repeating landscape scale patches of rather similar ecosystem types, then obtaining representation of these system types in a portfolio of conservation sites ordered spatially to retain functional elements of the overall East Kalimantan landscapes. Forman and Godron (1986), define landscape as a heterogeneous land area composed of a cluster of interacting ecosystems that is repeated in similar form throughout.

For biodiversity, particularly wildlife, it could be argued that it is better to define landscapes according to the definition of Dunning *et al*. (1992), namely an area of land containing a mosaic of *habitat* patches, often within which a particular "focal" or "target" habitat patch is embedded.

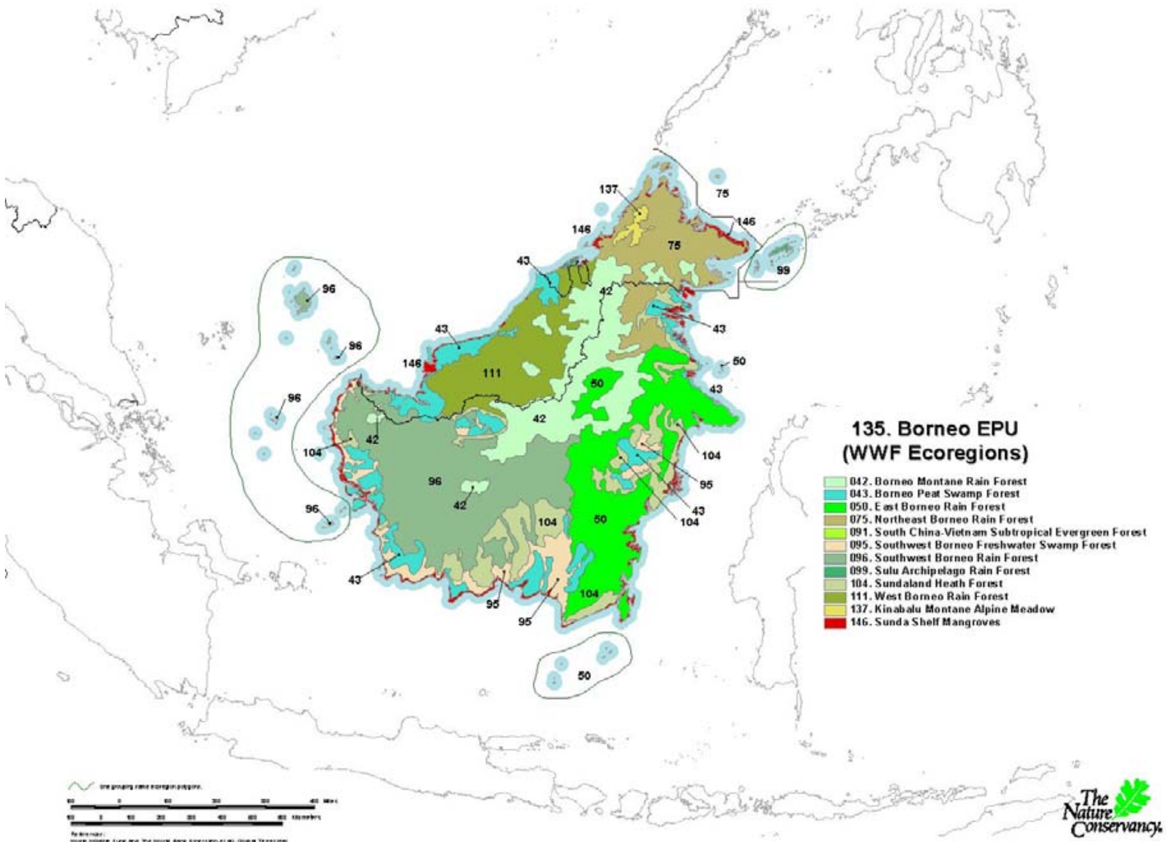
Unfortunately, in East Kalimantan there is very poor information available on the distribution of species of plants - endemic or otherwise – and for all animals, distribution information is also sparse. There are broad data on the spatial requirements for conserving viable populations of several mammals - Orangutan, Bornean Gibbon, Proboscis Monkey, Clouded Leopard, Mahakam River Dolphin and Sun Bear - but almost nothing on their specific habitat requirements. The areal requirements data indicate that a viable population of these large mobile species ranges from 150 to 800 square kilometers. This exemplifies the need to accommodate extensive landscape scales in ecoregional planning efforts.

The previous two definitions of landscape are not mutually exclusive, and both have utility in this ECA process. This assessment is able to represent some of the ecological patchiness in the East Kalimantan environment, despite the lack of detailed information as to whether the patches that are identified as ecological systems are, or if their subdivisions reflect, distinct animal habitats for certain species.

It is recognized that other efforts (WWF, Dasmann, Urdvardy) have attempted to define boundaries for ecoregions in Indonesia – all have informed TNC's approach to segregating large definable areas based upon similar floristic and ecological function attributes (precipitation patterns, geological components, representative vegetative communities, and faunal species limited to the habitats formed by these factors) for the purpose of conserving representative target species and natural communities. In East Kalimantan, quite a bit of ecological information has been gathered, which albeit primarily for commercial and industrial development purposes, has proven to be invaluable for defining our conservation assessment approach in this report.

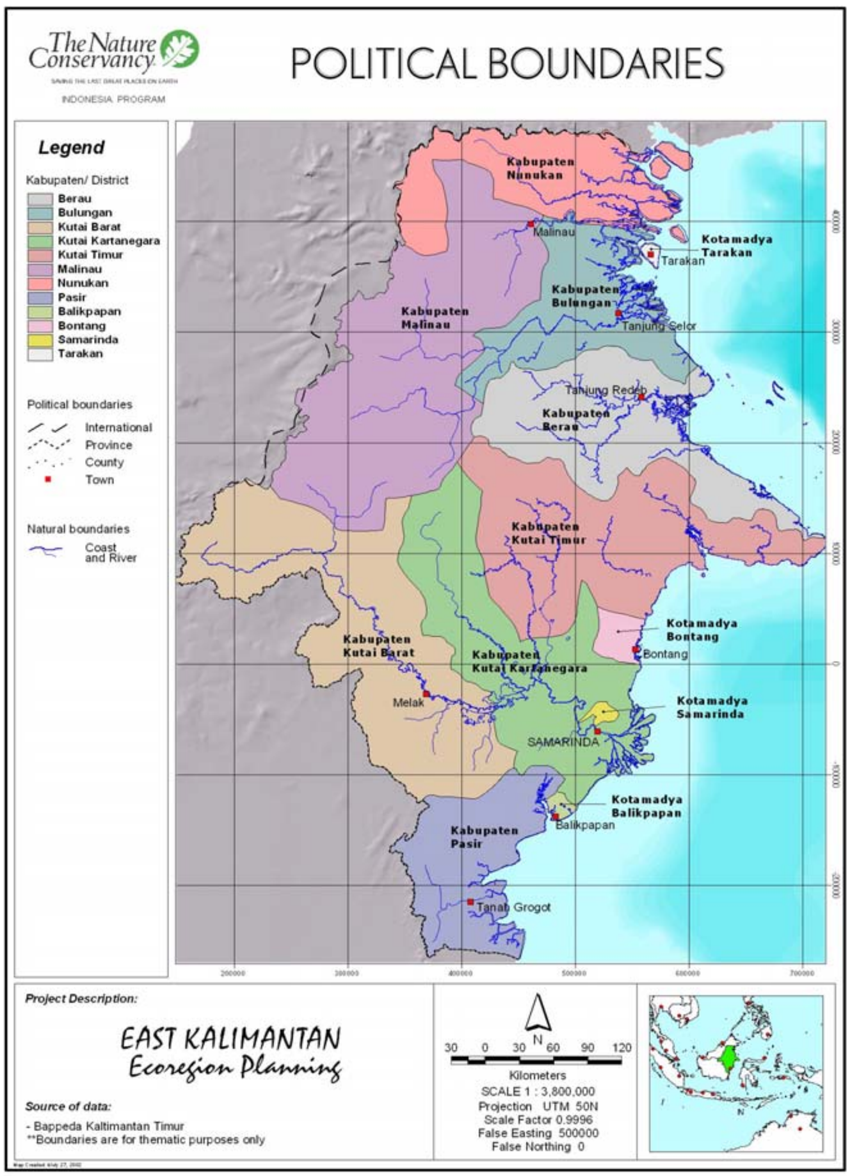
The WWF "ecoregions" for Indonesia as of 2001, when this effort was launched, most closely resembled what in the U.S. would be termed "ecological systems" or large vegetative communities, and thus fall short of the larger spatial planning needs as required in TNC's Designing a Geography of Hope (Fig. A) (these ecoregion designations have evolved three times since then to encompass larger groupings across broader locations outside of Indonesia – see WWF website on ecoregional descriptions at www.panda.org and most recently Wikramanayake 2002) This ECA integrated all of the 2001 WWF ecological categories into the landscape of East Kalimantan, but also added the "Major Rivers and associated Lakes" ecological system type which was not addressed in the WWF version, though they are dominant processes and community types on the island with species dependant solely upon them.

Figure A. **The Borneo Ecological Planning Unit –** based upon the 2000 WWF Ecoregions of the World.



Selection of Province-Scale Planning Area

It should be noted that the Province of East Kalimantan is largely defined by geomorphic features – primarily large mountain ranges that form the north, northwest and southwest borders (Fig. B) and the ocean which forms the east and southeast borders. It was decided by the ecoregional assessment team that there was a compelling case to be made for utilizing an admittedly political unit for this assessment since almost all of the available geologic, vegetative and cultural information for Kalimantan has been gathered only for this province due to its rich natural resources and a host of local and international companies seeking to exploit them. West Kalimantan and the Malaysian states of Sabah and Sarawak have good baseline information for some of their taxa or for specific forest types, but nothing comparable to the accumulation of broad databases that were available to us for East Kalimantan.



Since decentralization of government functions from January 2001 to present, all important natural resource allocation decisions are now made at the kabupaten level by district "governors" (*bupati*) who are concerned only with their districts– there is no spatial planning at hand to integrate individual kabupaten decisions with one another. This ECA will be an invaluable asset to local and provincial-level government entities who can make more informed decisions when the larger view is presented to them and the process for data gathering and assimilation is explained.

Socialization[Ψ] of the process and the product to those who will be responsible for ultimate implementation and decision making, has been paramount to the ECA planning team during every phase of this assessment. After significant consideration, the ECA team concluded that extending this planning process into neighboring countries (Malaysia) or out of the Province would have detracted from its applicability and relevance to the East Kalimantan local policy makers.

As indicated earlier, all component WWF "ecoregions" were incorporated into this effort within the planning unit as ecological system types – this was found to be their more appropriate utility. In the same way that vegetative communities span across and between more standard-defined ecoregions in the US and elsewhere (i.e. the Creosote-Scrub community spanning both the Sonoran and Mojave Ecoregions), these ecological system types also extended beyond the geographic boundaries of the planning unit to varying degree. This island-wide distribution was reflected in the categorization of our target ecological systems as "endemic", "widespread" or "limited" and subsequently influenced the goal setting for capturing these targets across the planning area.

The ECA team made a strategic decision to limit this assessment to the Indonesian province of East Kalimantan, though several of the ecological system types are distributed in other parts of Borneo. An example using the Lowland Rainforest ecological system type illustrates why this decision was made. To integrate this dominant matrix system type which circumnavigates the entire island would have required incorporating the three other Indonesian Provinces on Borneo, as well as the two Malaysian States of Sarawak and Sabah and the Nation-State of Brunei Darussalam. Such an approach would have transformed this planning process into an international effort, delayed information gathering, ground-truthing, and most likely reduced the relevance of the final product to those entities most responsible for implementation of the recommended conservation strategies. It would also not have been feasible within the one-year time frame and budget we were provided. This was determined to be an unnecessary risk for the planning effort and a good reality check for the standard stateside TNC recommendations for our global conservation programs.

Threats such as road construction, logging (primarily illegal) and forest fires which traversed the Upper Montane and Cloud Forest system types were considered on their total occurrence scale (Fuller, 2003), not just for their presence/absence or extent within East Kalimantan. Strategies for abating these threats though, will have to be limited to the East Kalimantan portion of this area since TNC currently has no relationship with Malaysia which contains the majority of the remaining landscape occurrence of this high altitude unique ecosystem.

From a more practical standpoint, this first test case of comprehensive ecoregional planning for a portion of Borneo has established a methodology and a rigor of logic which can be replicated when politically and financially feasible, across remaining Provinces and States of the island in the future to accomplish a truly ecoregional analysis of the whole Bornean Island. The pending "Heart of Borneo" initiative which is a collaborative effort among WWF-Indonesia, TNC and Conservation International holds great promise in bridging these

[Ψ] Socialization is the term used in Indonesia to mean the process of "marketing" a plan, process, or idea to gain acceptance and buy-in from a wide audience, usually of stakeholders who will be responsible for actually implementing the product.

international boundaries to assess the upper montane and cloud forest system types occurring in the central core of Borneo.

Consideration of Impacted Landscapes

Two recent studies in East Kalimantan have particular import to the discussion of whether or not sites or even broad landscapes which have already been subjected to extensive logging or burning should be considered for inclusion in our portfolio of sites. They have been proposed herein to both conserve biological diversity and as appendages to improve functionality of already chosen sites. The conclusions of the studies are summarized below:

Writing about the effect of fire on lowland forests in East Kalimantan, Dr. Ferry Slik and his colleagues wrote in 2002 that **“***fire renders them still valuable for conservation, especially since the studied forests were all heavily burnt and tree species diversity is likely to be higher in lightly burnt forest”*.

Further Mark van Nieuwstadt (pers. com.), a forest ecologist who has worked in East Kalimantan, wrote in 2002 that **“***The main conclusion of my thesis is, that these forests appear to have a greater recovery potential than expected, mainly due to the resprouting capacity of small stems in the forest undergrowth, which allows for the relatively rapid recovery of populations of shade tolerant trees. On the other hand, it is clear that repeated disturbances (such as logging in burned forest, or repeated fire) do cause greater damage than one would expect, because the limited recovery capacity is seriously reduced”*.

Selection of the TNC portfolio of conservation sites in East Kalimantan has been based on capturing the highest viability assemblages of target ecological systems that contribute to and preserve the functionality of Major River systems. However, some occurrences of lower viability or condition have been included - particularly if they would ostensibly contribute to functionality of the landscape ecosystems. These disturbed, burnt or selectively logged sites have been included with the knowledge that if they are protected from further such disturbances, they will have a good potential to recover in the long-term. They may eventually become important conservation areas in themselves, aside from their current function as valuable corridors connecting and thereby improving the functionality of highly ranked conservation sites.

Coarse Filter Conservation Targets - Ecological Systems

It is a reasonable assumption that the target ecological systems selected in this assessment represent the landscape heterogeneity (and the animal habitats) of East Kalimantan. In 1933, Aldo Leopold reported that wildlife diversity was greater in more diverse and spatially heterogeneous landscapes. Given this paradigm, it is anticipated that the portfolio of sites assembled through this ECA will also reflect the biological diversity of East Kalimantan.

There is limited empirical evidence to illustrate the interactions between the different landscapes and ecological systems identified in this portfolio. But, it is reasonable to expect that these interactions occur. For example, the Lowland Rainforest target system appears to be a true biological matrix which allows ready movement of its faunal elements into its other target system components, such as Lowland Limestone Forest, Heath Forest and Montane Forests, in such a way as to enrich them. Some faunal assemblages detailed below utilize various target systems but breed or are centered in the surrounding Lowland Rainforest matrix. However, because most of these target systems form important elements of river basins that dominate the ecology of East Kalimantan, it is reasonable to assume that in part they also represent interacting ecosystems.

Forest and River Targets

The initial set of target ecological systems selected for this Ecoregional Conservation Assessment is as follows:

1. Mangrove Forest
2. Freshwater Swamp Forest
3. Peat Swamp Forest
4. Heath Forest
5. Lowland Rainforest
6. Limestone (Karst) Forest
7. Lower Montane/Middle Montane Rainforest
8. Upper Montane Rainforest/ Cloud Forest
9. Major Rivers and associated Lakes

Their distribution within the planning area is shown at right and each is described in detail in Chapter 2.

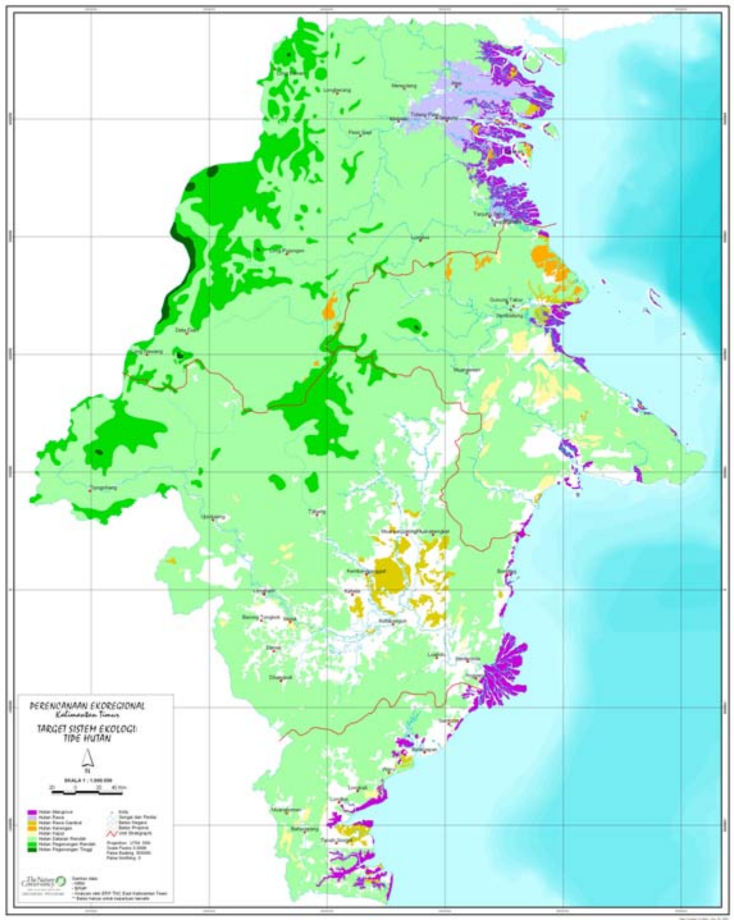


Figure C: Major Forest Types of East Kalimantan

Selection/Consideration of Important Areas and Species

Conservation Protected Areas

As identified in the WWF assessment (1998), East Kalimantan is poorly served by officially designated conservation protected areas (see Figure D). This ECA includes all of these areas in the portfolio of conservation sites: two national parks (Taman Nasional Kayan Mentarang and Taman Nasional Kutai -the latter severely degraded); four *Cagar Alam* or nature reserves (Muara Kaman Sedulang, Pedang Luway, Teluk Adang and Teluk Apar); two *Taman Wisata* or recreation parks (Bukit Soeharto and Pulau Sangalaki) and a *Suaka Margasatwa*, or game/ wildlife reserve (Pulau Semama).

Additionally, there are large forested areas that have various levels of protection. Wherever possible, these protected forests, *hutan lindung* (right), have been included in the portfolio where the option existed to choose between areas of similar habitat type and condition – one protected, the other unprotected. For the most part, *hutan lindung* are forests that have been designated, and ostensibly protected, due to their greater than 40% slope – which makes them impractical for current logging practices in addition to having critical watershed protection values.

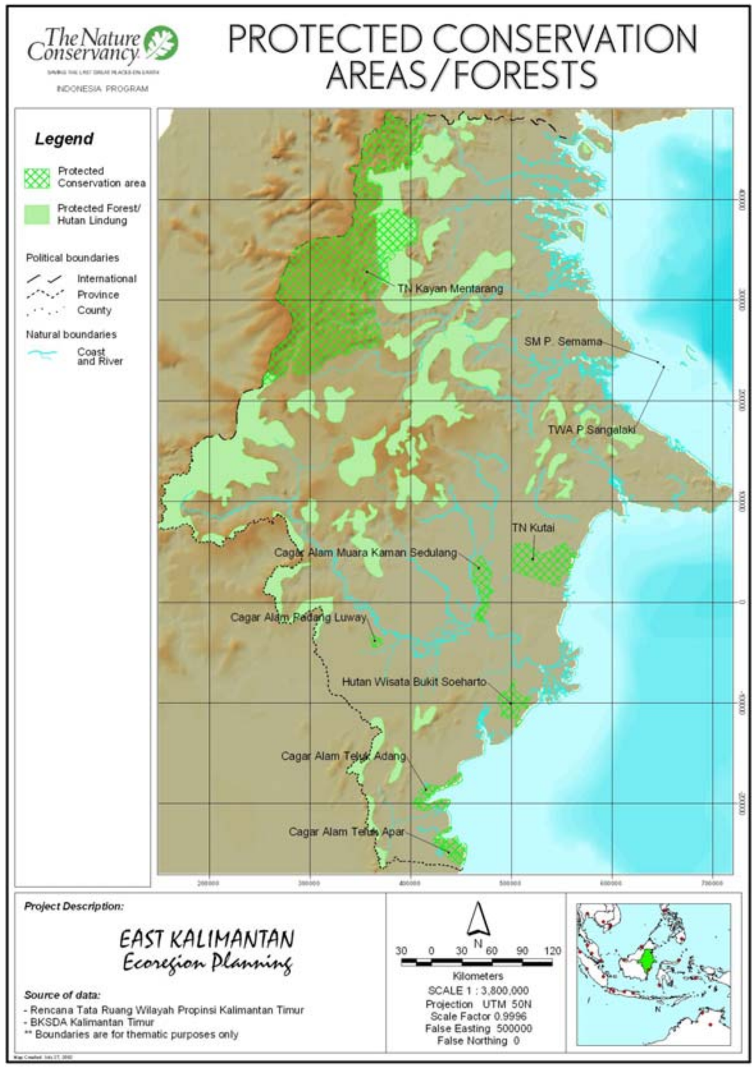


Figure D: Protected Areas of East Kalimantan

Important Bird Areas (from Holmes *et al*. 2001)

Bird Life International identified Important Bird Areas in Indonesia that contain species globally threatened, having a restricted distribution, characteristic of a specific biome, and occurring in good population densities.

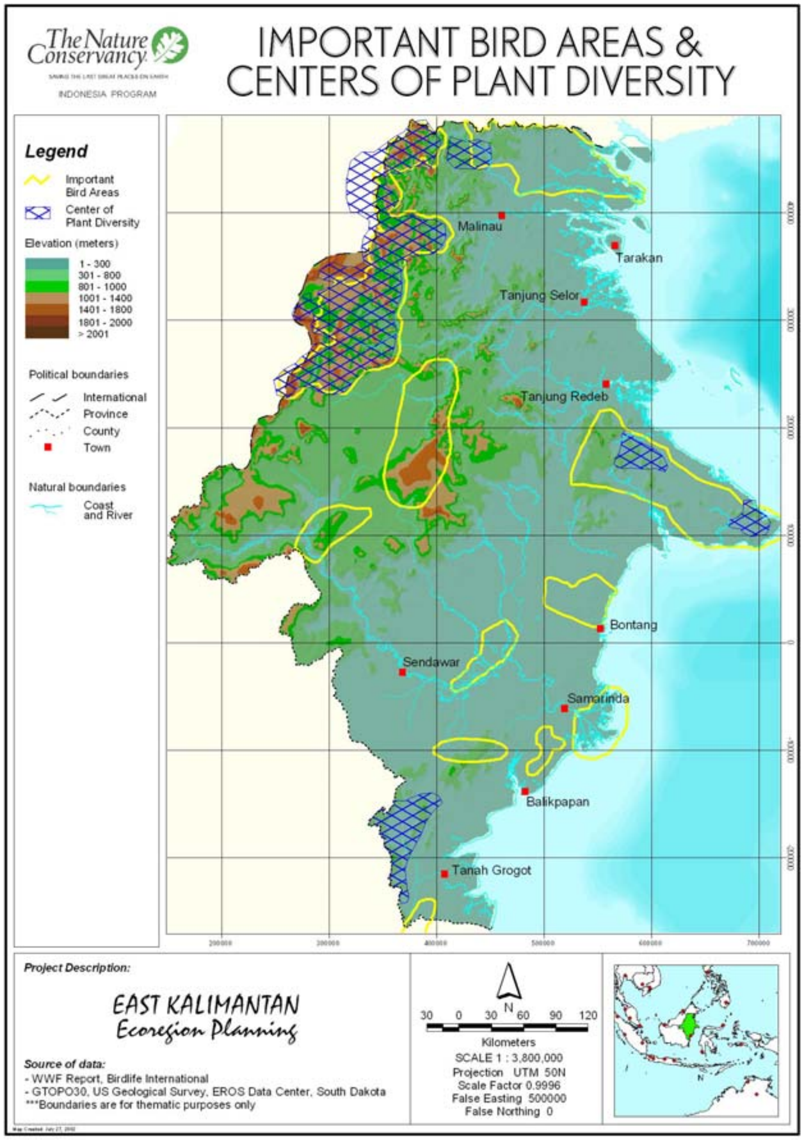
Ten areas (Figure E – sites outlined in yellow) were delimited as being important for birds in East Kalimantan. These areas are 1) Gunung Beratus; 2) Hutan Samarinda-Balikpapan; 3) Delta Mahakam; 4) Lahan Basah Mahakam Tengah; 5) Kutai; 6) Sangkulirang; 7) Sebuku/Sembakung; 8) Kayan Menterang; 9) Ulu Telen and 10) Long Bangun.

There is a database of bird observations at Bird Life International, Bogor, on which these areas are based. However, this database must be considered as nascent and requiring further definition. The very general boundaries of these areas are interpreted from knowledge of gross habitat types for bird assemblages and geography, and as such are imprecise.

Birdlife International Endemic Bird Areas

The digital layer of Endemic Bird Areas for Kalimantan was overlain with our proposed portfolio sites. In those instances where site boundaries could be slightly modified to fully incorporate these endemic bird areas, they were included. There were some areas that had already been converted to agricultural or human settlements which were not included for obvious reasons.

Figure E – Important Bird Areas and Centers of Plant Diversity in East Kalimantan



IUCN/WWF Centers of Plant Species Diversity Areas in East Kalimantan (WWF-IUCN 1994)

Natural history information on plants and animals at a species level is very sparse for East Kalimantan. No plants were found to have accurate enough or complete distribution maps that are essential to select them as potential target species for this ECA. The only botanical inclusion in the portfolio as a target group were five areas identified by WWF-IUCN as being important areas for plants in East Kalimantan.

These areas, which are shown on the map opposite (cross-hatched sites), are: 1) areas of limestone on the western edge of Pasir Kabupaten; 2) Lowland Rainforest and limestone plant communities on fractured limestones of the Sangkulirang Peninsula; 3) Lowland Limestone Forests on limestone massifs and outcrops; 4) the upper reaches (*Ulu* or *hulu*) of the Sembakung River; and 5) Kayan Mentarang National Park and the mountainous western areas that border with Serawak, Malaysia.

These areas were identified by plant experts as important, although their selection was not based on a rigorous review of plant distributions throughout East Kalimantan or for Borneo as a whole. Consequently, many sites may be represented only because they have been subjected to some collecting effort, while others may be excluded because they have not yet been surveyed. This dilemma is also true of the faunal species distribution records that were included as focal targets in this ECA.

Proposed Protected Areas

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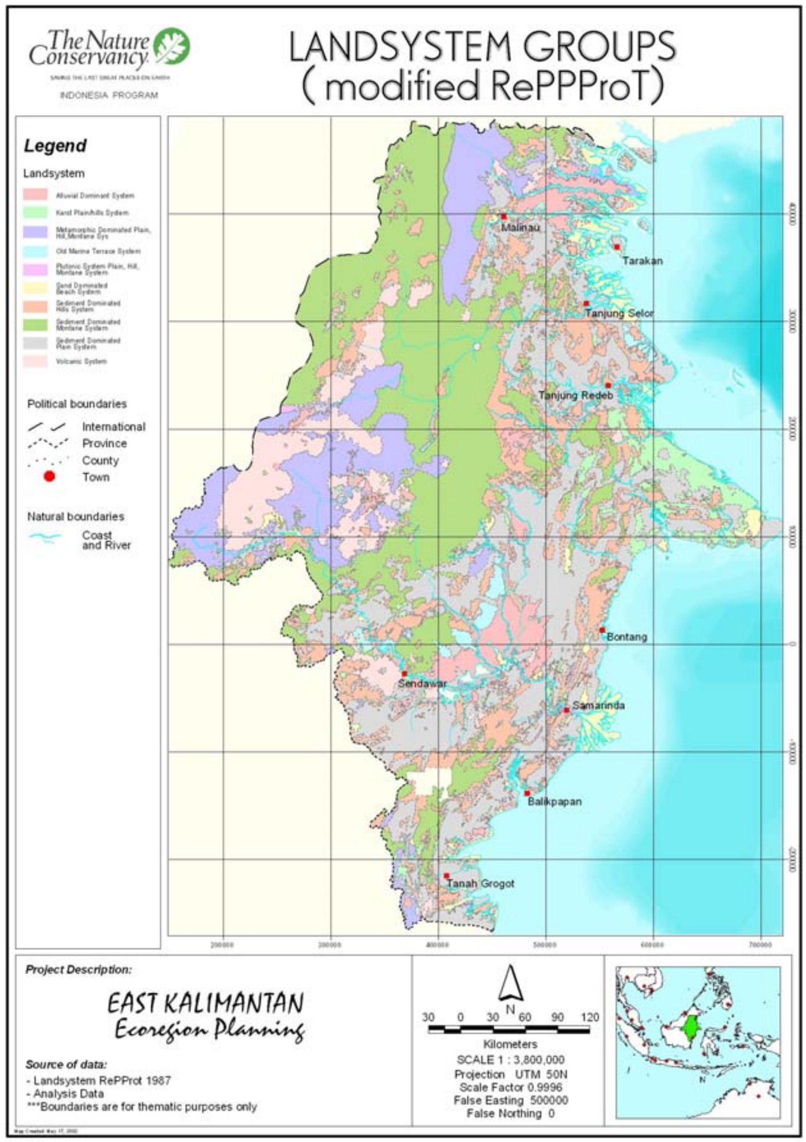
As mentioned previously, there are also 14 areas that have been proposed as protected areas by the respected ecologists MacKinnon *et al*. (1996:659). These areas are as follows: Muara Sebuku, Muara Kayan, Ulu Kayan, Gunung Berau, Sangkulirang, Sungai Berambai, Gunung Beratus, Apar Besar, Gunung Lumut, Mahakam Lakes, Pantai Samarinda, Ulu Sembakung, Apo Kayan and Batu Kristal. Where possible, if their current ecological conditions warranted and they helped us reach our target goals, these areas were included in the portfolio as expert nominated conservation sites.

RePPProT Aggregated Landsystems

In 1987, Indonesia's Department of Transmigration produced a land use map for Kalimantan (RePPProT 1987) based on a number of factors, including geology, soil, topography (slope and aspect), altitude, and climate. This map represented 42 land system types in East Kalimantan alone, which can reasonably be grouped into 10 major types based on parent rock material and structure (right). Because the eight terrestrial ecological system types identified in this ECA are quite heterogeneous, these 10 aggregated RePPProT types are variously present within the eight ecological systems. Therefore, the RePPProT types serve as a finer filter to further subdivide these ecological system targets and better represent some of the heterogeneity within them.



For example, Mangrove forests are generally transitional between terrestrial and marine/brackish environments and their ecology is greatly influenced by the substrate of sediment build up, rather than the underlying RePPProT landforms. There is, however, a noted area of exception to this, namely, the Mangroves that grow directly on top of limestone substrate in a small bay and its enclosed island on the northern coastline of the Sangkulirang peninsula. Such unique areas, identified to the ECA team by experts, were automatically included in the proposed portfolio as deserving of further conservation attention since it is likely they also harbor unusual plants and/or animals as well.

To capture more of the landscape heterogeneity, the portfolio of conservation sites selected will also contain representatives of all possible combinations of target ecological system types – as well as the important RePPProT land system types. Most importantly, though, only the target system- and not the RePPProT types- will be the initial basis of assembling the portfolio of sites. The landscape unit will be used as a secondary filter for checking representation of each target.

At the completion of the assembly phase, RePPProT types that have not been represented will be sought and added to the portfolio where possible. This approach is very similar to the TNC-US methodology of employing Ecological Land Units analysis to incorporate either in the selection of ecoregional portfolios up front, or, as we did, to use the information to cross-check the selected portfolio for under-represented heterogeneity of these geomorphic factors. It can be argued that either case insures that more subtle landscape variations, which plant and animal species often key on, are incorporated into the recommended conservation portfolio.

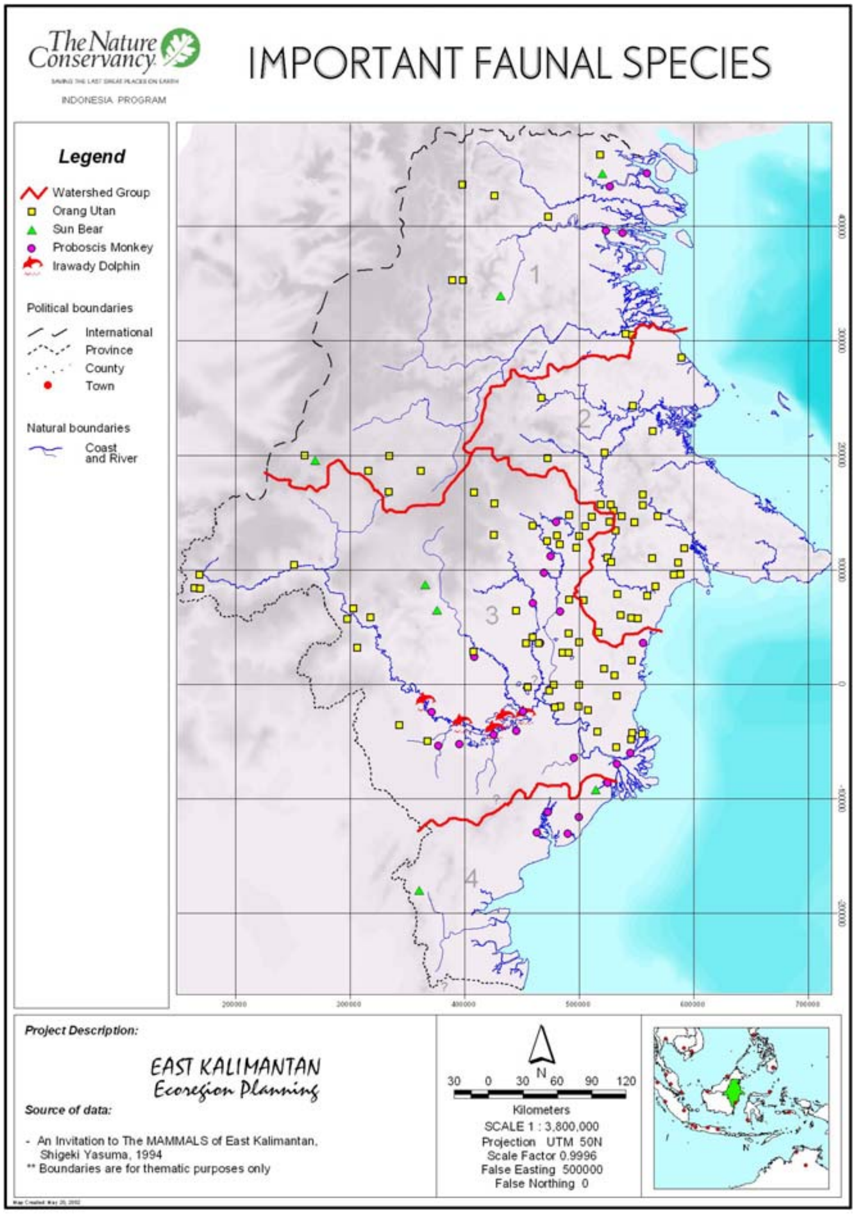
Fine-Filter Targets: Five Important Animal Species

The presence of five important wildlife species (Sun Bear, Orangutan, Bornean Gibbon, Mahakam River Dolphin, and Proboscis Monkey) (see Figure G) within potential portfolio sites in each stratigraphic unit was also assessed. These species were selected for one or more of the following reasons:

- large body size or vocally distinct, thereby easily detectable in the field (such as Gibbons)
- wide-ranging habits spanning several of our target forest system types
- presence at the top of their respective food webs
- natural history information which suggests that the species require unfragmented blocks of habitat, and therefore their presence in substantial numbers or in stable family groupings becomes a good indicator of viable forest types.

Clouded Leopard (*Neofelis nebulosa*) was initially considered in this assessment due to its globally-rare status, but was dropped when the ECA team concluded that virtually no recent, reliable occurrence or ecological information was available for this species. It is hoped that by capturing the full array of target ecological system types in the ECA portfolio, particularly the Upper Montane and Cloud Forest types, essential habitat for this and other high profile species such as the Sumatran Rhinoceros and Asian Elephant, if still extant, will also be captured within our recommended portfolio of conservation sites.

Figure G – Important Faunal Species – targets for portfolio assembly



Target ecological system occurrences that were otherwise equally ranked, using the criteria to be detailed later in this report, were examined for the presence of the five faunal target species. Those occurrences with a higher proportion of these target species were selected for the portfolio over less species-rich occurrences.

These species were considered when making portfolio selection decisions between target ecological system occurrences and their RePPProT subgroupings, but were not drivers of the initial portfolio selection. Unfortunately, at this time, none of the five faunal species has accurate and substantial enough distributional information (which would eliminate sampling bias) to justify including them as the primary basis for portfolio selection.

Had we decided to make our target species actual "drivers" of the portfolio sites inclusion or their configuration, we could have employed a habitat association model as was done in a recent assessment of primate diversity on Borneo (Reikjard & Neijman 2003) – but the information on habitat preferences and requirements was also inadequate to provide much comfort over so large a scale. The resulting portfolio of sites would have had to be seriously re-assessed via ground-truthing fieldwork to ensure relevance to the goals of this ecoregional exercise. Such an effort was cost and time prohibitive for this first phase assessment.

Selection of Stratigraphic Units

Using both of the previous definitions for landscapes, it is apparent that the physiography of East Kalimantan is dominated by major river systems and their catchment areas. It is also noted that these major river basins, their component ecological systems and their subdivisions, tend to be repeated throughout the Province. It could then be argued that, at the provincial scale, most of East Kalimantan is a combination of very similar landscapes, each dominated and ecologically integrated by a major river system.

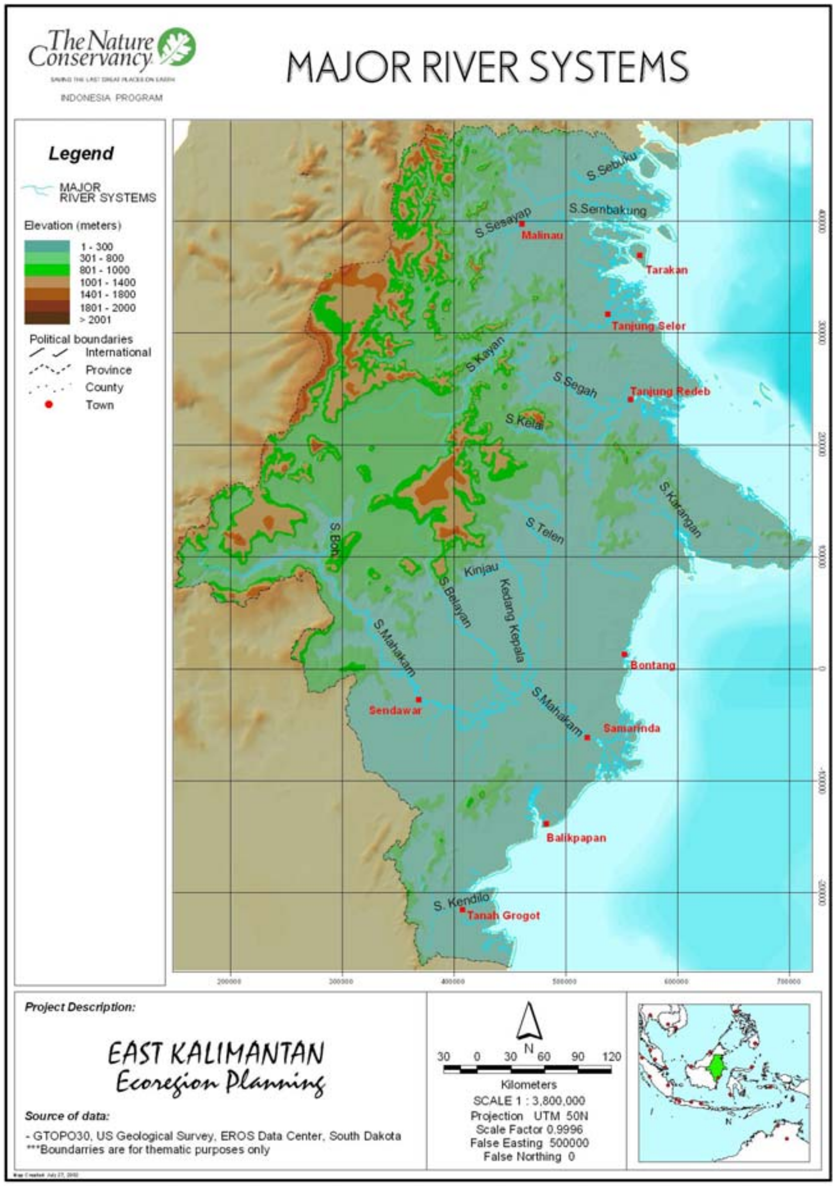
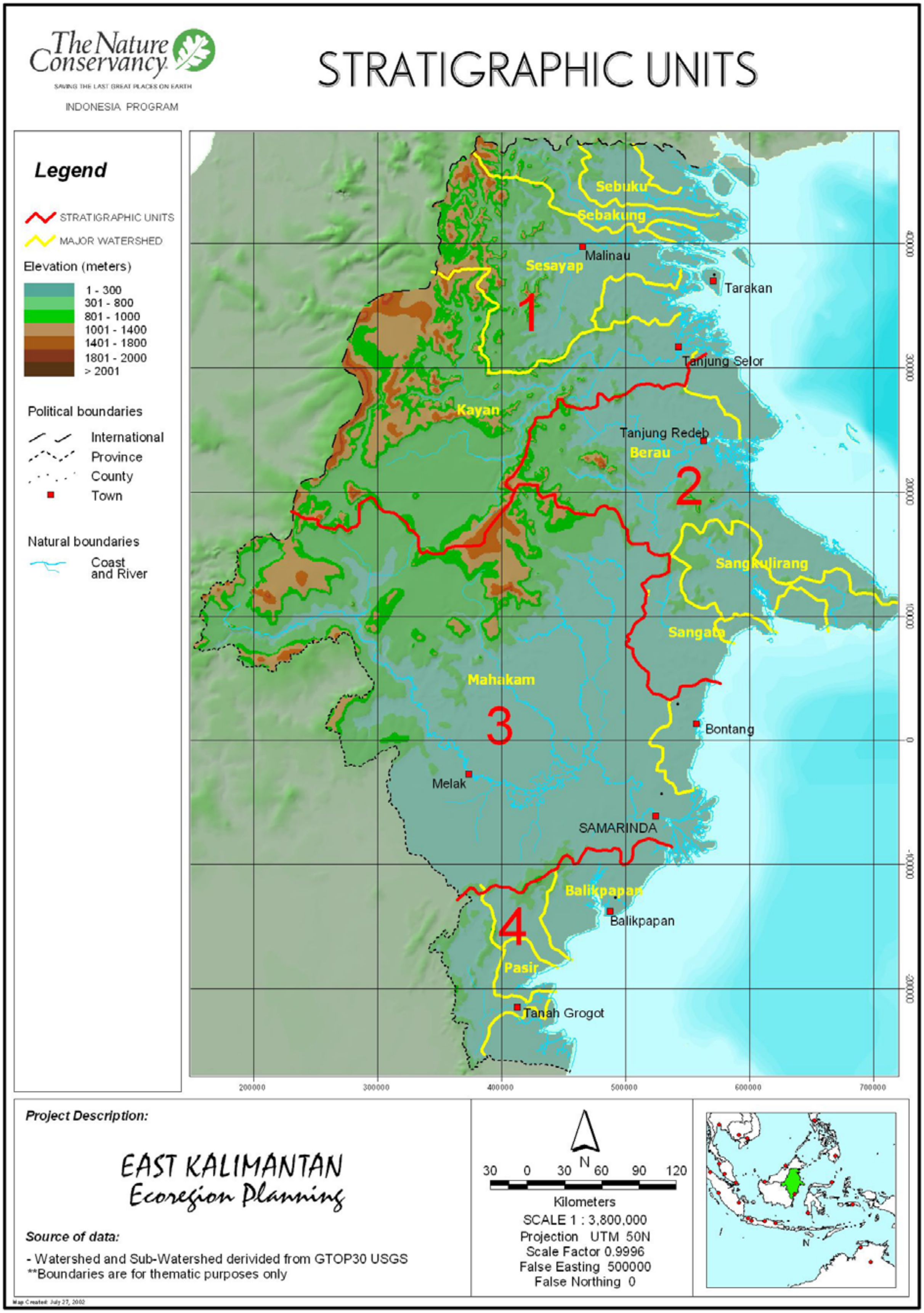


Figure H: Major River Systems of East Kalimantan

In the north and central regions these river systems are fed by upper catchment areas in the long north-to-south Iban Range bordering Serawak and Mt. Belayan to the north of the middle Mahakam area. The complexity of the landscapes has also been molded differently to some extent by the Pleistocene drainage patterns, which dominate the middle Mahakam area and its vicinity. Further, the limestone areas of the Sangkulirang/ Mangkalihat Peninsula also exert a great influence on that area. There are also major east to west trends in climate as evidenced by rainfall patterns (Figure J) and physiography.

To capture this heterogeneity, the East Kalimantan planning area was divided into four stratigraphic units (Fig.I), which are an aggregate of the major water catchment areas. The boundaries of these watershed aggregates define the four stratigraphic unit polygons. Because of this, these units also capture the major east to west trends in climate within their boundaries. They are generally described north to south as follows:


The Nature Conservancy
SAVING THE LAST GREAT PLACES ON EARTH
INDONESIA PROGRAM
STRATIGRAPHIC UNITS
Legend
STRATIGRAPHIC UNITS
MAJOR WATERSHED
Elevation (meters)
1 - 300
301 - 800
801 - 1000
1001 - 1400
1401 - 1800
1801 - 2000
> 2001
Political boundaries
International
Province
County
Town
Natural boundaries
Coast and River
Sebuku
Sebakung
Malinau
Sesayap
Tarakan
1
Tanjung Selor
Kayan
Tanjung Redeb
Berau
2
Sangkulirang
Sangata
Mahakam
3
Bontang
Melak
SAMARINDA
Balikpapan
Balikpapan
4
Pasir
Tanah Grogot
200000
300000
400000
500000
600000
700000
Project Description:
EAST KALIMANTAN
Ecoregion Planning
Source of data:
- Watershed and Sub-Watershed derivided from GTOP30 USGS
**Boundaries are for thematic purposes only
N
30 0 30 60 90 120
Kilometers
SCALE 1 : 3,800,000
Projection UTM 50N
Scale Factor 0.9996
False Easting 500000
False Northing 0

Stratigraphic unit 1, the northernmost unit, is the wettest of the four units and has no dry coastal zone (< 2,000 mm). It includes the entire mountainous country of Kayan Mentarang National Park, as well as the magnificent reaches of the large Kayan River. It has three large river systems (Kayan, Sesayap, Sebuku/Sembakung) which have deltas that merge to support one of the most extensive and important remaining Mangrove Forest communities in Kalimantan.

Stratigraphic unit 2, in the middle of the Province, is relatively dry and is dominated by precipitation zones totaling less than 3,000 mm average annual rainfall. The limestone of the Sangkulirang/ Mangkalihat Peninsula, and its Karst Forests dominates this unit and provides for a high degree of biological diversity and endemism. It has some near coastal mountains and shorter rivers.

Stratigraphic unit 3, extending to the southwest and south of stratigraphic unit 2, has the most even precipitation gradients, with approximate equal bandwidths of < 2,000 mm, 2,000 mm – 3,000 mm and >3,000 mm. It is characterized by the large Mahakam River Basin and its very long meandering rivers, lakes and extensive areas of Peat Swamp Forest and coastal Mangroves. It is dominated by alluvial and colluvial soils of various types. It also has extensive mountainous areas near the border with the Malaysian State of Serawak.

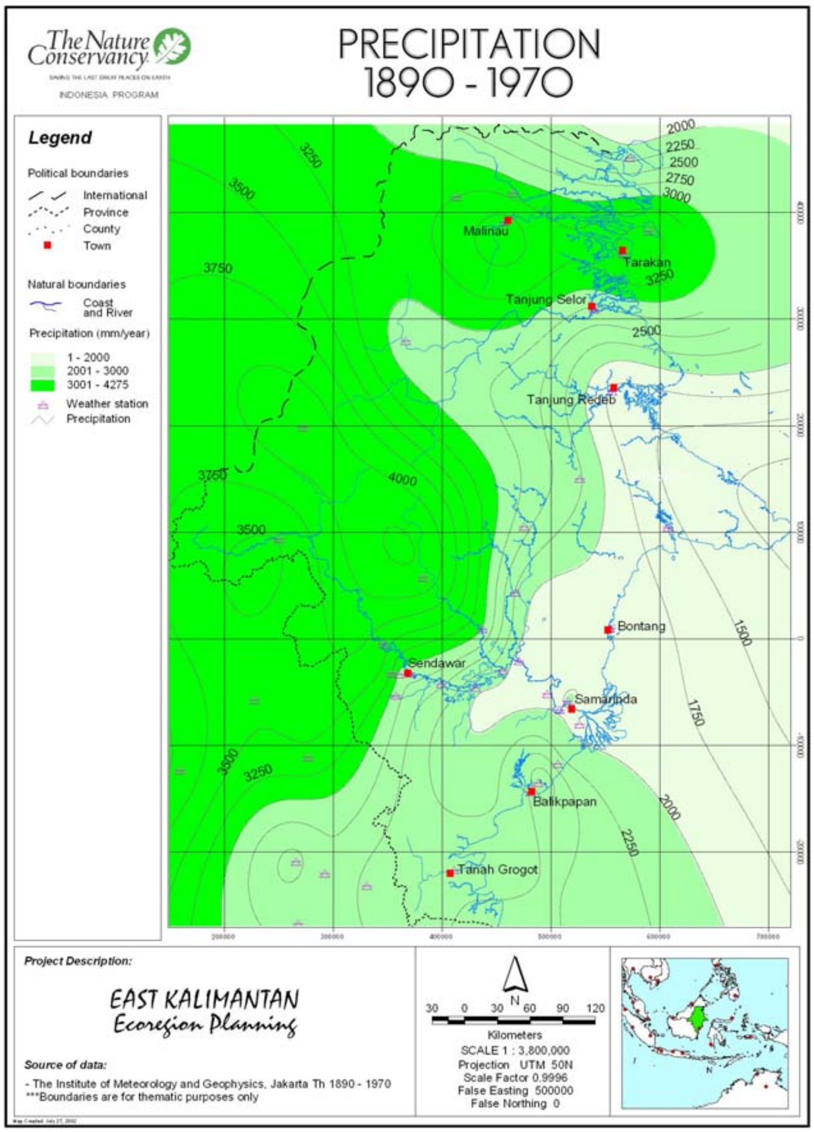
Stratigraphic unit 4, the most southerly and smallest of the planning area subunits, has moderate average annual rainfall in the 2,000 mm to 3,000 mm band. It has few high mountainous areas, its catchment areas are smaller, and it contains short narrow rivers with reduced deltas.

Identification of annual precipitation zones

In the portfolio assembly process, target ecological system occurrences were also selected to represent three major precipitation zones within each stratigraphic unit * (Figure J). In stratigraphic units 1 to 3 there are generally gradients that show increasing aridity from the western upper elevation areas eastward to the coast. The exception is the area in stratigraphic unit 1 between the Kayan and the Sesayap rivers. These trends in aridity also occur along the main gradients of the water catchment areas; they are more compressed in the 2,000 mm - 3,000 mm zone of the Mahakam River catchment compared to the Kayan River, for example.

From a biological standpoint, rainfall gradients within these catchments typically translate to trends in phenology of flowering and fruiting along the catchments. Such trends can be seen in the flowering occurrences (mast flowering) of dipterocarp species and Ficus species in East Kalimantan (Kade Sidiyasa pers. com.). It can be reasoned that in the past, many of the more vagile species, such as bats, birds, and pigs followed these trends in flowering and fruiting and exhibited local movement patterns along these river systems and associated catchment areas. Such is also the case with some of the more charismatic fauna like the Bornean gibbon and orangutan.

Figure J – Precipitation Zones across East Kalimantan



* The gradients for these precipitation zones were generated using mean annual rainfall data from 35 stations distributed throughout East Kalimantan from the period 1890-1970. Additionally, 6 of the 35 stations distributed north to south in the Province continued to generate data from 1990-2000. These gauges indicated a general drying trend by an average of 200 mm from the values reflected for those same stations in the first 80-year period.

Recognizing this important phenologic dynamic, rehabilitation of corridors (restoration would be difficult or impossible in many areas due to the extent of land conversion already undertaken) will be needed as part of the strategic approach to retain ecosystem function within these catchment areas. This rehabilitation could be accomplished via agroforestry or selected replanting with important local tree species, preferably those that incorporate more sustainable resource uses, to close the gaps between viable patches of native forest and create safe and functional pathways for these native fauna. In either case, planning such rehabilitation within known higher precipitation zones should lend itself towards higher success rates in the recovery process.

Additionally, as more is known, or can be more accurately modeled, on the future effects of global climate changes, it is recognized that planning for the eventual shifts of climatic factors in conservation planning exercises such as this, will improve the "resilience" of our major forest targets. This also makes a case for building in redundancy into the portfolio so that variations in global climate patterns will not be as likely to affect all examples of the major forest types and their incumbent flora and fauna. Likewise, it is projected that some of the more sensitive and restricted targets, such as the Upper Montane and Cloud Forests, may in fact have nowhere to move to as climates increase the altitudinal temperatures to eventually eliminate these forest types and the increasingly rare species that inhabit them (Lawton, et al., 2001; Kareiva, pers. comm. 2005).

Setting Goals for Target Ecological Systems

Goals were set to define the number and spatial distribution of target ecological systems as well as their RePPProT land system subdivisions (which probably reflect a finer degree of habitat type) needed to conserve these systems in East Kalimantan. Conservation of these targets depends on obtaining sufficient representation and replication to ensure that they persist in the face of environmental stochasticity across the planning unit. The difficulty arises in that there is no scientific consensus on how much area and how many populations are necessary to conserve a species target and its range of heterogeneity even in regions that are very well known biologically, such as the U.S. (TNC 2000). The assessment of such species requirements in East Kalimantan is even more of an expert value judgment. There are some general rules and assumptions, however, that are applicable and which were used in this planning process:

- Goals were based on historical distributions and abundance of target ecological systems where these are known or can be evaluated - this is particularly important with targets that have only recently, the last 20 years in most cases, been fragmented or seriously degraded (Peat Swamp Forests, Mangrove Forest, and Lowland Rainforests).
- As distribution of targets increases relative to the ecoregion (in this case what is known of the entire island of Borneo based upon the WWF "ecoregions"), the number of occurrences captured, or the percentage of area needed for conservation management attention, should decrease.
- Targets naturally distributed as small patches are subject to greater probabilities of attrition over time from factors such as wildfires, exotic invasive animals and plants and therefore should be represented at a higher percentage in the portfolio.

- Although in some U.S. situations, patchy (mosaic) communities may be more ecologically variable than matrix communities (TNC 2000), the reverse seems to be true in some forest types in East Kalimantan. For example, Lowland Rainforests exist on all 10 RePPProT land system types and tend to reflect the intensely complex Pleistocene drying pattern on lowland edaphic types. Variation in faunal and floral composition beneath the canopy is surely more subtly expressed than can be distinguished through aerial photography or satellite imagery.
- For widespread target systems (Lowland Rainforest, Lower Montane Forest, Mangroves and Major Rivers), it was decided that one element occurrence per stratigraphic unit within each precipitation zone (if possible) would be a minimum selection goal, coupled with a percentage goal for its overall areal extent.
- The number of target ecological system occurrences selected will also depend on the number required to ensure functionality of the Major River selected within each Stratigraphic Unit; this includes a functional buffer or riparian "belt"(500m – 2km) along the length of the river corridor and adequate areas of upper catchment area (*hulu*) and delta habitat at the terminus.

Goals were applied for each Stratigraphic Unit – resulting in separate preliminary portfolios for each. It was acknowledged that this approach would result in overrepresentation of some system types, but this also insured that the best representatives for each system type were being advanced for consideration in the ultimate portfolio of sites. Therefore, no high quality site would be overlooked because a particular system type had already met *a priori* goals elsewhere in the East Kalimantan planning area.

When all stratigraphic units were "rolled-up" to review progress towards overall conservation goals in the portfolio assembly, some less viable (i.e. lower ranking) areas were dropped when they resulted in over-representation of a particular system type. They were not eliminated, however, if they comprised the only representation of that particular ecological system type within the stratigraphic unit or within one of the three precipitation zones. Minimum portfolio assembly goals for target ecological system occurrences were based on the percentage of area of each stratigraphic unit and each precipitation zone occupied by the target system type (Table 1.1).

Table 1.1 - Portfolio Goals:

Target System	Distribution	Patch Size	GOAL
Upper Montane/ Cloud forest	limited	small to moderate	100%*
Lowland Limestone Forest	limited	small to large	70%
Freshwater Swamp Forest	limited	single, small	70%
Peat Swamp Forest	widespread	moderate	60%**
Heath Forest	widespread	small	60%**
Mangrove Forest	widespread	moderate	50%**
Lower Montane/Montane Rainforest	widespread	large	30%
Lowland Rainforest	widespread	matrix	20%
Major River	widespread	linear	4***

* Although Upper Montane/Cloud Forests in East Kalimantan are limited and are small to moderate in size, 100% of them are selected as a goal. They are extremely fragile habitats that retain a high percentage of endemic flora and fauna. Further, there

appears to be no competing land use proposed for them at this time. Also, a very large percentage of this ecosystem type is already included in existing conservation protected areas such as Kayan-Mentarang National Park.

** The goal for these targets is set higher than recommended for widespread target systems because their current areas have been greatly reduced in extent in just the last 50 years. The percentages also reflect that we are seeking "viable occurrences" which already limits the amount that can be captured meeting these criteria given ongoing threats and habitat degradation.

*** One example of a Major River would be selected for each of the four stratigraphic units.

Priority Setting (Ranking) of Target Ecological System Occurrences

Terrestrial targets

Evaluating and then ranking a group of factors related to actual or potential viability of the terrestrial conservation target occurrences facilitated setting priorities for these targets. In the U.S., rankings would normally be generated by Natural Heritage Programs or through expert advice that would suggest the area required for a viable population of a target species to persist in, say, Limestone Rainforest occurrences – or the distance between Mangrove occurrences that would begin to exceed the functional range of the mangrove assemblage of birds. In East Kalimantan such information is generally lacking. Therefore, we grouped the value for each occurrence of an ecological system type based on where the value lies in the quartile distribution of all values for its type across the planning area. This grouping is based on the logic that the life history strategy of animals in East Kalimantan has evolved to reflect the habitat patch variability within the region.

Target ecological system occurrences with smaller areas that fell in the lowest quartile could reasonably be expected to be less able to maintain viable populations of a suite of animals when compared to larger areas of that same system type that fell into the uppermost quartile. For example, a Mangrove occurrence that was a long distance from other Mangroves, such that it fell into the highest quartile for distance between occurrences, could be expected to have poor migration potential (both in and out) for mangrove birds, insects or primates compared to occurrences that were closer and fell into lowest (least distant) quartile.

There is some difficulty with this logic when it comes to habitat occurrences that have been recently fragmented, such as Peat Swamp Forests and the matrix Lowland Rainforest. However, because the boundaries of these units in this assessment are defined by the subcatchment areas and not the existing actual patch size, recent incidents of fragmentation may not bias the statistics as much as might be supposed, except perhaps in the determination of condition, discussed later in this report.

The occurrence factors considered are as follows:

1). ***Area***

Theory of nature reserve design argues that larger areas are better than smaller ones for the conservation of biological diversity. But, theories also suggests that several smaller areas of similar size grouped together within a large single area may, in some circumstances, be a preferred option, particularly if the risks of frequent burning, contagious disease vectors or other environmental factors relying on contiguity are high (SLOSS principle). It is unlikely in the case of Lowland Rainforest ecological dynamics that many disjunct habitat patches would suffice for the conservation of the wider ranging species, especially for those requiring structural maturity, canopy continuity and diversity for locomotion such as the highly arboreal Gibbon (Oka et al. 2000). Additionally, Davies and Payne (1982) estimated that the area required to conserve the minimum viable population of some of our priority focal species, estimated at 200 individuals, was 800 km^2 for the Clouded Leopard (ultimately not one of our focal species) and Sun Bear; 150-200 km^2 for Orangutan; and 150 to 400 km^2 for Hornbills. Such a patchwork quilt of forest occurrences would not be able to maintain the humid closed-canopy environment for many of the rare and fragile plants or forest dwelling birds. Factors of ambient humidity maintained within contiguous, closed-canopy forest may also play a role in susceptibility to fire spread.

Because the frequency distribution of area of the various element occurrences is not normal, most being strongly exponential, areas were categorized into Very Poor, Poor, Good and Very Good using medians and quartiles (Snedecor, 1989).

2). ***Shape***

Theory of nature reserve design suggests that the most viable shape for a conservation area to preserve its biological diversity, given that immigration, emigration and threats are multi-directional, is one that maximizes the area of the reserve in relation to its perimeter. A circular shape is the most robust design and provides the greatest buffer to invasion of exotic animals, plants, airborne pollutants, etc. It also provides the smallest boundary to manage and exposes the smallest perimeter to potential sources of wildfire (e.g. passing vehicles, human settlements).

To characterize the shape of target occurrences for each of our ecological systems, we used the Shape statistic from FRAGSTATS™: (version 3.1), which divides perimeter length by square root of area. The values of this Shape statistic were then grouped into quartiles, which formed the basis of four ranking categories:

Category	Description
IV – Very Good	tends to be full bodied or circular in shape
III - Good	more irregular but still a robust shape
II - Poor	irregular shaped or long and thin
I – Very Poor	very irregularly shaped, or very long and thin

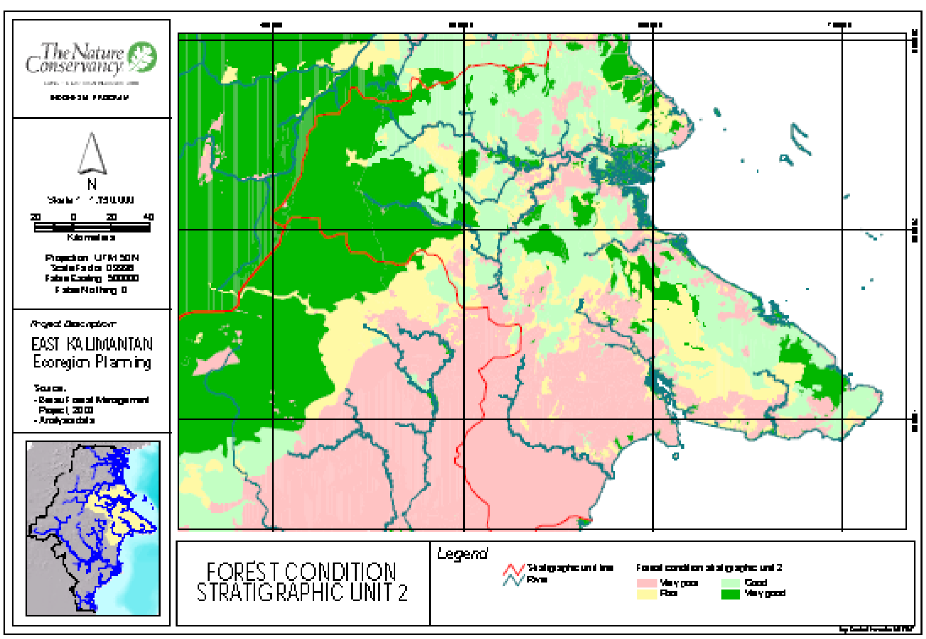
3). ***Condition***

Condition of each target ecological system occurrence was assessed based on the following categories:

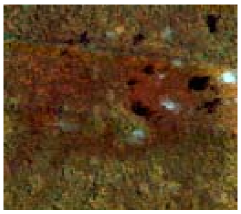
Ranking	Condition Description
Very Good	Completely or almost completely undisturbed (Figs a & b).
Good	Extent of logging not extensive, such that canopy cover > 60%. Logging roads visible or grown over, and not abundant. (Figs. c - g)
Poor	Extent of logging considerable, but forest could be rehabilitated to a natural condition over a long time frame (200 years) if protected from further major threats. Identified by either i) burnt once, with canopy cover between 30%- 60%; or ii) logged such that canopy cover is 30%-60% and logging roads are abundant (Figs. h & i).
Very Poor	Extent of disturbance great such that it is difficult or impossible to rehabilitate to a natural state within a period of approximately 200 years. Identified by either being i) burnt twice such that canopy cover is less than 20% - many areas have no standing trees; *or* ii) logged such that canopy cover is less than 30%; *or* iii) converted to rice fields, oil palm or tree plantations, market gardening, or both dry and wet lands that have been converted but not planted with crops (Figs. j - m).

These forest quality categories are illustrated opposite showing examples of different types of disturbances and how they were categorized. This is a modification of a standard methodology applied in assessing damage in East Kalimantan by the Indonesian Department of Forestry and also by the Berau Forest Management Program in East Kalimantan. It is a highly repeatable method.

If there were two or more disturbance types within a given target occurrence (patch) these were included in the ranking according to the method detailed in the following section *Viability Index of Occurrences.*



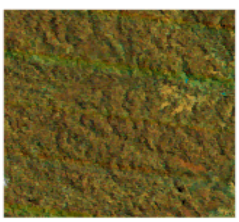
(a)
Primary forest, canopy dense (>60%), logging tracks absent, color depends on forest type (VV).



(b)
Primary Peat Swamp Forest, canopy dense (60%), logging tracks absent, color depends on forest type (SV).

(c)
Old logged forest, canopy dense (>60%), logging tracks absent, color dark brown mixed with green (LVD).

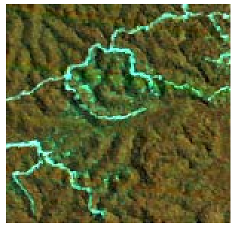
(d)
Old logged forest, canopy very dense (>80%), logging tracks overgrown-some visible, color chocolate (LSVB).



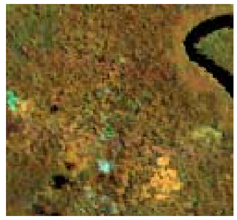
(e)
Old logged forest, canopy dense (>60%), logging tracks overgrown, color chocolate (LDB).

(f)
Recently logged forest, canopy dense (>60%) , logging tracks not abundant, color green (LDG).

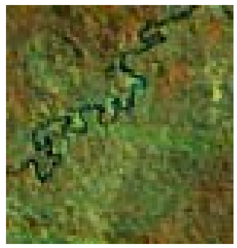
(g)
Recently logged (several months), canopy dense (> 60%), logging tracks not abundant, color yellowish brown (LDY).



(h)
Currently logged forest, canopy dense (>60%), logging tracks abundant (color green) (LVG).

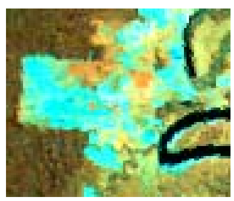


(i)
Logged forest, canopy dense (30-60%), logging tracks abundant, color mixed (LM).

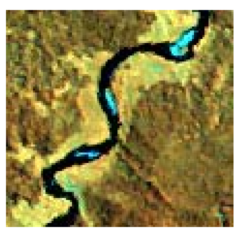


(j)
Intensively logged, canopy dense (<30%), logging tracks abundant, color green, remaining vegetation <15m tall (LOG).

(k)
Intensively logged, canopy dense (<30%), logging tracks abundant ,color yellow, remaining vegetation <10m tall (LOY).



(l)
Total conversion (B).



(m)
Conversion of riparian vegetation (A).

4). Landscape context

a. *Isolation*

Target ecological system occurrences that have others of the same type close-by are considered more viable because highly mobile species with large diurnal ranges, or those that have local seasonal migrations or seasonal shifts, could more easily utilize the occurrence if there is a close 'stepping stone' of a similar habitat. These habitat types are also considered to have a greater chance of being repopulated more rapidly by other similar habitat patches in the event they were burnt or otherwise damaged. Figure K shows the distances that were measured in a group of Lowland Limestone Rainforest occurrences. Occurrences in the lowest quartile for **area** of that system type (i.e. smallest size) were not included in the rankings for distance to nearest like occurrence. This was one way to eliminate all the artifactual and/or assumed to be non-viable vestigial occurrences of ecological system types.

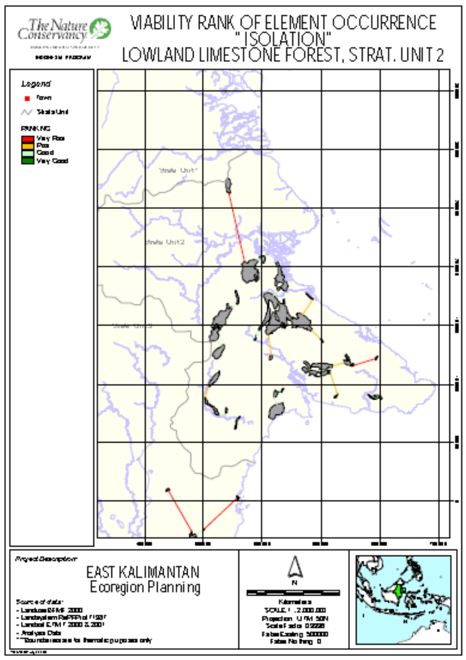


Figure K: Isolation ranking in karst forests

b. *Condition around a target ecological system occurrence*

The condition of forest within a buffer zone, set at two (2) kilometers around the occurrence, was ranked by the same method established for internal condition ranking above. The width of this buffer zone was set somewhat arbitrarily, but is considered to be wide enough to reflect the habitat that would immediately impact an occurrence. Information from the management plan for Lore Lindu National Park, Central Sulawesi (TNC 2002) for example, indicates that there is little detectable human impact on forests that are more than 500 meters from a village. In fact there is often a very sharp interface between primary forest and lands that have been converted for agricultural purposes for some time. This may not be the case however, for the impacts associated with hunting of "bush meat" for personal use or for markets.

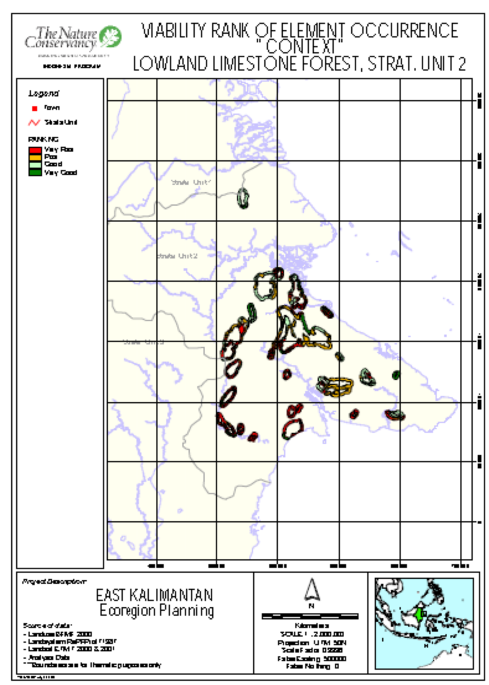


Figure L: Contextual ranking of karst forest

If there were two or more disturbance types within the 2 km buffer zone of a given target occurrence - these were ranked according to the method detailed in the following section.

Viability Index of Target Ecological System Occurrences

Terrestrial targets

As described above, the viability index for each target system, Lowland Limestone Rainforest for example, was evaluated for the following variables in this ecoregional assessment: **area** of the occurrence; **shape** of the occurrence; **condition of the forest within** the occurrence; and two factors representing the landscape context of the occurrence, namely its **isolation** and **condition of the buffer zone** within a 2 km wide zone around the occurrence. Further discussion with ecologists indicated that, for terrestrial system occurrences, these five factors should be weighted because some are more important than others for assessing the viability of a conservation target occurrence. These ecologists suggested that the most important factor was the condition of the forest within an occurrence, followed by (in order of decreasing importance) area of the occurrence, condition of the buffer zone around the occurrence, its isolation, and finally, its shape. Table 1.2 indicates the weighted percentages we utilized to reflect the relative importance of these five factors towards assessing occurrence viability.

Table1.2. Reference table to determine viability index loadings (weighting) to apply for the five factors involved in determining the viability index of a target terrestrial ecological system.

Factor / Rank loading	Very Good	Good	Poor	Very Poor
Condition inside	40	30	10	0
Area	30	20	10	0
Condition outside	15	10	5	0
Isolation	10	8	3	0
Shape	5	3	1	0

In the case of *Area, Isolation* and *Shape*, the viability ratings for each occurrence are entered as absolute values into the Viability Index database. For example, if an occurrence has a Poor *Area* rank, Very Good *Isolation* rank and Good *Shape* rank then the values that are entered into the viability index database for these factors are obtained from Table 1.2 and are: 10, 10, and 3, respectively, as highlighted in blue above. Condition both inside and outside of a targets occurrence is more complex, and being more important to the determination of viability, should reflect gradations of current condition rather than absolute values. These are calculated as follows:

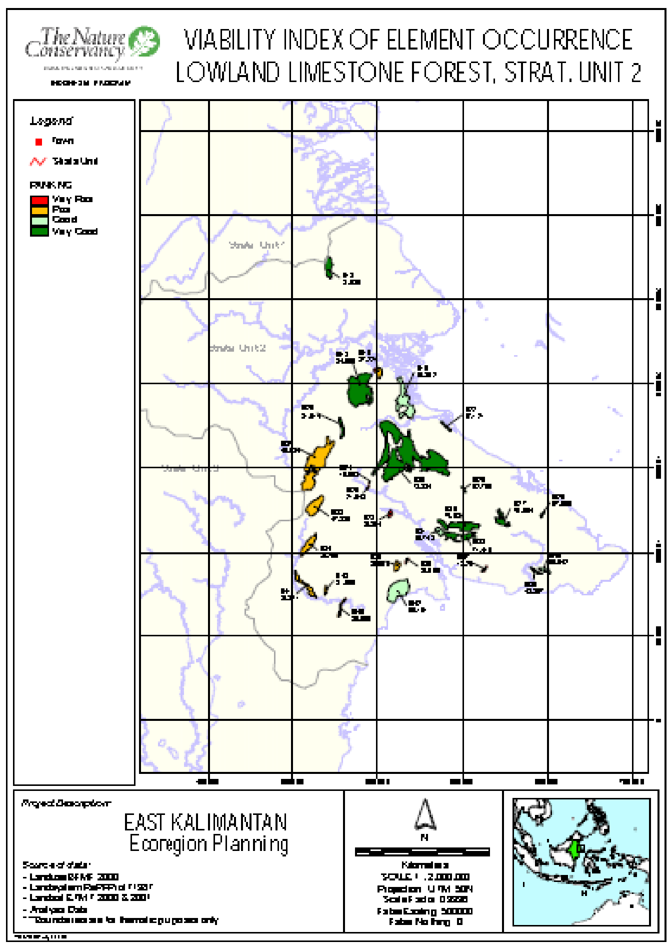
Condition inside- If there is an occurrence with only a single condition, for instance all the forest is in Good condition, then the value inserted into the viability index database is obtained from the above reference Table 1.2; for a value of 30. If there are two areas within an occurrence that are in different condition, for example, one side burned and the other untouched by fire, then the loading from Table 1.2 for each condition is multiplied by the proportion of the occurrence. These two values are then added together and become the value that is entered into the viability database for that occurrence. As an example, in Fig.L, 30% of the occurrence area is ranked as Very Good (loading value 40) and 70% of the area as Good (loading value 30). The rank that is entered into the viability index database for this occurrence is: (40 x 0.30) + (30 x 0.70) = 33.

Condition outside – This is very similar to the above calculation but the area considered is the area of the 2 km buffer zone around an occurrence, and the loading value from Table 1.2 will be different. As an example, in Figure L, assume that 20% of the buffer area of an occurrence is Poor (Loading value of 5) and 80% of the area is Good (loading value 10). Then the viability rank that is entered into the viability index database for this occurrence is (5 x 0.2) + (10 x 0.8) = 9.

Using the above example for a hypothetical occurrence, the viability index would be summed as follows:

Factor	Viability Rank
Condition inside	33
Area	10
Condition outside	9
Isolation	10
Shape	2
Total Rank Score	**64**

Figure L: Viability Indices of Karst Forest



The distribution of the Total Rank score (weighted) for each occurrence in each target ecological system type is again grouped into quartiles. The lowest, <25% quartile, achieve a Very Poor Viability Index (red), 25-50% Poor (orange), 50-75% Good (light green) and >75% Very Good (dark green). The Folio Text in Appendix V, Figure _._ shows a flow chart of the processes involved in calculating the Viability Index of each element occurrence.

Major Rivers and Lakes Target Ecological Systems

No standard, direct measure of the hydrologic condition of the Major Rivers themselves was available for this effort - at least not one that would enable a relatively objective comparison between any two rivers in the planning unit. Therefore, we developed a somewhat indirect assessment of functionality and condition of the rivers by ranking the condition of their surrounding vegetation coupled with flow contribution of their upper watersheds.

In accordance with the zone recommended by the Indonesian Forests Department for large rivers (U.U. No. 41:1995), and by local experts on river sedimentation factors, the presence of healthy forests or other natural vegetation bordering rivers on both sides to a width of at least 500 meters is considered essential to the viability of rivers. Such a vegetation buffer reduces sedimentation and pollution loads into the river, shades and reduces water temperatures, protects its banks and physical environments for fish and other fauna, and supplements through litter-fall the nutrients in the river along various stages of its course. Therefore, viability for the major rivers was calculated on the basis of the condition of the forests that border three segments of a river, namely, 1) the Upper Catchment Area, 2) the Mid-stream Buffer Zone and 3) the terminal Delta area. Viability assessments for these three segments are described as follows:

a. *Upper Catchment Area*
Identified by aggregates of the sub-catchments that define the smallest upper catchment polygon that can be generated using ESRI Hydrological Modeling (Version 1), using 250 cells as a minimum input. Only catchment areas for the first order rivers that have a maximum flow accumulation value in the 1^{st}-2^{nd} standard deviation grouping as generated by ESRI were considered (Appendix III.A for an example).

b. Midstream Buffer Zone
Defined by a width of 500 meters on both sides of the stream. The values for mid-stream buffer zones were calculated by assessing the combined areas of the mid-stream buffer zones of the river branches that are fed by the upper catchments. Condition of these combined areas was calculated using the same approach as to estimate condition of vegetation inside an element occurrence (see terrestrial section above).

c. Delta Areas
The condition of the terrestrial target ecological systems of Mangrove Forest, Freshwater Swamp Forest and Peat Forest occurrences that are in contact with the Rivers at or near their terminal deltas (See Fig.2.C.1). These ecological systems have already been ranked prior to their selection and these same values are included in the overall rank for this section of the Major River target occurrence.

Ranking condition of Upper Catchment areas, Mid Stream and Delta areas

The condition of the three river segments was ranked in exactly the same way that condition was ranked inside an occurrence or for the landscape context of an occurrence (see subsection entitled *Terrestrial Occurrences* above. However, slightly different loading factors were applied (Table 1.3).

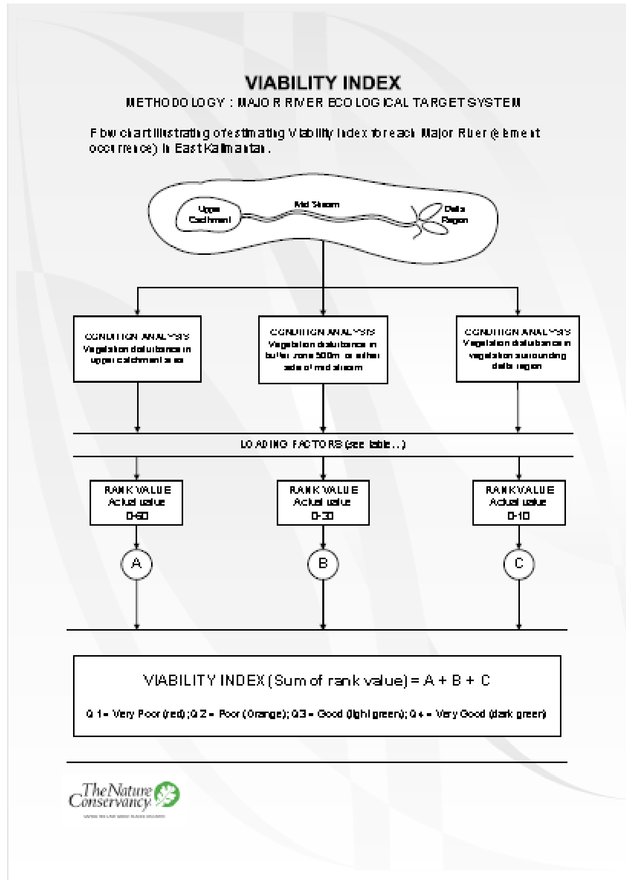
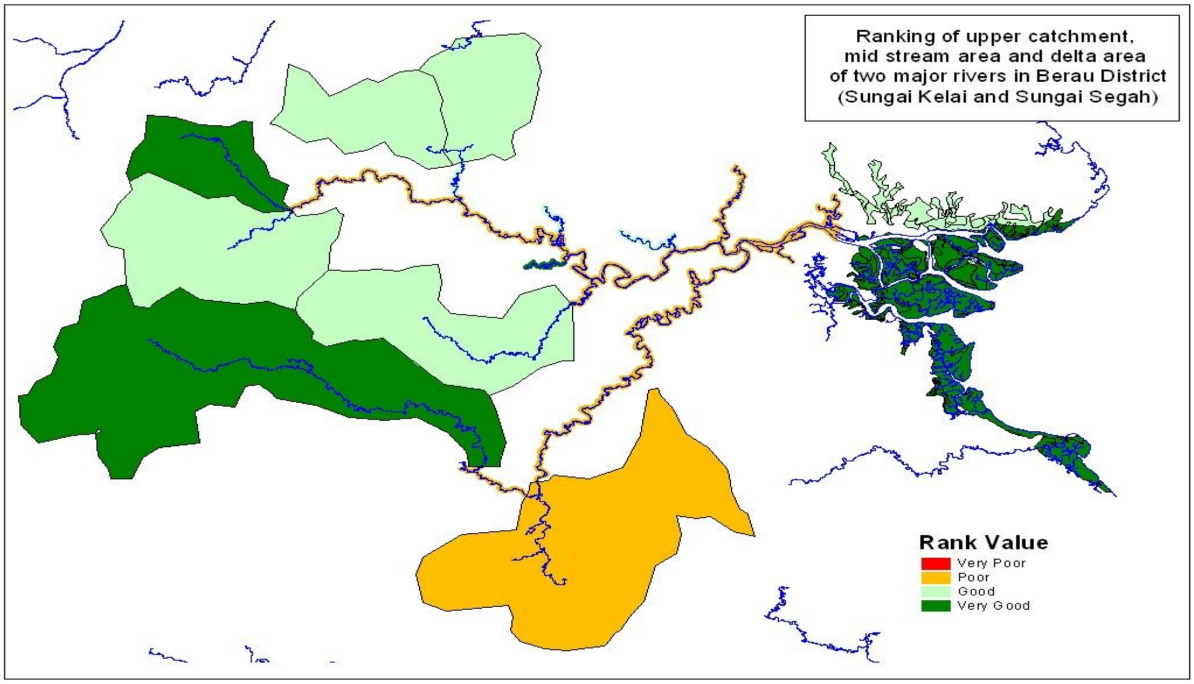
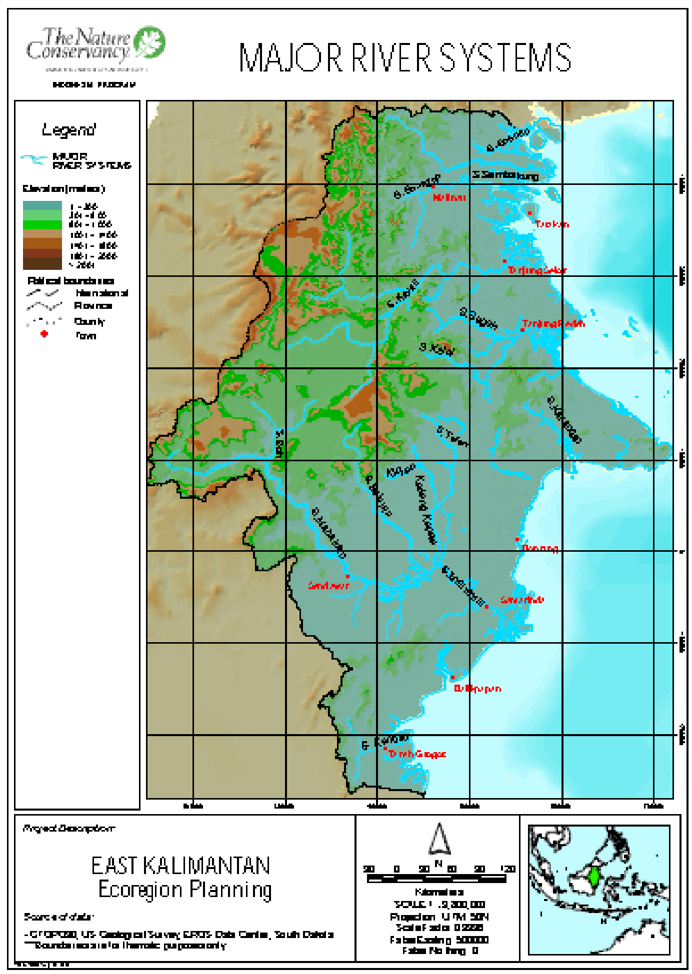


Table 1.3. Reference table for values to apply to condition of the three segments involved in determining the viability index of the Major Rivers:

River Part / Condition	Very Good	Good	Poor	Very Poor
Upper Catchment	60	40	10	0
Midstream	30	20	5	0
Delta area	10	7	2	0

A complication arises when a river has more than one principal Upper Catchment area. In such cases, the values for the river were derived from a summation of the combined area of all its selected Upper Catchments. Each individual catchment polygon was ranked and multiplied by the proportion of the total combined area they represent to that river. The viability index for these rivers was achieved by clustering their accumulated rank values into statistical quartiles - and then using these quartiles to rank them as Very Good, Good, Poor and Very Poor. The following diagram illustrates the component rankings for a single river in Stratigraphic Unit 2 as an example.





Major River Systems – Framework for Positioning of Portfolio Ecological System Occurrences

Because the East Kalimantan landscape is so fundamentally driven by its hydrologic and geomorphic components, largely centered around or contributing to the aspect of major river systems, this ecoregional assessment took a different approach than most other TNC ecoregional plans. Using the analogy of an organism's body, we viewed the Major Rivers as the skeleton framework upon which we attached the representative "body parts" comprised of a combination of element occurrences at multiple scales forming sites. To insure a healthy, viable and well-functioning body, one must have all the key component parts balanced and contributing to the processes that cleanse the circulatory system, allow the body to move when necessary to adapt to changing circumstances, and that will facilitate reproduction and continuity of its genetic makeup even in uncertain future scenarios.

To carry the analogy further, this body must resemble and reflect the regional differences that characterize the landscape that produced it – it must reflect the unique attributes of the East Kalimantan province. This is the theoretical foundation of our portfolio assembly process.

A single Major River, and associated lakes if present, was selected for the portfolio of conservation sites from each of the four stratigraphic units based upon its relative viability ranking described previously. Other conservation targets identified in this ECA (i.e. other target ecological systems, important bird areas, centers of plant diversity, and protected areas) and other important habitats (such as the 10 RePPProT land system aggregates, protected forests, proposed protected areas, or other areas with important faunal species), were selected to group around these rivers where possible. This was designed to ensure that functionality of selected rivers was the primary driver for assembling portfolio sites. There is one drawback however in this approach, which will be discussed in more detail in the Threats section – that of uncontrolled access for most human activities.

Geographic representation and replication of targets and their occurrences in the portfolio were ensured by selecting targets from each of the four stratigraphic units and within each precipitation zone present within each of these units.

Chapter 2 - Target Ecological Systems:

Descriptions, Conservation Issues, Unit Occurrences Ranking, Portfolio Design, and Results

A. Mangrove Forest

Photo: Mangrove Action Network

Description

Mangroves are the formation of trees found on the muddy shores of the tidal zone. They are found around the sheltered parts of the coastline of East Kalimantan and are particularly abundant in the major river delta systems, particularly those of the Mahakam and the Sebuku Rivers. While delta mangroves of the major river systems, such as the Mahakam and Sesayap Rivers, cover large areas, many of the mangroves at the mouths of the smaller rivers are very restricted to a narrow coastal strip. The larger rivers also have a thin belt of riparian mangroves along their banks, which may reach as far as 50 km inland. Also, there are mangroves on small islands just off the river deltas and in the Derawan fringing coral islands off the shores of stratigraphic unit 2. The delta mangroves in particular are dissected with watercourses that divide them into numerous smaller patches which, when taken together, constitute a single occurrence for the purpose of this ecological assessment.

East Kalimantan mangroves have been little studied but those of the Malaysian state of Sarawak have been closely studied (Chai 1982). The species composition of Indonesian mangroves reported in Whitmore (1984) and Tomascik *et al* (1997) provides a fairly comprehensive description of the value of this community type to the ecology of the adjacent marine environment.

Mangrove forests are highly productive natural ecosystems and tend to have a higher 'litter' production (of leaves, twigs, fruit and flowers) than lowland rainforests (Jiminez *et al*. (1985). This litter is broken down by detritivores to enrich the surrounding waters, particularly with nitrogen and phosphorus. The influence of mangroves on the nutrient levels of other coastal ecosystems is also considered important as tides transport these nutrients to other coastal areas (Ong *et al*. 1980).

Mangroves include a number of plant and animal species that are tolerant of the salt water and mud environments. The mangal vegetation provides food, through leaf fall and decay processes, as well as shelter to a unique and rich community of animals, particularly large crustaceans and molluscs (Kartawinata *et al*. 1979). Mangroves are also important spawning grounds and nurseries for prawns and many pelagic fish of commercial importance. Recent observations by TNC ecologists suggests that this community may also be an important protective feeding zone for hatchling sea turtles (EHB Pollard, pers. comm. 2003).

The Proboscis Monkey, *Nasalis larvatus*, Silver Langur, *Presbytus cristata*, Monitor Lizard, *Varanus salvator*, and Crocodile, *Crocodylus porosus* also rely heavily on this aquatic forest community. Mangroves also provide important feeding grounds for flocks of migratory Palaearctic wading birds (MacKinnon *et al*. (1996). Other studies in Malaysia and Australia also show that mangrove avifauna is distinct. For example in Borneo, Wells (1976) listed 21 species of birds that depended extensively or exclusively on mangroves.

Three main forms of mangrove system are represented in Kalimantan and elsewhere in Borneo (Ong 1982, Tomascik *et al.* 1997). These are the coastal/delta form, the estuarine/lagoon form and the island form. Mangrove forests occur along most of the coastline of Borneo; however, they are being rapidly diminished in nature and extent by human development processes. The greatest extent of remaining undisturbed mangroves on Borneo is in East Kalimantan (MacKinnon *et al*. 1996, Tomascik *et al.*1997).

Conservation issues and threats

Mangroves are the most threatened of the coastal habitats in East Kalimantan. MacKinnon *et al*. (1996: Table 3.1) report that the extent of this forest type in East Kalimantan has shrunk from an original area of 950,000 ha to 750,000 ha in 1996. In addition, no large expanses of mangroves are currently protected within existing conservation reserves. Only Kutai National Park has a narrow belt of coastal mangrove.

The chief threats to Mangrove forests are from conversion to fishponds (*tambak)*; for extraction of wood for various purposes; and for charcoal production. The extensive conversion of mangroves adversely impacts the stability of the coastline, local prawn stocks and pelagic fisheries, and affects the local economy. As a peripheral habitat, mangroves are particularly sensitive to environmental change and pollution. Currently, the removal of riparian vegetation coupled with agricultural development along the lower and middle reaches of many of the major river systems in East Kalimantan is causing excessive sedimentation and significant pollution. This is deleterious to the environment of mangroves, particularly to regeneration success of felled or damaged mangroves (Burbidge and Koesoebiono 1980). It is also extremely harmful to the terminal coastal reef ecosystems fed by the outflow of these large river systems.

The recent disasters along the Sumatran region of Banda Aceh and the islands and peninsular regions of southeast Asia that were hit by the tsunami caused by undersea earthquakes in December 2004 exemplified the vulnerability of coastal communities that have removed their protective barriers of mangrove forests to accommodate development and tourism. Those areas that maintained healthy mangrove forests were least likely to have suffered significant property damage or loss of life. This tragic series of events may have been a much needed wake up call to those governments and communities to begin to restore and protect their remaining coastal mangrove forests to buffer them from future repetitions of such horrendous outcomes.

The primary threats to Mangrove forest are further described below.

- **Tambak (fishponds)**

  In recent years, large areas of mangrove have disappeared from the East Kalimantan coastline, particularly in the region of Tanjung Selor and the Mahakam River delta through conversion to fishponds (*tambak*) where various fish species as well as shrimp are commercially raised.

  Most *tambak* in East Kalimantan are found in the Mahakam delta. CIRAD- PT WIN (2002) states that early maps of the Mahakam delta, prepared by the Dutch in the 1940's, showed it to be almost pristine and to have one of the largest single areas of *Nypa fructivora* palms in the world. As recently as 1996, the smaller areas of mangroves on the seaward side of the *Nypa* palms were very much intact, with only very small patches of *tambak*. However, in 1996, large excavators began to be used to build *tambak*. Between 1997 and 1999, during the economic crisis in Indonesia, almost all the outer mangrove belt and most of the huge *Nypa* palm zone was converted to *tambak*. This conversion process was much cruder than necessary, such that large expanses of mangrove were unnecessarily destroyed. CIRAD- PT WIN (2002) noted the historical importance of this outer mangrove belt to stabilize the coastline. It documents that the coastline is shifting such that many *tambak* in the outermost perimeter are destroyed, and it argues that the consolidation of the Mahakam delta now very much depends on the narrow inner zone of freshwater mangroves. In addition, the report predicts that if this inner zone is destroyed, the shift to the delta would impose a significant economic cost to adjoining agricultural lands.

One of the key conservation issues related to the Mahakam delta is the restoration of mangroves through a process of revegetating *tambak* 'islands'. Evidence suggests that opening up additional *tambak* can result in diminishing returns of artificially reared fish and shrimp, relative to the productivity of the formerly pristine mangrove stands (Whitten *et al.*1987a). Documentation of the economics of *tambak* is necessary in East Kalimantan. It must be done with consideration of the eventual costs of shoreline loss, property damage, and likely resulting community and political inertia to revegetate these same areas with Mangrove seedlings in the future (See Jakarta Post, 22 July & 28 July 2002).

It has been reported that the Mahakam delta freshwater mangroves still harbor viable populations of Proboscis Monkeys and that they are not yet irreversibly damaged. CIRAD-PT WIN (2002) suggests that mangroves could be regrown in the central islands in each *tambak* and that this would not create a significant loss of income to the local community. Rather, it may consolidate the delta and ensure a longer life for the *tambak*.

- **Wood Products**

Mangroves are exploited for chipwood, raw material for rayon, and building material. *Ceriops* and *Avicennia* mangrove trees yield poles and pilings that are durable and frequently used as local house building material. *Rhizophora* is a favored wood for boat building by locals. Large scale logging of mangroves, mainly *Rhizophora*, in East Kalimantan for chipwood began on Tarakan Island in 1972. Most mangroves in the Sebuku delta are under concession to be cut and exported for chips. A cutting rotation for mangroves of 30 years duration is believed to be sustainable, but the companies taking mangroves in East Kalimantan frequently have a much shorter cutting interval than this (MacKinnon *et al*. 1996). Also, it is reported by local villagers, that heavy equipment is used by these companies to root out the mangroves - which destroys any possibility of sustainable harvest. Five local Kabupaten in the northern parts of East Kalimantan, recently (Kaltim Post 16 June 2002) established a local government regulation (*perda*) to prevent locals from taking mangrove poles for the purpose of house construction.

- **Charcoal Production**

Mangroves are used widely for the purpose of charcoal production. They produce manageable-width poles that can be cut to length and easily burned in charcoal ovens and subsequently efficiently packed into bags for distribution and sale throughout the province. It is not known what percentage of all charcoal produced in the province of East Kalimantan or throughout the Indonesian archipelago is derived from mangrove wood.

- **Other Threats**

  The exploitation of mangroves for a variety of other purposes threatens their existence. Mangroves produce a great deal of firewood throughout Indonesia and in East Kalimantan. They are an important source of tannin used in medical treatments, and in the leather, wine and beer industry. (MacKinnon *et al*.1996).

Occurrence Unit Determination

Significant mangrove occurrences were identified first using LandSat imagery to locate them in the province. The ECA team then consulted individual experts and literature sources, followed by limited fly-over reconnaissance for those sites recommended for inclusion in the portfolio to verify presence and condition.

Mangrove occurrences were determined by the river system to which they related. This means that the Mahakam delta mangrove patch, for example, is regarded as a single occurrence and not as multiple occurrences. Although the various watercourses in a given delta dissect the mangrove forest, they do not substantially isolate the various patches of mangrove, but rather tend to integrate them ecologically. This is because the watercourses supply the mangroves with nutrients from upstream; they allow movement of the immense crustacean, molluscan and other communities, including pelagic fish nurseries, between the patches; and they evenly distribute the nutrient loads resultant from the heavy fall of mangrove leaf and other woody detritus, which is so important for the enriched nutritional status of the mangal plant and animal communities. Further, the characteristics of each river system, including nutrient levels, flow rates, flooding periodicities, pollutant and sedimentation loads all impact the mangroves that they feed, and argue for mangrove occurrences to be grouped on the basis of the individual river system terminus around which they are formed.

Islands with mangroves that are clearly within the umbrella of the delta bay were included in the river system that clearly most influences them. However, mangroves on islands that are further than 5 km from the coast were treated as separate occurrences.

Biological Value

Each mangrove occurrence was evaluated for the presence of one or more of the 5 ‘target’ faunal species (Mahakam River Dolphin, Proboscis Monkey, Sun Bear, Orangutan, Bornean Gibbon) as well as whether it overlapped with an Important Bird Area. Occurrence Rankings were also assessed from expert information relating to the viability of the occurrences, i.e. whether the occurrence was exceptional, typical or marginal. Unique occurrences (those which we were told by experts in the field were “best examples” or “one and only occurrences”) were also identified for ranking and inclusion in the eventual portfolio of recommended conservation sites.

Portfolio Design

The goal for East Kalimantan is 50% of the areal extent of viable mangrove forests, including 100% of mangroves in Kutai National Park. Of the 656,000 hectares present in East Kalimantan, we recommend conservation management of roughly 427,000, or 65% in the Portfolio. The rationale for the higher percentage is that the rate of degradation of this forest community is so rapid, that by the time of publication of this report, it is likely that a significant amount of Mangrove has already been totally converted or further degraded to the point it would not qualify under our "viability" criteria.

Appendix III presents the selected proportion of Mangroves in East Kalimantan and the selected proportion of Mangrove Forest in the various precipitation zones. Mangroves are at the interface of the land and sea, and as such are not greatly impacted by the RePPProT systems that abut them. The exception is a small set of occurrences that grow almost directly from limestone substrate on the central northern part of the Sangkulirang Peninsula (Ben Jarvis and PT Daisy report). This was an example of a report of a "unique" occurrence that led to its inclusion in the portfolio.

Results

Seven major occurrences were selected for the portfolio. The extent of mangrove varied greatly in each stratigraphic unit, with most in stratigraphic unit 1. However, mangroves were most damaged in stratigraphic unit 3 where the average occurrence had a viability ranking of Poor. In stratigraphic unit 3, mangrove forests of low viability were included in the portfolio because they were a functional necessity of the targeted Major River – the Mahakam. While it is recognized that the majority of this occurrence at the Delta Mahakam site is degraded or converted to *tambak* already, it will be our recommendation to the Natural Resources Dept. of BAPPEDA in that area to pursue restoration of this community type. If the natural riverine processes are protected upstream, and functioning as planned, then restoration should be fairly successful if there is the motivation of the local government to do so with the participation and compliance of the local communities. As more is learned of the protective nature of mangrove forests to coastal communities, there is a growing appreciation of the services provided by this natural soil stabilizing and water filtration agent.

Occurrences that were added to those of the target Major River were based on association with that rivers delta and to provide coastal continuity of mangroves. These occurrences could then act as both ecological stepping stones for the mangrove fauna, in particular the mangrove dependent assemblage of birds, and at the same time assist in consolidating the greatest extent of coastline.

Stratigraphic Unit 1 - The mangrove forest patches at the terminus of the Sebuku/ Sembakung river system are the primary representatives of this forest system type in the first stratigraphic unit. Total areal extent amounts to roughly 194,144 hectares.

Stratigraphic Unit 2 – Three Major Rivers occur in this Unit (Kelai/ Berau, Segah and Bungalung). Each of these has an extensive mangrove delta. However, the mangrove forests in the southernmost river are much damaged and generally have a Poor or Very Poor viability index. The mangrove forest selected for the portfolio contains the only element of the Kayan River delta found in this Unit and all of that in the Berau River delta. Additionally a small group of coastal mangroves growing directly on limestone substrate in the central northern part of the Sangkulirang peninsula is included to represent this unique ecosystem. All the small islands which have mangroves in the Derawan Island chain (*Kepulauan*) and Kepulauan Muaras are also included because these mangroves are important structural elements that stabilize these islands and their ecosystems which are so important as rookeries for sea turtles, mostly Green Turtles (*Chelonia mydas*) and for other small island and fringing reef communities.

Stratigraphic Unit 3 - The large patch of mangrove in the Mahakam and Samarinda Bay deltas are well represented in the Portfolio. The Mahakam mangroves are severely degraded in the near-coastal areas by fish and prawn ponds, however, mangroves to the inland side of the *Nypa* palms, which mark the major brackish water interface, appear to be in reasonable condition and apparently have suffered only opportunistic cutting for firewood.

Stratigraphic Unit 4 - Mangrove patches are captured in several places in this small stratigraphic unit – despite being fed by relatively small rivers, they have much potential for providing important habitat for many of the focal species at this southernmost portion of the planning area. The patches of mangrove forest here tend to be more linear – tracking the terminal flow courses of the rivers that feed them perpendicular to the coast rather than parallel as in the former occurrences represented in the portfolio. It remains to be seen whether the effect of this configuration affords these forests more or less susceptibility to the threats of conversion to *tambak* or cutting for firewood and charcoal purposes.

Overall, mangroves in the proposed portfolio of sites are poorly represented in lands having any protected status. In an attempt to not grossly over-represent the East Kalimantan goal for mangrove occurrences, much of the coastal strip mangrove is not well represented. These small coastal mangrove patches, which were possibly contiguous or almost so as recently as the middle of the twentieth century, undoubtedly played an important role in physically stabilizing the East Kalimantan coast as well as being important in the ecological dynamic of the coastal zone. More detailed and timely Conservation Area Planning at a later date may incorporate these smaller coastal patches in conservation initiatives related to the larger delta patches identified in this portfolio.

B. Freshwater Swamp Forests

Description

Freshwater Swamp Forests are found on alluvial soils that are flooded for long periods of time with fresh water. Freshwater swamps are widespread throughout Kalimantan and occupy about 7% of the land surface area (MacKinnon and Artha 1981). They are associated with coastal swamps, inland lakes and huge low-lying river basins. These are associated in East Kalimantan with coastal Peat Swamp Forest near Mangrove Forests from the mouth of the Sesayap River, in the most northern stratigraphic unit, to a distance of approximately 90 km inland.

These forests are less acidic and more nutrient rich than either Peat Swamp Forests or Heath Forests. Freshwater Swamps usually have taller trees and are more species rich than Peat Swamp Forests. They are extremely heterogeneous in soils and vegetation, although a few centimeters of peat may occur. This heterogeneity is borne out by the fact that all 10 aggregated RePPProT system types identified in this planning process are present underlying the single Sesayap Freshwater Swamps occurrence.

Floristic composition varies from floating grass mats, such as are common in the Mahakam lakes area, to *pandan* and Palm Swamp, scrub and forest. Prime Freshwater Swamp Forest has trees with an average height of 35m, some lianas and epiphytes. They share many species with lowland dry forests but are generally less rich in taxa. Forest structure is less layered and the trees are smaller and shorter. The most important trees in this type of forest are *Campnosperma, Alstonia, Eugenia, Canarium*, the tall legume *Koompassia, Calophyllum* and *Melanorrhoea*. The swamp Sago palm, *Metroxylon sagu*, also thrives there (Whitmore 1984).

Faunal diversity is usually higher in Freshwater Swamp Forests than in Peat Swamp Forests. There can be good densities of primates in these forests, which are most common along the rivers. The most common primate found in this forest type is the Long-tailed Macaque, *Macaca fascicularis.*

Conservation issues and threats

- **Conversion**

  Conversion of Freshwater Swamps, particularly for rice cultivation, is the major threat to this ecosystem. MacKinnon *et al*. (1996; Table 3.1) reports that the extent of this forest type in East Kalimantan has shrunk from an original area of 422,000 ha to 195,000 ha in 1996. Much of this conversion has occurred over the last 20 years. Our analysis shows however that there is, as of 2001, an extent of approximately 350,700 hectares in this province. This may be a factor of better satellite imagery available today than what was utilized for McKinnon's report.

- **Logging**

  These swamps contain trees of high commercial value, so logging is an ongoing threat to this target ecological system. Commercial forest concessions (HPH in Bahasa Indonesia acronym) completely cover the single occurrence of this community type.

- **Altered Hydrology**

  The structure and long-term viability of these swamps is threatened by alterations to water levels in the major river systems and more frequent flooding episodes. This is a consequence of changes in the hydrology of watersheds concomitant with wholesale land clearing and targeted clearing of riparian vegetation for agricultural purposes.

- **Wildfires**

  Wildfires over the last decade in East Kalimantan have encouraged dramatic changes in the floristic composition and structure of Swamp Forests. Fires favor the Paperbark, *Melaleuca cajuputi*, a fire resistant, understory tree species with inflammable bark. This species is found throughout South East Asia and Australia and often forms pure stands as a fire disclimax community.

Occurrence Unit Determination

Significant Freshwater Swamp forest was identified first using LandSat imagery to locate this ecological system in the province. The ECA team then consulted with individual experts and literature sources to verify classification and condition.

Freshwater Swamp Forest occurrences were determined by the secondary water catchment areas (*sub das*) to which they belong. Thus, if a *sub das* contained several patches of such forest, these were regarded as a single occurrence. This is logical, because Freshwater Swamp Forests are frequently flushed out by rivers and rely less on rain to sustain their moisture than do Peat Swamp Forests. Thus all such patches in a *sub das* likely share a common hydrologic and nutrient connectivity. Further, they often support a variety of communities that include tall trees and are closely connected ecologically to the surrounding Lowland Rainforest, Peat Swamp Forest and/or Mangrove Forest system types.

Biological Value

The Freshwater Swamp occurrence was evaluated for the presence of the 5 'Target' faunal species (Mahakam River Dolphin, Proboscis Monkey, Sun Bear, Orangutan, and Bornean Gibbon) as well as whether it overlapped with an Important Bird Area or Endemic Bird Area. Occurrence rankings were assessed from expert information relating to the viability of occurrences of this system type i.e., whether the occurrence was exceptional, typical or marginal. Unique occurrences, determined on the basis of expert comments that they were "one and only" examples of this forest type coupled with some other interesting physical or biologic feature, were also identified for inclusion in the portfolio. Since there was only the single large patch of this forest type in the planning area, this was a simple process.

Portfolio Design

The overall goal for Freshwater Swamp Forest in the East Kalimantan Portfolio (only occurring in stratigraphic unit 1) is 70%. The portfolio achieved a total of 89.5%.

Results

The single known area of Freshwater Swamp Forest occurs in SU-1. It contains all 10 RePPProT subdivisions recorded in East Kalimantan. Although most of these subdivisions are extremely small areas and lie on the edge of the swamp, it does indicate that this area has great environmental heterogeneity. Given the limitations on accuracy at which these boundaries can be drawn for an area at the scale of the entire province of East Kalimantan, it is possible that some of these subdivisions are artifacts of the digital overlay process. 89.5% of this swamp forest has been captured in the portfolio. Much of it (78%) is in very good condition and has an average ranking in the fourth (highest) quartile classification.

The selected Portfolio occurrence is known to support populations of the following 'target' fauna:

- Orangutan
- Proboscis Monkey
- Bornean Gibbon

C. Peat Swamp Forest

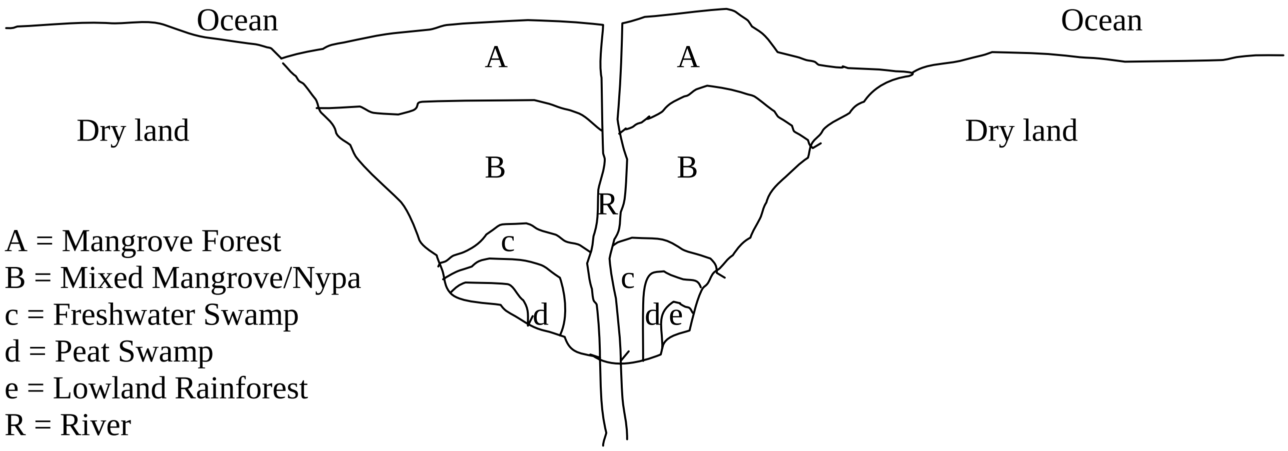
Description

In East Kalimantan, Peat Swamp Forests are most abundant in the lakes area of the middle Mahakam Basin and around the marine alluvial plains of the Kayan River. MacKinnon *et al*. (1996; Table 3.1) reports that the extent of this forest type in East Kalimantan has shrunk from an original area of 749,000 ha. to 594,000 ha. in 1996. Our LandSat analysis shows an areal extent of just over 303,000 hectares as of 2001 – indicating perhaps an even swifter decline of this endangered habitat type.

Peat Swamps are typically large rain-fed swamps throughout Kalimantan that occur behind the coastal mangrove swamps along the coast and in poorly-drained depressions at higher altitudes. The soil of these swamps has more than 65% organic matter content, which is commonly around 50cm deep but can be as much as 20 meters deep. The surface is a solid fibrous material forming a crust over the semi-liquid interior. It is extremely deficient in nutrients and has a high acidity ($pH \leq 4$).

Peat Swamps are drained by 'blackwater rivers', as is the case with the Heath Forests. Most peat swamps are zonal in nature with several concentric rings, starting with tall forest with an outer uneven canopy (See Figure2.C.1 – adapted from MacKinnon, 1996), then inner zones of trees of diminishing height- with a reduction in species richness of plants towards the center of the swamp. These forests share many of the tree species found in adjacent lowland evergreen dipterocarp forests. There are conspicuous parallels in structure and physiognomy between the more central parts of the Peat Swamp Forests and the Heath Forests (Whitmore 1984).

Fig.2.C.1. Schematic aerial diagram of river delta and typical component forest types



The largest patches of Peat Swamp Forest in East Kalimantan are in the middle Mahakam Basin. In that area, Unna Chokkalingam (pers. com.) considers that fragmentation of the Peat Swamp Forest probably began seriously about 20 years ago. But unlike some other Peat Swamps in Kalimantan (Mackinnon *et al*. 1996) those in the Mahakam Basin are not generally rain-fed swamps; instead they receive water from surrounding rivers and watercourses. As such, the Mahakam peat swamp forests were probably all integrated as well as connected to the small fingers of swamp forest that follow the rivers inland for some distances. Land conversion and burning has most likely created the existing fragmentation.

Unna Chokkalingam (pers. com.) considers that much of the Mahakam Peat Swamp Forest was in reasonably good condition before the last El Nino event of 1997-1998. Prior to that time, roughly 30-40 % had only been burned once, during the earlier El Nino in 1983-1984. The fires in 1997-1998 burnt all but a small area in the center of the large northeast patch (Belayan) and a few other scattered small fragments. These unburned fragments probably comprised less than 5% of the remaining Peat Swamp Forest.

Interestingly, Unna Chokkalingam (pers. com.) considers that the patches of Peat Swamp Forest burnt only in the period 1997-1998 are regenerating very well and, if not burnt again, would probably recover well. This is an area that could represent as much as 50-60% of the remaining Peat Swamp Forest. Unfortunately, areas that have been burnt twice, or that are located along the edges of the rivers and waterways, do not regenerate well and probably will not be given a chance to recover.

No species of mammal or bird is restricted to the Peat Swamp Forests, although many occur in this forest type, including the Bornean Gibbon, Orangutan and most other species of diurnal primates. Long–tailed Macaques (*Macaca fascicularis*) and Silver langurs (*Presbytis cristata*) are more abundant in Peat Swamp Forest than in other lowland forest types (see references listed in MacKinnon *et al*. 1996) and the Peat Swamps are a key habitat for the

Proboscis Monkey (*Nasalis larvatus*)(Bennett 1988b). Wells *et al*. (1979) found that in the Malaysian State of Sarawak, a small area of Peat Swamp Forest had about half the species of birds that were present in the surrounding matrix of lowland evergreen forest. The rivers draining these swamps are known to be very rich in species (Giesen 1990), although towards the center of the swamps these rivers tend to have impoverished fauna (MacKinnon *et al*. 1996).

Unna Chokkalingam (pers. com.) reports seeing a mother orangutan and her baby in a very damaged patch of Peat Swamp Forest, some 2 km from Desa Sabintulung. She also reports 'numbers' of orangutan nests near Loh Sakoh on the western side of the swamp on the Belayan River and in the center of the large unburned section peat swamp in the Belayan area suggesting that this forest type harbors some of the preferred food types for this important primate species that may no longer be found elsewhere in more typical forest habitat.

Chokkalingam *et al*. (2001) states that "Peatland trees and other flora appear to have played a minimal economic role historically in local livelihoods. The riparian areas were used for extraction of some timber, rattan and other forest products, as well as for swidden agriculture on flood clay soils (Richter 2000). In the peatlands, there was only limited harvest of some wood species such as *Shorea balengeran* for house construction and others for fuelwood. Harvesting was limited to about 0.5 km distance of existing water bodies, which could be accessed by small boats in the flood season and from where logs could be floated out. There was also harvest of some resin prior to 1965. Thus there appears to have been very low direct value for the trees and other forest products available in the peatlands till recently. A new medium-density fiber mill in the area has now provided a market for small-diameter logs in some sections of the area".

Schindele *et al.* (1989) and Hoffmann *et al.* (1999) state that large-scale fires occurred in the peatlands recently in the drought years of 1982/83 and 1997/98. Extreme drought conditions probably rendered the peat forests and peat itself susceptible to large-scale fires. Chokkalingam *et al*. (2001) reported that fire use by locals in the peatland areas probably provided primary ignition sources for these large-scale fires. The fires of 1982/83 are said to have been patchy and simultaneous, suggesting multiple sources, arising primarily from burning activities for agriculture or fishing in riparian areas and peatland edges and spreading into some peatland areas.

Conservation issues and threats

- **Lack of Community Interest**

  Local communities and migrants in these areas do not appear to value the trees and vegetative resources on peatlands very much and are primarily concerned with fishing (Chokkalingam *et al*. 2001). Such absence of community interest in the conservation of these forests is probably the major conservation concern as far as the long-term viability of existing occurrences in this province.

- **Wood Extraction**

  Chokkalingam (pers. com.) stated that "most of the Peat Swamp Forests are covered by timber concessions (HPHs). However, she has not seen any signs of logging away from the water channels or rivers. There are, though, some HPHs along the banks of the rivers with *Acacia mengium*. These plantations were burned and local villagers were encouraged to collect pole-sized trees along the edges of the Peat Swamps to replace the lost Acacia. Most of these were *Melotus* sp. and *Shorea* sp. Clearly this desire for pole-size trees to supply the new medium-density fiber mill in the area poses a threat to the borders of the Peat Swamp Forests.

- **Agricultural Conversion**

  Drainage and conversion to agriculture is a major threat to these fragile forests. About 10% of Peat Swamp Forests have been targeted for clearing and conversion for transmigration of new human communities. This has resulted in large areas of Peat Swamp Forest being converted to agriculture including rice, coconut and Sago plantations (Silvius *et al*. 1987).

- **Altered Hydrology**

  Changes to the hydrology are another major conservation issue. Drainage of peat swamps using a system of large canals (polder system) alters the hydrology of the swamps and the adjoining land. Peat dries out, shrinks and can retain less water during heavy rains. This increases flooding events downstream (Driessen 1978) and increases the susceptibility of these now dry swamps to long-lasting (in some cases years) fires.

- **Altered Water Chemistry**

  Changes to water chemistry from reclamation of Peat swamps impacts aquatic fauna in streams flowing from the swamps. This results in changes in soil temperatures and salinity increases -releasing organic compounds into streams that reduce the levels of soluble oxygen and increase acidity. This has adversely affected fish in drainage waters, which show a greater incidence of skin diseases (Haeruman 1986). Plankton diversity also declines (MacKinnon *et al*. 1996).

- **Fishing**

  Chokkalingam *et al*. (2001) states that the predominant economic activity of the communities living within the extensive peatlands of the Middle Mahakam Area is fishing, both for local consumption and export. Many villages have migrated down into the peatlands in response to better fishing opportunities and perhaps also in response to depletion of upland resources through large-scale commercial timber extraction, land clearing and conversion activities. Other villages already situated in or near the peatlands have shifted their primary activities from riparian/upland-based agriculture or resource extraction to fishing, following the destruction of rattan and wood resources in the large-scale fires of 1982/83.

- **Immigration/Transportation**

  Commercial introduction of nylon gillnets increased fishing capacities of individual households in the middle Mahakam basin and encouraged immigration of people, increasing pressure on the Peat Swamp Forest (Christensen *et al.* 1986).

  Development of motorized boat transport, and road construction in the surrounding uplands linked to logging, plantation, and transmigration projects increased market accessibility. Fish from the Middle Mahakam Area are now delivered as far away as Banjarmasin in South Kalimantan on the same day they were caught. Financial returns from fishing are high. Harvests are substantial and focus on the major peatlands, particularly peatland streams, lakes and pools (Christensen *et al.* 1986; Chokkalingam *et al*. (2001).

- **Fire**

  Chokkalingam *et al*. (2001) further state that "fire is used to clear land for swidden agriculture in the riparian areas." Such fire-use for resource extraction and cultivation in El Niño years, particularly with petrol fuels, may have contributed to the major conflagrations and led to major peatland transformation. Local communities suggested that long histories of burning in peatlands in the area had been responsible for the conversion of peat forests into open water and lakes. Endert (1927) also attributed the formation of the shallow water lakes in the area to repeated burning in the past. Large bands of charcoal in the surface peat deposits in the lakes provide evidence for these observations (Field surveys 2001). Charred exposed tree stumps have also been observed with the drying out of the lakes and grassy areas (Endert 1927; field surveys, 2001). This suggests the need for a longer-term perspective for the role and effects of fire within these peatlands".

  Jepsen *et al.* (1998) and Chokkalingam *et al*. (2001) state that burning of the swamp channels to clear them so that they can locate pools of water containing fish and turtles is practiced by thousands of poor local people whenever there are very dry seasons and difficult economic times. Repeated burning, opening up of forests and thinning out of dense herbaceous vegetation are thought by local people to enhance the abundance and diversity of fish stocks in those areas. The major transformation is from peat forests into open water or grassy patches with peat collapse and loss. These authors further state that most fires for fishing purposes in the peatlands tend to be restricted to within 0.5 to 1 km of the lakes, rivers and streams. Historical literature (Endert 1927) suggests that such burning of vegetation for fishing purposes may be a traditional practice in the area.

- **Hunting and Resin Collection**

  In 1997-1998, thousands of people entered deep into the remaining swamps to collect *kayu lem*, a resin that is sold commercially as an ingredient in the manufacture of mosquito coils. They also hunted turtles. Both these activities required them to burn the vegetation to facilitate their searches. The government and local businessmen encouraged these activities as alternative livelihoods to carry people through the hard times brought on by the El Nino weather conditions.

  Fire was also used in turtle hunting activities in large sections of the swamps (Jepsen *et al.* 1998). Limited livelihood options in the long drought period and the emergence of a new high-value market for turtle meat may have driven large-scale turtle hunting activities at this time. Migrants are also often involved in such fishing and reptile harvesting activities in the wetlands during the dry periods.

- **Lack of Information/ Regulations and Law Enforcement**

  Chokkalingam *et al*. (2001) point out that more needs to be known of the formal and informal regulations governing resource use in Peat Swamp Forest. In particular, types of equipment that may be used, protection of spawning grounds, and auctioning of tributary rivers for the harvesting of fish and reptiles (Transmigration Area Development Project 1980, Christensen *et al.* 1986). Local groups have built channels through the peatlands east of the Belayan River, and these appear to be more strictly policed and maintained with charges levied for products harvested.

Occurrence Unit Determination

Significant Peat Swamp forests were first identified using LandSat imagery to locate this ecological system in the province. The ECA team then consulted with individual experts and literature sources to verify current extent and condition.

The largest tracts of Peat Swamp Forest are in the middle Mahakam Basin, the Sesayap River and some smaller patches around the Berau River and the Sembakung River. The largest extent is that of the Mahakam Basin. The Mahakam Peat Swamp Forest was badly burned by fires in 1983-1984 and again in 1997-1998. Although these swamps behind the coastal mangroves are likely to be largely ambrogenous (rain fed) and not much connected to the river systems (MacKinnon *et al*. 1996), this appears not to be the case in the Mahakam Basin (U. Chokkalingam, CIFOR, pers. com.). In the Mahakam Basin, it is considered most likely that the original appearance, before land conversion fragmented this forest, was that of one large block, with fingers stretching along the upper reaches, similar to that which currently exists in the northern Sesayap River.

For this ECA analysis, a Peat Swamp Forest occurrence boundary was determined by the secondary water catchment area (*sub das*) to which it belongs. Thus, if a *sub das* has six patches of Peat Swamp Forest; these were regarded as one occurrence. This is logical, at least for the Mahakam Basin Forests, because all patches in a *sub das* likely share a common hydrological connection; they were probably physically connected in the recent past; and they are vulnerable to similar environmental threats.

Portfolio Design

The goal for East Kalimantan is 60% of all Peat Swamp Forests. The portfolio achieved 65.6% (2% of total in Stratigraphic Unit 1, 7.25% in Unit 2, 44.7% in Unit 3, and 10.4% in Unit 4). These were distributed to represent their actual proportions in each stratigraphic unit and in each annual precipitation zone, if possible.

Results

The distribution of Peat Swamp Forest varied greatly in each stratigraphic unit, with 65% of the areal extent in the Province found in SU-3. Sixty percent (60%) of these swamps also fell within the intermediate precipitation zone (2000 - 3000 mm). The portfolio should then represent the distributional inequity of this ecological system type in both Stratigraphic Units and precipitation zones. There was also a significant difference in the viability indices for the occurrences. Those in Units 1 and 2 are in better condition than those in Units 3 and 4.

Swamp Forests were most damaged in SU-4 and those in SU-3 of low viability were included in the portfolio because they are considered important for the ecological function of the Kinjau River and the middle Mahakam Lake area. Peat Swamps around the mouth of the Sesayap, Berau and Wain Rivers are also incorporated into the portfolio because they form a broad ecosystem alliance with Mangrove Forests and are ecologically important to the function of these rivers near their deltas, despite their individually poor viability ranking. The latter had a generally higher viability index than those in SU-3. Interestingly, there is no Peat Swamp Forest in the immense delta area of the Mahakam River, apparently neither extant nor historic.

The reasons for the low viability index for the middle Mahakam area occurrences are discussed in the previous Description and Threats sections. However, large tracts of Peat Swamp Forest associated with the Kinjau River are included because of the importance of the 'black rivers' flowing from these forests to native fish and other fluvifauna in this area – as well as their importance to terrestrial fauna and flora, particularly primates. This is also based upon expert opinion that, if further protected from fire and other human disturbance, occurrences selected in the portfolio could rehabilitate naturally. This is an important point, because the matrix lowland rainforests in the middle Mahakam area around these Peat Swamp Forests also have 'poor' or 'very poor' viability indices. They have been converted for agricultural purposes or have been burned on multiple occasions and would take a very long time (>200 years) to recover their natural floristics and structure – if at all. The key to this possibility is the absolute protection of the forests from further disturbances – which in this day and age is neither practical nor realistic in this particular area.

D. Heath Forest (Kerangas)

Description

Heath Forests are a lowland rainforest formation. In East Kalimantan there is a broad north to south central swath of Heath Forest patches, usually found on white sand soils, which usually originate from ancient sandstone beaches that were stranded by uplifting or falling sea level. The soils are of low fertility, highly acidic, commonly coarsely textured and free-draining.

Heath Forests have distinctive structural and vegetation characteristics and are generally less species rich than surrounding forests. Their trees are generally shorter and smaller and have fewer buttresses than those of other lowland mixed forests. Large woody climbing species, such as rattans, are rare. This forest type has a single layered uniform canopy (Whitmore 1984). Plants with a supplementary means of obtaining nutrients are also common (MacKinnon *et al.*1996). Heath Forests often form part of a mosaic with other lowland forest types and have a structure that variously may be described as ranging from tall, closed forests that are similar in structure to adjacent lowland mixed forests, to open scrubby vegetation (Mackinnon *et al.*1996). They are rich in genera of Australian plant species.

The low soil nutrition and xerophyllous nature of leaves of many plants in Heath Forests, including many that produce phenols in the leaves and thorns on branches to deter herbivores, create a habitat that has subsequently lower faunal diversity. Orangutan and macaques have been recorded in low numbers in Heath Forests (Davies and Payne 1982). Mammals, birds, turtles, snakes, frogs, cicadas, butterflies and dung beetles are also not abundant in these forests (Harrison 1965 and Cranbrook 1982 and Kitchener *et al*. 1997, Lloyd *et al*. 1968, Hanski 1983 and Holloway 1984). MacKinnon *et al.* (1996) describes the streams that drain Heath Forests as blackwater streams; they too are less speciose than other lowland forest streams (Johnson 1968).

Conservation issues and threats

- **Cutting/Burning**

  Heath Forest is a fragile ecosystem. It is rapidly, and frequently irreversibly, degraded following cutting or burning, to an open Savannah of shrubs and scattered trees over grass to become a formation often referred to as *padang*. It takes a very long time to regenerate – a process that is largely accomplished through coppicing rather than germination of seeds (Kartawinata 1978).

- **Logging**

  Some Heath Forest patches have particularly valuable trees, such as the conifer, *Agathis borneensis*, which make them targets for selected logging (Manaputty 1955). Also, with the proliferation of pulp and paper producing mills, the need for fibrous sources of all kinds regardless of wood quality or appearance is increasing the demand on this formerly less-desirable forest type.

- **Agriculture**

  Agricultural practices within Heath Forests are quickly destructive. Heath Forests have become agricultural sites for transmigration of people from other Indonesian islands. Heath Forest soils will typically tolerate only a single agricultural crop before becoming irreversibly degraded.

Occurrence Unit Determination

Significant Heath Forests were identified first using LandSat imagery to locate them in the province. The ECA team then consulted with individual experts and literature sources, followed by a limited aerial survey for those sites proposed for inclusion in the portfolio.

A Heath Forest occurrence was defined as each patch that is not physically connected to other Heath Forest patches. In the case of the large coastal patch north of the Berau Bay in SU-2, where it is divided by a primary river system, each dissected part was regarded as a separate occurrence since, unlike similarly configured peat swamp or freshwater swamp forests, they are not a hydrologically linked system.

Portfolio Design

The overall goal for Heath Forest in the East Kalimantan Portfolio is 60%. The portfolio achieved a total of 62.1%. (Stratigraphic unit 1, 20.8%; Unit 2, 40.7%; Unit 3, 0.5%; Unit 4, 0%). These were spatially distributed when possible to represent occurrences in each RePPProT subdivision and annual precipitation zone as indicated in Table A below.

Results

Nine of the 23 occurrences were selected for the portfolio. They account for 62.1% of the total area of Heath Forest in the East Kalimantan province. The largest occurrences of Heath Forest were in the coastal areas of stratigraphic unit 2, and were dominated by the Old Marine Terrace System and the Sediment Dominated Hill System of RePPProT land units.

The selected occurrences attempt to attain the 60% goal of representation in each stratigraphic unit, in each RePPProT subdivision of this forest type (N = 5), and in each of the three precipitation zones where they occur (See above Table A). Deviations from these goals result from the preferential selection of element occurrences that have a Very Good or Good viability index.

The extent of Heath Forest varied greatly in each stratigraphic unit, with 73% of the total area occurring in Unit 2. The goal of 60% could be met throughout the portfolio because most of these occurrences had a high viability rating. Most were relatively large units, not particularly irregular in shape and all were in good condition having avoided the wild fires of 1983/1984 and 1997/1998, and having soils largely unsuited to conversion for agricultural purposes. Until recently they were seldom cut and few people live in the vicinity.

Several of the Heath Forest occurrences were physically connected with other key element occurrences of other targets. For example, a large coastal area of Heath Forest was linked by ‘stepping stones’ of Heath with the selected Peat Swamp Forest around the mouth and brackish waters of the Berau River. The southern part of the body of these coastal occurrences was included in the portfolio, as well as the small ‘stepping stones’ with Good viability rankings.

Some of these occurrences were rated as having Poor and Very Poor viability- even though they were in Very Good condition inside their elements. Their low rating was based on their small size, relative isolation and, in one occurrence, its irregular shape. Another was conjoined with the Malinau River, a small branch of the Segah River; the larger element with Good viability was included.

Two other areas in stratigraphic units 1 and 2 were closely positioned to the Lower Montane/ Montane Rainforest system occurrences already selected. These were also included in the portfolio as important watersheds for one of the target Major Rivers (Kinjau River) as well as being located within an Important Bird Area. These two occurrences were also included in the portfolio because their viability was considered as Good and Very Good, respectively.

The large, irregularly shaped occurrences immediately to the east of the Malinau River occurrence are isolated from the other target ecological systems selected for the portfolio, although they are close to an isolated occurrence of Lowland Limestone Rainforest and fall within a restricted forest (*hutan lindung)*. One element occurrence is grouped with these two isolated Limestone occurrences to form a portfolio grouping which is unrelated to a target Major River.

The small cluster of occurrences on the Sangkulirang Peninsula had low viability rankings (even though their current internal condition was Very Good) and therefore was not included in the portfolio.

E. Lowland Rainforest

Photo courtesy of EHB Pollard

Description

Whitmore (1984) described five floristic zones defined by altitude in Borneo. These are the lowland dipterocarp zone at less than 300 meters above sea level (a.s.l.), hill dipterocarp zone (300-800 m), upper dipterocarp zone (800-1200 m), oak chestnut zone (1200-1500 m) and montane ericaceous zone (>1500 m). From these descriptions, Lowland Rainforest reaches from 0-800 meters above sea level. The available vegetation maps for East Kalimantan, produced by the German consultant group GTZ, drew the boundary of the interface of the Lowland Rainforests and the Lower Montane Rainforest at approximately 900 meters a.s.l. [*]

MacKinnon *et al*. (1996) stated that small mountains close to the sea, like Gunung Palung in West Kalimantan, may have moss forest (Upper Montane/Cloud Forest) as low as 800 m a.s.l., whereas on higher mountains, such as Gunung Mulu in Sarawak, Upper Montane Rainforest begins at 1,200 m and on others such as Mt. Kinabalu it may be as high as 1800m.

[*] Personal communications with forest experts working in East Kalimantan and examination of the literature indicated that the altitude reached by Lowland Rainforest varied greatly depending on height of mountains, isolation of mountains and proximity to the coast. Charles Cannon (pers. comm. 2002) considers that Lowland Rainforests in East Kalimantan generally transitioned into Lower Montane Rainforests at 1000 m a.s.l. Global Forest Watch in their Government of Indonesia/ World Bank 2000 update of Indonesian forest cover listed Lowland Forests (submontane) as below 1000m (and further subdivided this into lowlands that were < 300 m a.s.l.). However, Jim Jarvie (pers. comm. 2002) cautioned in accepting this altitude as the interface, observing that at Gunung Tete, a small isolated mountain in East Kalimantan, Lowland Rainforest transitions sharply to Upper Montane rainforest at an altitude of only 800 m.

In order to achieve an ecoregional scale-appropriate identification for this system type, we modified existing vegetation maps, which lacked coverage for a large part to the west of East Kalimantan (and also which did not differentiate between Lower Montane Rainforests and Upper Montane Rainforest/Cloud Forest), by drawing the upper boundary of Lowland Rainforests at the altitude of 1000 m a.s.l. There is, though, the awareness that some parts of the map designated as Lowland Rainforest may in fact be Montane Rainforest or Cloud Forest. Such anomalies can be sorted out in the more detailed analysis of Conservation Area Planning once sites are identified for conservation action. This potential for discrepancy should be kept in mind at the results reporting section.

Lowland Rainforests in Borneo are dominated by dipterocarp trees (named because of their winged seeds) and are frequently referred to as Lowland Dipterocarp Forests. Dipterocarps are extremely tall trees and frequently reach heights of 45m. In the richest forests, 10% of all trees and 80% of all emergents are dipterocarps, usually belonging to the genera *Dipterocarpus, Dryobalanops* and *Shorea*. The other dipterocarp emergents are commonly the legumes *Dialium, Koompassia* and *Sindora* (Ashton 1982).

One of the characteristics of these forests is that they are considered to be stratified into three or more vertical layers. However, this stratification is frequently not readily apparent, as different growth stages of plants tend to confuse the simple classical view of stratification. These forests also have flowers and fruits that are commonly borne on their trunks – referred to as cauliflory- the extent of which diminish with their altitudinal occurrence.

Lowland Rainforests also have dense tree crown epiphytes, including many ferns and orchids in the upper strata as well as abundant large woody climbers and bole climbers. Many of the enormous trees in this forest have very shallow root systems designed to utilize the soil nutrients limited to the surface soil resulting from the decomposition of leaf litter. Because many of these trees generally lack stabilizing taproots, they have evolved huge buttress roots to support their tall straight trunks. The ground layers are frequently sparse because the continuous upper canopy layer allows little light through.

Evidence suggests that if naturally disturbed, through formation of tree-fall gaps, these Lowland Rainforests take 120-140 years to regenerate to their original mature structure, although floristically they may contain the dominant trees after 60 - 70 years (Riswan *et al.* 1985). MacKinnon *et al.* (1996) estimate that it may take 200 years for a logged-over lowland forest to completely regenerate to its pre-logging structure and composition.

The predominant ecological formation type, or matrix formation, in the East Kalimantan assessment area is Lowland Rainforest. It blankets most of the lowlands up to an altitude of 1,000m. It is far from a homogeneous formation: its topography ranges from alluvial/colluvial plains, both flat, gently sloping, and gently undulating, to hilly areas, usually lower than 300 m a.s.l., and foothills. The formation occurs on volcanic, sedimentary and sedimentary substrates, and has a variety of soil types. This soil variety is represented in the land system types that the ECA team used at a later stage in this process to subdivide the Lowland Rainforest ecological system into discrete occurrences.

Lowland Rainforests are also often subdivided floristically into three altitudinal groupings of dipterocarp forest. Faunal studies by CIFOR (Center for International Forestry) in the Bulungan Kabupaten, near Kayan Mentarang National Park, have not elucidated clear trends in biological diversity or gradients in lowland dipterocarp forests on different substrate types or topography (D. Sheil, pers.com.; O'Brien 1997); they do show, however, that vegetation diversity in these Lowland Rainforests is very high- with 60% of the tree families and 36% of tree genera known for all of Kalimantan being recorded in just a single hectare plot (O'Brien 1997).

The Lowland Rainforest has close ecological connections to all the other lowland ecological systems embedded in it (Mangroves, Freshwater Swamp Forest, Peat Swamp Forest, Heath Forest and Karst Forest). In general, these other forest types have a poorer representation of the biological diversity present in the Lowland Rainforest. Perhaps the Karst Forest is the exception, because it has a mollusk fauna that has elements not represented in the matrix community and is likely to have other unique species, both vertebrate and invertebrate, when further surveys are carried out*. The interface between the Lowland Rainforest and the Lower Montane Rainforest is not sharp either faunally or floristically.

The phenology of Lowland Rainforest flowering and leaf growth is very complex and not necessarily closely tied to season. It can also be irregular, as is the case with dipterocarps, most species of which flower every four to five years in response to dry periods (Ashton 1988).

Insects pollinate many trees in Lowland Rainforest. MacKinnon e*t al*. (1996) examined the information available on a range of fauna and demonstrated that the population peaks of these insects (and fauna that feed on them) correspond frequently with the peaks of leaf and flower production, usually just after the driest parts of the year. These authors showed that availability of fruits affected animal feeding and reproductive behavior of frugivores. These seasonal trends in phenology of flowering and fruiting in Lowland Rainforests can be expected to impact the local movements of many faunal species throughout the Lowlands. Likewise, the number and movement of the fauna such as wild boar can dramatically impact the reproduction and recruitment of this forest type. Concerns now are that there are not enough wild boars in these forests to maintain the natural recruitment of large dipterocarps (Leighton and Cannon 1999 and Lisa Curren 2000).

Rainfall data indicate clear gradients of increasing aridity from the inland Lowland Rainforests (mean annual rainfall as high as 4000 mm) to those nearer to the coast rainfall less than 2000 mm). Presumably, these environmental gradients affect the periodicity of flowering and fruiting - encouraging the more vagile species of animals to move in a patterned way along the major inland-to-coastal axis, within the major watersheds. This has implications for the need for restoration and/or conservation of faunal corridors linking the inland and coastal Lowland Rainforest in each major watershed. This concept formed the process of Portfolio assembly and the conservation strategy referred to as the "Ridges to Reefs" approach.

* See Karst section for results of recent (2004) surveys

Many of Borneo's 200 land mammals, 500 bird species, 166 species of snakes, 183 species of amphibians (approximately half the frogs are tree frogs) and countless invertebrates are found in Lowland Rainforests (MacKinnon *et al*. 1996). Lowland forests are particularly rich in species of squirrels and birds - both show clear stratification. For example, Wells *et al*. (1979) showed that in the top canopy there are hornbills, barbets and pigeons; the middle canopy has trogons, woodpeckers and bulbuls; and the undergrowth, pittas, thrushes, babblers and pheasants. Invertebrates occur at relatively low densities in this forest type (Elton 1973), although a large invertebrate fauna, including moss-feeding moths, exploit the canopy epiphytes.

In East Kalimantan, large mammals are prominent and include 11 species of primates, including: Slow Loris; Western Tarsier; Hose's Langur; Maroon Langur; White-fronted Langur; Silver Langur; Proboscis Monkey; Long-tailed Macaque; Pig-tailed Macaque; Bornean Gibbon; and Orangutan. Other notable large mammals include two species of Muntjak, *Muntiacus muntjak; M. atherodes*, Sambar Deer, Wild Banteng Cattle; Bearded Pig; Sun Bear; and four species of wild felines: Clouded Leopard; Marbled Cat; Flat-headed Cat; and Leopard Cat.

There is also a wide variety of smaller mammals including rats, shrews (including seven species of tree shrew), 15 species of squirrel, porcupine, marten, weasel, otter, civet, mongoose and bats. The Asian Elephant, *Elephas maximus*, has been reported on the northern border of East Kalimantan and Sabah by Yasuma (1994), and there has been one recent indication (via a discovered carcass) that Sumatran Rhino have managed to persist on the western edge of the Province (EHB Pollard, pers. com. 8/02).

Conservation issues and threats

- **Need:** *The Natural Rehabilitation of Logged Forest*. It has been widely reported that, at current rates of logging, much of the Lowland Rainforest in East Kalimantan will be gone in 10 years time. Key strategically integrated areas need to be identified whereby rehabilitation of cut-over areas is allowed to occur naturally. The long-term survival of significant parts of the biological diversity of Borneo will depend on successful natural rehabilitation of Lowland Rainforest because it has been estimated that 80% of the original biological diversity is likely to survive in such naturally regenerated areas. The key is to prevent additional disturbances after the first logging event until the same or similar structural and compositional maturity is achieved – which, in the case of Lowland Dipterocarps will mean 70-100 years or more. This will require a strategic, long-term rotational system of logging with financial incentives for adherence to the schedule and stiff penalties for those who cut early or inappropriately. More on this strategy in later chapters on Conservation Strategies and Recommendations.

- **Logging**

  Logging of Lowland Rainforest at a huge scale in recent times has eliminated some 40% of this forest in Borneo, and less than 3% remains in so-called "gazetted conservation areas” (MacKinnon and Artha 1981). Logging includes both legal commercial harvest of timber on concessions known locally in its Bahasa Indonesia acronym as HPH’s , and illegal logging – frequently in the same areas, mostly close to roads and rivers, with timber being sold to the same outlets as legal logs at a fraction of the cubic metric price. Pulp mills, which have been grossly overbuilt and are therefore always demanding more lumber to reduce to a pulp mash, encourage the wholesale removal of not only those trees of legally harvestable size, but also trees of all sizes since even-grained boards of desirable lengths are not required.

It has been alleged that the proliferating practice of illegal logging has been supported at virtually every level of law enforcement and local government, all of whom profited from the kick-backs or themselves owned a stake in the pulp mills. Incentives to affect change of this activity are few in a nation of sharp economic disparity resulting in cultural acceptance of such corrupt practices. That attitude may be changing however as the damage to local watersheds is resulting in massive property damaging floods that also are claiming lives, as witnessed in the November 2003 floods in northwest Sumatra. An outcry of the public and the media has caused another reassessment of why this practice continues unabated and how it might be addressed effectively. The recent elections in 2004 hold great promise that the culture of systemic corruption will be seriously addressed by the new President.

- **Lack of Law Enforcement**

There are existing regulations that forbid logging on slopes greater than 40% or above 600 m a.s.l.. But, like most official regulations, there are ways around them, and plenty of incentive to do so for the individuals cutting the trees, for the ones who transport them, sell them and ultimately process them into pulp or lumber. These regulations need to be strictly enforced because illegal logging in these and other areas is rampant. Logging on high slopes is particularly damaging, as most of these areas are prone to erosion once logged. Forests with high erosion potential in many key water catchment areas need to be identified, rehabilitated, and protected from further disturbance.

- **Conversion**

Conversion of Lowland Rainforest for transmigration purposes has been a major threat in the past two decades, and continues at a limited scale today. The selection of regional development centers and potential areas for transmigration is well documented (TAD #17). However, these strategic development documents make almost no reference to environmental impacts resulting from clearing of Lowland Forests for agriculture in the Mahakam Basin. This has led to serious environmental problems in that basin, particularly erosion and altered surface and subsurface hydrological patterns. These result in downstream problems, including reduced water volumes, erosion and increased sedimentation loads and turbidity, heavier and more frequent flooding episodes, pollution with agricultural chemicals, and formation of huge rafts of invasive weeds such as water hyacinths, in the lakes.

- **Fire**

Fire is one of the major threats to Lowland rainforests and many other forests in East Kalimantan. In 1997-1998 over 50,000 km^2 of East Kalimantan burned, and some 23,000 km^2 of natural forest concessions were affected- mostly in the lowlands. This is nearly one-quarter (24%) of the area of all natural forest concessions in the province and included 90% of the important Lowland Rainforest within Kutai National Park (Hoffmann *et al.* 1999).

Nieuwstadt *et al.* (2002) and Slik *et al*. (2002) examined the aftermath of these fires in East Kalimantan in the vicinity of the Wain River and from Mt. Beratus in the south to several locations between Balikpapan and Samarinda. Mark van Niewstadt (pers. com.) considers that these forests appear to have a greater recovery potential than expected, mainly due to the resprouting capacity of small stems in the forest undergrowth, which allows for the relatively rapid recovery of populations of shade-tolerant trees. On the other hand, it is clear that repeated disturbances (such as logging in burned forest, or repeated fire) do cause greater damage than one would expect, because the already limited recovery capacity is seriously further reduced. In particular, Nieuwstadt *et al.* (2002) suggests that if future fires and other key disturbances, largely related to salvage felling of timber after fires, and further cycles of cutting of the forest, could be contained, then there would be good prospects of these forests regenerating. This would be particularly so if the exotic grass, known locally as *Alang-alang* (*Imperata cylindrica)* could be prevented from invading.

Nieuwstadt *et al.* (2000) states that the recovery capacity of forest vegetation after fire and other disturbances involves four main processes: tree survival; resprouting of damaged trees; germination of seeds in the seed bank; and the seed rain from mature surviving trees. Directly after the low intensity ground fire in the Wain River area, which burned accidentally in March 1998 after several months of drought, observers noted that survival of trees larger than 30cm dbh (diameter at breast height) was about 45%, with a range from 20% to 95% among species. This compares well with survival 6 months after fire in unlogged forest in Kutai National Park, East Kalimantan, which was about 25% (Leighton and Wirawan 1986). Sprouting after fire is important for forest regeneration and appears to play an important role in the persistence of many primary forest species in East Kalimantan (Nieuwstadt *et al.* 2002, Leighton and Wirawan 1986).

Interestingly, Leighton and Wirawan also found that, while fires killed most of the seeds lying dormant in the litter layer and in the upper 1.5 cm of the soil, seeds in deeper layers of the soil were unaffected. Because of the high mortality and the high germination incidence soon after the fire, the density of viable seeds remaining in the soil is greatly reduced. Under these circumstances the local seed bank has little potential for further regrowth. These areas, if further damaged, risk invasion by wind-dispersed species, including *Imperata cylindrica* (Alang-alang grass), *Pteridium caudatum* (Bracken fern), and *Dinochloa sp.* (Bamboo). It has previously been shown in East Kalimantan that complete conversion of a primary forest to *Imperata* grassland can take place rapidly after clearfelling and repeated burning (Kartawinata 1993).

Seedling establishment from the post-fire seed dispersal in the Wain River forest in 1997 was extensive, but it will take a long time before seedlings of primary species will have established in numbers comparable to the post-fire density of resprouts. For that reason the presence and performance of resprouts is a more important factor in the initial restoration of the forest than is the density of tree seed sources. However, seed production by trees that survive either as individuals in the burned area, or in pockets of unburned forest, will ultimately be the main source of regeneration of many primary forest tree species.

Slik *et al.* (2002) rather surprisingly found that species diversity of *Macaranga* trees was higher after a year in burnt areas than was the case in selectively logged areas! After 5-15 years, the number of trees per-surface-area recovered to predisturbance values in both burned and selectively logged forest. There was a difference though, in the recovery of number of tree species (biodiversity). In the case of burned forests, they have to be built up largely from the seed rain and seed bank, whereas in selectively logged forests, a large sapling and pole stand persists. However, much of the predisturbance tree species diversity can be found in burned forest 15 years after a single fire. Slik *et al*. (2002) state that “this renders them (Lowland Rainforest) still valuable for conservation, especially since the studied forests were all heavily burned and tree species diversity is likely to be higher in lightly burned forest”

- **Spread of Alang alang** (*Imperata cylindrica)*.

  Recently in East Kalimantan, *Alang-alang* grasslands have extended widely into Lowland Rainforest areas. *Alang-alang* is a fire disclimax community, which prevents natural rehabilitation of disturbed forest. It mainly results from conversion of forests to plantations on infertile soils and not from slash and burn (swidden) agriculture widely practiced by traditional people (Kiyono and Hastaniah 2000). The lack of regulations to prevent clearing for one-crop rotation, after which land is permanently abandoned, is a major factor in the spread of *Alang-alang* grassland and the permanent conversion of Lowland Rainforests.

- **Swidden agriculture**.

  MacKinnon *et al.* (1996) regard traditional swidden farming as causing little damage to the environment. Fallow land from swidden farming usually becomes secondary forest and ultimately develops into mixed dipterocarp forest after a fallow period longer than 70 years, if the seeds of primary forest species are provided (Okimori and Matius 2000). However, new technologies, increased population pressures, and the need for traditional farmers to plant cash crops have dramatically altered traditional swidden practices and telescoped the fallow period (Jessup and Vayda 1988). There is a need to identify areas of Lowland Rainforest where traditional swidden practices can be maintained and to discourage other farming techniques that are inimical to maintenance of forest structure and floristics.

- **Increased hunting pressure**.

  Traditionally, inland people of East Kalimantan have hunted a range of animals including all medium to large animals present in Lowland Rainforest. There are now substantial bush meat markets that have been established to serve the timber companies in the field, for example at Malinau. The dramatically shrinking populations of these animals and their increasing fragmentation has occurred as a result of large tracts of their habitat being logged or destroyed by land conversion or burning. This has resulted in much more intense hunting of given populations with a concomitant risk of driving particular species to local extirpation. Orangutans are particularly vulnerable to this activity since they are slow and easily discovered by hunters. They are killed for food as well as for export into the exotic pet trade, especially the more desirable babies that are taken from their dead mothers.

Occurrence Unit Determination

Significant Lowland Rainforest occurrences were identified first using LandSat imagery to locate them in the province. The ECA team then consulted with individual experts and literature sources, followed by a ground check or limited overflights to verify forest presence and condition for those sites proposed for inclusion in the portfolio.

It is more difficult to define an occurrence in this widespread matrix formation – which appears to have an ecological continuity with all its surrounding forest types. We chose to use an aggregation of the sub-watershed polygons to define boundaries of occurrences of Lowland Rainforests. This is based on the logic that polygons of such size are likely to enclose a similar topography, drainage pattern, edaphic factors and disturbance. However, there is much biogeographic information that indicates that the major river systems have also determined the distribution patterns of even large mammals in Kalimantan. Therefore, wherever a sub-watershed was *completely* transected by one of these major rivers, that sub-watershed also became two occurrences of Lowland Rainforest with the polygon boundary defined by the boundaries of the sub-watershed and the transecting river.

Portfolio Design

The goal for Lowland Rainforest in the East Kalimantan Portfolio was 20%. The recommended portfolio achieved 28.4% (SU-1, 14%; SU-2, 5.7%; SU-3, 6.0%; and SU-4, 2.1%). These were distributed to represent their actual proportions within each stratigraphic unit and within each annual precipitation zone. The total percentage includes all Lowland Rainforest in the following protected areas: Kutai National Park, Kayan Menterang National Park, Bukit Suharto, etc. Appendix III shows the percentage of this forest type captured within each of the 10 RePPProT subdivisions.

Results

The matrix Lowland Rainforest is very heterogeneous. All 10 RePPProT subdivisions are present, and most as large patches. (See Appendix III). All RePPProT land systems are present in the four stratigraphic units, although it is clear that several of these land systems dominate Lowland Rainforests in all three rainfall zones. These are *SDHS*, *SDMS*, *SDPS* (sediment dominated systems). In the medium and higher rainfall zones (>2000 mm), *MDPHMS* (metamorphosed systems) are also dominant. In the dry zone (<2000 mm), *KPHS* (karst plains and hills) is also dominant in stratigraphic unit 2.

The portfolio met the goals for Lowland Rainforests in each stratigraphic unit with occurrences that have a very good viability index in those sites located away from the major courses of the target Major Rivers and Lakes. The occurrences selected to protect the riparian sites along these rivers mostly have a Poor to Very Poor viability index as was expected given the nature of threats brought in by rivers as transportation corridors. These are included in the portfolio because their restoration (using agroforestry or other processes) or rehabilitation (using natural reforestation where possible) is deemed important to restore the ecological function of the Major Rivers and Lakes. The width of this riparian zone was set at 500 m on either side of the river. This is in accordance with the zone recommended by the Indonesian Forests Department for large rivers (U.U.No.41:1995) and by local experts on control of river sedimentation.

Wherever possible, Lowland Rainforest with Good or Very Good viability was selected to link other fragmented target ecological system types (Heath Forest, Lowland Limestone Rainforest, and Peat Swamp Forest), to form buffer zones around these types and also behind Mangroves and Freshwater Swamp Forest. In some coastal Mangrove occurrences in each of the four stratigraphic units some Lowland Rainforest areas of lower viability had to be selected because of their importance to protecting the hydrology of the adjacent Mangrove Forest.

Lowland Rainforest was selected in the upper catchment areas of each target Major River. This was done by an examination of the major drainage flows and then grouping the sub-catchment areas in order to capture the overall area of this major drainage flow. This method of aggregation forms the occurrence polygons for Lowland Rainforest in the portfolio. In the case of the Kinjau River in the Mahakam Basin, the Lowland Rainforest selected for the portfolio at its upper catchment was ranked Poor. However, it is included in the portfolio because rehabilitation of this catchment area is required to reduce sedimentation rates in the river (Hardwinarto *et al*. 1999). The upper catchment areas selected for the Sesayap and Balikpapan Rivers are somewhat protected because they lie in the Kayan Mentarang National Park and Sungai Wain Reserve. The upper catchment for the Segah River falls within the Sumalindo Timber Concession, and for the time being, under current management and ownership, has a Good viability ranking.

Lowland Rainforest viability scores were generally lowest in SU-3 because of the frequent wildfires, ongoing conversion and logging that have occurred throughout this forest type in the Mahakam Basin region. Viability scores were generally highest in SU-4, the Pasir Basin.

The low viability ranking of the Lowland Forest occurrences in Kutai National Park is somewhat disturbing. Clearly, a large part of this important national park, which is crucial for the conservation of Lowland Rainforest ecosystems, has been very badly damaged. However, there is promising new information on the ability of this forest to recover, if protected from further damage. Therefore it was retained in the proposed conservation portfolio. This recovery potential may be offset by the fact that illegal human settlements and agriculture have occurred within the National Park, and illegal logging continues unabated.

Lowland Rainforest is frequently further subdivided into hill dipterocarp (0-300 m a.s.l.), and two other categories 300- 800 m a.s.l. and >800 m a.s.l. The RePPProT types that most frequently represent these altitudinal groupings are well represented in the portfolio, confirming further that the use of these landsystem types in portfolio assembly does a good job in capturing altitudinal gradients that are classically suggested to represent such vegetation changes. See Appendix III for the representative quantities of each of the landsystem types for each ecological system type in the portfolio. Charts in Appendix III also show the amount of each forest type captured within the three precipitation zones present in the planning area.

Orangutan Conservation Issues

This ECA would be remiss if it neglected to highlight conservation issues surrounding the most globally charismatic of its megafauna – the orangutan. Much has been published about its ecology and the challenges the conservation community faces in terms of ensuring long-term survival of this close human primate relative (see Our Vanishing Relative by Neijman & Meikjaard). Little has been done on the ground however, short of establishment of "rehabilitation centers" which may send mixed messages to the general public on the urgency of native habitat protection for this complex great ape.

Predictions of the orangutan's demise in the wild follow those of the disappearance of its intact lowland rainforest habitat – that is, 10 years give or take a few. Although this rate of deforestation has been known for about a decade or more, not much has been done to abate the threat in meaningful terms. National parks and reserves set aside on paper, supported by national laws that technically prevent destructive activities within them, have done little to actually stem the tide of forest loss through illegal logging, illegal settlements, and wildfire associated with these activities. The future truly looks dim for this primate species and its habitat in the wild.

The threats are synergistic in nature, difficult to tease apart, and these entanglements must be understood to have any hope of abating them. Strategies to deal with the threats must be targeted at the sources of threat and must be coordinated at all levels of government to effectively reverse the trends of loss. Therefore, each source of stress will be simply listed here to acknowledge its role in the decline of the wild orangutan populations in Kalimantan. Detailed treatment of these threats and sources and strategies for abatement will be accomplished in Site Conservation Planning specific to the individual portfolio sites recommended in this assessment.

The primary sources of stress in Orangutan populations are the same as those to its habitat, with the exception of poaching:

- ***Illegal Logging***
- ***Illegal Human Settlements***
- ***Wildfire***
- ***Poaching***
- ***Poorly Managed Legal Logging***
- ***Roads***

F. Lowland Limestone (Karst) Forests

Description

As in most areas of the world where this biologically diverse geologic formation is found, there is a wide range of plant communities found on limestone substrates in Kalimantan. In addition to the Lowland Limestone Rainforest target, MacKinnon *et al*. (1996) identifies Lowland Scree Forest, Lowland Limestone Cliff Communities, Lower Montane Lowland Limestone Rainforest and Upper Montane Lowland Limestone Rainforest. In East Kalimantan, only the first three types are found – both of the Montane Lowland Limestone Rainforests are absent.

The Lowland Scree Forests and Lowland Limestone Cliff Communities are represented in this assessment within our Lowland Rainforests ecological system. They are mainly found on the RePPProT landsystem types *GBJ* (flat karst country with rolling hills) - which are extensive in the northeastern part of the Sangulirang Peninsula in stratigraphic unit 2 -and occasionally on the *KPR* type (rolling hills with highly fractured karst). These forests vary in structure considerably from Lowland Limestone Rainforest. They are characterized by being fairly open with massive emergents as opposed to the closed canopy typical of intact Lowland Limestone Rainforest.

Lowland Limestone Rainforests form dense irregular forests on steep limestone country where slopes are greater than 45^o. They are tall forests comprised mostly of dipterocarps, with dominants up to 40 meters, which are commonly buttressed. Common species are: *Hopea andersonii*, *H. dasyrachis* and *Shorea multiflora* and also the non-dipterocarp species *Brownlowia glabrata* and *Palaquium sericeum*. Shrub layer is sparse, with woody climbers and epiphytes sparse or rare (Anderson and Chai 1982). In East Kalimantan, they almost always are found on the RePPProT land system type *OKI* (steep sloping limestone outcrops), but occasionally also on *KPR* (rolling hills with highly fractured karst).

Surveys by KPSL-UNLAM (group from University of Lambung Mankurat) in Sangkulirang Peninsula, East Kalimantan, found no vertebrate fauna restricted to karst country, but have fauna typically found in the surrounding lowland forest matrix. These include Banteng, Orangutan, Bornean Gibbon, Sambar deer, Muntjak deer, and Mouse Deer. MacKinnon *et al*. (1996) reports that the Serow, *Capricornis sumatraensis*, an agile goat-like animal may also be present in these hills and states that pockets of endemic invertebrates are also likely to occur there. Derek Holmes (*in* MacKinnon *et al*. 1996: 311) considered that the Karst Forest supports an interesting and unusual semi-montane bird fauna, even though the area is lower than 200 meters and the highest summits reach only 600 meters. Leo Salas (pers. comm. 2003) a tropical forest ecologist working in the region, reports that Pigtail Macaques and Silver Langurs occupy the cliff walls of the extensive karst occurrences in the Sangkulirang area, exhibiting unique mountain-climbing abilities and utilizing caves as shelters.

New surveys completed in November 2004 discovered several newly described species of invertebrates and one new fish species limited in distribution to the caves of the Sangkulirang Peninsula (Scott Stanley, pers. comm.) This discovery represents the incredible value of this landform/forest system type to the biological diversity and ecology of the Borneo landmass. Much remains to be explored throughout this island and it should not be surprising that more endemic, newly described species will be found.

The karst forest is characterized by the presence of caves, generally infrequently encountered elsewhere in East Kalimantan. These caves have their own assemblage of vertebrate and invertebrate fauna that is yet to be fully explored. Recent cave survey expeditions by TNC in July/August 2004 have found at least 22 species of bats in this area (S. Stanley, pers.comm). Such cavernicolous bat species are likely to include *Megachiroptera* that are important pollinators of many tropical tree species and important dispersers of their seeds. Such fruit bat species are known to travel distances of up to 80 km a night to feeding areas (Stuart and Marshall 1976); hence the importance of these caves to the ecology of the surrounding karst forest and surrounding lowland forest cannot be underestimated. These fruit bats may also represent a crucial component for some of the more economically important fruit species such as the highly sought after Durian fruit *(Artocarpus heterophyllus).* The caves of this area have also been the focus of French anthropologists who have discovered globally significant human cultural artifacts, wall paintings, and indications of occupation over several millennia (Fagé and Chazine, 2001)

Scattered ranges of limestone hills, large boulders and outcrops are scattered throughout Borneo. However, the Karst country of the Mangkalihat Ranges in the Sangkulirang Peninsula is the most extensive in Southeast Asia outside Irian Jaya (now Papua). Anon (1979) considered that the extensive karst landscapes comprising the Mangkalihat Peninsula

- including more remote areas - should not be developed because the "steeply shaped limestone and its related solution process, including the subsurface hydrography, do not offer any chance for proposed land uses". This would provide the area with much needed protection irrespective of its significant biological and cultural holdings. The threat of increased cement production in Indonesia, with a globally insatiable market, may quickly negate any such protections from other land uses.

Conservation issues and threats

- **Wildfires**

  Wildfires are a major threat to these forests which, if burned once, are more susceptible to repeat burning. The fires of 1982/1983 damaged parts of the Karst Forest; those of 1997/1998 encroached even further.

- **Logging- legal and illegal**

  Selected logging in parts of the Karst Forests particularly around their perimeter are disturbing the ecotonal interface with the surrounding lowland forest matrix and may serve to further isolate faunal communities in the Karst Forests from associated adjacent populations.

  Theft of timber (illegal logging) from these forests is also prevalent and given time will seriously impact their margins.

- **Cement Quarrying**

  Quarrying of limestone for cement or for road-building is currently located at the margins of the Karst Forest, but, with recent increases in economic status and the consequent surge in building activity, particularly in nearby China, this threat looms on the horizon as a major source of destruction and fragmentation of these forests and their underlying geology.

- **Cave Disturbance**

  Human disturbance to caves for the purpose of collecting swift nests, as well as for tourism, poses a threat to the important populations of fruit bats, insectivorous bats, swiftlets and other cavernicolous species, some of which are likely to be endemic. The fruit bats are important to the floristics and structure (distribution pattern) of the forests in the karst community and also in the surrounding matrix forests. Human disturbance can be expected to increase as ecotourists visit these areas in increasing numbers to observe the numerous ancient cave paintings that have recently been shown to abound in these caves (Fagé and Chazine, 2001).

Occurrence Unit Determination

As in other discrete ecological system types, significant Karst Forests were identified first using LandSat imagery to determine their location within the province. The ECA team then consulted with individual experts and literature sources, followed by ground surveys, sometimes quite detailed, for priority sites proposed for inclusion in the portfolio.

A Karst Forest occurrence was defined as an individual patch that is not physically connected to other Karst Forest patches. In the case of several patches (e.g., in the Sanggata and Pasir regions) which are divided by primary river system, each dissected part was regarded as a separate occurrence since hydrology does not functionally link the patches as would be the case for Freshwater Swamp and Peat Swamp forests.

Portfolio Design

The overall goal for Lowland Limestone Forest in the East Kalimantan Portfolio was 60%, which was achieved.

Results

The overall goal was achieved with just over sixty percent (60.3%) of the known occurrences selected for the portfolio. These were distributed within the stratigraphic units as follows: SU-1, 89.8%; SU-2, 58.7%; SU-3, 64.8% and SU-4, 59.4%).

Twenty-two separate occurrences were included in the portfolio. In SU-1, there are only a few small occurrences, but the three largest of these, in the best condition, were selected. These account for 89.8% of those present in this unit, but, because they are all small, this does not unduly bias the achievement of the 60% goal for all of East Kalimantan.

In SU-2, many of the Lowland Limestone Forest occurrences in the middle precipitation zone (2000 – 3000 mm) were badly damaged by repeat fires in 1997/1998. These damaged occurrences were not included in the portfolio. This decision results in an under-representation of this forest type in the SU-2, especially in the median precipitation zone, where only a single element occurrence was selected, representing 10.7% of the available occurrences. In stratigraphic unit 2, more occurrences were selected from the lower precipitation zone (72.2%). Most of these are on the Sangkulirang-Mangkalihat Peninsula and are very close in annual precipitation values to the damaged elements and, as such, probably experience similar climate regimes. Therefore, it was felt that these occurrences would adequately represent this system type in SU-2. These selected occurrences also overlap with the Important Bird Area identified in this unit.

In stratigraphic unit 3, the occurrences were somewhat evenly distributed across the east to west precipitation gradient. Most had a Good or Very Good viability index - so each of the precipitation zones was well represented. One poor viability occurrence was included in the portfolio because it was located within Kutai National Park. Other occurrences were selected because they were adjacent to the Mahakam River and afforded that system some ecological support from particularly bat pollinators or were grouped inside a proposed protected forest area.

In stratigraphic unit 4, 59.4% of the occurrences were selected. The two largest of these had Very Good viability rankings. One was selected because it was in the upper catchment area of the largest river in this unit, the Kerang River, and the other was chosen because it was the largest coastal occurrence. A small occurrence with Good viability was included because it is an important element of the Wain River delta and the Balikpapan Bay ecosystem.

The majority of these occurrences (58%) were in the lowest precipitation zone of < 2000 mm. There were five RePPProT subdivisions that are located in these Lowland Limestone Rainforests indicating some substrate heterogeneity, although the predominant substrate was the RePPProT type *KPHS*: karst plain/hill system followed by *SDBS*: sand dominated beach system.

Most of the Limestone Karst Forest occurrences selected for the portfolio were not associated with the target Major River systems. The exception was an elongate occurrence adjoining the Mahakam River. Most were selected because they were large occurrences, and/or were associated with selected Heath Forest, Important Bird Areas and/or protected forest areas.

The largest patches of Lowland Limestone Rainforests are in the Sangkulirang-Mangkalihat Peninsula and these are well represented in the portfolio. It is clear from the Landscape Context ratings for Lowland Limestone Rainforest occurrences, that many of them are buffeted by threats from outside, particularly wildfires and logging, but that the other threats, while currently minor, have great potential to cause a substantial impact on the quality of the habitat inside these visually stunning and ecologically critical landscapes.

G. Lower Montane/Middle Montane Rainforests

Photo courtesy of EHB Pollard

Description

Lower Montane /Middle Montane Rainforests are distributed around the foothills and slopes of the mountain ranges to the west of East Kalimantan and the hilly areas in the upper Mahakam Basin and Malinau Districts. They are characterized by the following: trees that rarely exhibit cauliflory; usually no large woody climbers; frequent or abundant bole climbers; abundant vascular epiphytes; and occasional to abundant non-vascular epiphytes (Whitmore 1985). In this ecoregional assessment, this category includes rainforests in altitudes from 1000 meters above sea level to 1800 meters a.s.l.

Lower Montane to Middle Montane Rainforest tends to be very transitional between Lowland Rainforests and Upper Montane Forests. There is seldom a sharp transition in either plant or faunal species. In Lore Lindu National Park, Central Sulawesi, this intermediate formation type was the richest in species of birds - more so than in lowland areas which are reputed to be the richest for birds in Indonesia, and elsewhere in the Asian tropics (Coates and Bishop 1992; MacKinnon and Phillips 1993). Bird Life International states that several endemic bird species in Kalimantan appear to be restricted to Lower Montane Rainforest.

These include the Dulit Frogmouth, *Batrachostomus harterti*; Hose's Broadbill, *Calyptomena hosei* and Pygmy Darkeye, *Oculocincta squamifrons* (Sujatnika *et al*. 1995).

Mammal species are also usually moderately high in Lower Montane/ Cloud Forest in Lore Lindu National Park, and do not decline substantially from their diversity in lowland forests, except for bats, which decline dramatically above 1500m a.s.l. Evidence from Peninsular Malaysia suggests that biomass of primates (Caldecott 1980) and some groups of soil macrofauna (Collins *et al*. in MacKinnon *et al.* 1996) may often be highest in these lower montane rainforests, especially oligochaetes. This does not appear to be the case with the higher order primate Orangutan, which tend to favor vegetation below 1000m a.s.l. Nijman & Meijaard in Nijman (2001) stated that in East Kalimantan, the Bornean Gibbon was "confined to closed canopy forest in the lowlands and hills up to c.1500m a.s.l." Suzuki *et al*. (1997) noted that in the Berau and Kutai District of East Kalimantan, Bornean gibbon is more common on hills and uplands.

MacKinnon *et al.* (1996: Table 7.4) reported that there was no clear trend for gibbon to decline in density between altitudes of 0-900m. Numbers of groups of gibbon in Sabah (*H. muelleri*) also did not decline up to 1500m above sea level – although they did in the altitudinal range of 1500 – 3000m. However, it is possible that this decline at very high altitudes was strongly influenced by their typical low density in cloud forests. This would be expected given the low, stunted nature of the trees and the low abundance of fruit in cloud forests. It is reasonable to assume that gibbon group size would also decline markedly in upper montane rainforests (1800-2000m).

Evidence from Mt. Kinabalu, in the Malaysian State of Sabah, indicates that species richness of butterflies in these Lower Montane Rainforests is less than in Lowland Rainforests, but is higher than in the Upper Montane Rainforest /Cloud Forest system type.

Conservation issues and threats

- **Logging**

  Logging of Lower Montane Rainforest is much less than what occurs below 1000m a.s.l. because of the costs of operating on high slopes. However, there is some logging above 1000m. The contribution of such logging to increased suspended sediments in streams and rivers caused by erosion on these steep slopes is out of proportion to the relatively small areas that are logged. Also, the removal of forest from the lowland areas surrounding these Montane forests will be critically dependent upon the seed production from these protected forests to replenish and restore the lowland forests – provided of course that they are left alone for decades to naturally revegetate. This seems unlikely given current population and industrial development trends in the region.

- **Fire**

  Due to the fewer roads present in this forest system type, because of the legal logging restrictions, fire tends to occur less frequently than in the lower elevation forests. But contiguity of this forest type with adjacent more heavily used systems, such as lowland rainforest and karst forest, the danger of wildfire spread persists. Impacts are particularly damaging in the montane systems because of their removal of multiple-layers of vegetative habitat features – that is, the bole climbers, vines, ferns, tree orchids, mosses and fungi present at every level of the forest canopy. Each of these habitat features serves as home to numerous, and probably as yet undocumented endemic species of invertebrates and small vertebrates.

- **Alang alang (*Imperata cylindrica)* spread**.

  Recently in East Kalimantan, Alang-alang grasslands have extended widely into Lowland Rainforest areas. Alang-alang is a fire disclimax species, which prevents natural rehabilitation of disturbed forest. It mainly results from conversion of forests to *kebun* (garden plots) on infertile soils and not from slash and burn (swidden) agriculture widely practiced by traditional people (Kiyono and Hastaniah 2000). The lack of regulations to prevent clearing for one crop rotation, after which land is permanently abandoned, is a major factor in the spread of Alang-alang grassland and the permanent conversion of Lowland Rainforests. Such a source of invasive species may bring it into the Lower Montane region when or if this forest type begins to suffer substantially from deforestation in the eventuality that the lowland forests are depleted.

- **Swidden agriculture**.

  MacKinnon *et al.* (1996) regard traditional swidden farming as causing little damage to the environment. Fallow land from swidden farming usually becomes secondary forest, and ultimately develops into mixed dipterocarp forest after a fallow period longer than 70 years, if the seeds of primary forest species are provided by retaining nearby reproductive-aged standing forest (Okimori and Matius 2000). However, new technologies, increased population pressure and the need for traditional farmers to plant cash crops have dramatically altered traditional swidden practices and telescoped the fallow period (Jessup and Vayda 1988). There is a need to identify areas of Lower Montane/Middle Montane Rainforest where traditional swidden practices can be maintained and to discourage other farming techniques that are inimical to maintenance of forest structure and floristics.

- **Lack of Strict Enforcement of Government Regulations**.

  There are existing regulations that forbid logging on slopes greater than 45% or above 600 m a.s.l. (*Keputasan Presiden* No.48/1983). These regulations should be strictly enforced because illegal logging in these and other areas is rampant. Logging on high slopes is particularly damaging, as most of these areas are prone to erosion if they are logged. Such impacted forests with high erosion potential in many key water catchment areas need to be identified and rehabilitated with appropriate native species.

- **Increased Hunting Pressure**.

  Traditionally, inland peoples of East Kalimantan have hunted a range of animals including all medium to large mammals present in Lower Montane Rainforest. Additionally, there are now substantial bush meat markets that have been established to serve the workers of timber companies in the field, for example at Malinau in stratigraphic unit 1. The dramatically shrinking, and increasingly fragmented populations of these animals, particularly in the Lowland Rainforest systems due to large tracts of their habitat being logged or destroyed by land conversion or burning, have increased the role of the Montane ecosystems to absorb the remaining populations as refuges. For species such as Asian Elephant and Sumatran Rhinoceros, the upper elevation habitats in all likelihood provide their last stronghold.

Occurrence Unit Determination

Significant lower montane forests were identified through the use of LandSat imagery to locate them in the province. The ECA team then consulted with individual experts and literature sources, followed by limited ground truthing for some sites proposed for inclusion in the portfolio.

Lower Montane/ Middle Montane Forests cover large expanses around the foothills and mid-slopes of mountains. This trend is particularly evident on the western mountainous spine, to the north of the Central Mahakam Basin and on numerous smaller patches in Malinau, in the northern part of Kayan Mentarang National Park and to the west of Sangkulirang Peninsula. These are usually large patches and irregular in shape, occurring from 1000m to 1500m a.s.l. However, due to compression effects, some may be found with upper limits as low as 600m-800m a.s.l.

In this ecoregional assessment, each isolated patch of lower and middle montane forest, no matter how close to other patches, was regarded as a separate occurrence. Rivers were not regarded as separating this forest type into different occurrences because, at these altitudes, the rivers are usually found in sharp ravines and may be easily traversed by fauna along fallen logs, boulders, overhanging vegetation and other debris.

Portfolio Design

The overall goal for Lower Montane /Middle Montane Rainforest ecological system type in the East Kalimantan Portfolio was 60%. The portfolio achieved 80.54% (stratigraphic unit 1, 85%; unit 2, 68.7%; unit 3, 50%; and none from unit 4).The recognition of occurrences of this forest type in formally protected areas, coupled with inclusion of strategically important and high quality watershed polygons for the selected river systems resulted in surpassing our portfolio goals. These occurrences were distributed to represent their actual proportions in each stratigraphic unit and within each annual precipitation zone when possible.

Results

The portfolio goal was achieved with just over eighty percent (80.54%) of the known occurrences selected. These were distributed within the stratigraphic units as follows: SU-1, 73%; SU-2, 8%; SU-3, 19.05% and none in SU-4.

Sixty three separate occurrences were included in the portfolio. SU-1 contains the most and the largest occurrences of this forest type in the planning area. SU-4 contains none.

No Lower Montane/Middle Montane occurrences were in the lowest precipitation zone of < 2000 mm. There were eight of ten RePPProT subdivisions co-located in this forest type indicating substantial substrate heterogeneity, although the predominant substrate was the RePPProT type *SDMS*: sand dominated montane system, followed by *SDHS*: sand dominated hill system.

Most of the Lower Montane/Middle Montane Forest occurrences selected for the portfolio were associated with the target Major River systems as the predominant watershed for the selected river systems. Most were also selected because they were large occurrences, and/or were closely associated or contiguous with selected Upper Montane/Cloud Forest, priority Lowland Rainforest, or were identified as Important Bird Areas and/or protected forest areas.

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H. Upper Montane Rainforest /Cloud Forest

Photo courtesy of EHB Pollard

Description

Borneo is not particularly mountainous – few of its peaks exceed 2,000 meters above sea level (a.s.l.). Only five mountains on the island are taller than 2,500m a.s.l. - several of these are in East Kalimantan or near to it. These include Mt. Makita (Batu Ikeng) near Long Nawan at 2,987m, and Mt. Siho in Kayan Mentarang National Park, at 2,550m. They are mainly located along the western spine of East Kalimantan where it borders the Malaysian State of Sarawak.

The altitude of the interface between Upper Montane Rainforests/Cloud Forests and Montane Rainforests varies depending on the overall height of the summit of the mountain, its isolation, and distance from the sea. On larger peaks such as Mt. Kinabalu this interface occurs at 1,800m whereas on the lower isolated Gunung Palung it occurs at 800m. This compression effect is referred to as the *Massenerhebung Effect* (MacKinnon *et al*.1996). In this ECA we have adopted 1,800m as the altitude where these upper forest types interface with the Lower and Middle Montane Rainforest (see previous section).

The Cloud Forest is a unique and eerie place. Short, gnarled trees dripping with moss, frequently *Sphagnum* sp., as well as liverworts and filmy ferns abound. And, amongst these strange plants are a wide variety of orchids, both terrestrial and aerial. The silence of this upper altitude habitat is pierced with a range of calls from cryptic ground-dwelling birds not encountered in the lower montane forests.

These rainforests are characterized by an absence of cauliflory, very few bole climbers and large woody climbers, and frequent or abundant vascular and non-vascular epiphytes (Whitmore 1985). Soils tend to be more acidic in these forests. As a consequence, decomposers are less abundant and peat soils tend to accumulate over time. The cloud forests on the summits receive water only from atmospheric moisture (clouds) so their soils are particularly nutrient deficient (Burnham 1984). Several species of plants (e.g., rhododendrons and pitcher plants) have evolved complex strategies to overcome the lack of soil nutrients.

Upper Montane Rainforest/Cloud Forests are of great biological interest, not only because they represent Pleistocene refuges, but also because they are centers of speciation and endemism, particularly for smaller species of mammals, cryptic ground birds, amphibians and invertebrates. These mountainous areas have evolved a unique flora and fauna that is only partly shared with the Lower Montane/ Middle Montane Rainforests. Plants in the Upper Montane forests show a high level of endemism. For example, Smith (1970) reports that 40% of the plants found in the submontane parts of Mt. Kinabalu in the Malaysian State of Sabah, are found only on that particular mountain.

Upper montane flora found in the Upper Montane / Cloud Forests, is derived from both the Asian and Australasian regions. Trees in these upper montane zones include families from the temperate latitudes (Aceraceae, Araucariaceae, Clethracea, Ericaceae, Fagaceae, Lauraceae, Myrtaceae, Podocarpaceae, Symplocaceae, and Theaceae) (Whitmore 1984).

It should be noted that few of the high mountain areas of the East Kalimantan province have been surveyed. WWF and Birdlife International list three Upper Montane areas in East Kalimantan as Important Bird Areas; these are Kayan Mentarang, Ulu Telen, and Long Bangun.

Surveys of small ground mammals and bats along altitudinal gradients in Indonesia show that species richness declines with increasingly high altitudes and is lowest in the Upper Montane Rainforests and Cloud Forests (Kitchener and Yani 1996, 1988 – Flores Island; and Kitchener *et al*. 1997- Irian Jaya). However, in Lore Lindu National Park in the neighboring island of Sulawesi, there was no clear trend for species diversity of small ground mammals to decline with increasing altitude – although there was a dramatic decline in diversity of bats above 1500 meters (Maryanto and Yani 2002). Endemic rodents in many places in Indonesia are most commonly found in Upper Montane Rainforests/Cloud Forests (Musser 1977; Kitchener *et al*. 1991a,b,c, Kitchener and Yani 1996; Kitchener et al. 1997; Kitchener and Yani 1988; and Musser 1981).

Bird diversity in the tropics is generally highest in lowland forest areas and decreases with altitude (Coates and Bishop 1997; MacKinnon and Phillips 1993). However, in Lore Lindu

National Park, Central Sulawesi, bird diversity appeared to be highest in Lower Montane Rainforest (Raharjaningtrah and Memengko 2002). In New Guinea, Kikkawa and Williams (1971) found a sharp discontinuity in bird species at about 1,500 to 2,200 m which corresponded to the interface between Lower Montane Rainforest and Upper Montane Rainforests. Sujatnika *et al*. (1995) states that most of the endemic species of birds in Kalimantan are confined to the Upper Montane Rainforests with Kayan Mentarang National Park having the most extensive known list of rare, vulnerable and restricted-range bird species.

Primates, butterflies and a wide range of soil macrofauna, particularly beetles and oligochaetes, also decrease in biomass and species richness in Upper Montane Rainforest/ Cloud Forests compared to the lower altitude forest types (see MacKinnon *et al*. 1996: 332-339).

Conservation issues and threats

Tops of mountains in the province of East Kalimantan and surrounding administrative/ international units have been recommended for 100% protection because these high-altitude zones serve as repositories of unique biological diversity. There is also compelling evidence that each mountain-top occurrence is unique in nature (MacKinnon *et al*. 1996).

Upper Montane Rainforest/Cloud Forest is particularly sensitive to disturbances because regeneration is so slow at this altitude (MacKinnon *et al*. 1996). The natural communities are particularly sensitive to human activities and drought (Smith 1979). Further, these important catchment areas are extremely fragile environments, which readily erode – causing excess sedimentation to rivers if disturbed. Consequently, there should be a total ban on the removal of timber- whether selective or otherwise, from these upper elevation ecological system types.

Due to the extensive habitat disturbances and outright conversion of forests at lower elevations, these high altitude environments are the last refuge for many sensitive species that can tolerate the lower temperatures and higher moisture levels of Upper Montane/Cloud Forests. Species such as Sun Bear, Clouded Leopard, Asian Elephant and Sumatran Rhinoceros may still be found in this ecosystem where they have been extirpated from their former lower altitude ranges in Kalimantan (WWF 2002).

- **Roads**

  The primary threat to this ecological system is from human access via roads which are starting to transect and fragment the formerly contiguous blocks of habitat – particularly in the Kayan Mentarang National Park. International trade routes from neighboring Sarawak, Malaysia as well as inter-provincial roads from Western and Central Kalimantan are becoming more of an access issue bringing in poachers, illegal loggers and multiple sources of fires. While this is still a somewhat nascent threat, it promises to become more significant within a short time as plans for enhancement of these formal and informal routes develop.

- **Climate Change**

  While there is little that can be done to attenuate the effects of global climate change on the scale of consideration in this report, it should be mentioned that the Upper Montane/Cloud Forest ecological system type is the most vulnerable to the likely outcome of global warming. By incorporating the full altitudinal range of elevation for forest types in portfolio sites recommended in this ECA, it is hoped that the more mobile and facile species, both plants and animals, will have time and the genetic predilection for adaptation to differing altitudinal climate factors such as rainfall amounts, ambient humidity and temperatures, as well as unobstructed access to microhabitat refuges within the future changed landscapes. Contiguity of this system type with the lower elevation forests in Conservation Area design and management will at least provide the opportunity to accommodate such behavioral and functional adaptations.

Occurrence Unit Determination

Significant Upper Montane /Cloud Forests occurrences were identified first using LandSat imagery to locate them in the East Kalimantan province. The ECA team then consulted with individual experts and literature sources, followed by limited ground-truthing for those sites proposed for inclusion in the portfolio.

While Upper Montane Forests cover large expanses around the upper to mid-elevation of some mountains, Cloud Forests have historically been small and limited by biophysical factors to the peaks of mountains. The occurrences of this forest type usually are regular in shape - ovoid. Generally, as mentioned before, these two higher mountain types occur above 1400-1500m a.s.l. However, due to compression effects, some may be found as low as 800m a.s.l. Each isolated patch, no matter how close to other patches, was regarded as a separate occurrence.

Portfolio Design

The East Kalimantan ECA goal was to capture 100% of all Upper Montane Rainforest/Cloud Forest occurrences. There were 7 occurrences of this forest type in East Kalimantan, and the goal of 100% was achieved in the recommended portfolio of conservation sites. The table below presents the selected proportion of this target ecological system type and its RePPProT Landsystem subdivisions within each stratigraphic unit (all occurrences are within precipitation zone > 3000 mm; none were present in stratigraphic units 2 or 4).

Results

Seven sites were selected for the portfolio capturing 100% of the occurrences of this forest type. The extent of this target varied greatly in each stratigraphic unit, with most (62,785 hectares) located in stratigraphic unit 1. Stratigraphic unit 3 was the only other section containing this target system with only 2,252 hectares. All occurrences were located in precipitation zone 3 (>3000mm) as would be expected for such a moist tropical ecological community type. Five of the ten RePPProT landform subdivisions were represented in the seven occurrences of this forest type in East Kalimantan (see Appendix III).

I. Major Rivers and Associated Lakes

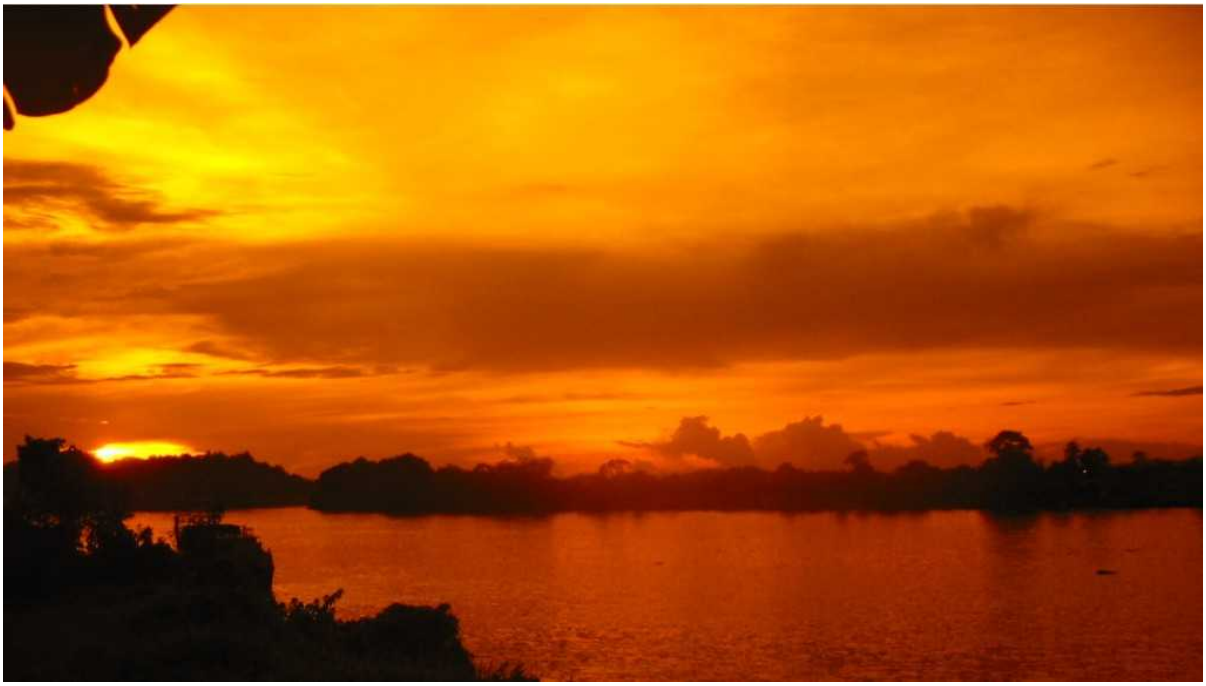


Photo courtesy of Donald Bason

Description

Rivers

Borneo is an island of great rivers, including the Mahakam and Kayan in East Kalimantan, which originate in the western Iban Mountains. The Mahakam River, at around 650 km in length, is one of the longest rivers in Indonesia; its catchment area encompasses approximately 77,700 sq.km (Suryadiptra *et al*. 2000). The chemical, physical and biological conditions in these large rivers change from the headwaters to their large terminal deltas at the sea. In the headwaters, rivers are narrow, turbulent, clear water and covered by a canopy of trees - whereas in the lower plain country, they are broad meandering ribbons, full of sediment, which colors them a muddy brown. Heavy rains produce dramatic changes in water levels, and flash floods are frequent.

Current velocity and concentration of dissolved salts is greater in the lower reaches of rivers than the headwaters, but temperatures are higher and consequently the concentration of dissolved oxygen tends to be less in the lower reaches (MacKinnon *et al*. (1996). Fish species as well as the Mahakam River Dolphin (*Pesut*), respond to these changes in flooding and water velocity. Pesut move from their core range area upstream into the tributaries following the first important rains where they appear to feed intensively in areas that harbor good populations of fish. The flooding cycle also greatly changes the fisheries catch in the area.

The aquatic fauna in rivers changes along each river's course in response to the chemical, physical and biological trends of the river. General trends in Borneo indicate that diversity of fish species increases with increasing stream order size, such that downstream generally has a higher diversity (KPSL- Univ. Lambung Mankurat 1989a in MacKinnon *et al*. 1996). A total of 394 (of which 149 are endemic) species of freshwater fishes are recorded from Borneo (Kottelat *et al*.1993). 290 species are recorded from the Kapuas River in West Kalimantan alone (Roberts 1989) - a similar number can be expected to occur in the Mahakam River in East Kalimantan.

The floodplains in East Kalimantan are important fisheries, particularly those in the Middle Mahakam Basin. Christensen (1986/87) reported that more than 40 fish species were intensively fished from the middle Mahakam Lakes area (including lakes, swamp and rivers). These involved some 20,000 to 35,000 tons/year which were sold as live/fresh fish, smoked fish, or dried and salted fish. Salmani (*in* Moersid and Christensen 1987), reported that the decline in catch of three fish species once common in the Mahakam lakes (i.e. Patin, *Pangasius nasutus;* Baung, *Mystus nemurus;* and Belida, *Chitala lopis*) suggests that the current levels of fishing are reducing fish densities as well as the biodiversity in the area.

The Mahakam River measures about 650 km from its origin in the Müller Mountains to the river mouth (MacKinnon *et al.*1996). The mean width of the Mahakam River in the important middle Makakam area is 200 meters, whereas mean depths at average water levels is 15 meters. Differences in the water levels of the main river between high and low water conditions range about 10 meters in 'normal years', but during extreme drought a maximum difference of 20 meters may be recorded. Mean clarity in the middle Mahakam area measured 23 cm at average water levels (Danielle Kreb pers. com.).

In the rainy season, the high velocities and water flows out of the lakes result in the disappearance of fish stocks from traditional fishing grounds. Consequently the fisheries are concentrated in the dry season (April to October). About 45% of the people in the lake area (70,000) reported making their living from fishing in 1979 (GTZ-TAD report, 1980). It is likely that this proportion has risen because Chokkalingam (2001) states that many villages have migrated down into the peatlands in response to better fishing opportunities and perhaps also in response to depletion of upland resources through large-scale commercial extraction, land clearing and conversion activities. Other villages already situated in or near the peatlands have shifted their primary activities from riparian/upland-based agriculture or resource extraction to fishing, as a result of destruction of the rattan and wood resources in the large-scale fires of 1982/83.

Important commercial river fish, such as cyprinids, move from the small tributaries onto the flood plains where they spawn almost immediately. Their eggs ripen quickly, sometimes in just a few days, allowing the fry to take advantage of the flush of algae, plants and invertebrates that follows flooding (Lowe- McConnell 1977). When floodwaters recede, fish are concentrated in smaller and smaller pools or streams and fall increasing prey to fishermen, other fish, birds, and other predators such as dolphins and otter-civets. The larger, slow moving rivers, such as the Mahakam and the Belayan are also heavily fished, but harvests are greatest in the blackwater rivers that drain the peat swamps.

The population of Irrawaddy dolphins, *Orcaella brevirostris*, in the Mahakam River, known locally as *Pesut*, was recently listed as Critically Endangered, based on surveys in 1999-2000 that estimated the population of mature individuals to be less than 50 (Kreb, in press). Between 1995 and 2001, at least 37 dolphins were killed, primarily from entanglement in gillnets, but also from vessel collisions and illegal hunting (Danielle Kreb, pers. comm.; also see Kreb (2000) for details on the deaths recorded in 1997-1999). Previous estimates of *Pesut* in the Mahakam numbered about 100 individuals (Sowelo 1994), indicating a dramatic decline in their numbers.

Danielle Krebs and Budiono (pers. com.) stated that in the Mahakam lake area, *Pesut* are distributed from about 180 km upstream from the mouth of the Mahakam River to an area near Muara Melak. They are focused around the area of Muara Pahu where they are found in greatest numbers primarily in deep pools located near confluences and meanders, and occasionally in appended lakes and connecting tributaries. These areas are also primary human fishing grounds and subject to intensive motorized vessel traffic. However, *Pesut* frequently make daily movements from this focal area upstream. Usually these daily movements are made by groups of about five individuals and they frequently are only about a kilometer in distance. Sometimes, though, individuals will travel as far as 30 km upstream. Most of these movements away from the focus area are shortly after the rainy season commences. At these times *Pesut* move in very directional ways to areas that are large sanctuary pool areas for fish. It is speculated that *Pesut* take advantage of these initial opportunities to feed in high-density fish areas. After the first flush of waters, *Pesut* do not appear to focus on these ‘pooled places” again. On occasion, a small group of *Pesut* has been observed trapped in clearer water in the Ratah River, between two areas of rapids.

Rivers are major landscape determinants and provide broad corridors for species that have wide local movement patterns, such as birds and bats that travel through these landscapes pollinating plants and dispersing their seeds. A common East Kalimantan bat species, *Eonycteris*, travels distances each night as far as 80 km in Malaysia as they move from their inland roost sites to feed in coastal mangroves (Start and Marshall1976). However, while rivers serve as conduits for mobile fauna to traverse the landscapes, they are also major geographic barriers to the distribution of some species. For example, the boundaries defining the distribution of subspecies of the Bornean Gibbon, and other gibbons tend to be large rivers. In fact, seas and rivers separate the nine species of gibbon from each other. In the case of the Bornean Gibbon, most of East Kalimantan is inhabited by the subspecies *H. m. abbotti*, while in the northern part of Berau this subspecies is replaced by *H. m. funereus*. However, *H. m. abbotti* appears to hybridize with the White-handed Gibbon, *H. agilis*, in its contact zone at the headwaters of the Barito River (Mather 1992).

Lakes

Surrounding the middle Mahakam region there are at least 32 (total 76 according to Bappeda I Kaltim, 1982) lakes that can be detected from the map at a scale of 1:50,000, their sizes ranging from around 1.2 hectares up to 15,000 hectares (Jempang). About 18% (totaling 89,719 ha) of all the natural lakes in Indonesia Borneo are located in the Kutai District, East

Kalimantan (Salmani 1987 *in* Moersid and Christensen 1987); almost 10% (totaling 48,000 ha) are located in the middle Mahakam area alone.

Some of the lakes are rounded, most are slightly rounded to elliptical, and the rest slightly irregular in shape. Their average depth varies between 0.40 – 3.00 meters, which classifies them all as shallow lakes. Because of their shallowness and exposure to wind, it can be deduced that all the Mahakam lakes are susceptible to mixing and would support high nutrient re-suspension in the water. This mixing process can be of great importance to the primary productivity of the lakes as well as to the fish yields. The surface area of most of these lakes changes from time to time. During an average dry season, surface areas may shrink by 80-96% from their maximum areas during the rainy season. In extremely dry seasons some lakes dry completely (Suryadiptra *et al*. 2002).

Suryadiptra *et al*. (2000) report that the Mahakam lakes are very rich in biodiversity. A recent study by Wetlands International – Indonesia Program of the 11 Mahakam lakes located in the southern part of the Mahakam River, found the following numbers of species: approximately 86 fishes, 125 birds, 25 mammals, 12 large reptiles, four amphibians and 300 tree species. Some of these animals are listed as endangered in the IUCN Red Data Book (such as the Storm's Stork *Ciconia stormii*); listed under Appendix I and II of CITES (eg. *Leptoptilos javanensis*, *Citra indica*, *Callagur borneoensis*) and also protected under the Indonesian regulations (Act number 7/1999) such as lesser mouse deer (*Tragulus javanicus*) and Sambar deer (*Cervus unicolor).*

Suryadiptra *et al*. (2000) states that the recorded 260 bird species from the lakes and nearby forests of the middle Mahakam area make the lakes a unique place of great ecological interest. Particularly notable are the 12 species of heron, important tern populations and thousands of migrating shorebirds.

Suryadiptra *et al*. (2000) further observe that at least 40% of Kalimantan's land mammal species are still found in the area adjacent to the lakes. The Ohong River (52 km long) and Perian River (72 km long) with its swamp forest vegetation form the center of the richest biodiversity in the Mahakam lakes, including a large population of Proboscis monkeys and seven of Borneo's eight Hornbill species. Two crocodile species (*Tomistoma schlegeli* and *Crocodylus* sp.) are still found in the Ohong River area.

In East Kalimantan, the major lakes are located in the Middle Mahakam region. These are the mixed-water lakes of Jempang (14,600 ha, 7-8 m deep); Semayang (10,300 ha, ~5m deep) and the black water lake, Melintang (8,900 ha, 4-6 m deep). They are, in actuality, a vastly enlarged part of the Mahakam River and its tributaries, which meander through them, continuously depositing silt and shifting its course. These lakes contain much the same fauna and flora as found in the rivers that feed them (MacKinnon *et al.*1996). Most are very shallow, with water levels typically fluctuating between 4-6 meters, with two high-water periods between October and May. (MacKinnon *et al.*1996).

Suryadiptra *et al*. (2000) reported that there are at least 86 aquatic plant species and genera in the Middle Mahakam Lake area. These are dominated by floating weeds (e.g., *Salvinia* *molesta* and *Eichhornia crassipes*, *Mimosa pigra* and *Polygonum barbatum*). The first three species dominate the larger Semayang, Jempang and Melintang lakes, while *P. barbatum* dominates Perian Lake. Total plant coverage in the Mahakam Lakes varied between 15 % - 90 %. Lake Tawar, with a surface area of 10.3 ha, was most densely covered by water hyacinth (90%) - this lake is now very difficult to enter because this plant blocks its inlet. Most floating plants are regularly flushed out of the lakes during heavy rains and enter the Mahakam River.

Unna Chokkalingam (pers. com.) stated that the Mahakam Lakes frequently silt up and river channels expand and change coarse remarkably. In dry periods, large parts of them are exposed and people plant rice in their centers. They also cut branches and place them over parts of the lake to “shade-fish”; this is said to greatly enhance the catch success for the fishermen. Conservation of these lakes is just as dependent on protecting the upper catchment areas where so much of the soil erosion and sedimentation comes from, as it is restoration and protection of the lakes themselves.

Danielle Kreb (pers. com.) observed that the high density of gillnets used in Lake Semayang and Lake Melintang causes physical obstruction to the movement of *Pesut*, thereby reducing available habitat for this critically endangered dolphin species. This threat, together with high sedimentation caused by devegetation of the surrounding shorelines, has probably resulted in the elimination of these lakes as primary habitat for *Pesut*, as reported by Tas'an and Leatherwood (1984).

Pesut occasionally move into the southern central waters of Lake Samayang. The impression is that this lake and the other Mahakam lakes are not particularly important for the *Pesut*, which is found elsewhere along the coast of Kalimantan. However, without more information on the ecology or their specific use of the lakes it would be premature to dismiss the importance of these lakes. It is possible for example; that births occur in the calmer waters of the lakes and that these areas are in fact very important in the life histories of the *Pesut*- even if only for short periods of their life cycles. [See section below entitled “Pesut Conservation Issues” for additional information.]

Gönner (2000) states that the Middle Mahakam Area remains a crucial breeding and migration site for many bird species. Between 1988 and 1999, he reports a total of 90 bird species around Lake Jempang, including important breeding populations of various herons and the Lesser Adjutant (*Leptoptilos javanicus*). He also recorded what appears to be the first breeding record in Borneo of the Little Tern (*Sterna albifrons*). He states that, despite the enormous damage of recent forest fires, most of the 90 species of birds were found in the swamps and waterways of the Middle Mahakam area, including 12 heron species, 2 stork species, 2 duck species, 6 crake/rail species, 23 wader species and 4 tern species

The appearance of visiting wading birds during the autumn migration depends on the water level of the Mahakam lakes. Significant numbers (mainly of Wood Sandpipers *Tringa glareola*) were only observed in extremely dry years (1993 and 1997), when the lakes had virtually disappeared. Vast mudflats and grasslands provided excellent feeding habitats for plovers, sandpipers and stilts. The shallow lakes also attracted large numbers of Whiskered

Tern (*Chlidonias hybridus*) and Little Terns (*Sterna albifrons*) as well as herons (mainly Javan Pond Herons (*Ardeola speciosa),* Great Egrets (*Egretta alba)* and Purple Herons (*Ardea purpurea*), which fed on dying fish. Whiskered Terns, both of northern (*C.h.hybridus*) and austral (*C.h.javanicus*) origin, visited the Middle Mahakam Area in large numbers for feeding during migration time, and (in smaller numbers) for wintering.

Goenner (2002) also recorded a large number of bird species (31) in the freshwater swamp forests directly adjacent to Lake Jempang. He states that the open water bodies were mainly used by raptors (6 species), terns (4 species) and 2 duck species.

Cox *et al.* (1993) reported that endangered mammals such as Proboscis Monkeys (*Nasalis larvatus*)*,* the Irrawaddy Dolphin (*Orcaella brevirostris*) and wild Banteng (*Bos javanicus*) still occur in significant numbers, and three species of crocodiles (*Crocodylus porosus, Crocodylus siamensis* and *Tomistoma schlegeli*) are also found in marshes in the Middle Mahakam Area.

Conservation issues and threats

- **Lack of Regulation**

  None of the Major Lakes or Major Rivers identified in this report has any form of protection by law. There was a proposal in 1981 to protect the Middle Mahakam Area as a nature reserve. However, the Indonesian Government rejected the proposition because of the high density of people already living there at that time (Scott 1989). Momberg *et al*. (1998), cognizant of the fact that the Middle Mahakam Area supported a large human population and an important fishery, recommended that "the area be given a Special Area status and a suite of policies and activities be enacted to maintain the ecological integrity and biodiversity of the area".

  Despite the lack of current protection mechnisms, there are nearby protected areas that could be expanded to include the important lakes. Northeast of Lake Semayang lies the Muara Kaman, a strict nature reserve or *cagar alam.* This area of 62,500 hectares was designated to protect a vast swamp area. Also, Batu Bunbuna, a 450ha reserve that was established in 1927 close to Muara Muntai (Rosenthal & Baum 1980).

- **Commercial Animal Trade**

  Fauna collected from the Mahakam lakes and its vicinity is considered by Suryadiptra *et al.* (2000) as one of the most significant threats to the biodiversity of the region. A recent (2000) field survey carried out by Wetlands International Indonesian Program discovered at least 23 rare fauna species (i.e., 2 Crocodiles, 7 turtles & tortoises, 3 snakes, 2 lizards, 5 mammals - including Mouse Deer and Barking Deer- and 4 bird species) being traded in the Muara Muntai area, both as live animals and animal skins.

- **Overfishing**

  Recent introduction of gill nets has affected species diversity of fish in the rivers and lakes (Zehrfeld *et al.* 1985). Limitations need to be considered on the net mesh size, restricting total numbers of fishermen; and establishment of catch quotas per family to reduce the detrimental impacts of probable over fishing.

- **Agriculture**

  Drainage of parts of the lakes for conversion to agriculture.

- **Dredging and Flood Control**

  Dredging and production of channels for navigation, flood protection and reservoir maintenance.

- **Coal Transportation**

  Danielle Kreb (pers. com.) considers that coal, which falls into the river from overloaded barges as they are tugged along, may contribute to the degradation of this primary habitat. Acidity tests conducted at several locations in this tributary indicated a higher than normal level of acidity.

Conservation Need: Management Plan for White-shouldered Ibis

A relict population of the endangered White-shouldered Ibis, *Pseudibidis davisoni*, is most often encountered on shingle banks of the Mahakam River above Long Iram and adjacent tributaries. It appears to be dependent on these habitats and the surrounding forests (Soezer and van der Heiden 1997). Momberg *et al*. (1998) consider that a conservation management plan, based on good biological information with subsequent commitment of the natural resource management agencies to implement it, is required to conserve this species and avoid its extinction in the next several years. The population appears to have declined significantly in recent years (EHB Pollard, pers.comm. 2003).

Pesut Conservation Issues:

Danielle Kreb (pers. com.) states that a range of factors threatens the surviving population of Pesut in the Mahakam River. She lists the following as being the most important to Pesut, but they also impact many other fauna in this uniquely rich area:

1. Direct mortality in gill nets is by far the most serious threat and accounts for 80% of the mortality of the Pesut. They get tangled up in nets, particularly at night. During the day, Pesut die when they are being released from nets by fishermen- who generally empty the nets twice a day. Kreb and Rahadi (2002) estimate the number of newborn Pesut in the Mahakam per year varies between three and five, whereas mortality per year is minimally five Pesut on average. From 1995 until 2001, 37 deaths were recorded based on interviews (30 deaths resulted from gillnet entanglement, 3 included deliberate kills, 2 because of vessel collisions). During 1997-98 at least seven Pesut were illegally live-captured from the river and taken to oceanaria.

2. Habitat displacement and direct strikes by boats which use the same areas often preferred by Pesut - consequently the dolphins move to other less favorable areas. This causes the animals to dive more than they might otherwise and is thought to generally contribute to higher stress, lower productivity (Kreb and Rahadi 2002) and direct mortality.

3. Reduction in their food supply (a range of fishes - including the large Patin, *Pangasius* spp.-and prawns). This occurs by:

   - Direct destruction of the habitat of their prey species by commercial boats. This happens by these boats striking the banks of the rivers and directly destroying the bank root systems where many fish spawn;

   - Riparian forest loss due to legal and illegal logging activities as well as forest fires have also caused a decrease in available animal and plant detritus from overhanging vegetation. This detritus forms the basis of the food chain for many invertebrates and fish;

   - High sedimentation and turbidity have also contributed to a decrease of available fish resources. This is due to: limited light penetration affecting aquatic plant life; accumulation of suspended sediments on gills of certain fish and causing death by suffocation; silt settling on the bottom of slow flowing river parts or lakes smothering food resources, eggs and spawning grounds;

   - Logging activities and forest fires also affect swamp forests where residual populations of blackfish remain in isolated refuges, which do not dry out during the dry season and provide the spawners for the next flood period. Also, juvenile fish and small fishes of other species shelter beneath floating mats of vegetation in the swamps; and

- Fishermen who work illegally with electric prods, frequently focus on Pesut feeding grounds and use the presence of Pesut to identify favorable places to fish. Most of these illegal fishermen are Banjar transmigrants and tend not to be local Kutai people who have a stake in maintaining viable populations of these native fishes.

4. Pollution from gold mining upstream, which commenced about 1980. Because Pesut eat fish and prawns that may spend part of their time upstream in the areas more contaminated by mercury and arsenic, they are likely to have increased loads of these heavy metals. The effect of these metals on reproduction and health of Pesut can only be speculated upon at this time, but is likely to be detrimental to the health, productivity and longevity of affected individuals.

5. Siltation in these lakes is caused not only by erosion from the Mahakam's upper catchment area (due to extensive logging since the early eighties), but also by the accumulation of dead aquatic plants, which are over abundant in the lakes and whose growth is supported by the high nutrient input to the water (eutrophication) from agriculture, fish cage farming and settlements surrounding the lakes (Hardwinarto *et al*. 1999; Suryadiptra *et al*. (2002).

6. There has been a major increase in the amount of aquatic vegetation (mainly *Eicchornia crassipes* and *Mimosa pigra*) in the lakes, which may have arisen from eutrophication due to nutrient enrichment from fish farming in the rivers and lakes or from agricultural activities surrounding the lakes. The presence of increased aquatic vegetation is in turn increasing the rate of siltation in the lakes by trapping more suspended material in the river. Not only does fish-farming lead to nutrient enrichment in the lakes but it probably contributes directly to the physical siltation process, through large amounts of waste food falling to the riverbed and being washed into the lakes (Suryadiptra *et al*. 2000).

7. Danielle Kreb (pers. com.) also strongly recommends the immediate establishment of conservation areas in major Pesut habitat, namely, 1) the confluence area of Muara Kaman and tributary Kedang Rantau, 2) the Pela tributary and southern part of Lake Semayang, and 3) the confluence area of Muara Pahu and Kedang Pahu tributary until Bolowan. She considers that, within these areas, it is important to increase awareness of local residents, install speed limit regulation for speedboats, gillnet-setting regulations, and step up active patrolling and law-enforcement of illegal fishing techniques and dolphin catches. Additionally, Suryadiptra *et al.* (2000) indicate the need for an integrated management plan for the Mahakam lakes and their upper catchment areas by involving various/relevant stakeholders and to restore some of the lakes (e.g., Lakes Tawar and Perian) by removing aquatic plants and sediment.

Occurrence Determination

Significant Major Rivers and Lakes were identified first using LandSat imagery to locate them in the East Kalimantan province. The ECA team then consulted with individual experts and literature sources, followed by a ground or aerial check for those rivers proposed for inclusion in the portfolio.

Major river systems in East Kalimantan are defined in this report as those having complex deltas at their terminus, usually with Mangrove Forest or Freshwater Forest adjoining. In East Kalimantan, this ECA recognized the following 12 major river systems:

Stratigraphic Unit 1
Sungai Sebuku
Sungai Sembakung
Sungai Sesayap
Sungai Kayan

Stratigraphic Unit 2
Sungai Segah
Sungai Kelai
Sungai Karangan
Sungai Kedang Kepala

Stratigraphic Unit 3
Sungai Kinjau
Sungai Belayan
Sungai Mahakam

Stratigraphic Unit 4
Sungai Kerang

Condition

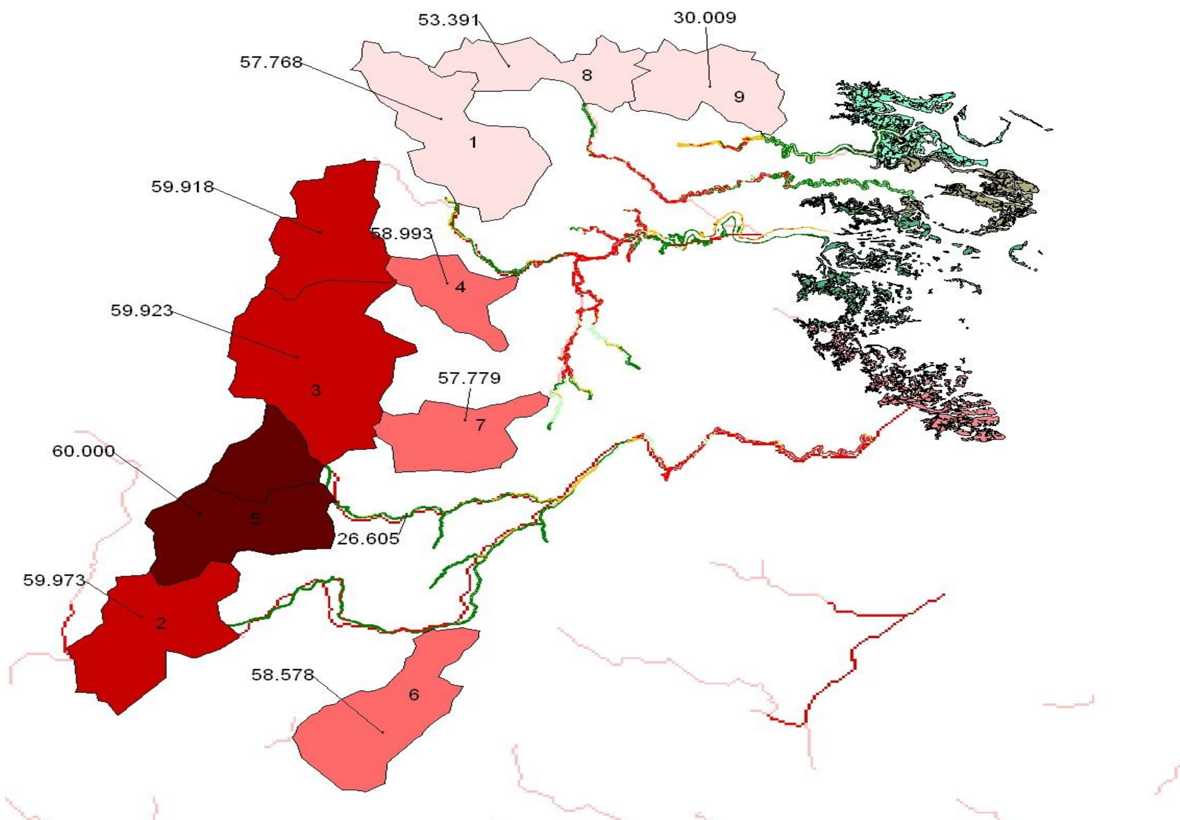
Condition of the above rivers was ranked based upon a cumulative score of three separate ranks assigned the major segments of the river system, namely the Upper Catchment Area, Mid-stream Buffer Zone, and the Terminal Delta. These individual segments were ranked accordingly:

Prime upper catchment area- identified by flow accumulation of the watershed and its polygon defined by an aggregation of the sub-watershed area boundaries. The condition was ranked as Very good, Good, Poor, or Very Poor.

***Mid stream buffer zone* –** identified as the belt zone within 500 meters on either side of the river, ranked according to the same condition criteria used to rate the Lowland Rainforest system. The conditions were ranked asVery good, Good, Poor, or Very Poor.

***Terminal Delta* –** identified as the forested area at the mouth of each river, usually defined by the zone of perennial inundation, and ranked according to the same condition ratings given Mangrove Swamp and Freshwater Swamp system types. The conditions were ranked as Very good, Good, Poor, or Very Poor.

The illustration below portrays the respective viability rankings for the individual segments of major rivers in stratigraphic unit 1. Red reflects a Poor or Very Poor viability rank – depending on the density of the color. Green shows those areas still in Good to Very Good condition.



Portfolio Design

The goal for each river system was 100% of prime catchment areas (captured in appropriate target rainforest ecological system types referred to previously), 100% of the vegetation in good to moderate condition bordering the length of the river to a width of 500 meters on each side of the river from catchment area to terminal delta mangroves, and 75% of the mangrove system at the mouth of each river (also captured in Mangrove ecological system referred to in previous chapters).

Chapter 3: Portfolio Results & Assessment Summary

A. Number of sites recommended within the Portfolio

There are a total of 33 conservation sites proposed within the East Kalimantan Portfolio. The sites range in size from a small 1,360 hectares at the combined *Pulau Derawan* three-island site, to the largest being the Kayan-Mentarang National Park site at 1.84 million hectares. The most complex site in terms of number of conservation targets and integration of aquatic and terrestrial targets is the *Rawa Sesayap* site in the Stratigraphic Unit 1.

Refer to the Portfolio Map opposite for reference. A detailed description of each of the proposed sites is included in Appendix I of this report.

B. Total Area encompassed within the Portfolio

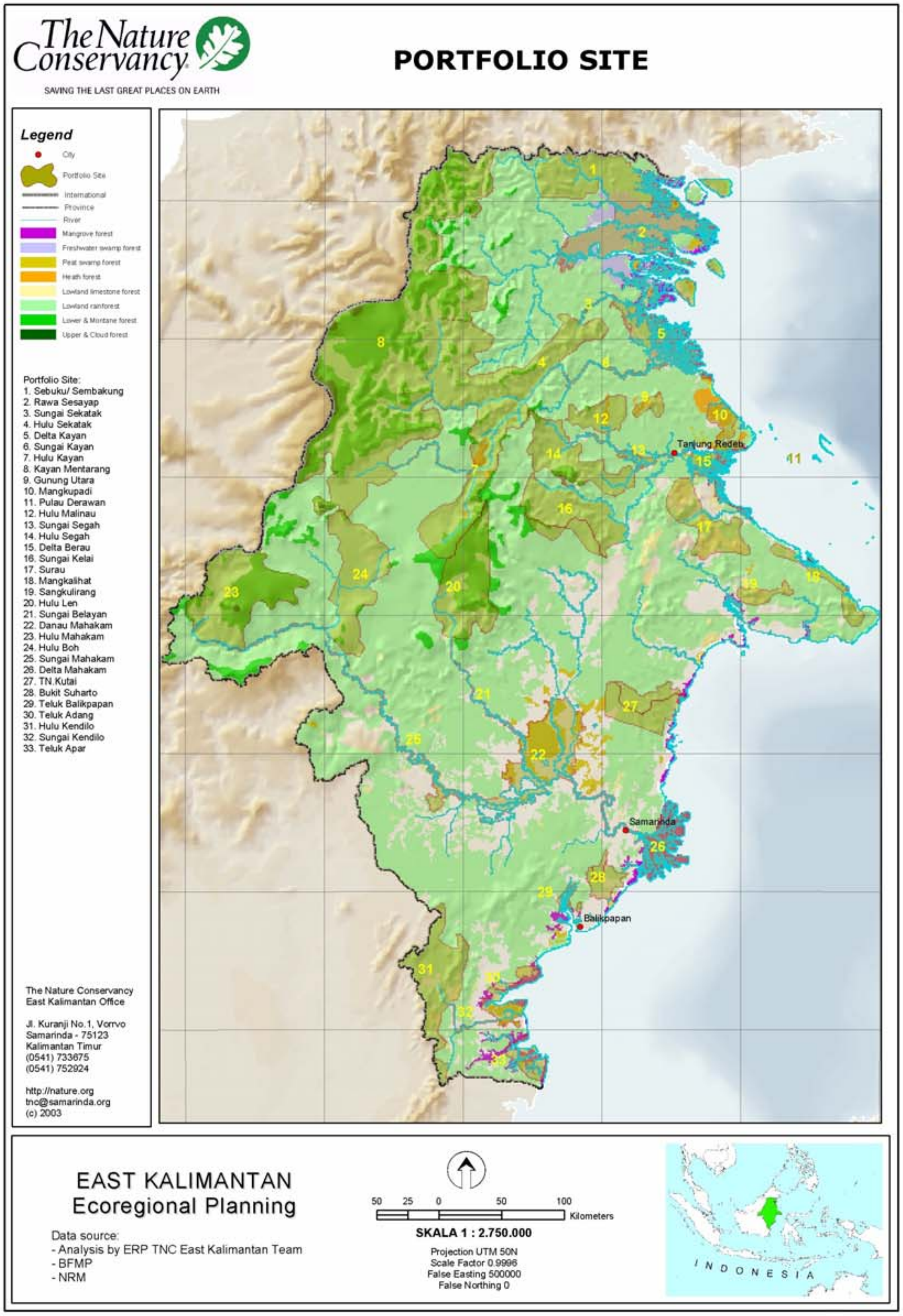
Out of a total of approximately 20 million hectares contained within the ecoregional assessment area, 17,408,103 hectares remain forested – the rest has been permanently denuded, developed or otherwise converted to non-forest status. The Portfolio consists of 6,515,145 hectares or **37.43%** of the forested regions of East Kalimantan, or **32.6%** of the Province total area.

C. Area of the Portfolio within "already protected areas"

While it appears that we have captured many of the "already protected areas" within our proposed portfolio of sites, it must be recognized that their official designation as National Parks (*Taman Nasional)*, Protected Forests (*Taman Wisata)* or Protected Areas (*Cagar Alam)* does not reflect the reality of a general lack of meaningful protection of their ecological integrity. That said, it is also recognized that there will be a higher degree of interest among current and future legislators and Provincial government officials to step up protection of already designated areas rather than trying to convince them to invest limited resources or political capital to establish new conservation areas.

The equally nebulous designation of Restricted Forest Area (*Hutan Lindung)* is a category of protection technically based upon degree of slope being at or more than 45%, but it is controlled at the individual *Kabupaten* level of government, and is changed to suit the whims of the *Bupati* or District Mayors. Even though supposedly off-limits to commercial logging interests, the demand for illegal logs to supply an overabundance of pulp and plywood mills makes this designation suspect as well. It does at least provide some guidance for the legal commercial loggers to set aside these areas within their HPH concessions and provides conservation groups like TNC the inroad for discussing greater, more meaningful set-asides within these leased areas.

Therefore, we are careful to propose in this Ecoregional Assessment, not the creation of new National Parks or even new Protected Areas, rather, the enhanced management of the recommended Portfolio Sites for the benefit of the target species and system types *as well as* their continuing regulated resource use and extraction.


The Nature Conservancy
SAVING THE LAST GREAT PLACES ON EARTH
PORTFOLIO SITE
Legend
City
Portfolio Site
International
Province
River
Mangrove forest
Freshwater swamp forest
Peat swamp forest
Heath forest
Lowland limestone forest
Lowland rainforest
Lower & Montane forest
Upper & Cloud forest
Portfolio Site:
1. Sebuku/ Sembakung
2. Rawa Sesayap
3. Sungai Sekatak
4. Hulu Sekatak
5. Delta Kayan
6. Sungai Kayan
7. Hulu Kayan
8. Kayan Mentarang
9. Gunung Utara
10. Mangkupadi
11. Pulau Derawan
12. Hulu Malinau
13. Sungai Segah
14. Hulu Segah
15. Delta Berau
16. Sungai Kelai
17. Surau
18. Mangkalihat
19. Sangkulirang
20. Hulu Len
21. Sungai Belayan
22. Danau Mahakam
23. Hulu Mahakam
24. Hulu Boh
25. Sungai Mahakam
26. Delta Mahakam
27. TN.Kutai
28. Bukit Suharto
29. Teluk Balikpapan
30. Teluk Adang
31. Hulu Kendilo
32. Sungai Kendilo
33. Teluk Apar
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Ecoregional Planning
Data source:
- Analysis by ERP TNC East Kalimantan Team
- BFMP
- NRM
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Kilometers
SKALA 1 : 2.750.000
Projection UTM 50N
Scale Factor 0.9996
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False Northing 0
INDONESIA
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D. Threats Assessment of the Planning Area & Portfolio

Understanding the threats to targets at specific conservation sites and the patterns of threats across multiple sites helps to determine which are in urgent need of conservation attention and to develop strategies to abate them at multiple locations. Ideally an ECA team should conduct at least a cursory threats analysis before the decision to work at one site in the Portfolio over another is made. Oftentimes though, State or Country Programs are already well invested in sites prior to the threats analysis, or even the entire ecoregional analysis is completed. However, threats analysis can be helpful in informing a program and its partners where future additional resources should be placed to abate those threats that can be feasibly dealt with and whose effects are reversible through some level of conservation management.

There are a wide variety of methods of analyzing threats to a species, ecological system or portfolio of sites. At the scale of ecoregional assessments it is important to identify and address those threats that are most responsible for the degradation of a site's or series of sites' viability rankings and to inform the development of multi-site strategies to abate them. One method we adopted was to construct a Correlation Matrix which lays out the threats and their relationship to the targets that comprise the sites that are being assessed.

First, we determined what threats are most critical to the individual forest targets, and then reviewed how those targets might be grouped to capture similar trends in threat type and levels. This led to the grouping of five major forest types together since they shared almost all threats we analyzed. These were the forest types most at risk to logging (both legal and illegal, and fire).

Table 1. Relationship of Major Threats to Portfolio Targets (Forest Types)

	Low-land	Karst	Heath	Peat	Fresh-water	Low/Mid Montane	Upper/Cloud Montane	Mangrove	River	Off-shore
Logging	X	X	X	X	X				X	X
Fires	X	X	X	X	X				X	X
Convert to Agriculture	X							X	X	X
Wood-cutting	X		X	X	X	X		X		
Hunting	X	X	X	X	X	X	X		X	X
Invasives	X									
Mining	X	X		X						

Then, because the two Montane Forest System types (Lower/Middle Montane and Upper Montane/Cloud Forest) shared most of their threats in common, we grouped them together. Mangrove forests we believed to experience a unique combination of threats (conversion to agriculture and ongoing woodcutting) so they remained in a class by themselves. Finally, the two aquatic systems (Major Rivers, and Offshore Coral Reefs) were grouped together to reflect their shared threat categories. Offshore coral reefs were added as an ecological system to be considered only in the threats assessment phase of this process – they were not an actual target ecological system of this ECA as were rivers and lakes. It became evident through our development of this threat matrix that activities occurring in the upper watersheds and rivers were going to have a direct impact to the coral reefs they drained into. Therefore, they are brought into the equation here only to reflect that direct linkage to these critically important marine systems.

The threats that continually appeared at the top of the stressors list for most of our targets, both at the coarse-scale ecological system type and the fine-scale species targets, were

- Fire (whether burned once, twice or never)
- Logging (legal & managed)
- Conversion to agriculture (oil and date palms, tambak, farms)
- Woodcutting (illegal logging & pole cutting for charcoal, pulp & chipwood)
- Mining (Coal, oil & gas, limestone for cement, other minerals)
- Hunting (bushmeat poaching as well as exotic animal trade)

These primary threats accounted for the majority of degradation of condition of all targets we identified in the ECA. Of these, the first four were considered the "killer threats" to all or most targets. While in some isolated areas (e.g. the karst community) the "killer" threats may have included mining of limestone for cement production, this did not apply to the whole of the portfolio and would be better addressed at the Site Conservation Planning level. What we were seeking were the worst of the worst that may lead to higher level strategies that address several target systems across the planning area.

Next, we reviewed the digital layers we had at our disposal to analyze the entire Province of East Kalimantan. There were few that were comprehensive enough to treat the area with equal coverage, and even fewer that were recent enough to warrant analysis for "current threat status". We settled on five sources of threat layers that had such standards of useful coverage. These were:

1. Fire Frequency
2. Major, Provincial-level recognized roads
3. Major Rivers
4. Human Settlements
5. Steepness of Slope (%)

While there were more sources of data for roads, including some rather extensive coverages of certain areas of the Province for minor roads that were easily detectable contrasted with the surrounding green forest cover, these did not allow an equal analysis for the entire Province. The better coverages for roads and rivers for those areas of the Province will be more appropriately utilized in Site Conservation Planning for those Portfolio Sites that occur within the more extensively covered landscapes.

For instance, the entire southeast quadrant of the East Kalimantan Province had been burned and deforested or converted to the point that small roads were indistinguishable from the surrounding denuded landscape. This would not have allowed us to treat the area equivalently in our analysis as other areas of the province and would have led to the conclusion that quadrant was less threatened by roads, when in fact it had already been completely converted.

The five sources of threat for which we had good, complete coverage allowed us to analyze quantitatively, the degree of threat posed to our portfolio sites. Below is the relationship of these coverages to the major forest types in our analysis, and which threat factors they were responsible for in effect "causing".

Table 2. Relationship of Sources of Threat to Threat Factors and Targets

	Logging	Fires	Hunting	Conversion	Woodcutting	Invasives	Mining (type)
Lowland	DRo, DS, -SI	FF, DRo, DS	DRo, DRi, DS	FF, DRo, DRi, DS, -SI	DRo, DRi, DS	FF, DRo, DS	Coal
Karst	DRo, DS, -SI	FF, DRo, DS	DRo, DRi, DS	FF, DRo, DRi, DS, -SI	DRo, DRi, DS	FF, DRo, DS	Limestone
Heath	DRo, DS, -SI	FF, DRo, DS	DRo, DRi, DS	FF, DRo, DRi, DS, -SI	DRo, DRi, DS	FF, DRo, DS	
Peat	DRo, DS, -SI	FF, DRo, DS	DRo, DRi, DS	FF, DRo, DRi, DS, -SI	DRo, DRi, DS	FF, DRo, DS	Peat
Freshwater Swamp	DRo, DS, -SI	FF, DRo, DS	DRo, DRi, DS	FF, DRo, DRi, DS, -SI	DRo, DRi, DS	FF, DRo, DS	
Low/Middle Montane			DRo, DRi, DS		DRo, DRi, DS		
Upper Mont./ Cloud			DRo, DRi, DS		DRo, DRi, DS		
Mangrove				DRi, DS	DS		
Rivers	DRo, DS, -SI	FF, DRo, DS, +SI	DS	DRo, DS, -SI			
Offshore							

Key to Sources:
DRo=Distance from roads
DRi= Distance from rivers
DS= Distance from settlements
FF= Fire frequency (0, 1x, 2x+)
SI= Slope or Steep terrain (- or + impact)

It was determined that, even though major rivers pose a threat to our sites somewhat equally to roads in terms of access for illegal loggers and woodcutters, they did not rise to the threat level that large roads did. The large roads allow big machinery to be brought in to cut many more logs and clear vast areas of timber, whereas the rivers simply facilitate access for small-scale woodcutters to come in, cut a few trees, then haul them out manually or with low technology to the adjacent river for floating down to a factory or other market. Better or more modern technology, or improvements in cost or design of boats in the future, may allow rivers to bring in more deleterious forms of woodcutting that will rival that of road-accessed commercial logging machinery. Such developments would warrant a new analysis for this ECA threats assessment to be relevant to conservation managers.

Table 3. Weighted scoring factors for threat coverages related to target groups.

TARGET	COVERAGE	WEIGHT
Lowland Rainforest	Roads	5
Limestone Karst Forest	Rivers	1
Heath Forest	Settlements	5
Peat Swamp Forest Freshwater Swamp	Fire Frequency Steep Terrain	1 1
Lower & Mid-Montane Forest	Roads Rivers	3 3
Upper Montane & Cloud Forest	Settlements	5
Mangrove Forest	Rivers Settlements	5 5
Major Rivers	Roads Settlements	3 5
Offshore Coral Reefs	Fire Frequency Steep Terrain +/-	1 0

For the five forest system types (Lowland, Heath, Freshwater Swamp, Peat Swamp and Karst) we weighted Roads and Settlements higher than the other threat factors because these seem to influence on a much more immediate term, the integrity of these timber-productive conservation targets. Settlements, and all they bring with them, including roads and fire and poachers and woodcutters, are one of the killer threats that are extremely difficult to tease out the intertwined and synergistic impacts to conservation integrity of our targets and sites.

For the Cloud Forest and Montane Forests (both Lower and Upper Montane), the primary threat is the presence of settlements, since technically it is illegal to perform any timber harvesting at these upper watershed areas due to slope and soil stability concerns. Roads and Rivers come in a close second due to their role as access points for poachers, fire sources and woodcutters intruding into these ecologically important pristine forests.

For Mangrove Forests, typically located on river deltas and coastal areas, the killer threat is conversion for *tambak* creation. While it is recognized that woodcutting of this forest type is a serious ongoing concern, it pales by comparison to wholesale removal of the community from the landscape for these agricultural interests.

And finally, for the Rivers and Offshore Coral Reef systems (the latter considered late in this process), again, the presence of settlements on or adjacent to the conservation target is the principle threat to maintenance of ecological integrity. Roads are second in terms of having a direct impact to this target – although they are directly related to and embedded within the settlements issue as well.

It was also agreed that the presence or absence of steep slopes would be one of the more significant factors in whether a site received the highest threat score of 100 points or was granted a reprieve of, in this case, 15 points subtracted from that score. This was to account for the situation of forest occurrences located on slopes steeper than 45%, which would place them under the protection of Presidential Decree No.48/1983 and make them difficult to access for logging – although the reality is that it would still be subject to some illegal logging, poaching, fire, and fragmentation by roads.

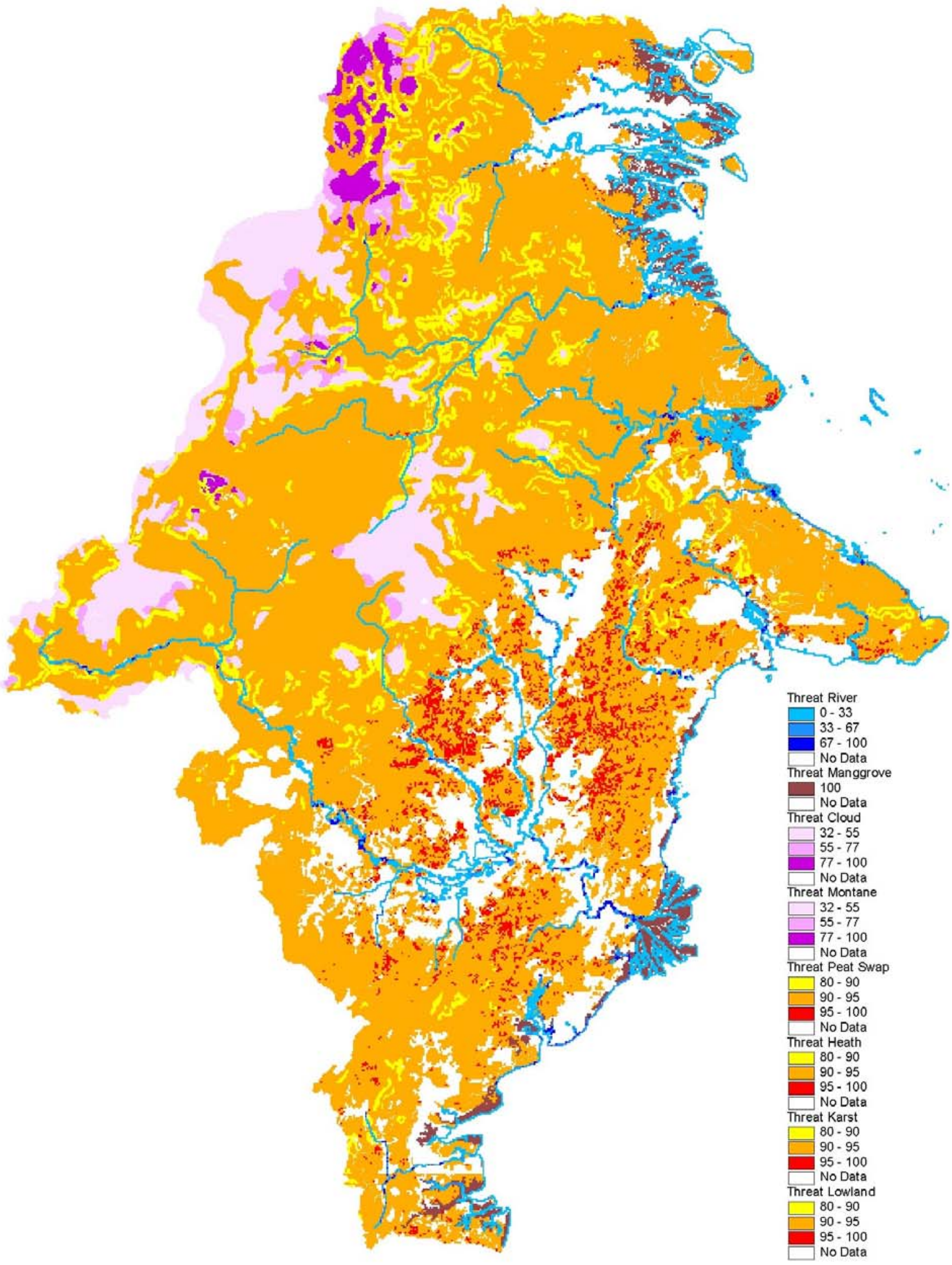
When the scores of the sites were evaluated based upon the degree of threat posed by each of these sources to the underlying forest types, a better picture emerged of the current status of threat for the whole site, and likewise for the entire Portfolio. This will assist the TNC Indonesia Program to prioritize which of the portfolio sites it invests in next to begin strategizing ways to abate the killer threats at those sites. It will also assist in defining strategies for threat abatement that cuts across several targets at multiple sites simultaneously – and even among multiple ecoregions.

Such high-level, broad threat abatement themes can best be evaluated by expanding the scope or view at which they can affect positive change to the conservation status of portfolio sites. This will be helpful as well to increase the transparency of operations to our partners on the ground who will understand why we choose to work at one place and not another and why we choose one or more conservation strategies at those sites.

A map of these threats to the Province of East Kalimantan is presented on the opposite page:

To properly interpret this threat map, it is important to compare degrees of threat *within* forest categories and not *between* categories. Degrees of threat are portrayed as shades of the individual color categories since the targets are experiencing the same group of threats at varying degrees from Medium Threat to High to Extreme Threat. It would not be correct to assume that a Medium threatened Lowland Rainforest is at the same degree of vulnerability as a Medium threatened Cloud Forest.

Mangrove Forests, as portrayed on the map, are all a single threat level, Very High, and therefore all receive the darkest color in their scale. Since all Mangrove occurrences are within close proximity to roads and settlements and rivers, and these factors all contribute to the threats of woodcutting and conversion to agricultural activities, they are assumed to all be extremely threatened. This does not reflect on their *current condition.* That is dealt with in a different analysis as explained in the Mangrove section of Chapter 2 and led to the differential selection of individual mangrove occurrences.


Threat River
0 - 33
33 - 67
67 - 100
No Data
Threat Manggrove
100
No Data
Threat Cloud
32 - 55
55 - 77
77 - 100
No Data
Threat Montane
32 - 55
55 - 77
77 - 100
No Data
Threat Peat Swap
80 - 90
90 - 95
95 - 100
No Data
Threat Heath
80 - 90
90 - 95
95 - 100
No Data
Threat Karst
80 - 90
90 - 95
95 - 100
No Data
Threat Lowland
80 - 90
90 - 95
95 - 100
No Data

E. Cross-cutting Themes in the Planning Area for the Portfolio

Clearly, forest fragmentation is a primary ecological threat that affects the integrity and capability of forest occurrences to support many of the target species – particularly the highly arboreal ones such as orangutan and gibbons. Fragmentation can also irreversibly affect the dynamic nature of ambient humidity which supports numerous rare plant species and the fauna that rely upon them for survival.

Each linear cut into a forest robs the interior of the closed-canopy-maintained humidity and creates edges that allow invasive species to intrude as well as providing access to humans and all they bring with them. In some cases where the linear intrusion is narrow and the surrounding forest retained, the natural seeding process or re-sprouting of cut trunks can refill the empty tract. However, the forest structure that maintains the humid dome of a closed canopy will take decades to restore. None of this natural rehabilitation/restoration is possible if the roads are continuously traveled or if they are widened by increased usage such as by logging trucks.

It is rare nowadays that retention of surrounding forest occurs once a linear access has been created – more often than not it leads to an array of logging activities, fire, and creation of settlements, agricultural clearing, and poaching of bush meat. Roads and linear access routes (powerlines, gaslines, timber drag lines) are, in effect, the Pandora's Box for tropical forest ecosystems – once opened, they can never completely be put back.

Fire, like access roads, is in the process of irreversibly converting vast areas of tropical forest ecosystems in Indonesia, particularly on the islands of Sumatra, Sulawesi, and Kalimantan. Once burned, they do have the potential for significant recovery over 5 to 7 decades to a similar structure and species composition - *if left alone*. However, with today's ever-expanding human population and global trade environment, each burn creates open land that is soon robbed of its remaining timber, converted to settlements or plantations for exotic commercially valuable species such as oil and date palms, or farmed over a short period until the shallow soils are exhausted of all nutrients.

The paradigm of "leave it alone and let it recover" is simply not a reality in the current exploding human environment in this developing country.

F. Current Conservation Strategies and Priority Portfolio Areas

In order to reduce or eliminate threats to the portfolio of conservation sites, it is essential to understand the nature of those threats; the key players involved in making those threats worse or better; and to recognize opportunities to engage multiple partners to change the course of those threatening activities. This can be accomplished by developing a suite of concurrent and complementary conservation strategies.

In the case of conservation of the portfolio of sites in East Kalimantan, the best strategies will be those that balance the need for human prosperity with the ecological integrity of the system and species targets. The challenge of protecting large functional landscapes will rely on planning for responsible and sustainable harvest of their natural resources. This is where innovative partnerships with some of those responsible for the major threats to these sites will be necessary and most effective in both the short and long term.

When the portfolio map is viewed in this light, the layers of forest concessions, road networks, coal mines, gas and oil fields, forest villages, and island communities forms an ominous picture. Working at each of these levels requires a flexible approach that integrates the needs of the many stakeholders (those who are interested in the products and services the forests provide) with the responsibility of making sure the forests and rivers and their inhabitants remain for future generations to both enjoy and gain a living from.

In the United States, TNC is able to work with private landowners to conserve a portion of these large functional landscapes – in some cases by purchasing their homeland, farm, or ranch to accomplish this goal. In Indonesia this approach is not possible, but there are reasonable alternatives. We are already working with some forest concessionaires to pay them for the lost productivity of significant blocks of their forest leases (HPH) to preserve standing timber for the benefit of orangutans, gibbons, and many of the other target species and ecological systems. This process is still in development, but it holds great promise.

In other cases, we are working with other conservation groups and the Forest Products Industry to develop a meaningful certification process that will recognize responsible forest managers by labeling their timber products as “environmentally friendly” in the way they were harvested and processed. This labeling will ostensibly permit the owners/operators to sell their product on the world market at higher than average prices or at markets that will only accept environmentally sound harvested wood – thereby rewarding them for taking the extra steps to manage their forests in a more ecologically sensible way. This too is in an experimental phase. It remains to be seen if this certification process will allow responsible forest managers to out-compete the illegal loggers and pulp and timber mills in the global marketplace. Constant vigilance will be required to spot and arrest any actions to defraud the labeling/certification process along the journey from concession forest to destination markets.

And finally, by working together with local governments at the National, Provincial and District levels, it is hoped that this ecoregional conservation assessment will be integrated into their own spatial plans for the management of the vast natural resources in East

Kalimantan. Early presentations of the ecoregional assessment process have been received with much enthusiasm on the part of these local government officials – recognizing the value in planning on a large-scale level for the benefit of local industries and the local peoples. In the Berau regency district alone, the local government has adopted 80% of the recommended portfolio sites within their jurisdiction (S. Stanley, pers. comm. 2004). We are hopeful this action will lead to other governmental entities and conservation groups working with The Nature Conservancy to accomplish the goals of this assessment on a much larger scale than we can do alone.

G. Recommendations for Additional Conservation Strategies

The following are recommendations of conservation strategies that could address several of the ongoing major threats specifically geared towards reducing the continued degradation of forest condition and target species integrity within the Portfolio sites. These strategies have worked to varying extent in other countries depending on local custom and culture as well as the degree of investment in the conservation programs themselves. Like many of the other conservation strategies discussed in this report, the following will result not in elimination of threats altogether, rather, a reduction in impact or scope of the threats; a mitigation of threats already impacting the targets; and in "buying time" for the landscapes, target species and forest communities we care about.

- Orangutan population monitoring for potential to introduce ecotourism visitation to select family groups or charismatic individuals. Or, strategic placement and support of captive/ orphaned orangutan rehabilitation centers in semi-wild conditions to serve this public education role and take the pressure off wild populations to serve in this capacity.
- Integration of local community hunters into anti-poaching patrols around key villages in proximity to portfolio sites. Monitor bush meat "take-out" from those areas and compare to non-patrolled areas to evaluate effectiveness of the program.
- Training of local inhabitants in the basics of conservation education by means of Indonesian trainers that "rove" around Portfolio sites. Can be monitored for effectiveness of message absorption and conservation effectiveness by tracking illegal logging/woodcutting activities as well as bush meat take-out from "educated" areas versus "naïve" areas.
- Peat Swamp rehabilitation/restoration techniques to reclaim and restore the Mahakam Lakes area and return functionality to that landscape – benefiting *Pesut* and the fishing industry.
- Mangrove Swamp rehabilitation/restoration techniques that restore functionality of that forest community type to the estuarine habitats – tying in to coastal property protection; coral reef protection from sedimentation and sea grass bed protection for sea turtles and others; shrimp, crab and fishing industries restoration by providing protected nurseries. The urgency of this activity has recently been recognized following the devastating 2005 tsunami that eliminated coastal communities that had developed up to the waters edge.
- Encourage rehabilitation of logged or burned forest sites in all forest categories with an appropriate experimental mixture of temperature and humidity range-tolerant species that may provide additional resilience to future global climate change – particularly at the upper elevation Montane and Cloud Forest sites. These could act as replacement community seed banks that will be able to respond to the changing conditions in the future. (See Lawton et al. 2001, and WWF 2003 for detailed rationale).

H. Recommendations for Further Analysis or Research to Strengthen the Portfolio

- Fig Tree spatial coverages from QuickBird or similar aerial photography or spectral image interpretation to understand distribution and relationship of this critical food plant species to arboreal and terrestrial faunal species of interest.
- More intensive ground surveys of Sangkulirang/Mangkalihat area for presence of endemic plants and cavernicolous species in the numerous caves.
- Relationship of human occupation of caves in S/M sites to species diversity and extinction patterns in the region
- Impact of roads on fragmentation of important terrestrial species such as pigs and Sun Bears and how this may affect tree species distribution or other important ecological processes in the future
- The role of silviculture in mimicking or substituting for natural processes that preserve ecological integrity of important forest patches on the landscape – both terrestrial and riparian (i.e. – lowland forest surrounding Montane systems, riparian buffer zones that protect water quality of rivers).

I. References

Anderson, J. A. R. and Chai, P. P. K. (1982). Vegetation. Gunung Mulu National Park, Serawak, Malaysian Borneo. Serawak Museum, Journal Special No. 2, **30** (51): 195-223.

Anon (1979). East Kalimantan Transmigration Area Development Project PTA 46 / ATA 140 / GTZ 76.2010.7 No. 17: Regional Development Plan 2. Draft Discussion Paper.

Anon (2002). Pendekatan Wilayah dan Tata Ruang dalam Pengelolaan Das Mahakam Semiloka Pengelolaan Dan Pendayagunaan Sumberdaya Air Dalam Pembangunan Di Era Autonomi Daerah. Pada Air Se Dunia, Samarinda 23 April 2002.

Ashton, P. S. (1982). Dipterocarpaceae. *Fl. Mal*. Ser. 1. **9**: 237 – 552.

Ave', J.B. and V.T. King. 1986. Borneo: The People of the Weeping Forest. Tradition and change in Borneo. Nat'l Museum of Ethnology, Leiden, the Netherlands. 142 pp.

Bengen, Dietriech G. (1999) *Pedoman Teknis Pengenalan & Pengelolaan Ekosistem Mangrove,* PKSPL-Institut Pertanian Bogor dan Proyek Pesisir, Bogor. 55 pp.

Bennett, E. L. (1988). Proboscis monkeys and their swamp forest in Serawak. *Oryx* **22** (2): 69 – 74

BirdLife International (2001) *Threatened Birds of Asia: the BirdLife International Red Data Book.* Cambridge, UK: BirdLife International

Brown, T. H. and Jarvie, J.K. (1998). The spatial planning process in Indonesia: institutional arrangements and possible improvements. Paper presented to the Indonesian Regional Science Association Conference. Jakarta, October 1998.

Burbidge, P. and Koesoebiono (1980). Mangrove exploitation. *Proceeding of Asian Mangrove Symposium, Kuala Lumpur*.

Burnham, C. P. (1984). Soils. In *Tropical Rainforests of the Far East* (Ed. T. C. Whitmore).

Caldecott, J. O. (1980). Habitat quality and populations of two sympatric Gibbons (Hylobatidae) on a mountain in Malaya. *Folia Primatol*. **33**: 291 – 309.

Chai, P. P. K. (1982). *Ecological studies of mangrove forest in Malaysia*. PhD thesis, Universiti Malaya, Kuala Lumpur.

Chokkalingam, U; Tacconi, L; and Yayat Ruchiyat (2001). Fire use, peatland transformation and local livelihoods: a case of positive reinforcement? International Symposium on Tropical Peatland, Jakarta, Indonesia, 22-23 August 2001

Choudury, Junaid K. (2000) Sustainable management of coastal mangrove forest development and social needs In *Mangrove and other coastal forest* http://www.eepsea.org/publications/research1, pp. 267 – 286.

Christensen, M. S., A. Mulu, and A. Akbar. (1986). Investigations into the fishery of the Middle Mahakam Area. Technical Cooperation for Area Development, Samarinda, East Kalimantan.

CIRAD-PT WIN (2002). Materials presented at a preliminary results discussion workshop, Samarinda, 18-19 July 2002. Mahakam Delta Stakeholders' Socioeconomic Analysis

Coates, B. J. and Bishop, K. D. (1992). *A guide to the birds of Wallacea, Sulawesi, the Mollucas and the Lesser Sunda Islands, Indonesia*. (Dove).

Cox, J.H., Frazier, R.S. & Maturbongs, R.A. (1993).Freshwater Crocodiles of Kalimantan (Indonesian Borneo). *Copeia* 2:564ff.

Cranbrook, Earl of (1982). The significance of the vertebrate fauna. In *Gunung Mulu National Park, a management and development plan* (Eds J. A. R. Andersen; A. C. Jeremy; and Earl of Cranbrook). Royal Geographical Society, London

Craven (2000). Opportunities for developing spatial planning capacity in East Kalimantan. Natural Resource Management Program Technical Report, August 2000, Jakarta.

DaviesG. And Payne, J. (1982). *A faunal survey of Sabah*. WWF, Malaysia, Kuala Lumpur.

Driessen, P. M. (1978). Peat soils. In *Soils and Rice*. Pp. 763 – 779, IRR, Los Banos, Philippines.

Dunning, J. B., B. J. Danielson, and H. R. Pulliam. (1992). Ecological processes that affect populations in complex landscapes. *Oikos* **65**:169-175.

Elton, C. S. (1973). The structure of invertebrate populations inside neotropical rainforest. *J. Anim. Ecol*. **42**: 55 – 104.

Endert, F. H. (1927). Floristisch verslag van de Midden Oost Borneo Expeditie, 1925. Uitgave van het Indisch Comite voor Wetenschappelijke Onderzoekingen, Pp. 200-312.

Forman, R. T. T. and Godron., M. (1986). *Landscape Ecology*. John Wiley & Sons, New York. 619 pp.

Fox, J. (1999). Legislation and policy for fire prevention and management. Working Paper No. 3, Planning for fire prevention and drought management project, ADB TA 2999-INO, BAPPENAS, Jakarta.

Goenner, C. (2000). Wetland Birds of Lake Jempang and the Middle Mahakam Area. *Kukila* **11**:13-36.

Giesen, W. (1990). Vegetation of the Negara River Basin. In: Conservation of Sungai Negara Wetlands, South Kalimantan. Pp. 1 – 51. PHPA/AWB- Indonesia and KPSL – UNLAM.

Haeruman (1985). Future of tropical forests in Indonesia, resolving land resource conflicts. Pp. X-X. In *The future of tropical Rain Forests in South East Asia* (eds?). Commission on Ecology Papers No. 10:111 – 114.

Hanski, I. (1983). Distributional ecology and abundance of dung and carrion – feeding beetles (Scarabaeidae) in tropical rain forests in Serawak, Borneo. *Acta Zool. Fenn*. **167**: 1 – 45.

Hardwinarto, S., Ruslim, Y., Sahuri, F., Santosa, B.B., Firdaus, F., and Wahono, F. N. (1999). Spatial distribution of suspended sediment in the river channels originating from the logging areas at the upstream of Melintang and Semayang Lakes, Kutai Regency, East Kalimantan. Ministry of Education and Culture RI. Directorate General of higher Education. Final Report, March 1999.

Harrison, J. L. (1965). The effect of forest clearance on small mammals. Bangkok Conference IUCN (Mimeo ms)

Hoffmann, A. A., A. Hinrichs, and F. Siegart. (1999). Fire damage in East Kalimantan in 1997/98 related to land use and vegetation classes: satellite radar inventory results and proposals for further actions. IFFM-SFMP Report No. 1a, MoFEC, GTZ, and KfW, Samarinda, Indonesia.

Holloway, J. D. (1984). Notes on the butterflies of the Gunung Mulu National Park. *Serawak Mus. J*. **30**: 89 – 131.

Holmes, D; Rombang, W. M. and Ovtaviani, D. (2001). Daerah Penting Bagi Burung Kalimantan (PKA, Bird Life International Indonesian Programme, Bogor).

IUCN/WWF (1994). Centres of Plant Diversity SEA Codes.

Jarvie, J. K. (1999). Spatial Planning in the provinces; gaps and opportunities for the NRM program. (USAID/NRM/EPIQ Technical report, Jakarta, May 1999).

Jepsen, P., F. Momberg, and H. van Noord. (1998). Trade in reptiles from the Middle Mahakam Lake Area, East Kalimantan, Indonesia, with evidence of a causal link to the forest fires. Bio-Regional Management and Integrated Park Management Project, Technical Memorandum 3. WWF Indonesia/EPIQ/USAID.

Jessup, T. C. and Vayda, A. P. (1988). Dayaks and forests of interior Borneo. The University Magazine of Archaelogy/ Anthropology University of Pennsylvania. *Expedition* **30** (1):5 – 17.

Jiminez, J. A., Lugo, A. E. and Cintron, G.(1985). Tree mortality in mangrove forests. *Biotropica* **17**: 177 – 185.

Johnson, D. S. (1968). Malayan black waters. *Proc. Symp. Rec. Adv. Trop. Ecol*. **1**:303 – 310.

Kartawinata, K. (1978). The Ecology 'Karangas' heath forest in Indonesia. Pp. 145 – 152. In *Glimpses of Ecology* (Eds J. S. Singh and B Gopal). International Scientific Publications, Jaipur.

Kartawinata, K. (1993). A wider view of the fire hazard. Pp. 261-266. *In* (Eds H. Brookfield and Y. Byron). *South-East Asia's environmental future:The search for sustainability*. (United Nations University Press, Tokyo).

Kartawinata, Adisoemarto, S. Soemodihardjo, S. and Tantra, I.G. H. K. (1979). Status pengetahuan hutan bakau di Indonesia. Pp. 21- 30. In Prosiding seminar Ekosistem hutan mangrove (Eds S.Soemodihardjo, A Nontji and A. Djamali). Lembaga Oseanologi Nasional, Jakarta.

Kikkawa, J. and Williams, W. T. (1971). Altitudinal distribution of land birds in New Guinea. *Search* **2**: 64 – 65.

Kitchener, D. J., How, R. A. and Maharadatunkamsi (1991a). A new species of Rattus from the mountains of west Flores, Indonesia. Rec. West Aust. Mus. 15 (3): 611-626.

Kitchener, D. J., Aplin, K. and Boeadi (1991b). A new species of Rattus from Gunung Mutus, South West Timor Island, Indonesia. Rec. West. Aust. Mus. 15 (2): 445-461.

Kitchener, D. J. and Yani, M. (1996). The ecology of *Rattus hainaldi* (Rodentia, Muridae) along an altitudinal gradient at Gunung Ranaka, Flores Island, Indonesia. Pp 51 In *Program and Abstracts of the Second International Conference on Eastern Indonesian – Australian Vertebrate Fauna; Lombok, 10-13 December 1996* (Lembaga Ilmu Pengetahuan Indonesia ed) Bogor: LIPI.

Kitchener, D. J.,Boeadi and Sinaga, M. (1997). Mammals of the Freeport Contract of Work Region, Irian Jaya: results from the survey of 14 February to 6 March 1997. *Unpublished Report* (Freeport)- available on CD.

Kitchener, D. J. and Yani, M. (1998). Small non-volant mammal diversity along an altitudinal gradient at Gunung Ranaka, Flores Island, Indonesia. *Tropical Biodiversity*. **5** (2): 159-162

Kiyono and Hastaniah (2000). The role of slash–and–burn agriculture in transforming dipterocarp forest into *Imperata* grassland. Pp. 199-207 In *Rainforest Ecosystems of East Kalimantan: El Nino, drought, fire and human impacts* (Eds E. Guhardji' M. Fatawi; M. Sutisna, T. Mori and S Ohta) (Springer- Verlag, Tokyo).

Kottelat, M. Whitten, A. J. Kartikasari, S. N. and Wiroatmodjo, S.(1993). The freshwater fishes of western Indonesia and Sulawesi (Periplus, Singapore).

Kreb, D. (1999). Observations on the occurrence of Irrawaddy dolphin, *Orcaella brevirostris*, in the Mahakam River, East Kalimantan, Indonesia. Z. Saug., 64, 54-58.

Kreb, D. and Rahadi, K.D. (2002). Living under an aquatic freeway: effects of boats on Irrawaddy dolphins (*Orcaella brevirostris*) in a coastal and riverine environment in Indonesia (unpublished manuscript).

Lawton, R., U.Nair, R. Pierce, and R.Welch. 2001. Climatic impact of tropical lowland deforestation on nearby montane cloud forests. Science 294(5542):584-587.

Leighton, M., and N. Wirawan. (1986). Catastrophic drought and fire in Borneo tropical rain forest associated with the 1982-1983 El Nino Southern Oscillation Event. Pages 75-102 in G.T. Prance, editor. Tropical rain forests and the world atmosphere. AAAS Selected Symposium 101. Westview, Boulder, Colorado.

Leopold, A. (1933). *Game Management*. (Charles Scribners, New York).

Lloyd, M., Inger, R. F. and King, F. W. (1968). On the diversity of reptile and amphibian species in a Bornean rainforest. *Am. Nat*. **102**: 497 – 516.

Lowe- McConnell, R. H. (1977). *Ecology of fishes in tropical waters*. Studies in Biology No. 76.

MacKinnon, J. and Artha, M. B. (1981). *National Conservation Plan for Indonesia*. Vol. 5: Kalimantan (FAO, Bogor).

MacKinnon, J. and Phillips, K. (1993). *A field guide to the birds of Borneo, Sunda, Java and Bali* (Oxford Press).

Manaputty D. N. (1955). Keluarga *Agathis* di Indonesia. *Rimba Indonesia* **4**: 132-188.

Marsh, C. W. and Wilson, W. L. (1981). A survey of primates in Peninsular Malaysian rainforests. Universiti Kebangsaan Malaysia and University of Cambridge, U.K. A survey of primates.

Maryanto, I and Yani, M. (2002). Mammals of Lore Lindu National Park . Pp. 124-137. In *Lore Lindu National Park Draft Management Plan 2002-2027* (The Nature Conservancy and PHPA, Jakarta).

Meijaard, E., D. Sheil, R. Nasi, D. Augeri, B. Rosenbaum, D. Iskandar, T. Setyanati, M. Lammertink, I. Rachmatika, A. Wong, T. Soehartono, S. Stanley, T. O'Brien. 2005. Life After Logging: Reconciling wildlife conservation and production forestry in Indonesian Borneo. CIFOR. Bogor, Indonesia. 345 pp.

Momberg, F. Jepson, P. and van Noord, H. (1998). Kalimantan Biodiversity Assessment: WWF Project for Integrated Park Management and Bioregional Planning. Final Report (WWF Indonesia, Jakarta).

Moersid, I.A. and Christensen, M. S. (1987). *Prosiding Lokakarya Perikanan Perairan Umum Wilayah Mahakam Tengah. Kota Bangun 7-9 November 1987.* Technical Report. Dinas Perikanan Pemda Tk I Kalimantan Timur .205pp.

Musser, G. G. (1981). Th Giant Rat of Flores and its relatives East of Borneo and Bali. *Bull. Amer. Mus nat. Hist.* **169**: 69-175.

Myers (1988). Threatened Biotas: hotspots in tropical forests. *Environmentalist* **8**:1-20

Nawir, A.A., L. Santoso, I. Mudhofar. 2003. Towards Mutually-Beneficial Company-Community Partnerships in Timber Plantations: Lessons Learnt from Indonesia. Working Paper No. 26. CIFOR. Bogor, Indonesia. 77 pp.

Nieuwstadt, N; Sheil, D. and Kartawinata, K. (2002). The ecological consequences of logging in the burned forests of East Kalimantan, Indonesia. *Conservation Biology* **15**(4): 1183-1186.

Nijman, V. (2001). Density and Biomass estimates of Gibbons (*Hylobates muelleri*) in Bornean rainforest: a comparison of techniques. Pp. 13-31. *In Forests (and) Primates conservation and ecology of the endemic primates of Java and Borneo* (Topenbos International, Bogor). 232pp.

Obidzinski, K and C. Barr. 2003. The Effects (of) Decentralization on Forests and Forest Industries in Berau District, East Kalimantan. Case Study No. 9. CIFOR. Bogor, Indonesia. 33pp.

O'Brien, T. G.(1997). Bulungan biodiversity survey: preliminary results. Unpublished Report (CIFOR and WCS, Jakarta).

Okimori and Matius (2000). Tropical secondary forest and its succession following traditional slash and burn agriculture in Mencimai, East Kalimantan. Pp 185-196. In *Rainforest Ecosystems of East Kalimantan: El Nino, drought, fire and human impacts* (Eds E. Guhardji, M. Fatawi, M. Sutisna, T. Mori and S. Ohta) (Springer- Verlag, Tokyo).

Ong, J. E. Gong, W. K. and Wong, C. H.(1980). Ecological survey of the River Merbok estuarine mangrove ecosystem. School of Biological Sciences, Universiti Sains Malaysia, Penang.

Ong, J. E. (1982). Mangroves and aquaculture in Malaysia. *Ambio*.**11**: 252-257.

Paw, J.N. and Thia-Eng Chua (1991) *An Assessment of the Ecological and Economic Impact of Mangrove Conversion in Southeast Asia,* (Eds, Loke-Ming Chou, Thia-Eng Chua, H. W. Khoo, P. E. Lim, J. N. Paw, G. T. Silvestre, M. J. Valencia, Allan T. White and P. K. Wong), *In* Towards and Integrated Management of Tropical Coastal Resources, ICLARM 22, pp. 201-212.

Raharjaningtrah, W and Memengko, C. (2002). Birds of Lore Lindu National Park . Pp. 92-124. In *Lore Lindu National Park Draft Management Plan 2002-2027* (The Nature Conservancy and PHPA, Jakarta).

Richter, F. (2000). Structure and dynamics of riverine forest vegetation. T_B Series No: T_B FTWF-19e. GTZ, Eschborn, Germany.

RePPProT (1987). *Review of Phase 1 Results, East and South Kalimantan*. 2 Vols. Regional Physical Planning Program for Transmigration, Direktorat Bina Program, Indonesia

Riswan, S. Kenworthy, J. B. and Kartawinata, K (1985). The estimation of temporal processes in the tropical rainforest: a study of primary mixed dipterocarp forest in Indonesia. *J. Trop. Ecol*. **1**: 171-182.

Roberts, T. S. (1989). The Freshwater Fishes of Western Borneo (Kalimantan Barat, Indonesia). California Academy of Sciences. San Francisco.

Rosenthal, H. and Baum, G. (1980). Project Proposal: Inland Fisheries in the Central Lake Area. TAD-Report 23.

Schindele, W., W. Thoma and K. Panzer. (1989). Investigation of the steps needed to rehabilitate the areas of east Kalimantan seriously affected by fire. FR-Report No. 5, GTZ and ITTO.

Scott, D. A. (1989). A directory of Asian Wetlands. IUCN, Gland 1181 S.

Silvius, M. J.; Djuharsa, E.; Taufic, A.; steeman, A. and Berczy, E. (comps) (1987). The Indonesian Wetlands Inventory. 2 Vols. PHPA-AWB/ Interwader.

Slik, J. W. F., Verburg, R. W.; and Kessler, P. J. A. (2002). Effects of fire and selective logging on the tree species composition of lowland dipterocarp forests in East Kalimantan, Indonesia. *Biodiversity and Conservation* **11**: 85-89.

Smith, J. M. B. (1970). Herbaceous plant communities in the summit zone of Mount Kinabalu. *Malay. Nat J*. **24**: 16- 9

Smith, J. M. B. (1979). Vegetation recovery from drought on Mount Kinabalu. *Malay Nat. J*. **32**: 341-342.

Snedecor, G., W. Cochran, D.Cox. (1989) 8th Ed. Statistical Methods. Iowa State Univ. Press.

Soezer and van der Heiden (1997). (Check Momberg et al 1998)

Sorenson, K.W. & B. Morris. (Eds.) 1997. People and Plants of Kayan Mentarang. UNESCO & World Wide Fund for Nature – Indonesia Program publications. Jakarta. 258 pp.

Sowelo (1994). (See Danielle krebs refs)

Sujatnika; Jepson, P., Soehartono, T. R., Crosby, M. J. and Mardiastuti, A. (1995). *Conserving Indonesian Biodiversity*.(Bird life International & Departemen Kehutanan: Bogor).

Suryadiputra, N. N; Gönner, C; Wibowo, P. and Ratnawati, E. (2000). The Mahakam Lakes. Paper presented at the Global Nature Fund Conference, June 16-17, 2000, Hannover, Germany.

Suzuki *et al*. (1997). The surveys of distribution of habitat and food of Orangutan (*Pongo pygmaeus*), its relationship with other animals and the conservation at Berau and Kutai District, East Kalimantan. Unpublished report.

Tacconi, L. 2003. Fires in Indonesia: Causes, Costs and Policy Implications. CIFOR Occassional Papers No. 38. CIFOR. Bogor, Indonesia. 24 pp.

Tacconi, L., K. Obidzinski, F.. Agung. 2004. Learning Lessons To Promote Forest Certification and Control Illegal Logging in Indonesia. CIFOR. Bogor, Indonesia. 81 pp.

Tasan *et al*. (1980). *Orcaella brevirostris* from Mahakam River. Jakarta.

The Nature Conservancy (2000). *Designing a Geography of Hope: a Practitioner's Hand book to Ecoregional Conservation Planning*. Vol. 1, 2nd Ed. (TNC).

Thiel, E. (1980). TAD report 16: Regional development Plan for selected regions. East Kalimantan Transmigration area development project PTA46 / ATA 140 (Eds K. Fasbender and D. Kebschuil).

Wells, D. R. (1976). Resident birds. In Birds of the Malay Peninsula (Eds Lord Medway and D. R. Wells). Chpt 1. Witherby, London.

Wells, D. R. Hails, C. J., and Hails, A. J. (1979). A study of birds of Gunung Mulu National Park, Serawak, with special emphasis of those of lowland forests. Royal Geography Society Gunung Mulu Expedition.

Whitten, A. J. Damanik, S. J., Anwar, J. and Nazaruddin, H. (1987). *The Ecology of Sumatra*. (2^{nd} Ed.). Gadjah Mada University press, Yogyakarta.

Whitmore, T.C. (1984). Tropical Rainforests of the Far East (2^{nd} Ed.). Clarendon Press, Oxford.

Wimberly, M. C., T. A. Spies, C. J. Long, and C. Whitlock. (2000). Simulating historical variability in the amount of old forests in the Oregon Coast Range. *Conservation Biology* 14:167-180.

Wong, S.T., C. Servheen, L. Ambu. 2004. Home range, movements and activity patterns, and bedding sites of Malayan Sun Bears, *Helarctos melayanus* in the rainforest of Borneo. Biological Conservation 119:169-181.

Woodroffe, Colin (1992) Mangrove Sediments and Geomorphology In *Tropical Mangrove Ecosystems* (Eds, Alistar I. Robertson and Daniel Alongi), American Geophysical Union, Washington D.C., pp. 7 – 41.

Yasuma (1994). *An Invitation (sic) to the Mammals of East Kalimantan*. *Pusrehut Special Publication No.3.* (Japan International Cooperation Agency/ Directorate General of Higher Education, Ministry of Education and Culture, Republic of Indonesia.